Managing risk and uncertainty in deep-sea fisheries: lessons from Orange Roughy

M. Lack
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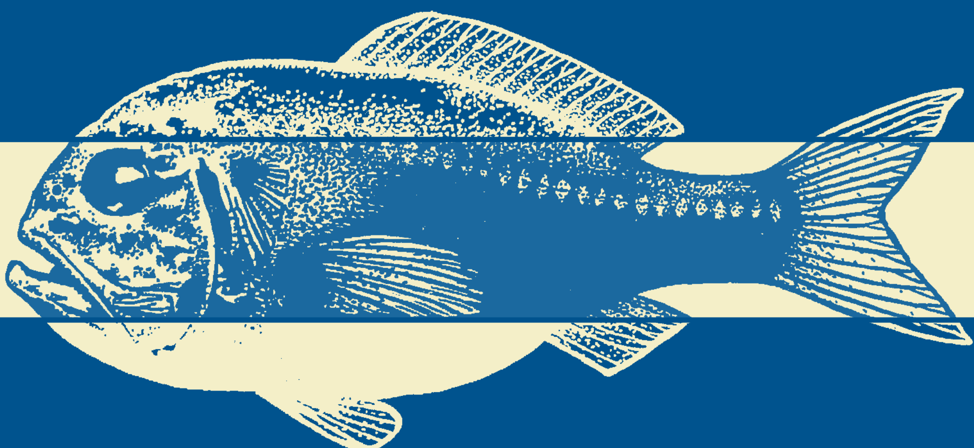

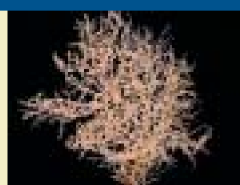

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Fisherman Allan Barnett with some of his huge catch of Orange Roughy. 28 Jun 1989

ACRONYMS

ACFM	Advisory Committee on Fisheries Management (ICES)
AFFA	Agriculture, Fisheries and Forestry, Australia
AFMA	Australian Fisheries Management Authority
BRS	Bureau of Rural Sciences (Australia)
CAY	Current Annual Yield
CBD	Convention on Biological Diversity
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources
CDS	Catch Documentation Scheme (CCAMLR)
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CPUE	Catch Per Unit Effort
CSIRO	Commonwealth Scientific and Industrial Research Organisation (Australia)
DPIE	Department of Primary Industries and Energy (Australia)
EBM	Ecosystem-based Management
EEZ	Exclusive Economic Zone
EU	European Union
ESD	Ecologically Sustainable Development
FAO	Food and Agricultural Organisation (UN)
FRDC	Fisheries Research and Development Corporation
ICES	International Council for the Exploration of the Seas
IPOA	International Plan of Action
ITQ	Individual Transferable Quota
IUCN	IUCN-The World Conservation Union
IUU	Illegal, Unreported and Unregulated
MCS	Monitoring, Control and Surveillance
MOU	Memorandum of Understanding
MPA	Marine Protected Area
MSE	Management Strategy Evaluation
MSY	Maximum Sustainable Yield
NEAFC	North-east Atlantic Fisheries Commission
NIWA	National Institute of Water and Atmospheric Research (New Zealand)
NM	nautical mile
NMFS	National Marine Fisheries Service (USA)
ORAG	Orange Roughy Assessment Group (Australia)
OSPAR	Commission for the Protection of the Marine Environment of the North-east Atlantic
RFMO	Regional Fisheries Management Organisation
SEAFO	South East Atlantic Fisheries Organisation
SEFAG	South East Fishery Assessment Group
SESSF	South Eastern Scalefish and Shark Fishery
SETF	South East Trawl Fishery
SETMAC	South East Trawl Management Advisory Committee
SSB	Spawning Stock Biomass
TAC	Total Allowable Catch
TACC	Total Allowable Commercial Catch
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea
UNFSA	United Nations Fish Stocks Agreement
UNGA	United Nations General Assembly
UNICPOLOS	United Nations Open-ended Informal Consultative Process on Oceans and the Law of the Sea
VMS	Vessel Monitoring System
WGDEEP	Working Group on the Biology and Assessment of Deep-sea Fisheries Resources (ICES)
WTO	World Trade Organisation
WWF	World Wide Fund for Nature

Scientific terms

$B_{current}$	Current biomass
B_{MSY}	Biomass at maximum sustainable yield
B_0	Pre-fished biomass
M	Natural mortality
mtDNA	mitochondrial deoxyribonucleic acid
U_{lim}	20% of pre-fished biomass
U_{pa}	50% of pre-fished biomass

EXECUTIVE SUMMARY

Deep-sea species are widely recognised as being very long lived (more than 100 years in some cases), late to mature, slow growing, of low fecundity, and prone to formation of dense aggregations for spawning and/or feeding. As a result they are relatively unproductive, highly vulnerable to over-fishing and potentially slow to recover from the effects of over-exploitation. Generally, deep-sea species will be depleted more quickly and recover even more slowly than more resilient, but nevertheless often over-fished, inshore species.

Scientists, managers and the general community are increasingly concerned about the impact of deep-sea fisheries on both the species they target and the ecosystems in which they operate. It is increasingly apparent that management is failing to protect deep-sea species and ecosystems. Fishing for deep-sea species has generally developed before there is a reasonable understanding of the biology of the species being targeted, and before formal stock assessments have been undertaken or management arrangements implemented.

Deep-sea fishing has expanded rapidly in the last 25 years. Forty per cent of the world's trawling grounds are now in waters deeper than the continental shelves. Much of the pressure being applied to deep-sea ecosystems derives from the systemic, global problem of over-capacity. Despite this, some countries not only refuse to take action to reduce capacity in their fishing fleets, but actively encourage the development of new fishing capacity through subsidies.

Deep-sea species occur in the waters of coastal States and on the high seas. In relation to species occurring on the high seas, conservation and management relies on Regional Fisheries Management Organisations (RFMOs), however few currently have a mandate to manage deep-sea species. Those that do have so far failed to deliver effective management due to inadequacies in their underlying conventions, and/or lack of political will to implement strong measures. Further, RFMOs are only now starting to look beyond measures designed to control at-sea fishing activity to trade- and market-based instruments that may complement traditional fisheries management measures. In the absence of a relevant RFMO, international law requires flag States to effectively monitor and control their vessels fishing for deep-sea species on the high seas to ensure the conservation of these resources. However many flag States fail to do so.

This report presents case studies of four Orange Roughy *Hoplostethus atlanticus* fisheries in New Zealand, Australia, on the high seas in the southern Indian Ocean, and in the north-east Atlantic Ocean. Orange Roughy is a deep-sea species that is found from the south-west Pacific Ocean to the north-east Atlantic. Its biological characteristics are typical of, albeit more pronounced than, many deep-sea species. Orange Roughy fisheries are typically associated with seamounts. These underwater mountains are commonly characterised by high levels of biodiversity and high levels of endemism. Trawling for Orange Roughy has been shown to have substantial and significant impacts on the benthic fauna of seamounts. Given the diversity and high levels of endemism which appear to characterise some deep-sea ecosystems such as seamounts, the creation of a representative network of marine protected areas (MPAs), designed to protect these ecosystems, could make a significant contribution to the conservation of biodiversity and, possibly, the re-building of depleted communities.

The very nature of deep-sea species makes them difficult and expensive to research. Despite Orange Roughy having been fished commercially for over 25 years in the southern hemisphere and despite considerable research, uncertainties persist in relation to key biological characteristics and, in particular, stock structure. Management of Orange Roughy operates in a highly uncertain environment. Combined with the known vulnerability of the species and the ecosystem in which it is found, fishing for Orange Roughy is a high-risk exercise. Unfortunately management has failed to take a sufficiently precautionary approach to dealing with this risk. Indeed, there is little discernible difference between the outcome for unmanaged Orange Roughy fisheries on the high seas and those that have been the subject of extensive research and management by a coastal State.

Analysis of Orange Roughy fisheries worldwide indicates that management has generally failed to ensure their sustainability. Of the 30 Orange Roughy fisheries identified in this report, nearly half have been fished to below 30% of the pre-fishing biomass. Only one is known to be above this level and the full impact of fishing on stocks in that fishery is yet to be felt. The status of half of the stocks is unknown, either because stock assessments are not carried out or because the uncertainties are so great that the assessments are inconclusive.

The analysis conducted in this report shows that Orange Roughy fisheries globally have typically been boom and bust. The case studies of Orange Roughy fisheries presented highlight the following reasons for this management failure:

- a lack of understanding of the biological characteristics of the species;
- inadequate stock assessment models;
- failure to take a precautionary approach in accounting for uncertainties inherent in stock assessments;
- failure to remove excess fishing capacity;
- inappropriate management methods;
- lack of political will to impose rigorous management decisions;
- lack of effective management regimes for discrete high seas and straddling stocks; and
- ineffective monitoring, control and surveillance measures (MCS).

The population biology of deep-sea species varies. As a result there is no 'one-size-fits-all' solution to management of these species. However the experience of Orange Roughy indicates that, at a minimum, the characteristics of these species dictate the need for different management to that applied to their more productive, inshore counterparts.

The particular vulnerability of, and the ongoing uncertainty associated with, deep-sea species and their ecosystems, may demand extreme measures. In some circumstances it will simply not be possible to manage deep-sea fisheries sustainably, that is, in a way that yields the levels of profit that are expected presently whilst ensuring the health of vulnerable marine ecosystems. The precautionary approach and the burden of proof dictate that in these circumstances fishing is excluded. It is imperative that existing management measures are reassessed in this context, and that future development of deep-sea fisheries is conditional on a full, transparent and inclusive assessment of the risks involved.

The following recommendations are made to address the deficiencies identified in management of deep-sea species.

Action Area 1

Adopting a more precautionary approach to management of deep-sea species and their habitats

1. To ensure that management arrangements for deep-sea species are consistent with a precautionary approach, coastal States and RFMOs with jurisdiction over management of deep-sea fisheries must, as a matter of urgency:

   (a) reassess, and amend where necessary, their existing management arrangements, MCS measures and research priorities for deep-sea fisheries in the context of

   - the demonstrated need for additional precaution in the management of deep-sea species and ecosystems arising from the biological characteristics of the species, the ongoing uncertainty associated with fundamental stock assessment parameters, with the trophic and benthic impacts of fishing, and with the capacity of deep-sea species and ecosystems to rebuild,
   - the appropriateness of the current target and limit reference points, in particular the use of 30% of pre-fishing biomass as a target taking into account the uncertainties inherent in the stock assessment advice,
   - the need for management strategies to reflect ecosystem-based management principles, including the use of networks of representative marine protected areas,
   - the demonstrated need for a combination of management measures to deal with ecosystem-wide issues,
   - in particular, the demonstrated vulnerability of deep-sea chondrichthyans to over-fishing as evidenced by the IUCN-The World Conservation Union Red List of Threatened Species and reflected in the development of the International Plan of Action for the Conservation and Management of Sharks;

   (b) where there is scientific advice that management strategies have failed or are likely to fail in relation to a stock or a fishery, address the question as to whether fishing should be allowed to continue at any level;

   (c) where management arrangements for deep-sea species are not in place, implement arrangements consistent with the context outlined above;

   (d) permit exploratory deep-sea fishing only under research protocols, and prevent the development of commercial fisheries based on the findings of such research until management arrangements, consistent with the context outlined above, have been implemented; and

   (e) as a first step towards broader ecosystem-based management, collate and report on all available information on trophic interactions, by-catch and benthic impacts so as to determine how best to incorporate this information into current stock assessment processes and to identify research gaps and inform research priorities.

Action Area 2

Addressing the underlying problem of over-capacity in world fisheries

2. Consistent with its core mandate to regulate and reduce subsidies that distort international

markets, the World Trade Organisation, in cooperation with international bodies with responsibility for fisheries management, must develop robust rules to effectively prohibit the subsidies that contribute to over-capacity and over-fishing, while allowing the use of government funds to reduce capacity.

3. Priority must be given to removal of subsidies that encourage creation of fishing capacity and the reduction of existing fishing capacity. To facilitate and expedite this process, an international fund to support structural adjustment of fishing fleets under approved arrangements should be established, with a country's access to this fund contingent on it having removed all forms of subsidies that encourage creation of excess fishing capacity.

Action Area 3

Maximising the potential of international tools and protocols to protect deep-sea ecosystems on the high seas

4. In order to maximise the effectiveness of conservation and management measures for deep-sea species:

   (a) RFMOs must consider the role that trade-based measures might play in monitoring and enforcing conservation and management measures for deep-sea species, and introduce such measures where appropriate;

   (b) port and market States must co-operate with the implementation and enforcement of conservation and management measures established by RFMOs; and

   (c) States involved in the trade of deep-sea species must implement, as a priority, harmonised trade codes for these species, noting the need for an adequate breakdown of codes by product form, in order to provide for meaningful trade analysis.

5. Flag States must take immediate action to ensure that they can effectively monitor and control their vessels operating on the high seas, and co-operate in identifying and prosecuting those found to be in breach of domestic or international law.

6. The formation of new RFMOs for deep-sea fisheries that are outside national or RFMO jurisdiction and, in particular, the process underway to create an RFMO in the south-west Indian Ocean must be expedited and based on conventions that are consistent with the requirements and provisions of current international laws and protocols.

7. RFMOs that have a mandate to manage deep-sea species must reassess their conventions in light of current international law and protocols and ensure that, where necessary, they are amended to provide consistency with current fisheries law and 'soft law'.

8. In establishing and/or reviewing these conventions, provisions requiring consensus decision-making and allowing members to opt-out of decisions taken by the RFMO should be avoided or removed.

9. Those with a legitimate commercial interest in deep-sea fisheries should initiate and co-ordinate their efforts to influence and enforce timely and effective management arrangements for these species and their ecosystems.

Action Area 4

Moving towards an ecosystem-based approach to management of deep-sea species and their habitats

10. Consistent with the recommendations of the 2002 World Summit on Sustainable Development and the 2003 World Parks Congress, all States and RFMOs should co-operate to establish a network of representative deep-sea and high-seas marine protected areas by 2012, noting the need for such a network to be based on sound ecological and scientific information and to be consistent with international law.

1 INTRODUCTION

Deep-sea fishing is a relatively new phenomenon. The depletion of fisheries based on traditional inshore species in the second half of the 20th century, together with the impact of the declaration of 200 nautical miles (nm) exclusion zones on access of international fleets to fishery resources, has created an economic imperative to fish in more remote and often deeper waters. Technological advances over the last 20-25 years in detecting and harvesting fish, and the increased availability of seabed mapping information, have facilitated this. The growth of deep-sea fisheries[1] has been rapid. Forty per cent of the world's trawling grounds are now in waters deeper than the continental shelves (Roberts, 2000).

Given the relatively short period of exploitation, and the difficulties and expense of research on deep-sea species, knowledge of these species and their habitats remains limited and management, therefore, continues to operate in an environment of considerable uncertainty. However, it is commonly accepted that deep-sea species display characteristics including extreme longevity, late age of maturity, slow growth and low fecundity. Many also form dense aggregations for spawning and/or feeding. As a result they are generally unproductive, highly vulnerable to over-fishing and potentially slow to recover from the effects of over-exploitation (Koslow *et al.*, 2000).

However, the extent to which all deep-sea species conform to this general description varies. The International Council for the Exploration of the Sea (ICES) has, for example, identified Blue Ling *Molva dypterygia*, Tusk *Brosme brosme*, alfonsino *Beryx* spp. and redfish *Sebastes* spp. as deep-sea species that 'have faster reproduction and growth rates and so can sustain somewhat higher exploitation rates than other deep-sea species' (ICES, 2003c).

Orange Roughy *Hoplostethus atlanticus* is a deep-sea species that is found from the south-west Pacific Ocean to the north-east Atlantic. Its characteristics are typical of, albeit more pronounced than, many deep-sea species. This report examines the experience of Orange Roughy fisheries and uses this as a basis to draw conclusions on how future management of fisheries for deep-sea species can be improved.

Structure of the Report

An overview of deep-sea fisheries is provided in Section 2. This is followed, in Section 3, by a description of the biological characteristics of Orange Roughy, a summary of Orange Roughy fisheries globally, a discussion of management and ecosystem impacts of these fisheries and an overview of international trade in Orange Roughy. Four case studies of Orange Roughy fisheries are presented in Section 4. These case studies, together with information on other Orange Roughy fisheries globally, are used, in Section 5, to identify lessons from the experience of Orange Roughy management. In Section 6 this analysis is used to identify implications for management of deep-sea fisheries more generally and to make recommendations for improved management of these species.

Emptying a catch of Roughy into the fish hold

1 There is no accepted definition of what constitutes a deep-sea fishery. A working definition adopted for the purposes of the *Deep Sea 2003* conference is that deep-sea fisheries are those that operate beyond the continental shelf break and at depths deeper than 200m. Other definitions include that of the International Council for the Exploration of the Sea which considers deep-sea fisheries to be those operating deeper than about 400m (ICES, 2003a) and that of Koslow *et al*., (2000) who define deepwater fisheries as fisheries deeper than about 500m, near the lower limits of the upper slope.

2 DEEP-SEA FISHERIES

Deep-sea fisheries operate in many parts of the world including the:

- south-west Pacific Ocean where New Zealand has fisheries for Orange Roughy, Black Oreo *Allocyttus niger*, Smooth Oreo *Pseudocyttus maculatus* and Blue Grenadier *Macruronus novaezelandiae*, and Australia has Orange Roughy and Blue Grenadier fisheries;
- north Pacific Ocean where a fishery for sablefish *Anoplopoma fimbria* operates along the continental slope of North America and where a fishery for Pelagic Armourhead *Pseudopentaceros wheeleri* operated in the 1960s and 1970s but has been fished to commercial extinction;
- Atlantic and Pacific Oceans where fisheries exist for *Sebastes* species including Pacific Ocean Perch *Sebastes alutus*;
- north-east Atlantic Ocean where France, Ireland, Faroe Islands, Greenland and Norway fish for deep-sea species such as Argentines *Argentina silus*, Ling *Molva molva*, Blue Ling, Tusk, Orange Roughy, Greater Forkbeard *Phycis blennoides*, Roundnose Grenadier *Coryphaenoides rupestris*, Black Scabbardfish *Aphanopus carbo* and deep-sea sharks (Squalidae);
- southern Atlantic where Namibia fishes for Orange Roughy;
- south-west Indian Ocean where a high seas fishery for Orange Roughy and alfonsino on the Madagascar Ridge has operated since 1998; and
- the Southern Ocean where countries including Argentina, Australia, Chile, France, South Africa, Spain, the United Kingdom, Uruguay and the Ukraine fish for deep-sea species, particularly Patagonian Toothfish *Dissostichus eleginoides* in both exclusive economic zones (EEZs) and on the high seas.

The biological characteristics of deep-sea species, the fragility of the habitats where they are most abundant, the poor track record or lack of management of these species to date and the warning signs provided by the collapse of depleted inshore fisheries based on more resilient species, have increased concern for the sustainability of deep-sea fisheries generally. It is likely that many species are being exploited at levels beyond safe biological and ecological limits. The following advice from ICES, on management of deep-sea fisheries in the north-east Atlantic Ocean, typifies the concerns held by many scientists and others for deep-sea species and habitats more generally:

> *Consistent with the precautionary approach, fishing should not be allowed to expand faster than the acquisition of information necessary to provide a basis for sustainable exploitation... A comprehensive data collection system is urgently required, and research on all stocks should be increased to provide the data necessary for assessment... Most exploited deep-sea species [in the ICES area] are at present considered to be harvested outside safe biological limits. ICES recommends immediate reduction in these fisheries unless they can be shown to be sustainable. New fisheries should be permitted only when they expand very slowly, and are accompanied by programs to collect data, which allow evaluation of stock status. (ICES, 2002b)*

Seamount fisheries

Deep-sea fisheries are commonly associated with seamounts (Box 1). Deep-sea species that aggregate on seamounts and banks include Orange Roughy, oreos (Oreosomatidae), alfonsino, Patagonian Toothfish, Pelagic Armourhead and *Sebastes* spp. (Koslow *et al.*, 2000). Of the deep-sea species, these are of particular concern because of the relative ease with which trawlers target them.

Seamounts are undersea volcanoes, typically cone-shaped and rising relatively steeply from the seabed. They can be very large features, not only in terms of their elevation but also in area, as some are more than 100 kilometres across at their base (Gubbay, 2003). While the biological diversity and vulnerability to exploitation of seamount species and habitats is not well understood, it is generally acknowledged that seamounts are highly productive, have high rates of biodiversity and endemism, and are vulnerable to disturbance.

In addition to the physical impacts discussed in Box 1, the impact on the trophodynamics of seamount habitats of the removal of the biomass of target and non-target species, which dominate the mid- to upper trophic levels, is not known. Given the long time scales on which many deep-sea species operate it may be some time before such impacts can be identified. Koslow *et al.* (2000) identify a range of potential impacts on deep-sea ecosystems flowing from the removal of large proportions of the biomass of deep-sea species. These include:

- shifts in the dominance of competing species;
- shifts in the size structure of fisheries;
- density dependent changes in fish populations (e.g. fecundity, growth rates, age at maturity); and
- reduction in detrital material provided by these species to the benthic community.

BOX 1

Seamount ecosystems

Seamounts are common and abundant features of the ocean floor. Developments in mapping technology now allow a better understanding of the structure of these features but also facilitate their exploitation (Figure 1). There are relatively few comprehensive studies of the biology and ecology of individual seamounts or seamount complexes. The research that has been undertaken shows that some seamounts support a wide variety, and high abundance, of some species, and can be characterised by high rates of endemism (i.e. many species are not found outside that seamount or seamount complex).

The tendency for the generally higher abundance of fish around seamounts than in surrounding waters, and for some species of fish to aggregate around seamounts, may be at least partly explained by the apparent increased concentration of plankton associated with some large and relatively shallow seamounts. This may be a result of localised upwellings, from the interaction of currents and seamount topography, which bring nutrients to the surface encouraging primary production, or by the trapping of diurnally migrating plankton in circulation cells. Seamounts can also support dense assemblages of benthic fauna, including suspension feeders such as corals, sponges, hydroids and ascidians. Again, this appears to result from the interaction of seamounts with currents, creating elevated levels of flow which remove sediments, increase the food supply for filter-feeders and provide hard bottom habitats suited to these fauna (Gubbay, 2003; Stone *et al*., 2003).

The high level of endemism associated with certain seamounts has been confirmed by recent studies such as that of Richer de Forges *et al*., (2000) who surveyed seamounts in the Tasman Sea and the south-east Coral Sea. The survey identified 859 macro- and megafaunal species, of which 29-34% were new to science. There was low species overlap between seamounts in different portions of the region, suggesting highly localised species distributions. Koslow and Gowlett-Holmes (1998) found some 300 species of fish and invertebrate macrofauna on seamounts around Tasmania, of which 24-43% were new to science and 16-33% were restricted to the seamount environment. The risk of severe depletion, and even extinction, of elements of the benthic seamount fauna, is increased by their highly specific habitat requirements, localised distributions and high levels of local endemism (Koslow *et al*., 2000). Cold-water corals, for example, living in pitch-black water at depths to 2000m, and at temperatures as cold as 4ºC, do not have the nutritional advantage of a symbiotic relationship with microscopic algae that is available to shallow-water corals as a result of the latter's access to sunlight. Cold-water corals must fend for themselves by feeding on particles carried on deep-sea currents (Southampton Oceanography Centre, 2003). As a result they are very slow growing, vulnerable, and considerably less resilient to disturbance.

The general abundance and common aggregations of fish around seamounts makes them attractive sites for fisheries. Trawl fisheries for a variety of deep-sea species are focused on seamounts. Seamount topography, along with advanced navigation and gear technology, results in a large number of tows of heavy trawl gear over a relatively small area. This creates intense local disturbance. Deep-sea communities are less adapted to disturbance than shallow water communities that must cope with regular storm events (Smith, 2001). Trawling has been shown to have significant and substantial impacts on the benthos of seamount communities (Koslow *et al*., 2000; Hall-Spencer *et al*., 2002; Southampton Oceanography Centre, 2003). Corals, in particular, appear to be a common bycatch of trawling in the initial stages of seamount fisheries.

The significance and vulnerability of seamount ecosystems, particularly those on the high seas, has been recognised internationally. The United Nations (UN) Open-Ended Informal Consultative Process on Oceans and the Law of the Sea (UNICPOLOS) noted, in May 2002, that seamounts are one of the underwater features on the high seas that have high levels of endemic species and constitute a large, as yet un-evaluated, reservoir of biological diversity that may be threatened by human activities in these areas. The United Nations General Assembly (UNGA) subsequently endorsed calls for urgent, co-ordinated action to integrate and improve the management of seamounts and other underwater features (UNGA, 2002-A/57/L/48 in Gubbay, 2003).

Unloading a catch of Orange Roughy

example, Rock Lobster *Jasus tristani* on the Vema Seamount, Pelagic Armourhead on the Emperor seamounts and seamounts in the northern Hawaiian Ridge, and Orange Roughy on seamounts in Australian and New Zealand waters (Gubbay, 2003).

Where stock assessments for these species are available they suggest that many stocks are now fished outside safe biological levels (Box 2). In many cases basic biological, fishery and ecological information is unavailable on target species. Little or no assessment of species, such as deep-sea sharks (Box 3), taken as incidental catch in these fisheries, has been conducted. The longer-term impacts of trawl gear on benthic communities and on their trophic relationships with associated seamount communities, as well as the removal of a large proportion of the biomass of target and non-target species, are largely unknown. As a result, management decisions are often poorly informed. In other cases, there may be a considerable amount of information and stock assessment advice available to managers, yet critical uncertainty surrounds this advice. In such cases management has often failed to reflect this uncertainty adequately when framing management strategies. In addition, the political will is often lacking to take strong management action to ensure sustainability. In combination, these factors have caused management to be largely ineffective in maintaining deep-sea stocks and ecosystems at sustainable levels.

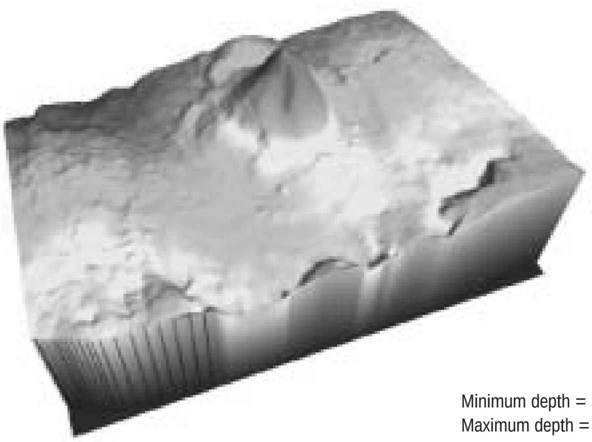
Few studies have been conducted to assess the nature and extent of these impacts. However, the protection of some seamounts off Australia, New Zealand, Alaska, and most recently off Scotland, may provide opportunities to compare fished seamounts with unfished areas and to track any recovery from the effects of fishing.

Management

The general experience with target deep-sea species has been one of rapid declines in catch after just a few years fishing. Fishing for these species has generally developed before there is a reasonable understanding of the biology of the species being targeted, and before formal stock[2] assessments have been undertaken or management arrangements implemented. This has resulted in over-exploitation and, ultimately, the collapse of the fishery. For

2 Group of individuals of a species which can be regarded as an entity for management or assessment purposes; a separate breeding population of a species; term used to identify a management unit of a fishery species. A distinct genetic population defined by movement pattern, part of a population potentially harvestable, or a quantity of fish from a given area. May be a total or a spawning stock. (FAO, 2003b)

Figure 1: A three-dimensional swath bathymetry image showing the St Helen's Hill seamount



Minimum depth = 590 metres
Maximum depth = 1200 metres

Source: Kloser *et al*., 2001

BOX 2

Sustainability

Traditionally, judgement about whether or not a fishery was sustainable was based largely on the status of the target stock. However the increased emphasis on sustainable development has meant, in theory at least, a broadening of the term in a fisheries management context. The FAO Code of Conduct for Responsible Fisheries (FAO, 1995) recognises that long-term sustainable use of fisheries resources is the over-riding objective of conservation and management. It identifies that management measures should seek to maintain or restore stocks at levels capable of producing maximum sustainable yield (MSY) by:

- avoiding excess fishing capacity and ensuring that exploitation of stocks remains economically viable;
- promoting responsible fisheries through providing appropriate economic conditions;
- taking into account the interests of all fishers;
- conserving biodiversity of aquatic habitats and ecosystems and protecting endangered species;
- allowing for the recovery, or where appropriate, active restoration of depleted stocks;
- assessing, and correcting where necessary, adverse environmental impacts from human activities; and
- minimising the impacts of fishing for those stocks on non-target species (fish and non-fish) and associated or dependent species.

The Code also states that 'States should assess the impacts of environmental factors on target stocks and species belonging to the same ecosystem or associated with or dependent upon the target stocks, and assess the relationship among the populations in the ecosystem.'

Despite this shift in theoretical emphasis, fisheries management has, in practice, been slow to move away from single species management regimes and to encompass what is now commonly known as ecosystem-based management (EBM)[3]. Generally, assessments that indicate that a stock has been fished below sustainable levels relate only to the impact of fishing on that stock, rather than the ecosystem it inhabits. The application of even this very narrow interpretation of sustainability to deep-sea fisheries is questionable.

