9th MEETING OF THE SCIENTIFIC COMMITTEE

Held virtually, 27 September to 2 October 2021

SC9-Doc12

Species Profiles
Secretariat

Background

At the second 2021 SPRFMO SC Web Meeting (29/30 June 2021) it was noted that the Species Profiles on the SPRFMO website require updating and Working Group Chairs were asked to coordinate revisions for the relevant resources. This document contains a compilation of the updated Species Profiles as of 28 August 2021, with further updates and revisions welcome.

PO Box 3797, Wellington 6140, New Zealand
P: +64 4 499 9889 – F: +64 4 473 9579 – E: secretariat@sprfmo.int
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Code: BWA

Scientific name: *Hyperoglyphe antarctica*

NIWA, New Zealand

Phylum	Vertebrata
Class	Actinopterygii
Order	Perciformes
Family	Centrolophidae
Genus and species	*Hyperoglyphe antarctica* (Camichael, 1819)
Scientific synonyms	*Mupus perciformis* (non Mitchell 1818), *Perca antarctica* (Carmichael 1918), *Palinurichthys antarcticus* (Carmichael 1918), *Diagramma porosa* (Richardson 1845), *Palinurichthys porosus* (Richardson 1845), *Hyperoglyphe porosa* (Richardson 1845).
Common names	Bluenose (Australia, New Zealand, UK), Antarctic butterfish, Antarkiese bottervis (South Africa), Antarktischer Schwarzfisch (Germany), Antarktisk sortfisk (Denmark), Big-eye, Deep Sea Trevalla (Australia), Matiri (New Zealand).
Molecular (DNA or biochemical) bar coding	No information available

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Species Characteristics

Global distribution and depth range

Bluenose has a widespread distribution in southern temperate oceans between the latitudes of about 25°–55° S. It has been recorded from Tristan da Cunha in the central south Atlantic, off South Africa, from various islands and submarine features across the Indian Ocean to the South Pacific. Adults of the species occur from depths of about 40 m to at least 1000 m (Anderson et al. 1998).
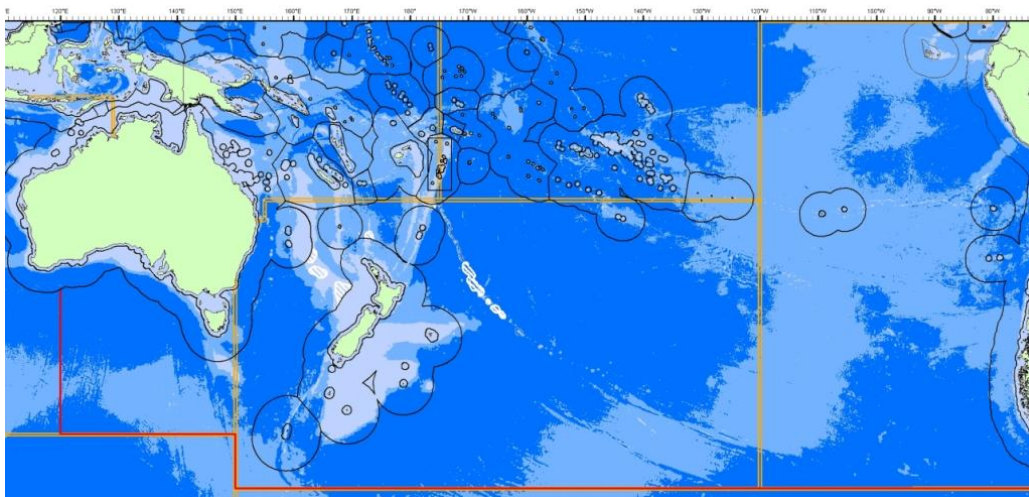

Figure 1: South Pacific high seas distribution of *Hyperoglyphe antarctica*.

Distribution within South Pacific area

Bluenose is present in the waters off South Australia and Tasmania, in the Tasman Sea as far north as New Caledonia, and throughout much of the New Zealand EEZ (McDowall 1982; Duffy et al. 2000). In the South Pacific they appear most abundant between about 200 m and 750 m (see Figure 1).

Relatively little is known about spawning aggregations and migratory movements. Tagging survey data indicate that bluenose may be generally sedentary in the short term (6-8months), although age specific migration may occur (Horn 2003).

Bluenose may also occur on the Foundation seamounts in the mid South Pacific.

General habitat

Bluenose are benthopelagic and occur most commonly over or near rocky areas, and at the edges of canyons and steep drop-offs at depths of 100-300 m (Armitage et al. 1994). Generally, bluenose remain close to the seabed during the day and move up in the water column at night (Kailola et al. 1993). Reports on their patterns of diurnal vertical migration are contradictory. Winstanley (1978) concluded they lived near the sea floor at night, and moved upwards during the day to feed; the review in Kailola et al. (1993) states the opposite. It is apparent from New Zealand commercial catch data that bluenose can be caught above the bottom during the day and night. Juveniles inhabit surface waters, sometimes far offshore, in association with floating debris (Last et al. 1993; Duffy et al. 2000).

Bluenose appear to prefer cold water as part of their habitat characteristics (Kailola et al. 1993). Schools of relatively small adults (50–60 cm) are occasionally taken by trawl over smooth, muddy substrates.

Biological characteristics

In the fist two years bluenose grow relatively quickly, to average sizes of 31 and 45cm fork length in the first and second year, respectively (Horn 1988). It is believed that juvenile fish recruit to a demersal lifestyle from a presumed pelagic one at a length of around 47 cm FL. Females grow faster than males, and fish first spawn at about 62 cm FL at age 4–5 years (Horn 1988).

Maximum recorded size is 140 cm FL; females reach a larger size than males. Age and growth have been investigated in New Zealand and Australian specimens, but an ageing method has yet to be validated (Morison & Robertson 1995a). Analyses of bomb ^{14}C in otoliths have indicated that maximum age for the species is at least 25 years (Paul et al. 2004), so some earlier ageing studies (i.e., Webb 1979; Jones 1985; Horn 1988) are now believed to be inaccurate. Assuming that the fine growth zones apparent in otolith sections are annual markers, maximum age of bluenose is in excess of 40 years (Paul et al. 2004), and they have an average fork length of about 50 cm after 3 years and about 70–80 cm after 25 years (Morison & Robertson 1995b). Growth of juveniles is rapid; it is estimated that they reach a fork length of about 31 and 45 cm after 1 and 2 years respectively.

Bluenose are serial spawners, with females releasing oocytes in three or four large batches. Average size at sexual maturity appears to be about 60 cm for males and about 70 cm for females, equating to an age of 7–12 years (Baelde 1996). Spawning occurs off Tasmania from late summer to autumn, but the aggregations can begin to form some months before spawning starts (Baelde 1996). No confirmed spawning areas have yet been identified in the New Zealand EEZ, although Horn & Massey (1989) examined gonadosomatic indices and suggested that spawning probably begins in late summer. Anecdotal reports suggest spawning occurs near East Cape of northeast New Zealand from January to April (Horn & Massey 1989). Bluenose are highly fecund, producing about 480 000 eggs per kg of body weight (Baelde 1996). Eggs are probably buoyant. It is assumed that the pelagic larvae are widely distributed by surface currents until they adopt a demersal existence, which occurs when they are about 47–50 cm long, or about 2 years of age (Kailola et al. 1993).

In Australian waters two distinct morphs of bluenose are caught. Specimens are distinguished by differing relative eye size, body colour and head shape, and are commonly referred to as 'big eyes' or 'small eyes' (Bolch et al. 1993). The distinct morphologies are possibly related to

sexual maturity, with a change in morphology occurring at around 40-50cm standard length, and sexual maturity being associated with the 'bigeye' morph (Bolch et al. 1993). No genetic differences have been observed between the two different Australian morphs (Bolch et al. 1993).

Morphological characteristics

Bluenose have seven to eight dorsal spines, 19–21 soft dorsal rays, three anal spines, and 15–17 soft anal rays. Bluenose have a compressed body with a continuous dorsal fin. The lateral line extends to the caudal fin.

Biological productivity

The onset of maturity at 7-12 years, moderate growth and moderate longevity indicates that this species has moderate biological productivity.

Role of the species in the ecosystem

The food of bluenose is somewhat varied. Bluenose generally feed on midwater organisms. Opportunistic observations of stomach contents of adult fish caught along the east coast of the North Island in New Zealand showed the main components to be pelagic tunicates (mainly *Pyrosoma*) and squid, with some small fish (often hoki) and only occasional crustaceans (Horn & Massey 1989). Off southeast Australia, Winstanley (1978) found the pelagic tunicate *Pyrosoma atlanticum* to be the most common food item in adult bluenose, with small quantities of squid, crustaceans, and fish. More generally, pelagic juvenile bluenose feed on fish larvae, small crustaceans, squids, ctenophores, and salps (Leim & Scott 1966).

Bluenose are prey at various stages of their life to other fishes (particularly sharks) and orcas.

Impacts of Fishing

Habitat damage

Longlining is the predominant fishing method for bluenose on the high seas and has minimal impact on the benthos. However, bottom trawling is also used and can have significant impact on the seafloor.

References

Anderson, O.F.; Bagley, N.W.; Hurst, R.J.; Francis, M.P.; Clark, M.R.; McMillan, P.J. (1998). Atlas of New Zealand fish and squid distributions from research bottom trawls. *NIWA Technical Report 42*. 303 p.

Armitage, R.O., Payne, D.A., Lockley, G.J., Currie, H.M., Colban, R.L., Lamb, B.G., Paul, L.J. (1994) (Eds.) Guide book to New Zealand commercial fish species. Revised edition. New Zealand Fishing Industry Board, Wellington, New Zealand 216 p.

Baelde, P. (1996). Biology and dynamics of the reproduction of blue-eye trevalla, *Hyperoglyphe antarctica* (Centrolophidae), off Tasmania, southern Australia. *Fishery Bulletin 94*: 199–211.

Bolch, C.J.S; Elliott, N.G.; Ward, R.D. (1993). Enzyme variation in south-eastern Australian samples of the blue-eye or deepsea trevalla, *Hyperoglyphe antarctica* Carmichael 1818 (Teleostei: Stromateoidei). *Australian Journal of Marine and Freshwater Research 44*: 687–697.

Duffy, C.A.J.; Stewart, A.L.; Yarrall, R. (2000). First record of pre-settlement juvenile bluenose, *Hyperoglyphe antarctica*, from New Zealand. *New Zealand Journal of Marine and Freshwater Research 34*: 353–358.

Horn, P.L. (1988). Age and growth of bluenose, *Hyperoglyphe antarctica* (Pisces: Stromateioidei), from the lower east coast, North Island, New Zealand. *N.Z. Journal of Marine and Freshwater Research 22(3)*: 369–378.

Horn, P.L. (2003). Stock structure of bluenose (*Hyperoglyphe antarctica*) off the north-east coast of New Zealand based on the results of a detachable hook tagging programme. *New Zealand Journal of Marine and Freshwater Research 37*: 623–631.

Horn, P.L.; Massey, B.R. (1989). Biology and abundance of alfonsino and bluenose off the lower east coast North Island, New Zealand. *New Zealand Fisheries Technical Report 15*. 32 p.

Jones, G.K. (1985). An exploratory dropline survey for deepsea trevalla (*Hyperoglyphe antarctica*) in continental slope waters off South Australia. *Fisheries Research Paper, Department of Fisheries (South Australia) No. 15*. 20 p.

Kailola, P.J.; Williams, M.J.; Stewart, P.C.; Reichelt, R.E; McNee, A,; Grieve, C. (1993). Australian fisheries resources. Pp. 384–386. Bureau of Resource Sciences, Canberra, Australia. 422 p.

Last, P.; Bolch, C.; Baelde, P. (1993). Discovery of juvenile blue-eye. *Australian Fisheries 52(8)*: 16–17.

Leim, A.H.; Scott, W.B. (1966). Fishes of the Atlantic coast of Canada. *Bulletin of the Fisheries Research Board of Canada 155*.

McDowall, R.M. (1982). The centrolophid fishes of New Zealand (Pisces: Stromateodei). *Journal of the Royal Society of New Zealand 12(2)*: 103–142.

Morison, A.K.; Robertson, S.G. (1995a). Age of blue-eye trevalla (*Hyperoglyphe antarctica*). Internal Report 218, Victorian Fisheries Research Institute, Marine Science Laboratories, Queenscliff, Victoria, Australia.

Morison, A.K.; Robertson, S.G. (1995b). Growth, age composition bnd mortality of blue-eye trevalla (*Hyperoglyphe antarctica*). Internal Report 220, Victorian Fisheries Research Institute, Marine Science Laboratories, Queenscliff, Victoria, Australia.

Paul, L.J.; Sparks, R.J.; Neil, H.L., Horn, P.L. (2004). Maximum ages for bluenose (*Hyperoglyphe antarctica*) and rubyfish (*Plagiogeneion rubiginosum*) determined by the bomb chronometer method of radiocarbon ageing, and comments on the inferred life history of these species. Final Research Report for Ministry of Fisheries Project INS2000/02, Objectives 1 & 2. 69 p. (Unpublished report held by Fisheries New Zealand).

Webb, B.F. (1979). Preliminary data on the fishery for deep-sea trevalla (*Hyperoglyphe porosa*) in Tasmania. *Tasmanian Fisheries Research No. 22*: 18–29.

Winstanley, R.H. (1978). Food of the trevalla *Hyperoglyphe porosa* (Richardson) off southeastern Australia. *New Zealand Journal of Marine and Freshwater Research 12(1)*: 77–79.

Code: BYX
Scientific name: *Beryx Splendens*

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Taxonomy

Phylum	Vertebrata
Class	Actinopterygii
Order	Beryciformes
Family	Berycidae
Genus and species	*Beryx splendens* Lowe, 1834
Scientific synonyms	None
Common names	Alfonsino, splendid alfonsino, slender alfonsino, imperador
Molecular (DNA or biochemical) bar coding	No information available

PO Box 3797, Wellington 6140, New Zealand
P: +64 4 499 9889 – F: +64 4 473 9579 – E: secretariat@sprfmo.int
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Species Characteristics

Global distribution and depth range

Beryx splendens has been reported from all tropical and temperate oceans (excluding the northeast Pacific) between latitudes of about 65° N and 43° S. It occurs from depths of about 25 m to at least 1300 m (Busakhin 1982). Its minimum and maximum depths appear to vary quite markedly between areas, e.g., it is found as shallow as 25 m off Oman in the Indian Ocean, but seldom shallower than 200 m in the New Zealand EEZ.

Distribution within South Pacific area

Distribution in the south west Pacific is shown in Figure 1. In the South Pacific they appear most abundant between about 300 m and 700 m (Anderson et al. 1998) and in the Juan Fernandez area they are known from about 400-500 m (Contreras *et al.*, 2007).

In Chile the catch data from within the EEZ indicate the presence of this species mainly on the submarine mounts located in the archipelago of Juan Fernandez, the area of Bajo O'Higgins and the continental shelf area from IV to X region.
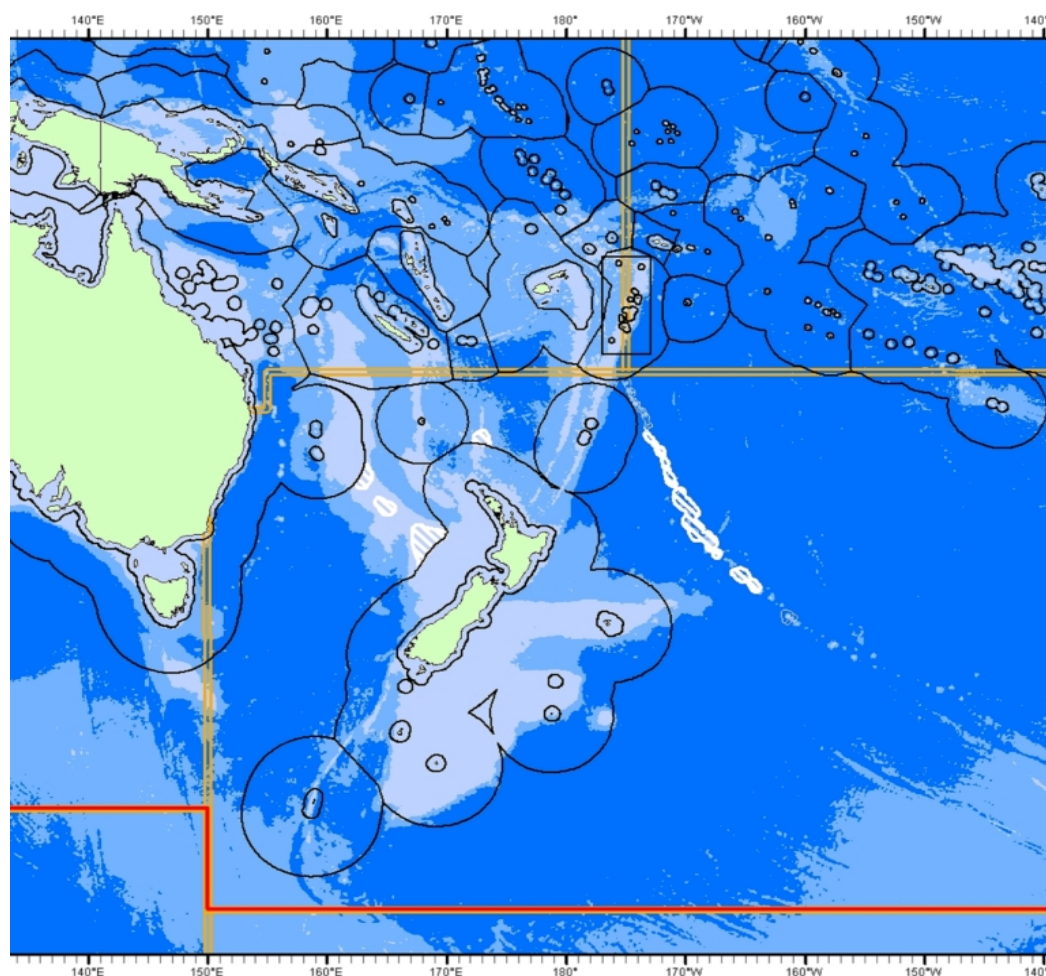

Figure 1: Known distribution of alfonsino on the high seas in the south west Pacific ocean.

General habitat

In the South Pacific, this fish inhabits outer continental shelves and slopes, and is often found over seamounts and underwater ridges. It is benthopelagic, often occurring near the bottom during the day, but ascending to feed in midwater during the night (Galaktionov 1984, Uchida & Tagami 1984). However, Horn & Massey (1989) observed the reverse pattern on some days, and concluded that no single consistent vertical migration behaviour could be attributed to alfonsino in New Zealand waters. In Chile there are no estimates of migration behaviour. Some information is assumed via a physiologic approximation realized by Saavedra *et al.*, 2006, which demonstrates that alfonsino present an enhanced metabolic capacity typically closely related with an increased migratory capacity.

Alfonsino are often found in association with bluenose (*Hyperoglyphe antarctica*), gemfish (*Rexea solandri*), hoki (*Macruronus novaezelandiae*), and javelinfish (*Lepidorhynchus denticulatus*).

Biological characteristics

Catch samples are seldom strongly biased to either sex (Horn & Massey 1989). *B. splendens* can reach about 50 cm fork length; females appear to reach a slightly larger size than males. Age and growth have been investigated in a number of areas (see Table 1 for a summary), and the ageing method of counting annual zones in otoliths has been validated (Massey & Horn 1990, Lehodey & Grandperrin 1996, Rico et al. 2001). Females tend to have a higher von Bertalanffy L_∞ value than males, but growth appears relatively similar between areas (i.e., east and west Atlantic, and North and South Pacific) (Lehodey & Grandperrin 1996, Rico et al. 2001, Gili *et al.,* 2002). Alfonsino have an average fork length of about 25 cm after 3 years and about 40 cm after 10 years. Maximum age is about 20 years. Growth of juveniles is probably rapid; it is estimated that they reach a fork length of about 15–20 cm in their first year.

Alfonsino are serial spawners and reproduce in the areas that they normally inhabit. Average size at sexual maturity appears to be about 30–34 cm (4–6 years old), and can vary between localities (González et al. 2003). Time of spawning also varies markedly between areas (Masuzawa et al. 1975, González et al. 2003). No published information on spawning of alfonsino in the South Pacific is available, although Horn & Massey (1989) examined gonadosomatic indices and suggested that spawning occurred about July–August in New Zealand waters. Eggs are buoyant and hatch after 1–8 days. The pelagic larvae can be widely distributed by surface currents until they adopt a demersal existence, probably when they are about 1 year old (Chikuni 1971). In Chile eggs and larvae (Wiff *et al.*, 2006) have not been observed.

Table 1: Comparison of von Bertalanffy growth parameters for alfonsino from different areas (where: M= males, F= female, L∞ = asymptotic length, K= rate at which L∞ is approached, t_0 = age at length = 0 according to von Bertalanffy growth function). **Table based on that from Lehoday & Grandperrin, 1996.**

Area	L∞		K		T_0		Source
	M	F	M	F	M	F	
New Caledonia							
Norfolk-Loyalty Ridges	45.2	50.8	0.146	0.134	-2.34	-2	Lehoy & Grandperrin 1996
New Zealand							
Palliser Bay	51.1	57.5	0.11	0.088	-3.56	-4.1	Massey & Horn 1990
Tuaheni	54.9	76.3	0.093	0.042	-4.3	-8.25	Massey & Horn 1990
Paoanui	49.1	-	0.144	-	-1.81	-	Massey & Horn 1990
Japan							
Sagami Bay	37.8		0.439		0.40		Ikenouye 1969
Sagami Bight	45.8		0.323		-.22		Masusawa et al. 1979
Zunan Sea	54.4		0.181		-0.08		Masusawa et al. 1979
Atlantic							
Angular Rise	48.5		0.170		-2.63		de Leon & Malkov 1979
New Year Rise	44.8		0.209		-0.89		de Leon & Malkov 1979

Morphological characteristics

B. splendens have four dorsal spines, 13–16 soft dorsal rays, four anal spines, and 26–30 soft anal rays. The first infraorbital bone has a spine projecting laterally on its anterior end. Lateral line extends to caudal fin. In young fishes, the second dorsal ray is elongated.

Biological productivity

González et al. (2003) noted that alfonsino have a specialist life-history style, are only moderately fecund and moderately productive, and appear relatively sedentary. Hence, they concluded that alfonsino are relatively susceptible to growth overfishing and population depletion.

Role of the species in the ecosystem

The alfonsino feeds by hunting macrofauna, mainly small squids and fish, but also crustaceans (i.e., copepods, amphipods, shrimps, prawns, and euphausiids). It normally occurs within 20 m of the bottom, but is believed to make feeding forays off the bottom, generally at night. Alfonsino are prey at various stages of their life to other bony fishes and sharks.

Alfonsino are often found in association with bluenose (*Hyperoglyphe antarctica*), gemfish (*Rexea solandri*), hoki (*Macruronus novaezelandiae*), and javelinfish (*Lepidorhynchus denticulatus*) In Chile it is associated to Orange roughy.

