Seafood Watch
Seafood Report

MONTEREY BAY AQUARIUM®

Orange Roughy
(Hoplostethus atlanticus)

Final Report
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Melissa M Stevens
Fisheries Research Analyst
Monterey Bay Aquarium

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Monterey Bay Aquarium's Seafood Watch® program evaluates the ecological sustainability of wild-caught and farmed seafood commonly found in the United States marketplace. Seafood Watch defines sustainable seafood as species, whether fished or farmed, that can exist into the long-term by maintaining or increasing stock abundance and conserving the structure, function, biodiversity and productivity of the surrounding ecosystem. Seafood Watch® makes its science-based recommendations available to the public in the form of regional pocket guides that can be downloaded from the web (www.montereybayaquarium.org) or obtained from the program by emailing seafoodwatch@mbayaq.org. The program's goals are to raise awareness of important ocean conservation issues and to shift the buying habits of consumers, restaurateurs and other seafood purveyors to support sustainable fishing and aquaculture practices.

Each sustainability recommendation on the regional pocket guides is supported by a Seafood Report. Each report synthesizes and analyzes the most current ecological, fisheries and ecosystem science on a species then evaluates this information against the program's conservation ethic to arrive at a recommendation of "Best Choices", "Proceed with Caution" or "Avoid". In producing the Seafood Reports, Seafood Watch seeks out research published in academic, peer-reviewed journals whenever possible. Other sources of information include government technical publications, fishery management plans and supporting documents, and other scientific reviews of ecological sustainability. Seafood Watch Fishery Analysts also communicate regularly with ecologists, fisheries and aquaculture scientists, and members of industry and conservation organizations when evaluating fisheries and aquaculture practices. Capture fisheries and aquaculture practices are highly dynamic; as the scientific information on each species changes, Seafood Watch's sustainability recommendations and the underlying Seafood Reports will be updated to reflect these changes.

Parties interested in capture fisheries, aquaculture practices and the sustainability of ocean ecosystems are welcome to use Seafood Reports in any way they find useful. For more information about Seafood Watch® and Seafood Reports, please contact the Seafood Watch program at Monterey Bay Aquarium by calling 831-647-6873 or sending an email to seafoodwatch@mbayaq.org.

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Executive Summary

Orange roughy is an extremely deep-living species characterized by slow growth, great longevity (>100 years), late age at maturity (approximately 30 years), and low fecundity relative to other teleosts (bony fishes). Their aggregating behavior around prominent underwater features, such as seamounts, allows rapid exploitation and possible overfishing to occur. This has been the outcome on several fishing grounds around New Zealand, Australia and Namibia. Upon acknowledging significant declines, management has addressed this issue with continued biomass surveys of various fisheries, monitoring of commercial catch, biological research for stock assessment purposes, implementation of the Quota Management System (New Zealand, Australia), and severely restricted catch limits compared to historical levels. While the goal of each country's management is to reach sustainability, there are still many uncertainties with regard to biological knowledge of the species and its surrounding ecosystem, deep-sea oceanographic conditions, and general stochasticity of long-lived marine fish populations. Therefore, it is difficult to be confident that current quotas are indeed sustainable.

In addition, bottom trawling, the method used to catch orange roughy, causes considerable damage to benthic communities by reducing biomass, abundance, and overall diversity in trawled areas. Management has not adequately researched and addressed this issue, and many researchers advocate the protection of seamounts, which they feel sustains ecosystems in specific regions of the deep-sea. Habitat destruction, bycatch of non-target organisms (vertebrate and invertebrate), and overfishing result in this species being placed on our AVOID list.