Annex II of the UN Fish Stocks Agreement (UNFSA) (UN, 1995) elaborates on the use of MSY in fisheries management. It specifies the need for precautionary target and limit reference points and highlights that the risks of exceeding limit reference points should be very low. In particular it specifies that 'the fishing mortality rate which generates MSY should be regarded as a minimum standard for limit reference points.' This is of particular importance in management of deep-sea species because the yield curves of these species tend to be very flat topped, because of the high age at recruitment to the fishery, so that MSY is not well defined. As a result there may be no warning signals in the form of declining catches and effort could easily become too high before it is apparent (Basson *et al*., 2002). However, in those deep-sea fisheries where management is in place, MSY remains the target rather than the limit reference point. Under these circumstances current approaches to management of deep-sea fisheries compromise sustainability of target, non-target and associated species as well as deep-sea habitats.

3 A discussion of the application of EBM to fisheries management can be found in Ward *et al.,* 2002.

Where deep-sea species have been managed, output controls in the form of total allowable catches (TACs) and, often, individual transferable quotas (ITQs), have frequently been used. The appropriateness of such management measures, particularly as the sole management measure for deep-sea species and ecosystems, has been questioned. In part this derives from uncertainties in the stock assessments on which TACs for deep-sea species are established. However TAC/ITQ management is primarily designed for target species and does not deal with problems such as bycatch and benthic impacts. There is increasing recognition of the need to supplement ITQ management with gear controls, closed areas and other input controls in order to better address both target species and broader ecosystem concerns.

Views on management of deep-seas fisheries vary.

- Roberts (2002) asserts that given the characteristics of deep-sea species and habitats and the high costs of deep-sea fishing 'there is probably no such thing as an economically viable deep-water fishery that is also sustainable.'
- Merret and Haedrich (in Roberts, 2002) argue that deep-sea species must be considered as non-renewable resources.
- There is also an argument that, given the tendency for biomass to decline very quickly and the likelihood that long-term yields will be very low, deep-sea fish stocks should be 'mined', that is, intentionally over-fished (Clark, 2001).

Orange Roughy exhibits all the characteristics ascribed to deep-sea species, and is probably at the extreme of the low productivity/high vulnerability spectrum to which most known deep-sea species belong. It has been exploited consistently in various parts of the world for over 25 years and is probably one of the most studied deep-sea species. Consequently, it provides a useful case study for consideration of the issues raised in relation to deep-sea fisheries generally.

BOX 3

Deep-sea sharks

Of particular concern in relation to the exploitation of deep-sea resources is the impact, either through targeted fishing or bycatch, on deep-sea chondrichthyans. As a taxonomic group, chondrichthyans display characteristics that make them vulnerable to over-fishing. 'Many, if not all, grow slowly, mature at relatively late ages, have a small number of young and low natural mortality. These characteristics result in very low rates of potential population increase with little capacity to recover from over-fishing (either direct or indirect) and other human impacts, including pollution and habitat destruction. However, knowledge of the population status of most of the known species of chondrichthyan fishes is seriously limited.' (Cavanagh *et al*., 2003)

Deep-sea sharks are a common bycatch in deep-sea fisheries for bony fish including Orange Roughy. While some of these shark species have little or no commercial value and are discarded, others are valued for their liver oil and flesh. For example, the livers of the Longnose Velvet Dogfish *Centroscymnus crepidater*, taken in Australia's largest demersal trawl fishery, are rich in squalene (liver oil), containing 61–73% by weight, while its fillets can retail for up to USD8 per kilogramme in Australia (Stevens in Cavanagh *et al*., 2003). The commercial value of some of these species, combined with the fact that catches of other deep-sea resources are falling and the lack of directed management of bycatch species, has seen an increase in targeted fishing effort towards these species in some areas.

The Shark Specialist Group of the IUCN – Species Survival Commission, has recently compiled an assessment of the status of Australasian chondrichthyans using the IUCN Red List of Threatened Species™ criteria, widely recognised as the most authoritative source of information on extinction risk. This report expresses concern that some deep-sea fisheries are taking shark species about which very little is known and, indeed, some that are yet to be taxonomically described, including five species of *Apristurus*, a genus of deepwater catfish taken as a bycatch in Orange Roughy fisheries in both Australian and New Zealand waters. A number of chondrichthyan species taken in deep-sea fisheries already fall into the threatened categories of the Red List, including the 'Critically Endangered' category (Cavanagh *et al*., 2003). Many others are simply categorised as 'Data Deficient', indicating that there are insufficient data to make an assessment of their conservation status. In many cases it is unclear whether current levels of catch are sustainable, with any increases in fishing effort, particularly if unregulated – an obvious cause for concern for species that, as a taxonomic group, are considered to have little capacity to sustain, or recover from, fishing pressure.

The FAO International Plan of Action (IPOA) for the Conservation and Management of Sharks applies to States in the waters of which sharks are caught, and to States the vessels of which catch sharks on the high seas. It recommends that these States adopt a national plan of action for the conservation and management of shark stocks whether catches occur as a result of directed or non-directed fisheries.

3

ORANGE ROUGHY

Orange Roughy stocks worldwide constitute a single species in the family Trachichthyidae within the order Beryciformes. The Trachichthyidae are commonly known as slimeheads. It is hardly surprising that New Zealand adopted the name 'Orange Roughy', reflecting the bright orange colour and rough scales of the fish, for marketing purposes.

Unlike many other deep-sea species, which have soft watery flesh that is not favoured by consumers (McAllister *et al.*, 1999 in Roberts, 2002), Orange Roughy has firm flesh that produces a white, boneless fillet that is also amenable to freezing. As a result it commands a relatively high value, compounding the risk of over-fishing. The United States is the dominant market for Orange Roughy. Other markets include Japan, France, Spain and Germany (Anon., 2002).

Biology

A summary of the main biological and life history characteristics of Orange Roughy is provided in Table 1[4]. Variations in the length, weight and age at maturity of fish are evident between regions and there remains some uncertainty about the accuracy of the methods used to determine the age of Orange Roughy. However there is general agreement that Orange Roughy is characterised by relatively low fecundity, slow growth, low and possibly episodic recruitment, extreme longevity and the formation of

Table 1: Biological and life history characteristics of Orange Roughy

CHARACTERISTIC	ORANGE ROUGHY
Fecundity	Relatively low; relative fecundity ranges from around 22 000-50 000 eggs/kg body mass (Branch, 2001).
Spawning behaviour	Spawning occurs once a year in dense aggregations, often associated with pinnacles and canyons (Annala *et al.*, 2003). Fish are thought to travel up to 200km to spawn (Francis & Clark, 1998). It is likely that all Orange Roughy do not spawn every year (Annala *et al.*, 2003).
Growth	Slow growing Validated age and length data suggest that 3.1, 5.5 and 7.6cm (standard length (SL)) relate to 1, 2 and 3 year olds respectively (Mace *et al.*, in Stevens, 2003). The von Bertalanffy growth coefficient (k) used in stock assessments ranges from 0.055 to 0.07 suggesting an extremely low growth rate in comparison to that of shallow water fish (Branch, 2001). Age at maturity[5] used in stock assessments ranges from 23-40 years (Branch, 2001). Mean length at maturity varies between regions, averaging 24cm off South Africa and 42cm in the north-east Atlantic (Horn *et al.*, and Thomsen in Stevens, 2003).
Natural mortality	Low; estimates range from 0.04 (Australia), 0.045 (New Zealand) and 0.064 (Namibia).
Size	In New Zealand waters maximum length is about 50cm, average length 35cm SL and maximum weight is 3.6kg. Maximum lengths of 60cm have been recorded in Australia.
Life span	Both otolith zone counts and radio-isotope ratios suggest that Orange Roughy live for more than 100 years (Clark *et al.*, 2000).
Aggregating behaviour	Orange Roughy aggregate for spawning and for feeding around topographic features including seamounts, plateaus and canyons.
Diet	Opportunistic feeders on mesopelagic and benthopelagic prawns, fish and squid with mysids, amphipods and euphausiids occasionally important (Annala *et al.*, 2003).
Distribution	The global distribution of Orange Roughy extends from the north-east Atlantic Ocean southwards to off north-west Africa, the western Mediterranean Sea, the south Atlantic Ocean off Namibia and through the ridges of the southern Indian Ocean from Africa to Australia and the south-west Pacific Ocean to east of New Zealand and the eastern Pacific Ocean off Chile.
Habitat	Orange Roughy principally inhabit waters between 500-1500m at temperatures of 4-7°C over steep continental middle and lower slopes and oceanic ridges.

4 A comprehensive compilation of this information can be found in Branch (2001).
5 The mean or median age at first maturity is the age at which 50% of a cohort spawn for the first time (FAO, 2003b)

predictable (spatially and temporally), dense spawning and feeding aggregations. As a result Orange Roughy is a relatively unproductive species with sustainable yields estimated at between 1 and 2% of pre-fished biomass annually (Annala *et al.,* 1998).

The collection of data on Orange Roughy, like that on deep-sea species generally, is complicated by the fact that, as a result of being hauled up from such great depths, most fish are dead when they reach the surface. This has ruled out the use of tagging for the purposes of collecting information on ageing, growth and stock structure. Assessment of these characteristics has therefore relied on otolith analysis, radiometric analysis, length/weight data and studies of the environmental and genetic characteristics of the fish.

Determining stock structure of Orange Roughy populations remains a problem in most parts of the world and is a major source of uncertainty in those countries carrying out formal stock assessments for the species. Methods based on environmental characteristics of the fish (e.g. trace elements in otoliths, morphometric differences, parasite analysis) as well as genetic studies have been used to identify stocks. The results of mtDNA restriction-site analysis have provided the best discriminatory power and the results tend to echo the findings from environmental studies (Branch, 2001).

Orange Roughy fisheries

The global reported catch of Orange Roughy is shown in Figure 2 and major Orange Roughy fisheries are identified in Figure 3. Key features of these fisheries are summarized in Appendix I.

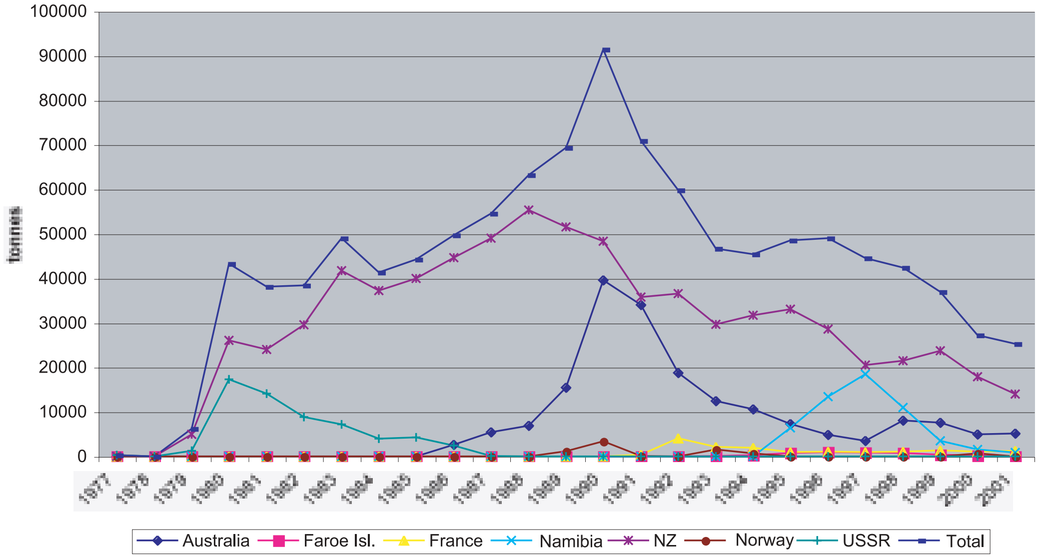
Orange Roughy is taken by demersal trawling. This involves the towing of a trawl net along, or immediately adjacent to, the ocean floor. The net is spread by two kite-like 'otterboards' that are attached to the ends of the net. The depth of the net and otterboards are controlled from the vessel by changing speed and the length of wire 'warps' which attach the otterboards to the vessel. Fish that pass between the boards and within the mouth of the net are funnelled down by the tapered body of the trawl net and into the bag or 'codend' of the net. The footrope of the net typically has heavy bobbins so epibenthic organisms are removed or damaged along the track of normal trawl operations (Koslow *et al.,* 2001).

Since the first catches of Orange Roughy were reported in 1977, over one million tonnes of Orange Roughy have been caught worldwide. The global catch in 2001 was just over 25 000t (FAO Fishery Information, Data and Statistics Unit, 2003c). The first reported catches were made by the then USSR, in the south-west Pacific Ocean. Orange Roughy catches have been recorded continuously since 1979 in that region. Catches in other UN Food and Agriculture Organisation (FAO) Statistical Areas did not occur until the late 1980s and early 1990s when fishing commenced in the eastern Indian Ocean and the north-east Atlantic Ocean. The records show that catches were first taken in the south-east Atlantic Ocean in 1994 and in the western Indian Ocean, in 2000. While the species had been taken since the 1970s it was not until the 1980s, when spawning aggregations were found around seamounts off New Zealand and southern Australia, that catch of Orange Roughy expanded significantly. Exploration of these areas was encouraged by the decline in many inshore species.

The FAO acknowledges that its database understates the actual catch of Orange Roughy (FAO, 2003a). This is demonstrated by the absence, for example, of any records for Orange Roughy catch by Chile, which is known to operate an Orange Roughy fishery (Appendix 1) and South Africa and Japan, both of which have acknowledged fishing for Orange Roughy in the western Indian Ocean (FAO, 2002).

While the FAO data may understate the total catch, they do provide an indication of the general Orange Roughy catch trends. Figure 2, together with the summary of Orange Roughy fisheries in Appendix I, indicates that Orange Roughy fisheries globally have typically been boom and bust.

Figure 2: Reported world catch of Orange Roughy



Source: FAO Fishery Information, Data and Statistics Unit, 2003c

Management

Depending on their location, Orange Roughy fisheries are subject to:

- management imposed by relevant coastal states (Australia, New Zealand, Namibia, Chile);
- management imposed by the European Union (EU) on its members;
- management imposed by the North-east Atlantic Fisheries Commission (NEAFC) and, potentially, the South East Atlantic Fisheries Organisation (SEAFO)[6], on their members;
- management agreed bilaterally for straddling stocks; or
- no management at all (for example, high seas stocks).

The four case studies presented in this report provide examples of management by coastal states, by the EU and NEAFC and of the absence of management of a high seas stock. The South Tasman Rise fishery is an example of a straddling Orange Roughy stock. Bilateral management of this fishery by Australia and New Zealand has been dogged by disputes between the parties and what is regarded by them as illegal, unreported and unregulated (IUU) fishing (Box 4). The South Tasman Rise fishery illustrates clearly the boom-bust nature of Orange Roughy fisheries and the difficulties associated with managing a straddling stock.

Bringing on board a shot of Orange Roughy

6 SEAFO was formed under the Convention on the Conservation and Management of Fishery Resources in the South East Atlantic Ocean which came into force in April 2003.

Figure 3: Major fisheries for Orange Roughy (tonnes) (indicative only)

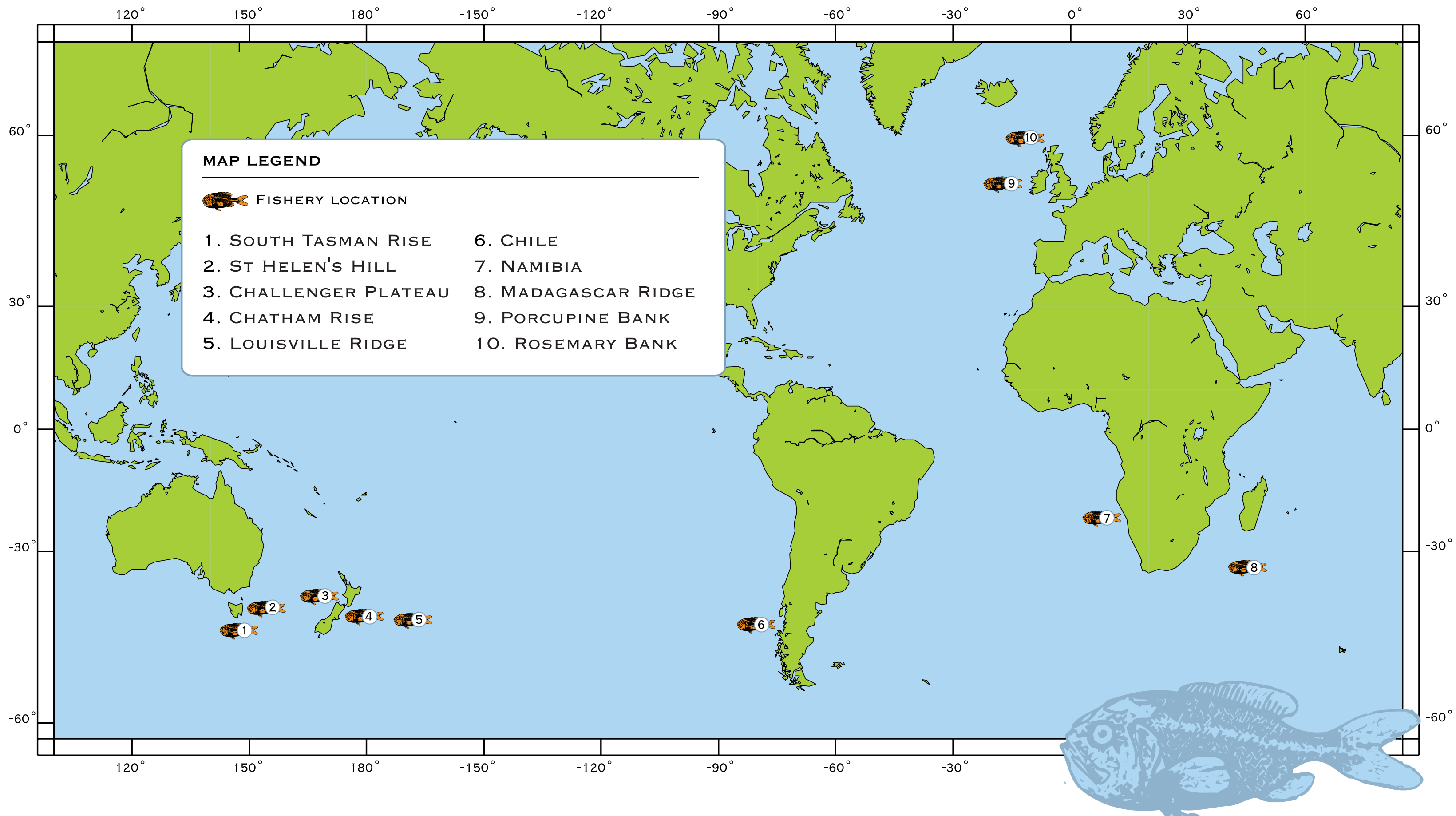


Illustration credit: CSIRO
Map by hiwire.com.au

Orange Roughy fisheries are found in the waters of New Zealand, Australia, Namibia and Chile and of a number of countries in the north-east Atlantic Ocean. They also exist in international waters in the north-east Atlantic Ocean, on the Madagascar Ridge in the southern Indian Ocean, on the Challenger Plateau between Australia and New Zealand, and on the Louisville Ridge east of New Zealand in the Pacific Ocean.

BOX 4

South Tasman Rise - a straddling Orange Roughy stock

The South Tasman Rise is an undersea ridge extending south from Tasmania into the Southern Ocean straddling the Australian Fishing Zone and the high seas. An Orange Roughy fishery, centred on a small number of pinnacles on the Rise, developed in 1997 and was fished by Australian and New Zealand vessels. Most of the fish is taken in international waters. Australia claims the right under the UN Convention of the Law of the Sea (UNCLOS) (UN, 1982) to manage the fishery as a straddling stock. However since the UNFSA did not come into force until December 2001, it has been difficult to control Australian and foreign catches. A short history of the fishery is provided below.

1997 Australian and New Zealand vessels took around 2000t of Orange Roughy and 1100t of Oreo Dory.

Australia and New Zealand developed a memorandum of understanding (MOU), to apply from 1 March 1998 to 28 February 1999, restricting catch of Orange Roughy to 2100t, divided on an 80/20 basis respectively, and allowing a further 300t for research.

1998 Australia took 2052t in February, prior to the MOU commencing and at which time New Zealand considered itself excluded from the fishery; New Zealand believed Australia to be in breach of the spirit of the MOU.

During the MOU period a total of 1944t (including research quota) was taken.

1999 The MOU expired and due to disagreements between the parties, largely regarding Australia's catch in February 1998, was not renewed; however the parties agreed that catch in 1999/2000 should be capped at 2100t and that New Zealand should have a one-off additional catch of 250t.

Australia closed the fishery to its vessels when they had taken 1700t. However, in the absence of an MOU, New Zealand found itself without a regulatory mechanism to control its fleet and the New Zealand catch exceeded 1600t.

In the winter (June-August) of 1999 three South African vessels and a Belize-registered vessel began operations in the fishery. South African vessels are reported to have taken 750t of Orange Roughy and anecdotal reports suggest that the Belize vessel may have taken 600t. Australia and New Zealand regarded this as IUU fishing and diplomatic exchanges between the four countries ensued. South Africa eventually withdrew its vessels.

Total catches by the two parties in 1999/00 were over 3300t and total removals were around 4650t.

2000 A new MOU was signed by Australia and New Zealand setting a TAC of 2400t, apportioned on a 75/25 basis and providing for 'repayment' of 640t of New Zealand's over-catch in the previous year.

Despite considerable searching and effort only 830t were taken in 2000/01.

2001 The 2001/02 catch was only 188t of Orange Roughy and effort declined from 1100 to 150 shots.

2002 The TAC for 2002/03 was reduced to 1800t. Just over 100t were taken.

Source: Prince and Diver, 2001; AFFA, 2002; AFFA, 2003

Orange Roughy on the back deck of a trawler

The management of Orange Roughy fisheries has been, and continues to be, conducted in an extremely uncertain environment. One of the key parameters for management of these fisheries is the size of the pre-fishing stock, the pre-fished biomass (B_0). Initial estimates of B_0 have often significantly over-stated the size of the resource (Box 5).

Many early attempts to estimate the pre-fished biomass and the size of the current biomass were based on trawl surveys, and in the early days of the New Zealand and Australian fisheries were based on the results of such surveys. However this technique was found to have serious shortcomings and was replaced by the development of acoustic survey techniques which are considered to provide a more accurate assessment of biomass.

In fisheries where acoustic surveys are carried out it may now be possible to be reasonably confident about the size of the current biomass and to provide estimates of the size of the pre-fished biomass. However other parameters remain subject to considerable uncertainty. For example, fundamental biological information, such as stock structure and natural mortality, and the true extent and scale of the fishery, may be far from clear for Orange Roughy fisheries. There are also strong indications that Orange Roughy recruitment is highly episodic and many stock assessment models do not account well for this. If long periods without recruitment are a characteristic of Orange Roughy, the conventional fisheries management approach of 'fishing down' the biomass and then extracting a set percentage of the pre-fished biomass on an annual basis, may not be appropriate (FAO, 2002).

As a result, stock assessments, where they are conducted, may not be conclusive. In addition the longevity of the species and the relatively high age at first maturity mean that the full impacts of fishing have not yet been felt in even the longest standing of the Orange Roughy fisheries. Considerable uncertainty therefore surrounds the appropriateness of the current reference points used for Orange Roughy. Levels of 30%B_0 are commonly used target reference points equating to what is believed to represent MSY for the species. However, as indicated in Box 2, it is recommended that MSY be used as a limit rather than a target reference point and that is particularly the case for vulnerable deep-sea species such as Orange Roughy. In addition, the UNFSA emphasizes that the risk of the limit reference point being exceeded should be very low. This has not been reflected in management strategies for Orange Roughy, where probabilities of, for example, 50% have been assigned. Even where more precautionary target reference points of 50%B_0 have been established, there has not been markedly greater success in sustaining the stocks (Appendix 1). This suggests that other factors, such as uncertainty in the assessments and the level of precaution adopted by management in response to this uncertainty, have been influencing management outcomes.

A haul of Orange Roughy

BOX 5

Stock assessment

Assessment and management of Orange Roughy stocks have been characterised by initial over-estimation of biomass and by ongoing uncertainty related to the biology/life history characteristics of Orange Roughy.

In Australia, for example, very early estimates of Orange Roughy biomass were made based on little information. In 1987, the Division of Fisheries Research of the Commonwealth Scientific and Industrial Research Organisation (CSIRO) provided rough estimates of the biomass on the Sandy Cape ground (off the west coast of Tasmania). This advice was that '... the lowest estimate would be not less than 2 to 3 hundred thousand tonnes. A reasonable figure would be close to 1 million tonnes.' (Harden Jones, 1987).

Some months later, acknowledging the degree of uncertainty associated with estimating biomass, CSIRO advised that the size of the Orange Roughy resource in south-east Australian waters '...lies between one hundred thousand and 1 million tonne...The first objective of our work is to get the number of zeros correct ...' (Harden Jones, CSIRO, *in litt*. to D. Bryan, July 1987).

Today, the best estimate of the pre-fished biomass on the Sandy Cape ground (now known as the Western Zone of the Orange Roughy fishery) is around 18 000t (Wayte & Bax, 2002). The best estimate of total pre-fished biomass of the stocks in south-east Australia is around 200 000t.

The lack of information and techniques with which to make an assessment in the early days of the Australian fishery are acknowledged, however these overly optimistic assessments had significant impacts on decisions taken by fisheries managers and commercial decisions of the industry. TACs were set too high and fishers invested heavily in larger vessels and gear. As better assessments were made and TACs were reduced, increasing pressure was brought to bear on management, often successfully, to defer TAC reductions in order to minimise the socio-economic impacts. The fishing industry continues to blame, justifiably or not, these early, overly optimistic biomass assessments for the excess capacity problem that persists.

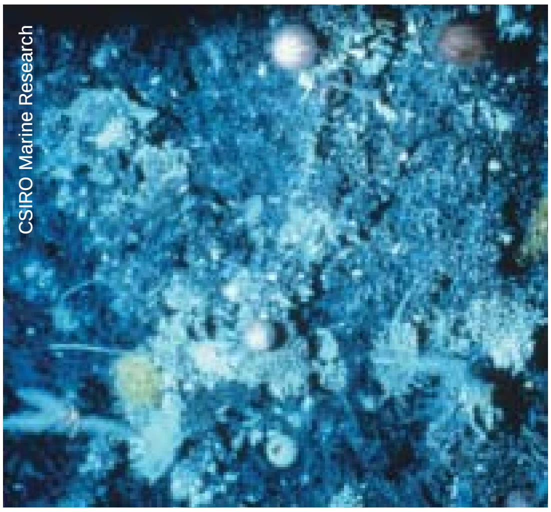
Ecological effects of fishing

Three broad ecosystem concerns arise from Orange Roughy fisheries:

1. associated species bycatch;
2. trawl impacts on the sea floor; and
3. trophic interactions.

Most fishing for Orange Roughy is conducted on aggregations. As a result, incidental catch of other species is relatively less than that in trawling operations more generally. However, while the proportion of bycatch in deep-sea trawls may be lower than in other trawl fisheries, there is nearly 100% mortality of bycatch owing to the depths from which it is taken.

As in any trawling operation, the size and shape of the net mesh used will determine the size and shape of species that are retained in the codend. Species taken in trawling operations for Orange Roughy vary according to location. The species contained in Table 2 are indicative of bycatch in Orange Roughy trawling operations in Australia, New Zealand, the north-east Atlantic Ocean and the southern Indian Ocean.



Surface of a seamount showing the diversity of encrusting species

The trawled surface of Pedra Branca Seamount, south of Tasmania

Table 2: Bycatch in Orange Roughy fisheries

COMMON NAME	SCIENTIFIC NAME	TAKEN AS BYCATCH IN
Alfonsino	*Beryx* spp.	Australia, NE Atlantic, S. Indian Ocean
Argentines	*Argentina silus*	NE Atlantic
Basketwork Eels	*Diastobranchus capensis*	New Zealand
Black Scabbardfish	*Aphanopus carbo*	NE Atlantic
Bluemouth	*Helicolenus dactylopterus*	NE Atlantic
Blue Ling	*Molva dypterygia*	NE Atlantic
Boarfish	*Pseudopentaceros richardsoni*	S. Indian Ocean
Cardinal Fish	*Epigonus* spp.	New Zealand, NE Atlantic, S. Indian Ocean
Chimaerids	Chimaeridae	New Zealand, NE Atlantic
Deep-water sharks	Squalidae; *Apristurus* spp.	Australia, New Zealand, NE Atlantic
Greater Forkbeard	*Phycis blennoides*	NE Atlantic
Hake	*Merluccius australis*	New Zealand
Ling	*Genypterus blaccoides*	New Zealand
Mora	*Mora moro*	New Zealand, NE Atlantic
Oreo-Black	*Allocyttus niger*	S. Indian Ocean, Australia, New Zealand
Oreo-Smooth	*Pseudocyttus maculatus*	Australia, New Zealand
Oreo-Spiky	*Neocyttus rhomboidalis*	Australia, New Zealand
Roundnose Grenadier	*Coryphaenoides rupestris*	NE Atlantic
Rattails	*Coryphaenoides subserrulatus*	Australia, New Zealand
Slickheads/smoothheads	Alepocephalidae	New Zealand, NE Atlantic
Whiptails	Macrouridae	Australia
Arthropods	Arthropoda	New Zealand
Corals	Including Gorgonacea, Antipatheria and Scleractinia	Australia, New Zealand, NE Atlantic, S. Indian Ocean
Echinoderms	Echinodermata	New Zealand
Molluscs	Mollusca	New Zealand

Source: Anderson & Clark, 2003; AFMA, 2000; Smith 2001; Clark *et al*., 2000; ICES, 2002a; ICES, 2003a; Knuckey & Liggins, 1999; McClatchie *et al*., 2001; Marine Work Group and Friends of the Irish Environment, 2002; Wetherbee, 1999.

