Biological Aspects and Feeding Habits of Spinetail Devil Ray *(Mobula mobular)* landed in the Palabuhanratu Nusantara Fishing Port

Fahira Anggi Novyanti[1]*, Selvia Oktaviyani[2], Moch. Rudyansyah Ismail[1], Yuniarti M.S.[1], Alexander M.A Khan[1]

[1]Faculty of Fisheries and Marine Sciences, Padjadjaran University
Jatinangor KM 21, West Java, Indonesia
[2]Research Center for Oceanography, National Research and Innovation Agency
East Ancol, North Jakarta 14430, Jakarta, Indonesia
Email: fahiraanggi27@gmail.com

Abstract

Optimal management of aquatic resources requires a good understanding of the biological aspects and other information related to these resources. This study was conducted to determine the biological aspects and feeding habits of *Mobula mobular* landed in the Palabuhanratu Nusantara Fishing Port. The research was conducted from September 2021 to May 2022. Data collected through a direct survey that included aspects of biology, stomach contents and information on fishing grounds. It was recorded that 21 individuals of *M. mobular* landed in the area during the study period. According to the Chi-Square test, the sex ratio between females and males is balanced with the growth pattern of *M. mobular* was negatively allometric. The male of *M. mobular* was generally found as immature individuals. The prey items identified in the stomachs belong to five groups: decapods, copepods, gastropods, Polychaeta, and others. Decapods were the most important prey (Index of Relative Importance 99,54%), while the other prey groups were only as complementary food. *M. mobular* is categorized as a plankton feeder. The fullness index value was 23.8%, while the vacuity index was 76.2% and categorized as relatively low fed. *M. mobular* is classified as an omnivorous animal that tends to be carnivorous with an animal preference with a trophic value of level 3.

Keywords: Biological aspects, Decapods, Mobula mobular, Plankton feeder, Palabuhanratu

INTRODUCTION

Mobula mobular is a species of the family Mobulidae which is the largest megafauna in the tropics, subtropics and temperate climates (White *et al*., 2018). This species is a pelagic fish and filter feeder with the main food of small fish, zooplankton, crustaceans, and ichthyoplankton (Coasaca-Céspedes *et al*., 2018). Like other fish, the growth of *M. mobular* can be influenced by internal and external factors. The internal factors in the form of genetics, age, or size, resistance to inducing disease and ability to utilize food. While external factors include physical properties, water chemistry, as well as biological components including food availability is very important to assess the role of predators, and the structure and dynamics of the community so that it is wider to understand trophic relationships in an inhabited ecosystem (Bucking, 2015). As the main eater of zooplankton, the foraging process of *M. mobular* is influenced by the environment that affects the distribution of zooplankton. Therefore, they are highly vulnerable to environmental changes, such as ocean acidification and warming (Weeks *et al*., 2015).

Threats to *M. mobular* are generally due to the relatively high catch of the group as bycatch in both pelagic and target fisheries (Blaber *et al*., 2009). The significant market demand causes increased fishing pressure because the body parts of the rays have high economic value for meat, skin and gills (Wijayanti *et al*., 2018). In addition, from a biological perspective, this group also has unique characteristics, such as a slow growth rate, length of sexual maturity, long lifespan and low fecundity (Croll *et al*., 2016). At this time the entire *Mobula* spp. has been registered in CITES Appendix II (Convention on International Trade in Endangered Species of Wild Fauna and Flora) and two of these species, namely *M. alfredi* and *M. birostris*, have been designated as protected fish with full protection status based on Minister of Marine Affairs and Fisheries Decree No. 4 of 2014. Therefore, *M. mobular* has a high level of vulnerability to extinction.

