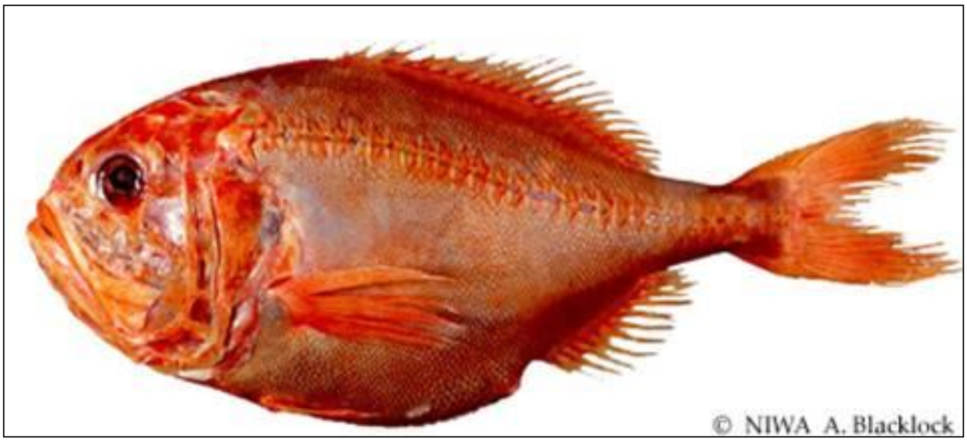
South Pacific Regional Fisheries Management Organisation

FAO species code: ORY
Scientific name: *Hoplostethus atlanticus*



Taxonomy

Phylum	Vertebrata
Class	Actinopterygii
Order	Beryciformes
Family	Trachichthyidae
Genus	*Hoplostethus*
Species	*Hoplostethus atlanticus* (Collet, 1889)
Scientific synonyms	*Hoplostethus gilchristi*, *Hoplostethus islandicus*
Common names	Orange roughy, slimehead, atlantischer sagebauch, burfiskur, deep sea perch, degenfisch, granatbarsch, huichidai, kaiserbarsch, olho-de-vidro, orenzi rufi, red roughy, reloj, soldakfisk, l'Empereur
Molecular (DNA or biochemical) barcoding	Available in the Barcode of Life Data System (BOLD), at: http://www.boldsystems.org/index.php/Taxbrowser_Taxonpage?taxid=11104

Species characteristics

Global distribution and depth range

Hoplostethus atlanticus has been reported in the North Atlantic from Nova Scotia to Norway, down the eastern South Atlantic to South Africa and across the south-central Indian Ocean to Western Australia. In the Pacific region it occurs along the shelf edge of southern Australia, on ridge and hill features in the Tasman Sea, around the entire New Zealand shelf, on hill features and ridges to the east of New Zealand, and off central and southern Chile (Branch, 2001). It has been recorded from depths of 180 m to at least 1800 m though their maximum depth range is unknown (Kotlyar, 1996). In the Pacific they are seldom recorded shallower than 500 m and are most common in depths from 700 m -1100 m (Anderson et al. 1998). There are suggestions of an ontogenetic shift in depth from shallower-to-deep waters (Dunn et al. 2009; Dunn & Forman 2011).

Distribution within South Pacific area

The area in the Southwest Pacific known to be occupied by this fish outside EEZs on the high seas based on catch and effort data reported to Australia and New Zealand (Clark 2006), scientific observer data and habitat assumptions – is about 220,000 km^2.

General habitat

In the South Pacific, orange roughy aggregate in cold waters (3-9˚C) at depths between 800 and 1,600 m. Aggregations form on steep continental slopes, and over canyons, ridges, and other underwater topographical features such as seamounts, especially for spawning and feeding (Clark et al. 2000, Uiblein et al. 2003, Clark et al. 2016). Orange roughy are bentho-pelagic, generally occurring near the bottom but at times ascending to feed or spawn 50-200 m above the seafloor around areas with higher water mass movement (Lorance et al. 2002). Orange roughy are considered a relatively sedentary species that show little movement between fisheries management zones based on the evaluations of parasite and trace-element analyses (Edmonds et al. 1991).

Biological characteristics[1]

Morphology

Morphology: four to six dorsal spines, 15-19 soft dorsal rays, three anal spines, and 10-12 soft anal rays; 196-25 ventral scutes. Pale orange through bright brick red in colour, with mouth and gill cavity bluish black.