There is limited management of species taken as bycatch to Orange Roughy fishing and some, particularly deep-sea sharks, are very vulnerable to over-fishing. A variety of deep-sea sharks are taken in Orange Roughy hauls including Shovelnosed Dogfish *Deania calcea*, Owston's Dogfish *Centroscymnus owstoni*, Portuguese Dogfish *Centroscymnus coelolepis*, Longnose Velvet Dogfish, Black dogfish *Centroscylliun fabricii*, Leafscale Gulper Shark/Cochon *Centrophorous squamosus* and *Etmopterus* and *Apristurus* spp. (Stevens pers. comm. in Gordon, 1999; Wetherbee, 1999; Marine Work Group and Friends of the Irish Environment, 2002). In Australia there is a view that catches of oreos and deep-sea sharks taken in conjunction with Orange Roughy fishing are almost certainly above sustainable levels and should be brought under management control (Caton, 2002). Consideration is being given to the most effective way to bring management of deep-sea shark species under the quota management system of the Australian South Eastern Scalefish and Shark Fishery (SESSF). In New Zealand oreos are subject to ITQ management.

The substrate is damaged by the physical effects of trawl gear contacting the seamount or pinnacle during fishing. Consequently, benthic species and the nature of the substrate are altered. Seamount habitats and cold-water coral reefs have been identified as particularly vulnerable to trawling activity (ICES, 2003b; Hall-Spencer *et al.*, 2002).

Orange Roughy fishing is centred on seamounts. In New Zealand, for example, 60-70% of Orange Roughy catch is taken on seamounts. A number of studies have identified the significant impacts of trawling on seamounts.

- Recent surveys have identified strong contrasts between fished and unfished seamounts in New Zealand. Photographic transects on fished seamounts identified only small and isolated occurrences of coral (2-3% of the photograph area) while on unfished seamounts 100% cover was often recorded. Evidence of damage from trawl gear (wire and net remnants, gouges from trawl doors or bobbins) was also evident on fished seamounts. Catch composition in fish trawls conducted on the seamounts also varied with very small catches of bottom living invertebrates on fished seamounts and large quantities of coral in catches from unfished seamounts (Clark & O'Driscoll, in press).
- A study comparing the benthic fauna of fished and unfished seamounts to the south of Tasmania, Australia (Koslow *et al.*, 2001) has also shown that '...the substrate of heavily fished seamounts now consists predominantly of either bare rock or coral rubble and sand and…the abundance and species richness of the benthic fauna…was also markedly reduced.' This situation was in contrast to that on unfished seamounts, where the fauna was dense, diverse and dominated by suspension feeders, and the benthic biomass was 106% greater than on the heavily fished seamounts.
- Recent surveys of the deep waters around Scotland have shown that the effects of demersal trawling in the deep-sea are already widespread (Southampton Oceanography Centre, 2003). Research in 2000 on a unique collection of sandy and cold-water corals to the north-west of Scotland known as the Darwin Mounds, has shown that the Mounds have been damaged by trawling (Southampton Oceanography Centre, 2003). The Mounds are home to the deep-water coral *Lophelia pertusa* and particularly high densities of a single-celled organism *Syringammina fragilissima*. The corals themselves also provide a habitat for invertebrates such as sponges and brisingiid starfish (ICES, 2002a)[7].

The ICES Advisory Committee on Ecosystems identified the impacts of trawling on corals as follows:

> *The most obvious impact of trawling is mechanical damage caused by the gear itself.*
> *The impact of trawled gear kills the polyp and breaks up the reef structure. The breakdown of this structure will alter the hydrodynamic and sedimentary processes, and recovery may not be possible or could be seriously impaired. It may also cause a loss of shelter around the reef and organisms dependent on these features will have a less suitable habitat. Trawls also cause re-suspension of sediments that could affect corals growing downstream. (ICES, 2002a)*

Coral bycatch is common in Orange Roughy fisheries, particularly in the early stages of the fishery. Anderson and Clark (2003) estimate that coral bycatch in the first year of the Orange Roughy fishery on the South Tasman Rise was 1750t. This fell to 100t per year by the third year. The decline in coral bycatch probably reflects the tendency for vessels to trawl their nets repeatedly along the same towline. Large amounts of accumulated coral are removed by the initial tows and over time the coral bycatch along these towlines is reduced. The coral bycatch on the South Tasman Rise was dominated by the reef-forming Stony Coral *Solenosmilia variabilis*. Although not well identified, the second most common group of corals on these seamounts was likely to have been the gorgonians (golden and bamboo corals) with very little black coral present. The findings of photographic surveys comparing fished and unfished seamounts on the Chatham Rise (Clark & O'Driscoll, in press) are consistent with the findings on the South Tasman Rise.

Orange Roughy is considered to feed at the fourth-plus trophic level, eating small fish and squid, which eat small crustaceans, which live in the surface coral communities and eat detritus and microscopic plants from the surface. It is estimated that Orange Roughy can satisfy only about 10% of its energy requirements from local production. Where Orange Roughy are found in large aggregations they apparently must subsist on prey that drift past their seamount habitat (Koslow, 1997). The impact on the seamount habitats favoured by Orange Roughy of removals of large proportions of the biomass of Orange Roughy and other bycatch, and the impact of trawling on the invertebrate fauna which colonises the substrate of these habitats, would appear severe but is not well understood.

7 In August 2003, in response to a proposal by the United Kingdom, the EU introduced emergency measures that prohibit, with immediate effect and for a period of six months, the use of bottom trawling in the area of the Mounds (Commission of the European Communities, 2003). The EU is pursuing a permanent ban on the use of bottom trawling gear in the area.

INTERNATIONAL TRADE IN ORANGE ROUGHY

The availability of international trade data for Orange Roughy is limited. Few countries involved in the catch and trade of Orange Roughy have specific customs codes under which to record their import, export and re-export of this species. The main consumer market, the USA, and the main producer country, New Zealand, do have customs codes for Orange Roughy. Chile, also a small producer country, introduced one commodity code for Orange Roughy in 2002. However, Australia, Canada, the EU, Japan and Namibia do not have customs codes or record trade information for Orange Roughy, despite being producers and/or consumers of the product. Significantly, no trade information is available from China, which has emerged as a major exporter/re-exporter of Orange Roughy to the USA in recent years, and is identified in FAO's Capture Production database as having caught Orange Roughy in recent years.

Analysis of the data available from New Zealand and the USA does however provide some insights into management issues relating to the global exploitation of the species.

New Zealand has consistently been the world's largest producer of Orange Roughy and has five separate product codes for Orange Roughy commodities. Data on Orange Roughy imports and exports by New Zealand have been collected since 1989. Since that time, New Zealand exports of Orange Roughy have been recorded for a total of 55 different destinations. However, over the period 1989 to July 2003, 87% of exports by volume were to the USA, primarily as frozen fillets. Australia accounted for a further 5% and Europe 2%.

Exports of frozen fillets to the USA peaked in 1990 at 14 238t, but declined progressively over the following years to a low of 3158t in 2001. However, exports of this product to the USA doubled to 6956t in 2002. This increase equates to around 13 000t of fish (greenweight). Possible explanations for this lie in a small (15%) increase in total New Zealand catch between 2001 and 2002, and release of New Zealand stores of Orange Roughy product on to the market following the price declines in 2000 and 2001 associated with increased product from the Madagascar Ridge fishery. The increase is not

Orange Roughy processing factory in Tasmania, Australia

explained by New Zealand imports/re-exports of product, since imports in 2002 totalled only 23t of fillets.

The USA is the largest consumer market for Orange Roughy products and has one customs code for frozen fillets. Data has been collected against this code since 1995 (Table 3). There have been no recorded exports/re-exports from the US over this period.

According to US trade data, over the period 1995 to 2002, the US imported an average of 10 117t of Orange Roughy fillets per year, peaking at 13 134t in 1997. Since 1997 imports have levelled off to between 9000 and 10 000t per year (Figure 4). Over that period the US imported Orange Roughy from 21 countries, however imports from New Zealand dominated the US market. The most significant source countries in 2002 were New Zealand (65%), China (18%), Australia (7%) and Chile (5%). Namibia also emerged as a significant source of Orange Roughy imports into the US during the period. Imports into the US from Namibia rose from 95t in 1995 to a peak of 3646t in 1997, representing almost one-third of the total US imports in that year. However, reflecting the rapid development and then decline of the Namibian Orange Roughy fishery, imports from Namibia had declined to just over 200t by 2002.

The increase in imports in both 2000 and 2002 may be explained by the influence of the Madagascar Ridge fishery. Product from the fishery is likely to have flowed on to the market in 2000, resulting in the average value of imports into the US falling from USD10.45/kg to USD8.81/kg in that year. There is some evidence (Sanford Limited, 2000) that product was withheld from the market in response to the price fall. The placement of this product on to the market in 2002 may therefore account for the increased volume of imports in 2002.

Although both the US and New Zealand have customs codes for Orange Roughy, and the latter is the dominant exporter to the US market, the trade data on Orange Roughy between these two countries are a poor match. For example, in 1999 New Zealand trade records show an export of 3830t of frozen fillets to the USA, while US trade statistics record an import of 5258t from New Zealand for that same period. Further, New Zealand trade records show exports to the USA of Orange Roughy in a range of product forms yet the US has only one import commodity code. While these other codes account for only several hundred tonnes (product weight) annually of New Zealand Orange Roughy exports, it is unclear where the USA is recording such commodities. This raises the question as to whether the USA, as the major market for Orange Roughy, needs to expand its range of product codes.

Despite these discrepancies, as the major global consumer market for Orange Roughy the US data still provide the best overall picture of trade demand for Orange Roughy products. These data therefore provide a useful basis for comparison with FAO's estimates of the global catch of Orange Roughy. Figure 5 compares the US imports, converted to greenweight, with the FAO estimates of global catch for the period 1995-2001. Two main issues emerge through this comparison.

First, this comparison suggests that, particularly in recent years, the FAO figures are likely to substantially underestimate the actual global catch of Orange Roughy. FAO has itself recognised that its database understates the actual catch (FAO, 2003a). For example in 2001, estimates based on conversion factors of 3.5 and 4[8] suggest that the greenweight equivalent of US imports is between 30 702t and 35 088t of Orange Roughy compared to the FAO global catch estimate of 25 258t - a potential underestimate of 30%. The level of catch underestimated by FAO in recent years should be considered as a minimum given that the USA is not the only market for Orange Roughy. Significant catches of Orange Roughy have been taken by Ireland and other countries in recent years and, while some of this catch may be processed through countries such as China and re-exported to the US, it is likely that European markets such as France and Germany also consume significant quantities. Australia and New Zealand also have small domestic markets for Orange Roughy. Therefore, global catch of Orange Roughy is likely to be significantly greater than that estimated in the FAO catch statistics.

The second issue that arises from the comparison between FAO global catch data and the US import statistics relates to differences in trend. Following the peak in 1997, US imports of Orange Roughy show a stable trend over the past four years (Figure 4). This stability masks the fact that the US market is being supplied by a number of individual Orange Roughy fisheries that appear to peak and then decline, such as the Namibian fishery. In comparison, the FAO catch data shows a steady decline in global catch over the same period. While the FAO data does reflect the rise and fall of the Namibian fishery over this period it does not appear to reflect the marked increase in production that is reported to have arisen from the Madagascar Ridge fishery. Total catch from the eastern Indian Ocean is reported at just under 2000t over the peak period of the fishery in 2000 and 2001, whereas minimum estimates suggest a catch of around 12 000t for this period.

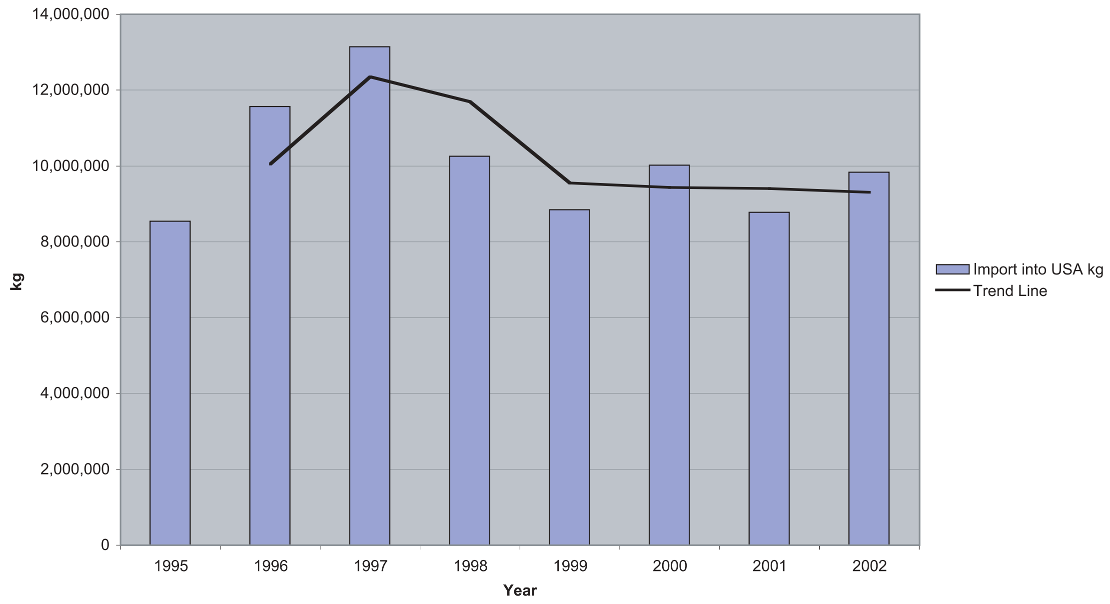
8 The conversion factor used varies between countries. Australia uses a conversion factor of 4 for conversion of frozen fillets to greenweight while New Zealand uses 3.5.

Table 3: Imports of frozen fillets of Orange Roughy into the USA, by country of origin, 1995-2002 (product weight, kg)

COUNTRY OF ORIGIN	1995	%	1996	%	1997	%	1998	%	1999	%	2000	%	2001	%	2002	%
Argentina	-	-	16 801	0.15	-	-	-	-	-	-	-	-	-	-	-	-
Australia	519 960	6.09	500 382	4.33	737 610	5.62	1 426 001	13.92	1 554 746	17.59	1 085 574	10.84	862 146	9.83	694 089	7.06
Brit. Virgin Islands	-	-	-	-	-	-	-	-	1816	0.02	138 932	1.39	53 122	0.61	92 845	0.94
Canada	32 539	0.38	45 102	0.39	7294	0.06	-	-	20 645	0.23	-	-	4304	0.05	9605	0.10
Chile	-	-			19 050	0.15	-	-	172 508	1.95	561 806	5.61	580 070	6.61	480 349	4.89
China	-	-	603 181	5.22	1 080 517	8.23	17 669	0.17	887 395	10.04	1 400 004	13.98	1 769 198	20.17	1 806 003	18.37
Iceland	-	-	-	-	-	-	-	-	-	-	-	-	-	-	354	-
Japan	14 590	0.17		-	8544	0.07	9000	0.09	-	-	-	-	11 115	0.13	-	-
Lithuania	3660	0.04	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Morocco	-	-	-	-	-	-	16 526	0.16	-	-	-	-	-	-	-	-
Namibia	94 099	1.1	1 273 458	11.02	3 646 112	27.76	3 149 819	30.74	940 560	10.64	1 680 796	16.78	1 014 488	11.57	201 566	2.05
Netherlands	200	0.002	-	-	-	-	39 435	0.38	-	-	-	-	-	-	-	-
New Zealand	7 874 429	92.21	8 855 248	76.61	7 519 544	57.25	5 563 764	54.29	5 258 863	59.51	4 185 050	41.78	4 017 685	45.80	6 425 364	65.36
Seychelles	-	-	-	-	-	-	-	-	-	-	-	-	36 979	0.42	-	-
South Africa	-	-	-	-	16 086	0.12	-	-	-	-	-	-	-	-	43 503	0.44
South Korea	-	-	264 852	2.29	98 102	0.75	-	-	-	-	18 144	0.18	-	-	-	-
Spain	-	-	-	-	-	-	25 550	0.25	-	-	-	-	-	-	-	-
Thailand	441	0.01	-	-	-	-	-	-	-	-	909 284	9.08	375 819	4.28	77 532	0.79
Trinidad & Tobago	-	-	91	0.001	-	-	-	-	-	-	-	-	-	-	-	-
Uruguay	-	-	-	-	1440	0.01	-	-	-	-	-	-	47 052	0.54	-	-
Viet Nam	-	-	-	-	-	-	-	-	-	-	36 759	0.37	-	-	-	-
Total	8 539 918		11 559 115		13 134 299		10 247 764		8 836 533		10 016 703		8 771 978		9 830 856	

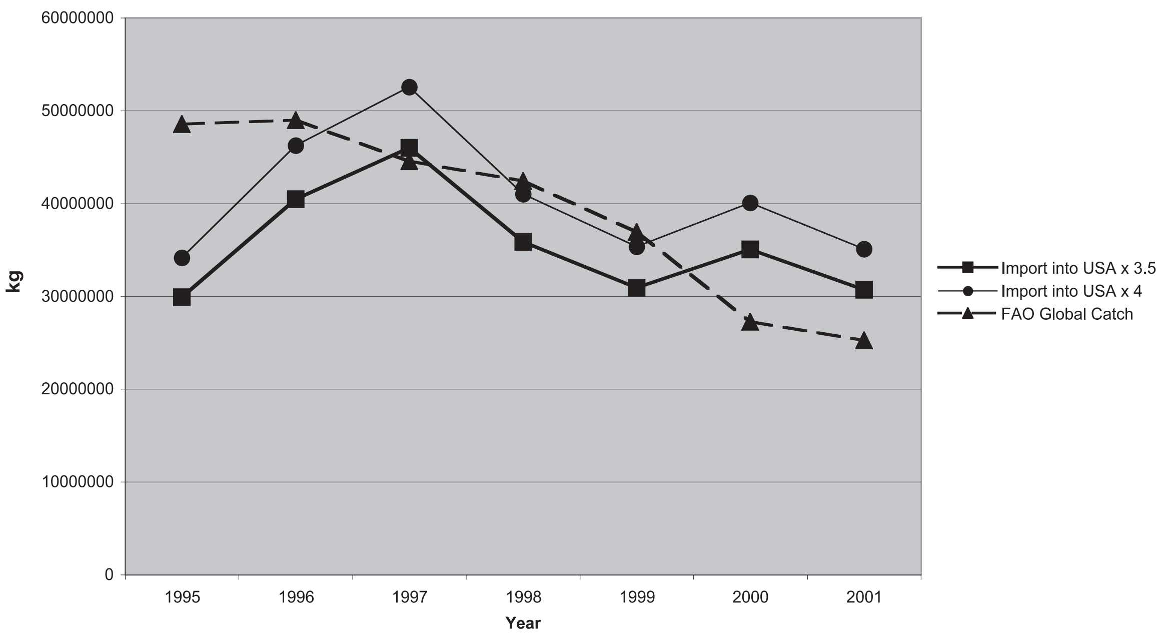
Source: National Marine Fisheries Service (NMFS) (2003)

Figure 4: Imports of frozen fillets of Orange Roughy into the USA, 1995-2002 (Product weight, kg)



Source: NMFS, 2003

Figure 5: FAO Orange Roughy catch data and US import data (Greenweight, using 2 conversion rates, kg)



Sources: FAO Fishing Information, Data & Statistics Unit, 2003c; NMFS, 2003

4

ORANGE ROUGHY FISHERY CASE STUDIES

CASE STUDY 1: CHATHAM RISE, NEW ZEALAND

Located:	In the New Zealand EEZ to the East of the South Island; in Quota Management Area ORH3B (Chatham Rise, Puysegur and Southern)
First significant fishing:	1979 (earlier by foreign trawlers)
Fishing method:	Bottom trawl
Spawning aggregation:	Yes, in winter (mid-June to mid-August)
Highest annual catch:	32 800t in 1988/89
Latest annual catch:	10 000t in 2001/02 (provisional)
Effort:	The number of vessels fishing for Orange Roughy on Chatham Rise fell from 20 to less than 10 between the late 1980s and the late 1990s
Value of Fishery:	USD18.5m (based on port price 2001)
Stock status:	Three main Orange Roughy stocks are recognised on the Chatham Rise. north-west Chatham: status uncertain but recent catches not considered sustainable; north-east Chatham: stock estimated to be above B_{MSY} and may be rebuilding; south Chatham: status uncertain but may be rebuilding.
Major uncertainties:	Stock structure, patterns of recruitment, current biomass level
Management methods:	Total Allowable Commercial Catch (TACC) and ITQs, gear restrictions and area restrictions. The ORH3B TACC has been distributed across a number of subareas since 1991/92. The total catch limit for Chatham Rise in 2002/03 is 10 400t.
Management strategy:	A constant rate of harvest strategy is applied. The target biomass, B_{MSY}, is set at 30%B_0. The long-term Current Annual Yield (CAY)[9] equates to a catch that is around 2% of B_0 and 6% of B_{MSY}.
Main bycatch:	Smooth Oreo, deepwater dogfish (Squalidae), deep-sea catfish (*Apristurus* spp.), slickheads, rattails (*Coryphaenoides subserrulatus, C. serrulatus* and *Caelorinchus innotabilis*) and Basketwork Eels.
Other impacts:	Benthic habitat; biomass removal, particularly invertebrate fauna; functional dynamics

The fishery

Initial catches of Orange Roughy around New Zealand were by foreign trawlers in the late 1970s. Foreign vessels were largely excluded from these waters following the declaration of New Zealand's 200nm EEZ in 1978. The domestic Orange Roughy fishery expanded rapidly from 1979 reaching a peak at around 54 000t in 1988/89, of which 60% was taken on the Chatham Rise. Fishing focused initially on the spawning aggregation on the Chatham Rise (Figure 6). The Rise is a ridge extending eastwards from the South Island of New Zealand, at depths of 200-300m on top and dropping to over 2000m on the flanks. It has a large number of smaller knolls and hills, which are often clustered in multiple peak complexes (Clark, 1999).

During the first decade of the Chatham Rise fishery, fishing focused on flat ground and more than 60% of the Orange Roughy catch was taken during the spawning season in a very restricted area by around 20 large trawlers. Catch rates were high with rates of 41t per vessel per day reported during the peak spawning period (Robertson & Grimes in Anon, 1983). Catches on Chatham Rise peaked at 32 800t in 1988/89 however by the late 1980s catch rates were dropping and the area fished was expanding. Despite the decline in catch rates, total catch remained between 20 000 and 30 000t per year during the 1980s and into the early 1990s (Annala *et al.*, 2002). This was made possible by the discovery and development of new seamount fisheries on the east and south of the Rise resulting in serial depletion of

9 Current Annual Yield (CAY) is defined as: the one-year catch calculated by applying a reference fishing mortality (F_{ref}) to an estimate of the fishable biomass present during the next fishing year. F_{ref} is the level of (instantaneous) fishing mortality that, if applied every year, would, within an acceptable level of risk, maximise the average catch from the fishery (New Zealand Ministry of Fisheries, 1998).

many of these seamount complexes (Clark, 1999). During the 1990s more than 50% of the catch came from four seamount complexes on the eastern and north-west Chatham Rise and all have shown a decline in catch rate (Annala *et al.*, 2003). Since the mid-1990s catches have been around 8000t per annum and over 90% of this has been taken by less than 10 trawlers (Clement, 1999). Despite the overall reduction in catch, Chatham Rise remains the largest Orange Roughy fishery in New Zealand.

Stock status

A major research programme was introduced in the Chatham Rise fishery in the early 1980s based on annual trawl surveys and supplemented by commercial catch records and data collected from scientific observers on vessels (Clark *et al.*, 2000; Clark, 2001). As more information became available it was apparent that the initial TACs had been set too high. The pre-fished biomass of the three stocks on Chatham Rise is now estimated to be between 516 000 and 589 000t (Annala *et al.*, 2003). However considerable uncertainty persists in the stock assessments. In 1983 the following research needs were identified (Robertson & Grimes in Anon, 1983) for New Zealand's Orange Roughy stocks:

- the age structure and mortality of each Orange Roughy population and how this is affected by fishing;
- stock structures; and
- the level of recruitment for each population.

While there is still some debate about age and mortality these issues have been largely resolved. However some 20 years later and despite a major research programme, stock structure within the Chatham Rise fishery remains unclear (Francis & Clark, 1998) and patterns and levels of recruitment remain uncertain. Reliable estimates of biomass remain problematic for Orange Roughy and productivity parameters are not well known (Clark, 2001).

The research effort on the Chatham Rise fishery has changed over time. Trawl surveys were discontinued in 1994. The increasing concentration of fish in a small area had made the random trawl technique inadequate. Monitoring now relies heavily on acoustic surveys and commercial catch-per-unit-effort (CPUE) data. An egg survey was carried out on the north-west Chatham Rise in 1996 but was not very successful. The latest acoustic survey data in the north-east region is from 2000 (National Institute of Water and Atmospheric Research (NIWA) research survey) and from 2003 (industry vessel survey). In the north-west the latest acoustic data is from a NIWA survey in 2002. There remains doubt as to the reliability of CPUE data as an indicator of abundance at low stock and effort levels.

Current assessments of Chatham Rise Orange Roughy stocks are summarised in Table 4. The north-east Chatham Rise stock, after having declined to a minimum of between 25-35%B_0 in the early 1990s, is currently assessed as having rebuilt to a level above that required to support MSY and to be rebuilding at current catch levels. This is supported by both the NIWA assessment and the industry-funded assessment carried out by the CSIRO.

Table 4: Stock assessment estimates for Chatham Rise Orange Roughy stocks (tonnes)

Stock Management Unit	B_0	B_{MSY}	$B_{Current}$	$B_{Current}/B_0$	2001/02 subarea catch limit	2001/02 Catch (p)	2002/03 TACC
North-east Rise	356 000 – 404 000	104 000 – 121 000	122 000 – 189 000	34-54%	7000	6700	7000
North-west Rise	65 000 – 90 000	20 000 – 27 000	14 000 – 39 000	21-44%	2000	2200	2000
South Rise	95 000	28 500	23 100	24%	1400	1100	1400

(p) provisional

Source: Annala *et al.*, 2003

NIWA's 'base-case' estimate of available yield from the fishery is 10 400t. The maximum catch able to be taken while ensuring a 50% probability that the stock will not drop below optimal levels over the next 10 years (meeting the target criterion) is estimated by NIWA to be 12 700t. On the basis of the assessment that $B_{current}$ is greater than B_{MSY}, NIWA estimates that the minimum yield that will ensure that the stock in 2010/11 is closer (i.e., fished down toward) to B_{MSY} is 7100t.

The stock assessment advice (Annala *et al.*, 2002, 2003) acknowledges that 'the only direct information that supports [the] predicted rebuild is the set of CPUE biomass indices from the spawning box' and that there is some doubt about the representativeness of the CPUE series. The acoustic biomass estimates used in the stock assessment are based on a combination of three surveys (two in 1998 and one in 2000) and is uncertain as an estimate of absolute biomass.

In the north-west, the uncertainties associated with both the egg and acoustic surveys mean that the stock status is uncertain. However there is general agreement that current catches are not sustainable in the long term. The subarea catch limit was reduced from 2500t, its level since 1994/95, to 2000t in 2001/02.

The stock assessment for the South Chatham Rise suggests that stocks are below that which will support MSY but recent catches are thought likely to allow the stock to rebuild to that level. However the assessment of this stock is uncertain because of inadequacies in the assessment model. None of the four CPUE series available support the rebuilding predicted by the model, which the assessment acknowledges is based on an unrealistic assumption that there is no net migration of fish between the four sectors of the fishery.

Management

The New Zealand *Fisheries Act 1996* requires that fish stocks are maintained at or above the levels that can produce the MSY and that stocks currently below (or above) the level that can produce MSY are brought up (or down) to that level. The prime management tool is the setting of species-specific TACCs for quota management areas and allocation of the TACCs as ITQs. A CAY strategy is applied to Orange Roughy stocks on the Chatham Rise and the B_{MSY} is $30\%B_0$.

The Chatham Rise fishery is managed as part of the Quota Management Area ORH3B and up until the early 1990s the two were synonymous. TACCs for the fishery have been set since 1981/82 peaking at 38 300t in 1988/89. By 1995/96 the TACC for ORH3B had been reduced to 12 700t and it remains at that level. Since 1991/92 the TACC has been distributed across subareas within ORH3B in accordance with a series of voluntary catch-limit agreements between industry and the Minister of Fisheries (Table 5). After being reduced by around 50% in 1994/95 the Chatham Rise catch limit was stable at 7200t until 2001/02 when it was increased to its current level of 10 400t.

The trend in the Chatham Rise TACC and catch are shown in Figure 6. Catches on the Chatham Rise have been in line with the catch limit whereas catches in other areas of ORH3B have generally fallen well short of the subarea catch limits (Annala *et al.*, 2003).