*) Corresponding author
www.ejournal2.undip.ac.id/index.php/jkt

Diterima/Received : 04-10-2022, Disetujui/Accepted : 08-05-2023
DOI: https://doi.org/10.14710/jkt.v26i2.16068

Analyzing food habits in natural habitats is one of the essential aspects to know in the context of conservation and resource management. The abundance of food associated with primary production may indicate the presence of *M. mobular* because when food is available in natural habitats this species tends to migrate to areas of high productivity in surface waters (Rambahiniarison *et al*., 2018). The need for food is a factor in an organism's continued growth and development. Therefore, studying food habits and feeding habits is one of the basic references for managing a particular biota (Taunay *et al*., 2013). Analysis of stomach contents can make it easier to determine the composition of their diet and better understand their feeding habits and their trophic role in the ecosystem (Torres-Rojas *et al*., 2010).

One of the Indonesian waters that have fishery potential and is a fishing area for Mobula rays is Palabuhanratu waters, Sukabumi, West Java. The catch of Mobula then landed at the Nusantara Fishing Port, Palabuhanratu. Local fishermen catch this group of fish as by-catch of gill nets. Therefore, this study was conducted to collect information on the biological aspects and feeding habits of Mobula (*M. mobular*), which landed at Palabuhanratu Nusantara Fishing Port.

MATERIALS AND METHODS

Biological aspects include sex determination, disc width (DW) measurements, and body mass. The total disc width was measured from the tip of the fin to the other fin using a rolling meter to the nearest 1 cm (Šantić *et al*., 2013). Determination of *M. mobular* sex was done visually, based on the presence or absence of claspers as male reproduction organs. Clasper maturity of males referred to criteria by Dharmadi & Fahmi (2008). The determination for clasper maturity of males was under the following conditions: (1) Juvenil/ Non-calcified: claspers undeveloped as small, not calcified and very soft as well as less than the pelvic fins length. Testes small, sperm ducts straight and thread-like; (2) Adolescent/ Non-full calcified (NFC): clasper becoming extended, approaching tips of posterior pelvic lobes, as long as or a bit longer than posterior pelvic lobes, still soft, flexible, and the clasper was not fully calcified. Testes enlarged, sperm ducts eventually beginning to meander (coil); (3) Adult/ Full calcified (FC): claspers full length and calcified, longer than the pelvic fins. Testes are greatly enlarged, sperm ducts meandering almost their entire length and tightly filled with sperm.

Feeding habits

After the fish landed, fish dissection and the entrail stomach were removed and preserved in 96% ethanol. After that, the prey was identified at the laboratory. The stomach content of each *M. mobular* was placed in a beaker for subsampling. Subsamples were then thoroughly identified using a Leica MZ6 microscope with a magnification of 4x10. The weight of the stomach, empty stomach and entrail contents, respectively, were recorded to an accuracy of 0.0001 g. In this study, feeding habit is also known using the fullness index (%FI) and the vacuity index (%VI). The fullness index was calculated as stomach contents mass divided by fish mass multiplied by 100 (Hyslop, 1980) and the results are divided into five categories Empty, Poor (1/4 full), Medium (1/2 full), Good (3/4 full) and Heavy (Suseelan & Nair, 1969). The vacuity index was estimated as the number of empty stomachs divided by the total number of stomachs multiplied by 100 (Berg, 1979) and the result is divided into five categories: 0 VI < 20 = Edacious; 20 VI < 40 = Relatively edacious; 40 VI < 60 = Moderately fed; 60 VI < 80 = Relatively low fed; 80 VI < 100 = Low fed.