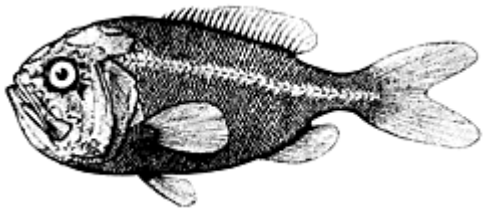
Sustainability Criteria	**Conservation Concern**			
	Low	**Moderate**	**High**	**Critical**
Inherent Vulnerability			√	
Status of Stocks			√	
Nature of Bycatch		√		
Habitat Effects			√	
Management Effectiveness		√		

Overall Seafood Recommendation for Orange Roughy:

Best Choices ▮ **Good Alternative** ▮ **Avoid** ▮

Life History Information:

Species Name: *Hoplostethus atlanticus*
Order *Beryciformes,* Family Trachichthyidae



(© CSIRO)

Distribution & Habitat:

The orange roughy is an extremely deep-living species that occurs in 500-1500 meters (m) worldwide (Koytylar 1996; Merrett and R.L. 1997), and is especially abundant off the coasts of New Zealand, Australia, southwest Africa (Namibia), and in the northeast Atlantic Ocean (Fig. 1) (Merrett and R.L. 1997; Horn et al. 1998). Orange roughy aggregate near prominent topographic features such as seamounts, plateaus and canyons, especially during spawning and feeding (Clark et al. 2000; CSIRO 2000; Annala et al. 2001). Other fishes associated with orange roughy in these habitats are the oreos (deep-sea dories), also fished commercially (Merrett and R.L. 1997).

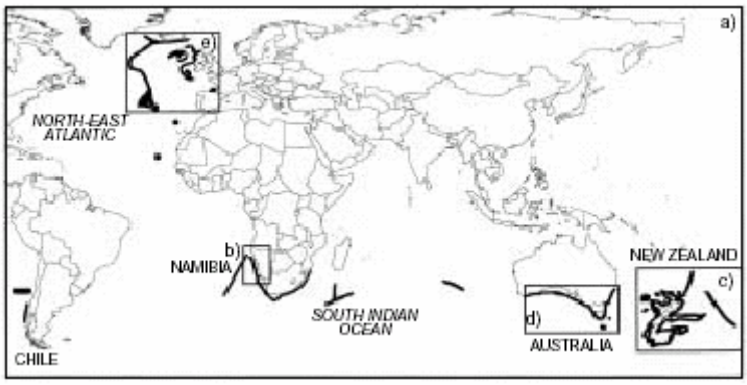


Figure 1: Worldwide distribution of orange roughy, courtesy of T.A. Branch (2001)

Life History:

Orange roughy, like many deep-dwelling fishes, grow slowly, live long (some live over 100 years), and mature later than most other marine fishes (~30 years) (Mace et al. 1990; Annala et al. 2001). They are commonly caught at 35 cm in length (Annala et al. 2001), but are known to obtain a maximum standard length of 50 cm and 3.6 kg (Annala et al. 2001), and have been recorded to 60cm (CSIRO 2000). Although debate continues as to the accurate maximum age, studies have indicated longevity up to130 years with age at first maturity between 20 and 32 years (Fenton et al. 1991; Smith et al. 1995; Horn et al. 1998). Radiometric studies (Fenton et al. 1991) have validated these ages. This kind of longevity, while astonishing to some, has gained wider acceptance as more deep-sea fishes are discovered to have similar longevity, such as rockfish (*Sebastes* spp.) and oreo dories (Stewart et al. 1995; Cailliet et al. 2001).

Orange roughy are synchronous spawners (Pankhurst 1988), forming dense aggregations for spawning and feeding events. It is thought they migrate up to 200 kilometers to spawn, as mature fish are widespread but spawning occurs in just a few specific areas (Francis and Clark 1998). Time of spawning varies between areas: in the southern hemisphere, spawning occurs from June to August (Clark 1995) (and is variable within that area), while in the north Atlantic near the Faroe Islands, the main spawning season is between late January and early March (Thomsen 1998). For most stocks, spawning occurs annually, though not all mature fish spawn every year (Bell et al. 1992; Zeldis et al. 1997; Annala et al. 2001). Mean length at maturity varies between regions, averaging 24 cm off South Africa and 42 cm in the northeast Atlantic (Horn et al. 1998; Thomsen 1998).

Fecundity is relatively low for orange roughy (Annala et al. 2001), ranging from 20,000-70,000 eggs kg body mass^{-1} (Pankhurst 1988; Clark et al. 1994; Koslow et al. 1995). Newly fertilized eggs, nourished by positively buoyant oil globules, ascend from deep spawning areas (~700m) to approximately 200m of water (Bulman and Koslow 1995). Egg development takes approximately 10 days; the eggs are thought to sink near the end of the development stage and hatch near the sea bottom (Bulman and Koslow 1995; Zeldis et al. 1995; Annala et al. 2001).