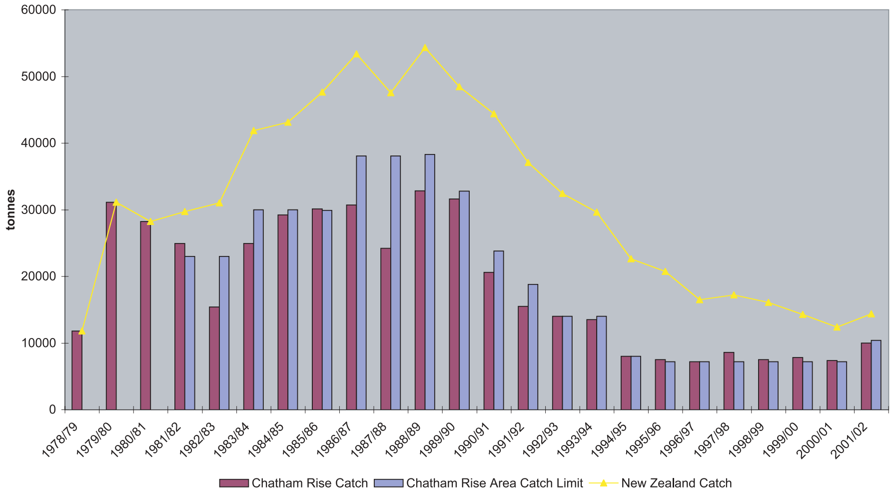
Table 5: Chatham Rise subarea catch limits 1992/93[1] to 2002/03 (tonnes)

YEAR	NORTH-WEST RISE	NORTH-EAST RISE	SOUTH RISE	CHATHAM RISE	ORH3B TACC
1992/93	3500	4500	6300	14 300	21 300
1993/94	3500	4500	6300	14 300	21 300
1994/95	2500	3500	2000	8000	14 000
1995/96	2250	4950	South Rise managed as part of north-east Rise from 1995/96 to 2000/01	7200	12 700
1996/97	2250	4950		7200	12 700
1997/98	2250	4950		7200	12 700
1998/99	2250	4950		7200	12 700
1999/00	2250	4950		7200	12 700
2000/01	2250	4950		7200	12 700
2001/02	2000	7000	1400	10 400	12 700
2002/03	2000	7000	1400	10 400	12 700

1. While subarea catch limits were first implemented in 1991/92 the current subarea definitions did not apply until 1992/93

Source: Annala *et al*., 2002, 2003

Figure 6: Trends in Chatham Rise subarea catch limits and catch



Source: Annala *et al*., 2002, 2003

The north-east subarea catch limit was increased from 4950t, its level since 1995/96, to 7000t in 2001/02. The increase in the area catch-limit for the Chatham Rise in 2001/02 was based on the findings of two separate stock assessments which indicated that the biomass in the north-east subarea is greater than B_{MSY} and that yield estimates were similar to, or greater than, current catches. Between 1995/96 and 2000/01 the south and north-east Rise subareas were managed under a single subarea catch limit. While the stock assessment for the north-east suggested the possibility of an increased catch limit, the south Rise subarea could not sustain an increase above current levels. As a result separate limits for the north-east and south were re-introduced from 2001/02.

Average catches in the north-east Rise over the previous five years had been just under 4000t so the increase in the catch limit equated to allowing a 75% increase in catch. Provisional figures indicate that nearly 6700t of the 7000t limit were taken in 2001/02. Some conservation groups in New Zealand opposed the increase on the grounds that there was considerable uncertainty in the assessments. However, the minister, in making his decision to increase the limit for the north-east Rise, indicated that the 7000t limit was a precautionary limit since it did not take full advantage of the available yields of up 10 400t suggested by the stock assessment (Hodgson, 2001).

Each of the three recognised stocks on the Chatham Rise is, has been or may have been, fished below the 30%B_0 limit despite the early introduction of management and substantial research effort. This is in large part explained by the early estimates of biomass being too high, resulting from a paucity of information during the first years of the fishery and inadequate understanding of the life history and biological characteristics of the species. In particular, the use of trawl survey biomass estimates as absolute, the assumption of M = 0.1 (thought at the time to be conservative), and the use of Gulland's common rule of thumb yield estimator Y = 0.5*M*B0, were inappropriate (M. Clark, NIWA, *in litt*. to M. Lack, October 2003). Other factors that may have contributed include (Smith, 2001):

- at the time of the introduction of the ITQ system there were limited skills and facilities for undertaking stock assessment in New Zealand;
- the initial definition of ITQs as fixed quantities created political and financial problems for substantial reductions in Orange Roughy quota in the late 1980s;
- Orange Roughy are much less productive than initially believed; and
- broad area TACs are not appropriate for individual seamount fishery management and can lead to serial depletion of species as individual seamounts are over-fished within a management area.

Figure 6 depicts stability in the Chatham Rise catch since the mid-1990s at around 8000t per year. Clark (2001) suggests that the experience of the Chatham Rise fishery may indicate that where the pre-fished biomass is sufficiently large, and where there is an extensive research programme and early intervention in the form of catch controls, it may be possible to sustain a viable, valuable Orange Roughy fishery. He cautions, however, that current catch levels on the Chatham Rise may not be sustainable when the full impacts of fishing on recruitment to the fishery and the effects of possible episodic recruitment are realised in 5-10 years time. These factors, together with the acknowledged uncertainties in the stock assessments imply that, despite the apparent stability and recent upturn in catch, 25 years of fishing is still a relatively short time period given the longevity of Orange Roughy. As a result it is too early to tell whether stocks on Chatham Rise can sustain a substantial fishery.

CASE STUDY 2: ST HELEN'S HILL, AUSTRALIA

Located:	Seamount off Eastern Tasmania in the Australian EEZ; located in the Eastern Zone of the SESSF
First significant fishing:	1989
Fishing method:	Bottom trawl
Spawning aggregation:	Yes
Highest annual catch:	A total of 23 200t in the Eastern Zone in 1990 of which 16 947t taken on St Helen's Hill.[10]
Latest annual catch:	A total of 1584t in the Eastern Zone in 2002; the latest catch on St Helen's Hill was 578t in 2001; the Hill is closed from 2002-2004
Effort:	The number of vessels operating in the Eastern Zone peaked at 67 in 1990 but has been around 38 since 1994. The annual number of shots peaked at 2763 in 1991 but since the mid-1990s has been around 600.
Value of Fishery:	The value of the Orange Roughy catch on St Helen's Hill in 2001 is estimated at USD1.1m.
Stock status:	Overfished[11]; the biomass level (7-13%B_0) is well below the target level; short-term biomass trend is steady and the long term-trend is down; both short- and long-term trends in CPUE are down.
Major uncertainties:	Stock structure both within the Eastern Zone and between the Eastern and Southern Zones
Management methods:	TACs and ITQs together with input controls (limited entry, mesh size and area restrictions, closed areas); vessel monitoring system (VMS) required on all vessels. The Eastern Zone TAC in 2003 is 820t with St Helen's Hill closed to trawling.
Management strategy:	To maintain the spawning biomass of each Orange Roughy stock above 30% of the spawning biomass at the onset of significant commercial fishing (1988)[12] and where there is a greater than 50% probability that a stock is below 30% of the 1988 spawning biomass, then the TAC for the stock will be set in future such that the biomass reaches 30%B_0 by 2004.
Main bycatch:	Bycatch from spawning aggregations is very limited however species such as Smooth Oreo Dory and Spiky Oreo Dory, deep-sea sharks, Alfonsino *Beryx splendens* and whiptails are taken in small quantities.
Other impacts:	Benthic habitat; biomass removal, particularly invertebrate fauna; functional dynamics

The fishery

Orange Roughy fishing in Australia began in 1986 with the discovery of a non-spawning aggregation off Sandy Cape on the west coast of Tasmania and a number of smaller non-spawning aggregations to the south of Tasmania over 1987 and 1988. However it was not until 1989 that the first spawning aggregation, on St Helen's Hill to the east of Tasmania, was discovered. The discovery of Orange Roughy came at a time when other stocks, particularly Gemfish *Rexea solandri* were showing signs of over-fishing and catch controls were being introduced. In this environment, fishers were keen to take advantage of the Orange Roughy stocks. This enthusiasm was reflected in increased investment in the fishery that was encouraged by poorly substantiated and overly optimistic assessments of Orange Roughy biomass (Tilzey & Rowling, 2001). For example, estimates of up to 1 million tonnes were made for the biomass in south-eastern Australian waters (Harden Jones, CSIRO, *in litt.* to D. Bryan, July 1987). As evidenced by the following statement by an industry spokesman, industry holds these estimates responsible for the subsequent over-capitalisation of the fleet:

> *I was at a SETMAC [South East Trawl Management Advisory Committee] meeting when the then chief scientist of CSIRO announced that he had found off Patrick Head an aggregation of Orange Roughy of at least a million tonnes and*

10 Reported data adjusted for under-reporting, misreporting and general losses (Wayte & Bax, 2002).
11 Defined as a fish stock for which the amount of fishing is excessive (exceeding the limit reference), or from which the catch depletes the biomass (below the limit reference), or a stock that reflects the effects of previous excessive fishing (Caton, 2002).
12 This is the management strategy for all Orange Roughy stocks in Australia. The reference to 1988 is based on the first significant fishing for Orange Roughy that occurred in Australian waters rather than on St Helen's Hill where it did not begin until 1989.

> *that there were seven hills around Tasmania but the thing was he felt he had not put enough noughts in the equation. That precipitated the Orange Roughy gold rush. (Parliament of Australia, 1997)*

Immediately prior to the discovery of the St Helen's Hill aggregation in 1989, the total annual catch of all species in the then South East Trawl Fishery (SETF) had been around 25 000t and Orange Roughy landings around 7000t. Landings of Orange Roughy in the SETF increased to over 40 000t in 1990 and the total SETF catch in that year exceeded 62 000t (Tilzey & Klaer, 1994). In 1990 the Orange Roughy taken on St Helen's Hill is estimated to have been worth over USD23 million.

The Orange Roughy fishery on St Helen's Hill was initially characterised by very high catch rates ranging from several tonnes to more than 50t per shot for bottom time of typically no more than a few minutes (Koslow *et al.*, 1997). The 1990 management quota of 12 000t was caught within only three weeks. In the words of a fisherman operating at the time:

> *... when they [Orange Roughy] were first caught on St Helen's Hill you could, quite frankly, tow a chaff bag through the water and catch Orange Roughy, the fish were sitting on the bottom waiting to be caught. (Parliament of Australia, 1997)*

The sheer volume of fish, together with the impact of the rough scales of the fish on the nets caused nets to burst in the early days of the fishery. The unreported mortalities incurred in these incidents were significant. Media reports from the early 1990s indicate that the volume of fish also resulted in considerable wastage of Orange Roughy as a result of poor handling and storage practices on board vessels. Large quantities of Orange Roughy were dumped at garbage tips in Tasmania during this period (Moya, 1990). A selection of media clippings from this period is at Appendix II.

Orange Roughy catch (adjusted for misreporting) on St Helen's Hill peaked at 17 000t in 1990. The number of vessels operating in the Eastern Zone also peaked in that year at 67 and the number of shots peaked the following year at nearly 2800. Since then vessel numbers have halved and the annual number of shots is now around a quarter of that in the early 1990s. Between 1999 and 2001 the annual catch on St Helen's Hill was between 400 and 600t. The Hill was closed to fishing in 2002.

During the first five years of the fishery total removals exceeded the TACs significantly. Many fish were lost due to burst bags and the introduction of ITQs in 1992, together with an inadequate surveillance system, meant that false catch reports, in terms of both quantity and area of catch, were common. Fishers were well aware that the surveillance in place was inadequate to ensure that individuals complied with their ITQs. This created an environment where operators felt they would be disadvantaged, relative to their counterparts, if they did not over-fish. Despite the allocation of access rights through ITQs, the race for the fish continued. Some estimates suggest, for example, that the 1993 catch landed in Hobart was twice the recorded catch (Bax, 2000a). While time series of catch for assessment purposes have since been corrected to take account of this, it did mean that the fishery dependent data gathered in the first five years of the fishery 'severely influence[d] assessment of the Orange Roughy stock' (Bax, 2000b) and hence the management decisions on TACs.

Stock status

The Orange Roughy Assessment Group (ORAG) advises the South East Fishery Assessment Group (SEFAG) on the performance of the fishery against the management criteria. SEFAG then makes a recommendation to SETMAC on TAC action. After consideration by SETMAC a recommendation is made to the Board of the Australian Fisheries Management Authority (AFMA), which is ultimately responsible for management of the fishery. This structure facilitates stakeholder, particularly industry, participation in decision making by providing for a broad range of representation on these committees. The key developments in the stock assessment and management responses for St Helen's Hill/Eastern Zone are summarised in Table 6.

Table 6: Key developments in the St Helen's Hill/Eastern Zone stock assessment

YEAR	DEVELOPMENT
1989	• First TAC set at 15 000t based on a biomass figure of 300 000t and a 5% 'safe fish-down rate'
1990 to 1993	• Annual acoustic surveys; egg production survey in 1992; increasing evidence of the extreme longevity of Orange Roughy, in 1992, and to 1500t in 1993. • B_0 estimated at 110 000t and TAC reduced to 7500t. • AFMA adopted management strategy of maintaining stocks at $30\%B_0$ or greater.
1994	• The BRS classified Orange Roughy in the South East Fishery as 'at or near full exploitation' (McGill, 1995). • Stock assessments based on separate stocks in the Eastern and Southern Zones and a single stock across the zones (combined) found that there was a 66% probability that a separate Eastern Zone stock was $<30\%B_0$ and a 92% probability that a combined stock was $<30\%B_0$. • Industry refuted the assessment and AFMA sought an external review. • Review found assessment consistent with international best practice, suggested some changes and that more weighting be given to the combined assessment. • Assessment was re-run with suggested changes. Results indicated a 44% probability that a separate Eastern zone stock was <30% B_0 and 75% probability that combined stock was <30% B_0 (the latter implying that the rebuilding component of the management strategy be invoked). • The TAC was increased to 2000t for 1995.
1997	• Assessment results depended on the level of natural mortality used (0.045 or 0.064). The lower rate indicated that the rebuilding criterion could only be met if the TAC was reduced from 2000t to 500t. The higher rate indicated that it could be met with no change to the TAC. • Industry disputed the validity of the acoustic survey on which the assessment largely relied. • TAC was maintained at 2000t in 1998, 1999 and 2000; no stock assessments conducted; research effort concentrated on re-analysis of acoustic biomass estimates and other biological data, conduct of an acoustic survey of St Helen's Hill and updating the model to a full Bayesian model.
2000	• The results of the assessment were again dependent on the rate of natural mortality used (0.048 or 0.064) - the lower rate indicated the rebuilding criterion could be met if the TAC was reduced to <1000t. The higher rate indicated it could be met with no change in the TAC. • AFMA adopted a policy of stepping down the TAC by 200t per year; TAC reduced to 1800t.
2001	• Probability that biomass < $30\%B_0$ was 68-99%. There was a 51-86% probability that AFMA's criterion could not be met even if catches from 2002 to 2004 were reduced to zero - assessment was very sensitive to the inclusion of age composition data. • Overall, results indicated that it was increasingly unlikely that AFMA's performance criterion could be met without a substantial reduction in the Eastern Zone TAC. • TAC was reduced, in line with step-down strategy, to 1600t and an industry-initiated closure of the St Helen's Hill implemented.
2002	• In all cases and for all future catch levels the probability that biomass in 2004 will be less than 30% of 1988 biomass is 75->99%. • AFMA's rebuilding criterion will not be met even with zero catch; at zero catch levels it is likely to take another 15 years to achieve a 50% probability that biomass is above $30\%B_0$. • Stepping down strategy abandoned. TAC reduced to 820t, 100t of which to be used for research. St Helen's Hill remained closed to trawling. • External review of stock assessment conducted and concurred that stocks are substantially depleted and that the scientific advice for management of roughy fisheries should move to a full management strategy evaluation (MSE). In the interim the fishery should be managed in such a way that there is a measurable increase in biomass.
2003	• AFMA Board sought advice from SETMAC as to why Orange Roughy fisheries that did not meet previously identified management criteria should remain open beyond 2003. • No assessment undertaken; effort directed to determining levels of monitoring that would lead to a detectable increase in biomass. • Decision on TAC for 2004 pending. • Development of MSE, as recommended by reviewers, not funded.

Stock assessments have relied on acoustic surveys (1990, 1991, 1992, 1993, 1996 and 1999), an egg production survey in 1992 and age composition data from the spawning aggregation (1992, 1995 and 1999). The 1994, 1995, 1996 and 1997 assessments used stock reduction analysis to estimate pre-fished biomass, current biomass and to project likely stock trajectories under different TACs. In 2000, a full Bayesian model was applied for the first time.

In 2001, the stock assessment clearly indicated that AFMA's rebuilding strategy had failed and that it was increasingly unlikely that the 2004 rebuilding target would be met. In response the TAC was reduced by just over 10% and St Helen's Hill closed. While this closure was a positive step, it reflected in large part an already apparent trend for an increasing number of operators to move from fishing on St Helen's Hill to St Patrick's Head, a seamount further south in the Eastern Zone.

It was not until 2002 that a significant adjustment to the TAC was made with a reduction from 1600t to the present 820t. The delay in management action has frustrated scientists, as illustrated by the following:

> *In general assessment scientists are frustrated by the failure of managers to apply the precautionary principle, despite the fact that biomass estimates for major species such as Gemfish and Orange Roughy have fallen well below the biological reference points adopted by management as minimum desirable stock sizes… Good science does not translate into good management without the political will to act on scientific findings. (Tilzey & Rowling, 2001)*

Management

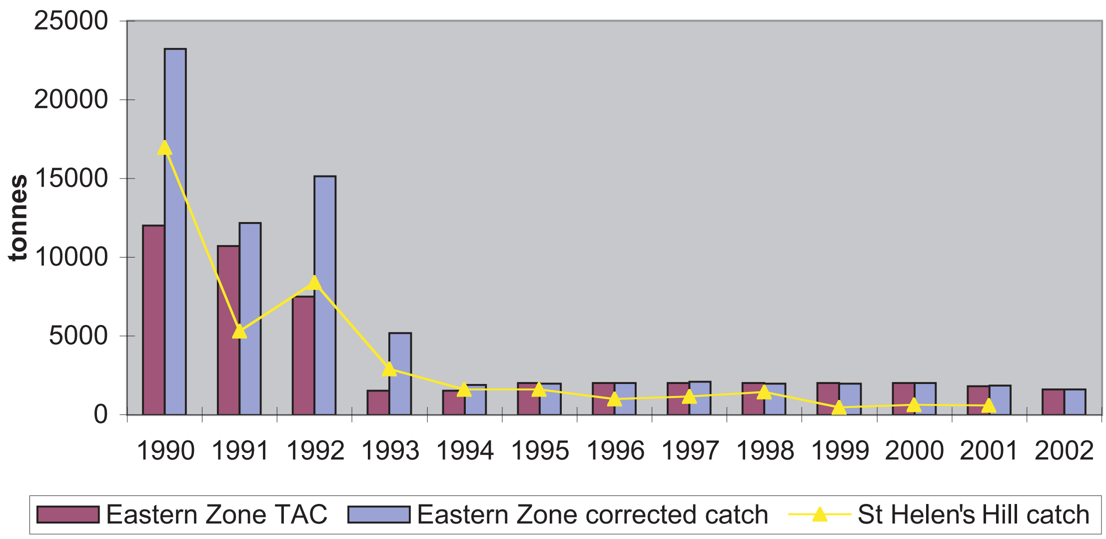
AFMA manages the St Helen's Hill Orange Roughy fishery as part of the Eastern Zone of the SESSF. Up until 1992, management of the trawl fishery relied largely on input controls (limited entry, transferable units of vessel capacity, gear restrictions, area restrictions) together with competitive TACs for Orange Roughy and Gemfish. Orange Roughy management zones and competitive TACs had been introduced in 1989 following discoveries of substantial Orange Roughy grounds on the West coast of Tasmania and in May 1989 at St Helen's Hill. The St Helen's Hill ground was closed on 9 August 1989, after just over three months fishing in an attempt to provide some protection to the spawning aggregation (Anon, 1989).

When the St Helen's Hill aggregation was discovered there were virtually no data on which a biomass estimate could be based and estimates of the size of the resource varied from 50 000t to more than 1 million tonne (Koslow *et al.*, 1997). Kenchington (1987) noted, in the late 1980s, that:

> *In the case of Australian Orange Roughy, the biomass of single aggregations has been estimated only to within three orders of magnitude. The size of the entire national resource is a matter for pure guesswork.*

In the absence of credible estimates, what were considered at the time to be conservative, TACs were set from 1989 onwards while research was undertaken. In November 1989 the first TAC for the Eastern Tasmanian Zone as a whole was set at 15 000t based on a biomass estimate of 300 000t and a 'safe fishing-down rate' of 5%. This TAC applied to the 1989/90 season and by the time it was set an estimated 14 000t had already been taken of the season's TAC (DPIE, 1989). Trends in TAC and catches in the Eastern Zone Orange Roughy fishery are shown in Figure 7.

Figure 7: Orange Roughy catch and TACs in the Eastern Zone and St Helen's Hill



Source: Wayte and Bax, 2002

An ITQ management regime was introduced for the 16 main trawl species, including Orange Roughy, in 1992. AFMA's legislative objectives under the *Fisheries Management Act 1991* require it, among other things, to exercise the precautionary principle in pursuit of ecologically sustainable development (ESD). The main strategy, adopted by AFMA in 1993, used in pursuit of ESD in the Orange Roughy fishery is:

- to maintain the spawning biomass of each Orange Roughy stock above 30% of the spawning biomass at the onset of significant commercial fishing (1988)

  - noting that for eastern/southern stock(s) if there is to be less than a 10% chance of the stock being below 30%B_0, then the current spawning biomass should be kept at around 38%B_0; and

- where there is a greater than 50% probability that a stock is below 30% of the 1988 spawning biomass, then the TAC for the stock will be set in future such that the biomass reaches 30%B_0 by 2004.

ORAG[13] has also provided management advice in relation to the following strategy:

- where there is a greater than 50% probability that the stock is below 20% of the 1988 spawning biomass, then the TAC will be zero until there is a greater than 50% probability that the spawning biomass exceeds 20%B_0 (the limit level).

AFMA has not formally adopted this strategy.

Management of the St Helen's Hill fishery commenced in 1989 the same year that significant commercial catch first occurred. Within 3 years it was clear that the early TACs were not sustainable (Box 6). The fishery has been managed by a combination of limited entry, management zones, catch limits, and subsequent and significant reductions to those limits based on regular stock assessments reflecting a substantial amount of research. Despite this, the fishery on St Helen's Hill has now been closed, the TAC for the whole of the Eastern Zone reduced to 820t and AFMA's management strategy will not be achieved. There are a number of possible explanations as to why this happened:

- Despite the early implementation of TACs, total removals significantly exceeded the TAC in the years 1990 to 1993. Improvements in gear technology, surveillance and monitoring have largely addressed this problem since the mid-1990s, however, this did affect the accuracy of the early stock assessments and management decision making.
- The early assessments were flawed and uncertainties remain in the current assessments. Some significant biological characteristics of Orange Roughy, for example longevity, were not well understood when the first estimates of biomass and 'safe yields' were made. Uncertainty remains in relation to natural mortality and stock structure. There may have been fundamental uncertainties in the earlier stock assessment models, which did not represent the potential for Orange Roughy stocks to experience extended periods of poor recruitment (Koslow & Tuck, 2001).
- The management strategy was not precautionary enough. A 50% probability of the stock climbing above 30%B_0 may not have been sufficiently precautionary given the life history characteristics of the species, and uncertainties surrounding stock assessments.
- The management strategy has not been adhered to. Stock assessments have indicated, from at least 2000 and arguably 1997, that the performance criterion was unlikely to be reached without, at a minimum, substantial reductions in the TAC. Yet the TAC remained steady at 2000t between 1995 and 2000, was reduced by only 10% in 2001 and 12.5% in 2002. In 2003, when all indications were that a zero TAC was warranted, catch was reduced by nearly 50%. Deviations from the management strategy are apparent, for example the adoption of the 'step-down' (i.e. gradual reduction) approach in 2000.
- Some aspects of the management strategy have not been adopted into management practice. For example, the 20%B_0 limit reference point for Orange Roughy has not been formally implemented although it has been recommended by ORAG and used in stock assessment reports since at least 1995. The BRS notes in its assessment of the South East Fishery that even where decision rules are in place for setting TACs they have not been followed because of a failure to formally adopt these rules (Caton, 2002).
- Concern with the socio-economic implications of TAC reductions may have overridden the will to take tough TAC actions. The close participation of industry, through the AFMA co-management model, in the development of stock assessment and TAC setting advice may have allowed industry to defer, or to soften, management decisions that were clearly required in response to stock assessment advice. For example, industry's reluctance to accept the 1997 stock assessment advice

13 ORAG will be replaced by the Deepwater Assessment Group in 2003/04 as part of revised arrangements flowing from the formation of the South Eastern Scalefish and Shark Fishery.

effectively deferred changes to the TAC for 3 years. The next stock assessment did not show markedly different results and it can be argued that the subsequent TAC reductions should have been imposed three years earlier.

AFMA is currently faced with the choice between closing the Eastern Zone of the Orange Roughy fishery or keeping it open at a low-level TAC. The closure of the fishery would create an effort displacement problem for the broader SESSF and also affect fishing for other species in the area. Modelling suggests that the differential impact on stock recovery (i.e. to 20%B_0 with a 50% probability) of closure of the fishery compared with an annual 800t catch is about 10 years. Management must balance the disruption to industry and the speed of recovery and must take into account the experience with this species when deciding whether the 20%B_0 rebuilding target and the 50% level of confidence are sufficiently conservative.

A recent review of the Orange Roughy stock assessment (Francis & Hilborn, 2002) recommended that in the long term, scientific advice for management of the roughy fishery(ies) should move towards a full management strategy evaluation. However, funding for the development of such a strategy has not been provided and there is little likelihood that the recommendation will be adopted.

The rise and fall of St Helen's Hill through the eyes of the media

6 May 1989	Plenty of 'gold' on the sea bed
29 June 1989	Roughy Gamble pays off: East coast fisherman discovers a hot spot
30 June 1989	Orange roughy over-fishing alleged by East Coast man
31 July 1989	Bid to control boom fishery
5 August 1989	Roughy trawling ban to cost 90 jobs: claim
23 August 1989	Orange roughy fishing ban extended for two weeks
7 September 1989	Fishermen hit limit on roughy catch
8 September 1989	Catch limit on roughy to protect the future
9 September 1989	Warning of violence over-fishing limits
11 September 1989	Fishing halt called
12 September 1989	Fisheries Minister under fire
30 March 1990	Crackdown to stop roughy dumping
22 May 1990	Slow start to new season for roughy
21 June 1990	Closure of the Hill
24 June 1990	Boffins move in to study roughy 'hot spot': the Hill where orange is gold
13 July 1990	Orange roughy ground closed
21 September 1990	Error allows East Coast fish haul to exceed quota
15 October 1990	More Orange Roughy bans on horizon
13 December 1990	Cut roughy catches, or destroy fishery - CSIRO
14 December 1990	Roughy fishery over-estimated
16 December 1990	Roughy's rough times: fishermen fear the worst as new limit looms
15 October 1991	More bans likely on roughy
16 October 1991	Action on roughy 'too late'
1 January 1992	Angry fishermen consign corpse of their industry to the deep

Source: Headlines from The Mercury, Hobart and The Examiner, Launceston, Tasmania

CASE STUDY 3: NORTH-EAST ATLANTIC FISHERIES

Located:	In the EEZs of France, England, Scotland, Ireland, Iceland and Faroe Islands and in international waters in the north-east Atlantic[14 15]
First significant fishing:	1991
Fishing method:	Demersal trawling
Spawning aggregation:	Main fishery (ICES Subareas VI and VII) is on spawning aggregations.
Highest annual catch:	5802t in 2002 (provisional estimate)
Latest annual catch:	5802t in 2002 (provisional estimate)
Effort:	The number of French vessels targeting Orange Roughy in Subareas VI and VII had fallen to zero by 2002. However the Irish fleet developed over the 2000 to 2002 period.
Value of Fishery:	USD20.5m[16] (2002)
Stock status:	The latest assessment in 2000 indicates that Orange Roughy in Subarea VI is outside safe biological limits. The situation in Subarea VII is highly uncertain. It appears that catch rates have been maintained by sequential depletion of previously unexploited aggregations. The status of Orange Roughy in other ICES areas is unknown.
Major uncertainties:	Stock structure; recruitment; level of exploitation
Management methods:	The EU introduced TACs and national quotas for Orange Roughy in 2003 applying to the catch of member countries within EU waters and on the high seas. The TAC in Subarea VI is 88t and in Subarea VII 1349t. Vessels flying the flags of EU member countries must hold a specific deep-sea fishing permit before fishing in EU and international waters for deep-sea species; EU members must restrict the aggregate power and capacity of their deep-sea fleet; VMS must be carried; observers must be carried on request; deep-sea species can only be landed at designated ports; data provision on catch and effort is mandatory. NEAFC implemented a temporary measure to limit effort on deep-sea species in 2003, based on the highest level of effort from previous years. Further measures will be considered at the November 2003 meeting.
Management strategy:	None
Main bycatch:	Small quantities of Bluemouth, Mora, Greater Forkbeard, Argentine, Roundnose Grenadier, Black Scabbardfish, Blue Ling and Portuguese Dogfish/siki sharks, Chimaerids (*Chimaera monstrosa* being the most important) and deep-sea sharks are taken as bycatch in Orange Roughy fisheries. Cardinal fish are discarded in large numbers.
Other impacts:	Benthic impacts, particularly damage to cold-water corals; biomass removal; functional dynamics

The fisheries

A Russian fishery for species including Orange Roughy operated around the southern seamounts of the Mid-Atlantic Ridge as early as the 1970s (Gubbay, 2003). None of the trawl surveys to the west of the British Isles in the 1970s or 1980s gave any indication of aggregations of Orange Roughy. Occasional large hauls of up to 20t were recorded in the 1970s by German trawlers fishing for Blue Ling on some of the northern banks of the Rockall Trough (ICES Subarea VI), but a fishery never developed (Basson *et al.*, 2002). The main fishing for Orange Roughy in the north-east Atlantic began in 1991. The fishery for Orange Roughy, and other deep-sea species, in the north-east Atlantic developed as a response to declining catch rates and available quotas for shelf species (Commission of the European Communities, 2001). Since the early 1990s over 37 000t of Orange Roughy has been taken in the area, over 80% of this in ICES Subareas VI and VII[17].