Impacts of fishing

6.4   Habitat damage

The main method used to catch this species is a high-opening trawl generally fished hard down on the bottom. Trawling for this species on seamounts impacts habitat (Clark and O'Driscoll 2003, Koslow et al. 2001), but the precise impact of this on the alfonsino populations or other species on the seamounts is unknown.

Severe damage of coral cover from bottom trawl fishing for orange roughy inside the Australian EEZ has been documented (Koslow et al. 2001). Video images reveal bare rock and pulverized coral rubble where bottom trawling has occurred.

As fishing gear disturbs soft sediment they produce sediment plumes and re-mobilise previously buried organic and inorganic matter. This increase in the rates of nutrients into the water column has important consequences for the rates of biogeochemical cycling (Kaiser et al. 2002).

10   References

Anderson, O.F.; Bagley, N.W.; Hurst, R.J.; Francis, M.P.; Clark, M.R.; McMillan, P.J. (1998). Atlas of New Zealand fish and squid distributions from research bottom trawls. *NIWA Technical Report 42*. 303 p.

Busakhin, S.V. (1982). Systematics and distribution of the family Berycidae (Osteichthyes) in the World Ocean. *Journal of Ichthyology 22 (6)*: 1–21.

Chikuni, S. (1971). Groundfish on the seamounts in the North Pacific. *Bulletin of the Japanese Society of Fisheries Oceanography 19*: 1–14. (In Japanese, English translation held by the Fisheries Research Board of Canada.)

Clark, M.; O'Driscoll, R. (2003). Deepwater fisheries and aspects of their impact on seamount habitat in New Zealand. *Journal of Northwest Atlantic Fishery Science 31*: 441-458

Contreras F.J., Canales, C.; Leal, E. (2007). Investigación evaluación de stock y CTP Alfonsino, 2006. Pre-Informe Final. Subsecretaría de Pesca-Instituto de Fomento Pesquero.

Galaktionov, G.Z. (1984). Features of the schooling behaviour of the alfonsina *Beryx splendens* (Berycidae) in the thalassobathyl depths of the Atlantic Ocean. *Journal of Ichthyology 24 (5)*: 148–151.

González, J.A.; Rico, V.; Lorenzo, J.M.; Reis, S.; Pajuelo, J.G.; Afonso Dias, M.; Mendonça, A.; Krug, H.M.; Pinho, M.R. (2003). Sex and reproduction of the alfonsino *Beryx splendens* (Pisces, Berycidae) from the Macronesian archipelagos. *Journal of Applied Ichthyology 19*: 104–108.

Horn, P.L.; Massey, B.R. (1989). Biology and abundance of alfonsino and bluenose off the lower east coast North Island, New Zealand. *New Zealand Fisheries Technical Report 15*. 32 p.

Koslow, J.A.; Gowlett-Holmes, K.; Lowry, J.K.; O'Hara, T.; Poore, G.C.B.; Williams, A. (2001). Seamount benthic macrofauna off southern Tasmania: community structure and impacts of trawling. *Marine Ecology Progress Series 213*: 111-125.

Lehodey, P.; Grandperrin, R. (1996). Age and growth of the alfonsino *Beryx splendens* over seamounts off New Caledonia. *Marine Biology 125*: 249–258.

Kaiser, M.J.; Collie, J,S.; Hall, S.J.; Jennings, S.; Poiner, I.R. (2002). Modification of marine habitats by trawling activities: prognosis and solutions. *Fish and Fisheries 3*:114-136.

Massey, B.R.; Horn, P.L. (1990). Growth and age structure of alfonsino (*Beryx splendens*) from the lower east coast, North Island, New Zealand. *New Zealand Journal of Marine and Freshwater Research 24*: 121–136.

Masuzawa, T.; Kurata, Y.; Onishi, K. (1975). Results of group study on a population of demersal fishes in waters from Sagami Bay to southern Izu Islands: population ecology of Japanese alfonsino and other demersal fishes. *Japan Aquatic Resources Conservation Association Fishery Research Paper 28*. 105 p. (In Japanese, English translation held by the NIWA library, Wellington, New Zealand.)

Rico, V.; Lorenzo, J.M.; González, J.A.; Krug, H.M.; Mendonça, A.; Gouveia, E.; Afonso Dias, M. (2001). Age and growth of the alfonsino *Beryx splendens* Lowe, 1834 from the Macronesian archipelagos. *Fisheries Research 49*: 233–240.

Saavedra, L., Quiñones, R., Niklitschek, E. (2006). Metabolismo aeróbico y anaeróbico de Orange roughy, Alfonsino y otras especies batipelágicas asociadas a la zona de mínimo oxígeno de los montes submarinos de Juan Fernández. XXVI Congreso de Ciencias del Mar, Iquique, Chile, May 22 - 26, 2006.

Uchida, R.N.; Tagami, D.T. (1984). Groundfish fisheries and research in the vicinity of seamounts in the North Pacific Ocean. *Marine Fisheries Review 46 (2)*: 1–17.

Wiff, R.; Tascheri, R. (2005) Investigación y CTP Alfonsino (2005). Informe Final Fase II. SUBPESCA-IFOP. 30p+anexos

Code: CJM
Scientific name: *Trachurus Murphyi*

Taxonomy

Phylum	Chordata
Class	Osteichthyes/Actinopterygii
Order	Perciformes
Family	Carangidae
Genus and species	*Trachurus murphyi* (Nichols, 1920)
Scientific synonyms	Historically *Trachurus symmetricus murphyi*
Common names	Chilean Jack mackerel (FAO, Chile, Russia), Murphy's mackerel (New Zealand), Pacific Jack mackerel (Russia), Peruvian Jack mackerel (Australia, Russia), Jack mackerel, horse mackerel, jurel (Chile, Peru, Ecuador).
Molecular (DNA or biochemical) bar coding	See Poulin et al. 2004.

PO Box 3797, Wellington 6140, New Zealand
P: +64 4 499 9889 – F: +64 4 473 9579 – E: secretariat@sprfmo.int
www.sprfmo.int

Species characteristics

- ### Global distribution and depth range

The Chilean jack mackerel is distributed in the sub-tropical waters, of the south eastern Pacific Ocean, both inside EEZs and on the high sea, ranging from the Galapagos Islands and south of Ecuador in the north to southern Chile; ranging from the South America in the east to Australia and New Zealand in the west (Evseenko 1987, Jones 1990, Serra 1991a, and Elizarov et al. 1993; Kotenev *et al.*, 2006; Gerlotto *et al.*, 2012) (see Fig. 1).

Serra (1991a) summarised depths for aggregations of *T. murphyi* and Guzman et al. (1983) used hydroacoustic equipment to record the species down to 250 m off the coast of northern Chile; in central and southern Chilean waters, Bahamonde (1978) described it as occurring down to 300 m; and, Japanese trawlers have recorded it to depths of 300 m beyond the Chilean EEZ (Anon 1984, Anon 1985).

Cordova et al. (1998) described a diurnal migratory behaviour, with fish being found deeper during the day (50-180 m) than at night (10-40 m).
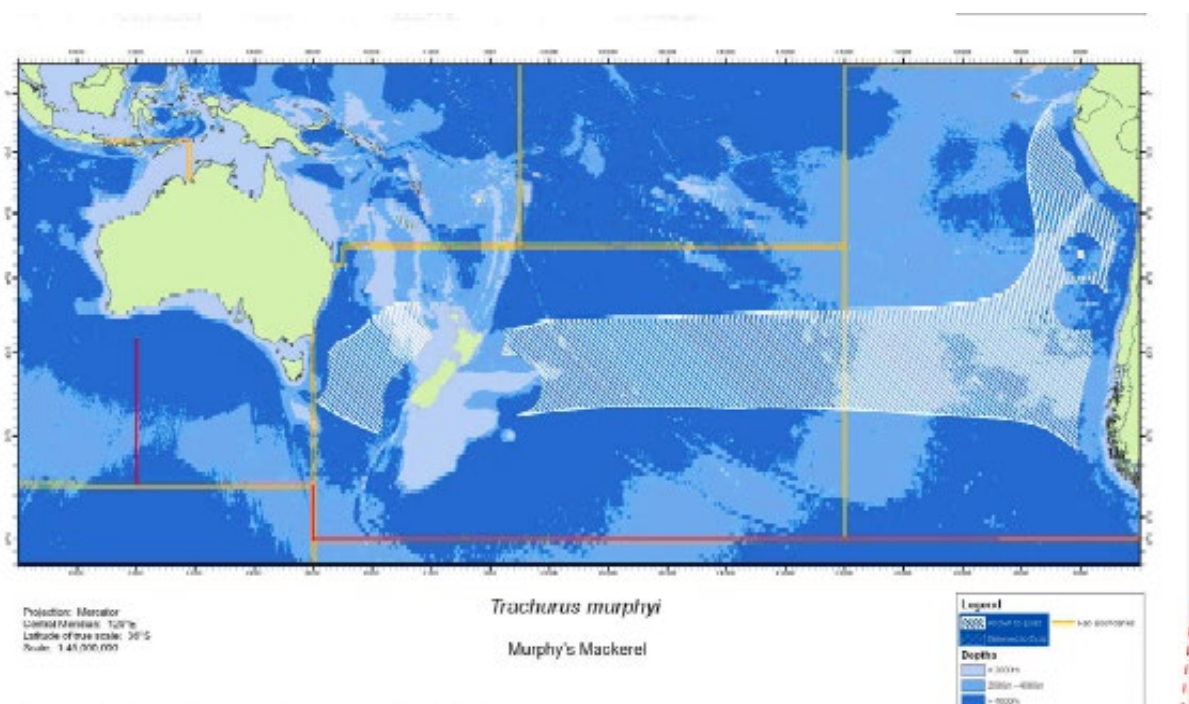

Figure 1. Distribution of Jack mackerel in the high seas in the South Pacific

- ### Distribution within South Pacific area

Elizarov *et al.* (1993) coined the phrase "Jack mackerel belt" to describe the distribution of *T. murphyi* across the South Pacific (Fig. 1). The Jack mackerel belt is described as having a north-south breadth of "10 to 15 degrees" across "the southern sub region of the southeast Pacific Ocean (SEPO) and southwest Pacific Ocean (SWPO)", which varies with season as "spawning groups concentrate mainly in the north of 40ºS in spring and summer and south of 40ºS in autumn and winter to feed".

Gerlotto *et al.,* (2012) consider a metapopulation, where a source population creates several subpopulations that can remain independent during prolonged periods, depending on the environmental conditions, some particular spatial characteristics observed between the Peruvian and Centre-South Chilean parts of the distribution, lead that the metapopulation definition is likely to better describe the stock of T. murphyi, that can be described as four metapopulation, the Central Pacific-Centre South Chilean stock; the Northern Chilean stock; the Peruvian stock and Central South and Southwest Pacific Ocean stocks respectively.

- ### General habitat and behaviour

T. murphyi is a schooling pelagic species adapted to both neritic and oceanic environments. According to the average catch pattern by fishing areas of jack mackerel *T. murphyi*, the highest concentrations in the Peruvian sea are associated with the high dynamics of coastal upwellings (Ñiquen and Peña 2008, Chernyshkov *et al*. 2008) and manifestations of interdecadal variability patterns (warm and cold periods), which define a favorable scenario for *T. murph*yi. Likewise, studies by Dioses (1995) and Grechina *et al*. (1998) indicate that the oceanic fronts formed by the convergence of cold coastal waters and surface subtropical waters, would be the preferred habitat of the *T. murphyi* resource, which is evidenced by the catches of this resource. On the other hand, Bertrand *et al*. (2004) report that *T. murphyi* is located in oxygenated water (above oxycline). It is noted that, the optimal oxygen content value for the presence of jack mackerel *T. murp*hyi would be between 1 and 3 ml/L, above oxycline (Dioses 2013a).

- ### Biological characteristics

Morphology: body elongate and slightly compressed. Enlarged, scute-like scales on primary lateral line. Termination of dorsal accessory lateral line below 2nd to 5th soft ray of dorsal fin. Pectoral fin tip extending to be above the two detached spines anterior to the anal fin. Eye moderate size with well-developed adipose eyelid. Posterior margin of upper jaw below anterior margin of eye. Jaws vomer, palatine, and tongue bearing minute teeth (Kawahara et al. 1988).

Colour when fresh: dark blue dorsal body, silver-white ventrally; upper posterior margin of opercula bear a black spot; pale pelvic fins; caudal, pectoral, and dorsal fins dusky; anal fin pale in the front, dusky in the rear.

Several authors have described *T. murphyi* to be an indeterminate batch spawner, based on histological studies and on the oocyte-size-frequency-distribution (OSFD) of reproductively active females, and their "presence over a long temporal extension of seven to nine months per year" (Dioses et al. 1989, George 1995, Oyarzún et al. 1998, Perea et al 2013). This conclusion is supported by evidence from Evseenko (1987) and Bailey (1989) who state that *T. murphyi* spawns wherever environmental conditions are suitable. The suitable environmental conditions seem to be water warmer than 15 ºC, with highest densities having been found in waters of 16 – 19 ºC, and low current (less than 15 cm.s^{-1}) (Evseenko 1987, Nuñez et al. 2004).

Trachurus murphyi spawns in austral spring and summer, with the main spawning season from October to December (Serra 1983 and 1991a, Elizarov et al. 1993, Oyarzún et al. 1998, and Perea et al 2013) and it spawns throughout its whole distribution range. Santander and Flores

(1983) and Dioses et al (1989) described Jack mackerel spawning in Peru as mainly occurring between 14º00'S and 18º30'S. However, more recent analyses by Ayon and Correa (2013) show that between 1966 and 2010 Jack mackerel larvae were present (and therefore spawning occurred) every year along the whole Peruvian coast, with clear year to year north-south shifts in the centres of higher larvae abundance associated with shifts in environmental conditions. The annual mean larvae densities for the positive stations in the period 1966-2010 estimated by Ayon and Correa (2013) ranged from 3 to 1131 larvae/m^2, with a median of 21 larvae/m^2, noting that while the frequency and abundance of larvae has been variable there has been no particular trend for the 56 years of observations. However, they describe important changes with time in the spatial larvae distribution. From 1960 to 1979 Jack mackerel larvae were present particularly in the southern part of Peru, while during the period 1980-1989 there was a wide distribution along the whole Peruvian coast, with higher densities north of Punta Falsa (06ºS). Later on, during the period 1990-1999 the main larvae distribution areas were to the north of 16ºS, with an expansion toward the south between 2000 and 2010. The centers of gravity of the larvae spatial distribution per year also showed some important differences in the distribution by latitude and distance from the coast, with three clear periods: the first one between 1966 and 1978 with main larvae concentrations between 14°S and 18ºS closer to the coast; the second between 1979 and 1994 more to the north, between 4°S and 14ºS, and more offshore; and, the third one between 1995 and 2010, with the centers of gravity located in an intermediate position between the other two (Ayon y Correa 2013).

In Peru, the spawning areas are limited by the CCW (salinities lower than 35,0 ups) and SSW (salinities higher than de 35,1 ups), with temperatures above 18ºC and oxygen content around 5,0 mL/L. In these water columns the spawning schools of Jack mackerel tend to be located at depths between 10 and 80 m, with an ideal salinity of 34,9 to 35,1 ups and an oxygen content from 3.0 to 5.0 mL/L (Dioses 2013a).

On the other hand, the main spawning ground of the Chilean subpopulation is off central Chile in coastal waters and extending beyond 200 miles of the EEZ to about 93º W (Serra 1991b, Nuñez et al. 2004, and Arcos et al. 2005). An additional area of spawning has been recorded in the area between 105°E and 125°E (Kotenev et al 2006).

The results of 85 seasonal surveys of eggs and larvae between 1981 and 2007 off northern Chile (north of 24º S) found that egg and larva density peaked in winter-spring, with a greater concentration towards the southern part of this area (Braun and Valenzuela 2008).

Annual surveys of the distribution of early developmental stages of *T. murphyi* between 1999 and 2007, in waters off central Chile, found that most spawning was centered between 33 and 38º S and from 82 to 92º W (Núñez et al. 2008). Higher densities of eggs and larvae were associated with water temperatures of 16-18º, moderate winds (4-8 m s-1), a low turbulence index (< 100 m3 s-3), and slower current speeds (< 15 cm s-1) (Núñez et al. 2008). This supports the view that spawning occurs along the subtropical convergence, between the southern and northern limits (42 ºS and 36 ºS). The western centre of the spawning occurs within 130 ºW to 155 ºW and 35 ºS to 40 ºS (Evseenko 1987, Elizarov et al. 1993).

According to Oyarzún and Gacitua (2002) and Oliva et al. (1995), 10–15% of females spawn each day during the period of most intensive spawning, meaning that the average female spawns every 7–10 days at this time.

In Chile the mean length at first spawning has been described at 22 cm (Marcelo Oliva, Instituto de Investigaciones Oceanológicas, Universidad de Antofagasta, Chile, pers. comm.) and 23 cm

FL (Basten & Contreras 1978), and more recently is considered to be 25 cm FL, but the size at first maturity has been reported to vary between 21.6 and 30 cm FL among different areas (Cubillos et al. 2008).

The length at first maturity of *T. murphyi* in Peru was first estimated as 25,0 cm fork length (FL) by Abramov and Kotylar (1980) and 23 cm total length (21 cm FL) by Dioses et al. (1989). More recently, Perea et al (2013) analyzed information from 1967 to 2012 and estimated a total length at first maturity of 26.5 cm, with no significant changes over observed period. They also confirmed that in Peru *T. murphyi* has a single relatively extended spawning period with a maximum in November each year, showing that for the more than four decades of observations *T. murphyi* has spawned regularly every year in Peruvian waters. They also noted that the reproductive activity of *T. murphyi* has a greater variability off Peru and the spawning period has peaks of lesser magnitude but extend longer than observed in the spawning occurring off Chile. Perea et al (2013) also report that the highest frequency of months with high gonadosomatic index (GSI) are observed during the period 1986-1998, while in the previous years (1967-1985) there were fewer months with relatively high GSI, and this frequency has been even lower from 1999 to-date.

Several papers have been published describing *T. murphyi* growth functions. Cubillos et al. (1998) summarised 22 studies. *T. murphyi* can be described as having a moderate growth rate. In Chile ages are estimated using transversely sectioned otoliths. The maximum recorded age is 19 years, which contrasts strongly with the maximum age of 35 years estimated in New Zealand and the maximum age reading of 11 years reported in Peru.

The method used to estimate ages for *T. murphyi* in Chile have been validated using the bomb radiocarbon method (Ojeda et al. 2008).

In Peru, the age and growth of Jack mackerel has been determined by the direct reading and measuring of annual growth rings in whole otoliths (Dioses 2013b) and have been confirmed by independent observations through the reading of micro-increments or daily rings in otoliths (Goycochea 2013) and length frequency analysis of commercial and research survey catches (Diaz 2013). The growth parameters estimated by Dioses (2013b) are L_∞=80.77 cm, W_∞=3744.10 gr., K=0.155/year, and t_0=-0.356. The same author tested the validity of the methodology being used by checking the growing similarity between rings (whose growth decreases with the formation of a new ring) and the monthly variation of otolith marginal increment, while Goycochea (2013) and Diaz (2013) obtained very similar results using independent methods and different sources of data.

Kochkin (1994) sampled specimens from both the South West Pacific Ocean (SWPO) and the South East Pacific Ocean (SEPO) between 1983 and 1990 and investigated growth using otoliths and length frequencies. His estimated von Bertalanffy relationship was $L_t = 74.2405[1 - e^{-0.1109(t + 0.8113)}]$, and he determined L_{max} to be $0.943L_\infty$.

Gili et al. (1996) investigated growth using otoliths sampled from the central Chile fishery. Their estimates of growth parameters were: K=0.094; L_∞=70.8 cm FL; and t_0=-0.896.

Natural mortality has been estimated to be in the range of 0.30 to 0.22 y^{-1} based on size composition data (Cubillos et al. 2008). The Chilean assessment model uses a value of 0.23 y^{-1} for all age groups (Canales and Serra, 2008 unpublished report)

Natural mortality for *T. murphyi* in Peru has been estimated as M= 0.31 per year, based on the growth parameters of the von Bertalanffy growth function and other traits of the Jack mackerel life cycle in Peru.

- **Biological productivity**

The biology of *T. murphyi* is reasonably well known. Biological productivity is believed to be medium, with first spawning at 20 – 25cm, moderate fecundity, fairly rapid growth and a maximum age of ~20-30 years. Annual replacement yields are moderately high.

- **Role of species in the ecosystem**

This species is a generalist feeder capable of utilising a wide range of prey species (Konchina 1979) and may be acting as an energy flow channeler from primary producers to top predators. However, its wide range of prey species shows that it is not restricted to this role. As the "bloom" event in the early to mid-1990s indicated (4.4 M t were taken in the Chilean fishery in 1995) (Table 1), which coincided with a peak in aerial sightings records in New Zealand waters (P.R. Taylor, NIWA, New Zealand, unpublished data), population size of *T. murphyi* can be extremely high. Little is known about its predators, though Bailey (1987) tentatively identified juvenile jack mackerel from the stomachs of albacore tuna (*Thunnus alalunga*) taken in the central South Pacific (36ºS to 42ºS and 148ºW to 165ºW) as *T. murphyi*. It has also been found in the stomach contents of swordfish off the Chilean coast (M. Donoso, IFOP, Chile, pers. comm.). Generally it can be expected that its predators will be similar to those of other carangid mackerels and will include tunas, billfish, and sharks. As a consequence of the large size of the Jack mackerel and its important role as both predator and prey, this species is likely an important node in Pacific Ocean predator-prey networks.

Impacts of Fishing

- **Habitat damage**

No direct habitat damage known in the mid-water trawl and purse seine fisheries and such damage is unlikely due to the gear types used.

References

Abramov, A.A., Kotlyar, A.N. (1980). Some biological features of the Peruvian jack mackerel, *Trachurus symmetricus murphyi*. Journal of Ichthyology 80: 25–31.

Anon (1984). Report of survey for the development of new distant water trawling grounds in 1983. Kaihatsu News No 40.

Anon (1985). Report of survey for the development of new distant water trawling grounds in 1984. Kaihatsu News No 45.

Arcos, D., C. Gatica, P. Ruiz, A. Sepulveda, M.A. Barbieri, R. Alarcon, S. Nuñez, J. Chong, J. Cordova, A. Rebolledo, C. Gonzales, F. Contreras, M. Aguayo, F. Vejar, P. Torres and C. Toro. (2005). Condición biologica de jurel en Alta Mar, año 2004. Informe Final Proyecto FIP 2004-33. Fondo de Investigación Pesquera.

Ayón, P. and J. Correa. (2013). Spatial and temporal variability of Jack mackerel *Trachurus murphy* (Nichols 1920) larvae in Peru between 1966-2010. In: J. Csirke, R. Guevara-Carrasco y M. Espino (eds). 2013. Ecology, Fishery and Conservation of Jack mackerel (*Trachurus murphyi*) in Peru. Rev. peru. biol. special issue 20 (1): 083-086. (Volume published in Spanish with titles, abstracts and captions in English).

Bahamonde, R. (1978). Distribución y abundancia relitiva de los principales recursos demersales entre Corral (40ºS) y el Cabo de Hornos (57ºS). Instituto de Fomento Pesquero IFOP/JAMARC. Informe Interno.

