Code: GIS
Scientific name: *Dosidicus gigas*

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Taxonomy

Phylum	Mollusca
Class	Cephalopoda
Order	Teuthida
Family	Ommastrephidae
Genus and species	*Dosidicus gigas (*d'Orbigny, 1835*)*
Scientific synonyms	None
Common names	Humboldt squid, jumbo flying squid, jibia, pota.
Molecular (DNA or biochemical) bar coding	Available in the Barcode of Life Data System (BOLD), at: http://www.boldsystems.org https://www.boldsystems.org/index.php/Public_SearchTerms?query=%22Dosidicus%20gigas%22[tax], 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 (Cosgrove & 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_4$3-/m² 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).

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 (Taipe et al. 2001). Off Chile, the *D. gigas* fishery is carried out in an 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 population 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 2006b) and southern hemisphere (Arguelles et al. 2001, 2008, 2017, Arguelles &

Tafur 2010, Arguelles & Taipe 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.

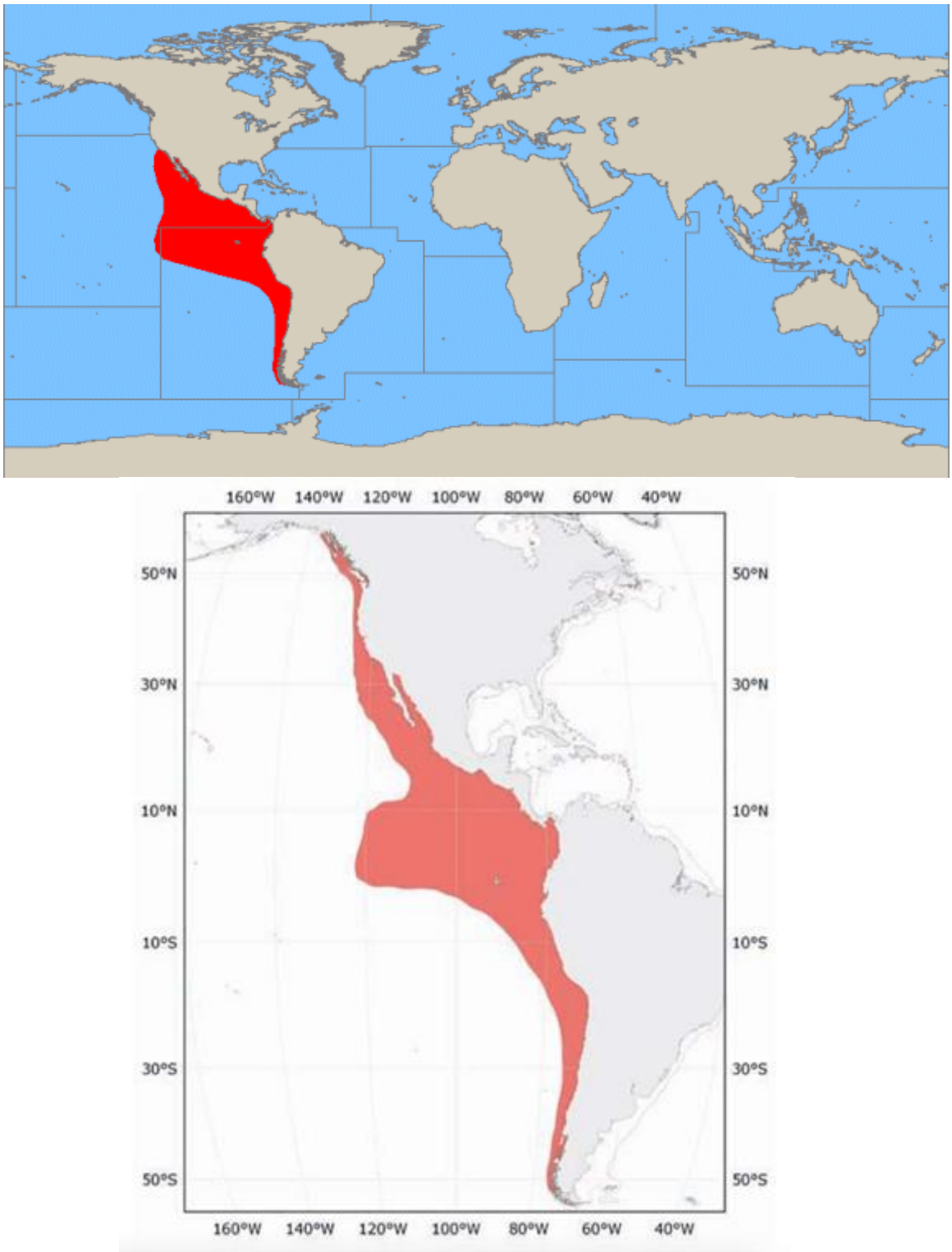

Figure 1. Known distribution of *D. gigas*. *Source: Roper et al. (2010).*

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*, *Eucleoteuthis* and *Hyaloteuthis*). They can be distinguished 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 elongates 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 base 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. There is 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 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 ranging from 3-4 m for the major equatorial diameter (Staaf et al. 2008).

D. gigas has a flexible and opportunistic behaviour (Markaida 2006b) which allows it 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 estimated as 514 m for males and 642 mm for females. In EEZ off the coast Chile, only individuals with large size at maturity (56.5 and 63.8 cm of mantle length for males and females respectively) were 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 conditions 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 at 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 euphausidae and the squat lobster *Pleuroncodes monodon* (Alegre at 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 & 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). However, in Peruvian waters the high inter individual variability of nitrogen isotope with mantle length indicates that *D. gigas* can prey on al high variety of resources at any stage of their life cycle (Lorrain et al. 2011, Arguelles 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.

