PART 2: EXPERT CONSULTATION BACKGROUND DOCUMENTS

DEEP-SEA RESOURCES AND FISHERIES[1]

by

D.W. Japp and S. Wilkinson[2]

1. INTRODUCTION

This paper was commissioned as an overview document to be presented at the Expert Consultation on Deep-Sea Fisheries in the High Seas organized by the Food and Agricultural Organization of the United Nations in November 2006. This expert consultation is a follow-up to Deep Sea 2003, a conference dedicated to deep-sea fisheries and related issue held in Queenstown, New Zealand in December 2003. At this conference there was also a strong desire expressed by some scientists, non-governmental organizations (NGOs) and seafood industry representatives to work with governments and other agencies on solutions to the management of deep-sea ecosystems and "to contribute constructively towards the development of long term management frameworks within which legitimate fisheries could continue" (Shotton, 2003).

This paper aims to provide a broad overview of global deep-sea fisheries, informing decision-makers, fishery managers, administrators, NGOs and other interested and affected parties. As far as possible, the text does not include detailed taxonomic nomenclature and scientific terminology and should therefore give readers an uncomplicated perspective on deep-sea fisheries and related issues. It is also stressed that a review of the literature and data available on deep-sea fisheries presents an enormous amount of information. Many authors have quite different points of view regarding the deep sea including artisanal line fisheries (in which deep would be interpreted to be 400 metres [m]) and large industrial trawling in which deep sea has a quite different interpretation. This overview therefore provides an opinion on different aspects of deep-sea fisheries and aims at stimulating discussion around the major issues.

2. DEFINING "DEEP SEA"?

No clear definition(s) exists for "deep sea". In the context of this review the author focused on a definition used by FAO[3] consisting of regions off the shelf and deeper than 200 m. In a broad sense, the deep sea can be defined as the area (Figure 1) from the near shore >200 m water depth to the shelf edge (approximating the 500 m depth contour) and extending beyond the shelf to include the slope, or depths that technology presently permits trawling (about 1 500 m water depth). Depths fished by other gears (demersal longlines and traps for example) may extend this range somewhat by a further 1 000 m or as deep as 2 500 m.

In the context of this review, deep sea refers primarily to demersal resources, or marine fauna found on or near the sea bed (benthic and benthopelagic). The emphasis is on marine fish in the taxonomic

---

[1] This document was prepared for the Expert Consultation on Deep-sea Fisheries in the High Seas which took place in Bangkok, Thailand from 21 to 23 November 2006.

[2] The views expressed in this paper are solely those of the authors, Dave W. Japp, P.O. Box 50035, Waterfront, Cape Town, 8002, E-mail: jappy@iafrica.com, and S. Wilkinson.

[3] Please note that this is not the official FAO definition, but has been used in other FAO documents. (FAO. Report on DEEP SEA 2003, an International Conference on Governance and Management of Deep-sea Fisheries. Queenstown, New Zealand 1–5 December 2003. *FAO Fisheries Report*. No. 772. Rome, FAO. 2005. 84p.)

Class Pisces including the cartilaginous fish (Chondrichthyes) and bony fishes (Osteichthyes). Further, the exploited resources reviewed include meso-pelagic fish (mostly caught off the bottom, but generally in deeper than 200 m water depth) but not the highly migratory stocks of tunas, billfishes and shark (pelagic stocks – Figure 1). Crustaceans are also impacted by deep-sea exploitation but are not discussed in any detail in this paper.

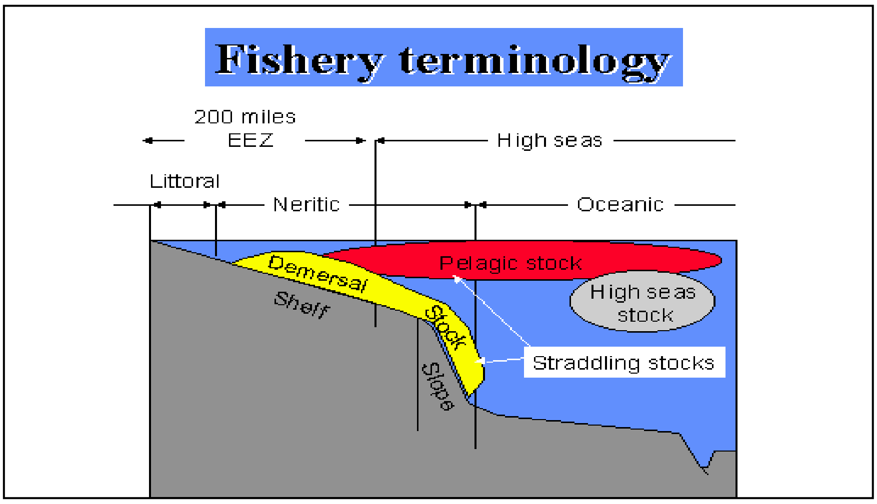


Figure 1. Fishery terminology used to define deep sea.

In some instances deep sea has also been defined as extending to the known depth limits of the oceans in which deep-sea trenches, hydrothermal vents and seamounts are considerations. Although these areas are of academic interest (e.g. biodiversity, geology and plate tectonics, biochemical, etc.) they are, with the exception of many seamounts, not presently impacted directly by fishing.

It should also be kept in mind that our perception of what is actually deep has changed over time. Historically, offshore trawling described activity on the shelf, generally not exceeding 500 m water depth. The abundance of target species such as the gadoids (e.g. cods and hakes) did not necessitate fishing beyond this depth. The distinction between the directed effort on the shelf and that off the shelf was always clear. The deepwater exploratory operations of the large Russian freezer trawlers in international waters in the 1950s and 1970s was, for example, distinctly different from the coastal-based trawling that developed on the continental shelves and remaining within economically viable distances from home ports. The target areas of these high seas fleets were the oceanic ridges (annex 1, Figures 12-14) and seamounts where species such as alfonsino (*Beryx* sp.) and orange roughy (*Hoplostethus atlanticus*) were often caught in large quantities.

The main point here is that in the last two decades there has been a systematic increase in the depths fished by coastal offshore fisheries, effectively merging shelf fishing with the deep sea. The primary reason for this is obviously the depletion of once abundant shelf resources and the subsequent gradual shift in fishing effort to deeper water off the shelf and onto continental slopes in search of better catches. Although deep-sea species might not have been intentionally targeted, it certainly resulted in increased landings of a new spectrum of species that could be defined as deep sea bycatch. The extent of the deep-sea areas between 200–2 000 m is illustrated in Annex 1 as well as the trends in deep-sea catches in each ocean region are elaborated on later in Figures 12-14 (Annex 1). The location of seamounts and their proximity to the continental shelves, as illustrated by Stocks and Boehlert (2003) in their international census of marine life also provides a useful perspective.[4]

[4] There was much debate on the definition of “deep-sea” at the expert consultation. The following captures the salient points defining “deep-sea” emanating from the discussions: “Deep Sea Fisheries are fisheries that mostly target resources found at the edge of the continental shelves extending into deeper water down the slopes. The areas in which these fisheries occur include seamounts and oceanic ridges found predominantly (but not exclusively) on the high seas. In most instances (but not

Gordon (2003) also pointed out the differences between continental slopes, seamounts and ocean ridges and gives an excellent description of the differences in the physical environments between these areas. Gordon (2003) also notes that the physical area considered here as deep sea (200–2 000 m) comprises only 8.8 percent of the total ocean area in the world. Contributing to this "merging" of the deep-sea domains was undoubtedly the considerable advances in technology and vessel capacity that facilitated the systematic extension of the coastal fleets into deeper water (but was not the primary reason for moving into deeper water). In doing so a new species assemblage has been impacted, quite different from those target species and bycatch traditionally exploited on the continental shelves.[5]

3. IT'S ALL RELATIVE – THE HISTORICAL DEVELOPMENT OF DEEP-SEA FISHERIES

Successful exploitation of the deep sea in this author's view relates to a combination of three main factors:

- resource availability/abundance;
- technology and information; and
- economics (costs and benefits).

Prior, even to Columbus landing in North America, Spanish (basque) fishers targeted cod (with lines and longlines) from boats sailed from Spain across the North Atlantic to the Grand Banks returning with salted cod. What made this fishery viable was the use of salt to preserve their catch. This was a simple technological advancement that at the time was not known amongst fishers in other parts of the world. Gear constraints and depths fished were not major limitations as cod availability was high, so that there was no need to fish "deep". Given the time and risks involved, the trade off with the value of the catch was quite remarkable. Simply speaking, all three conditions for a viable deep-sea fishery had been fulfilled.

By comparison, the use of steel trawlers (steam driven) started in the late 19th century and resulted in the rapid advancement of offshore fishing. Despite the evolution of modern-day trawling, bigger and more robust sea-going vessels, etc. in the early part of the 20th century, effort remained relatively close inshore. Technology was not critical as resource abundance inshore was high. For example, hake-directed effort off the Agulhas Bank (Japp *et al*. 1994) in the first half of the 20th century was sustained in relatively shallow water (< 100 m). The South African hake fishery has systematically moved into deeper water and the most recent trend is to target deepwater hake at depths exceeding 600 m resulting in a distinctly different bycatch (deepwater) component.

From 1953, fishers in Russia began fishing deep, targeting rock fish (*Sebastes* sp.) and Atlantic halibut (*Hippoglossus hippoglossus*) off the continental shelf (on the slopes) in the Barents Sea (Lapshin and Korotov, 2003). These fishers are considered by some to be the "pioneers" of deepwater fishing in Russia and were the forerunners of the operations of the large bottom and midwater exploratory freezer trawlers that started in 1967 targeting roundnose (rock) grenadier (*Coryphaenoides rupestris*) and black halibut (*Reinhardtius hippoglossoides*) at depths up to 1 000–1 100 m in the North Atlantic. Simultaneously deepwater fishing (on the slopes of the continental shelf) for sablefish (*Anoplopoma fimbriata*) was started in the Pacific Ocean by the Russian high seas (industrial) fleets. The Atlantic fleet (Russian) vessels also systematically moved south along the Mid-

---

exclusively) these fisheries target stocks and species not found on continental shelves and which generally have low productivity. The depths at which these resources are found are centred below 200 m and occur mostly from 400 m into deeper water and impact unique ecosystems that include coldwater corals and other fauna".

[5] It should be noted that the exploitation of these new species assemblages are not necessarily target species. For example, the shift of effort into deeper water (> 600 m) off the South African coast in recent years (since 2003) was primarily to target larger deepwater hake Merluccius paradoxus due to reduced catch rates in the shallower shelf areas (350 – 550 m water depth). This resulted in a significantly different (incidental) bycatch component i.e. deepwater species.

Atlantic Ridge conducting exploratory fishing around the Azores and Walvis Ridge (Japp, 2003). Data from these exploratory cruises reflect high levels of detail when describing grounds and species targeted (Anon, 1996).

Some of these vessels have, until recently, still been active in the South East Atlantic targeting hake and horse mackerel in the Benguela region under the jointly managed International Commission for South East Atlantic Fisheries (ICSEAF, disbanded in 1990 at the time of Namibian independence). Up to 2004, some of these vessels were still fishing horse mackerel in Namibian (Japp, 1996) and South African waters and were also used when the deep sea South West Indian Ocean fishery developed (Japp, 2004). Uncertainty relating to the historical catches of not only hake in the Benguela region, but also unknown quantities of orange roughy (*Hoplostethus atlanticus*) in the ICSEAF period, has influenced time series data used in resource assessments of these stocks (Oelofsen and Staby, 2003; Butterworth and Brandao, 2003). Unreported catches of deepwater species in the South Pacific by international high-seas vessels, particularly in areas close to or beyond the EEZs such as the Louisville Ridge[6] might also have occurred.

Deepwater effort in these periods (pre-1980) almost certainly contributed to stock depletion, particularly affecting accumulated stocks of long-lived species such as orange roughy.[7] These vessels, which were the first modern day deep-sea operations, were large (up to 120 m) powerful fuel-inefficient vessels capable of deep tows using both mid-water pelagic directed nets and heavy otter trawl gear with rock hoppers and heavy steel bobbins. Abundance of deepwater stocks was high, technology was limiting but functional, and the economics was driven by volume and relatively low fuel costs and cheap crews.

More recently (since 1980) fishing techniques and technology have advanced enormously and this is reflected in the FAO catch statistics aided by more responsible reporting of catches. The development of the orange roughy fishery off both Australia and New Zealand since 1980 is perhaps the best (but not exclusive) example of advancements in deep-sea fishing. Even given the improvement in monitoring and effort limitation, unregulated high seas activity poses huge problems. The Tasman Rise controversy in 1999 (Annala and Clark, 2003) raised many issues related to deep-sea trawling and openly challenged the management and governance of deep-sea fisheries in the high seas. In a subsequent development from 1996, Australian, New Zealand and South African-flagged deep-sea equipped freezer trawlers began exploiting orange roughy and other deepwater species in the South West Indian Ocean (SWIO) (Japp, 2003). This fishery peaked quickly and declined rapidly as more and more high seas operators became involved (effort is believed to have peaked at about 35 vessels). This was primarily a seasonal fishery targeting winter aggregations of orange roughy.[8]

When catch rates of orange roughy declined, effort switched to alfonsino (*Beryx splendens*). Effort has since declined even further and trawling in the area is no longer economically viable for most operators. Clearly, of the three basic requirements for an effective deep-sea fishery, technology has played a role, but the main incentive was good catch rates combined with high product value. Many of deep sea SWIO operators very quickly lost interest when the returns (catch rates) declined and international fuel prices increased - the economic incentive was lost. It is a moot point that the declaration of eleven benthic protected deep-sea areas in the Indian Ocean (IUCN, 2006) came at time when the economic incentive to fish in the deep sea areas had already been lost (Figure 2).[9]

---

[6] Noting that Annala and Clark (2003) reported an established deep sea fishery in this area from 1993.

[7] It is believed that although large volumes of orange roughy (for example) may have been caught by international high seas vessels from the 1950s to 1980s, markets for these species had not been developed. Catches were mostly processed as fishmeal, minced or discarded.

[8] Discussion at the Expert Consultation clarified the origins of the SWIO fishery unknown to the authors. It is understood that the SWIO grounds had been investigated prior to 1996 by New Zealand companies and that the initial target species was alfonsino.

[9] Noting the emphasis in "Benthic" protected areas as opposed to fully "Marine Protected Areas". Ref. Pers comm.. G. Patchel at the expert consultation. Dimensions and coordinates of the grounds protected are given in IUCN / SIODFA questions and answers communication (IUCN, 2006).

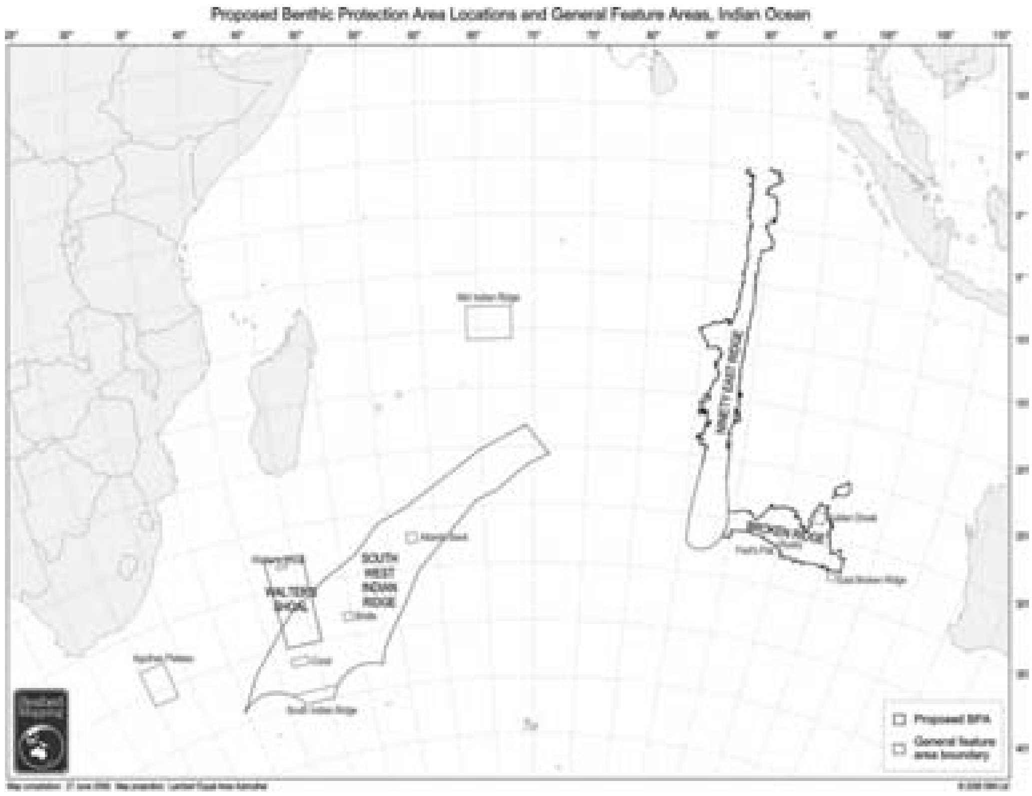


Figure 2. Declared benthic protected areas in the South Indian Ocean in collaboration with the *Southern Indian Ocean Deepwater Association (SIODFA)*

With respect to historical deep-sea effort it is generally believed that deep-sea fishing expanded rapidly in the last 10-20 years due primarily to factors such as new technology and surplus fishing vessel capacity. Although effort and technology are important factors, economics and market demand are, in this author's view, the main drivers of deep-sea fisheries. Technology provides the tools to catch efficiently, but ultimately distances offshore, catch rates and fuel costs will dictate global deep-sea effort. Nevertheless the development of a remarkable array of deep sea technology has advanced deepwater fishing as well as having increased the potential to fish even deeper than present.

4. DEEPWATER TECHNOLOGY

In deepwater fishing, emphasis is naturally placed on trawl gear, although the use of alternative gear types should not be ignored (e.g. demersal longlines and traps). Demersal trawling has developed primarily around the use and modifications of otter boards and warps (Thiele and Niedzwiedz, 2003). These modifications are sensitive to many different factors including hydrodynamics, length and tension of warps and door balancing (fixation points). Deepwater gear is heavy gear requiring combinations of bobbins, rock hoppers, warps and chains (Figure 3).

Efficient utilization of this gear requires a high level of skipper/fishing master skill particularly when positioning gear on seamounts or specific trawl lines to keep clear off foul ground. Skippers now have advanced acoustic tools, including 3-dimensional bathymetric charts, global positioning and multi-beam sounders (Figure 4), variable pitch propellers and thrusters to assist them.

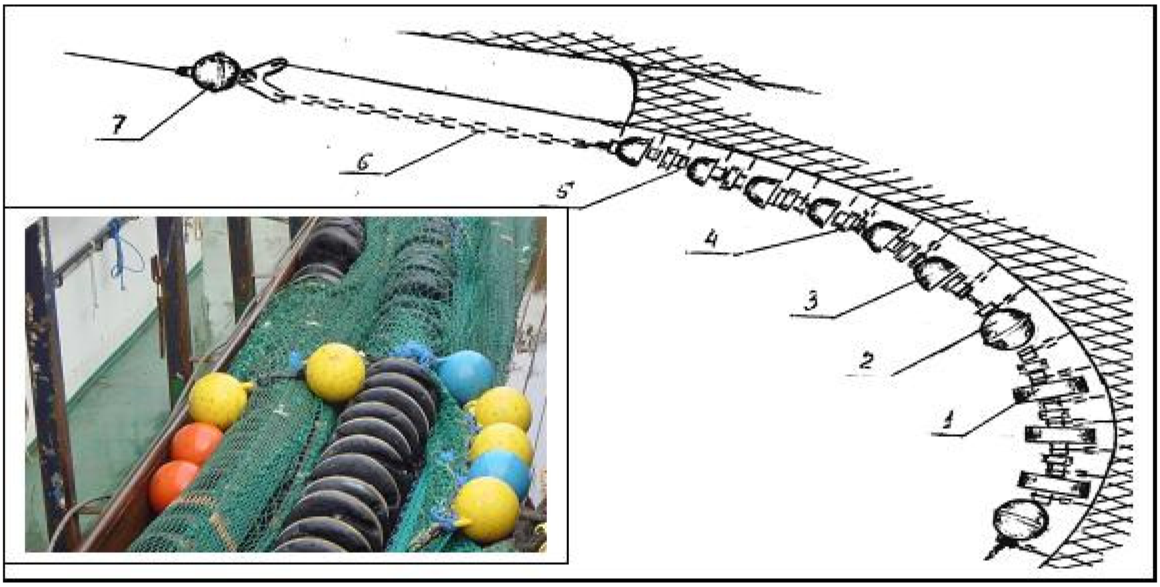


Figure 3. Typical deepwater trawl gear (head and foot ropes of an orange roughy trawl) - *schematic after Thiele and Niedzwiedz, 2003*. [1, bobbin (rubber); 2, spherical bobbin (metallic); 3, half spherical bunt bobbin (rubber); 4, rubber disk; 5, becket bobbin with chains; 6, chain; 7, bobbin-butterfly danleno]

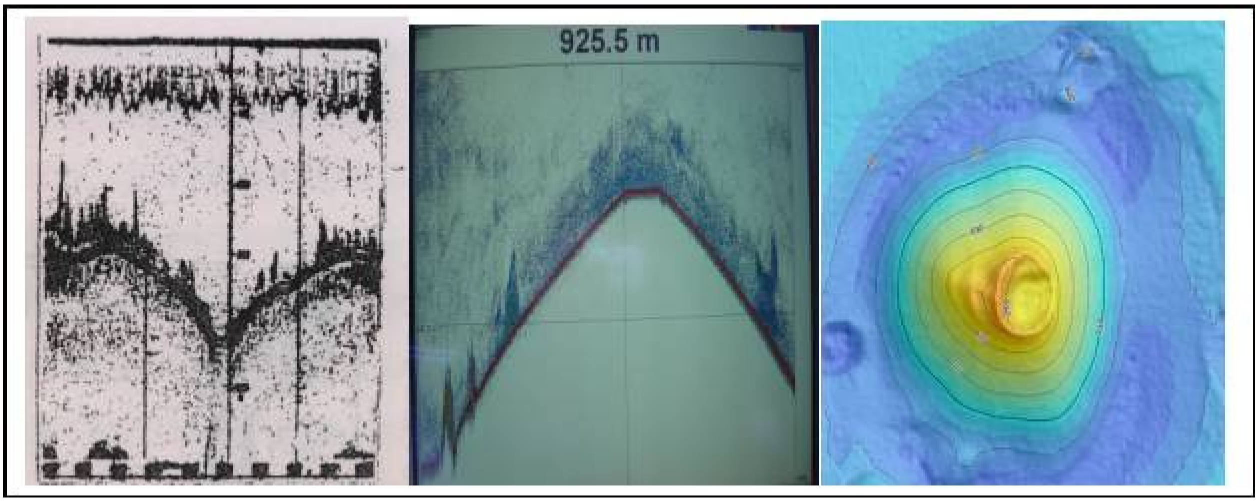


Figure 4. Echographs shown on three different displays and with different echo sounders. Scaling is important when interpreting the extent of, for example, seamounts. Often seamounts are incorrectly perceived as dramatic rises in the deep ocean whereas gradients are often more gradual than perceived and dependent on the tracking and vessel speed over sub-sea features. The figure (left) is a paper trace recording of the echo sounders used by the Russian high seas vessel off the Azores in 1970s, a seamount (center) off the Louisville Ridge (orange roughy targets) and an example of 3-D charting of a seamount (right).

Vessel and winch power, rather than vessel size, is important with most modern vessel constructions which are smaller and more fuel-efficient than older vessels. Control of gear deployed (warp length when trawling deep is generally 2-3 times the water depth) is essential, especially when pinpointing targets on seamounts and slopes (Figure 5).[10] Fish aggregations are often dense and skippers have learned to open and close gear to prevent excessive catches which can be as much as 60 t in less than a minute of bottom trawl time (Figure 6).

[10] Noting comments at the expert consultation that these diagrammatic representations are not fully descriptive of deep-sea targeting practices and that there are many variations with respect to species, depths and grounds and sub-sea structures fished.

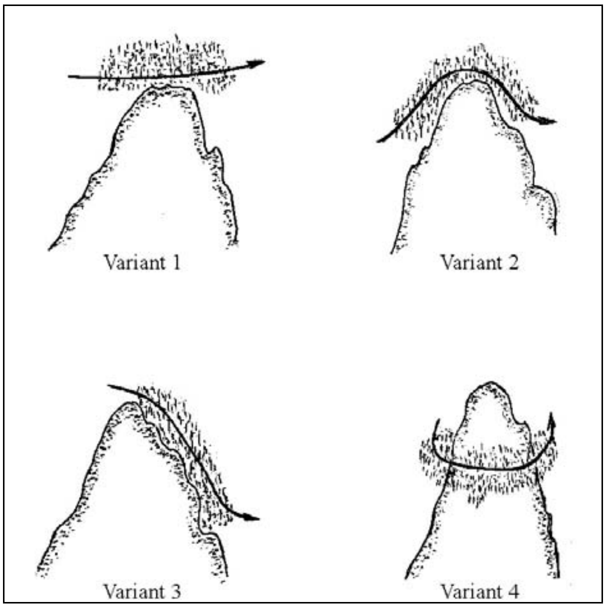


Figure 5. Typical distribution pattern of roundnose grenadier on the deep-water banks of the Mid-Atlantic ridge and trawling direction required based on target position on the seamount. (*taken from Oleg M. Lapshin and Viktor K. Korotkov. 2003. The results of deep sea fisheries development in Russia/USSR and related scientific research*.

Figure 6. A 40 t bag of orange roughy. Deep water trawling on seamounts requires precision navigation and experience in fish behaviour. Gear is often used to herd aggregations. Deepwater trawling is mostly done down slopes and must also accommodate currents. Nets are monitored for fullness to avoid over-catching with the use of escape panels to prevent unnecessary wastage.

5. DEEP-SEA EXPLOITATION - IMPACTS ON HABITAT AND BIODIVERSITY

Presently, trawling, and particularly deep-sea trawling, is under enormous pressure globally. Recent declarations by the United States of America, the European Union, Australia and New Zealand have called for bans or stricter controls on deepwater trawling on the high seas. As mainstay species like cod and hake become depleted by overfishing, deepwater species such as forkbeard, orange roughy, black scabbardfish and roundnose grenadier are also being targeted. This global trend to halt or at least severely limit trawling and deep-sea exploitation seems to be gathering momentum and it is in the interest of fishers and managers to proactively address the problem.

Addressing these concerns is complicated by the high degree of variability in the deep-sea environment. This variability includes not only oceanographic conditions, but also habitat types that are associated with high biodiversity. The sea bed, for example interacts with currents and weather to form a variable and dynamic deepwater fisheries habitat. Deepwater current regimes influence the distribution of many deepwater species. Variability in currents occurs at many different levels, from local or diurnal shifts around seamounts, dynamic upwelling on continental slopes and on the largest scale, global circulation patterns.[11] Many organisms at these depths survive with low light intensity and tolerate low temperatures. It is possible that between 500 000 and 100 million species may inhabit deep-sea areas (IUCN press release reported in Washington Post, 2006). Because this variability occurs on a range of scales the distribution of the many species in the deep-sea environment has in many instances, evolved unique biological and behavioural adaptations. It is these adaptations that often make them vulnerable to over exploitation (such as aggregating behaviour, slow growth and low fecundity).

[11] Industry observers have noted that shifts in bottom temperatures in the South West Indian Ocean significantly affect orange roughy availability and that these temperatures seem to be associated with the periodic global circulation patterns of deep ocean currents.

Deep-sea resources found off the continental shelves evolved relatively undisturbed until the mid 20th century. The accumulated biomass of species such as orange roughy and the deep sea cods and the many other species unique to these depths was sustained within the deep-sea ecosystem. The relatively recent exploitation of these species is seen by many as unsustainable, and it is thought to be only a matter of time before they are mined out completely. Further, because of the difficulty in accessing the deep-sea environment quantification of, for example, biodiversity and stock size (biomass) is extremely difficult. Advances in fishing technologies and the efficiency of fishing gear have also reduced refuges for many of the target species (habitat destruction). However, some observers and scientists believe that it is this precision of fishing operations that in fact has the potential to contribute to the sustainable management of deep-sea fisheries. The innovative use of technology which might include *in situ*, analytical and laboratory studies is likely to reveal much about deep-sea species and ecosystems (Shotton, 2003). Appropriate use of this technology may also facilitate the evaluation of the effects of environmental variability on fisheries. Carter and Clark (2003) for example have demonstrated how in the New Zealand deep-sea environment, the sea bed is complex and interacts with currents and weather systems to form variable and dynamic deep-ocean habitats. With technology, it is now possible to define the shape and position of sea bed features that can be resolved on a relatively fine scale such that detailed habitat maps are now possible. Making use of both observations and models, our understanding of the ocean and its interaction with climate has also improved dramatically and can be used to improve our evaluation of environmental effects on fisheries. Australia has been a leading proponent of the Ecosystem Approach to Fisheries (EAF) and has developed policy integrating environmental assessments into their fisheries management systems (Wilkinson, 2003).

Because of the many difficulties in managing fisheries and ecosystems there are now strong moves to create sanctuaries or marine protected areas (MPAs) that can be both a fisheries management and biodiversity conservation tool. These MPAs can take many different forms and can be used to achieve many different objectives, e.g. the recently declared MPAs in the South Indian Ocean. They may range from simple seasonal closed areas to reduce impacts on spawning aggregations, to completely protected (closed) areas in which all forms of usage is forbidden. In New Zealand, orange roughy exploitation is strictly controlled by a Quota Management System (QMS) with Fisheries Management Areas (FMAs) and Quota Management Areas (QMAs) that limit both target and bycatch species (Clement, 2002). The New Zealand Ministry of Fisheries has worked closely with the orange roughy fishers closing fishing grounds and monitoring stock recovery. Orange roughy fisheries have a poor track record with numerous examples of stock collapse, e.g. St Helens Hills of Tasmania, Namibia and the South West Indian Ocean. Shotton (2003) summarised the discussion on MPAs as follows:

> "If closed areas are to be used, managers ideally need to understand stock structures, movements and long term migrations to determine critical habitats, how large an area should be closed, and whether there is scope for seasonal closures as a management tool. Their establishment must be accompanied by baseline surveys (e.g. population size, structure) at time of closure in order to be able to determine the effects of closure. Where such surveys are not possible, the establishment of large closed areas (particularly if possible before fisheries become established) may be very important for species conservation and reducing the overall impact of fisheries on deepwater stocks."

6. BIOLOGY, FISH BEHAVIOUR, MARKETS AND ECOSYSTEM EFFECTS OF THE EXPLOITATION OF DEEP-SEA FISHES

Fundamental to the understanding of deep-sea fisheries is the biology and behaviour of the many different species exploited. This understanding is required beyond just target resources. Internationally fisheries management is moving towards managing ecosystems rather than target resources (EAF or the Ecosystem Approach to Fisheries Management, FAO 2003). This approach becomes even more difficult in the deep sea as our knowledge of the biology and life history strategies of many deep-sea species is relatively poor, simply because we do not fully understand the complexity of deep-sea habitats, which is exacerbated by the paucity of, and difficulty in obtaining good information. Nevertheless there is still a vast amount of biological information on many species and some, such as orange roughy, have been thoroughly researched. Even so, there are still gaps in our understanding relating to behaviour (aggregating), recruitment, spawning processes and age and growth (Paul *et. al*., 2003).[12] A common trend in most species found on continental shelves is for larger, older fish to migrate into deeper water. This is true for most hake species and there is some evidence suggesting that sex ratios of the larger fish are skewed towards females, further emphasizing the potential impacts on stocks when fishing effort shifts into deeper water.

Slow growth also implies low productivity (which has also been also linked to low fecundity). This increases the vulnerability of these species and stocks to overfishing (when the mining out of accumulated biomass exceeds the rate at which new biomass is regenerating). In many instances the references to these basic characteristics (slow growth, low fecundity, high age at first maturity, etc.) are often used loosely. Gordon (2003) summarised the state of knowledge of many of the families of common deep-sea fishes clearly illustrating how much uncertainty there is in our knowledge and understanding of the biology of most species. Gordon (2003) using the ICES Deep–Sea Working Group species vulnerability ranking, concluded that the squalid sharks, orange roughy and grenadiers could be classified as biologically vulnerable whilst others such as scabbardfish and ling were much less so and stocks in these groups are probably more likely to sustain exploitation (assuming under a controlled management and effort regime).

With respect to ecosystem effects in general, behavioural strategies such as the vertical migration of mesopelagic animals, is an important component of energy transport from surface waters to deeper levels. This implies very broad effects on deep-sea ecosystems. Sea surface productivity, upwelling regimes, continental shelves and slopes etc. will all have critical inputs to the food availability in deep-sea environments. Whilst stock assessment or management procedures may be able to provide good bases for decision-making, the collection of appropriate ancillary biological data to be used in more comprehensive analyses may be crucial for elucidating patterns in population distribution and viability (Shotton, 2003). With regard to EAF in general, participants in Deep Sea 2003 concluded:

> "the single most important first step in moving towards an ecosystem approach to fisheries management is to get single species fishing mortality under control and, in particular, to reduce it to appropriate levels where necessary. In order for this to happen, it is essential to develop better integration of assessment and management of marine resources with appropriate management frameworks that ensure single stock management whilst taking account of wider environmental or ecosystem issues".

7. DEEP-SEA FISH SPECIES GROUPINGS AND GLOBAL TRENDS IN DEEP-SEA CATCHES

Quantifying deep-sea catch and effort is problematic for the reasons already described in the preceding sections. The following assessment of global trends in deep-sea catches is based only on the FAO databases. We tried a different approach to that used by Garibaldi and Limongelli (2002) who looked at trends in oceanic captures and clustering of Large Marine Ecosystems (LMEs). We focused on catch trends in the main oceanic areas (Annex 1, Figure 12-14) by firstly identifying the]main deepwater species only (no large pelagic species or crustaceans) and then grouping and ranking by Order (a similar approach to that of Gordon, 2003). Within each Order we identified the main deep-sea species groupings (Families) and then reverted to the individual species trends where emphasis was considered relevant. This allowed us to make broad comparisons between oceanic areas as well as noting differences between northern and southern hemisphere deep-sea effort. It is stressed that

[12] Paul *et al.* estimated orange roughy age > 70 years and several other species such as cardinal (*Epigonus* sp.) up to 50 years and Rubyfish as much as 80+ years.

within the Orders used there is certainly some overlap with species that historically were caught in relatively shallow seas, but which are now targeted both on and off the shelf, e.g. cods and hakes. Garibaldi and Limongelli (2002) did define many deep-sea species, but also included many of the meso-pelagic species such as lantern and light fishes which were excluded from this analysis.

In Table 1 we split and rank, by catch volume, the orders and families of the dominant deep-sea species reported in the FAO Capture Fisheries Production database. We have also given the different Families within each order an arbitrary "Market Value" ranking based on as far as possible our experience. These rankings are by no means concise, and are only used as relative indicators between groups. The dominant deep sea Order are the Gadiformes that can be split between the Gadidae (cods, whiting, saithe etc), the hakes (merluccidae) and grenadiers (macrouridea) (Figure 7).

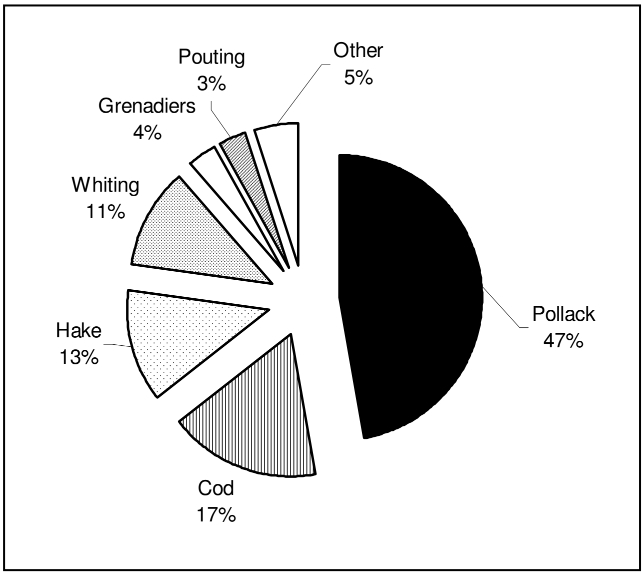


Figure 7. Global Proportions of reported catches of the main deep sea species groups within the Gadidae

With respect to volumes landed, the gadiformes are second only to the Trichuridae (in the Order Percifomes, Table 1) comprising mostly frostfish, hairtails, cutlass fish and many other similar species that are either bathy or meso-pelagic and are caught in large numbers in different oceans using predominantly mid-water trawl gear. With respect to market value however the gadiformes are amongst the most highly valued species and are broadly categorised and sold as "whitefish". Species such as Atlantic and Pacific cod, pollack, hake and hoki compete on the international markets.[13] The Beryciformes (Table 1) comprise the two most definitive deepwater species sold on international markets, these being the orange roughy (Trachichthyidae) and alfonsino (*Beryx* sp.).

Orange roughy catches were first reported from the late 1970s, and alfonsino about 10 years earlier (targeted by the Russian exploratory high seas vessels as noted earlier). Although orange roughy catches peaked in about 1990, catches have since declined as our understanding (Figure 8) of the species and the impacts of exploitation has improved with more stringent management regimes been put in place (New Zealand effort is the highest, with relatively small quantities caught in other parts of the world, including Namibia, Chile, Australia and the North East Atlantic – Figure 9, after Branch, 2001).

[13] Pollack, Hoki and South African trawl hake all have Marine Stewardship Council (MSC) certification.

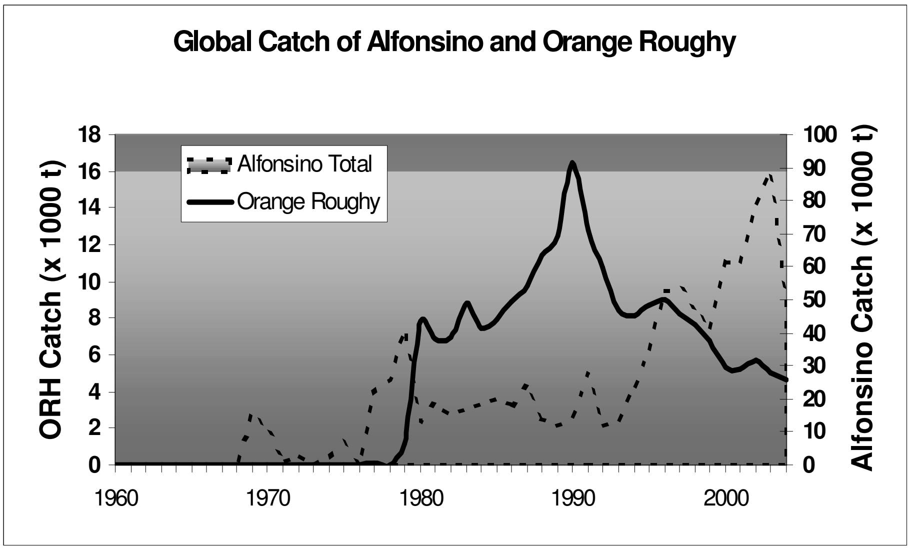


Figure 8. Historical catches (global) of orange roughy and alfonsino

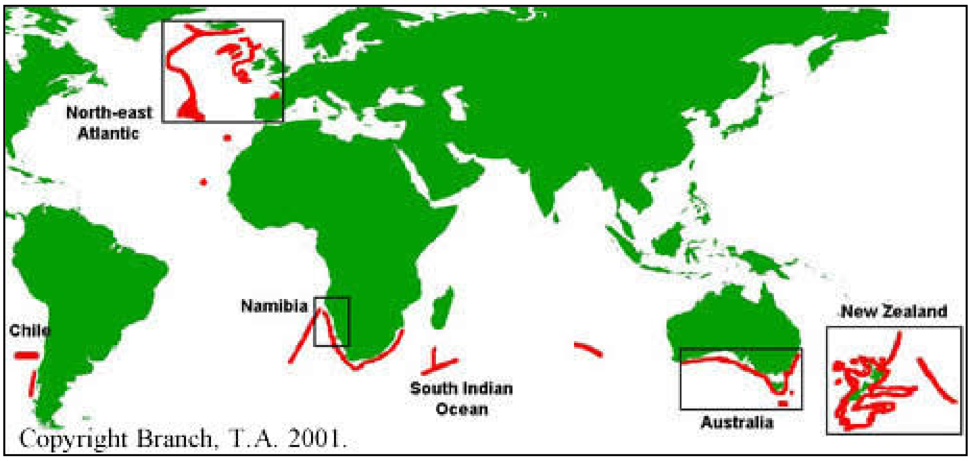


Figure 9. Global distribution of orange roughy

There is an extensive amount of literature and associated research conducted on orange roughy, primarily because of this species' sensitivity to over-exploitation and the associated difficulties in assessing and managing the stocks. Orange roughy are one of the highest valued commercially-caught fish products (with the exception of perhaps Patagonian toothfish) and are sold predominantly in the United States of America. Because aggregations are mostly targeted, catches are often clean with low bycatch (Figure 6 and Figure 10a). However, in many fishing areas, particularly seamounts, catches are often mixed with significant quantities of deepwater dories, cods (the "ribaldo", Moro moro is a common bycatch) as well as Trichuridae (Figure 10b). Alfonsino (Figure 10c) are also a popular product, but are sold mostly in Japan and the Far East (Europe and United States of America are also strong markets for Alfonsino). With regard to orange roughy markets, the product is easily processed and can be frozen, then thawed for reprocessing into frozen fillets (mostly "shatter packs") and value-adding. Alfonsino by comparison is generally not value-added and is sold whole or in headed and gutted form (Figure 10c).

Figure 10. Commercial catches of : a) (from far left) clean orange roughy, b) mixed orange roughy with bycatch and c) clean alfonsino frozen whole in cartons for export.

Trends in the global catches of the other major Orders (Table 1) are shown in Figure 11. Dories are a common group caught in trawls and catches can be quite easily separated between those caught in deepwater and the more common species traditionally caught on the shelf (e.g. *Zeus capensis*). The deepwater dories are found in most oceanic regions, and are caught and processed in viable volumes in New Zealand and a few other countries. In New Zealand oreo dories are strictly managed under the Quota Management System and are mostly caught as a bycatch in the orange roughy-directed trawls (although it is possible to target some species). Since 1981 (Figure 11) there are no indications that catches are declining (noting that there are quota limitations).

Scabbard fish (Perciformes – Trichuridae) catches worldwide are substantial and although they have been included as a deepwater species, they are caught extensively in mid-water, in relatively shallow and deep-sea areas including on and off the continental shelf. They are often associated with other mid-water species such as horse mackerel (*Trachurus* sp.). Total catch has increased since mid-1990 and is now over 1.5 million tonnes per annum. Other species in the same group include several species targeted by deep-sea longliners, such as the oilfish (*Ruvettus pretiosus*) and the Escolar. Other minor Perciforme species targeted (Figure 11) in deepwater include wreckfish, boarfish (also called armourheads) and cardinals (*Epigonis* sp.). Wreckfish (*Polyprion* sp.) are also caught in most oceans and are a deep sea bass (rock cod) with a high market value. They are difficult to catch and are mostly caught with dropper lines. Catches of armourhead have declined in the last decade – this small migratory shoaling species is often found on or around seamounts and has been heavily fished in the Pacific and north Atlantic oceans.

With respect to catch trends, the Lophiformes (deep sea anglers) have been increasingly targeted in the last decade (Figure 11) to the extent that of all the minor deep-sea species (excluding gadiformes and hairtails) have been the most heavily targeted group (this trend is undoubtedly associated with the high market value placed on species such as monkfish and the New Zealand stargazer). Similarly the cusk eels (*Ophididae*) have also been increasingly targeted by deep-sea fisheries with catches increasing steadily since the 1970s. Cusk eels are a frequent bycatch in deepwater trawls, but are also specifically targeted in some fisheries[14].

The Scorpaeniformes are a commonly caught deepwater species, although comparatively, catch volumes are small. Sablefish are an important fishery on the west coast of the United States of America and blue rock fish (*Helicolenus dactylopterus*) are caught extensively on hard grounds by trawl and longline in all oceans. Globally however, catches of deepwater rock fishes are declining (Figure 11).

[14] The New Zealand ling (*Genypterus blacodes)* and the South African kingklip (*G. capensis)* are significant deep-sea commercial species reported to be long-lived and aggregate seasonally.

The last deepwater species groups considered are the chondrichthyans comprising mostly deepwater dogsharks (Squalidae), the Chimaeriformes and the skates and rays (Rajiformes). Commercially, these species have low market ranking (Table 1) and volumes reported are also relatively low. This is, however, not believed to be a true reflection of the commercial mortality of these species that have historically been discarded and misreported in most fisheries (Cavanagh and Kyne, 2003). The global (FAO) data do not suggest any trends in the reported landings. Chondrichtyans make up a significant component of deep-sea biodiversity with numerous species classified critically endangered or vulnerable.

8. DEEP-SEA EXPLOITATION BY OCEANIC REGION

In Figures 12-14 we illustrate decadal trends by oceanic region. The intention here is to identify trends in the total catches in each area with particular reference to the status of the main deep-sea species in the last 10 years[15].

In the Eastern Pacific (Figure 12) catches are dominated by gadiformes, more specifically pollock, cod, hakes and grenadiers. Catches peaked at 20 million tons in the preceding decade and in the last 10 years, have started to slowly decline. The situation is quite different in the Southeast Pacific where the dominant gadoid is hake - catch volumes are increasing, but at about 4.5 million tons, catches are significantly lower than the total deep-sea fish mortality in the Northeast Pacific. In the Central Eastern Pacific catch volumes are even lower than in the temperate regions with rock fishes dominating.

In the North Western Pacific decadal catches are nearly double that reported for the Northeast Pacific and are also dominated by pollock and cod. Hairtail adds a large proportion to the catch. The trend however, shows a sharp decline in catches in the last 10 years from a peak of about 50 million tons to <38 million tons. As in the Eastern Central Pacific, catches in the Western Central Pacific are dominated by scabbards and hairtails. The catch trend is strongly upward in the last decade. Total volumes are much lower than the more temperate northern and southern oceanic regions (approximating 500 000 tonnes). The Southwest Pacific is the most diversified of all the deep-sea areas. Total catch of deep-sea species in the last decade increased marginally to just over 4 million tonnes comprising mostly hoki (merluciddae) with comparatively smaller volumes of orange roughy, alfonsino, oreo dories and other deepwater-directed bycatch species. As in the other oceanic regions the data suggest that volumes taken in the northern oceanic regions are substantially higher than in the southern oceans.

Historically, in the Northwest Atlantic, catch volumes were as high as the North East Pacific, with similar species targeted (cods, pollock, hakes) and a relatively small proportion of scorpaenids. Catches of deep-sea species in this oceanic region have declined steadily in the last three decades, primarily associated with the collapse of the cod fishery. Catch volumes in the Western Central Atlantic are comparatively low (100 000 t in 10 years) but have nevertheless increased significantly in the last decade (comprising of predominantly scabbard fish).

The Indian Ocean (Figure 14) is covered by two reporting areas; the Western Indian and Eastern Indian. In both areas deep-sea catches are dominated by hairtails with only relatively small proportions of grenadiers, orange roughy and alfonsino reported.

In the Northeast Atlantic (Figure 13) total deep-sea catch has been sustained in the last decade at nearly 38 million tonnes. Species targeted are similar to the Northeast Pacific (cods, pollack, whiting and hake). In the Central Eastern Atlantic the species targeted differ somewhat to the species in the Central Pacific with a higher proportion of hake and whiting although still dominated by scabbard. Total catch in the last decade has declined although at about 700 000 tonnes, is comparatively lower

[15] Note that our graphs reflect decadal catch volumes (cumulative totals) and do not reflect inter-annual catches.

than both the northern and southern temperate water deep-sea catch estimates. Hake dominates the catches in the South (West and East) Atlantic. In the South West catches have increased since the 1970s and in the last decade approximated 7 million tons. The trend in the South East Atlantic is the opposite having peaked at about 7 million tons in the 1970s[16] and declining. Presently the decadal catch approximates 3 million tons (predominantly hakes) in the Southeast Atlantic.

The last region of interest is the Mediterranean and Black Seas (Figure 13). Catches in this region in the preceding decade peaked at over 800 000 tonnes and in the last 10 years have declined to nearly 600 000 tonnes (60 000 tonnes annually). Catches in this area consist mostly of whiting and hake.

In summary it is clear that catch volumes of what can be defined as deep sea species are significantly higher in the northern temperate water oceans (comprising of predominantly gadoids) than in the southern oceanic areas. In contrast, the southern oceanic regions catches have historically been much lower and have been dominated by hakes. Although the species diversity of deep-sea resources appears similar in most oceans, reported commercial catches in the southern oceanic regions suggest a greater diversity of fishing activity and species targeted. Stocks in the southern oceanic regions also show less indications of stock “stress” with both lower volumes being taken and generally fewer downward trends in the last decade. In the central oceanic regions, deep-sea volumes caught are significantly lower than in the temperate seas and are dominated by large volumes of hairtails and scabbard fishes. These data suggest that in the last decade there has been a shift away from species such as the scorpaenids (which appear to have declined) to targeting on scabbards and hairtails.

These observations suggest not only a disparity between northern and southern hemisphere historical fishing effort, but possibly also a fundamental difference in regimes with significantly higher productivity in the northern oceans.

ACKNOWLEDGEMENTS

We would like to acknowledge the financial support of FAO for the preparation of this paper. Further the support, editing and advice that was provided by Ms Jessica Sanders, Dominique Gréboval and Ross Shotton. Ms S. Wilkinson (CapFish, Cape Town) provided technical support and analysis of FAO data as well as compiling graphs and integration into GIS.

REFERENCES

Anderson, O.F. & Clark, M. 2005. Bycatch in the orange roughy (Hoplostethus atlanticus) fishery on the South Tasman Rise. In: Shotton, R. (ed.). Deep Sea 2003: conference on Governance and Managemetn of Deep-sea Fisheries. Part 2: Conference poster papers and workshop papers. Queenstown, New Zealand, 1–5 December 2003 and Dunedin, New Zealand. 27-29 November 2003. *FAO Fisheries Proceedings. No. 3/2*. Rome, FAO. 487p.

Annala, J. & Clark, M. 2005. Issues in the management of high-seas orange roughy fisheries in the New Zealand Region. In: Shotton, R. (ed.). Deep Sea 2003: Conference on Governance and Management of Deep-sea Fisheries. Part 2: Conference poster papers and workshop papers. Queenstown, New Zealand, 1–5 December 2003 and Dunedin, New Zealand. 27-29 November 2003. *FAO Fisheries Proceedings.* No. 3/2. Rome, FAO. 487p.

Anon. 1996. The trade allowance on a catching of fish on underwater raisings of an open part of the Atlantic Ocean. JSC Polmar, Ltd. (Murmansk, Russia).

Butterworth, D.S. & Brandao, A. 2005. Experiences in Southern Africa in the management of deep-sea fisheries. In: Shotton, R. (ed.). Deep Sea 2003: conference on Governance and

[16] Exploitation of hake in the Benguela in the ICSEAF period reached an estimated peak of 1 million tons p.a.

Managemetn of Deep-sea Fisheries. Part 1: Conference reports. Queenstown, New Zealand, 1–5 December 2003. *FAO Fisheries Proceedings.* No. 3/1. Rome, FAO. 781p.

Cavanagh, R.D. & Kyne, P.M. 2005. The conservation status of deep-sea chondrichthyan fishes. In: Shotton, R. (ed.). Deep Sea 2003: Conference on Governance and Management of Deep-sea Fisheries. Part 2: Conference poster papers and workshop papers. Queenstown, New Zealand, 1–5 December 2003 and Dunedin, New Zealand. 27-29 November 2003. *FAO Fisheries Proceedings.* No. 3/2. Rome, FAO. 487p.

Clement, G. (ed). 2002. New Zealand Commercial Fisheries: The atlas of area codes and TACCs. 2002/2003. Clement and Associates Ltd., Nelson, New Zealand.

FAO. 2003. Fisheries Management – 2. The Ecosystem Approach to Fisheries. FAO Technical Guidelines for Responsible Fisheries 4, Suppl. 2. FAO, Rome.

Garibaldi, L. & Limongelli, L. 2002. Trends in oceanic captures and clustering of large marine ecosystems: two studies based on the FAO capture database. *FAO Fisheries Technical Paper*. No. 435. Rome, FAO. 2002. 71 p.

Gordon, J.D.M. 2005a. Biological parameters of deepwater fishes. *In*: Shotton, R. (ed.). Deep Sea 2003: Conference on Governance and Management of Deep-sea Fisheries. Part 2: Conference poster papers and workshop papers. Queenstown, New Zealand, 1–5 December 2003 and Dunedin, New Zealand. 27-29 November 2003. *FAO Fisheries Proceedings.* No. 3/2. Rome, FAO. 487p.

Gordon, J.D.M. 2005b. Environmental and biological aspects of deepwater fishes. *In*: Shotton, R. (ed.). Deep Sea 2003: Conference on Governance and Management of Deep-sea Fisheries. Part 1: Conference reports. Queenstown, New Zealand, 1–5 December 2003. *FAO Fisheries Proceedings.* No. 3/1. Rome, FAO. 781p.

IUCN - The World Conservation Union. 2006. Fishing companies announce world's first voluntary closure to high-seas deepwater trawling. Southern Indian Ocean Deepwater Fisheries Association (SIODFA). Information doc.

Japp, D.W. 1996. Preliminary assessment of historical high seas fishing activity in the SEAFO area (working doc.)

Japp, D.W. & James, A. 2005. Potential exploitable deepwater resources and exploratory fishing off the South African coast and the development of the deepwater fishery on the south Madagascar ridge. *In*: Shotton, R. (ed.). Deep Sea 2003: Conference on Governance and Management of Deep-sea Fisheries. Part 1: Conference reports. Queenstown, New Zealand, 1–5 December 2003. *FAO Fisheries Proceedings.* No. 3/1. Rome, FAO. 781p.

Japp, D.W., Sims, P. & Smale, M.J. 1994. A review of the fish resources of the Agulhas Bank. *S. Afr. J. Sc.* 90 (3). 123-134pp.

Oelofsen, B. & Staby, **A.** 2003. The Namibian orange roughy fishery: Lessons learned for future management. *FAO Fisheries Proceedings 3/1 & 3/2*. Rome, FAO 2006.

Paul, L., Tracey, D., Neil, H., Horn, P., Andrews, A. & Sparks, R. 2005. How old are these deep-sea species? Applying improved techniques to validate longevity. *In*: Shotton, R. (ed.). Deep Sea 2003: Conference on Governance and Management of Deep-sea Fisheries. Part 2: Conference poster papers and workshop papers. Queenstown, New Zealand, 1–5 December 2003 and Dunedin, New Zealand. 27-29 November 2003. *FAO Fisheries Proceedings.* No. 3/2. Rome, FAO. 487p.

Shotton, R. (ed.). 2005a. Deep Sea 2003: Conference on Governance and Management of Deep-sea Fisheries. Part 1: Conference reports. Queenstown, New Zealand, 1–5 December 2003. *FAO Fisheries Proceedings.* No. 3/1. Rome, FAO. 781p.

Shotton, R. (ed). 2005a. Deep Sea 2003: Conference on governance and management of deep-sea fisheries. Part 2: Conference poster papers and workshop papers. Queenstown, New Zealand, 1–5 December 2003 and Dunedin, New Zealand. 27-29 November 2003. *FAO Fisheries Proceedings.* No. 3/2. Rome, FAO. 487p.

Stocks, K.I. & Boehlert, G.W. 2005. Towards an international census of marine life research programme on seamounts. *In*: Shotton, R. (ed.). Deep Sea 2003: Conference on Governance and Management of Deep-sea Fisheries. Part 2: Conference poster papers and workshop papers. Queenstown, New Zealand, 1–5 December 2003 and Dunedin, New Zealand. 27-29 November 2003. *FAO Fisheries Proceedings.* No. 3/2. Rome, FAO. 487p.

Thiele, W. & Niedzwiedz, G. 2003. Technical requirements and prerequisites for deepwater trawling. *In*: Shotton, R. (ed.). Deep Sea 2003: Conference on Governance and Management of Deep-sea Fisheries. Part 1: Conference reports. Queenstown, New Zealand, 1–5 December 2003. *FAO Fisheries Proceedings.* No. 3/1. Rome, FAO. 781p.

Wilkinson, V. 2005. Environmental assessment of fisheries – working towards an ecological sustainable future. *In*: Shotton, R. (ed.). Deep Sea 2003: Conference on Governance and Management of Deep-sea Fisheries. Part 2: Conference poster papers and workshop papers. Queenstown, New Zealand, 1–5 December 2003 and Dunedin, New Zealand. 27-29 November 2003. *FAO Fisheries Proceedings.* No. 3/2. Rome, FAO. 487p.

ANNEX 1: Figures and Tables

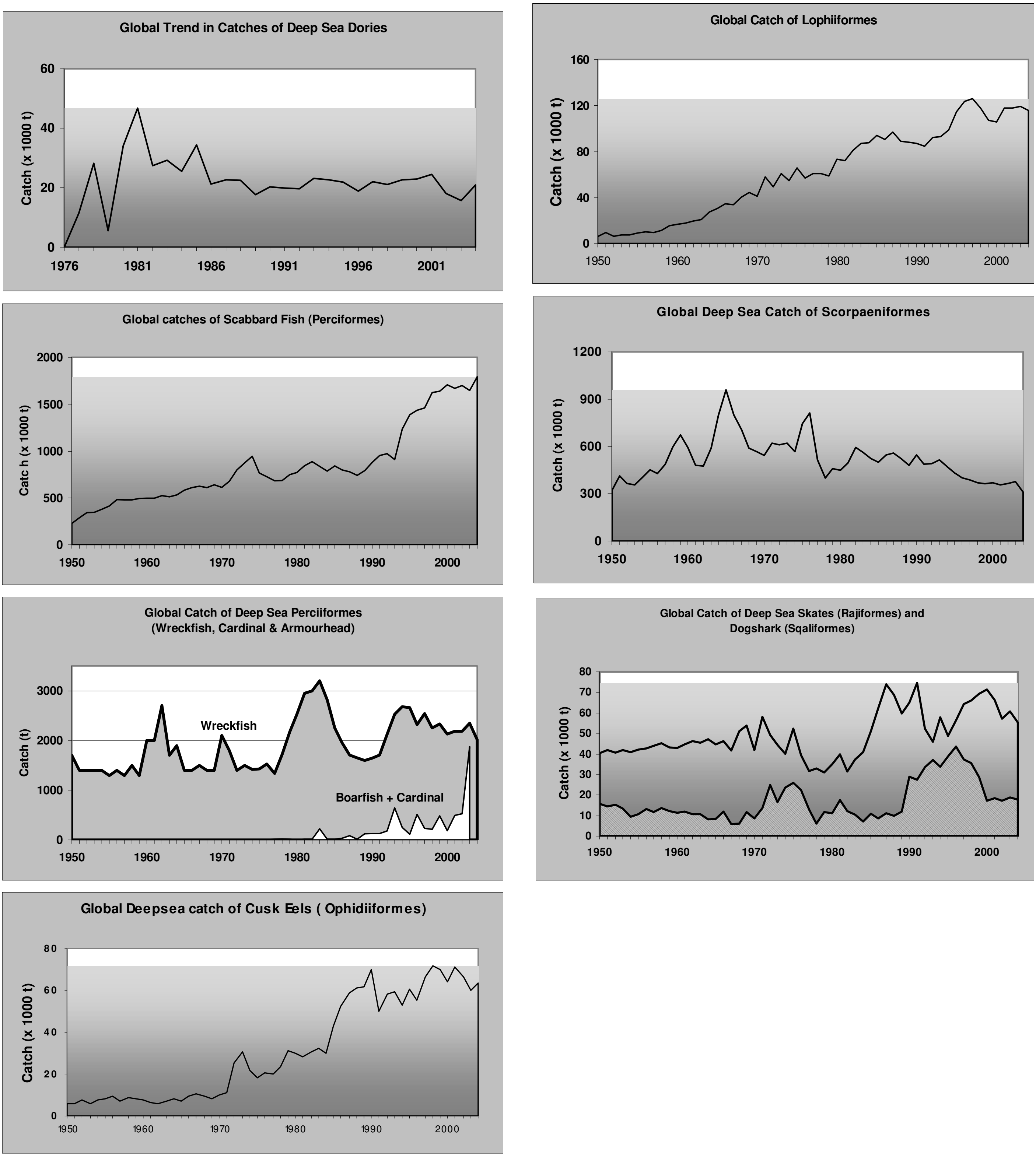


Figure 11: Global trends in deep sea catches of the main fish orders (excluding the Gadiformes and Beryciformes)

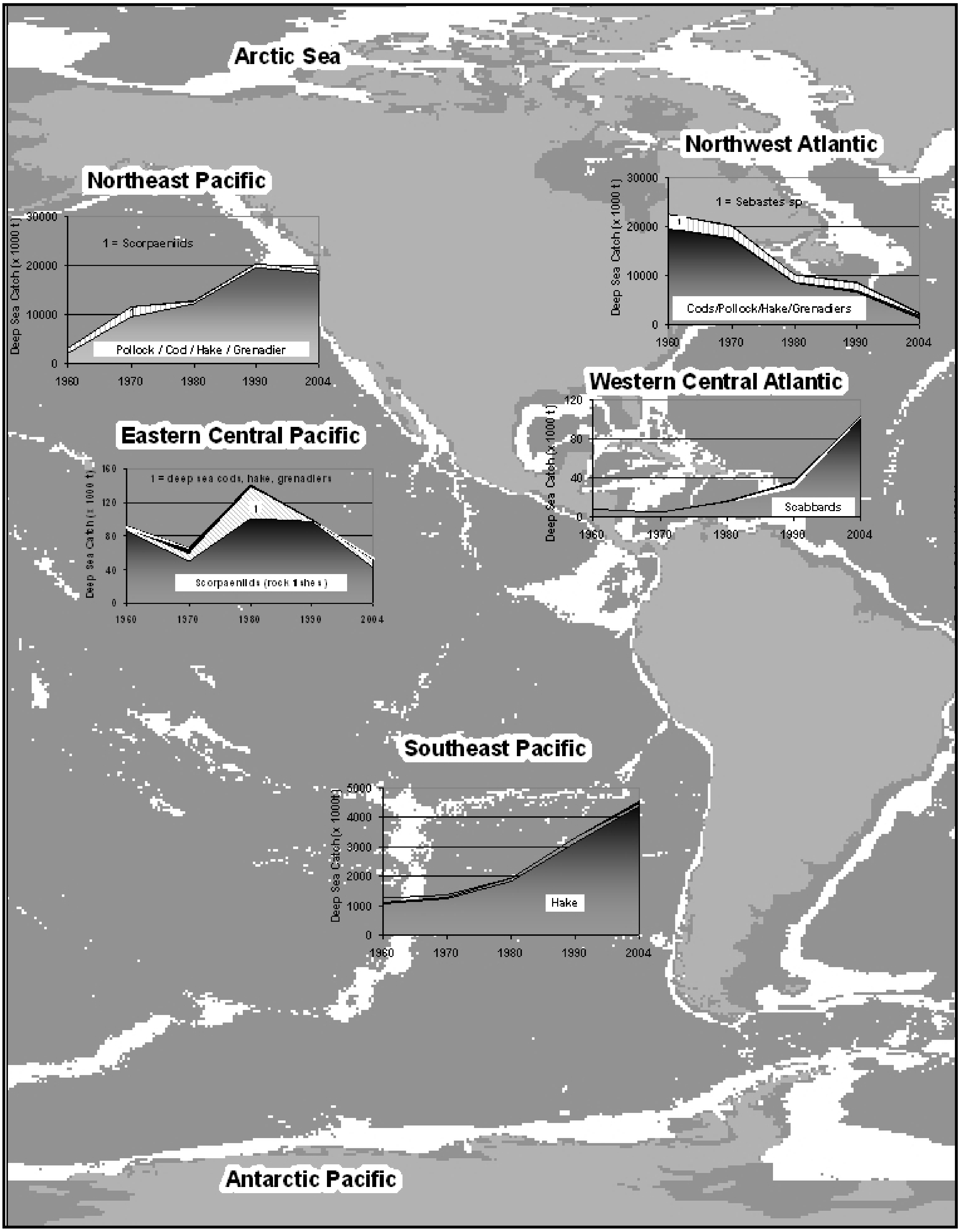


Figure 12. Decadal trends in deep sea catches for the western Pacific and eastern Atlantic oceans.