Bailey, K. (1987). Townsend Cromwell surveys South Pacific albacore resource. Catch, 14(7); 20–22.

Bailey, K. (1989). Description and surface distribution of juvenile Peruvian jack mackerel, *Trachurus murphyi*, Nichols from the subtropical convergence zone of the central South Pacific. Fishery Bulletin 87: 273–278.

Basten, J.; Contreras, P. (1978). Observaciones preliminares sobre la pesquería del jurel *Trachurus murphyi* (Nichols) en la zona norte de Chile. Períoda julio 1975–julio 1978. Universidad del Norte Departamento Pesquerías Informe Técnico. 62 p.

Bertrand, A., M. Segura, M. Gutiérrez & L. Vásquez. (2004). From small-scale habitat loopholes to decadal cycles: a habitat-based hypothesis explaining fluctuation in pelagic fish populations off Peru. Fish and Fisheries 5: 296 – 316

Braun, M. and V. Valenzuela (2008). Seasonal distribution and abundance of jack mackerel (*Trachurus murphyi*) eggs and larvae off northern Chile 1981-2007. Paper presented to the SPRFMO Chilean Jack Mackerel Workshop, Santiago, 30 June – 4 July 2008.

Canales, C. and R Serra. (2008). Chilean jack mackerel stock assessment model. Paper presented to the SPRFMO Chilean Jack Mackerel Workshop, Santiago, 30 June – 4 July 2008.

Chernyshkov, P., E.Timokhin and A. Glubokov. (2008). Inter-annual and seasonal variability of oceanological conditions in the Southern Pacific Ocean in connection with the pelagic ecosystem structure. Paper presented to the SPRFMO Chilean Jack Mackerel Workshop, Santiago, 30 June – 4 July 2008.

Cordova et al. (1998). Evaluación hidroacústica del recurso jurel en la ZEE de Chile. IFOP/FIP 98-11. Informe Final. 200 págs. +figs.

Cubillos, L., C Gatica and R Serra. (2008). Short review of natural mortality and size at first maturity on jack mackerel (*Trachurus murphyi*) in the southeastern Pacific. Paper presented to the SPRFMO Chilean Jack Mackerel Workshop, Santiago, 30 June – 4 July 2008.

Cubillos, L., R. Alarcón, L. Vilugran, A. Sepúlveda, M. George-Nascimento, M. Araya, M. Medina, J. Zambrano, M. Guzman, L. Martinez, J. Peñailillo, R. Gili, Z. Young, V. Alegria, V. Bocic, L. Muñoz y L. Cid. (1998). Validación de los métodos aplicados en la determinación de edad y crecimiento y determinación de la mortalidad del jurel en la zona centro.sur. Informe Final Proyecto FIP 95-10, 170 p.

Dioses, T. (2013a). Abundance and distribution patterns of Jack mackerel *Trachurus murphyi* (Nichols 1920) in Peru. In: J. Csirke, R. Guevara-Carrasco y M. Espino (eds). 2013. Ecology, Fishery and

Conservation of Jack mackerel (*Trachurus murphyi*) in Peru. Rev. peru. biol. special issue 20 (1): 067-074. (Volume published in Spanish with titles, abstracts and captions in English).

Dioses, T. (2013b). Age and growth of Jack mackerel *Trachurus murphyi* (Nichols 1920) in Peru. In: J. Csirke, R. Guevara-Carrasco y M. Espino (eds). 2013. Ecology, Fishery and Conservation of Jack mackerel (*Trachurus murphyi*) in Peru. Rev. peru. biol. special issue 20 (1): 045-052. (Volume published in Spanish with titles, abstracts and captions in English).

Dioses, T. (1995). Análisis de la distribución y abundancia de los recursos jurel y caballa frente a la costa peruana. *Informe Progresivo del Instituto del Mar del Perú 3*, 55 pp.

Dioses, T., Alarcon, V.H.; Nakama, M.H.; Echevarria, A. (1989). Desarrollo ovocitario, fecundidad parcial y distribucion vertical de los cardumenes en desove del jurel *Trachurus murphyi* (N). (Oocyte development, partial fecundity and vertical distribution of the spawning schools of jack mackerel, *Trachurus murphyi* N.). Revista de la Comision Permanente del Pacifico Sur. 287–294.

Elizarov, A.A.; Grechina, A.S.; Kotenev, B.N.; Kuzetsov, A.N. (1993). Peruvian jack mackerel, *Trachurus symmetricus murphyi*, in the open waters of the South Pacific. Journal of Ichthyology 33: 86–104.

Evseenko, S.A. (1987). Reproduction of the Peruvian jack mackerel *Trachurus symmetricus murphyi* in the South Pacific. Journal of Ichthyology 27: 151–160.

George, M.R. (1995). Aspects of the reproductive cycle of southern Pacific jack mackerel, *Trachurus murphyi* Nichols, 1920, off northern coast of Chile. Ices C.M 1995/H30: 12.

Gerlotto, F., Gutiérrez, M., & Bertrand, A. (2012). Insight on population structure of the Chilean jack mackerel (*Trachurus murphyi*). *Aquatic Living Resources, 25*(4), 341-355.

Gili, R., V. Alegría, V. Bocic, L. Cid y H. Miranda. (1996). Estudio biológico pesquero del recurso jurel en la zona centro sur, V a X Regiones. Determinación de la estructura de edad y parámetros de crecimiento del jurel. FIP 018 - 93.

Grechina A., S. Núñez & D. Arcos. (1998). El desove del recurso jurel, *Trachurus symmetricus murphy* (Nichols), en el océano Pacífico Sur. En D. Arcos (Ed.). Biología y ecología del jurel en aguas chilenas. Instituto de Investigación Pesquera, Chile: 117 – 140.

Guzman, O.; Castillo, J.; Lillo, S.; Pineda, P.; Rodriguez; Giakoni, I. (1983). Estudio de recursos pelágicos. Programa monitoreo de los recursos pelágicos. I. Prospección zona Arica–Coquimbo. (18º30'–30º00'S). CORFO. Gerencia de Desarrollo. IFOP (AP 83–32). 48 p.

Kawahara, S.; Uozumi, Y.; Yamada, H. (1988). First record of a carangid fish *Trachurus murphyi* from New Zealand. Japanese Journal of Ichthyology 35: 2 212–214.

Kochkin, P.N. (1994). Age determination and estimate of growth rate for the Peruvian jack mackerel, *Trachurus symmetricus murphyi*. Journal of Ichthyology 34: 39–50.

Konchina, Y.V. (1979). The feeding of the Peruvian jack mackerel, *Trachurus symmetricus murphyi*. Journal of Ichthyology 19: 52–61.

Kotenev, B.N., Kukhorenko, K.G., Glubokov, A.I. (2006). Main results of the Russian multidisciplinary ecosystem research, and exploratory fish-finding of concentrations of hydrobionts and their fisheries development in the south Pacific. Moscow: VNIRO. 37 p.

Núñez, S, S Vásquez, P Ruiz and A Sepúlveda. (2008). Distribution of early developmental stages of jack mackerel in the Southeastern Pacific Ocean. Paper presented to the SPRFMO Chilean Jack Mackerel Workshop, Santiago, 30 June – 4 July 2008.

Ñiquen, M.A. and C.L. Peña. (2008). Distribution of jack mackerel (*Trachurus murphyi*) related to oceanographical features between north Perú to north Chile. Paper presented to the SPRFMO Chilean Jack Mackerel Workshop, Santiago, 30 June – 4 July 2008

Ojeda, V. Bocic and L. Muñoz. (2008). Methodology employed for age determination in Chilean jack mackerel (*Trachurus murphyi*). Paper presented to the SPRFMO Chilean Jack Mackerel Workshop, Santiago, 30 June – 4 July 2008. Doc. CHJMWS pap #8: 11p

Oliva, J; G. Claramunt; G. Herrera; C. Padilla y P. Pizarro (1995). Reproducción In: Alegría, V. (Ed.), Estudio Biológico Pesquero sobre el recurso jurel en la zona norte (Regiones I y II). IFOP.

Oliva, M.E. (1999). Metazoan parasites of the jack mackerel *Trachurus murphyi* (teleostei, Carangidae) in a latitudinal gradient from South America (Chile and Peru). Parasite 6: 223-230.

Oyarzún, C. y S. Gacitúa. (2002). Aspectos reproductivos, fecundidad parcial y frecuencia de desove del jurel, año 2001. In: Cubillos, L. (Ed.) Condición biológica del jurel en alta mar, año 2001. Preinforme Final Corregido, FIP 2001-12. 168 p. + Anexo.

Oyarzún, C., J. Chong y M. Malagueño. (1998). Fenología reproductiva en el jurel, *Trachurus symmetricus* /Ayres, 1855)(Perciformes, Carangidae) en el área de Talcahuano-Chile: 1982-984. En: D. Arcos (ed). Biología y Ecología del Jurel en Aguas Chilenas: 67.75.

Perea, A., J. Mori, B. Buitron y J. Sánchez. (2013). Reproductive aspects of Jack mackerel Trachurus murphy (Nichols 1920) in Peru. In: J. Csirke, R. Guevara-Carrasco y M. Espino (eds). 2013. Ecology, Fishery and Conservation of Jack mackerel (*Trachurus murphyi*) in Peru. Rev. peru. biol. special issue 20 (1): 029-034. (Volume published in Spanish with titles, abstracts and captions in English).

Poulin, E., L. Cárdenas, C. E. Hernández, I. Kornfield y F. P. Ojeda. (2004). The brief history of the Chilean jack mackerel: population genetic inference from the mitochondrial DNA control region. J. Fish Biol. 65: 1160-1164.

Santander, H.; Flores, R. (1983). Los desoves y distribución larval de ciertas especies pelágicas y sus relaciones con las variaciones del ambiente marino frente al Perú. En Sharp, G.D. y J.Csirke (eds) Actas de la Consulta de Expertos para examinar los cambios en la abundancia y composición por especies de recursos de peces neríticos. San José, Costa Rica, 18-29 abril 1983. Una reunion preparatoria para la Conferencia Mundial de la FAO sobre ordenación y desarrollo pesqueros. FAO Fish.Rep./FAO,Inf,Pesca, (291) vol.2: 553p.

Serra, J.R. (1983). Changes in the abundance of pelagic resources along the Chilean coast. In: G.D. Sharp and J. Csirke (Eds.) Proceedings of the Expert Consultation to examine changes in abundance and species composition of neritic fish resources. San José, Costa Rica, 18 - 29 April 1983. FAO Fish. Rep. 291 (2): 255 - 284.

Serra, R and A Glubokov. (2008). Population structure of Chilean jack mackerel, *Trachurus murphyi*, in the South Pacific Ocean: Full proposal for an international joint research programme. Paper presented to the SPRFMO Chilean Jack Mackerel Workshop, Santiago, 30 June – 4 July 2008.

Serra, R. (1991a). Important life history aspects of the Chilean jack mackerel, *Trachurus symmetricus murphyi*. Investigacion Pesquera (Chile) 36: 67–83.

Serra, R. (1991b). Long - term variability of the Chilean sardine. In: Proceedings of the International Symposium on the Long - Term Variability of Pelagic Fish Populations and their Environment. T. Kawasaki, S. Tanaka, Y. Toba and A. Taniguchi (eds.) New York: Pergamon Press. pp 165 - 172.

Code: EPI
Scientific name: *Epigonus Telescopus*

Taxonomy

Phylum	Vertebrata
Class	Actinopterygii
Order	Perciformes
Family	Epigonidae
Genus and species	*Epigonus telescopus* (Risso, 1810)
Scientific synonyms	None known
Common names	Black cardinalfish
Molecular (DNA or biochemical) bar coding	No information

PO Box 3797, Wellington 6140, New Zealand
P: +64 4 499 9889 – F: +64 4 473 9579 – E: secretariat@sprfmo.int
www.sprfmo.int

Species Characteristics

Global distribution and depth range

Black cardinalfish are widely distributed in the North Atlantic from Iceland to the Canary Islands, in the western Mediterranean, and in the South Atlantic, Indian, and Southwest Pacific Oceans (Abramov 1992).

Black cardinalfish are found from 75–1200 m, but their preferred depth range is 600–900 m (Field et al. 1997). The preferred depth range of schools (600-900 m) overlaps the upper end of the depth range of orange roughy (*Hoplostethus atlanticus*) and the lower end of alfonsino (*Beryx splendens*) and bluenose (*Hyperoglyphe antarctica*).

Distribution within South Pacific area

In the Southwest Pacific, black cardinalfish are found between Australia and New Zealand (Abramov 1992) (see Figure 1).
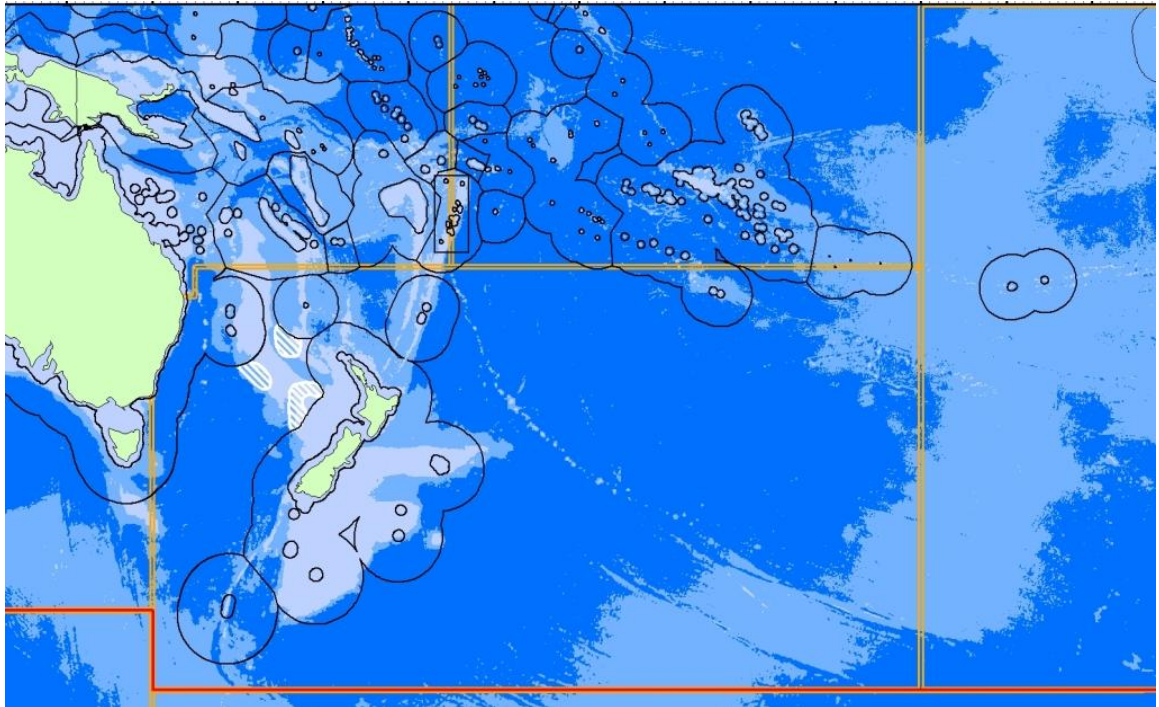

Figure 1: Known distribution of black cardinalfish on the high seas in the South Pacific Ocean.

General habitat

Black cardinalfish are bathy-demersal. Adults are benthic or bentho-pelagic on continental slopes where they are found mostly in mobile schools up to 150 m of the bottom over hills and rough ground. The juveniles are pelagic.

Biological characteristics

The average size of black cardinalfish landed by the commercial fishery in New Zealand is about 50–60 cm fork length (FL) (Fisheries New Zealand 2021). Length frequency

distributions from research surveys are unimodal with a peak at 55–65 cm FL. Otolith readings from over 700 fish from eastern New Zealand waters validated using the radiometric and bomb radiocarbon methods (Andrews & Tracey 2007, Neil et al. 2008) indicate that this species is relatively slow-growing and long lived with maximum ages of over 100 years and the bulk of the commercial catch being between 35 and 55 years of age.

However, Pshenichny et al. (1986) (as cited in Abramov 1991), examined whole otoliths and considered that black cardinalfish on the North Atlantic Ridge attained a length of about 70 cm at only 10 years. Pshenichny et al. (1986) (as cited in Vinnichenko 1997), stated that black cardinalfish become sexually mature at age 7. These age estimates are well below Tracey et. al.'s assumed estimates of age at full recruitment and maximum ages. However Pshenichny et al. (1986) also reported lengths at maturity as 40-50 cm, similar to Tracey et al's estimate of age at full recruitment of 45 years.

The juveniles are pelagic and undergo major ontogenetic changes (Mauge & Mayer 1990). Juveniles are thought to be mesopelagic until they reach a length of about 12 cm (5 years of age), after which they become primarily demersal (Neil et al 2008). Larger juveniles have been caught in bottom trawls at depths of 400–700 m, extending into deeper water as they grow, with adult fish caught primarily at 800–1000 m (Dunn 2009).

Reproductive biology is not well known (Dunn 2009). From research surveys and Observer Programme data in New Zealand, spawning may occur between November and July. Northern species of cardinal fish also appear to spawn in autumn/early winter (Mauge & Mayer 1990). A probit analysis of maturity at length indicated that fish became sexually mature at around 50 cm length, at an age of approximately 35 years (Field & Clark 2001). Maturity was also inferred to be between ages 26 and 44 years (mean 33 years) from changes in δ^{13}C in otoliths (Neil et al 2008).

Life history parameters are given below (Tracey et al. 2000, Field & Clark 2001, Dunn 2009):

Parameter	Symbol	All	Male	Female
Natural mortality	M	0.034	–	–
Age at recruitment	A_r	45	–	–
Age at maturity	A_s	35	–	–
Gradual maturity	S_m	13	–	–
Von Bertalanffy parameters	L_{inf}	70.8	70.9	67.8
	K	0.034	0.038	0.034
	t_0	-6.32	-4.62	-8.39
Length-weight parameters	a	0.113	–	–
	b	2.528	–	–
Recruitment variability	σ_R	1.2	–	–
Recruitment steepness		0.75	–	–

Morphological characteristics

Second dorsal fin with one spine and 10 soft rays. No stout spine near rear edge of operculum. The eighth spine of the first dorsal fin is small and low and positioned between the first and second dorsal fins. Scale pockets pinkish with a dark greyish-purple

margin giving the body a dark purple hue, darker in larger individuals. Fins dusky in small and dark greyish-purple in larger individuals with no distinctive markings (McMillan et al 2011).

Biological productivity

This is a slow growing and long-lived species with late maturation. The bulk of the commercial catch is between 35 and 55 years of age. Accordingly, black cardinalfish are relatively susceptible to growth overfishing and population depletion.

Role of the species in the ecosystem

Black cardinalfish are assumed to be carnivorous, feeding on small fishes and planktonic invertebrates. Prey items observed during research surveys in New Zealand waters include mesopelagic fish, particularly lighthouse fish (*Phosichthys argenteus*), natant decapod prawns, and cephalopods (Tracey 1993). Predators of black cardinalfish are not documented but predation is expected to vary with fish development.

Impacts of Fishing

Habitat damage

The main method used to catch this species is a high-opening trawl generally fished hard down on the bottom. Trawling for this species on seamounts impacts habitat (Clark and O'Driscoll 2003; Koslow et al. 2001), but the precise impact of this on the black cardinalfish populations or other species on the seamounts is unknown.

Studies have shown that repeated trawl disturbances alter the benthic community by damaging or removing macro-fauna and encouraging anaerobic bacterial growth. Severe damage of coral cover from bottom trawl fishing inside the Australian EEZ has been documented (Koslow et al. 2001). Video images reveal bare rock and pulverized coral rubble where bottom trawling has occurred.

Bottom trawling also tends to homogenise the sediment, which damages the habitat for certain fauna. Benthic processes, such as the transfer of nutrients, remineralisation, oxygenation and productivity, which occur in undisturbed, healthy sediments, are also impaired.

As fishing gear disturbs soft sediment they produce sediment plumes and re-mobilise previously buried organic and inorganic matter. This increase in the rates of nutrients into the water column has important consequences for the rates of biogeochemical cycling (Kaiser et al. 2002).

Trawling for orange roughy, oreo, and cardinalfish, like trawling for other species, is likely to have effects on benthic community structure and function (e.g., Rice 2006) 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).

References

Abramov, A. (1991). Age and growth of two species of bigeyes, Epigonus angustifrons and E. elegans, from the Indian and Pacific Oceans. *Journal of Icthyology* 31: 125-131.

Abramov, A. (1992). Species composition and distribution of Epigonus (Epigonidae) in the world ocean. *Journal of Ichthyology* 32: 17–31.

Andrews, A.H., Tracey, D.M. (2007). Age validation of orange roughy and black cardinalfish using lead-radium dating. Final Research Report for Ministry of Fisheries Research Project DEE 2005-02 Objective 1. 40 p. (Unpublished report held by Fisheries New Zealand, Wellington.)

Clark, M.R.; King, K.J.; McMillan, P.J. (1989). The food and feeding relationships of black oreo, *Allocyttus niger*, smooth oreo, *Pseudocyttus maculatus*, and eight other fish species from the continental slope of the south-west Chatham Rise, New Zealand. *Journal of Fish Biology* 35: 465–484.

Clark, M.; O'Driscoll, R. (2003). Deepwater fisheries and aspects of their impact on seamount habitat in New Zealand. *Journal of Northwest Atlantic Fishery Science* 31: 441-458

Dunn, M.R. (2009). Review and stock assessment for black cardinalfish (*Epigonus telescopus*) on the east coast North Island. *New Zealand Fisheries Assessment Report* 2009/39. 55 p.

Field, K.D., Clark, M.R. (2001). Catch-per-unit-effort (CPUE) analysis and stock assessment for black cardinalfish *Epigonus telescopus* in QMA 2. *New Zealand Fisheries Assessment Report* 2001/23. 22 p.

Field, K.D.; Tracey, D.M.; Clark, M.R. (1997). A summary of information on, and assessment of the fishery for, black cardinalfish, *Epigonus telescopus* (Risso, 1810) (Percoidei: Apogonidae). New Zealand Fisheries Assessment Research Document 1997/22. 5 p.

Fisheries New Zealand (2021). Fisheries Assessment Plenary, May 2021: stock assessments and stock status. Compiled by the Fisheries Science Team, Fisheries New Zealand, Wellington, New Zealand. 1782 p

Hermsen, J.M, Collie, J.S, Valentine, P.C. (2003). Mobile fishing gear reduces benthic megafaunal production on Georges Bank. *Marine Ecology Progress Series 260*: 97–108.

Hiddink, J.G., Jennings, S., Kaiser, M.J., Queiros, A.M., Duplisea, D.E., Piet, G.J. (2006). Cumulative impacts of seabed trawl disturbance on benthic biomass, production, and species richness in different habitats. *Canadian Journal of Fisheries and Aquatic Sciences 63*: 721–36.

Jennings, S; Dinmore, T A; Duplisea, D E; Warr, K J; Lancaster, J E (2001) Trawling disturbance can modify benthic production processes. *Journal of Animal Ecology 70*: 459–475.

