Deep sea squid in Sulawesi Sea, North Sulawesi Province, Indonesia

Abstract. This study was aimed to identify one of the deep sea squids caught in artisanal fisheries by traditional fishermen in Sulawesi Sea, North Sulawesi Province. Samples were collected using vertical hand line of traditional fishermen. The specimen was ~~molecularly~~ identified using Cytochrome c oxidase subunit 1 (CO1). For morphometric characteristics, all body parts were measured and each part was compared with mantle size. ~~Results showed that t~~The specimen was identified as *Sthenoteuthis oulaniensis* and had 99.35% similarity to *S. oualaniensis* (CO1) from China (NCBI - MN101944)~~ with sufficient genetic variations~~. Based on the body size, species recorded in the present study belongs to the dwarf form, the smallest form of *S. oualaniensis* group~~s~~. The species has the following morphometric characteristics: Head length is 0.28 of mantle length, tentacle length is 1.158 mantle length, and fin area is 0.5 mantle length. The fourth arm is the shortest and the second arm is the longest among the squid arms. *S. oulaniensis* recorded in the present study belonged to dwarf form living in equatorial waters. This finding ~~has~~ may contribute~~d~~ to the list of marine resources of fisheries interest from~~ marine resources, especially squid, in~~ Indonesian waters.

Keywords: squid species identification, CO1 gene, morphometric, traditional fishermen, hand line.

Running title: Deep Sea Squid

INTRODUCTION

Commented [SM1]: This is a very elaborate introduction. I have tried to trim it. Considerable improvement in the language usage is also necessary.

Squids ~~belong to~~ is a cephalopod~~,~~ mollusk, living in the marine environment. ~~Cephalopod means head feet, since the feet are separated as a number of arms circling the head.~~ This group is an ecological opportunist adapted to exploit favorable environmental conditions (Rodhouse 2013). ~~Squid (*Loligo* sp) is one of cephalopod members that are importantly economic fisheries commodities worldwide (Prakasa et al. 2014).~~ It is a favorite food type due to its high~~ly~~ nutritional content with ~~high~~ high-quality protein for human consumption (Roper et al. 1984) and nearly all body parts are edible (Triharyuni and Puspasari 2012). Cephalopod production from fishing has continued to grow (Doubleday et al. 2016), with total commercial annual catches varying between 3.5 and 4.9 million tonnes in 2008–2017 (FAO 2019) and averagely supports about 15 and 20% of marine fishery landings and landed values, respectively (FAO 2019). Demand for this commodity has increased in both fresh and processed forms (Baskoro and Mustaruddin 2019). High market demand for squids as an export commodity of Indonesia has made squids become one of the major catches besides fish and lobster (Wulandari 2018). ~~This trend will urge fishermen to conduct intensive fishing, while the squid production is still dependent upon the stock in the wild (Tresnati et al. 2012). The squids, in general, with the other coleoid cephalopods, are semelparous, have high reproductive rates and generally shortlived approximately one year with a single spawning event, then die (Anusha and Fleming 2014; Rodhouse et al 2014). They~~ Squids also grow fast with high feeding rates and conversion efficiencies (Arkhipkin et al 2015).

These biological features make them be ecological opportunists in which they can quickly exploit favorable environmental conditions, but their abundance responds rapidly to poor conditions so that recruitment and abundance may be highly variable on annual time scales (Rodhouse et al 2014). Therefore, high dependence on ~~the~~ wild stocks can lead to stock overfishing.

In Indonesia, squid production is far below the world market demand ~~in spite of~~despite its increasing squid production, ~~so that the export development is still wide opened~~ (Triharyuni and Puspasari 2012; Hulalata et al 2013). This condition is caused by an uneven distribution of squid fisheries across the country. Only several regions do the squid fisheries, and the others do ~~in~~ on a very low scale for local consumption.

Information on this group is, so far, mostly related ~~with~~ to commercial promotion ~~as~~ for fisheries production. ~~This group has been introduced together with other cephalopod groups as export commodity. Very few studies have been accomplished, so that people's knowledge on squids is very limited and they know the animal under a common name "squid", but there are so many species belonging to this group. At fishermen community's level, squids have different names with their morphological characteristics. Nevertheless, several members of this group that usually occur in regular period of time have disappeared for longer time.~~ It is evident that there is a major artisanal and small-scale inshore element to the world squid fishing fleet and that large volumes of loliginid squids caught in tropical and subtropical regions have high species diversity. Thus, a ~~species identification~~ taxonomic study on this group in Indonesian waters is needed. ~~In this area, t~~ The taxonomy of the squid fauna generally is poorly understood. Correct species identification is the basis of ~~the~~ ecological studies (Veijalainen 2011).