Distribution of young (0+ and 1+ cohorts) is not well understood because young orange roughy are rarely encountered during trawling operations (Mace et al. 1990). In New Zealand, large catches of juveniles have been found in only one area, at a depth of 800-900 m, 150 km east of the north Chatham Rise main spawning ground (Annala et al. 2001). Based on otolith (earbone) studies, young orange roughy are thought to grow very slowly; validated age and length data suggest that 3.1 cm, 5.5 cm, and 7.6 cm (standard) length individuals are 1, 2, and 3 years old, respectively (Mace et al. 1990). In this same study, parameters of the Von Bertalanffy Growth Function (VBGF: a commonly used growth model for fishes) were estimated. Maximum theoretical length (L_∞) was 42.5 cm and growth coefficient (k) was 0.059-0.075 year^{-1} (Mace et al. 1990). Compared to other teleost fishes, this growth rate is extremely low, lending to the emerging theory that deeper-living fishes grow slowly and live longer than their shallow water counterparts (Cailliet et al. 2001) (Tracey and Horn 1999). Natural mortality, based on otolith age data from a 1984 research survey of the Chatham Rise, is estimated at 0.045 year^{-1}; a similar estimate was obtained in 1998 from a relatively unexploited population in the Bay of Plenty off northern New Zealand (Doonan 1994).

Orange roughy are thought to be opportunistic predators, taking advantage of prey often associated with seamounts, such as prawns, squid and small fishes that drift past or migrate down during the day (Koslow and Bulman 2002) (Rosecchi et al. 1988). Other prey items include amphipods, mysids and decapod crustaceans, depending on local abundance of these items (Bulman and Koslow 1992; Thomsen 1998). Availability of prey on and around seamounts may explain non-spawning aggregations observed on certain fishing grounds (Bulman and Koslow 1992). Currents are intensified as they pass around seamounts, and eddies form in their lee, enabling the fish to stay in the same place to feed on their prey as it passes by, or to rest (Griffin 1999).

Availability of Science:

As evidenced in the above paragraphs, researchers have elucidated much about orange roughy life history. Some aspects of life history, such as maximum age, remain controversial, mainly due to issues regarding ageing methodologies (Gauldie and Cremer 1998). Additional

research has indicated genetic and biological differences exist between aggregations, but more work needs to be completed to be confident of the differences between stocks. Because orange roughy aggregate to spawn, abundance estimates gathered using acoustic surveying techniques are thought to be reliable (Bull et al. 2000).

Market Information

Common/Market names:

The common name for members of the Berycidae family is "slimehead". New Zealand marketing firms introduced this species to the world in the late 1970s with a new common name, orange roughy, due to its bright red/orange color and large, rough scales (Merrett and R.L. 1997) (Branch 2001).

Seasonal Availability:

Orange roughy is fished year round in various regions. Catch is highest during winter spawning seasons (June to August in southern hemisphere, January to March in north Atlantic).

Product forms:

Fresh, frozen fresh. May be refrozen with little tissue damage (Merrett and R.L. 1997).

Import/Export Statistics:

The National Marine Fisheries Service (NMFS), in conjunction with U.S. Customs and Census Bureau, track import and export statistics of all marine and freshwater products. U.S. exports of orange roughy are minor (brokered only), as the U.S. fleet does not participate in the fishery. Imports into the U.S. for orange roughy remained relatively steady over the last 6 years between 2,000 and 3,000 metric ton (mt) per year (Table 1).

Table 1: Annual Imports of orange roughy (fillets, kilograms) by top 10 countries (by volume), through U.S. Customs (NMFS 2001).

