DEEP-WATER FISHING

TIME TO STOP
THE DESTRUCTION

REPORT 2005

TIME TO STOP THE DESTRUCTION – THE SCANDAL OF DEEP-WATER FISHING

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TIME TO STOP THE DESTRUCTION

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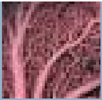
Malcolm has worked extensively on fisheries issues, including consultant to Greenpeace's campaign during the mid 1990s against sandeel fisheries for fishmeal and oil in the North Sea. He was a member of the Royal Society of Edinburgh's Inquiry into Scottish Fisheries, which published its influential findings in 2003. In 2000 he was lead author of *'Choose or Lose'*, a groundbreaking report that argued for a radical change in European fisheries policy, which lead directly to the development of a 2 million euro project, 'Invest in Fish SW' in the UK. This unique stakeholder-lead project is currently developing and evaluating the economic, social, environmental and fiscal pros and cons of future options for fish and fisheries. He remains Technical Consultant to the project.



Time to call a halt - the scandal of deep-water fishing

"Ninety per cent of the two-thirds of the surface of the Earth covered by sea lies beyond the shallow margins of the continents; and most lies under 2 km or more of water. We may therefore, with some justification, speak of the deep-sea bottom as constituting the most typical environment, and its inhabitants as the typical life forms, of the solid face of our planet. Yet, because of the remoteness of this habitat and the difficulties in observing and sampling these organisms, they are known to only few scientists; and as living rather than pickled specimens to less than a handful."

John Gage and Paul Tyler, Introduction to Deep-Sea Biology

How quickly things change. When John Gage and Paul Tyler wrote their ground-breaking book (1) on deep sea life some 15 years ago, the idea that this extraordinary world could in any way be threatened by human activities might have seemed unlikely – although even then they highlighted the potential impact of fisheries and other threats to the deep sea world, including mining and dumping.

While few people have been fortunate to see the wonders of the deep sea with their own eyes, by now quite a few of us will have (usually unwittingly) eaten fish hauled from the depths. Our increasing technological capacity, that allows us to discover more about this parallel world, has also allowed an explosive growth in deep sea fisheries. Fed by the failure to fish sustainably in shallower waters, there has been a rush to discover fish stocks living in deep seas. This fishery is working its way down the continental slopes and on to seamounts (underwater mountains), and other deep sea habitats.

Deep sea bottom trawling uses large, heavy gear that is designed to drag, across the sea bed, causing massive collateral damage. Habitats, such as ancient corals, some of them thousands of years old, which provide shelter for hundreds of other unique species, are also destroyed by these fishing activities. Overall, they catch tens of thousands of tonnes of species along with those being targeted, which are then dumped dead or dying back into the sea. Because of the slow growth of many of these deep sea fish (which may be older than your great-grandmother when you eat them), and because good breeding years may only occur once every decade or less, it will take centuries for nature to repair the damage already done.

The time is long overdue to call a halt to this destruction. Even deep sea fisheries nominally under the control of coastal states have major problems, while on the high seas – beyond territorial waters – bottom-trawl fisheries such as those in the northeast Atlantic have seen a free-for-all that has laid waste to the region. Deep sea life has a right to survival for its own sake; but preservation of these deep sea life forms is also enlightened self interest. The marine life now being trashed by deep sea bottom trawling is potentially a valuable alternative resource. The very differences that makes this life so alien paradoxically means that they have already provided insights in areas as diverse as immunology, enzyme technology, physiology and medicine. Those that have survived the onslaught could provide many more.

This report provides an overview of life in the deep oceans, particularly those threatened by deep sea bottom trawling, and documents the astonishing damage that has been done in the space of just a few years. It is easy to be cynical about warnings that 'time is running out' but the near-universal outcry from scientists and others involved in this issue needs to be heeded, and effective action taken to protect what remains. Greenpeace, along with a broad coalition of environmental organisations and numerous marine scientists are joining with a growing number of countries calling for an immediate moratorium on high seas bottom trawling to allow the time needed to find out what is in the deep ocean and develop the measures to manage, protect and share its resources in an equitable and sustainable way.

deep-water fishing

TIME TO STOP THE DESTRUCTION

I IT'S LIFE ... BUT NOT AS WE KNOW IT

i What lies beneath

As late as the mid-nineteenth century most were convinced that, due to the absence of light and plants, coupled with the cold temperatures and the enormous pressure exerted by the overlying water, the deep seas would be lifeless. Even when scientific expeditions and the laying of submarine cables began to reveal the diversity of life existing in the depths, it took time for this opinion to shift.

We now know that deep sea marine life is extraordinarily diverse. Some species are relatives of forms living in shallower waters: corals, starfish, brittle stars, and sea-urchins, crabs and other crustaceans, and marine wormsBut others are not obviously related to anything that we are familiar with elsewhere on the planet. While there is growing interest in alien life that might live on other planets, right now we are discovering equally bizarre life-forms deep beneath the waves. There is a real buzz in the scientific world as remote sensing vehicles and other tools reveal more and more about this life with every expedition.

Much of this life is associated with the seabed. If we could view the planet beneath the seas we would see that the landmass of the continents extends outwards in a 'continental shelf' typically a couple of hundred metres below the surface. This is where the majority of human activities are concentrated. The shelf then drops steeply several thousand meters, and then declines more gently to the vast, undulating, ooze-covered abyssal plain typically around five kilometres deep. Superimposed on this overall topography are seamounts (underwater mountains that don't break the surface) together with smaller hills and undulations. Canyons and ridges are associated with the continental break and slope, while trenches that can dive eleven kilometres below the surface, and mid-ocean ridges rising above the seafloor, are formed by movement of the giant continental plates that jostle above the fluid interior of the earth.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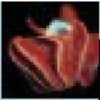
The remarkable but thinly spread life-forms on the abyssal plane and in the ocean trenches and mid-ocean ridges are currently out of reach of bottom trawling (which can get down to a still remarkable two kilometres depth), and it may be that the density of fish is too low to prevent commercial fishing. They are, however, already subject to the all-pervasive influence of persistent organic pollutants that originate from human activities onshore or in the shallow coastal zone, and may in the future be vulnerable to the pollution and disturbance that would be caused by mining of the seabed.

On the continental slopes the increased amounts of food descending from the highly productive shallower waters create a frontier where the deep sea species increase in abundance and diversity, and also mix with species derived from coastal waters. Tragically, the irresponsible development and application of technology means that this abundance of life is now accessible to deep sea bottom trawling, and indeed is being increasingly targeted.

ii Seamounts, mounds, ridges and canyons

Superimposed on the deep underwater terrain are numerous features such as seamounts, smaller mounds, ridges, banks and undersea canyons. These provide a very different habitat for deep sea life, with a very different mix of species, compared to the flatter areas covered by muddy sediments.

Globally there are anywhere between 14,000 and 50,000 seamounts (2), although this partly depends how high a feature has to be to be classified as a seamount – some estimates suggests that there are hundreds of thousands of distinct sites. Of these, so far, less than 200 seamounts have been surveyed in any detail (2), and on these have been found many species that appear unique to one location, or a restricted area – between 10 to 50



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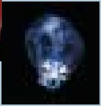

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percent of the total at any one site. Even if the rate of discovery of new species tails off as more seamounts are surveyed, they are clearly a treasure house of biological diversity.

