Acta Aquatica Turcica

E-ISSN: 2651-5474 17(4), 463-473 (2021) DOI: https://doi.org/10.22392/actaquatr.812389

Fisheries and Biological Aspects of Dusky Shark *Carcharhinus obscurus* (Lesueur, 1818) in Muncar Fishing Port, Banyuwangi, Indonesia

Ahmad IRSAN[1], Fahma WIJAYANTI[1*], Yayan Mardiansyah ASSUYUTI[1,2], Ranny Ramadhani YUNENI[3]

[1] Department of Biology, Faculty of Science and Technology, Universitas Islam Negeri Syarif Hidayatullah, Jl. Ir H. Juanda No. 95, Tangerang Selatan, Banten, Indonesia 15412
[2] Laboratory of Ecology, Center for Integrated Laboratory, Universitas Islam Negeri Syarif Hidayatullah, Jl. Ir H. Juanda No. 95, Tangerang Selatan, Banten, Indonesia 15412
[3] WWF Indonesia, Graha Simatupang Tower 2 Unit C Lt 7th-11th, Jl. TB Simatupang, Jakarta 12540

*Corresponding Author: fahma.wijayanti@uinjkt.ac.id

Research Article

Received 07 August 2020; Accepted 17 June 2021; Release date 01 December 2021.

How to Cite: Irsan, A., Wijayanti, F., Assyuti, Y. M., & Yuneni, R. R. (2021). Fisheries and biological aspects of Dusky Shark *Carcharhinus obscurus* (Lesueur, 1818) in Muncar Fishing Port, Banyuwangi, Indonesia. *Acta Aquatica Turcica, 17*(4), 463-473. https://doi.org/10.22392/actaquatr.812389

Abstract

The high of catching intensity or overfishing of dusky whaler shark, *Carcharhinus obscurus* (Lesueur, 1818), has threatened its sustainability. Even though fisheries and biological aspects of *C. obscurus* are important as a basic assessment for making regulation of shark fisheries management. However, those studies never been reported in Indonesia. The aim of this study is to identify the number of catches and biological aspects of *C. obscurus*. This study was conducted from January to March 2018 at Fishery Port Technical Implementation Unit (FP-TIU) Muncar, Banyuwangi, Indonesia. 54 *C. obscurus* individuals were obtained using random sampling survey method. Here, we found that the number of *C. obscurus* landed in 2018 was higher compared to 2014 and 2017. The shark length ranged from 172 to 394 cm. Percentages of male and female adults of *C. obscurus* were 22.22 and 46.30%, respectively. Whilst in the juveniles were 20.37% males and 11.11% females. The maturity rate based on clasper length, male landed sharks was 82.61% classified within full calcification and 17.39% non-full calcification level. The sex ratio of *C. obscurus* sharks that are landed was 1:1.34 (M: F).

Keywords: *Carcharhinus obscurus*, Carcharhinidae, maturity, sex ratio, Muncar

Muncar Balıkçı Limanı, Banyuwangi, Endonezya'daki Gölgeli Köpek Balığının Carcharhinus obscurus'un (Lesueur, 1818) Biyolojik Özellikleri ve Balıkçılık Açısından Değerlendirilmesi

Özet

Gölgeli köpekbalığı *Carcharhinus obscurus*'un (Lesueur, 1818) yüksek yakalama yoğunluğu veya aşırı avlanması, sürdürülebilirliğini tehdit etmektedir. *C. obscurus*'un balıkçılık ve biyolojik yönlerinin bilinmesi, köpek balığı balıkçılığı yönetiminin düzenlenmesinde temel teşkil etmektedir. Ancak, bu çalışmalar şimdiye kadar Endonezya'da hiç rapor edilmemiştir. Bu çalışmanın amacı, *C. obscurus*'un avlanma sayısını ve biyolojik yönlerini belirlemektir. Bu çalışma Ocak-Mart 2018 tarihleri arasında Endonezya, Banyuwangi, Muncar'da Balıkçılık Limanı Teknik Uygulama Birimi (FP-TIU) gerçekleştirilmiştir. Rastgele örnekleme yöntemi kullanılarak toplam 54 *C. obscurus* bireyi elde edilmiştir. 2018 yılında *C. obscurus* sayısının 2014 ve 2017 yıllarına göre daha fazla olduğu tespit edilmiştir. Yakalanan köpekbalıklarının boyu 172 ile 394 cm arasında değişmektedir. *C. obscurus*'un erkek ve dişi erişkinlerinin yüzdeleri sırasıyla %22,22 ve %46,30 olarak belirlenmiştir. Gençlerde ise %20,37 erkek ve %11,11 dişi idi. Klape uzunluğuna göre olgunluk oranı, karaya çıkan erkek köpekbalıkları %82,61 tam kalsifikasyon ve %17,39 tam olmayan kalsifikasyon düzeyinde sınıflandırılmıştır. Karaya çıkan *C. obscurus* köpekbalıklarının cinsiyet oranı 1:1.34 (E:D) olarak belirlenmiştir.

Keywords: Carcharhinus obscurus, Carcharhinidae, olgunluk, cinsiyet oranı, Muncar

INTRODUCTION

Carcharhinus obscurus (Lesueur, 1818) is widely distributed in the world, has a wide range with a certain migration pattern (Musick et al., 2009) ranging from nearshore to a depth of 500 m (Carpenter and Niem, 1998; White et al., 2006; Rigby et al., 2019) but not evenly distributed throughout warm tropical and subtropical waters (White et al., 2006). Distribution in Indonesia, *C. osbcurus* is spread from southeastern Sumatra to Sulawesi and Papua (Froese and Pauly, 2017). The morphology character of *C. osbcurus* has a body length of up to 600 cm (White et al., 2006) and the maturity level of the gonads at the age of 17-23 years (Last and Steven, 1994).

The high demand for sharks in national and international markets results in an increase its catching activity which leads to overfishing and will threat the existence of shark populations as well as disturb the trophic level of the marine ecosystem. Overfishing of sharks from southern Java (Indian Ocean) has increased over the past 5 years (Prihatiningsih et al., 2018). Due to the long-life cycle and low fecundity (Compagno, 1984; Last and Steven, 1994; Camhi et al., 1998), sharks and other chondrichthyans are vulnerable to overfishing (Galucci et al., 2006).