	Australia	New Zealand	Namibia	Japan	China	South Korea	Canada	Thailand	Vietnam	Chile	Total Imports (kg):	Total value (US$):
1995	519,960	7,874,429	94,099	14,590	0	0	32,539	441	0	0	8,539,918	80,271,933
1996	500,382	8,855,248	1,273,458	0	603,181	264,852	45,102	0	0	0	11,559,115	94,290,207
1997	737,610	7,519,544	3,646,112	8,544	1,080,517	98,102	7,294	0	0	19,050	13,124,299	98,676,729
1998	1,426,001	5,563,764	3,149,819	9,000	17,669	0	0	0	0	0	10,247,764	83,800,792
1999	1,557,746	5,258,863	940,560	0	887,395	0	20,645	0	0	172,508	8,836,533	92,317,698
2000	1,085,574	4,185,050	1,680,796	0	1,400,004	18,144	0	909,284	36,759	561,806	10,016,703	88,268,315
2001	862,146	4,017,685	1,014,488	11,115	1,769,198	0	4,304	375,819	0	580,070	8,771,978	68,947,893

Fishery Description & Stock Status

Fishing Range, Distribution, and Status:

The fishery for orange roughy first developed off New Zealand in 1979 and later in Australia (1980s), with South Africa (Namibia) and north Atlantic fisheries (Faroe Islands)

following in the 1990s (Fig.1). There is also a small fishery in the southern Indian Ocean, south of Madagascar (Strutt 2000), as well as the waters off the Juan Fernandez archipelago off southern Chile (Branch 2001). In the late 1980s the orange roughy catch was ~50,000 tons yr^{-1}, in 1990 it peaked at ~90,000 tons (~81,600 mt; FAO 1997), and in 1995-96 was down to just over 20,000 tons (Fig. 2; Branch 2001).

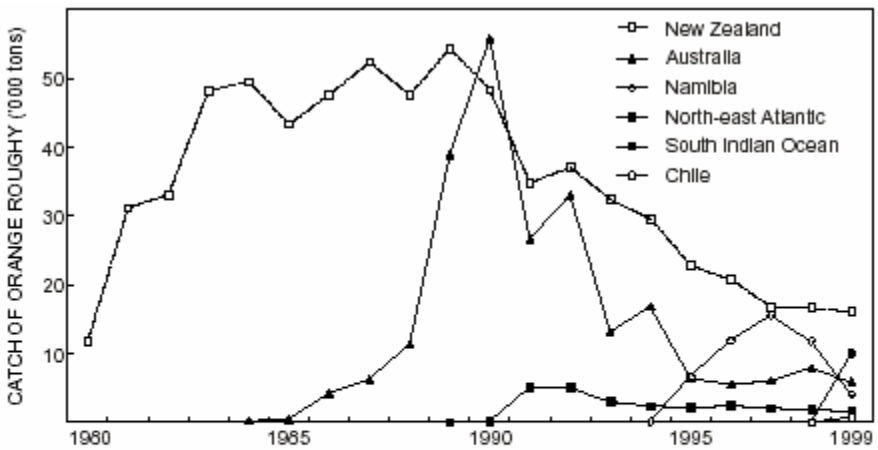


Fig. 2: Catch history of orange roughy around the world. The catches shown represent the year in which the fishing season ended. Most of the North-East Atlantic catches were made by France, the Faroe Islands and Iceland, and the remainder (<100 tons per year) by Ireland, the United Kingdom, Spain and Norway (catch data for 1999 incomplete). The 1983 and 1984 catches for New Zealand correspond to 15-month periods owing to a change in the timing of the season. Overruns are included only for Australia. For New Zealand assessment purposes, overruns are assumed to be 30% until 1984, gradually reduced to 10% in 1992 and reduced further to 5% after 1994–95 (Annala *et al.* 2000). Sources – New Zealand, Annala *et al.* (2000); Australia, Bax (2000); Namibia, McAllister and Kirchner (in press); North-East Atlantic, ICES (2000); South Indian Ocean fishery, Strutt (2001); Chile, government statistics (www.sernapesca.cl)

Courtesy of T.A. Branch (2001)

New Zealand:

Orange roughy continues to be one of the most valuable fisheries for New Zealand (Clark 1995). Historically exploitation focused on the "Spawning Box" of the Chatham Rise (Fig. 3), with annual reported catches of 40-50,000 tons $year^{-1}$ for most of the 1980s (Annala et al. 2001). The Challenger Plateau, Lord Howe Rise, Puysegur Bank, and Ritchie Banks have also been very productive orange roughy fishing areas in the 1990s.