The Orange Roughy grounds discovered in the North Atlantic have been areas where Orange Roughy aggregate in relatively small units, usually associated with seamounts or other hydrographical or

14 The north-east Atlantic is defined as the area of NEAFC.

15 France, England (UK), Scotland (UK) and Ireland are members of the EU. These countries and Iceland are members of NEAFC. Denmark is also a member of NEAFC on behalf of the Faroe Islands.

16 Valued at average price on market at Lorient, France May to November 2002.

17 A map of ICES fishing areas can be found at http://www.ices.dk

topographical features. It is unknown whether or not these populations represent independent stock units (ICES, 2002c). The fishery in Area VI is based largely around seamounts such as Rosemary Bank and the Hebridean Terrace seamount. In Subarea VII the fishery operates on steeply sloping ground that includes some seamounts (J. Gordon pers. comm. to L. Heaps, October 2003). The main fishery is on spawning aggregations (ICES, 2002b).

French trawlers recorded the first major catches, over 5000t/year in 1991 and 1992, from ICES Subareas VI and VII. Catches dropped significantly to just under 3000t in 1993 and by 1999 had reached a low of around 1800t. The French fishery in Subarea VI appears to have collapsed. After a peak of 3500t in 1991, annual catches declined sharply and between 1994 and 2002 have ranged between 100 and 300t. The CPUE for Orange Roughy declined quite quickly after the fishery commenced in 1991, and by 1994 it was 25% of initial catch rates (ICES, 2003c). In Subarea VII, after an initial decline from its peak of 3100t in 1992, the French fishery yielded between 800t and 1100t annually between 1996 and 2001. However, it is thought that these catches may reflect sequential fishing down of newly discovered aggregations rather than the capacity of the stock to sustain this yield (ICES, 2002c). Between 1996 and 2001 only one French vessel targeted Orange Roughy in Subarea VII. In 2002 this vessel reallocated its effort towards other deep-sea species. In 2002 there were no French vessels targeting Orange Roughy in Subareas VI or VII (ICES, 2003b).

During the 1990 to 1999 period, French vessels took 75% of the total Orange Roughy catch in the north-east Atlantic. Irish trawlers began catching Orange Roughy on the Porcupine Bank in Subarea VII in 2000. Provisional figures indicate that by 2002 the Irish catch reached 5284t, representing 90% of the total north-east Atlantic Orange Roughy catch of 5800t in that year (ICES, 2003b).

Three other small Orange Roughy fisheries operate in the north-east Atlantic:

- a Faroese fishery mainly in Division Vb and international waters (Hatton Bank and mid-Atlantic ridge);
- a small Icelandic coastal fishery in Division Va; and
- a fishery outside the Azorean EEZ in ICES Subarea X (ICES, 2002b).

Stock status

ICES provides scientific and management advice to the EU and NEAFC on stocks in the north-east Atlantic Ocean. ICES conducted stock assessments for deepwater species in 1998 and 2000. However, the assessments are imprecise.

- In the absence of age data they rely largely on time-series of CPUE. ICES acknowledges the problems associated with the use of CPUE data for an aggregating species targeted by only a small part of the fleet. Little or no fisheries-independent data exists on which to determine abundance, length and age composition or recruitment indices (NEAFC, 2002a). ICES (2002c) has identified the need to improve data used for assessment purposes. Two suggestions for improved data quality were made:
  - abundance indices derived from egg, acoustic and trawling surveys would provide a fishery-independent reflection of stock dynamics (few such surveys exist at present); and
  - commercial CPUE should be made available on a much finer spatial scale and, ideally, on a haul-by-haul basis (such data are currently being collected but cannot be used for confidentiality reasons).
- There is concern that the catch data available may not accurately reflect catches taken in international waters.
- The lack of effort data, in particular, has prevented new assessments being carried out. The available data has in fact deteriorated over the period when deep-sea fisheries have expanded most rapidly (ICES, 2002c).
- The assessments are based on stocks that are defined by an area and a species. These stocks may have little relevance to the biological stocks and, as recognised by ICES, the ICES Subareas are often inappropriate for deep-sea stock delineation.

ICES establishes limit (lim) and precautionary limit (pa) reference points. For stocks such as Orange Roughy where no absolute biomass estimates are available, ICES uses indices of abundance, for example CPUE. These indices are denoted by U (the index of exploitable biomass). ICES has adopted the reference points of U_{pa} ($50\%B_0$) and U_{lim} ($20\%B_0$) as the reference points for all deep-sea species (ICES, 2000). A summary of stock advice provided by ICES is provided in Table 7.

WGDEEP considers Orange Roughy to be the most vulnerable deep-sea fish in the ICES Area (ICES, 2003a). The last analytical assessment for Orange Roughy was carried out in 2000, using data up to 1998. The 2002 advice, based on only CPUE data up to 2001, concluded that Orange Roughy in Subarea VI is outside safe biological limits. ICES noted that catch had been very low since 1993, that the stock is depleted and has not shown any signs of recovery

Table 7: Summary of ICES assessments of north-east Atlantic Orange Roughy stocks

YEAR	FINDINGS
Prior to 1998	• No assessment conducted. General advice on the need for a precautionary approach to management of deep-sea species: 'a cautious approach should be adopted' and that 'fishing effort should be kept at a low level until sufficient information is gathered from existing fisheries to enable scientifically-based management decisions'.
1998	• Subarea VI: stocks below U_{lim} and Subarea VII: stocks below U_{pa}
2000	• Subarea VI: Stock fished down very quickly. Biomass below U_{pa} and may be close to U_{lim} • Subarea VII: assessment results unreliable and situation unclear • Assessment results should be treated with caution since they are based on short time-series and little is known about the general distribution of Orange Roughy in these areas. • In Subarea VII CPUE trends may only reflect fish density on successive exploited aggregations.
2002	• Subarea VI: No assessment; commercial CPUE series no longer reflects abundance of Orange Roughy due to changed targeting practices; stock heavily depleted • Subarea VII: assessments were unreliable and situation remains unclear. • No valid assessments possible. In Subarea VII CPUE is stable but reflects sequential discovery of new aggregations; recent high landings unlikely to be sustainable. • '…the exploitation of Orange Roughy should be strictly limited and the stocks/populations closely monitored. Data obtained should be incorporated into appropriate management measures. These considerations should also apply to areas where there is currently no exploitation of Orange Roughy. There should be no directed fishery in Subarea VI.'
2003	• No updated evaluations were made since CPUE series for the major deep-sea fisheries (including Orange Roughy) were not updated/provided. • No information was received to suggest that the status of stocks had changed markedly from 2002. However the ICES Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (WGDEEP) noted '…the continued increase in the catch level of Orange Roughy in Sub-area VII from target fisheries. This species is recognised as depleted in Subarea VI and WGDEEP highlighted the danger of sequential depletion of the aggregations in Subarea VII. The Advisory Committee on Fisheries Management (ACFM) advised in 2002 that '…the exploitation of Orange Roughy should be strictly limited and the stocks/populations closely monitored'. Despite this advice the Subarea VII landings increased from 3411t in 2001 to over 5000t in 2002.

Sources: Gordon 2001; ICES, 2000; ICES, 2002b; ICES, 2003b

and that even the low levels of catch in the area are likely to adversely affect the recovery of the stock (ICES, 2002b). The poor state of the Orange Roughy stocks in Subarea VI resulted in fishers targeting other species such as grenadier, Black Scabbard and Portuguese Dogfish (ICES, 2002c).

The stock status in Subarea VII is highly uncertain. While landings have increased and catch rates have stabilised in recent years, this may reflect the sequential discovery and subsequent fishing of previously unexploited aggregations. The status of Orange Roughy stocks in other areas of the north-east Atlantic is unknown (ICES, 2002b).

With the last analytical stock assessment available for Orange Roughy based on data up to 1998 and the latest ICES advice, based purely on updated CPUE data up to 2001, the current status of Orange Roughy is unknown. However ICES' advice on deep-sea species generally leaves no doubt as to the seriousness of the situation:

> *Most exploited deepwater species are at present considered to be harvested outside safe biological limits. ICES recommends immediate reduction in these fisheries unless they can be shown to be sustainable. New fisheries should be permitted only when they expand very slowly, and are accompanied by programs to collect data, which allow evaluation of stock status. (ICES, 2002b)*

Management

Responsibility for management of fisheries in the north-east Atlantic lies with the EU and NEAFC, and with coastal States that are not EU members.

The introduction of management arrangements for deep-sea species in the north-east Atlantic has been slow. New fisheries for deep-sea species, Orange

Roughy being a prime example, have been allowed to develop without appropriate data collection, monitoring or management controls in place.

ICES scientists first warned about the need for precaution in management of deep-sea stocks in 1994. The first stock assessments in 1998 prompted scientists to issue strong advice on precaution in 1999. ICES' ACFM did not act upon this advice until 2000 when it advised the EU to take action. The advice included recommendations for selected species. For Blue Ling they recommended '…that there be no directed fisheries for this stock and measures be implemented to reduce/minimise catches of this stock in mixed fisheries'. The directed fisheries for Blue Ling are on spawning aggregations. For Roundnose Grenadier, ICES recognised that the stocks were reaching a critical state and recommended an immediate reduction in fishing effort by 50% for large parts of the north-east Atlantic. A similar recommendation was made for Black Scabbardfish. For the other deep-water fish species they recommended that fisheries be permitted only when they expand very slowly, and are accompanied by programmes to collect data that allow evaluation of stock status.

The EU had noted in 1994, in reference to deep-sea fish resources, that 'a precautionary approach should be taken in the development of new fisheries or the enhancement of many of the existing fisheries' (Anon. in Gordon, 2001b). In January 2003 the EU implemented fixed catch limits for deep-sea fish stocks including Orange Roughy. The Orange Roughy TACs for 2003 and 2004 are 88t in Subarea VI and 1349t in Subarea VII. The TACs relate to catch in both EU and international waters (Commission of the European Communities, 2002a).

The following EU regulations (Commission of the European Communities, 2002b) also apply to deep-sea fisheries from January 2003:

- Vessels targeting deep-water fish must hold a specific licence granted by EU Member States. The capacity of those vessels must not be greater than that of the vessels which in any one of the years 1998, 1999 or 2000 landed more than 10t of deep sea fish. It is illegal for vessels that do not carry the special fishing permit for deep-sea species to retain on board, land or transship more than a certain amount of those fish.
- Independent scientific observers are placed on board vessels carrying licences to harvest deep-sea fish according to a sampling plan submitted by Member States to the Commission.
- Fishing activities will be monitored closely through VMS and additional information will be recorded in the vessels' logbooks including details of fishing gear used and the time spent in the water.
- Catches of deep-sea species can only be landed in designated ports.

The EU intends to review and adapt, as required, its management scheme for deep-sea fish stocks on the basis of a report to be submitted by the Commission by June 2004.

ICES has cautioned against the use of TACs and quotas for the protection of deep-sea stocks and recommends a combination of effort reduction, gear restrictions and closed areas. While this advice has not been adopted by the EU, NEAFC appears to be inclined towards effort controls for deep-sea species. In response to the ICES advice and strong recommendations in 2002, from its own Deep-Sea Working Group on the Appraisal of Regulatory Measures for Deep-Sea Species, on the urgency and form of measures to protect deep-sea species, NEAFC has agreed on a temporary management measure. NEAFC Parties have agreed to freeze fishing effort (aggregate power, aggregate tonnage, fishing days at sea or number of vessels) at levels no higher than that of recent years. It is not clear how the Parties to NEAFC have chosen to implement this agreement. An extraordinary meeting of NEAFC was convened in May 2003 with the intention of developing a 'comprehensive interim deep-sea management scheme' based on effort controls. However this meeting failed to reach agreement on fundamental issues such as the definition of deep-sea species, which species should be subject to the management scheme and how to measure effort. A draft recommendation for conservation and management measures for deep-sea species in the NEAFC Regulatory Area in 2004 will be reconsidered at the annual NEAFC meeting in November 2003 (NEAFC, 2003).

Large areas of the ICES area lie outside EEZs. These include parts of fishing areas around the Rockall Bank, Hatton Bank and south-west part of Lousy Bank, the Mid-Atlantic Ridge north of the Azores EEZ, part of the Reykjanes Ridge south of the Icelandic Sea as well as the substantial fishing area off Rockall that was formerly within the EEZ of the United Kingdom (ICES, 2000). Data on the proportion of Orange Roughy catch taken inside and outside EEZs is not available. From the information available to it, ICES considers that the main catches of Orange Roughy in international waters are taken in Subareas X and XII. Reported catches in these Subareas have accounted for around 12% of total Orange Roughy catch since 1989. However ICES is concerned that landing statistics provided to it may not reflect the true scale of fishing activity in international waters.

In addition to the lack of management, data collection and research on north-east Atlantic deep-sea species, such as Orange Roughy, national and EU-sponsored initiatives have actively encouraged the expansion of deep-sea fleets. The recent 'renewal' of the Irish fleet is a good example. The expansion of Irish fishing activity into deep-sea fisheries in recent years has been encouraged by the subsidisation of new vessel construction under the Irish Sea Fisheries Board's Whitefish (demersal) Fleet Renewal Program and the Fishing Fleet Development Measure of the Irish National Development Plan (Irish Sea Fisheries Board, 2003). These national measures have been supported by EU grants[18].

From March 2000, with funding from the Irish Government and the EU, about USD2.4 million were allocated for sea trials aimed at developing Ireland's deep-sea fishery over a two year period (Marine Work Group and Friends of the Irish Environment, 2002). It is difficult to reconcile this initiative with the 1993 position taken by the EU that a precautionary approach should be taken with the development or expansion of deep-sea fisheries.

Five of the seven trawlers involved in the first year of the trial were brought into the Irish fleet under the Whitefish Fleet Renewal Program. By 2006 the Renewal Program and the Fishing Fleet Development Measure will have provided USD187 million towards renewal and modernisation of the Irish demersal fleet. Not all of these funds have been directed at deep-sea vessels, however several deep-sea vessels up to 46m in length will be introduced under the Fleet Development Measures Program (Marine Work Group & Friends of the Irish Environment, 2002).

Faced with the recent introduction of TACs by the EU and the possibility of effort controls by NEAFC, it is possible that the transfer of Irish fishing effort from inshore to deep-sea species may provide only a short-lived economic reprieve. In the early 1990s ports such as Lorient, in southern Brittany, were feeling the impact of decreased landings of inshore stocks. This was compensated for by the transfer of effort into deeper water and the resultant substantial catches of species such as Orange Roughy. However, the downturn in catches of these deep-sea species in recent years together with concerns for stock status, the introduction of TACs and proposed effort constraints may mean that Lorient has simply deferred, rather than avoided, the major economic and social dislocation that so commonly accompanies stock depletion. The director of the Port of Lorient has been quoted as saying:

> *We did wonder whether these fisheries were viable, whether we might not be going too far. But without answers to our questions we carried on. This was our lifeline. If these deep-sea fisheries collapsed, the port would go down with it. (Anon, 2002)*

NEAFC's ad hoc working group on deep-sea fisheries has identified a number of Orange Roughy aggregations as particularly vulnerable to fishing and made the following recommendations to protect them:

- The Hebridean Terrace seamount is an area where aggregations of Orange Roughy were exploited during the early 1990s. This large seamount is presumed to have been inhabited by the main component of the spawning stock in Subarea VI. It is suggested that a complementary measure be considered in order to protect remaining spawners on the Hebridean Terrace seamount.
- In Subarea VII, as a precautionary measure, an area should be closed to the west of Porcupine Bank. A closed area covering two or three statistical rectangles would ensure that a component of the stock in this area is protected from depletion and would preserve a potential for recovery of aggregations that are now under heavy fishing pressure.
- In other areas the precise fishing locations are unknown and this precludes the formulation of advice on closed areas (NEAFC in ICES, 2003b).

None of these measures have yet been implemented.

In a move that appears inconsistent with a desire to protect sensitive areas, the EU is considering a proposal to allow bottom trawling within a part of the Azores EEZ. Currently, trawling is prohibited within the EEZ as it is considered too damaging to fish stocks and benthic habitats. The proposal would allow bottom trawling beyond 100nm and so leave the way open for the European deep-sea fleet to commence operations in the waters around the Azores (WWF & Seas at Risk, 2003). However a proposal has also been developed, for consideration by the EU, to implement a bottom trawling ban in the waters now classified as high seas around the Azores along with the Darwin Mounds, some Irish reefs and the Madeira and Canary Islands EEZ. The proposal is yet to be considered but is likely to face stiff opposition from some EU members and some sectors of industry.

18 As part of its Review of the Common Fisheries Policy the EU decided in December 2002 that it would phase out grant aid for fleet renewal after 2004.

Processing line for Orange Roughy

CASE STUDY 4: MADAGASCAR RIDGE

Located:	On the high seas directly south of the Island of Madagascar in the south-west Indian Ocean (Figure 8)
First significant fishing:	1999
Fishing method:	Trawling
Spawning aggregation:	Yes
Highest annual catch:	Unknown. Estimates range from 12 218t in 2000 to 50 000t between 1999 and early 2001.
Latest annual catch:	Unknown. Best FAO estimate for 2001 is 1569t (FAO, 2002). Anecdotal reports suggest that Orange Roughy catch has continued to decline since that time.
Effort:	Vessel numbers increased from 7 to more than 40 in 2000 but have dropped markedly since then. Anecdotal reports suggest that between 10 and 12 boats operated in the winter of 2003.
Value of Fishery:	Unknown
Stock status:	Unknown; but concern already expressed that catches may have exceeded sustainable levels (FAO, 2002)
Major uncertainties:	Very little biological data collected in the area; stock structure is unknown; no estimate of biomass
Management methods:	None. Attempts have been underway since November 1999 to develop a South-West Indian Ocean Fisheries Commission. Management controls over flag State vessels operating in the area vary between States.
Management strategy:	None
Main bycatch:	Cardinal fish (*Epigonus* spp.), Black Oreo, Spiky Oreo, Smooth Oreo, Boarfish and alfonsino; small quantities of black coral (*Antipatheria* spp.)
Other impacts:	Benthic impacts; biomass removal; functional dynamics

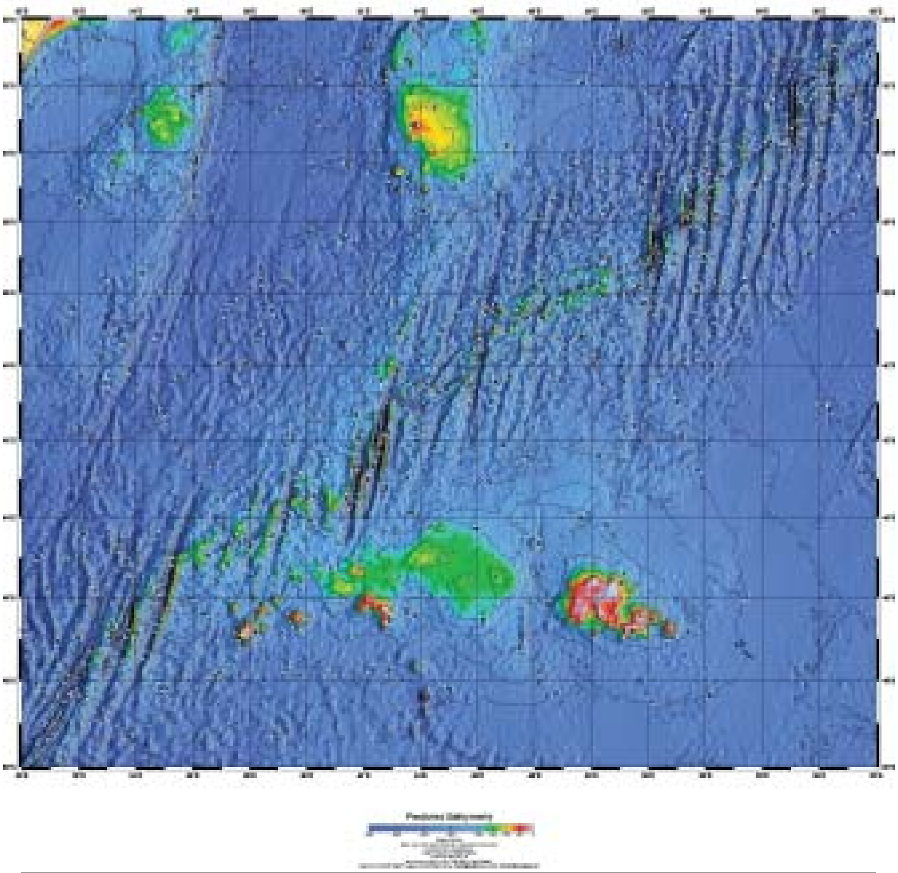
The fishery

The spawning aggregation on the Madagascar Ridge was first discovered by Australian vessels in 1999. The fishery expanded quickly in 1999 and 2000. Accurate data on catch is not available and estimates vary widely. Some provisional estimates (FAO, 2002) suggest 12 218t in 2000 as the highest annual catch and a total of 17 500t over 1999 and 2000. It is acknowledged, however, that these estimates may, on the one hand, include some double counting and on the other, are incomplete. Other estimates range from about 10 000t being taken in each of 1999 and 2000 (Tracey & Clark in FAO, 2001), to a peak catch of 20 000t in 2001 (Gianni in Yune, 2003). One estimate suggests that the fishery yielded around 50 000t between 1999 and early 2001 (Barratt & Tilzey, 2001). However it is generally accepted that the latter estimate is too high.

On the basis of the information provided to the Second Ad Hoc Meeting on Management of Deepwater Fisheries Resources of the Southern Indian Ocean (FAO, 2002) Japan, Namibia and New Zealand reported taking about 9900t over 2000 and 2001. South African port records for this period indicate that vessels flying flags of countries other than Japan, New Zealand and Namibia reported carrying a further 1000t (product weight). Assuming this product is headed and gutted this equates to around 2000t greenweight[19]. A minimum estimate of catch over 2000 and 2001 is therefore around 12 000t. This excludes known, but unquantified catches, from Australia and South Africa and catches from vessels not entering South African ports.

19 A conversion factor of 2 (used by New Zealand and Australia) has been applied

Figure 8: Bathymetric map of Madagascar Ridge



Source: Seabed Mapping-Austral Fisheries Pty Ltd

The Indian Ocean Orange Roughy catch in 1999 and 2002 was at least sufficient to have an impact on the international market. In its *Report to Shareholders* in 2000, Sanford Limited remarked:

> *Lower quantities of Orange Roughy fillets were sold to the United States when the price dropped by 10% due to increased catches in the Indian Ocean. Catches are expected to increase from this area over the next few months and prices will continue to be under pressure. (Sanford, 2000)*

However after substantial catches in 1999 and 2000, catches declined markedly. It is unclear whether this drop was a result of disturbance to the spawning aggregation process by the large number of vessels operating in the area in 2001 (up to 40 factory trawlers are reported to have operated there in 2001 with queues of up to 20 vessels), an indication of the impact of fishing on the biomass in the two previous years, or a combination of the two factors. Recent reports from an Australian company fishing in the area indicate that Orange Roughy catches in the 2003 season were very low and that their operations are now focused on other species (M. Exel pers. comm. to M. Lack September, 2003). The number of vessels operating in the fishery has decreased substantially in recent years and it is reported that between 10 and 12 vessels operated in the 2003 winter fishery (B. Rose pers. comm. to M. Burgener September, 2003). The number of port calls in South Africa from vessels carrying Orange Roughy may provide some insight into trends in the numbers of vessels participating in the fishery. The number of such port calls declined from 49 in 2000 to 32 in 2001, and up to May 2002 only five had been recorded (FAO, 2002).

Participants at the Second Ad Hoc Meeting on Management of Deepwater Fisheries Resources of the Southern Indian Ocean (May 2002) provided an outline of their fishing activity in the South-West Indian Ocean (Table 8). This includes, but is not restricted to, operations on the Madagascar Ridge. From the information provided it appears that vessels from at least nine flag States may have fished for Orange Roughy either on or near the Madagascar Ridge since 1999. A further three States, China, Norway and Spain, are recorded in the FAO's Capture Production database as having taken Orange Roughy in the western Indian Ocean over that period.

Table 8: Fishing activity in the South-West Indian Ocean

FLAG STATE	OPERATIONS
Australia	Australian vessels operated each year from 1999-2003. Vessels are relying increasingly on alfonsino rather than Orange Roughy. Observer reports indicate bycatch of Cardinal fish, oreos, Boarfish and alfonsino (AFMA, 2000).
European Union	No information on deepwater fishing in the area had been reported to the Commission although it is believed that EU trawlers have operated in the area.
France	Deepwater fishing in the area restricted to within their EEZ around Crozet, Kerguelen and St Paul islands. No indication that any Orange Roughy taken in these areas.
Japan	Two vessels operated in 2001 targeting alfonsino and Orange Roughy on seamounts. Two vessels operated until end April in 2002 but ceased operations due to poor demand for alfonsino. Total catch in 2001 was 4144t of which 2904t were alfonsinos; 411t of Orange Roughy; 150t of Smooth Oreo Dory; 93t of Cardinal Fish; small quantities of Boarfish and Black Dory; and over 500t other species.
Namibia	One vessel operated in 2000 (as a joint venture with a French company) taking 761t of Orange Roughy. Two vessels operated in 2001 taking 191t.
New Zealand	Mid-1990s 2 vessels took substantial quantities of alfonsino. Started targeting Orange Roughy in 1999. In 2000, 8 vessels targeted Orange Roughy. By 2001 only 2 vessels remained in operation (some smaller vessels no longer operate under the New Zealand flag). In 2000 catches of Orange Roughy were about 8500t. Total catch of all species in 2001 was 1400t.
South Africa	Maximum of 4 vessels in 2000.
Ukraine	Fished in the area between 1980 to 2001. Maximum of 13 vessels in 1981; highest catch of 6000t (of mixed species) in 1981; No record of Orange Roughy catches.
Other countries	Other flag States reported to have fished for deep-sea species in the southern Indian Ocean include Cook Islands, Taiwan, Korea, Belize, Argentina and Chile (FAO, 2002). South African data (for 2000 and 2001) indicate that vessels flying the flags of Mauritius, Norway, Panama and St Vincent and Grenadines declared Orange Roughy on board when they entered South African ports.

Source: FAO, 2002; AFMA, 2000

Stock status

Stock status is unknown. There is no formal or informal stock assessment process in place. Limited scientific data has been collected from the Madagascar Ridge fishery. Some length/weight and gonad data have been collected and some otolith samples aged. Australia's BRS has undertaken some spatial modelling of the proposed south-west Indian Ocean convention area in an attempt to predict the distribution of Orange Roughy stocks (FAO, 2001).

A New Zealand analysis of a small sample (18) of Orange Roughy otoliths collected from the Indian Ocean indicated that the mean age at onset of maturity for Indian Ocean Orange Roughy was 32.4 years. This is higher than that found for the New Zealand and Australian fish. The analysis concluded that 'Orange Roughy from the Indian Ocean have lower productivity, and emphasise that cautious exploitation and strong management is needed to ensure a sustainable fishery.' (FAO, 2001)

Management

Two Ad Hoc Meetings, arranged by FAO, on Management of Deepwater Fisheries Resources of the Southern Indian Ocean have been held, in June 2001 and May 2002, as input to moves to develop a South-West Indian Ocean Fisheries Commission. These meetings have attempted to collate and discuss available information on the fishery and to discuss, in particular, data collection requirements.

These meetings noted that the information and management protocols for effective fisheries management in the area were lacking and were urgently required. The report of the first meeting noted that ‘current levels of catch and effort may already exceed levels that will permit sustainable fisheries in the area’ (FAO, 2001). Participants at the second meeting agreed that, based on the experience of the management of Orange Roughy, and deep-sea species more generally, in other areas, there was an urgent need to introduce effective management measures for these species in the Southern Indian Ocean. Participants agreed that, at a minimum, the following measures should be taken to implement effective management of these fisheries:

(i) catch and effort data should be secured in appropriate detail by appropriate statistical areas;

(ii) appropriate management areas should be used for each species;

(iii) countries fishing in the area should take immediate management measures to control catch and/or effort for their national fishing at levels no greater than current levels; and

(iv) wherever possible, measures should also be taken to effectively control unreported and unregulated fishing. Concern was expressed about operations of vessels that had been chartered from countries that did not insist on provision of data relating to the operations of their vessels in high seas fisheries. This concern had arisen in part because of charters arranged by operators who had previously worked as skippers in the fishery (FAO, 2002).