Reproduction

Spawning occurs in a few specific areas, generally at depths of 700-1000 m and associated with bottom features such as pinnacles and canyons, and it is believed that some individuals may migrate up to 100 km to reach a spawning ground (Coburn & Doonan 1994, Francis & Clark 1998). Time of spawning in the southern hemisphere extends from May to August (the southern winter) with differences in the onset of spawning between areas which seems to be

[1] It should be noted that most of the reported biology is based on data collected from within EEZs. However, from the data collected on the high seas most of these assumptions about orange roughy biology appear to hold.

consistent from year to year (Pankhurst 1988, Bell et al. 1992, Young et al. 2004). Although spawning occurs annually, apparently not all mature fish spawn every year (Bell et al. 1992, Branch 2001, Doonan 2013), with the age at which 50% of fish spawn estimated to be between 32-41 years (Cordue 2014). In the Southwest Pacific, fecundity is relatively low, ranging from 20,000–70,000 eggs per kg of body weight (Pankhurst 1988, Clark et al. 1994, Koslow et al. 1995), while fecundity in the Southeast Pacific has been estimated to be slightly greater, ranging from 16 056 -115 944 egg per kg body weight (Young et al. 2004). Newly fertilised eggs are 2-3mm in diameter and rise in the water column as they develop but are thought to sink near the end of the development stage to hatch near the bottom about 10-20 days after fertilisation (Bulman & Koslow 1995, Zeldis et al. 1995). The distribution and behaviour of young (<3 years old) orange roughy is poorly known because they are rarely encountered during trawling (Mace et al. 1990), but they are likely to be demersal from at least 6 months after hatching. Juvenile fish have yet to be found in Chilean waters (Young et al. 2003).

Sexes do often co-occur (e.g., Anderson 2011). Seasonal catch samples from particular grounds are seldom strongly biased to either sex, but samples from individual trawl tows can be strongly biased, likely indicating sexually distinct substructure in aggregations, particularly during spawning.

Length at maturity and growth

Orange roughy are synchronous spawners (Pankhurst 1988, Young et al. 2004). The onset of sexual maturity has been associated with the formation of a transition zone found in the otoliths of large fish, where annuli width changes permanently from being wide and opaque to fine and more translucent (Francis & Horn 1997; Horn et al. 1998). On the basis of this assumption, Horn et al. (1998) found significant differences in mean size and age at sexual maturity between grounds off Namibia, New Zealand, Tasmania and Hatton Bank southwest of the United Kingdom, with a greater age at onset of maturity found at grounds with a greater modal length of the mature population. In the southwest Pacific, size and age at maturity parameters range from 28-34 cm and 23-31 years. Gili et al. (2002) also examined the transition zone and estimated for the Chilean stock fishery in the southeast Pacific that length at onset of maturity was about 33cm at 30 to 32 years. These parameter values are similar to those reported in New Zealand, although modal lengths for mature individuals are bigger for the Chilean grounds.

Orange roughy can reach up to 58 cm standard length in the southern hemisphere, especially off central Chile where on average fish are larger than in New Zealand, Australia, and Namibia. Sexual dimorphism in length is evident, with females generally reaching a larger size than males across the South Pacific (Tingley & Dunn 2018).
Age and growth estimates of orange roughy from a number of localities have been investigated and revised over the years, indicating that this species can live in excess of two centuries (Tracey & Horn 1999, Gili et al. 2002, Horn et al. 2016, Horn & Maolagáin 2019). Annual zone formation in the otoliths of juvenile fish were initially validated by Mace et al. 1990, indicating very slow growth to a length of only 7.6 cm after 3 years. Decay rates of naturally occurring radionuclides in otoliths to age fish were then first applied to orange roughy by Felton et al. (1991), who concluded that fish 38-40 cm long were 77-149 years old. Additional work by Smith et al. (1995) and Francis (1995a, 1995b) reanalysed the data, and concluded that the longevity of this species probably exceeded 100 years. Radiometric ages were shown to correlate with those derived from counts of zones in otolith thin sections (Smith et al. 1995). Age estimates in excess of 130 years were derived using the thin section method (Branch 2001, Gilli et al. 2002), indicating a very slow growth rate for this species. More recent and sophisticated radiometric ageing have confirmed longevity of at least 100-150 years (Andrews and Tracey 2003, 2007),

with several specimens from the Louisville Seamount Chain recently being aged at up to 230 years – the oldest age estimate for orange roughy thus far (Horn & Maolagáin 2019).