Estimates of stock abundance vary between fishing regions around New Zealand. The management approved target level (B_{MSY}) is 30% of pristine biomass (B_o) (Annala et al. 2001), however, many stocks in New Zealand waters are now estimated to have decreased below this level, including a portion of those in Cape Runaway to Banks Peninsula (ORH 2A, 2B, 3A; Figs. 3, 7), Chatham Rise and Puysegur Bank (ORH 3B), Challenger Plateau and off the west coast of the South Island (ORH 7B; Annala et al. 2001). Two areas of the Chatham Rise (northeast and south) appear to show improved biomass or catches near the maximum sustainable yield (MSY) since the 1997 stock assessment (Annala et al. 2001).

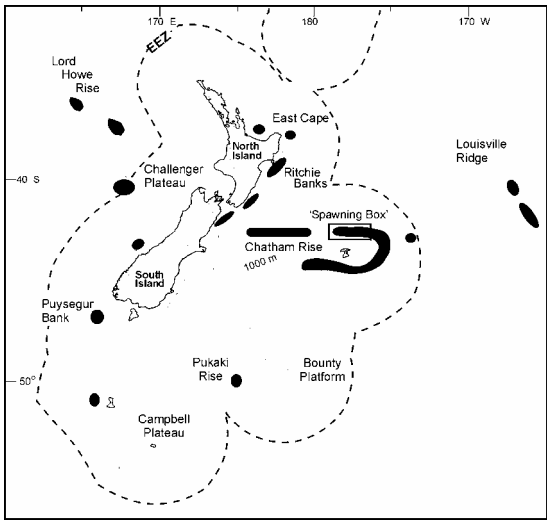


Fig. 3. Distribution of orange roughy around New Zealand. (Clark et al. 2000)

Australia:

Upon discovering its presence around 1980, commercial fishers began targeting orange roughy in waters surrounding southern Tasmania. Major spawning areas, such as "St. Helens, Maatsuyker, and Pedra Branca" were discovered and rapidly exploited (Fig. 4; Branch 2001). Annual catches ranged from 26,000 to 54,000 tons between 1989 and 1992 (Fig. 2; Branch 2001) before catch limits were severely restricted and individual transferable quotas (IFQs) were adopted (CSIRO 2000). Fishing on the South Tasman Rise (STR) developed rapidly in 1997, about the same time as Australian fishers protested the presence of non-Australian vessels near the southern boundary of the Australian Fishing Zone (AFR; CSIRO 2000). The Australian and New Zealand governments developed cooperative management strategies for the STR fishery in 1998, allocating a proportion of the catch from the area between the two countries (Tilzey 1999). The estimated catch from the STR fishery for 1999-2000 was 346 tons valued as AUS $835,000 (AFMA 2002).

Orange roughy is also caught in the Great Australian Bight (<400t/yr), off Western Australia (<250t/yr), and off Lord Howe Island (Fig. 4; CSIRO 2000).

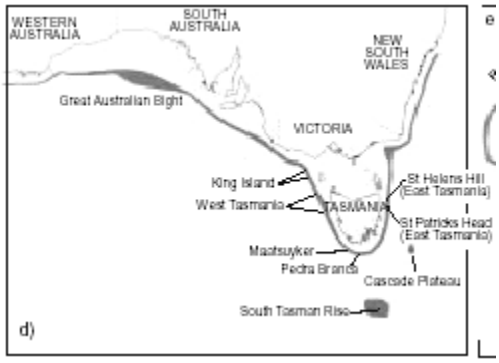


Figure 4: Distribution of orange roughy around southern Australia, (Branch 2001)

Namibia:

Initial exploration for orange roughy off the country of Namibia occurred in 1994 (Branch 2001). In 1995-96, four specific spawning grounds were discovered (NZODA 1998) and continue to form the focus of the fishery (Fig. 5b; Branch 2001). In 1997 total catch reached 15,500 tons; catch limits were enacted by the Namibian Ministry of Fisheries and Marine Resources with 3 companies and 5 vessels involved in the fishery (Branch 2001). Initial assessments suggested fishing effort could sustain a 50% reduction of original spawning biomass (Branch 2001); this turned out to be overly optimistic, and within 6 years the aggregating biomass dropped to 10-50% of pristine levels (Boyer et al. 2001). The total allowable catch (TAC) was accordingly reduced from 12,000 tons in 1998 to 1,875 tons in 2000 (Branch 2001).