Kaiser, M.J., Collie, J.S., Hall, S.J., Jennings, S., Poiner, I.R. (2002). Modification of marine habitats by trawling activities: prognosis and solutions. *Fish and Fisheries* 3:114-136

Koslow, J.A.; Gowlett-Holmes, K.; Lowry, J.K.; O'Hara, T.; Poore, G.C.B.; and Williams, A. (2001). Seamount benthic macrofauna off southern Tasmania: community structure and impacts of trawling. *Marine Ecology Progress Series* 213: 111-125.

Mauge, L.A., Mayer, G.F. (1990). Apogonidae. In Quero, JC. (eds.) Check-list of the fishes of the eastern tropical Atlantic. JNICT, Lisbon; SEI Paris; UNESCO, Paris vol. 2, 714-718.

McMillan, P.J., Francis, M.P., James, G.D., Paul, L.J., Marriott, P.J., Mackay, E.; Wood, B.A.; Griggs, L.H.; Sui, H.; Wei, F. (2011). New Zealand fishes. Volume 1: A field guide to common species caught by bottom and midwater fishing. *New Zealand Aquatic Environment and Biodiversity Report* No. 68.

Morgan, M.J; Wilson, C.E; Crim, L.W (1999). The effect of stress on reproduction in Atlantic cod. Journal of Fish Biology 54(3): 477–488.

Neil, H.L.; McMillan, P.J.; Tracey, D.M.; Sparks, R.; Marriott, P.; Francis, C.; Paul, L.J. (2008). Maximum ages for black oreo (*Allocyttus niger*), smooth oreo (*Pseudocyttus maculatus*) and black cardinalfish (*Epigonus telescopus*) determined by the bomb chronometer method or radiocarbon ageing, and comments on the inferred life history of these species. Final Research Report for Ministry of Fisheries Research Project DEE2005-01 Objectives 1 & 2: 63 p. (Unpublished report held by FNZ, Wellington.)

Reiss, H., Greenstreet, S.P.R., Siebe, K., Ehrich, S., Piet, G.J., Quirijns, F., Robinson, L., Wolff, W.J, Kronke, I. (2009). Effects of fishing disturbance on benthic communities and secondary production within an intensively fished area. *Marine Ecology Progress Series 394*: 201–213.

Rice, J. (2006). Impacts of Mobile Bottom Gears on Seafloor Habitats, Species, and Communities: A Review and Synthesis of Selected International Reviews. Canadian Science Advisory Secretariat Research Document 2006/057. 35 p. (available from http://www.dfo-mpo.gc.ca/CSAS/Csas/DocREC/2006/RES2006_057_e.pdf).

Tracey, D.M.; George, K.; Gilbert, D.J. (2000). Estimation of age, growth, and mortality parameters of black cardinalfish (*Epigonus telescopus*) in QMA 2 (east coast North Island). *New Zealand Fisheries Assessment Report 2000/27*. 21 p.

Vinnichenko, V.I. (1997). Russian investigations and deepwater fishery on the Corner Rising seamount in Subarea 6. Sci. Counc. Stud. NAFO. pp. 41-49.

Code: GIS
Scientific name: *Dosidicus gigas*

(c)2003 MBARI

Sonja Heinrich, 2004

Taxonomy

Phylum	Mollusca
Class	Cephalopoda
Order	Teuthida
Family	Ommastrephidae
Genus and species	*Dosidicus gigas*
Scientific synonyms	None
Common names	Humboldt squid, jumbo flying squid, jibia, pota.
Molecular (DNA or biochemical) bar coding	No information

PO Box 3797, Wellington 6140, New Zealand
P: +64 4 499 9889 – F: +64 4 473 9579 – E: secretariat@sprfmo.int
www.sprfmo.int

Species characteristics

Global distribution and depth range

D. gigas is endemic to the Eastern Pacific, ranging from Northern California to Southern Chile, and reaching 125–140˚W at the equator (Figure 1). It is transboundary and straddling along the whole coast. Between 36 ˚S and 38 ˚S *D. gigas* are found from 400 to 600 nm offshore. Mating, spawning, and early development all occur within the area of the San Pedro Martir Basin (Gilly et al. 2006). *D. gigas* exhibits both horizontal and vertical movements between depths of hypoxic oxygen minimum layer and surface waters and forages in both shallow shelf and deeper waters (Bazzino et al. 2010).

Its range is limited by the isoline of phosphate concentration of 0.8 mg-at $P-PO_4^{3-}/m^2$ in the 0-100m layer (Aleksandronets et al. 1983, as cited by Nigmatullin et al. 2001).

Figure 1: Known distribution of *D. gigas*. *Source: Fabio Carocci. Food and Agriculture Organization of the United Nations (FAO). Marine Resources Service (FIRM).*

Distribution within South Pacific area

Large concentrations occur along the coast of northern Peru (Taipe et al. 2001). Straddling stocks occur off the coasts of Peru, Chile and Ecuador. Proportions inside and outside EEZs are unknown but trends have shown an increase of abundance in the high seas when coastal numbers are high. Large aggregations have been found in the zone of divergence of the Peruvian Oceanic current (17-22˚ S) (Nigmatullin 2002).

General habitat

D. gigas are nektonic squid that lives in the epi-pelagic zone. *D. gigas* are associated with Californian and Peruvian currents.

Biological characteristics

The reproductive part of the species range is located between 25˚ N and 20-25˚ S, mostly not further than 50-150 nm from the shore. However, from 10˚ N to 15-20˚ S it stretches from 200-450 nm offshore (Nigmatullin et al. 2001) (Figure 1). Spawning is known to occur in the San Pedro Martir Basin and along the entire coast of Peru with the greatest numbers spawning in the northern zone between 3˚ S and 8˚ S and the central zone between 12˚ S and 17˚ S. The Costa Rica Dome (a permanent feature in the ocean density structure relatively consistently located near latitude 9°N and longitude 89°N) could potentially be a common spawning ground for both northern and southern stocks of *D. gigas* as when catches are poor in Peruvian waters they appear higher off the coast of California.

D. gigas are monocyclic so they have only one reproductive season during their life. There is a distinct peak in spawning during spring and summer in the southern hemisphere (Nigmatullin et al. 2001; Tapie et al. 2001), and a secondary peak from July to August (Tafur & Rabi 1997; Tafur et al. 2001). Individual spawning periods are long and intermittent (batch spawning) (Nigmatullin et al. 2001). Spawning takes place both over the continental slope and in adjacent oceanic areas. It is presumed that spawning takes place in the near-surface water layer, but egg masses are unknown.

Studies of age and growth, using analyses of mantle length-frequency distributions and aging analyses using statoliths, show *D. gigas* grows quickly and does not live for more than 2 years having an average life span of ~1 year (Masuda et al. 1998; Hernandez-Herra et al. 1998; Arguelles et al. 2001; Nigmatullin et al. 2001). Hernandez-Herrera et al. (1998) observed that *D. gigas* can grow to 52 cm in the first year. Squid hatched in different seasons have different growth rates, with the highest rates being observed in those that hatched in winter (Masuda et al. 1998). *D. gigas* can reach a mantle length of up to 120 cm and can weigh up to 65 kg (Nigmatuulin et al. 2001). Statolith aging studies confirmed high growth rates but also found that some very large individuals can live for 18 months to 2 years (Nigmatullin et al. 2001).

The size at first maturity, in *D. gigas* from Peruvian waters, fluctuated between the years 1991 and 1995 (Tafur et al. 2001). Males matured faster than females and had size at first maturity between 136 and 474 mm between 1991 and 1995. The range of size at first maturity for females from Peruvian waters was between 285 and 327 mm (Tafur et al. 2001). Hernandez-Herrera et al. (1996) and Markaida et al. (2004) showed that populations within the Gulf of California mature at a larger size; 510 mm for females and 420 mm for males. Significant differences were found in size and age at first maturity between the winter/spring and summer/autumn hatching cohorts of *D. gigas* off the Peruvian Exclusive Economic Zones, except for age at first maturity for males (Liu et al., 2013). For the winter/spring hatching cohort, size and age at first maturity were 544 mm ML and 419 d old for females, and 497 mm ML and 387 d for males (Table 2). For the summer/autumn hatching cohort, size and age at fi rst maturity were 552 mm ML and 446 d old for females, and 556 mm ML and 420 d for males

Embryonic development lasts for 6-9 days at 18˚C. The mantle length (ML) at hatching averages 1.1 mm (Yatsu et al. 1999). Ontogenesis includes the following phases: paralarvae (1-10 mm ML), juvenile (15-100mm ML), sub-adult (150-350 mm ML), and adult (400-1000 mm ML), with three transitional periods. During these periods the morphology, food spectrum, and ecological status of the squid change (see Nigmatullin et al. 2001).

Biological productivity

Productivity is very high. The onset of maturity is early, fecundity is high and the species is very short-lived ~1 year, which indicates that the proportion of the total biomass that can be harvested is very large.

Role of species in the ecosystem

D. gigas is thought to play an important role in oceanic food webs. They are prey to a variety of predators such as pelagic fish, marine birds, and mammals. Juveniles are preyed upon by large carnivorous fish, small tuna, squid, and gulls; sub-adults are preyed upon by dorado, snake mackerel, yellowfin tuna, and other large tunas, fur seals; and adults by sharks, swordfish, striped marlin, sperm whales and pilot whales (Nigmatullin et al. 2001). Sperm whale stomach contents from the southeast Pacific have shown that *D. gigas* is their main prey (Clarke et al.1988). Before the moratorium on commercial whaling, the biomass of *D. gigas* consumed by exploited sperm whales in the eastern Pacific was estimated to be nearly 10 million tonnes (Clarke et al. 1998).

Studies in the Gulf of California have reported that the jumbo squid feeds predominantly on mesopelagic fishes such as myctophids. Pteropods, micronekton squid, megalopae, and euphausiids have also been reported in the stomachs of jumbo squid (Markaida 2006a).

D. gigas prey in the Southeast Pacific appears similar to that in the Gulf of California. A predominance of myctophids was observed, however, the gonostomatid *Vinciguerria lucetia* was the second in fish prey importance (Shchetinnikov 1989).

D. gigas are recognized as voracious and adaptable predators of a broad range of prey including small crustaceans and fishes at early life stages and shift to micronekton, larger fishes, and cephalopods (including cannibalism) as they grow (Nigmatullin et al., 2001; Alegre et al., 2014). Ontogenetic changes in the morphology of the capture apparatus (e.g., arms and beaks) seem to reflect the increasing capacity to seize or bite different size spectrum of prey (Franco-Santos and Vidal, 2014; Gong et al., 2018). Prey size increases as the squid grow (Schchetinnikov, 1989). Prey size, on average, is commonly between 5-7 cm and occasionally larger 10-15 cm for larger adult squid (Markaida & Sosa-Nishizaki 2003). A high occurrence of cannibalism (up to 70%) has been observed (Markaida 2006a).

Stable isotope analyses have complemented stomach content studies, suggesting that larger adult squid consumed prey of a higher trophic position than myctophids (Ruiz-Cooley et al. 2006).

Impacts of Fishing

Habitat damage

There is likely to be minimal if any damage to the habitat due to the fishing methods employed.

References

Anderson, C. I. H., Rodhouse, P. G. (2001). Life cycles, oceanography and variability: ommastrephid squid in variable oceanographic environments. *Fisheries Research 24*: 133-143.

Arancibia, H., M. Barros, S. Neira, U. Markaida, C. Yamashiro, L. Icochea, L. Cubillos, R. Leon y E. Acuña. (2006). Informe de Avance proyecto FIP 2005-38. Análisis del impacto de la jibia en las pesquerías chilenas de peces demersales. Universidad de Concepción / Universidad del Norte, 239 pp + Anexos.

Arguelles, J., Rodhouse, P.G., Villegas, P., Castillo, G. (2001). Age, growth and population structure of the jumbo flying squid *Dosidicus gigas* in Peruvian waters. *Fisheries Research* 54: 51-31.

Clarke, R., Paliza, O., Aguayo, A. (1988). In: Pilleri, G. (Ed.), Sperm whale of the southeast Pacific. Part IV fatness, food and feeding. Investigations on Cetacea, Vol. XXI, pp. 53-195.

Fernandez, F., Vasquez, J.A. (1995). The jumbo flying squid *Dosidicus gigas* (Orbigny, 1835) in Chile: analysis of an ephemeral fishery. *Estudios Oceanologicos 14*: 17-21.

Gilly, WF., Elliger, CA., Salinas, CA., Camarilla-Coop, S., Bazzino, G., Beman, M. (2006) Spawning by jumbo squid Dosidicus gigas in San Pedro Martir Basin, Gulf of California, Mexico. *Marine Ecology Progress Series 131*: 125-133.

Hernandez-Herra, A., Morales-Bojorquez, E., Cisneros, M., Neverez, M., Rivera, I. (1998). Management strategy for the giant squid (*Dosidicus gigas*) from Gulf of California, Mexico. *Calif. Coop. Oceanic Fish. Invest. Rep*. 39: 212-218.

Mangold, K. (1976). La migration chez les Cephalopodes. *Oceanis* 2(8): 381-389. {In French].

Markaida, U., Quinonez-Velazquez, C., Sosa-Nishizaki, O. (2004). Age, growth and maturation of jumbo squid *Dosidicus gigas* (Cephalopoda: Ommastrephidae) from the Gulf of California, Mexico. *Fisheries Research* 66: 31-47.

Markaida, U., Sosa-Nishizaki, O. (2003). Food and feeding habits of jumbo squid *Dosidicus gigas* (Cephalopoda: Ommastrephidae) from the Gulf of California, Mexico. *Journal of the Marine Biological Association of the United Kingdom* 83: 507-522.

Markaida, U. (2006a). Food and feeding of jumbo squid *Dosidicus gigas* in the Gulf of California and adjacent waters after the 1997-98 El Nino event. *Fisheries Research* 79(1-2): 16-27.

Markaida, M. (2006b). Population structure and reproductive biology of jumbo squid *Dosidicus gigas* from the Gulf of California after the 1997-98 El Nino event. *Fisheries Research 19*: 28-37.

Masuda, S., Yokawa, K., Yatsu, A., Kawahara, S. (1998). Growth and population structure of *Dosidicus gigas* in the Southeastern Pacific Ocean. In: Okutani, T. (Ed.) Contributed papers

to International symposium on large pelagic squids, July 18-19, 1996, JAMARC, Tokyo, pp. 107-118.

Morales-Bojorquez, E., Cisneros-Mata, M.A., Nevarez- Martinez, M.O., Hernandez-Herrera, A. (2001). Review of stock assessment and fishery biology of *Dosidicus gigas* in the Gulf of California, Mexico. *Fisheries Research* 54: 83-94.

Nevarez-Martinez, M.O., Mendez-Tenorio, F.J., Cervantes-Valle, C., Lopez-Martinez, J., Anguiamo-Carrasco, M.L. (2006). Growth, mortality, recruitment, and yield of the jumbo squid (*Dosidicus gigas*) off Guaymas, Mexico. *Fisheries Research* 79: 38-47.

Nigmatullin, C.M., Nesis, K.N., Arkhipkin, A.I. (2001). A review on the biology of the jumbo squid *Dosidicus gigas* (Cephalopoda: Ommastrephidae). *Fisheries Research* 54: 9-19.

Nigmatullin, Ch. M., (2002). Preliminary estimates of total stock size and production of Ommastrephid squids in the world ocean. *Bulletin of Marine Science* 71(2): 1134.

Rocha, F., Vega, M.A. (2003). Overview of cephalopod fisheries in Chilean waters. *Fisheries Research* 60: 151-159.

Rodhouse, P.G. (2001). Managing and forecasting squid fisheries in variable environments. *Fisheries Research* 54: 3-8.

Ruiz-Cooley, R.I., Markaida, U., Gendron, D., Aguiniga, S. (2006). Stable isotopes in jumbo squid (*Dosidicus gigas*) beaks to estimate its trophic position: comparison between stomach contents and stable isotopes. *Journal of the Marine Biological Association of the United Kingdom* 86(2): 437-445.

Shchetinnikov, A.S. (1989). Food spectrum of *Dosidicus gigas* (Oegopsida) in the ontogenesis. *Zoologicheskii Zhurnal* 68: 28-39 [In Russian with English Abstract].

Taipe, A., Yamashiro, C., Mariategui, L., Rojas, P., Roque, C. (2001). Distributions and concentrations of jumbo flying squid (*Dosidicus gigas*) off the Peruvian coast between 1991 and 1999. *Fisheries Research* 54: 21-32.

Tafur, R., Villegas, P., Rabi, M., Yamashiro, C. (2001). Dynamics of maturation, seasonality and reproduction and spawning grounds of the jumbo squid *Dosidicus gigas* (Cephalopoda: Ommastrephidae) in Peruvian waters. *Fisheries Research* 54: 35-50.

Tafur, R., Rabi, M. (1997). Reproduction of the jumbo flying squid, *Dosidicus gigas* (Orbingy, 1835) (Cephaloopda: Ommastrephidae) off Peruvian coasts. *Scientia Marina* 61 (suppl. 2): 33-37.

Vecchoine, M. (1999). Extraordinary abundance of squid paralarvae in the tropical eastern Pacific Ocean during El Nino of 1987. *Fishery Bulletin* 97: 1025-1030.

Waluda, C.M., Yamashiro, C., Rodhouse, P.G. (2006). The influence of the ENSO cycle on the light-fshery for *Dosidicus gigas* in the Peru current: An analysis of remotely sensed data. *Fisheries Research* 79(1-2): 56-63.

Waluda, C.M., Trathan, P.N., Rodhouse, P.G. (2004). Synchronicity in southern hemisphere squid stocks and the influence of Southern Oscillation and Trans Polar Index. *Fisheries Oceanography* 13(4): 255-266.

Xinjun, C., Xiaohu, Z. (2005). Catch distribution of jumbo flying squid and its relationship with SST in the offshore waters of Chile. *Marine Fisheries/Haiyang Yuye* 27(2): 173-176.

Yatsu, A., Yamanaka, K., Yamashiro, C. (1999). Tracking experiments of the jumbo squid, *Dosidicus gigas*, with an ultrasonic telemetry system in the Eastern pacific Ocean. *Bull. Nat. Res. Inst. Far Seas Fish.* 36: 55-60.

Yokawa, K. (1995). Isozyme comparison of large, medium and small size specimens of *Dosidicus gigas*. Proc. Res. Conf. Squid resource. *Fish Cond. Hachinohe, f.y. 1993*, 48-52 [In Japanese].

Gong, Y., Ruiz-Cooley, R. I., Hunsicker, M. E., Li, Y., and Chen, X. (2018). Sexual dimorphism in feeding apparatus and niche partitioning in juvenile jumbo squid Dosidicus gigas. Mar. Ecol. Prog. Ser. 607, 99–112.

Franco-Santos, R. M., and Vidal, E. A. G. (2014). Beak development of early squid paralarvae (Cephalopoda: Teuthoidea) may reflect an adaptation to a specialized feeding mode. Hydrobiologia 725, 85–103.

Liu, B.L., Chen, X.J., Chen, Y., Tian, S.Q., Li, J.H., Fang, Z., Yang, M.X. (2013). Age, maturation, and population structure of the Humboldt squid Dosidicus gigas off the Peruvian exclusive economic zones. Chin. J. Oceanol. Liminol. 31 (1), 81–91

Bazzino G, Gilly WF, Markaida U, Salinas-Zavala CA, Ramos-Castillejos J. (2010). Horizontal movements, vertical- habitat utilization and diet of the jumbo squid (Dosidicus gigas) in the Pacific Ocean off Baja California Sur, Mexico. Prog Oceanogr 86: 59–71

Code: JMC
Scientific name: *Jasus Caveorum*

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Taxonomy

Phylum	Arthropoda
Class	Crustacea
Order	Decapoda
Family	Palinuridae
Genus and species	*Jasus caveorum* (Webber & Booth, 1995)
Scientific synonyms	None
Common names	Foundation seamount rock lobster
Molecular (DNA or biochemical) bar coding	No information available

PO Box 3797, Wellington 6140, New Zealand
P: +64 4 499 9889 – F: +64 4 473 9579 – E: secretariat@sprfmo.int
www.sprfmo.int

Species characteristics

- ### Global distribution and depth range

Jasus caveorum has been reported only from the non-emergent Foundation Seamount Chain, near 35°S 120°W in the south-east Pacific Ocean, where it has been taken between 140 m (the shallowest depth fished) and 180 m (Webber & Booth 1995).

- ### Distribution within South Pacific area

The general area assumed to be occupied by this lobster is about 90 000 km^2 of the Foundation Seamount Chain.

- ### General habitat

This lobster lives on firm substrates on and near seamount crests.

- ### Biological characteristics

Morphology: Rostrum smaller and less robust than supraorbital horns; short, squat carapace spines; a broad, shallow carapace transverse groove; antennal flagellum with many narrow pale rings; a smooth first abdominal tergum; small, flat squamae confined to a single lateral transverse row on each side of abdominal terga two to six, rows not meeting medially; a large, distoventral spine on the first pereopod propodus in males, a row of two or three tufts of setae and two or three small spines on ventral margin of second pereopod merus; all surfaces of merus of male fifth pereopod smooth; and body and legs spotted red on an off-white to yellow-orange background (Webber & Booth 1995).

Sexes co-occur but are often segregated. Males reach at least 129 mm carapace length. Egg-bearing is during winter, and spring hatching can be expected. Most of the commercial catch has been comprised of males.

Based on other species of *Jasus* (for example, *J. edwardsii*—Frusher et al. 1999; MacDiarmid & Booth 2003) and on the specimens of this species available, it can be expected that males grow larger than females. Recently mature males and females will moult once or twice per year (including in the case of females just before the winter egg-bearing season); there will be a long (many months) phyllosoma larval period that will be distributed reasonably or very widely in the east South Pacific Ocean; and settlement will be by the postlarval puerulus stage. Furthermore, this lobster will be nocturnally active, and feed on a wide range of foods, but particularly invertebrates.

There is no information on age and growth, but these lobsters are probably long-lived (decades).

-
- ### Biological productivity

Biological productivity is probably low. The onset of maturity is late, fecundity is low, annual growth rate is relatively slow and the species is long-lived..

- Role of species in the ecosystem

The role of this lobster in the seamount ecosystem is unknown, apart from it presumably being one of the larger predatory crustaceans. Most of the lobsters taken in June-July 1995 bore numerous small, unidentified stalked barnacles, some specimens being heavily infested ventrally at the anterior of the abdomen, on the pleopods, and around the mouthparts (Webber & Booth 1995). Crabs of the genus *Chaceon* were caught in the same traps and were also infested with similar barnacles.

Rock lobsters are prey at various stages of their life to fishes such as tunas and bramids (phyllosoma and puerulus) and to octopuses, and sharks and other bottom-feeding fishes (juveniles and adults). The precise diet of this lobster is unknown, but it is expected that it consumes a wide range of foods, probably with particular focus on other invertebrates. It has been taken in pots using finfish as bait.

Impacts of Fishing

-
- Habitat damage

Potting has been the main fishing method used in this fishery. It is a relatively benign method, probably causing little direct damage to the environment.

It is also believed that trawling has occurred on the Foundation seamounts. Bottom trawling has adverse effects on the habitat. The impact of bottom trawling on the lobster population is unknown.