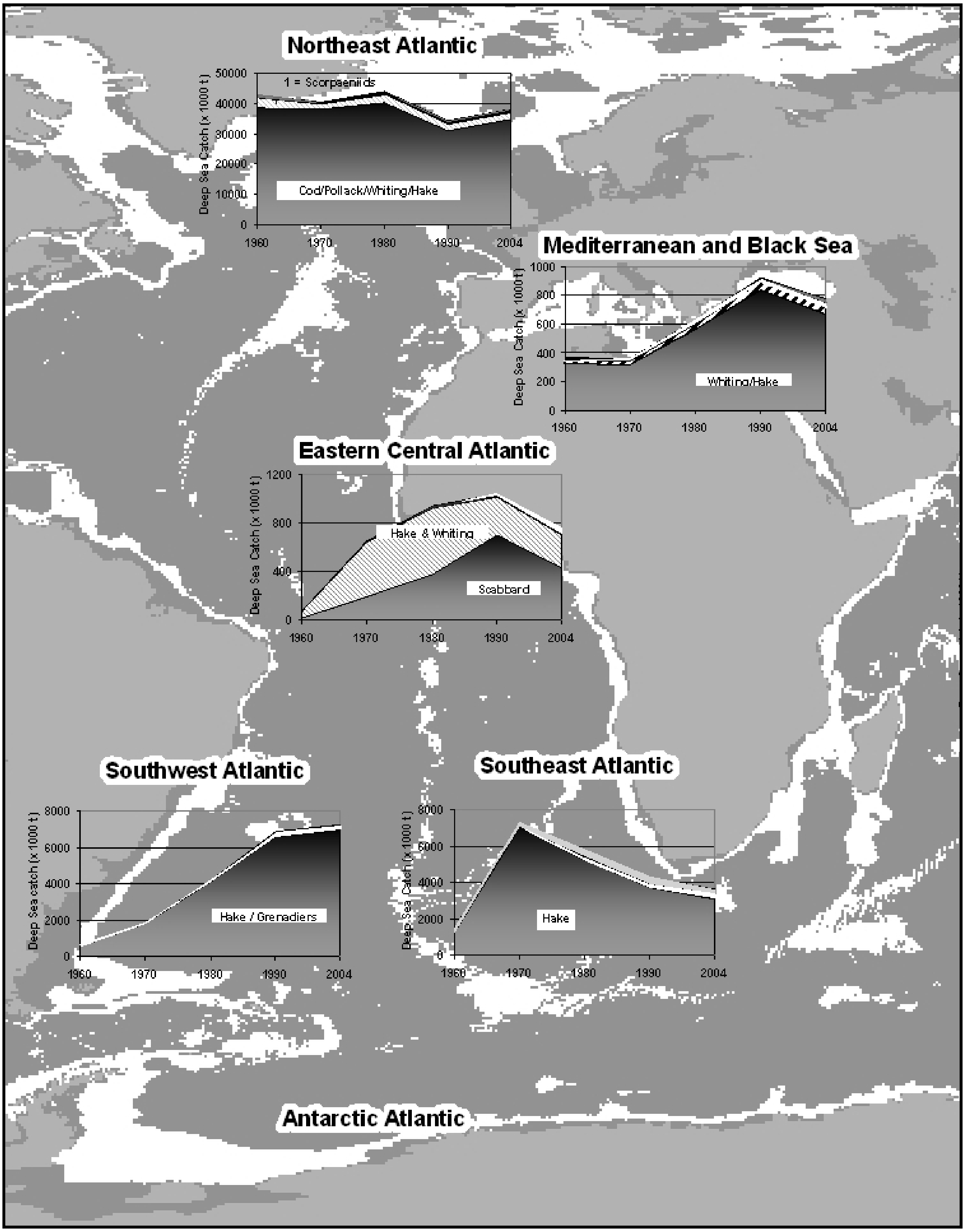


Figure 13. Decadal trends in deep sea catches for the Atlantic Ocean, Mediterranean Sea and Black Seas.

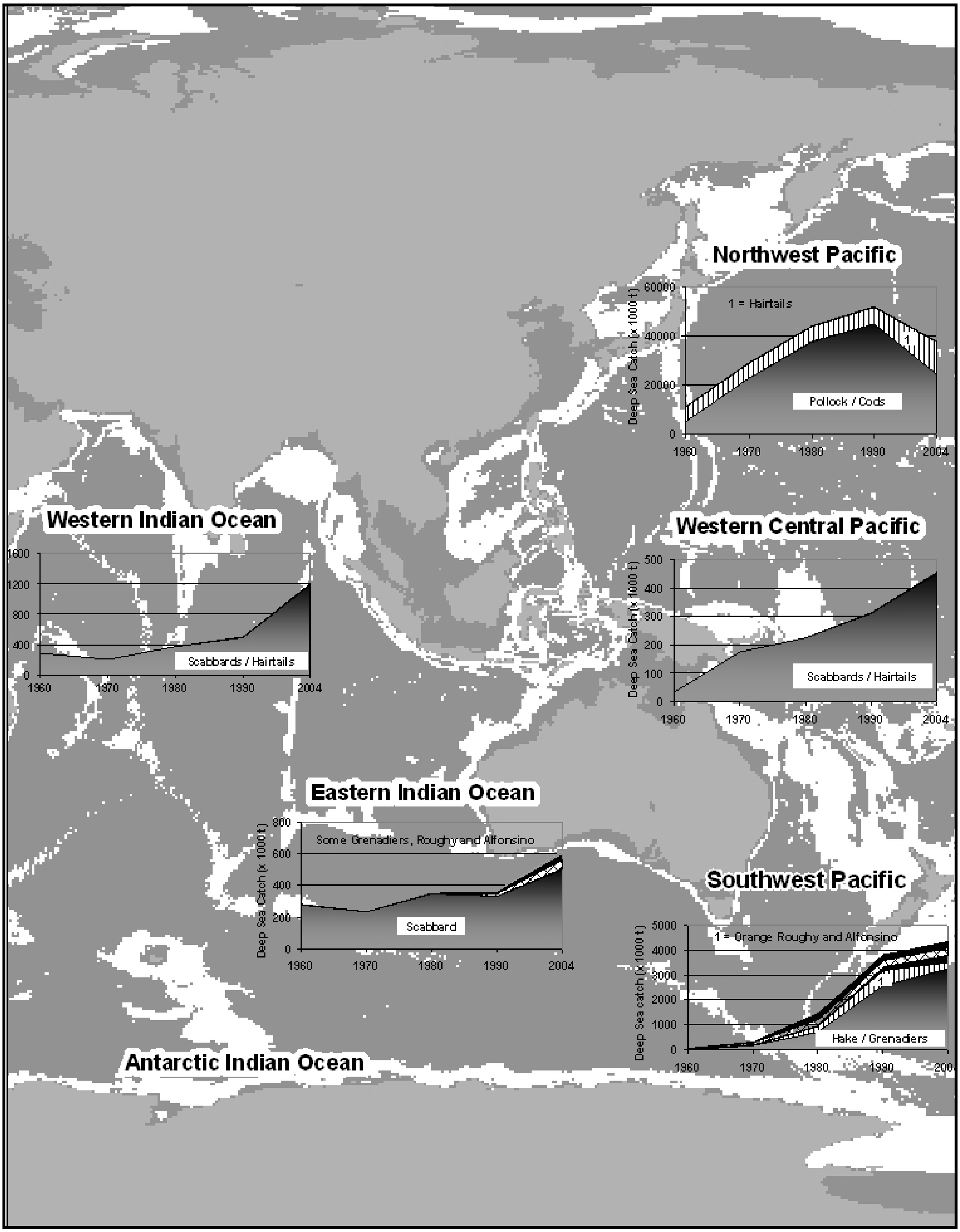


Figure 14. Decadal trends in deep-sea catches for the Indian and Western Pacific Oceans areas.

			Relative Ranking (5 = highest, 1 = low, O = Negligible)			
Order	**Families**	**Depths**	**Catch Volume**	**Market Value**	**Trend (volume)**	**Common Names**
Gadiformes	Gadidae	Shelf,Slope,Seamounts	4	4	Declining	Cods, Whiting, Pollack, Saithe, Pouting,Pollock, Ribaldo (moridae)
	Merluccidae	Shelf and Slope	3	4	Stable/Increasing	Hakes
	Macrouridae	Slope	4	3	Stable/Increasing	Grenadiers
Beryciformes	Berycids	Slope	3	4	Declining	Alfonsino
	Trachichthyidae	Shelf and Slope	3	5	Stable/Declining	Orange Roughy, Slime heads
Zeiformes	Zeidae	Slope & Seamounts	2	3	Stable	Deepwater Dories
Perciformes	Polyprionidae	Shelf and Slope	2	5	Increasing	Wreckfish
	Pentacerotidae	Seamounts	2	4	Decreasing	Armourheads, Boarfish
	Apogonidae	Slope & Seamounts		2	Stable or Decreasing	Cardinals - epigonus sp
	Gempylidae	Shelf,Slope,Seamounts	5	3	Increasing	Snake mackerels, Snoek
	Trichuridae	Shelf,Slope,Seamounts	5	2	Increasing	Escolar, Oilfish (ruvettus), Snoek, Gemfish, Frostfish, Buttersnoek, Cutlass
Ophidiiformes	Ophidiidae	Shelf,Slope,Seamounts	3	2	Uncertain	Cuskeels,Ling, Botrulas,Bathitids
Lophiiformes	Anglers	Shelf,Slope,Seamounts	3	4	Increasing	Monkfish, Stargazers
Scorpaeniformes	Sebastinae	Shelf,Slope,Seamounts	3	3	Increasing	Sablefish, Rock fish
Stromatoidea	Ruffs	Slope & Seamounts	2	2	Uncertain	Bluenose, Black ruff
Nototheniidae	Icefishes	Shelf and Slope	3	3	Increasing	Toothfish and Icefish
Squalidae	Squaliidae	Shelf,Slope,Seamounts	1	0	Uncertain	Dogshark
Chimaeriformes	Chimaeriidae	Shelf,Slope,Seamounts	1	1	Uncertain	Chimaera’s
Rajiformes	Rajiidae	Shelf,Slope,Seamounts	1	1	Uncertain	Rays

CAN DEEP WATER FISHERIES BE MANAGED SUSTAINABLY?

by

M.P. Sissenwine and P.M. Mace[1]

Summary

Governance of deepwater fisheries has a high profile in the international community, including the explicit attention of the United Nations General Assembly (UNGA). This attention reflects concerns about the sustainability of deepwater fisheries and the fragility of deepwater ecosystems, and concern that there is a gap in the international fisheries governance framework when it comes to deepwater fisheries on the high seas.

Deepwater fisheries are considered by Food and Agriculture Organization of the United Nations (FAO) as those fisheries that occur beyond the continental shelf/slope break which typically occurs at about 200 metre (m). The current technological limit of these fisheries is about 2 000 m. However, many species not usually considered as deepwater are fished at depths well above 200 m (e.g. the North Pacific walleye Pollock fishery, one of the world's most productive, occurs over a range of 90-500 m). According to the FAO statistical database, deepwater fisheries produced 5.9 million metric tonnes (t) in 2004 or less than 4 percent of the total production from fisheries and aquaculture (including freshwater). Most of this catch is of species that generally occur in depths of less than 500 m, and some of the species that account for much of the catch occur in shallow nearshore waters as well as beyond 200 m in depth.

Deepwater fisheries should not all be "painted with the same brush" (or, in other words, hairtails and blue whiting are not the same "kettle of fish" as orange roughy and oreo dories) as there is a great deal of difference between the species fished in the shallow end of the range of deepwater fisheries, and species that are fished at depths centered below 500 m. Species fished in the shallow end of the range have similar biological characteristics to shelf species. They are productive compared to some deeper water species, such as orange roughy. The discourse about deepwater fisheries would be well served by a common understanding of what constitutes a deepwater fishery and what makes them different from other fisheries.

Deepwater fisheries beyond 500 m generally have a history of less than three decades, during which early expectations of sustainable yield have often been too optimistic, the biomass on many fishing grounds has been depleted, and biogenic habitats have been impacted. The deepwater fisheries that have attracted the most attention are those for orange roughy at depths of about 700 m and below. Simply stated, the global track record for sustainable management of deepwater fisheries beyond 500 m is not good. Deepwater fisheries have failed to be sustainable for one or more of the following fundamental reasons:

- they have been unregulated;
- initial scientific assessments based on limited data have often been too optimistic; and/or
- management has not responded to, or has been slow to respond to, scientific advice calling for improved conservation.

This experience clearly points to the need to strictly adhere to the precautionary approach and apply an ecosystem approach. More specifically:

[1] The views expressed in this paper are solely those of the authors, Michael Sissenwine, Marine Science Consultant, m_sissenwine@surfglobal.net and Pamela Mace, New Zealand Ministry of Fisheries, Pamela.Mace@fish.govt.nz.

- all deepwater fisheries should be authorized by a competent management authority with constraints set cautiously, and new fisheries should have a development plan that ensures the rate of development is consistent with the gathering of knowledge;
- management strategies for deepwater fisheries need to be re-examined in light of the poor track record to date; in particular biological reference points should be set more conservatively and explicit “fishing down” phases should be avoided;
- steps need to be taken to address habitat and biodiversity impacts of deepwater fisheries;
- research is needed to improve resource assessments, knowledge about the distribution of resources off fishing grounds, understanding of stock structure, and understanding the functional value and vulnerability of habitat and biodiversity;
- new multilateral arrangements are needed to manage high-seas fisheries in some areas, although individual nations could prevent overfishing on the high seas if they consistently applied the FAO Code of Conduct for Responsible Fisheries (CCRF) and the Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas (Compliance Agreement); and
- there is a need to improve compliance with fishery conservation measures and reporting of fishery-dependent data. It is time to seriously consider extending catch documentation schemes, such as the Commission for the Conservation of Antartic Marine Living Resources (CCAMLR) scheme used to reduce illegal, unregulated, and unreported (IUU) fishing of toothfish, to all fish that enter into international trade.

An unanswered question is, will the benefit-cost ratio for deepwater fisheries for long-lived, low-productivity species be positive if the full costs of research and management are taken into account?

1. INTRODUCTION

Management of deepwater fisheries has a high profile[2] within scientific communities, environmental organizations, and policy makers including the United Nations General Assembly (UNGA). Interest in these fisheries is stirred by concern about their sustainability and their impact on habitats and biodiversity. However, the term “deepwater fishery” means different things to different people. In fact, these fisheries are diverse and they should not be “painted with the same brush.”

Ocean depth zones are indicated in Figure 1 (FAO, 2005). In general, continental shelves are thought of as extending to about 200 m depth. For fisheries, the deepwater zone can be taken beginning at the continental shelf/slope break. This corresponds to the Terms of Reference of this paper which considers deepwater fisheries to be off-shelf and generally deeper than 200 m. However, the International Council for Exploration of the Sea (ICES, 2005)[3] applies the term deepwater to fisheries at depths greater than 400 m. New Zealand, a country where deepwater fisheries are particularly important, defines deepwater fisheries as fisheries with a center of distribution greater than 500 m. One problem with using 200 m to define deepwater fisheries is that many shelf fisheries, including some of the world’s largest and most productive fisheries, extend to much greater depths. For example, the Alaska pollock fishery, which yielded about 2.7 million tonnes from the North Pacific Ocean in 2004, takes place from 90 to 500 m.

Another aspect of deepwater fisheries is their relationship to the water column or sea floor. Fisheries for mesopelagic and bathypelagic species (defined by the ocean depth zones in Figure 1), which live in

---

[2] Over 100 scientists participating in the tenth Deep-Sea Biology Symposium and the second International Symposium on Deep Sea Corals issued a statement of concern which was submitted to the United Nations General Assembly calling for a moratorium on deep-sea bottom trawl fishing on the high seas. Similarly, the Marine Conservation Biology Institute collected 1136 signatures of scientists expressing profound concern about bottom trawling impacts on deep-sea coral and sponge communities and calling on the United Nations to take appropriate action. see http://www.mcbi.org/DSC_statement/sign.htm
[3] See http://www.ices.dk

the water column without association with the sea floor, might be considered deepwater fisheries (as the species occur at depths of at least 200 m). However, these species generally do not grow to a large enough size to make them valuable commercial fisheries (FAO, 2005; p. 189) and/or they have not proven to be viable commercial fisheries due to processing or marketing problems. Their distributions may be too diffuse to make fishing them practical. The important deepwater fisheries are for demersal species which are close to, or in contact with, the seafloor much of the time, and benthopelagic species that are associated with the seafloor.

It is important to recognize the diversity in fisheries referred to as deepwater by FAO, as those at the shallower end of the deepwater range are similar to shallow water fisheries in terms of biology, scientific issues, management regimes and sustainability. This is especially true if 200 m is used to define the shallow end of the deepwater range. Fisheries at depths in the vicinity of 1 000 m and deeper are relatively recent (developing over the last three decades), and they are quite different from shallow water fisheries in terms of species biology, scientific challenges, and management issues. These are the fisheries for which there is the greatest concern about long-term sustainability.

This paper discusses the species caught by deepwater fisheries, the catch history and state of deepwater fisheries, the habitat and biodiversity impacts of fishing, scientific challenges, and current management regimes. It concludes with recommendations to address concerns about the sustainability of deepwater fisheries and impacts on habitat and biodiversity. The paper emphasizes deepwater fisheries with the center of their range greater than 500 m. It draws heavily on experience in New Zealand, where deepwater fisheries beyond 500 m are particularly important. Orange roughy fisheries in Australia, Namibia, Chile and the South Tasman Rise are also used as illustrative examples.

2. DESCRIPTION OF DEEPWATER FISHERIES

FAO lists 76 species (by common name) as deepwater species (FAO 2005, Table C3.1, page 195). The trend in reported catch[4] of these deepwater species is given in Figure 2. A substantial amount of the catch probably comes from continental shelf fisheries which are not normally considered to be deepwater, although the species caught are known to range to depths greater than 200 m. Unfortunately, the spatial resolution of catch reporting to FAO is inadequate to categorize catch by depth or to determine if it is from within Exclusive Economic Zones (EEZs) or from the high seas.

The total reported catch of deepwater species (defined as above) in 2004 was 5.9 million tonnes which is less than 4 percent of the total global production (including freshwater) from capture fisheries and aquaculture. The reported catch in 2004 is the highest on record. The reported catch has increased steadily since the 1950s, with an accelerating trend since the mid-1990s.

Table 1 gives the 2004 reported catch for selected deepwater species. The species in the table were selected either because of their high reported catch (greater than 100 000 t) in 2004 and/or because they have received attention due to management concerns. Appendix 1 gives the reported 2004 catch for all deepwater species (according to FAO 2005) by ocean area.[5]

[4]Reported catches throughout this paper (unless otherwise stated) are from the FAO Fisheries Global Information System (FIGIS) Global Capture Production 1950-2004 on line database, at:
http://www.fao.org/figis/servlet/TabLandArea?tb_ds=Production&tb_mode=TABLE&tb_act=SELECT&tb_grp=COUNTRY
[5] Note that FAO's list of deepwater species did not include *Sebastes* spp. (redfish), although these species are commonly considered deepwater. This paper uses the same list of species as FAO (2005). Thus *Sebastes* spp. are not included in Figure 2, Table 1, or Appendix I. However, the status of redfish stocks is considered in Section 2.4 and Table 3.

Table 1. Reported 2004 catch of selected "deepwater" species. Catches were not necessarily made in "deep" waters (i.e. many of the catches have been recorded from waters shallower than 200 m).

Species	Scientific name	2004
Alfonsinos nei	*Beryx* spp	7 199
Antarctic toothfish	*Dissostichus mawsoni*	2 584
Black scabbardfish	*Aphanopus carbo*	11 987
Blue grenadier	*Macruronus novaezelandiae*	163 305
Blue ling	*Molva dypterygia*	7 785
Blue whiting(=Poutassou)	*Micromesistius poutassou*	2 427 862
Bombay-duck	*Harpadon nehereus*	162 873
Greenland halibut	*Reinhardtius hippoglossoides*	111 785
Hairtails, scabbardfishes nei	*Trichiuridae*	182 917
Largehead hairtail	*Trichiurus lepturus*	1 587 451
Ling	*Molva molva*	35 384
Northern prawn	*Pandalus borealis*	446 138
Orange roughy	*Hoplostethus atlanticus*	25 881
Oreo dories nei	*Oreosomatidae*	20 284
Patagonian grenadier	*Macruronus magellanicus*	216 401
Patagonian toothfish	*Dissostichus eleginoides*	24 827
Southern blue whiting	*Micromesistius australis*	152 041
Tilefishes nei	*Branchiostegidae*	73 894
	Grand total	5 660 598

The species listed in Table 1 account for more than 96.3 percent of the reported catch of deepwater species in 2004. Two species, blue whiting and largehead hairtail, account for about 75 percent of the reported catch. The species that has received the most attention due to management concerns, orange roughy, accounts for only 0.5 percent of the reported catch of deepwater species in 2004 and a trivial amount of the total global production of fisheries. These three species illustrate the diversity in species and fisheries referred to as deepwater by FAO. Largehead hairtail is a relatively fast growing, early maturing species that is taken mostly near shore. However, its depth range extends to about 300 m, so it is listed as a deepwater species by FAO (2005). Blue whiting is also a relatively fast growing, early maturing species, but it is typically fished at a depth of about 400 m, mostly in the Northeast Atlantic. Thus it is defined as a deepwater species by both FAO and ICES. Blue whiting is a straddling stock in the Northeast Atlantic. Orange roughy is very long lived, with an advanced age of maturity of at least 25-30 years. The species is fished at depths of about 700-1 250 m and beyond. Fishing grounds for orange roughy may occur entirely within EEZs, or straddle the boundary between EEZs and international waters of the high seas, or be entirely on the high seas. The catch history of orange roughy (as reported to FAO) is given in Figure 3.

Table 2 gives some relevant characteristics of species that have been classified as deepwater (according to FAO 2005). Most of the information is from Fishbase,[6] an online database for fish species. There are numerous different entries in Fishbase for some species, and they do not always agree. The values in Table 2 are typical values found in Fishbase. In some cases, information was not available in Fishbase, although this does not necessarily mean it is unknown.

---

[6]See: http://www.fishbase.org/search.php

Table 2. Characteristics of selected deepwater species. Primarily from Fishbase (website address given in footnote 4).[7]

Species	Recorded depth range (m)	Main depth range (m)	Maximum age (yr)	Age of maturity (yr)
Alfonsino	180–1 300	400–600	23	
Antarctic toothfish	0–1 600	500–1500	31	
Black scabardfish	200–1700	600–800	32	
Blue grenadier (hoki)	10–1 000	300–800	25	3–7
Blue ling	150–1 000	250–500	20	9–11
Blue whiting	mostly 300–400	300–400	20	2
Bombay duck	inshore to deepwater			
Hairtails	0–400		15	
Greenland halibut	1–2 000	350–1500	22	7–12
Ling	100–1 000		25	
Northern prawn	20–1 330		5	
Orange roughy	180–1 800	500–1200	150	≥ 25–30
Oreos	220–1 550	600–1200		
Patagonian grenadier (hoki)	30–500		14	
Patagonian toothfish	0–1 600	500–1500	21	6
Tilefish	30–400			

Clearly, the species that account for most of the reported FAO deepwater catch (blue whiting, Bombay duck and hairtails) are a very "different kettle of fish" from the species that have attracted the most concern about their sustainability (orange roughy and oreos). Much of the catch of the high volume species actually takes place in relatively shallow water. For example, hairtails are taken in shallow coastal waters and estuaries in Asia, and Bombay duck are taken with bag nets in deltas in coastal India. Most of the so-called deepwater species overlap with typical shallow water species in terms of their depth range and biology. For example, Atlantic cod has a depth range from nearshore to 600 m, it has a life span of about 25 years, and it matures at 2-7 years (based on typical entries in Fishbase). In terms of life span and age at maturity, none of the species differ much from cod, except for orange roughy and oreos. It is also important to keep in mind that deepwater species of sharks, which have a very low fecundity, are likely to be particularly vulnerable to overfishing. However, deepwater species are not all long-lived and late maturing, and thus they do not necessarily have low productivity and low resilience, as is often stated.

2.1 Deepwater fisheries of the North Atlantic Ocean

Deepwater fisheries of the North Atlantic account for more than 50 percent (3.1 million tonnes) of the global deepwater catch reported to FAO. Most of the deepwater fishing in the Atlantic is in the Northeast Atlantic. Gordon (2001) and Gordon *et al.* (2003) give a general description of these fisheries. Deepwater fishing by longliners began in the mid 1800s, but it expanded after World War II as technology for deepwater trawling developed, and the expansion accelerated in the 1990s when new markets for deepwater species were created. Spain, Ireland, the Faroe Islands, Scotland, United Kingdom, Ireland and Norway are important participants in deepwater fisheries.

Deepwater fisheries occur along the northern part of the Mid Atlantic Ridge and around Rockall Plateau, northeast of Ireland. The total catch of deepwater species in the Northeast Atlantic in 2004 was 2.7 million tonnes, more than half of the global total. Blue whiting accounted for 2.4 million

[7] Recorded depth ranges include numerous records some of which may be sporadic and therefore may not be useful for characterizing species as deepwater or otherwise. Most of the main depth ranges of the fisheries taking place on these species were compiled by participants at the Expert Consultation after the initial draft of this paper was presented.

tonnes (almost 90 percent). Other important species in terms of volume were Greenland halibut, ling, northern prawn, roundnose grenadier, and tusk (also known as cusk). Orange roughy accounted for 1 240 t of the reported catch.

Deepwater fisheries of the Northwest Atlantic date back to the early 1960s with the arrival of western European and USSR fleets. The reported catch from the Northwest Atlantic in 2004 was smaller than that in the Northeast Atlantic with a total reported catch of 421 438 t, mostly of northern prawn and Greenland halibut. Northern prawn is primarily taken on the Flemish Cap southeast of Newfoundland. Greenland halibut are taken on the continental shelf and slope on the so called “tail” of the Grand Banks, and off Labrador. Blue whiting, the dominant species reported from the Northeast Atlantic, was not present in the Northwest Atlantic reported catch.

2.2 Deepwater fisheries of the South Pacific Ocean

The total reported deepwater fisheries catch in the South Pacific was 426 112 t in 2004 or about 7 percent of the global deepwater total, small compared to the reported catch from the North Atlantic. However, the South Pacific accounted for most of the global reported catch of orange roughy.

Most of the deepwater fishing of the South Pacific takes place in the Southwest Pacific near New Zealand and Australia and in the Southeast Pacific near Chile. The most important species in the Southwest Pacific in term of volume of catch in 2004 were blue grenadier or hoki (154 532 t), southern blue whiting (42 276 t), pink cusk-eel (21 176 t), oreo dories (19 787 t) and orange roughy (18 157 t or 70 percent of the global total of 25 881 t). The Southeast Pacific reported catch was primarily Patagonian grenadier (also known as hoki; 71 177 t) and southern blue whiting (33 169 t). Patagonian toothfish (6 470 t) is another important deepwater species in the Southeast Pacific. The Pacific Antarctic had a reported catch of Antarctic toothfish of 2 558 t.

2.3 Other oceans

The remaining ocean areas accounted for about 43 percent of the global total reported catch of deepwater fish species in 2004, but this amount is deceiving. Most of the catch is from a few species which have a depth range including the FAO definition of deepwater (greater than 200 m), but they are probably caught primarily in continental shelf fisheries, sometimes very nearshore.

The reported deepwater catch for the North Pacific Ocean in 2004 was 1.6 million tonnes, or 27 percent of the global total. However, most of this catch was hairtails (1.5 million tonnes) which are probably taken on the Asian continental shelf (they are reported from the Northwest Pacific).

Historically, there was a significant fishery for pelagic armourhead along the Hawaiian and Emperor Seamount chain beginning in 1969 (Shotton 2005). The total catch of pelagic armourhead by USSR vessels is estimated to have been 133 400 t during the period 1967-1977. The catch by Japan during the period 1969-1977 is estimated to have been from about 180 000 to 285 000 t. By the late 1970s, the catch of pelagic armourhead had declined sharply and it was replaced by catches of alfonsino for a period. Eventually, the fisheries for both species disappeared, and there is no evidence the stocks will recover in the foreseeable future. Recently, Clark *et al.* (in press) estimated that about 800 000 t of armourhead were taken between 1968-1985. Although the actual amount of catch may be uncertain, it is clear that it was substantial. These fisheries provided an early warning of the fragility of deepwater fisheries.

The reported catch of deepwater species from the South Atlantic in 2004 was 294 063 t (5 percent of the global total), mostly of Patagonian grenadier (hoki, 145 224 t), southern blue whiting (76 596 t), and pink cusk-eel (19 293 t). Patagonian toothfish (16 081 t) are important in the Southeast Atlantic and Atlantic zone of the Antarctic Ocean. Orange roughy (1 845 t) were also in the reported catch. They were probably caught almost entirely by the fishery that developed in the Namibian EEZ during the late 1980s and early 1990s.

The reported deepwater catch from the Indian Ocean totaled 351 267 t or 6 percent of the global deepwater total. The reported catch was dominated by hairtails (174 771 t) and Bombay duck (154 277 t), which are most likely caught near shore on the South Asian continental shelf. A total of 13 457 t catch of toothfish (mostly Patagonian) was reported from the Indian Ocean and Indian Ocean zone of the Antarctic. The reported Indian Ocean catch of orange roughy in 2004 was 2 559 t. It was the unregulated high-seas fishing for orange roughy in the Indian Ocean in the late 1990s and early 2000s that raised concerns about the adequacy of the international framework for managing deepwater high-seas fisheries. Reported orange roughy catches from the Indian Ocean are given in Figure 4. The figure indicates a peak in the catch in 1999. Interesting, only four countries have reported Indian Ocean catches of orange roughy according to the FAO official database. The Second *Ad Hoc* Meeting on the Management of Deepwater Fisheries Resources of the Southern Indian Ocean (FAO 2002) indicates catches by several other countries and a significantly higher total catch.

2.4 Status of deepwater fisheries

At present, the most comprehensive global information on the state of fisheries is FAO (2005). FAO is currently updating this information. Table D1-17 of FAO (2005; 214-235) consider 584 species (or species group)-statistical area combinations, which are referred to as stocks. In actuality, these so-called stocks are often comprised of several biological stocks. However, this is the highest resolution information that is available on a global scale. Of the 584 stocks, information on the status of the stock is given for 441 or 76 percent. The stocks are classified as follows:

- **Not Known (N) -** Not enough information to make a judgment.
- **Underexploited (U) -** Underdeveloped or new fishery. Believed to have significant potential for expansion in total production.
- **Moderately exploited (M) -** Exploited with a low fishing effort. Believed to have some limited potential for expansion in total production.
- **Fully exploited (F) -** The fishery is operating at or close to optimal yield/effort, with no expected room for further expansion.
- **Overexploited (O) -** The fishery is being exploited above the optimal yield/effort level believed to be sustainable in the long term, with no potential room for further expansion and a high risk of stock depletion/collapse.
- **Depleted (D) -** Catches are well below historical optimal yield, irrespective of the amount of fishing effort exerted.
- **Recovering (R) -** Catches are again increasing after having been depleted or a collapse from a previous high.

Maguire *et al.* (2006) updated some of the status of stock determinations in FAO (2005) primarily based on reports of the International Council for Exploration of the Sea (ICES) and information collected from Regional Fishery Management Organizations (RFMOs). Status of stock information for deepwater species extracted from FAO (2005) and Maguire *et al.* (2006) is given in Table 3 for those stocks where there is enough information to make a judgment.

Table 3. Status of stock information for fisheries for deepwater species (extracted from FAO 2005, Tables D1-17, and Maguire *et al.* 2006, Table 4).

When two or more letters are given for state of stock, a "-" means the status is either of the two ratings (e.g. F-O means either fully or overexploited, N-O means uncertain but probably overexploited). A "/" means that there are ratings for more than one stock (e.g. M/F means there is a stock that is moderately exploited and another that is fully exploited).

Ocean Area	Species	Status of stock
NW Atlantic	Greenland halibut	O/O
	Tusk	F
	Northern prawn	F
	Redfish	D
NE Atlantic	Blue ling	N-O
	Black scabbardfish	N-O
	Blue whiting	O
	Bluntnose sixgill shark	N-O
	Common mora	N-O
	Forkbeards	N-O
	Greenland halibut	N-O
	Greenland shark	N-O
	Ling	N-O
	Longnose velvet dogfish	N-O
	Orange roughy	N-O
	Rabbit fish, Rattail, Chimaera	N-O
	Redfish	F/O
	Roundnose grenadier	N-O
	Roughhead grenadier	N-O
	Northern prawn	N-F
	Tusk	N-O
	Wreakfish	F-O
SW Atlantic	Patagonian grenadier (hoki)	M
	Southern blue whiting	F-O
	Patagonian toothfish	M-F
	Pink cusk-eel	M-F
SE Atlantic	Kingklip	N-F
	Geryons	F
W Indian	Bombay duck	F
E Indian	Hairtails, scabbardfishes	M-F
	Largehead hairtails	M-F
NW Pacific	Largehead hairtails	F-O
W Central Pacific	Hairtails, scabbardfishes	M-F
	Largehead hairtails	M-F
SW Pacific	Blue grenadier (hoki)	M/F
	Southern blue whiting	F
	Orange roughy	F-O
	Oreo dories	F-O
	Silver gemfish	F-O
SE Pacific	Blue grenadier (hoki)	F-O
	Patagonian toothfish	M
Southern Ocean (Antarctic)	Lanternfishes	U
	Patagonian toothfish	F/F/O/D
	Antarctic toothfish	F-O

A striking feature of Table 3 is how few stocks of species subject to deepwater fishing are represented in the global database. There are 50 determinations of stock status in Table 3, of which 29 (58 percent) are approaching being overexploited (N-O or F-O), overexploited (O), or depleted (D). This is greater than the percentage of all stocks combined that are in these three categories (25 percent), as reported by FAO (2005). However, the number of stocks of deepwater species for which information is available may be too small to make this comparison meaningful, particularly since many of the determinations are uncertain (e.g. given as N-O). Most of the information is for the North Atlantic where two Regional Fisheries Management Organizations and ICES routinely consider stock status, including the status of deepwater stocks. Most other regions of the world either lack RFMOs and international scientific bodies, like ICES, or they are less active.

Another way of examining the overall status of deepwater fisheries is through analysis of catch trends based on a simple generalized fishery development model incorporating five phases: (1) Undeveloped: low initial catches; (2) Developing: rapidly rising catches; (3) Maturing: catches reaching and remaining around their historical maximum; (4) Senescent: catches consistently falling below the historical maximum; (5) Recovering: catches showing a new phase of increase after a period of senescence. This approach was applied by Maguire *et al.* (2006) using the methodology described by Grainger and Garcia (1996). The method was applied to all oceanic deepwater species that produced more than 100 000 t of total reported landings for the period 1950-2004. The species were: Argentines, Beaked redfish, Black Scabbardfish, Blue grenadier, Blue ling, Blue whiting, Deep-sea smelt, Electron sub Antarctic, Geryons, Greenland halibut, Grenadiers, Hector lanternfish, Ling, Longspine snipefish, Orange roughy, Patagonian grenadier, Patagonian toothfish, Queen crab, Roundnose grenadier, Sablefish, Silver gemfish, Silver scabbardfish, Silver warehou, Southern blue whiting, and Tusk (also known as Cusk). These are not exactly the same species as FAO (2005) categorises as deepwater, but there is a great deal of overlap between the two lists.

The catch history of oceanic deepwater species is given in Figure 5. The results of the analysis are given in Figure 6. The results indicate that fisheries for these deepwater species developed slowly in the 1950s when most such fisheries were underdeveloped. Maguire *et al.* (2006) commented that oceanic deepwater fisheries have been relatively slow to develop compared to oceanic epipelagic fisheries. However, the deepwater fisheries caught up in the 1980s. By the early 2000s, more than 50 percent were already classified as senescent or recovering. This is somewhat higher than about 35 percent reported as senescent or recovering from a similar analysis for the development of global fisheries overall (Garcia *et al*. 2005).

3. ECOSYSTEM CONCERNS

Deepwater fisheries have three types of ecosystem effects:

- Food web effects - Removal of deepwater species from marine ecosystems can alter energy flow and change the way ecosystems function. Catches of a large volume of some species may indirectly affect predators and/or prey. The catches of other species that are relatively small in volume are less likely to affect energy flow.

- Discards - As with most fisheries, some organisms are unintentionally caught and discarded at sea. Mortality of discarded species may also alter energy flow, and the mortality inflicted on some discarded species may be unsustainable.

- Alteration of habitat and biodiversity - Aside from organisms that are caught (retained or discarded), when fishing gear comes in physical contact with the sea floor it may damage physical structures and kill organisms even if they are not captured. Other forms of unobserved mortality such as fish that are not caught but die as a result of contact with the gear, and “ghost fishing” by lost or abandoned gear may also be substantial.

While logically, food web effects must occur, very little is know about them. They may be more important for shallow water fisheries where large volumes of forage (prey) species are caught, and for oceanic large pelagic or highly migratory species fisheries, where top predators are usually caught. Food web effects of this nature have been highlighted as a concern for blue whiting in the Northeast Atlantic where catches of this important "deepwater" prey species exceed 2 million tonnes annually. Food web effects are also likely to be a consideration in waters below 500 m, where it is common for one or two species to dominate the fish biomass. For example, it seems likely that the removal of 70-90 percent of the biomass of orange roughy from ecosystems in which they were initially by far the most abundant fish species will have a major effect on ecosystem structure and function (Section 6).

Much more is known about discarding than other mechanisms through which fisheries affect ecosystems. The most recent global information on discards is in an FAO report by Kelleher (2005). Maguire *et al.* (2006) summarized relevant information from Kelleher (2005).

It is estimated that the overall average rate of discarding is about 8 percent for all marine fisheries, but there are large differences by fishery and country. Shrimp trawling has the highest estimated discard rate (62.3 percent, ranging from 0 to 96 percent). Most of the estimates of discards from shrimp fisheries are for shallow water fisheries. However, there are estimates for deepwater northern prawn fisheries, such as the NW Atlantic Flemish Cap fishery. The aggregate discard rate for cold/deepwater shrimp fisheries is 39 percent, but it can be reduced to about five percent when bycatch reduction devices (BRDs) are used. BRDs are mandated for the Flemish Cap fishery, which accounts for most of the deepwater catch of northern prawn.

The estimated overall discard rate for bottom trawling for finfish is 9.6 percent. There is no basis to judge if the rate is higher or lower for deepwater bottom trawling. However, bottom trawling for finfish overwhelmingly occurs in less than 200 m depth such that deepwater fisheries cannot account for much of the estimated 1.7 million tonnes of total discards from this type of fishing. For deepwater fisheries, the species discarded may be small specimens of the target species, and numerous invertebrates including coldwater corals (*Lophelia* spp.). Many of the discarded species of finfish, and especially of invertebrates, are probably not yet described in the scientific literature.

Discarding of coldwater corals by deepwater bottom trawlers has received particular attention. In addition to the potential ecological significance of coldwater corals, they have also gained status as charismatic species akin to marine mammals and sea turtles. They form deep-sea reefs that rival tropical coral reefs in their beauty. Rarely has the impact of expanding deepwater trawling been documented in its initial stage, before habitats have been impacted. However, there were observers on board the vessels fishing for orange roughy on the South Tasman Rise (south of Tasmania, Australia, straddling the Australian EEZ) for the first four years of the fishery. Anderson and Clark (2003) estimated that in the first year of fishing an average of 1.6 t of coral were brought up per hour of trawling, which extrapolates to 1 700 t of coral bycatch compared to an orange roughy target catch of 4 000 t. Gianni (2004) estimated the bycatch of coldwater coral in the first year of the fishery as 10 000 t compared to an orange roughy catch of 4 000 t. Apparently, Gianni scaled up Anderson and Clark's estimate to take account of the observer coverage level of 15%. However, Anderson and Clark had already taken account of the level of observer coverage in their estimate. Thus, Gianni's estimate is incorrect.

Bycatch of coldwater corals is an obvious indication of the impact physical contact of trawl gear on the sea bed can have on habitat. The amount of coral brought up in trawl nets must be minor in comparison to the impact of heavy bottom trawl gear when it comes in contact with the bottom. The scientific literature, conservation campaigns of environmental non-governmental organizations (NGOs), and the popular media routinely publish vivid "before and after" photos of bottom habitat that has been impacted by bottom trawling (Figure 7). The ecological importance of this habitat alternation is difficult to quantify, but complex "three dimensional" biogenic structure is known to provide shelter from predators for some species. When the structure is destroyed, these species may disappear. Another concern is that seamounts and other deepwater areas where deepwater trawl fisheries occur appear to have a high proportion of endemic species (species that are not known to occur elsewhere) which means that if they are exterminated locally, the species may be lost globally. However, the degree of endemism is uncertain (Section 4.2.4).

Deepwater fisheries are also prosecuted with demersal longlines. This type of gear is particularly important in the Southern Ocean, but also in the Northeast Atlantic. The overall discard rate for demersal longliners is 7.5 percent (ranging from 0.5 to 57 percent), and in the Commission for the Conservation of Antarctic Living Marine Resources (CCAMLR) area it is estimated at 12.7 percent. In addition to discards of many species of finfish by longline fisheries in the Southern Ocean, bycatch of seabirds has been a serious problem. In 2003, concerns about the longline bycatch of seabirds led the FAO Committee on Fisheries (COFI) to adopt an International Plan of Action for the Reducing the Incidental Catch of Seabirds in Longline Fisheries.[8] The Commission for Conservation of Antarctic Marine Living Resources (CCAMLR)[9] introduced a seabird bycatch reduction program which has reduced the mortality of seabirds by 80 percent.

4. SCIENTIFIC CHALLENGES

Some of the scientific challenges for deepwater fisheries are similar to those for all fisheries and some are unique. The key types of scientific information that are needed for an ecosystem approach to managing deepwater fisheries are stock assessments and habitat and biodiversity impact assessments.

4.1 Stock assessments

Stock assessments provide a scientific evaluation of the status of a fish stock and its potential yield. There are several key elements of a stock assessment.

4.1.1 Stock structure

Ideally fisheries should manage an interbreeding group of fish that are reproductively isolated from other fish of the same species. Such groups of fish are referred to as stocks. The challenge is to determine stock structure (i.e. which groups of fish are stocks) for a species and to assess the individual stocks. A variety of methods are used to determine stock structure including tagging, genetics, microconstituent and stable isotope analysis of hard parts (e.g. ear bones), and differences in the occurrence of parasites. Some of these approaches are impractical for deepwater species (e.g. traditional tagging – although new methods of *in situ* tagging have been shown to be feasible for some deepwater species; Sigurdsson *et al.* 2006, www.star-oddi.com), while others that are routinely applied to shallow water species are equally applicable (e.g. genetics). An additional challenge for deepwater species is collecting samples, particularly in areas and seasons where fishing does not occur.

For some deepwater species, the range of the species is unknown. This means that it is unknown if a fishery on a local fishing ground is exploiting an entire stock, or merely fishing a small portion of a stock which is distributed over a vast area far away from the main fishing ground. This is a particular problem for orange roughy, to the extent that it is unknown if declining catch rates experienced for many orange roughy fisheries is a threat in terms of the reproductive potential of a stock, or if it is simply a problem of localized depletion.

In general, stock structure is poorly known for deepwater species compared to species fished at shallower depths. This reflects both unique challenges of determining the stock structure of deepwater species, and the fact that researchers have been studying the stock structure of shallower water species much longer than they have been studying any aspect of the biology of deepwater species.

---

[8] See: http://www.fao.org/figis/servlet/static?dom=org&xml=ipoa_seabirds.xml for the FAO International Plan of Action for Seabirds.

[9] See: http://www.ccamlr.org/default.htm

4.1.2 Demographics

One of the most important factors determining the productivity and resilience of a fish population is the lifespan of the species (which is closely related the natural mortality rate) and its age of maturity. Species with a long life span that mature at an advanced age have low productivity and low resilience. Unfortunately, it has proven difficult to determine the age of deepwater fish species. The typical way that age is determined for shallow water species is to look for patterns in hard parts (ear bones, vertebrae and scales) that correspond to seasonal differences in growth. These patterns can be validated by modal analysis, with tagging studies or by keeping animals in captivity. In deepwater, there is little seasonal variability in environmental conditions that might be associated with seasonal patterns in growth. However, Mace *et al.* (1990) found clear evidence of annual rings and a seasonal progression of marginal increments in juvenile orange roughy otoliths and were able to validate these rings using modal analysis for ages 0-4. Thus, even the low seasonal variation in deep water may be adequate, at least for juveniles. Radioisotope analyses have been used to determine the age of some species. However, this method is not practical for the large number of age determinations (thousands per year) that are used in state-of-the-art assessments for shallow water species. Information on the age composition of the fish in the commercial catch and in the population (based on fish collected by research vessels) is also valuable in assessment models to estimate the fishing mortality rate and population size.

In general, the demographic information available for deepwater species is much less than for shallow water species, at least compared to shallow water fishery assessments conducted in North America and Europe. Lack of information and misinformation on the age and growth of orange roughy during the early period of development of the fishery in New Zealand (until the late 1980s) led to a serious overestimate of the productivity of the species and its potential sustainable yield (Mace *et al.* 1990, Clark 1995 and Section 6).

4.1.3 Fishery-dependent information

Data on (1) catch biomass, (2) size and age composition of the catch, (3) fishing effort, and (4) discards, provides the basic information on fisheries used in stock assessments. Age composition data may be more difficult to obtain for deepwater species than for shallow water species for the reason discussed above. However, the other types of fishery-dependent data should be no more difficult to obtain for deepwater fisheries. The fact that there are relatively few large vessels engaged in deepwater fisheries could be an advantage in keeping track of fishing activity and collecting data. For some countries, where most of the deepwater catch enters international trade, catch data can be verified by export records.

While collection of fishery-dependent information for deepwater fisheries is not inherently more difficult than for other fisheries, in practice, the amount of available fishery-dependent data is problematic in some cases. As noted above, the reported catch by deepwater fisheries on the high seas in the Indian Ocean during the early 2000s is not consistent with unofficial reports on the magnitude of catches and the countries participating in the fishery. There are no reported catches of pelagic armourhead from the Pacific Ocean during the period when the former USSR and Japan are estimated to have taken hundreds of thousands of tonnes of the species from the Hawaiian and Emperor seamounts (as described in Section 2.3). Recent reports of ICES on deepwater fisheries of the Northeast Atlantic also raise concerns about fishery-dependent data. For example, ICES (2005) stated,

> "It is also of concern that the landings statistics that are available may not reflect the true scale of the recent fishing activity, especially in waters outside the national EEZs."

Another challenge for assessments of deepwater species is that it is also difficult to interpret catch per unit effort data for fisheries that are conducted on dense concentrations of fish (Clark 1996), particularly those on spawning aggregations. However, this problem is also common for shallow water species (e.g. purse seine fisheries for schooling species like herring). It is one important reason that fishery-independent abundance indices are a valuable information source for stock assessments.

4.1.4 Fishery-independent relative abundance indices

An important input to stock assessments is an index of relative abundance which tracks changes in the size of a population. Since fishery-dependent catch per unit effort data often track abundance poorly, fishery-independent resource surveys are usually considered to be superior sources of data for tracking abundance. The most common fishery-independent methods for tracking relative abundance are trawl surveys, acoustic surveys, and surveys of planktonic fish eggs and larvae. Photographic techniques may also be used for surveys. All of these techniques have been tried for deepwater fisheries, especially in New Zealand (see reviews by Clark 1996, 2005).

Unfortunately, application of all of these methods is difficult for deepwater fisheries. Trawl surveys are logistically difficult and time consuming when trawls are towed at great depth. Also, the entire area occupied by deepwater species is vast. Thus, trawl surveys are usually limited to spawning and/or fishing grounds, not the entire range of a stock as may often be covered for shallow water species.

Egg and larval surveys are rarely used for deepwater species, but they have been tried and abandoned for deepwater species in New Zealand (Clark 2005). Again, such surveys are challenging because potentially vast areas may be involved, eggs can disperse rapidly in strong currents, and little is known about the planktonic early life history of most deepwater species.

Deepwater acoustic surveys have also been used to assess deepwater species. Designing and building acoustical systems that can be towed at great depth is technically challenging. More importantly, the target strength of deepwater species is difficult to determine. Species like orange roughy which have oil filled swim bladders have low target strength, making them hard to detect. In addition, they are often associated with other species with much higher target strengths. Another problem is that for acoustic surveys of deepwater species that are associated with seamounts and canyons, it is hard to distinguish dense concentrations of fish from bottom features. Undoubtedly, inaccurate acoustic survey results have led to some overly optimistic assessments of the potential yield, with disastrous results, for several deepwater fisheries (particularly orange rough, Section 6).

Surveys using cameras to sample for deepwater species of fish have also been attempted. However, photographic techniques cannot sample enough water volume or area of sea bottom to be practical except perhaps for a few specific research applications.

4.1.5 Spatial and temporal patterns of spawning and recruitment

Most shallow water species spawn annually after they reach maturity. While interannual variability in recruitment of shallow water species is a major source of uncertainty in stock assessments and management, the general pattern is understood. There is some detectable or measurable recruitment to the stock annually, and the spatial distribution of recruits is similar from year to year. For deepwater species, the patterns are unknown, and difficult to determine because it is difficult to determine the age of individual fish and the full spatial range of the stock may be unknown.

Orange roughy illustrate the uncertainty. Does the abundance on a spawning ground where a fishery occurs track the abundance of spawners as they return annually to spawn, or is it tracking interannual variability in the component of the population that returns to the particular location to spawn? Is there annual recruitment such that a fishery can be sustained, or is recruitment extremely intermittent, as it might be for a species with a life span of more than 100 years? Might recruitment variability for orange roughy be expressed spatially (where there is a good year-class) instead of temporally (when there is a good year-class)? The answers to these questions are fundamentally important to the issue of sustainably fishing the resource over the range of a stock, even if a fishery cannot be sustained at each individual site where recruitment might intermittently occur. For example, if recruitment variability is expressed spatially rather than temporally, fisheries might be allowed to overfish some concentrations of orange roughy on some fishing grounds, so long as the number of concentrations left unfished is sufficient to result in a total fishing mortality that is appropriate to sustain the stock. Such knowledge would allow an area rotation harvest strategy to be designed, but it would require knowledge of the relationships between spawning concentrations (e.g. are they part of the same stock such that spawning in one location has the potential to be the source of recruitment at another location?). Unfortunately, there are no orange roughy stocks for which recruitment has been able to be estimated at the population level, let alone on finer spatial scales. This problem largely hinges on the difficulty of ageing this species.

4.1.6 Models

Models are used to integrate various sources of data on fisheries to assess trends in abundance, population biomass, current sustainable yield, and long term potential sustainable yield or Maximum Sustainable Yield (MSY). The assessment models used for deepwater species range from simple analyses of trends in catch or relative abundance indices, to complex computer models using sophisticated statistical techniques. Some of the modelling techniques used for deepwater species in New Zealand and Australia are especially complicated as they attempt to integrate disparate types of input data and to capture the full range of uncertainty in the biology of deepwater species in relationship to fisheries. Unfortunately, these models estimate so many parameters that it is not unusual for quite different interpretations of the available data to fit the data equally well (or equally poorly). In some cases, the best fit to the data may give parameter estimates that are inconsistent with each other or implausible (Section 6).

In general, input data to assessment models is much more of a limiting factor for assessments than the models themselves. To a degree, more sophisticated models give a more rigorous interpretation of the available data, but they also run the risk of lulling scientists and managers into a false sense of confidence. Use of poor data can be misleading and result in poor assessments and poor consequent management actions (Boyer *et al.* 2001). This is ironic since one of the reasons for building sophisticated models is to capture uncertainty more realistically.

In Section 6, orange roughy assessments in New Zealand are used to illustrate the potential value and pitfalls of sophisticated models that are used to assess deepwater fisheries.

4.2 Habitat and biodiversity impact assessment

Taking an ecosystem approach to managing fisheries requires consideration of the impact of fisheries on habitat and biodiversity. Habitat and biodiversity assessments are difficult to conduct for shallow shelf ecosystems, but they are even more of a challenge for deep-sea ecosystems. This is an extremely controversial issue with some people comparing the impact mobile bottom fishing has on benthic communities to clear cutting forests. It is unclear if the comparison is in terms of how humans see it visually, or the impact on ecosystem processes, or in terms of the proportion of the earth’s land area that has been cleared to the proportion of the sea floor that has been altered, or if it is merely a statement intended to steer emotions. Regardless, the impact of fishing on habitat and biodiversity is an issue that has gained importance at high levels, such as the UNGA, and it needs to be addressed with objective research. There are several scientific issues to be addressed.

4.2.1 Habitat change caused by gear contact

The first issue to be addressed to assess the habitat and biodiversity impact of fishing is to determine the changes that are caused when fishing gear comes in contact with the seafloor. Damage to biogenic communities, such as coldwater coral reefs, is obvious, but what about other types of habitats? There is also a need to characterize habitat alteration in the context of functional aspects of the habitat rather than relying on aesthetics from a human perspective.

4.2.2 Recovery time of habitat

Some studies have followed the recovery of habitat in areas that are protected from further fishing activity, such as extensive studies on the northern edge of Georges Bank of the Northeastern United States (Collie *et al.* 2000). There is also evidence that some coldwater coral reefs are very old. For example, fragments taken from the coldwater coral reef at the Sula Ridge off the Norwegian coast have been dated at 8 500 years old, which is just after the end of the last ice age. This 300 m deep reef is about 13 km long and 400 m wide with an average height of 15 m, rising to 35 m in some places. The growth rate of the reef has been estimated as 1 mm per year.[10] Clearly, the recovery time from trawling damage to such a reef is very long. However, there are many types of habitat that are impacted by contact with fishing gear, and not all habitats are as fragile and slow to recover as coldwater coral habitat.

4.2.3 Habitat mapping

A key to protecting habitat from fishing impacts is knowledge of where the most fragile habitat is located. Side-scan sonar is increasingly used to survey and map habitat off North America, Europe, and elsewhere. These efforts have identified previously unknown areas of coldwater coral, and in some cases, managers have responded by closing the areas to bottom fishing.

4.2.4 Degree of endemism

Many studies of the biodiversity associated with coldwater coral reefs and deep-sea ecosystems on seamounts have discovered species that appear to be endemic. This raises the concern that the localized impact of fishing may drive endemic species to extinction. However, is the rate of endemism really as high as it appears to be, or is the apparent large number of endemic species an artifact of under-sampling? Many studies indicate that the number of new species discovered increases steadily with an increase in sampling intensity, suggesting that there are many more species to be discovered in the area being sampled (Parin *et al.* 1997, Richer de Forges 2000, Rowden *et al.* 2002). If this is the case, many species that now appear to be endemic on a particular seamount, might be discovered on other seamounts in the future if sampling is more intense. Realistically, there will never be absolute proof that a species is endemic. This would require a complete inventory of species with complete knowledge of their geographic range. Therefore it would be useful for marine scientists to agree on statistically rigorous criteria for labeling a species endemic, perhaps with a range of degrees of certainty (e.g. possibly endemic, probably endemic, endemic). Such criteria need to take account of the possibility that a species that at first appears to be localized, might later be discovered to be global. Orange roughy are an example of this issue. They were probably presumed to be a relatively rare species with localized distribution in the Atlantic when they were discovered. They are now known to be common in the Pacific and Indian Oceans.

The fact that it is difficult to say with certainty that species are endemic does not mean that management should ignore the possibility that some species that are endemic may be jeopardized by fishing. Scientists need to objectively assess the risk so that managers can fulfill their responsibility to manage risk.

4.2.5 Spatial overlap between fishing and unique elements of deep-sea ecosystems

It is known that some deepwater fisheries concentrate on the peak of seamounts, and other submarine feature, which are also areas commonly covered with fragile biogenic communities, such as coldwater coral reefs. These areas may also be the habitat of endemic species. What is unknown is the degree of spatial overlap between fishing activity and fragile habitat and endemic species. For example, do endemic species on the tops and gentle slopes of seamounts where fishing occurs also inhabit the steep slopes of the seamount outside of the area that is feasible to fish with existing technology? The degree

---

[10] See http://www.ices.dk/marineworld/deepseacoral.asp

of overlap between fishing and endemic species is probably a key factor in determining the risk of extinction.

4.2.6 Functional value of habitat and biodiversity

While humans may value some aspects of deep-sea ecosystems for their beauty, existence value, and potential undiscovered benefits (such as new pharmaceuticals that might cure dreaded diseases), their value in terms of the functionality of the ecosystems is also an important consideration of an ecosystem approach. For example, how important are coldwater coral reefs as habitat for young fish, and thus, how might the loss of this habitat adversely impact production of fisheries? It seems likely that coldwater corals provide shelter from predators for some species. However, it is difficult to translate the association between young fish and habitat into the productivity of a population. Another issue is the functional importance of biodiversity, such as its importance in terms of ecosystem stability and robustness.

The scientific challenges associated with the functional value of habitat and biodiversity are daunting for shallow water ecosystems. They are not tactical for deep-sea ecosystems. Realistically, the best option is to use lessons learned from shallow water ecosystems to make inferences about deep-sea ecosystems.

4.2.7 Mitigation options

The impact of fishing on habitat and biodiversity might be mitigated by modifying fishing gear and/or fishing practices. There are many examples of such changes (sometimes referred to as “conservations engineering”) successfully mitigating ecosystem impacts, such as the CCAMLR program to reduce seabird bycatch in deepwater longline fishing for toothfish and the use of bycatch reduction devices in the Northwest Atlantic fishery for northern prawn to protect juvenile fish (Section 3). Since the significance of habitat and biodiversity impacts on deep-sea ecosystems is unlikely to be scientifically understood for the foreseeable future, it is prudent to mitigate potential impacts. Experience has shown that mitigating impacts by conservation engineering requires the fishing industry to apply their fishing gear expertise for catching more fish regardless of impact, to reducing impact with a minimum loss of fishing power. Engineers and scientists can help, but a cooperative approach with the industry works best. Mitigating impacts requires not only successful conservation engineering, but also incentives to apply the mitigation techniques (e.g. enforcement of regulations on gear). It will probably be easier to enforce gear regulations if the fishing industry believes in the gear because they helped design it. Ultimately, the fishing industry should have the incentive to cooperate with efforts to mitigate ecosystem impacts since these impacts may adversely affect the productivity of fisheries, and even if they don’t, the industry risks being found guilty in the court of public opinion of crimes against marine ecosystems if it does not respond to the public’s concerns.

5. MANAGEMENT FRAMEWORKS AND EXPERIENCE MANAGING DEEPWATER FISHERIES

5.1 National frameworks

Most fisheries for true deepwater species probably occur within national EEZs. As noted in Section 1, much of the catch of species FAO has characterized as deepwater is probably taken in relatively shallow water fisheries on the Asian continental shelf (e.g. about 2 million tonnes in total of Bombay duck and hairtails from the Indian Ocean and largehead hairtail from the NW Pacific Ocean). True deepwater fisheries occur in the EEZs of North America (the United States and Canada), Europe (Iceland, Norway, and members of the European Union), Africa (in particular Namibia), South America (in particular the southern area), Australia and New Zealand.

In general, the deepwater fisheries within the EEZs mentioned above are subject to well-developed fishery management frameworks. These frameworks require collection and reporting of fishery-dependent data. Fishery-independent resource surveys are conducted for some (but certainly not all) fishery resources. The management frameworks include mechanisms for obtaining scientific advice based on stock assessments, and legally binding conservation measures are implemented and updated regularly. There is usually some capability to enforce conservation measures, although compliance is a problem in many cases (e.g. note concerns expressed by ICES about the accuracy of catch reporting for some northeast Atlantic deepwater fisheries, Section 4).

National management frameworks that apply to deepwater fisheries within EEZs usually have policy goals requiring fisheries to be conducted in a sustainable manner using an MSY-based harvest strategy, or of maintaining stocks at biomass levels near or above those associated with MSY. General goals are often operationalized in the form of harvest strategies and control rules. Ecosystem considerations, such as impacts on habitat and biodiversity, are also addressed by some national management frameworks. For example, Norway protected the Sula Ridge coldwater coral reef described in Section 4 from bottom trawling within a few months of its discovery by a research cruise. In 2003, the European Commission promulgated regulations to protect coldwater corals on the Darwin Mounds, off Western Scotland.[11] Similarly, coldwater coral habitat in several areas off North America, New Zealand and Australia has been closed to bottom trawling. However, vast areas of coldwater corals are not protected. For example, it is estimated that 30-50 percent of the coldwater corals within the Norwegian EEZ have been damaged by bottom trawling.[12]

In spite of the existence of well-developed national frameworks for managing most deepwater fisheries within EEZs, many of these fisheries have been overfished and some have collapsed. This is indicated by the state of deepwater fisheries reviewed in Section 2. The case study of deepwater fisheries for orange roughy and related fisheries in Section 6 illustrates the difficulties of managing deepwater species even within EEZs where management frameworks are well developed.

5.2 International frameworks

As noted earlier, the FAO fisheries statistical database does not allow high-seas fisheries to be readily distinguished from EEZ fisheries. However, based on knowledge of the species caught, bottom topography, and reports of RFMOs and ICES, it is clear that high-seas deepwater fisheries occur in the Northeast Atlantic, Northwest Atlantic, Southwest Pacific, Southern Ocean and Indian Ocean. Gianni’s (2004) review of high-seas bottom trawl fisheries is consistent with this conclusion.

The Northeast Atlantic Fisheries Commission (NEAFC)[13] provides the fisheries management framework for high-seas deepwater fisheries in the Northeast Atlantic. NEAFC receives scientific advice on management from ICES. As described in Section 4, ICES has expressed concern about the quality of fishery-dependent data for deepwater fisheries of the Northeast Atlantic. The amount of fishery-independent data and demographic information is also limited for deepwater fisheries. Nevertheless, ICES (2005) repeated a previous warning on deepwater fisheries, other than deepwater sharks, as follows:

> “Most exploited deepwater species are considered to be harvested unsustainably: however, it is currently not possible to provide advice for specific fisheries for deep-sea species. Consistent with a precautionary approach, ICES recommends immediate reduction in established deep-sea fisheries unless they can be shown to be sustainable. Measures should also be implemented to reduce exploitation of deep-sea species by fisheries primarily targeting shelf species (hake, anglerfish, and megrim). New deep-sea fisheries or expansion of existing fisheries into new

[11] Commission Regulation (EC) No 1475/2003 of 20 August 2003 on the protection of deep-water coral reefs from the effects of trawling in an area north west of Scotland. L 211/14. Official Journal of the European Union, 21.8.2003. Cited by Gianni (2004).

[12] See http://www.ices.dk/marineworld/deepseacoral.asp

[13] See http://www.neafc.org/index.htm

fishing areas should not be permitted unless the expansion is very cautious, and is accompanied by programmes to collect data which allow evaluation of stock status as the basis for determining sustainable exploitation levels.

Ling and tusk are in many fisheries taken together and therefore the advised effort reduction, calculated on the basis of ling should apply to all fisheries taking ling and tusk as their main catch. The advised reduction is 30% compared to the 1998 effort level.

Concerning blue ling, there should be no directed fisheries. Technical measures such as closed areas on spawning aggregations should be implemented to minimize catches of this stock in mixed fisheries."

For deepwater sharks, ICES (2005) advised:

"The stocks of Portuguese dogfish and Leafscale Gulper shark are considered to be depleted. Given their very poor state, ICES recommends a zero catch of deepwater sharks."

ICES (2005) also gave advice on the "Seamounts, distribution of cold-water corals, and other vulnerable deep-water habitats"[14] identifying four candidate areas on Hutton Bank (Figure 8), northwest of Ireland for closure to bottom trawling.

NEAFC responded by propagating new regulations in 2006 on reporting fishery-dependent data,[15] and by reducing fishing effort on deepwater fisheries to 70 percent of the previous level.[16] This is a step in the right direction relative to advice from ICES, but it is unknown if this reduction in fishing effort will translate into a reduction in catch and fishing mortality sufficient to conserve deepwater stocks. It is too early to tell if there will be compliance with new regulations on reporting of fishery-dependent data.

According to the report of the 2005 annual meeting of NEAFC (7-11 November), some members of the Commission felt that more time was necessary to consider ICES's recommendation on closed areas to protect coldwater corals.[17] No action was taken. However, NEAFC has agreed to management measures prohibiting fishing with bottom trawls and static fishing gear on (a) the Hecate and Faraday seamounts and a section of the Reykjanes Ridge, (b) the Altair seamounts and (c) the Antialtair seamounts.[18]

The Northwest Atlantic Fisheries Organization (NAFO)[19] is the competent RFMO for the Northwest Atlantic. It has its own scientific body, referred to as the Scientific Council, to advise on scientific aspects of fisheries management. NAFO members are required to report fishery-dependent data, and there are several fishery-independent resource surveys conducted in the NAFO area, some sampling as deep as 1 500 m. The main deepwater species that are fished in the Northwest Atlantic are redfish, northern prawn and Greenland halibut.

NAFO (2006) gives the Scientific Council's most recent assessment of the state of the main deepwater fisheries. As noted in Section 2, Greenland halibut and redfish have been assessed to be overexploited and/or depleted, while northern prawn is fully exploited. The report of the Scientific Council expresses concern about the quality of fishery-dependent data, particularly about the lack of information on discards. A brief excerpt from the Scientific Council's advice on one of the stocks of Greenland

---

[14] See http://www.ices.dk/committe/acfm/comwork/report/2005/sept/NEAFC%20Request%20and%20OSPAR%20request%2027%209%20without%20annex.pdf
[15] See http://www.neafc.org/measures/dss_info.htm
[16] See http://www.neafc.org/measures/dss_conservation.htm
[17] See http://www.neafc.org/reports/annual-meeting/docs/full_reports/24neafc_annual_vol-1-main-report_2005.pdf
[18] See http://www.neafc.org/measures/deep-water_05_06.htm
[19] See http://www.nafo.int/

halibut (NAFO Subarea 2 and Div. 3KLMNO off Newfoundland and Labrador) illustrates the management situation for at least one key deepwater fishery in the area:

> "The 2003 catch could not be precisely estimated, but was believed to be within the range of 32 000 t to 38 500 t. A fifteen year rebuilding plan has been implemented by Fisheries Commission for this stock. The catches in 2004 and 2005 were 25 500 and 23 000 t, which exceed the rebuilding plan TACs by 27% and 22%, respectively."