References

Alegre, A., Ménard, F., Tafur, R., Espinoza, P., Argüelles, J., Maehara, V., Flores, O., Simier, M., Bertrand, A. (2014). Comprehensive model of Jumbo squid *Dosidicus gigas* trophic

ecology in the Northern Humboldt current system. *PLoS One* 9(1), e85919: 11p doi: 10.1371/journal. pone.008591

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.

Argüelles, J., Tafur, R., Taipe, A., Villegas, P., Keyl, F., Dominguez, N., Salazar, M. (2008). Size increment of jumbo flying squid *Dosidicus gigas* mature females in Peruvian waters, 1989–2004. *Progress in Oceanography.* 79: 308-312.

Argüelles, J., Tafur, R. (2010). New insights on the biology of the jumbo squid *Dosidicus gigas* in the Northern Humboldt Current System: size at maturity, somatic and reproductive investment. *Fisheries Research.* 106: 185-192.

Arguelles, J., Lorrain, A., Cherel, Y., Graco, M., Tafur, R., Alegre, A., Espinoza, P., Taipe, A., Ayón, P., Bertrand, A. (2012). Tracking habitat and resources use for the jumbo squid *Dosidicus gigas*: a stable isotope analysis in the Northern Humboldt Current System. *Marine Biology* 159: 2105-2116.

Argüelles, J., Csirke, J., Mariategui, L., Castillo, R. (2017). Distribution, size composition, possible stock structure and the assessment of jumbo flying squid (*Dosidicus gigas*) off Peru. Paper presented at the 5th meeting of the Scientific Committee of the SPRFMO, Shanghai, China. 23-28 September. SPRFMO Doc. SC5-SQ07_ rev1: 11 p. (https://www.sprfmo.int/assets/SC5-2017/ SC5-SQ07-rev1-Distribution-Size-Stock-structure-andAssessment-for-Jumbo-flying-squid.pdf)

Argüelles, J., Taipe, A. (2018). Variabilidad espacio temporal de la estructura por tallas de *Dosidicus gigas* (d'Orbignyi, 1835) en aguas peruanas entre 1958 y 2012. *Boletin Instituto Mar Perú.* 33(2): 167-177.

Arkhipkin, A., Murzov, S. (1986). Age and growth patterns of *Dosidicus gigas* (Ommastrephidae). In: Ivanov, B. (Ed.) Present state of fishery for squids and prospects of its development. VNIRO Press, Moscow. (In Russian, Spanish Translation). 107-123.

