ORANGE ROUGHY AND OTHER DEEPWATER BENTHIC FISHES

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Summary

Information on conditions under which deeper water fishes live is presented. Summary accounts of the taxonomic characteristics, distribution, biology, and fisheries for some of the world's major commercial deepwater species are given. The fishes covered are orange roughy, the grenadiers, scabbard fish, alfonsinos, oreosomatid fishes, and cardinal fish.

1. Foreword

The fishes covered in this section are deepwater fishes, inhabiting the continental slope at depths between about 500 m and 1500 m. For many countries with industrial fisheries, over fishing of the commercial fish species from the shelf has lead to the development of fishing in the deep water below 500 m. On these grounds some fishes live which are largely unknown on the traditional fish markets. Their forms are different from those of shelf fishes, often with characteristics of very large eyes, and strong coloration of the body from red or purple to black. They live in a less productive environment than fish on the continental shelf, and are often slow growing, and longlived. This makes the fisheries and their management very different from those in shallow water.

2. The Deepwater Environment

As one moves offshore away from the continental shelf to the slope, oceanic conditions in which fishes live change substantially. The amount of light penetrating the sea decreases with depth, and even in the clearest water light is not detectable below 1000 m. Phytoplankton production occurs only in the top 200 m of the water column, so the amount of energy directly available to deepwater fish is reduced. Biological material disperses as it sinks to the sea floor, to enter the benthic energy cycle unless upwelling occurs to bring it back to upper water layers. Many of the animals that live in the mesopelagic zone undertake vertical migrations to feed in the upper layers at night, and return to greater depths during the day. Although the bulk of primary and secondary production is near the surface, the migration of zooplankton down to depths of 800–1000 m brings this energy to deepwater fish that don't themselves migrate.

Physical and chemical conditions of waters of the continental slope are generally more uniform than in shallow water, although can still vary considerably in localized areas. Water temperatures are typically 4–6°C at depths of 800–1000 m, and at these depths several major water masses are characterized by low salinity. Oxygen levels vary with depth, but deep bottom sediments are often oxidized, and anoxic conditions don't occur.

Pressure is a major factor in deepwater, as it increases by one atmosphere for every 10 m depth. Fishes must therefore be able to cope with much higher pressure than surface animals, and be adapted accordingly. Currents are generally less than at the surface, but deep oceanic current flows, and localized tidal effects can extend to below 1000 m.

Topography of the continental slope is highly variable. It is not a uniform bottom contour, and many areas where deepwater fisheries occur are characterized by topographic features such as seamounts, ridges, and canyons which can cause localized upwelling, or conditions suitable for aggregations of fish.

3. Orange Roughy, *Hoplostethus atlanticus*, Collett, 1889

The orange roughy is one of 55 species of the Trachichthyidae family or slime heads, characterized by mucus cavities on the head, a distinct spine at the preopercle angle, the pelvic fins with one normal spine and six or seven soft rays and the abdomen with a median ridge of scutes. Most slime heads occur in deep water. The orange roughy is a big fish, reaching 60 cm SL. The color of the body is red to dark orange. The opercular membrane is black. In contrast to many teleosts, their swim bladder is not filled with a gas or air, but a waxy substance.

Orange roughy live along the slope between -450 m and -1700 m, but mostly from -800 and -1 200 m. The species occurs in most oceans of the world, with the apparent exception of the North Pacific Ocean. They live in a range of habitat, and occur in small numbers over large areas in the appropriate depth range, but frequently form aggregations on or near seamount features and canyon edges. They generally stay within 50–100 m of the seafloor, and do not undertake extensive vertical migrations.

Commercial trawl fisheries developed in the late 1970s off New Zealand, and since then new fisheries have started in a number of countries around the world. The main fishing grounds occur in the Southern Pacific where 33 000 mt were caught in 1996 mostly by New Zealand (about 30 000 mt) and Australia (3500 mt), the Eastern Indian Ocean (400 mt caught by Australia), the Western Indian Ocean, the Southeast Atlantic (13 000 mt caught by Namibia) and in the North Atlantic (around 2000 mt taken by Faroes and France). The total catches in 1996 according to the fishery statistics of FAO were 47 000 mt. Since then, catches have decreased with reduced allowable catch quotas in New Zealand, Australia, and Namibia, as the fisheries have become fully exploited. The total reported catch in 1998 was 37 000 mt. New fishing grounds have recently been developed in the Indian Ocean (in international waters) and off Chile. A feature of all orange roughy fisheries is the dense aggregations that form, enabling very high catch rates, with large catches able to be taken in a very short time (a few minutes or less).