Nearly 26 species of shark species representing the families from the Squalidae, Rhynchiddae, Carcharhinidae, Lamnidae, Alopiidae, and Sphyrnidae, families have large size and high market value (Fahmi and Dharmadi, 2013). Sharks from the Carcharhinidae family are the most traded in Indonesia. There are 27 species of shark from family Carcharhinidae which have an important economic value in Indonesia (White et al., 2006), and *Carcharhinus obscurus* is one of them. Local people have been catching sharks from generation to generation (Simeon et al., 2016) and selling at fishing ports. *C. obscurus* has been landed in several fishing ports in Indonesia, from Fishery Port Technical Implementation Unit (FP-TIU) Muncar (Harlyan et al., 2016) to West Nusa Tenggara (Nurcahyoet al., 2016; Sentosa et al., 2016; Dewi et al., 2018; Yulianto et al., 2018) and Central Sulawesi (Zamrudet al., 2016). The FP-TIU Muncar is one of the sales and landing shark centers in Indonesia.

Due to its population declines (Rigby et al., 2019), *C. obscurus* is categorized as an endangered species, but not included in the CITES list related to trade management. The lack of information on the biological aspects of *C. obscurus* is the reason why Indonesia does not have regulations to protect dusk whaler sharks. Rigby et al. (2019) suggested that to support the creation of shark and ray management policies and sustainable fisheries, sufficient information is needed covering biological, management, social, and economic aspects. Furthermore, the aims of the study to analyze the number of catches, length frequency distribution, clasper length, and sex ratio of *C. obscurus* landed at FP-TIU Muncar, Banyuwangi.

MATERIALS and METHODS

Study site

The Fishery Port Technical Implementation Unit (FP-TIU) Muncar is located in Kedungrejo Village, Muncar District, Banyuwangi Regency, East Java Province (Figure 1). Initially, the FP-TIU Muncar was a Special Work Area for Muncar Fisheries based on the Decree of the Head of the East Java Regional Fisheries Service Number 15 of 1984. Later, the name is changed to FP-TIU Muncar based on the East Java Governor Regulation No. 31 of 2014. The management of fish landing and marketing of FP-TIU Muncar is assisted by four fish auction places (FAP) including Port, Kalimoro, Sampangan, and the new Port of FAP.

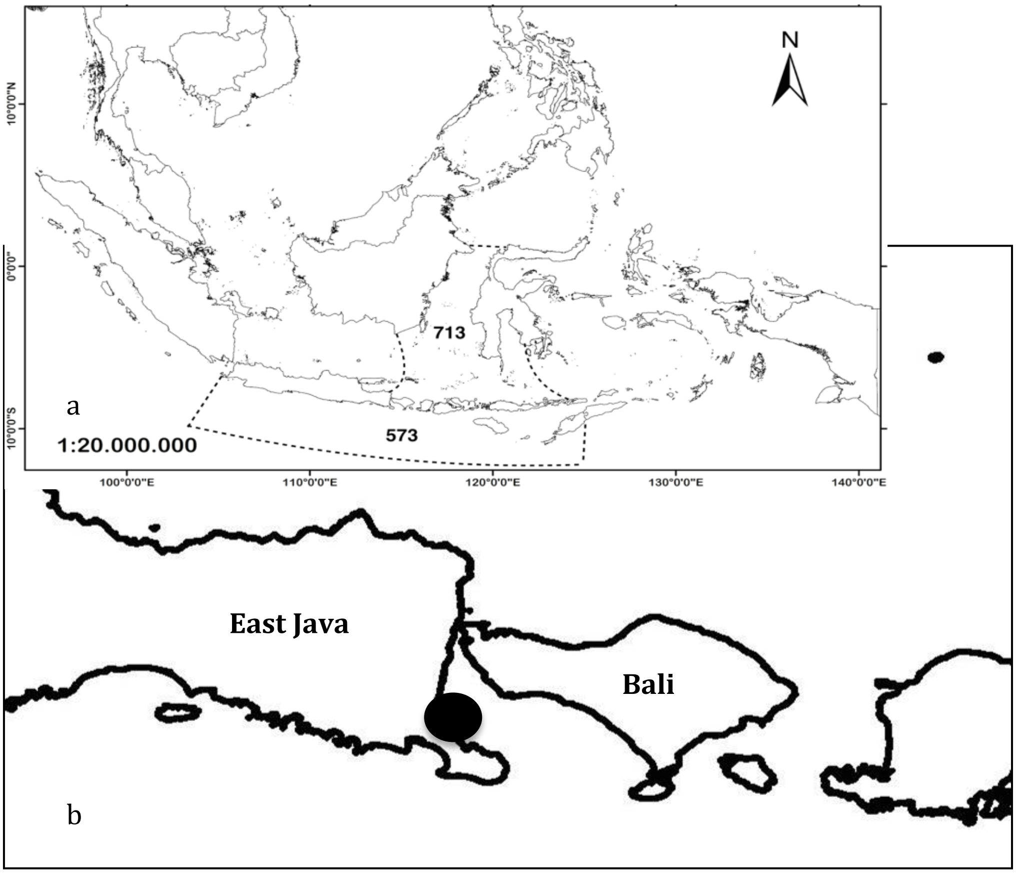

Figure 1. a) Map of Prohibition of Fishing in Fisheries Management Area of Republic of Indonesia (FMA-RI) with dash line. b) Map of FP-TIU Muncar, Banyuwangi (black circle).

Fishery production at FP-TIU comes from various fisheries commodities including sharks, which are landed at FP-TIU Muncar mostly originating from fishing sites along with the Bali to Makassar Strait. Most of the sharks landed (78%) are the main catches of Muncar fishermen. 12 species of 4 shark families were landed at FP-TIU Muncar from 2014 to 2015 i.e the family of Alopiidae (*Alopias pelagicus*), Lamnidae (*Isurus paucus* and *I. oxyrinchus*) and Sphyrnidae (*Sphyrna lewini*, *S. zygaena* and *S. mokarran*). Commonly landed carcharhinid sharks were *Carcharhinus limbatus*, *C. leucas*, *C. obscurus*, *C. falciformis*, *C. longimanus*, *Galeocerdo cuvier*, and *Prionace glauca* (Harlyan et al., 2016).