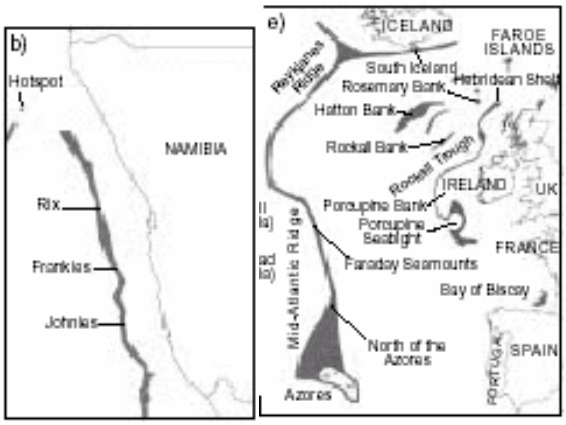


Figure 5: Distribution of orange roughy around b) Namibia, e) North-East Atlantic, Courtesy of T.A. Branch (2001)

Northeast Atlantic:

Early deep-sea fishery exploration in the northeast Atlantic was conducted by Russian trawlers primarily targeting roundnose grenadier (*Corypaenoides rupestris*) and Greenland halibut (*Reinhardtius hipposglossoides*) (Lorance and Dupouy 2001). Word of large orange roughy catches in the Southern hemisphere motivated a search for this species in the northeast Atlantic; in the late 1980s catches of many deep-water species, including orange roughy, increased (Charuau et al. 1995). French trawlers fishing in the area landed most of the area's catch in 1990s, up to 15,000 tons in 1996 (Anon. 1998). The Faroese fleet has taken their catch mainly from the area north of the Azores, peaking at 1,300 tons in 1996 (Fig. 5e Branch 2001). Icelandic trawlers began to fish for orange roughy south of Iceland in 1991, but catches have not been significant (<100 tons year^{-1}; Branch 2001). Infrequent catches are recorded by Spain, Ireland, the United Kingdom and Norway (Branch 2001).

Fishing Method & Impacts:

Commercial fishing for orange roughy requires heavy-duty trawl gear towed several kilometers behind and up to a kilometer below the vessel (Fig. 6; Clark 1999; CSIRO 2000). Trawling gear (from this and other fisheries) has been implicated in the destruction of benthic communities, as well as decreasing overall faunal diversity. Probert et al. (1997) examined bycatch occurring in orange roughy trawls from the Chatham Rise fishing area of New Zealand and found the largest bycatch to be slow-growing corals, which they suggested may take more than a century to recover (Probert et al. 1997). Another study by Clark et al. (2000) on this area

found declines in abundance of 10 of 18 bycatch species of fish and sharks from 1979 to 1997 (Clark et al. 2000). A photographic survey of the continental slope south of Tasmania showed that trawl operations remove a significant amount of organisms: the average benthic biomass of dredge samples from unfished seamounts was 106% greater than from heavily fished seamounts, and the number of species per sample was 46% greater than in trawled areas (Koslow 1999).