The Scientific Council estimated that the 2006 exploitable biomass was the lowest since 1970, the first year for which an estimate is available. It was also "strongly recommended" that steps be taken to address bycatch in the fishery.

For the Southern Ocean, the Commission for Conservation of Antarctic Marine Living Resources (CCAMLR)[20] provides a framework for international management of deepwater fisheries. The Convention that empowers CCAMLR calls for an ecosystem approach as described in Article II:

> "…maintenance of the ecological relationships between harvested, dependent and related populations of Antarctic marine living resources and the restoration of depleted populations …"

CCAMLR also applies a precautionary approach. Its website states that:

> "Where insufficient data are available to assess sustainable harvesting levels or other conservation measures, a 'precautionary approach' has been developed to take account of the potential risks associated with incomplete knowledge about the dynamics of a particular resource."

CCAMLR has a Scientific Committee which gives scientific advice on fisheries management and ecosystem issues.

The main deepwater species fished in the Southern Ocean are Antarctic and Patagonian toothfish. The total catch (Figure 9) of these two species reported from the Southern Ocean peaked at 18 508 t in 2003 before declining to 13 766 t in 2004. The species are considered to be fully to over-exploited. Illegal, unregulated and unreported (IUU) fishing has been a serious problem with these fisheries, although CCAMLR has taken steps to improve compliance with its conservation measures (e.g. a catch documentation scheme). The toothfish stock near the Prince Edward Islands (South Africa) illustrates the vulnerability of toothfish resources to IUU. In this area, IUU fishing drove the stock down to a few percent of its pre-exploitation level (Maguire *et al.* 2006).

In keeping with CCAMLR's ecosystem approach and its adoption of the precautionary approach, CCAMLR has protocols for exploratory fishing and fisheries development. Historically, fisheries have developed without regulation until enough scientific evidence has accumulated to convincingly indicate that regulation is needed. CCAMLR, however, requires that exploratory fishing and development of new fisheries be authorized, monitored and accompanied by collection of data for scientific purposes. This approach should serve as a model for all fisheries, especially deepwater fisheries which seem to be particularly susceptible to overfishing.

The remaining ocean area where high-seas deepwater fisheries are significant is the Indian Ocean. At present, there is no international convention for management of these fisheries, and they have been largely unregulated. There are reports of fishing in the Southwest Indian Ocean quickly fishing out local concentrations of deepwater species, such as orange roughy (summarized by Gianni 2004). Habitat damage from these fisheries is undocumented, although it almost certainly occurred. Catches seem to have been under-reported (Section 2).

---

[20] See http://www.ccamlr.org/default.htm

In response to unregulated fishing in the Indian Ocean, the Southern Indian Ocean Deepwater Fisheries Association,[21] a fishing vessel operators' organization, with members that have been fishing for deepwater species in the Indian Ocean since 1996, agreed to a voluntary closure to fishing of 309 000 km^2 to conserve deepwater corals. Much of the area is pristine, never before subjected to bottom trawling.

A promising development in terms of a fisheries management framework for high-seas fisheries in the Indian Ocean is the South Indian Ocean Fisheries Agreement (SIOFA) signed by six countries in July 2006. Unfortunately, there are several countries with a history of deepwater fisheries in the Indian Ocean that are not yet parties to the agreement. The Agreement[22] commits the six countries to take concrete action to:

- establish effective mechanisms to monitor fishing in the SIOFA;
- provide annual reports on fishing operations, including amounts of captured and discarded fish; and
- conduct inspections of ships visiting ports of the Parties to verify they are in compliance with SIOFA regulations, and to deny landing and discharging privileges to those who do not comply.

While the agreement represents a clear commitment to monitor fisheries, it is not clear on intentions about sustainably managing fisheries. However, it is a step in the right direction.

For the Southwest Pacific, bilateral arrangements have been used to manage high-seas deepwater fishing on straddling stocks. For example, Australia and New Zealand have bilateral arrangements to manage the orange roughy fisheries on the South Tasman Rise (South of Tasmania, Australia) and the Challenger Plateau (west of New Zealand). Unfortunately, these arrangements have often not been successful in sustaining the fisheries (Section 6). Other high-seas deepwater fisheries in the Southwest Pacific are managed by flag state control of their own vessels. For example, New Zealand requires its vessels fishing on the high seas to have a high-seas fishing permit and to land their catch at a New Zealand port. This improves reporting on high-seas catches, but it does not restrict catches.

There are many other international arrangements concerning fisheries.[23] To date, none of them have played a significant role in managing high-seas deepwater fisheries. Clearly many of them lack competency to do so, such as the tuna commissions. It is unclear if others could manage deepwater fisheries even if their members agreed to do so.

Since high-seas deepwater fisheries in areas other than those discussed above appear to be minor, there is little call for additional international management arrangements. However, no one knows when a new international deepwater fishery might emerge or become known (some may be occurring now without being detected). Experience indicates that such fisheries develop and collapse quickly when unregulated (e.g. the pelagic armourhead fishery in the North Pacific during the late 1970s and 1980s), such that it may already be too late to negotiate an agreement once a new fishery begins.

6. CASE STUDY – ORANGE ROUGHY FISHERIES

In this section, a moderately-detailed summary and evaluation of the specific case of orange roughy (*Hoplostethus atlanticus*) fisheries on the Chatham Rise, New Zealand will be presented, followed by much briefer summaries of the history of other orange roughy fisheries in New Zealand, Australia, Namibia, Chile and the South Tasman Rise. There are also a few comments about oreo (*Allocyttus*,

---

[21]See: http://www.fao.org/newsroom/en/news/2006/1000360/index.html
[22] See Web address in the previous footnote 14.
[23] See the following FAO Web address for intergovernmental fishery organizations: http://www.fao.org/fi/body/rfb/index.htm

Neocyttus and *Pseudocyttus* sp.) fisheries in selected areas. The Chatham Rise orange roughy fisheries epitomise the evolution of the development of fishing, data collection, stock assessment and management of major deepwater fisheries.

6.1 Specific example: Chatham Rise orange roughy

The Chatham Rise orange roughy stock complex, located off the east coast of New Zealand from about 174.5°E to 173.667°W and 42.167°S to 46°S (Ministry of Fisheries 2006) is the largest known stock or stock-complex of orange roughy yet discovered, has been and still is supporting the longest-running orange roughy fishery, has the longest history of data collection, has had the greatest investment in research, and uses "state-of-the-art" stock assessment models and management tools. As such, it should have the greatest chance of any orange roughy fishery of being a success story. Whether or not this is the case is considered below.

For the period before the declaration of New Zealand's EEZ in 1978, it is known that vessels from the former Soviet Union were fishing for orange roughy in this area. Catches are unknown, but are believed to have been of the order of 2 000 - 3 000 t annually since 1973 (Robertson 1985). Fishing on the Chatham Rise during 1979 and 1980 was unregulated and recorded catches increased to 31 100 t (Table 4). An arbitrary total allowable catch (TAC) was set at 23 000 t in 1981.

6.1.1 Brief history of assessment methods and results

The discovery of "huge" aggregations of orange roughy on the Chatham Rise generated considerable excitement at the time. In retrospect, scientists, managers and fishers alike were misled by the apparently large biomass and dense aggregations, implicitly equating high biomass with high productivity. In fact, fisheries scientists thought they were taking a conservative approach by assuming life history parameters that were similar to or lower than averages used for other temperate water teleosts (e.g. a natural mortality of 0.1, a Brody growth coefficient of 0.2, and ages of maturity and recruitment of 5; Robertson 1986, Robertson and Mace 1988).

A wide area trawl survey was conducted for the first time in 1982. Based on various area expansion assumptions, this resulted in an estimate of then-current biomass of 792 800 t. As a result, the TAC was increased to 30 000 t. Two further (stratified random) trawl surveys in July 1984 and July 1985 led to estimates of the 1985 biomass of 509 500 t and an estimate of the unfished biomass, B_0, of 608 700 t (Table 4). Applying $Y = ½ MB_0$ (where Y = long-term sustainable yield and M = natural mortality; Gulland 1971), and using a "conservative" estimate of M=0.1, resulted in a yield estimate of 30 435 t and a TAC recommendation of 30 000 t. In the following year, the 1984 and 1985 survey results were re-analysed by adjusting for local high density and school height. Biomass estimates were multiplied by 10 whenever dense schools were observed on the colour sounder during a research tow. This increased the estimate of unfished biomass to 935 000 t. Applying $Y = ½ MB_0$ resulted in an estimate of long-term sustainable yield of 46 700 t and a TAC recommendation of 47 000 t, excluding catch overruns. However, it was believed that the difference between total removals and recorded landings was substantial (the former being up to 30 percent higher than the latter, Table 4) due to burst nets, escape windows in nets and lost or abandoned gear. Therefore, it was recommended that the TAC should only increase by about 8 000 t.

Table 4. Estimates of the unfished biomass, B_0, estimates of sustainable yields, annual TACs or catch limits, reported catches and catches adjusted for estimated overruns for Chatham Rise orange roughy.

Catches are reported to the nearest 100 t and are estimated for a 1 October-30 September fishing year. Estimates of B_0 and sustainable yields are calculated about six months in advance of the fishing year indicated and are used to inform the catch limits for that year. Where ranges are given, they represent the range of medians resulting from alternative assumptions; confidence intervals are not included. Estimates of sustainable yields are based on ½ MB_0 for 1985-86 and 1986-87, and the application of F_{MSY} or proxies to current biomass thereafter (see text). Blanks indicate that estimates were not made.

Fishing year	Estimates of B_0 (t)	Estimates of sustainable yields (t)	TAC or catch limit (t)	Estimated catch (t)	Catch plus estimated overruns (t)
1978-79			–	11 800	15 300
1979–80			–	31 100	40 400
1980–81			–	28 200	36 700
1981–82			23 000	24 900	32 400
1982–83			23 000	15 400	20 000
1983–84	> 792 800		30 000	24 900	32 400
1984–85			30 000	29 200	38 000
1985–86	608 700	30 435	29 865	30 100	38 500
1986–87	935 000	46 750	38 065	30 700	38 700
1987–88	406 500	17 430	38 065	24 200	30 000
1988–89	389 000	8 000	38 300	32 800	40 000
1989–90			32 787	31 600	37 900
1990–91	411 000	5 500	23 787	20 600	23 700
1991–92	383 000	2 200	23 787	15 500	17 100
1992–93	399 000-473 000	3 200	14 300	14 000	15 400
1993–94	411 000-508 000	2 900-7 000	14 300	13 500	14 900
1994–95	416 000-442 000	2 900-4 800	8 000	8 000	8 400
1995–96		3 200-5 100	7 200	7 500	7 900
1996–97			7 200	7 200	7 600
1997–98	482 000-503 000	7 940-8 940	7 200	8 600	9 000
1998–99			7 200	7 500	7 900
1999–00			7 200	7 800	8 200
2000–01	449 000-495 000	5 870-8 540	7 200	7 550	7 900
2001–02	475 000-589 000	10 270-15 940	10 400	9 600	10 100
2002–03			10 400	10 800	11 300
2003–04			10 150	9 550	10 000
2004–05	469 300-558 300		10 150	10 400	10 900
2005–06			10 150	9 900	10 400
2006-07	531 600	13 830	9 400		

Subsequently, there were two rapid developments that substantially reduced the estimates of sustainable yields. First, Mace and Doonan (1987) suggested that uncertainty about B_0 and uncertainty about then-current stock size relative to B_0 meant that use of $Y = ½ MB_0$ might no longer be applicable and that it would be more prudent to base yield estimates on the product of $F_{0.1}$[24] and an estimate of current biomass, $B_{current}$. The estimate of $F_{0.1}$ was 0.18 (still based on the assumption of $M = 0.1$), while the estimate of the 1987 biomass was 96 800 t, resulting in a revised yield estimate of 17 430 t. It was recommended that the TAC needed to be reduced to avoid collapse to dangerously low levels within 20 years.

Next, in early 1988, a survey was conducted to locate small juveniles for ageing studies (using modal analysis and marginal increments) in the hope of being able to differentiate between eight substantially

[24] This is a level of fishing mortality that has been used as reference level in several fisheries around the world.

different competing estimates of the age-length relationship. The results indicated that none of the extant age-length relationships were likely to be even remotely correct and that orange roughy were much longer-lived with a much higher age of maturity and much slower growth than indicated by any of the eight previous studies (the new results suggested that M = 0.05 or less, the Brody growth coefficient was of the order of 0.06, and the average age of maturity was at least 20 years; Mace *et al.* 1990).

The 1989 assessment used a draft version of the Mace *et al*. (1990) results in a simple stock reduction model (Sissenwine 1988) with M = 0.05, an age of recruitment of 20, $F_{0.1}$ = 0.067, B_0 = 389 000 t and a 1988 biomass of 128 000 t (Robertson 1989). This resulted in a long-term sustainable yield estimate of about 8 000 t. Subsequent studies have resulted in even smaller estimates of M (0.03-0.045) and higher estimates of the median age of maturity (28-34 years).

Thus, over a period of only two years, the estimate of unfished biomass was reduced from 935 000 t to 389 000 t, while the estimate of sustainable yield was reduced from 46 750 t to 8 000 t. Over the ensuing 17 years (1990-91 to 2006-07), considerably more data were collected on commercial catch per unit effort (CPUE), commercial length-frequency data from observer programmes, fishery-independent stratified trawl surveys, length-frequency data from trawl surveys, deepwater acoustic surveys using trawls for species identification, and ageing of samples from both commercial catches and research trawl catches. As data have accumulated, the sophistication of assessment models has increased. Bayesian models were first introduced in 2001 (Smith *et al.* 2002, Bull *et al*. 2003). Resulting estimates of sustainable yields (median estimates for alternative runs) are included in Table 4.

6.1.2 Brief history of management

Table 4 shows that catch limits and estimated removals (last column) exceeded or far exceeded estimates of sustainable yields for all years from 1988-89 until about 1997-98. The early TACs and catch limits were influenced by what, in retrospect, were overly optimistic stock assessments, along with a belief that these assessments were "conservative". In 1997-98, the Chatham Rise was split into three sub-areas for assessment and management purposes (the East Chatham Rise, often referred to as the Northeast Chatham Rise – which contains the largest spawning aggregation; the Northwest Chatham Rise – which contains smaller, known spawning aggregations; and the South Chatham Rise – which may actually be a continuation of the East Chatham Rise since no major spawning aggregations have been located there). It is interesting to note that since this time, estimates of the re-combined B_0 have increased moderately, while estimates of combined sustainable yields have increased substantially and have been somewhat higher than the catch limit. The assumption that these are separate populations with no migration between them may have resulted in erroneously high estimates of the biomass of each component (through, for example, "double counting").

A comprehensive individual transferable quota (ITQ) system was introduced in New Zealand in October 1986 and shortly thereafter the New Zealand government increased the Chatham Rise orange roughy quota by 7 800 t (to 38 000 t), selling off the increase to the industry for $NZ 23 400 000 (ITQs were initially designated as absolute tonnages; Sissenwine and Mace 1992). This increase in quota preceded the beginning of the substantial downward revisions of both biomass and productivity, summarised in the previous section, by only a few months. However, since ITQs had been awarded in terms of absolute tonnage and the industry had already paid a substantial amount for the increase in quota, it was difficult to rapidly reduce TACs. This situation was no doubt one of the key reasons for moving to a proportional ITQ system (in which ITQs are set as a proportion of the TAC) in April 1990, as it would have cost the government more than $NZ 100 000 000 to buy back sufficient quota to reduce the TAC to the then-estimated long-term sustainable yield (Sissenwine and Mace 1992).

In response to the dramatic reductions in estimates of long-term sustainable yields, it was decided to manage the fishery in a "fishing-down phase" while gradually reducing quotas towards the long-term sustainable yield. It was agreed that the TAC would be reduced by 5 000 t per year to the sustainable level, the latter being recalculated periodically as new data became available. Resistance to quota reductions meant they never came into force at this level for the entire quota management area (ORH3B, which includes the Chatham Rise, hill complexes to the east and a vast area to the south which extends into the sub-Antarctic), although they were more or less approximated for the Chatham Rise portion of the management area. Over the period 1988-89 to 1995-96, the catch limit for the Chatham Rise was reduced from 38 300 t to 7 200 t (Table 4) and a number of different management measures were introduced: in 1997-98, the Chatham Rise was split into three parts, various catch-spreading arrangements to reduce the focus on the main spawning ground during the spawning season were implemented, the main spawning fishery was closed for two years, and exploratory fishing in the southern sub-Antarctic regions of the management area was encouraged. Most of these measures were introduced in cooperation with the fishing industry as part of several formal and informal voluntary agreements.

6.1.3 Recent assessment and management events

Assessments for the East Chatham Rise (then referred to as the Northeast Chatham Rise) conducted in 2001 produced what many scientists, managers and industry representatives believed were overly optimistic estimates of current biomass. Results from 13 model runs suggested that biomass had declined from an unfished level of 350 000-400 000 t, down to a low of 90 000-130 000 t in 1991-92 or 1992-93 around the time the main spawning fishery was closed, and had subsequently rebuilt to 120 000-190 000 t (34-54 percent B_0) in 2001. However, there were no data to support such a substantial rebuild. Short-term sustainable yields based on F_{MSY} were estimated to be 7 800-11 800 (Table 4), with corresponding long-term sustainable yields of 6 600-7 700 t. The catch limit for the East Chatham Rise (excluding the Northwest Chatham Rise and the South Chatham Rise) was set "conservatively" at 7 000 t.

In early 2005, a similar assessment was conducted with updated information. However, this assessment was even more optimistic in that it estimated a greater extent of rebuild even though all indices applicable to recent years continued to decline. In fact, the model was insensitive to any of the post spawning fishery closure datasets. No matter which sets of such data were included or excluded (or even if all of them were excluded), the estimated extent of rebuilding since the spawning fishery closure was similar (Dunn 2006).

As a result, it was determined that a major review of the assessment inputs and model assumptions was needed and the assessment was rejected. Three major workshop reviews, all including external experts, were undertaken between October 2005 and February 2006. Workshop participants determined that the ageing data for orange roughy were not only extremely imprecise, they were biased in a way that could not easily be rectified. Otoliths collected in adjacent years but read several years apart often led to substantially different length-age relationships. A considerable amount of research has been put into orange roughy ageing in New Zealand and Australia and it has been possible to conclude with a high degree of certainty that growth is slow, the median age of maturity is about 25-30+, and maximum age is of the order of 120-150; however, production ageing to determine the annual age composition of the catch has proven to be very imprecise and inconsistent, to the extent that it is impossible to estimate the number of new fish recruiting to the fishery each year to an acceptable degree of precision. Workshop participants recommended that the use of ages in orange roughy stock assessment models should be abandoned, at least until adequate ageing techniques can be developed. Research into ageing will still continue, but at a reduced level. In the meantime, the hypothesis that the fishery started on a large accumulated biomass and that recruitment has been extremely low for the last decade or two cannot be rejected. This could be the result of a pattern of episodic recruitment for orange roughy. Episodic recruitment with a periodicity of the order of 1-2 decades has been shown for some other long-lived species (e.g. some *Sebastes* spp, Mayo 1980), but it could be even longer for orange roughy which has an unusually high age of maturity and a very long lifespan.

It is interesting to note that stock assessment scientists in New Zealand were already issuing warnings about the possibility of recruitment failure as early as 1987.

The three workshop reviews also identified problems with commercial length frequency data and acoustic estimates of biomass. Regarding the latter, orange roughy have an oil-filled swim bladder and, as a result, have a very low target strength that may be swamped by other species with much larger target strengths when they occur in mixed species aggregations. In addition, there is no definitive estimate of their actual target strength with the two primary estimates (Barr and Coombs 2001, Kloser and Horne 2003) resulting in a 2-fold difference in biomass estimates. Finally, they are frequently found associated with submarine knolls or seamounts and often seem to be hard on the bottom, which means that a potentially large but unknown tonnage may occur in the acoustic shadow zone. It was recommended that acoustic estimates of biomass, which previously had been treated as absolute, should be treated as relative estimates and expert groups should be formed to develop appropriate Bayesian priors for them. The review panels also made recommendations for further work to be undertaken.

Armed with the recommendations of the three review panels, the assessment was repeated in early 2006. However, despite numerous refinements, the results changed relatively little between 2005 and 2006, even though all post closure indices continued to decline with the addition of one more year of data. For the base run for the main spawning plume and surrounding flat area (a sub area of the East Chatham Rise, but estimated to encompass more than 90 percent of the total biomass in that area), B_0 was estimated to be 323 800 t, with biomass declining to 37 percent of this level in 1991-92 and thereafter increasing to 56 percent B_0 (181 000 t in 2004-05; top panels in Figure 10). Again, the estimated increase in biomass was insensitive to all datasets collected following the spawning fishery closure. The median short-term yield based on F_{MSY} was estimated to be 11 200 t, with a corresponding long-term yield of 6 100 t. The 2006 assessment was accepted, but with strong reservations.

Based on sensitivity analyses in which recruitment was estimated, rather than the base case where it was assumed to be constant over time, or where natural mortality was arbitrarily halved (bottom panels in Figure 10), it was concluded that the largest uncertainty was the extent of the biomass increase, “which appears to be driven by model assumptions about productivity, rather than recent data” (Ministry of Fisheries 2006). The absence of data on incoming recruitment levels and the time lag between spawning and maturity (50 percent maturity about 28-34 years) compared to the current duration of the fishery (28 years) necessitates the assumption that recruitment has been constant over time. Attempts to estimate recruitment in (unconstrained) assessment models result in a single unbelievably large spike in recruitment that has fed the current fishery, with extremely low levels of recruitment since. The default hypothesis of constant recruitment cannot fit both the catch history and the recent declining trends in abundance indices (Figure 10).

It should also be noted that the assessment runs presented in Figure 10 did not include consecutive annual (2002-2005) industry-derived acoustic estimates of the biomass of the main spawning plume that have declined monotonically to an extent that exceeds the cumulated catch from the spawning box (an area encompassing the main historical and current spawning plumes). The most recent (2006) industry point estimate continues the declining trend. The catch limit was not changed as a result of this assessment (although 250 t had been added by moving quotas from the Northwest Chatham Rise, due to sustainability concerns for that sub-area).

6.2 Other orange roughy fisheries

Other orange roughy fisheries have exhibited similar patterns of overestimation of initial biomass, rapid fishing down and overshooting of biomass targets.

6.2.1 New Zealand

The second largest orange roughy stock discovered in New Zealand waters is the Challenger stock off the west coast of the two main islands. Approximately 18 months before the discovery of small juveniles that demonstrated slow growth, probable high ages of maturity and longevity, and low productivity, an "adaptive management experiment" was initiated for Challenger orange roughy. The TAC was increased from 6 190 t to 10 000-12 000 t beginning in 1986-87 to determine the response of the stock to increased fishing mortality. The result was that the stock crashed dramatically within three years, with the TAC being reduced from 12 000 t to 2 500 t in a single year (1989-90) and, over the next few years, it was further decreased to 1 900 t, then 1 425 t, then in 2000-01 it was essentially closed and remains so today, except that industry-sponsored research surveys have taken place in the last two years.

This experience certainly resulted in New Zealand taking a more precautionary approach subsequently. However, assessing and managing orange roughy fisheries has remained a difficult task. Currently, of 10 "stocks" or management areas, three are believed to be near or above the target biomass (B_{MSY} = 30% B_0), five are believed to be below this level, and the status of the other two (exploratory) fisheries is unknown. Most fisheries have historically been characterised by sequential depletion of particular underwater features (Clark 1999), but there are now measures in place to reduce this tendency in some areas (e.g. feature limits of 100-500 t).

6.2.2 Australia

Australian orange roughy fisheries began around 1982, but substantial catches were not made until 1986. Early catches were of a similar magnitude to those being realised in New Zealand at the time (Bax *et al.* 2005). Initial scientific estimates of biomass were in the hundreds of thousands to millions of tonnes (Harden Jones 1987, Kenchington 1987). An assessment based largely on anecdotal information suggested a biomass of 500 000-700 000 t in the Sandy Cape area off the Tasmanian coast (Kenchington 1987). However, this "aggregation" was essentially fished out in a single year with a catch of 5 000 t. In fact, according to Bax *et al.* 2005, until 1989 most aggregations were essentially fished out in the first year.

The discovery of large aggregations on the hills off southern and eastern Tasmania resulted in a substantial increase in catches (37 000 t in 1989 and 58 600 t in 1990; Bax *et al.* 2005). The initial (unsupported) biomass estimate (in 1989) for the eastern zone was 300 000 t. An acoustic survey in 1990 resulted in an estimate of the spawning biomass of 57 000 t. Acoustic and egg production estimates conducted in 1991 provided confirmation for the 1990 estimates, and scientists suggested that the "fishdown" phase had been completed, and that the stock was potentially below the target of 50 percent B_0. Further surveys in 1992 resulted in a reduction in the previous year's biomass estimate of almost 40 percent. By the end of 1992, the then-current biomass was estimated to be 25-30 percent of the unfished level. In 1995, it was estimated that the stock had a 73-75 percent probability of being below 30 percent B_0 (the revised management target). Throughout this period, TACs were set several times higher than scientifically-recommended levels. The 2005 TAC was set at 720 t, compared with TACs in the range of 12 000-20 000 t from 1987 to 1990. These overly-optimistic TACs were exacerbated by catches that were much higher than TAC levels in some years.

The situation was similar in the southern zone except that there it was further exacerbated by an adaptive management experiment in which the TAC was set at 13 000 t even though sustainable yields were estimated to be of the order of 2 100-3 000 t (Bax *et al.* 2005). The TAC for the southern zone was 100 t in 2005 and was revised to 10 t for 2006.

The Cascade Plateau fishery off the east coast of Tasmania may be the one Australian example where a truly precautionary approach has been adopted from the start. A precautionary quota of 1 000 t was instituted before substantial catches had been taken (Bax *et al.* 2005). The 1 000 t limit was reached in 1997 after which a cooperative research and management programme was developed with the fishing industry and the TAC was increased to 1 600 t. This fishery has continued to the present day with TACs in the range of 700-1 600 t. The 2006 assessment indicated that the female spawning biomass was about 73 percent (range 62-82 percent) of the unfished level.

6.2.2.1 Recent developments in Australia

In late October 2006, the Australian Fisheries Management Authority (AFMA) closed all orange roughy fisheries except the Cascade Plateau fishery to directed fishing. Bycatch quotas for 2007 in the closed fisheries range between 25-50 t. The 2007 quota for the Cascade Plateau itself has been reduced from 700 t to 400 t.

In early November 2006, the Australian Department of Environment and Heritage listed orange roughy under its Environment Protection and Biodiversity Conservation Act as "conservation-dependent". In the authors' opinion, this listing is not warranted as rough calculations indicate that there are at least 50 million orange roughy in Australian waters, and AFMA has already taken appropriate steps to facilitate rebuilding of the stocks, and to conserve the one remaining stock that has a directed fishery. It is nevertheless interesting that the addition of orange roughy to Australia's threatened species list does not preclude fishing.

6.2.3 Namibia

Exploratory fishing for orange roughy in Namibian waters began in 1994 and management controls on catches were first imposed in 1997 (Butterworth and Brandao, 2005). Only four consistently fishable aggregations were found in the 1990s, although a more southern fishery has recently developed. In 1998, a biomass estimate of 300 000 t (200 000 – 500 000 t) for the entire area was estimated from exploratory commercial trawl data using a swept area method (Branch 1998). Following the approaches adopted by New Zealand and Australia, a deliberate fishing down strategy was implemented with an initial TAC of 12 000 t and a gradual reduction towards 5 000 t (90 percent of the MSY estimated at that time) over a 14-year period (Figure 11). Within a year, the swept area estimate was revised downward to 225 000 t, and acoustic/trawl research surveys suggested an even lower estimate of 150 000 t. Subsequent research survey estimates of biomass continued to decline and the TAC was reduced to 9 000 t in 1999 (Boyer *et al.* 2001). This TAC was substantially under caught and the following year the TAC was further reduced to 1 875 t, though it was increased again to 2 650 t for 2003. Recent assessments suggest that the unfished biomass for the entire area was probably in the region of 100 000 t (Butterworth and Brandao 2005).

6.2.4 Chile

The following section summarizing the history of Chilean orange roughy fisheries was contributed by Edwin Niklitschek of the Universidad Austral de Chile.

The Chilean orange roughy fishery began after the first seamount exploration around the Juan Fernandez Archipelago in 1998. Managed under a special regime for developing fisheries, individual 10-year quotas were auctioned in 1999. With limited information on stock size, a 2 000 t quota was considered precautionary compared to orange roughy quotas elsewhere in the world, and the quota was maintained at that level through the first seven years of the fishery. At the commencement of the fishery, a collaborative agreement was signed and implemented between the fisheries management authority and the quota holders, initiating a research program which included a biological monitoring program from 1999. A low-cost acoustic monitoring program was implemented in 2002, with annual acoustic surveys since then, and several complementary research initiatives (Boyer *et al.* 2003, 2004, Niklitschek *et al.* 2006). Commercial catches reached a peak of 1 870 t in 2001, declining to less than 800 t in 2005 (Figure 12). Given this trend, the fisheries management authority and the industry agreed to close the commercial fishery in 2006, allocating only a research quota of 500 t.

Total biomass estimates for the Juan Fernandez seamounts (where more than 80% of historical catches in Chile have been taken) show a decreasing trend from 27 000 t in 2003 to 14 500 t in 2006 (Figure 13). Nonetheless, individual seamounts have shown inconsistent trends, suggesting high inter-annual variability that does not appear to be directly related to fishing pressure (Figure 13).

Interpreting the causes for the rapid reduction in orange roughy landings and the apparently correlated changes in estimated biomass is far from simple. Lower catches are at least partly the result of large effort reductions from about 450 vessel-days in 2002 to less than 150 vessel-days in 2004. This effort reduction resulted from agreements between quota holders to consolidate fishing activities in response to the high operational costs for fresh fish vessels (which, by regulation, are the only vessels allowed to fish for orange roughy) operating on only four major seamounts at Juan Fernandez, 280 nm offshore from the coast at Talcahuano. The long distance from operating ports to fishing grounds and the high seasonal variability in abundance on the four seamounts has adversely affected the viability of commercial fishing operations.

Cumulated catches of 3 780 t between 2003-2006 cannot explain the apparent reduction in estimated biomass of about 12 500 t. [25] Some other factors must be playing a relevant role. Three main hypotheses being considered in Chile to explain this are: i) emigration or behavioral changes due to habitat degradation or perturbation by fishing activity; ii) intermittent spawning behavior leading to different components of the population spawning in different years; and iii) methodological problems associated with the interaction between fish behavior and the acoustic dead zone.

6.2.5 South Tasman Rise

Aggregations of orange roughy were discovered south of Tasmania on the South Tasman Rise just outside the Australian fishing zone in late 1997. Catches had already peaked at 3 930 t by 1997-98. The following year, they declined to 1 705 t, then increased to 3 360 t in 1999-00, declined to 830 t in 2000-01, and have ranged from 2-170 t since. This fishery illustrates the rapidity with which an orange roughy fishery can develop and crash. A formal Memorandum of Understanding to regulate the fishery was signed by New Zealand and Australia in late 1998, only about a year after the stock was discovered (Tilzey, 2000). An initial precautionary TAC was set at 2 100 t, increased to 2 400 t in 2000-01 and was then gradually reduced to 600 t in 2004-05. However, although Australian and New Zealand catches were regulated, there was heavy fishing in 2000 by vessels from South Africa and Belize. Since 2000-01, recorded catches have been substantially less than the "precautionary" TACs. In 2003-04, 67 tows were made for a total of 2 t of orange roughy catch. New Zealand vessels have not fished in the area since 2000-01. There has been no formal stock assessment agreed for this fishery, although standardized CPUE analyses have been carried out (Wayte *et al*. 2001, 2003).

6.3 Summary for orange roughy

Based on the cases summarised above for New Zealand, Australia, Namibia, Chile and the South Tasman Rise (as well as cases not included in these brief summaries), there have essentially been two patterns of fishery development:

- Small stocks have frequently been fished down to low, often uneconomic, levels within a few years of being discovered, long before effective management can be put in place.

- Larger stocks have mostly been characterised by initial estimates of the unfished biomass that have typically been 2-10 or more times the retrospective estimates of the unfished biomass. Unrealistically high initial estimates of unfished biomass have in turn led to unreasonably high estimates of sustainable yields. In most cases, managers, the industry and some scientists have

[25] Note that the 2006 biomass estimate is currently under review and could change; however, the observation that estimated biomass appears to have declined faster than cumulated catches is still likely to hold (and has also been noted in several other orange roughy fisheries).

labelled these initial estimates as "conservative" or "precautionary" and when they have ultimately found that they were not at all conservative, they have generally taken refuge in the belief that it is permissible to institute a "fishing down" phase in which TACs are gradually reduced over time to the new estimates of sustainable yields (which tend to keep going down faster than the TACs). In almost all cases, this has led to biomass targets (even those as low as 30% B_0) being overshot. As a result, many orange roughy fisheries now have TACs that are less than 2 000 t and are likely to remain at these levels until and unless the stocks rebuild. Orange roughy fisheries actually do have the potential to produce higher sustainable yields but, unfortunately, it will take many years if not decades for most of them to rebuild back to biomass levels near or above B_{MSY}.

For both patterns, the discovery of new stocks seems to have almost invariably led to a gold rush mentality.

These two patterns of fishery development have been repeated over and over and, at least on the surface, it appears that previous experience has had little influence on management approaches. In fact, even though previous experience has ultimately influenced scientific advice, which has generally become progressively more precautionary, management has continued to be hampered by the rapidity with which an orange roughy fishery can develop, followed by the difficulty of dealing with the fishing fleet overcapacity that develops as a result. In retrospect, very few orange roughy fisheries have been managed in a precautionary way. If they had been, the build up of fishing capacity and overshooting of biomass targets might have been mitigated or avoided altogether.

6.4 Oreo fisheries

Oreo fisheries have developed along the way, as a "poor cousin" of orange roughy, even though they were being commercially fished off New Zealand before orange roughy. There has been less assessment and management attention paid to them because of their lower value. But their lower value may have also protected them relative to orange roughy because there has been less of a gold rush and they may also be slightly more productive than orange roughy. In New Zealand, both smooth and black oreos and, to a lesser extent, spiky oreos are often caught in conjunction with orange roughy, although there are also areas where they predominate in the catch. Where assessments have been conducted, they have generally shown that the assessed stock is above the specified target (B_{MSY} = 25% B_0), or that the assessment has been inconclusive. However, few assessments have been conducted because oreos are spread over very large areas and, due to their relatively low commercial value, it has generally not been cost-effective to conduct fishery-independent surveys on them.

6.5 Evolution of data collection programmes and stock assessment models for deepwater species

The discussions in the next three sections are restricted to the situations in New Zealand and Australia.

In New Zealand, biomass estimates were initially based on area swept estimates from stratified random trawl surveys conducted between depths of 750-1 200 m, using the mean of the estimates based on the door spread and the distance between the wingtips. Yield estimates were then calculated as $Y = ½ MB_0$, where Y = yield, M = natural mortality and B_0 is the unfished biomass (Gulland 1971). Once a sufficiently long series of trawl surveys had been developed, the biomass estimates derived from them were treated as relative estimates of biomass rather than as absolute estimates. At that time, stock reduction models (Sissenwine, 1988; Francis, 1990, 1992b) were used to estimate the unfished biomass, and the current status of the stock relative to this level. The stock reduction method was extended to allow stochastic recruitment in 1995 (Francis *et al.* 1995). Subsequently, age-structured Bayesian models were developed to incorporate information from a number of different sources as well as allowing the use of priors based on other fisheries and other information outside the model (Smith *et al.* 2002, Bull *et al*. 2003). Smith *et al.* (2002) produced the first formally accepted Bayesian assessment of Chatham Rise orange roughy in 2001. From this point on, Bayesian assessment models have been used in most New Zealand orange roughy and oreo assessments, with numerous refinements continuing to be incorporated. However, the utility of these models for species that are difficult to age and for which there is virtually no information about incoming recruitment is currently being questioned (Sections 6.1.3 and 6.5.1)

Over the past few years, there has been an increasing tendency to favour acoustic surveys as the mechanism for obtaining estimates of biomass, and Bayesian models for stock assessments, at least for the largest, most important stocks. Australia has also favoured the use of full Bayesian analysis and acoustic surveys for their most important fisheries.

6.5.1 Future prognosis for deepwater assessments, particularly orange roughy assessments

Orange roughy stock assessments have always been uncertain, and various beliefs have been held about whether estimates of stock size and sustainable yields were biased in one direction or the other. However, in recent years, there has been growing unease that stock assessments for several New Zealand orange roughy stocks have been decidedly over-optimistic, as reflected by concerns expressed in stock assessment reports (Ministry of Fisheries 2006).

For example, since the most recent assessment of the East Chatham Rise orange roughy stock was completed in April 2006, assessment scientists, managers and the commercial fishing industry itself have become increasingly concerned about the assessment results and the future of the East Chatham Rise stock. In fact, Mace (in press) has suggested it is an example of a failed stock assessment. In retrospect, the 2001 assessments, which gave similar results, are also likely to be deficient.

Even though the 2006 East Chatham Rise assessment suggests a short-term F_{MSY} yield of about 11 200 t, experienced fishers are concerned that they may not even be able to catch the current quota of 7 250 t in the next fishing season. Given the low productivity of the species, F_{MSY} yields have been calculated to be only 6.5 percent of the available biomass (which itself may be an overestimate) and, given that orange roughy on the East Chatham Rise form dense aggregations in well-known locations, fishers ought to (at least acoustically) encounter of the order of 10-16 times the F_{MSY} yield. If the assessment is correct, fishers should be complaining that their catches are being unduly restricted, not that they believe they will have difficulty catching the quota. Another ominous indicator of the optimism of the stock assessment is that some fishers have now switched to much larger (squid) trawls, in order to maintain commercially viable catch rates.

Punt (2005) suggested that the following will be features of assessments of deepwater species in the future:

- several alternative models will be included in assessments and hypotheses regarding spatial structure will be emphasised to a greater extent;
- most model parameters will be estimated within assessment models, rather than being pre-specified;
- uncertainty will be quantified by means of Bayesian posterior distributions; and
- prior distributions will be developed based on meta-analysis.

We think it is more likely that the current Bayesian models may be discarded in the near future, along with other age-structured models, in favour of simpler approaches. Age-structured models are generally thought of as superior to other assessment models because they can be used to track both large and small year classes as they move through populations, they can provide retrospective estimates of recruitment and recruitment variability, and they may enhance the ability to make informed short-term predictions of future stock size based on estimates of the sizes of incoming year classes. However, these advantages will not be realised if age readings are both highly imprecise and substantially biased, as is currently the case for New Zealand orange roughy. In addition, as mentioned above, age readings are not the only problematic source of data for orange roughy assessments.

Regarding the second bullet point in Punt's list, the concept of estimating as many parameters as possible within a Bayesian model does not seem to have worked well for orange roughy in New Zealand. It may be misleading to estimate multiple model parameters within assessment models when most or all of the data are imprecise or biased and estimates of parameters are confounded. For example, for assessment runs conducted for East Chatham Rise orange roughy in 2005, it appeared that CPUE data were not fit much if any better when β (a power function parameter determining the relationship between CPUE and biomass) was estimated; rather, the fit of the model was improved for some other data set such as the survey data or the age data. Since the purpose of estimating β was to get a better fit to the CPUE, the assessment working group questioned whether it actually should be estimated at all. As another example, estimating the age of 50 percent recruitment for orange roughy often resulted in a selectivity ogive that was well to the right of the maturity ogive implying a vulnerable biomass that is much smaller than the mature biomass (e.g. vulnerable biomass as low as 15 percent of mature biomass for the Mid-East Coast orange roughy stock, Ministry of Fisheries 2006). This is not supported by knowledge of how the fisheries currently operate – fishing has actually become less concentrated on spawning aggregations during the spawning season, and fishing outside the spawning season results in catches that include large juveniles. Therefore, the selectivity ogive should probably be somewhat to the left of maturity ogive.

In general, the evolution of Bayesian models for orange roughy in New Zealand has been to estimate as many parameters as possible within the model during the start of an assessment cycle, but then to fix progressively more of them as the assessment has evolved, in order to prevent the model from providing biologically unreasonable results.

It is possible that the "evolution" of assessment models for orange roughy may culminate in a reversion to simpler methods of estimating sustainable yields, such as the product of F_{MSY}, $F_{0.1}$ or M and a survey estimate of current biomass, at least until and unless better ageing techniques can be developed and/or some other source of data can be shown to be useful for assessing stock status. This would actually amount to a reversion to a methodology similar to that used in newly-developed fisheries when few data were available, except that future results are likely to be more reliable as they will have the benefit of past experience.

6.6 Evolution of management strategies and paradigms for deepwater species

The management strategy in New Zealand has been explicitly based on "moving stocks towards B_{MSY}", as required in the New Zealand Fisheries Act of 1996. In practice, this has meant implementing a fishing-down phase for fisheries on new stocks and setting quotas considerably higher than long-term sustainable yields until the stock approaches B_{MSY}. The estimate of B_{MSY} that is commonly used is 30 percent B_0 (Francis 1992a), based on a stock-recruitment steepness parameter (Mace and Doonan 1988) of 0.75. Several scientists have questioned the validity of such a low percent B_0 as an estimate of B_{MSY} for a low-productivity species like orange roughy, even on a single species basis. Using the same steepness parameter of 0.75, Brandao and Butterworth (2003) estimated B_{MSY} for Namibian orange roughy as being only about 25 percent B_0. From an ecosystem perspective, removing 70-75 percent of the biomass of what is often the dominant fish species in deepwater areas is almost certain to alter the structure and function of the remaining biological community. A steepness parameter of 0.75 is well above the range of values estimated or assumed for long-lived stocks off the northwest coast of the U.S. (Dorn 2002).

For most New Zealand stocks, quotas have been progressively reduced as biomass has declined towards 30 percent B_0. However, the 30 percent level has almost invariably been overshot due to changes in stock assessment models, gaps of 2-5 years between assessment updates, underestimates of the extent of decline and downward revisions of estimates of B_0. As a result it has been necessary to implement rebuilding plans or, in some cases (Challenger and Puysegur stocks), to close fisheries.

Until recently, Australia used a similar management approach, although in some years the target biomass was set at 40 percent B_0 or even 50 percent B_0. More recently, a harvest strategy framework based on fishing mortality target and limit reference points (Smith and Smith 2005) has been adopted to set recommended biological catches. Essentially, the harvest strategy now involves setting a target fishing mortality that will result in a stock fluctuating around 50-60 percent B_0, and closing a fishery once it falls below 20 percent B_0. Based on these strategies, the recommended biological catch for several species is 0 t, and most orange roughy fisheries have been restricted to bycatch quotas only (Section 6.2.2.1).

New Zealand is now planning to develop Management Strategy Evaluation approaches for orange roughy stocks. However, it is currently unclear which dataset(s) will be used to inform the management strategy. All of the traditional data inputs to stock assessment models seem to be fraught with problems. Commercial CPUE is problematic for orange roughy because it often seems to decline too rapidly at the beginning of a fishery to be attributed to a fishing down effect alone (Butterworth and Brandao 2005, Section 6.2.4 and footnote 25) while, after the fishing down phase, it may be maintained by improvements in methods of capture and locating new, previously untouched aggregations. Trawl surveys have been useful in certain circumstances, but their utility is questionable if most of the orange roughy are contained in large, dense aggregations that saturate the trawl net. Acoustic surveys may work reasonably well when they are focussed on schools of almost pure orange roughy on flat areas, but there are numerous problems when orange roughy are on seamounts or knolls, or when they are mixed with other species, most of which have higher target strengths.

6.7 The bottom line for orange roughy

For orange roughy, there is a poor understanding of the dynamics of the species, there are major stock assessment challenges, and the species is valuable. This is a dangerous combination of factors, which is acutely illustrated by the failure to sustain most orange roughy fisheries.

7. CONCLUSIONS AND RECOMMENDATIONS

The title of this paper asks if deepwater fisheries can be managed sustainably. The authors' first conclusion is that the discourse about the management of deepwater fisheries would be a lot more meaningful if terminology categorizing fisheries by depth zone was less ambiguous. Nevertheless, our short answer to the question is that most of the fisheries discussed in this paper can be managed sustainably. Most of the species classified as deepwater overlap in their depth range with continental shelf species, and other shallow water species. Their life history characteristics are similar. They are subject to management frameworks that are also similar, if not identical. Not all shelf/shallow water fisheries are managed sustainably, but it is generally accepted that sustainable management is an achievable objective.

However, for the "poster child" deepwater fisheries for orange roughy, the track record so far is discouraging. The jury is still out on their sustainability in the future. The experience with orange roughy and other species with relatively low productivity (e.g. pelagic armorhead, tilefish, wreckfish and Pacific Ocean perch; Moore 1999, Moore and Mace 1999) is somewhat unique, but as technology for deepwater fishing advances, and demand for a wide variety of marine products increases, more "orange roughy like" situations may emerge in the future.

To manage deepwater fisheries sustainably, we recommend strict adherence to the precautionary approach and application of an ecosystem approach. More specifically:

- All deepwater fisheries should be authorized by a competent management authority with constraints set cautiously, and new fisheries should have a development plan that ensures the rate of development is consistent with the gathering of scientific knowledge. The CCAMLR approach might be a useful model. Australia's approach for the orange roughy fishery on the Cascade Plateau off the east coast of Tasmania (described in Section 6) might also serve as a good example.

- For fisheries, the idea of preauthorizing exploration and development before it begins may seem "foreign" since most fisheries have been unregulated until it is demonstrated that regulation is necessary. However, other industries that exploit natural resources must be preauthorized. In the United States, the National Environmental Protection Act requires an Environmental Impact Statement (EIS) before such activities can be authorized. Similar processes exist in other countries, and applying them to fisheries is one of the elements of a precautionary approach.[26]

- Strategies that have been applied to manage deepwater fisheries need to be re-examined and improved in light of the poor track record to date. Management reference points (such as MSY and B_{MSY}) need to be set more conservatively, and TAC decisions or decisions on other conservation measures, need to account for uncertainty by erring in favor of conservation and sustainability. We are not able to specify how much more conservatively reference points and TACs should be set, but a more focused review of this specific aspect of experience with deep water fisheries might yield some useful guidance.

- Strategies that explicitly incorporate a "fishing down phase" for new fisheries should be abandoned, due to the universal tendency to substantially overestimate the pre-fishery biomass. For species with very low productivity, the so-called fishing down phase seems more like a rationalization for mining the resource.

- Steps need to be taken to address habitat and biodiversity impacts of deepwater fisheries. This should include habitat mapping for candidate areas for fishing, and protection from fishing of a representative portion of the habitats. Conservation engineering should be applied to reduce bycatch and habitat impacts.

- Research is needed to improve resource assessments, knowledge about the distribution of resources off fishing grounds, understanding of stock structure, and determining the functional value and vulnerability of habitat and biodiversity. Research efforts of countries involved in deepwater fisheries might benefit from more international coordination, cooperation and information sharing.

- New multilateral arrangements are needed to manage high-seas fisheries in some areas. The Indian and South Pacific Oceans are the highest priorities for such arrangements, but there is a potential need in other ocean areas as well. Like tuna fisheries, fishing fleets for high-seas deepwater fisheries are likely to operate globally. This means that international organizations dealing with these fisheries would benefit from close coordination and routine communication, or even more formal linkage mechanisms.

- Where multilateral arrangements to manage high-seas deepwater fisheries sustainably are lacking, individual nations should prevent overfishing on the high seas by consistently applying the FAO Code of Conduct for Responsible Fisheries[27] and the Compliance Agreement,[28] as described in Maguire *et al.* (2006). The former is not binding, but it describes steps most nations have agreed they should apply to their fisheries to be responsible, such as the precautionary approach and an ecosystem approach. The later is legally binding and requires states to authorize the fishing activities of the vessels flying their flag.

- In general, there is a need to improve compliance with fishery conservation measures, such as TACs and reporting of fishery-dependent data, for all fisheries. This includes deepwater fisheries. It is time to seriously consider extending catch documentation schemes, such as the CCAMLR

[26] See FAO Technical Guidelines for the Precautionary Approach:
http://www.fao.org/DOCREP/003/W3592E/W3592E00.HTM
[27] See: http://www.fao.org/figis/servlet/static?xml=CCRF_prog.xml&dom=org&xp_nav=4
[28] See: http://www.fao.org/figis/servlet/static?xml=CCRF_prog.xml&dom=org&xp_nav=2,2

scheme used to reduce IUU fishing of toothfish, to all fish that enter into international trade. A global catch documentation scheme that would allow buyers and consumers to know the origin of fish would have many benefits. It would be more efficient than the current trend for international fisheries of re-developing catch documentation schemes for individual fisheries.

An unanswered question is, will the benefit-cost ratio for "orange roughy like" deepwater fisheries be positive if all the costs of research and management, as characterized above, are taken into account? The New Zealand examples, in which the fishing industry pays for all of the costs of research and compliance, and some of the costs of management, indicates that these fisheries have had a positive benefit-cost ratio for periods of up to 25 years for at least one stock (the East Chatham Rise stock, which is the largest orange roughy stock yet discovered worldwide). However, all stocks that have been discovered since about 1990 have been relatively small and many have only yielded large catches for 2-5 years. It remains to be seen whether small fishing operations (of the order of a few hundred tonnes, up to about 2 000-5 000 t) will be both economically viable and sustainable. If not, such fisheries should probably be closed for sufficient time to enable biomass to accumulate to levels well above B_{MSY}, at which point a surplus may again be made available for harvest. Unfortunately, it may take several decades for biomass to rebuild to such levels.

Our final thought about deepwater fisheries concerns their priority in the list of issues that are currently before fishery scientists, managers, the fishing industry, international fisheries organizations and other stakeholders. The deepwater fisheries that are receiving the most attention are trivial in terms of global yield, food security, employment and environmental impact, in comparison to shallow water fisheries, particularly the large number of small scale coastal fisheries in developing countries. Both need to be managed responsibly, but we hope that the current high profile that deepwater fisheries have is not detracting from critically needed efforts to improve the condition of other fisheries upon which millions of people depend for food and livelihoods.

ACKNOWLEDGEMENTS

The authors thank Malcolm Clark and Jake Rice for helpful suggestions for improving the accuracy and content of this paper. Thanks also to Edwin Niklitschek for contributing the section on Chilean orange roughy fisheries (Section 6.2.4). However, as usual, the authors take full responsibility for any errors or omissions.

REFERENCES

Anderson, O.F. & Clark, M.R. 2003. Analysis of the bycatch in the fishery for orange roughy, *Hoplostethus atlanticus*, on the South Tasman Rise. *Marine and Freshwater Research* 54:643-652.

Bax, N.J., Tilzey, R., Lyle, J., Wayte, S.E., Kloser, R. & Smith, A.D.M. 2005. Providing management advice for deep-sea fisheries: lessons learned from Australia's orange roughy fisheries. In: R.Shotton (ed). Deep Sea 2003: Conference on the Governance and Management of Deep-sea Fisheries. Part 1: Conference Papers. *FAO Fisheries Proceedings* 3/1: 259-272.

Barr, R. & Coombs, R.F. 2001. *In situ* target strength measurements and chirp responses of orange roughy (*Hoplostethus atlanticus*). Final Research Report for the Ministry of Fisheries Research Project ORH 1999/01A. 45 pp. (Unpublished report available from Ministry of Fisheries, Wellington, New Zealand).

Boyer, D., Kirchner, C., McAllister, M., Staby, A. & Staalesen, B. 2001. The orange roughy fishery of Namibia: lessons to be learned about managing a developing fishery. *South African Journal of Marine Science,* 23:205–221.

Boyer, D., Nelson, J., Hampton, I. & Soule, M. 2004. Acoustic surveys of orange roughy in Chile. 55 pp. Fisheries Resource Surveys, Cape Town.

Boyer, D., Niklitschek, E., Hampton, I., Nelson, J., Soule, M., Lafon, A. & Boyer, H. 2003. Evaluación hidroacústica de biomasa de las principales agregaciones reproductivas de orange roughy Hoplostethus atlanticus (2003) en los montes submarinos adyacentes al Archipiélago de Juan Fernández (V Región de Valparaíso). 95 pp. Universidad Austral de Chile/ Fisheries Resource Surveys, Cape Town, South Africa.

Branch, T.A. 1998. Assessment and adaptive management of orange roughy off southern Africa. M.Sc. thesis, University of Cape Town. 204 pp.

Brandao, A & Butterworth, D.S. 2003. Stock assessment of Namibian orange roughy populations using an age-structured production model and all available indices of abundance from 1994 to 2002, and making allowances for annually variable aggregation of the stocks. Unpublished report. National Marine Information and Research Centre, Namibia. DWFWG/WkShop/Mar03/doc3, 39 pp.

Bull, B., Francis, R.I.C.C., Dunn, A., McKenzie, A., Gilbert, D.J. & Smith, **M.H.** 2003. CASAL (C++ Algorithmic Stock Assessment Laboratory): CASAL User Manual v2.01-2003/08/01. NIWA Technical Report 124. 223 pp.

Butterworth, D.S. & Brandao, A. 2005. Experiences in southern Africa in the management of deep-sea fisheries. In: R.Shotton (ed). Deep Sea 2003: Conference on the Governance and Management of Deep-sea Fisheries. Part 1: Conference Papers. *FAO Fisheries Proceedings* 3/1: 226-234.

Clark, M.R. 1995. Experience with the management of orange roughy (*Hoplostethus atlanticus*) in New Zealand, and the effects of commercial fishing on stocks over the period 1980-1993. p. 251-266 *In*: Hopper, A.G. (ed.). Deep-water fisheries of the North Atlantic oceanic slope. Kluwer, Netherlands.

Clark, M.R. 1996. Biomass estimation of orange roughy: a summary and evaluation of techniques for measuring stock size of a deepwater fish species in New Zealand. *Journal of Fish Biology* 49(Supplement A): 114-131.

Clark, M.R. 1999. Fisheries for orange roughy (*Hoplostethus atlanticus*) on seamounts in New Zealand. *Oceanologica Acta* 22(6): 593-602.

Clark, M.R. 2005. Counting deepwater fish: challenges for estimating the abundance of orange roughy in New Zealand fisheries. In: R. Shotton (ed). Deep Sea 2003: Conference on the Governance and Management of Deep-sea Fisheries. Part 1: Conference Papers. *FAO Fisheries Proceedings* No. 3/1:169–181.

Clark, M.R., Vinnichenko, V.I., Gordon, J.D.M., Beck-Bulat, G.Z., Kukharev, N.N. &. Kakora, A.F. (in press). Large scale distant water trawl fisheries on seamounts. Chapter 17. In: Pitcher, T.J., Morato, T., Hart, P.J.B., Clark, M.R., Haggan, N. Santos, R.S. (eds). Seamounts: ecology, fisheries, and conservation. Blackwell Fisheries and Aquatic Resources Series.

Collie, J.S., Hall, S.J., Kaiser, M.J. & Poiner, I.R. 2000. A quantitative analysis of fishing impacts on shelf-sea benthos. *Journal of Animal Ecology* 69:785-798.

Dorn, M.W. 2002. Advice on west coast rockfish harvest rates from Bayesian meta-analysis of stock-recruit relationships. North American Journal of Fisheries Management 22:280-300.

Dunn, M.R. 2006. CPUE analysis and assessment of the Northeast Chatham Rise orange roughy stock (part of ORH 3B) to the end of the 2003-04 fishing year. New Zealand Fisheries Assessment Report 2006/59. 67 p.

FAO. 2002. Report of the Second Ad Hoc Meeting on Management of Deepwater Fisheries Resources of the Southern Indian Ocean- Fremantle, Western Australia, 20-22 May 2002, FAO *Fisheries Report* No. 677. FAO, Rome.

FAO. 2005. Review of the state of world marine fisheries. FAO *Fisheries Technical Paper* 457. FAO, Rome. 235pp.

Francis, R.I.C.C. 1990. A maximum likelihood stock reduction method. New Zealand Fisheries Assessment Research Document 90/4. 12 pp.

Francis, R.I.C.C. 1992a. Recommendations concerning the calculation of maximum constant yield (MCY) and current annual yield (CAY). New Zealand Fisheries Assessment Research Document 92/8.

Francis, R.I.C.C. 1992b. Use of risk analysis to assess fishery management strategies: a case study using orange roughy (*Hoplostethus atlanticus*) on the Chatham Rise, New Zealand. *Canadian Journal of Fisheries and Aquatic Sciences*, 49:922-930.

Francis, R.I.C.C., Clark, M.R., Coburn, R.P., Field, K.D. & Grimes, P.J. 1995. Assessment of the ORH 3B orange roughy fishery for the 1994-95 fishing year. New Zealand Fisheries Assessment Research Document 95/4. 43 pp.

Garcia, S.M., de Leiva Moreno, J.I. & Grainger, R. 2005. Global trends in the state of marine fisheries resources 1974-2004. In: Review of the state of world marine fishery resources. *FAO Fisheries Technical Paper,* No. 457. FAO, Rome. 235 pp.

Gianni, M. 2004. High Seas Bottom Trawl Fisheries and their Impacts on the Biodiversity of Vulnerable Deep-Sea Ecosystems: Options for International Action. IUCN, Gland, Switzerland.

Gordon, J.D.M. 2001. Deep-water fisheries at the Atlantic frontier. *Continental Shelf Research* 21:987-1003.

Gordon, J.D.M., Bergstad, A., Figueriredo, I. & Menezes, G. 2003. Deepwater fisheries of the Northeast Atlantic: I. Description of current trends. *Journal of Northwest Atlantic Fisheries Science* 31:137-150.

Grainger, R. & Garcia, S. 1996. Chronicles of marine fishery landings (1950-1994): trend analysis and fisheries potential. *FAO Fisheries Technical Paper* No. 359. FAO, Rome. 51 pp.

Gulland, J.A. 1971. The Fish Resources of the Ocean. Fishing News (Books) Surrey. 255 pp.

Harden Jones, F.R. 1987. Orange roughy (*Hoplostethus atlanticus*) on the west coast of Tasmania: report on a trip in the MT Seamount Enterprise 31 January to 3 February 1987. Unpublished report. Marine Laboratories, Division of Fisheries Research, CSIRO, Tasmania. Final revision, 31 March 1987.

ICES. 2005. Report of the ICES Advisory Committee on Fisheries Management, Advisory Committee on the Marine Environment and Advisory Committee on Ecosystems, 2005. ICES Advice, Volume 10. International Council for Exploration of the Sea. Copenhagen, Denmark. Available at: http://www.ices.dk/committe/acfm/comwork/report/2005/oct/Deep%20water.pdf

Kelleher, K. 2005. Discards in the world's marine fisheries. An update. *FAO Fisheries Technical Paper* No. 470. FAO, Rome. 131 pp. (Includes a CD-ROM).

Kenchington, T.J. 1987. Through a glass darkly: a preliminary assessment of an orange roughy resource off Cape Grim. Unpublished MS presented to DPFRG in February 1987, and again at the DPFRG Workshop on Trawl Fish Resources, Sydney 25-26 June 1987.

Kloser, R.J. & Horne, J.K. 2003. Characterising uncertainty in target-strength measurements of a deepwater fish: orange roughy (*Hoplostethus atlanticus*). *ICES Journal of Marine Science* 60:516-523.

Mace, P.M. in press. Technological needs for fish stock assessments and fisheries management. Proceedings of the Australian Society of Fish Biologists Workshop on Cutting Edge Technologies in Fish and Fisheries Science 28-29 August 2006.

Mace, P.M. & Doonan, I.J. 1987. Biomass and yield estimates for North Chatham Rise orange roughy. (Draft prepared fort the Standing Committee on orange roughy. 42 pp.) Subsequently revised and published as New Zealand Fisheries Assessment Research Document 88/45. 28 pp.

Mace, P.M. & Doonan, I. 1988. A generalised bioeconomic simulation model for fish population dynamics. New Zealand Fisheries Assessment Research Document No. 88/4. 51pp.

Mace, P.M., Fenaughty, J.M., Coburn, R.P. & Doonan, I.J. 1990. Growth and productivity of orange roughy (*Hoplostethus atlanticus*) on the North Chatham Rise. *New Zealand Journal of Marine and Freshwater Research* 24:105-119.

Maguire, J.J., Sissenwine, M., Csirke, J., Grainger, R.& Garcia, S. 2006. The state of the world's highly migratory, straddling and other high seas fishery resources and associated species. *FAO Fisheries Technical Paper* 495. FAO, Rome. 69pp.

Mayo, R.K. 1980. Exploitation of redfish, *Sebastes marinus* (L.) in the Gulf of Maine-Georges Bank region, with particular reference to the 1971 year-class. *Journal of Northwest Atlantic Fisheries Science*. 1:21-37.

Ministry of Fisheries. 2006. Report from the Fisheries Assessment Plenary, May 2006: stock assessments and yield estimates. New Zealand Ministry of Fisheries. 875 pp.

Moore, J.A. 1999. Deep-sea finfish fisheries: lessons from history. Fisheries 24(7):16-21.

Moore, J.A. & Mace P.M. 1999. Challenges and prospects for deep-sea finfish fisheries. *Fisheries* 24(7):22-23.

NAFO 2006. Report of the Scientific Committee, 1-15 June 2006. Northwest Atlantic Fisheries Organization. Dartmouth, NS, Canada. http://www.nafo.int/publications/frames/science.html

Niklitschek, E., Boyer D., Merino, R., Hampton, I., Soule, M., Nelson, J., Cornejo, J., Lafon, A., Oyarzún, C., Roa, R. & Melo, T. 2005. Estimación de la biomasa reproductiva de orange roughy en sus principales zonas de concentración, 2004. 159 pp. Universidad Austral de Chile, Valparaíso.

Parin N.V., Mironov, A.N. & Nesis, K.N. 1997. Biology of the Nazca and Sala y Gomez submarine ridges, an outpost of the Indo-West Pacific fauna in the eastern pacific ocean: compostion and distribution of the fauna, its communities and history. Advances in Marine Biology 32:145-242.

Punt, A.E. 2005. The challenges of, and future prospects for, assessing deepwater marine resources: experience from Australia, New Zealand, Southern Africa and the United States. In: R. Shotton (ed). Deep Sea 2003: Conference on the Governance and Management of Deep-sea Fisheries. Part 1: Conference Papers. FAO Fisheries Proceedings No. 3/1: 138-148.

Richer de Forges, B., Koslow, J.A. & Poore, G.C.B. 2000. Diversity and endemism of the benthic seamount fauna in the southwest Pacific. *Nature* 405:944-947.

Robertson, D.A. 1985. Orange roughy. In: J.A. Colman, J.L. McKoy & G.G. Baird (comps & eds). Background papers for the total allowable catch recommendations for the 1986-87 fishing year: 136-141. (Report held by the Ministry of Fisheries, Wellington, New Zealand.)

Robertson, D.A. 1986. Orange roughy. In: G.G. Baird & J.L. McKoy (comps & eds). Background papers for the total allowable catch recommendations for the 1986-87 fishing year: 88-108. (Report held by the Ministry of Fisheries, Wellington, New Zealand.)

Robertson, D.A. 1989. Assessment of the Chatham Rise (area 3B) orange roughy fishery for the 1988-89 season. New Zealand Fisheries Assessment Research Document 89/1. 19 pp.

Robertson, D.A. & Mace, P.M. 1988. Assessment of the Chatham Rise orange roughy fishery for 1987/88. New Zealand Fisheries Assessment Research Document 88/37.

Rowden, A.A., Clark, M.R., O'Shea, S. & McKnight, D. 2002. Benthic biodiversity of seamounts on the northwest Chatham Rise. *New Zealand Marine Biodiversity Biosecurity Report* No. 2, p. 21.

Shotton, R. 2005. Deepwater Fisheries. In: Review of the state of world marine fisheries. *FAO Fisheries Technical Paper* 457. FAO, Rome. 235pp.

Sigurdsson, T., Thorsteinsson, V. & Gustafsson, L. 2006. In situ tagging of deep-sea redfish: application of an underwater fish tagging system. *ICES Journal of Marine Science* 63:523-531.

Sissenwine, M.P. 1988. A quick method of estimating absolute biomass from a time series of relative biomass and catch data. New Zealand Fisheries Assessment Research Document 88/3. 4 pp.

Sissenwine, M.P. & Mace, P.M. 1992. ITQs in New Zealand: the era of fixed quota in perpetuity. Fishery Bulletin 90:147-160.

Smith, A.D.M., Punt, A.E., Wayte, S.E., Starr, P.J., Francis, R.I.C.C., Stokes, K., Hilborn, R. & Langley, A. 2002. Stock assessment of the northeast Chatham Rise orange roughy for 2001. New Zealand Fisheries Assessment Report 2002/25. 30 pp.