Data sampling

The study was conducted in January to March 2018. The research location was at the Fishery Port Technical Implementation Unit (FP-TIU) Muncar, Banyuwangi, East Java, Indonesia. Experimental data were collected from fish landing by fisheries man, using a survey method with random sampling techniques. Data on biological aspects including, total length, clasper length, level of maturity of the classification, and sex ratio were recorded. The maturity level of male sharks is categorized based on clasper condition and of the female is based on the presence of embryos (White et al., 2006). Observation of the clasper condition is divided into non-calcification, non-full calcification, and full calcification (Dharmadi et al., 2012). The amount of shark catch was adopted from Harlyan et al. (2016) and Caesar et al. (2019). Supporting information of fisheries including the number of fish catch, fishing locations, and fishing gear were collected by interviews with fishermen.

Data analysis

The total length was tabulated in a long frequency at 32 cm intervals and the comparison between male and female sharks was analyzed descriptively. The correlation between clasper length and total length is used linear regression analysis and the sex ratio was tested using Chi-Square. Furthermore, comparison of sex ratio using the following formula (Effendie, 2002):

$$Sex\ ratio = \frac{Nbi}{Nji} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where:
Nbi = Female fish number of the size group of i
Nji = Male fish number of the size group of i

RESULTS

Fisheries and sex ratio

From the research was conducted at FP-TIU Muncar from January to March 2018, we found that the amount of *C. obscurus* landed with 54 individuals (Figure 2). The catches of *C. obscurus* males landed were 23 individuals with a percentage of 43% and female were 31 individuals with a percentage of 57%. The result of sex ratio analysis shows that the ratio of male and female sharks is 1:1.34. Chi-square analysis showed the results of X^2 = 1.185: X^2 table (0.05) = 3.841. Besides, the number of *C. obscurus* landed in 2018 was higher compared to 2014 and 2017 (Figure 2).

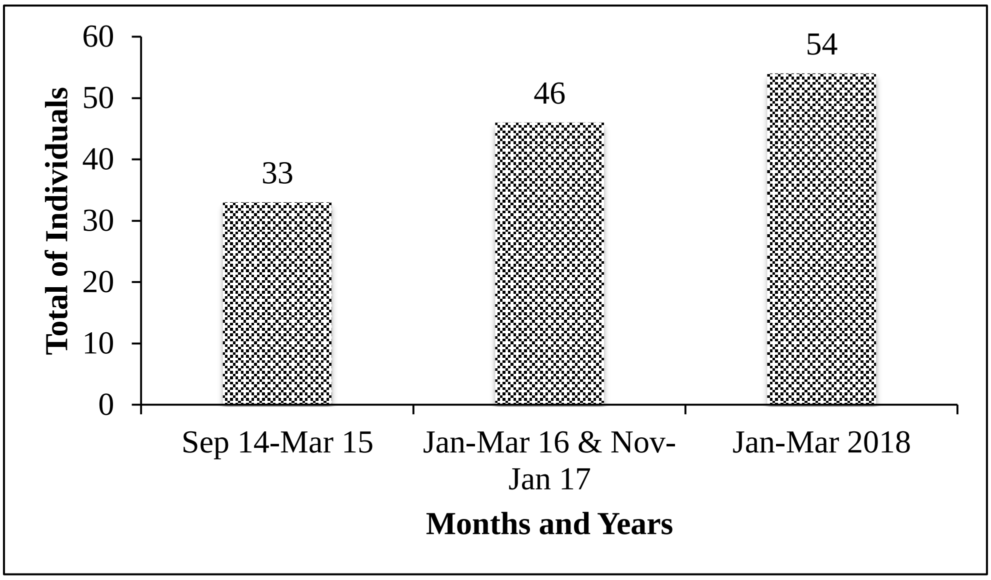

Figure 2. The total catch of *C. obscurus* in 2015 (Harlyan et al., 2016), 2016 (Caesar et al., 2019; Zulfiaty et al., 2019) and 2018 (this study) at FP-TIU Muncar.

Frequency of Total Length, Weight, and Maturity

The measurements on 54 individuals showed the *C. obscurus* are spread in a total length interval of 32 cm divided into seven classes where male and female sharks occur at size ranges of 268-299 cm. Male sharks have a smaller total length than females the size ranges from 172-331cm and 172-394 cm, respectively (Figure 3). Apart from the total length, the size of the shark landed is also seen through the weight of the shark. Figure 4 shows the shark's body weight for 3 months. The results obtained from weighing the shark body weight showed that the *C. obscurus* shark landed weighed 68-193 Kg with a total weight of 8.604,43 Kg. *C. obscurus* landed at FP-TIU Muncar based on total length spread at juvenile and adult. Adult sharks were 12 individuals (22.22%) and juveniles were 11 individuals (20.37%), while adult females were 25 individuals (46.30%) and juveniles were 6 individuals 11.11% (Figure 5).