Arkhipkin, A., Rodhouse, P., Pierce, G., Sauer, W., Sakai, M., Allcock, L., Arguelles, J., Bower, J., Castillo, G., et al. (2015). World squid fisheries. *Reviews in fisheries science & aquaculture,* 23:2, 92-252, DOI: 10.1080/23308249.2015.1026226

Bazino, G., Salinas-Zavala, C., Markaida, U. (2007). Variability in the populations structure of jumbo squid (*Dosidicus gigas*) in Santa Rosalia, Central Gulf of California. *Ciencias Marinas* 33 (2): 173-186.

Bazino, G., Gilly, W., Markaida, U., Salizas-Zavala, C., Ramos-Castillejo, J. (2010). Horizontal movements, vertical-habitat utilization and diet of the jumbo squid (*Dosidicus gigas*) In the Pacific Ocean off Baja California Sur, Mexico. *Progress in Oceanography 86:59-71.*

Bizikov, V.A. (1996). Atlas of morphology and anatomy of the gladius of squids. Moscow: VNIRO Publishing, 248 pp. (In Russian with English summaries of all 11 chapters).

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.

Clarke, R., Paliza, O. (2000). The Humboldt Current squid *Dosidicus gigas* (Orbigny, 1835). *Revista de Biologia Marina y Oceanografia.* 35: 1-38.

Csirke, J., Alegre, A., Argüelles, J., Guevara-Carrasco, R., Mariátegui, L., Segura, M., Tafur, R., Yamashiro, C. (2015). Main biological and fishery aspects of the jumbo squid (*Dosidicus gigas*) in the Peruvian Humboldt Current System. Paper presented at the 3rd meeting of the Scientific Committee of the SPRFMO. Port Vila, Vanuatu. 28 September - 3 October 2015. SPRFMO Doc. SC-03-27: 33p. (http://www.sprfmo.int/assets/Meetings/ Meetings-2013-plus/SC-Meetings/3rd-SC-Meeting-2015/ Papers/SC-03-27-Biological-and-fishery-aspects-of-thejumbo-squid-in-the-Peruvian-Humboldt-current.pdf)

Csirke, J., Arguelles, J., Alegre, A., Ayon, P., Bouchon, M., Castillo, G., Castillo, R., Cisneros, R., Guevara-Carrasco, R., Lau, L., Mariátegui, L., Salazar, C., Tafur, R., Torrejon, J., Yamashiro, C. (2018). Biology, population structure and fisheries of jumbo flying squid (*Dosidicus gigas*) in Peru. *Boletin Instituto Mar Perú* 33(2):302-364.

Cosgrove, J.A., Sendall, K.A. (2005). First records of *Dosidicus gigas*, the Humboldt squid in the temperate Northeastern Pacific. *Archives of the British Columbia Royal Museum, Victoria, Canada. 10 p.* (https://www. researchgate.net/publication/265815348)

Cubillos, L., Ibáñez, Ch., Gonzales, C., Sepúlveda, A., Gallardo, M., Garrido, J., Cid, E., Bruno, C., Pincheira, C., Mena, R., Carrasco, P., Torres, R., Vera, C. (2004). Informe Final. Pesca de jibia (*Dosidicus gigas*) con red de cerco entre la V y X regiones, año 2003. Instituto de Investigación pesquera. 48 p.

d'Orbigny, A. (1835). Mollusques. Voyage dans l'Amérique Méridionale 5 (3), 758 pp. (1835-1847).

Ehrhardt, N.M., Solis, N.A., Jacquemin, P.S., Ortiz, J., Ulloa, P., Gonzales, G., García, F. (1986). Análisis de la biología y condiciones del stock del calamar gigante *Dosidicus gigas* en el Golfo de California México, durante 1980. *Ciencia Pesquera. Inst. Nal. Pesca. Sria Pesca. México* 5:63-76.

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.

Franco-Santos, R.M., 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.

Gilly, W.F., Elliger, C.A., Salinas, C.A., 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.