Smith, A.D.M & Smith, D. 2005. A harvest strategy framework for the Southeastern Shark and Scalefish Fishery. Unpublished progress report. Marine and Atmospheric Research, CSIRO, Hobart, Australia.

Tilzey, R. 2000. South Tasman Rise trawl fishery. *In*: Caton, A.; McLoughlin, K. (eds) Fishery status reports 1999: resource assessments of Australian Commonwealth fisheries. BRS, Canberra.

Wayte, S., Bax, N., Clark, M. & Tilzey, R. 2001. Analysis of orange roughy catches on the South Tasman Rise, 1997–2000. Report provided to the Orange Roughy Assessment Group. (Unpublished report held by CSIRO, Hobart.)

Wayte, S., Bax, N., Clark, M. & Tilzey, R. 2003. Analysis of orange roughy catches on the South Tasman Rise, 1997–2002. Report provided to the Orange Roughy Assessment Group. 14 pp. (Unpublished report held by CSIRO, Hobart.)

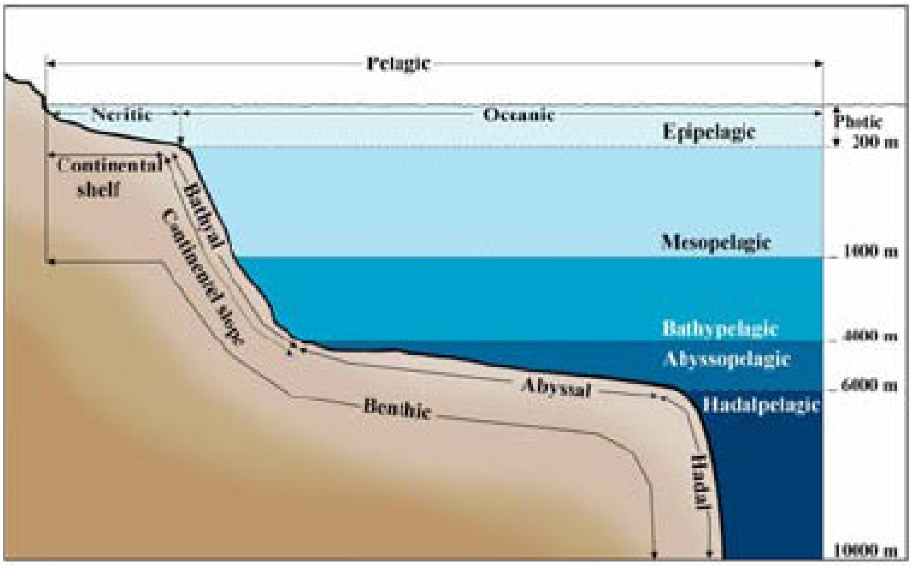


Figure 1. Ocean depth zones (FAO 2005).

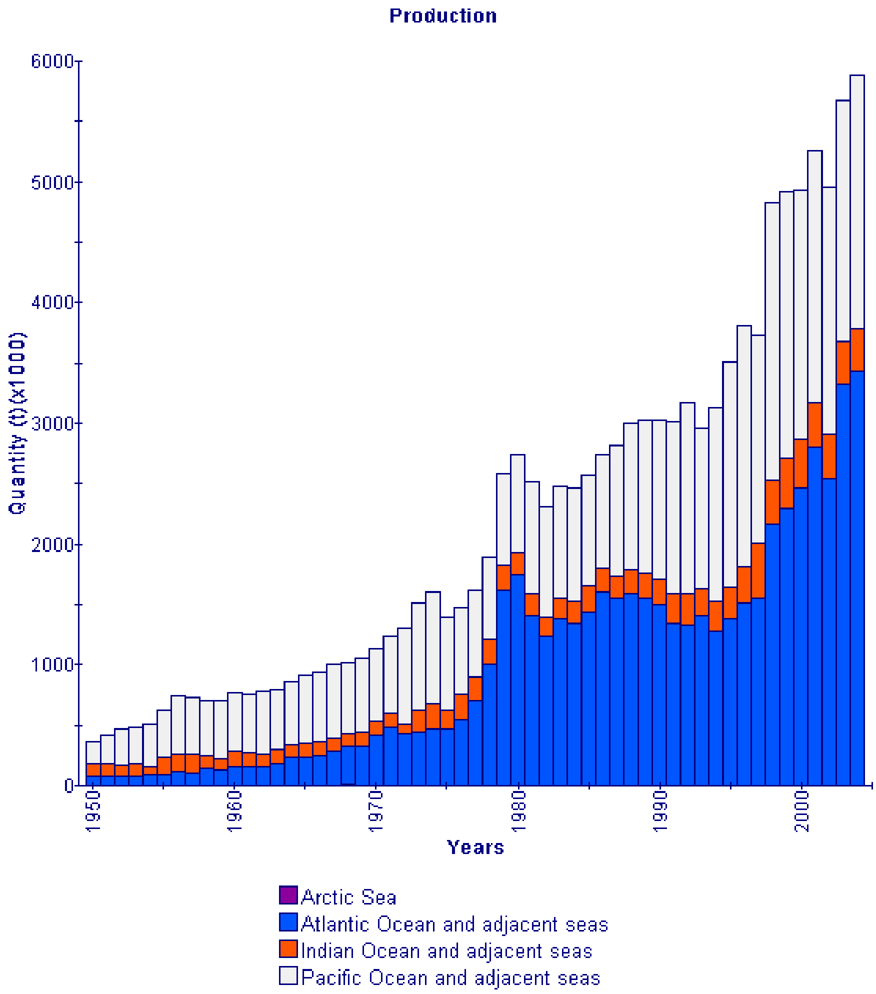


Figure 2. Reported catch of deepwater species by ocean from 1950-2004 (from FAO FIGIS online database).

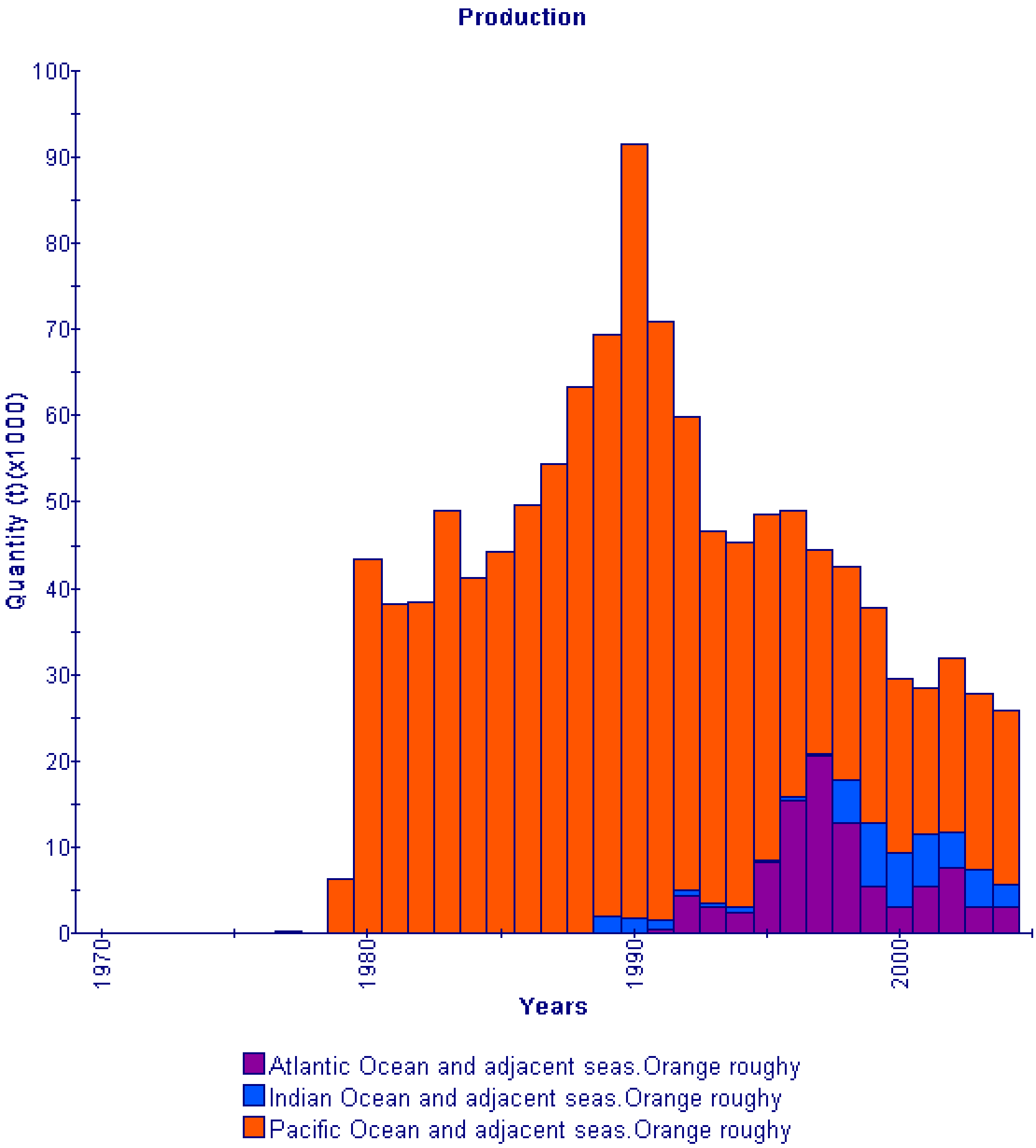


Figure 3. Reported catch of orange roughy by ocean, 1950-2004.

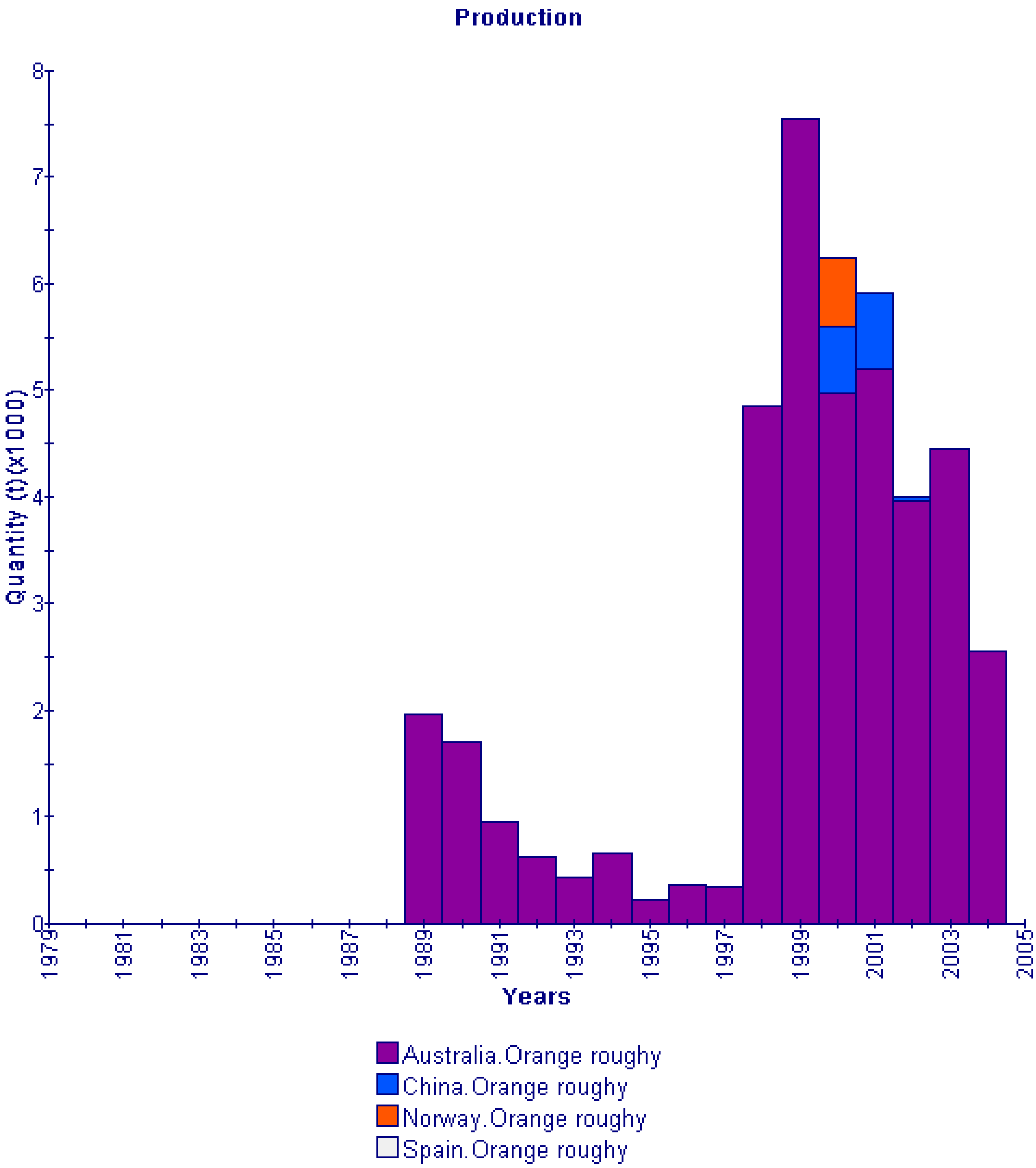


Figure 4. Reported Indian Ocean catch of orange roughy.

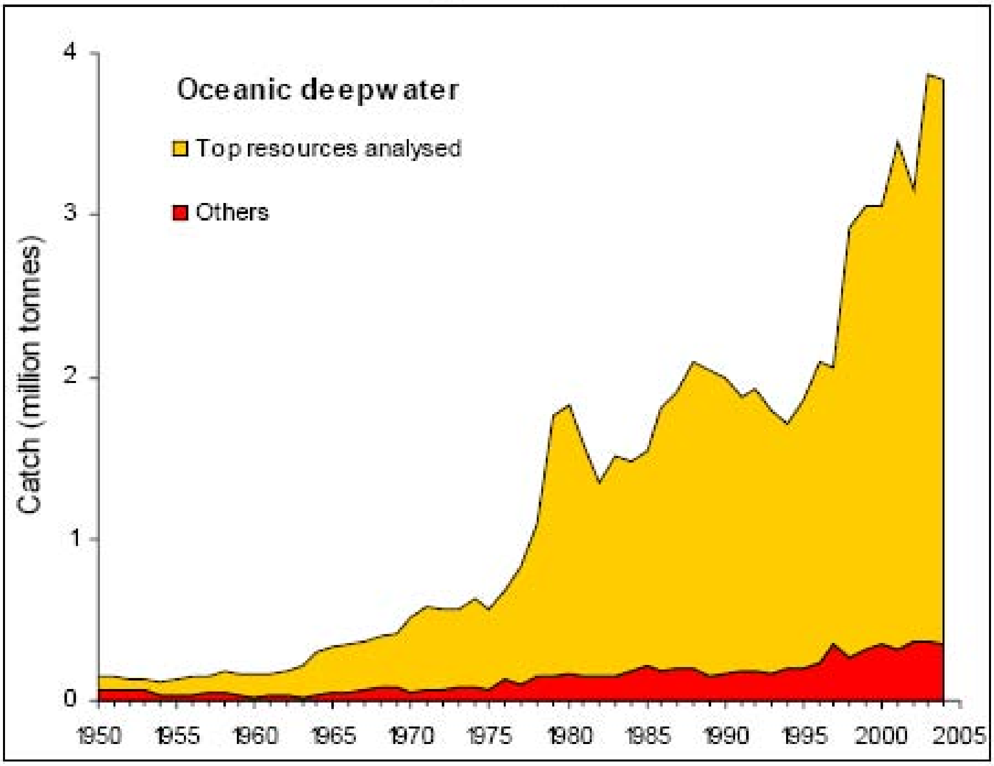


Figure 5. Catch history of oceanic deepwater species (from Maguire *et al.* 2006)

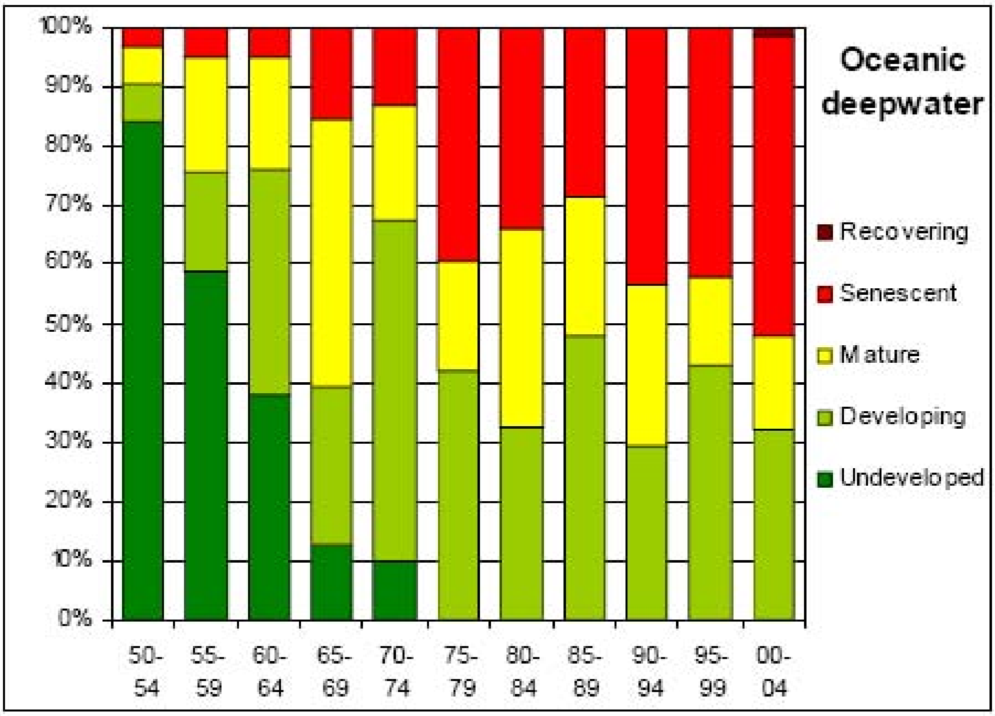


Figure 6. The status of development of the world's top oceanic deepwater fisheries (in terms of cumulative catch 1950-2004).

Figure 7. Before and after pictures of the impact of bottom trawling on a biogenic community including coldwater corals (from Gianni 2004). Original photos by Dr. Keith Sainsbury, CSIRO, Australia.

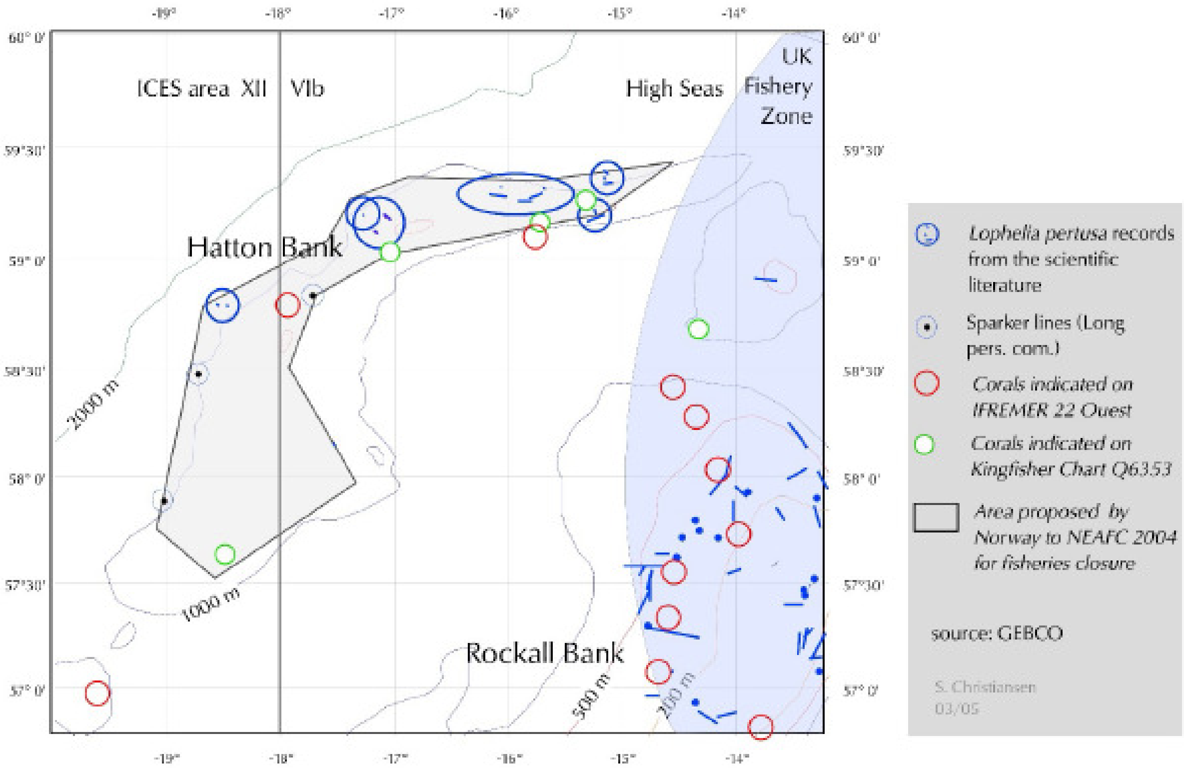


Figure 8. Known and likely locations of coldwater corals on Hutton Bank in the Northeast Atlantic (ICES 2005). [29]

[29] See http://www.ices.dk/committe/acfm/comwork/report/2005/sept/NEAFC%20Request%20and%20OSPAR%20request%2027%209%20without%20annex.pdf

.

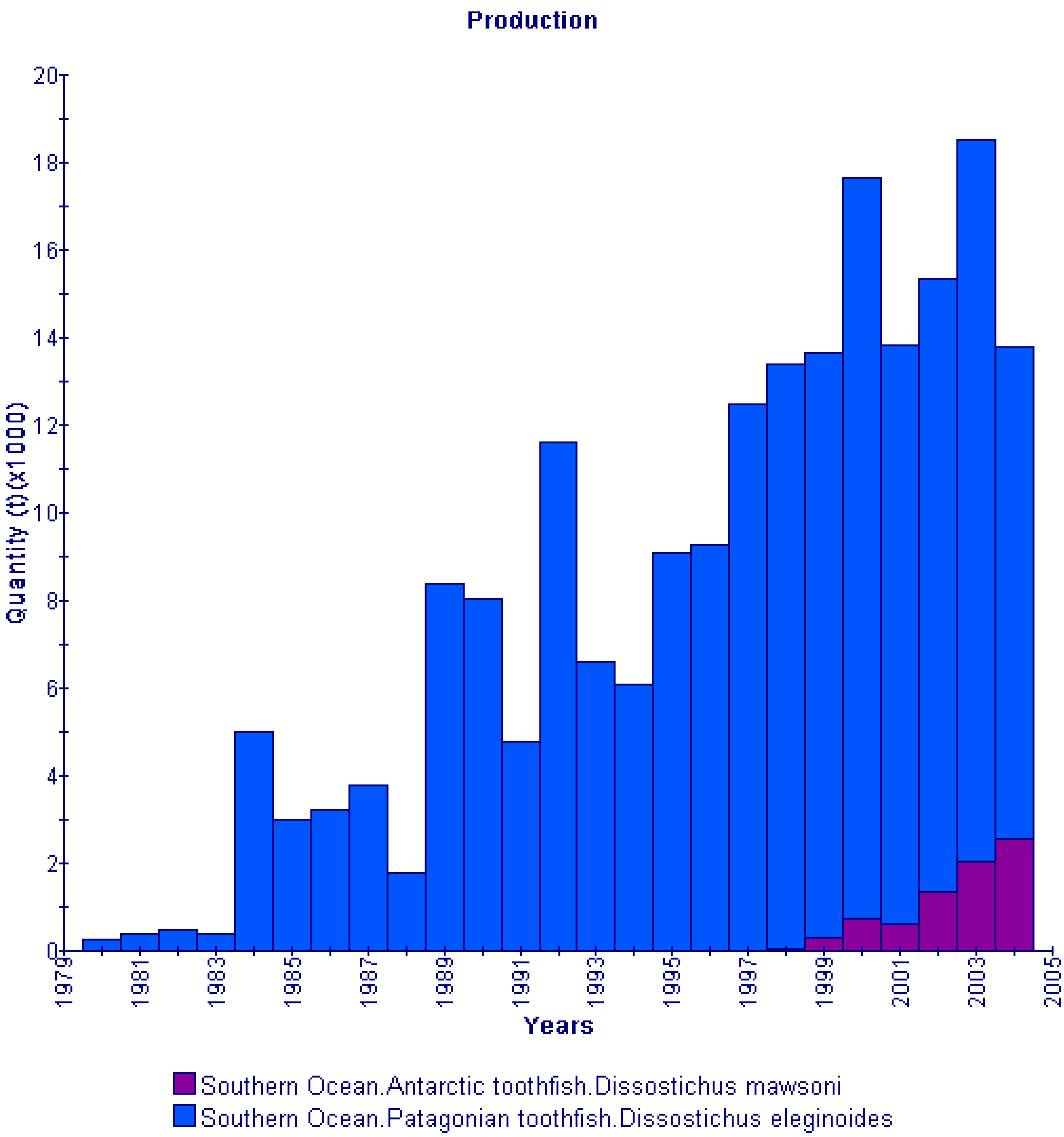


Figure 9. Reported catches of toothfish from the Southern Ocean.

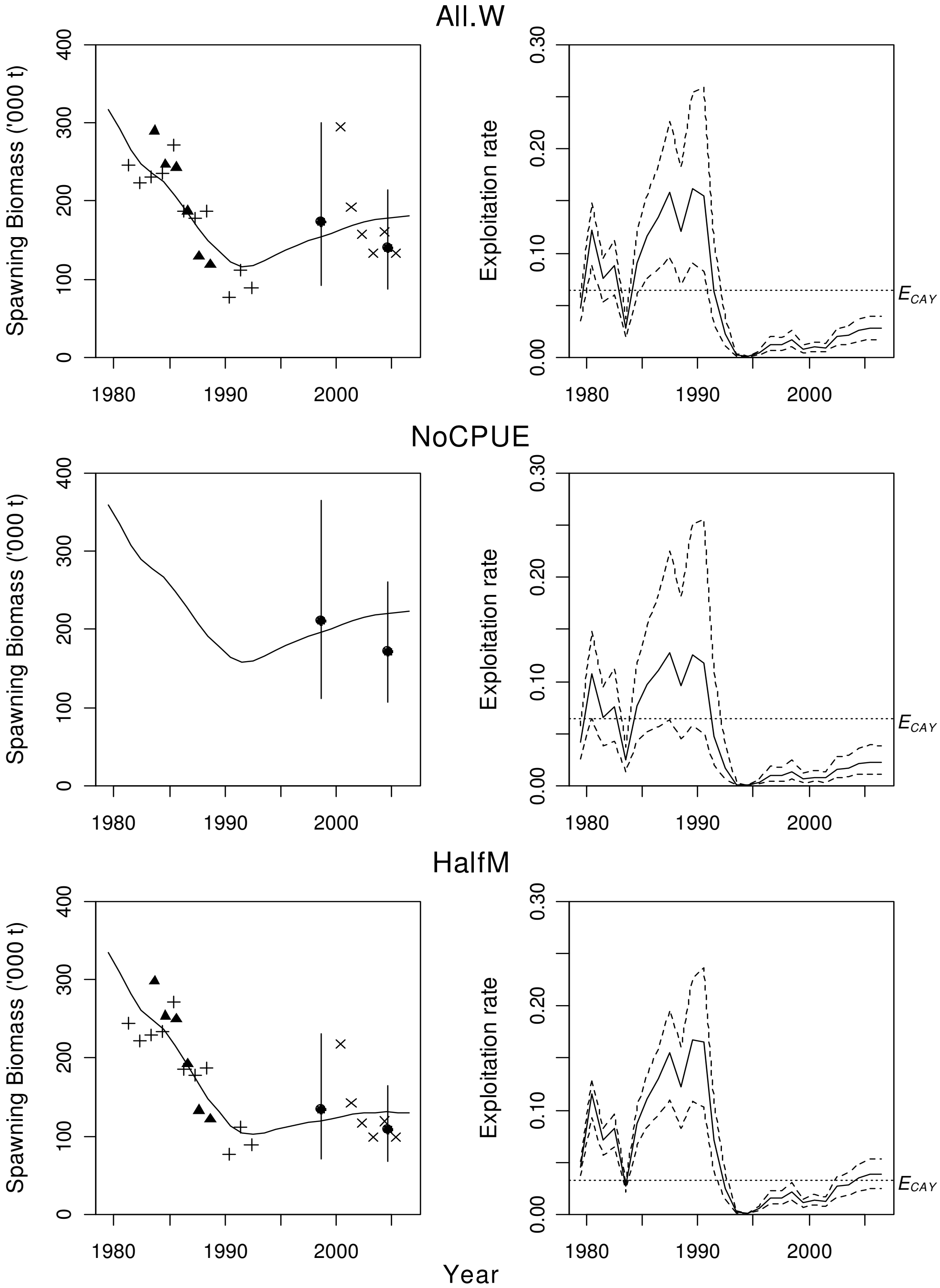


Figure 10. Estimated spawning biomass and exploitation rates for the main fishing and spawning area for orange roughy on the East Chatham Rise in New Zealand (Figure 5, p 425 in Ministry of Fisheries 2006). All.W includes all available abundance indices (+, spawning box pre-closure commercial CPUE; x, spawning box post-closure commercial CPUE; ▲, non-spawning commercial CPUE; all plotted without confidence intervals; and wide-area acoustic surveys including 95% confidence intervals. Estimated exploitation rates include 95 percent confidence intervals. All alternatives also included trawl survey estimates of biomass for the years 1984-90, 1992 and 1994. NoCPUE excludes all commercial CPUE indices. HalfM is the same as All.W except that natural mortality (M) was arbitrarily halved (0.0225 vs. 0.045). E_{CAY} is the exploitation rate associated with an F_{MSY} harvest strategy.

Over a 14-year period, a "soft-landing" at a TAC of 90 percent of the estimated MSY was envisaged, with resource abundance still in excess of the MSY level at the end of the period.

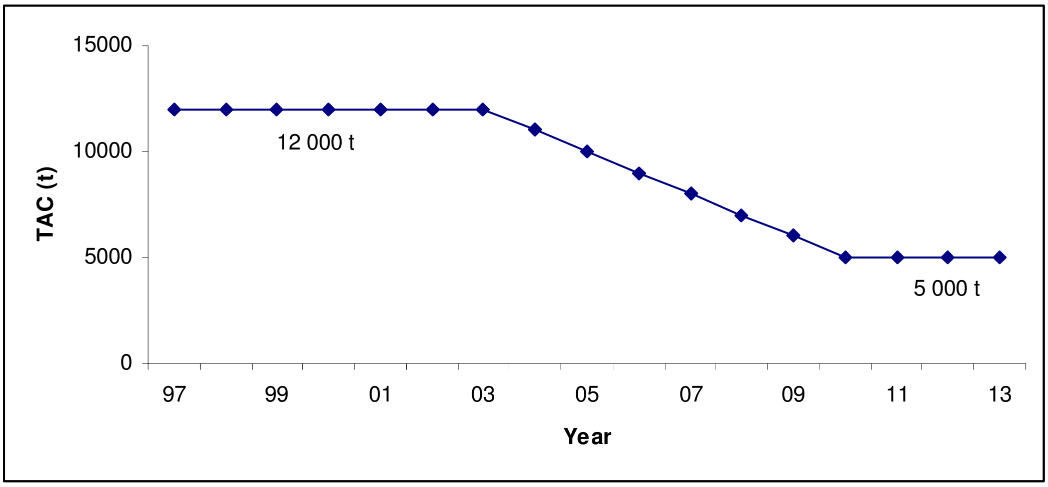


Figure 11. The fishing down strategy for Namibian orange roughy as planned in 1997 (Figure 2 from Butterworth and Brandao 2005)

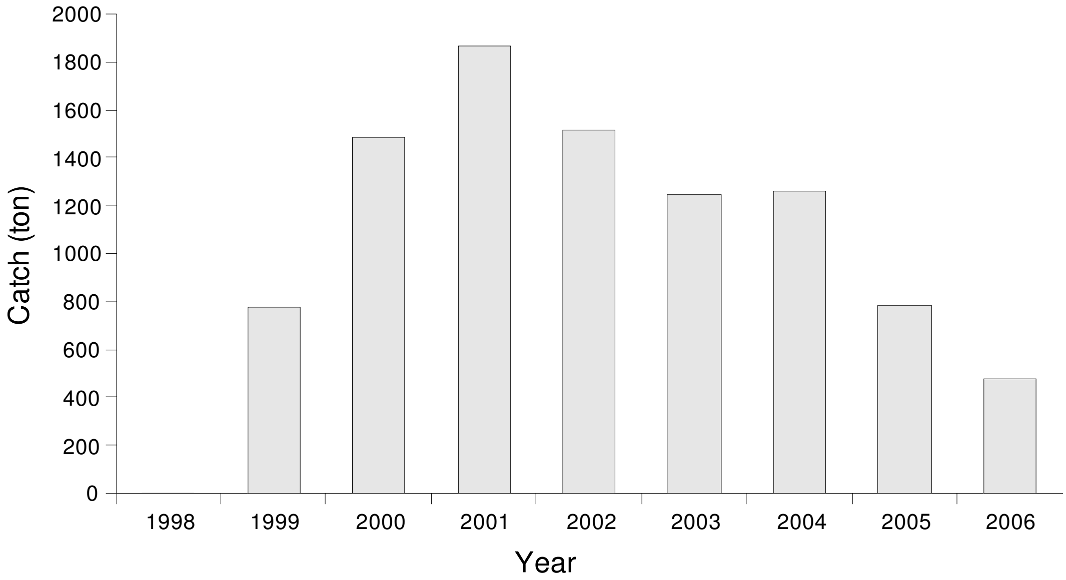


Figure 12. Total orange roughy landings in Chile 1998-2006.

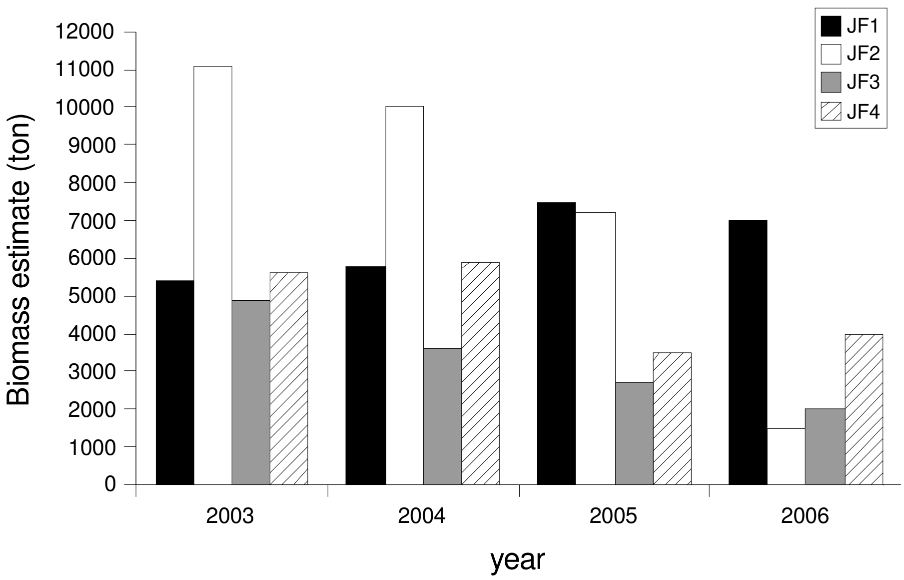


Figure 13. Estimated biomass for orange roughy in Juan Fernandez seamounts JF1-JF4, the main fishing area off Chile.

APPENDIX 1 - 2004 CATCH OF DEEPWATER SPECIES

Reported catch in metric tonnes (t) in 2004 and other selected years of species FAO considers to be deepwater (FAO 2005, page 195, Table C3.1). Extracted from FAO's FIGIS on-line database.

Ocean Area	Species	Scientific name	1970	1980	1990	2000	2004
Arctic Sea	Greenland halibut	*Reinhardtius hippoglossoides*	200	0 -	0 -	0 -	0 -
	Roundnose grenadier	*Coryphaenoides rupestris*	500	0 -	0 -	0 -	0 -
		Total Arctic Sea	700	0 -	0 -	0 -	0 -
Atlantic Ocean and adjacent seas	Alfonsinos nei	*Beryx spp*	0 -	91	534	537	1 701
	Black scabbardfish	*Aphanopus carbo*	0 -	0 -	8 328	12 387	11 987
	Blue antimora	*Antimora rostrata*	0 -	0 -	0 -	21	44
	Blue ling	*Molva dypterygia*	6 700	36 817	14 000	16 146	7 785
	Blue whiting(=Poutassou)	*Micromesistius poutassou*	38 811	1 108 535	577 493	1 472 105	2 427 862
	Bluntnose sixgill shark	*Hexanchus griseus*	0 -	0 -	0 -	0 -	30
	Boarfishes nei	Caproidae	0 -	0 -	0 -	0 -	747
	Bonnetmouths, rubyfishes nei	Emmelichthyidae	0 -	0 -	25	0 -	6
	Cape bonnetmouth	*Emmelichthys nitidus*	0 -	769	568	50 *F*	156
	Cape elephantfish	*Callorhinchus capensis*	0 -	237	546	380 *F*	559
	Cardinalfishes, etc. nei	Apogonidae	0 -	0 -	0 -	0 *0*	699
	Common mora	*Mora moro*	0 -	0 -	50	0 -	147
	Cusk-eels nei	*Genypterus spp*	0 -	0 -	0 -	57	0 -
	Cusk-eels, brotulas nei	Ophidiidae	0 -	0 .	0 -	524	580
	Elephantfishes nei	*Callorhinchus spp*	300	1 687	850	1 390	1 619
	Elephantfishes, etc. nei	Callorhinchidae	0 -	0 -	0 -	0 -	6
	Escolar	*Lepidocybium flavobrunneum*	0 -	0 -	0 -	82	98
	Forkbeards nei	*Phycis spp*	100	108	0 -	762	1 697
	Geryons nei	*Geryon spp*	0 -	5 834	2 326	6 605	4 410
	Greeneyes	Chlorophthalmidae	0 -	15 656	0 -	0 -	0 -
	Greenland halibut	*Reinhardtius hippoglossoides*	164 728	93 625	121 839	107 691	109 906
	Greenland shark	*Somniosus microcephalus*	0 -	48	54	45	70
	Grenadiers nei	*Macrourus spp*	1 500	737	19 987	10 505	5 331
	Hairtails, scabbardfishes nei	Trichiuridae	0 -	0 -	112 *F*	10 070	7 807
	Hector's lanternfish	*Lampanyctodes hectoris*	18 200	40	571	0 -	0 *0*
	Kingklip	*Genypterus capensis*	3 600	10 317	4 524	7 922 *F*	12 310
	Lanternfishes nei	Myctophidae	0 -	586	0 -	1 065	175
	Largehead hairtail	*Trichiurus lepturus*	15 811	67 480	91 187	26 028	38 848
	Ling	*Molva molva*	47 700	56 496	52 397	43 320	35 384
	Longnose velvet dogfish	*Centroscymnus crepidater*	0 -	0 -	0 -	1	301
	Longspine snipefish	*Macroramphosus scolopax*	0 -	29 020	2 813	0 -	0 -
	Northern prawn	*Pandalus borealis*	38 759	122 727	226 033	362 936	438 552
	Oilfish	*Ruvettus pretiosus*	0 -	0 -	0 -	52	142
	Orange roughy	*Hoplostethus atlanticus*	0 -	0 -	0 -	3 009	3 085
	Oreo dories nei	*Oreosomatidae*	0 -	0 -	0 -	10	497
	Pandalus shrimps nei	*Pandalus spp*	2 100	9 096	19 433	35 640	2 425
	Patagonian grenadier	*Macruronus magellanicus*	0 -	6 642	30 123	142 676	145 224
	Patagonian toothfish	*Dissostichus eleginoides*	0 -	494	9 165	16 387	11 577
	Pink cusk-eel	*Genypterus blacodes*	1 100	6 722	35 344	17 521	19 293
	Portuguese dogfish	*Centroscymnus coelolepis*	0 -	0 -	1 543	1 868	4 021
	Rabbit fish	*Chimaera monstrosa*	0 -	0 -	0 -	15	617
	Ratfishes nei	*Hydrolagus spp*	0 -	0 -	0 -	573	551
	Red crab	*Geryon quinquedens*	0 -	2 546	1 527	8 391	6 220
	Red scorpionfish	*Scorpaena scrofa*	0 .	0 .	0 .	1	0 *0*

	Roughhead grenadier	*Macrourus berglax*	0 -	0 -	3 220	8 795	2 054
	Roundnose grenadier	*Coryphaenoides rupestris*	31 689	22 586	11 884	30 770	24 751
	Royal red shrimp	*Pleoticus robustus*	100	233	135	391	272
	Scarlet shrimp	*Plesiopenaeus edwardsianus*	1 084	994	23	55	118
	Silver scabbardfish	*Lepidopus caudatus*	16 700	9 894	19 352	3 734 *F*	7 802
	Slimeheads nei	Trachichthyidae	0 -	0 -	0 -	3	46
	Southern blue whiting	*Micromesistius australis*	0 -	78 047	193 630	84 321	76 596
	Tilefishes nei	Branchiostegidae	1 400	168	351 *F*	1 119	1 052
	Tusk(=Cusk)	*Brosme brosme*	30 578	55 619	44 909	32 531	20 041
	White snake mackerel	*Thyrsitops lepidopoides*	0 *0*	0 -	21	10	77
	Wreckfish	*Polyprion americanus*	500	248	543	617	475
Total Atlantic Ocean and adjacent seas			421 460	1 744 099	1 495 440	2 469 118	3 435 753
	Alfonsinos nei	*Beryx spp*	0 -	0 -	0 -	1 668	6
	Antarctic stone crab	*Paralomis spinosissima*	0 -	0 -	0 -	0 -	1
	Antarctic toothfish	*Dissostichus mawsoni*	0 -	0 -	1	0 -	26
	Blue antimora	*Antimora rostrata*	0 -	0 -	0 -	24	1
	Blue grenadier	*Macruronus novaezelandiae*	0 .	0 .	1 372	8 964	8 773
	Bombay-duck	*Harpadon nehereus*	78 700	116 190	142 559	175 001	154 277
	Bonnetmouths, rubyfishes nei	Emmelichthyidae	0 -	3 691	0 -	0 -	0 -
	Cardinal fishes nei	*Epigonus spp*	0 -	0 -	0 -	6	6
	Cardinalfishes, etc. nei	Apogonidae	0 .	0 .	0 .	0 .	450 *F*
	Geryons nei	*Geryon spp*	0 -	552	664	886	204
	Ghost shark	*Callorhinchus milii*	0 .	0 .	0 .	82	112
	Grenadiers nei	*Macrourus spp*	0 -	0 -	0 -	348	551
Indian Ocean and adjacent seas	Hairtails, scabbardfishes nei	Trichiuridae	28 300	63 830	60 933	148 702	134 391
	Lanternfishes nei	Myctophidae	0 -	6	0 *0*	0 -	1
	Largehead hairtail	*Trichiurus lepturus*	1 390	5 507	6 714	43 155	40 380
	Oilfish	*Ruvettus pretiosus*	0 -	0 -	0 -	0 -	18
	Orange roughy	*Hoplostethus atlanticus*	0 -	0 -	1 712	6 239	2 559
	Oreo dories nei	Oreosomatidae	0 -	0 -	0 -	175	0 -
	Pacific sleeper shark	*Somniosus pacificus*	0 -	0 -	0 -	0 -	8
	Patagonian toothfish	*Dissostichus eleginoides*	0 -	142	1 250	13 600	6 765
	Pelagic armourhead	*Pseudopentaceros richardsoni*	0 -	0 -	0 -	121	0 -
	Pink cusk-eel	*Genypterus blacodes*	0 *0*	0 -	2 *F*	1 148	1 265
	Redfish	*Centroberyx affinis*	0 -	0 -	0 -	337	968
	Silver gemfish	*Rexea solandri*	0 .	898	992 *F*	447	503
	Wreckfish	*Polyprion americanus*	0 -	0 -	0 -	0 -	2
Total Indian Ocean and adjacent seas			108 390	190 816	216 199	400 903	351 267
Pacific Ocean and adjacent seas	Alfonsinos nei	*Beryx spp*	1 900	2 337	1 956	7 264	5 492
	Antarctic toothfish	*Dissostichus mawsoni*	0 -	0 -	0 -	751	2 558
	Blue antimora	*Antimora rostrata*	0 -	0 -	0 -	0 -	16
	Blue grenadier	*Macruronus novaezelandiae*	100	18 757	261 168	274 615	154 532
	Bluenose warehou	*Hyperoglyphe antarctica*	0 .	0 .	1 485	2 793	3 178
	Bombay-duck	*Harpadon nehereus*	200	8 453	12 527	2 752	8 596
	Bonnetmouths, rubyfishes nei	Emmelichthyidae	0 .	0 .	0 -	582	2 812
	Cape bonnetmouth	*Emmelichthys nitidus*	0 .	0 .	0 .	2 825	3 248
	Cardinal fishes nei	*Epigonus spp*	0 .	0 .	0 -	5 792	2 070
	Cardinalfishes, etc. nei	Apogonidae	0 *0*	1	132	60 *F*	0 *0*
	Chimaeras, etc. nei	Chimaeriformes	0 .	0 .	0 .	40	193
	Common mora	*Mora moro*	0 .	0 .	0 -	1 358	1 403
	Cusk-eels nei	*Genypterus spp*	1 300	1 029	1 652	557	563
	Cusk-eels, brotulas nei	Ophidiidae	0 -	0 -	0 -	1	383
	Dark ghost shark	*Hydrolagus novaezealandiae*	0 .	0 .	0 .	1 819	1 793
	Deepsea smelt	*Glossanodon semifasciatus*	16 500	9 601	6 355	5 970	5 223
	Elephantfishes nei	*Callorhinchus spp*	100	1 289	2 900	603	1 297

	Escolar	*Lepidocybium flavobrunneum*	0 -	0 -	0 -	53	36
	Ghost shark	*Callorhinchus milii*	1 100	1 200	1 461	1 228	1 191
	Golden king crab	*Lithodes aequispina*	0 .	0 .	0 .	1 797	982
	Greenland halibut	*Reinhardtius hippoglossoides*	15 800	0 -	10 159	6 186	1 879
	Grenadiers nei	*Macrourus spp*	0 -	2 305	0 -	0 -	219
	Grenadiers, rattails nei	Macrouridae	0 -	0 -	2 209	3 428	24 909
	Hairtails, scabbardfishes nei	Trichiuridae	15 500	18 372	28 764	47 085	40 719
	Hapuku wreckfish	*Polyprion oxygeneios*	1 600	2 273	1 105	1 513	1 540
	Lanternfishes nei	Myctophidae	0 -	0 -	0 -	0 -	578
	Largehead hairtail	*Trichiurus lepturus*	535 010	603 817	660 161	1 413 779	1 508 223
	Longnose velvet dogfish	*Centroscymnus crepidater*	0 .	0 .	0 .	0 .	1
	Longspine snipefish	*Macroramphosus scolopax*	0 .	0 .	0 -	0 -	544
	Northern prawn	*Pandalus borealis*	0 .	0 .	0 -	8 520	7 586
	Oilfish	*Ruvettus pretiosus*	261	803	6 281	2 645	5 659
	Orange roughy	*Hoplostethus atlanticus*	0 -	43 327	89 766	20 206	20 237
	Oreo dories nei	Oreosomatidae	0 -	34 069	20 283	22 775	19 787
	Pandalus shrimps nei	*Pandalus spp*	6 000	1 999	1 326	0 -	0 -
	Patagonian grenadier	*Macruronus magellanicus*	0 -	18 361	128 002	91 310	71 177
	Patagonian toothfish	*Dissostichus eleginoides*	0 -	414	9 387	10 951	6 485
	Pelagic armourhead	*Pseudopentaceros richardsoni*	0 -	0 -	0 -	6	107
	Pink cusk-eel	*Genypterus blacodes*	2 500	10 175	20 005	30 769	26 977
	Ratfishes nei	*Hydrolagus spp*	0 .	0 .	0 -	975	1 452
	Red cusk-eel	*Genypterus chilensis*	1 400	1 849	1 323	608	548
	Redfish	*Centroberyx affinis*	0 -	0 -	0 -	1 246	742
	Silver gemfish	*Rexea solandri*	0 -	4 834	8 183 *F*	1 249	1 262
	Silver scabbardfish	*Lepidopus caudatus*	0 -	3	1 633	1 619	2 891
	Silvery lightfish	*Maurolicus muelleri*	0 -	3 200	0 -	0 -	0 -
	Slimeheads nei	Trachichthyidae	0 -	0 -	0 -	4	14
	Southern blue whiting	*Micromesistius australis*	0 -	12 534	37 981	68 152	75 445
	Spotted gurnard	*Pterygotrigla picta*	0 -	0 -	0 -	55	53
	Thorntooth grenadier	*Lepidorhynchus denticulatus*	0 .	0 .	0 -	3 833	6 341
	Tilefishes nei	Branchiostegidae	4 000	3 599	2 186	8 207 *F*	72 842
	White warehou	*Seriolella caerulea*	0 .	0 .	532	2 407	2 330
Total Pacific Ocean and adjacent seas			603 271	804 601	1 318 922	2 058 388	2 096 113
Grand total			1 133 821	2 739 516	3 030 561	4 928 409	5 883 133

site last updated: Sep 30 2006

CURRENT LEGAL AND INSTITUTIONAL ISSUES RELATING TO THE CONSERVATION AND MANAGEMENT OF HIGH-SEAS DEEP-SEA FISHERIES

by

***Erik J. Molenaar*[1]**

Executive summary

This report analyzes the current regional and global legal and institutional framework relating to the conservation and management of high seas deep sea species and fisheries, identifies gaps and shortcomings therein and offers a range of solutions to address these.

The objectives and species coverage of the constitutive instruments of various existing relevant Regional Fisheries Management Organizations (RFMOs) and Arrangements indicate that (part of) the Fish Stocks Agreement is already applicable to discrete high seas fish stocks. Even though that state practice ‘merely’ consists of the texts of constitutive instruments, there seem to be no scientific, pragmatic or other factors apart from the issue of the allocation of fishing opportunities, that would necessitate RFMOs and Arrangements, in performing their functions, to explicitly or implicitly distinguish between straddling and discrete high seas fish stocks.

There is a need to establish new RFMOs or Arrangements with competence to manage deep sea species and fisheries. While negotiations to establish these in the Southern Pacific and the North-West Pacific are already underway, there are currently no RFMOs or Arrangements for the Central Atlantic, the South-West Atlantic, the Central Pacific, the North-East Pacific and for areas of the Arctic. The constitutive instruments of these RFMOs or Arrangements should relate to straddling fish stocks as well as to discrete high seas fish stocks and should be consistent with the Fish Stocks Agreement and other rules of international law, and in particular the precautionary approach to fisheries and the ecosystem approach to fisheries. Where appropriate and necessary, bodies dedicated to deep sea species and fisheries should be established. Existing RFMOs and Arrangements should be reformed to achieve a similar result.

At the global level, one of the most prominent gaps is the non-applicability of the Fish Stocks Agreement to discrete high seas fish stocks. Other relevant shortcomings relate to the regime for sedentary species, both on the continental shelves of coastal States and on the seabed beyond the limits of national jurisdiction (the Area). The report examines the advantages and disadvantages as well as the types of instruments (i.e. legally binding and non-legally binding) that could be developed to address these shortcomings.

COFI already agreed in 2005 on the need for non-legally binding guidance by FAO on the conservation and management of deep sea species and fisheries, presumably in the form of Technical Guidelines. However, in view of the possible urgency of the matter, FAO Members may also want to consider developing an international plan of action (IPOA), a Model Arrangement or a legally binding instrument (whether or not developed within FAO).

[1] Senior Research Associate, Netherlands Institute for the Law of the Sea (NILOS), Utrecht University and Associate Professor, Faculty of Law, University of Tromsø. The author is grateful to B. Kuemlangan, A. Oude Elferink and Y. Takei for comments on an earlier version, but remains of course responsible for the current text. The author can be contacted at: E.Molenaar@law.uu.nl.

1. PURPOSE, DEFINITIONS AND STRUCTURE OF THE REPORT

1.1 Purpose

This report was commissioned by the Food and Agricultural Organization of the United Nations (FAO) to serve as a background document for the FAO Expert Consultation on Deep Sea Fisheries in the High Seas, scheduled to take place in Bangkok, Thailand between 21-23 November 2006.

According to the applicable Terms of Reference (ToR),[2] the main purpose of this report is to:

> discuss legal and institutional issues in the context of FAO's possible role or options that may be pursued by FAO in [the conservation and management of high seas deep sea fisheries], where appropriate, to promote effective conservation and management of high seas deep sea resources.
>
> The options highlighted should aim at promoting a comprehensive conservation and management regime - one that ensures a consistent approach to conservation and management for high seas deep sea resources in light of relevant considerations including the ecosystems approach to fisheries.

This report strives to minimize overlap with the three other background documents that were prepared for the Expert Consultation.[3]

1.2 Definitions

In accordance with these ToR, 'deep sea' or 'deepwater' are taken as being off-shelf and generally greater than 200m. Moreover, the report will be confined to addressing 'high seas deep sea fisheries'. While these fisheries *only* take place on the high seas, the stocks of deep sea species that are targeted could either be 'straddling stocks' or 'discrete high seas stocks'. The very purpose of the Expert Consultation implies that high seas deep sea fisheries do not target highly migratory species, anadromous stocks or catadromous species, because relatively elaborate legal and/or institutional regimes are largely in place for these.[4]

The term 'straddling stocks' does not appear in the LOS Convention,[5] and is only mentioned but not defined in the Fish Stocks Agreement.[6] However, it is commonly understood to mean those stocks referred to in Article 63(2) of the LOS Convention, namely stocks which "occur both within the exclusive economic zone and in an area beyond and adjacent to the zone". Consistent with this wording, discrete high seas stocks are in this report understood to be stocks that occur exclusively on the high seas and therefore not within adjacent maritime zones of coastal States.[7] Admittedly, however, the verb 'occur' does not always offer fisheries management authorities and others

---

[2] These ToR are a direct result of agreement within FAO's Committee on Fisheries (COFI) at its 26th Session (2005) as to the need of "convening technical meetings to develop a code of practice/technical guidelines" and "reviewing [the] legal framework needed to support conservation and management of deepwater fisheries" (Report of the Twenty-Sixth Session of the Committee on Fisheries (COFI), Rome, 7-11 March 2005 (*FAO Fisheries Reports* No. R780), at p. 15, para. 89). See also FAO Doc. COFI/2005/6 'Deep Sea Fisheries', in particular at p. 4, paras 22-24.

[3] These focus on management, high seas marine protected areas and a review of deep sea resources and fisheries.

[4] See Arts 64, 66 and 67 of and Annex I to the LOS Convention (United Nations Convention on the Law of the Sea, Montego Bay, 10 December 1982. In force 16 November 1994, 1833 *United Nations Treaty Series* 396; <www.un.org/Depts/los>) and international organizations such as the present five 'tuna-RFMOs', the North Atlantic Salmon Conservation Organization (NASCO) and the North Pacific Anadromous Fish Commission (NPAFC).

[5] See note 4 above.

[6] 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, New York, 4 August 1995. In force 11 December 2001, 34 *International Legal Materials* 1542 (1995); <www.un.org/Depts/los>.

[7] However, this does not necessarily mean that the range of distribution of that stock is exclusively within the regulatory area of a single RFMO or Arrangement.

sufficient guidance for the classification of stocks. It has been suggested that the discreteness or not of a stock may depend above all on the significance of transboundary effects of exploitation.[8]

The ToR use 'fisheries' and '(deep sea) resources' almost interchangeably, but do not offer definitions for these terms. For the purpose of this report, deep sea fisheries are presumed to target 'fish'.[9] As the ToR advocate comprehensiveness, this report defines fish to include not only molluscs and crustaceans but also sedentary species[10] as defined in Article 77(4) of the LOS Convention.[11] This definition is thus somewhat broader than that in Article 1(1)(c) of the Fish Stocks Agreement, which excludes sedentary species (but includes molluscs and crustaceans).

It should be realized, however, that the term 'discrete high seas fish stocks' looses its accuracy and thereby its usefulness when linked to the broad definition of fish proposed in this report. This is a result of the sovereign rights of coastal States over sedentary species on their (outer) continental shelves. Not only does the freedom of fishing on the high seas above these outer continental shelves not apply to sedentary species, but fishing for other species can also be constrained by coastal State regulation in order to avoid or mitigate impacts on sedentary species (see further subsections 4.2.1 and 4.2.6).

While the purpose of this report as well as of the Expert Consultation is to strive towards a comprehensive and effective regime for the conservation and management of *targeted* deep sea fish species on the high seas, the mere reference to the ecosystem approach to fisheries (EAF) in the ToR already indicates that issues such as by-catch and other impacts on the broader marine ecosystem must be an integral part of this regime. It must also be noted that presently no legally binding global instrument relevant to marine capture fisheries - not even the Fish Stocks Agreement - contains a definition of EAF.[12] This report therefore uses the definition of EAF incorporated in the FAO Technical Guidelines on 'The ecosystem approach to fisheries',[13] namely:

> An ecosystem approach to fisheries strives to balance various societal objectives by taking into account the knowledge and uncertainties about biotic, abiotic and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries.[14]

1.3 Structure

This report is structured as follows. The following section analyzes the current global legal and institutional framework relating to the conservation and management of high seas deep sea fisheries. Its subsections examine relevant global instruments and institutions. Section 3 focuses on the relevant regional legal and institutional framework, with subsections dealing with relevant regional fisheries management organizations (RFMOs) and Arrangements,[15] their objectives, species coverage and relevant practice as well as relevant non-fisheries instruments. Based on the analyses of the global and

---

[8] E.J. Molenaar, "The South Tasman Rise Arrangement of 2000 and other Initiatives on Management and Conservation of Orange Roughy", 16 *International Journal of Marine and Coastal Law* 77-118 (2001), at pp. 85-89.
[9] Marine mammals are thus excluded from the scope of this report.
[10] See subsection 2.2.1.
[11] It is worth noting that UN Doc. A/61/154, of 14 July 2006, 'Impacts of fishing on vulnerable marine ecosystems: actions taken by States and regional fisheries management organizations and arrangements to give effect to paragraphs 66 to 69 of General Assembly resolution 59/25 on sustainable fisheries, regarding impacts of fishing on vulnerable marine ecosystems. Report of the Secretary-General', at p. 15, para. 45(d) discusses the harvesting of corals as an example of target species.
[12] Note however that the new NAFO Convention (NAFO/GC Doc. 06/3, note 140 below) contains a description of "an ecosystem approach to fisheries management" in the Preamble. Note also the 'Report on the work of the United Nations Open-ended Consultative Process on Oceans and the Law of the Sea [(ICP)] at is seventh meeting' (UN Doc. A/61/156, of 17 July 2006), which contains in paras 3-8 consensual elements on ecosystem approaches and oceans that the UNGA is invited to take into account when drafting its annual 'Oceans' resolution.
[13] FAO Technical Guidelines for Responsible Fisheries No. 4, Suppl. 2 (FAO, Rome: 2003).
[14] At p. 6.
[15] As defined by Art. 1(1)(d) of the Fish Stocks Agreement. In this report, references to RFMOs include Arrangements, unless provided otherwise.

regional legal and institutional framework, Section 4 examines the need and options for reform at the regional and at the global level. Its subsections focus on establishing new RFMOs or Arrangements, reforming existing RFMOs and Arrangements, discrete high seas fish stocks, coastal State jurisdiction over the (outer) continental shelf and other non-legally binding guidance by FAO and legally binding instruments.

2. CURRENT GLOBAL LEGAL AND INSTITUTIONAL FRAMEWORK RELATING TO THE CONSERVATION AND MANAGEMENT OF HIGH-SEAS DEEP-SEA FISHERIES

2.1 General

As requested by the ToR, subsection 2.2 of this report addresses global fisheries instruments such as the LOS Convention, the Fish Stocks Agreement, the Compliance Agreement[16] and the Code of Conduct[17]. The Johannesburg Plan of Implementation (JPOI) of the World Summit on Sustainable Development[18] is not reviewed. While its various objectives and targets are certainly relevant - for instance those on marine biodiversity and the ecosystem approach[19] - they do not explicitly deal with or refer to either deep sea species or deep sea fisheries. Moreover, even though the ToR only requires a review of "international fisheries instruments", subsection 2.2.5 concisely discusses various relevant global 'non-fisheries' instruments such as the CBD,[20] the CITES Convention[21] and the CMS[22].

Finally, subsection 2.3 on relevant global institutions offers an overview of the competence of FAO, the United Nations (UN) and other global institutions that could play a role in the further development of the international legal regime for the conservation and management of high seas deep sea fisheries.

2.2 Relevant global instruments

2.2.1 LOS Convention

As the 'Constitution for the Oceans', the LOS Convention *also* provides the basic international legal framework for high seas deep sea fisheries. Due to the present wide participation by States in the LOS Convention,[23] this framework has near-universal application. The LOS Convention recognizes the sovereignty, sovereign rights and jurisdiction of coastal States with respect to marine living resources within their maritime zones[24] and the right for all States for their nationals to engage in fishing on the high seas.[25] These rights are qualified by obligations owed to each other[26] and to the international community. The latter obligations are aimed at safeguarding such international community interests as conservation and optimum utilization of marine living resources and the protection and preservation of the marine environment, including rare or fragile ecosystems and habitats of depleted, threatened or endangered species and other forms of life.[27]

---

[16] Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas, Rome, 24 November 1993. In force 24 April 2003, 33 *International Legal Materials* 969 (1994); <www.fao.org/legal>.

[17] Code of Conduct for Responsible Fisheries. Adopted by the Twenty-eight Session of the FAO Conference, Rome, 31 October 1995, <www.fao.org/fi>.

[18] The text of the JPOI is available at <www.unep.org>.

[19] See *inter alia* paras 30-31.

[20] Convention on Biological Diversity, Nairobi, 22 May 1992. In force 29 December 1993, 31 *International Legal Materials* 822 (1992); <www.biodiv.org>.

[21] Convention on International Trade in Endangered Species of Wild Fauna and Flora, Washington, D.C., 3 March 1973. In force 1 July 1975, 993 *United Nations Treaty Series* 243; <www.cites.org>.

[22] Convention on the Conservation of Migratory Species of Wild Animals, Bonn, 23 June 1979. In force 1 November 1983, 1651 *United Nations Treaty Series* 355; <www.cms.int>.

[23] As of 14 September 2006, there were 150 parties to the LOS Convention (information obtained from <www.un.org/Depts/los>).

[24] Arts 2(1), 49(1), 56(1)(a), 56(3) and 77 of the LOS Convention.

[25] Art. 116 of the LOS Convention. See also Art. 92(1).

[26] E.g. Arts 63(2) and 116(b).

[27] See e.g. Arts 61(2), 62(1), 117-119, 192 and 194(5) of the LOS Convention.

The LOS Convention does not impose restrictions on coastal State sovereignty within internal waters, territorial seas or archipelagic waters on this issue. However, in the case of deep sea stocks that *also* occur on the high seas (essentially straddling stocks), coastal States may be required to cooperate with other States pursuant to obligations under customary international law relating to transboundary resources and damage.

The sovereign rights of coastal States over marine living resources in their exclusive economic zones (EEZs) are subject to the obligation to conserve, the objective of optimum utilization and the obligation to cooperate with other States in relation to transboundary resources, which, for this report, concerns only straddling species.[28] These obligations and objectives are not, however, applicable to sedentary species.[29]

The obligation to conserve marine living resources in Article 61 of the LOS Convention requires the coastal State, among other things, to determine the total allowable catch (TAC) by taking account of the best scientific evidence available. A large number of factors and considerations must be taken into account, including relevant environmental factors, the interdependence of stocks and the effects on associated and dependent species. While no reference is made to the EAF - let alone an obligation to pursue such an approach - these qualified obligations can be viewed as obligations to take account of several ecosystem considerations.

The right of all States for their nationals to engage in fishing on the high seas is subject to the obligations to conserve and to cooperate with other States, including - in relation to straddling stocks - coastal States.[30] The obligation to conserve in Articles 117 and 119 of the LOS Convention is elaborated in a similar fashion as Article 61 discussed above.

Article 77(1) of the LOS Convention recognizes a coastal State's sovereign rights over its continental shelf "for the purpose of exploring it and exploiting its natural resources". These natural resources consist of the non-living resources of the sea-bed and subsoil together with living organisms belonging to sedentary species, which are defined as "organisms which, at the harvestable stage, either are immobile on or under the sea-bed or are unable to move except in constant physical contact with the sea-bed or the subsoil".[31] The legal continental shelf of a coastal State may extend beyond 200 nautical miles from the baselines.[32] This is the so-called 'outer continental shelf'. The sovereign rights of a coastal State over its continental shelf are also important in case the coastal State has not established an EEZ or exclusive fishery zone (EFZ). This situation is very relevant for the Mediterranean Sea.