Stomach contents of *M. mobular* were analyzed using the frequency of occurrence percentage (%O) which every food item in the stomach contents was recorded and expressed as a percentage of the total number of fish stomachs examined, gravimetry percentage method (%W) is estimated weight of each food item or total food content of each fish (Mahesh *et al*., 2018), and numerical percentage (%N) is the individual quantities of each food category in each stomach are recorded and expressed as a percentage of the total amount of food in all fish stomachs examined or as a proportion of the food in each fish stomach examined, raised to the total percentage composition (Hynes, 1950). The main food items were identified using an index modified by Manko (2016) formula Index of Relative Importance (IRI) and Index of Relative Importance percentage :

$$IRI_i = (\%N_i + \%W_i)\%O_i$$

$$\%IRI_i = 100 \times \frac{IRI_i}{\sum_{i=1}^{n} IRI_i}$$

In addition, an analysis of the trophic level of *M. mobular* was also carried out to determine the feeding behavior of *M. mobular*. The result of trophic level is divided into four categories (Stergiou & Karpouzi, 2002): H; 2.0 < TROPH < 2.1 = Herbivores; OV; 2.1 < TROPH < 2.9 = Omnivore with plant preference; OA; 2.9 < TROPH < 3.7 = Omnivore with an animal preference; CD; 3.7 < TROPH < 4.0 = Carnivora with a preference for *decapods* and fish; CC; 4.0 < TROPH = Carnivora with a preference for fish and *cephalopods*

The relationship between disc width and body mass of *M. mobular* is expressed by the equation (Effendie, 2002):

$$W = \alpha DW^{\beta}$$

Note: W = Body mass of fish (kg); DW = Disc width of fish (unit); α = Constant (intercept); β = The disc width exponent (slope)

The intercept and slope values were obtained from linear regression of disc width and body mass through the transformation log. The value of b provides information about the fish's condition and growth pattern. The relationship is said to be isometric (b=3) if the growth pattern of disc width is directly proportional to the pattern of body weight growth. However, if weight growth is more dominant than disc width growth, it is said to be positively allometric (b>3). Otherwise, if disc width growth is more prevalent than weight growth (b<3), it is said to be negatively allometric. Then the relationship between disc width and body mass was tested by t-test with an evident level of 5% or a=0.05 (Morey *et al*., 2003). The sex ratio shows the proportion between the number of females and males. Thus, continued by the Chi-square test to evaluate the homogeneity of the sex ratio at a 95% confidence interval.

RESULTS AND DISCUSSION

During the study, a total of 21 *M. mobular* were landed in the Palabuhanratu Nusantara Fishing Port, consisting of 13 females and eight males. *M. mobular* is the dominant species from the catch of the Mobulidae family in Indonesia at 50.4%, followed by *M. tarapacana* (23.5%), *M. birostris* (13.7%), *M. thurstoni* (8.8 %), and *M. kuhlii* (2.0%). Dian *et al*. (2016) also mentioned that in tuna fishing operations using drift net fishing gear in the South Indian Ocean waters of Java, the most caught were *M. japanica* or a synonym of *M. mobular*.

The total disc width ranges from 90 to 222 cm DW for females and 98 to 215 DW for males. The mass of females ranged from 9 to 93 kg and males from 7 to 70 kg (Table 1). The Chi-square test (a=0.05) result showed that the proportion between the number of females and males and was not significantly different from the expected 1:1 ratio. This means that the proportion of the number of females and males is said to be balanced.

The sex ratio of males and females of *M. mobular* is said to be balanced because *M. mobular* females are more numerous than males. Similar research was also conducted by Dian *et al*. (2016) in the Indian Ocean South of Java and obtained the ratio of male and female Plampangan rays (*M. japanica*, synonym of *M. mobular*) was 0,58:1, where the number of females was more than males. According to Saputra *et al*. (2009), the number of male and female fish must be balanced or the number female fish more so that it can be said that the population is still ideal for maintaining its sustainability. Differences influence the number of male and female fish caught in terms of behavior, food, genetics and fishing factors (Suhendra *et al*., 2017).

The disc width and body mass relationships of *M. mobular* were W = $0.00009DW^{2.52016}$, respectively (Figure 1). The t-test analysis against b values showed that *M. mobular* had a negative allometric growth pattern. It means that the disc width was faster than the body mass. This relationship is sustainable to the morphological character *M. Mobular,* which are big body and spreads to the side. Of 8 male individuals, the clasper maturity level of male *M. mobular* was generally found in the NC (Non-calcified), which was included in the juvenile category with a clasper length from 0,2 to 1,7 cm.