The growth and productivity parameters used for populations in assessments of New Zealand's EEZ orange roughy stocks have been: L_∞ between 33 and 38 cm (dependant on sex and area), k_{male} = 0.070 yr^{-1}, k_{female} = 0.061 yr^{-1}, *M*= 0.045 yr^{-1} (Fisheries New Zealand 2021). Parameters used for orange roughy assessments in Chilean waters have been females: L_∞ = 48.7 cm, k = 0.03 yr^{-1}, *M* = 0.04 yr^{-1}; males: L_∞ = 43.5 cm, k = 0.04 yr^{-1}, *M* = 0.04 yr^{-1} (Gilli et al. 2002, Payá et al. 2005). Australian productivity parameters vary between populations. For the continental slope populations (St Helens and southern Tasmanian populations); females: L_∞ = 31 cm (22-40), k = 0.048yr^{-1}, *M* = 0.04 yr^{-1}; for males: L_∞ = 40 cm (28-52), k = 0.064 yr^{-1}, *M* = 0.04 yr^{-1} (Smith et al. 1995). While eastern Australian populations show a combined: L_∞ = 38.6 cm, k = 0.060 yr^{-1}, M= 0.04 yr^{-1} (Upston et al. 2014). Fish on the Cascade Plateau are larger and longer-lived with an M of 0.02 (Wayte & Bax 2007).

Biological productivity

Orange roughy have low productivity. This is due to a combination of the late onset of maturity, and low annual growth rate in relation to size.

The proportion of biomass that can be harvested sustainably is relatively small. These annual harvest values have been estimated to be between 2.1% and 2.3% of virgin biomass (Cordue 2014).

Role of species in the ecosystem

Orange roughy are a dominant species demersal fish species at depths of 750-1100 m. An analysis of New Zealand demersal fish assemblages using research trawl data found them to be the most frequently occurring species in the mid-slope assemblage (Francis et al. 2002).

Orange roughy are thought to be opportunistic predators taking advantage of prey often available around underwater features—usually prawns, squid, and small fishes (Rosecchi et al. 1988, Labbé & Arana 2001, Koslow & Bulman 2002). Other prey items include amphipods, mysids, and decapod crustaceans (Rosecchi et al. 1988, Bulman & Koslow 1992). Juveniles feed mainly on crustaceans, switching to squid and fishes as they grow larger (Stevens et al. 2011). Food consumption is considered to be higher in this species compared to other deepwater fishes due to their faster metabolism (Koslow 1997).

Predators of orange roughy are likely to change with fish size. Larger orange roughy have been observed with healed soft flesh wounds, typically in the dorso-posterior region, the shape and size of which suggest they were caused by a species of deepwater dogfish (Dunn et al. 2010). Giant squid and sperm whales have also been observed to prey upon orange roughy (Gaskin & Cawthorn 1967; Jereb & Roper 2010).

Impacts of Fishing

Habitat damage

The main gear used to catch this species is a high-opening demersal trawl generally fished the seabed (on flats and slopes), or with doors and parts of the sweeps off the seafloor (on underwater topographic features). Trawling for orange roughy, like trawling for other species, is likely to have long-term effects on the benthic community structure and function where fishing occurs (e.g., Rice 2006, Clark et al. 2019) and there may be consequences for benthic productivity (e.g., Jennings et al 2001, Hermsen et al 2003, Hiddink et al 2006, Reiss et al 2009).

Underwater topographic features such as seamounts, knolls and pinnacles are widely regarded as fragile habitats and are susceptible to damage from such practices (Althaus et al. 2009, Clarke et al. 2010), along with the habitat-forming species that reside upon them and contribute to local-scale habitat complexity and relief (Clark and O'Driscoll 2003, O'Driscoll and Clark 2005, Koslow et al. 2001). The effects of trawling on orange roughy populations at smaller spatial scales are currently unknown due to a paucity of studies on species-habitat interactions (i.e., if there are specific habitat-forming species orange roughy associate with).

The Cumulative Bottom Fishery Impact Assessment for Australian and New Zealand bottom fisheries in the SPRFMO Convention Area, 2020 (SC8-DW07_rev1) reviewed and assessed habitat impacts of demersal fisheries. It also assessed the extensive and complex management in place to mitigate benthic impacts within SPFRMO, which is mainly based on spatial restrictions of fishable areas.

Other considerations

It is unknown whether fishing during spawning or other diel behaviours disrupts activities or spawning success of orange roughy, as has been concluded for other deepwater fish (e.g.,van Overzee & Rijnsdorp 2015). Koslow et al. (1995) and several others observed intensive avoidance behaviour of orange roughy to approaching large objects in the pelagic environment.

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