The provisions of the LOS Convention leave no doubt that coastal States have exclusive access to the sedentary species on their continental shelves and that they are not subject to the obligation to conserve them. The exclusive focus on exploitation is also reflected in the key role accorded to the words "harvestable stage" in the definition of sedentary species. Part XII of the LOS Convention on the protection and preservation of the marine environment does not resolve that defect. Even the relatively specific obligation on ecosystems and habitats under Article 194(5) is clearly not intended for the exploitation of target species. This is not to say, however, that coastal States may not be subject to relevant obligations under general international law, for instance pursuant to the CBD. Finally, Article 78(2) stipulates that the exercise of the sovereign rights of the coastal State "must not infringe or result in any unjustifiable interference with navigation and other rights and freedoms",

[28] Arts 56(1)(a), 61(2), 62(1) and 63-67 of the LOS Convention.
[29] Arts 56(3), 68 and 77(4) of the LOS Convention.
[30] Arts 116-119 of the LOS Convention.
[31] Art. 77(4) of the LOS Convention.
[32] Art. 76 of the LOS Convention.

which includes the freedom of high seas fishing. No further guidance is provided as to how the justifiability of interference with high seas fishing should be assessed (see also subsection 4.2.6).[33]

A few comments on the regime of the Area are also warranted. This regime is primarily formed by Part XI of the LOS Convention, the 1994 Implementation Agreement[34] and the acts of the International Seabed Authority (ISA). The LOS Convention defines 'Area' as "the sea-bed and ocean floor and subsoil thereof, beyond the limits of national jurisdiction"; 'activities in the Area' as "all activities of exploration for, and exploitation of, the resources of the Area"; and 'resources' as "all solid, liquid or gaseous mineral resources *in situ* in the Area at or beneath the sea-bed, including polymetallic nodules".[35] While it may have been generally assumed that the regime of the Area and the principle of the common heritage of mankind did not apply to *any* marine living resources of the Area, the current debate on marine genetic resources has highlighted doubts on this assumption for the reason that many States - in particular developing States - reject it.[36] If this uncertainty also necessitates reform of the international legal framework for the purpose of this report, is discussed in subsection 4.2.1.

It is finally important to point out the obvious, namely that the LOS Convention does not use a separate category of deep sea stocks or species. Apart from shared and straddling stocks, the other categories of stocks or species are based on life-cycle characteristics (anadromous stocks and catadromous species) or are in various ways implicitly or explicitly defined (highly migratory species, marine mammals and sedentary species). From a systematic perspective, it would therefore not be a problem to add a new category of deep sea species or stocks based on similar characteristics, on listing in an Annex or on a definition. This could be done by means of an amendment to, or an Implementation Agreement of, the LOS Convention.

2.2.2 Fish Stocks Agreement

As is already evident from the full title of the Fish Stocks Agreement, it applies exclusively to straddling fish stocks and highly migratory fish stocks and therefore not to discrete high seas fish stocks.[37] Furthermore, even though the Fish Stocks Agreement applies in part also within EEZs and EFZs, it does not apply in marine areas under coastal State sovereignty (i.e. internal waters, territorial seas and archipelagic waters).[38] As the negotiations on the WCPFC Convention[39] have shown,[40] this poses actual or potential problems in relation to highly migratory fish species in sizeable archipelagic waters. But for deep sea stocks or species this is probably less of a problem. As pointed out in

[33] For a discussion see E.J. Molenaar, "Addressing Regulatory Gaps in High Seas Fisheries", 20 *International Journal of Marine and Coastal Law* 533-570 (2005), at pp. 557-563. See also L.A. Kimball, "Deep-Sea Fisheries of the High Seas: The Management Impasse", 19 *International Journal of Marine and Coastal Law* 259-287 (2004), at pp. 275-277, 279-281 and 286;

[34] Agreement relating to the Implementation of Part XI of the United Nations Convention on the Law of the Sea of 10 December 1982, New York, 28 July 1994. In force 28 July 1996, 33 *International Legal Materials* 1309 (1994); <www.un.org/Depts/los>.

[35] Arts 1(1)(1) and (3) and 133(a) of the LOS Convention.

[36] See the Report of the Ad Hoc Open-ended Informal Working Group established by the UNGA to study issues relating to the conservation and sustainable use of marine biological diversity beyond areas of national jurisdiction (UN Doc. A/61/65, of 20 March 2006), at p. 9, paras 29-31.

[37] See also Arts 2 and 3. It also does not apply to highly migratory species other than fish. For the definition of fish see subsection 1.2.

[38] See Art. 3 of the Fish Stocks Agreement and the discussion by E. J. Molenaar, "The Concept of "Real Interest" and Other Aspects of Co-operation through Regional Fisheries Management Mechanisms," 15 *International Journal of Marine and Coastal Law* 475–531 (2000), at pp. 480-481.

[39] Convention on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean, Honolulu, 5 September 2000. In force 19 June 2004, 40 *International Legal Materials* 277 (2001); <www.wcpfc.org>.

[40] While the words "all waters" in Art. 3 of the WCPFC Convention, note 39 above, can be interpreted to include also archipelagic waters, the linkage between "areas under national jurisdiction" and "sovereign rights" in Art. 7 serves as an argument for their exclusion. At any event, during the negotiations the Chairman made assurances that archipelagic waters would be excluded for the purpose of the assessment of financial contributions. See Molenaar, note 38 above, at p. 481, n. 23.

subsection 2.2.1 in relation to areas under sovereignty, coastal States may still be bound to an obligation to cooperate under customary international law.

As an Implementation Agreement of the LOS Convention, the Fish Stocks Agreement must not be presumed to have the intention to change the jurisdictional framework of the LOS Convention. The reality is less straightforward. While the basic LOS Convention resource entitlements of both coastal and flag States remain unaltered, many of its obligations are broadened, deepened and more specified. Examples include:

- the obligation to apply the precautionary approach (Articles 5(c), 6 and Annex II);
- the obligation to protect biodiversity in the marine environment (Article 5(g));
- the obligation to take account of a wide range of ecosystem considerations (Article 5);
- the obligation to strive for compatibility (Article 7);
- the specific duties of flag States (Articles 18 and 19);
- the general duty of port States (Article 23(1)); and
- the key role accorded to RFMOs as the preferred governance vehicles at the regional level (Article 8). This provision is intended to eventually lead to a situation where fishing is reserved for States that are members of RFMOs or that cooperate with them.

The Fish Stocks Agreement also contains new rights or rights that were at best only implicitly incorporated in the LOS Convention. These include:

- the undefined right of States with a ‘real interest’ to become members of RFMOs (Article 8(3));
- the carefully circumscribed non-flag State enforcement powers on the high seas (Articles 21 and 22);
- the specific enforcement powers of port States (Article 23(2) and (3));[41] and
- the implicit rights of developing States (Articles 24-26).

None of these broadened, deepened or more specified obligations or new or more explicit rights are therefore in principle applicable to discrete high seas fish stocks. As at the time of writing this report there were only 61 parties to the Fish Stocks Agreement,[42] it must be emphasized that these obligations and rights are also not universally applicable to straddling deep sea fish stocks either.

2.2.3 Compliance Agreement

The Compliance Agreement was negotiated by means of a diplomatic conference convened by the FAO Council. The Agreement’s primary purpose is to tackle the problem of re-flagging fishing vessels in order to avoid compliance with applicable conservation and management measures on the high seas. Article III, which is the core of the Agreement, specifies that a flag State is responsible for fishing vessels under its flag that operate on the high seas, that no high seas fishing should occur without prior flag State authorization and that no authorization shall be given unless the flag State is able to exercise effectively its responsibilities under the Agreement. The flag State is also required to maintain a record of high seas fishing vessels and to provide a range of information for each of its high seas fishing vessels to FAO (Articles IV and VI). Some of these obligations are also laid down in Article 18 of the Fish Stocks Agreement.

The Compliance Agreement is a concise treaty with a relatively specific purpose. Apart from elaborating the general obligations of flag States laid down in Articles 91 and 94 of the LOS Convention, it does not modify its jurisdictional framework. The Preamble to the Compliance

[41] Even though it can also be argued that port States already have such powers under customary international law.
[42] As of 14 September 2006 (information obtained at <www.un.org/Depts/los>).

Agreement notes that the Agreement will form an integral part of the Code of Conduct, which was eventually adopted two years later. This linkage is confirmed in Article 1.1 of the Code of Conduct.

It is important to note that the Agreement is not limited to a particular type of high seas fisheries or species. Article II(1) reveals that it applies above all to fishing vessels operating on the high seas. Moreover, the definition of 'fishing vessel' in Article I(a) is linked to "marine living resources"; a much broader term than 'fish'.

Finally, it should be observed that the Compliance Agreement presently suffers from a similar limited participation as the Fish Stocks Agreement. At the time of writing, there were only 34 parties. However, the participation of the European Community (EC) should be counted as participation of all current 25 European Union (EU) Member States.[43]

2.2.4 Code of Conduct

The Code of Conduct was developed within FAO to provide guidance to States, organizations as well to as individuals involved in diverging capacities (e.g. fishers, consumers and researchers) in the broadest possible spheres relevant to the conservation and management of living aquatic resources. As is evident in the consistent use of "should" in its provisions, the Code is a non-legally binding instrument. However, Article 1.1 of the Code points out that parts of it are based on the LOS Convention and that some of the Code's provisions are also laid down in the Compliance Agreement. These parts are therefore legally binding for States that are parties to these other conventions. As the Code was adopted within the framework of FAO, all FAO Member States have committed to it. Participation is therefore essentially universal.

The Code of Conduct is in part a framework instrument. Further guidance on responsible fisheries is laid down in the numerous Technical Guidelines developed by FAO, the four international plans of action (IPOAs) that were elaborated within the framework of Article 2(g) of the Code, and the Port State Model Scheme[44].

The scope of the Code of Conduct not only covers marine resources - including therefore high seas deep sea fish species - but also freshwater resources and aquaculture. Worth highlighting are the various provisions that call for taking into account a broad array of ecosystem considerations.[45] It should be noted that many of the Code's provisions are insufficiently specific. Therefore, it may be useful and/or necessary to develop Technical Guidelines and/or an IPOA to provide effective and comprehensive guidance for specific types of fisheries or fisheries for specific species. The Technical Guidelines on inland fisheries and those on the management and conservation of sharks - the latter of which have been developed to support implementation of the IPOA on Sharks[46] - are precedents in this regard.[47]

2.2.5 Relevant 'non-fisheries' instruments

One of the most important non-fisheries instruments of relevance to this report is the CBD. One of the CBD's broad objectives is the conservation and sustainable use of biodiversity. While specific obligations related to components of biodiversity such as those on *in-situ* conservation are not

---

[43] Information obtained from <www.fao.org/Legal>. However, as Cyprus and Sweden had deposited their instruments of acceptance prior to their accession to the EU, they must be subtracted from the 25 EU Member States.

[44] Model Scheme on Port State Measures to Combat Illegal, Unreported and Unregulated Fishing (Annex E to the 'Report of the Technical Consultation to Review Port State Measures to Combat Illegal, Unreported and Unregulated Fishing. Rome, 31 August–2 September 2004' (*FAO Fisheries Report.* No. 759 (Rome, FAO: 2004)), endorsed by COFI at its 26th Session (2005) (FAO Fisheries Reports No. R780, note 2 above, at para. 25).

[45] See *inter alia* Arts 6.2, 6.4, 6.5, 6.6, and 7.2 of the Code of Conduct.

[46] International Plan of Action for the Conservation and Management of Sharks. Adopted by COFI in February 1999 and endorsed by the FAO Council in June 1999; text available at <www.fao.org/fi>.

[47] Technical Guidelines Nos 4, Suppl. 1, and 6.

applicable in areas beyond national jurisdiction (ABNJ),[48] the general obligations related to processes and activities *are*.[49] But even these more general obligations are still very significant in light of the participation in the CBD, which was at the time of writing even broader than that in the LOS Convention.[50]

The main objective of the CITES Convention is the protection of endangered species against over-exploitation through the regulation of international trade. Trade includes pursuant to Article I(c) of the CITES Convention "introduction from the sea", which is defined in Article I(e) as "transportation into a State of specimens of any species which were taken in the marine environment not under the jurisdiction of any State".[51] International trade in endangered species is regulated by means of listing species on the three Appendices to CITES, with each Appendix requiring different types of regulation. Even though some fish species, for instance various species of sharks, sturgeons and the famous coelacanth,[52] have already been listed on Appendices I or II, the suitability of the CITES listing criteria for commercially exploited aquatic species remains contested.[53]

The aim of the CMS is to conserve migratory terrestrial, avian and marine species throughout their range of distribution. Various forms of regulatory action are possible, for instance prohibitions of intentional taking, habitat protection and the development of agreements that do not merely deal with conservation but also with management, which thus encompasses utilization.[54] While Appendix I lists species threatened with extinction, Appendix II lists species that are in need of, or would significantly benefit from, international cooperation by means of global or regional agreements. At the time of writing, Appendices I and II already included some fish species, for example various species of sharks and sturgeons. However, none of the agreements that have been established under Article IV so far relate to fish and none have a utilization component.[55]

2.3 Relevant global institutions

2.3.1 FAO

The purposes and functions of FAO are set out in the Preamble to and Article I of its Constitution.[56] While the purposes relate primarily to the common welfare of peoples, the functions also include the promotion and recommendation of national and international action relating to the conservation of natural resources. The Code of Conduct (and thereby its IPOAs and Technical Guidelines) should be regarded as an example of international action. Other important functions of FAO are the collection, analysis, interpretation and dissemination of information relating to agriculture (which includes fisheries and marine products), furnishing technical assistance as well as the residual category of "all necessary and appropriate action to implement the purposes of the Organization".

---

[48] Reference can be made to the following definition of 'marine environment not under the jurisdiction of any State' agreed at the 54th Meeting of the Standing Committee of CITES (2-6 October 2006): "those areas beyond the waters and the continental shelf, comprising the seabed and subsoil, subject to the sovereign rights or sovereignty of any State consistent with international law, as reflected in the [LOS Convention]" (SC54 Doc 19, at p. 5).
[49] See in particular Arts 3, 4, 5, 7(c), 8(l) and 22 of the CBD.
[50] For information see <www.biodiv.org>.
[51] See note 48 above.
[52] Information obtained from <www.cites.org>.
[53] Reference can here be made to the FAO Ad Hoc Expert Advisory Panel for Assessment of Listing Proposals for Commercially-Exploited Aquatic Species (see Report of the Twenty-Sixth Session of the Committee on Fisheries (COFI), Rome, 7-11 March 2005 (*FAO Fisheries Reports* No. R780), at p. 9, para. 54).
[54] See the definitions in Art. I(1)(a), (f), (h) and (i), the listing under Art. III and the agreements under Arts IV and V of the CMS.
[55] See <www.cms.int> for an overview of these agreements. Note, however, that in July 2006, a Meeting on Identify Options for International Cooperation on Migratory Sharks under the Convention on Migratory Species was convened in the Seychelles.
[56] Constitution of the Food and Agriculture Organization of the United Nations, Quebec City. Opened for signature and entered into force on 16 October 1945; <www.fao.org/Legal>.

Article VI(1) of the Constitution enables the establishment of commissions as well as regional fisheries advisory bodies “to advise on the formulation and implementation of policy and to coordinate the implementation of policy”. An example of the latter category is the Fishery Committee for the Eastern Central Atlantic (CECAF). Article VI(2) allows for the establishment of “committees and working parties to study and report on matters pertaining to the purpose of the Organization”, pursuant to which the Committee on Fisheries (COFI) was established. In accordance with its Rules of Procedure, COFI can establish subsidiary bodies to deal with certain specific issues (e.g. the Sub-Committee on Aquaculture). Article XIV of the Constitution enables the approval of “agreements concerning questions relating to food and agriculture”; examples of these are the IOTC Agreement[57] and the Compliance Agreement.

As the Compliance Agreement shows, jurisdictional issues are not necessarily beyond the mandate of FAO. This would be confirmed once again if the Port State Model Scheme is modified and converted into a legally binding instrument by means of negotiations facilitated or convened by FAO - as was advocated during the Review Conference on the Fish Stocks Agreement (UNFSA Review Conference) in May 2006.[58] However, according to FAO, the work of COFI (and thereby FAO) is to complement rather than supplant the efforts of other organizations working in the field of fisheries and aquaculture.[59] This underscores the general need for the effective functioning and development of international law. Under different political or practical circumstances, the Compliance Agreement might therefore not have been developed and negotiated within FAO but somewhere else, for example by means of a diplomatic conference convened by the United Nations General Assembly (UNGA). A similar argument may be made with regard to the possible conversion of the Port State Model Scheme.

2.3.2 UNGA and other UN bodies

Whereas the UN Charter[60] does not refer explicitly to the law of the sea or the conservation and management of marine living resources, the LOS Convention’s purpose of establishing a stable and equitable legal order for the oceans[61] is closely related to Charter’s primary purpose, namely maintaining international peace and security.[62] The competence of the UNGA in relation to the law of the sea and the conservation and management of marine living resources is implied in the fact that the diplomatic conference that produced the LOS Convention was convened by the UNGA. This is also the case for the negotiations that led to the two implementation agreements of the LOS Convention. The competence of the UNGA is also implied in its annual ‘Oceans’ and ‘Fish’ resolutions, its creation of the annual informal consultative process (ICP) on Oceans and the Law of the Sea and the establishment of the Ad Hoc Open-ended Informal Working Group to study issues relating to the conservation and sustainable use of marine biological diversity beyond areas of national jurisdiction. Significant is finally the recognition by the 8th Conference of Parties (CoP) to the CBD of the UNGA’s “central role in addressing issues relating to the conservation and sustainable use of biodiversity in marine areas beyond national jurisdiction”.[63]

By contrast, most States regard the mandate of the annual meeting of States parties to the LOS Convention (SPLOS) as essentially administrative.[64] In addition, the competence of the UNFSA Review Conference that was convened and suspended (but not closed) in May 2006 pursuant to Article 36 of the Fish Stocks Agreement, is not only limited but suffers from non-Party issues as

---

[57] Agreement for the Establishment of the Indian Ocean Tuna Commission, Rome, 25 November 1993 (105th Session FAO Council). In force 27 March 1996, <www.iotc.org>.
[58] See Report of the Review Conference on the Fish Stocks Agreement (UN Doc. A/CONF.210/2006/15, of 5 July 2006), at p. 39, para 43(d).
[59] Information obtained at <www.fao.org/fi/body/cofi/cofi.asp>.
[60] Charter of the United Nations, San Francisco, 26 June 1945. In force 24 October 1945, 1 *United Nations Treaty Series* xvi; <www.un.org/aboutun/charter>.
[61] See the Preamble.
[62] Art. 1(1) of the UN Charter.
[63] CoP Decision VIII/24 (2006) ‘Protected Areas’, at para. 35 (Preamble prior thereto).
[64] See ‘Report of the Sixteenth Meeting of States Parties’, UN Doc. SPLOS/148, of 28 July 2006, pp. 18-19, paras 92-96.

well.[65] Furthermore, the competence of UN-OCEANS is in principle limited to "enhance cooperation and coordination among Secretariats of the International Organizations and Bodies concerned with ocean related activities".[66] The work of its Task Force on Marine Biodiversity beyond National Jurisdiction is similarly limited.[67]

Lastly, since the operation of the Trusteeship Council set up pursuant to Chapter XII of the UN Charter was suspended in 1994, various suggestions have been made to revive the Council by giving it a new environmental mandate.[68]

2.3.3 Other international bodies

It is instructive to note that the 8th CoP of the CBD recognized the central role of the UNGA while at the same time also recognizing the CBD's key role in supporting the work of the UNGA with regard to marine protected areas beyond national jurisdiction "by focusing on provision of scientific and, as appropriate, technical advice relating to marine biological diversity, the application of the ecosystem approach and the precautionary approach, and in delivering the 2010 [protected areas] target".[69]
The analyses of the purposes of the CITES and the CMS carried out in subsection 2.2.5 apply in principle equally to the competence of the CoPs of the CITES and the CMS.

3. CURRENT REGIONAL LEGAL AND INSTITUTIONAL FRAMEWORK RELATING TO THE CONSERVATION AND MANAGEMENT OF HIGH SEAS DEEP-SEA FISHERIES

3.1 Relevant RFMOs and Arrangements

There are currently several RFMOs and Arrangements that regulate fisheries other than tuna (-like) or anadromous species and whose regulatory areas either include high seas areas or consist exclusively of high seas areas. Table I categorizes these RFMOs and Arrangements as pre-Fish Stocks Agreement or post-Fish Stocks Agreement, with the latter distinguishing furthermore between those already in operation and those not yet in operation or under negotiation.

Included in the last subdivision is a recent initiative relating to the management of high seas bottom trawling in the North West Pacific Ocean. As the participants in this initiative "recognized the importance of establishing a new international management arrangement for bottom trawl fisheries on the high sea[s] of the North Western Pacific Ocean",[70] it is possible that these initiatives lead to a NWPOF Agreement[71]. The term 'Agreement' is chosen here for reasons of consistency, inspired by the fact that the Draft SPOF Agreement[72] is modeled on the SIOF Agreement[73] - which is an

---

[65] Cf. UN Doc. A/CONF.210/2006/15, note 58 above, at pp. 5-6 and 29, paras 13-18 and 134
[66] Report of the First Inter-Agency Meeting of UN-OCEANS (2005), p.2 (text at <www.oceansatlas.org>).
[67] See the 2005 Report, note 66 above, at p. 6.
[68] P. Sands, *Principles of International Environmental Law* (Cambridge, Cambridge University Press, 2nd edition, 2003), p. 94 reports that President Gorbachev of the Soviet Union proposed in 1990 to expand the function of the Council "to include responsibility for environmental protection in areas beyond national jurisdiction, the global commons." Also noteworthy is Malta's proposal to change to role of the Council into a guardian and trustee of the resources of the global commons (as reported by S. Busuttil and K. Yazaki, "Preface" in A. Agius and S. Busuttil with T. Kim and K. Yazaki (eds) *Future Generations and International Law* (London, Earthscan Publication: 1998), at p. xi). Note, also that para. 178 of UNGA Resolution 60/1, of 16 September 2005, reads "Considering that the Trusteeship Council no longer meets and has no remaining functions, we should delete Chapter XIII of the Charter and references to the Council in Chapter XII".
[69] CoP Decision VIII/24 (2006) 'Protected Areas', at para. 42.
[70] Draft Record of the First Inter-governmental Meeting on Establishment of [a] New Mechanism for Management of High Seas Bottom Trawling in the North Western Pacific Ocean (Doc. NWPBT/01/Rec rev2 (on file with author)), at p. 2.
[71] North West Pacific Ocean Fisheries Agreement.
[72] Chair's Draft Pacific Ocean Regional Fisheries Management Agreement of 8 September 2006, text at <www.southpacificrfmo.org>. However, discussions at the Second International Meeting on the Establishment of the South Pacific Regional Fisheries Management Organization at Hobart, Australia, 6-11 November 2006 showed that some delegations preferred a fully-fledged RFMO.

Arrangement and not (also) a constitutive instrument for an RFMO - and by the assumption that a NWPOF Agreement may be modeled on the Draft SPOF Agreement.[74] The regulatory area of the NWPOF Agreement could be the high seas areas of FAO Statistical Area No. 61, but excluding high seas areas already covered by existing RFMOs and Arrangements (e.g. so it seems, the CBS Convention[75]) as well as areas of high seas that are surrounded by an EEZ of a single State (e.g. the Sea of Okhotsk).[76] Most of the current bottom trawling in the envisaged regulatory area seems to occur above the Emperor Seamount chain.

Table 1. Overview of the various relevant RFMOs and Arrangements

Pre-Fish Stocks Agreement	**Post-Fish Stocks Agreement**	
	In operation	*Not in operation (n.i.o.) or under negotiation (u.n.)*
CBS Convention[77] CCAMLR Convention[78] GFCM Agreement[79] NAFO Convention[80] NEAFC Convention[81]	SEAFC Convention[82] STR Arrangement[83]	SIOF Agreement[84] (n.i.o.) Draft SPOF Agreement[85] (u.n.) Possible NWPOF Agreement[86] (u.n.)

As a consequence of this report's focus on the high seas/ABNJ, RFMOs or Arrangements that have no high seas areas in their regulatory areas are not discussed. Also excluded are bodies that do not qualify as RFMOs or Arrangements within the meaning of the Fish Stocks Agreement. In order to qualify, such bodies must have the competence to impose legally binding conservation and management measures on its members or participants.[87] ICES (International Council for the Exploration of the Sea) and PICES (North Pacific Marine Science Organization) are examples of bodies that do not meet these requirements.[88] Also excluded are FAO regional fishery bodies that do not have high seas areas within their areas of competence and/or that merely have an advisory role. CECAF and the Western Central Atlantic Fishery Commission (WECAFC) fall within the latter

---

[73] Southern Oceans Fisheries Agreement, Rome, 7 July 2006. Not in force, text on file with author.

[74] However, the NWPOF Agreement may also be modeled on the CBS Convention, note 75 below, due to the significant overlap in participation.

[75] Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea, Washington, 16 June 1994. In force 8 December 1995, 34 *International Legal Materials* 67 (1995); <www.afsc.noaa.gov/refm/cbs>.

[76] Cf. (Draft) Establishment of an interim targeted protection mechanism for vulnerable marine ecosystems and management of high seas bottom trawl fisheries in the North Western Pacific Ocean (Doc. NWPBT/01/WP 2 rev4 (on file with author)), at p. 2.

[77] See note 75 above.

[78] Convention on the Conservation of Antarctic Marine Living Resources, Canberra, 20 May 1980. In force 7 April 1982, 19 *International Legal Materials* 837 (1980); <www.ccamlr.org>.

[79] Agreement for the establishment of a General Fisheries Council for the Mediterranean (Rome, 24 September 1949. In force 20 February 1952, 126 *United Nations Treaty Series* 239). Amendments adopted by the FAO Council at its 113th Session in November 1997 entered into force on 29 April 2004; amended version available at <www.fao.org/Legal/>).

[80] Convention on Future Multilateral Cooperation in the Northwest Atlantic Fisheries, Ottawa, 24 October 1978. In force 1 January 1979, 1135 *United Nations Treaty Series* 369; <www.nafo.ca>.

[81] Convention on Future Multilateral Cooperation in the North-East Atlantic Fisheries, London, 18 November 1980. In force 17 March 1982, 1285 *United Nations Treaty Series* 129; <www.neafc.org>.

[82] Convention on the Conservation and Management of the Fishery Resources in the South East Atlantic Ocean, Windhoek, 20 April 2001. In force 13 April 2003, 41 *International Legal Materials* 257 (2002); <www.fao.org/Legal/treaties>.

[83] Arrangement between the Government of Australia and the Government of New Zealand for the Conservation and Management of Orange Roughy on the South Tasman Rise. Signed for New Zealand on 17 February 2000 and for Australia on 25 February 2000. In effect on 1 March 2000; text at 16 *International Journal of Marine and Coastal Law* 119-124 (2001).

[84] See note 73 above.

[85] See note 72 above.

[86] See note 70 above.

[87] See Art. 1(1)(b) and (d) of the Fish Stocks Agreement.

[88] The Loophole Agreement (Agreement between the Government of Iceland, the Government of Norway and the Government of the Russian Federation Concerning Certain Aspects of Co-operation in the Area of Fisheries, St. Petersburg, 15 May 1999. In force summer 1999, <www.oceanlaw.net>) is, for various reasons, excluded as well.

category. It is submitted that these bodies cannot effectively contribute to the sustainable management of deep sea species without first transforming in modern RFMOs or Arrangements. This recommendation is repeated in subsection 4.1 below.

3.2 Objectives and species coverage

Table III (included in the Annex to this Report) gives an overview of the objectives and species coverage of relevant RFMOs and Arrangements. Also incorporated are the amendments to the objectives and species coverage of the NAFO Convention and the NEAFC Convention that have recently been proposed as part of reform-efforts. This overview gives rise to several conclusions. First, the objectives and species coverage of the RFMOs and Arrangements established prior to the adoption of the Fish Stocks Agreement are generally narrower than those established thereafter. The CCAMLR Convention and - to a lesser extent - the CBS Convention and the STR Arrangement,[89] are exceptions to that general rule. The objectives of the (old) NAFO Convention, the (old) NEAFC Convention, and the STR Arrangement are exclusively related to the conservation and management of target species and not (also) to the broader environment.

Most of the constitutive instruments of the RFMOs and Arrangements that were/are adopted after the Fish Stocks Agreement distinguish between on the one hand fishery resources - which are targeted species - and on the other hand more broadly all marine living resources or the marine ecosystem - which may be impacted by fishing activities.[90] Conversely, the CBS Convention, the CCAMLR Convention and the GFCM Agreement (potentially) apply to all the marine living resources in their regulatory areas. Regarding sedentary species as defined in Article 77(4) of the LOS Convention, it is worth noting that only the old NEAFC Convention explicitly excludes these. All the other constitutive instruments either include sedentary species explicitly[91] or implicitly by means of the (potential) applicability to all marine living resources. As regards the GFCM Agreement, it should be noted that there are no areas within its scope of application that belong to the ‘Area’.

Second, apart from the STR Arrangement, which relates exclusively to orange roughy (*Hoplostethus atlanticus*), none of the other objectives and species coverage relate explicitly to deep sea species or fisheries. Nevertheless, the species listed in Section 5 of the Annex to the SEAFC Convention include various deep sea species, such as orange roughy and deep-sea red crab (*Chaceon maritae)*[92] and Annex I to the NAFO Convention includes Greenland halibut (*Reinhardtius hippoglossoides*) and possibly other deep-sea species.[93] The NWPOF Agreement is also expected to relate exclusively or mainly to deep sea species (as target species). Even the CBS Convention, which relates in principle exclusively to walleye pollock (*Theragra chalcogramma*), could in the future be used for marine living resources other than pollock. It is also important to note that the wording of the objectives and species coverage of all the other RFMOs and Arrangements does not explicitly or implicitly *exclude* deep sea species or fisheries either. As the discussion in subsection 3.3 shows, some of these other RFMOs and Arrangements indeed regulate deep sea species and thereby confirm their competence in that regard. Finally, there is no apparent distinction between RFMOs and Arrangements established prior to and after the adoption of the Fish Stocks Agreement.

---

[89] The objective and species coverage of the STR Arrangement is relatively narrow even though it was agreed upon after the adoption of the Fish Stocks Agreement.

[90] These are: the new NAFO Convention, the new NEAFC Convention, the SEAFC Convention, the SIOF Agreement and the Draft SPOF Agreement.

[91] These are: the new NEAFC Convention, the SEAFC Convention, the SIOF Agreement and the Draft SPOF Agreement. As regards the new NEAFC Convention, the term “jurisdiction” replaces the term “fisheries jurisdiction” in Arts 5 and 6. This means that NEAFC will only regulate sedentary species on coastal States’ outer continental shelves if these coastal States so request. The species coverage of the old NAFO Convention implicitly covers sedentary species beyond coastal States’ outer continental shelves.

[92] See also note 96 below.

[93] The new NAFO Convention will probably no longer include the list of species (cf. the September 2006 Report, note 140 below, at p. 3, para. 4(b)).

Third, none of the objectives and species coverage contain wording related to the classification of stocks. Even though all the RFMOs and Arrangements (with the exception of the SIOF Agreement) were mainly or exclusively established to regulate straddling fish stocks within the meaning of Article 63(2) of the LOS Convention, neither their objectives nor their species coverage refer explicitly to the straddling nature of the fish or other species covered. There is once again no apparent distinction between RFMOs and Arrangements established prior to and after the adoption of the Fish Stocks Agreement.

The STR Arrangement is a special case because Australia and New Zealand were unable to agree as to whether orange roughy in the regulatory area constituted a discrete high seas fish stock or not.[94] It is also worth noting that the objective of the SIOF Agreement is similar to those of the other constitutive instruments of RFMOs and Arrangements, even though its negotiation process was primarily aimed at establishing a regulatory framework for discrete high seas fish stocks.[95] This similarity also exists with respect to the objectives of the SEAFC Convention and the Draft SPOF Agreement, even though both were/are negotiated in full awareness of the presence of discrete high seas fish stocks in the (envisaged) regulatory area.[96] It is too early to say anything about the objective of a possible NWPOF Agreement, but it is worth noting that in the envisaged regulatory area there may well be discrete high seas fish stocks of pelagic armourhead (*Pseudopentaceros wheeleri* and *P. richardsoni*), alfonsino (*Beryx splendens*) and oreo dories (*Allocyttus* spp., *Neocyttus* spp. and *Pseudocyttus* spp.).[97]

Fourth, the fact that the SEAFC Convention, the SIOF Agreement and the Draft SPOF Agreement were (are) negotiated in full awareness of the presence of discrete high seas fish stocks in the (envisaged) regulatory area is also important. This is because they were (are) negotiated after the adoption of the Fish Stocks Agreement and their (draft)texts draw heavily on the Fish Stocks Agreement. The GFCM Agreement cannot be grouped together with these.[98] The STR Arrangement is once again a special case because it is non-legally binding and only Australia was a party to the Fish Stocks Agreement at the time when it signed the Arrangement. It nevertheless draws on the Fish Stocks Agreement in spite of the disagreement as to stock classification. As regards the NWPOF Agreement initiative, it can be noted that at the time of writing all the participants, except South Korea, were party to the Fish Stocks Agreement. Consequently, it is likely that the Fish Stocks Agreement will be extensively drawn on. A similar argument can finally also be made with respect to the new NAFO Convention which draws on the Fish Stocks Agreement despite the presence of discrete high seas fish stocks within the NAFO Regulatory Area.[99]

In summary, the constitutive instruments of various RFMOs seem to indicate that (part of) the Fish Stocks Agreement is already applicable to discrete high seas fish stocks. The objectives of relevant RFMOs and Arrangements are formulated in a general way, without classifying stocks or species as

---

[94] See the Preamble.

[95] For some information about the complex negotiation process of the SIOF Agreement see Molenaar, note 8 above, at pp. 109-115 as well as Molenaar, note 33 above, at pp. 541-542. A formal account of the negotiation process is incorporated in the 'Final Act of the Conference on the Southern Indian Ocean Fisheries Agreement', which was adopted on 7 July 2006.

[96] With respect to the SEAFC Convention, the deep sea red crab stock "is generally agreed to be a discrete stock" (A. Jackson, "The Convention on the Conservation and Management of Fishery Resources in the South East Atlantic Ocean 2001: An Introduction", 17 *International Journal of Marine and Coastal Law* 33-77 (2002), at pp. 38 and 47). As regards the Draft SPOF Agreement, see Doc. SP/01/WP1 (February 2006), at pp. 1-2. Note also that Art. 26(2) of the Draft SPOF Agreement refers explicitly to Arts 116-119 of the LOS Convention. This could be primarily related to the issue of non-parties to the Fish Stocks Agreement, to the issue of high seas discrete fish stocks or to both.

[97] Information provided by C. Ahn, Ministry of Maritime Affairs and Fisheries of South Korea, August 2006. See also the 'Report submitted in accordance with paragraph 17 of General Assembly resolution 59/25 of 17 November 2004, to assist the Review Conference to implement its mandate under paragraph 2, article 36 of the United Nations Fish Stocks Agreement - Report of the Secretary-General' (UN Doc. A/CONF.210/2006/1, of 4 January 2006), at pp. 25-26, para. 113.

[98] While the 1997 amendments to the GFCM Agreement were also approved after the adoption of the Fish Stocks Agreement, the current text of the GFCM Agreement does not draw on the Fish Stocks Agreement and the 1997 amendments were also not adopted in the face of full awareness of the presence of discrete high seas fish stocks in the regulatory area.

[99] Cf. UN Doc. A/CONF.210/2006/1, note 97 above, at p. 74, n. 48.

straddling or discrete high seas. It seems that the competence of all these RFMOs and Arrangements thereby covers discrete high seas fish stocks as well. There are no indications that these RFMOs and Arrangements, in performing their functions, explicitly or implicitly distinguish between straddling and discrete high seas fish stocks. Perhaps apart from the issue of the allocation of fishing opportunities, such a distinction would also not be warranted by scientific, pragmatic or other factors.

3.3 Relevant practice by relevant RFMOs and Arrangements

The discussion in the previous subsection concluded that even though the constitutive instruments of some RFMOs and Arrangements may not refer to deep sea species or fisheries in their objectives and species coverage or otherwise, deep sea species or fisheries are not explicitly or implicitly excluded either. This view is supported by the regulation of deep sea species by some of these RFMOs. Such regulation thereby confirms their competence in that regard.

Deep sea fisheries are a relatively new phenomenon for NEAFC, which established the NEAFC Deep-Sea Working Group, which met for the first time in June 2002. It is worth noting that NEAFC relies on ICES for scientific advice. In 1994, ICES had already established a dedicated study group on deep sea resources but re-established this group as the Working Group on the Biology and Assessment of Deep Sea Fisheries Resources (WGDEEP)[100] in 2001.[101]

NEAFC seems to be the only RFMO that has established a dedicated body to deal with deep sea species. Despite the absence of a dedicated body, deep sea species and fisheries have been regulated by CCAMLR (e.g. toothfish (*Dissostichus* spp.)). No dedicated body exists within the GFCM either. However, the efforts of the Sub-Committee on Marine Environment and Ecosystems (SCMEE) of the GFCM Scientific Advisory Council also relate to the impact of deep sea fisheries on sensitive marine ecosystems (but not to deep sea species as target species).[102] Finally, a dedicated body is not likely to be established within the framework of the SEAFC Convention, as most of the target species are deep sea species. This would be similar for the SIOF Agreement, once it enters into force, and for the NWPOF Agreement. The situation is very different for the SPOF Agreement as not only deep sea species but also commercially significant stocks of small pelagic fish occur in its envisaged regulatory area.

3.4 Relevant non-fisheries instruments

In view of the need for RFMOs and Arrangements to pursue an EAF, they should cooperate and coordinate with relevant non-fisheries instruments at the regional level. Of particular importance in this regard are the instruments, action plans and bodies established under the regional seas programme of the United Nations Environmental Programme (UNEP), other regional marine environmental protection bodies such as the OSPAR Commission[103] and the Helsinki Commission[104] and regional advisory bodies such as ICES, PICES and the Mediterranean Science Commission (CIESM).

---

[100] Previously named Working Group on the Biology and Assessment of Deep Sea Fisheries.

[101] Cf. Final Report of the NEAFC Deep-Sea Working Group (Bergen, June 2002), at p. 21.

[102] This advice has, *inter alia*, led to Recommendation GFCM/2006/3 'Establishment of Fisheries Restricted Areas in Order to Protect the Deep Sea Sensitive Habitats'.

[103] Established by the Convention for the Protection of the Marine Environment of the North-East Atlantic, Paris, 22 September 1992. In force 25 March 1998, <www.ospar.org>.

[104] Established by the Convention on the Protection of the Marine Environment of the Baltic Sea Area, Helsinki, 9 April 1992. In force 17 January 2000; <www.helcom.fi>.

4. REFORM OF THE INTERNATIONAL LEGAL AND INSTITUTIONAL FRAMEWORK

4.1 Reform at the regional level

4.1.1 Establishing new RFMOs or Arrangements

Despite recent progress in the form of the adoption of the SIOF Agreement and the negotiations on the SPOF Agreement and the NWPOF Agreement, there are still several gaps in high seas coverage with relevant RFMOs or Arrangements. These are displayed in Table II below. The mere listing of these gaps does not imply that straddling or discrete high seas deep sea fish stocks actually occur in these high seas areas.[105] As subsection 3.2 concluded that the CBS Convention could also function as an arrangement for the conservation and management of deep sea fisheries, it is not regarded as a gap.

In addition to the various FAO initiatives proposed in subsection 4.2 - which will guide States in establishing new RFMOs or Arrangements as well as in reforming existing RFMOs and Arrangements - a **possible role for FAO** would be to kick-start negotiations by inviting coastal States and high seas fishing States that have a duty and/or a real interest to participate in a prospective RFMO or Arrangement. Such a FAO initiative would appear especially pertinent for the high seas areas in the Central Atlantic that are currently included in the areas of application of CECAF and WECAFC. FAO's involvement in the negotiations of the SEAFC Convention and of the SIOF Agreement/SWIOFC Statutes[106] could serve as a model.

Table 2. Gaps in high seas coverage with relevant RFMOs or Arrangements

Ocean	Description of the gap
Atlantic	• the high seas areas in the Central Atlantic that are currently included in the areas of application of CECAF and WECAFC • the high seas areas in the South-West Atlantic (FAO Statistical Area No. 41, except the high seas areas covered by CECAF)
Arctic	• all high seas areas except those covered by the NEAFC Convention[107] (even though access to much of this area is often limited due to sea-ice)
Pacific	• the high seas areas of the Central Pacific to the extent that these are not covered by the SPOF Agreement • the high seas areas of the North-East Pacific to the extent that these are not covered by the CBS Convention

4.1.2 Reforming existing RFMOs and Arrangements

As briefly mentioned in subsection 3.2, some RFMOs like NAFO and NEAFC have already started processes of reform. Such reform includes an overhaul of their constitutive instruments in order to align them with the requirements of the Fish Stocks Agreement, to address the calls for wider use of the EAF as well as to take action against destructive fishing practices pursuant to paragraphs 66-71 of UNGA Resolution 59/25.[108] It is not ruled out that the 2006 UNGA 'Fish' Resolution may contain further recommendations in relation to high seas bottom-trawling. In view of the current objectives and species coverage of the relevant RFMOs and Arrangements listed in Table I, processes of reform

[105]Note the brief description of deep sea fisheries in UN Doc. A/61/154, note 11 above, at p. 9, para. 18.
[106] The South West Indian Ocean Fisheries Commission was established as an advisory body under Art. VI(1) of the FAO Constitution. The SWIOFC Statutes were adopted by means of FAO Council Resolution 1/127 on 25 November 2004.
[107] According to Art. 1(1)(a), the Convention Area extends to the North Pole. The proposed amendments to the NEAFC Convention (see note 142 above) do not change that.
[108] See in this regard also the 'Performance Review Panel Report of the North East Atlantic Fisheries Commission, NEAFC', available at <www.neafc.org>.

also appear necessary for the GFCM. Such processes are not necessarily required in relation to the STR Arrangement, as the SPOF Agreement may eventually replace it.

While these regional processes of reform devote much attention to the impact of (deep sea) fisheries on the broader marine environment, much less attention seems to be devoted to the conservation and management of targeted deep sea species.[109] Only NEAFC and ICES (which provides scientific advice to NEAFC) have established dedicated bodies that also deal with targeted deep sea species.

In addition to the initiatives of FAO proposed in subsection 4.2 - which will guide States in establishing new RFMOs or Arrangements as well as in reforming existing RFMOs and Arrangements - a **possible role for FAO** would be to stimulate processes of reform within the GFCM, if only because the GFCM is an RFMO that has been established under the FAO Constitution.

4.2 Reform at the global level

4.2.1 Discrete highs seas fish stocks

The analysis in subsection 2.2 highlighted that discrete high seas fish stocks are currently covered by Section 2 of Part VII of the LOS Convention and other global legally binding and non-legally binding international instruments - most importantly the Compliance Agreement and the Code of Conduct - but not by the Fish Stocks Agreement.[110]

The need to address this gap in the global legal framework has been recognized repeatedly in recent years, for instance at the St. John's Conference in May 2005.[111] Subsequently, in its 2005 Fish Resolution, the UNGA encouraged "States, as appropriate, to recognize that the general principles of the [Fish Stocks Agreement] should also apply to discrete fish stocks in the high seas". The exact same wording was also agreed on at the UNFSA Review Conference in May 2006.[112]

At the UNFSA Review Conference in May 2006, there was general agreement for the view that

> [RFMOs] with competence to regulate straddling fish stocks have the necessary competence to conserve and manage high-seas discrete stocks. There is no obstacle for such [RFMOs] to adopt management measures in respect of such stocks in accordance with the general principles set forth in the [Fish Stocks Agreement].[113]

This view is supported by the analysis in subsection 3.2, which *inter alia* concluded that there is already state practice through RFMOs and Arrangements by which parts of the Fish Stocks Agreement are already applicable to discrete high seas stocks. However, that state practice 'merely' consists of the texts of constitutive instruments. State practice has more weight if it consists of actual conservation and management measures that apply explicitly or implicitly to discrete high seas fish stocks and which are adopted and applied in accordance with the Fish Stocks Agreement. As was highlighted in subsection 3.2, there seem to be no scientific, pragmatic or other factors apart from the issue of the allocation of fishing opportunities, that would necessitate RFMOs and Arrangements, in performing their functions, to explicitly or implicitly distinguish between straddling and discrete high seas fish stocks.

---

[109] Note, however, the attention devoted to target species in UN Doc. A/61/154, note 11 above, at pp. 14-15 and 40, paras 41-45 and 205.

[110] For an alternative view see M.W. Lodge and S.N. Nandan, "Some Suggestions Towards Better Implementation of the United Nations Agreement on Straddling Fish Stocks and Highly Migratory Fish Stocks of 1995", 20 *International Journal of Marine and Coastal Law* 345-379 (2005), at p. 371.

[111] See para. 13(A) of the Ministerial Declaration adopted at the 'Conference on the Governance of High Seas Fisheries and the UN Fish Agreement: Moving from Words to Action', available at <www.dfo-mpo.gc.ca/fgc-cgp>.

[112] Cf. Doc. A/CONF.210/2006/15, note 58 above, at p. 31, para. 2.

[113] Doc. A/CONF.210/2006/15, note 58 above, at p. 33, para. 16.

The view reproduced above suggests that the international community currently has a preference for a regional solution for the identified gap in the global international legal framework. State practice through RFMOs and Arrangements would ensure that all members and participants are under a legal obligation to apply the Fish Stocks Agreement *mutatis mutandis* equally to discrete high seas fish stocks. However, this regional approach has various shortcomings.

First, there are no obligations in the absence of RFMOs and Arrangements. The only way in which this shortcoming can be addressed is by filling spatial gaps. While this is already under way, it is not completed.

Second, some commentators[114] argue that a significant weakness of this regional approach is its inability to address fishing by non-members.[115] According to these commentators, this inability is caused by the need to rely on the more general obligations on cooperation that are laid down in the LOS Convention instead of the broader, deeper and more specified obligations in the Fish Stocks Agreement. However, there are others[116] that argue that the regional governance role of RFMOs and Arrangements is no longer fundamentally challenged and that the more specified duty of States to cooperate with RFMOs and Arrangements pursuant to Article 8(3) of the Fish Stocks Agreement is already part of customary international law. It must be admitted that the carefully circumscribed non-flag State enforcement powers on the high seas under Articles 21 and 22 of the Fish Stocks Agreement would not be available for discrete high seas fish stocks. However, the current practice within RFMOs to combat fishing activities by non-members through, *inter alia*, port State measures and trade measures has not yet been challenged, for example from the perspective of international trade law.

The preference for a regional approach at the UNFSA Review Conference may to a large extent have been motivated by its limited mandate under Article 36 of the Fish Stocks Agreement. Moreover, a preference for a regional approach also does not exclude pursuing a global approach in parallel. This could take the form of a legally binding instrument by which the Fish Stocks Agreement is applied in part or as a whole to discrete high seas fish stocks. The main advantage of such an instrument *would* be that it addresses the aforementioned shortcomings of a regional approach. A major disadvantage *could* be that non-parties to the Fish Stocks Agreement feel that the pace of reform is too fast and will no longer attempt to catch up at all.[117] This would then threaten the aim of universal participation in the Fish Stocks Agreement and thereby in the law of the sea as a whole.

4.2.2 Suitability or lack of suitability

The way in which such a legally binding instrument ensures that the Fish Stocks Agreement applies in part or as a whole to discrete high seas fish stocks is of critical importance. As participation in negotiations would be open to parties as well as non-parties of the Fish Stocks Agreement, negotiations may be used by non-parties to ensure that certain hard-fought components of the package deal of the Fish Stocks Agreement - for instance non-flag State enforcement - will not be part of the new instrument. This would then lead to a loss of uniformity in the international law of the sea. One possible solution to this problem is to focus on provisions in the Fish Stocks Agreement that are for obvious scientific, pragmatic or jurisdictional reasons *not suitable* for discrete high seas fish stocks.

---

[114] For instance M. Hayashi, "Governing deep-sea fisheries: future options and challenges", in R. Shotton (ed.) *Deep Sea 2003: Conference on the Governance and Management of Deep-sea Fisheries* (FAO Fisheries Proceedings, FAO: 2005), Part 1: Conference reports, pp. 590-595, at p. 593.

[115] Essentially, unregulated fishing within the meaning of para. 3.3.1 of the IPOA on IUU Fishing (International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing. Adopted by consensus by FAO's Committee on Fisheries on 2 March 2001 and endorsed by the FAO Council on 23 June 2001; text available at <www.fao.org/fi>).

[116] For instance M.W. Lodge, "Improving international governance in the deep sea", in Shotton, note 114 above, pp. 62-65, at p. 64 and E.J. Molenaar, "Global, Regional and Unilateral Approaches to Unregulated Deep-Sea Fisheries", in Shotton, note 114 above, pp. 415-432, at p. 422.

[117] It should be noted that Japan's ratification of the Fish Stocks Agreement on 7 August 2006 is an important step towards more universal participation.

Article 7 (on compatibility) as well as provisions that refer to coastal States or areas under national jurisdiction would appear to be obvious candidates.[118] There are various ways in which this could be achieved, for instance by listing the provisions that are not to apply or by securing agreement on a single substantive provision with wording that captures the rationale of *mutatis mutandis* application as well as the rationale of lack of suitability.

4.2.3 Definitions of Fish, Discrete High Seas Fish Stocks and/or Fish Stocks Discrete to Areas Beyond National Jurisdiction (ABNJ)

Before dealing with the need for a definition of high seas fish stocks, it must be decided whether the instrument should apply exclusively to 'fish' as defined in Article 1(1)(c) of the Fish Stocks Agreement or to this report's definition of fish, which *also* includes sedentary species as defined in Article 77(4) of the LOS Convention.

In considering these options, account should be taken of the view held by some States that the regime of the Area and the principle of the common heritage of mankind also apply to marine genetic resources of the Area (see subsection 2.2.1). If that view becomes broadly supported, the underlying reasoning may also be relevant to other marine living resources of the Area, including sedentary species. However, the analysis of the objectives and species coverage of relevant RFMOs and Arrangements in subsection 3.2 reveals that the objectives and species coverage of the CBS Convention and the CCAMLR Convention (potentially) apply to all marine living resources in their regulatory areas.[119] Moreover, the definitions of fishery resources of the other constitutive instruments - except for the old and new NAFO Convention and the old NEAFC Convention - explicitly include sedentary species in the Area.[120]

The objectives and species coverage of these RFMOs and Arrangements therefore seem to indicate that, at least as regards sedentary species as defined in Article 77(4) of the LOS Convention, the regime of the Area and the principle of the common heritage of mankind are not applied in their regulatory areas. In fact, the definition of sedentary species in Article 77(4) is so broad that the true limitation is that the regulatory mandates of these RFMOs and Arrangements is confined to fishing activities. As the exploration and exploitation of marine genetic resources - also known as 'bioprospecting' - is aimed at qualitative rather than quantitative removals of organisms, they would not be treated as fishing activities.[121]

In view of the above, it seems that opting for this report's definition of fish would avoid a legal gap in the global legal framework - as sedentary species would otherwise not be covered - and would also be consistent with the present regional legal framework's species coverage. If that option is pursued, however, it seems also necessary to incorporate a definition of 'fishing activities' that ensures that marine genetic resources and bioprospecting are excluded from the scope of the instrument. Such definitions can be found in many of the constitutive instruments of the newer RFMOs.

Opting for this report's definition of fish would not only broaden the species coverage but also the spatial coverage. While outer continental shelves were already excluded due to the sovereign rights of coastal States over sedentary species, the spatial scope would be broadened by the inclusion of sedentary species occurring in the Area. Instead of applying to discrete high seas fish stocks, it would apply to fish stocks discrete to ABNJ. One option would be to use wording analogous to Article 63(2) of the LOS Convention, for instance "fish stocks that occur exclusively in areas beyond national

---

[118] E.g. Arts 3, 5 (*chapeau*), 8, 11(d) and (e) and 16.
[119] The GFCM Agreement is not listed here as there are not pockets of the Area within its scope of application.
[120] Sedentary species in the Area are implicitly covered by the old NAFO Convention.
[121] Reference should here be made to the debate on bioprospecting within Antarctic Treaty Consultative Meetings (ATCMs), during which no suggestion has yet been made that this could possibly be regulated within the framework of the CCAMLR Convention (see e.g. ATCM Resolution 7 (2005) 'Biological Prospecting'). The suggestion also does not seem to have been seriously discussed during recent Annual CCAMLR Meetings (but see the Report of the 21st Annual CCAMLR Meeting (2002) (Doc. CCAMLR-XXI), at p. 76, para. 13.17).

jurisdiction" or "fish stocks that occur exclusively on the high seas or in the Area". More elaborate definitions or lists of species may be opted for as well. It should be noted, however, that such alternatives were considered during the negotiations on the Fish Stocks Agreement but eventually did not secure the necessary support.[122]

4.2.4 Possible role(s) of FAO

As regards possible role(s) of FAO, it must be noted that the UNFSA Review Conference recommended that FAO revise its global fisheries statistics database, presumably to facilitate the identification of potential discrete high seas fish stocks.[123] However, a proposal for FAO to develop Technical Guidelines on the conservation and management of discrete high seas fish stocks found insufficient support. One observer openly wondered what the benefit of such guidelines would be.[124] It seems indeed not so useful to have specific guidance for stocks that are classified by means of a legal instead of a scientific definition. By contrast, technical guidance on the conservation and management of deep sea species and fisheries *per se*, would not be based on a legal definition. Moreover, as most discrete high seas fish stocks seem in fact to be deep sea species,[125] they would effectively also address discrete high seas fish stocks. Some further comments on the scope of guidance developed by FAO are offered in subsection 4.2.7.

Furthermore, it would probably not be appropriate or useful to address the sensitive issue of allocation of fishing opportunities in FAO Technical Guidelines, if only because of their non-legally binding nature. Another possible role for FAO would arise if the international community prefers the global instrument under discussion to have a more elaborate definition or list(s) of species and asks FAO for guidance.

4.2.5 Form of the instrument

There are several options for the form of the instrument under discussion. The most likely are a Protocol to the Fish Stocks Agreement and an Implementation Agreement of the LOS Convention. As regards the latter, this could relate exclusively to discrete high seas fish stocks (or fish stocks discrete to ABNJ) but it could *also* include a number of other issues where reform is regarded necessary, for instance those discussed in the following subsections and/or the issues covered by the recent European Union (EU) proposal for an Implementation Agreement.[126] By contrast, the amendment procedures of the LOS Convention and the Fish Stocks Agreement are unlikely to be used for reasons similar to those that led to the 1994 Implementation Agreement and the Fish Stocks Agreement.

It is submitted that while nothing in the Compliance Agreement would get in the way of adding an Annex or a Protocol, it is not a logical choice. This is evident if the substance of the instrument would draw heavily on the Fish Stocks Agreement and even more so if it would consist of a single substantive provision with wording that captures the rationale of *mutatis mutandis* application of the Fish Stocks Agreement and/or the rationale of lack of suitability of some of its provisions. But even if the substance of the new instrument would not draw on the Fish Stocks Agreement at all, the simple fact that it would deal with rights and obligations for States on the conservation and management of a certain category of fish stocks, would make a linkage with the LOS Convention logical. This is due, *inter alia*, to the latter's categorization of fish stocks and its separate section 2 on the living resources of the high seas in Part VII. Also, the precedent of the linkage between the LOS Convention and the Fish Stocks Agreement - which deals specifically with two categories of fish stocks - is arguably

[122] For a short discussion see Molenaar, note 8 above, at pp. 85-86.
[123] Cf. Doc. A/CONF.210/2006/15, note 58 above, at p. 35, para. 19.
[124] Cf. Doc. A/CONF.210/2006/15, note 58 above, at p. 14, paras 64-65.
[125] Cf. UN Doc. A/CONF.210/2006/1, note 97 above, at p. 23, para. 104.
[126] This proposal is laid down in the Annex to the Statement given by Austria, on behalf of the EU, at the 7th Meeting of the ICP (2006).

already sufficient by itself. These arguments far outweigh the circumstance that the Compliance Agreement relates primarily, but not exclusively,[127] to the high seas.

4.2.6 Coastal state jurisdiction over the (outer) continental shelf

As regards the rights and obligations of coastal States over their outer continental shelves, there are two issues where reform seems particularly necessary. The first relates to the fact that the LOS Convention currently does not clearly require coastal States to conserve sedentary species. The obligations in relation to ecosystems and habitats under Article 194(5) lack clarity and do not relate to target species.

The second concerns the lack of guidance offered by the LOS Convention as to how the justifiability of interference by coastal States with high seas fishing above outer continental shelves should be assessed. Some States take the view that

> "in conformity with the [LOS Convention], the coastal State was fully entitled to adopt any conservation and management measures it deemed necessary to protect its sedentary species on the continental shelf. Those may include the possibility of imposing restrictive measures on fishing activities in the high seas over its continental shelf, including on fishing practices that were deemed to have a negative impact on sedentary species."[128]

However, the fact that only "some" States take this view means that others do not and/or that yet others have not yet determined a position on the issue. As far as could be ascertained, no coastal State had yet imposed such measures.[129] Also, the cited view does not take account of the relevance of the presence of RFMOs or Arrangements that have spatial competence over these outer continental shelves and their regulation of fisheries impacting on sedentary species of outer continental shelves. It is noteworthy that in the recent past several RFMOs have imposed restrictions for the purpose of protecting benthic species in areas that clearly lie above the (outer) continental shelves of coastal States.[130] However, agreement on such restrictions at the multilateral level does not necessarily mean that unilateral action by coastal States is ruled out. Finally, so far no coastal State has concluded the LOS Convention's procedure involving the Commission on the Limits of the Continental Shelf (CLCS) for establishing the outer limits of its continental shelf. The precise spatial scope of their rights is therefore unclear as well.

In conclusion, there seems to be a need for clarification of the relationship between the sovereign rights of coastal States over sedentary species on their outer continental shelves, the freedom of high seas fishing, the presence of and regulation by RFMOs or Arrangements and the consequences of not having established final and binding outer limits. While clarification on the second issue could be provided in the course of an international dispute settlement procedure, this would not resolve the first issue. The international community may in any event prefer not to wait for such a procedure and commence negotiations towards a legally binding instrument that incorporates clarification on both issues.

---

[127] See, for instance, Art. III(1).

[128] See UN Doc. A/61/65, note 36 above, at p. 7, para. 22. See also the fourth preambular paragraph to the SPOF Agreement, which notes that coastal States have the right to conserve "living marine resources upon which fishing has an impact".

[129] It is worth noting, however, that by 2020 New Zealand intends to have established some marine protected areas beyond its EEZ to protect benthic communities (cf. UN Doc. A/61/154, note 11 above, at p. 23, para. 93). However, it is not clear if these areas are on New Zealand's outer continental shelf or if New Zealand intends to do this unilaterally.

[130] E.g., Recommendation GFCM/2006/3 'Establishment of Fisheries Restricted Areas in order to Protect the Deep Sea Sensitive Habitats' and the decision by NEAFC in November 2006 to close fishing in areas on the Hatton and Rockall bank to protect cold water corals (the latter information was provided by K. Hoydal, Secretary of NEAFC, 28 November 2006). The areas closed to bottom trawling by NAFO in September 2006 (information provided by J. Fischer, Executive Secretary of NAFO, 27 November 2006) and the areas closed to all fishing by SEAFC in October 2006 (Conservation Measure 06/06 'On the Management Of Vulnerable Deep Water Habitats And Ecosystems In The SEAFO Convention Area') all seem to lie in the Area.

As regards the form of such an instrument, an Implementation Agreement to the LOS Convention seems the most likely option for reasons similar to those mentioned in subsection 4.2.1. Likewise, the issue of the outer continental shelf could be the only issue addressed by this Implementation Agreement or could be part of a package. In case the international community decides to resolve the gap identified in subsection 4.2.1 by means of an Implementation Agreement that applies to this report's broad definition of fish - including sedentary species therefore - it would seem logical to *also* incorporate clarification on the two issues discussed in this subsection.

As the required clarification would be essentially jurisdictional, there would seem to be **no obvious role for FAO**.

4.2.7 Other non-legally binding guidance by FAO and legally binding instruments

Subsection 4.1.2 noted that while the ongoing processes of reform within RFMOs are primarily focused on EAF and the impact of (deep sea) fisheries on the broader marine environment - in part due to the UNGA's efforts in combating destructive fishing practices -, much less attention seems to be devoted to the conservation and management of targeted deep sea species. This defect applies to the regional as well as to the global level. The following subsections deal with non-legally binding guidance by FAO and legally binding instruments.

4.2.8 Non-legally binding guidance by FAO

COFI already agreed on the need to develop guidance in the form of a code of practice or of Technical Guidelines on deep sea fisheries at its 26th Session in 2005.[131] It should be noted that the title (but not the prospectus) of this Expert Consultation - namely 'Deep Sea Fisheries in the High Seas' - suggests that the spatial scope of this guidance is limited to the high seas. It is submitted that this needs to be carefully considered.

As far as could be ascertained, none of the existing Technical Guidelines or IPOAs has a scope based on stock-classifications used by the law of the sea. A choice for such a scope may be perceived by some States as a choice for a jurisdictional/legal approach instead of a technical or scientific approach and thereby inappropriate in view of FAO's mandate. Moreover, some States may argue that limiting the scope to the high seas or ABNJ would be discriminatory against States that have a particular interest in these areas. This latter argument is also voiced against a (limited) UNGA moratorium on high seas bottom trawling as well as against the EU proposal for an Implementation Agreement, whose spatial scope is limited to ABNJ. While these objections certainly have merit, it is suspected that they are *also* used to frustrate any reform whatsoever, for the reason that explicit restrictions on the sovereign rights of coastal States are unacceptable to many States. All this friction would be avoided by broadening the scope of the guidance to deep sea fisheries and species in general.

As regards the form of the guidance, the COFI Report refers to a code of practice or Technical Guidelines. Another alternative would, in light of the existence of the IPOA on Sharks and the Technical Guidelines on sharks,[132] be an IPOA, whether or not supported by Technical Guidelines to further its implementation.[133] The choice for the form of guidance depends first of all on the nature of the substance, the level of prescription and whether it is aimed only at States or also at other relevant actors. Another important consideration for the form and spatial scope is if the non-legally binding guidance is intended to be converted into a legally binding instrument at a later stage or that such an option should at least be kept open. This is not a theoretical possibility as some States were in favor of the option to develop a "single global arrangement for the management of [deep sea] fisheries" during

---

[131] See note 2 above.

[132] See notes 46 and 47 above and accompanying text.

[133] A less appropriate form of guidance would be a manual modeled on the 'Manual for the monitoring and management of queen conch', developed by FAO (see FAO Doc. COFI:FT/X/2006/3 'CITES Issues with respect to International Fish Trade and the CITES/FAO MOU', at p. 5, para. 17).

the 26th Session of COFI in 2005.[134] Such a two-stage approach may for instance be pursued with regard to the Port State Model Scheme.[135] It seems that an IPOA is more suitable for a two-stage approach than Technical Guidelines.

As regards the substance, it would seem to be especially pertinent to determine if, in view of the characteristics of deep sea species and (new and exploratory) deep sea fisheries, there are particular needs for the collection and sharing of data or for guidelines for the application of the precautionary approach and for precautionary reference points. Account may also be taken of relevant efforts within ICES[136] as well as the work of the FAO ad hoc Expert Advisory Panel for the Assessment of Proposals to Amend Appendices I and II of CITES Concerning Commercially-exploited Aquatic Species[137].

Another form of guidance that FAO may wish to consider is to develop a Model Arrangement for the conservation and management of deep sea fisheries, based on a similar rationale as that of the Port State Model Scheme. Accordingly, such a Model Arrangement would offer guidance to States in establishing Arrangements at the regional level. It has to be pointed out, however, that the fact that the Draft SPOF Agreement seems to be partly modeled on the SIOF Agreement could indicate that enough guidance is already available.

4.2.9 Legally binding instrument

The international community may feel that the risk of loss of marine biodiversity posed by deep sea fisheries is so high that reliance on voluntary implementation of non-legally binding FAO instruments by coastal States, flag States, RFMOs and other actors is not sufficient. Some States already voiced these sentiments during COFI's 26th Session in 2005 (see above). In case a two-stage approach was chosen (see also above), this decision may also come after assessments have shown that voluntary implementation has been inadequate. The observations made above on the spatial scope apply here as well.

The instrument may as a minimum contain the suggestions made above in relation to the collection and sharing of data and the precautionary approach. In view of the decentralized nature of international law and the absence of hierarchy among its forms/manifestations as well as its law-making processes, particular care should be taken to ensure that proposed reform minimizes competition or overlap with existing legal regimes. The most directly relevant legal regimes are of course existing RFMOs and Arrangements. On the other hand, it may also be argued that the conservation and management of deep sea fisheries and species would benefit from global regulation. This could take various forms. One form would be for the instrument to mandate a new or existing global body to assess the risk of fishing for certain deep-sea species or the risk of using certain fishing practices. Of the existing global bodies, possible candidates would be **COFI**, the UNGA or the UN Trusteeship Council (see subsection 2.3). In view of the commitment to closer cooperation between the FAO and CITES - most recently expressed by the conclusion of a FAO/CITES Memorandum of Understanding at Geneva on 3 October 2006[138] - it may be considered to convert the abovementioned FAO ad hoc Expert Advisory Panel into a permanent body.