There are 290 species of squids and about 30–40 species have substantial commercial importance (Arkhipkin et al 2015) belonging to the family Ommastrephidae, Loliginidae, Onychoteuthidae, and Gonatidae. Triharyuni and Puspasari (2012) have grouped family Lolinginidae from Indonesian waters into several genera, Afrololigo, Allotheuthis, Dorytheuthis, Heterololigo, Loliolus, Lollinguncula, Pickfordiateuthis, Sepioteuthis, and Urotheuthis ~~(Wulandari 2018)~~, but there are much more species to be described ~~(Jerep and Roper 2010)~~. In Rembang waters, Central Java, four species were found, *Loligo chinensis*, *L. singhalensis*, *L. edulis*, and *L. duvaucelli*, in which *L. duvaucelli* is the most often caught species (Reference?).

In North Sulawesi, Indonesia, there is no squid fisheries and the squid catches are bycatch of other fisheries, but squid production of different species is available every month. Squid catches are obtained at a certain moon period, especially ~~in~~ during the early new moon, when the large squid schools come near the surface. The local fishermen catch them using small mesh-sized seine, lift net or using scoop net ~~for those who have simple fishing facility~~. A small group of fishermen along Manado Bay, North Sulawesi, Indonesia, have benefitted from deep sea squid as an income source and food ~~ingredients~~ by relying on hand line fishing or jig fishing as ~~practiced~~ practised by ~~foreign~~ international squid fisheries ~~men~~ (Sundaram and Sawant 2014). Nevertheless, very few fishermen do squid fishing, the amount of catches is very low. This ~~animal~~ species ~~has become~~is a very important resource~~, so that~~ and its sustainability needs to be maintained, and thus, basic information on this resource needs to be ~~provided~~ studied. This study is intended to identify the ~~deep~~ deep-sea squid caught by local fishermen of Manado Bay in Sulawesi waters. The findings are expected to ~~be able to~~ enrich the inventory of economically importantly ~~economic~~ squid species and develop squid fisheries in this area for future regional economic growth.

MATERIALS AND METHOD

Squid samples were obtained from fishermen's catch in the Sulawesi Sea, North Sulawesi, about 5 miles from the shore of Manado Bay. ~~In relation with this study,~~ The fishing operations were carried out at the geographic position covered by the area formed in the east border (1º 30' 45"N and 124º 42' 49"E to 1º 32' 47"N and 124º 42' 59"E) and the west one (1º 29' 30"N and 124º 40' 48"E to 1º 33' 45"N and 124º 40' 50'E) (Figure 1).

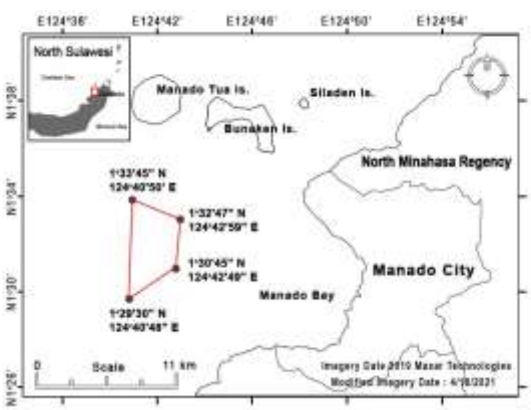

Figure 1. Sampling location. Red lines point out the sampling area.

All samples were measured ~~in order~~ to describe the species physical characteristics through comparison of mantle size and other morphometric characters, such as head length, tentacle length, arm length, fin length and fin width. For DNA identification, a piece of the squid arm was taken and preserved in 95% ethanol solution before extraction to wash the sample from salt~~-~~water and draw water from the cell. All samples were preserved in 95% ethanol and stored at room temperature before DNA extraction.

Commented [SM2]: How many samples? When was this collection made? What was the gear used for catching squids? How did you measure? Did you take the weight of the animal? Did you record the sex and maturity?