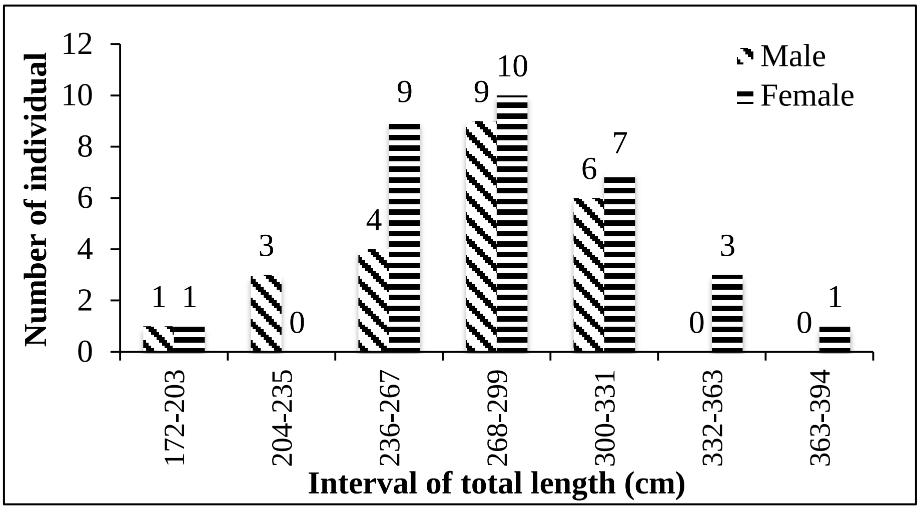

Figure 3. The frequency of total length

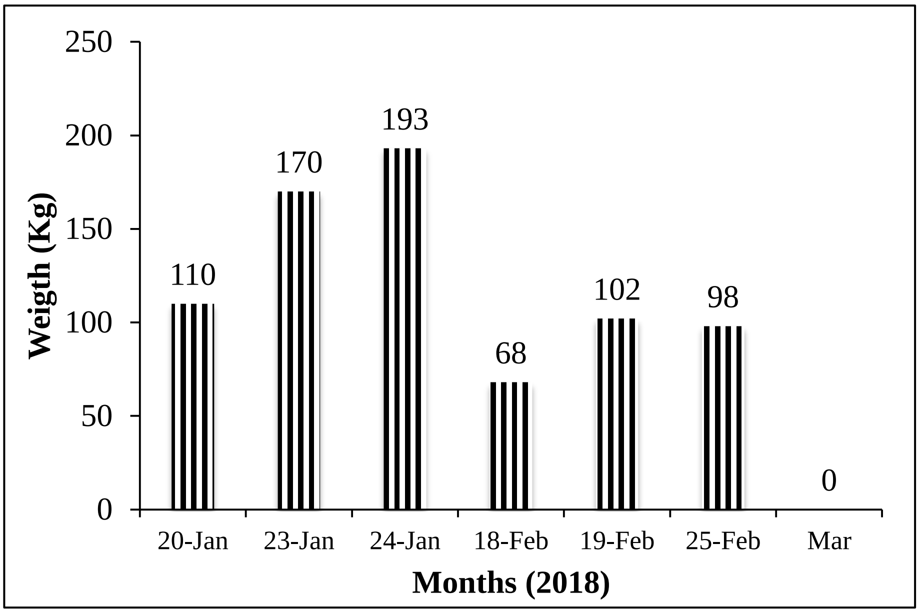

Figure 4. Bodyweight of *C. obscurus* per individual

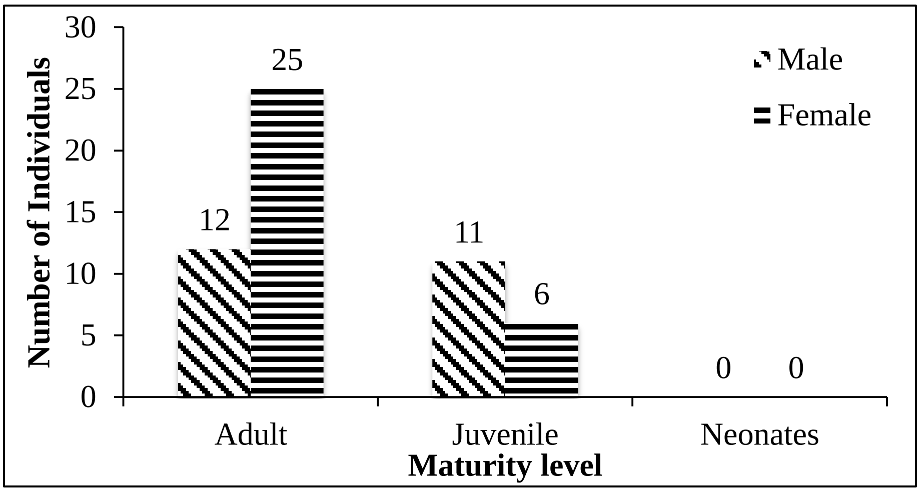

Figure 5. Maturity level is based on total length

Correlation of clasper with a total length

The length of the clasper at the level of full calcification (FC) is 17-46 cm, at the level of non-full calcification (NFC) has a class length of 19-23 cm and non-calcification (NC) has a length of 0 cm. Based on the measured class length, 19 male individuals were included in the FC category (82.61%), 4 NFC individuals (17.39%) and there were no individuals in the NC category (Figure 6).

The results of the analysis of the total length relationship with the length of clasper in this study have the equation y = 0.2047x-25.87 which means that with each 1% increase in the total length, the length of the class will increase by 0.2047. The regression analysis has a correlation value R^2 = 0.595 (Figure 7). The longest class size is 46 cm from 310 cm and 324 cm individuals, while the shortest class length is 17 cm from 197 cm individuals.