M. mobular males and females had a negative allometric growth pattern, which means that the growth in body width was faster than in weight. The same results also occur in the study by Utami *et al*. (2014), that *Dasyatis* sp showed a negative allometric growth pattern. The results of research by Dian *et al*. (2016) in the Indian Ocean South of Java on female *M. japanica* (synonym of *M. mobular*) also obtained the same results. The similarity of these results is because *M. mobular* was caught at the same location in the waters of Palabuhanratu Bay where these waters face the Indian Ocean directly. Meanwhile, different results were shown by Salim *et al.* (2017) that *M. japanica* (synonym of *M. mobular*) landed at Muncar Fishing Port produced an isometric pattern, namely the growth of body width along with weight growth. According to Effendie (2002), the difference in the value of b indicates that growth is relative and can change according to time, environment, food availability, and age. The value of the relationship between width and weight is not always fixed. The value will change and differ from one location to another. This is due to ecological and biological factors that affect the habitat of stingrays (Utami *et al*., 2014).

The size of *M. mobular* that landed in this study was primarily included in the group of immature rays. Dharmadi *et al*. (2011) found that the disc width of *M. japanica* (a synonym of *M. mobular*) for both males and females with the lowest frequency of body width was at 100-140 cm DW for the sub-adult group and 150-200 cm DW or the adult group between 200-600 cm DW. In Indonesian waters, the disc width of males ranges from 205-210 cm DW, with a maximum width of 310 cm (White *et al*., 2006).

Table 1. Total specimens of *M. mobular* landed in the Palabuhanratu Nusantara Fishing Port.

Species	Disc width (cm)	Body mass (kg)	Sex	Clasper
M. mobular	125	15	Male	NC 1,7 cm
M. mobular	218	77	Female	
M. mobular	215	70	Male	FC 5 cm
M. mobular	109	11	Male	NC 1,3 cm
M. mobular	175	38	Female	
M. mobular	222	93	Female	
M. mobular	163	13	Female	
M. mobular	126	16	Male	NC 1,5 cm
M. mobular	127	15	Female	
M. mobular	99	7	Male	NC 0,7 cm
M. mobular	112	9	Female	
M. mobular	98	12	Male	NC 1,5 cm
M. mobular	162	47	Female	
M. mobular	134	31	Female	
M. mobular	155	31	Female	
M. mobular	144	24	Female	
M. mobular	113	12	Female	
M. mobular	103	9	Female	
M. mobular	90	14	Female	
M. mobular	103	10	Male	NC 0,7 cm
M. mobular	110	13	Male	NC 0,2 cm