Standing above the ocean floor, seamounts modify the flow of the prevailing ocean currents rather like drifting snow over and behind an obstacle. As water currents sweep past seamounts they accelerate, increasing the flow of food to animals on the mounts. The turbulence around seamounts may also cause nutrient rich deep water to be brought closer to the surface, fertilising plant and other growth, and they can in turn be dragged down in the lea of seamounts, making this enhanced productivity available to filter feeders on the seamounts. It is not only seamounts that can act in this way. On a smaller scale, canyons and ridges can provide similar effects and habitats, as can even simple mounds of sand found on the sea bottom.

Seamounts and similar ocean floor features also differ from the ooze covered abyssal plain by providing a solid surface. Corals and other species can find a firm purchase on the slopes and crests of seamounts, and these in turn provide a foothold or shelter for other animals. The recirculation of water in the lee of seamounts may have another important effect: the planktonic young of species may be retained in their vicinity, rather than being swept out to sea. Although these mechanisms are not well understood, this, and the relative isolation of many seamounts, may help explain why so many unique species have evolved.

Seamounts and other topographical features not only provide a habitat for invertebrate life, but also encourage aggregations of fish. It is these fish have become an important target of deep sea fisheries.

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iii The bizarre life of soft sediments ...

Despite the gap of up to several thousand meters between the seabed and the surface water, the fate of deep sea species is closely tied to what happens near the surface. There is a seasonal flush of growth of the microscopic plants in these sunlit layers. This in turn supports microscopic animals and larger animals higher up the food web. When this surface life dies, their remains, dominated by plant material, slowly sink through the water. Some of this is eaten on the way down, but ultimately much of it settles out on the seabed some weeks or months later. This nourishment from above supports life in the ocean depths.

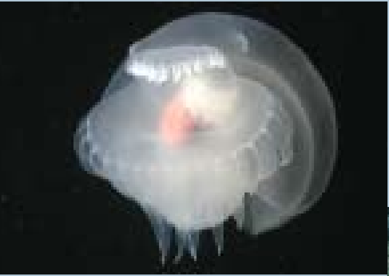
And such bizarre life! There are ‘shape-shifting' holothurians, soft-bodied sea cucumbers. These distant relatives of starfish shift across the seabed, sometimes in great herds, grazing on the food from above. They can change shape, lifting off to hover and drift in the currents above the seabed, and descend to new areas. There are sea lilies (crinoids), which have arms that radiate from the top of a stem, which are used to filter out food particles drifting past. While at first glance they might seem more like plants than animals, they are also distant relatives of starfish. They are living fossils, whose discovery came as a major surprise to biologists. Another strange group are the fascinating cirrate or bat octopods, whose tentacles are linked by a web, and which are found in the water above the deep sea bed and upwards into the gloomy depths (1).

Gigantism is one of the characteristics of the deep oceans. Giant deep sea squid are the most well known (though never yet seen alive despite the fact that it is increasingly caught by deep sea trawling), whose diet includes deep sea fish, possibly including the orange roughy (1, 3), but many other giant life forms also live here. There are giant sea-spiders all legs and no body, and also giant relatives of woodlice, 15-20 cm long. There are worms buried in the sediments, which protrude a tongue 50 cm long to lick up the organic matter settling from above, and which betray their presence by leaving patterns on the sediments like the spokes of a wheel. Even single-celled organisms have remarkable giant deep sea forms: Xenophyophores are distantly related to the

deep-water fishing

TIME TO STOP THE DESTRUCTION

microscopic amoeba familiar from school textbooks, but which can grow to between 12 and 20 cm across. They have been likened to large golf balls or brains scattered on the surface of the seabed, and can be quite common in some places. They feed by sending out threadlike sticky arms of protoplasm over the surface. In addition to these bizarre life forms there are many deep sea forms of sponges, sea pens, sea anemones molluscs , starfish, brittlestars, urchins, barnacles, crabs and squat lobsters which are readily recognisable as relatives of the shallow water species – although this did not prevent one strangely shaped deep sea sponge sparking off a long running controversy that it might be a device (the 'Eltanin antenna' (4)) left behind by an alien UFO!



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iv … and the fragile beauty of deep water corals

Amongst all these deep water habitats the diverse deep sea coral reefs, associated mainly with seamounts and similar habitats, are the jewel in the crown. They include sea fans (also known as horny or gorgonid corals), stony corals and black corals. Unlike their warm water relatives, these corals do not depend on a mutual association with microscopic plants held within their bodies for part of their food, and are therefore liberated from sunlit surface waters. These 'coldwater' corals in turn create a habitat for a host of other species (2). Within their branches, and on the rocky surrounds glass and barrel sponges, anemones, starfish, sea lilies, molluscs and crustaceans can be found. In turn these support other species – well over 100 species have been found living in association with glass sponges at one site. Some of these organisms can be very long lived and also very slow growing. Gorgonian corals in the North-East Atlantic have been aged at between 300 and 500 years old, while in the deep seas off New Caledonia, sea lilies and bamboo corals are similarly ancient (2). Some seamount corals have been estimated at ages between 300 and 2,000 years old. Other remarkable species have also been found in the vicinity of seamounts, notably the velvety black cloaked, red eyed, luminous Vampyroteuthis infernalis (literally 'the vampire squid from hell') the squid equivalent to the Coelacanth, which has been photographed above the Sumisu Seamount by a Japanese research vessel (5), although Vampyroteuthis is probably a widespread species, living between 600–800 m depth (6).

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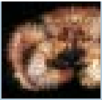

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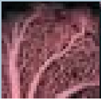
Corals are also a feature of mounds formed on soft sandy areas in deep seas. Lophelia pertusa is a stony coral which, although capable of colonising steep terrain, only requires small hard areas to get started, and can then build on the skeletons of its ancestors to cover extensive areas. In the Rockall Trough in the North-East Atlantic, the Darwin Mounds, formed of sand and elevated only a few metres above the surrounding terrain, support dense coral colonies on their tops and extensive aggregations of xenophyophores in their lee (7). Over 1,300 invertebrate species have been identified as associated with such reefs. In common with those corals colonising rocky habitats in the deep sea, they are also very persistent. In Norwegian waters, Lophelia banks can be 30 metres high (4), which build up at around 1.3 mm annually, so even colonies a few metres across may be centuries old while the ages of the largest colonies can be measured in millennia (7). In recent years, these deep sea reefs have been found in numerous locations around the world.

The key characteristics of many of these deep water species, whether on soft sediments or on seamounts and other rocky areas, is that they are slow growing, and they live in habitats usually far removed from the turbulent, damaging conditions of surface waters. As a result they can be unadapted for, and highly vulnerable to disruption, whether by the direct effects of a heavy trawl, or the indirect effects of the clogging sediments stirred up by such activities.