The second meeting was also provided with a summary of documented information relevant to the common deep-sea species harvested in the Southern Indian Ocean. The summary included the following comments in relation to Orange Roughy:

- sustainable catch rates for Orange Roughy are 2% of B_0 which is much lower than for shelf species;
- few Orange Roughy/alfonsino fisheries have been well managed from a sustainability perspective;
- the current sustainable biomass target is 30%B_0 but many stocks had been depleted to levels of 10-20%B_0;
- the apparent episodic nature of recruitment of Orange Roughy stocks, whereby there may be long periods without recruitment, meant that conventional approaches of 'fishing down' the biomass and then taking a percentage of B_0 may not work; and
- use of judgement would be important in the management of this fishery and rates of exploitation should be set conservatively (FAO, 2002).

Despite this advice, in the absence of a RFMO for the area, management remains the responsibility of individual flag States. The management arrangements in place are known to include, but may not be restricted to, the following:

- Australia has limited its licences to fish in the area to those with past history of fishing in the area; operators must have a high seas fishing permit; VMS is required; provision of data is mandatory; observers have been present on Australian boats since the beginning of the fishery and have collected conventional scientific data and otoliths;
- South African vessels must have a high seas licence and VMS; scientific observers have been carried on some trips and otoliths and other biological data have been collected;
- Namibian vessels must report data regarding high seas operations and carry an observer upon request; and
- New Zealand vessels are required to have a high seas fishing permit, to report in detail on fishing operations, to carry VMS and to carry observers upon request.

The Orange Roughy fishery on Madagascar Ridge has now experienced its fifth season. While some MCS measures, observer and mandatory data collection procedures have been introduced by some flag States operating in the area, there is no upper limit on catch or effort. There is limited scientific research being conducted and certainly no co-ordinated research effort. Inter-governmental discussions regarding the development of a RFMO for the south-west Indian Ocean are into their fourth year with no end, or decisions, yet in sight. International inertia and a failure of flag States to apply precautionary restrictions on their vessels operating on Madagascar Ridge may have already sealed the fate of the Orange Roughy population in the area and perhaps that of the other deep-sea species on which that effort is now being directed. This is despite many of the countries known, or thought, to have fished in the area having signed or ratified agreements including UNCLOS, the UNFSA and the FAO Compliance Agreement.

5

ANALYSIS OF ORANGE ROUGHY MANAGEMENT

Management arrangements for Orange Roughy first took effect in 1981 in the Chatham Rise fishery in New Zealand. The most recent arrangements are those introduced by the EU and NEAFC for stocks in the north-east Atlantic in 2003. The context in which Orange Roughy fisheries are managed varies. New Zealand, Australia, Namibia and Chile manage fisheries in their EEZs solely under domestic legislation.

In the north-east Atlantic the fishing activity of EU member countries is subject to management arrangements imposed by the EU. Multilateral management occurs through NEAFC where members, including the EU, are subject to jointly agreed management measures. Bilateral management of Orange Roughy stocks also occurs with Australia and New Zealand jointly managing the straddling stock on the South Tasman Rise. The high seas fisheries on Madagascar Ridge and Louisville Ridge are subject to no formal management at all.

While Orange Roughy stock structure remains a source of great uncertainty it is possible from Appendix 1 to identify 30 Orange Roughy fisheries that are considered to represent, or are managed as, separate stocks. Given the lack of knowledge of stock structure and the uncertainty associated with current stock delineation it is possible that the fisheries identified comprise more than 30 biological stocks. A summary of the key features of the management arrangements and status of the identified stocks is provided in Table 9.

Table 9: Summary of management and status of known Orange Roughy fisheries

STATUS	NUMBERS OF FISHERIES	% OF FISHERIES
No management arrangements/or not specific to Orange Roughy	6	20%
Management arrangements specific to Orange Roughy in place	23	77%
- of which main management measure		
- Catch limits	23	
- Effort controls	1[1]	
Management objective specified	18	60%
Stock status <30%B_0	14	47%
- of which stock status <20%B_0	at least 6	
Stock status uncertain/unknown	15[2]	50%
- of which no stock assessments conducted	6	
- of which concern for sustainability of current catch levels expressed	8	

1. In the north-east Atlantic NEAFC has introduced effort controls for its members in respect of deep-sea stocks and the EU has imposed TACs for deep-sea stocks.

2. It has not been possible to confirm the status of scientific understanding of the fishery in Chile.

The summary in Table 9 suggests limited management success. Only one fishery, Chatham Rise, is considered to be above $30\%B_0$. However, even in this, the longest standing Orange Roughy fishery, stocks have in the past been fished below $30\%B_0$. It also seems that it is still too early to tell whether management has succeeded in sustaining an economically viable fishery. The high age at maturity (and recruitment to the adult fished population) means that changed levels of recruitment induced by fishing down the stock will not enter the fishery for some years yet (Clark, 2001). The full impact of fishing is yet to be reflected in the status of the stocks.

Forty-seven per cent of Orange Roughy fisheries are known to be below $30\%B_0$ and the status of a further 50% is unknown. Of the latter, concern for the sustainability of current catch levels has been expressed for more than half. This could imply that at least 75% are in fact less than $30\%B_0$.

In New Zealand and Australia Orange Roughy fisheries are managed to maintain catch at or above $30\%B_0$. In Namibia the target has been set at $50\%B_0$. ICES has adopted $50\%B_0$ and $20\%B_0$ as target and limit reference points respectively for all deep-sea species which are considered to be data-poor.

Whether the commonly adopted reference point of $30\%B_0$ is sufficiently precautionary for a species such as Orange Roughy has also been questioned. Koslow and Tuck (2001) suggest that 'a more conservative management strategy seems warranted, whereby fishing ceases at biomass levels between 30% and $50\%B_0$ rather than continuing at reduced levels, based on the assumption that the stock will rebuild with a steady input of recruits at long-term mean levels.' However, as described below, the adoption of the more precautionary $50\%B_0$ may have failed to prevent over-fishing of the Namibian population.

Management has generally failed to ensure the sustainability of Orange Roughy fisheries. The evidence suggests that most Orange Roughy fisheries, regardless of the extent or nature of management and research effort, have been over-fished. There is, for example, little discernible difference between the outcome on St Helen's Hill and that on Madagascar Ridge despite the enormous difference in the amount of management and research effort in the two fisheries. In Australia, for example around USD4m has been spent on Orange Roughy research projects funded by just one of several fisheries research funding agencies (C. Ashby, FRDC, *in litt*. to M. Lack, November 2003).

In addition, management has done little to address the broader ecosystem impacts of Orange Roughy fisheries, particularly those on seamounts. There is little or no management of the catch of, or impact on, non-target species, many of which are also long lived and of low productivity. There is evidence, in particular, of substantial benthic bycatch of corals, which may take more than 100 years to recover (Probert in Branch, 2001). Recent moves in some parts of the world to protect seamounts from trawling through the declaration of marine protected areas (MPAs) are welcome. Given the high degree of endemism associated with seamounts it is likely, however, that such isolated, and in some cases ad hoc, initiatives are insufficient to protect seamount biodiversity effectively.

The failure of Orange Roughy management is being recognised by consumer groups. The Monterey Bay Seafood Watch programme, which provides advice to consumers on the status of seafood, has recently placed Orange Roughy in its 'Avoid' category based on habitat destruction, bycatch of non-target organisms (vertebrate and invertebrate) and over-fishing of the target species (Stevens, 2003).

What has caused management failure?

The case studies presented in this report identify a range of possible reasons for the failure to manage Orange Roughy fisheries effectively and to adequately protect their associated ecosystems and habitats. These reasons include:

- a lack of understanding of the biological characteristics of the species;
- inadequate stock assessment models;
- failure to take a precautionary approach in accounting for uncertainties inherent in stock assessments;
- failure to remove excess fishing capacity;
- inappropriate management methods;
- lack of political will to impose rigorous management decisions;
- lack of effective management regimes for discrete high seas and straddling stocks; and
- ineffective MCS measures.

Understanding of the biological characteristics

The lack of understanding of Orange Roughy was a legitimate problem for its early management in New Zealand and, to a lesser extent, in Australia. Not only was little known about the species when commercial catches began in New Zealand, but being deep-sea made Orange Roughy technically difficult and expensive to research, particularly using the methods traditionally used for inshore species. It was probably not until the early to mid-1990s that the weight of scientific opinion, based on both research and the experience of Orange Roughy fisheries, favoured the view that the species was long-lived and not very productive and was therefore likely to be vulnerable to over-fishing. By this time acoustic surveys were also providing a more accurate means of biomass estimation and a firmer basis for management decision making. The impact of the lack of knowledge in the early years of the New Zealand and

Australian fisheries continues to be reflected in their generally depleted state today. However, a lack of knowledge about the vulnerability of the species can no longer be accepted, if it ever should have been, as a legitimate reason for management failure.

Adequacy of stock assessment models

Early estimates of biomass were based on trawl surveys. This technique has been largely discredited as a means of estimating biomass of deep-sea species such as Orange Roughy. Acoustic surveys have proven more effective. However the early reliance on trawl surveys together with the lack of understanding of the species itself, resulted in over-optimistic assessments of biomass and over-estimation of the potential sustainable yield, for example 5% rather than the now accepted 1-2%, of Orange Roughy stocks. As a result, most catch limits imposed in the early years of Orange Roughy fisheries proved to be unsustainable.

Stock assessment models for Orange Roughy have become increasingly sophisticated and the data on which they are based have improved. However the availability of reliable, comprehensive fishery-independent data remains a problem for stock assessment. Stock structure remains an issue in many assessments. In addition some of the fundamental characteristics of the stock assessment models are themselves being questioned. Koslow and Tuck (2001) have, for example, examined whether recruitment variability has been incorrectly parameterized in the assessment models and whether this can explain the continued depletion of stocks even when catch limits are set at levels which the models suggest should lead to rebuilding. Recruitment to Orange Roughy stocks appears to be highly episodic (Clark 2001, Koslow *et al.*, 2000). However, some stock assessment models for Orange Roughy assume stochastic recruitment variability, which underestimates the risk of stock collapse.

It is well demonstrated in fisheries that few models are perfect and few fisheries have adequate data. However, inadequacies in the data and stock assessment models for Orange Roughy cannot, and should not in themselves, be used as an excuse for management failure. Whether these deficiencies are driven by lack of research and monitoring expenditure and/or lack of scientific expertise is largely irrelevant. Management must deal with them in a risk management context. The risks posed by these uncertainties must be recognised, quantified where possible, and the management response must be explicitly precautionary.

The precautionary approach

As discussed above, uncertainty persists about key questions such as longevity, age at recruitment, natural mortality and stock structure of Orange Roughy. Fishery-independent data is lacking and stock assessment models are imperfect. As a result stock assessments are far from conclusive. Knowledge of the deep-sea ecosystems in which Orange Roughy are found is also generally lacking, particularly on a fishery-specific level.

However, despite these uncertainties, there is little disagreement that Orange Roughy is especially vulnerable to fishing. Further, there is an increasing body of evidence that shows that trawling on seamounts for Orange Roughy has significant and long lasting impacts, particularly on benthic communities.

In this context the need for a precautionary approach to management cannot be questioned. However the experience of Orange Roughy management to date is not consistent with a precautionary approach.

It must be acknowledged that the introduction of management of the New Zealand and Australian fisheries in the 1980s preceded explicit recognition, globally, of the need for precautionary management of fisheries. The FAO Code of Conduct for Responsible Fisheries and the UNFSA represented the first official acknowledgment of the need for a 'precautionary approach' to management of fish stocks.

By the mid-1990s there was therefore an acceptance of the need for a precautionary approach to fisheries management and there was certainly sufficient information and experience to indicate that, on the balance of probabilities, Orange Roughy was very vulnerable to over-fishing. However, by this time most Orange Roughy fisheries in New Zealand and Australia were already over-fished, despite the early introduction of management, and the unmanaged French fishery in the north-east Atlantic also showed signs of decline.

It might be expected that fisheries that have developed since that time would have been managed in a more precautionary manner. In addition to those covered in the preceding case studies, in the last decade the following new fisheries for Orange Roughy have developed:

- Louisville Ridge, in the high seas in the south-west Pacific Ocean
- Namibian Orange Roughy fisheries, in the Namibian EEZ
- South Tasman Rise, straddling the Australian EEZ/high seas
- East Coast Deepwater Zone, in the Australian EEZ
- Cascade Plateau, in the Australian EEZ

Louisville Ridge

There have been no attempts to manage the Louisville Ridge fishery and it expanded rapidly from 2 to 40 vessels over two years and within three years was considered by some operators to be commercially non-viable (France & Exel, 2000). Australian vessels have not operated there since 1998/99 but New Zealand vessels have fished Louisville Ridge consistently since 1993/94. New Zealand effort in the fishery has, however, declined with the number of trawls in recent years being about one-quarter, and the number of vessels about one-third of the number in 1994/95. Attempts by New Zealand to estimate pre-fished and current biomass for the fishery have been largely unsuccessful. However, decreasing catches over time and generally low values of CPUE suggest that stock sizes are small. The fishery remains unregulated and the long distance from New Zealand to the fishery means that vessels fishing on the Ridge are likely to stay there and fish hard even if catch rates are low (Clark & Anderson, 2003).

South Tasman Rise

The straddling stock of Orange Roughy on the South Tasman Rise (Box 4) has fared little better despite attempts by Australia and New Zealand to manage it bilaterally. Conflicts between the parties, fishing by States not party to the agreement, and little apparent regard to the experience in Orange Roughy fisheries elsewhere in Australia and New Zealand have resulted in the fishery being commercially un-viable after only five years of fishing. Despite the lack of information on the size of the fishery, it is classified as over-fished (BRS, 2003).

Namibia

Based on the experience of Orange Roughy fisheries in other countries, Namibia's approach to the management of its four Orange Roughy fisheries can be considered to be more precautionary than most. For example, as a precautionary measure, Namibia explicitly adopted a limit reference point of 50%B_0, compared to the 30%B_0 commonly adopted elsewhere, limited the number of vessels to five and set TACs from 1998 for each of the four 'hot spots'. However within six years of the commencement of commercial fishing the aggregating biomass dropped to 10-15%B_0 (Branch, 2001). Branch offers a number of reasons for the failure of even this seemingly precautionary management:

- the original biomass estimates on which TACs were set were overly optimistic;
- the exploratory phase of the fishery, 1994-1996, should have been subject to catch constraints;
- the delay, until 1997, in beginning acoustic surveys of the fishery; and
- the failure to pay enough attention to declining commercial CPUE in the early years of the fishery.

Recent acoustic surveys of an aggregation, known as Frankies, which has been closed to fishing since 1998, have yielded an abundance estimate back at the 1997 level. Scientists have interpreted this result as suggesting that declines in abundance indices may not be entirely catch-induced, but may include some combination of intermittent aggregation and fishing disturbance effects (Butterworth & Brandão, 2003). As a result of the acoustic surveys on Frankies the stock assessment advice is that the other three major aggregations are likely to be less substantially depleted than was thought to be the case in 2000. On the basis of this advice the TAC has been increased from 1875t in 2001/02 to 2650t in 2003/04. Only time will tell whether this increase was justified.

East Coast Deepwater Zone

Australia's East Coast Deepwater Zone is centred around Lord Howe Island. It encompasses waters over the seamounts adjacent to northern New South Wales, including those of the Lord Howe Rise. In 1993/94 operators took approximately 68t of Orange Roughy and around 30t of other species including oreos, Cardinal Fish and Mora from the northern Lord Howe Rise region (Caton *et al*., 1999). In 2000/01 433t of Orange Roughy were caught on the Lord Howe Rise. Preliminary stock assessments indicate that Lord Howe Rise is becoming over-exploited. Long term, potentially sustainable catches, assuming a single stock, are in the order of 400-500t (Wayte & Bax, 2002).

Cascade Plateau

The Cascade Plateau Orange Roughy population in the Australian EEZ has been fished since 1996. The fishery is based on both spawning and non-spawning aggregations. The fishery is now Australia's largest domestic Orange Roughy fishery with a TAC in 2003 and 2004 of 1600t (including 100t for research). The management strategy adopted for the Cascade Plateau sector is to set annual catch limits such that by 2010, the spawning biomass will be above 30% of pre-fishing levels as at 1988.

No formal assessment of the Cascade Plateau stock has been made and comparatively little is known of its status. Industry is currently funding research on this fishery, which includes collecting biological data and an acoustic (hull-mounted) survey of spawning biomass (Caton, 2002). Simple deterministic population modelling suggests the pre-fishing biomass would have to have been about 25 000t or larger, and the biomass in 2000 about 18 000t or larger, for the current catch of 1600t to be within the preliminary management target for this fishery. Preliminary acoustic estimates for 2000 suggested a spawning biomass of between 5000 and 15 000t however these are based on school area only and there is also some suggestion of considerable year-to-year variability in spawning.

There is no indication of a declining catch trend in this fishery however any decline would be disguised by the high variability in catch data. The stock could be above, at or below the preliminary management target for this fishery. Annual acoustic and biological surveys of the spawning aggregation will continue until current biomass estimates are refined and a formal stock assessment completed (Smith & Wayte, 2003).

The fishery was managed by competitive quarterly TACs, together with a strategic fishing and research programme until April 2001 when ITQs were introduced. This cooperative process, in contrast to the rapid fish-down of other Orange Roughy stocks in the Australian Fishing Zone, has provided greater opportunity and more time to determine acceptable catch rates. The quarterly TAC approach also reduced pressure on the spawning aggregation. However, the move to annual ITQs has disrupted the pattern of fishing, the coverage of data collection and funding arrangements for research as well as increasing pressure on the spawning aggregation (Smith & Wayte, 2002). This is particularly unfortunate given that, previously, very little of the catch had been taken inside the spawning season and the spawning aggregation therefore represented a rare chance to study relatively undisturbed spawning behaviour of a deep-sea species (J. Prince, Biospherics Pty Limited, *in litt.* to M. Lack, November 2003). In an attempt to take a more precautionary approach to management of the Cascade Plateau, a mandatory two-week spawning closure will be introduced in 2004 in order to shift effort away from the spawning period.

This brief examination of management of more recent fisheries for Orange Roughy fails to indicate a discernible change in the level of precaution applied to their management. The summaries of stock assessment advice and management responses in the case studies show a slowness to respond to scientific advice and to establish or abide by management strategies for Orange Roughy fisheries.

Failure to address excess global fishing capacity

The pressure on Orange Roughy stocks both within EEZs and on the high seas reflects the depletion of inshore fisheries, the increasing level of regulation of these fisheries and the consequent creation of excess fishing capacity. Increased global demand for seafood products and technological advances allowing deep-water fishing and greater precision in the location of seabed features have also contributed to increased pressure on deep-sea resources. Failure of individual States to remove excess capacity from their inshore fleets leaves these vessels free to explore deeper waters and high seas areas for new fisheries. Of further concern is the continued encouragement that some countries provide to development of new fishing capacity. The development of an Irish Orange Roughy fishery in ICES subarea VII since 2000 has been the result of a deliberate attempt to develop, partly through subsidisation, a deep-sea fleet in order to take pressure off inshore stocks and to sustain an ailing fishing industry. In the light of increasing international concern for the conservation of deep-sea species and their habitats, for the high level of fishing capacity worldwide and for the role that fishing subsidies play in encouraging the development of excess capacity, the development of this Irish fishery for deep-sea species including Orange Roughy seems little less than irresponsible. The introduction of TACs for EU member countries will curtail their catches dramatically. Now displaced from both inshore and deep-sea stocks, where will this capacity turn next?

Management methods

The most widely used management tool for Orange Roughy has been the application of TACs with, in many cases, the allocation of catches as ITQs. However, while management has centred on single species TACs/ITQs, a package of measures has generally been utilised. The package includes various combinations of TACs/ITQs, limited entry, gear controls and area and seasonal closures. Over time the area of application of TACs has become better targeted to reflect improved understanding of stock structure and some area and seasonal closures have been applied, particularly on known spawning grounds. Monitoring arrangements including the use of VMS and sophisticated paper trails for catch monitoring are increasingly being used, minimising the risks associated with misreporting and illegal catch where they are in place.

Despite the combination of measures, effort has continued to increase in some Orange Roughy fisheries. Simply restricting the number of licences through limited entry does not necessarily control total effort, since individual boats simply fish harder. ITQs may need to be accompanied by more stringent forms of effort control.

In some cases, for example, New Zealand Orange Roughy fisheries, TACs have also been applied to bycatch species such as oreos. In theory it can be argued that if the TAC on the target species is effective (for example it does not routinely exceed catches by a significant amount) the incidental catch of other species should be constrained by the target species TAC. Unfortunately, in many Orange Roughy fisheries TACs still significantly exceed catches, providing an incentive to keep fishing in order to take the TAC. In addition even where TACs reflect actual catch of the target species the resultant bycatch may be unsustainable.

The effectiveness of single species TAC management for deep-sea species has come under scrutiny in recent times. ICES, for example, has expressed reservations about the use of TACs for management of deep-sea species in the north-east Atlantic. NEAFC has indicated that it is likely to proceed toward an effort-based regime for deep-sea species including Orange Roughy. The alternative management arrangements being considered by NEAFC for deep-sea species centre on the introduction of a licensing system that restricts the size of the fleet having access to deep-sea species together with gear restrictions, closed areas or seasons, and the carrying of scientific observers.

The establishment of the number of licences and determination of appropriate gear restrictions under an effort-based regime are usually burdensome. In addition such a regime would not place any direct control on catch. There would be an inevitable lag between increased catches and the introduction of more stringent effort controls. Orange Roughy has proven itself to be critically vulnerable to such lags.

As the principles of EBM become reflected in fisheries management regimes, it is clear that management regimes that focus only on target species rather than on the ecosystems of which they are a part are inappropriate. A combination of management measures, including area-based measures, addressing ecosystem-wide concerns is the only practicable way in which fisheries and their impact on their supporting ecosystems, deep-sea or otherwise, can be managed.

Political will

Ultimately the success of management arrangements for Orange Roughy, whether by TACs, effort controls or a combination of factors, will be determined by the political will to take precautionary action in the face of uncertainty and in spite of the socio-economic consequences of those actions. Neither management systems based on effort controls nor TACs are immune from the political and socio-economic pressures that are brought to bear when tough resource management decisions need to be made.

Management regimes for discrete high seas and straddling stocks

There are no management arrangements for high seas Orange Roughy stocks such as those on Madagascar Ridge and Louisville Ridge and attempts to manage the straddling stock on the South Tasman Rise have been ineffective. Few RFMOs have management jurisdiction over bottom trawling for deep-sea species. There is an urgent need to develop such a regime for the south-west Indian Ocean and processes for the establishment of such organisations generally need to be fast-tracked. Madagascar Ridge has demonstrated that the process is currently just too slow. It is likely that the fishery for Orange Roughy in that area has been severely depleted, and possibly over-fished, while negotiations continue. There is already highly developed expertize within the fishing industry to exploit deep-sea resources. This expertize is readily and rapidly transferred around the world in response to discoveries of new stocks, as demonstrated by the experience on Madagascar Ridge. Further, greater availability of bathymetric information facilitates targeted exploration of areas where such resources are likely to occur. Ironically, the depletion of the very resources that such future RFMOs are being established to manage also serves to reduce the incentive and impetus to continue progress towards their development.

In the absence of such organisations, it is imperative that flag States take responsibility for their vessels on the high seas to regulate the catch of Orange Roughy.

Monitoring, control and surveillance measures

Management measures are only effective if they are enforced. Despite the early introduction of catch limits in the Australian and New Zealand fisheries they were largely ineffective in the first few years because of the inability of the MCS measures available to enforce them. Monitoring and enforcing TACs was new to both countries. The level of sophistication and resourcing of MCS has increased over time in those fisheries and over-catch is no longer considered to be a systemic problem. However the early catch overruns exacerbated the impact of, what in retrospect were, overly optimistic catch limits. The St Helen’s Hill case study demonstrates the impact of, among other things, inadequate MCS in the initial stages of the fishery. The impact of the damage is still being felt. The lesson from this experience is that species such as Orange Roughy do not provide a second chance to get MCS measures right. The management arrangements for deep-sea species, and the MCS measures that support them, must be effective from the outset of the fishery.

Summary

The above discussion, together with the case studies presented earlier, may lead to a conclusion that given the uncertainties in stock assessments, the low levels of sustainable yield, difficult and expensive assessment techniques, and apparently significant impact on benthic communities, it is simply not worth the ecological risk to allow commercial exploitation of Orange Roughy stocks. An alternative view is that these fisheries should simply be 'mined' and abandoned once commercially unviable. The latter approach is inconsistent with biodiversity conservation, with the goal of ensuring healthy, well-managed fisheries for the future, with the domestic fisheries and environmental legislation of many States and with a number of international legal instruments and protocols. The general failure of management to date is not an argument for no management, it is an argument for better management.

There is some evidence (Clark, 2001) that it may be possible to manage Orange Roughy fisheries sustainably, that is, in a manner that ensures the long term economic viability of the fishing industry and healthy ecosystems. However it is going to take some major changes in the approach to management of Orange Roughy if this is to occur. Closures of some existing fisheries and decisions not to allow commercial exploitation of new fisheries may be necessary.

The key to better management appears to lie not so much in the method of management, that is, TACs or effort controls, but in the way Orange Roughy fisheries are allowed to develop, in the establishment of management objectives, and in the political will to take hard decisions to apply and enforce these objectives, in relation to both new fisheries and over-fished stocks.

The following section draws on the lessons learned from experience in Orange Roughy management to make recommendations on the effective management of deep-sea fisheries.

6 OBSERVATIONS AND RECOMMENDATIONS FOR MANAGEMENT OF DEEP-SEA FISHERIES

The experience of Orange Roughy fisheries provides lessons for future management of that species and for other deep-sea species that share similar, albeit not always so pronounced, biological and life history traits. The experience indicates that:

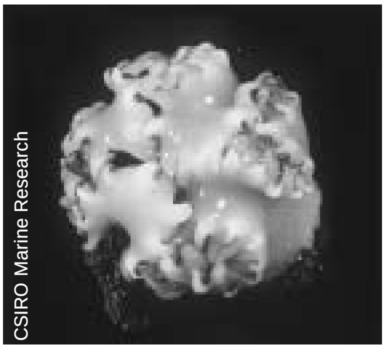
- expansion of deep-sea fisheries is driven by the depleted state of inshore fisheries, the tightening of regulations to contain catch and effort in those fisheries and the consequent creation of excess capacity for which a financial return is sought;
- continuing and increasing consumer demand for seafood combined with declining supplies of inshore species provide a market environment that encourages exploitation of deep-sea species;
- management at all levels has generally failed to deliver healthy and well-managed deep-sea fisheries;
- management, despite the best of intentions in some fisheries, has not been sufficiently precautionary;
- management, where it has been applied, has had a single species focus, with little regard for broader ecosystem-wide impacts of fishing;
- there is a dearth of information on the impacts of deep-sea fishing on the functional dynamics of ecosystems, including that associated with removal of biomass of target and non-target species;
- deep-sea fisheries, are focused on areas of high ecological vulnerability such as seamounts, where demersal trawl fisheries, in particular, have been shown to have severe and longstanding impacts on the substrate and benthic communities;
- the nature of deep-sea species provides no scope for delay in implementing management controls nor for management error, that is, a highly risk-averse management approach is required;
- effective management of deep-sea fisheries requires swift, strong and pre-emptive management action, particularly in high seas areas;
- new approaches are required to manage 'new' deep-sea fisheries; and that
- reassessment and amendment of management arrangements for existing deep-sea fisheries is required.

The level of concern for deep-sea species and their habitats, particularly for seamounts, has been highlighted earlier in this report and reinforced by the examples of Orange Roughy fisheries provided. To address these concerns action needs to be taken in four broad areas:

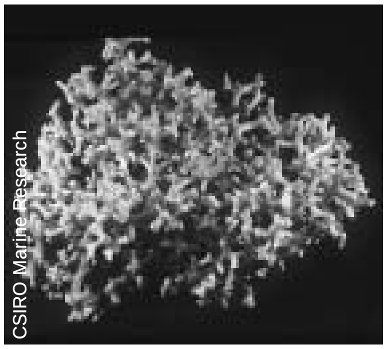
1. adopting a more precautionary approach to management of deep-sea species and their habitats;
2. addressing the underlying problem of over-capacity in world fisheries;
3. maximising the potential of international tools and protocols to protect deep-sea ecosystems on the high seas; and
4. moving towards an ecosystem-based approach to management of deep-sea species and their habitats.

Each of these areas is discussed below.

A squat lobster (*Gastroptychus* spp.), Benthic crustacean that lives on seamounts and is sometimes caught as bycatch.