References

Frusher, S.; Prescott, J.; Edmunds, M. (1999). Southern rock lobsters. In *Under Southern Seas. The Ecology of Australia's Rocky Reefs* (Ed. by N. Andrew), pp. 106–13. University of New South Wales Press, Sydney.

MacDiarmid, A.; Booth, J.D. (2003). Crayfish. In *The living reef. The ecology of New Zealand's rocky reefs*. (Eds Andrew, N.; Francis, M.) Craig Potton Publishing.

Webber, W.R.; Booth, J.D. (1995). A new species of *Jasus* (Crustacea, Decapoda, Palinuridae) from the eastern South Pacific Ocean. *New Zealand Journal of Marine and Freshwater Research 29*: 613–622.

Code: MAS
Scientific name: *Scomber Japonicus*
1
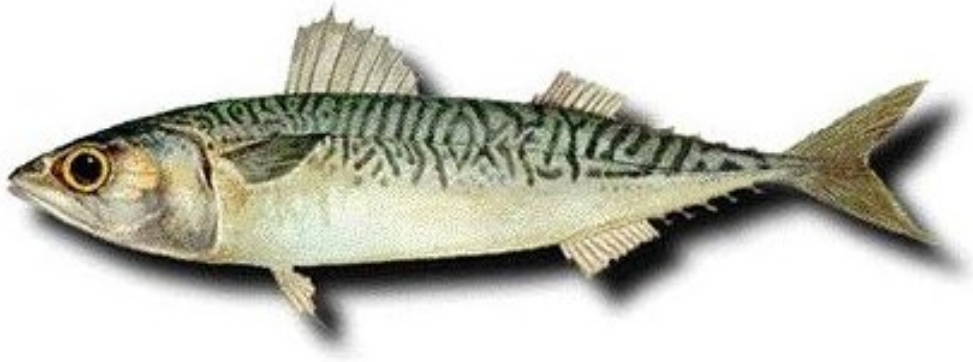
Taxonomy

Phylum	Vertebrata
Class	Actinopterygii
Order	Perciformes
Family	Scombridae
Genus and species	*Scomber japonicus*, Houttuyn, 1782
	Scomber colias, Scomber australasicus (Note that *Scomber australasicus* Cuvier 1832 is a valid species in its own right, but appears to have an Australasian only distribution. *S. australasicus* has been used erroneously in the past as a synonym for *S. japonicus* in the eastern Pacific).
Scientific synonyms	
Common names	Chub mackerel, caballa, cavalinha, estornino, mackerel, blue mackerel
Molecular (DNA or biochemical) bar coding	No information

PO Box 3797, Wellington 6140, New Zealand
P: +64 4 499 9889 – F: +64 4 473 9579 – E: secretariat@sprfmo.int
www.sprfmo.int

Species Characteristics

Global distribution and depth range

The distribution of *S. japonicus* is reported as circum-global and cosmopolitan. In the Atlantic Ocean it occurs off the east coast of North America from New Scotia, Canada to Venezuela. On the South American east coast, it occurs from southeast Brazil to south Argentina. On the European coast *S. japonicus* is reported from the United Kingdom to France. *S. japonicus* is reported from almost the whole coast of Africa. It occurs in the Mediterranean and Red Seas. It is apparently absent in the Indian Ocean, from Indonesia and Australia. In the Pacific Ocean *S. japonicus* is fished off Japan and the west coast of South America from Ecuador to Chile (Collette, 2001). *S. japonicus* appears to be replaced by *Scomber australasicus* in the South West Pacific (found off New Zealand and eastern Australia).
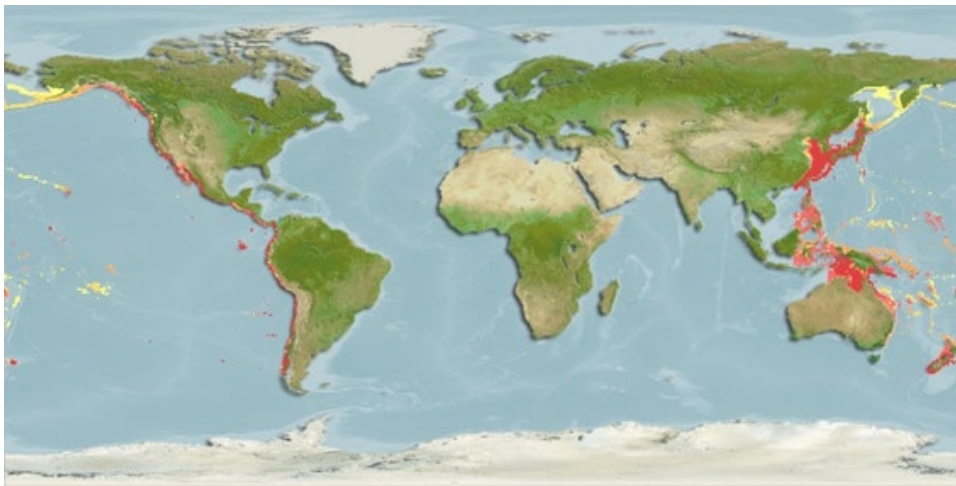

Figure 1. Distribution of chub mackerel *Scomber japonicus* (Houttuyn, 1782). Source: FishBase, 2020

Distribution within South Pacific area

Matsui (1967) describes the distribution of *S. japonicus* in South Pacific to be from Panama to Chile, around including around the Galapagos Islands, with austral limits at Guamblin Island, at 45°41'S. The longitudinal distribution includes areas outside EEZ limits in the south (off Chile), but it occurs mainly within 100 nm of the coast in the north.
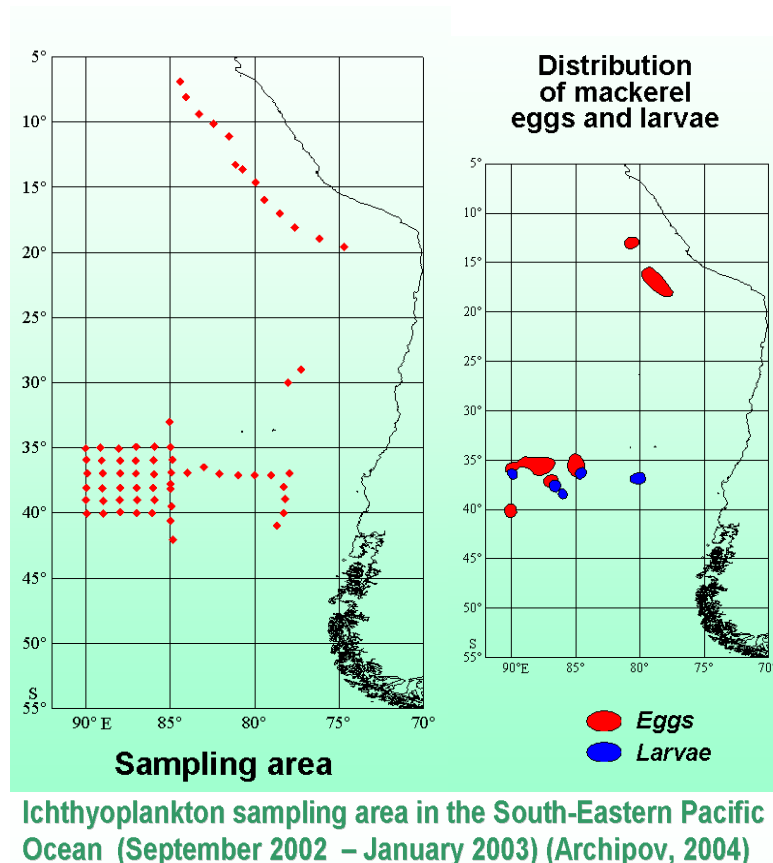
Figure 1: Distribution of chub mackerel eggs and larvae in the Southeastern Pacific ocean (from Archipov 2004).

General habitat

S. japonicus is a pelagic fish with gregarious behavior. In the Eastern South Pacific waters it forms schools usually with jack mackerel (*Trachurus murphyi*) and sardine (*Sardinops sagax*) at the adult stages, but also with anchovy (*Engraulis ringens*) when smaller than 15 cm. It is uncommon for *S. japonicus* to inhabit waters deeper than 50 m and according to Maridueña & Menz (1986) the species undertakes vertical migration to surface for feeding. However, Hernández (1991) relates the occurrence of *S. japonicus* about the Big Canaries Islands to be over the continental slope, from the surface to 300 meters depth. This species in habits warm and temperate waters of the Atlantic, Indian and Pacific oceans and adjacent seas (Collette and Nauen, 1983)

Biological characteristics

S. japonicus is a heterosexual fish, without evidence of sexual dimorphism (Kramer, 1969; Castro and Santana, 2000). Histological studies demonstrate *S. japonicus* as a partial spawner, with an extended period of reproductive activity (Peña *et al*., 1986; Dikerson *et al*. 1992). Off Peru the spawning season is described to be from August to March, mainly in high summer (Miñano and Castillo, 1971; Mendo 1984). Near Ecuador there seems to be a secondary period in September (Serra *et al*, 1982; Maridueña & Menz, 1986). In Chilean waters the spawning season is identified in November through March in northern and southern areas. This has been confirmed with results from projects monitoring pelagic

fisheries in these regions, which report an increase of mature fishes at the end of the year, and high values of gonadosomatic index (GIS) within January and March (Martínez *et al.*, 2006). The length of 50% maturity was estimated by Pardo & Oliva (1992) in the north region as 26cm, a mean between macro and microscopic criteria.

Growth of the species is characterised as very fast in the first two years, manifested in a high growth rate (*k*). Fishes can reach 50% of the asymptotic length in this period, considering that L_∞ are reported in the literature to be approximately 45 cm and longevity between 9 to 10 years. Table 1 shows the growth parameters reported in the literature for this species from the eastern Pacific in both hemispheres. Considerable additional data are available from the northwestern Pacific, but not reported here (e.g. Choi et al. 2000).

Table 1: Growth parameters estimated for *S. japonicus* in the eastern Pacific Ocean.

	Country	L_∞ (cm)	k	t0 (years)
Parrish y MacCall, 1978	USA (California)	43.60	0.244	-3.022
Aguayo,1982	Chile	44.60	0.160	-1.550
Mendo,1984	Perú	40.57	0.408	-0.050
Pizarro,1984	Ecuador	39.20	0.230	-1.790
Aguayo y Steffens, 1986	Chile	44.37	0.164	-1.543
Canales *et al.*, 2004	Chile	37.56	0.264	-0.500
Martinez *et al.*, 2006	Chile	41.43	0.184	-1.541
Caramantin *et al.*, 2008	Perú	41.30	0.390	-0.400

Morphological characteristics

S. japonicus present a fusiform and elongate body, with a sharp muzzle. Inter-pelvic process is small and single. No well developed corselet. Swim bladder is present. First haemal spine is posterior to first inter-neural process and 12 to 15 inter-neural bones under first dorsal fin. Anal fin spine conspicuous clearly separated from anal rays but joined to them by a membrane. Back with narrow stripes which zigzag and undulate. Caudal peduncle with 5 finlets on the upper and lower edge. Distance between dorsal fins shorter than or equal to the first dorsal fin base. Lateral line not interrupted and caudal fin forked. Belly is unmarked (Pacific population) or with wavy lines. Dorsal color green and yellow, with thin blue lines (Collette and Nauen, 1983).

Maximum length is about 50 cm, while the most common lengths are around 30 cm.

Key morphological features are:

- Dorsal spines (total): 9 - 11;
- Dorsal soft rays (total): 11 - 12;
- Anal spines: 0;
- Anal soft rays: 12 – 14; and
- Vertebrae: 31.

Biological productivity

Medium – onset of maturity is moderate, fecundity is moderate, annual growth rate is moderate and the species is moderately long lived.

Role of the species in the ecosystem

According to Hernández (1991), it is difficult to determine the trophic level of *S. japonicus* on the food web, mainly due to the diversity of food items found inside their stomachs. In some areas the species seems to eat from phytoplankton to copepods, larvae and small juveniles of other fish species as anchovy, and is considered opportunistic predators (Konchina 1982; Alegre *et al.*, 2015). In this way, *S. japonicus* can vary their trophic level between the second and fortieth levels, depending on the moment and the type of food available. *S. japonicus* are predated upon by a large range of species, such as tunas, sharks and even dolphins and whales. These features make the species a very important component of the trophic web, as a link between production levels and top predators.

Impacts of fishing

Habitat damage

There are no known habitat damage issues for this essentially purse seine and mid-water trawl fishery.

References

Alegre, A., Bertrand, A., Espino, M., Espinoza, P., Dioses, T., Ñiquen, M., ... & Ménard, F. (2015). Diet diversity of jack and chub mackerels and ecosystem changes in the northern Humboldt Current system: A long-term study. *Progress in Oceanography, 137*, 299-313.

Choi, Y. M., Park, J. H., Cha, H. K., and K. S. Hwang. (2000). Age and growth of common mackerel, *Scomber japonicus* Houttuyn in Korean waters. *J. Korean. Soc. Fis. Res.* 3:1-8.

Caramantin-Soriano, H., Vega-Pérez, L. A., & Ñiquen, M. (2008). Growth parameters and mortality rate of the Scomber japonicus peruanus (Jordán & Hubb, 1925) along the Peruvian coast, South Pacific. *Brazilian Journal of Oceanography*, *56*, 201-210.

Castro, J. J., & Santana, A. T. (2000). Synopsis of biological data on the chub mackerel (Scomber japonicus Houttuyn, 1782). FAO Fisheries Sypnosis. No. 157. FAO. Rome.

Collette, B.B. and C. Nauen. (1983). FAO Species catalogue. 2. Scombrids of the world. An annotated and illustrated catalogue of tunas, mackerels, bonitos and related species known to date. FAO Fish. Synop., 125:1-137 pp.

Collette, B.B. (2001). Scombridae. Tunas (also, albacore, bonitos, mackerels, seerfishes, and wahoo). p. 3721-3756. In: K.E. Carpenter and V. Niem (eds.) FAO species identification guide for fishery purposes. The living marine resources of the Western Central Pacific. Vol. 6. Bony fishes part 4 (Labridae to Latimeriidae), estuarine crocodiles. FAO, Rome.

Dickerson, T. L., Macewicz, B. J., & Hunter, J. R. (1992). Spawning frequency and batch fecundity of chub mackerel, Scomber japonicus, during 1985. CalCOFI Rep, 33, 130-140.

Hernández, J., J., C. (1991). Ecología trófica de la caballa (*Scomber japonicus,* Houttuyn, 1780) en aguas del archipiélago canario. Tesis Doctoral, Departamento de Biología. Universidad de Las Palmas de Gran Canaria, 242p.

Konchina, Y. V. (1982). Feeding of the Pacific mackerel, *Scomber japonicus*, near the Peruvian coast. Journal of ichthyology, 22, 102-111.

Kramer, D. (1969). Synopsis of the biological data on the pacific mackerel, Scoinber japonicus Houttuyn (northeast Pacific). U.S. Fish Wildl. Seri'., Circ., 302. 18 pp.

Maridueña, L.S. y A. Menz. (1986). Caballa, *Scomber japonicus* Houttuyn, 1780. En: Bases Biológicas y Marco Conceptual para el Manejo de los Recursos Pelágicos en el Pacífico Suroriental. Convenio de Cooperación BID/SELA. OLDEPESCA. Documento de Pesca 1.

Martinez, C., Bohm, G., Cerna, F., Días, E., Muñóz, P., Aranis, A., Caballero, L., Aravena, R., Ossa, L., (2006). Estudio biológico-pesquero de la caballa entre la I-X Regiones. Proyecto FIP N° 2005-19. Fondo de Investigación Pesquera – Chile. 416p.

Matsui, T. (1967). Review of the mackerel genera *Scomber* and *Rastrelliger* with description of a new species of *Rastrelliger*. *Copeia (1*): 71-83.

Mendo, J. (1984). Edad, crecimiento y algunos aspectos reproductivos y alimentarios de la caballa *Scomber japonicus peruanus. Boletín Inst. Mar Perú 8(4)*: 104 – 156.

Miñano J. and J. Castillo. 1971. Primeros resultados de la investigación biológico-pesquera de la "caballa" Scomber japonicus peruanus J. y H. Serie Informes Especiales Instituto del Mar del
Perú -Callao N° IM-84, p. 1-16.

Pardo, A. S., Oliva J. L., (1992). Estimación de la talla de primera madurez de caballa (*Scomber japonicus peruanus*) en la zona norte de Chile durante el período de máxima actividad reproductiva. Invest Pesq. (Chile) 37:97-106.

Peña, N., Alheit, J., & Nakama, M. E. (1986). Fecundidad parcial de Caballa del Perú (Scomber japonicus peruanus). Bol. lnst. Mar PerU: 10(4).

Serra, R., O. Rojas, M. Aguayo. (1982). Caballa, *Scomber japonicus peruanus* Jordan y Hubbs. 47 págs. En: Estado Actual de las Principales Pesquerías Nacionales. Bases para un Desarrollo Pesquero. CORFO. Gerencia de Desarrollo. IFOP. Santiago, Chile.

Torrejón-Magallanes, J., Sánchez, J., Mori, J., Bouchon, M., & Ñiquen, M. (2017). Estimación y variabilidad temporal de talla de madurez gonadal de la caballa (*Scomber japonicus peruanus*) en el litoral peruano. Revista peruana de biología, 24(4), 391-400.

Code: OFJ
Scientific name: *Ommastrephes bartrami*

Taxonomy

Phylum	Mollusca
Class	Cephalopoda
Order	Teuthida
Family	Ommastrephidae
Genus and species	*Ommastrephes bartrami* (Lesueur, 1821)
Scientific synonyms	*Ommastrephes caroli* Furtado, 1887
	Loligo bartrami Lesueur, 1821
Common names	Neon flying squid, Red flying squid, Red ocean squid, Tintenfisch, Kalmar, Pfeilkalmar, Pota saltadora, Encornet volant, Encornet carol, Pota velera, Akaika, Bartram's squid, Aka-ika, Murasaki-ika, Baka-ika.
Molecular (DNA or biochemical) bar coding	No information available

PO Box 3797, Wellington 6140, New Zealand
P: +64 4 499 9889 – F: +64 4 473 9579 – E: secretariat@sprfmo.int
www.sprfmo.int

Species characteristics

Global distribution and depth range

O. bartrami is the most broadly distributed species in the family Ommastrephidae with a circumglobal distribution (Murata 1990) (Figure 1). *O. bartrami* is found in subtropical and warm temperate waters of all oceans except the Southeast Pacific. It is most prominent in the North Pacific, off the east coast of Japan and the west coast of USA. Distributions of *O. bartrami* are patchy and highly aggregated (Chen & Chiu 1999).

In the North Pacific (42 - 45˚ N) *O. bartrami* have been observed between 0 - 40 m at night and between 150 – 300 m during the day (Murata & Nakamura 1998). Further south (26-28˚ N) *O. bartrami* has been observed between 40 - 70 m at night and between 400 -700 m during the day (Nakamura 1991). In the North Atlantic submersible observations of *O. bartrami* were between 540 – 1 050 m during the day and in surface waters at night (Moiseev 1991). Smaller squid spend more time at the surface where they have been observed flying across the water.

Figure 1: Distribution of *Ommastrephes bartrami*. *Source: Adapted from: Roper C.F.E., M.J. Sweeney and C.E. Nauen 1984. Cephalopods of the world. Food and Agriculture Organization, Rome,* Italy. Vol. 3: 277 pp. See also note below about distribution in the South Pacific.

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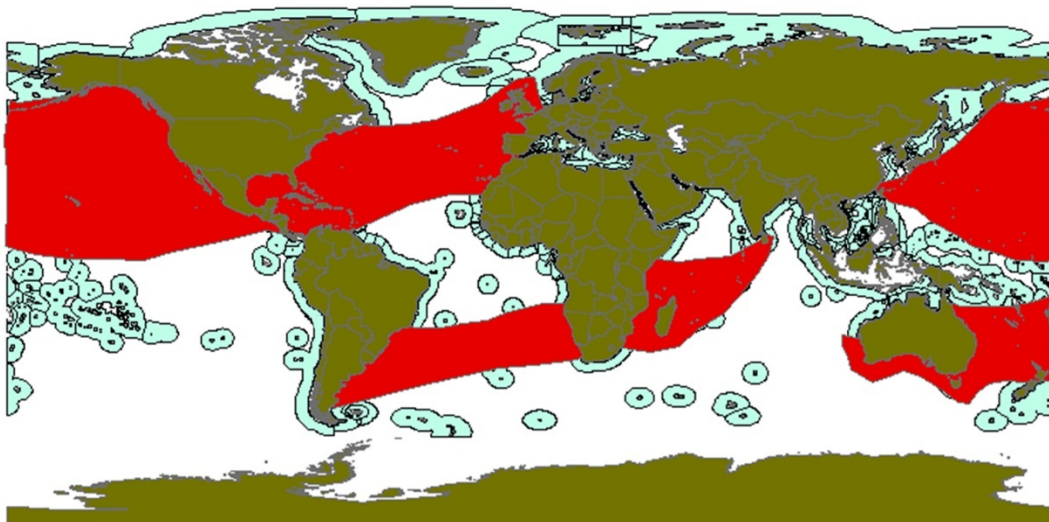
- **Distribution within South Pacific area**

O. bartrami has been recorded in temperate and subtropical waters along the south, east and west coasts of Australia. *O. bartrami's* distribution extends across the Tasman Sea to Norfolk Island and at least as far south as south-east Tasmania. In the South Pacific it is also present on the high seas to the east of the Peruvian current (Alexeyev 1994).

- **General habitat**

O. bartrami is an oceanic squid that lives in the water column and undergoes vertical migrations.

- **Biological characteristics**

Spawning in Australian waters is thought to occur in spring to summer and over the continental shelf (Dunning & Brandt 1985). In the North Pacific spawning occurs between winter and summer (Araya 1983). Many details related to spawning remain unknown. It has been suggested that *O. bartrami* is a continuous spawner like its close relative *Sthenoteuthis oualaniensis*, however, evidence is not conclusive.

Juvenile squid are virtually absent from net, jigging or driftnet collections and very little is known about their biology or ecology. Egg masses have never been observed and paralarval distribution suggests hatching occurs somewhere near the sea surface where temperatures range between 21 to 25˚C (Hayase 1995; Bower 1996). The distribution of paralarvae in the northern hemisphere also suggests that spawning does not occur in near-shore waters (Bower 1996; Yatsu et al. 1998).

In the Northern Pacific age and growth of *O. bartrami* has been investigated based on the examination of statolith microstructure, however, daily increments still remain to be validated. Growth rates were found to vary by sex, geographic region, hatching season, food availability and ambient temperatures (Forsythe 2004). Slower growth rates have been observed in the late spring and summer compared to autumn (Ichii et al. 2004). Female *O. bartrami* grow faster than males with individual growth rates ranging from 1.1 to 2.5 mm day^{-1} and from 1.1 to 2.1 mm day^{-1} respectively. (Yatsu et al., 1997; 1999).