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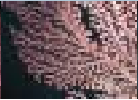

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II DEEP-SEA FISH

This abundant life provides shelter or food for a similarly diverse array of deep sea fish. In many cases these also differ markedly from the species found in shallow waters due to the adaptations that they have evolved for life in the cold, dark deep waters of the oceans. Like other deep sea life, many are slow growing and slow to reproduce. Good breeding years can be irregular and separated by a decade or more, and even then they produce relatively few young. These are features that have made them uniquely vulnerable to overfishing.

i Fish of seamounts and rocky seabeds

The Orange roughy (Hoplostethus atlanticus) is probably the best-known seamount fish, due to the fisheries targeting the spawning aggregations that concentrate over seamounts. These chubby bright scarlet or orange fish have a global distribution, and until recently they were found in astonishing numbers over seamounts as far ranging as New Zealand and Tasmania, Namibia, Madagascar and in the North-East Atlantic. Under natural circumstances they live well over a hundred years, grow only very slowly and may not start breeding until they are 25-30 years old. As often the case with deep sea species, it is still not know where the young fish live. In the temperate regions of the South Pacific (primarily off South Africa, New Zealand and Southern Australia) oreos often occur with orange roughy and are also fished.

The alfonsinos (Beryx and Centroberyx spp.) are found over seamounts in the tropics and subtropics. The little that is known about their life history suggests that they are also vulnerable to overfishing (8). The diet of alfonsinos, consisting of smaller fish, crustaceans and squid (9) is probably typical of many seamount fish. The young of the prehistoric-looking pelagic armourhead (Pseudopentaceros wheeleri) are carried away from seamount spawning grounds on the Hawaiian Ridge, and others in the central Northern Pacific, to live in the surface waters of the

Northern and Subarctic Pacific for the first two years of life. They then transform into bottom feeders, migrating between their feeding grounds in the north and the seamounts spawning grounds (10, 11). Other populations and species of armourhead also migrate over long distances. The pelagic armourhead was one of the first seamount species to be decimated by intense fishing, during the 1970s and 1980s (12).

Not all deep sea species that occur over rocky ground are necessarily associated with seamounts. The roundnose grenadier (Coryphaenoides rupestris) inhabits banks and ridges (and also the continental slope) in the North-East Atlantic. Again, these slow growing fish produce relatively few young. Redfish or rockfish (Sebastes) are a ubiquitous family of fish found in many marine habitats. Deep sea forms are found along the continental margins of the North Pacific and North Atlantic. Redfish are remarkable because they are viviparous, giving birth to relatively few live young rather than spawning. These deep sea forms tend to be long-lived; individuals over 50 years are common in unfished populations, and 200 year olds have been found in the Gulf of Alaska (13).

ii Open plain and continental slope fisheries

Among the more eye-catching– and it has to be said, repulsive – species found on some muddy sea floors of deep ocean plains and continentals slopes are primitive jawless hagfish. Writhing masses scavenge dead or dying animals falling from above, entering through bodily orifices to consume them from the inside out, and covering themselves in an abundant slimy secretion that deters other fish.

Tripod fish are another distinctive form found in very deep waters. As the name implies, in a world where food may be encountered only rarely, they sit it out on the seabed, raised on their rigid fins and tail into the current, with a host of sensitive antennae pointing forward to detect the vibrations created by approaching prey. Other species over the open plain and continental slope tend to share a common body form, one quite distinct from those on seamounts. They tend to have a large head, a dagger-shaped body, and a fin that extends along much of the length of the upper and lower sides, often without a separate tailfin.

The most frequently encountered group are the grenadiers or rat-tailed fish (Macrourids), named after their long, whip-like tails. They can catch other fish, but also scavenge off the seabed. They also tend to be much weaker swimmers than species found in the vicinity of seamounts. Male macrourids, as well as those of another major group, the cusk-eels (brotulids), are responsible for the characteristic drumming sound that can be heard at these depths. The sound, amplified by the resonation of their swim bladder, allows them to advertise their presence to each other. The many species of morids (codling), cusk-eels and hakes are more robust, stronger swimmers, and tend to be active predators. Hake is an important predator of other fish on the upper continental slope. Swimming up into shallower waters at night, they are an important link between deep and surface water ecosystems. Their life history is more similar to fish from shallower waters, tending to mature earlier and live shorter lives than other deep-water species. A very different fish found on the Pacific continental shelf are sleek sablefish (black cod). They can reach a great age of over 100 years, even though the young live in surface waters and mature relatively early.

The icefish are (or were) the most important predatory fish found around the Antarctic and in the Southern Ocean. There are two subgroups, the more robust cod icefish (Nototheniidae) and the crocodile icefish (Channichthyidae – their snouts having a passing resemblance to crocodiles). The largest cod icefish are the Antarctic and Patagonian toothfish. Among the more remarkable features of the group are the presence of 'antifreeze', and the absence of haemoglobin in their blood. In most other animals, haemoglobin makes blood red, and carries oxygen throughout the body. Icefish have colourless blood: the highly oxygenated seas, and intense cold that slows body processes down, have allowed them to dispense with haemoglobin. In common with many deep sea fish, particular species tend to be found at different depths throughout the region, rather than being associated with any one area. Their ability to range over long distances is attested by one Patagonian toothfish that turned up off Greenland, having swum some 10,000 km via the deep cold waters underlying the tropics and equator (14).

The last major group found on the deep plains and slopes are flatfish, whose chief representatives in the Atlantic are the Greenland and Atlantic halibuts. Although classed as flatfish, the halibuts spend more time off the bottom than usual, and have evolved partially back to a form more typical of 'normal' fish. The Atlantic halibut (Hippoglossus hippoglossus) is an enormous fish when full grown reaching up to 300 kg and 3-4 metres in length, although most of the fish now caught weigh between 2.3 and 56 kg. The Greenland halibut (Reinhardtius hippoglossoides) can reach 1.2m in length and a weight of 45 kg prior to heavy fishing, and can be found down to depths of 2,000m.

iii Deep sea fish and marine mammals

Evidence is now emerging of the importance of deep sea fish to some marine mammals. Marine mammals have co-existed with their prey for millennia without depleting the stocks, as is evident from the abundance of both in areas unexploited by fisheries. Orange roughy, for example, are eaten by sperm whales (15). One recently discovered example is the importance of Greenland halibut and other deep sea species in the diet of over-wintering Canadian and western Greenland populations of narwhales (whose single long ivory tusk was taken and mistaken for the horn of the unicorn in Medieval Europe) in Baffin Bay and the northern Davies Strait (16). In order to reach the halibut, the narwhales have to regularly dive to a depth of 800 metres or greater. Recently a fishery for Greenland halibut has started in this area, and the researchers express their concern over the impact this may have on the narwhales. Hooded seals off eastern Greenland also feed on Greenland halibut, and have been recorded diving in excess of one kilometre in pursuit of the fish. In order to do this, they have to hold their breath for dives that can last longer than 50 minutes (17).

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III THE SCANDAL OF DEEP WATER FISHERIES

Deep sea bottom trawlers target orange roughy, roundnose grenadier, smoothhead, redfish and blue ling in the North-East Atlantic, while in the North-West Atlantic northern prawns, redfish and Greenland halibut are taken. Greenland halibut are also fished, together with northern prawns, over the slopes of the 'nose' and 'tail' of the Grand Banks off Newfoundland.