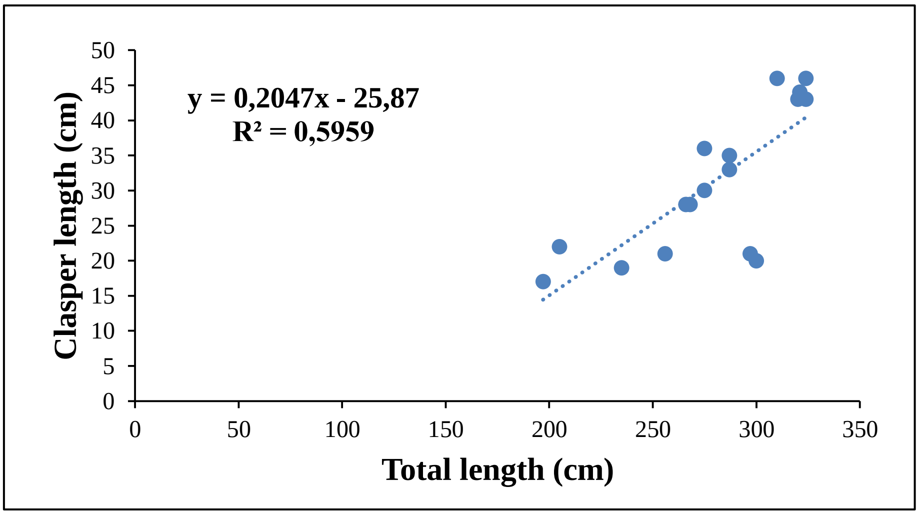

Figure 6. Maturity level based on clasper

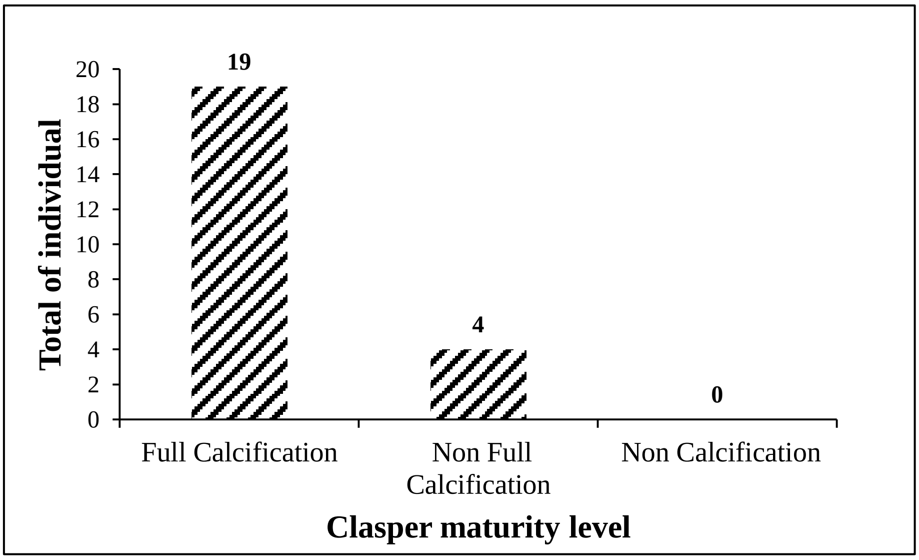

Figure 7. Correlation of clasper with a total length

DISCUSSION

Indonesia is a country in the Asia region where global production is caught by sharks, rays, and chimaeras (FAO, 2020) and number 4 in the world which exports fins (Nicholas et al., 2017). This is demonstrated by the number of shark captures that have been increasing from 2015 (Harlyan et al., 2016) to 2018 with an increase by 21 individuals in Muncar (Figure 2). The increase in fishing is due to the use of fishing gear, season, and amount of demand. Sharks were caught by Muncar fishermen using bottom and surface longlines fishing gear. Season, fishing gear, month, fishing ground, engine power, and hook number affect the number of shark captures (Smale, 1991; Fahmi and Sumadhiharga, 2007; Manojkumar et al., 2012; Taylor and Bennett, 2013; Sentosa et al., 2016; Pratiwi et al., 2018; Yulianto et al., 2018; Priyanti et al., 2019). Longline gears used by Muncar fishermen consist of main ropes, branch ropes, buoys, and hooks. The number of hooks baited mostly with tuna and other bony fishes is 500 pieces per unit of long lines.

Captured sharks are mostly processed for food products, where fin, meat, liver, skin, and bone organs are used for consumption. The productivity of shark captures is predicted to increase per the demand for shark fins or other organs. High demand for shark fin in the market from China has led to increased shark fishing (Dent and Clarke, 2015), increase hunting, and threatens the preservation of its stock in the wild (Daley et al., 2002). Therefore, the certification approach and business compliance analysis are a part of the solution to control the sustainable management of shark fisheries resources (Zamrud et al., 2019).

Longline fishing gear is used in several regions in Indonesia (Sentosa et al., 2016; Pratiwi et al., 2018; Yulianto et al., 2018) where that target sharks as the main catch (Sentosa et al., 2016). Fishermen from the TanjungLuar Fishing Port, East Lombok, West Nusa Tenggara are a group of fishermen who use longlines to catch sharks (Fahmi and Sumadhiharga, 2007; Sentosa et al., 2016). The fishermen's catches have similarities with those obtained by Muncar fishermen because the fishing gear and the location of the same fishing operations are around the waters of Bali and Lombok (Nurcahyo et al., 2016; Sentosa et al., 2016).

The location of the fishermen's catch is in the area of the Prohibition of Fishing in Fisheries Management Area of Republic of Indonesia (FMA-RI) 573 and 713 (Sentosa, 2016; Figure 1a). Area 713 is an area from the Makassar to Bali Strait. Both straits are influenced by oceanographic conditions from the Indonesian Through Flow (ITF) and have high potential fishery resources (Suniada and Susilo, 2017; Efendi et al., 2019; Puspasari et al., 2019; Syah et al., 2019). Furthermore, sea surface temperature and chlorophyll-a in the Bali Strait affect the production of sardine fish (Puspasari et al., 2019), where the fish (Osteichthyes and Chondrichthyes), Mollusca, crustaceans, and algae are a food source of the shark genera Carcharhinus (Smale, 1991; Saïdi et al., 2007).

As it is seen in the total captures of sharks, the percentage of females is higher than males. This indicates that more female sharks are found due to influences by environmental conditions, body size, behavior, foraging, and spawning. Hoffmayer et al. (2014) suggested that temperature, depth, maturity, and cruising influence the presence of female sharks. Furthermore, more female sharks are caught due to the process of foraging to support the maturity of the gonads. More female sharks is believed to have a better implication to the preservation of the specific resources and producing offspring (Bhagawati et al., 2017).