O. bartrami matures between the age of 7-10 months and has an estimated life span of ~1 year (Yatsu et al. 1997; 1998). Size at maturity in Australian waters is thought to be greater than 40 for cm female and greater than 30 cm in males (Dunning & Brandt 1985).
Size at maturity in the North Pacific has been reported at about 30-33 cm in males and 40-55 cm in females (Yatsu et al. 1998).

The maximum recorded size in Australian waters for females is 477 mm mantle length and for males, 397 mm mantle length (Dunning & Brandt 1985). Maximum size reported in North Pacific is 406 mm males and 562 mm females (Murata 1990).

There is no information describing migratory movements of *O. bartrami* in the South Pacific. However in the North Pacific, *O. bartrami* make an annual round-trip migration between subtropical spawning grounds and northern feeding grounds near the subarctic boundary (Murata & Nakamura 1998). During spawning migrations *O. bartrami* have been observed to migrate at a rate of up to 17 km day^{-1} (Araya 1983).

O. bartrami have been observed to fly a distance of 10 - 20 m at 1 - 2 m height off the sea surface. It is believed that the gliding-like flying behaviour is analogous to flying fish with the aim of escaping from predators (Murata 1988).

Immature male and female squid school together, but with the onset of sexual maturity sexual segregation occurs. Squid larger then 400 mm are typically found in schools of less than 20 individuals (Dunning & Brandt 1985).

O. bartrami display high variability in abundance. Due to this there is a considerable body of research investigating correlations between squid abundance and environmental variables. Examples of this research, which is predominantly undertaken by the Chinese and Japanese, are spatial and temporal analyses using Grays incidence methods (Chen et al. 2002) and forecast modelling using artificial intelligence (Chen et al. 2003; Cui et al. 2003).

●
●   **Biological productivity**

Very high – onset of maturity is early, fecundity is high, annual growth rate is relatively rapid and the species is very short lived, which indicates that the proportion of the total biomass that can be harvested is very large.

●   **Role of species in the ecosystem**

O. bartrami are opportunistic predators. Similarly to *S. ouloualensis* and *D. gigas*, *O. bartrami* display ontogenetic changes in diet with growth. Those between 15-19 cm mantle length feed mostly on planktonic crustaceans, whereas larger individuals feed primarily upon myctophids and squid (Murata 1990; Watanabe et al. 2004).

A high incidence of cannibalism, (up to 60% of identified squid material, which made up 50% of stomach contents) has been observed in *O. bartrami* (Seki 1993).

Marine mammals, seabirds, sharks and swordfish prey heavily upon *O. bartrami.* (Aydin et al. 2003; Seki 1993; Stillwell & Kohler 1985; Toll & Hess 1981). In Australian waters the only known predators are pelagic sharks.

Impacts of Fishing

●   **Habitat damage**

There is likely to be minimal damage to the habitat due to the fishing methods employed.

References

Alexeyev, D.O. (1994). New data on the distribution and biology of squids from the Southern Pacific. *Ruthenica 4(2):*151-166.

Araya, H. (1983). Fishery, life history and stock assessment of *Ommastrephes bartrami* in the North Pacific Ocean. *Memoirs of the National Museum of Victoria. 44*: 269-283.

Aydin, K.Y.; McFarlane, G.A.; King, J.R.; Megrey, B.A. (2003). The BASS/MODEL report on trophic models of the subarctic Pacific basin ecosystems. *North Pacific Marine Science Organization (PICES) Report #25*, 93pp.

Bower, J.R. (1996). Estimated paralarval drift and inferred hatching sites for *Ommastrephes bartrami* (Cephalopoda: Ommastrephidae) near Hawaiian Archipelago. *Fisheries Bulletin 94(3)*: 398-411.

Chen, X., Tian, S., Ye, X. (2002). Study in population structure of flying squid in northwestern Pacific based on gray system theory. *Journal of Shanghai Fisheries University 11(4)*: 335-341.

Chen, X., Qian, W., Xu, L., Tian, S. (2003). Study on *Ommastrephes bartrami* fishing ground and forecasting models from 150˚ E to 165˚ E in the North Pacific Ocean. *Marine Fisheries Research/ Haiyang Shuichan Yanjiu 24(4)*: 1-6.

Chen, C., Chiu, T. (1999). Abundance and spatial variation of *Ommastrephes bartrami* (Mollusca: Cephalopoda) in the Eastern North Pacific observed from an exploratory survey. *Acta Zoologica Taiwanica 10(2)*:135-144.

Cui, X., Fan, W., Shen, X. (2003). Development of the fishing condition analysis and forecasting system of *Ommastrephes bartrami* in the northwest Pacific Ocean. *Journal of Fisheries of China 27(6)*: 600-605.

Dunning, M., Brandt, S.B. (1985). Distribution and life history of deep water squid of commercial interest from Australia. *Australian Journal of Marine and Freshwater Research 36*: 343-359.

Forsythe, J.W. (2004). Accounting for the effect of temperature on squid growth in nature: from hypothesis to practice. *Marine and Freshwater Research 55(4)*: 331-339.

Hayase, S. (1995). Distribution of the spawning grounds of flying squid, *Ommastrephes bartrami*, in the North Pacific Ocean. *Japan Agricultural Research Quarterly. 29(1)*: 65-72.

Ichii, T., Mahapatra, K., Sakai, M., Inagake, D., Okada, Y. (2004). Differing body size between the autumn and winter-spring cohorts of neon flying squid (*Ommastrephes bartrami*) related to the oceanographic regime in the North Pacific: a hypothesis. *Fisheries Oceanography 13(5)*: 295-309.

Moiseev, S.I. (1991). Observation of the vertical distribution and behavior of nektonic squids using manned submersibles. *Bulletin of Marine Science. 49(1-2)*: 446-456.

Murata, M., Nakamura, Y. (1998). Seasonal migration and diel vertical migration of the neon flying squid, *Ommastrephes bartrami,* in the North Pacific. In: Okutani, T. (Ed.),

Contributed papers to International symposium on Large Pelagic squids. Japan Marine Fishery Research Centre, Tokyo, pp. 13-30.

Murata, M. (1990). Oceanic resources of squids. *Marine Behaviour and Physiology 18*: 19-71.

Murata, M. (1988). On the flying behaviour of neon flying squid *Ommastrephes bartrami* observed in the central and northwestern North Pacific. *Nippon Suisan Gakkaishi 54(7):* 1167-1174.

Nakamura, Y. (1991). Tracking the mature female of flying squid *Ommastrephes bartrami*, by an ultrasonic transmitter. *Bulletin of Hokkaido National Fisheries Research Institute 55*. 205-208.

Seki, M.P. (1993). The role of neon flying squid *Ommastrephes bartrami,* in the North Pacific food web. *Bulletin International North Pacific Fisheries Commission 53*:207-215.

Stillwell, C.E., Kohler, N.E. (1985). Food and feeding ecology of the swordfish *Xiphias gladius* in the western North Atlantic Ocean with estimates of daily ration. *Marine Ecology Progress Series 22(3)*: 239-247.

Toll, R.B., Hess, S.C. (1981). Cephalopods in the diet of the swordfish, *Xiphias gladius*, from the Florida straits. *Fisheries Bulletin. 79(4)*: 765-774.

Watanabe, H., Kubodera, T., Ichii, T., Kawahara, S (2004). Feeding habits of neon flying squid *Ommastrephes bartrami* in the transitional region of the central North Pacific. *Marine Ecology Progress Series. 266*: 173-184.

Yatsu, A., Mori, J., Tanaka, H., Watanabe, T., Nagasawa, K., Ishida, Y., Meguro, T., Kamei, Y., Sakurai, Y. (1999). Stock abundance and size compositions of the neon flying squid in the central North Pacific Ocean during 1979-1998. Proceedings of the 1998 Science Board Symposium on the impacts of the 1997/98 El Nino event on the North Pacific Ocean and its marginal seas. 10: 119-124.

Yatsu, A., Mochioka, K., Morishita, K., Toh, H. (1998). Strontium/calcium ratios in statoliths of the neon flying squid, *Ommastrephes bartrami* (Cephalopoda) in the North Pacific ocean. *Marine Biology 131*: 275-282.

Yatsu, A., Midorikawa, S., Shimada, T., Uozumi, Y. (1997). Age and growth of the neon flying squid, *Ommastrephes bartrami*, in the North Pacific. *Fisheries Research 29*: 257-270.

Code: ORD
Scientific name: Oreosomatidae
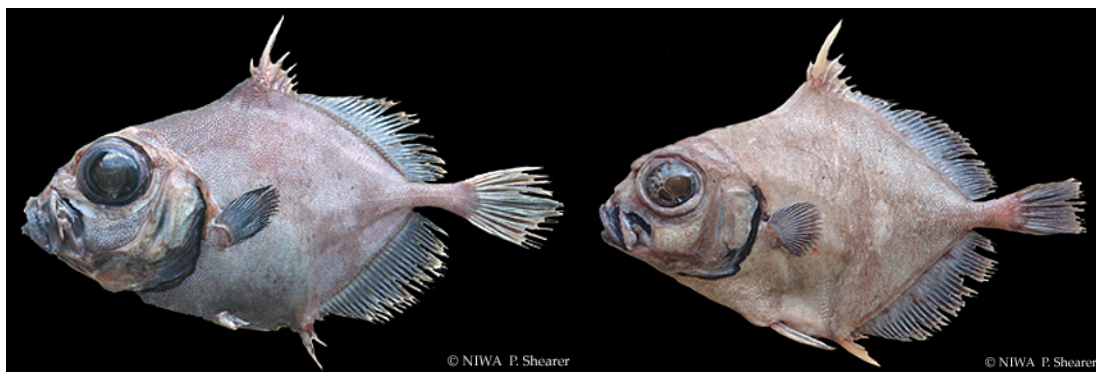
Black oreo

Spiky oreo

Smooth oreo

Taxonomy

Phylum	Vertebrata
Class	Actinopterygii
Order	Zeiformes
Family	Oreosomatidae
Genus and species	*Allocyttus niger* James, Inada & Nakamura, 1988
	Neocyttus rhomboidalis, Gilchrist, 1906
	Pseudocyttus maculatus, Gilchrist, 1906
Scientific synonyms	None
Common names	*Allocyttus niger* – black oreo;
	Neocyttus rhomboidalis – spiky oreo; *Pseudocyttus maculatus* – smooth oreo
Molecular (DNA or biochemical) bar coding	No information available

Species Characteristics

Global distribution and depth range

The black oreo inhabits New Zealand and Australian waters, the southern Tasman Sea and the Louisville Ridge only, between latitudes of about 38º and 53º S (James et. al. 1988). Black oreo occurs in depths from 450–1450 m, but is most abundant between 600 m and 1000 m (Anderson et al. 1998) (Figure 1).

The spiky oreo has been reported off southern Africa, Argentina, the southeast Indian Ocean, along southern Australia, throughout the New Zealand shelf area, in the Tasman Sea and on the Louisville Ridge. It has been recorded from depths of 200 m to 1500 m, but is most abundant between 600 m and 1000 m (Anderson et al. 1998) (Figure 2).

The smooth oreo inhabits the continental slopes of southern continents (Australia, New Zealand and Chile) (Karrer 1990). On the high seas it is known from the central Tasman Sea and the Louisville Ridge. It has been recorded from depths of 400 m to at least 1500 m, but is most abundant between 700 m and 1400 m in the Pacific region (Anderson et al. 1998) (Figure 3).
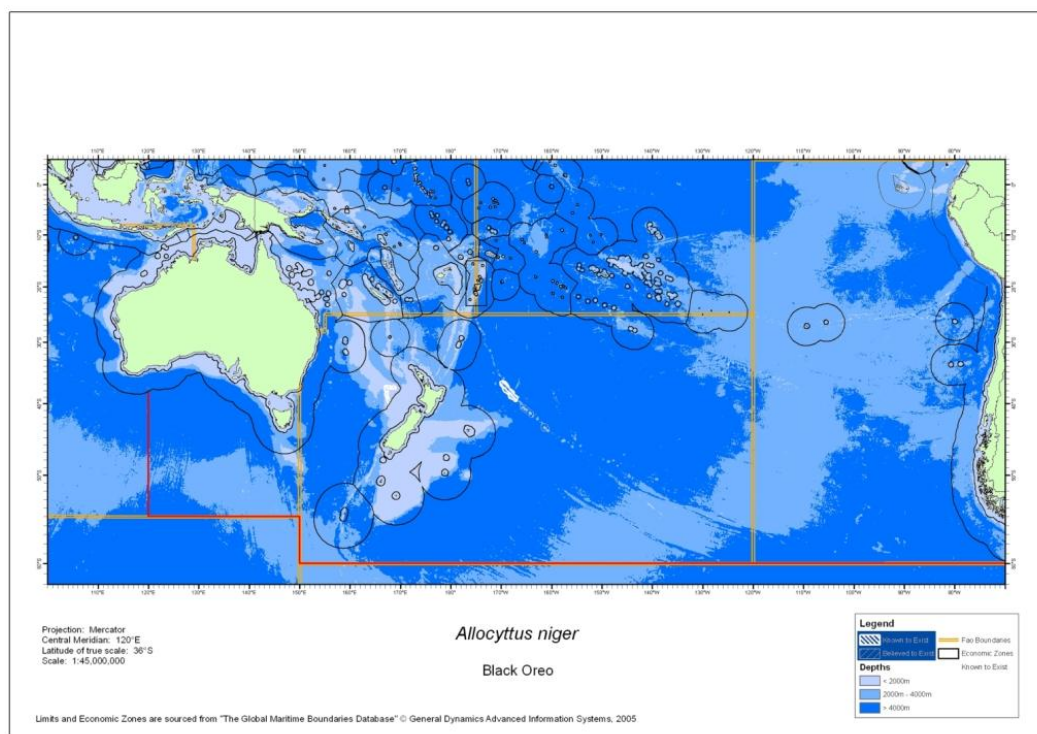

Figure 1: Distribution of black oreo fishing grounds in the South Pacific.
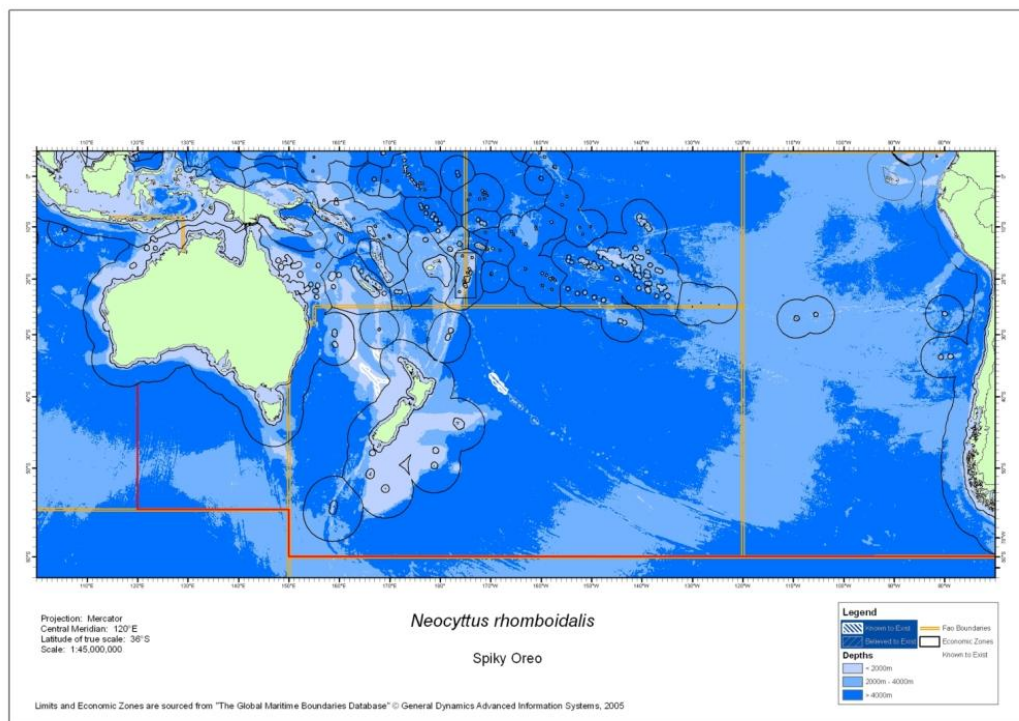
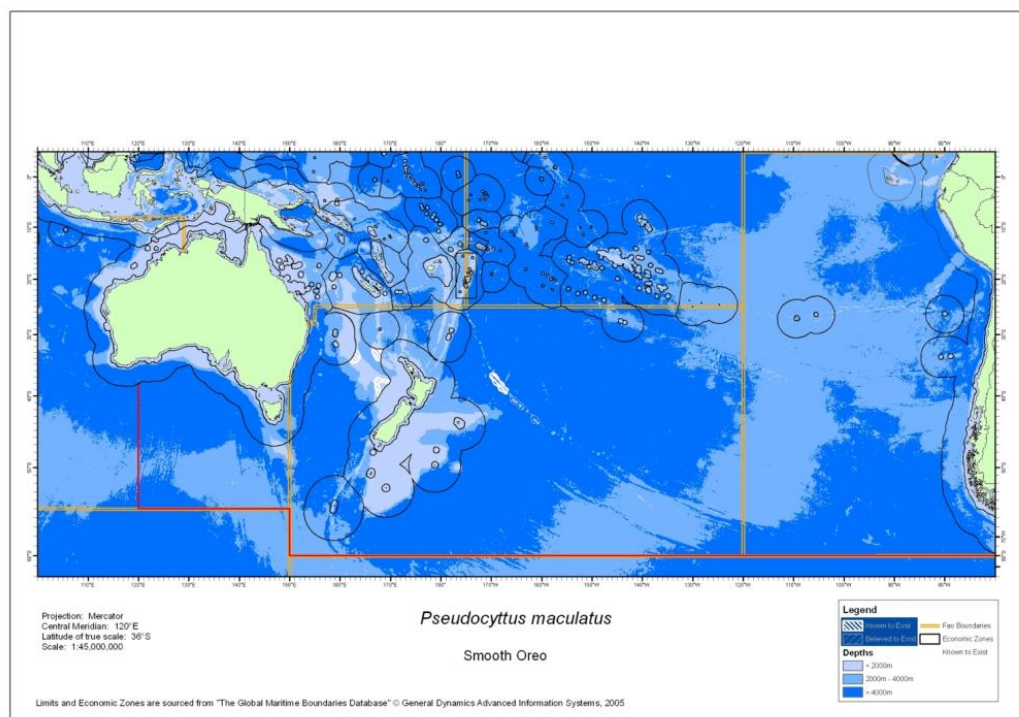Figure 2: Distribution of spiky oreo fishing grounds in the South Pacific.

Figure 3: Distribution of smooth oreo fishing grounds in the South Pacific.

Distribution within South Pacific area

The areas of known distributions outside EEZs for each species of oreo are given in Figures 1-3 above. Based on catch effort data reported to New Zealand and Australia (Clark 2006), scientific observer data and habitat assumptions the area assumed to be occupied by each species is: black oreo 64,000 km^2; spiky oreo, 205,000 km^2; and, smooth oreo 172,000 km^2.

General habitat

Black oreo and spiky oreo are found close to the seabed in deep water. The adults form large shoals over rough ground near pinnacles and canyons. Juveniles are pelagic and inhabit oceanic waters where they tend to be dispersed over smooth grounds (Kailola et al. 1993). Smooth oreos inhabit deep continental slopes, with adults occurring near the bottom, often in large schools near pinnacles and canyons. Juveniles occur near the surface, often in association with krill (Heemstra 1990). There is no evidence of marked vertical migration by any of these species during day or night (Clark et al. 1989).

Biological characteristics

For all oreo species sexes co-occur but schools often appear to be segregated by sex based on sampling data.

The juveniles of all species are quite different in shape from the adults (Paulin et al. 1989). Most juveniles have an expanded belly with large warty protuberances.

Black oreo

Morphology: : Body scales cannot be dislodged, predorsal profile slightly concave and not rising steeply, pelvic spine extends to vent, small fin spinules, premaxillary bone wide, pectoral rays 17 to 20. (McMillan 2011).

Black oreo can reach a total length of about 55 cm; females reach a larger size than males. Age estimates in excess of 150 years have been derived from counts of zones in otolith thin sections, an un-validated method (Smith & Stewart 1994; Doonan et al. 1995), indicating a very slow growth rate for this species. Productivity parameters used in assessments of New Zealand's black oreo stocks are: von Bertalanffy L$_\infty$ and k, 40 cm and 0.043 yr^{-1} for females, 37 cm and 0.056 yr^{-1} for males; M = 0.044 yr^{-1} (Fisheries New Zealand 2021) length and age at maturity for females are 34 cm and 27 years.

Black oreo are synchronous spawners, spawning in Australasian waters in late spring to early summer (Pankhurst et al. 1987; Lyle et al. 1992). Fecundity is about 17,500 eggs per kg of body weight. Eggs float near the surface and larvae probably also inhabit surface waters (Kailola et al. 1993). Black oreo appear to have a pelagic juvenile phase, but little is known about this phase because few small fish have been caught. The pelagic phase may last for 4–5 years until the fish reach lengths of 21–26 cm (McMillan et al. 1997). The adults feed mainly on salps and benthic crustaceans (Clark et al. 1989).

Spiky oreo

Morphology: Body scales can be dislodged, predorsal profile strongly concave and rises steeply, pelvic spine extends to vent, moderate fin spinules, premaxillary bone narrow, pectoral rays 19 to 22 (McMillan et al. 2011).

Spiky oreo can reach a total length of about 44 cm; females reach a larger size than males. A maximum age in excess of 120 years has been derived from counts of zones in otolith thin sections, an un-validated method (Smith & Stewart 1994), indicating a very slow growth rate for this species. Available productivity parameters for spiky oreo stocks are: L_∞ = 36 cm, k = 0.051 yr^{-1}, for combined sexes (Smith & Stewart 1994). Length at maturity is estimated to be 22 cm and 34 cm for males and females, respectively.

Spiky oreo are synchronous spawners, spawning in Australian waters from late winter to spring (Lyle et al. 1992; Stewart 1992). Eggs float near the surface and larvae probably also inhabit surface waters (Kailola et al. 1993). Spiky oreo are also presumed to have a pelagic juvenile phase. The adults feed mainly on salps, but also eat fish, crustaceans, and squid (Lyle & Smith 1997).

Smooth oreo

Morphology: First dorsal spine longer than second, fin spines small, operculum fully scaled but with no strong ridge or radiating striations, body scales easily dislodged. (McMillan 2011)

Smooth oreo can reach a total length of about 60 cm; females reach a larger size than males. Maximum age estimates of about 100 years have been derived from counts of zones in otolith thin sections, an unvalidated method (Smith & Stewart 1994; Doonan et al. 1995), indicating a very slow growth rate for this species. Current productivity parameters used in assessments of New Zealand's smooth oreo stocks are: von Bertalanffy L_∞ and k, 51 cm and 0.047 yr^{-1} for females, 44 cm and 0.067 yr^{-1} for males; M = 0.063 yr^{-1} (Fisheries New Zealand 2021). Length and age at maturity for females are 40 cm and 31 years.