One step further would be to give that new or existing body the competence to regulate deep sea fisheries globally.[139] However, in view of the fierce opposition by some States to blanket moratoria

[134] See FAO Fisheries Reports No. R780, note 2 above, at p. 14, para. 86. Note that the global agreement on discrete high seas fish stocks advocated by Hayashi, note 114 above, at p. 593, would concern first of all deep sea species.
[135] See note 58 above.
[136] As advocated in UN Doc. A/CONF.210/2006/1, note 97 above, at p. 24, para. 108.
[137] See FAO Fisheries Reports No. R780, note 2 above, at p. 9, para. 54.
[138] The MoU is contained in CITES Doc. SC53 Doc. 10.1 and in Annex I to FAO Doc. COFI:FT/X/2006/3, note 134 above.
[139] See also M.W. Lodge, "Improving International Governance in the Deep Sea", 19 *International Journal of Marine and Coastal Law* 299-316 (2004), at p. 307 and R. Shotton and M. Haward, "Requirements for Managing Deep-Sea Fisheries", in Shotton, note 114 above, at pp. 704-709.

and a species-by-species (instead of a stock-by-stock) approach - inspired by the moratorium on commercial whaling, the listing of certain whale species on the Annexes of CITES and the suitability of the CITES listing criteria to commercially exploited aquatic species - this alternative is not likely to find sufficient support. Possibly, however, support would be broader in case the global body is only given a mandate by default, namely in the absence of an RFMO or Arrangement with spatial and substantive competence. It is worth noting that a mandate by default-rationale is also a crucial element in the proposals by various States for a recommendation by the UNGA on high seas bottom trawling on the high seas.

As regards the form of the instrument, it seems that an Implementation Agreement to the LOS Convention seems the most likely option for reasons similar to those mentioned in subsection 4.2.1.

ANNEX I

Table 3. Overview of the objectives and species coverage of relevant RFMOs and Arrangements

RFMO or Arrangement		Objective	Species coverage
CBS Convention		(1) to establish an international regime for conservation, management, and optimum utilization of Pollock resources in the Convention area; (2) to restore and maintain the Pollock resources in the Bering Sea at levels which will permit their maximum sustainable yield; (3) to cooperate in the gathering and examining of factual information concerning Pollock and other living marine resources in the Bering Sea; and (4) to provide, if the Parties agree, a forum in which to consider the establishment of necessary conservation and management measures for living marine resources other than Pollock in the Convention Area as may be required in the future (Art. II)	Pollock and other living marine resources, as may be required in the future (Art. II)
CCAMLR Convention		Conservation (defined as including rational use) of Antarctic marine living resources in line with several conservation principles with are regarded as reflecting an ecosystem approach (Art. II)	Antarctic marine living resources, defined as "the populations of fin fish, molluscs, crustaceans and all other species of living organisms, including birds, found south of the Antarctic Convergence." (Art. I(2))
GFCM Agreement		The development and proper utilization of the living marine resources in the Mediterranean and the Black Sea and connecting waters (Preamble)	The living marine resources in the Mediterranean and the Black Sea and connecting waters (Preamble)
NAFO Convention	Old	The conservation and optimum utilization of the fishery resources of the Northwest Atlantic area (Preamble)	All fishery resources of the Convention Area, with the following exceptions: salmon, tunas and marlins, cetacean stocks managed by the International Whaling Commission or any successor organization, and sedentary species of the Continental Shelf, i.e., organisms which, at the harvestable stage, either are immobile on or under the seabed or are unable to move except in constant physical contact with the seabed or the subsoil (Art. I(4)) The list of species in Annex I includes Greenland halibut (*Reinhardtius hippoglossoides*) and possibly other deep-sea species

	New[140]	The ensure the long term conservation and sustainable use of the fishery resources in the Convention Area and, in so doing, to safeguard the marine ecosystems in which these resources occur (Art. II) New Article III contains various principles that shall be applied in giving effect to the objectives of the Convention. These are clearly inspired by Article 5 of the Fish Stocks Agreement and include the obligation to apply the precautionary approach, to need to preserve marine biological diversity and to take account of a broad range of ecosystem considerations	"Fishery resources" means all resources of fish, molluscs and crustaceans within the Convention Area excluding (i) sedentary species subject to the exclusive sovereign rights of Coastal States pursuant to Article 77 of the [LOS] Convention, and (ii) in so far as they are managed by other international Conventions or Agreements, anadromous, catadromous stocks as well as highly migratory species listed in Annex I of the [LOS] Convention (Art. I(f)) "Living marine resources" means all living components of the marine ecosystems (Art. I(j)) The list of species is removed from the Annexes and will form part of the Financial Regulations[141]
NEAFC Convention	Old	The conservation and optimum utilisation of the fishery resources of the North-East Atlantic area (Preamble)	All fishery resources of the Convention Area, with the exception of sea mammals, sedentary species i.e., organisms which, at the harvestable stage, either are immobile on or under the seabed or are unable to move except in constant physical contact with the seabed or the subsoil and, in so far as they are dealt with by other international agreements, highly migratory species and anadromous stocks (Art. 1(2))
	New[142]	The long-term conservation and optimum utilisation of the fishery resources of the North-East Atlantic area, and in doing so to safeguard the marine ecosystems in which the resources occur (Preamble) To ensure the long-term conservation and optimum utilisation of the fishery resources of the Convention Area, providing sustainable economic, environmental and social benefits (Art. 2) Pursuant to new Article 4, NEAFC shall *inter alia* "(b) apply the precautionary approach; (c) take due account of the impact of fisheries on other species and marine ecosystems, and in doing so adopt, where necessary, conservation and management measures that address the need to minimize harmful impacts on living marine resources and the marine ecosystems; and (d) take due account of the need to conserve marine biological diversity"	"Fishery resources" means resources of fish, molluscs, crustaceans and including sedentary species,[143] excluding in so far as they are dealt with by other international agreements, highly migratory species listed in Annex I of the [LOS Convention], and anadromous stocks (Art. 1(b)) "Living marine resources" means all living components of marine ecosystems (Art. 1(c)) "Marine biological diversity" means the variability among marine living organisms and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems (Art. 1(d))
SEAFC Convention		"The long-term conservation and sustainable use of the fishery resources in the Convention Area" (Art. 2) Article 3 contains various general principles by which Contracting Parties are bound in giving effect to the objective. These are clearly inspired by Article 5 of	"Fishery resources" means resources of fish, molluscs, crustaceans and other sedentary species within the Convention Area, excluding (i) sedentary species subject to the fishery jurisdiction of coastal States pursuant to [Article 77(4) of the LOS Convention] and (ii) highly migratory species listed in Annex I of the [LOS

140 Based on the Report of the Working Group on the Reform of NAFO (Lunenburg, September 2006) (NAFO/GC Doc. 06/3), at Annex 5 (WG WP 06/1, Revision 3, Corr.). The new NAFO Convention had not yet been approved at the 2006 NAFO General Meeting (information provided by S. Ekwall, EU Commission and J. Fischer, NAFO Secretariat).

141 NAFO/GC Doc. 06/3, note 140 above, at p. 3.

142 The amendments to the NEAFC Convention as agreed at the meeting of the Working Group on the Future of NEAFC in June 2005 (see Annex 1 to the Final Report of the June 2005 meeting of the Working Group on the Future of NEAFC) were adopted by a postal vote sometime in May 2006 (information provided by K. Hoydal, NEAFC Secretariat, 28 November 2006).

143 See also note 91 above.

	the Fish Stocks Agreement and include the obligation to apply the precautionary approach, to protect biodiversity in the marine environment and to take account of a broad range of ecosystem considerations	Convention]; "Living marine resources" means all living components of marine ecosystems, including seabirds; The list of species in Section 5 of the Annex includes various deep sea fish species
SIOF Agreement	"to ensure the long-term conservation and sustainable use of the fishery resources in the Area" (.…) "and to promote the sustainable development of fisheries in the Area" (Art. 2) Article 4 contains several general principles that should be applied by the Contracting Parties in giving effect to their duty to cooperate. These are clearly inspired by Article 5 of the Fish Stocks Agreement and include the obligation to apply the precautionary approach, to protect biodiversity in the marine environment and to take account of a broad range of ecosystem considerations	"Fishery resources" means resources of fish, molluscs, crustaceans and other sedentary species within the Area,[144] but excluding: (i) sedentary species subject to the fishery jurisdiction of coastal States pursuant to article 77(4) of the [LOS] Convention; and (ii) highly migratory species listed in Annex I of the [LOS] Convention (Art. 1(f))
STR Arrangement	"conservation and management of orange roughy on the South Tasman Rise" (Preamble)	Orange roughy, whether or not the species can be classified as a straddling stock or as a discrete high seas stock (Preamble)
Draft SPOF Agreement	"to ensure the long-term conservation and sustainable use of fishery resources in the Area (…); to avoid adverse impacts on the marine environment and its ecosystems in the Area through fishing; and to promote the protection of the marine habitats in the Area on which fishery resources are reliant (Art. 2) Article 4 contains several conservation and management principles that should be applied by the Contracting Parties in giving effect to their duty to cooperate. These are clearly inspired by Article 5 of the Fish Stocks Agreement as well as Article 4 of the SIOF Agreement and include the obligation to apply the precautionary approach, to protect biodiversity in the marine environment and to take account of a broad range of ecosystem considerations	'Fishery resources' means the resources of fish, molluscs, crustaceans and other sedentary species within the Area,[145] but excluding: (i) sedentary species subject to the fishery jurisdiction of coastal States pursuant to article 77(4) of the [LOS] Convention; and (ii) highly migratory species listed in Annex 1 of the [LOS] Convention (Art. 1(e))
Possible NWPOF Agreement	Whereas the objective and principles still have to be agreed on, the full title of the First Inter-governmental meeting indicates already that they would not only relate to targeted demersal deep sea species but also to the broader marine environment.	Whereas the target fisheries and species still have to be agreed on, as the arrangement would focus on bottom trawling, the species covered would seem to be primarily demersal species. Some of these may be discrete high seas fish stocks.[146] Moreover, as noted in the box to the left, the objective would also relate to the broader marine environment.

[144] Art. 1(c) defines the term 'Area' as the "area to which this Agreement applies, as prescribed in article 3".
[145] Art. 1(c) defines the term 'Area' as the "area to which this Agreement applies in accordance with article 3".
[146] See note 97 above and accompanying text.

HIGH SEAS MARINE PROTECTED AREAS AND DEEP-SEA FISHING[1]

by

Kristina M. Gjerde[2]

Summary

Experiences in coastal and offshore waters under national jurisdiction have shown marine protected areas (MPAs) to be an important tool for biodiversity conservation and ecosystem-based oceans and fisheries management. Spatial and temporal closures established as a fisheries management tool are here considered as a subset of MPAs. If properly designed and managed, MPAs can help protect, recover and maintain fish stocks, population size distribution, trophic complexity, ecosystem resilience, habitat structure, biological diversity as well as species' feeding, breeding, spawning and nursery grounds. MPAs are not a panacea however: their goals are most effectively achieved when human activities, including destructive practices, are controlled in the context of effective ecosystem-based management both within and outside the MPA. Further studies and adaptive management would assist in improving MPA design and effectiveness.

International law sets forth clear obligations for States to protect and preserve the marine environment and to conserve marine resources and biodiversity. Governments at the World Summit on Sustainable Development set a target of 2012 for the development of representative networks of MPAs, consistent with international law and based on scientific information. To assist in implementing these obligations and targets, the United Nations, the Parties to Convention on Biological Diversity, the FAO's Committee on Fisheries and the Review Conference for the Fish Stocks Agreement have called for greater use of MPAs in fisheries management to improve fisheries and to protect biodiversity. Efforts are now underway to develop agreed criteria and biogeographic classification systems for representative MPA networks. At the regional level, there are active programs for developing MPAs in areas beyond national jurisdiction in the Northeast Atlantic, the Mediterranean and the Southern Ocean. Several Regional Fisheries Management Organizations (RFMOs) have also recently closed areas to protect seamounts or cold water corals or to prevent deep-sea fisheries from expanding into new or deeper waters. More comprehensively, Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) uses rules on new and exploratory fisheries to control and restrict fisheries absent adequate data and is initiating work towards a system of MPAs.

In taking measures including MPAs in the deep sea, it will be important to account for the heightened susceptibility of many deep-sea fish species to rapid depletion and the vulnerability of most deep-sea ecosystems to rapid damage. Even a small numbers of tows from bottom contacting trawl gear can cause significant impacts to seamount communities. Intense fishing with other gears may have a severe cumulative impact. Most deep sea bed habitats will be very slow to recover, and their loss is predicted to result in reduced abundance and diversity of fish as well as other species. Despite the absence of data on many aspects of deep-sea ecosystems, it is already possible to draw on a variety of sources to identify key species and/or habitats of concern. Predictive modelling can aid in identifying the spatial distribution of key features such as stony corals. Data already available for some areas of the deep seas include: historic and current catch and bycatch data; bathymetry from bottom swath

---

[1] This document was prepared for the Expert Consultation on Deep-sea Fisheries in the High Seas which took place in Bangkok, Thailand from 21–23 November 2006.

[2] The views expressed in this paper are solely those of the author: Kristina Gjerde, IUCN High Seas Policy Advisor, kgjerde@it.com.pl.

The author gratefully acknowledges the expert assistance of Malcolm Clark, Harlan Cohen, Robert George, Sarah Gotheil, Andrew Hurd, J. Anthony Koslow and Alex Rogers in reviewing various drafts of this report. The author also thanks the participants of the FAO Experts Consultation on Deep Sea Fisheries in Bangkok, Thailand (November 2006) for their comments.

mapping; oceanographic monitoring (e.g. drifters, etc.), satellite/remote sensing, altimetry and sediment thickness.

Protection of vulnerable deep-sea ecosystems may require a combination of management tools, including a major reduction in effort in fisheries using bottom contacting gears, improved spatial management to prevent overlap with vulnerable areas, closing areas to bottom contacting gears (i.e. MPAs), and substitution or modification of gears to reduce contact with the benthos. The effectiveness of such measures will depend of how effort is redistributed, the scale of the areas protected, and the relative effectiveness of any substituted gear.

Several major governance and legal issues at the global and regional levels could hinder the effectiveness of High Seas MPAs as a deep-sea fisheries management tool. These include: substantive and implementation gaps in the regime in United Nations Convention on the Law of the Sea (UNCLOS) and the Convention on Biological Diversity (CBD) for protection of marine biodiversity in areas beyond national jurisdiction, the current lack of RFMOs competent to manage deep-sea fisheries in 75 percent of the high seas, and the inconsistent implementation of ecosystem-based and precautionary management measures by those RFMOs that do have the legal competence. Some of these issues will be addressed if the 2006 United Nations General Assembly (UNGA) Resolution on Sustainable Fisheries is effectively implemented. However, the lack of a binding global agreement such as the UN Fish Stocks Agreement for discrete deep-sea fish stocks on the High Seas means that there are neither binding conservation, governance, enforcement or dispute resolution rules, nor are there formal mechanisms to review management effectiveness.

In developing plans for High Seas MPAs with respect to deep-sea fisheries, there will be a need for: science-based criteria and transparent processes for identifying areas appropriate for fishing as well as for MPAs (including vulnerable marine ecosystems); rules and research so that information and understanding can precede exploitation; and finer-scale management and reporting so that experts can identify what and where has been fished and what and where can be protected. At the same time, many marine experts suggest that MPAs need to be vastly scaled up in number and size to protect deep-sea biodiversity at ecosystem, species and genetic levels. Improved cooperation between, among and within regional fisheries and marine environmental bodies, intergovernmental and non-governmental organizations, governments, the research community, and the deep sea fishing industry will be essential.

1. INTRODUCTION

Marine protected areas (MPAs) are now widely accepted as an important tool to conserve marine biological diversity and productivity, including ecological life support systems. They have the potential to make a significant contribution to modern fisheries management, which recognizes the need to protect biodiversity to preserve ecosystem structure, functions and processes upon which fisheries – and all marine life -- depend. This report focuses on MPAs in the water column and on the seabed beyond areas of national jurisdiction (the "High Seas"[3]) with respect to deep-sea fisheries management. It builds upon the outcomes and background reports from a recent FAO workshop on MPAs for Fisheries Management, held in Rome in June 2006.[4] Annex I contains a list of acronyms used in this report.

---

[3] Technical definitions used herein are based on the legal background report prepared for the FAO MPA Workshop by Young, T.R. 2007. The Legal Framework for MPAs and Successes and Failures in Their Incorporation into National Legislation, at page 11.

[4] Conclusions and Recommendations – Key points. FAO. Report and documentation of the Expert Workshop on Marine Protected Areas and Fisheries Management: Review of Issues and Considerations. Rome, 12–14 June 2006. *FAO Fisheries Report.* No. 825. Rome, FAO. 2007. 332 pp.

Five reports were prepared for the FAO MPA Workshop: 1) Martin, K., Samoilys, M.A., Hurd, A.K., Meliane, I., and Lundin, C.G. 2007. Experiences in the Use of Marine Protected Areas with Fisheries Management Objectives: A Review Of Case Studies, 2) Botsford, L.W., Micheli, F. and Parma, A.M. 2007. Biological and Ecological Considerations in the Design, Implementation and Success of MPAs; 3) Pomeroy, R.S., Mascia, M.B., and Pollnac, R.B. 2007. Marine Protected Areas:

Although the topic of MPAs as they relate to deep-sea fishing on the high seas is vast, this report specifically addresses the following issues:

1. Use of MPAs in coastal areas, in particular as it relates to fisheries management;
2. Rationales and views expressed for the creation of High Seas MPAs;
3. Present status of High Seas MPAs;
4. High Seas MPAs and Deep-sea Fishing: Special considerations related to deep-sea species/habitat specifications (benthic) and conservation;
5. High Seas MPAs and Deep-sea Fishing: Special considerations related to deep-sea fisheries management;
6. RFMO involvement in High Seas MPAs and deep water fisheries;
7. High Seas MPAs: Deep-sea fisheries and compliance;
8. High Seas MPAs and Deep-sea Fishing: Governance and legal issues at the global level;
9. High Seas MPAs and Deep-sea Fishing: Governance and legal issues at the regional level; and
10. Next steps for High Seas MPAs and Deep-sea Fisheries.

2. SUMMARY ON THE USE OF MPAs IN COASTAL AREAS, IN PARTICULAR AS IT RELATES TO FISHERIES MANAGEMENT

In coastal areas, MPAs are frequently used to improve biodiversity conservation and fisheries management as well as for other cultural, socio-economic, spiritual, aesthetic, historic and intrinsic reasons. These reasons may include protecting natural quality environments for their non-use benefits to present and future generations. The discussion below will focus on MPAs and their role in fisheries management and biodiversity conservation, as biodiversity conservation is now recognized as an inextricable component of responsible fisheries management.[5]

A commonly accepted definition for MPAs, used in the Convention on Biological Diversity (CBD) Programme of Work on Marine Biodiversity, provides:

> *any defined area within … the marine environment, together with its overlaying waters and associated flora, fauna and historical and cultural features, which has been reserved by legislation or other effective means, including custom, with the effect that its marine and/or coastal biodiversity enjoys a higher level of protection than its surroundings.*[6]

MPAs have a wide variety of names, such as specially protected areas, marine reserves, preserves, sanctuaries, wilderness areas, specially managed areas and parks. They can be equally varied in purpose, from strict protection from all human use to zoned multiple use areas. The World Conservation Union (IUCN) has provided a category system to differentiate the varying levels of management that such areas may be afforded.[7] The degree of regulation is not necessarily the same

---

The Social Dimension; 4) Christie, P. and White, A.T. 2007. Best Practices in Governance and Enforcement of Marine Protected Areas: An Overview; 5) Young, above ft. 2.

[5] 1995 FAO Code of Conduct for Responsible Fisheries. As noted in the Introduction: "This Code sets out principles and international standards of behaviour for responsible practices with a view to ensuring the effective conservation, management and development of living aquatic resources, with due respect for the ecosystem and biodiversity."

[6] CBD Conference of the Parties, Decision VII/5, note 11. IUCN uses a slightly different definition of a marine protected area: "any area of the intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment." Kelleher, G. (ed.), 1999. Guidelines for Marine Protected Areas. IUCN, Gland, Switzerland and Cambridge, UK.

[7] The six IUCN Categories for Protected Areas (PAs) are:

Category I.A Strict Nature Reserve/Wilderness Area (Science/Research): PAs managed for scientific and research purposes;
Category I.B Strict Nature Reserve/Wilderness Area (Protection): PAs managed for wilderness protection purposes;
Category II National Park: PAs managed for ecosystem protection and recreation;

throughout the area; indeed most large MPAs are zoned into different area categories. The Tasman seamount reserve in southeast Australia is an example of an MPA for deep-sea biodiversity that is zoned vertically so restrictions on fishing vary by depth, as opposed to horizontally.[8]

Regardless of name, size, design or purpose, all MPAs have in common the goal of providing an enhanced level of protection than exists in surrounding waters or seafloor. Fisheries closed areas such as those used for stock restoration or habitat recovery are sometimes excluded under MPA definitions, as their primary purpose is not biodiversity conservation and their protection may be temporary or seasonal.[9] Increasingly though, and for the purposes of this paper, fisheries closed areas are included in the general category of MPAs, as these areas generally provide a higher level of protection than their surroundings. The objectives and design of the MPA will ultimately determine its conservation and fisheries benefits. It is recognized however that the process of identification, selection, design and management may greatly differ if the MPA is designated pursuant to fisheries or conservation legislation, or if the area is within a nation's territorial sea, EEZ or continental shelf or on the High Seas. Management plans are rarely adopted for fisheries closed areas, whereas they are a common tool for most other MPAs. Individual nations can establish and enforce MPAs within their zones of national jurisdiction, whereas High Seas MPAs require international cooperation; consultation; and consent.

MPAs are now widely accepted as an important tool to conserve the biological diversity and productivity of the oceans and as an essential component in the implementation of an ecosystem approach to oceans and fisheries management.[10] Unlike conventional fisheries management tools that depend on control of effort or take, large scale MPAs or networks of MPAs may be better suited to protecting the structure, functions and processes that underpin ecological life support systems. MPAs also have the potential to protect us from our own ignorance and prevent significant harm, a critical component of a precautionary approach.

Category III Natural Monument: PAs managed for conservation of specific natural features;
Category IV Habitat/Species Management Area: PAs managed for species/habitat/ecosystem conservation through management intervention;
Category V Protected Landscape/Seascape: PAs managed for landscape/seascape protection and recreation; and
Category VI Managed Resource Area: PAs managed for sustainable use of natural ecosystems.

IUCN/WCPA, 1994. Guidelines for Protected Area Management Categories; Young, above ft. 2 (Appendix 1).

[8] See Young, above ft. 2; Martin et al., above ft. 3; Kimball L. 2005. The International Legal Regime of the High Seas and the Seabed Beyond the Limits of National Jurisdiction and Options for Cooperation for the Establishment of Marine Protected Areas (MPAs) in Marine Areas Beyond the Limits of National Jurisdiction. Secretariat of the Convention on Biological Diversity, Montreal, Technical Series no. 19. Available at: http://www.biodiv.org/doc/publications/cbd-ts-19.pdf.

[9] Area closures, as described in Martin et al., "are fisheries management tools, often used in combination with other measures within a target-species based management, to support the management of a fisheries resource, or as a restoration tool for a fishery that has been over-exploited. They can encompass areas closed to all fishing activities, areas closed to fishing for single species, or areas with gear or vessel restrictions - both as temporal or permanent measures to manage fishing effort. Area closures usually aim at stock enhancement or recovery, but also include recovery for sensitive habitats and avoidance of specific vulnerable species. Broader ecosystem objectives are increasingly taken into account. Although generally aiming at enhancing the stock of a particular fisheries resource, area closures can also yield positive results for several other associated or dependent species." Martin et al above ft. 3. It should be noted however that areas closed for stock enhancement purposes may cause other species to increase or decline.

[10] Ecosystem-based management for the oceans has been defined as: "an integrated approach to management that considers the entire ecosystem, including humans. The goal of ecosystem-based management is to maintain an ecosystem in a healthy, productive and resilient condition so that it can provide the services humans want and need. Ecosystem-based management differs from current approaches that usually focus on a single species, sector, activity or concern; it considers the cumulative impacts of different sectors. Specifically, ecosystem-based management:

- emphasizes the protection of ecosystem structure, functioning, and key processes;
- is place-based in focusing on a specific ecosystem and the range of activities affecting it;
- explicitly accounts for the interconnectedness within systems, recognizing the importance of interactions between many target species or key services and other non-target species;
- acknowledges interconnectedness among systems, such as between air, land and sea; and
- integrates ecological, social, economic, and institutional perspectives, recognizing their strong interdependences.

Scientific Consensus Statement on Marine Ecosystem-Based Management Prepared by scientists and policy experts to provide information about coasts and oceans to U.S. policy-makers. Released on March 21, 2005, available at: http://compassonline.org/files/inline/EBM%20Consensus%20Statement_FINAL_July%2012_v12.pdf.

The Heard Island and McDonald Islands (HIMI) Marine Reserve established by Australia in the sub-Antarctic provides a useful example of an MPA designated as part of a comprehensive management scheme for fisheries and biodiversity that encompasses large deep-sea areas.[11] The HIMI Marine Reserve is designed to:

- protect nursery grounds e.g. Antarctic cods and icefishes nearshore, toothfish, rattails/grenadiers (macrourids) and skates in deeper waters;
- establish/maintain refuges from fishing;
- create a reference area to determine impact of fishery on different types of habitats; and
- assist research programmes to obtain a better understanding of the impacts of fisheries on marine environment and food-web.

MPAs can also be an important tool for restoring damaged seascapes and for enhancing the recovery of over-fished stocks. In recent years more vigorous efforts have been undertaken by fisheries management bodies around the world to create MPAs for the purposes of re-establishing lost biodiversity, trophodynamic integrity and fish density and biomass.

In coastal waters, studies by the US National Research Council and others have demonstrated that effectively managed MPAs can contribute to conservation and sustainable use of marine biodiversity and resources by safeguarding areas that are:

- vital to maintaining viable populations of threatened or endangered species;
- important for species and genetic diversity;
- critical breeding, nursery and feeding habitats such as seagrass beds, mangroves and coral reefs;
- of adequate size to encompass representative examples of marine life and ecosystems to ensure their long-term viability;
- unique, rare or have other outstanding values or features;
- spatially complex and slow to recover, such as benthic habitats like maerl beds, corals reefs, and sponge beds;
- spawning sites for species, for example groupers, subject to commercial fishing pressure when the animals congregate in large numbers to spawn;
- offshore nursery areas, migratory corridors or other vulnerable population bottlenecks; and
- reference sites for long-term research and monitoring.[12]

Fisheries-related benefits of effectively designed and implemented MPAs are thought to include:

- protection of specific life stages (larval nursery grounds);
- protection of critical functions of an exploited population (feeding grounds, spawning grounds);
- spillover of an exploited species;
- dispersion center for larval recruitment of an exploited species;
- protection of habitat and genetic diversity;
- ecological offsets – to compensate for environmental damage elsewhere;[13]

---

[11] Gotheil, S. 2006. Heard Island and McDonalds Islands Deep-Sea Fishery, Case Study prepared for IUCN Global Marine Program.

[12] National Research Council Committee on Ecosystem Management for Sustainable Marine Fisheries (NRC), 2001. Marine Protected Areas: Tool for sustaining ocean ecosystem. NRC: USA, 288 pages; Martin et al., above ft. 3.

[13] T. Ward and E. Hegerl, 2003 Marine Protected Areas in Ecosystem-based Management of Fisheries. A report for the Department of the Environment and Heritage, Australia.

- restoration of fisheries productivity by promoting the recovery of populations of species, recolonisation of areas by previously scarce organisms, increase in size and age of individuals, and recovery of habitat and thereby increasing structural complexity;[14] and
- protection of components of ecosystems that are not protected by other forms of fisheries management.

Theory and modelling simulation, as well as a growing amount of actual experience, support the idea that MPAs can help meet these fisheries-related objectives. However, further efforts are required to test how to maximize these benefits in practice. Just as with other fisheries management measures, MPAs must be carefully planned, designed and implemented if they are to achieve their objectives. Many MPAs have had little or no baseline data for comparison, or were too small or too recent to demonstrate the effects of protection.[15] Good monitoring and evaluation procedures are also essential to learn from the results.

The contrasting combination of the physical connectivity of seawater combined with the increasingly known genetic isolation of marine species means that networks of MPAs are well-suited to support marine ecosystem health within single ecosystems as well as across ocean basins. Networks of protected places can help maintain biological connections between interdependent MPAs. A common example is where larvae from one MPA support populations of one or more species within other MPAs or spawning, breeding or key feeding sites for migratory species.

Coastal experience has also demonstrated the value of a representative approach to MPAs that seeks to protect not just what is known to be of value today, but also what may turn out to be important tomorrow. For example, tropical coral reef communities in many parts of the world are now doing better where adjacent mangrove, seagrasses and coral rubble have been protected, though their importance to coral reef ecosystems may not have been and may still not be fully understood.[16]

Representative systems of MPAs seek to provide protection for examples of all major ecosystem components in conjunction with their characteristic habitats and species within and across each bioregion. Authorities in Australia are now developing a "bioregionalization" or biogeographic understanding of ecological communities, to help them achieve their goal of a "comprehensive, adequate and representative system" of MPAs.[17] It will also serve as a cornerstone for ecosystem-based management. Bioregionalization can be done even absent detailed knowledge by taking advantage of available information on fish fauna and other well-known species groups, depth, temperature, salinity, bottom type and complexity. Groups of experts in carefully designed processes have frequently been used to bring together such information. Currently, these efforts can be complemented by complex computer programs such as MARXAN, which can generate a wide variety of network options to achieve the most cost-effective and ecologically efficient results.

Strictly protected areas where no extractive activities are allowed (no-take areas) may provide added value for fisheries management as reference sites for measuring the effects of fisheries-induced changes, and also as sustainability indicators and reference points.[18] Strictly protected areas are also promoted as an important insurance policy as they provide a hedge against uncertainty (including resource assessment uncertainty), risk of fisheries collapse, and provide greater resilience in the face

---

[14] Gell, F.R. and Roberts, C.M. 2003. The fishery effects of marine reserves and fishery closures. WWF: Washington DC, USA, 90 pp; Sweeting, C.J. and Polunin, N.V.C. 2005. Marine Protected Areas for management of temperate North Atlantic Fisheries – lessons learned in MPA use for sustainable fisheries exploitation and stock recovery. A report to DEFRA. 64 pp; Botsford et al., above ft. 3.

[15] Sainsbury, K and Sumalia, U.R., 2003. Incorporating ecosystem objectives into management of sustainable marine fisheries, including "best practice" reference points and use of marine protected areas, in: Responsible Fisheries in the Marine Ecosystems (Sinclair, M. and Valdimarsson, G. (eds.)), FAO, Rome (Italy) 343-361.

[16] Wilkinson, Clive (ed.) 2004. Status of Coral Reefs of the World. Vol. 1. p.103.

[17] Environment Australia 2003. The Commonwealth Marine Protected Areas Program. ISBN 0642549184; Australian Government. 2006. Marine Bioregional Planning.

[18] Sainsbury and Sumalia, above ft. 14.

of ecological and social change by maintaining structure, function and processes of ecosystems and biodiversity.[19]

In the face of increasing oceanic changes, including warming temperatures, shifting circulation patterns and sea water acidification, MPAs are increasingly promoted as a vital precautionary tool to maintain ecosystem health and resilience. As has been suggested by experience with tropical coral reefs, areas that are protected from other external pressures will most likely be better able to withstand such changes.[20] Improving the conservation of marine ecosystems through reforming fisheries management and through representative MPA systems are now viewed by some experts as two essential safeguards to preserving ocean life.[21]

The importance of embedding MPAs in a larger framework for integrated coastal management and/or ecosystem-based management has also been confirmed in coastal areas.[22] Likewise, MPAs for fisheries management are most effective when part of a suite of other measures to improve fisheries sustainability and eliminate destructive practices (e.g. effort reductions, gear restrictions, monitoring and compliance mechanisms). Otherwise the problems may just be shifted elsewhere.[23]

The actual choice, size and spacing of MPAs will depend on the characteristics of the specific ecosystem targeted as well as on conservation and management objectives. It is widely acknowledged that optimal MPA design for fisheries management is subject to considerable uncertainty due to limited knowledge and poor understanding of many aspects of fish biology and ecology. This lack of certainty may sometimes be an impediment to action, but as has been demonstrated elsewhere, management can evolve and adapt as experience and knowledge grow. Moreover, as indicated by Botsford *et al.* (2007) such uncertainty is also a problem affecting fisheries management generally, which additionally has considerable additional problems due to "implementation uncertainty."[24]

Some guidance exists for developing MPAs in data poor situations. For example, Botsford *et al.* (2007) conclude that in such situations "reserves [i.e. no-take MPAs], probably in combination with some form of effort limitation, tend to be more advisable when many species are taken by the same gear and when the resources have a persistent spatial structure due to low mobility of the individuals."

Similarly, experience in areas with complex habitats and relatively sedentary species or periodic aggregations of species suggests that MPAs would also be an appropriate and useful tool for deep-sea fisheries management, despite the dearth of knowledge. A recent review of case studies from Northeast Atlantic temperate waters found that area closures, if combined with effort removal, generally lead to increases in associated fauna, habitat complexity and enhanced survival in fish species.[25] The review also concluded that MPAs play an important role in preventing damage by fishing gear especially to biogenic, slow-growth-recovery habitats (as e.g. maerl beds, deep-water

---

[19] Worm, B., Barbier, E.B., Beaumont, N., Duffy, J.E., Folke, C. Halpern, B.S., Jackson, J.B.C., Lotze, H.K., Micheli, F., Palumbi, S.R., Sala, E. Selkow, K.A., Stachowicz, J.J., and Watson, R (2006). Impacts of Biodiversity Loss on Ocean Ecosystem Services. Science, Vol. 314, pp. 787-790. In this comprehensive study, the authors reported that marine biodiversity loss caused by overexploitation, pollution and habitat destruction is increasingly impairing ocean ecosystem services necessary to provide food, maintain water quality, and recover from perturbations. Based on a mega-analysis of the impacts of 44 fully protected marine reserves and 4 fishery closures, they concluded that marine reserves and closures were an important way to build resilience to reverse these trends.

[20] Schubert, R., Schellnhuber, H.-J., Buchmann, N., Epiney, A., Griesshammer, R., Kulessa, M., Messner, D., Rahmstorf, S., Schmid, J. 2006. The Future Oceans – Warming Up, Rising High, Turning Sour, WGBU German Advisory Council on Global Change. WBGU, Berlin, 110 pp; Grimsditch, G.D. and Salm, R.V. 2006. Coral Reef Resilience and Resistance to Bleaching. IUCN, Gland, Switzerland. 52pp.

[21] Id.

[22] Christie and White, above ft. 3.

[23] ICES WGDEC 2005. Report of the Working Group on Deepwater Ecology (WGDEC), 8-11 March 2005. ICES Headquarters, Copenhagen. ICES CM 2005/ACE:02. 76p.

[24] Botsford et al., above ft. 3.

[25] Department for Environment Food and Rural Affairs (DEFRA). 2006. The potential role of Marine Protected Areas (MPAs) for fisheries management purposes: Fisheries Directorate's summary of the main conclusions emerging from three desk studies. Web-source: http://www.defra.gov.uk/fish/science/index.htm.

corals, sponge communities). In contrast, habitats subject to frequent natural disturbance are unlikely to benefit from MPAs.

Fragmentation of ecosystems and habitats may present a significant threat to deep-sea biodiversity as it does in tropical rainforests. Many marine experts suggest that MPAs need to be vastly scaled up in size and number to maintain foodchain structure, productivity and flows and to safeguard biodiversity at ecosystem, species and genetic levels.[26] Experts may need to investigate the appropriate size and scale of MPAs and MPA networks and systems to ensure comprehensiveness, adequacy and representativity.

As revealed in the discussions at the FAO workshop on MPAs and the background discussion papers, several important lessons have been learned that would be valuable in the deep-sea context as well:

- MPAs require political will as well as supportive legal and jurisdictional frameworks.[27]
- It may be necessary to harmonize legislation between sectors and to ensure institutional coordination, consultation and cooperation among agencies with relevant interests.[28]
- Zonation schemes may be advantageous in locations with sufficient capacity for enforcement of detailed, spatially explicit regulations.[29]
- Involvement of stakeholders both within and beyond MPA boundaries is key. MPAs with community and industry support are generally more successful as it is easier to secure compliance.[30]

An important area for further study is whether stakeholder relations in offshore fisheries may be different from those in coastal areas. In coastal areas, local communities and fishers often have a direct interest in safeguarding a specific area or region, as options for fisheries expansion are limited by time and fuel costs. Is the equation changed in the open ocean, and particularly on the High Seas, where fishers are free to move on to new areas or resources?[31] Is there less economic incentive for High Seas fishers to support sustainable management of the fishery? To secure effective enforcement of High Seas MPAs, persistent problems of illegal, unregulated and unreported (IUU) fishing activities and non-compliance by some RFMO member states will need to be considered and addressed. As will be described in Section 7 below, significant new efforts may be necessary to enhance compliance and secure enforcement with deep-sea fisheries conservation and management measures.

3. OVERVIEW OF MAIN RATIONALES AND VIEWS EXPRESSED FOR THE CREATION OF HIGH SEA MPAs

On the High Seas, the main rationales for creation of MPAs are similar to those described above for coastal areas. In addition, MPAs are viewed as an important vehicle for implementing the "shared obligations of all countries to protect against the destruction of marine species and ecosystems, and the collapse of shared fisheries."[32] Under the international law of the sea as reflected in UNCLOS, all nations are entitled to exercise their high seas freedoms consistent with their obligations to protect the marine environment, to conserve natural resources, and to cooperate with other States for these

[26] See Sainsbury and Sumalia, above ft. 14.
[27] Young, above ft. 2. Christie and White, above ft. 3. Strong traditions and cultural norms may replace the need for a legal base among local users, but may not provide adequate protection from outsiders.
[28] Martin et al., above ft. 3
[29] Christie and White, above ft. 3.
[30] Martin *et al.*, above ft. 3.
[31] F. Berkes, T. P. Hughes, R. S. Steneck, J. A. Wilson, D. R. Bellwood, Crona, C. Folke, L. H. Gunderson H. M. Leslie, J. Norberg, M. Nyström, P. Olsson, H. Österblom, M. Scheffer, B. Worm, 2006. Globalization, Roving Bandits, and Marine Resources. Science Vol 311 17 March 2006 1557-1558.
[32] Young, above ft. 2, at page 11.

purposes.[33] The UN Fish Stocks Agreement further elaborates on these duties by requiring the use of best scientific information available and the application of the precautionary approach to protect biodiversity in the marine environment.[34]

The high level of support by most governments for High Seas MPAs today was presaged by commitments made at the 2002 World Summit on Sustainable Development (WSSD) to significantly reduce the rate of loss of biodiversity by 2010 (para. 44), and to promote ocean conservation and sustainable development (paras. 30-32). In specific, world leaders committed to:

30(d) Encourage the application by 2010 of the ecosystem approach,

32(a) Maintain the productivity and biodiversity of important and vulnerable marine and coastal areas, including in areas within and beyond national jurisdiction,

32(c) Develop and facilitate the use of diverse approaches and tools, including the ecosystem approach, the elimination of destructive fishing practices, the establishment of marine protected areas consistent with international law and based on scientific information, including representative networks by 2012 and time/area closures for the protection of nursery grounds and periods, proper coastal land use and watershed planning and the integration of marine and coastal areas management into key sectors…

One of the primary driving forces for High Seas MPAs is concern by many states, scientists, conservation organizations and the public over the impacts of fishing activities on marine biodiversity. Evidence of declines in fish stocks, ecosystem shifts and collapses, bycatch of vulnerable long-lived species such as albatrosses, leatherback and loggerhead sea turtles, sharks and marine mammals, and destruction of benthic habitats by bottom dragging gear were perceived as not being addressed effectively by traditional fisheries management tools or organizations in line with public expectations or with the biodiversity protection and impact minimization requirements of the UN Fish Stocks Agreement (articles 5(g) and 5(f)) or of the FAO Code of Conduct for Responsible Fishing (article 6.6).

With respect to deep-sea fisheries, MPAs – in conjunction with gear restrictions and effort controls – are viewed as an important vehicle for protecting vulnerable deep-sea ecosystems. Mounting concern over the impacts of deep-sea bottom trawling on seamounts, cold water corals and other vulnerable ecosystems resulted in a United Nations General Assembly (UNGA) resolution in 2004 (UNGA 59/25) that urged States and regional fisheries management organisations (RFMOs) to take urgent action to protect seamounts, cold water corals and hydrothermal vents from destructive fishing practices, including bottom trawling that has adverse impacts on vulnerable marine ecosystems.[35] In

---

[33] On the high seas, all states are entitled to enjoy the freedoms of navigation, overflight, laying of submarine cables and pipelines, construction of artificial islands or installations, fishing, and marine scientific research, subject to the conditions laid down in UNCLOS and other rules of international law. The duties to protect the marine environment, including rare or fragile ecosystems as well as the habitat of depleted, threatened and endangered species and other forms of marine life, and to cooperate on a global or regional basis for the protection of the marine environment, are stated in UNCLOS Articles 192, 194.5 and 197. The duties to conserve living resources in the high seas and to cooperate for these purposes are specified in UNCLOS Articles 116-120. Thus UNCLOS imposes specific conditions on the exercise of these high seas freedoms. Kimball above ft. 7.

[34] Young, above ft. 2 at page 13, citing Fish Stocks Agreement articles 5(b)(c)(d).

[35] In Res 59/25, the UN General Assembly:

> 66. Calls upon "States, either by themselves or through regional fisheries management organizations or arrangements, where these are competent to do so, to take action urgently, and consider on a case-by-case basis, and on a scientific basis, including the application of the precautionary approach, the interim prohibition of destructive fishing practices, including bottom-trawling that has adverse impacts on vulnerable marine ecosystems, including seamounts, hydrothermal vents and cold-water corals located beyond national jurisdiction, until such time as appropriate conservation and management measures have been adopted in accordance with international law;
>
> 67. Calls upon regional fisheries management organizations or arrangements with the competence to regulate bottom fisheries to urgently adopt, in their regulatory areas, appropriate conservation and management measures, in accordance

2006 the UN Secretary General released a report on the Impacts of Fishing on Vulnerable Marine Ecosystems: Actions taken by States and regional fisheries management organizations and arrangements.[36] This report concluded that: "Some States have undertaken, or are in the process of undertaking, extensive efforts to protect some fishery habitat areas within their national jurisdiction, in particular through the establishment of protected areas. However, this is not the case in the high seas, though deep-sea habitats in these areas are extremely vulnerable and require protection."[37]

In response to these concerns, in November 2006 the UNGA called on States and RFMOs to take measures to "prevent significant adverse impacts on vulnerable marine ecosystems" or to refrain from fishing.[38] The relevant paragraphs of this UNGA Resolution on Sustainable Fisheries are further described in Section 3 and attached in Annex II.

The UN Fish Stocks Agreement Review Conference in May of 2006 also emphasized the need for RFMOs to take significant steps to reduce fishing impacts on marine biodiversity and to incorporate the ecosystem and precautionary approaches more fully into all types of fisheries management measures. The Review Conference urged States and RFMOs to develop management tools, *to include marine protected areas*, to effectively conserve and manage straddling and highly migratory fish stocks and discrete high seas fish stocks and to protect habitats, marine biodiversity and vulnerable marine ecosystems in accordance with the best available scientific information and consistent with international law.[39]

---

with international law, to address the impact of destructive fishing practices, including bottom-trawling that has adverse impacts on vulnerable marine ecosystems, and to ensure compliance with such measures;

68. Calls upon members of regional fisheries management organizations or arrangements without the competence to regulate bottom fisheries and the impacts of fishing on vulnerable marine ecosystems to expand the competence, where appropriate, of their organizations or arrangements in this regard;

69. Calls upon States to urgently cooperate to establish new regional fisheries management organizations or arrangements, where necessary and appropriate, with the competence to regulate bottom fisheries and the impacts of fishing on vulnerable marine ecosystems in areas where no such relevant organization or arrangement exists;

70. Requests the Secretary-General, in cooperation with the Food and Agriculture Organization, to include in his next report concerning fisheries, a section on the actions taken by States and regional fisheries management organizations and arrangements to give effect to paragraphs 66 to 69 above in order to facilitate discussion of the matters covered in those paragraphs; (UNGA 59/25, para. 66-70).

[36] UN Sec. Gen. 2006. The Impacts of Fishing on Vulnerable Marine Ecosystems: Actions taken by States and regional fisheries management organizations and arrangements to give effect to paragraphs 66 to 69 of General Assembly resolution 59/25 on sustainable fisheries, regarding the impacts of fishing on vulnerable marine ecosystems Report of the Secretary-General July 2006 A/61/154 (hereinafter UN Sec. Gen. Impacts of Fishing Report).

[37] Id., para. 203.

[38] UNGA 61/L.38. Paragraph 83 contains the key operative language:

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

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

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

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

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.

[39] UNFSA 2006. Report of the Review Conference on the 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 A/CONF.210/2006/15.

A second driving force is the desire to improve biodiversity conservation through an ecosystem approach to oceans management.[40] Representative networks of MPAs and other area-based management measures are widely viewed as key tools – though not the only ones – to improve integrated conservation and sustainable use of marine biological diversity beyond areas of national jurisdiction.[41] Thus High Seas MPAs were endorsed at both the CBD Conferences of the Parties[42] and at the UN *Ad hoc* Open-ended Informal Working Group to study issues relating to the conservation and sustainable use of marine biological diversity beyond areas of national jurisdiction (hereinafter UN High Seas Working Group). Discussions continue as to how best to implement High Seas MPAs in the context of a wider ecosystem approach to High Seas management and within the framework of UNCLOS. As some states fear that High Seas MPAs may impinge on high seas freedoms, it is acknowledged that such MPAs should be established consistent with international law and in the context of best available scientific information, the precautionary approach and the ecosystem approach.

A third major driver is the desire to improve the results of conventional fisheries management by implementing an ecosystem approach to fisheries management.[43] Fisheries managers and others hope that observed declines in global fish stocks and damage to associated habitats can be prevented or reversed by moving beyond traditional single species management to also incorporate action to protect ecosystem processes, structures and functions through new tools such as MPAs.

At its 26th session in March 2005, FAO's Committee of Fisheries (COFI) recommended that FAO develop technical guidelines on the design, implementation and testing of MPAs and agreed that FAO should assist its members to achieve the World Summit on Sustainable Development (WSSD) goal with respect to representative networks of MPAs by 2012.[44] As a result, FAO hosted a workshop in June 2006 on MPAs, and some RFMOs are also initiating measures (see Section 6 below). The November 2006 UNGA Sustainable Fisheries resolution specifically "encourages accelerated progress to establish criteria on the objectives and management of marine protected areas for fisheries purposes."[45] It further welcomes the proposed work of FAO on the technical guidelines and urges coordination and cooperation among all relevant international organizations and bodies.

Within the fishing industry, views have been changing with regard to MPAs. Many who were initially opposed to MPAs at the national level now see them as valuable tools for improving sustainability and for protecting habitat. In at least one instance MPAs have also served to broaden domestic support for expenditure on effective enforcement against illegal, unreported and unregulated (IUU) fishing.[46] For example, industry support for the Heard Island and McDonald Islands (HIMI) Marine Reserve in the sub-Antarctic waters of Australia resulted in establishment of one of the largest MPAs on the planet.[47] In New Zealand, after years of contesting the government's designation of 19 seamounts as protected areas, seafood industry leaders proposed their own "Benthic Protected Areas" encompassing 31 percent of New Zealand's EEZ. In the Southern Indian Ocean, an industry alliance, the Southern Indian Ocean Deepwater Fishers Association[48] (SIODFA), recently agreed to prohibit trawling by their

---

[40] See the Scientific Consensus Statement on Marine Ecosystem-Based Management, ft. 9 above.
[41] Report of the United Nations Ad hoc Open-ended Informal Working Group to study issues relating to the conservation and sustainable use of marine biological diversity beyond areas of national jurisdiction A/61/65, para 59-62 (hereinafter UN High Seas Working Group Report).
[42] CBD Decision VII/5 February 2004 calls for effectively managed and ecologically based MPAs that contribute to a global network, building on national and regional systems. It also notes that MPAs beyond national jurisdiction are extremely deficient in purpose, numbers and coverage. CBD Decision VIII/24 March 2006 calls for the CBD Executive Secretary, Parties and other States to cooperate to develop scientific and technical information, including scientific and ecological criteria, relevant to High Seas MPAs.
[43] Martin et al., above ft. 3.
[44] FAO Committee on Fisheries, 2005. COFI Report, para. 103.
[45] UNGA 61/L.38, 2006 Resolution on Sustainable Fisheries, para. 92.
[46] Graham, A., 2006. Personal observation.
[47] Gotheil, above ft. 10.
[48] Austral Fisheries Pty Ltd, Perth, Australia; Bel Ocean II Ltd, Port Louis, Mauritius; Sealord Group, Nelson, New Zealand; TransNamibia Fishing Pty Ltd, Walvis Bay, Namibia.

companies' vessels in 11 areas of the Southern Indian Ocean to protect benthic biodiversity and sites of outstanding scientific interest.[49]

Some in the fishing industry and a few countries still perceive MPAs as a threat to their economic interests and their freedom to fish without restraint. They may also perceive MPAs and the new focus on biodiversity conservation as a threat to their dominance in decision making within fisheries management arenas. According to Molenaar, some States fear that biodiversity conservation or non-utilization of marine living resources may become superior to the socio-economic interests of utilization.[50] Others assert that there is a pressing need to improve the current balance between biodiversity conservation and socio-economic considerations to meet the requirements in UNCLOS, CBD and the Fish Stocks Agreement to protect and preserve the marine environment and to conserve and sustainably use marine living resources.

It should also be noted that some scientists and others have questioned whether MPAs are the right way to protect deep-sea habitats beyond national jurisdiction, as too little is known about their ecology, function and locations to identify which areas should be protected.[51] They also note the ICES's Working Group advice in 2005 on the danger of relying on incomplete information, since decisions to close areas to bottom trawling may inadvertently divert trawling to similarly sensitive habitats that are currently unmapped.[52] Instead they support an immediate interim prohibition of deep sea bottom trawling for the High Seas. Some scientists further caution that deep-sea ecosystems such as seamounts, corals and sponges warrant complete protection because of their value as "ecosystem engineers" and biodiversity reservoirs (see Section 4).

In response, some States and industry representatives now view MPAs as the less restrictive and hence preferable alternative to a global gear restriction, even a temporary one.

4. PRESENT STATUS OF HIGH SEAS MPAs: OPPORTUNITIES AND MAIN HURDLES

As noted above, there is a high level of support among many countries for High Seas MPAs as a tool for implementing ecosystem-based oceans and fisheries management, provided they are established consistent with international law and based on the best available science and the precautionary approach.

Yet additional effort to meet the 2012 target for representative networks is required at a variety of levels and in a variety of arenas. As was recognized at the UN High Seas Working Group, there is a need for further work within the framework of UNCLOS to develop an integrated approach to

---

[49] Industry initiatives to declare "benthic protected areas" are a welcome step. However, some have raised concern over the selection process. When New Zealand's National Institute of Water and Atmospheric Research (NIWA) assessed the industry proposed Benthic Protected Areas (BPAs) in New Zealand's EEZ using advanced reserve selection software, their report concluded that "…despite their large geographic area, the focus of this proposal on existing areas that have both very low fishing value and low fish diversity, makes it a poor option for the long-term protection of demersal fish diversity in New Zealand's EEZ." Leatherwick, J., Julian, K., and Francis, M. 2006. "Exploration of the use of reserve planning software to identify potential Marine Protected Areas in New Zealand's Exclusive Economic Zone" NIWA Client Report HAM2—6-064. An NGO analysis of the Southern Indian Ocean BPAs indicated that much of the voluntarily closed areas were in depths below 2 000 m where bottom trawling was unlikely to occur. Deep Sea Conservation Coalition, 2006. http://www.savethehighseas.org/publicdocs/Indian-Ocean-map.pdf. It is suggested that this concern underscores the necessity of having a clear and open process for selection and designation of MPAs, one that is based on the best available science, data that are shared by all, and includes industry and conservation organizations as part of the process, with the support of governments that can patrol and enforce the applicable regulations.

[50] Molenaar, E.J. 2005. "Addressing Regulatory Gaps in High Seas Fisheries" in The International Journal of Marine and Coastal Law special issue on High Seas Fisheries Governance Moving from Worlds to Action (Gjerde, K.M. (ed.), vol 20, nos. 3-4. pp. 533-571. A few countries may remain opposed to High Seas MPAs based on concerns that they may inhibit the high seas freedom of navigation.

[51] ICES WGDEC, above ft. 22.

[52] Id.

establishing, managing and enforcing High Sea MPAs, recognizing the existing role and mandate of such bodies as FAO, the International Maritime Organisation (IMO) and the Convention on Biological Diversity and of regional seas conventions.[53]

Work is already underway to develop criteria for the identification of ecologically and biologically significant areas, representative systems of MPAs, and biogeographic classification systems. As previously mentioned, the FAO has been charged with developing technical guidelines for the design, establishment and management of MPAs for fisheries management purposes and has already sponsored one workshop on this topic.[54] The Canadian government in December 2005 hosted an experts' workshop on criteria to identify ecologically and biologically significant areas.[55] The Autonomous University of Mexico, in cooperation with the Australian and Canadian governments, UNESCO and its Intergovernmental Oceanographic Commission (IOC), and the World Conservation Union (IUCN), convened a workshop in January 2007 on biogeographic classification systems for the open ocean and deep seabed. The Portuguese government is planning a workshop in October 2007 to further develop criteria for High Seas MPAs and representative systems and networks of MPAs. All these workshops will feed into discussions at relevant UN, CBD and regional processes.

With respect to deep-sea fisheries and MPAs, the November 2006 UNGA Resolution on Sustainable Fisheries[56] calls on States and RFMOs to assess the impacts of all types of bottom fishing on the high seas, and within 1-2 years to prohibit any high seas bottom fisheries which cannot be managed to prevent "significant adverse impacts" to vulnerable marine ecosystems. The resolution further calls on States to close areas of the high seas to all bottom fishing where vulnerable marine ecosystems are known or *likely* to occur, unless or until they are able to regulate such fisheries to prevent significant adverse impacts on vulnerable marine ecosystems. Also, the UNGA called for development of standards and criteria for identifying vulnerable marine ecosystems and the creation of a global database of information on vulnerable marine ecosystems in the High Seas. MPAs may be one of the means that states and RFMOs prefer to "prevent significant adverse impacts on vulnerable marine ecosystems." The global database on information regarding vulnerable marine ecosystems could make a significant contribution towards identifying potential areas for MPAs.

At the same time, the International Seabed Authority (ISA) is fostering efforts to identify criteria for "preservation reference zones" and MPAs on the deep seabed with regard to seabed mining activities. Research coordinated through the ISA has been critical in fostering efforts to fill many of the data gaps on deep seabed ecosystems. Rapid advances in understanding the diversity, distribution and abundance of deep-sea life and how it changes over time are being fostered by coordinated research projects such as the Census of Marine Life (CoML) and the Hotspot Ecosystem Research on Margins of European Seas (HERMES) project.

The IMO has recently adopted revised guidelines for the identification and designation of Particularly Sensitive Sea Areas (PSSAs). While shipping is unlikely to directly affect deep seabed ecosystems, it may have impacts through shipwrecks containing potentially harmful cargoes (e.g. the Prestige) and through operational discharges of ship-board wastes, including deliberately discarded fishing gear. The PSSA Guidelines may provide a useful tool for identifying areas in need of a higher level of protection from the impacts of shipping, including on the High Seas.[57]

Though it is acknowledged that the UNGA has the central role in legal developments regarding High Seas MPAs, the CBD parties and Secretariat maintain an active interest and role in progressing High

[53] UN High Seas Working Group Report, above ft. 40.
[54] Key Points from FAO Workshop on MPAs, above ft. 3.
[55] Rice, J. 2006. Report Of The Scientific Experts' Workshop On Criteria For Identifying Ecologically Or Biologically Significant Areas Beyond National Jurisdiction– 6-8 December 2005, Ottawa, Canada, Fisheries & Oceans Canada www.biodiv.org/doc/meetings/ cop/cop-08/information/cop-08-inf-39-en.doc.
[56] UNGA 2006 Res. 61/L.38.
[57] IMO Res. A.982(24) adopted on 1 December 2005. Revised Guidelines For The Identification And Designation Of Particularly Sensitive Sea Areas.

Seas MPAs. The 8th CBD Conference of the Parties (COP) in March 2006 agreed that the CBD has a key role in supporting the UNGA work by providing scientific and as appropriate, technical information and advice relating to marine biodiversity, the application of the ecosystem approach and the precautionary approach and delivering the 2010 target [for achieving a significant reduction in the rate of loss of biodiversity].[58] At the 9th COP in 2008, CBD parties will consider progress with work identified in its decisions relating to conservation and sustainable use beyond national jurisdiction, including MPAs. Also the 9th COP will consider further supporting action as required, in cooperation with competent international bodies.[59] The 8th CBD COP further invited the UNGA to establish a timely follow-up process to the first UN High Seas Working Group to continue discussion on ways to enhance conservation and sustainable use of biodiversity beyond national jurisdiction. In November 2006, the UNGA approved a second meeting of the Working Group in 2008.

The 2008 UN High Seas Working Group will provide an important forum for discussing MPAs and the wider issue of High Seas biodiversity conservation. It will focus on five topics with respect to marine biological diversity beyond areas of national jurisdiction:

- The environmental impacts of anthropogenic activities;
- Coordination and cooperation among States as well as relevant intergovernmental organizations and bodies for conservation and management;
- The role of area-based management tools;
- Genetic resources beyond areas of national jurisdiction; and
- Whether there is a governance or regulatory gap, and if so, how it should be addressed.[60]

The UN High Seas Working Group will be in a good position to address governance and regulatory gaps in the high seas legal regime that may hinder the establishment of High Seas MPAs. As noted by Young (2006), UNCLOS provides the general framework for regulating activities on the high seas, but it lacks specific regulatory measures that could govern MPA establishment and management at the international level.[61] To address this gap, the European Union has proposed an implementing agreement to UNCLOS. According to the 2006 UN High Seas Biodiversity Working Group Report, some of the goals of such an agreement could be to more explicitly incorporate the principles of ecosystem management and precaution into High Seas biodiversity conservation, to develop mechanisms to establish and enforce MPAs, to develop requirements under UNCLOS and the CBD for environmental impact assessments, and to enhance cooperation and coordination among international organizations and bodies. Some nations do not see the need for a new instrument to support MPA establishment, on the grounds that existing regulatory regimes are sufficient to provide at least sector-specific protection.[62] For example, many RFMOs are now empowered to adopt biodiversity conservation measures, including closed areas. Thus progress on a comprehensive system of MPAs might be hindered by lack of a specific international agreement, but it would still be possible to designate MPAs with respect to fisheries activities via RFMOs, given political will.

At the regional level, Parties to the OSPAR Convention for the protection of the Northeast Atlantic have committed to developing an ecologically coherent network of MPAs by 2010 that includes a large section of the Northeast Atlantic beyond national jurisdiction. OSPAR has already developed MPA criteria and management guidelines.[63] Progress within the OSPAR Region on High Seas MPAs has been slow as some members maintained that absent an agreement at the international level, OSPAR lacked the competence to establish and manage High Seas MPAs. The Mediterranean has a specific legal agreement that enables designation of MPAs beyond national jurisdiction. This

[58] UNEP/CBD/COP/VIII/24.
[59] Id., at paras. 8 and 9.
[60] 2006 UN General Assembly Oceans and Law of the Sea Resolution 61/L.30. Relevant paragraphs are in Annex III.
[61] Young, above ft. 2 and Kimball, above ft. 7 provide a comprehensive overview of the international legal regime regarding high seas MPAs.
[62] UN High Seas Biodiversity Working Group Report, above ft. 40.
[63] Kimball, above ft. 7.

agreement provided the basis for designation in 2001 of the Pelagos Sanctuary for Mediterranean Cetaceans straddling areas within and beyond national jurisdiction.[64]

The Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) and the Committee for Environmental Protection of the Antarctic Treaty have recently considered means to work on the bioregionalization of the Southern Ocean and on the development of scientifically-based principles and criteria for MPAs. CCAMLR's mandate, unlike many RFMOs, specifically calls for it to promote conservation of all Antarctic marine living resources. Conservation is defined to include "rational use" as well as the obligations to maintain ecological relationships and to prevent or minimize the risk of changes in the marine ecosystem that are not potentially reversible over two or three decades.[65]

At the scientific level, progress towards MPAs may be stymied if efforts to obtain data and understanding are not rapidly escalated and do not precede expansion of deep-sea fisheries into new areas. CCAMLR has strict rules to control new and emerging fisheries, and to prevent them from expanding in effort or area when adequate information is lacking. Similar controls have been adopted with respect to specific areas within NEAFC, NAFO and SEAFO, but are not applied outside these temporarily protected areas (see Section 9).

Promising new approaches are being developed to identify sensitive benthic habitats for priority protection as well as to scope out biogeographic regions and classification systems. These systems are based on modelling the environmental preferences of specific groups of species inhabiting vulnerable areas. Using one of these approaches, known as Environmental Niche Factor Analysis, scientists within the Census of Marine Life (CoML) Census of Seamounts (CenSeam) programme have predicted what seamounts globally are likely to be favourable for the growth of stony corals.[66] These data can be overlayed on information relating to the occurrence of commercially valuable fish species, identifying areas where fisheries are likely to impact on stony coral communities. Using such methods, scientists can "fill in gaps" in our knowledge of the distribution of species in vulnerable habitats, helping managers to direct conservation efforts at areas likely to be sensitive to environmental impacts of fishing.

Efforts to develop seamount classification systems based on biological and physical factors are progressing but nevertheless remain hampered by lack of basic data.[67] Brodie and Clark (2003)

---

[64] Id.

[65] ARTICLE II of CCAMLR provides:

1. The objective of this Convention is the conservation of Antarctic marine living resources.

2. For the purposes of this Convention, the term 'conservation' includes rational use. Any harvesting and associated activities in the area to which this Convention applies shall be conducted in accordance with the provisions of this Convention and with the following principles of conservation:

(a) prevention of decrease in the size of any harvested population to levels below those which ensure its stable recruitment. For this purpose its size should not be allowed to fall below a level close to that which ensures the greatest net annual increment;

(b) maintenance of the ecological relationships between harvested, dependent and related populations of Antarctic marine living resources and the restoration of depleted populations to the levels defined in sub-paragraph (a) above; and

(c) prevention of changes or minimization of the risk of changes in the marine ecosystem which are not potentially reversible over two or three decades, taking into account the state of available knowledge of the direct and indirect impact of harvesting, the effect of the introduction of alien species, the effects of associated activities on the marine ecosystem and of the effects of environmental changes, with the aim of making possible the sustained conservation of Antarctic marine living resources.

[66] Clark, M.R., Tittensor, D., Rogers, A.D., Brewin, P., 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. Census of Marine Life on Seamounts (CenSeam) Data Analysis Working Group, UNEP, UNESCO IOC, CoML and NIWA. UNEP-WCMC, Cambridge, U.K. Limited data on octocorals prevented their inclusion in the study.

[67] Brodie, S. and Clark, M. 2003. The New Zealand Seamount Management Strategy – Steps towards Conserving Offshore Marine Habitat. In Beumer, J.P., Grant, A., Smith, D.C. (eds). Aquatic Protected Areas: what works best and how do we know? Proceedings of the World Congress on Aquatic Protected Areas, Cairns, Australia, August 2002. Australian Society of Fish Biology, pp. 664-673; Rowden, A.A., Clark, M.R. and Wright, I.C., 2005. Physical characterisation and a biologically

describe the initial process used to identify 19 seamounts as candidate MPAs in New Zealand. The biophysical criteria used were: representativeness, comprehensiveness, ecological importance and uniqueness, productivity, vulnerability and naturalness. Scientists divided the region into four basic biogeographic regions, and then refined the regions based on other factors likely to influence species distribution in and around the seamount. These included: depth in the water column; elevation; area; gradient, water mass at depth; sediment types (e.g. ooze, coral, rocky, often heterogeneous on any single seamount); and geological association. Scientists were unable to develop a biologically focused classification for all known New Zealand seamounts because they had insufficient data to classify almost 50 percent of them.

Computer tools and the use of proxies as surrogates for data can help overcome some of the data deficiency problems in developing representative MPA systems. Scientists at the University of York have laid out another approach for identifying potential areas to serve as part of a proposed global network of strictly protected marine reserves on the High Seas.[68] The network developers used existing data from a wide variety of sources, including expert advice, and fed the data into the computer program MARXAN to determine the optimal configuration for the marine reserve network. The selected sites were chosen according to a set of defined principles: the coverage of 40 percent of biogeographic zones, bottom types, fauna and oceanographic features. Similar approaches have been used elsewhere to design MPAs and MPA networks, including in the Great Barrier Reef Marine Park.