The fish are caught by bottom trawl gear, with some limited mid-water fishing. It is a valued food fish, marketed fresh or frozen, as skinless, boneless fillets. The flesh has a mild taste, and can be cooked in a wide variety of ways.

Orange roughy can form very large schools for reproduction. They may undertake substantial migrations to the spawning grounds, in some areas off New Zealand moving several hundred km. For spawning they aggregate near the bottom, but plumes can extend up to 100 m above at times Females generally reach sexual maturity at about 30 cm in length, although this varies between fishing grounds They are single determinate batch spawners, with developing maturation of gonads from 5–6 months prior to spawning during winter months. Off New Zealand, Australia, and Namibia spawning takes place between mid-June and early August. This occurs in a number of separate spawning grounds, with 11 major sites known in the New Zealand region, 2 in southern Australia, and 4 off the Namibian coast. The location and timing of the formation of aggregations for spawning is very consistent between years. The actual timing of spawning may be related to shortening daylight length towards the middle of winter. Off the British Isles, spawning takes place from the end of January with a maximum in February and March. Depending on fish size, females have from 30 000 to 380 000 eggs. Fecundity varies between locations, and over time within a population. In Australia, fecundity increased as stock size declined in the early 1990s, possibly a compensatory response to fishing. It is likely that females do not spawn each year, as in many areas off New Zealand and Australia about half the large fish do not develop their gonads in any given year. The eggs are large (over 2 mm diameter) and pelagic, rising to near the surface before sinking again to hatch close to the bottom after about 10 days. Little is known about larval stages and distribution, but small juveniles are believed to recruit to near-bottom waters after 1 year.

The size of orange roughy differs between parts of the world. Fish in New Zealand and Australia are typically about 35 cm SL, those off Namibia around 25–30 cm, and in the North Atlantic about 50 cm SL. These differences are possibly related to the length of time prior to maturation, after which adult growth is believed to be very slow.

Interestingly, the size frequency of the stocks in New Zealand and Australian waters has not changed substantially, despite heavy fishing pressure for between 5 and 15 years. Reasons for this are uncertain, but it might reflect that recent recruitment levels (in the last 10–20 years) have been relatively low over a large geographical area, and new recruits have not been entering the population in sufficient numbers to shift the size structure towards smaller fish.

In the Southwest Pacific, the growth of orange roughy is believed to be very slow. Fish don't mature until about 25 years of age, and the bigger fish might live to over 100 years. Growth and longevity of orange roughy is subject to keen scientific debate. Age has been estimated by otolith zone counts, measurement of Pb-Rn radioisotope ratios, daily otolith growth increments, and micro chemical composition. Results have varied, although most indicate high longevity. Maximum ages from the various techniques range from 15–20 years to several hundred years. Juvenile ages (to 5 years) for New Zealand fish based on otolith zone counts have been validated by modal length analysis, but adult ages have not.