Smooth oreo are synchronous spawners, spawning in Australasian waters in late spring to early summer (Pankhurst et al. 1987; Lyle et al. 1992). Fecundity is about 10,800 eggs per kg of body weight. Eggs float near the surface and larvae probably also inhabit surface waters (Kailola et al. 1993). Smooth oreo appear to have a pelagic juvenile phase, but little is known about this phase because few small fish have been caught. The pelagic phase may last for 5–6 years until the fish reach lengths of 16–19 cm (Doonan et al. 1997).

The adults feed mainly on salps (Clark et al. 1989).

Biological productivity

The biology of the oreo species is moderately well known. Biological productivity is believed to be very low. This is due to a combination of late onset of maturity, low fecundity, low annual growth rate in relation to size and high longevity. The proportion of biomass that can be harvested sustainably is very small.

Role of species in the ecosystem

Oreos appear to be bentho-pelagic grazers, feeding mainly on salps. However, the presence of fish, squid, and benthic invertebrates in their diets indicates that they are also opportunistic predators. Dietary composition appears to change with fish size in smooth and black oreos (Clark et al. 1989, Stevens et al. 2011).

Impacts of Fishing

Habitat damage

The main method used to catch this species is a high-opening trawl generally fished close to or on the bottom. Trawling for this species on seamounts impacts habitat (Clark and O'Driscoll 2003; Koslow et al. 2001), but the precise impact of this on the oreo populations or other species on the seamounts is unknown.

Studies have shown that repeated trawl disturbances alter the benthic community by damaging or removing macro-fauna and encouraging anaerobic bacterial growth. Severe damage of coral cover from bottom trawl fishing inside the Australian EEZ has been documented (Koslow et al. 2001). Video images reveal bare rock and pulverized coral rubble where bottom trawling has occurred.

As fishing gear disturbs soft sediment they produce sediment plumes and re-mobilise previously buried organic and inorganic matter. This increase in the rates of nutrients into the water column has important consequences for the rates of biogeochemical cycling (Kaiser et al. 2002).
Trawling for orange roughy, oreo, and cardinalfish, like trawling for other species, is likely to have effects on benthic community structure and function (e.g., Rice 2006) 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).

References

Anderson, O.F.; Bagley, N.W.; Hurst, R.J.; Francis, M.P.; Clark, M.R.; McMillan, P.J. (1998). Atlas of New Zealand fish and squid distributions from research bottom trawls. *NIWA Technical Report* 42. 303 p.

Clark, M.R. (2006). Counting deepwater fish: challenges for estimating the abundance of orange roughy in New Zealand fisheries. In: Shotton, R. (ed). Deep Sea 2003: Conference on the Governance and management of deep-sea fisheries. Part 1: conference papers. FAO Fisheries Proceedings No. 3/1: 169–181.

Clark, M.R.; King, K.J.; McMillan, P.J. (1989). The food and feeding relationships of black oreo, *Allocyttus niger*, smooth oreo, *Pseudocyttus maculatus*, and eight other fish species from the continental slope of the south-west Chatham Rise, New Zealand. *Journal of Fish Biology* 35: 465–484.

Clark, M., O'Driscoll, R. (2003). Deepwater fisheries and aspects of their impact on seamount habitat in New Zealand. *Journal of Northwest Atlantic Fishery Science* 31: 441-458.

Cryer, M., Hartill, B., O'Shea, S. (2002). Modification of marine benthos by trawling: toward a generalization for the deep ocean? *Ecological Applications* 12(6): 1824-1839.

Doonan, I.J.; McMillan, P.J.; Kalish, J.M.; Hart, A.C. (1995). Age estimates for black and smooth oreo. *New Zealand Fisheries Assessment Research Document* 95/14. 26 p.

Doonan, I.J.; McMillan, P.J.; Hart, A.C. (1997). Revision of smooth oreo life history parameters. *New Zealand Fisheries Assessment Research Document* 97/9. 11 p.

Fisheries New Zealand (2021). Fisheries Assessment Plenary, May 2021: stock assessments and stock status. Compiled by the Fisheries Science Team, Fisheries New Zealand, Wellington, New Zealand. 1782 p

Heemstra, P.C. (1990). Oreosomatidae. Pp. 226–228 in Gon, O.; Heemstra, P.C. (eds.), Fishes of the Southern Ocean. J.L.B. Smith Institute of Ichthyology, Grahamstown, South Africa.

James, G.D.; Inada, T.; Nakamura, I. (1988). Revision of the oreosomatid fishes (Family Oreosomatidae) from the southern oceans, with a description of a new species. *New Zealand Journal of Zoology* 15: 291–326.

Kailola, P.J.; Williams, M.J.; Stewart, P.C.; Reichelt, R.E.; McNee, A.; Grieve, C.
(1993). Australian fisheries resources. Bureau of Resource Sciences, Canberra, Australia. 422 p.

Kaiser, M.J., Collie, J.S., Hall, S.J., Jennings, S., Poiner, I.R. (2002). Modification of marine habitats by trawling activities: prognosis and solutions. *Fish and Fisheries* 3:114-136.

Karrer, C. (1990). Oreosomatidae. Pp. 637–640 in Quero, J.C.; Hureau, J.C.; Karrer, C.; Post, A.; Saldanha, L. (eds.), Check-list of the fishes of the eastern tropical Atlantic (CLOFETA). JNICT, Lisbon; SEI, Paris; and UNESCO, Paris. Vol. 2.

Koslow, J.A.; Gowlett-Holmes, K.; Lowry, J.K.; O'Hara, T.; Poore, G.C.B.,
Williams, A. (2001). Seamount benthic macrofauna off southern Tasmania: community structure and impacts of trawling. *Marine Ecology Progress Series* 213: 111-125.

Lyle, J.M.; Smith, D.C (1997). Abundance and biology of warty oreo (*Allocyttus*

verrucosus) and spiky oreo (*Neocyttus rhomboidalis*) (Oreosomatidae) off south-eastern Australia. *Marine and Freshwater Research* 48: 91–102.

Lyle, J.M.; Riley, S.; Kitchener, J. (1992). Oreos – an underutilised resource. *Australian Fisheries* 51(4): 12–15.

McMillan, P.J.; Doonan, I.J.; Hart, A.C. (1997). Revision of black oreo life history parameters. *New Zealand Fisheries Assessment Research Document* 97/8. 13 p.

Pankhurst, N.W.; McMillan, P.J.; Tracey, D.M. (1987). Seasonal reproductive cycles in three commercially exploited fishes from the slope waters off New Zealand. *Journal of Fish Biology* 30: 193–211.

Paulin, C.; Stewart, A.; Roberts, C.; McMillan, P. (1989). New Zealand fish, a complete guide. *National Museum of New Zealand Miscellaneous Series* No. 19. 279 p.

Smith, D.C.; Stewart, B.D. (1994). Development of methods to age commercially important dories and oreos. F*inal Report, Australian Fisheries Research and Development Corporation*, Project 91/36.

Stevens, D.W., Hurst, R.J., Bagley, N.W. (2011). Feeding habits of New Zealand fishes: a literature review and summary of research trawl database records 1960 to 2000. *New Zealand Aquatic Environment and Biodiversity Report No. 85*. 218 p.

Code: ORY
Scientific name: *Hoplostethus atlanticus*
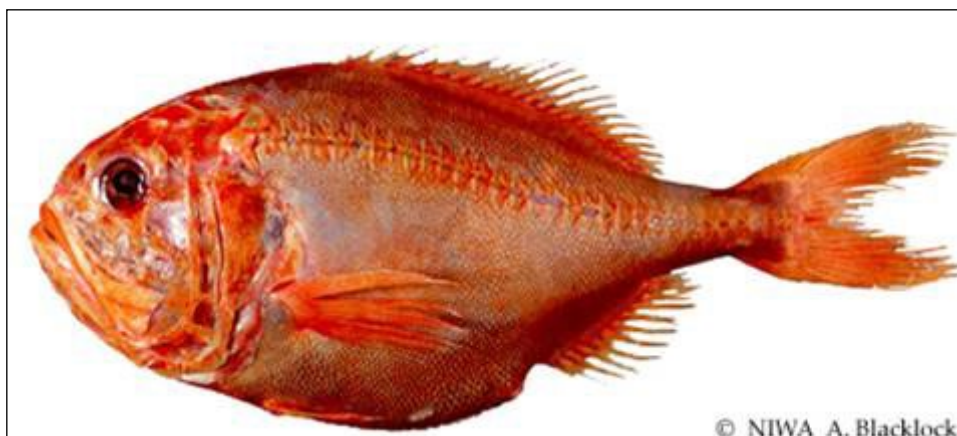
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Taxonomy

Phylum	Vertebrata
Class	Actinopterygii
Order	Beryciformes
Family	*Hoplostethus atlanticus* (Collet, 1889)
Genus and species	*Hoplostethus gilchristi, Hoplostethus islandicus*
Scientific synonyms	None
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) bar coding	Accession DQ108113.1 cytochrome oxidase subunit 1; accession DQ108112.1 cytochrome oxidase subunit 1; accession DQ108111.1 cytochrome oxidase subunit 1; accession DQ108110.1 cytochrome oxidase subunit 1; accession DQ108109.1 cytochrome oxidase subunit 1; accession AM230657 Hoplostethus atlanticus microsatellite DNA, locus Hat58; accession AM230656 Hoplostethus atlanticus microsatellite DNA, locus Hat54; accession AM230655 Hoplostethus atlanticus microsatellite DNA, locus Hat25; and, accession AF146639 Hoplostethus atlanticus clone Hat9a microsatellite sequence.

PO Box 3797, Wellington 6140, New Zealand
P: +64 4 499 9889 – F: +64 4 473 9579 – E: secretariat@sprfmo.int
www.sprfmo.int

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 (Kotlyar, 1996), but in the Pacific it is seldom recorded shallower than 500 m and is most common in depths from 700 m -1100 m (Anderson et al. 1998).

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 aggregates in deep, cold waters (3-9 °C) over steep continental slopes, canyons, ocean ridges, and underwater topographical features such as seamounts, especially during spawning and feeding (Clark et al. 2000). Orange roughy can also be dispersed over smooth bottoms, rough bottoms, and steep, rough grounds. Orange roughy are bentho-pelagic, generally occurring near the bottom but at times ascending to feed or spawn 50-100 m above the seafloor.

Biological characteristics[1]

Sexes co-occur but are often segregated. Seasonal catch samples from particular grounds are seldom strongly biased to either sex, but samples from individual trawl tows can be strongly biased, indicating some degree of schooling by sex, particularly during spawning.

The fish can reach about 58 cm standard length in the southern oceans, especially off central Chile where on average fish are larger than in New Zealand, Australia, and Namibian grounds; females reach a slightly large size than males. Age and growth of orange roughy from a number of localities have been investigated (Tracey & Horn 1999, Gili et al, 2002). Annual zone formation in the otoliths of juvenile fish has been validated, indicating very slow growth to a length of only 7.6 cm after 3 years (Mace et al. 1990). Decay rates of naturally occurring radio-nuclides in otoliths to age fish was 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

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[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.

derived from counts of zones in otolith thin sections (Smith et al. 1995). Age estimates in excess of 130 years have since been 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 100-150 years (Andrews and Tracey 2003, 2007).

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 otolith 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 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.

Spawning occurs in a few specific areas, generally at depths of 700-1000 m, 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 with differences in the onset of spawning between areas which seems to be 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). 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 is slightly greater, ranging from 16 056 -115 944 egg per kg body weight (Young et al. 2004). Newly fertilised eggs 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).

Current productivity parameters used in assessments of New Zealand's orange roughy stocks are: $L\infty$ = 33-38 cm (dependant on sex and area), k = 0.065 yr^{-1}, M= 0.045 yr^{-1} (Ministry of Fisheries 2006a). Parameters used in assessments of Chilean orange roughy stocks are: females: $L\infty$ = 53.8 cm, k = 0.03 yr^{-1}, M = 0.04 yr^{-1}; males: $L\infty$ = 47.86 cm, k = 0.04 yr^{-1}, M = 0.04 yr^{-1} (Gilli et al. 2002). Australian productivity parameters vary between populations. For the continental slope populations (St Helens and southern Tasmanian populations); females: $L\infty$ = 31 cm (22-40), k = 0.048yr^{-1}, M = 0.04 yr^{-1}; for males: $L\infty$ = 40 cm (28-52), k = 0.064 yr^{-1}, M = 0.04 yr^{-1}. Fish on the Cascade Plateau are larger and longer-lived with an M of 0.02 (Smith & Waite 2004).

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.

Biological productivity

Orange roughy have very low productivity. This is due to a combination of late onset of maturity; low fecundity; low annual growth rate in relation to size; and high longevity. The proportion of biomass that can be harvested sustainably is very small. These annual harvest values have been estimated to be in the range of 1.0 to 2.0% of virgin biomass (Francis 1992).

Role of species in the ecosystem

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). Availability of prey on and around underwater features may explain the non-spawning aggregations observed on some fishing grounds. Juveniles feed mainly on crustaceans, switching to squid and fishes as they grow larger. In the main fishing grounds orange roughy tend to be the dominant large demersal fish biomass in the ecosystem.

Impacts of Fishing

Habitat damage

The main method used to catch this species is a high-opening trawl generally fished hard down on the bottom. Trawling for this species on seamounts, knolls and pinnacles impacts habitat and benthic invertebrate species (Clark and O'Driscoll 2003, O'Driscoll and Clark 2005, Koslow et al. 2001), but the precise impact of this on the orange roughy populations or other species is unknown, although habitat loss is quite evident for benthic invertebrate species such as some crustaceans, echinoids, startfish (Koslow 2007).

Studies have shown that repeated trawl disturbances alter the benthic community by damaging or removing macro-fauna and encouraging anaerobic bacterial growth. Severe damage of coral cover from bottom trawl fishing for orange roughy inside the Australian EEZ has been documented (Koslow et al. 2001). Video images reveal bare rock and pulverized coral rubble where bottom trawling has occurred. Clark and Koslow (in press) have reviewed available data on the impacts of fishing (including bottom trawling) on seamounts, and have noted that damage to the habitat-forming corals is one of the most prominent and observable impact on the ecosystem structure of deepwater seamounts.

As fishing gear disturbs soft sediment they produce sediment plumes and re-mobilise previously buried organic and inorganic matter. This increase in the rates of nutrients into the water column has important consequences for the rates of biogeochemical cycling (Kaiser et al. 2002).

Trawling for orange roughy, oreo, and cardinalfish, like trawling for other species, is likely to have effects on benthic community structure and function (e.g., Rice 2006)

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).

References

Anderson, O.F.; Bagley, N.W.; Hurst, R.J.; Francis, M.P.; Clark, M.R.; McMillan, P.J. (1998). Atlas of New Zealand fish and squid distributions from research bottom trawls. NIWA Technical Report 42. 303 p.

Andrews, A.H.; Tracey, D.M. (2003). Age validation of deepwater fish species, with particular reference to New Zealand orange roughy, black oreo, smooth oreo, and black cardinalfish. Final Research Report for Ministry of Fisheries Research Project DEE2000/02 Objective 1. National Institute of Water and Atmospheric Research, Wellington, New Zealand. 25 p.

Andrews, A.H.; Tracey, D.M. (2007). Age validation of orange roughy and black cardinalfish using lead-radium dating. Final Research Report for Ministry of Fisheries Research Project DEE2005-02 Objective 1. 42 p.

Bell, J.D.; Lyle, J.M.; Bulman, C.M.; Graham, K.J.; Newton, G.M.; Smith, D.C (1992). Spatial variation in reproduction, and occurrence of non-reproductive adults, in orange roughy, Hoplostethus atlanticus Collett (Trachichthyidae), from southeastern Australia. Journal of Fish Biology 40: 107–122.

Branch, T.A. (2001). A review of orange roughy Hoplostethus atlanticus fisheries, estimation methods, biology and stock structure. South African Journal of Marine Science 23: 181–203.

Bulman, C.M.; Koslow, J.A. (1992). Diet and food consumption of a deep-sea fish, orange roughy Hoplostethus atlanticus (Pisces: Trachichthyidae), off southeastern Australia. Marine Ecology Progress Series 82(2): 115–129.

Bulman, C.M.; Koslow, J.A. (1995). Development and depth distribution of the eggs of orange roughy, Hoplostethus atlanticus (Pisces: Trachichthyidae). Marine and Freshwater Research 46: 697–705.

Clark, M.R. (2006). Counting deepwater fish: challenges for estimating the abundance of orange roughy in New Zealand fisheries. In: Shotton, R. (ed). Deep Sea 2003: Conference on the Governance and management of deep-sea fisheries. Part 1: conference papers. *FAO Fisheries Proceedings No. 3/1*: 169–181.

Clark, M.R., Koslow, J.A. (in press). Impacts of fisheries on seamounts. Chapter 19. In: Pitcher, T.J., Morato, T., Hart, P.J.B., Clark, M.R., Haggan, N. Santos, R.S. (eds). Seamounts: ecology, fisheries, and conservation. Blackwell Fisheries and Aquatic Resources Series.

Clark, M.; O'Driscoll, R. 2003: Deepwater fisheries and aspects of their impact on seamount habitat in New Zealand. Journal of Northwest Atlantic Fishery Science 31: 441-458

Clark, M.R.; Anderson, O.F.; Francis, R.I.C.C.; Tracey, D.M. (2000). The effects of commercial exploitation on orange roughy (Hoplostethus atlanticus) from the continental slope of the Chatham Rise, New Zealand, from 1979 to 1997. Fisheries Research 45: 217–238.

Clark, M.R.; Fincham, D.J.; Tracey, D.T. (1994). Fecundity of orange roughy (Hoplostethus atlanticus) in New Zealand waters. New Zealand Journal of Marine and Freshwater Research 28: 193–200.

Coburn, RP., Doonan, IJ. (1994). Orange roughy on the northeast Chatham Rise: a description of the commercial fishery, 1979-88. New Zealand Fisheries Technical Report No. 38.

Cryer, M., Hartill, B., O'Shea, S. (2002). Modification of marine benthos by trawling: toward a generalization for the deep ocean? Ecological Applications 12(6): 1824-1839

Cryer, M., Nodder, S., Thrush, S., Lohrer, D., Gorman, R., Vopel, K., Baird, S. (unpublished). The effects of trawling and dredging on bentho-pelagic coupling process in the New Zealand EEZ. New Zealand Aquatic Environment and Marine Biodiversity Report 2005/ ?. 66p.

Edmonds, J.S.; Caputi, N.; Morita, M. (1991). Stock discrimination by trace-element analysis of otoliths of orange roughy (Hoplostethus atlanticus), a deep-water marine teleost. Australian Journal of Marine and Freshwater Research 42: 383–389.

Fenton, G.E.; Short, S.A.; Ritz, D.A. (1991). Age determination of orange roughy Hoplostethus atlanticus (Pisces: Trachichthyidae) using 210Pb:226Ra disequilibria. Marine Biology 109: 197–202.

Francis, R.I.C.C. (1992). Recommendations concerning the calculation of maximum constant yield (MCY) and current annual yield (CAY). New Zealand Fisheries Assessment Research Document 92/8. 15 p.

Francis, R.I.C.C. (1995a). The longevity of orange roughy: a reinterpretation of the radiometric data. New Zealand Fisheries Assessment Research Document 95/2. 13 p.

Francis, R.I.C.C. (1995b). The problem of specifying otolith-mass growth parameters in the radiometric estimation of fish age using whole otoliths. Marine Biology 124: 169–176.

Francis, R.I.C.C.; Clark, M.R. (1998). Inferring spawning migrations of orange roughy (Hoplostethus atlanticus) from spawning ogives. Marine and freshwater Research 49: 103–108.

Francis, R.I.C.C., Clark, M.R. (2005). Sustainability issues for orange roughy fisheries. Bulletin of Marine Science 76(2): 337-351.

Gili, R., Cid, L., Pool, H., Young, Z., Tracey, D., Horn, P. y Marriott, P. 2002. Estudio de edad, crecimiento y mortalidad natural de los recursos orange roughy y alfonsino. Informe Final. FIP N° 2000-12. 129 p. Age, growth and natural mortality of orange roughy and alfonsino. (Final report in Spanish available in www.fip.cl) Final Report. FIP N° 2000-12. 129 p. (In Spanish).

Horn, P.L.; Tracey, D.M.; Clark, M.R. (1998). Between-area differences in age and length at first maturity of the orange roughy Hoplostethus atlanticus. Marine Biology 132: 187–194.

Johnston, P.A. and Santillo, D. (2004). Conservation of Seamount Ecosystems: Application of a Marine Protected Areas concept. Arch. Fish. Mar. Res. 51(1–3): 305–319.

Kaiser, MJ., Collie, JS., Hall, SJ., Jennings, S., Poiner, IR. (2002). Modification of marine habitats by trawling activities: prognosis and solutions. Fish and Fisheries 3:114-136

Koslow, J.A. (2007). The Silent Deep. The Discovery, Ecology, and Conservation of the Deep Sea. London: The University of Chicago Press.

Koslow, J.A.; Gowlett-Holmes, K.; Lowry, J.K.; O'Hara, T.; Poore, G.C.B.; and Williams, A. (2001). Seamount benthic macrofauna off southern Tasmania: community structure and impacts of trawling. Marine Ecology Progress Series 213: 111-125.

Koslow, J.A.; Bell, J.; Virtue, P.; Smith, D.C. (1995). Fecundity and its variability in orange roughy: Effects of population density, condition, egg size, and senescence. Journal of Fish Biology 47: 1063–1080.

Koslow, J.A.; Bulman, C.M. (2002). Trophic ecology of the mid-slope demersal fish community off south Tasmania, Australia. Marine and Freshwater Research 53: 59–72.

Kotlyar, A.N. (1996). Beryciform fishes of the world ocean. Moscow, VNIRO Publishing.

Labbé, J; Arana, P.M. (2001). Alimentación de orange roughy, Hoplostethus atlanticus (Pisces: Trachichthyidae), en el archipiélago de Juan Fernández, Chile. Revista de Biología Marina y Oceanografía 36(1): 75–82.

Lester, R.J.B.; Sewell, K.B.; Barnes, A. Evans, K. (1988). Stock discrimination of orange roughy Hoplostethus atlanticus by parasite analysis. Marine Biology 99: 137–143.

Levin, PS., Holmes, EE., Piner, KR., Harvey, P&C. (2006). Shifts in Pacific ocean assemblage: the potential influence of exploitation. Conservation Biology

Mace, P.M.; Fenaughty, J.M.; Coburn, R.P.; Doonan, I.J. (1990). Growth and productivity of orange roughy (Hoplostethus atlanticus) of the north Chatham Rise. New Zealand Journal of Marine and Freshwater Research 24: 105–119.

Ministry of Fisheries (2006a) Report from the fisheries assessment Plenary May 2006: stock assessments and yield estimates. 875 p. Complied by Ministry of Fisheries Science Group. Unpublished. Held at NIWA library Wellington.

Ministry of Fisheries (2006b) Medium Term Research Plan…. Xxx p. Complied by Ministry of Fisheries Science Group. Unpublished. Held at Ministry of Fisheries, Wellington.

Morato, T., Cheung, W.W.L. and Pitcher, T.J. (2004). Vulnerability of Seamount Fish to Fishing: Fuzzy Analysis of Life-History Attributes. In T. Morato and D. Pauly (Eds.),

Seamounts: Biodiversity and Fisheries (pp. 51-60). Fisheries Centre Research Reports Volume 12 Number 5.