Extraction, PCR, and sequencing

Genome DNA extraction of all samples used Innu PREP DNA Micro Kit (Analytic Jena). The CO1 gene was amplified applying universal primer pairs LCO1490: 5'-ggtcaacaaatcataaagatattgg-3' and HCO2198: 5'taaacttcagggtgaccaaaaaatca-3' (Folmer et al. 1994). Polymerase chain reaction (PCR)was carried out in 35 cycles at 95ºC (30 sec.), 50ºC (30 sec.), 72ºC (50 sec.). The PCR product was visualized in 1% (b/v) agarose gel electrophoresis. Bi-directional sequencing was done by First Base CO (Malaysia) using Big Dye© terminator chemistry (PerkinElmer).

Data analysis

The specimen chromatogram was edited using Mega X v10.1 software (Kumar et al. 2018). The sequences were then compared with Gen Bank data using BLAST (BasicLocal Alignment Search Tools) method (Altschul et al. 1997) and BOLD Systems (Ratnasingham and Hebert 2007). In this study, the sample sequence was compared with that of 6 specimens from the China Sea. *Sepia latimanus* was also used as an outgroup ~~in order~~ to strengthen the comparison. This ~~specimen~~ species is ~~one of~~ a cephalopod ~~members~~ having an internal skeleton called cuttlebone. The phylogenetic tree was built using Neighbor-Joining Method (Saitou and Nei 1987). Similarity index was also calculated.

RESULTS AND DISCUSSION

DNA characteristics

Commented [SM3]: Morphological descriptions first please.

Based on molecular identification using the Internal Transcribed Spacer (ITS) region, the DNA bands obtained were around 500-750bp, the success of PCR was detected by the presence of a single DNA band around 680 bp, the PCR results can be seen in Figure 2.

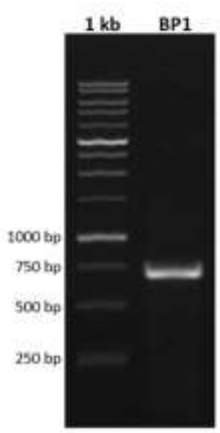

Figure 1. PCR product of the sample specimen

The sample was identified as *Sthenoteuthis oualaniensis* as shown in the BLAST results in the Gen Bank of NCBI. This species, according to the WoRMs ~~details~~ database, has synonymized names such as *Loligo brevitentaculata* Quoy & Gaimard, 1832 (synonym), *L. oualaniensis* Lesson, 1830 (original combination), *L. vanikoriensis* Quoy & Gaimard, 1832 (synonym), and *Symplectoteuthis oualaniensis* (Lesson, 1830). This species belongs to class Cephalopod, subclass Coleoides, suborder Decapodiformes, order Oegopsida, superfamily Ommastrephidea, family Ommastrephidae, subfamily Ommastrephinae, and genus *Sthenoteuthis* (~~Jerep~~ Jereb and Roper, 2010). *Sthenoteuthis oualaniensis* from the Sulawesi Sea has a similarity ~~rate~~ of 99.35% to NCBI record (acc. no. MN101944.1) and 96.8% to five other NCBI records from the China Sea (Table 1). *Sepia latimanus* used as an outgroup ~~clearly~~ indicates the great difference from the specimen and supports the kinship status of the specimen ~~on~~ stud~~y~~ied.

Table 1. Similarity ~~rate~~ of *S. oulaniensis* from Sulawesi Sea and those from the Gen Bank DNA sequence database.

	1	2	3	4	5	6	7
Sthenoteuthisoualaniensis, Sulawesi Sea, Indonesia (Query Sequence)							
MN101944, *Sthenoteuthis oualaniensis*(COI), China (NCBI)	0.007						
F411104, *Sthenoteuthis oualaniensis*(COI), China (NCBI)	0.032	0.028					
MF411103, *Sthenoteuthis oualaniensis*(COI), China (NCBI)	0.032	0.028	0.000				
MF411102, *Sthenoteuthis oualaniensis*(COI), China (NCBI)	0.032	0.028	0.000	0.000			
MF411101, *Sthenoteuthis oualaniensis*(COI), China (NCBI)	0.032	0.028	0.000	0.000	0.000		
MF411098, *Sthenoteuthis oualaniensis*(COI), China (NCBI)	0.032	0.028	0.000	0.000	0.000	0.000	
AB430406.1_*Sepia_latimanus* (COI), Sulawesi Sea, Indonesia (OutGroup)	0.220	0.224	0.217	0.217	0.217	0.217	0.217

The difference is demonstrated in specimen grouping (Figure 3) as well in which there are 3 different groups formed, and only one compared *S. oualaniensis* of six NCBI records is in the same group as *S. oualaniensis* specimen ~~on~~ used in the study. It reflects that this species has sufficient genetic variations. Group 1 consists of 5 NCBI specimens from China waters, group 2 comprises specimen from Sulawesi Sea and 1 NCBI China specimen, and group 3 is an outgroup.