Deep sea fisheries can be highly profitable to those involved in catching and marketing, especially when new sources are discovered and effectively mined without replenishment in the first few years. An internet search for recipes for orange roughy shows how it has been successfully touted as an alternative to more familiar but increasingly scarce, and therefore expensive whitefish.

Globally, the eight most important deep sea fisheries by tonnage, recorded in the FAO Fishstat Plus database for 2001, were:

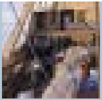
* Roundnose grenadier (Coryphaenoides rupestris) 53,669t, most important fishing countries Spain 38,225t, France 8,494t, Denmark 2,229t, Russian Federation 1,992t, UK 1,030t
* Argentines (Argentina spp.) 49,036t, most important fishing countries Norway 14,668t, Faeroe Islands 9,952t, UK 7,955t, Ireland 7,505t, Netherlands 3,659t, Iceland 2,478t
* Ling (Molva molva) 36,988t, most important fishing countries Norway 13,562t, UK 8,095t, Spain 4,267t, France 2,987t, Iceland 2,864t, Faeroe Islands 2,558t, Ireland 1,463t
* Tusk (aka Cusk, Lump) (Brosme brosme) 28,524t, most important fishing countries Norway 18,778t, Iceland 3425t, Faeroe Islands 2,992t, Canada 1,498t
* Orange roughy (Hoplostethus atlanticus) 25,258t, most important fishing countries New Zealand 14,044t, Australia 5,161t, Ireland 2,759t, France 1,254t
* Blue ling (Molva dypterygia) 19,347t, most important fishing countries UK 5,980t, Spain 4,472t, France 3,666t, Faeroe Islands 2,454t, Norway 1,020t
* Black scabbardfish (Aphanopus carbo) 14,834t, most important fishing countries Portugal 6,753t, France 5,070t, Spain 1,323t
* Blackspot (red) seabream (Pagellus bogaraveo) 1,323t, most important fishing country Portugal 1,128t

Other important deep sea species caught using bottom trawls are cardinal fish (Epigonus telescopus), alfonsino, and red bream (Beryx decadactylus).

Many of the deep sea fisheries lie within the nominal control of coastal states. Here, it should be relatively easy to regulate the fisheries to ensure that they are sustainable, and that they do not have disastrous impacts on seabed habitats. However, in practice much of the management of these deep water stocks has been dreadful, and even less attention has been paid to the impact the heavy bottom trawling gear has on the habitat.

One important consequence of this mismanagement, and the incredible global demand for fish, is that the search for new deep sea stocks has extended onto the high seas, where there is either no management at all, or where controls are so lax as to make little difference. One paradox of high seas bottom trawling is that there is so little monitoring of them that there is little information of their impact, particularly of the collateral destruction on habitats. However, there is no doubt that wherever bottom trawling occurs on the high seas it will cause major damage to seabed habitats, as this is part of the very nature of this type of fishing.

The remainder of this report documents the nature of the destruction by deep sea bottom trawling, drawing on examples from the high seas where available, and from those within the jurisdiction of coastal states where it is not. The damage done to fish stocks is depressing, but has been fairly well highlighted. The collateral destruction caused to seabed habitats continues to receive less attention, and it is this aspect that is particularly emphasised over the following pages. It concludes by describing who is responsible for this destruction.



i The sequential decimation of fish stocks

A cursory glance at the total landings of deep sea fish might suggest that these fisheries are sustainable, these having fluctuated up to 1,000,000 tonnes from the mid-1960s. But it doesn't take much digging to reveal the underlying scandal of the sequential decimation of one species after another (18). It is a grim story: stocks destroyed before the basic science was done, and the sequential mining of successive areas for individual species (including roundnose grenadier Coryphaenoides rupestris and orange roughy); serial depletion of related species and varieties (redfish, Sebastes), political expediency and fish wars (Greenland halibut); fishing down the food web for increasingly low value species (a general characteristic of deep sea bottom trawling); destruction subsidised by us, the public, through government funding; a total lack of precaution; and attempts to apply precaution which turned out not at all precautious (all of which are applicable to orange roughy); and a reckless failure to give heed to the wider impact on deep sea life (all deep sea trawled species). In short, the more you look, the worse it gets.

When fisheries biologists and managers assess the sustainable level of a fishery they generally tend to assess each stock in isolation. They simplify the role that fluctuating conditions in the physical environment may play, and don't take into account the wider impact on other species. This approach has been vigorously challenged by marine biologists (a wider discipline than fisheries science) and environmental groups. Attitudes are changing, but this varies from country to country and generally tends to be more in word than deed. Fisheries scientists are now increasingly speaking out on the wider impacts of fishing, but the management response tends to either be limited set-asides for marine protected areas or that the scientist's advice is effectively ignored. This is true of much fishing, but deep sea fisheries in general, and those on the high seas in particular, are the ultimate and frequent victim of this 'out of sight, out of mind' management regime.

ii Collateral destruction

The collateral damage from deep sea bottom trawling, which is virtually ignored on the high seas, even where primitive regulatory bodies exist, falls into two categories: the impact on deep seabed habitats, and that on other species swimming in association with the targeted stock.

Deep sea bottom trawling is the equivalent of clear cutting ancient forests – except that it appears to be happening over an even greater area, and at greater speed (19). The farming equivalent would be to remove cattle and sheep with a vast net, while simultaneously tearing up the pasture that fed them, and the wildlife that surrounds them. Attention has been focused on the vulnerability and protection requirements of deep rocky seabed habitats, typically including cold water corals, especially so off Norway, Tasmania and New Zealand. However, the plight of soft-sediment deep sea habitats, also vulnerable to bottom trawling, also needs far greater recognition as it hardly features in current thinking.

iii Deep sea corals

One of the scandals associated with deep sea bottom trawling is how little attention has been paid to its impact on deep water corals on the high seas. But there can be no doubt, from what is known of bottom trawling's impact on Lophelia reefs in the North-East Atlantic, and from seamounts in New Zealand waters, that the damage will be substantial.

Norway Norwegian long line and gill net fishers were among the first to blow the whistle on the impact of bottom trawling on coldwater corals. Trawlers had moved into Norwegian Lophelia coral areas, targeting Greenland halibut, redfish and saithe (20). The trawl 'doors' used to keep the mouth of the nets open weigh two to five tonnes each (21), and the mouth of the nets are 30–40 meters across (20). Not surprisingly, corals were being crushed and cleared by this gear, and the catches from traditional fisheries were said to be falling. Other fishers believed that this was because the corals were important feeding and nursery areas for young fish.

deep-water fishing

TIME TO STOP THE DESTRUCTION

Researchers used sonar and remote controlled submarines to assess the fishers' complaints (20). They found vast areas where the coral had been smashed, toppled or turned into rubble. The major damage was clearly associated with bottom trawling, and it was confirmed that the cleared areas also supported fewer fish. Long line catches of redfish were six-fold higher within surviving reef areas, while catches of ling and tusk were two to three times greater. In surviving areas the researchers saw dense aggregations of redfish on the reefs. For plankton-feeding redfish it appears to be the physical shelter that attracts the fish; for others, such as ling, the reefs themselves are important feeding grounds (22).