As evidenced by the industry–led initiative to ban bottom trawling in specific areas in the Southern Indian Ocean, the fishing industry may possess the most detailed geophysical, fisheries and bycatch information upon which to identify potentially vulnerable areas. However, to date such information has not been made widely available. To solve the issue of information insufficiency, the fishing industry, together with all other data holders such as national marine scientific research institutions, could be requested to share their data through the new global database on vulnerable marine ecosystems called for in the 2006 UNGA resolution. Additionally, the burden of proof to establish where it is safe to fish might be placed on the fishers themselves, as they are in the best position to obtain and make available the necessary information.

It is clear that significant cooperative efforts using information from all available sources will be essential. At the same time, there is a need for an agreed process to be in place in all regions and/or at the global level for identifying MPAs and establishing protective measures (See Section 8). To enhance confidence in High Seas MPAs, mechanisms for transparent, science-based and participatory decision-making for their selection, monitoring, management and enforcement will need to be established. To implement effectively an ecosystem-approach to the High Seas, mechanisms are also needed to ensure conservation and sustainable use outside of the MPAs.

5. HIGH SEAS MPAs AND DEEP-SEA FISHING: SPECIAL CONSIDERATIONS RELATED TO SPECIES/HABITAT SPECIFICITIES (BENTHIC) AND CONSERVATION

The current state of knowledge with respect to deep-sea benthic habitats and species as they relate to deep-sea fishing has been summarized in the comprehensive report of the UN Secretary General of the Impacts of Bottom Fishing. Rather than once again summarizing the extensive literature on the topic,

---

focussed classification of "seamounts" in the New Zealand region", New Zealand Journal of Marine and Freshwater Research. Data on sediment type and surface complexity are key, but data may also be needed on association, origin, depth at peak, depth at base, elevation, slope, area, Chl. a, distance to continental shelf, wintertime SST, annual amplitude of SST, spatial SST gradient and summertime SST anomaly. Intensive sampling remains required to test the biological meaningfulness of the proposed New Zealand classification system and to ensure that it does not underestimate biological diversity.

[68] Roberts, C.M., Mason, L. and Hawkins, J.P. 2006. Roadmap to Recovery: a global network of marine reserves. Greenpeace 2006. Available at:http://oceans.greenpeace.org/en/our-oceans/marine-reserves/roadmap-to-recovery

the relevant paragraphs from the UN report are extracted below, followed by some supplemental information:

29. Among all the fishing gears currently used particular concern has been raised over the adverse impacts of bottom trawling on vulnerable marine ecosystems and their associated biodiversity. Bottom trawling raises two main issues. One concern, common to all fishing gear, is the sustainability of the exploitation of target fish stocks due to excess fishing effort or capacity. The second is the ecosystem impacts of trawl fisheries deriving from: (i) the inadequate selectivity of trawl nets and consequent impact on target species (through capture of juveniles) and non-target species whether discarded or not; and (ii) their physical impact on the bottom, and its fauna and the resulting damage to vulnerable ecosystems as critical habitats for marine biodiversity.

32. While there is some evidence to suggest that bottom-set longlines, bottom-set gillnets, pots and traps (including when "ghost fishing"), all may be impacting the deep-sea, bottom trawling and dredging appear to be having the most obvious disruptive impact due to their widespread use and their contact with the bottom.

50. Deep-sea habitats are particularly sensitive to anthropogenic disturbance due to the longevity, slow growth, low reproductive rates and endemism of the individuals that structure the habitat, their susceptibility to increased sedimentation, their fragility and limited ability to recover from physical fragmentation. A large number of studies have documented the effects of mobile fishing gear on benthic habitat, including the loss of habitat complexity, shifts in community structure, and changes in ecosystem processes.

52. A number of studies provide evidence of damage to deep-sea benthic communities. For example, damage to benthic invertebrates on seamounts by fishing activities has been well documented. Also impacted are deep-water precious corals which often occur in the area of seamounts. With their slow growth rates and often low levels of recruitment, if depleted, coral community recovery could take centuries. ….

53. Some species of sponges appear so fragile that they totally disintegrate when hit by the pressure wave from trawl gear.

The design and implementation of MPAs for deep-sea fisheries may also benefit from considering other attributes of deep-sea life and processes. Some of these are highlighted below.

Only 4 percent of the seafloor consists of mid-ocean ridges, seamounts and submarine canyons, making them quite rare in contrast to the extent of abyssal plains and sedimented slopes.[69] The steep angles and generally faster currents along ridges, seamounts and canyons keep the surfaces clear of sediment, providing habitats suitable for growth of large sessile suspension feeders, including a wide variety of soft, stony and reef building corals, sponges, hydroids and echinoderms (feather stars and crinoids). These erect species in turn provide structural complexity and habitat for a wide variety of other species, such that many scientists consider them as "ecosystem engineers", vital centres of ecological activity similar to trees in a forest.[70]

Fish species richness and abundance are often far greater on seamounts, coral reefs and other complex benthic habitats than on the surrounding seabed.[71] Video surveys of Lophelia reefs in the Northeast Atlantic revealed that far more fishes (80 percent abundance) and more fish species (92 percent) are associated with *Lophelia* reefs than the adjacent seabed, and that 17 of the 25 species recorded were of

[69] Glover, A.G. and Smith, C.R. 2003. The deep-sea floor ecosystem: current status and prospects of anthropogenic change by the year 2025. Environmental Conservation 30(3): 219-241.
[70] Clark et al., above ft. 65.
[71] Costello, M.J., McCrea, M., Freiwald, A. 2005. Role of cold-water Lophelia pertusa coral reefs as fish habitat in the NE Atlantic. In: Cold-water Corals and Ecosystems (A. Freiwald and J.M. Roberts (eds.)). Springer-Verlag, Berlin Heidelberg, pp. 771-805.

commercial importance. Costello *et al.* (2005) conclude that the loss of reefs would result in a reduced abundance and biodiversity of fish due to habitat loss, while calling for further research.

The protruding mass of seamounts interacts with currents, which generally serves to concentrate local food supplies. Thus benthic and pelagic communities are often of high biomass compared to surrounding areas. Almost 800 species have been observed in and around seamounts, though not all are directly seamount associated.[72] The best known seamount associated species are: orange roughy, alfonsinos, pelagic armourhead, oreos, and rockfishes, which may form dense aggregations over seamounts to spawn or feed.[73] Pelagic predators have also been found in increased numbers in the water column around seamounts, including species of tunas, billfishes, sharks, marine mammals and seabirds. These pelagic fish primarily use seamounts as feeding grounds, but may also use the areas for spawning and nursery grounds and possibly as navigational markers.[74]

The depths of greatest coral diversity and abundance may frequently coincide with the preferred range for seamount fisheries, i.e., in the upper 1 500 m. A recent report by the CenSeam Data Analysis Working Group reveals that most cold water corals occur between 250 m to 1 500 m, with some species (octocorals) prevalent down to 2 000 m. The diversity of corals is generally greatest on the peaks and upper slopes of seamounts, where the currents are strongest.[75] This is also the area of greatest intensity of fishing on seamounts.[76] The preferred depth range for alfonsino is between 250 m and 750 m and for orange roughy between 700 m and 1 200 m depth.[77] Recent efforts to model stony coral distribution also show that geographic areas where fisheries take place for alfonsino and orange roughy also coincide with areas which are favourable for the occurrence of these corals (e.g. SW Indian Ocean).[78]

Trawling that contacts the bottom is widely recognized as the most destructive form of deep-sea fishing with regard to impacts to the seafloor habitats and benthic communities. Large-scale destruction of deep-sea coral reefs and coral and sponge beds has been recorded from many parts of the world.[79] On seamounts, the entire framework of a cold-water coral reef along with the associated fauna can be removed. Suggestions by New Zealand commercial fishers that the impact of fishing can be restricted to the "trawl corridor" (preferred tow path), leaving adjacent areas on the same seamount unaffected, have not been upheld by research to date.[80] O'Driscoll and Clark (2005) observed that targeted seamounts usually showed at least some trawling in all directions. O'Driscoll and Clark further note that even a small number of tows may lead to significant impact. A single trawl can sweep the seafloor over a width of 100-200 m (doorspread). On a small seamount the threshold level of five tows in a given direction may represent a significant fraction of the total seabed area.[81] The intensity of trawling on seamounts is often quite high. Clark and O'Driscoll (2003) reported that between several hundred and several thousand trawls may be carried out on small seamount features in the New

[72] Froese, R. and Sampang, A. 2004. Taxonomy and biology of seamount fishes. In: Seamounts: Biodiversity and Fisheries (eds. T. Morato and D. Pauly). Fisheries Centre, University of British Columbia, Canada. Fisheries Centre Research Reports, 12 (5), 25-31; Morato, T., Cheung, W.W.L. and Pitcher, T.J. (2004) Additions to Froese and Sampang's checklist of seamount fishes. In: T. Morato and D. Pauly (eds.), Seamounts: Biodiversity and Fisheries. Fisheries Centre Research Reports 12 (5) Appendix 1: 1-6. Fisheries Centre, University of British Columbia, Canada.
[73] Morato, T. and Clark, M. in press. Seamount fishes: ecology and life histories. In: Seamounts: Ecology, Fisheries and Conservation (eds. T.J. Pitcher, P.J.B Hart, T. Morato, R.S. Santos, and M.R. Clark). Blackwell.
[74] Allain, V., Kirby, D., and Kerandel J. 2006. Seamount Research Planning Workshop Report, 20-21 March 2006. Oceanic Fisheries Program, Secretariat of the Pacific Community, Noumea, New Caledonia. WCPFC-SC2-2006/EB IP-5, pp. 56.
[75] Clark et al., above ft. 65.
[76] Clark, M. R, and O'Driscoll, R.L,. 2003. Deepwater Fisheries and Aspects of Their Impact on Seamount Habitat in New Zealand; Journal of Northwest Fisheries Science, 441- 458.
[77] Australia Department of Environment and Heritage, 2006 (report on Orange Roughy for listing as endangered species)
[78] Clark et al., above ft. 65.
[79] Freiwald, A., Fossaa, J.H., Grehan, A., Koslow, T., Roberts, J.M, 2004. Cold Water Coral Reefs. UNEP-WCMC, Cambridge, UK.
[80] O'Driscoll, R.L. and Clark, M.R., 2005. Quantifying the relative intensity of fishing on New Zealand seamounts" New Zealand Journal of Marine and Freshwater Research, 2005, Vol. 39: 839-850.
[81] Id.

Zealand orange roughy fishery.[82] O'Driscoll and Clark (2005) documented that bottom trawling off New Zealand averaged 130 km of trawled seafloor *per square kilometer* of seamount.

Initial coral bycatch can be extremely high, and then decreases as only rubble may remain. Anderson and Clark (2003) estimated that for the orange roughy fishery in the South Tasman Rise, total coral bycatch (comprising a large number of species but dominated by reef-forming *Solenosmilia variabilis*) was 1 750 tons per year in the first years of the fishing in 1997 - 1998; by 2000 - 2001 coral bycatch was 100 ty^{-1}.[83] The loss of corals and other structurally important animals could lower survivorship and recolonisation of the associated fauna, and hence would have major long-term implications for seamount ecosystems. In highly insular faunas, it could also mean the loss of many potentially endemic species.

The impact of trawling on seafloor biota differs depending on the gear type used. As noted by the CenSeam Data Analysis Working Group, the most severe damage has been reported from the use of bottom trawls in the orange roughy fisheries on seamounts off southern Tasmania and New Zealand and on cold water coral reefs in the North Atlantic.[84] Midwater trawls used for alfonsino fisheries may have only a small impact on seamount benthos if they are deployed well above the seafloor. However, in many cases the gear is considered most effective when fished very close to, or even lightly touching, the bottom. Thus, scientists predict that the effects of the alfonsino fisheries on the benthic fauna would likely be comparable to that of the orange roughy fisheries.[85]

Intense fishing with other gears such as long-lines and gillnets may also have severe cumulative negative impacts in deep-seabed environments. Recovery rates for the sessile organisms rising above the deep seafloor from any type of intense disturbance will be very low as they grow slowly and live in an environment where natural disturbances are rare.[86]

The impacts of bottom trawling are not limited to organisms living on hard surfaces. In the Northeast Atlantic, most deep-water bottom trawling and a considerable proportion of static gear fishing occurs in areas of soft bottom sediments.[87] According to Dr. John Gordon, chair of the ICES Study Group on the Biology and Assessment of Deep-Sea Fisheries Resources between 1995 and 2000, the effect of fishing activity on these areas has been largely ignored although photographic evidence at depths between 700 and 1 300 m in the Rockall Trough shows the presence of trawl marks on the seabed in 2 to 12 percent of all photographs.[88]

Organisms found on soft sediments such as sea fans (octocorals), hydrocorals (stylasterids) sponges (*Phylum Porifera*) and xenophyophores are also highly sensitive, according to an ICES working group report.[89] Like the better known stony corals, these organisms generally serve to increase habitat complexity and provide refuge for a large variety and number of species.[90] The physical disturbance

[82] Clark and O'Driscoll, above ft. 75.

[83] Anderson, O. F. and Clark, M. R. 2003. Analysis of bycatch in the fishery for orange roughy, Holplostethus atlanticus, on the South Tasman Rise. Marine and Freshwater Research 2003, 54, 643-652.

[84] Clark et al. above ft 66; see also Fossaa J.H., Mortensen P.B., Furevik D.M., 2002. The deep-water coral Lophelia pertusa in Norwegian waters: distribution and fishery impacts. Hydrobiologia 471:1-12; Reed, J. K., Shepard, A. N., Koenig, C. C., Scanlon, K. M. , and Gilmore, R. G. Jr. 2005. Mapping, habitat characterization, and fish surveys of the deep-water Oculina coral reef Marine Protected Area: a review of historical and current research. Freiwald, A. and Roberts, J. M. Cold-Water Corals and Ecosystems. 443-465. Berlin, Springer-Verlag.

[85] Clark et al. above ft 65; Clark and O'Driscoll above ft. 75.

[86] ICES WGDEC, above ft. 22.

[87] Gordon, J.D.M. DEEP WATER DEMERSAL FISHERIES, A report for JNCC. Available at: http://www.jncc.gov.uk/page-2525-theme=default

[88] Gordon, above ft. 86.

[89] Xenophyophores are macrofauna-sized agglutinated protists, closely related to Foraminerifera. They can range in size from 10 cm to 25 cm. As they are very fragile, they are easily damaged by trawled gears and the sediment plumes they create. ICES WGDEC, above ft. 22 at p. 58.

[90] In addition to deep-sea scleractinian corals, the study also describes seven other sensitive deep-sea habitats (three geological features - hydrothermal vents, cold seeps and slopes of oceanic islands, and four biological - xenophyophore

by the trawl doors and the net being dragged along the seabed will destroy and disturb fauna living on the surface and will also plough the soft sediments and disturb and probably kill the infauna. These effects will be accentuated by trawls using heavy rockhopper gear. The fine sediments resuspended by the trawl may well smother the seabed fauna over wide areas.[91] Sediment clouds raised by bottom trawls clog the filters of suspension feeders. Sponges are especially sensitive as they cannot sort particles but must use energy to filter all particles and pass them through the digestive process.[92]

Scientists are now able to produce relatively detailed bathymetry of seamounts with the use of GPS satellite navigation, multibeam swath-mapping, and recently available satellite altimetry data, but few seamounts have been mapped or sampled in detail. Though there is often a regional similarity between seamount biota, individual or clusters of seamounts may potentially harbour a high degree of endemism.[93] Many factors, including relative age and degree of isolation, habitat complexity and depth, are thought to influence biotic composition and biogeographic affinity of seamounts. However, efforts to develop seamount classification systems have not yet found ways to pick up this fine scale diversity and potential endemism.[94] Recent analyses of the occurrence of corals on seamounts have revealed that many species are confined to single oceans or to single regions within oceans. Only relatively few species of corals occur on seamounts globally or have a wide distribution encompassing several oceans. Interestingly, many of these are reef-forming species or are associated with cold-water coral reefs (e.g. *Solenosmila variabilis*, *Madrepora oculata*, *Lophelia pertusa*, *Desmophyllum dianthus*).[95]

The ecosystem effects of deep-sea fishing have also been poorly studied. Some deep-sea ecologists are concerned about the impacts of removal of large quantities of biomass (fish populations, both target species and 'bycatch') from the food web of 'food-poor' or low energy environments characteristic of the deep sea.[96] Such impacts could significantly disrupt food web and trophic level interactions amongst bottom dwelling communities and should be further investigated.[97]

In sum, there is still limited understanding of the factors that influence the biodiversity and abundance of life of seamount and other deep-sea habitats. Research on the ecology and biogeography of deep-sea benthic species and ecosystems remains critical. Its absence continues to confound approaches to develop a methodology for identifying vulnerable ecosystems or representative, special or unique areas as candidates for MPAs. Relatively few areas have been sampled sufficiently to characterize the communities, their diversity, endemism and biogeography. The relevant scales for endemism and for the bioregionalization of seamount fauna are still poorly understood. Dedicated field sampling is required to elucidate these issues, but future programs must be carefully designed, given the vast number of seamounts in the world's oceans—on the order of $10^4 – 10^6$.

---

fields, sponge grounds, fire corals and non-sclereractinan corals). Only vents and cold seeps were found not to be vulnerable to bottom fishing as no fishing presently occurred there. ICES WGDEC above ft.22 at 56.

[91] Gordon, above ft. 86

[92] ICES WGDEC, above ft. 22 at 60; Fossaa, J.H. and Tendal, O.S. "Discovering deep-water sponges" (ICES article), www.ices.dk/marineworld/sponge.asp; Gage, J.D. Roberts, J.M., Hartley, J P., and Humphery, J.D. 2006. Potential impacts of deep-sea trawling on the benthic ecosystem along the northern European continental margin. American Fisheries Society.

[93] Koslow, J.A., Gowlett-Holmes, K., Lowry, J.K., O'Hara, T., Poore, G.C.B. and Williams, A. (2001) Seamount benthic macrofauna off southern Tasmania: community structure; Marine Ecology Progress Series, 213. pp. 111-125; Stocks, K.L. and Hart, P.J.B (in press). Biogeography and biodiversity of seamounts. In: Seamounts: Ecology, Fisheries and Conservation (eds. T.J. Pitcher, P.J.B Hart, T. Morato, R.S. Santos, and M.R. Clark). Blackwell.

[94] Rowden et al., above ft. 66.

[95] Clark et al., above ft. 65.

[96] Gordon, above ft. 86.

[97] Koslow, J.A., Boerhlert, G.W., Gordon, J.S.M., Haedrich, R.L., Lorance, P. and Parin, N. 2000. Continental Slope and Deep Sea fisheries, implications for a fragile ecosystem, ICES Journal of Marine Science, 57: 548-557.

6. HIGH SEAS MPAs AND DEEP-SEA FISHING: SPECIAL CONSIDERATIONS RELATED TO FISHERIES MANAGEMENT

The history of deep-sea fisheries management has caused many scientists to question whether deep-sea fisheries can be conducted on a sustainable basis.[98] Experts have agreed on the need for a highly precautionary approach[99], but the record of its application by fisheries managers is patchy at best. This suggests that unless standards and expectations for deep-sea fisheries management are raised, fisheries managers may be unlikely to adopt non-traditional conservation measures such as MPAs. In addition to broadening their mandate, RFMOs may also need to expand their expertise to encompass ecosystem-based management and biodiversity concerns. Political will is another essential ingredient.

6.1 Vulnerability of deep-sea fisheries to overfishing

According to the FAO report on deep-sea fisheries prepared for the 2005 COFI meeting:

> *Deep sea fishery resources are particularly vulnerable to overexploitation due to their low productivity - the fish reproduce slowly and take a long time to grow to maturity. Not enough is known about the population biology of deep-sea stocks and the impacts of fishing on sea-bottom habitats, making responsible management difficult. Compounding matters is the fact that many deep-water species are found on the high seas, where governance is particularly complex.*[100]

As acknowledged in the UN Secretary General's Report on the Impacts of Bottom Fishing (para 44):

> *"…Most fisheries on seamounts often follow "boom and bust" cycles. Most of these aggregating species are easily fished towards depletion, sometimes within one season. For many species, the recovery of such stocks takes several decades."*

Glover and Smith (2003) have predicted that given current management practices, most if not all deep-sea fisheries will be commercially extinct within 10-20 years.[101] In Australia, orange roughy have been proposed for listing as an endangered species, having shown an overall decline in catch rate by around 90 percent since peak landings between 1989 and 1992.[102] According to the report of the Australian Threatened Species Scientific Committee, one or two seasons of heavy, unregulated fishing of spawning aggregations can quickly render the species commercially unviable.[103] One controversial study of five deep-sea species in Canada found them to meet IUCN criteria for listing as "critically

---

[98] Glover and Smith, above ft. 68. Koslow et al., 2000 above ft. 96; Clark, M.R. 2001. Are deepwater fisheries sustainable? – the example of orange roughy (Hoplostethus atlanticus) in New Zealand. Fisheries Research 51 (2001) 123-135; Large, P.A., Hammer, C., Bergstad, O.A., Gordon, J.D.M., Lorance, P. 2003.Deep-water Fisheries of the Northwest Atlantic: II Assessment and Management Approaches. J. Northw. Atl. Fish Science, Vol. 31: 151-163; Merrett, N.R. and Haedrich, R.L. 1997. Deep-Sea Demersal Fish and Fisheries. Chapman & Hall, London; Lack, M, Short, K., and Willock, A. 2003. Managing Risk and uncertainly in Deep Sea fisheries: lessons from Orange Roughy. TRAFFIC Oceania and the WWF Endangered Seas Programme (www.panda.org/downloads/marine/OrangeRO.pdf).

[99] The need for a highly precautionary approach has been repeatedly stressed by scientists, including at the 2003 Conference on the Management and Governance of Deep Sea Fisheries, held in Queenstown, New Zealand, organized by the Ministry of Fisheries, New Zealand and the Department of Agriculture, Fisheries and Forestry of Australia, with the technical cooperation of the FAO Fisheries Department. (www.deep sea.govt.nz) (Queenstown, New Zealand 1-5 December, 2003) ("DEEP SEA 2003") and at the Woods Hole 2004 Symposium on Deep-sea Fisheries: Ecology, Economics and Conservation, convened by the Woods Hole Oceanographic Institution and the New England Aquarium (Woods Hole, Massachusetts, USA, 12-14 September 2004) Report available at:
http://www.whoi.edu/institutes/oli/activities/symposia_deepsea.html

[100] FAO report 2005/6 prepared for COFI 2005. Deep Sea Fisheries; see also The State of the World Fisheries and Aquaculture (SOFIA), FAO Fisheries Department, Food and Agriculture Organization of the United Nations, Rome, 2004 at pp. 91-99.

[101] Glover and Smith, above ft. 68.

[102] Australia, 2006 Advice to the Minister for the Environment and Heritage from the Threatened Species Scientific Committee (TSSC) on Amendments to the list of Threatened Species under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)

[103] Id.

endangered”.[104] Only two of the five were target species, indicating the high vulnerability of many non-target species. Deep-sea sharks are thought to be exceptionally vulnerable due to their limited range and low fecundity. In the Northeast Atlantic, leafscale gulper shark and the Portuguese dogfish have both declined by 80 percent in 10 years.[105]

6.2 Application of scientific advice into decision-making

Experience in the Northeast Atlantic may provide some insight into past difficulties of ensuring science-based management for deep-sea fisheries. ICES and other experts have been warning of the need to change deep-sea fisheries management practices since 1994 when French vessels started bottom trawling on the slopes of the Rockall Trough. ICES scientific advisors have continually warned that a “cautious approach should be adopted to exploitation and that fishing effort should be kept at a low level until sufficient information was gathered from existing fisheries to enable scientifically-based management decisions.” In 1998 it was estimated that many deep-water stocks were beyond safe biological limits.[106] In 2002 Gordon observed that:

> *There is general agreement amongst scientists, the fishing industry and the politicians that the deep-water stocks are seriously overexploited but political imperatives dictate that uncertainties and inconsistencies in the scientific assessment and advice are used to postpone the urgent action that is required.*[107]

In 2004 and again in 2005 ICES strongly advised a “complete overhaul of deep-sea fisheries” in the Northeast Atlantic.[108] Specifically, ICES advised that no new fisheries for deep-sea fish should be allowed, and existing deep-sea fisheries should be reduced to low levels until research suggests increased harvests can be sustainable. In 2005, ICES also advised zero catch of depleted deep-sea shark species such as leafscale gulper shark and the Portuguese dogfish. No further reductions in effort were agreed beyond the 2004 decision to reduce effort by 30 percent from the previous highest levels, pending further information from ICES. In November 2006, NEAFC adopted a 6-month ban on orange roughy fisheries for the first half of 2007 with a full review planned in June 2007, and agreed to reduce current levels of overall deep-sea fishing effort by 5 percent.

To enable the establishment of MPAs for biodiversity conservation purposes, let alone develop effective and ecologically coherent systems and networks of MPAs, future decision-making will need to be guided by a more precautionary approach. Review and assessment of the performance of RFMOs, as called for by the UN Fish Stocks Agreement review conference, could provide an important means to improve the capacity and willingness of RFMOs and their member states to implement precautionary and ecosystem-based measures, including MPAs.

6.3 The boom and bust nature of most seamount fisheries means that fishers frequently expand their operation into new areas

The targeting and rapid decline of spawning aggregations on seamounts means that the fishery must frequently expand to new seamounts.[109] In New Zealand, active searching for pristine seamount habitat meant that by 2000 about 80 percent of the known seamounts in fishable range had been

---

[104] Devine, JA, Baker, KD, and Haedrich, RL, 2006. Deep-sea fishes qualify as endangered
A shift from shelf fisheries to the deep sea is exhausting late-maturing species that recover only slowly. Nature, Vol. 439|5, p. 29.
[105] ICES WGDEC, above ft. 22
[106] Gordon, above ft. 86
[107] Gordon above ft. 86; see also Large et al. above ft. 97.
[108] ICES WGDEC, above ft. 22
[109] Clark, M.R. 1999. Fisheries for orange roughy (Hoplostethus atlanticus) on seamounts in New Zealand. Oceanologica Acta 22(6). 593-603; O’Driscoll and Clark, above ft. 79.

fished.[110] Clark (1999) describes how in the 1980s the fishers moved sequentially eastwards along the Chatham Rise, one seamount at a time.[111]

This pattern of boom and bust fishing and the ability to rapidly move on to new areas creates a challenge with respect to the establishment of MPAs to protect vulnerable ecosystems. Though the history of rapid serial depletion of many deep-sea fish stocks and RFMO standards for evidence to close fisheries once they are underway may be considered as two separate problems, what they have in common is that if high levels of scientific evidence are required to close an area, then without restrictions on expansion, there is a high likelihood that the seamount habitat will be fished before it can be identified, assessed and protected.

6.4 The lack of knowledge of benthic habitat means that closure of some areas may shift fishing into new, as yet unmapped, areas that may be similarly vulnerable or more significant biologically

The ICES Deep Sea Ecology Working Group in 2005 stressed the danger of relying on incomplete datasets to close areas since decisions to close areas to bottom trawling may inadvertently divert trawling to similarly sensitive habitats that are currently unmapped.[112] The ICES Working Group noted an urgent need for mapping and sampling of seamount ecosystems, cold-water corals and other vulnerable deep-sea habitats along continental margins and deep ocean areas of the outer continental shelf below the high seas and on the seabed area beyond national jurisdiction. This can be a quandary, as ICES has also advised that the only proven way of preventing damage to deep-water biogenic reefs from fishing activities is through spatial closures to towed gear that potentially impacts the bottom.[113]

6.5 Need for a combination of management tools to reduce the impacts of mobile bottom contacting gear

A Canadian experts' meeting in 2006 identified the advantages and disadvantages of a range of fisheries management tools to reduce the impacts of mobile bottom contacting gear:[114]

- major reduction in effort in fisheries using mobile bottom contacting gears—effectiveness depends on how remaining effort is distributed spatially and temporally;
- spatial management of effort taking into account the spatial distribution of benthic habitats and communities—effectiveness depends on how effort is redistributed and the timeframe over which it is applied;
- implementation of areas where use of those gears is not permitted—highly effective in protecting long-lived sedentary species such as large deep-water corals and sponges, but in larger contexts depends on what happens to effort that is excluded by areas closed;
- substitution of another gear type or modification of gear type to reduce contact with benthos and seafloor—effectiveness depends on nature and relative effectiveness of new or modified gear.

Building on this analysis, this author suggests that protection of vulnerable deep-sea ecosystems may require a combination of management tools, including a major reduction in effort in fisheries using bottom contacting gears, improved spatial management to prevent overlap with vulnerable areas, closing areas to bottom contacting gears (i.e. MPAs), and substitution or modification of gears to

---

[110] Clark and O'Driscoll above ft. 75
[111] Clark 1999, above ft. 97.
[112] ICES WGDEC, 2005 above ft. 22.
[113] ICES 2002. Report of the ICES Advisory Committee on Ecosystems, ICES Cooperative Research Report No. 254. December 2002. pp. 28-33.
[114] DFO, 2006. Impacts of Trawl Gears and Scallop Dredges on Benthic Habitats, Populations and Communities Canadian Science Advisory Secretariat Science Advisory Report 2006/025.

reduce contact with the benthos. Effectiveness will depend of how effort is redistributed, the scale of the areas protected, and the relative effectiveness of any substituted gear.

6.6 Problems of illegal, unregulated and unreported (IUU) fishing activities

Illegal, unregulated and unreported fishing is a pervasive and serious problem for all high seas fisheries. High seas deep-water fisheries are unregulated or poorly reported in many areas, so information on fishing areas, fishing effort, and on target and bycatch species is generally poor. Such data are a prerequisite to managing these fisheries. The problems of unregulated and unreported deep fisheries are compounded by the current absence in 75 percent of the high seas of RFMOs with competence to manage deep-sea bottom fisheries or to establish MPAs (see Sections 6 and 9). While some nations regulate their vessels engaged in deep-sea bottom fishing on the high seas at least with respect to catch data, most do not. [115] The absence of an RFMO or other arrangement makes it difficult to establish and enforce a High Seas MPA that would be respected by all relevant fishing states and vessels. The recommendations of the UN Fish Stocks Agreement Review Conference and the report of the High Seas Task Force have outlined a range of actions that states can adopt to address the overall problem of IUU fishing activities in the high seas. An essential first step for deep-sea fisheries is the adoption of binding interim measures among those fishing outside of RFMO areas, establishment of regional agreements or arrangements, or the expansion of the mandates of existing RFMOs. Another option is establishment of a global mechanism with the competence to act in their absence. Measures to enhance compliance and enforcement of High Seas MPAs are discussed in Section 7 below.

6.7 Difficulty of limiting access to deep-sea fisheries on the high seas

In emphasising the importance of RFMOs for ensuring sustainable fishing and protecting marine biodiversity, the Fish Stocks Agreement seeks to limit access to fishing in areas covered by an RFMO to only those states which are members of the RFMO or similar arrangements, or which agree to apply its conservation and management measures (Fish Stocks Agreement art. 8.3). To be able to effectively contain expansion of deep-sea bottom fisheries, all deep-sea fisheries on the high seas will need to be made subject to similar terms. Otherwise it may prove difficult to prevent further “boom and bust” fishing and to reduce deep-sea fisheries to the appropriate levels of effort required to ensure sustainability.

6.8 Need for management at finer temporal and geographical scales

One feature particular to deep-sea fisheries may be their small spatial scale, as they often focus on specific benthic features such as seamounts and deep-sea corals, where fish abundance and biodiversity are greatest.[116] As ICES has recommended, systems will need to be developed and implemented for recording effort and catches at a finer temporal and geographical scale than is the case at present. At the same time, management actions will need to be implemented that take into account this finer scale spatial resolution.[117] As revelation of areas where substantial catches of fish are being taken may increase the number of vessels fishing particular features, such information may have to be restricted to fisheries managers and enforcement officers. In addition, further information on fishing strategies is required from commercial fishing companies. This is to assess what areas of the seabed are actually fished and what constitutes fishable ground and non-fishable ground.

[115] UN Sec. Gen. Impacts of Fishing Report, above ft. 35 at para. 103-105
[116] Brodie and Clark above ft. 66.
[117] ICES WGDEC, above ft. 22.

7. RFMO INVOLVEMENT IN HIGH SEAS MPAs AND DEEPWATER FISHERY MANAGEMENT

Though discrete high seas fish stocks (i.e. high seas stocks that are neither anadromous, catadromous, highly migratory nor straddling) are not specifically covered by the Fish Stocks Agreement, the Agreement sets forth a common standard for fisheries management. The 2005 UN General Assembly Resolution on Sustainable Fisheries (A/RES/60/31) encourages "States, as appropriate, to recognize that the general principles of the Fish Stocks Agreement should also apply to discrete fish stocks in the high seas." At the Fish Stocks Review Conference it was agreed that "RFMOs with competence to regulate straddling fish stocks may also have the necessary competence to conserve and manage high seas discrete stocks. There is no obstacle for such RFMOs to adopt management measures in respect of such stocks in accordance with the general principles set forth in the [Fish Stocks] Agreement."[118] Many States and several RFMOs have in practice been applying parts of the Fish Stocks Agreement to discrete fish stocks.[119]

The UN Sec. Gen. Impacts of Fishing Report reviews the actions of states and RFMOs with respect to deep-sea fisheries management and measures taken to address vulnerable marine ecosystems. This section updates that report where possible.

The actions taken by states and RFMOs since 2004 should be read in the context of the requirements of articles 5 and 6 of the Fish Stocks Agreement, including the duties to prevent overfishing, protect biodiversity in the marine environment and to not allow the absence of adequate scientific information to be a reason for postponing or failing to take conservation and management measures.[120] Most of these Fish Stocks Agreement provisions are also incorporated in Article 6 of the FAO Code of Conduct adopted in 1995.

Though deep-sea fisheries occur in many ocean regions, of the 50 regional fisheries bodies, only five are competent to regulate discrete and straddling high seas bottom fisheries.[121] Specific RFMOs that can exercise competence over deep-sea fisheries are the Commission on the Conservation of Antarctic Marine Living Resources (CCAMLR); the General Fisheries Commission for the Mediterranean (GFCM); the Northwest Atlantic Fisheries Organization (NAFO); Northeast Atlantic Fisheries Commission (NEAFC) and the South East Atlantic Fisheries Organization (SEAFO).

The most comprehensive and precautionary approach to deep-sea fisheries and MPAs has been adopted under CCAMLR for the Southern Ocean. This could serve as a model for other regions. In 2006, the CAMLR Commission adopted a Conservation Measure that continues a temporary prohibition on high seas bottom trawling in the Convention Area with a review scheduled in 2007 with respect to relevant criteria for determining what constitutes significant harm to benthos and benthic species. This follows a 2005 decision to initiate action on a comprehensive system of MPAs. In 2005 CCAMLR agreed on the need to develop a strategic approach to MPA design and implementation throughout the CCAMLR area, in harmony with measures taken under the Antarctic Treaty and the

---

[118] UN FSA Review Conference Report above ft. 38. Annex, para 16

[119] Molenaar, E.J. (report for FAO) Current Legal and Institutional Issues Relating to the Conservation and Management of High Seas Deep Sea Fisheries; see also Molenaar, above ft. 49.

[120] In a slightly summarized form, UNFSA Article 5 calls for States to: a) adopt measures to ensure the long-term sustainability of the fish stocks; b) use the best scientific information available; c) apply the precautionary approach in accordance with Article 6; d) asses the impacts of fishing; e) adopt measures for species belonging to the same ecosystem or associated with or dependant upon the target fish stocks; f) minimize pollution, waste, discards, catch by lost or abandoned gear and impacts on associated or dependent species; g) protect biodiversity in the marine environment; h) take measures to prevent or eliminate overfishing and excess fishing capacity; j) collect and share data; k) promote and conduct scientific research and develop appropriate technologies; and l) implement and enforce conservation and management measures through effective monitoring, control and surveillance. Article 6 on application of the precautionary approach further calls for States to apply the precautionary approach in order "to protect the living resources and preserve the marine environment" (Art. 6.1). States are also to "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." (Art. 6.2).

[121] Molenaar, above ft. 49.

Madrid Environmental Protection Protocol.[122] CCAMLR agreed on some basic parameters for MPAs with the general goal of maintaining biodiversity and ecosystem processes that could include the protection of:

- representative areas;
- scientific areas to assist with distinguishing between the effects of harvesting and natural ecosystem changes, and to provide opportunities for understanding of the Antarctic marine ecosystem in areas not subject to human interference; and
- areas potentially vulnerable to impacts by human activities, to mitigate those impacts and/or ensure sustainability of the rational use of marine living resources.

CCAMLR also noted the potential need for interim protection to be afforded to areas identified as candidate sites, but where more information is required before a conclusion on protection can be reached.[123] Work on bioregionalization has begun with a workshop in September 2006. CCAMLR also has rules in place to control the development of new and exploratory fisheries, and hence areas are closed to fishing until CCAMLR determines that the fishery is sustainable and that appropriate rules are in place to prevent adverse ecosystem impacts or long-term damage.

In the Northeast Atlantic, NEAFC in late 2004 closed five areas on an interim three-year basis to bottom fishing in response to a proposal from Norway. At the same time, NEAFC deferred decisions on two other proposals, one from Norway and the other a request from the regional seas organization—OSPAR, for protection of deep-sea corals in the Rockall Bank and Hatton Bank. No action was taken on these two proposals in 2005. The Secretary General's report notes that the reason given by NEAFC was that "current information is insufficient to support scientifically based closures."[124] At the time it was also debated whether NEAFC had the legal authority to close areas to fishing for biodiversity conservation purposes, as opposed to purposes directly related to stock management.[125] NEAFC has since initiated a reform process and expanded its mandate to include ecosystem-based management. In November 2006, it agreed to close Hatton Bank and three areas of Rockall Bank from 2007 to 2009, based on earlier solicited ICES advice. One of the areas recommended by ICES "South Rockall" (area: 3214.5 sq km) was not accepted. OSPAR has expressed an interest in incorporating these temporarily protected areas into their regional network of MPAs. This provides a useful opportunity to enhance regional cooperation and coordination, one of the key recommendations of the NEAFC performance review panel.[126] Cooperation between regional organizations on matters of High Seas biodiversity conservation may be most successful if it occurs early and often.

In the Northwest Atlantic Ocean, NAFO agreed in September 2006 to move towards an ecosystem approach and to expand NAFO's mandate to minimize harmful impacts and preserve marine biodiversity. NAFO members also agreed to protect four seamount areas from high seas bottom trawling for a three year period.[127] These areas will be fully closed in 2007, and as of January 1, 2008,

---

[122] Grant, S. 2005. "The Challenges of marine protected area development in Antarctica", PARKS Magazine issue on High Seas MPAs. vol. 15, no.3 (Gjerde, K.M. and Kelleher, G., (eds.)).

[123] Id.

[124] The dilemma posed by requiring more information to protect an area than to fish in it is described by John Gordon, chair of the ICES deep-sea fisheries assessment study group between 1995-2000, as follows: "It is perhaps not much of a consolation, but at least in the Rockall Trough we know a lot about the ecosystem that is being destroyed. From the small amount of available knowledge, the Hatton Bank is a different ecosystem and we will never know what we are in the process of destroying." http://www.ices.dk/reports/ACE/2002/SGCOR02.pdf#search=%22John%20Gordon%20JNCC%20ICES%20%20fish%22; REPORT OF THE STUDY GROUP ON MAPPING THE OCCURRENCE OF COLD WATER CORALS By correspondence May 2002 ICES CM 2002/ACE:05 Ref: E, WGECO

[125] Norwegian proposal submitted to NEAFC, 2004.

[126] Performance Review Panel, 2006. Report of the North East Atlantic Fisheries Commission, para, 3.6.3.3. available at: http://www.neafc.org/news/docs/performance-review.pdf.

[127] "NAFO reform in Full Swing" 2006 Annual Meeting Press Release 22 September 2006, available at: http://www.nafo.int/about/frames/about.html

20 percent of the fishable area of each seamount may be opened to a small scale and restricted exploratory fishery. In the event hard corals are encountered in these four areas, the fishery will be subject to closure. These measures will be reviewed in 2010 at which time they may be ended, extended, or possibly made permanent.[128]

SEAFO in the Southeast Atlantic adopted a conservation measure in October 2006 suspending all deep-sea fishing activities in 10 areas as of 1 January 2007 for three years.[129] Small scale exploratory fishing may resume in 2008 in 20 percent of the defined areas, and where vessels encounter hard corals, an immediate temporary closure is to be declared. Vessels in these areas are to carry scientific observers. SEAFO has not adopted other measures related to the protection of sensitive deep-sea habitats (other than corals inside the 10 partially closed areas).

In the Mediterranean, the GFCM has closed on a precautionary basis the deeper waters of the Mediterranean below 1 000 m, and in 2006 closed three areas to bottom trawling in shallower waters. According to recent scientific studies on deep-sea corals in the Mediterranean, coral diversity and abundance are higher in the unprotected shallower waters: the deepest known coral occurrence is 1 200 m.[130]

With regard to areas lacking competent RFMOs, in the Southern Indian Ocean an agreement to promote sustainable management was opened for signature in July 2006, seven years after negotiations commenced. The agreement is based largely on provisions of the Fish Stocks Agreement. A new agreement for the South Pacific is in the early stages of negotiation: a preliminary meeting was held in February 2006. With respect to an area in the North Pacific, Russia, Japan, Korea and the United States met in August 2006 to discuss a possible arrangement to regulate deep-sea fishing in the region where the first deep-sea bottom fisheries emerged in the late 1960s.

With a few exceptions (e.g. CCAMLR and the GFCM 1000 m depth closure in the Mediterranean), it would appear that the current closures are small in scale compared to the potential area where deep-sea fisheries may occur and only temporary in duration. As evidenced from the experience in CCAMLR, where there are both political will and a specific conservation mandate, RFMOs can move rapidly to establish rules to protect vulnerable areas and to lay the groundwork for the establishment of comprehensive systems of MPAs. However, there is much to be done to make up for the slow pace of progress in the past.

8. HIGH SEAS MPAs: DEEP-SEA FISHERIES AND COMPLIANCE

Issues regarding compliance with and enforcement of High Seas MPAs for deep-sea fisheries will need to be addressed in the larger context of high seas fisheries management and governance. IUU fishing is a major problem that can undermine any fisheries measure. Nevertheless, there are a variety of mechanisms that can improve compliance and enforceability today of RFMO-designated MPAs for deep-sea fisheries. Practices employed by Australia for its remote Heard Island and McDonald Islands fisheries (which also incorporate rules adopted by CCAMLR) indicate currently available technologies and practices:[131]

1) Vessel Monitoring Systems for all vessels, centralised by CCAMLR since 2004. Gear codes can now be attached to VMS monitoring devices.
2) Fishing operators must report when they enter and exit the fishery, and have the duty to complete a daily logbook, whose data are transmitted to Australian authorities.

[128] Id.
[129] Conservation Measure 06/06 on the on the Management of Vulnerable Deep Water Habitats and Ecosystems in the SEAFO Convention Area. Available at: http://www.seafo.org/.
[130] Taviami, M, Freiwald, A. and Zobrowius, H. 2005. "Deep coral growth in the Mediterranean Sea: an overview" In: Cold-water Corals and Ecosystems (eds. A. Freiwald and J.M. Roberts). Springer-Verlag, Berlin Heidelberg, pp. 137-156.
[131] Gotheil, above ft. 10.

3) Cameras to assist observers will be introduced by 2008.
4) An International Telecommunications Union radio/call sign (IRCS) is mandatory on all vessels for the identification of legal vessels, and each buoy has to be marked with the IRCS number.
5) Independent officers are in charge of notifying and monitoring the unloading and export of all catches, in accordance with CCAMLR's Catch Documentation Scheme, and inspectors are appointed under CCAMLR.
6) Specific requirements for the packaging and labelling of catches help to determine the amount of catch to be deducted from the TAC and provide additional surveillance to ensure that fishing has been conducted by a legally authorised vessel.
7) Most infringements to the rules, such as overcatch, the use of smaller mesh sizes than authorised, etc. are punished by a reduction of fishing quotas defined in "penalty units".
8) Presence of an armed patrol vessel to intercept illegal vessels: At HIMI, the presence of the *Oceanic Victory* helped to reduce illegal catches of toothfish from about 7 000 t in 1997 to between 0 and 265 t during the 2004-05 season.
9) The HIMI Marine Reserve further benefits from a "Territory Watch Programme" wherein authorized fishers are encouraged to report suspicious activities in the HIMI area.
10) A dedicated database is used to trace and investigate suspected violations to HIMI regulations. Any type of boat or aircraft will be tracked.
11) Regular patrols by civilian and Australian Defence Force vessels to detect and deter any illegal activity, principally linked to IUU fishing.
12) The Australian Government also relies on the French Government, with whom it signed an agreement in 2003 to cooperate for the conduct of surveillance activities around HIMI, including in the Reserve, and Îles Kerguelen.

Comparable measures could be adopted to enhance compliance with and enforcement of High Seas MPAs as part of a wider enforcement regime for deep sea fisheries. However, mutually agreed at-sea enforcement mechanisms, such as those available under the Fish Stocks Agreement, would also be necessary to authorize the boarding of ships by non-flag states on the high seas. At the same time, as discussed at the Fish Stocks Agreement Review Conference in May 2006 and described in the Final Report of the High Seas Task Force,[132] efforts to enhance compliance must comprehensively address the fishing industry, flag states, states of nationality and corporate registration, port states, RFMOs, and market states.

To enhance compliance, positive incentives may be directed at the most affected stakeholders—the deep-sea fishing industry. Some have suggested that a system of fishing rights or privileges for deep-sea fisheries in specific areas may be useful. Others have noted, however, that there is no legal right or authority to allocate exclusive rights to common property resources, such as those that exist on the high seas.[133] Instead, if agreed to by states and if equitable issues are addressed, revocable contracts granting conditional access to specific areas might be agreed upon via an RFMO, with strict and carefully monitored conditions for sustainability and protection of marine biodiversity. Other forms of incentives noted by Young (2006) include tax benefits and streamlined license renewal for those able to document compliance; certification systems that enable users to access particular markets or obtain a premium price; and voluntary codes of conduct with clearly explained benefits for those who comply.[134]

---

[132] High Seas Task Force, 2006. Closing the net: Stopping illegal fishing on the high seas. Governments of Australia, Canada, Chile, Namibia, New Zealand, and the United Kingdom, WWF, IUCN and the Earth Institute at Columbia University. Available at: http://www.high-seas.org/.

[133] Osherenko, G. 2006. "New Discourses on Ocean Rights: Understanding Property Rights, the Public Trust, and Ocean Governance", Paper 1537, ExpressO Preprint Series.

[134] Young, above ft. 2.

Flag states have an important role to play in ensuring responsible and sustainable use of resources as well as in enforcing regulations with respect to MPAs in areas beyond national jurisdiction. As noted at the FAO Workshop on MPAs, flag states could contribute by a range of methods, including through effort management of their national fleet, independent on-board observers, gear regulations and technological requirements to ensure compliance with MPAs and other spatial controls. Flag states (as well as port states and RFMOs) could require that VMS equipment be used and that data be made available to the relevant RFMO as well as flag and port state enforcement agencies on a real time basis as a condition to fish on the high seas. Broad based cooperation could ensure that sufficiently stringent measures and penalties (high enough to serve as a credible deterrent) are imposed. For example, global cooperation would be necessary to prevent "ports of convenience" from emerging where IUU fishers/transhippers can go to process illegal catches. Penalties for vessels caught fishing in contravention of the conditions of their permits could result in denial/revocation of fishing permits and landing privileges.[135]

States may also assert controls over their nationals and corporations, and could establish regulations requiring transparency of overseas vessel ownership, applicable to beneficial owners, and by making it illegal for their nationals and corporations to re-flag vessels to avoid compliance with conservation measures. Many have recommended that legislation similar to that found in the United States' Lacey Act be adopted to make it an offence for a national to be involved in activities contravening regional and internationally agreed conservation measures.[136]

Port states, market states and RFMO member states may take mutually supportive action to address the acknowledged problems of flag state compliance.[137] Port states can enact strict vessel inspection and catch documentation requirements, and harmonize them on a regional and ideally global basis. These could require vessels to document that the catch was harvested only in approved areas and/or outside of designated MPAs and provide certificates to that effect. Market states could agree to purchase or allow the transhipment of catch only if it is properly documented and certified as caught in compliance with conservation measures, including geo-spatial restrictions like MPAs.

RFMOs can also impose conditions on access to fisheries resources. In addition to catch documentation schemes, they can use their allocation authority to limit or deny access to fishing vessels of non-complying members and may implement schemes for boarding and inspection of vessels of member states on the high seas.[138]

Where no RFMOs currently exist, interim arrangements such as catch documentation and certification schemes could be established, possibly on a global scale, for application by flag, port and market states. The Convention on International Trade in Endangered Species provides a useful precedent for global monitoring of trade in species of concern. Requirements to document 'introduction from the sea' might be used to require identification of where the commercial product is harvested, and permits issued for exports or imports only if the cargo owner is able to document that the catch was not obtained in a restricted area or is obtained in compliance with any geo-specific requirements. As noted by Young (2006), the CITES provision on "introduced from the sea" can only be implemented by knowing (or accepting vessel operator's statements about) where the species was harvested.[139]

---

[135] Rayfuse, R. 2005. "To Our Children's Children's Children From Promoting to Achieving Compliance in High Seas Fisheries" in The International Journal of Marine and Coastal Law special Issue on High Seas Fisheries Governance, Moving from Words to Action (Gjerde, KM (ed.)). vol. 20, nos. 3-4, pp. 509-532.

[136] Schmidt, C-C. 2005. "Economic Drivers of Illegal, Unreported and Unregulated (IUU) Fishing", in The International Journal of Marine and Coastal Law, Special Issue on High Seas Fisheries Governance, Moving from Words to Action (Gjerde, KM (ed.)) vol. 20, nos. 3-4, 479-508; Ortiz, P. "An Overview of the U.S. Lacey Act Amendments of 1981 and a proposal for a Model Port State Fisheries Enforcement Act", report prepared for the High Seas Task Force. Available at: http://www.high-seas.org/.

[137] Young, above ft. 2 at 19.

[138] Rayfuse, above ft. 134

[139] Young, above ft. 2.

9. HIGH SEAS MPAs AND DEEP-SEA FISHERIES: GOVERNANCE AND LEGAL ISSUES AT THE GLOBAL LEVEL

Current legal and institutional issues relating to the conservation and management of high seas deep sea fisheries are covered in depth in the complementary paper by Erik Japp Molenaar and will not be addressed here.[140] This section instead focuses on some of the major issues related to governance and law at the global level that will be important to address in the context of High Seas MPAs for deep-sea fisheries and for biodiversity conservation in general.

9.1 Adequacy of the regime in UNCLOS and the CBD for protection of marine biodiversity including through MPAs in areas beyond national jurisdiction

Many commentators and states have highlighted the need to build on the present high seas legal regime to enable the effective establishment, management and enforcement of MPAs. They also stress the need to develop mechanisms for transparent, science-based and participatory decision-making.The principles of ecosystem-based management and precaution and the duty to protect marine biodiversity are incorporated into fisheries management via the Fish Stocks Agreement. However, these principles and duties are not as yet applied on a consistent basis to fishing or to other activities that may impact marine biodiversity beyond national jurisdiction. Other activities or issues of concern include underwater noise, cable and pipeline laying, marine scientific research, proposals for CO_2 disposal or sequestration, bioprospecting, deep seabed minerals mining and deep seabed oil and gas exploration and exploitation. Also, while the Fish Stocks Agreement provides authority for States to enforce fisheries conservation and management measures (including MPAs) on other RFMO members or States Parties, there is no comparable authority to enforce MPAs established outside the remit of an RFMO or the Agreement. Moreover, even an MPA established by one RFMO would not necessarily be binding on non-members or non-parties to the Agreement.

We have seen that a growing number of RFMOs have or will soon have the legal authority to adopt measures for biodiversity conservation purposes, including MPAs (closed areas) with respect to fisheries activities. However some feel that absent a specific legal mandate for RFMOs to act, or a mechanism to ensure their transparency and accountability, little progress will occur. This underscores the need to have a consistent and coherent approach to establishment of MPAs that is not captive to any single special interest but rather takes into consideration the broader interests of civil society and future generations.

As a first step, basic criteria and guidelines for achieving the WSSD goal of representative networks could be developed and applied through a variety of relevant international bodies (e.g. FAO, IMO, ISA, and IOC) to assist nations in reaching part ways towards that goal by 2012. However, many believe that an overarching agreement on high seas biodiversity—an implementing agreement to UNCLOS just as the Fish Stocks Agreement is an implementing agreement to UNCLOS -- would better enable integrated area-based management and enforcement. At the same time, inclusive processes and participatory mechanisms could be developed. Also necessary will be mechanisms to address adverse influences on high seas biodiversity stemming from activities outside of MPAs, for example, through specific environmental impact assessment requirements and performance review processes. Such a development could be in the interests of all, as raising the standard of biodiversity conservation throughout the high seas could decrease the need for site-specific interventions.

9.2 Adequacy of regime for deep-sea fisheries

As noted in Section 6 above, the Fish Stocks Agreement sets forth generally accepted standards for deep-sea fisheries management. Nevertheless, absent a new agreement or expansion of the Fish Stocks Agreement to incorporate discrete deep-sea fisheries on the high seas, it remains unclear whether states must also apply the Fish Stock Agreement’s provisions relating to RFMO governance, dispute

[140] Molenaar, above ft. 118.

resolution, or enforcement. In 2005, COFI urged Members to fully apply the FAO Code of Conduct and four related International Plans of Action (IPOAs) to deep-sea fishing and to ensure that their vessels operated in a manner consistent with the ecosystem approach to fishing, and to fully report on their fishing activities,[141] but again, there are no binding standards upon which to assess state or RFMO performance or to base possible enforcement actions.

Additional concerns are that large areas of the globe are not covered by an existing organization with competence to regulate discrete high seas fisheries and consequently, there is no body with competence to establish High Seas MPAs for this purpose. Current gaps in RFMO coverage include the Pacific Ocean, Southwest Atlantic, Indian Ocean and the Caribbean. While action is being taken in the Southern Indian Ocean, the South Pacific and Northwest Pacific, it may be some while before these agreements come into effect.

9.3 Different standards applied to mineral seabed resources and living seabed resources

The incongruence in international law regarding impacts from potential mineral mining compared to deep-sea trawling on the seabed beyond national jurisdiction is worth noting. Under UNCLOS and the implementing agreement for Part XI, the International Seabed Authority (ISA) has responsibility to develop regulations to control pollution, conserve natural resources of the "Area" (i.e. the seabed beyond national jurisdiction) and prevent damage to flora and fauna of the marine environment from minerals activities before any seabed mining activities may occur. For example, before any exploitation of polymetallic nodules may occur, the contractor must propose areas to be set aside and used exclusively as "preservation reference zones" in which no mining shall occur, so that representative and stable biota of the seabed remain in order to assess any changes in the flora and fauna of the marine environment due to mining.[142] Furthermore, contractors are required to gather environmental baseline data, to establish environmental baselines against which to assess the likely effects of their activities on the marine environment, and to establish a programme to monitor and report on such effects.[143] Similar provisions are under consideration in the draft regulations for sulphide and cobalt-crust deposits found at hydrothermal vents and seamounts.[144] Outside of the CCAMLR provisions for new and exploratory fisheries, similar requirements do not exist with respect to deep-sea fisheries, although such fisheries may have comparably large-scale and potentially irreversible impacts. As at the national level, environmental impact assessment requirements may assist in levelling the playing field between economic sectors, and enable regulators to impose comparable standards.

9.4 The adequacy of high seas enforcement powers

Problems of non-compliance and illegal activities are serious impediments to sustainable fisheries, particularly due to inconsistent flag and port state performance. The problems with flags and ports of non-compliance, and the lack of effective at-sea enforcement provisions under UNCLOS for areas beyond national jurisdiction do not occur only in high seas fisheries management, but also with respect to illegal discharges from merchant ships, illegal dumping, and trafficking in drugs or migrants. Solutions to remedy these problems may need to be dealt with as a whole at the global level as well as at the sector-specific level. As described in Section 7 above, potential approaches for improving the enforceability of high seas MPAs designated by RFMOs include strengthening both flag and port state enforcement, catch documentation and tracing schemes, further use of agreed at-sea boarding and

---

141 FAO, 2005. Report of the 26th session of the Committee on Fisheries (Rome, Italy, 7-11 March 2005) para. 83-94.

142 Regulation 31.7, Regulations for Prospecting and Exploration for Polymetallic Nodules in the Area, 19 July 2000. See Document ISBA/6/A/18 for official text. This regulation also requires the contractor to set aside an "impact reference zone," representative of the environmental characteristics of the Area, to be used for assessing the effect of that contractor's activities in the Area on the marine environment. Available at www.isa.org

143 Regulation 31.4, Regulations on Prospecting and Exploration for Polymetallic Nodules in the Area, note 24. In 2001, the Authority's Legal and Technical Commission adopted recommendations for the guidance of the contractors for the assessment of the possible environmental impacts arising from exploration for polymetallic nodules in the Area, Document ISBA/7/LTC/1/Rev.1, 13 February 2002.

144 Regulation 33, ISBA/10/C/WP.1, 24 May 2004.Available at www.isa.org.

inspection schemes (as envisaged by the Fish Stocks Agreement), systematic use of modern information and communications technologies to identify and track illegal activities, and harsh penalties. Comparable mechanisms would need to be developed to enable effective enforcement of MPAs established through other (non-RFMO) agreements. A globally harmonized yet stringent regime for port state inspections and enforcement would decrease some of the need for enhanced at-sea enforcement powers, though visual surveillance, monitoring and tracking would remain essential.

10. HIGH SEAS MPAs AND DEEP-SEA FISHERIES: GOVERNANCE AND LEGAL ISSUES AT REGIONAL LEVEL

At the regional level, several governance and legal issues also stand out as of immediate importance in determining the effectiveness of MPAs as a tool for managing deep-sea fisheries and protecting deep-sea biodiversity.

10.1 Adequacy of RFMO coverage, competence and consistency

RFMOs are the obvious fora for establishing High Seas MPAs relating to deep-sea fisheries management and conservation. However, as noted in Section 5, gaps in area coverage and legal mandate mean that only five RFMOs currently have competence to regulate deep-sea fisheries on the high seas. Within these five, many have noted very uneven performance: CCAMLR has a very complex and precautionary regime applicable to deep-sea fisheries, while some of the others have enacted measures only after many of their deep-sea fisheries have virtually collapsed.[145] The GFCM, NAFO, NEAFC and SEAFO have focused on protecting a few vulnerable areas from the impacts of bottom fishing, but have not yet adopted a large-scale systematic approach for their geographic area.

RFMO track records in implementing ecosystem-based and precautionary management measures and the lack of science-based decision making processes were discussed at the Fish Stocks Review Conference in May 2006. The Conference stressed the need for RFMOs to incorporate more fully the precautionary approach and the ecosystem approach and encouraged the use of MPAs as a tool. As a way to assess progress, the Conference also recommended that RFMOs should undertake performance reviews.

New requirements for states and RFMOs with respect to deep sea bottom fisheries are set forth in the 2006 UNGA Resolution on Sustainable Fishing (A/61/105, see Section 3 above). RFMOs should adopt measures detailed in paragraph 83 (A-D) of the resolution no later than December 31, 2008. In areas where a new RFMO or arrangement for deep-sea fisheries is under negotiation, states should accelerate their negotiations and adopt, no later than December 31, 2007, interim measures consistent with paragraph 83 of the resolution. At the same time, flag states should either adopt and implement measures in accordance with paragraph 83 or cease to authorize their flag vessels to conduct bottom fisheries in areas where there is no competent RFMO. Such measures should be made publicly available through the FAO. State and RFMO implementation of such measures will be assessed by the UNGA in 2009. These steps should help to improve the adequacy and consistency of deep-sea fisheries management and protection of vulnerable deep sea ecosystems, if combined with credible RFMO performance review and improvements.

10.2 Adequacy of scientific knowledge and expertise within RFMOs

In some RFMOs the scientific advisory bodies may need to be supplemented with additional expertise regarding elements of implementing the ecosystem approach or identifying vulnerable marine areas. The need for additional expertise is rapidly apparent in light of the call by the UNGA in the 2006 Sustainable Fisheries Resolution for RFMOs and States to, inter alia:

[145] UN Sec. Gen. Impacts of Fishing Report, above ft. 35. See also Molenaar, above at ft. 49.

1. assess, on the basis of the best available scientific information, whether individual bottom fishing activities would have significant adverse impacts on vulnerable marine ecosystems;
1. 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;
2. improve scientific research and data collection and sharing;
3. identify areas where vulnerable marine ecosystems are known to occur or are likely to occur (UNGA 61/L.38, para 83(A-C)).

The lack of this type of expertise was highlighted in the June 2006 report of NAFO's Scientific Council, which stated that their current expertise is principally focused on stock assessment of fin-fish, squid and shrimp, environment influence, and extends to seals through a joint NAFO/ICES Working Group.[146] As a result, at its June 2006 meeting the Scientific Council was unable to make recommendations with respect to criteria for determining areas of marine ecological and biological significance, in particular areas associated with seamounts, hydrothermal vents, and cold-water corals or provide information on their distribution.[147] They suggested that additional expertise could be obtained either through the contracting parties or through cooperation with other organizations such as ICES. The Scientific Council also noted that it lacked the competence required to implement certain aspects of the ecosystem approach to fisheries. At least on an interim basis, ICES and its working groups on deep-sea fisheries and deep-sea ecology may be in a useful position to supplement or advise the scientific bodies to RFMOs or arrangements in need of additional expertise. ICES may however also need to enhance its capacity and expertise on these matters.

10.3 Adequacy of geographic coverage of regional organizations responsible for comprehensive environmental management

Some regionally-based agreements that establish comprehensive environmental protection regimes also enable regional organizations to designate MPAs. Examples described above include Antarctica, the Mediterranean and Northeast Atlantic. These allow for designation of different types of MPAs to manage current and potentially threatening activities. However, they cannot directly regulate fishing and shipping activities. As these organizations may have the broadest expertise to identify significant and vulnerable areas that would benefit from protection, effective coordination and cooperation with the relevant RFMOs is essential. In the past, this cooperation has been patchy, as the RFMOs may have lacked an interest in or a mandate for ecosystem-based management and/or biodiversity conservation.[148] These problems are now widely acknowledged, and a variety of mechanisms are being developed to enhance cooperation. For example, CCAMLR and the Environment Committee of the ATCM both send observers to each others meetings, and provide full reports on activities of relevance to the others mandate. They are now collaborating on the MPA initiative for the Southern Ocean. Similar exchanges and formal agreements between regional seas bodies and RFMOs, as well as with relevant global bodies, may enhance cooperation.

However, many High Seas regions presently lack regional marine agreements or organizations that can manage activities (other than fishing and shipping) that may negatively affect high seas biodiversity or identify and establish MPAs. The patchwork of geographic and political coverage can operate as a restriction on action.[149] Some have suggested that a global mechanism could help fill that gap until regional organizations are established. In the interim, regional grouping of states and user states could develop agreements amongst themselves to identify and protect vulnerable and representative marine ecosystems, based on globally agreed MPA criteria and guidelines.

---

[146] NAFO, 2006. REPORT OF SCIENTIFIC COUNCIL MEETING 1-15 JUNE 2006, available at: http://archive.nafo.int/open/sc/2006/screpjun06.pdf.
[147] Id.
[148] Royal Commission on Environmental Pollution, 2004. Turning the Tide – Addressing the Impact of Fisheries on the Marine Environment, 25th Report, December 2004 at 253. Available at www.rcep.org/uk/fishreport.htm.
[149] Young, above ft. 2.

11. NEXT STEPS FOR HIGH SEAS MPAs

Assuming RFMOs undertake the necessary reforms, and interim measures and arrangements are adopted in areas lacking competent RFMOs, MPAs can become an effective tool for deep-sea fisheries and biodiversity conservation and management on the High Seas. However, given the large gaps in information, the vulnerability of deep-sea fisheries to rapid depletion and the potential for long term and potentially irreversible damage to deep-sea ecosystems, a large-scale approach that reflects a high level of precaution and prevention will be necessary. As called for by the FAO Code of Conduct and the Fish Stocks Agreement, the absence of adequate scientific information should not be used as a reason for postponing or failing to take conservation and management measures to protect the living marine resources or preserve the marine environment. The 2006 UNGA Resolution on Sustainable Fisheries sets forth steps for all states and RFMOs to take in the absence of information, and details mechanisms to help develop the basic information required. But that too will take time. This time-lag highlights the continuing need for mechanisms such as a suspension of high seas bottom trawling, a dramatic reduction in effort and area, and/or a reversal in the burden of proof so as to make best use of the data already available within the fishing industry.