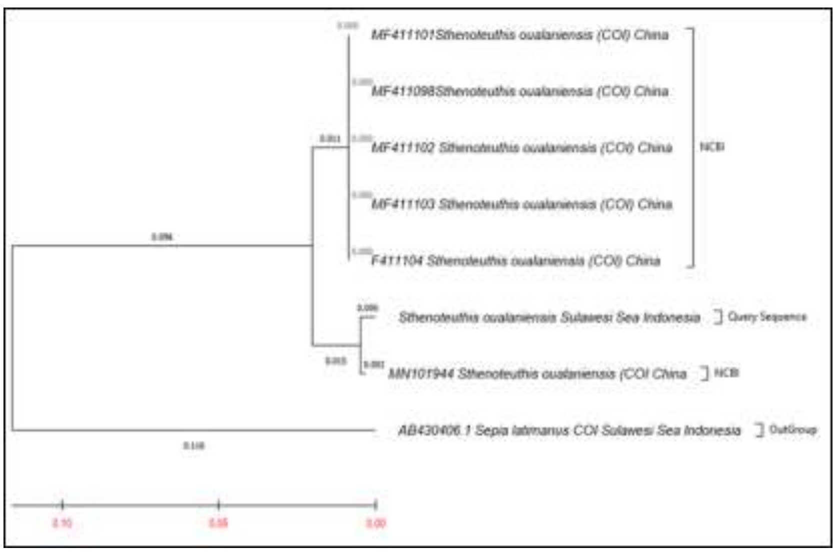

Figure 3. Phylogenetic tree of *S. oulaniensis*

Morphological description

Sthenoteuthis oualaniensis has the following morphometric characteristics: Head length is 0.28 of mantle length (ML), tentacle length is 1.158 ML, fin width is 0.3 ML, and fin length is 0.4 ML. The fourth arm is the shortest and the second arm is the longest among the squid arms (Figure 4).

Commented [SM4]: Do the morphometric characters match with previous descriptions? You mention a lot of morphometric measurements in Methods, but none of these are described here.

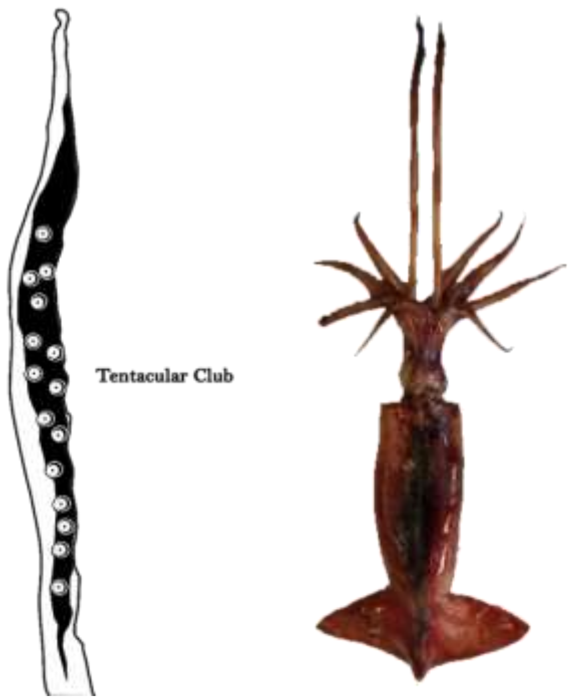

Figure 4. Tentacular club (left) and Squid *Sthenoteuthis oulaniensis*.