Astonishingly, the researchers concluded that between 30 and 50% of reef areas within Norwegian waters had already been destroyed or damaged by bottom trawling, and that this had largely been done in just the ten years since 'rockhopper' gear became widely available. Rockhoppers are intentionally designed to operate over rough ground, including corals, which had previously been difficult to trawl. By the late 1990s, double trawls were being used which allowed an even greater area to be swept.

These findings sparked further research and action by the Norwegian government. Two huge areas of continuous Lophelia reefs were discovered near the Norwegian continental shelf break (in the Sula region, and the reef off Røst), and there is evidence that these date back to the end of the last ice age. One thousand square kilometres in the Sula region, and the Røst reef have now received protection from bottom trawling (23-25).

North-East Atlantic Many more areas of Lophelia have now been discovered along the margin of Europe from Norway via Shetland and Faeroes and down the western fringe of the British Isles (26). Depending on local conditions, these may occur as individual mounds, hills or peaks, or in fields of such peaks.

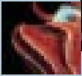
An especially rich area of large mounds has been discovered on the steep slopes on either side of the Rockall Trough, to the west of Ireland (27). The largest 'mounds', on the Porcupine Seabight, on the eastern wall of the Trough, are steep-sided and can be up to 350 m high (1,150 ft) and two km across the base. The mounds are composed of coral skeletons, amplified by the accumulation of drifting sediments in currents that can be up to half a meter per second. These currents are responsible for the high flux of food that allows the coral to grow in the first place. The reefs certainly date back to immediately after the last ice age (ca 10,000 years ago) and may go back far longer.

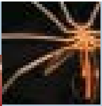
There are tantalising brief references to Lophelia in the reports from late nineteenth century research voyages, indicating that even more extensive coral beds once existed between Scotland and the Faeroes, and between Ireland and the Porcupine Bank. These state that it "forms stony copses covering many miles" affording shelter for "multitudes" of other species. These prior observations led to the modern conclusion that "it seems possible that, at least in UK territorial waters, the previous extent of cold-water coral habitats has already been substantially reduced by trawling activity (...) it is unlikely that the extent and significance of this damage will ever be fully appreciated" (26).

iv Seamounts

The impact of bottom trawling on seamounts is alarming because of their limited size, many unique species, and because so many seamounts are in international waters where research, let alone conservation, is very limited. The impact of seamount bottom trawling relies heavily on research in the waters of coastal states, particularly off Tasmania and New Zealand.

In a 1997 survey of seamounts off Tasmania, between 24–43% of the invertebrate species found were new to science, and many of the species differed markedly from those found on the nearest adjacent seamounts, off New Zealand. Ninety-five percent of a heavily fished seamount was found to be bare rock compared with just 10% on the most comparable un-fished seamount. In 2003 two heavily fished seamounts in New Zealand were found to have coral cover no greater than 2-3%, compared to two relatively untouched seamounts that had 100% coral coverage (28). The effect of bottom trawls on Tasmanian seamounts was also evident in the rapid reduction of coral hauled to the surface in commercial





trawls (without any change in trawling technique), declining in one survey from 1,750 to 100 tonnes per year between 1997 and 2000 (29). In the words of the Australian Government Fisheries Research and Development Corporation (30) "The fauna is highly vulnerable to trawling and is likely to have limited resilience, as its slow growth and low natural mortality are adapted to an environment with little natural disturbance."

Deep sea corals have now also been discovered in the seas off Japan, Alaska, California, Nova Scotia, Maine, North Carolina, Florida, Colombia, Brazil, Sweden and Mauritania, as well as on the high seas (31). Some protection has been applied by countries including Norway, Australia, New Zealand, the USA and Canada within their national waters.

v Speak up for the holothurians . . .

Deep sea corals and the communities they support are dramatic and, quite rightly, are receiving attention and demands for protection. However, also needing protection is the bizarre but largely unseen life of the deep soft seabeds – the holothurians, sea lilies, giant worms, sea-spiders, crustaceans, and protozoa. Some deep sea fisheries, such as those for grenadiers or deep water flat fish occur either entirely or in part on these soft sediments. There has been little field work, and only few theoretical reviews (32) on the impact of deep sea bottom trawling on these soft sediment communities.

Nevertheless, deep sea soft sediment communities can be expected to be even more sensitive to bottom trawling than has already been demonstrated for their shallower water equivalents (33), for the same reasons as the deep sea fish species are vulnerable to overfishing – slower growth and lower reproductive potential. A high seas bottom trawling moratorium would allow the time to assess these soft sediment areas of the deep sea and to determine if any such areas could be sustainably fished and how and what areas might need protection.

vi . . . and don't forget the bycatch

Bottom trawling removes very large amounts of other animals that happen to be unfortunate enough to be swimming or living in the vicinity of the target species. In the North-East Atlantic where only a few species are targeted, many others are dumped, along with undersized fish of the target species. In the late 1990s, (34) the French fleet typically retained only eight species, while discarding 43 others. Around 48% of the weight of the catch was discarded, this proportion increasing with depth. It was estimated that these amounted to at least 17,500 tonnes each year, and could be larger still.

To make matters worse, it is likely that most of the deep sea fish that escape through the mesh during the haul die later, and of course are never recorded in such statistics. Deep sea fish tend to have fragile skins, easily damaged by contact with the mesh and with other fish. One study found that these 'no-catch discards' could add as much as 66–86% to the catch in numbers, and a further 10–45% in terms of weight (35). The loss in numbers is the more important statistic, because it means that many younger fish, that would have grown to reproduce, are being lost.

It is fairly easy to say what most people would want for the marine environment; that fisheries take place without causing the 'functional extinction' of species – in other words a healthy ecosystem where all species are not only present but abundant enough to continue to play their normal role. Establishing what level of fishing allows that to happen is uncertain, even for shallow water fisheries. But one attempt to fully incorporate environmental fluctuations into single stock assessments suggests that the best long term yields come from leaving far more fish in the sea – around 75% of the virgin stock for typical shallower sea fisheries (36). One might expect deep sea species to need even more. This is before taking account of the impact of other species that depend on these fish for food.

deep-water fishing

TIME TO STOP
THE DESTRUCTION

IV WHO IS RESPONSIBLE?

Those primarily responsible are the fishers and fishing companies who moved into deep sea fisheries in search of new markets. Though in some cases this was an attempt to survive the depletion of shallow water species, this does not excuse the damage that is being wrought.

Just eleven countries were responsible for 95% of reported high seas bottom trawl catch in 2001. These were Spain, Russia, Portugal, Norway, Estonia, Denmark/Faeroe Islands, Japan, Lithuania, Iceland, New Zealand and Latvia.

In the **North-East Atlantic**, an estimated 25,000–55,000 tonnes of deep sea fish were caught by bottom trawlers in 2001, worth $35-75 million. The main species caught were roundnose grenadier, blue ling, smootheads, Greenland halibut, orange roughy and deep sea sharks. Deep sea forms of redfish are also caught, and part of this comes from "demersal" trawling (38), which can be expected to involve contact with the seabed. Spain appears responsible for at least half the catch, with Russia, Lithuania and Estonia responsible for much of the remainder. In the **North-West Atlantic** around 125,000 tonnes (worth ca. $215 million) were caught, mainly Northern prawn (ca. 60,000 tonnes), Greenland halibut, redfish caught by bottom trawl, and skates. The main countries responsible were Spain, Russia, Portugal and Estonia.