Goicochea-Vigo, C., Morales-Bohorquez, E., Zepeda-Benitez, V., Hidalgo-de-la-Toba, J., Aguirre-Villaseñor, H., Mostacero-Koc, J., Atoche-Suclupe, D. (2019). Age and growth estimates of the jumbo flying squid (*Dosidicus gigas*) off Peru. *Aquatic Living Resources.* 32:7

Gong, Y., Ruiz-Cooley, R.I., Hunsicker, M.E., Li, Y., Chen, X. (2018). Sexual dimorphism in feeding apparatus and niche partitioning in juvenile jumbo squid *Dosidicus gigas*. *Marine Ecology Progress Series*. 607, 99–112.

Ibáñez, Ch., Sepúlveda, R., Ulloa, P., Keyl, F., Pardo-gandarillas, C. (2015). The biology and ecology of the jumbo squid *Dosidicus gigas* (Cephalopoda) in Chilean waters: a review. *Latin American Journal of Aquatic. Research.* 43(3): 402-414.

Li, G., Chen, X., Zou, X., Liu, B. (2016). China's National Report Part II: Squid Jigging Fishery. Paper presented at the 4th meeting of the Scientific Committee of the SPRFMO. The Hague, Kingdom of the Netherlands, 10-15 October 2016. SPRFMO Doc. SC-04-11 rev1: 11 p. (http://www. sprfmo.int/assets/Meetings/Meetings-2013-plus/SCMeetings/4th-SC-Meeting-2016/SC04-papers/SC-04- 11-rev1-Chinas-Annual-Report-Part-II-Revised-Squidjigging-fishery.pdf)

Li, G., Chen, X., Liu, B., Xu, L. (2017). China's Annual Report to the 2017 SPRFMO Scientific Committee, Part II: the squid jigging fishery. Paper presented at the 5th meeting of the Scientific Committee of the SPRFMO. Shanghai, China, 23-28 September 2017. SPRFMO Doc. SC5-Doc. 17: 9 p. (http://www.sprfmo.int/assets/00-SC5-2017/SC5-Doc17-Chinas-Annual-report-part-II-Squid.pdf)

Liu, B., Chen, X., Lu, H., Chen, Y., Qian., W. (2010). Fishery biology of the jumbo flying squid *Dosidicus gigas* off the Exclusive Economic Zone of Chilean waters. *Scientia Marina* 74 (4):687-695.

Liu, B., Chen, X., Chen, Y., Tian, S., Li, J., Fang, Z., Yang, M. (2013). Age, maturation, and population structure of the Humboldt squid *Dosidicus gigas* off the Peruvian Exclusive Economic Zones. *Chinese Journal of Oceanology and Limnology.* Vol. 31(1): 81-91.

Liu, B., Chen, X., Yi, Q. (2013a). A comparison of fishery biology of jumbo flying squid, *Dosidicus gigas* outside three Exclusive Economic Zones in the Eastern Pacific Ocean. *Chinese Journal of Oceanology and Limnology. 31(3): 523-533*. (http://dx.doi.org/10.1007/s00343-013-2182-3)

Liu, B., Chen, X., Chen, Y., Tian, S., Li, J., Fang, Z., Yang, M. (2013). Age, maturation and population structure of the Humboldt squid *Dosidicus gigas* off Peruvian Exclusive Economic Zones. *Chinese Journal of Oceanology and limnology.* 31(1):81-91.

Lorrain, A., Arguelles, J., Alegre, A., Munaron, J.M., Richard, P., Cherel, Y. (2011). Sequential isotopic signature along gladius highlights contrasted individual foraging strategies of jumbo squid (D*osidicus gigas*). *Plos ONE* 6(7): e22194. doi:10.1371/journal.pone.0022194

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.

Nesis, K.N. (1983). *Dosidicus gigas*. In Boyle, P.R. (Ed.), Cephalopod Life Cycles. Volume 1. Academic Press, London. 215-231.

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.

Nigmatullin, Ch., Markaida, U. (2008). Oocyte development, fecundity and spawning strategy of large sized jumbo squid *Dosidicus gigas* (Oegopsida: Ommastrephinae). *Journal of the Marine Biological Association of the United Kingdom,* 89(4):789-801.

Rodhouse, P.G., Nigmatullin, Ch.M. (1996). Role as consumers. *Philosophical Transactions of the Royal Society B: Biological Sciences* 351: 1003–1022.

