

## 9<sup>th</sup> MEETING OF THE SCIENTIFIC COMMITTEE

*Held virtually, 27 September to 2 October 2021*

SC9-WP02\_rev1

### *GIS *Dosidicus gigas* Species Profiles*

#### **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 an updated Jumbo Flying Squid species profile which was further edited during SC9. The SC agreed that the Secretariat remove the outdated versions, finalise drafts based on this expert review and load the new short versions to the website. The Species Profiles for Jumbo flying squid (GIS) included in this document was accepted by the SC, pending final editorial changes.

Code: GIS

Scientific name: *Dosidicus gigas*



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## Taxonomy

<b>Phylum</b>	Mollusca
<b>Class</b>	Cephalopoda
<b>Order</b>	Teuthida
<b>Family</b>	Ommastrephidae
<b>Genus and species</b>	<i>Dosidicus gigas</i> (d'Orbigny, 1835)
<b>Scientific synonyms</b>	None
<b>Common names</b>	Humboldt squid, jumbo flying squid, jibia, pota.
<b>Molecular (DNA or biochemical) bar coding</b>	Available in the Barcode of Life Data System (BOLD), at: <a href="http://www.boldsystems.org">http://www.boldsystems.org</a> (Ref.: <a href="https://www.boldsystems.org/index.php/Public_SearchTerms?query=%22Dosidicus%20gigas%22[tax]">https://www.boldsystems.org/index.php/Public_SearchTerms?query=%22Dosidicus%20gigas%22[tax]</a> , see in Public Data to access DNA sequences)

## Species characteristics

### Global distribution and depth range

*Dosidicus gigas* is endemic to the Eastern Pacific, ranging from Northern California to Southern Chile, and to 140°W at the equator (Figure 1) (Nesis 1983, Nigmatullin et al. 2001). However, more recently the distribution limits shifted to 60°N and 50°S (Arkhipkin et al. 2015). Its range is stretched meridionally and is semi-oceanic (Nigmatullin et al. 2001) although the occasional presence of jumbo flying squid has been reported in higher latitudes, from 56°57'N off Cape Edgecumbe, Alaska (Crosgrove & Sendall 2005) to 50°00'S off Tierra del Fuego, Chile. Its range is limited by the isoline of phosphate concentration of 0.8 mg-at P-PO<sub>4</sub><sup>3-</sup>/m<sup>2</sup> in the 0-100m layer (Aleksandronets et al. 1983, as cited by Nigmatullin et al. 2001).

Adult squid undergo diel vertical migration with a night lift to the 0-200 m water layer, plunging in the daytime to 800-1000 m and deeper (Yatsu et al. 1999; Nigmatullin et al. 2001, Gilly et al. 2006, Bazino et al. 2010, Sakai et al. 2017, Csirke et al. 2018).