For the **South-West Indian Ocean**, orange roughy and alfonsino are the principle target of high seas bottom trawlers, and New Zealand, Japan and Australia were the principle countries involved in a short-lived fishery that peaked in 2000 with 40 vessels involved. By 2001 the catch was just 7.9 tonnes. The **South-West Pacific Ocean** had a significant fishery for orange roughy, with New Zealand and Australian trawlers catching ca. 3,900 tonnes in 2001, and a further 200 tonnes taken by vessels registered with other countries.

The remainder of high seas bottom trawl fisheries comes from areas such as that off Namibia, although they are not of the same scale as those in the Northern Atlantic. Overall, it is unlikely that the number of vessels engaged globally is more than the equivalent of 150–200 full time vessels, around 0.01% of the global fishing fleet.

i Time out, now!

One of the few potential routes for bringing high seas bottom trawling under control is via the United Nations (UN). For this reason, a number of countries, along with marine scientists and environmental groups are pressing for the UN to impose a moratorium on high seas bottom trawling, so that sufficient time is provided to assess deep sea biodiversity and ecosystems, and to develop legally binding international regimes to conserve and manage the bottom fisheries of the high seas in a sustainable and equitable manner. Over one thousand marine scientists recently petitioned the UN for such a moratorium, which would not only "ban bottom trawling to protect deep-sea ecosystems wherever coral forests and reefs are known to occur within their Exclusive Economic Zones", but also require a moratorium to be established by the UN, in conjunction with other international bodies, on high seas bottom trawling (31).

While damaged sites should be protected and allowed to recover, the prevention of bottom trawling on virgin sites is one important reason for imposing a moratorium on high seas bottom trawling. The good news is that such a moratorium will not bring the global fishing industry crashing to its knees. According to the most comprehensive assessment currently available (37), bottom trawl fisheries on the high seas landed around 170–215,000 tonnes in 2001. To those unaware of the scale of global fisheries, this is an eye-opener. But this represents just 0.2–0.25% of the total global marine fish catch in 2001, which was a mind-boggling 83,700,000 (83.7 million) tonnes. In monetary terms, the high seas deep sea bottom trawl catches were worth $300–400 million, again an astonishing figure to an outsider, but representing less than 0.5% of the total value of world fisheries. A moratorium on high seas bottom trawling will not bring widespread hardship to the global fishing industry.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ii The weakest link

If the UN does agree to a moratorium on high seas bottom trawling, there will need to be a framework for implementing it. The most obvious route is via Regional Fisheries Management Organisations (RFMOs) and the UN Fish Stocks Agreement (FSA). The problem is that the coverage of the high seas, and particularly deep sea fisheries, by these RFMOs is patchy and the FSA does not apply to discrete stocks. Where they exist, many RFMOs can sometimes seem to be little more than bodies intended to divide up the spoils and prevent fish wars.

Currently the five RFMOs that can institute conservation measures over bottom trawling within their areas of competency are the North-West Atlantic Fisheries Organisation (NAFO), the North-East Atlantic Fisheries Commission (NEAFC), the South East Atlantic Fisheries Organisation (SEAFO), the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) and the General Fisheries Commission of the Mediterranean (GFCM). Yet other than CCAMLR and the GFCM (which recently passed a measure banning bottom trawling below 1,000m), over the past 10 years, none of these organisations have implemented the precautionary principle or ecosystem based management approach that they are supposed to under the UN Fish Stocks Agreement. There needs to be a radical transformation of these fisheries bodies into Regional Ecosystem Management Organisations reconstituted so that their approach to fisheries management was from an ecosystem point of view and their decisions were based on the precautionary principle if they were to even begin to adequately address the impacts of deep sea fisheries on these marine ecosystems. Such a process would take time. The negative impacts on marine biodiversity from high seas bottom trawling are being felt now. Immediate measures must be taken to stop this. Only a UN General Assembly moratorium on high seas bottom trawling offers the opportunity to immediately halt this destruction while providing the space for longer-term, comprehensive oceans governance measures to be developed that take consideration of associated and dependent marine biodiversity in fisheries management decisions.

CCAMLR in principle has one of the most progressive management regimes of any regulatory body for either the high seas or coastal states. However, it has severe problems with Illegal, Unregulated or Unreported (IUU) fishing – put bluntly, with fishing pirates. Attempts to introduce tracing mechanisms to demonstrate that fish come from legitimate fisheries continue to have severe problems, for example with the highly valuable long line fishery for Patagonian Toothfish (Chilean Sea Bass) (39). These indicate the scale of the problem that would have to be overcome if a moratorium of high seas bottom trawling was ever to be relaxed.

At the opposite extreme lies the dysfunctional and discredited NEAFC. Its annual reports, and a meeting held in 2003 which attempted to reach agreement on the management of deep sea stocks, are hardly bedtime reading (38, 40-42). Nevertheless, for those prepared to wade through the text, they do contain some extraordinarily revealing statements regarding the attitude of many of the national representatives. Some are openly critical of the failure to agree measures to regulate deep sea bottom trawl fisheries (which includes part of the deep sea redfish stocks), and emphasize how damaging this failure is for NEAFC's credibility. Others simply keep their heads down. After several meetings at which attempts were made to agree to measures for deep sea fisheries, the best that they could come up with was an agreement that catches should not exceed the levels of previous years. For those stocks which are in decline and needing the greatest protection, historic catch levels are unlikely. So, in effect, this agreement gives permission to continue fishing the most endangered stocks as hard as they can. Then, at the Commission meeting in late 2004, the Norwegian government tabled a proposal that would close 6 selected areas within the NEAFC area to all forms of trawling. The European Union countered with a proposal that would exclude the Hatton Bank – one of the key areas for protection under the Norwegian proposal. The EU also suggested the exclusion of pelagic or mid-water trawling in the list of limited gears in the areas closed. A few piecemeal measures were agreed for some token areas, and their closure took effect from January 1, 2005 until December, 31 2007. However, according to the NEAFC convention, management of areas need to be directly related to a particular fish stock. As these closures are for the conservation of seamounts, changes are needed within the NEAFC convention to enable NEAFC to carry out more of such closures in the future. If past performance is a guide, the outlook seems rather bleak.

Other than these few areas, the impact of deep sea bottom trawling on sensitive habitats has simply not been addressed. Indeed it is worse than this. There is another, legally binding agreement – the Oslo and Paris Convention, OSPAR – which includes the NEAFC area. This Agreement, which is lead by the environmental departments of governments around the North-East Atlantic, is supposed to set up a network of protected areas throughout the North-East Atlantic. But the reaction within NEAFC, far from welcoming this work and finding ways of cooperating, has been to try to reject the legitimacy of bodies such as OSPAR. In the words of the European Commission representative at the deep sea fisheries meeting "... if NEAFC does not get this right the field will be open for environmental conventions to move into an area where NEAFC should have exclusive competence" (40). From the text, it is not clear whether the Commission spokesperson really advocated excluding bodies such as OSPAR (which would be of questionable legality), or was attempting to provoke other representatives to take action within NEAFC, rather than have it done for them by a body less biased towards interests within the fishing industry.