Deep-sea anemone



Deep-sea coral

Precautionary approach

The weight of international agreement on the need for a precautionary approach, as reflected in the development of principles and guidelines with respect to the approach and its application in policies, is considerable. The experience of Orange Roughy fisheries exemplifies how management of deep-sea species has been inconsistent with these principles and guidelines or interpretation of the application of the precautionary principle:

- In the face of uncertainty about stock assessments, decisions to reduce catches have been deferred while second opinions were sought (see for example the St Helen's Hill Case Study).
- TACs have been immediately increased in response to any indication that stocks may be rebuilding.
- New fisheries have either gone unrestrained (e.g. the French and Irish fisheries in the north-east Atlantic) or the catch limits imposed have proven to be less than precautionary.
- F_{MSY} has been commonly used as a target rather than a limit reference point.
- Socio-economic considerations such as the economic welfare of the fishing industry have outweighed fisheries conservation objectives on many occasions. It is acknowledged that 'socio-economic conditions' are an integral part of a precautionary approach however socio-economic welfare will be short lived if the resource on which it is based collapses as a result of a failure to take hard management decisions.

The uncertainties and management issues that have characterised Orange Roughy fisheries are evident to varying degrees in attempts to manage other deep-sea species. The estimation of the biomass of these species is inherently difficult. Yet, where management strategies are in place, they rely on reference points related to B_0. Not only are the estimates of current biomass unknown or uncertain but similar uncertainty relates to B_0 itself. In addition, key parameters such as stock structure and natural mortality remain uncertain. In other cases target deep-sea species remain unregulated and the status of the stocks is not formally assessed or assessments are severely compromised by the lack of and/or poor quality of the data.

The impact on the ecosystem of fishing for deep-sea species, particularly on seamounts and particularly by trawling, are generally agreed to be significant and substantial, yet few management strategies incorporate benthic, trophic or associated species impacts. The extreme longevity and low productivity of target and non-target fish species (for example deep-sea chondrichthyans) and invertebrate fauna affected by fishing for these species, increases the uncertainty about the impact of fishing and the potential for rebuilding of over-fished deep-sea communities.

While there may be little information on ecosystem impacts of deep-sea fishing in relation to each and every deep-sea species or fishery, there is a growing body of literature, as evidenced in the Orange Roughy case studies, of the likely nature and extent of these impacts in deep sea fisheries, which can and should inform current and future management more explicitly. In the first instance such information, together with any fishery-specific data should be collated and assessed explicitly in the formulation of management arrangements in individual deep-sea fisheries. At present there is no evidence that this is occurring.

The extent and nature of the uncertainties associated with deep sea species demands that a more precautionary approach is required to the management of these species and their habitats than is applied to their relatively more productive and resilient inshore counterparts. Yet, generally, the management approaches to deep-sea species fail to meet even the basic standards for the application of the precautionary approach in fisheries management as spelt out in the accepted interpretations identified above.

Recommendations

1. To ensure that management arrangements for deep-sea species are consistent with a precautionary approach, coastal States and RFMOs with jurisdiction over management of deep-sea fisheries must, as a matter of urgency:

   (a) reassess, and amend where necessary, their existing management arrangements, MCS measures and research priorities, for deep-sea fisheries in the context of

   - the demonstrated need for additional precaution in the management of deep-sea species and ecosystems arising from the biological characteristics of the species, the ongoing uncertainty associated with fundamental stock assessment parameters, with the trophic and benthic impacts of fishing, and with the capacity of deep-sea species and ecosystems to rebuild,
   - the appropriateness of the current target and limit reference points, in particular the use of 30% of pre-fishing biomass as a target taking into account the uncertainties inherent in the stock assessment advice,
   - the need for management strategies to reflect EBM principles, including the use of networks of representative MPAs,
   - the demonstrated need for a combination of management measures to deal with ecosystem-wide issues,
   - in particular, the demonstrated vulnerability of deep-sea chondrichthyans to over-fishing as evidenced by the IUCN Red List of Threatened Species and reflected in the development of the IPOA for the Conservation and Management of Sharks;

   (b) where there is scientific advice that management strategies have failed or are likely to fail in relation to a stock or a fishery, address the question as to whether fishing should be allowed to continue at any level;

   (c) where management arrangements for deep-sea species are not in place, implement arrangements consistent with the context outlined above;

   (d) permit exploratory deep-sea fishing only under research protocols and prevent the development of commercial fisheries based on the findings of such research until management arrangements, consistent with the context outlined above, have been implemented; and

   (e) as a first step towards broader EBM, collate and report on all available information on trophic interactions, bycatch and benthic impacts so as to determine how best to incorporate this information into current stock assessment processes and to identify research gaps and inform research priorities.

Orange Roughy catches were dumped in Tasmania when processing facilities couldn't cope with the volumes being caught in the early days of fishing on St Helen's Hill

Over-capacity

Much of the pressure being applied to deep-sea ecosystems derives from the systemic, global problem of over-capacity. Over-capacity drives fishing fleets into deeper water and onto the high seas where, in most cases, deep-sea species fall outside the management jurisdiction of States and RFMOs. Where management is in place, IUU fishing, also driven by excess capacity, may undermine it. Over-capacity derives largely from displacement of vessels as inshore species are progressively depleted and/or as regulations limit fishing effort or catch. The severely diminished state of fish stocks has been recognised globally. The FAO's IPOA for the Management of Fishing Capacity acknowledges the role of excess capacity in causing over-fishing. Despite this, some countries not only refuse to take action to reduce capacity in their fishing fleets but actively encourage the development of new fishing capacity through subsidies of one form or another. Efforts to eliminate subsidies and to better align fishing capacity with the availability of fisheries resources must be a priority. Fishing nations, RFMOs, international bodies, with responsibility for fisheries management and other international bodies such as the World Trade Organisation (WTO), that can leverage change in key areas must pursue the removal of subsidies vigorously. The structural adjustment associated with the removal of excess capacity usually requires the injection of public funds. Investment in this process will deliver long term benefits, however, it is acknowledged that at an individual State level, such funding may not be readily available. The creation and administration of an international fund to finance approved structural adjustment programmes could, therefore, facilitate the removal of excess capacity and should be explored as a matter of urgency.

Trawlers fishing on St Helen's Hill, Tasmania

The Examiner

Recommendations

2. Consistent with its core mandate to regulate and reduce subsidies that distort international markets, the World Trade Organisation, in cooperation with international bodies with responsibility for fisheries management, must develop robust rules to effectively prohibit the subsidies that contribute to over-capacity and over-fishing, while allowing the use of government funds to reduce capacity.
3. Priority must be given to removal of subsidies that encourage creation of fishing capacity and the reduction of existing fishing capacity. To facilitate and expedite this process an international fund to support structural adjustment of fishing fleets under approved arrangements should be established with a country's access to this fund contingent on it having removed all forms of subsidies that encourage creation of excess fishing capacity.

International tools and provisions

Where deep-sea species are found outside EEZs and in areas not under the management jurisdiction of RFMOs, the effective management of the species and their habitats requires special consideration. Even where straddling stocks or high seas stocks are under management arrangements, IUU fishing may undermine these. There is, therefore, a need to consider the international tools and protocols that are available to assist in implementing effective management in these areas.

Useful approaches that need to be explored include:

- the timely formation of new RFMOs to manage deep-sea fisheries on the high seas;
- the use of market and trade-based measures to supplement or, in the absence of other management, control the nature of trade in deep-sea species;
- drawing on broader international instruments to achieve good fisheries management outcomes; and
- international co-operation to identify and protect a network of representative MPAs on the high seas (discussed in the section on EBM).

High seas management by RFMOs

At the moment there are few RFMOs that have the mandate to manage deep-sea fisheries. Those that do include the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), the North Atlantic Fisheries Organisation, NEAFC and SEAFO. High seas fisheries for many deep-sea species remain unregulated. This analysis has identified areas such as the Madagascar Ridge and Louisville Ridge as examples of management failure on the high seas. The South Tasman Rise straddling stock has also been over-fished despite bilateral attempts to manage it. There is a need for new RFMOs to be established with specific management responsibility for deep-sea fisheries in order to provide a framework in which proactive management of these fisheries can be implemented.

IUU fishing can compromise the effectiveness of conservation and management measures for deep-sea species on the high seas. The impact of IUU fishing on the effectiveness of CCAMLR 's conservation and management measures for Patagonian Toothfish is a good example. It is largely within the power of flag States to eliminate IUU fishing. However many States, despite being members of RFMOs and signatories to binding international conventions, continue to abrogate their responsibilities in relation to vessels operating under their flag, and for their nationals involved in IUU fishing. Other rogue States simply operate outside all international laws and protocols providing flags of convenience for IUU vessels.

Current international law and protocols provide a sound framework for the introduction and enforcement of strong conservation and management measures. However many RFMOs pre-date the UNFSA and some pre-date UNCLOS. As a result, the conventions that underlie these organisations may not reflect the requirements and provisions of current international law and protocols. It is important that RFMOs review the conventions under which they operate to ensure that they can maximise the potential provided by the international framework.

To date, RFMOs have had limited success in managing deep-sea fisheries. CCAMLR, for example, continues to face opposition from within its own membership to moves to introduce strong conservation, management and MCS measures for Patagonian Toothfish. One of the key constraints to timely and effective management decisions by RFMOs is the requirement for consensus decision making or the inclusion of opt-out clauses in RFMO conventions. Such provisions allow individual members of RFMOs to delay and to undermine the management and conservation efforts of the organisation and individual member States. In addition, consensus decision-making tends to result in a lowest common denominator outcome in terms of conservation and management measures.

Broader international instruments

Market and trade-related measures are also likely to play a role in supporting fisheries conservation and management measures for deep-sea species. Trade certification schemes, such as CCAMLR's Catch Documentation Scheme (CDS) for Patagonian Toothfish, have the potential to eliminate opportunities for the marketing of illegally-caught fish, thereby removing the economic incentive to fish illegally. Monitoring of official trade data of major trading countries may, either in support of trade certification schemes, or independently, provide verification of catch to indicate whether catch limits are being exceeded and/or to increase confidence in catch data included in stock assessments. It may also provide accurate assessments of catch in cases where RFMOs are not in place.

This report has highlighted the difficulty in tracking Orange Roughy trade because of the lack of species specific and product-form specific trade codes. This problem will apply to most deep-sea species and should be addressed by major importing and exporting countries. The potential for double counting of product in trade analyses will be reduced considerably if countries involved in the importing, processing and re-exporting of Orange Roughy products have appropriate Orange Roughy trade codes in place.

Port and market States can also play a vital role in enforcing the conservation and management measures implemented by RFMOs. For example, the effectiveness of the Patagonian Toothfish CDS has been enhanced considerably by the co-operation and participation of port and market States that are not members of CCAMLR.

Eco-labelling and certification schemes are likely to also have a role to play in the effective conservation of deep-sea species by influencing consumer demand for these species in more affluent, ecologically aware markets. Where high seas catch of deep-sea species proves difficult to control, or if individual States fail to manage their own resources sustainably, such schemes may sway consumer demand away from poorly managed or uncertified product towards those that have met sustainability criteria. In addition to formal certification schemes there are a range of independent groups, for example the Seafood Choices Alliance in North America, that provide consumer advice on the conservation and management status of marine species and make recommendations to the public, restaurants and chefs on which species should be avoided.

Co-ordinated international efforts by members of the fishing industry, from the catching, processing, marketing sectors, can also play a key role in lobbying for effective management and monitoring fishing and marketing activity in relation to deep-sea species. The recent establishment of the Coalition of Legal Toothfish Operators demonstrates how those with a legitimate commercial interest in a deep-sea species and its ecosystem can contribute effectively to efforts by governments, RFMOs and conservation groups to achieving sustainable management.

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) can also provide support to national, bilateral and multilateral fisheries management measures, combat IUU fishing where this targets fish that primarily enter international trade, and provide a standardised global monitoring system for application of trade-related measures to marine fish. Importantly, CITES provides global coverage and has a membership of more than 160 parties. This coverage represents a significant advantage to RFMOs that have both limited membership and area of jurisdiction. For species, such as deep-species found on the high seas, for which no management arrangements are in place, CITES can highlight the need to develop co-ordinated conservation measures and act as a first step towards these (IUCN, WWF & TRAFFIC, 2002).

Fisheries management has tended to operate in isolation from other international tools. Only in relatively recent times has, for example, the potential role of CITES in supplementing fisheries management measures, been acknowledged. The Convention on Biological Diversity (CBD) also provides a sound basis for its parties to implement, either unilaterally or jointly, measures to ensure the conservation and sustainable use of biodiversity. The CBD applies to areas within EEZs and on the high seas.

A trawl cod-end full of Orange Roughy and oreo bycatch

Recommendations

4. In order to maximise the effectiveness of conservation and management measures for deep-sea species:
   - (a) RFMOs must consider the role that trade-based measures might play in monitoring and enforcing conservation and management measures for deep-sea species, and introduce such measures where appropriate;
   - (b) port and market States must co-operate with the implementation and enforcement of conservation and management measures established by RFMOs; and
   - (c) States involved in the trade of deep-sea species must implement, as a priority, harmonised trade codes for these species noting the need for an adequate breakdown of codes by product form in order to provide for meaningful trade analysis.
5. Flag States must take immediate action to ensure that they can effectively monitor and control their vessels operating on the high seas, and co-operate in identifying and prosecuting those found to be in breach of domestic or international law.
6. The formation of new RFMOs for deep-sea fisheries that are outside national or RFMO jurisdiction and, in particular, the process underway to create an RFMO in the south-west Indian Ocean must be expedited and based on conventions that are consistent with the requirements and provisions of current international laws and protocols.
7. RFMOs that have a mandate to manage deep-sea species must reassess these conventions in light of current international law and protocols and ensure that, where necessary, they are amended to provide consistency with current fisheries law and 'soft law'.
8. In establishing and/or reviewing conventions, provisions requiring consensus decision-making and allowing members to opt-out of decisions taken by the RFMO should be avoided or removed.
9. Those with a legitimate commercial interest in deep-sea fisheries should initiate and co-ordinate their efforts to influence and enforce timely and effective management arrangements for these species and their ecosystems.

The Santo Rocco di Bagnara:pioneer trawler for Orange Roughy in Australia

Ecosystem-based management approaches

Ward *et al.*, (2002) define EBM as: 'Management of the uses and values of ecosystems in conjunction with stakeholders to ensure ecological integrity is maintained, and recognising that ecosystems are dynamic and inherently uncertain'. They go on to explain that in a fisheries context EBM means:

> *... taking careful account of the condition of ecosystems that may affect fish stocks and their productivity. It also means taking equally careful account of the ways fishing activities may affect marine ecosystems. This means, where necessary, changing the way in which the fishery operates, adjusting the type of gear used, or imposing closed areas to protect biodiversity or habitats critical to the whole fishery or to the biodiversity of the region. And further, it means taking an inclusive approach to setting goals and objectives for harvested fish and the ecosystem the fish comes from, recognising ecosystem interactions, integrating activities across a range of other users and resource sectors and respecting the broad range of values society has for the marine environment. (Ward et al., 2002)*

This interpretation of EBM may seem a long way from the single species-based management that has characterised deep-sea species such as Orange Roughy to date. However, in practice, most management arrangements for Orange Roughy exhibit some of the characteristics of EBM. In addition, single species management is not necessarily inconsistent with the objectives of EBM. It has been argued (e.g. Mace, 2001; Sissenwine and Mace, 2001; National Research Council, 1999) that constraining fishing mortality within precautionary limits and, where required, reducing fishing mortality may make a significant contribution to sustaining and rebuilding both fish stocks and marine ecosystems.

Information on broader, more pervasive, ecosystem impacts of fishing and on the trophodynamics of marine ecosystems is lacking in most fisheries. It is even more difficult to gather in deep-sea fisheries than in fisheries closer to shore. Under these circumstances it may well be the case that precautionary, single species-based management approaches are a good first step for achieving EBM objectives in deep-sea fisheries. However there is a need to address the lack of information and to incorporate, where necessary, risk-based management approaches to ecosystem-wide impacts in setting catch or effort limits in target deep-sea fisheries.

There are demonstrable signs that ecosystem-based principles are being included in fisheries management and that fisheries management arrangements are being assessed against these principles. In Australia, for example, fisheries management arrangements are now required to be assessed against ecological sustainability guidelines in order to be approved under the *Environment Protection and Biodiversity Conservation Act 1999*. Failure to meet the standards can result in product from a fishery being ineligible for export. Approved fisheries are required to address any issues arising from these assessments over a five-year period.

Many deep-sea target species have proven to be quickly depleted and slow to recover. Management of these species has generally failed. The collateral damage of these fisheries on bycatch species and benthic habitats is significant and substantial. These factors make deep-sea habitats such as seamounts and deep-sea coral reefs prime candidates for the creation of representative networks of MPAs. MPAs may be either off limits to fishing or restrict the nature and/or area of fishing activity (and/or other forms of activity). Given the diversity and high levels of endemism which appear to characterise some deep-sea ecosystems such as seamounts, the creation of MPAs may not protect all deep-sea species or ecosystems. However a representative network of MPAs could make a significant contribution to the conservation of biodiversity and possibly the rebuilding of depleted communities.

Within EEZs some deep-sea marine reserves have already been established. For example Australia has created the Lord Howe Island Marine Park and the Tasmanian Seamounts Marine Reserve, 19 seamounts have been protected in New Zealand and the EU has provided interim protection for the Darwin Mounds. In other areas controls on the nature of fishing operations create quasi MPAs, for example the ban on trawling in waters in the Azores exclusion zone. The OSPAR[20] Commission has also been developing guidelines for the selection and management of offshore MPAs and its Biodiversity Committee has discussed how this might relate to seamounts. Seamounts are also included on the initial OSPAR list of threatened and/or declining habitats (Gubbay, 2003).

While these are positive developments they are, generally, ad hoc and are not based on a comprehensive assessment of biodiversity, vulnerability or conservation value. For example the selection of the seamounts protected in new Zealand has been described as 'to some extent…a stab in the dark' (Clark & O'Driscoll, in press).

While the extent to which individual States are protecting representative deep-sea ecosystems remains an issue, a more pressing issue is perhaps the protection of ecosystems in waters outside state jurisdiction. Gianni (2003), for example, has emphasised the need to expedite efforts to establish management arrangements, mechanisms and

20 The Oslo and Paris Conventions

measures in high seas areas outside the competency of regional fishery bodies where unregulated fishing on seamounts takes place. This raises questions of the adequacy of the international framework for establishing, managing, monitoring and enforcing MPAs on the high seas. This issue has been acknowledged by UNICPOLOS which, at its 2003 meeting, proposed that the UNGA:

> *… invite the relevant international bodies at all levels, in accordance with their mandate to consider urgently how to better address, on a scientific and precautionary basis, the threats and risks to vulnerable and threatened marine ecosystems and biodiversity beyond national jurisdiction; how existing treaties and other relevant instruments can be used in this process consistent with international law, in particular with the UNCLOS and consistent with the principles of an integrated ecosystem-based approach to management, including the identification of those marine ecosystem types that warrant priority attention; and to explore a range of potential approaches and tools for their protection and management. (UN General Assembly, 2003)*

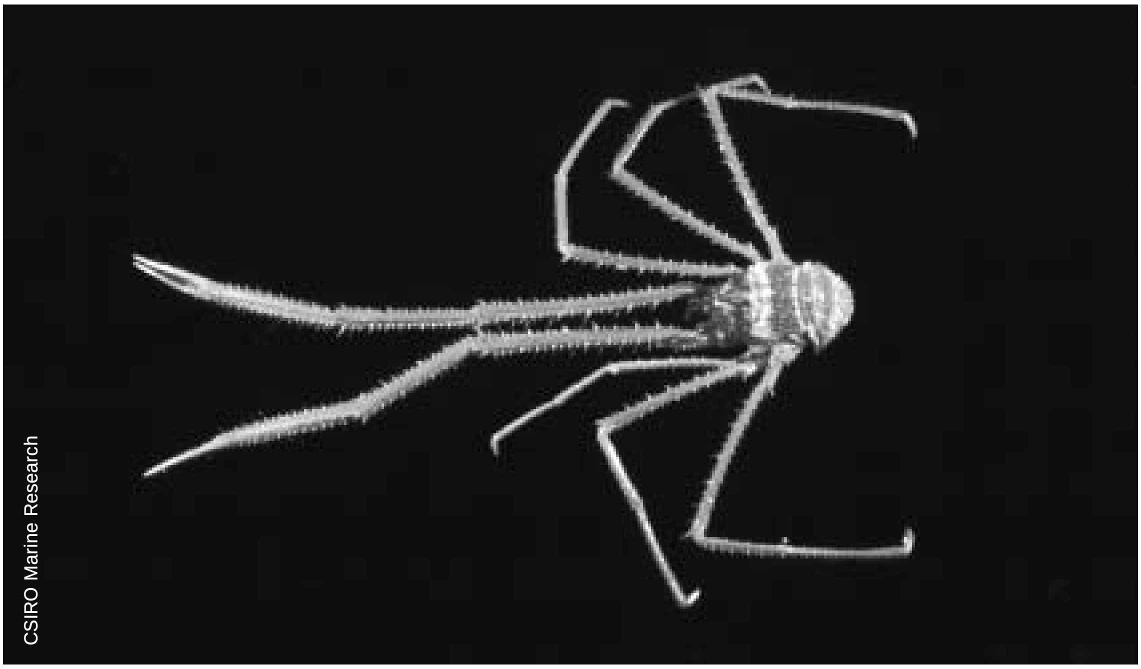
UNCLOS provides for the protection of vulnerable marine ecosystems and biodiversity both within and outside national jurisdiction (Articles 192 and 194(5) and Section II of Part VII). The FAO Code of Conduct (Article 6) and IPOAs developed under the Code, the UNFSA (Article 5), the CBD, the FAO Compliance Agreement, and chapter 17 of Agenda 21 are also relevant.

The first step in any process of protecting high seas communities will be the identification of representative areas. This will involve getting agreement on what is worth protecting and the extent to which resources are, currently or potentially, threatened by activities such as fishing (Cripps & Christiansen, 2001).

In practice, the implementation of any management arrangements relating to high seas fisheries, whether they be catch controls, effort limits, MPAs or a combination of all of these, will depend, ultimately on political will and the good will of the parties involved. To date, despite the proliferation of RFMOs and international 'soft law', both have been in short supply. While this has not prevented attempts by like-minded, responsible fishing nations to implement and enforce high seas management measures, these have had very limited success.

Recommendations

10. Consistent with the recommendations of the 2002 World Summit on Sustainable Development and the 2003 World Parks Congress, all States and RFMOs should co-operate to establish a network of representative deep-sea and high-seas MPAs by 2012, noting the need for such a network to be based on sound ecological and scientific information and to be consistent with international law.



A squat lobster (*Gastroptychus* spp.), Benthic crustacean that lives on seamounts and is sometimes caught as bycatch.

Conclusions

The experience of the last decade demonstrates that, if any lessons have been learned, they are not being translated into different or better management outcomes. Little heed is being paid to the growing body of evidence that indicates that deep-sea species and their habitats are highly vulnerable to fishing. Global moves to encourage the adoption of a precautionary approach to fisheries management have had little apparent impact, as the global experience with Orange Roughy clearly demonstrates. Similarly, international agreements to reduce fishing capacity, to remove subsidies which encourage over-fishing, to encourage co-operation in management of fish stocks and flag States to take responsibility for their vessels fishing on the high seas, appear to have gone largely unheeded, to the detriment of deep-sea species and their associated ecosystems.

The variation in the population biology of deep-sea species, and hence the nature of appropriate management strategies, will vary. There is no 'one-size-fits-all' solution to management of these species. However there is a sufficiently broad range of common characteristics to allow some general conclusions to be drawn about their management. At a minimum, the characteristics of these species mean that different approaches to those traditionally applied to their more productive, inshore counterparts are required. The management record of those comparatively more resilient inshore species is hardly encouraging and it can be expected that, generally, deep-sea species will be depleted more quickly and recover more slowly than those species.

The adoption of the above recommendations in relation to management of deep-sea species and ecosystems may ultimately result in a decision to close a fishery or to prevent the development of a commercial fishery based on these species. Such measures are not advocated lightly. However the particular vulnerability of, and the ongoing uncertainty associated with, deep-sea species and their ecosystems may demand extreme measures. It must be recognised that in some circumstances it will simply not be possible to manage deep-sea fisheries sustainably, that is, in a way that yields the levels of profit that are expected presently whilst ensuring the health of vulnerable marine ecosystems. The precautionary approach and the burden of proof dictate that in these circumstances fishing is excluded. It is imperative that existing management measures are reassessed in this context and that future development of deep-sea fisheries is conditional on a full, transparent and inclusive assessment of the risks involved.

Catch from an Orange Roughy shot

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Appendix 1: Global Orange Roughy fisheries

AREA	COMMERCIAL FISHING BEGAN	STOCK STATUS	CATCH AND CATCH LIMITS	MAIN MANAGEMENT MEASURES
NEW ZEALAND **Chatham Rise, Puysegur & Southern (ORH3B)**	1979/80	NW Chatham Rise: uncertain but biomass declining; recent catches probably not sustainable in the long term NE Chatham Rise: spawning Stock biomass (SSB) >that which will support MSY; stock may be rebuilding & will continue to increase at recent catch levels S. Chatham Rise: SSB <that which will support MSY; recent catches likely to move stock towards B_{MSY} & Southern (ORH3B) Puysegur: Uncertain; voluntary closure in place since 1997/98 & zero catch should move stock towards B_{MSY}	Highest catch: 32 785t (1988/89) Latest catch: 11 325t (2001/02) Highest TAC: 38 300 (1988/89) Current TAC: 12 700t	New Zealand first introduced a TAC for Orange Roughy in the Chatham Rise in 1981/82. ITQ management introduced for all fisheries in 1986. Area and gear restrictions also apply.
East coast (ORH2A, 2B & 3B)	1981/82	Northern Stock: at about 80% of B_{MSY}; current catch limit and recent catches are sustainable Southern Stock: <30%B_0	Highest catch: 10 537t (1989/90) Latest catch: 1666t (2001/02) Highest TAC: 10 632t (1992/93) Current TAC: 800t	
Northern North Island (ORH1)	1989/90	Stock assessment last updated 2000. Within the Mercury-Colville Box, stock is below B_{MSY}; Elsewhere the stock is probably above that needed to support MSY or stock status is unknown	Highest catch: 1021t (1996/97) Latest catch: 1294t (2001/02) Highest TAC: 1190t (1995/96) Current TAC: 1400t (30t in M-C box)	
West Coast South Island (ORH7B)	1984/85	Biomass estimated to be < B_{MSY}; unlikely that current TAC and recent catch levels will allow stock to move towards levels to support MSY	Highest catch: 1750t (1988/89) Latest catch: 95t (2001/02) Highest TAC: 1708t (1988/89) Current TAC: 110t	
Challenger Plateau (ORH7A)	1980/81	Stock <10% B_{MSY}; recent catches >estimated safe yields	Highest catch: 12 181t (1987/88) Latest catch: <1t Highest TAC: 12 000t (1988/89) Current TAC: 1t	Stock straddles New Zealand EEZ and high seas. TAC applies to catches of New Zealand vessels both inside and outside the EEZ.

Appendix 1: Global Orange Roughy fisheries (CONT.)

AREA	COMMERCIAL FISHING BEGAN	STOCK STATUS	CATCH AND CATCH LIMITS	MAIN MANAGEMENT MEASURES
AUSTRALIA **South Eastern Scalefish and Shark Fishery** **1. Eastern Zone**	1989/90	Overfished; current management objectives, strategies and performance indicators can no longer be reached.	Highest catch: 23 200t (1990) Latest catch: 1484 (2002) Highest TAC: 15 000t (1989/90 Current TAC: 820t	TACs/ITQs; limited entry; mesh and area restrictions; logbooks; quota monitoring; transiting and reporting requirements for Orange Roughy zones; VMS
2. Southern Zone	1989	Overfished; current management objectives, strategies and performance indicators can no longer be reached.	Highest catch: 18 350t (1989) Latest catch: 167t (2002) Highest TAC: 12 750t (1991) Current TAC: 340t	
3. Western Zone	1986	Overfished; highly unlikely that stocks are above reference point; current management objectives, strategies and performance indicators can no longer be reached.	Highest catch: 5128t (1987) Latest catch: 294t (2002) Highest TAC: 1500t (1992) Current TAC: 450t	
4. Cascade Plateau	1996	Uncertain; no quantitative biomass estimate available. Informal management strategy is to set annual catch limits such that by 2010 the SSB will be >30% of pre-fishing levels (1988)	Highest catch: 1600t (1999) Latest catch: 1599t (2002) Highest TAC: 1600t (1998) Current TAC: 1500t plus 100t research quota.	
5. East Coast Deepwater Zone (Lord Howe Rise)	1993/94	Probably a straddling stock with that on the north-west Challenger Plateau. Preliminary stock assessments indicate that the fishery is becoming over-exploited.	Latest catch: 433t (2000/01) Current TAC: 500t (trigger limit of 100t)	Limited entry and catch triggers. TAC does not apply to catches outside the EEZ, but unless an observer is carried operators are restricted to single jurisdiction trips. VMS must be carried if fishing outside the EEZ.
Great Australian Bight Trawl Fishery	1988	Uncertain; no stock assessment	Highest catch: 3757t (1989) Latest catch: 239t (2002)	Limited entry; gear and area restrictions; maximum vessel length of 40m ; logbooks; No TAC or reference point on Orange Roughy
Western Deepwater Trawl	Early 1990s	Uncertain; no stock assessment	Highest catch: 235t (1994/95) Latest catch: 104t (2001/02)	Limited entry; logbooks; No TAC or reference point for Orange Roughy

Appendix I: Global Orange Roughy fisheries (CONT.)