S. oualaniensis is known as purpleback flying squid, a tropical Indo-Pacific species that occurs in the Pacific from southern Japan to southern Queensland and from just south of Baja California to northern Chile. *S. oualaniensis* belongs to family Ommastrephidae widely distributed in the tropical and subtropical areas of the Pacific Ocean and Indian Ocean, and this species is important for resource exploitation in South China Sea as one of the major target species of large-scale light falling-net fishing (Yu et al 2019; Zhao et al 2021). There is relationship between purpleback flying squid abundance and environmental variables (Alabia et al 2016; Mohamed et al 2018). Cephalopods are sensitive to water temperature (Li et al 2020) that becomes one of the major environmental factors affecting squid activities, including aggregation, breeding, and emigration (Klemas 2013). Deep sea squids *Sthenoteuthis oulaniensis* are distributed from 0-4,500 M depth with a peak at 0-500 M depth, water temperature of 25 – 32^{o}C, salinity of 34-35 PSU (Jerep and Roper 2010). These seawater temperature ranges covers that of Sulawesi Sea that enables to support the occurrence of this squid species based on 10 years of Sulawesi Sea water temperature data (Sea water temperature Sulawesi today | Indonesia (seatemperature.info). Besides sea surface temperature (SST), sea surface height anomaly (SSHA) at −0.05–0.05 m and chlorophyll-a concentration higher than 0.18 µg/L are required to gain higher catch (Zhao et al 2021).

S. oualaniensis are sexually dimorphic and the females tend to grow larger than the males in most cases (Chembian and Mathew 2014). Purpleback squid *S. oualaniensis* has a short lifecycle, a rapid growth rate, and high fecundity (Zhang et al 2013). According to Roper et al (2010), this species is highly active predator with major prey groups of fish, cephalopods, crustaceans, and others. This species is known to be one of the fastest-growing squid species with daily length increase of about 1.0 mm in the dwarf and middle-sized forms and 3.8 mm in the giant form is about 3.8 mm. For this, *S. oualaniensis* can move at high speeds through the water, easily manoeuver and quickly respond to their environment changes. Under distress of external factors, such as predation, this species can reach a high speed and glide above the surface over ten meters**.** They also found that the cruising speed of an adult squid is between 3 to 10 km per hour, their burst speed achieves greater speeds of up 35 km per hour, and it can be important for sudden changes in movement and escape behavior. They can occur into shoals from 2 individuals to 800 individuals, and when geographical distributions overlap they can exist with other members of similar-sized family Ommastrephidae schools, *Dosidicus gigas* and *Ommastrephes bartramii* that are distributed from the Indo-Pacific to Indian Ocean as well (Liu et al 2016). Ommastrephidae squids are known 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) (Gong et al. 2020). These species are highly migratory, undertake diel vertical migrations of several hundred meters and seasonal migrations between the shelf and open ocean (Stewart et al 2013). Thus, they can work as important linkages between both neritic and oceanic food webs (Arkhipkin 2013; Alegre et al 2014).

In North Sulawesi, this squid species fishing is done by artisanal fishermen using jigging with artificial flashing bait, and the fishing operation has been done in Sulawesi Sea. In the present study, the squids *S. oualaniensis* caught in Sulawesi Sea had a size range of 60 mm to 11.0 cm ML. They belong to dwarf form with body size of 90-100 mm ML for mature males and 90-120 mm ML in mature females (Nesis 1993). The occurrence of *S. oulaniensis* in Sulawesi waters could result from the influence of environmental factors. Similar finding is also reported that changes in marine environments affect cephalopod fishery resources at different spatial and temporal scales (Zhang et al 2012). Furthermore, the distribution of purpleback flying squid *S. oulaniensis* in this area could not be separated from the impact of the Kuroshio from the Pacific Northern Equatorial current toward the east coast of Luzon, Philippines that forms the southward-flowing Mindanao Current (Qiu and Lukas 1996) and transfers the upper ocean waters from the Pacific to the Indian Ocean through the Indonesian Seas (Taufiqurrahman et al 2020). As the water mass enters the Indonesian Seas, the warm and relatively salty characteristics of the Pacific water tend to disappear due to strong vertical tidal mixing. The mixing is believed to affect the carbon, oxygen, and nutrient (nitrate, phosphates) concentrations in the eastern Indonesian Seas and subsequently in the Indian Ocean (Ayers et al. 2014). This event makes Indonesian marine waters be fertile to support the high occurrence of marine animals in the area. The Indonesian Throughflow is the only ocean connector pathway in the equator (Sprintall et al 2014), and it has an important purpose in the transport of mass and heat from the Pacific into the Indian Ocean (Feng et al 2018). The throughflow brings the eggs and larvae, along with the rich detritus of the sea that is swept up from the offshore deep basins. It is in agreement with Dell et al (2011) that the biophysical environment plays an essential role in controlling the distribution and abundance of pelagic predators in the ocean. Cheng et al (2018) who studied the swordtip squid *Uroteuthis edulis* found that complex oceanographic conditions might affect their population in the Southern East China Sea due to seasonal changes in the Kuroshio Current and Mainland China Coastal Current during the northeasterly monsoon and southwesterly monsoon seasons.