Regardless of the detail, it does indicate how much bodies such as NEAFC will have to be reformed before they can be relied upon to implement a UN moratorium, and work constructively to ensure that any high seas bottom trawling would eventually be resumed in a sustainable manner.

iii Not so many fish in the sea

The lack of resilience of deep sea life, –the many centuries that these complex ecosystems take to recover from damage inflicted in seconds – gives added urgency to the need for an immediate moratorium on high seas bottom trawling. Continuing to ignore the consequences of clear-cutting these deep sea forests would be a scientific and environmental disaster.

The high seas are part of our global commons, and nation states are supposed to be the stewards of this commons, entrusted to manage them sustainably on our behalf for now and for the future. Comprehensively protecting deep sea biodiversity would be one of the most significant single scientific and environmental acts of modern times. The sheer scale of the biodiversity that would be preserved for its own sake, as well as for demonstrably cautious and sustainable use is greater than almost anywhere else on earth. Scientists and environmentalists are in agreement on the way forward: an immediate moratorium on high seas bottom trawling. A United Nations General Assembly Resolution placing a moratorium on high seas bottom trawling is the most immediate way to provide for the widespread protection of the underwater forests and other vulnerable ecosystems, and the deep sea life that depends on them. It would allow for a 'time out' to make proper scientific assessments of deep sea ecosystems, and to develop the policy solutions necessary to conserve these ecosystems well into the future.

In January 2005, Secretary-General Kofi Annan stated*, ***"For too long, the world acted as if the oceans were somehow a realm apart – as areas owned by no-one, free for all, with little need for care or management. The Law of the Sea Convention and other landmark legal instruments have brought important progress over the past two decades in protecting fisheries and marine ecosystems. But this common heritage of all humankind continues to face profound pressures."***

The Secretary General's advisory body on the implementation of the Millenium Development Goals, the UN Millennium Project, has since recommended that "global fisheries authorities must agree to eliminate bottom trawling on the high seas by 2006 to protect seamounts and other ecologically sensitive habitats and to eliminate bottom trawling globally by 2010".

The time has passed for a leisurely approach to conserving what is left of the biodiversity and resources of the world's oceans. It is time to address what could be the biggest unseen environmental disaster of our time. Only bold, innovative, visionary and decisive action has any chance of preventing the massive and irreversible destruction of the biodiversity and resources of the oceans, to the cost and detriment of all countries and all peoples. An immediate UN General Assembly moratorium on high seas bottom trawl fishing must be adopted and implemented now if we are to preserve the biodiversity of the deep sea for the future.

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* Port Louis, Mauritius, 13 January 2005 - Secretary-General's remarks at meeting organized by the Seychelles and the United Kingdom, "Reefs, Island Communities and Protected Areas -- Committing to the Future" At http://www.un.org/apps/sg/sgstats.asp?nid=1257.

deep-water fishing

TIME TO STOP
THE DESTRUCTION

References

1 | Gage, J. D.; Tyler, P. A (1991). Deep-Sea Biology: A natural history of organisms at the deep-sea floor. Cambridge University Press, Cambridge. 504 pages.

2 | Morato, T.; Pauly, D. (2004). Seamounts: Biodiversity and fisheries. Report 12(5). Fisheries Centre, University of British Columbia, Vancouver. URL: http://www.seaaroundus.org/report/seamounts.htm

3 | Anon. (undated). Web page: South African Museum - The giant squid. Access Year: 2004. Access Date: October 10. URL: http://www.museums.org.za/sam/resources/marine/architeuthis/myths.htm

4 | Hatch, L. (undated). Web page. The Eltanin Antenna Identified! Access Year: 2004.Access Date: October 10th 2004. URL: http://www.larryhatch.net/ELTANIN.html

5 | Anon. (2004). Plate 7, p. 143 in Future Needs in Deep Submergence Science: Occupied and Unoccupied Vehicles in Basic Ocean Research. Committee on Future Needs in Deep Submergence Science, National Research Council, Washington. 152 pages. URL: http://www.nap.edu/openbook/0309091144/html/143.html

6 | Seibel, Brad A.; Thuesen, Erik V.; Childress, James J. (1998). Flight of the Vampire: Ontogenetic Gait-transition in Vampyroteuthis infernalis (Cephalopoda: Vampyromorpha). Journal of Experimental Biology: 201, 2413-2424. URL: http://www.cephbase.utmb.edu/refdb/pdf/6415.pdf

7 | Johnston, Charlotte; Tasker, Mark L. (2002). Darwin Mounds proposed Special Area of Conservation. Joint Nature Conservation Committee. 8 pages. URL: http://www.jncc.gov.uk/management/committee/papers02-06/jncc02p10.pdf

8 | Gonzalez, J. A.; Rico, V.; Lorenzo, J. M.; Reis, S.; Pajuelo, J. G.; Dias, M. A.; Mendonca, A.; Krug, H. M.; Pinho, M. R. (2003). Sex and reproduction of the alfonsino Beryx splendens (Pisces, Berycidae) from the Macaronesian archipelagos. Journal of Applied Ichthyology 19, 104-108.

9 | Durr, J.; Gonzalez, J. A. (2002). Feeding habits of Beryx splendens and Beryx decadactylus (Berycidae) off the Canary Islands. Fisheries Research 54, 363-374.

10 | Seki, M. P.; Somerton, D. A. (1994). Feeding Ecology and Daily Ration of the Pelagic Armorhead, Pseudopentaceros wheeleri at Southeast Hancock Seamount. Environmental Biology of Fishes 39, 73-84.

11 | Martin, A. P.; Humphreys, R.; Palumbi, S. R. (1992). Population Genetic-Structure of the Armorhead, Pseudopentaceros wheeleri, in the North Pacific Ocean - Application of the Polymerase Chain-Reaction to Fisheries Problems. Canadian Journal of Fisheries and Aquatic Sciences 49, 2386-2391.

12 | Somerton, D. A.; Kikkawa, B. S. (1992). Population-Dynamics of Pelagic Armorhead Pseudopentaceros wheeleri on Southeast Hancock Seamount. Fishery Bulletin 90, 756-769.

13 | Love, M.S.; Yoklavich, M.; Thorsteinson, L.(2002). The Rockfishes of the Northeast Pacific. University of California Press. Berkeley, California.

14 | Moller, P. R.; Nielsen, J. G.; Fossen, I. (2003). Fish migration: Patagonian toothfish found off Greenland - This catch is evidence of transequatorial migration by a cold-water Antarctic fish. Nature 421, 599-599.

15 | Weeber, Barry; Szabo, Michael (2004). Best Fish Guide. Part One. Summary of Ecological Rankings for New Zealand Commercial Fisheries. Royal Forest and Bird Protection Society of New Zealand, Wellington. 87 pages. URL: http://www.forest-bird.org.nz/bestfishguide/bestfishguide_report1.pdf

16 | Laidre, K. L.; Heide-Jorgensen, M. P.; Jorgensen, O. A.; Treble, M. A. (2004). Deep-ocean predation by a high Arctic cetacean. ICES Journal of Marine Science 61, 430-440. URL: http://www.sciencedirect.com/science/article/B6WGG-4C47MFG-2/2/a4339ffb8ada5d6cbc18ab40000c598d

17 | Folkow, L. P.; Blix, A. S. (1999). Diving behaviour of hooded seals (Cystophora cristata) in the Greenland and Norwegian Seas. Polar Biology 22, 61-74.