In developing plans for MPAs with respect to deep-sea fisheries on the High Seas, the following elements are worth further consideration:

- Protection of deep-sea coral and seamount diversity will need to be targeted in the upper 1 500 meters, where most of the coral diversity and targeted deep-sea fish stocks are located, and where the greatest fishing pressure takes place.
- Sponge beds and other communities that may be found on soft bottom habitats are also vulnerable to the impacts of deep-sea bottom fishing and will need to be considered for protection. These species also enhance local biodiversity but are very sensitive to increased turbidity and very slow to recover.
- At the scientific level, efforts to obtain data and understanding will need to be rapidly escalated and precede expansion of deep-sea fisheries in effort or into new areas. Rules to strictly control new and emerging fisheries and to prevent long term damage, such as those adopted by CCAMLR, may provide a useful model.
- Further work is necessary to identify and map deep-sea ecotypes and bioregions, to model the distribution of deep-sea species, and to understand the factors that influence the biodiversity of seamounts and other deep-sea habitats.
- Research on the ecology and biogeography of deep-sea benthic species and ecosystems remains critical. Its absence continues to confound approaches to develop a methodology for identifying vulnerable ecosystems or representative, special or unique areas as candidates for MPAs.
- Where areas have been proposed for protection, but the RFMO considers that there is a need for additional information or data, RFMOs might consider adopting an approach similar to that applied by CCAMLR by providing interim protection to an area so that further information can be gathered or further studies pursued.
- Vastly improved management and reporting on deep-sea fisheries, including at finer temporal and spatial scales than at present, is essential. Information on fishing areas, fishing effort, fishing strategies and targeted and bycatch species will need to be collected and assessed to identify what and where has been fished, what can be fished and where and what can be protected.
- To enable a fair assessment of socio-economic interests and biodiversity considerations, an agreed open, transparent and participatory process will need to be in place in all regions and/or at the global level for identifying MPAs and establishing protective measures. The development of consistent criteria, principles and guidelines by a spectrum of intergovernmental organizations, governments, scientists, conservation organizations and fishing industry representatives may assist RFMOs in developing such a process at least with respect to MPAs addressing high seas fishing activities.

- To secure a comprehensive system of High Seas MPAs, enhanced coordination mechanisms will need to be established between RFMOs and regional seas organizations and among specialized regimes with the capacity to regulate uses on the High Seas. Memoranda of understanding, participation in meetings, exchange of information between Secretariats and at the national level could assist in enhancing coordination.
- To implement effectively an ecosystem-approach to the High Seas and coordinate individual MPA designations within a larger ecosystem and biogeographic framework, mechanisms will also be needed to ensure conservation and sustainable use throughout the High Seas. The European Union has proposed an implementing agreement to UNCLOS for this purpose, though some suggest that this can be done through better use of existing mechanisms. There is an urgent need for broader discussion of this issue.

Efforts will also need to be directed towards applying the lessons learned at the FAO workshop on MPAs for fisheries management described in Section 1 above. These include: i) the need for political will as well as supportive legal and jurisdictional frameworks throughout the High Seas; ii) the advisability of harmonizing legislation between sectors and mandating institutional coordination, consultation and cooperation among agencies with relevant interests; iii) the possible use of zonation schemes, where there is sufficient capacity for enforcement of detailed, spatially explicit regulations; and iv) the need for involvement of stakeholders both within and beyond MPA boundaries, recognizing that on the High Seas, additional mechanisms may be necessary to enhance compliance and secure enforcement.

In the long run, the effectiveness of MPAs on the High Seas will hinge on the continued commitment and political will of nations to address broader issues related to high seas fisheries management and oceans governance on a global basis. Problems of poor implementation, compliance, decision-making, and enforcement within RFMOs and IUU fishing everywhere will need to be resolved at the same time as significant efforts are invested into improving scientific knowledge, deep-sea fisheries management and biodiversity conservation.

ANNEX I: LIST OF ACRONYMS

CBD	Convention on Biological Diversity
CCAMLR	Convention for the Conservation of Antarctic Marine Living Resources
COFI	Committee of Fisheries of the FAO
COP	Conference of the Parties
EEZ	Exclusive Economic Zone
FAO	UN Food and Agriculture Organisation
GFCM	General Fisheries Commission for the Mediterranean
HERMES	Hotspot Ecosystem Research on Margins of European Seas
ICES	International Council for the Exploration of the Sea
IMO	International Maritime Organisation
IOC	Intergovernmental Oceanographic Commission
IPOA	International Plan of Action
ISA	International Seabed Authority
IUCN	The World Conservation Union
IUU	Illegal, Unreported and Unregulated fishing
MPA	Marine Protected Area
NAFO	Northwest Atlantic Fisheries Organisation
NEAFC	North-East Atlantic Fisheries Commission
OSPAR	Commission for the protection of the marine environment of the North-East Atlantic
PSSA	Particularly Sensitive Sea Areas
RFMO	Regional Fisheries Management Organisation
SEAFO	South East Atlantic Fisheries Organization
SIODFA	Southern Indian Ocean Deepwater Fishers Association
UNCLOS	United Nations Convention on the Law of the Sea
UNGA	United Nations General Assembly
WSSD	World Summit on Sustainable Development

ANNEX II: Section X, 2006 UN General Assembly "Sustainable Fisheries" Resolution (A/61/L.38)

X
Responsible fisheries in the marine ecosystem

76. *Encourages* States to apply by 2010 the ecosystem approach, notes the Reykjavik Declaration on Responsible Fisheries in the Marine Ecosystem and decision VII/11 and other relevant decisions of the Conference of the Parties to the Convention on Biological Diversity, notes the work of the Food and Agriculture Organization of the United Nations related to guidelines for the implementation of the ecosystem approach to fisheries management, and also notes the importance to this approach of relevant provisions of the Agreement and the Code;

77. *Encourages* States, individually or through regional fisheries management organizations and arrangements and other relevant international organizations, to work to ensure that fisheries and other ecosystem data collection is performed in a coordinated and integrated manner, facilitating incorporation into global observation initiatives, where appropriate;

78. *Also encourages* States to increase scientific research in accordance with international law on the marine ecosystem;

79. *Calls upon* States, the Food and Agriculture Organization of the United Nations and other specialized agencies of the United Nations, subregional and regional fisheries management organizations and arrangements, where appropriate, and other appropriate intergovernmental bodies, to cooperate in achieving sustainable aquaculture, including through information exchange, developing equivalent standards on such issues as aquatic animal health and human health and safety concerns, assessing the potential positive and negative impacts of aquaculture, including socio-economics, on the marine and coastal environment, including biodiversity, and adopting relevant methods and techniques to minimize and mitigate adverse effects;

80. *Calls upon* States to take action immediately, individually and through regional fisheries management organizations and arrangements, and consistent with the precautionary approach and ecosystem approaches, to sustainably manage fish stocks and protect vulnerable marine ecosystems, including seamounts, hydrothermal vents and cold water corals, from destructive fishing practices, recognizing the immense importance and value of deep sea ecosystems and the biodiversity they contain;

81. *Reaffirms* the importance it attaches to paragraphs 66 to 69 of its resolution 59/25 concerning the impacts of fishing on vulnerable marine ecosystems;

82. *Welcomes* the important progress made by States and regional fisheries management organizations or arrangements with the competence to regulate bottom fisheries to give effect to paragraphs 66 to 69 of its resolution 59/25, to address the impacts of fishing on vulnerable marine ecosystems, including through initiating negotiations to establish new regional fisheries management organizations or arrangements, but on the basis of the review called for in paragraph 71 of its resolution 59/25 recognizes that additional actions are urgently needed;

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

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

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

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

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

84. *Calls upon* regional fisheries management organizations or arrangements with the competence to regulate bottom fisheries to make the measures adopted pursuant to paragraph 83 publicly available;

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

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

87. *Further calls upon* States to make publicly available through the FAO a list of those vessels flying their flag authorized to conduct bottom fisheries in areas beyond national jurisdiction, and the measures they have adopted pursuant to paragraph 86;

88. *Emphasizes* the critical role played by the FAO in providing expert technical advice, in assisting with international fisheries policy development and management standards, and in collection and dissemination of information on fisheries-related issues, including the protection of vulnerable marine ecosystems from the impacts of fishing;

89. *Commends* the FAO for its work on the management of deep sea fisheries in the high seas, including the expert consultation held on 21 to 23 November 2006 in Bangkok, Thailand, and further invites the FAO to establish at its next Committee on Fisheries meeting a timeframe of relevant work with respect to the management of the deep sea fisheries in the high seas, including enhancing data collection and dissemination, promoting information exchange and increased knowledge on deep sea fishing activities, such as through convening a meeting of States engaged in such fisheries, developing standards and criteria for use by States and regional fisheries management organizations or arrangements in identifying vulnerable marine ecosystems and the impacts of fishing on such ecosystems, and establishing standards for the management of deep sea fisheries, such as through the development of an international plan of action;

90. *Invites* the FAO to consider creating a global database of information on vulnerable marine ecosystems in areas beyond national jurisdiction to assist States in assessing any impacts of bottom

fisheries on vulnerable marine ecosystems and invites States and regional fisheries management organizations or arrangements to submit information to any such database on all vulnerable marine ecosystems identified in accordance with paragraph 83;

91. *Request* the Secretary-General, in cooperation with the Food and Agriculture Organization of the United Nations, to include in his report to the 64th session concerning fisheries a section on the actions taken by States and regional fisheries management organizations or arrangements in response to paragraphs 83 to 90, and *decides* to conduct a further review of such actions during the 64th session of the United Nations General Assembly in 2009, with a view to further recommendations, where necessary;

92. *Encourages* accelerated progress to establish criteria on the objectives and management of marine protected areas for fisheries purposes and in this regard welcomes the proposed work of FAO to develop technical guidelines in accordance with the Convention on the design, implementation and testing of marine protected areas for such purposes, and urges coordination and cooperation among all relevant international organizations and bodies**;**

93. *Notes* that the Second Intergovernmental Review Meeting of the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA) held 16 - 20 October 2006 in Beijing, and urges all States to implement the GPA and to accelerate activity to safeguard the marine ecosystem, including fish stocks, against pollution and physical degradation;

94. *Reaffirms* the importance it attaches to paragraphs 77 to 81 of its resolution 60/31 concerning the issue of lost, abandoned, or discarded fishing gear and related marine debris and the adverse impacts such debris and derelict fishing gear has on, *inter alia*, fish stocks, habitats and other marine species, and urges accelerated progress by States and regional fisheries management organizations and arrangements in implementing these paragraphs of the resolution;

95. *Further encourages* the FAO Committee on Fisheries to consider the issue of derelict fishing gear and related marine debris at its next meeting in 2007, and in particular the implementation of relevant provisions of the FAO Code of Conduct for Responsible Fisheries;

ANNEX III: Excerpts from 2006 UN General Assembly Oceans and Law of the Sea Resolution (A/61/L.30)

89 *Reaffirms* its role relating to the conservation and sustainable use of marine biological diversity beyond areas of national jurisdiction; notes the work of States, relevant complementary intergovernmental organizations and bodies on these issues, including the Convention on Biological Diversity and the Food and Agriculture Organization of the United Nations, and invites them to contribute to its consideration of these issues within the areas of their respective competence;

91 *Takes note* of the report of the Ad Hoc Open-ended Informal Working Group to study issues relating to the conservation and sustainable use of marine biological diversity beyond areas of national jurisdiction,[4] and requests the Secretary-General to reconvene, in accordance with paragraph 73 of resolution 59/24, and with full conference services, a meeting of the Working Group in 2008, to consider:

(a) The environmental impacts of anthropogenic activities on marine biological diversity beyond areas of national jurisdiction;

(b) Coordination and cooperation among States as well as relevant intergovernmental organizations and bodies for the conservation and management of marine biological diversity beyond areas of national jurisdiction;

(c) The role of area-based management tools;

(d) Genetic resources beyond areas of national jurisdiction; and

(e) Whether there is a governance or regulatory gap, and if so, how it should be addressed;

98 *Notes* the work of States, relevant intergovernmental organizations and bodies, including the Convention on Biological Diversity, in the assessment of scientific information on, and compilation of ecological criteria for the identification of, marine areas that require protection, in light of the objective of the World Summit on Sustainable Development to develop and facilitate the use of diverse approaches and tools such as the establishment of marine protected areas consistent with international law and based on scientific information, including representative networks by 2012;

99 *Notes* the report of the Scientific Experts' Workshop on Criteria for Identifying Ecologically or Biologically Significant Areas beyond National Jurisdiction, held in Ottawa, from 6 to 8 December 2005,[150] and encourages experts to participate in follow-up workshops;

101 *Calls upon* States and international organizations to urgently take action to address, in accordance with international law, destructive practices that have adverse impacts on marine biodiversity and ecosystems, including seamounts, hydrothermal vents and cold water corals;

108 *Calls upon* States, individually, or in collaboration with each other or with relevant international organizations and bodies, to improve understanding and knowledge of the oceans and the deep sea, including, in particular, the extent and vulnerability of deep sea biodiversity and ecosystems, by increasing their marine scientific research activities in accordance with the Convention;

[150] A/AC.259/16.

APPENDIXES OF PART 2: EXPERT CONSULTATION BACKGROUND DOCUMENTS AND PRESENTATIONS

APPENDIX 2.A: INVENTORY OF HIGH SEAS DEEPWATER RESOURCES AND FISHERIES

by

Alexis Bensch[1]

1. INTRODUCTION

In 2003, an international conference on deep-sea fisheries was organized to address the growing issues related to the exploitation of deep-sea fishery resources. The outcomes of conference were presented at the 26th session of the FAO Committee of Fisheries (COFI) in 2005. COFI made recommendations for future FAO activities, in particular concerning the collection of information on past and present deep-sea fisheries and the inventory of deepwater stocks.

In 2003, FAO published the "Strategy for Improving Information and Status and Trends of Capture Fisheries (Strategy-STF)". One of the required actions recommended by the Strategy-STF is the global inventory of fish stocks and fisheries. In 2004, FAO launched the Fishery Resources Monitoring System (FIRMS), a partnership of international organizations and regional fishery bodies. In addition, a project specifically designed to implement the Strategy-STF was initiated the same year under the FAO FishCode program, referred in this document as FishCode-STF.

Under these two initiatives, a methodology has been developed for the inventory of marine resources and fisheries and the data collection phase started together with the fine-tuning of the methodology.

This document introduces the inventory methodology and the FIGIS tools available for the management and dissemination of the data collected by the inventory. The current status and geographical coverage of this global inventory are also presented. In the last section, actions are proposed in order to incorporate the deep-sea fisheries and resources in this global initiative.

2. FAO GLOBAL INVENTORY OF MARINE RESOURCES AND FISHERIES

2.1. Objectives

The global inventory of marine resources and fisheries is one of the required actions identified by the Strategy for Improving Information on Status and Trends of Capture Fisheries, with the following main objectives:

- Help identifying gaps in fisheries management, and responsibility for managing fisheries (coastal States, high seas, or both).
- Help estimating the contribution of these un-monitored fisheries and promote policy-making taking into account the communities depending upon these fisheries.
- Provide the skeleton for a more systematic collection of fisheries related indicators.
- Provide the backbone to characterize fisheries management and its effectiveness: governance systems, management measures, scientific advice and related management actions, and response of fisheries resources.

---

[1]The views expressed in this paper are solely those of the author, Alexis Bensch, FAO Fisheries Department, Fisheries Information Officer, FAO, Rome, Italy, alexis.bensch@fao.org

2.2. Inventory methodology

The FAO methodology for the inventory of marine resources and fisheries has been elaborated analysing reports produced by different fisheries organizations and taking in consideration different geographical scales of reporting and purposes (management, scientific studies, etc.).

In order to develop a comprehensive inventory with information originated from different sources, produced at different geographical scales (national, regional or global) and from experts with different backgrounds, a preliminary step has been to work on definitions and to develop a standardized but flexible structure for the description of the fishery and resource units inventoried. A following step has been the design of an inventory format including the modelling of relationships between inventoried units.

2.2.1. Definitions

Fishery: A fishery is an activity leading to the harvesting of fish, within the boundaries of a defined area. The fishery concept fundamentally gathers indication of human fishing activity, including from economic, management, biological/environmental and technological viewpoints.

Marine Resource: Biotic element of the marine ecosystem, including genetic resources, organisms or parts thereof, populations, etc. with actual or potential use or value (sensu lato) for humanity.

Whereas *Marine Resource* is primarily a biological concept covering the description of marine species populations within defined geographic areas and including ecological and assessment aspects (*Stock* being a particular case of *Marine Resource*), the *Fishery* concept puts emphasis on the human aspects, including fishing activity, exploitation, socio-economic issues and management.

2.2.2. Structured description of inventoried units

In order to get to a practical inventory with a minimum level of homogeneity authorizing advanced queries and comparisons and to encompass at the same time different view points, flexible but standardized structures have been designed for the description of marine resources and fisheries. In both cases, the reporting structure includes:

- A set of key attributes which identity the inventoried unit. A marine resource is always identified by a species (or a species group) and a geographical area. Capture fisheries are identified by a geographical area and other attributes related to the fishing activity. Target species or gear used are often part of the key attributes for a fishery (e.g. Atlantic Northern Bluefin longline fishery.), but other attributes like vessel nationality, exploitation form or fishing season might be utilised (e.g. Senegalese industrial shrimp fishery).
- A set of thematic topics which document the inventoried unit. Depending on the topic, information is collected only as a text, or additionally by valuing specific qualitative attributes with standardized term or quantitative indicators (e.g. fleet size, annual catches, etc.).

Table 1 presents the key attributes and main thematic topics used for *Marine Resources* and *Fisheries*. Examples of qualitative attributes are provided in Table 2.

Table 1 – Key attributes and main reporting topics for the description of a marine resource or fishery.

Marine Resource	**Fishery**
Key attributes - Species or group of species - Area of distribution Main reporting topics - Habitat and Biology - Geographical distribution - Water Area Overview - Exploitation (fishery overview) - Biological Assessment - Management Overview - Biological state and trend	Key attributes - Fishing Area - Other key descriptor of the fishing activity Main reporting topics - Fishery area overview - Fishing activity (target species, gear, vessel, etc.) - Harvested resource - Production system - Socio-economic assessment - Post-harvest use - Management - Status and trends

Table 2 – Standardized attributes for the description of a Fishery fishing ground.

Attribute	**List of possible values**
Climatic Zone	Polar, Temperate, Tropical
Depth Zone	Coastal Shelf, Slope Abyssal, Seamount
Bottom type	Soft bottom, Seagrass, Hard bottom, Coral reef
Horizontal Distribution	Estuarine, Littoral, Neritic, Oceanic
Vertical Distribution	Demersal/benthic, Pelagic

The geographic component

Geo-referencing of information is a key point of the inventory of fisheries (fishing area) and marine resources (distribution area). The FIGIS system includes referencing and mapping tools of the geographical systems used by the data providers (e.g. spatial management units used by RFBs, global systems like EEZs, FAO statistical areas, Large Marine Ecosystems, etc.).

2.2.3. Inventory format and modelling of relationships between inventoried units

Both marine resources and fisheries can be defined at various geographical scales or levels of aggregation. At regional or national scales, the number of marine resources or fisheries inventoried may vary according to the level of aggregation. The basic principle of the inventory is that a marine fishery or a resource is included as long as it is recognized as a specific operational unit for monitoring, management or other purposes.

Hierarchies

In many situations, it is found that different sets of criteria might be successively applied to decompose *fisheries* into sub-fisheries: each partitioning stage is usually driven by a distinct thematic approach and the resulting set of fisheries constituting the inventory is organised in a hierarchical tree (see Table 3).

Table 3 - Example of hierarchical relationship between three inventoried fisheries.

Geo-reporting standpoint	Fishery Name	Thematic approach
Mexico	Shrimp fishery - Pacific Ocean	Resource
Mexico	Industrial Shrimp fishery - Pacific Ocean	Production system
Mexico	Artisanal Shrimp fishery - Pacific Ocean	Production system

Overlaps
Following the principal that any fishery or marine resource used as a unit by stakeholders has a place in the inventory, it may occur that two units overlap. For example, the inventory might include two distinct fisheries targeting the same resource or operated by vessels belonging to the same fleet. This is notified in the inventory by cross-referencing the fisheries under a specific attribute "Related Fisheries".

Relationship between marine resources and fisheries inventories
A given resource or stock may be exploited by many fisheries (e.g. a longline and a purse seine fishery may both exploit Yellowfin tuna), and a single fishery may exploit many stocks at the same time (e.g. multi-species trawl fisheries). The template used for the inventory includes the possibility to set relationships between marine resources and fisheries

2.3. Data entry, management and dissemination

Specific spreadsheet templates and guidelines have been designed for the inventories of marine resources and fisheries.

Once validated, data are imported into the FIGIS system. Each inventoried unit is assigned a unique identifier and referenced in the system. The information collected on each reference through the inventory is recorded as an “Observation” belonging to a data owner, with a reporting date. Under this model, further information may be provided on a referenced unit by adding new observations.

The FIGIS system has been designed to facilitate web-based data management and dissemination. The FIRMS partnership web site[2] is an example of the application of this technology. Marine resources inventoried by the member organizations might be retrieved through a query panel or through a tree browser (see Figure 1). The information collected on each inventoried unit is visualized through a standardized “fact sheet” (see Figure 2). On-line data editing is also possible, with access restricted to the data owners.

[2] http://firms.fao.org

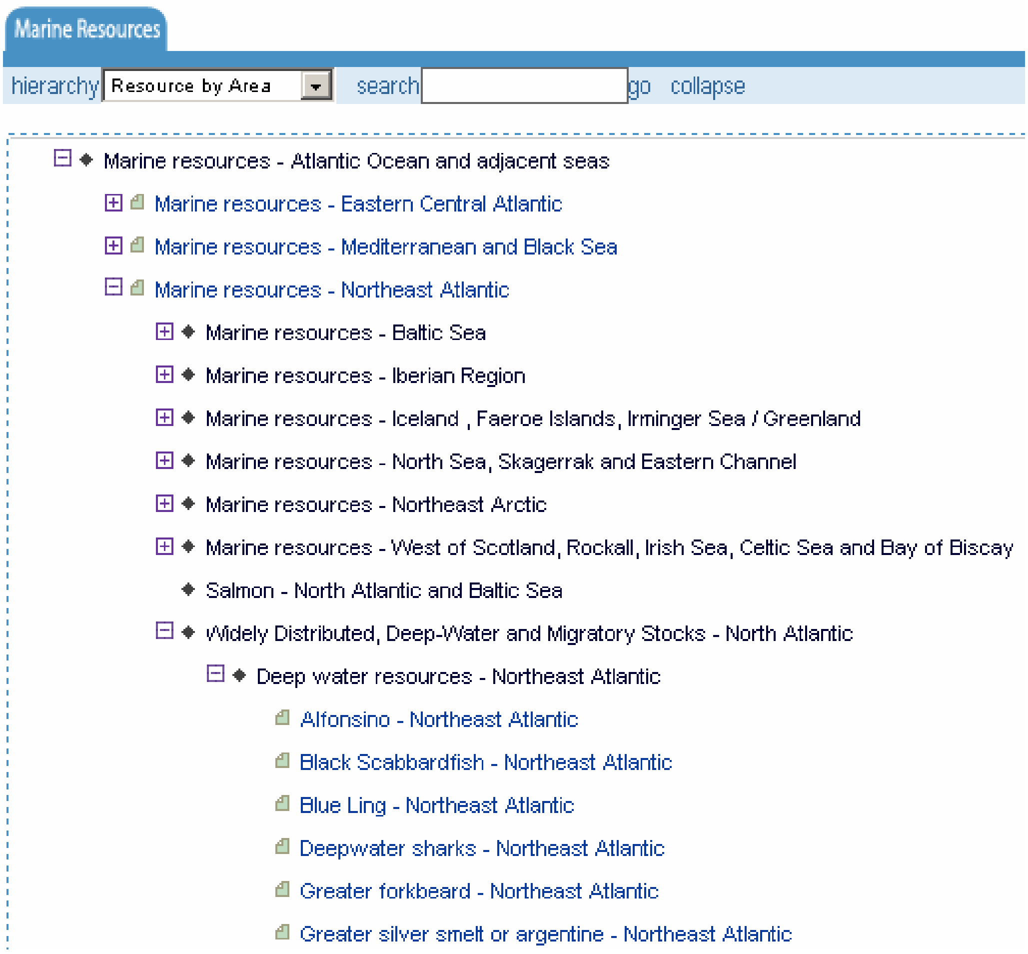


Figure 1 – FIGIS component: the FIRMS Marine Resources Inventory browser.

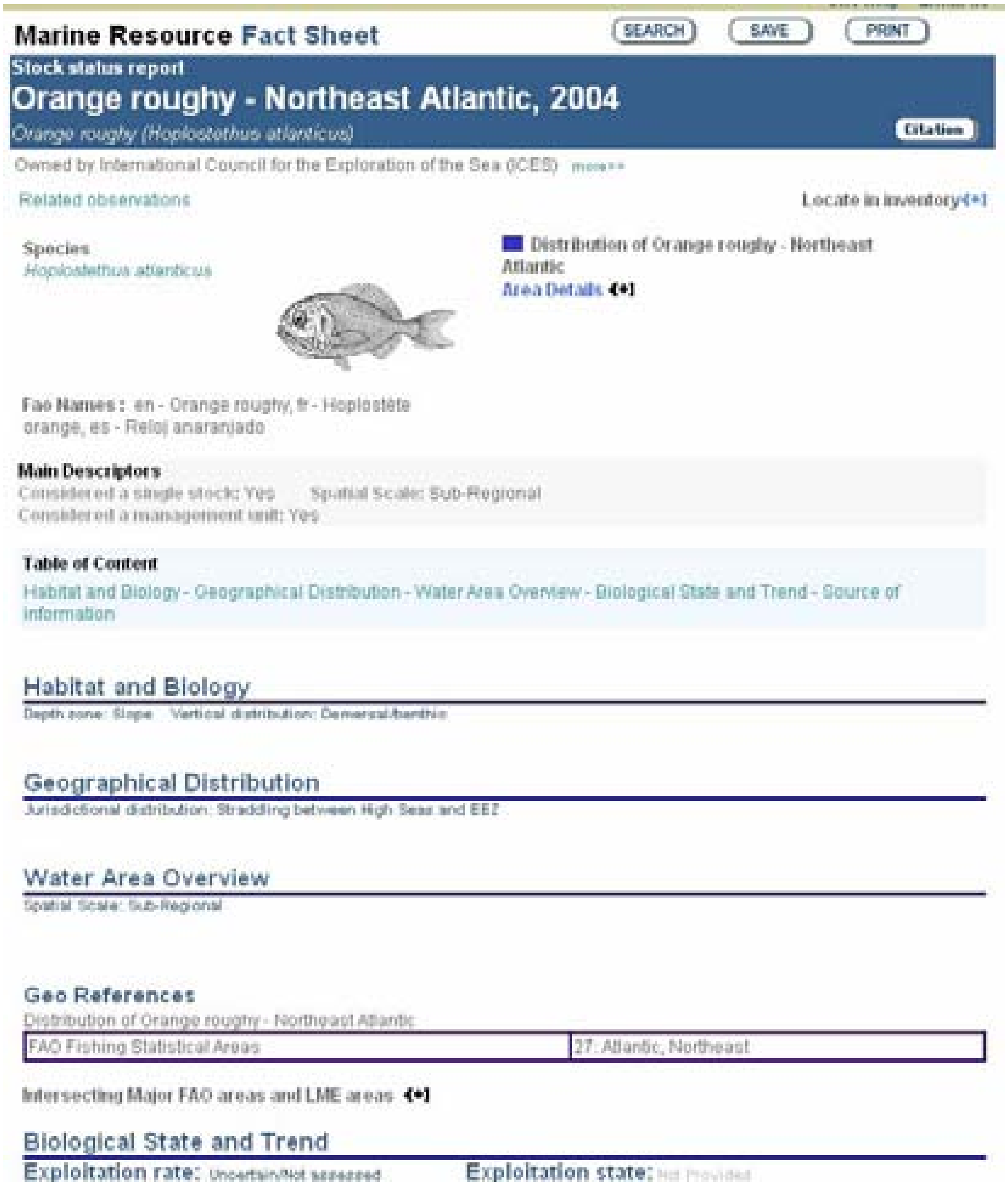


Figure 2 – FIGIS component: the FIRMS Marine Resource Fact Sheet.

2.4. Implementation process and status regarding high seas deepwater fisheries

The global inventory of marine resources and fisheries has been initiated by the FAO Fisheries department through three main channels for data collection:

- inventories performed by FIRMS partners, including FAO regional fishery bodies (e.g. CECAF);
- inventories resulting from a direct collaboration established between FAO and national or regional organizations (e.g. Bureau of Rural Sciences in Australia, National Marine Fishery Service in the USA); and
- regional inventories elaborated by FAO consultants. This third category concerns essentially developing countries where the FishCode STF project is implementing some activities related to the improvement of fishery data collection systems. A preliminary inventory is first elaborated by the project, based on the literature and other internet resources available. National or regional consultants are hired in a second step to revise and complete the inventory. Inventories are finally validated by FAO experts.

The inventory of high seas deepwater resources overlap with these three sources, but will require a complete review. In particular:

- In the latter stage, inventories made by FIRMS partners mainly focus on marine resources, but not fisheries, except in a few regions (ICES in the North East Atlantic, CCAMLR is the Southern Seas).
- FIRMS partnerships don't have global coverage for deepwater resources (see Figure 3).
- Many high seas deepwater fisheries are marginal, sometimes not managed and might not have been identified or well documented in the inventories completed at that stage.
- Most of the inventories covered by the FishCode STF project concern developing countries. Even if many of these countries do have fisheries targeting straddling deep-sea resources, they are not the main states concerned by the exploitation of high seas deepwater discrete fish stocks.
- Until now, inventories of fisheries undertaken by FAO have concentrated on current active fisheries, and might not include the past deepwater fisheries which were not sustainable and are no longer active.
- Many high seas deepwater fisheries are unmanaged and unregulated, and consequently under documented.

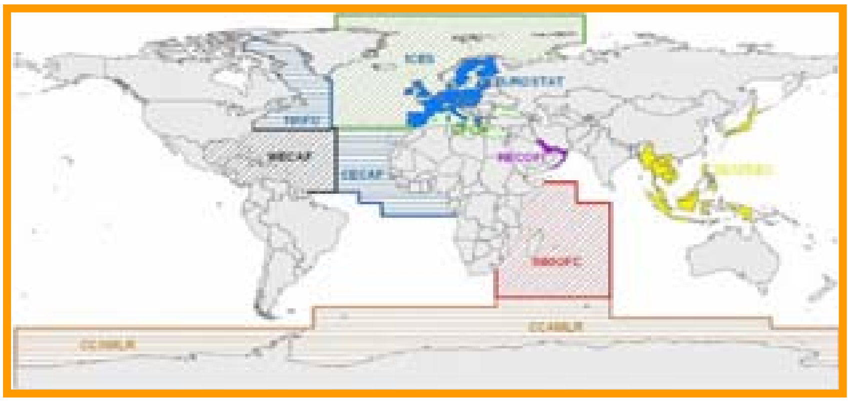


Figure 3 - Competence areas of the current FIRMS partners (excluding Tuna commissions).

3. ROADMAP FOR THE INVENTORY OF HIGH SEAS DEEPWATER RESOURCES AND FISHERIES

The FAO global inventory of marine resources and fisheries offers a valuable framework for the inventory of high seas deepwater resources and fisheries, in terms of methodology, but also data already collected and tools for data management and dissemination.

The main data sources to be considered would be:

- Fisheries science literature
- Fisheries and marine resources already included in the FAO global inventory
- Deepwater resources databases
- Seamount information systems
- Geo-referenced information: EEZs, bathymetry (see Figure 4)
- FAO fisheries country profiles
- FAO catch statistics database
- FAO database on discards
- The High Seas Vessels Authorization Record (HSVAR)
- FISH INFO network and FAO Globefish database (trade information)
- Regional Fishery Bodies (e.g SEAFO)
- Administrations of fishing nations (fisheries, coast guards, etc.)
- The fisheries industry (e.g. International Coalition of Fishery Associations, ICFA)
- NGOs (e.g. IUCN, WWF, Greenpeace, etc.)

This activity could be coordinated by the FAO project "Promotion of sustainable fisheries: support for the Plan of Implementation of the World Summit on Sustainable Development (II)" (GCP/INT/942/JPN) but would require some external financial support to cover:

- data management and dissemination of the inventory under the FIGIS system, and
- services of national/regional experts to validate the inventories

A regional approach is recommended for this inventory. Particular attention should be put on the collection of the status of each fishery and other quantitative indicators like the fleet size and annual catches.

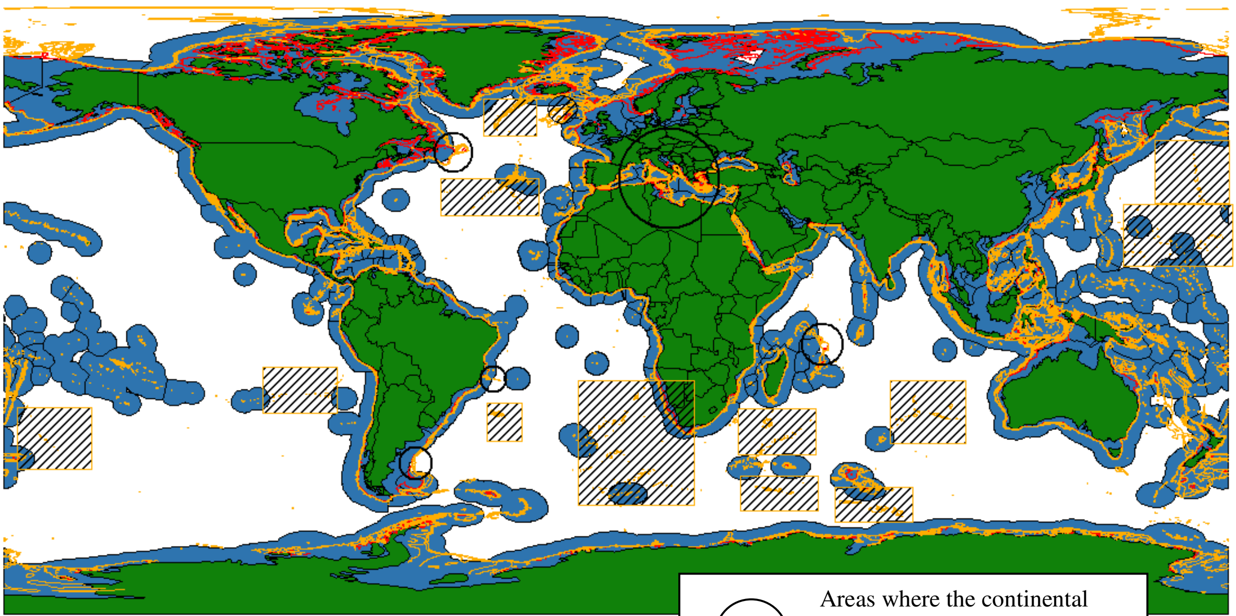


Figure 4 – Spatial distribution of EEZ and high seas bathymetric range compatible with deep seas fisheries activities.

Areas where the continental shelf ends outside the EEZs

High seas areas with occurrences of bathymetry between 500 and 2000m

REFERENCES

FAO. Report of the twenty-sixth session of the Committee on Fisheries. Deep-sea fisheries. Rome, 7-11 March 2005. *FAO Fisheries Report*. No. 780. Rome, FAO. 2005. 88p.

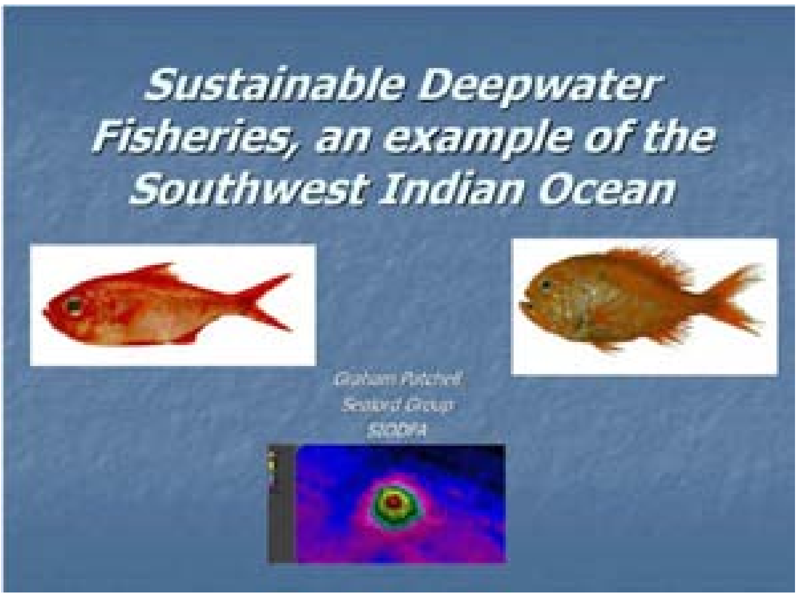
FAO. Report on DEEP SEA 2003, an International Conference on Governance and Management of Deep- Sea Fisheries. Queenstown, New Zealand 1–5 December 2003. *FAO Fisheries Report*. No. 772. Rome, FAO. 2005. 84p.

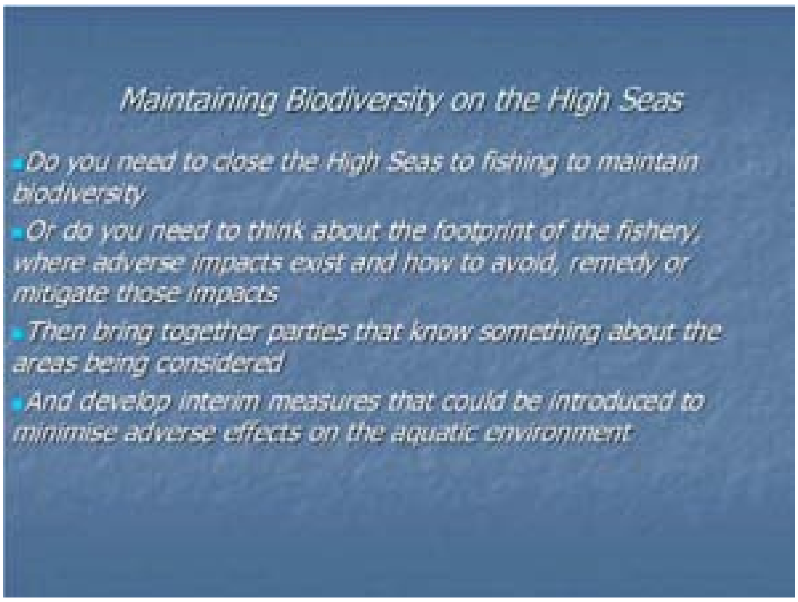
FAO. Strategy for Improving Information on Status and Trends of Capture Fisheries. Stratégie visant à améliorer l'information sur la situation et les tendances des pêches de capture. Estrategia para mejorar la información sobre la situación y las tendencias de la pesca de captura. Rome/Roma, FAO. 2003. 34p.

APPENDIX 2B: PRESENTATION ON BENTHIC PROTECTED AREAS IN THE SOUTHWEST INDIAN OCEAN

by

Graham Patchell, Sealord Grp, SIODFA



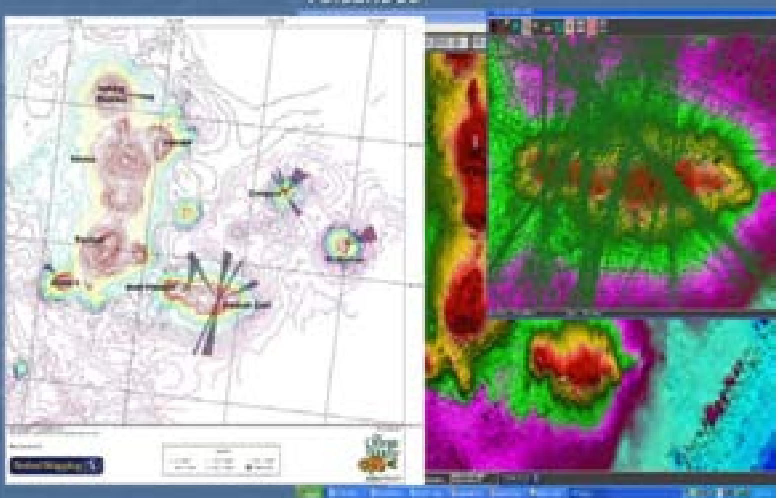


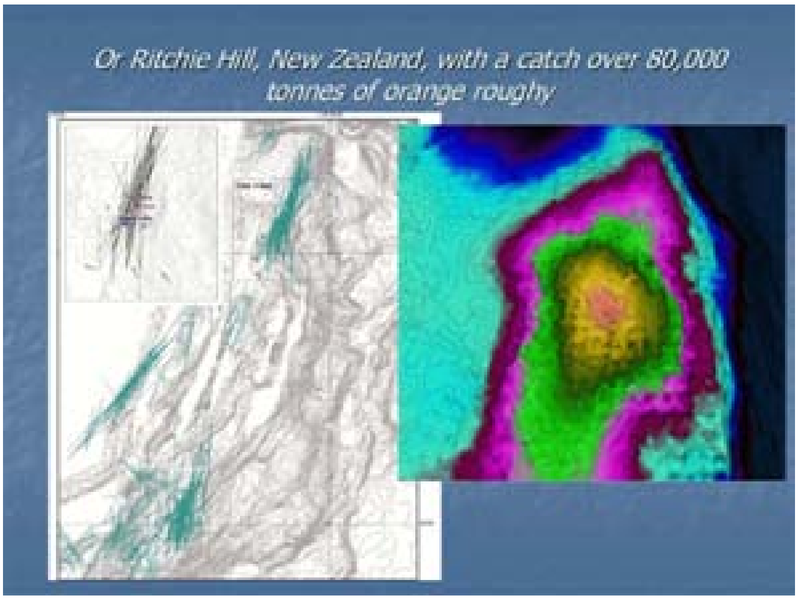
What does a seamount look like, where can you trawl?

How much of the habitat is really fished on with bottom trawls?

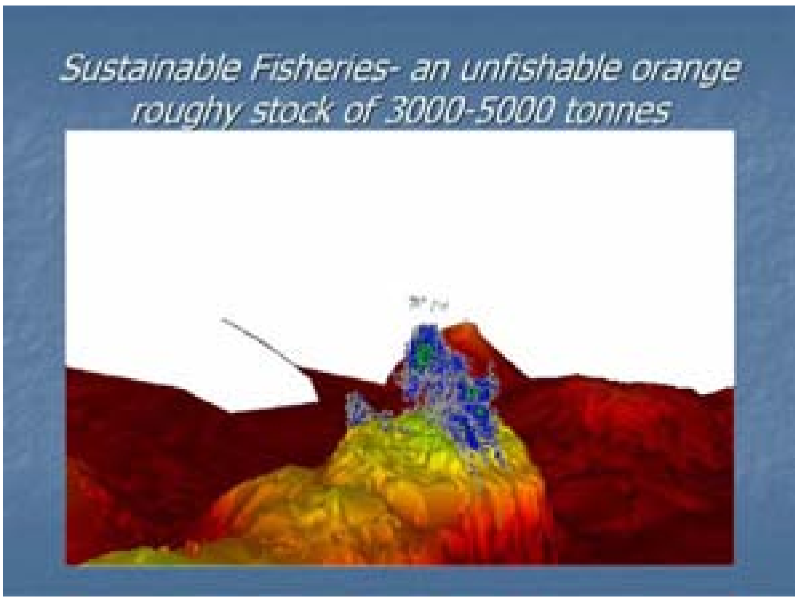
- Within existing RFMO's on the high seas
  - Large areas
- Within EEZ's
  - Northern Hemisphere substantial
  - Southern Hemisphere much less
- South Hemisphere High Seas?
  - Less than 1% trawled on

Example, the New Zealand Eastern Chatham Rise Volcanoes



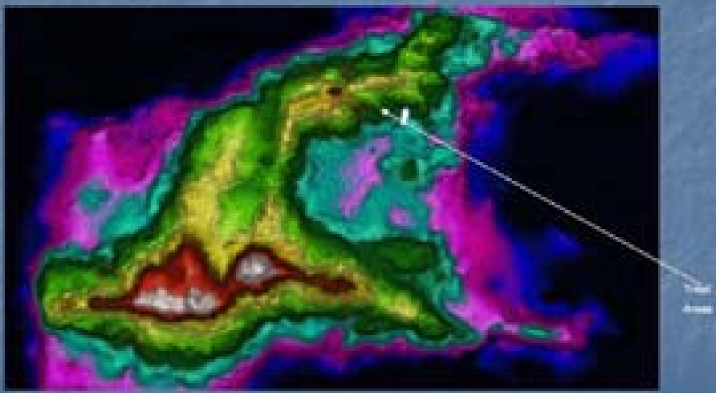

Or Ritchie Hill, New Zealand, with a catch over 80,000 tonnes of orange roughy


The Current Indian Ocean Fishery 2006
4-5 trawlers in the deepwater fishery during 2003-2006.
Unsubsidised, mixed species fishery, deepwater species bottom trawling and midwater trawling for alfonsino and boarhead.
Most operators in the fishery failed, (more than 40 vessels in 2000) the stocks did not!
Our research indicates the fishery is sustainable at current effort levels. Highly valuable IP, in an unregulated fishery.
FISHING NEWS International
ROUGHY BONANZA IN INDIAN OCEAN

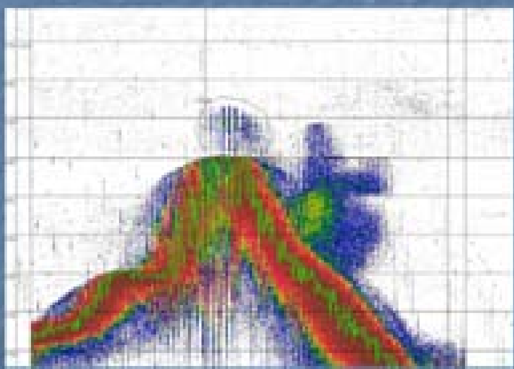

Sustainable Fisheries- an unfishable orange roughy stock of 3000-5000 tonnes

Heavily fished seamount on Southwest Indian Ridge

Area 124 km²



Sustainability? 2006 status 50%Bo

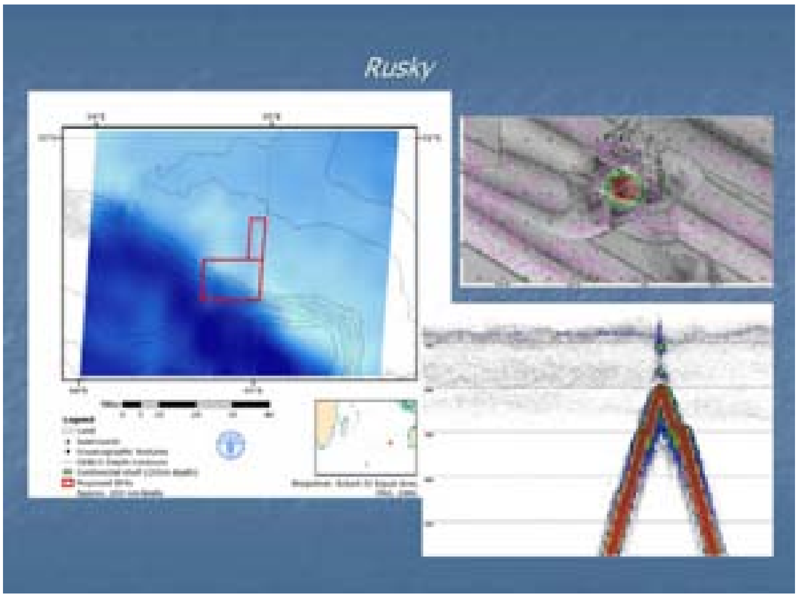


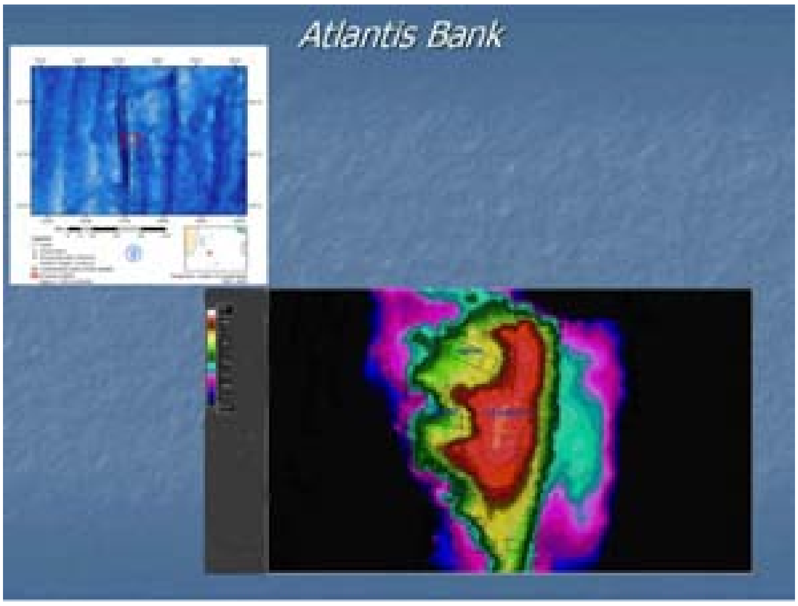
South Indian Ocean Benthic Protected Areas

What are they?

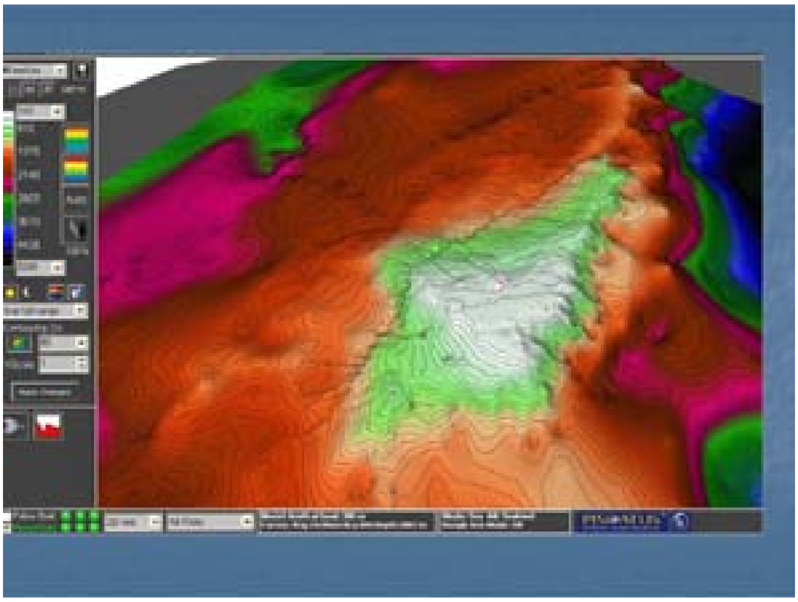
- Regions where bottom trawling and dredging is prohibited.
- BPAs provide for the maintenance of representative benthic habitats for the preservation of biodiversity.
- Midwater trawling may be permitted: SIODFA members have agreed that no trawling (mid-water or demersal) will occur in SIODFA BPAs.
- SIODFA cannot talk for other users.

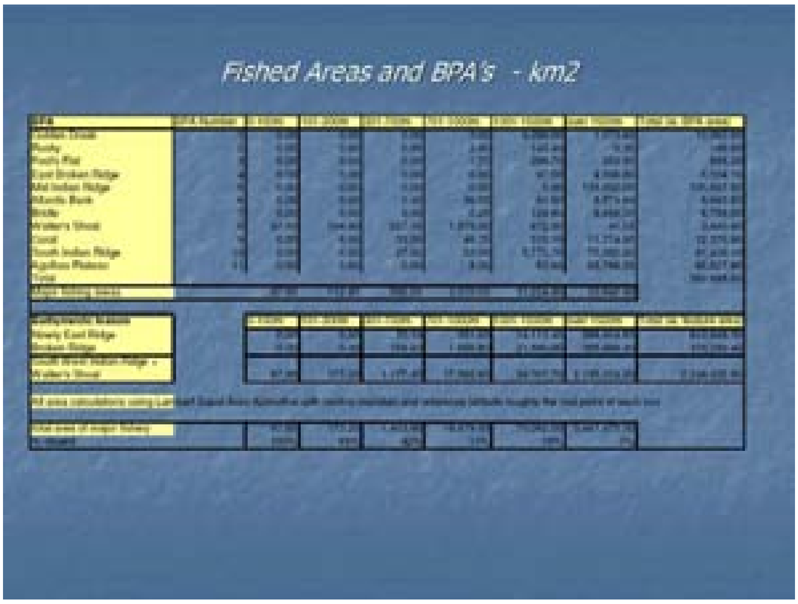

SIODFA Benthic Protected Areas


Rusky


Atlantis Bank


And Fools Flat

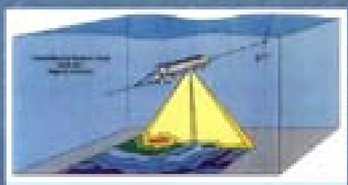


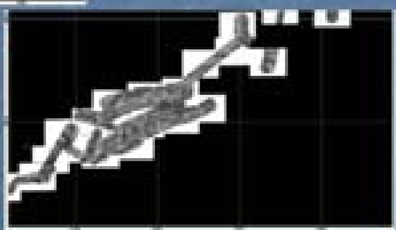

Fished Areas and BPA's - km2

SIODFA and Resource Management

- BPA's <u>must be</u> complemented by effective resource management
  - Fisheries data collection
  - Database compilation
  - Data analysis
  - Provision of resource management advice
  - Annual management plans
  - Compliance

Extensive swath mapping of habitat 1996, 2001

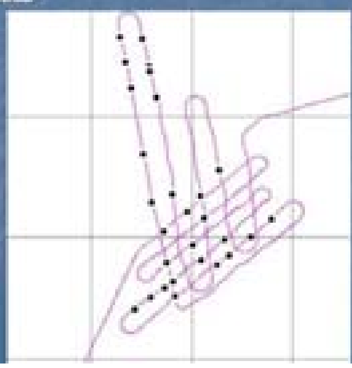




SIODFA Members have undertaken extensive research activities since 1996 in the Indian Ocean

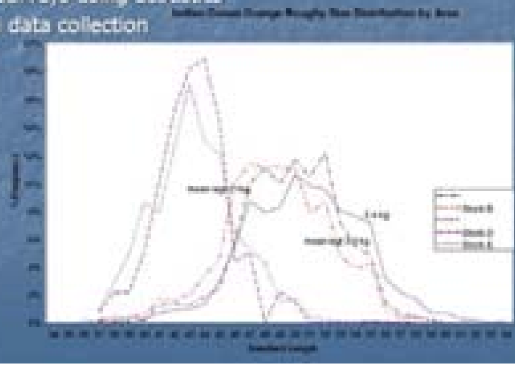
- Swath mapping of habitat
- Biomass surveys using acoustics

Stock Assessment using commercial vessel acoustics and 'Splash' surveys



SIODFA Members have undertaken extensive research activities since 1996 in the Indian Ocean

- Swath mapping of habitat
- Biomass surveys using acoustics
- Biological data collection



2006 SIODFA Research programme for all vessels in the fishery

Adopted by all SIODFA operators for the 2006 season.

- **Manuals provided to vessels include:**
  - **Acoustic data logging protocols**
  - **Biological Sampling of Orange Roughy**
  - **Coral reporting form**
  - **Shark reporting form**
- **Briefing of all skippers and factory managers in the fishery**

APPENDIX 2C: PRESENTATION ON CONSERVATION OF MEDITERRANEAN DEEP-SEA ECOSYSTEMS

by

François Simard, The World Conservation Union (IUCN)

IUCN
The World Conservation Union

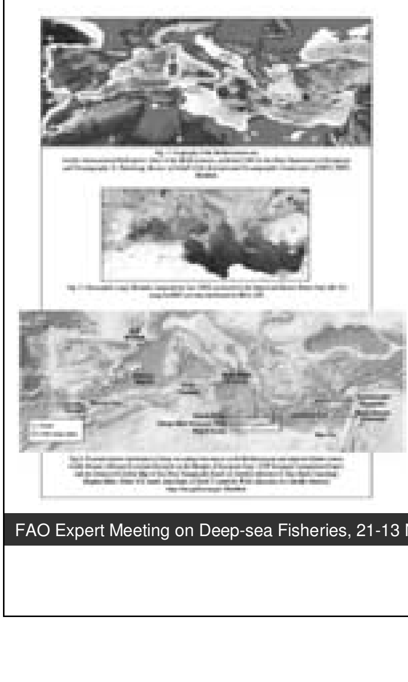
Conservation of the Mediterranean Deep-sea Ecosystems

François Simard
Marine Programme Coordinator
Advisor for Fisheries and Maritime Affairs

IUCN Center for Mediterranean Cooperation
IUCN Global marine Programme

FAO Expert Meeting on Deep-sea Fisheries, 21-13 November

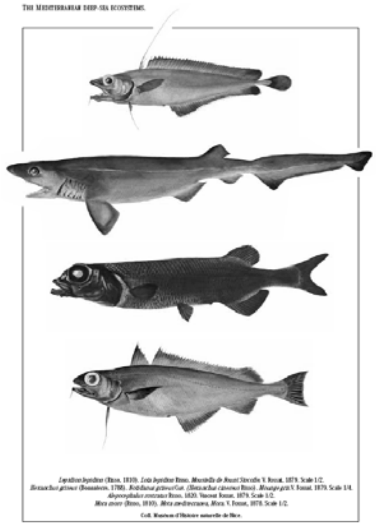
IUCN
The World Conservation Union



1- What is the Mediterranean deep sea ?

► An almost closed sea (few exchanges with the ocean, very slow vertical water circulation).
► Important depth down to 3000 m. in the western basin and 5000 m. the eastern basin.
► A constant temperature of 12°C due to its peculiar geology formation (depths in the oceans are around 2-3 °C).
► High biodiversity and endemism rates
► A number of special features: sea mounts, submarine canyons, cold seeps, brine pools, cold water corals.
► A large High sea (80 % of the whole) due to non declaration of EEZ by riparian states.

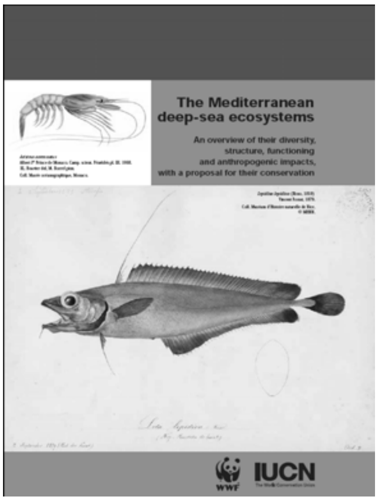
FAO Expert Meeting on Deep-sea Fisheries, 21-13 November



2- What is the issue ?

- ► Very poor knowledge of the ecosystems and of the biodiversity (according experts 5-7% of the existing ecosystems are described).
- ► Increasing pressure from fisheries. Since most Med fisheries are small scale and traditional, deep sea fisheries are not developed for the time being.
- ► Increasing land based pollution, and accumulation of debris and toxic products on the bottom due to rivers and sea currents.
- ► Still poor international cooperation in the High seas.

FAO Expert Meeting on Deep-sea Fisheries, 21-13 November

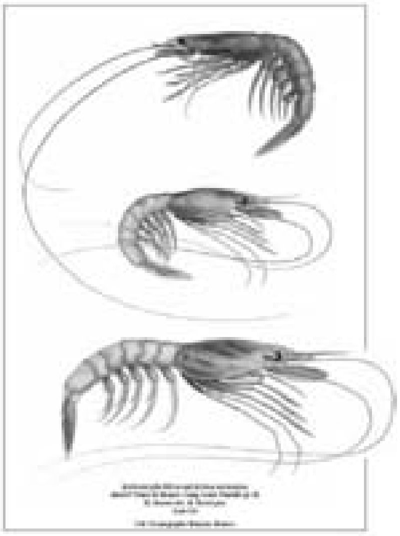


3. IUCN action

- ► Conducting a study in cooperation with IUCN members and partners
  - ► WWF Mediterranean Programme,
  - ► Marine Sciences Institute of Catalonia
- ► Presenting the results and conducting consultation with the relevant organisations
  - ► International Commission for the Scientific Exploration of the Mediterranean Sea -CIESM-,
  - ► Scientific Advisory Committee of the General Fisheries Commission for the Mediterranean -GFCM-
- ► Presenting the two proposals to the relevant international bodies
  - ► European Commission, Fisheries Directorate;
  - ► General Fisheries Commission for the Mediterranean – GFCM-

FAO Expert Meeting on Deep-sea Fisheries, 21-13 November

IUCN
The World Conservation Union



4. Conclusions of the report

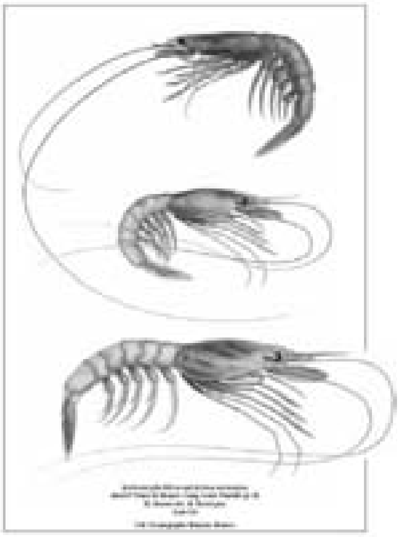
The proposal presented in detail in the document is structured on two levels:

- A general approach based on preventing an extension of fishing practices beyond 1000 m. depth as a precautionary measure, by seeking the agreement of stakeholders and implementing the CBD recommendations, and

- A site-based approach aiming at the creation of a network of Marine Protected Areas encompassing unique habitats, such as submarine canyons, cold seeps, brine pools, deep-water coral reefs and seamounts

FAO Expert Meeting on Deep-sea Fisheries, 21-13 November

IUCN
The World Conservation Union



4. Why 1000 metres?

- No fisheries are developed deeper than 1000 metres

- Few populations of commercial value below this depth

- Presence of interesting biological communities below this depth

- Important concentration of juvenile shrimps

FAO Expert Meeting on Deep-sea Fisheries, 21-13 November

IUCN
The World Conservation Union


IUCN

Mediterranean Conservationists and Fishermen Work Together to Protect Deep Seas

5. Results

At its 29th session, in Roma, the GFCM discuss one of the proposal of the IUCN/WWF reports and considering its importance and validity:

- *ADOPTS*, in conformity with the provisions of Article V of GFCM Agreement that :The Members of the GFCM shall prohibit the use of towed dredges and trawl nets fisheries at depths beyond 1000 m of depth.

IUCN
The World Conservation Union

RECOMMENDATION GFCM/2006/3

ESTABLISHMENT OF FISHERIES RESTRICTED AREAS IN ORDER TO PROTECT THE DEEP SEA SENSITIVE HABITATS

The General Fisheries Commission for the Mediterranean (GFCM),

ADOPTS, in conformity with the provisions of paragraph 1 (b) and (h) of Article III and Article V of the GFCM Agreement that :

1. Fishing with towed dredges and bottom trawl nets shall be prohibited in the areas bounded by lines joining the following coordinates:
2. For the same areas, Members shall call the attention of the appropriate authorities in order to protect these areas from the impact of any other activity jeopardizing the conservation of the features that characterize these particular habitats.

a) Deep Sea fisheries restricted area "Lophelia reef off Capo Santa Maria di Leuca"

39°19.08' N18°41.04'E
39°47.34' N18°58.80'E
39°42.24' N18°33.00'E
39°13.80' N18°31.44'E

b) Deep Sea fisheries restricted area "The Nile delta area cold hydrocarbon seeps"

31° 30.00' N, 33° 10.00' E
31° 30.00' N, 34° 00.00' E
32° 00.00' N, 34° 00.00' E
32° 00.00' N, 33° 10.00' E

c) Deep Sea fisheries restricted area "The Eratosthemes Seamount"

33° 00.00' N, 32° 00.00' E
33° 00.00' N, 33° 00.00' E
34° 00.00' N, 33° 00.00' E
34° 00.00' N, 32° 00.00' E

IUCN
The World Conservation Union

6. Next steps

- Continuing to support research efforts on Mediterranean deep sea ecology, and disseminating results and info
- Pursuing the second proposal of the IUCN/WWF study: the creation of a network of MPA encompassing deep sea unique habitats
- Documenting the sites and proposing to the concerned states a conservation status
- Strengthening the existing experts network in supporting the WCPA Marine Mediterranean Specialist Group
- Organising discussion forums for improvement of Mediterranean High sea governance

FAO Expert Meeting on Deep-sea Fisheries, 21-13 November

Deep-sea fisheries, as a result of technological development and market demand, are, in many areas, being exploited at increasingly unsustainable rates and, in some cases, with considerable damage to benthic habitats. This has lead to increasing concern on the part of many States over the conservation, management and governance of deep-sea fisheries.
The Expert Consultation on Deep-sea Fisheries in the High seas sought to further address issues in deep-sea fisheries and was held in Bangkok, Thailand, from 21 to 23 November 2006. The Consultation built off the results and request of other international fora such as the DEEP SEA 2003 and the FAO Committee on Fisheries. Presentations and discussion revolved around four main aspects of deep-sea fisheries in the high seas, including: the overall resource, management of the resource, legal issues and high seas marine protected areas.

ISBN 978-92-5-105822-0 ISSN 0429-9337

9 789251 058220

TR/M/A1341E/1/10.07/1500