Roper, F.E., Nigmatullin, C., Jereb P. (2010). Family Ommastrephidae *Steenstrup, 1857*: 269-347. *In* P. Jereb & C.F.E. Roper, eds. (2010). Cephalopods of the world. An annotated and illustrated catalogue of cephalopod species known to date. Volume 2. Myopsid and Oegopsid Squids. FAO Species Catalogue for Fishery Purposes, FAO, Rome, No. 4, Vol. 2: 605p. +10 colour plates. http://www.fao.org/3/i1920e/i1920e.pdf

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.

Sakai, M., Tsuchiya, K., Mariategui, L., Wakabayashi, T., Yamashiro, C. (2017). Vertical migratory behavior of jumbo squid (*Dosidicus gigas*) off Peru: records of Acoustic and pop-up Tags. JARQ 51(2): 171-179. https://www.jircas.go.jp

Sakai, M., Vijai, D., Yamashiro, C., Wakabayashi, T. (2018). Observations on embryos and embryonic development from an egg mass of the jumbo squid *Dosidicus gigas* spawned under captive conditions. *Boletin Instituto Mar Perú* 33(2): 153-159.

Sandoval-Castellanos, E., Uribe-Alcocer, M., Díaz-Jaimes, P. (2007). Population genetic structure of jumbo squid (*Dosidicus gigas*) evaluated by RAPD analysis. *Fisheries Research.* 83: 113–118.

Sandoval-Castellanos, E., Uribe-Alcocer, M., Díaz-Jaimes, P. (2009). Lack of genetic differentiation among size groups of jumbo squid (*Dosidicus gigas*). *Ciencias Marinas.* 35(4): 419–428.

Sandoval-Castellanos, E., Uribe-Alcocer, M., Díaz-Jaimes, P. (2010). Population genetic structure of the Humboldt squid (*Dosidicus gigas*, d'Orbigny, 1835) inferred by mitochondrial DNA analysis. *Journal of Experimental Marine Biology and Ecology. 385: 73–78.*

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

Staaf, D., Camarillo-Coop, S., Haddock, S., Nyack, A.L., Payne, J., Salinas-Zavala, C., Seibel, B., Trueblood, L., Widmer, C. (2008). Natural egg mass deposition by the Humboldt squid (*Dosidicus gigas*) in the Gulf of California and characteristics of hatchlings and paralarvae. *Journal of the Marine Biological Association of the United Kingdom,* 88(4):759-770*.*

Staaf, D.J., Ruiz-Cooley, R.J., Elliger, C., Lebaric, Z., Campos, B., Markaida, U., Gilly, W.F. (2010). Ommastrephid squids *Sthenoteuthis oualaniensis* and *Dosidicus gigas* in the eastern Pacific show convergent biogeographic breaks but contrasting population structures. *Marine Ecology Progress Series.* 418: 165-178

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) (Cephalopoda: Ommastrephidae) off Peruvian coasts. *Scientia Marina* 61 (suppl. 2): 33-37.

Tafur, R., Perea, A., Buitrón, B. (2018). Aspectos reproductivos del calamar gigante *Dosidicus gigas* (d'orbigny, 1835) en el mar peruano. *Boletín Instituto Mar Perú*. 33 (2):119-136.

Wormuth, J.H. (1976). The biogeography and numerical taxonomy of the oegopsid squid family Ommastrephidae in the Pacific Ocean. *Bulletin of the Scripps Institution of Oceanography.* 23: 90 p*.*

Wormuth, J.H. (1998). Workshop deliberations on the Ommastrephidae; a brief history of their systematics; and a review of the systematics, distribution, and biology of the genera *Martialia* Rochebrune and Mabille, 1889; *Todaropsis* Girard, 1890; *Dosidicus* Steenstrup, 1857; *Hyaloteuthis* Gray, 1849 and *Eucleoteuthis* Berry, 1916. In Voss, N. A., M. Vecchione, R. B. Toll & M. J. Sweeney (Eds.) *Systematics and biogeography of cephalopods. Smith. Contrib. Zool.* 586 (II): 373-384.

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.