The sex ratio of *C. obscurus* landed at FP-TIU Muncar is similar to the previous study (Harlyan et al., 2016). The condition shows that the continuity of reproduction in nature can still occur where fishing activities are balanced category. A balanced sex ratio is assumed in a state in nature that can still do reproduction and allow fertilization of the egg by spermatozoa (Effendie, 2002). Furthermore, a balanced sex ratio indicates the absence of intraspecific competition and stable shark migration. Taylor and Bennett (2013) suggested that intraspecific competition and individual migration are thought to affect sex ratio. The sex ratio has similarities where females are compared to males (Harlyan et al., 2016). Different results were shown from previous studies of *C. obscurus* where the sex ratio of females was higher than male (Caesar et al., 2019; Zulfiaty et al., 2019) and an inverse male was higher than female (Taylor and Bennett, 2013; Nurcahyo et al., 2016). An unbalanced sex ratio indicates that the survival of *C. obscurus* reproduction in nature is disturbed where reproduction is low if the male population is more than females (Candramila and Januardi, 2007).

The results of measurements on 54 individuals showed *C. obscurus* landed where male sharks have a smaller total length than females. Our study found the maximum total length that was caught reached 394 cm. The largest catches of *C. obscurus* compared to FP-TIU Muncar were 420 cm (Compagno et al., 1989) and 210 tons at Nanfanao Fish Market in Northeast Taiwan (Joung et al., 2015). The weight of sharks in Muncar is heavier than in previous studies where it weighed 180 kg (Castro, 1983) and lighter than in KwaZulu-Natal weighing 450 kg (Dudley et al., 2005). The size of *C. obscurus* sharks that were caught the most in this study is large than previous studies at Muncar with a size range of 160 to 385 cm (Harlyan et al., 2016), 383 cm at KwaZulu-Natal (Dudley et al., 2005), and 224 cm at South Africa (Smale, 1991). Castro (1993) suggested in North American waters, concluded that *C. obscurus* sharks can reach a maximum size of up to 360 cm. Furthermore, the fishing gear and the location of the caught are thought to affect the size of the *C. obscurus*. The fishing gear used is longline sharks where commonly used to caught large sharks were families of Carcharhinidae, Lamnidae, Alopiidae, and Sphyrnidae (MFM, 2015) with sizes of 3-4 meters (White et al., 2006). The longline shark fishing gear is perfect for obtaining *C. obscurus*, due to their characteristic that is included in semi-pelagic and large sharks.

Total frequency length data can be used to categorize shark maturity, where most of those caught are in the adult category. The adult male category of *C. obscurus* was size range of 257-300 cm with age 23 yr and newborn sized range of 69-100 cm (Natanson et al., 1995; White et al., 2006). Joung et al. (2015) suggested the age at maturity level for females 16.6 yr and 15.5 yr for males. Furthermore, *C. obscurus* can reach 37 yr of age based on age analysis of the spine and up to be 40 or 50 yr old (Natanson et al., 1995). Juvenile and adult categories of sharks caught are influenced by seasons, location, and fishing gear (Fahmi and Sumadhiharga, 2007; Taylor and Bennett, 2013; Hoffmayeret al., 2014).

Clasper can be used to determine the level of sexual maturity in male sharks. The maturity level based on the condition is divided into full conditions containing calcium substances and ready to fertilize an egg or Full Calcification (FC), some contain calcium, but are not ready to fertilize an egg or Non Full Calcification (NFC) and does not contain calcium, it is not ready to fertilize an egg or Non-Calcification (NC) (Dharmadi et al., 2012). Calcium is a substance that influences the hardening of the classification and is needed in the development of sexual maturity (Chodrijah and Faizah, 2016a). Mature male sharks are caught more than immature sharks based on clasper length in FP-TIU Muncar. Different results from previous studies in Muncar where immature category sharks were caught (Harlyan et al., 2016).

Adult or mature sexually (FC) caught is assumed to have experienced a reproductive cycle. The young individuals (NFC) caught will cause growth overfishing, i.e. the number of young fish caught in a catch rate that has not reached the optimum growth rate and allows the reduction of adult fish populations (Efendi et al., 2019). Landed male individuals who are still in the NFC category are assumed not to have the opportunity to reproduce and become a threat to sharks which are the top predators to maintain their population. Maintaining a balance in the ecosystem is very important because all the organisms live in symbiosis (Ferretti et al., 2010).

The correlation of total length with clasper length is generally used to determine the size of the Elasmobranchii subclasses when reaching maturity (Carrier et al., 2004). The analysis shows that the correlation between the two parameters (x: total length, y: class length) is less than 1, but has a positive correlation. It is mean that the growth of clasper length will follow the body length. Chodrijah and Fauziah (2016ab) suggested that the total length with clasper length are positively correlated. The clasper is increasingly filled with calcium, the correlation between the length of the class and the total length of body is getting smaller (Dharmadi et al., 2007). Therefore, the condition of class that is filled with calcium has a length that is not closely related to the total body length.

CONCLUSION

The number of *C. obscurus* in FP-TIU Muncar has increased in recent years with the adult and juvenile categories being the target of catch. Our results indicate that there has been overfishing by Muncar fishermen. Management activities of fisheries in FP-TIU Muncar need to be carried out considering the conservation status of sharks of *C. obscurus* categorized as endangered species. Biological research data of *C. obscurus* in waters throughout Indonesia is needed, it can be proposed to become regulation from the government to the community. Furthermore, government regulations on conservation status and socialization of regulations to the community are solutions to protect *C. obscurus* from endangered.

ACKNOWLEDGEMENT

The authors would like to acknowledge local people and fishermen of Muncar to help data collected and WWF Indonesia (Marine Program) for research funding.

REFERENCES

Bhagawati, D., Nurani, T., & Abulias, M.N. (2017). Species, performance and sex ratio of shark landed in

Pelabuhan Perikanan Samudra Cilacap. *Jurnal Iktiologi Indonesia*, 17, 185-200.

Caesar, H., Ulfah, M., Miswar, E., Yuneni, R.R. (2019). Biological aspects and the status of shark conservation at the Muncar fishing port, Banyuwangi Regency. 2nd Proceedings Symposium of Sharks and Indonesian Rays 2018, Fisheries Research Center.Maritime and Fisheries Human Resources and Research Agency, Marine and Fisheries Ministry, Jakarta, 307-313 p. [Indonesian]

Camhi, M., Fowler, S.L., Musick, J.A., Bräutigam, A., Fordham, S.V. (1998). Sharks and Their Relatives – Ecology and Conservation. IUCN/SSC Shark Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK. iv + 39 pp.