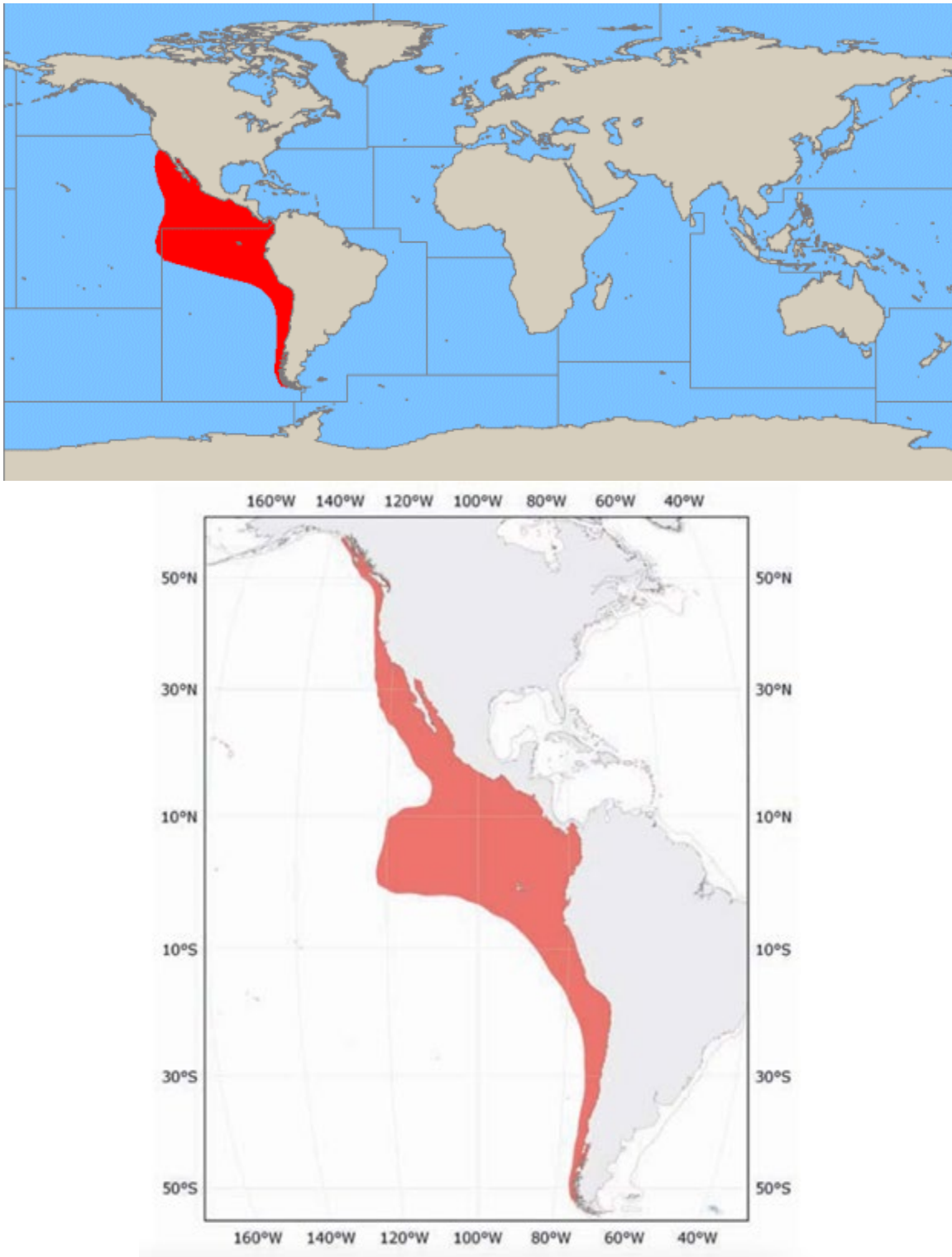


Figure 1. Known distribution of *D. gigas*. Source: Roper, Nigmatullin and Jereb (2010).

## Distribution within South Pacific area

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). *D. gigas* is commonly found along the entire Peruvian coast, occupying areas that can be located between 10 and more than 500 nautical miles (nm) away from the coast (Csirke et al. 2015), however large concentration occurs along the coast of northern Peru (Taibe et al. 2001). Off Chile, the *D. gigas* fishery is carried out in extensive area from 32°30'S to 40°S and from the coast to 84°W (Fernandez & Vasquez 1995, Cubillos et al. 2004, Ibáñez et al. 2015).

## General habitat and behaviour

*D. gigas* is a pelagic species inhabiting the areas offshores of the continental shelves, from the surfaces to depths of at least 1200 m (Nigmatullin et al. 2001). *D. gigas* can aggregate into schools that vary during the ontogeny (juvenile schools, 20-40 individuals; subadults schools, 20-200 individuals; adult schools, 2-5 to 10-12 individuals).

## Population units and intraspecific groups

Based on biogeographic examinations, some authors proposed the existence of at least two stocks or populations units of jumbo flying squid (*D. gigas*) throughout its range in the Eastern Pacific Ocean, one in the northern hemisphere and one in the southern hemisphere (Wormuth 1976, 1998, Nesis 1983, Clarke & Paliza 2000), which has been ratified by more recent genetic studies that have confirmed that the jumbo flying squid off Mexico (NE Pacific) and off Peru and Chile (SE Pacific) belong to separate populations and have been separated for a long enough time to develop significant genetic differences (Sandoval-Castellanos et al. 2007, 2009, 2010, Staaf et al. 2010).

About intraspecific groups, Nigmatullin et al. (2001) identified and described three intraspecific groups of this species that have been observed in both the northern (Bazino et al. 2007, Markaida 2006) and southern hemisphere (Arguelles et al. 2001, 2008, 2017, 2018, Arguelles & Tafur 2010, Arguelles & Taibe 2018, Liu et al. 2013, 2013a, Li et al. 2016, 2017, Arkhipkin et al. 2015, Csirke et al. 2015), distinguishable by their maximum size and by the size at which male and females reach sexual maturity, with somewhat different areas of distribution and environmental preferences, which overlap partially and which, according to Nigmatullin et al. (2001), could correspond to different population stocks or subunits.

## Biological characteristics

Morphology: According to Nigmatullin et al. 2001, in terms of many of the important morpho-functional characteristics, that is, in the development of the jet propulsion system, fins, gladius, brain, statocysts, statoliths, etc. *D. gigas* has no substantial differences from the other four genera of Ommastrephinae (*Ommastrephes*, *Stenoteuthis*, *Eucloteuthis* and *Hyaloteuthis*). Distinguishing by the absence of large mantle skin photophores (only minor photophores are present), by the absence of eye and intestinal photophores in paralarvae (which are present in juveniles and subadults), and by elongated and attenuated arm ends. The arms of *D. gigas* have up to 200 pairs

of suckers. The gladius is a typical ommastrephid type and characterised by double marginal ribs on the rachis, long lateral plates, being arc-like bent on the short stem, and the drop-like callus of the hypostracum on the ventral side of cone flages (Bizikov, 1996).