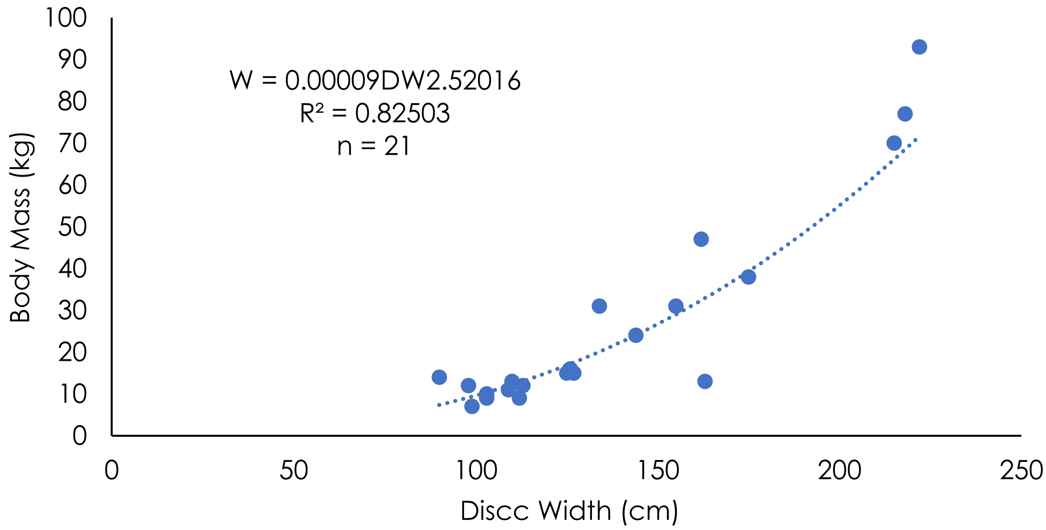

Figure 1. Disc width-body mass relationship for *M. mobular*

Seen from the maturity of the *M. mobular* clasper, generally more caught in immature conditions. This indicates that the fish have not reproduced so it, becomes an indicator of unsustainable fishing (Salim *et al.*, 2017). According to Fitriya (2017), if many relatively young male fish are found, the catch can disrupt the population balance and cause overfishing because the caught fish have not yet reached maturity or have not reached optimum growth. The results of the analysis of nine stomachs of *M. mobular* showed that the composition of the diet of this species is quite varied. Prey items identified in the stomach belonged to five major groups: decapods, copepods, gastropods, Polychaeta and other prey (Table 2).

Table 2 result that Decapoda was present in all stomach samples containing food and served 98.6% of the total number of prey and 99.5% of the total weight. Decapods were the most important ingested prey group, constituting 99,54% of the total IRI. Another group of prey is found in the stomach, which has a low percentage of IRI value, so it can be considered less important or complementary food. Identification up to the species level is difficult because the food is almost or has been digested. Other biota groups (fish bones, scales and fish eggs) can also only be recorded without any other calculations. Decapods were the most common group of the nine stingray stomachs. This shows that the food habits tend to be plankton feeders. According to Coasaca-Céspedes *et al*. (2018), the Mobula ray is a filter feeder that preys on small animals such as fish and zooplankton crustaceans. This study is in line with Metillo *et al*. (2018) that the order of %IRI from the highest includes *Lucifer crustaceans* (Decapods), copepods, flatworms, plant fragments and Mollusca larvae.

Nine of the 2 individuals contained food in their stomachs. The results of the *M. mobular* feeding intensity based on the fullness index obtained a value of 23.8% while the gastric vacuity index obtained a value of 76.2% (Table 3). The results obtained based on Vacuity Index (%VI) show that *M. mobular* is included in the relatively low fed category. The high number of empty stomachs is thought to be due to several factors, one of which is the availability of food in nature. In addition, Shibuya *et al*. (2009) stated that the high empty stomach could be caused by the fishing time that is not following the activities of fish that are looking for food.

According to Simeon *et al*. (2016), another factor usually occurs because fish experience stress from fishing gear. When a fish is caught, it vomits its stomach contents, which is called regurgitation. The trophic level value of *M. mobular* is 3, which is included in the omnivore category with animal preference because the food in the stomach of *M. mobular* is zooplankton as its main food. These

Table 2. Diet composition from nine non-empty stomachs *of M. mobular* (frequency of occurrence (%Oi), percentage numerical (%Ni), percentage gravimetric (%Wi) and index of relative importance (%IRI)).

Prey	%Oi	%Ni	%Wi	IRI	%IRI
Decapods	100.0	98.6	99.5	19810.0	99.54
Copepods	55.6	1.2	0.3	82.2	0.41
Gastropods	11.1	0.1	0.1	2.2	0.01
Polychaeta	33.3	0.1	0.1	6.7	0.03

Table 3. Percentage fullness index and vacuity index of *M. mobula*

Species	Empty	Full gut					Stomach total	*Fulness Index*	*Empty Index*
		Poor (I)	Medium (II)	Good (III)	Heavy (IV)	Total full			
M. mobular	16	2	2	1	0	5	21	23.8	76.2

results are the same as Sentosa & Hedianto (2018), where the *M. japanica* (synonym of *M. mobular*) has a trophic value of level 3.4, and a fish belonging to the omnivorous category tends to be carnivorous.