This evidence is supported by the closest kinship to the deep sea squid *S. oulaniensis* specimens from China waters of NCBI record and they could originate from the same ancestor despite in genetic variations. Genetic diversity could result from population size, in which the larger population size within species is, the higher genetic diversity will be. This finding has reconfirmed the distribution of *S. oulaniensis* reported in previous studies. The present study has provided information on the occurrence of one of the importantly economic squid resources in Indonesian waters, especially the Sulawesi Sea, that can be used for national economic development. As center of biodiversity, we strongly believe that there are more squid species living in this waters that need to be described, so that there are more taxonomic works need to be done on species richness of squids in Sulawesi Sea waters as well for future development. Besides, other biological studies of the species need to be done as well in order to have better understanding on this species that future management and conservation efforts could be well prepared.

Commented [SM5]: These descriptions are not relevant to the main objective of your study which was to identify the deep-sea squids in the area. The text provided here are available from literature and have little relevance to this study.
I suggest that this MS is rewritten keeping in mind the data collected and inferences from the data.

ACKNOWLEDGEMENTS

We would greatly appreciate Sam Ratulangi University Manado for providing small research grant and laboratory facilities. Our high appreciation is also addressed to Ms. Isroja Paransa who has involved in this study, but passed away in the middle of study.

REFERENCES

Alabia I.D, Saitoh S, Igarashi H, Ishikawa Y, Usui N, Kamachi M, Awaji T, Seito M. 2016. Future projected impacts of ocean warming to potential squid habitat in western and central North Pacific. ICES J. Mar. Sci. 73: 1343–1356.

Alegre A, Ménard F., Tafur R, Espinoza P, Argüelles J, Maehara V et al. 2014. Comprehensive model of jumbo squid *Dosidicus gigas* trophic ecology in the northern Humboldt current system. PLoS One 9:e0085919.doi: 10.1371/journal. pone. 0085919

Altschul SF, Madden TL, Schaffer AA, Zhang J, Zhang Z, Miller W, Lipman DJ. 1997. Gapped BLAST and PSI-BLAST: a new generation of protein database search program, Nucleic Acids Research 25: 3389-3402.

Anusha JR., Fleming AT. 2014. Cephalopod: Squid biology, ecology and fisheries in Indian waters. International Journal of Fisheries and Aquatic Studies 1(4): 41-50.

Arkhipkin AI. 2013. Squid as nutrient vectors linking Southwest Atlantic marine ecosystems. Deep. Res. Part II Top. Stud. Oceanogr. 95: 7–20. doi: 10. 1016/j.dsr2.2012.07.003

Arkhipkin AI, Rodhouse PGK, Pierce GJ, Sauer W, Sakai M, Allcock L, Arguelles J, Bower JR, Castillo G, Ceriola L et al. 2015. World squid fisheries. Rev. Fish. Sci. Aquac. 23: 92–252.

Ayers JM, Strutton PG, Coles VJ, Hood RR, Matear RJ. 2014. Indonesian throughflow nutrient fluxes and their potential impact on Indian Ocean productivity. Geophys Res Lett. 41(14):5060–5067. doi: 10.1002/2014GL060593.

.Baskoro MS, Mustaruddin. 2019. The integrated development strategic of capture fisheries based on local superior resources: Case Study of Squid Fisheries in South Bangka Regency. Jurnal Ilmu dan Teknologi Kelautan Tropis 11(3): 541-553. (Abstract)

Chembian AJ, Mathew S. 2014. Population structure of the purpleback squid *Sthenoteuthis oualaniensis* (Lesson, 1830) along the south-west coast of India. Indian Journal of Fisheries, 61(3): 20–28.