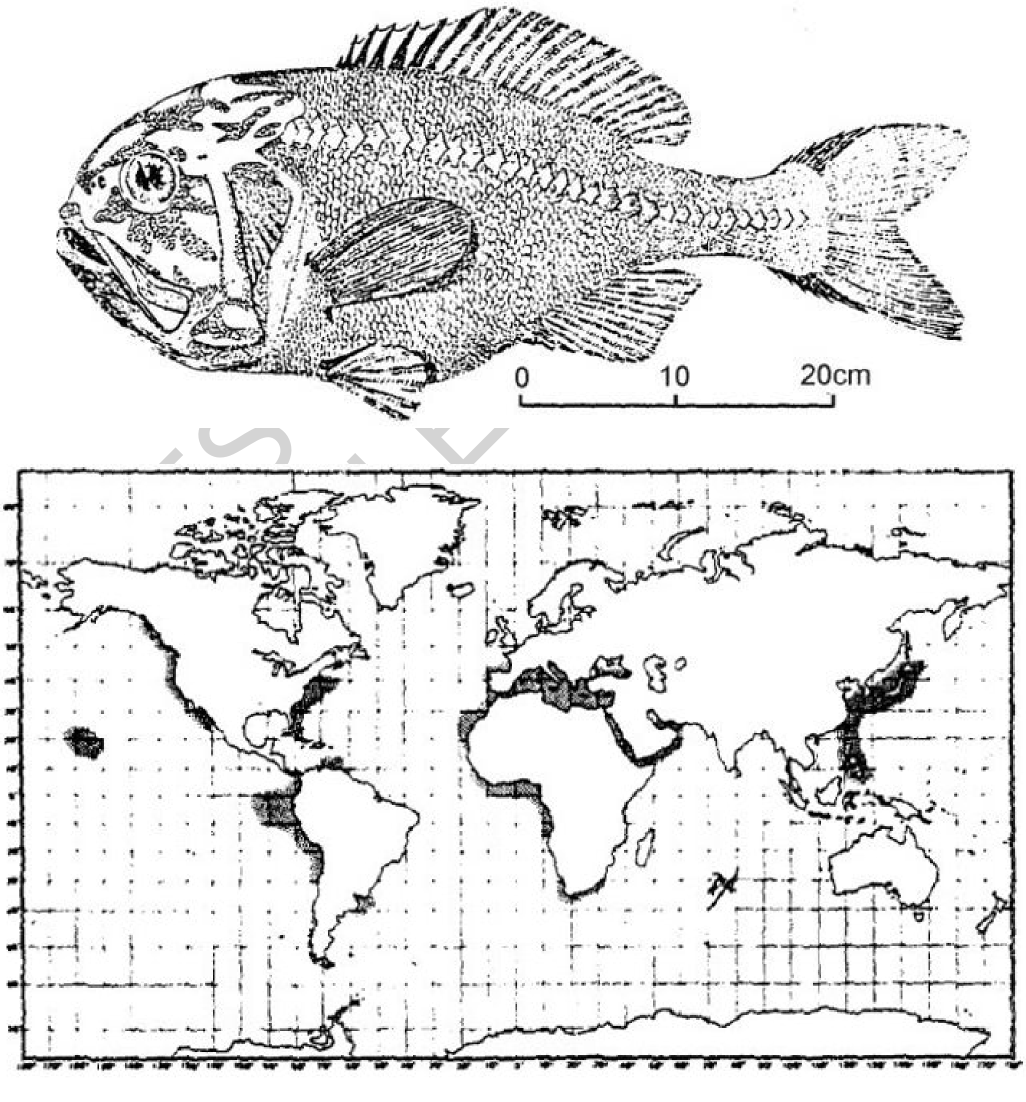

Figure 1a. Orange roughy. 1b. Map of the distribution of orange roughy

Slow growth and high longevity means that orange roughy is a relatively unproductive species. Long-term sustainable yields for the fisheries are much lower than for most commercial shelf species, and their recovery from over fishing may be slow. They are also vulnerable to depletion by commercial fishing, because of their dense schooling behavior, and the predictable location and timing of spawning and feeding aggregations. In both New Zealand and Australia, stocks have been fished down rapidly, and quota levels have had to change dramatically in recent years as stock sizes declined and in some cases became over fished.

In the Southwest Pacific, orange roughy feed on shrimps, squids and fishes. Prey composition varies with area, size of fish, and depth distribution. They are benthopelagic feeders, probably taking their prey close to the bottom.

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Biographical Sketches

Malcolm R. Clark gained his PhD in fisheries science from Victoria University of Wellington (N.Z.). He joined the Deepwater Fisheries group of The Ministry of Agriculture and Fisheries as a fisheries scientist researching orange roughy in 1985. He is now the Principal Scientist of the Deepwater Fisheries Research Group at NIWA in Wellington. He has carried out research on orange roughy and other New Zealand deepwater species since 1985, with a focus on stock assessment. New Zealand has been at the forefront of deepwater fishing, research and management, and Malcolm has advised on aspects of the development, research, and management of deepwater fisheries in New Caledonia, Namibia, and Chile. Results of his scientific work have been presented widely at international conferences in recent years, in particular the lessons to be learned from the New Zealand experience with deepwater fisheries. Other areas of research expertise include trophic studies, seamount ecology, and the impacts of fishing on benthic habitat. Author of over 25 scientific papers on the fisheries, biology and ecology of deepwater fishes, as well as numerous less formal reports, documents, and popular articles.

Jean-Claude Quero has been an ichthyologist and taxonomist at ISTPM/IFREMER (France) at the Laboratory of La Rochelle, since 1966. He has been co-author in Clofnam (UNESCO), 1973, Fnam (UNESCO), 1984-1986 and editor of Clofeta (UNESCO), 1990. He was a key contributor and co-author of FAO species identification sheets, fishing area 34, 47; French reviser of text of OECD 1990; author of a popular treatise on the commercial French fishes and editor of one on other commercial marine products. He has published widely on fish taxonomy, and is the author of many scientific notes.