Based on the calculation of the trophic level, a value of 3 is obtained, indicating that the *M. mobula*r group is included in the omnivore category and tends to be carnivorous with animal preference. Which is included in the omnivore category with animal preference because the food in the stomach of M. mobular is zooplankton as its main food. These results are the same as Sentosa & Hedianto (2018), where the *M. japanica* (synonym of *M. mobular*) has a trophic value of level 3.4, and a fish belonging to the omnivorous category tends to be carnivorous.

CONCLUSION

During the research, 21 individuals of *M. mobular* were found caught in gillnets that landed in the Palabuhanratu Nusantara Fishing Port. The sex ratio between male and female individuals is in a balanced condition with more females. Most of the individuals are included in the category of immature rays. The relationship between the width and body weight of *M. mobular* is known and its growth pattern is negative allometric. Types of food found in the stomach belonged to five major groups: decapods, copepods, gastropods, Polychaeta and other prey. Decapods are the most important prey group with IRI percentage value of 99.54%, so their food habits were plankton feeders. *M. mobular* caught had a fullness index of 23.8% while a Vacuity index of 76.2% and was categorized as relatively low in eating or relatively low in eating. *M. mobular* is classified as an omnivorous animal that tends to be carnivorous with an animal preference with a trophic value of level 3.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the help of the gill nets fisherman group in collecting material for this study. In addition, we want to thank Mrs. Nurul Fitriya from the Oceanographic Research Center, National Research and Innovation Agency (RCO, BRIN), Jakarta, for her assistance in the laboratory.

REFERENCES

Berg, J. (1979). Discussion of methods of investigating the food of fishes, with reference to a preliminary study of the prey of Gobiusculus flavescens (Gobiidae). *Marine Biology*, 50(3), 263–273. doi: 10.1007/BF00394208

Blaber, S.J.M., Dichmont, C.M., White, W., Buckworth, R., Sadiyah, L., Iskandar, B., Nurhakim, S., Pillans, R., Andamari, R., Dharmadi, & Fahmi. (2009). Elasmobranchs in southern Indonesian fisheries: The fisheries, the status of the stocks and management options. *Reviews in Fish Biology and Fisheries*, 19(3), 367–391. doi: 10.1007/s11160-009-9110-9

Bucking, C. (2015). Feeding and Digestion in Elasmobranchs: Tying Diet and Physiology Together. In *Fish Physiology* (Vol. 34). Elsevier Inc. doi: 10.1016/B978-0-12-801286-4.00006-X

Coasaca-Céspedes, J.J., Segura-Cobeña, E., Montero-Taboada, R., Gonzalez-Pestana, A., Alfaro-Córdova, E., Alfaro-Shigueto, J., & Mangel, J.C. (2018). Preliminary analysis of the feeding habits of batoids from the genera Mobula and Myliobatis in northern Peru. *Revista de Biologia Marina y Oceanografia*, 53(3), 367–374. doi: 10.22370/rbmo.2018.53.3.1368

Croll, D.A., Dewar, H., Dulvy, N.K., Fernando, D., Francis, M.P., Galván-Magaña, F., Hall, M., Heinrichs, S., Marshall, A., Mccauley, D., Newton, K. M., Notarbartolo-Di-Sciara, G., O'Malley, M., O'Sullivan, J., Poortvliet, M., Roman, M., Stevens, G., Tershy, B.R., & White, W.T. (2016). Vulnerabilities and fisheries impacts: the uncertain future of manta and devil rays. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 26(3), 562–575. doi: 10.1002/aqc.2591

Dharmadi, & Fahmi. (2008). Biodiversitas Ikan Pari yang Tertangkap di Perairan Samudara Hindia. *Prosiding Seminar Nasional Ikan V*, *1996*, 187–195.