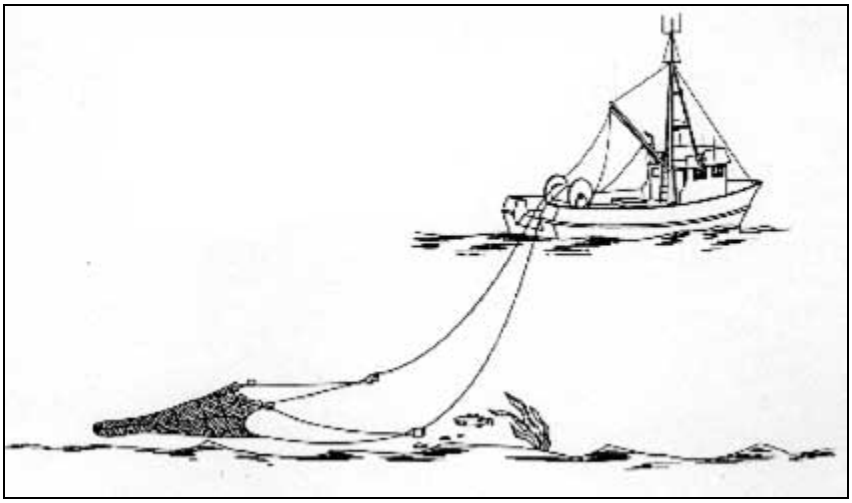


Figure 6: Diagram of bottom trawl (Courtesy: Matt Squillante)

While bycatch of other fishes is often low (due to the dense aggregating behavior of orange roughy), observed species landed with orange roughy around New Zealand include: black oreo (*Allocyttus niger*), smooth oreo (*Pseudocyttus maculates*; Puysegur Bank), deepwater dogfish (Squalidae), slickheads (Alepocephalidae), rattails (*Coryphaenoides* spp.), and basketwork eels (*Diastobranchus capensis*; Chatham Rise; Clark and Tracey 1993).

Management & Monitoring Information:

New Zealand:

The Ministry of Fisheries ("MFish") is the Government agency responsible for the conservation and management of fisheries within the 200-mile EEZ (exclusive economic zone) of New Zealand. MFish is charged with consistently monitoring the fishery resource and making timely and appropriate policy advice on all aspects of fisheries management to the Government. The Ministry is also responsible for carrying out the Government's policies to manage and conserve fisheries, and to actively encourage compliance of fisheries regulations by all fishers. Regulations are enforced through the use of commercially logged catch records, observer programs and surveillance teams (Staff 2002).

In 1986, New Zealand adopted the Quota Management System, whereby Individual Transferable Quotas (ITQs) were allocated to established fishers in the orange roughy fishery. Each ITQ represents a portion of the TACC (total allowable commercial catch), which is adjusted each year based on stock assessments and the best available scientific data (Annala et al. 2001).

There are 5 major fisheries for orange roughy around New Zealand as assessed by MFish (Fig. 7). Contributors to the management regime include MFish staff, science providers, and representatives of stakeholder groups (Annala et al. 2001).

1. Northern North Island (ORH 1)
2. Cape Runaway to Banks Peninsula (ORH 2A, 2B, & 3A)
3. Chatham Rise and Puysegur (ORH 3B)
4. Challenger Plateau (ORH 7A)
5. West coast South Island (ORH 7B)

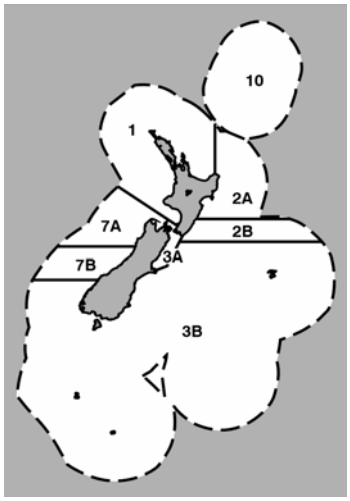
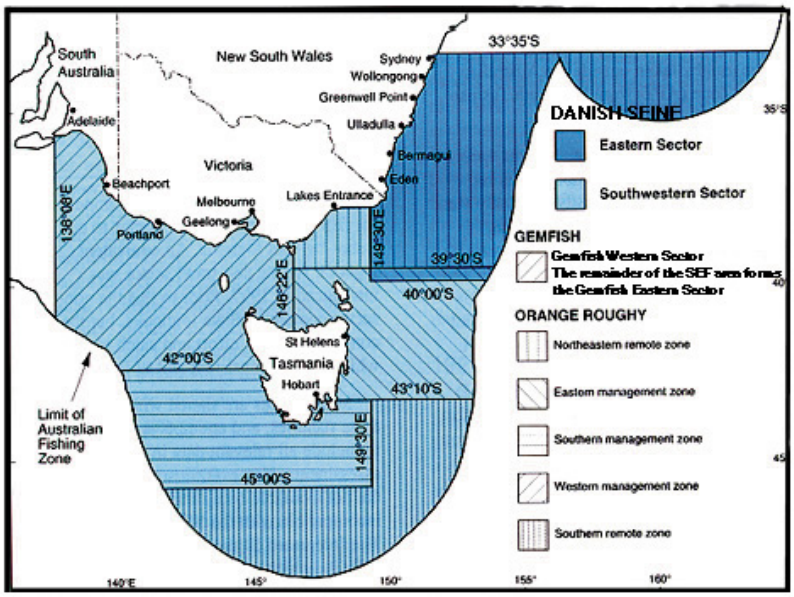