*Dosidicus gigas* has a conical-cylindrical mantle whose greatest radius is not always located in the open part, but often reaches its maximum near the middle portion. This does not seem related to gonadic growth or maturation, since it is also observed in immature specimens. The radius of the mantle is reduced gradually towards the area of insertion of the fins, ending as a conical tip. The edge of the bade of the mantle in its ventral portion slightly turns outwards and upwards, between the cartilages that join the mantle with the siphon.

The fins have a rhomboid shape. The siphon is strong and muscular, with deep invagination and anterodorsally rounded. The foveola - the cleft that gives space to the siphon at the back of the head - has on average seven longitudinal grooves and four to five secondary folds on either side. The cartilage that joins the mantle with the head has an inverted T-shape bifurcation, characteristic of the Ommastrephidae family.

The head is generally wider in the back, with two large, very conspicuous globular eyes, without eyelids (Oegopsida) and placed on the sides of the head with an anterior projection. With a proportionally large and strong beak.

The eight arms are practically identical, except for the right or left IV arm of the males, which is hectocotylized (copular organ), whose protective membrane is remarkably thick and has 13 holes on one side.

The ends of the arms are narrow and have 100 to 200 tiny suckers. In the corneal rings of the larger suckers there are from 8 to 25 little teeth. In the tentacular club the suckers are arranged in four rows. The two of tentacles are thinner than the arms and twice the length. The color of the skin can range from pale pink to purple, passing through brown (Ehrhardt et al. 1986, Roper et al. 2010).

*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). In Peruvian waters spawning extends throughout the year, with a main spawning peak during October to January, and a secondary peak in July and 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. In the Gulf of California, egg mass was found in warm waters (25-27°C) at a depth of 16 m in. The egg mass resembled a semi-transparent grey cloud, with dimensions ranged from 3-4 m for the major equatorial diameter (Staaf et al. 2008).

*D. gigas* has a flexible and opportunistic behaviour (Markaida 2006) which allows to respond quickly to environmental variability (Rodhouse & Nigmatullin 1996); which is manifested in changes in the distribution, abundance, growth rate, size at maturity and longevity associated with the availability of food and oceanographic conditions (Arguelles et al. 2008).

*D. gigas* grows quickly and does not live for more than 2 years having an average life span of ~1 year (Arkhipkin & Murzov 1986, Masuda et al. 1998, Arguelles et al. 2001; Nigmatullin et al. 2001,

Markaida et al. 2004, Liu et al. 2013, Goicochea-Vigo et al. 2019), although, some very large individuals can live for 18 months to 2 years (Nigmatullin et al. 2001).

Regarding the size at maturity, Nigmatullin et al. (2001) have reported three population groups each with different maturity ranges. Squid with small size at maturity (130-260 mm and 140-340 mm for males and females respectively), squid with medium size at maturity (240-420 and 280-600 mm for males and females respectively) and squid with large sizes at maturity (> 400-500 and 550-650 to 1000-1200 mm for males and females respectively). These groups have been reported by Tafur et al. (2018) for the period 1989-2016 who estimated the average mantle size or length at first maturity for smaller specimens with an average first maturity of 201 mm (with annual estimates between 91 and 336 mm) in males and 306 mm (with annual estimates between 186 and 447 mm) in females. And for larger specimens, first maturity was estimates in 514 m for males and 642 mm for females. In EEZ off the coast Chile, only individual with large size at maturity (56.5 and 63.8 cm of mantle length for males and females respectively) was found (Liu et al. 2010).

Embryonic development lasts for 6-9 days at 18°C. The mantle length (ML) at hatching averages 1.1 mm (Yatsu et al. 1999). In another study, Sakai et al. (2018) observed the early stages of embryonic development of jumbo flying squid under controlled condition and determined that at 20°C the eggs hatched 6.5 days after spawning. 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).

The maximum potential fecundity was estimated in 32 million oocytes, and this potential is closely related to female size (Nigmatullin & Markaida 2008).

### 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. 1988).

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). The jumbo flying squid in the northern Peruvian Current system consume high percentages by weight of mesopelagic fish, such as *Vinciguerria lucetia*, *Lampanyctus* spp., *Myctophum nitidulum*, *M. aurolaternatum* and *Diogenichthys laternatus*, as well as cephalopods, including their own species (cannibalism), the squid *Abraliopsis affinis*, the nautilus *Argonauta* spp., several species of Loliginidae, and other invertebrates such as euphausiidae and the squat lobster *Pleuroncodes monodon* (Alegre et al. 2014)

*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-Coolley et al. 2006). However, in Peruvian waters the high inter individual variability of nitrogen isotope with mantle length indicates that *D. gigas* can prey on a high variety of resources at any stages of their life cycle (Lorrain et al. 2011, Argüelles et al. 2012), indicating that *D. gigas* has a high potential to adapt to environmental changes.

## Impacts of Fishing

### Habitat damage

There is likely to be minimal if any damage to the habitat due to the highly selective type of fishing methods (jiggers) that are mostly employed.

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