Morato, T., Watson, R., Pitcher, T.J. and Pauly, D. (2006). Fishing down the deep. Fish and Fisheries 7(1):24-34.

Niklitschek, E., D. R. Boyer, R. Merino, I. Hampton, M. Soule, J. Nelson, J. Cornejo, A. Lafon, C. Oyarzún, R. Roa & T. Melo. 2005. Estimación de la biomasa reproductiva de orange roughy en sus principales zonas de concentración, 2004. Universidad Austral de Chile, Valparaíso. FIP 2004-13. 161 p. (Final report in Spanish available in http://www.fip.cl/pdf/informes/inffinal%202004-13.pdf).

Niklitschek, E., J. Cornejo, E. Hernández, P. Toledo, C. Herranz, R. Merino, A. Lafon, L. Castro, R. Roa y Aedo, G. 2007. Evaluación hidroacústica de alfonsino y orange roughy, año 2006. Informe Final Proyecto FIP 2006-09. CT 07-007. Universidad Austral de Chile-Universidad de Concepción. Chile. 221 p. (Final report in Spanish available in http://www.fip.cl/pdf/informes/inffinal%202006-09.pdf).

Niklitschek, E., P. Toledo and A. Lafón. 2009. Unidades Poblacionales de Orange roughy (*Hoplostethus atlanticus*). Informe Final Proyecto FIP 2006-55. CT 09-002. Universidad Austral de Chile, Centro Trapananda. Coyhaique, Chile. 140 p.

Pankhurst, N.W. (1988). Spawning dynamics of orange roughy, Hoplostethus altanticus, in mid-slope waters of New Zealand. Environmental Biology of Fishes 21: 101–116.

Rosecchi, E.; Tracey, D.M.; Webber, W.R. (1988). Diet of orange roughy Hoplostethus atlanticus (Pisces: Trachichthyidae) on the Challenger Plateau, New Zealand. Marine Biology 99: 293–306.

Sissenwine, M. P., and Mace, P. M. (in press). Can deep water fisheries be managed sustainably? 55p.

Smith, A.D.M.; and Waite, S.E. (Eds) (2004). Fisheries Assessment Report: The South East Fishery 2003. Australian Fisheries Management Authority, Canberra. 246pp.

Smith, D.C.; Fenton, G.E.; Robertson, S.G.; Short, S.A. (1995). Age determination and growth of orange roughy (Hoplostethus atlanticus): a comparison of annulus counts with radiometric ageing. Canadian Journal Fisheries and Aquatic Science 52: 391–401.

Smith, P.J.; Benson, P.G.; McVeagh, S.M. (1997). A comparison of three genetic methods used for stock discrimination of orange roughy, Hoplostethus atlanticus: allozymes, mitochondrial DNA, and random amplified polymorphic DNA. Fishery Bulletin 95: 800–811.

Smith, P.J.; Robertson, S.G.; Horn, P.L.; Bull, B.; Anderson, O.F.; Stanton, B.R.; Oke, C.S. (2002). Multiple techniques for determining stock relationships between orange roughy, Hoplostethus atlanticus, fisheries in the eastern Tasman Sea. Fisheries Research 58: 119–140.

Subsecretaría de Pesca (2007). Ficha de desempeño económico de orange roughy. Subsecretaría de Pesca, Valparaíso, Chile.

Tracey, D.M.; Horn, P.L. (1999). Background and review of ageing orange roughy (Hoplostethus atlanticus, Trachichthyidae). New Zealand Journal of Marine and Freshwater Research 33: 67–86.

Young, Z., F. Balbontín, J. Rivera, M. Ortego, R. Tascheri, M. Rojas y S. Lillo. 2000. Estudio biológico pesquero del recurso orange roughy. Informe Final. FIP N° 99-05. 73 p. (Final report in Spanish available in www.fip.cl).

Young, Z., E. Díaz, R. Bahamonde, R. Tascheri, Y. Muñoz, A. Olivares, M. I. Ortego, J. Rivera & J. Oliva. 2004. Monitoreo y propección de orange roughy, 2001. IFOP. FIP N° 2001-04. Final Report. 127 p. Exploratory fishing and monitoring of orange roughy (Final report in Spanish available in www.fip.cl).

Zeldis, J.R.; Grimes, P.J.; Ingerson, J.K.V. (1995). Ascent rates, vertical distribution, and a thermal history model of development of orange roughy, Hoplostethus atlanticus eggs in the water column. Fishery Bulletin 93: 373–385.

Code: PJJ
Scientific name: *Projasus parkeri*

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Taxonomy

Phylum	Arthropoda
Class	Crustacea
Order	Decapoda
Family	Palinuridae
Genus and species	*Projasus parkeri* (Stebbing, 1902)
Scientific synonyms	None
Common names	Deepwater rock lobster, Parker's crayfish, Cape jagged lobster.
Molecular (DNA or biochemical) bar coding	No information available

PO Box 3797, Wellington 6140, New Zealand
P: +64 4 499 9889 – F: +64 4 473 9579 – E: secretariat@sprfmo.int
www.sprfmo.int

Species Characteristics

Global distribution and depth range

This palinurid lobster appears to be widespread in the western South Pacific Ocean between approximately 33°S and 45°S. It has most often been found associated with seamounts, banks, and ridges, at depths of 330–1200 m.

P. parkeri has been reported from the western South Pacific Ocean at depths of 330–1200 m, all records have been reported from between 33°S and 45°S (Webber & Booth 1988; Griffin & Stoddart 1995; Museum of New Zealand records). *P. parkeri* is also found in the Indian Ocean (at and near St Paul and Amsterdam Islands, and off Natal) and in the Atlantic Ocean. It is expected that *P. parkeri* will be widespread in the western part of the South Pacific region between 33°S and 45°S, but it is not clear how far east its distribution extends: The eastern-most record is from the Louisville Ridge (168°W), further east of 85°W the species is replaced by *P. bahamondei* (Parin et al. 1997; Retemal & Arana 2000).

- **Distribution within South Pacific area**

The general area assumed to be occupied by this lobster is about 80 000 km^2 between 33°S and 45°S along the Lord Howe Rise.

- **General habitat**

In the South Pacific, *P. parkeri* has most often been taken from and observed on firm substrates— particularly those associated with ridges, banks, and seamounts and when trawls have inadvertently touched hard substrates. However, off southern Africa, *P. parkeri* has also been taken on generally soft '*Nephrops* grounds' (Berry 1971).

- **Biological characteristics**

Morphology: Prominent supraorbital horns with a row of two spines behind each. A single median spine followed by two submedian rows of eight spines. Low median carina on the first five segments of abdomen; sixth segment with two pairs of submedian spines and others on posterior margin Light orange to straw brown in life (Webber & Booth 1988; Tracey et al. 2005).

Sexes co-occur but are often segregated. Females reach at least 92 mm carapace length (CL), males 82 mm CL, but it is expected that on average males reach a larger size than females. Size at onset of breeding in females is <68 mm CL, and because egg-bearing females have been taken virtually all year round, either spawning is also year-round or there is a very prolonged egg development period.

The phyllosoma larva has not been confirmed, but based on other palinurids it can be expected to be long-lived (many months) and widespread. Settlement is by the post larval puerulus stage, described by Webber & Booth (1988).

There is no information on age and growth, but these lobsters are probably long-lived (decades).

- **Biological productivity**

Stock Productivity is low. The onset of maturity is late, fecundity is low, annual growth rate is relatively slow and the species is long-lived, which indicates that the proportion of the total biomass that can be harvested is small.

- **Role of species in the ecosystem**

The role of this lobster in the seamount ecosystem is unknown, apart from it presumably being one of the larger predatory crustaceans. Submersible and ROV observations on seamounts in and north of the Bay of Plenty have frequently shown this lobster out on the open seafloor.

Rock lobsters are prey at various stages of their life to fishes such as tunas and bramids (phyllosoma and puerulus) and to octopuses, and sharks and other bottom-feeding fishes (juveniles and adults). The precise diet of this lobster is unknown, but it is expected that it consumes a wide range of foods, probably with particular focus on other invertebrates. It has been taken in pots using finfish as bait in the Indian Ocean.

Impacts of Fishing

- **Habitat damage**

Potting has been the main fishing method used in this fishery. It is a relatively benign method, probably causing little direct damage to the environment.

References

Berry, P.F. (1971). The spiny lobsters (Palinuridae) of the east coast of southern Africa: distribution and ecological notes. *Oceanographic Institute, Investigational Report 27*: 1–23.

Griffin, D.J.G.; Stoddart, H.E. (1995). Deep-water decapod Crustacea from eastern Australia: lobsters of the families Nephropidae, Palinuridae, Polychelidae and Scyllaridae. *Records of the Australian Museum 47*: 231–263.

Parin, N.; Mironov, A.; Nesis, K. (1997). Biology of the Nazca and Sala y Gomez submarine ridges, an outpost of the Indo-West Pacific fauna in the Eastern Pacific ocean: composition and distribution of the fauna, its communities and history. *Advances in Marine Biology 32*: 145–242.

Retemal, M.A.; Arana, P.M. (2000). Descripcion y distribucion de cinco crustaceos decapodos recolectados en aguas profundas en torno o las islas Robinson Crusoe y Santa Clara (Archipielago de Juan Fernandez, Chile). *Investigaciones Marinas, Valparaiso 28*: 149–63.

Tracey, D.M.; Anderson, O.F.; Oliver, M.D. (Comps) (2005). A guide to common deepsea invertebrates in New Zealand waters. *New Zealand Aquatic environment and Biodiversity Report 1*.

Webber, W.R.; Booth, J.D. (1988). *Projasus parkeri* (Stebbing, 1902) (Crustacea: Decapoda: Palinuridae) in New Zealand and description of a *Projasus* puerulus from Australia. *National Museum of New Zealand Records 3*: 81–92.

SPRFMO
South Pacific Regional Fisheries Management Organisation

Code: YMO
Scientific name: *Sthenoteuthis oualaniensis*

Source: http://tolweb.org

Taxonomy

Phylum	Mollusca
Class	Cephalopoda
Order	Teuthida
Family	Ommastrephidae
Genus and species	*Sthenoteuthis oualaniensis* Lesson (1830)
Scientific synonyms	*Symplectoteuthis oualaniensis* Lesson (1830)
	Loligo oualaniensis Lesson (1830)
	Ommastrephes oceanicus Orbigny (1835)
	Loligo vanicoriensis Quoy/Gaimard (1832)
Common names	Purpleback squid, Encornet bande violette, Pota cardena, Yellow backed squid, Tobiika, Hoyenjoo, Flying squid, Purple squid.
Molecular (DNA or biochemical) bar coding	*S. oualaniensis* rhodopsin gene partial cds, GenBank accession number AY545185.

PO Box 3797, Wellington 6140, New Zealand
P: +64 4 499 9889 – F: +64 4 473 9579 – E: secretariat@sprfmo.int
www.sprfmo.int

Species characteristics

- Global distribution and depth range

S. oualaniensis occurs from the Red Sea to Australia and from the west coast of Central America to the east coast of Africa, occupying a band from approximately 40˚ north to approximately 40° south of the equator (Roper et al. 1984) (Figure 1). However, it has a patchy distribution, being concentrated in areas of high primary productivity (Nesis 1977 as cited by Snyder 1998). Unlike *D. giga*s, it does not form dense aggregations (Nigmatullin et al. 2002).

Vertical distributions change during ontogenesis. Young *S. oualaniensis* (0.5-10 cm mantle lengths (ML) usually occur at depths of 15-50 m (Zuev et al. 1985 as cited by Shchetinnikov 1992). Medium sized *S. oualaniensis* (<15 cm ML) aggregate in shoals of up to 50-60 individuals. *S. oualaniensis* regularly appear in the surface waters at night and actively feed there (Zuev et al. 1985 as cited by Shchetinnikov 1992). The shoals become smaller as *S. oualaniensis* grow and larger females (>27 cm) often occur alone. In the Arabian Sea large females have been observed between 400- 1100 m depths in the daytime and 50-500 m at night time. In contrast, medium sized females have been observed at 50-200 m in the day and at depths of 0-100 m in the night (Bizikov 1995).
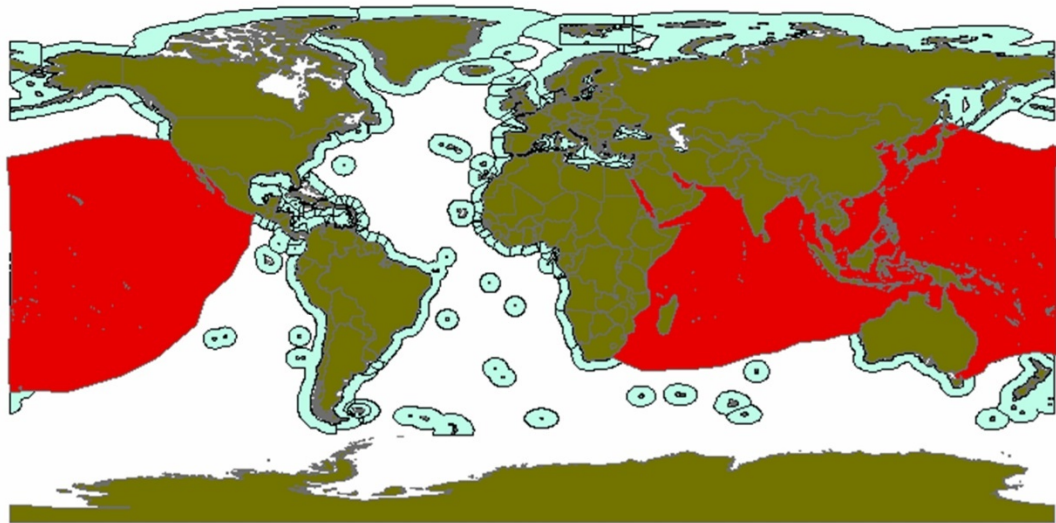

Figure 1: Global distribution of *Sthenoteuthis oualaniensis*. *Source: Adapted from: Roper C.F.E., M.J. Sweeney and C.E. Nauen 1984. Cephalopods of the world. Food and Agriculture Organization, Rome, Italy. Vol. 3: 277 pp.*

- Distribution within South Pacific area

S. oualaniensis is found off the northern and eastern coasts of Australia, and extends down to 38˚ S. Their distribution extends across the Pacific Ocean to South America.

- General habitat

S. oualaniensis are oceanic squid that live in the water column and undergo diel vertical migrations. Larvae are planktonic. Juveniles are often associated with the continental slope. *S. oualaniensis* can be found in both temperate and tropical waters.

- Biological characteristics

Based on the available evidence, *S. oualaniensis* appears to be a "continuous spawner" (Harman et al. 1989, Young and Hirota, 1998. Rocha et al. 2001) with continuous asynchronous ovulation, ovulation during the spawning period, monocyclic maturation of oocytes, spawning over an extended period where spawning is intermittent but spawning events are continuous (i.e., as the oviducts fill, they are emptied) and somatic growth during the period of spawning. The batch fecundity of a female about 300 mm ML is 250,000 eggs in the combined oviducts (Harman et al. 1989). The number of oocytes in various stages of development – a proxy of potential fecundity – in a female of 251 mm ML was estimated to be 1,643,000 (Harman et al. 1989).

The length of the spawning period and the frequency of spawning episodes during this period are unknown. In addition, geographic variability in the spawning season might occur. Data from Australia suggest that *S. oualaniensis* spawn in summer along the continental shelf (Dunning & Brandt 1985); however, high numbers of paralarvae in the northern Pacific provide support for spring spawning (Chesalin & Zuyev 2002).

Growth studies of *S. oualaniensis* based on gladius microstructure from the North Pacific concluded that the duration of the life cycle was approximately 1 year. Females grow faster than males and mature at approximately 25 cm ML, whereas males were found to be mature at 15 cm ML (Bizikov 1995). In Australian waters female size at maturity was 19 cm ML and males was 20 cm ML (Dunning & Brandt 1985). *S. oualaniensis* from near New Caledonia (Rancurel 1980) and Taiwan (Tung 1976) reach maturity at similar sizes. Maximum sizes recorded in Hawaiian waters for females are 335 mm ML (1.6 kg), and for males, 210 mm (Young & Hirota 1998).

S. oualaniensis are sexually dimorphic, with females growing much larger than males. Sex specific differences have also been observed in sucker ring dentition in the arms (Snyder 1998). Females have been observed to have a larger central tooth in the distal region of the ring and smaller teeth in the proximal region, both of which the males lacked. Large differences in parasite loads have also been observed between males and females (Snyder 1998). Females had larger parasite loads than males even though both sexes were found in the same locations. It has been hypothesised that the main route for infection is via ingestion of infected prey. Therefore the difference of parasite loads between males and females may reflect a difference in the feeding spectrum between the two sexes. The dimorphism in sucker ring dentition, and the differences in size, also suggests a difference in the feeding spectrum of males and females (Snyder 1998).

In Hawaiian waters sex ratios are approximately equal among young squid but catches of larger squid show skewed sex ratios of 3:1 females to males (Young & Hirota 1998). In the Philippines the ratio of females to males caught by jigging machines has been observed as 4:1 (Siriraksophon & Nakamura 2001).

Depths occupied by this species are low in oxygen. *S. oualaniensis* has a very high metabolic rate (standard metabolism of 348 ml O_2/kg/hr) that exceeds that of many fast swimming oceanic fishes (Shulman et al. 2002). Common with other squid species, energy metabolism is based mostly on protein: however, in *S. oualaniensis,* during metabolism a considerable proportion of the protein is catabolised anaerobically (Shulman et al. 2002), thus enabling these squid to inhabit zones of very low oxygen concentration.

- **Biological productivity**

Very high – onset of maturity is early, fecundity is high, annual growth rate is relatively rapid and the species is very short lived. Based on the biological characteristics and phenotypic plasticity, the population(s) potential productivity might be expected to be high.

- **Role of species in the ecosystem**

S. oualaniensis are prey to blue marlin, sooty tern, brown noddy, skipjack and yellowfin tuna, wahoo and scalloped hammerhead shark (Young, 1975). *S. oualaniensis* is also a large component of the tropical oceanic seabird *Phaethon rubricauda* diet (Corre et al., 2003) and a primary prey in the diet of some sperm whales (Wang et al. 2002).

Fast growth rates and high metabolism indicate the requirement of high food intake. It has been estimated that adult *S. oualaniensis* require 8-10% of their own body weight as a daily food ration (Shulman et al. 2002).

The feeding spectrum of *S. oualaniensis* was investigated in the southeast Pacific and was found to change considerably with mantle length. Young feed mainly on amphipods, euphausiids and fish larvae, whereas adults feed primarily on myctophids and secondarily on squid (predominantly *Dosidicus gigas*) (Shchetinnikov 1992). Similar prey items have been found in similar sized specimens for the Indian Ocean (Nigmatullin et al. 1983 as cited by Shchetinnikov 1992). Cannibalism is rarely observed in the south-eastern Pacific however, high rates have been recorded in the tropical Pacific and the Indian Ocean (Young 1975; Nigmatullin et al. 1983 as cited by Shchetinnikov 1992).

Impacts of Fishing

- **Habitat damage**

There is likely to be minimal damage to the habitat due to the fishing methods employed.

References

Bizikov, V.A. (1995). Growth of *Sthenoteuthis oualaniensis*, using a new method based on gladius microstructure. *ICES Marine Science Symposium 199*: 445-458.

Chesalin, M.V., Zuyev, G.V. (2002). Pelagic cephalopods of the Arabian sea with an emphasis on *Sthenoteuthis oualaniensis. Bulletin of Marine Science 71(1)*: 209-221.

Dunning, M., Brandt, S.B. (1985). Distribution and life history of deep-water squid of commercial interest from Australia. *Australian Journal of Marine and Freshwater Research 36*: 343-359.

Harman, R.F., Young, R.E,. Reid, S.B., Mangold, K.M., Suzuki, T., Hixon, R.F. (1989). Evidence for multiple spawning in the tropical oceanic squid *Sthenoteuthis oualaniensis* (Tuethoidae: Ommastrephidae). *Marine Biology 101*: 513-519.

Nigmatullin, Ch. M., Parfenjuk, A.V., Sabirov, R.M. (2002). Preliminary estimates of total stock size and production of Ommastrephid squids in the world ocean. *Bulletin of Marine Science 71(2)*:1134.

Rancurel, P. (1980). Note pour servir a la connaissance de *Symplectoteuthis oualaniensis* (Lesson, 1830) (Cephalopoda, Oegopsida): variations ontogeniques du bec superieur. *Cahiers de l'Indo Pacifica. 2*: 217-232.

Rocha, F., Guera, A., Gonzalez, A.F. (2001). A review of reproductive strategies in cephalopods. *Biological Reviews. 76*: 291-304.

Roper, C.F.E., Sweeny, M.J., Nauen, C.E. (1984). FAO Species Catalogue , Vol. 3, Cephalopods of the world. An annotated and illustrated catalogue of species of interest to fisheries. *FAO Fisheries Synopsis. 125(3)*: 157-181.

Shchetinnikov, A.S. (1992). Feeding spectrum of squid *Sthenoteuthis oualaniensis* (Oegopsida) in the Eastern Pacific. *Journal of the Marine Biological Association UK 72*: 849-860.

Shulman, G.E., Chesalin, M.V., Abolmasova, G.I., Yuneva, T.V., Kideys, A. (2002). Metabolic strategy in pelagic squid of genus *Sthenoteuthis* (Ommastrephidae) as the basis of high abundance and productivity: An overview of Soviet investigations. *Bulletin of Marne Science 71(2)*: 815-836.

Siriraksophon, S., Nakamura, Y. (2001). Ecological aspects of the purpleback flying squid, *Sthenoteuthis oualaniensis* (Lesson) in the west coast of Philippines. International conference on the international oceanographic data and information exchange in the western pacific: The needs of scientific research programmes for oceanographic and coastal data. pp. 187-194.

Snyder, R. (1998). Aspects of the biology of the giant form of *Sthenoteuthis oualaniensis* (Cephalopoda: Ommastrephidae) from the Arabian Sea. *Journal of Molluscan Studies 64*: 21-34.

Tung, I. (1976). On the reproduction of common squid, *Symplectoteuthis oualanrensrs* (Lesso*n).* Report of the Institute of Fishery Biology of Ministry of Economic Affairs and National Taiwan University. 3 (2): 26-48.

Wang, M.C.W., Walker, W.A., Shao, K.T., Chou, L.S. (2002). Comparative analysis of the diets of pygmy sperm whales and dwarf sperm whales in Taiwanese waters. *Acta Zoologica Taiwanica 13(2)*: 53-62.

Young, R.E., Hirota, J. (1998). Review of the ecology of *Sthenoteuthis oualaniensis* near the Hawaiian Archipelago. In: Okutani T (ed.) Contributed papers to international symposium on large pelagic squids. Japan Marine Fishery Resources Research Center, Tokyo, p 131-143.

Young, R.E. (1975). A brief review of the biology of the oceanic squid, *Symplecttoteuthis oualaniensis* (Lesson). *Comparative biochemistry and physiology B 52*:141-143.