Figure 7: Orange roughy management zones, (Annala et al. 2001)

Australia:

Commonwealth regulation of the trawl fishery before the mid 1980s was based largely on individual state restrictions regarding gear and fish size. As stocks declined in the face of increased effort, fishery managers acted accordingly. In 1985 new vessels were restricted from entering the South East Trawl Fishery (SET), and in January 1992, ITQs went into effect for the orange roughy catch (AFMA 2002). Permits were distributed on a historical catch and vessel size basis to be renewed each year, as the TAC is reduced over time, allowing stocks to eventually rebuild (AFMA 2002). As of April 1999, there were 110 vessels participating in the South East Trawl Fishery, which operates on the South Tasman Rise (Fig. 8; AFMA 2002).



Management boundaries within the South East Fishery trawl sector. The management area for the non-trawl sector extends from the Western Australia – South Australia border to Fraser Island (Qld) with the exception of areas subject to State control. **Source: BRS Fishery Status Reports 1998**

Figure 8: Australia's Southeast Trawl Fishery (AFMA 2002)

Namibia:

Namibia's EEZ was created in 1990. Since the discovery of orange roughy stocks in 1994, the Namibian Ministry of Fisheries and Marine Resources, with help from the government of New Zealand, have established a management regime for orange roughy based on the precautionary approach (Charuau et al. 1995). Monitoring and surveillance activities include: "observers aboard every fishing vessel and monitoring of all landed fish (facilitated by the fact that landings are done in two ports only)…two patrol vessels and one patrol aircraft are active throughout the year. Furthermore, a Vessel Monitoring System is under evaluation." (Charuau et al. 1995). There is still a lack of trained Namibians in all sectors. The Namibian Maritime and Fisheries Institute is training crews for the industry as well as observers and inspectors (Charuau et al. 1995).

Northeast Atlantic:

Orange roughy and other fisheries in the northeast Atlantic are assessed and managed individually by countries, and as a collective through the North Atlantic Fisheries Organization (NAFO). The International Council for the Exploration of the Sea (ICES) gives scientific council. The waters in this area are shared collectively among interested fishing countries, including Canada, the U.S., the European Union, France, Iceland, Norway, and Poland (NAFO 2002). Participating NAFO countries have established the following regulatory measures:

> "*Hail reporting system of fishing vessels and air surveillance in Regulatory Area; improved inspections and transparency of apparent infringements; reporting of catch on board of fishing vessel and effort plans; minimum fish size and processed length equivalent; pilot project for observers and satellite tracking. These and other regulations became binding measures during 1994-95" (NAFO 2002).*

Recommendation

Orange roughy have been fished commercially for a little over 20 years. In that time, a majority of identified stocks have noticeably diminished, as evidenced by decrease in catch, disappearance of stocks in certain areas, and increased effort to land historical levels of fish. Because orange roughy are extremely long-lived, the effects of fishing activities may have yet to be fully appreciated. Management is addressing the issue of overfishing by limiting entry and allowable catch while monitoring stock recovery, but they have failed to address the overall effect of trawling and loss of considerable orange roughy biomass on the deep-sea ecosystem. Habitat destruction, bycatch of non-target organisms (vertebrate and invertebrate), and overfishing result in this species being placed on our AVOID list.

Sustainability Criteria	Conservation Concern			
	Low	Moderate	High	Critical
Inherent Vulnerability			√	
Status of Stocks			√	
Nature of Bycatch		√		
Habitat Effects			√	
Management Effectiveness		√		

Overall Seafood Recommendation for Orange Roughy:

Best Choices **Good Alternative** **Avoid**

Acknowledgements

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