AREA	COMMERCIAL FISHING BEGAN	STOCK STATUS	CATCH AND CATCH LIMITS	MAIN MANAGEMENT MEASURES
NORTH EAST ATLANTIC				
1. ICES Subarea VI	1991	Outside safe biological limits; Below 50%B0 and may be less close to 20%B0	Highest catch: 3502t (1991) Latest catch: 313t (p) (2002)	In 2003 the EU introduced TACs of 88t in Area VI and 1349t in Area VII and permit, reporting, landing and capacity restrictions. NEAFC introduced interim effort restrictions in 2003.
2. ICES Subarea VII	1991	Uncertain	Highest catch: 5452t (p) (2002) Latest catch: 5452t (p) (2002)	
3. ICES Division Va	1991	Unknown	Highest catch: 700t (1993) Latest catch: 10t (p) (2002)	
4. ICES Division Vb	1992	Unknown	Highest catch: 419t (1995) Latest catch: 1t (p) (2001)	
CHILE (Juan Fernandez archipelago and off southern Chile)	1998	Could not be confirmed	Highest catch: 1493t (2002) Latest catch: 1493t (2002) Highest TAC: 2500t (2002) Current TAC: 2500t	TAC and ITQs
NAMIBIA	1994	Four aggregations considered discreet populations and managed as separate stocks and individual TACs are set. One aggregation has been closed to trawling since 1999 Biomass estimate of about 300 000t in 1996 and 1997. Limit reference point set at 50%B0. By 2000 biomass on three aggregations was considered to be below 30%B0. However recent assessments suggest that abundance may be higher than previously thought.	Highest catch: 18 516t (1997) Latest catch: 857t (2001) Highest TAC: 12 000t (1997) Current TAC: 2650t	Namibia imposed TACs in 1997. Vessel numbers limited to five. The Convention on the Conservation and Management of Fishery Resources in the South-east Atlantic Ocean came into force on 13 April 2003. No specific management arrangements are yet in place.

Appendix 1: Global Orange Roughy fisheries (CONT.)

AREA	COMMERCIAL FISHING BEGAN	STOCK STATUS	CATCH AND CATCH LIMITS	MAIN MANAGEMENT MEASURES
MADAGASCAR RIDGE	1999	Unknown	Highest catch: estimated at between 12 000t and 20 000t (2000)	Negotiations are underway to develop an RFMO for the southern Indian Ocean. A third Inter-governmental consultation in the establishment of the South West Indian Ocean Fisheries Commission will be held in 2004. Some flag States have imposed licensing, reporting, observer requirements on vessels operating in the area.
LOUISVILLE RIDGE **(approx. 600km east of New Zealand)**	1993	Uncertain; Stock assessments attempted but biomass estimates only possible for one of three groups of seamounts; stocks sizes appear to be small.	Highest catch: 13 250t (1994/95) Latest catch: 1363t (2000/01)	None apart from any high seas requirements placed on vessels by individual flag States.
SOUTH TASMAN RISE **Straddling stock (Australian EEZ and high seas to the south of Tasmania)**	1997	Overfished; although size and extent of the resource remain unquantified recent landings have been less than 10% of the TAC.	Highest catch: 4650t (est) (1999/00) Latest catch: 108t (2002) Current TAC: 1800t	Limited entry and TACs for Australian operators. MOU between Australia and New Zealand.

Source: A. Sancho, TRAFFIC South America, in litt. to A. Willock September 2003; Annala *et al.*, 2003; AFFA, 2002; Branch, 2001; Bureau of Rural Sciences, 2003; Butterworth and Brandão, 2003; Caton, 2002; Clark and Anderson, 2003; CSIRO, 2001; FAO, 2000; ICES, 2000; ICES, 2003a; Ministry of Fisheries and Marine Resources, 2003; Sherbourne, 2001; Smith & Wayte, 2002 and 2003

Appendix II: A selection of media clippings on the St Helen's Hill fishery (from The Examiner)

No let up likely on fishing of orange roughy

Fishing gen

17 FEB 1987

The Federal Government is likely to allow intensive fishing of the rich orange roughy fishing ground off Tasmania's North-West Coast to continue.

The Primary Industry Minister, Mr Kerin, will look at recommendations made by the South-East Trawl Management Advisory Committee later this week but it is understood that he is likely to accept them unchanged.

This is despite the fact that March-April is believed to be the delicate deep-sea fish's spawning season.

SETMAC's recommendation has been slammed by several groups, which claim that fishing in the recently-discovered area should be completely stopped until more is known about the resource.

But although Mr Kerin's office has issued a warning to fishermen not to invest heavily in the resource, it is understood to be planning to allow fishing to continue.

● Mr Kerin

A CSIRO research vessel will move into the area, about 70 km west of Cape Grim, early next month and will conduct an extensive assessment of the patch.

The State Government has also dismissed the possibility of taking action to stop the open-slather on the resource.

The Fisheries Minister, Mr Groom, said that although he would be speaking with Mr Kerin at the earliest possible opportunity, it was not a State Government matter.

He said that he would be asking Mr Kerin to ensure that the area was managed properly and would ask for the State to be given a greater say in its management.

Tasmania was not getting its share of value from the huge resource, he said.

No curbs on fishing area

Fishing -gen

12 FEB 1987

No immediate restrictions will be placed on the rich orange roughy fishing grounds off Tasmania's North-West Coast, but the CSIRO will send its largest research boat to the area next month.

The South East Trawl Management Advisory Committee finished its two-day meeting in Melbourne yesterday, and resisted pressure from the Tasmanian Fishing Industry Council to close the grounds.

The SETMAC chairman, Mr Bruce Lilburn, said that a variety of opinions emerged, but advice from State and CSIRO scientists indicated no biological need to close the so-called "hot spot" 70km west of Cape Grim.

He said that there had been no agreement on long-term management options, but that the Federal Primary Industry Minister, Mr Kerin, would decide on any planning strategy.

The CSIRO boat will stay in the area for about six weeks researching the orange roughy and its habits, about which little is known.

The TFIC feared that the small patch would be quickly fished out by the 30 trawlers that have flocked from Victoria, NSW and South Australia.

The manager of the TFIC, Mr Dale Bryan, said that he had been disappointed with the lack of agreement between the four State-based industries at the meeting.

"The meeting was a waste of time and the fate of the fishing industry will be left in the hands of the bureaucrats," Mr Bryan said.

He said that the area should have been protected at a time when the fish were spawning and so little was known about the fish.

He said that on top of the 20 to 30 boats already fishing the area, about another 20 would come.

"They will hammer hell out of the area," Mr Bryan said.

Kerin denies roughy threat

24 FEB 1987

Fishing gen

There was very little evidence that available orange roughy stocks in Bass Strait were being run down, the Federal Primary Industry Minister, Mr Kerin, said in Launceston yesterday.

Mr Kerin said that on the evidence available from scientists the 20,000 tonne quota was an appropriate level to strike at this time, despite the fact that between only 6000 and 8000 tonnes was caught in 1986.

He said that further action would be taken after an assesment of the fish stocks by a CSIRO vessel during March-April.

Mr Kerin said that it was believed 190,000 tonnes of orange roughy could be in the one area being fished by up to 20 fishermen.

He said that another four areas were known of.

Mr. Kerin said that the figure was an interim decision and not a final one.

The State Sea Fisheries Minister, Mr Ray Groom, said that according to his information a 10,000 tonne quota would have been more appropriate.

Fisheries Minister under fire

Fisheries /Fishing deep sea

12 SEP 1989

By CHRISTINE MIDDAP

The Sea Fisheries Minister, Mr Llewellyn, should stop playing politics and concentrate on expanding his knowledge of the fishing industry, according to a group of fishermen and processors.

The comment came after a meeting in Launceston yesterday organised by Bridport fisherman and joint owner of the Bridport Fish Factory, Mr Alan Barnett.

The meeting, which drew 26 people from as far as Western Australia, follows the joing State-Federal Government's decision last week to limit the size of the orange roughy catch on Tasmania's East Coast.

Some fishermen estimated that up to 1000 jobs Australia-wide could be lost by the limitations, and are concerned that their whole livelihoods and lifestyle could be ruined by Mr Llewellyn's "closed mind."

"We are all in 100 per cent disagreement with what he's done, and we want Mr Kerin (the Federal Industry and Energy Minister) to know that Llewellyn does not have the support of the industry," Mr Barnett said.

"He has obviously made a political decision because we aren't getting any valid answers from him — he just doesn't want to know the real story or is unavailable for comment."

Last week, Mr Kerin announced that only 1000 tonnes of orange roughy could be taken from the fisheries off St Helens until April 30.

Mr Kerin said that the measure was part of a new interim stock protection strategy for the fish, which had been agreed to after discussions with the industry.

However, fishermen and processors yesterday claimed that the Government had effectively closed all other types of trawling and stopped any further development of the industry by banning fishing in an area of 500 square nautical miles.

"Other fishermen have been stopped from taking blue grenadier, black trevally and morwong because of these restrictions," Mr Barnett said.

"Why should they be penalised because of this?"

Fishermen and processors from Victoria and Western Australia chartered aircraft for yesterday's gathering, and will stay in Launceston for another meeting with the South-East Trawl Fishing Industry Committee this morning.

Flinders Island fisherman Mr John Hammond said, "We're certainly hoping for some sort of resolution out of these meetings because we are just as keen to preserve the industry as anyone — after all it is our livelihood we're talking about.

"Mr Llewellyn has gone the wrong way about things and has not consulted with the industry at all — he just doesn't want to expand his knowledge of the fishing industry and see what is really going on."

The fishermen called on Mr Llewellyn to provide some biological reason for the restrictions, and are asking that proper surveys and research be carried out to properly assess the situation.

State moves on roughy fishery

31 JUL 1989

Fishing deep sea /Fisheries /Pollution

The Tasmanian Government has warned fishermen that the orange roughy fishery must be harvested responsibly and not destroyed by over-exploitation.

The Primiary Industry Minister, Mr Llewellyn, said yesterday that the booming orange roughy fishery was increasingly important to Tasmanian employment and revenue.

Mr LLewellyn said that that schools of orange roughy near St Helens were spawning for the first known time in Australian waters.

But he warned that spawning aggregations of o range roughy must not be fished.

"I have personally asked the Federal Primary Industry Minister, Mr Kerin, to consider an outright ban on trawling of any spawning aggregations," Mr Llewellyn said yesterday.

He said that Mr Kerin had agreed to urgently investigate Tasmania's request "especially now that we have the first verification that the fishery reproduces and replenishes itself in our waters.

"About 10,000 tonnes of the fish were taken from deep water aggregations off Tasmania's east and south coasts during the past three months alone," he said.

"A significant part of these

● Mr Llewellyn.

catches is landed here for processing."

The minister said that orange roughy exhibited a slow growth rate which indicated that the species could be susceptible to over-fishing.

He said that departmental scientists had been closely monitoring the size, composition and reproductive condition of commercial cathes as part of an intensive study of the species.

Mr Llewellyn said that he was concerned at the level of orange roughy waste in the industry, due to either burst nets or fish being dumped because of excessively large catches.

"I welcome timely action by fishermen who are acting responsibly by using net windows, which allow fish to escape once the net is filled to a manageable level," he said.

"I also welcome the announcement by the Environment Minister, Mr Aird, that the Tasmanian Development Authority and his department are investigating secondary processing of orange roughy waste in Tasmania."

North-west orange roughy processor, Stanley Fish Pty Ltd, has been ordered by the Circular Head Council to find an alternate site for dumping the fish waste by next Friday or it could face permanent closure.

The move comes following complaints from two members of the Environment Department after surveying the Stanley tip where the waste was being dumped.

Mr Llewellyn also announced that a special scientific workshop, including eminent Australian and New Zealand scientists, would be held at the Marine Research Laboratories at Taroona in September to consider the research findings on the orange roughy.

A code of practice is being developed to improve techniques

Slow start to new season for roughy

22 MAY 1990

Fishing - deep sea

The long-awaited and lucrative orange roughy season has started slowly off north-east Tasmania with dense aggregation of the deep sea school fish so far elusive.

A fleet of 25 trawlers, each worth $1 million or more, began fishing about 40 km off St Helens at midnight on Sunday, but none had returned by late yesterday and radio reports of catches have not been good.

A 12,000 tonne limit, worth about $30 million, has been tentatively placed on the 1990 catch, but could be increased or decreased as the season progresses.

The orange roughy industry is only three years old, and is already one of the Commonwealth's richest fisheries but little is known of the habits of the fish, which live a kilometre beneath the surface.

● Mr Llewellyn

The CSIRO has charted a vessel for intensive scientific research of the fishery during the season, and when necessary the fleet will stop fishing at its request to allow research to proceed.

The recommendations of the scientists will determine the exact limit of the catch. The Sea Fisheries Minister, Mr Llewellyn, has warned fishermen that all regulations will be strictly policed.

A second fishery near Matsuyker Island, off the south coast, will also be worked this year, and industry authorities are determined that neither fishery is over-exploited or wiped out for short-term gain.

Three years ago open slather fishing was permitted on the so-called "hot spot" off Cape Grim, which launched the industry. The fishery yielded thousands of tonnes, but a spokesman for the Tasmanian Fishing Industry Council, Dale Bryan, yesterday said that it had not reformed.

The season is expected to last up to three months during which the five major processors will employ several hundred people around the State.

The delicately flavored fillets sell for about $8 a kg, and more than half the catch is exported to the US and Europe.

Error allows East Coast fish haul to exceed quota

21 SEP 1990

Fishing deep sea

Orange roughy fishermen caught a third more fish than the quota allowed from the East Coast fishery this season — an extra 4000 tonnes — because of a "bureaucratic error".

An administrative bungle, worth $6 million to roughy fishermen and processors, has been blamed for 16,000 tonnes of the lucrative deep sea fish being landed, instead of the 12,000-tonne limit placed by the Federal Government.

Apparently, Government bureaucrats monitoring the progress of the catch off St Helens failed to keep up with landing receipts filed by processors, turning a $16 million catch into a $24 million catch.

A statement from Primary Industry Minister John Kerin's offices yesterday seemed to confirm this, claiming that a late season rush was partially to blame.

Mr Darby Ross, manager of the Hobart-based Austral Fisheries, which has two roughy boats, said that the season started slowly after opening last May.

"There was a major acceleration in catches late in the season and because of an administrative glitch, we thought we still had 8000 to go," he said. "But in reality, there were only 4000."

Mr Ross, who is involved with the Government Industry Technical Liaison Committee, the combined body responsible for researching the roughy fishery, thought the over-run would harm the fishery.

"The 12,000 tonne quota was always an arbitrary figure and I believe an overly cautious one."

Mr Ross said that the Minister's office would consider reducing the quota next year if the extra fish caught proved detrimental to the fishery.

The East Coast fishery off St Helens, known as "The Hill", has yielded 28,000 tonnes of the delicate orange roughy to deep sea trawlers in the past two years.

Scientists believe that The Hill is a permanent spawning aggregation of the fish and processors and fishermen have invested millions in gearing up for the roughy boom.

Scientific research is attempting to determine exactly what is a sustainable annual yield. Almost $1 million has been spent so far, yet little is still known about the fish, which lives 1000 metres below the surface.

A research vessel spent several weeks on The Hill this season, using sophisticated camera and sounding equipment, but CSIRO trawl fishery expert Dr Tony Smith said that the results would not be quickly forthcoming.

"This is the first year that a proper survey has been attempted and we still have many problems to overcome," Dr Smith said.

"It may be several years before we see concrete results."

The scientists have to work out the equations before they can discover any answers.

Probe into orange roughy dumping

Fishing deep sea

About 30 tonnes of orange roughy worth about $250,000 was dumped and buried on the Glenorchy tip yesterday.

The Primary Industry Minister, Mr Llewellyn, last night said there would be an investigation into the dumping.

It is believed to be the third in the past four months.

It is believed that the fish were held too long in the water after being caught and [illegible] some had discolored.

Warning of violence over fishing limits

Fishing deep sea — 9 SEP 1989

CANBERRA — Federal Government limitations on Tasmania's East Coast orange roughy fishery could lead to violence as fishermen fought among themselves for the limited catch, National Party deputy leader, Mr Lloyd, said yesterday.

The Primary Industries and Energy Minister, Mr Kerin, announced on Wednesday that fishermen would be allowed to take only a further 1000 tonnes of orange roughy until April 30, next year.

Mr kerin also said that an area off St Helens would continue to be closed to fishing, although the closed area would be reduced in size.

Mr Lloyd said the new restricted area meant that other fishermen after morwong, black Tasmanian trevally or blue grenadier had been banned from fishing an area of 500 square nautical miles.

He said the limit on orange roughy catches could be used to set quotas for next year's fishing, and fishermen would be desperate to catch as much as possible to ensure their quota was higher.

Mr Lloyd said fishermen had told him fights had broken out in similar circumstances in the past.

He said fishermen disputed federal research figures claiming there was between 100,000 and 500,000 tonnes of orange roughy in the area.

The fishermen said they had measured up to one million tonnes of the fish, Mr Lloyd said.

Roughy trawling ban to cost 90 jobs: claim

Fishing deep sea — 5 AUG 1989

By SARAH MAGUIRE

A two-week ban on the trawling of orange roughy off Tasmania's East Coast before the end of the season will result in the loss of up to 90 jobs, claims a St Helens fish processing factory owner.

Mr Ivan Bailey, of Georges Bay fisheries, said that the Government decision, announced yesterday by the Federal Primary Industries Minister, Mr Kerin, and his Tasmanian counterpart, Mr Llewellyn, would mean the loss of up to 70 jobs at St Helens' two fish processing factories and 20 jobs from trawlers.

The ban, which will come into effect at 1 am on Wednesday, applies to the orange roughy spawning aggregation off St Helens Point, which Mr Bailey estimates is fished by between 20 and 30 trawlers.

"We view it fairly seriously. We think they should've let the season run its normal course, then put in proper guidelines in consultation with New Zealand which has a lot more knowledge of the long-term effects," Mr Bailey said.

"It should have been a bit more of a research-based decision," he said.

But Mr Bailey stressed that the ban, during which scientists will conduct surveys to determine the size of the aggregation and the capacity of the stock to tolerate more trawling, was welcomed and vital for the formulation of a long-term management plan to secure the future of the orange roughy industry.

"To that extent, we're pleased something has been done," he said.

"If we can get a long-term fishery, the benefits to Tasmania will be tremendous.

"They just could have gone about it a little better."

Mr Bailey said that the orange roughy season usually lasted a few months while the fish were spawning and was expected to finish within a few weeks, but that smaller catches were made periodically outside of the season.

The Federal Primary Industries Minister, Mr Kerin, said that a cautious approach was needed in the harvesting of the species and that he shared with Mr Llewellyn concerns that continued fishing of the aggregation could threaten the sustainable yield of the orange roughy.

"We know very little about the size of the stock, but it is known that orange roughy is slow to replace itself and therefore easily over-exploited," Mr Kerin said.

"The overriding objective is to ensure the viability of the resource," he said.

"Orange roughy has been a major earner of export income for Australia and it is up to us all to ensure that this continues."

Mr Kerin said that he had also consulted with relevant Ministers and Fisheries Department heads in Victoria, NSW and South Australia, who had all been very supportive of the ban.

He said that the ban was the first step towards developing a comprehensive strategy for managing the fishery.

Move to stop fish waste

30 MAR 1990

The State Government is moving to implement a code of practice of all fin-fish after reports that a large shipment of orange roughy was dumped on a Hobart tip after being rejected for export processing.

Primary Industry Minister, Mr Llewellyn, said that he was tired of waiting for the Federal Government to act on a management plan for handling and landing of fish.

"I have just about run out of patience for the establishment of very tight and tough management and monitoring procedures for landing and monitoring the actual size of the catch that is landed in Tasmania and elsewhere," he said.

"And for the establishment of a code of practice to make sure that these sorts of things don't happen."

Mr Llewellyn said that he had instructed the Sea Fisheries Department to put into place a code of practice for Tasmania and welcomed an indication of support for the new code by the Tasmanian Fishing Industry Council.

Orange roughy ground closed

13 JUL 1990 Fishing deep sea

Acoustic and camera studies of East Coast orange roughy will mean the closure of the fishing area known as The Hill off St Helens this week and for another week at the end of July.

The Director of the Australian Fisheries Service, Mr Geoff Gorrie, said that the surveys would allow more accurate estimates of orange roughy numbers.

The first closure will end at 8 pm on Sunday, July 1, and the second will run from 11.59 pm on Tuesday, July 24, to 8 am on Wednesday, August 1.

The closures were foreshadowed by the Minister for Primary Industries and Energy, Mr Kerin, on April 26, after being proposed initially by the Government-Industry Technical Liaison Committee as part of the stock protection strategy for orange roughy.

the survey will be done by the CSIRO chartered research vesel, Tasmanian Enterprise, working 24 hours a day, and it is essential that other ships be out of the area during the survey.

The closures cover the same area as was closed in May this year, but this time not only will fishing be banned, but the carriage of trawl gear will be banned as well.

The work is regarded as important to help determine the total allowable catch for orange roughy in the Eastern zone of the fishery.

Concerns on roughy fishing

Fishing deep sea

By IAN MACPHERSON

11 JUL 1989

Uncontrolled fishing of orange roughy off the East Coast near St Helens has caused mixed feelings within the community.

About 15 mainland and Tasmanian boats, including large trawlers, have been engaged in uncontrolled fishing of orange roughy in the area for many weeks.

One local businessman has called for government controls to be applied before stocks are wiped out.

Mrs Christine Bailey, a partner in the Georges Bay Fishery, said that she had mixed feelings about the issue.

"The ocean is a vast harvest, but it's not a bottomless pit," Mrs Bailey said.

"We need scientific evidence to show us just what is out there, so we can be reassured that we are not going to be fished out.

"It must be a concern to everybody. My immediate raction is that we should be cautious," she said

"The quantity being caught is that large, it makes you wonder if we are doing the right thing."

Mrs Bailey said that on the other hand, the fishing plunder had meant an extra 31 local people getting regular work at the fishery.

"They are making good money," she said.

"Some of the boats are steaming off to Hobart and some probably to Melbourne."

Mrs Bailey said that there were no St Helens fishermen sharing in the bounty.

"Your're talking about hundreds of thousands of dollars to get into roughy . . . you need a fair size vessel and the licences are astronomical."

Mrs Bailey said that two years ago, orange roughy was caught off Devonport in even larger quantities.

"They were an absolute gold mine," she said.

Mrs Bailey said that for two months in the winter, orange roughy grouped together to spawn.

"That's why they are able to catch them the way they are.

"Once they spawn, then they disperse again," she said.

"So the boats won't be able to catch them in such vast quantities."

Mrs Bailey said that most of the fish being processd at the fishery would be exported to America.

"We're by no means doing the bulk of it, but our shed has been going flat out.

"We've put through about 80 tonnes in the last three weeks.

"Some people are saying they (the fish) will go on for another two months, but I think that's a bit hopeful.

"Four weeks would be more realistic," said Mrs Bailey.

"Financially it's been good for the town, but there's that nagging concern . . . are we overfishing."

Catch limit on roughy to protect the future

8 SEP 1989

Fishing deep sea

Fishermen and processors complaining about further restriction of the East Coast orange roughy fishery were irresponsible, the Sea Fisheries Minister, Mr Llewellyn, said yesterday.

The Federal Industry and Energy Minister, Mr Kerin, announced on Wednesday that only 1000 tonnes of orange roughy could be taken from the fishery off St Helens until April 30.

● Mr Llewellyn

Mr Llewellyn, replying to protests over the decision, said that he had no sympathy for the dissenting fishermen.

"If the fishermen want it all in one year then they will destroy their future," he said.

"This fishery has to be a sustained fishery for the State.

"Responsible fishermen understand this; only irresponsible fishermen are talking this way without considering the well-being of the industry.

"I have got no sympathy for them."

He said that claims of job losses caused by the decision were exaggerated.

"It is a seasonal fishery, they are only around for a few months so they can't complain that it will put people out of work," he said.

Mr Kerin said a limit of 15,000 tonnes had been set down for the fishery, after the Federal Government had considered a report form the South-East Trawl Management Advisory Committee.

But already 11,000 tonnes have been taken from the fishery since the season opened on May 1.

Mr Lewellyn said that caution was needed with the fishery because little was known about orange roughy and the fishery.

"We do know that they are slow to mature and can grow to between 60 to 70 years of age.

"We know that there is a spawning population there, and if we throw it open and fishermen can whale in then the spawning population might not return.

"And that would be totally irresponsible."

He said that a management plan had been structured by the SETMAC working party report with a monitoring process to be set up next season which would tie in with other studies.

Mr Llewellyn said that while the fishery was not under State Government control, he supported the decision by Mr Kerin.

"But because the fish caught are landed on our shore we want best value we can get through processing and so on," he said.

WWF

WWF is one of the world's largest and most experienced independent conservation organizations, with almost 5 million supporters and a global network active in more than 90 countries.

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- ensuring that the use of renewable natural resources is sustainable
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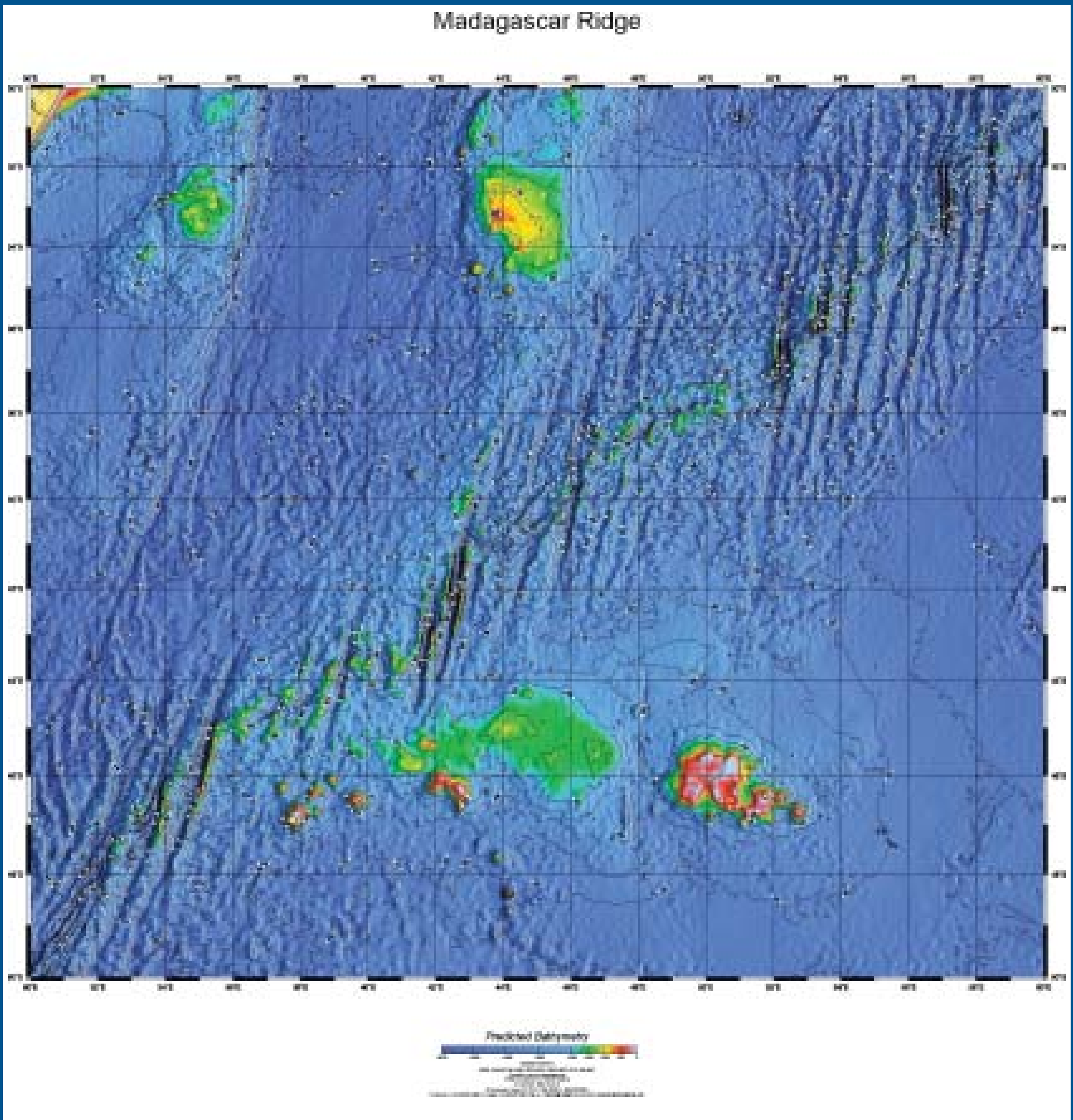
TRAFFIC Oceania is part of TRAFFIC, the world's largest wildlife trade monitoring netwrok which works to ensure that trade in wild plants and animals is not a threat to the conservation of nature.

TRAFFIC has offices covering most parts of the world, with its head office located in Cambridge, UK.

TRAFFIC is a joint programme of WWF, the conservation organization and IUCN-The World Conservation Union and works in close co-operation with the Secretariat of the Convention of International Trade in Endangered Species of Wild Fauna and Flora (CITIES).

TRAFFIC's mission is to ensure that trade in wild plants and animals is not a threat to the conservation of nature.



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