18 | Koslow, J. A.; Boehlert, G. W.; Gordon, J. D. M.; Haedrich, R. L.; Lorance, P.; Parin, N. (2000). Continental slope and deep-sea fisheries: implications for a fragile ecosystem. ICES Journal of Marine Science 57, 548-557.

19 | Watling, Les; Norse, Elliott A. (1998). Disturbance of the Seabed by Mobile Fishing Gear: A Comparison to Forest Clearcutting. Conservation Biology 12, 1180-1197. URL: http://www.blackwell-synergy.com/links/doi/10.1046/j.1523-1739.1998.0120061180.x/abs

20 | Fosså, 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. URL: http://www.imr.no/Dokumenter/fossa.pdf

21 | Roberts, Callum M. (2002). Deep impact: the rising toll of fishing in the deep sea. Trends in Ecology & Evolution 17, 242-245. URL: http://www.sciencedirect.com/science/article/B6VJ1-45FYM08-K/2/fe8bd293545f91701336107354b74de3

22 | Husebo, A.; Nottestad, L.; Fossa, J. H.; Furevik, D. M.; Jorgensen, S. B. (2002) Distribution and abundance of fish in deep-sea coral habitats. Hydrobiologia 471, 91-99.

23 | Anon. (2002). Web page. World's largest Lophelia pertusa reef discovered off Røst in Lofoten. Producer: Institute of Marine Research. Access Year: 2004. Access Date: 12 August. URL: http://www.imr.no/english/news/2002/worlds_largest_lophelia_pertusa_reef_discovered_off_rost_in_lofoten

24 | Anon. (undated). Web page. Coral reefs in the North Atlantic? Producer: ICES. Access Year: 2004. Access Date: 12 August. URL: http://www.ices.dk/marineworld/deepseacoral.asp

25 | Anon. (2003). Web page. Coral Reefs in Norway: Lophelia pertusa. Producer: Institute of Marine Research. Access Year: 2004. Access Date: 12 August. URL: http://www.imr.no/coral/news.php

26 | Roberts, J. M.; Long, D.; Wilson, J. B.; Mortensen, P. B.; Gage, J. D. (2003). The cold-water coral Lophelia pertusa (Scleractinia) and enigmatic seabed mounds along the north-east Atlantic margin: are they related? Journal: Marine Pollution Bulletin 46, 7-20.

27 | Kenyon, Neil H.; Akhmetzhanov, Andrey M.; Wheeler, Andrew J.; van Weering, Tjeerd C. E.; de Haas, Henk; Ivanov, Michael K. (2003). Giant carbonate mud mounds in the southern Rockall Trough. Journal: Marine Geology 195, 5-30. URL: http://www.sciencedirect.com/science/article/B6V6M-47TFG6M-3/2/a0300039ef2b0086668a094b763ccc3b

28 | Clark, M. ; O'Driscoll, R. (2003). Deepwater Fisheries and Aspects of Their Impact on Seamount Habitat in New Zealand. Journal of Northwest Atlantic Fishery Science 31, 441-458. URL: http://www.nafo.ca/publications/journal/J31/session1/clark.pdf

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

30 | Anon. (undated). Web page. Seamount fauna off southern Tasmania: impacts of trawling; conservation and role within the fishery. Australian Government Fisheries Research and Development Corporation. Access Year: 2004. Access Date: 13 August. URL: http://www.frdc.com.au/pub/reports/files/95-058.htm

31 | Norse, E. A.; Morgan, L. E. (2004). Web page. 1,136 Scientists Call for Protection of Deep-Sea Corals: Scientists' Statement on Protecting the World's Deep-sea Coral and Sponge Ecosystems. Producer: Marine Conservation Biology Institute. URL: http://www.mcbi.org/DSC_statement/sign.htm

32 | Gage, J. D. (2001). Deep-sea benthic community and environmental impact assessment at the Atlantic Frontier. Continental Shelf Research 21, 957-986.

33 | Thrush, S. F.; Dayton, P. K. (2002). Disturbance to marine benthic habitats by trawling and dredging: Implications for marine biodiversity. Annual Review of Ecology and Systematics 33, 449-473.

34 | Allain, V.; Biseau, A.; Kergoat, B. (2003). Preliminary estimates of French deepwater fishery discards in the Northeast Atlantic Ocean. Fisheries Research 60, 185-192.

35 | Gordon, J. D. M. (2003). The Rockall Trough, Northeast Atlantic: the Cradle of Deep-sea Biologial Oceanography that is Now Being Subjected to Unsustainable Fishing Activity. Journal of Northwest Atlantic Fishery Science 31, 57-83. URL: http://www.nafo.ca/publications/journal/J31/session1/gordon.pdf

36 | Roughgarden, J. (1998). How to manage fisheries. Ecological Applications 8, S160-S164. URL: http://links.jstor.org/sici?sici=1051-0761%28199802%298%3A1%3CS160%3AHTMF%3E2.0.CO%3B2-T

37 | Anon. (2004). Report of the 22nd Annual Meeting of the North-East Atlantic Fisheries Commission Volume I: Main Report. North-East Atlantic Fisheries Commission, London. 31 pages. URL: http://www.neafc.org/reports/docs/neafc_amreps/22neafc_annualmeeting_2003.pdf

38 | Gianni, M. (2004). High Seas Bottom Trawl Fisheries and their Impacts on Biodiversity of Vulnerable Deep-Sea Ecosystems. URL: http://www.iucn.org/themes/marine/pdf/MattGianni-CBDCOP7-Impact-HS-BottomFisheries-Complete.pdf

39 | Anon. (2003). Report of the Twenty-Second Meeting of the Commission. Commission for the Conservation of Antarctic Living Resources, Hobart. 214 pages. URL: http://www.ccamlr.org/pu/e/pubs/cr/03/all.pdf

40 | Anon. (2003). Report of the Extraordinary Meeting of the North-East Atlantic Fisheries Commission 14-15 May 2003. Volume 1: Main Report. North-East Atlantic Fisheries Commission. London. 12 pages. URL: http://www.neafc.org/reports/docs/neafc_em/em2003mainreport.pdf

41 | Anon. (2003). Report of the Extraordinary Meeting of the North-East Atlantic Fisheries Commission 14-15 May 2003. Volume II: Annexes. North-East Atlantic Fisheries Commission, London. 66 pages. URL: http://www.neafc.org/reports/docs/neafc_em/em2003_annexes.pdf

42 | Anon. (2004). Report of the 22nd Annual Meeting of the North-East Atlantic Fisheries Commission Volume II: Annexes. North-East Atlantic Fisheries Commission, London. 48 pages. URL: http://www.neafc.org/reports/docs/neafc_amreps/22annrep_2003_annexes.pdf

43 | Agnew, D. J. (2000). The illegal and unregulated fishery for toothfish in the Southern Ocean, and the CCAMLR catch documentation scheme. Marine Policy 24, 361-374.

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