Candramila, Junardi. (2007). Composition, diversity and sex ratio of Elasmobranchii fish from the Kakap River in West Kalimantan. *Jurnal Biospecies*, 1, 41-46. [Indonesian]

Carrier, J.C., Musick, J.A., Herthaus, M.R. (2004). *Biology of sharks and their relatives*. CRC Press, Washington D. C.

Carpenter, K.E. & Niem, V.H. (1998). *FAO Species identification guide for fishery purposes the living marine resources of the Western Central Pacific volume 2. Chepalopods, Crustaceans, Holothurians and Sharks.* Roma: Food and Agriculture Organization of the United Nations.

Castro, J.I. (1983). *The sharks of North American Waters*.Texas A & M University Press, USA.

Chodrijah, U., & Faizah, R. (2016a). Size structure and sex ratio of Kejen shark (*Carcharhinus falciformis*) in the South Waters of West Nusa Tenggara.1st Proceedings of Indonesian Sharks and Rays 2015, Marine and Fisheries Ministry & WWF Indonesia, Bogor, 43-49 p. [Indonesian]

Chodrijah, U., & Faizah, R. (2016b). Size distribution and sex ratio of tiger sharks (*Galeocerdo cuvier*) in the Indian Ocean waters of the Southern part of West Nusa Tenggara.1st Proceedings of Indonesian Sharks and Rays 2015, Marine and Fisheries Ministry& WWF Indonesia, Bogor, 121-126 p. [Indonesian]

Compagno, L.J.V. (1984). *FAO species catalogue. Vol.4. Sharks of the world: an annotated andillustrated catalogue of shark species known todate Part 2 Carcharhiniformes*. Food and Agriculture Organization of the United Nations, Roma.

Compagno, L.J.V., Ebert, D.A., & Smale, M.J. (1989) Guide to the sharks and rays of southern Africa. New Holland (Publ.) Ltd., London. 158 p.

Daley, R.K., Stevens, J.D., Last, P.R., & Yearsley, G.K. (2002). *Field Guide to Australian Sharks and Rays*. CSIRO Marine Research and Development Corporation, Australia.

Dewi, S.P.S., Lasniroha, R., Pumpun, Y.K., Abidin, Z., & Wardono, S. (2018). Catch composition and fishing ground of shark Appendix II cites landed in Namosain, East Nusa Tenggara. *Jurnal Penelitian Perikanan Indonesia*, 24, 149-156. [Indonesian]

Dent, F., & Clarke, S. (2015). *State of the global market for shark products*. FAO Fisheries and Aquaculture Technical Paper 590. Rome.

Dharmadi, Fahmi, & Wiadnyana, N.N. (2012). Identification of vulnerable species and biological of sharks from the Indian Ocean (SEASTAR 2000). Proceedings of the 7th International Symposium on SEASTAR 2000 and Asian Bio-logging Science (The 7th SEASTAR2000 workshop), 43-47 p.

Dharmadi, Fahmi, & Adrim, M. (2007). Long frequency distribution, body length relationship, class length, and genital ratio of shark Lanjaman (*Carcharhinus falciformis*). *Jurnal Litbang Perikanan Indonesia*,13, 243-254. [Indonesian]

Dudley, S.J.F., Cliff, G., Zungu, M.P., & Smale, M.J. (2005). Sharks caught in the protective gillnets of KwaZulu-Natal, South Africa. *African Journal of Marine Science*, 27, 07-127.

Effendie, I.M. (2002). *Fisheries Biology*. Yayasan Pustaka Nusantara, Yogyakarta. [Indonesian]

Efendi, H.P., Dhewi, R.T., & Ricky. (2019). Diversity of species and length distribution of sharks in the Makassar Strait waters.2nd Proceedings Symposium of Sharks and Indonesian Rays 2018, Fisheries Research Center, Maritime and Fisheries Human Resources and Research Agency,Marine and Fisheries Ministry, Jakarta, 33-42. [Indonesian]

Fahmi, & Dharmadi. (2013). *An overview of the status of shark fisheries and their conservation efforts in Indonesia*. Directorate of Conservation of Areas and Fish Species, Directorate General of Marine, Coastal and Small Islands, Marine and Fisheries Ministry, Jakarta.

Fahmi, & Sumadhiharga, K. (2007). Size, sex and length at maturity of four common sharks caught from Western Indonesia. *Marine Research Indonesia*, 32, 7-19.

Ferretti, F., Worm, B., Britten, G.L., Heithaus, M.R., & Lotze, H.K. (2010). Patterns and ecosystem consequences of shark declines in the ocean. *Ecology Letters*, 13, 1055-1071.

Food and Agriculture Organization (FAO). (2020). Global capture production - http://www.fao.org/fishery/statistics/global-capture-production/en. [Accessed February 1th 2020].

Froese, R., & Pauly, D. (2017). *Carcharhinus obscurus*. www.fishbase.org. [Accessed October 10th 2017].

Harlyan, L.I., Kusumasari,A., Anugrah, M., & Yunaeni, R.R. (2016). Data collection of sharks landed at Muncar Beach Fishing Port, Banyuwangi.1st Proceedings of Indonesian Sharks and Rays 2015, Marine and Fisheries Ministry& WWF Indonesia, Bogor, 23-32 p. [Indonesian]

Hoffmayer, E.R., Franks, J.S., Driggers, W.B., McKinney, J.A., Hendon, J.M., & Quattro, J.M. (2014). Habitat, movements and environmental preferences of dusky sharks, *Carcharhinus obscurus*, in the northern Gulf of Mexico.*Marine Biology*, 161, 911-924.

Joung, S.J, Chen, J.H, Chin, C.P., &Liu, K.M. (2015). Age and growth of the dusky shark, *Carcharhinus obscurus*, in the Western North Pacific Ocean. *Terrestrial Atmospheric and Oceanic Sciences*, 26, 153-160.