Cheng HL, Kuo WL, Hsin YH, Kae YW, Yan LW. 2018. Variation in the catch rate and distribution of swordtip squid Uroteuthis edulis associated with factors of the oceanic environment in the Southern East China Sea. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 10: 452–464

Dell J, Wilcox C, Hobda AJ. 2011. Estimation of yellowfin tuna (*Thunnus albacares*) habitat in waters adjacent to Australia'seast coast: making the most of commercial catch data. Fisheries Oceanography 20: 383–396.

Doubleday ZA, Prowse TAA, Arkhipkin A, Pierce GJ, Semmens J, Steer M et al. 2016. Global proliferation of cephalopods. Curr. Biol. 26: 387–407. doi: 10.1016/j.cub.2016.04.002

Feng M, Zhang N, Liu Q, Wijffels S. 2018. The Indonesian throughflow, its variability and centennial change. Geosci Lett. 5(1): 3. doi:10.1186/ s40562-018-0102-2.

FAO. 2019. FAO Yearbook: Fishery and Aquaculture Statistics 2017. Rome: Food and Agriculture Organization of the United Nations.

Folmer O, Black M, Hoeh W, Lutz R, Vrijenhoek R. 1994. DNA primers for amplification of mitochondrial cytochrome c oxidase subunit I from diverse metazoan invertebrates. Molecular Marine Biology and Biotechnology 3 (5): 294-299.

Gong Y, Li Y, Chen X, Yu W. 2020. Trophic niche and diversity of a pelagic squid (*Dosidicus gigas*): A comparative study using stable isotope, fatty acid, and feeding apparatuses morphology. Front. Mar. Sci. 7: 642. doi:10.3389/fmars.2020.00642

Hulalata A, Makapedua DM, Papaparang RW. 2013. Study on dry salted squid (*Loligo* sp.) processing at different water content and consumer's preference level. Jurnal Media Teknologi Hasil Perikanan, Manado 1 (2): 26-33. [in Indonesian]

Jerep P, Roper CF. 2010. Cephalopods of the World. An Annotated and Illustrated Catalogue of Cephalopod Species Known to date, Vol. 2. Myopsid and Oegopsid. FAO Rome, 605 p.

Klemas V. 2013. Fisheries applications of remote sensing: An overview. Fish Res. 148:124–136.

Kumar S, Stecher G, Li M, Knyaz C, Tamura K. 2018. MEGA X: Molecular Evolutionary Genetics Analysis across computing platforms. Molecular Biology and Evolution 35: 1547-1549.

Li JJ, Wang JT, Chen XJ, Lei L, Guan CT. 2020. Spatio-temporal variation of Ommastrephes bartramii resources (winter & spring groups) in Northwest Pacific under different climate modes. South China Fish. Sci. 16: 62–69.

Liu BL, Chen XJ, Li JH, Chen Y. 2016. Age, growth and maturation of *Sthenoteuthis oualaniensis* in the eastern tropical Pacific Ocean by statolith analysis. Marine and Freshwater Research, 67(12), 1973–1981. https://doi.org/10.1071/MF14427

Mohamed KS, Sajikumar KK, Ragesh N, Ambrose TV, Javasankar J, Koya KPS, Sasikumar G. 2018. Relating abundance of purpleback flying squid Sthenoteuthis oualaniensis (Cephalopoda: Ommastrephdae) toenvironmental parameters using GIS and GAM in south-eastern Arabian Sea. Journal of Natural History 52 (29-300: 1869-1882. (Abstract).

Nesis KN. 1993. Population structure of oceanic ommastrephids, with particular reference to *Sthenoteuthis oualaniensis*: A review. In: Okutani, T., R. K. O'Dor and T. Kubodera (eds.) Recent Advances in Fisheries Biology. Tokai Univ Press, Tokyo: 375-383.

Prakasa G, Boesono H, Ayunita NND. 2014. Fisheries bioeconomic analysis of the squid (Loligo sp.) caught in "cantrang" in TPI Tanjung Sari regency. Journal of Fisheries Resources Utilization Management and Technology 3 (2): 19-28. [in Indonesian]

Qiu B, Lukas R. 1996. Seasonal and interannual variability of the North Equatorial Current, the Mindanao Current, and the Kuroshio along the Pacific western boundary. Journal of Geophysical Research: Oceans 101 (C5): 12315-12330

Ratnasingham S, Hebert PDN. 2007. BOLD: the barcode of life data system. Molecular Ecology Notes 7: 355–364.