Dharmadi, D., Sunarno, M.T.D., & Edrus, I.N. (2011). Perikanan dan Aspek Biologi Ikan Pari Lampengan, Mobula japanica di Perairan Selatan Jawa. *Bawal*, 3(6), 369–376.

Dian, N., Tampubolon, Prawira, R., & Setyadji, B. (2016). Beberapa aspek biologi pari famili Mobulidae pada perikanan tuna di Samudera Hindia Selatan Jawa. *Prosiding Simposium Hiu Dan Pari Di Indonesia*, 140, 83–89.

Effendie, M. (2002). Biologi Perikanan. In *Yayasan Pustaka Nusantara*.

Fitriya, N. (2017). Aspek biologi dan status populasi ikan hiu di perairan kepulauan seribu. *Pusat Penelitian Oseanografi*, *2017*.

Hynes, H.B.N. (1950). The Food of Fresh-Water Sticklebacks (*Gasterosteus aculeatus* and *Pygosteus pungitius*), with a Review of Methods Used in Studies of the Food of Fishes. *The Journal of Animal Ecology*, 19(1), p.36. doi: 10.2307/1570

Hyslop, E.J. (1980). Stomach contents analysis—a review of methods and their application. *Journal of Fish Biology*, 17(4), 411–429. doi: 10.1111/j.1095-8649.1980.tb02775.x

Mahesh, V., Ambarish, P.G., & Rekha, J.N. (2018). Stomach Content Analysis Techniques in Fishes. *Recent Advances in Fishery Biology Techniques for Biodiversity Evaluation and Conservation*, *January*, 104–115.

Manko, P. (2016). Stomach content analysis in freshwater fish feeding ecology. University of Prešov, p.116.

Metillo, E., Tamada, S., Hayashizaki, K., & Nishida, S. (2018). Feeding Habits of Mobula japanica (Chondrichthyes, Mobulidae) in Butuan Bay, Mindanao Island, Philippines. *Science Diliman*, 30(1), 24–44.

Morey, G., Moranta, J., Massuti, E., Grau, A., Linde, M., Riera, F., & Morales-Nin, B. (2003). Hubungan berat-panjang dari littoral ke ikan lereng yang lebih rendah dari Mediterania Barat. *Sumber Daya Nelayan, 62,* 89–96.

Rambahiniarison, J.M., Lamoste, M.J., Rohner, C.A., Murray, R., Snow, S., Labaja, J., Araujo, G., & Ponzo, A. (2018). Life history, growth, and reproductive biology of four mobulid species in the bohol sea, Philippines. *Frontiers in Marine Science*, 5, p.269 doi: 10.3389/fmars.2018.00269

Salim, M.G., Kamal, M.M., & Fachrudin, A. (2017). Analisis Hasil Tangkapan, Biologi, dan Nilai Pemanfaatan Ikan Pari Famili Mobulidae Di PPP Muncar, Jawa Timur. *http://repository.ipb.ac.id/handle/123456789/84350*

Šantić, M., Rada, B., & Pallaoro, A. (2013). Feeding habits of brown ray (Raja miraletus Linnaeus, 1758) from the eastern central Adriatic Sea. *Marine Biology Research*, 9(3), 301–308. doi: 10.1080/17451000.2012.739698

Saputra, S.W., Soedarsono, P., & Sulistyawati, G.A. (2009). Beberapa aspek biologi ikan Kuniran (Upeneus spp) di perairan Demak. *Jurnal Saintek Perikanan*, 5(1), 1–6.

Sentosa, A.A., & Hedianto, D.A. (2018). Tingkat Trofik Hiu Dan Pari Yang Tertangkap Di Perairan Sekitar Nusa Tenggara. *Prosiding Seminar Nasional Ikan ke-10*, pp. 285–294.