Last, P.R., & Stevens, J.D. (1994). *Sharks and rays of Australia*. Marine Biological Association of the United Kingdom. Melbourne, Australia.

Manojkumar, P.P., Zacharia, P.U., & Pavithran, P.P. (2012). Fishery of elasmobranchs with some observations on the biology and stock assessment of *Carcharhinus limbatus* (P. Muller & Henle, 1839) exploited along Malabar coast. *Indian Journal of Fisheries*, 59, 35-41.

Marine and Fisheries Ministry (MFM). (2015). *National action plan for shark and ray conservation and management 2016-2020*. Directorate of Marine Biodiversity Conservation and Management, Directorate General of Marine Zone Management, Marine and Fisheries Ministry, Jakarta. [Indonesian]

Natanson, L.J., Casey, J.G., & Kohler, N.E. (1995). Age and growth estimates of the dusky shark, *Carcharhinus obscurus*, in the western North Atlantic Ocean. *Fish Bulletin*, 93, 116-126.

Nurcahyo, H., Sangadji, I.M., & Yudiarso, P. (2016). Species composition, length distribution and shark sexlanded in East Java, Bali, NTB and NTT.1st Proceedings of Indonesian Sharks and Rays 2015, Marine and Fisheries Ministry & WWF Indonesia, Bogor, 33-41 p. [Indonesian]

Prihatiningsih, Nurdin, E., & Chodrijah, U. (2018). Species composition, catch per unit of effort, season and fishing ground of shark in the Indian Ocean Southern Java waters. *Jurnal Penelitian Perikanan Indonesia*, 24, 283-296. [Indonesian]

Puspasari, R., Rachmawati, P.F., & Muawanah, U. (2019). Climate variability impact on Bali sardine fishery: Ecology and fisheries perspective. *Fisheries Management and Ecology*, 26, 540-547.

Rigby, C.L., Barreto, R., Carlson, J., Fernando, D., Fordham, S., Francis, M.P., Herman, K., Jabado, R.W., Liu, K.M., Marshall, A., Pacoureau, N., Romanov, E., Sherley, R.B., &Winker, H. (2019). *Carcharhinus obscurus*. *The IUCN Red List of Threatened Species* 2019: e.T3852A2872747. https://dx.doi.org/10.2305/IUCN.UK.2019-3.RLTS.T3852A2872747.en. Downloaded on 23 February 2020.

Saïdi, B., Bradaï, M.N., Bouaïn, A., & Capapé, C. (2007). Feeding habits of the sandbar shark *Carcharhinus plumbeus* (Chondrichthyes: Carcharhinidae) from the Gulf of Gabès, Tunisia.*Cahiers de Biologie Marine*, 48, 139-144.

Sentosa, A.A., Widarmanto, N., Wiadnyana, N.N., & Satria, F. (2016). The shark catch composition differences of drift and bottom longline based in Tanjung Luar, Lombok. *Jurnal Penelitian Perikanan Indonesia*, 22, 105-114. [Indonesian]

Simeon, B.M., Apriliani, I.M., & Gautama, D.A. (2016). Strategy to shift shark fishing operations in Muncar Beach Fishery Port, Banyuwangi Regency, East Java.1st Proceedings of Indonesian Sharks and Rays 2015, Marine and Fisheries Ministry& WWF Indonesia, Bogor, 233-240 p. [Indonesian]

Smale, M.J. (1991). Occurrence and feeding of three shark species, *Carcharhinus brachyurus*, *C. obscurus* and *Sphyrna zygaena*, on the Eastern Cape coast of South Africa. *South African Journal of Marine Science*, 11, 31-42.

Suniada, K.I., & Susilo, E. (2017). Relationship of oceanography conditions and pelagic fisheries in Bali strait waters. *Jurnal Penelitian Perikanan Indonesia*, 23, 275-286. [Indonesian]

Syah, A.F., Setyowati, N., & Susilo, E. (2019). Preliminary findings on distribution of Bali Sardinella (*Sardinella lemuru*) in relation to oceanographic conditions during southeast monsoon in Bali Strait using remotely sensed data. *Journal of Marine Science*, 01, 25-30.

Taylor, S.M., & Bennett, M.B. (2013). Size, sex and seasonal patterns in the assemblage of Carcharhiniformes in a sub-tropical bay. *Journal of Fish Biology*, 82, 228-41.

White, W.T., Last, P.R., Stevens, J.D., Yearsley, G.K., Fahmi, & Dharmadi. (2006). *Economically important sharks and rays of Indonesia*. ACIAR. Canberra, Australia.

Yulianto, I., Booth, H., Ningtias, P., Kartawijaya, T., Santos, J., Sarmintohadi, Kleinertz, S., Campbell, S.J., Palm, H.W., &Hammer, C. (2018).Practical measures for sustainable shark fisheries: Lessons learned from an Indonesian targeted shark fishery.*PLoS ONE*, 13(11), e0206437.

Zamrud, M., Hesroni, & Musram, S. (2016). Tracking the shark trade in Banggai islands Central Sulawesi.1st Proceedings of Indonesian Sharks and Rays 2015, Marine and Fisheries Ministry& WWF Indonesia, Bogor, 143-150 p. [Indonesian]

Zamrud, M., Hidayat, J.A., & Chadidjah, S. (2019). Trade monitoring and compliance of dried shark fin's exporters in south Sulawesi based on certification approach. 2nd Proceedings Symposium of Sharks and Indonesian Rays 2018, Fisheries Research Center, Maritime and Fisheries Human Resources and Research Agency, Marine and Fisheries Ministry, Jakarta, 179-186 p. [Indonesian]

Zulfiaty, E., Wiadnya, D.G.R., Lelono, T.D., & Yuneni, R.R. (2019). Species composition and biological aspects of tiger shark (*Galeocerdo cuvier*) caught in Bali strait and Makassar strait (WPP 573 and 713). 2nd Proceedings Symposium of Sharks and Indonesian Rays 2018, Fisheries Research Center, Maritime and Fisheries Human Resources and Research Agency, Marine and Fisheries Ministry, Jakarta, 109-118 p. [Indonesian]