Rodhouse PGK. 2013. Role of squid in the Southern Ocean pelagic ecosystem and the possible consequences of climate change. Deep Sea Research Part II: Topical Studies in Oceanography 95: 129-138 (ABSTRACT)

Rodhouse PGK, Pierce GJ, Nichols OC, Sauer WHH, Arkhipkin AI, Laptikhovsky VV, Lipinski MR, Ramos J, Gras M, Kidokoro H, Sadayasu K, Pereira J, Lefkaditou E, Pita C, Gasalla M, Haimovici M, Sakai M, Downey N. 2014. Environmental effects on cephalopod population dynamics: implications for management of fisheries. Adv. Mar. Biol. 67: 99–223.

Roper CFE, Nigmatullin C, Jereb P. 2010. Family Ommastrephidae. In: Jereb, P. and Roper, C.F.E. (eds), Cephalopods of the World. An annotated and illustrated catalogue of species known to date: pp. 269-347. FAO, Rome.

Saitou N, Nei M. 1987. The neighbor-joining method: a new method for reconstructing phylogenetic trees. Molecular Biology and Evolution 4 (4): 406-425.

Sprintall J, Gordon AL, Koch-Larrouy A, Lee T, Potemra JT, Pujiana K, Wijffels SE. 2014. The Indonesian seas and their role in the coupled ocean-climate system. Nat Geosci. 7(7):487–492. doi: 10.1038/ngeo2188.

Stewart JS, Gilly WF, Field JC, Payne JC. 2013. Onshore offshore movement of jumbo squid (Dosidicus gigas) on the continental shelf. Deep. Res. II Top. Stud. Oceanogr. 95, 193–196.doi: 10.1016/j.dsr2.2012. 08.019

Sundaram S, Sawant D. 2014. Large scale exploitation of Indian squid, *Loligo duvauceli* by jigging from nearshore waters of Ratnagiri, Maharashtra Mar. Fish. Infor. Serv., T & E Ser., No. 221.

Taufiqurrahman E, Wahyudi AJ, Masumoto Y. 2020. The Indonesian throughflow and its Impact on Biogeochemistry in the Indonesian Seas. Review. ASEAN Journal on Science & Technology for Development 37 (1): 29–35. DOI 10.29037/ajstd.596

Tresnati J, Mallawa A, Nuraeni L, Rapi NL. 2012. Size structure, age groups and growth of squid Loligopealeii in the waters of Barru Regency, South Sulawesi. The Proceedings of 2nd Annual International Conference Syiah Kuala University 2012 & 8th IMT-GT Uninet Biosciences Conference Banda Aceh, 22-24 November 2012 2 (1): 13-16.

Triharyuni S, Puspasari R. 2012. Production and fishing season of squids (*Loligo* spp.) in Rembang waters, Central Java. J. Lit. Perikan. Ind. 18 (2): 77-83
Veijalainen A, Broad GR, Wahlberg N, Longino JT, Sääksjärvi. 2011. DNA barcoding and morphology reveal two common species in one *Pimpla molesta* stat. rev. separated from *P. croceipes* (Hymenoptera, Ichneumonidae). ZooKeys 124: 59-70
Wulandari DA. 2018. Morphology, classification, distribution of family Lolinginidae squids. Oseana 43 (2): 48 – 65. [in Indonesian]
Yu J, Hu Q, Tang D, Zhao H, Chen P. 2019. Response of *Sthenoteuthis oualaniensis* to marine environmental changes in the northcentral South China Sea based on satellite and in situ observations, PLOS One. 16 p.
Zhang YW, Wang KY, Lu HJ, Chang KJ. 2012. A study on moon phase effect to the hatching of swordtip squid (*Urotheuthis edulis*). J. the Fisheries Society of Taiwan 39: 209-222.
Zhang YM, Yan YR, Lu HS, Zheng ZW, Yi MR. 2013. Study on feeding and reproduction biology of purple flying squid Sthenoteuthis in the western South China Sea. Journal of Guangdong Ocean University 13: 56–64. (in Chinese with English Abstract).
Zhao C, Shen C, Bakun A, Yan Y, Kang B. 2021. Purpleback flying squid *Sthenoteuthis oualaniensis* in the South China Sea: Growth, Resources and Association with the Environment. Water 13, 65. https://doi.org/10.3390/w13010065