Shibuya, A., Araújo, M.L.G., & Zuanon, J.A.S. (2009). Analysis of stomach contents of freshwater stingrays (Elasmobranchii, Potamotrygonidae) from the middle Negro River, Amazonas, Brazil. *Pan-American Journal of Aquatic Sciences*, 4(4), 466–475.

Simeon, B.M., Baskoro, M.S., Taurusman, A.A., & Gautama, D.A. (2016). Kebiasaan Makan Hiu Kejen (Carcharinus Falciformis): Studi Kasus Pendaratan Hiu Di Ppp Muncar Jawa Timur. *Marine Fisheries : Journal of Marine Fisheries Technology and Management*, 6(2), 203. doi: 10.29244/ jmf.6.2.203-209

Stergiou, K.I., & Karpouzi, V.S. (2002). Feeding habits and trophic levels of Mediterranean fish. *Reviews in Fish Biology and Fisheries*, 11, 217–254.

Suhendra, C., Utami, E., & Umroh. (2017). Biologi Reproduksi Ikan Keperas (Cyclocheilichthys Apogon) Di Perairan Sungai Menduk Kabupaten Bangka. *Akuatik Jurnal Sumberdaya Perairan*, 11(1), 1–11.

Suseelan, C., & Nair, K.S. (1969). Food and Feeding Habits of the Demersal Fishes off Bombay. *Indian Journal of Fisheries* 16, 56–74.

Taunay, P. N., Wibowo, E., & Redjeki, S. (2013). Studi Komposisi Isi Lambung Dan Kondisi Morfometri Untuk Mengetahui Kebiasaan Makan Ikan Manyung (*Arius thalassinus*) Yang Diperoleh Di Wilayah Semarang. *Jurnal of Marine Research*, 2(1), 87–95.

Torres-Rojas, Y.E., Hernández-Herrera, A., Galván-Magaña, F., & Alatorre-Ramírez, V.G. (2010). Stomach content analysis of juvenile, scalloped hammerhead shark Sphyrna lewini captured off the coast of Mazatlán, Mexico. *Aquatic Ecology*, *44*(1), 301–308. doi: 10.1007/s10452-009-9245-8

Utami, M.N.S., Redjeki, S., & Taufiq-SPJ, N. (2014). Studi Biologi Ikan Pari (Dasyatis sp) di TPI Tasik Agung Rembang. *Diponegoro Journal of Marine Research*, 3(2), 79–85. doi: 10.14710/jmr.v3i2.4967

Weeks, S.J., Magno-Canto, M.M., Jaine, F.R.A., Brodie, J., & Richardson, A.J. (2015). Unique sequence of events triggers manta ray feeding frenzy in the Southern Great Barrier Reef, Australia. *Remote Sensing*, *7*(3), 3138–3152. doi: 10.3390/rs70303138

White, W.T., Corrigan, S., Yang, L., Henderson, A.C., Bazinet, A.L., Swofford, D.L., & Naylor, G.J.P. (2018). Phylogeny of the manta and devilrays (Chondrichthyes: Mobulidae), with an updated taxonomic arrangement for the family. *Zoological Journal of the Linnean Society*, 182(1), 50–75. doi: 10.1093/zoolinnean/zlx018

White, W.T., Last, P.R., Stevens, J., Yearsley, G.K., Fahmi, & Dharmadi. (2006). *Economically important sharks and rays of Indonesia*. (No. 435-2016-33677).

Wijayanti, F., Abrari, M. P., & Fitriana, N. (2018). Keanekaragaman Spesies dan Status Konservasi Ikan Pari di Tempat Pelelangan Ikan Muara Angke Jakarta Utara. *Jurnal Biodjati*, 3(1), p.23. doi: 10.15575/biodjati.v3i1.1613