Biological characteristics of bigeye thresher shark landed in Cilacap Ocean fishing port, Cilacap Regency, Central Java, Indonesia

ABSTRACT

Shark is the top predator of the marine food chain which has a unique biological condition, namely a long life cycle and is prone to population decline in nature if its utilization is not carried out wisely. This study aims to determine the biological conditions of bigeye thresher shark (*Alopias superciliosus*) which includes the size of the length at first capture (Lc), the size of the length at first maturity (Lm) in male sharks, the relationship between length and weight to growth patterns and condition factors, sex ratio and sexual maturity in male sharks during March-June 2023 landed at the Cilacap Ocean Fishing Port Fish Landing Site. The results of the analysis that has been done show the size of the length at first capture (Lc) in female, male and combined sharks is 142 cmFL, 150 cmFL and 154 cmFL. The size of length at first maturity in male sharks is 160 cmFL. The length-weight relationship in combined male and female bigeye thresher sharks was $W=0{,}00003L^{2{,}805}$, indicating a negative allometric growth pattern. Condition factor values of the length-weight relationship equation for negative allometric growth ranged from 0,23-2,29 with a sex ratio of female and male bigeye thresher sharks of 1:1,7 where the sex ratio was unbalanced. Sexual maturity of bigeye thresher shark in the classification of 14.5% NC category, 19.7% NFC category, and 65.8% FC category which indicates most are in the ready to spawn category. Most of the sharks capture are mature in size, so that in the utilization of bigeye thresher shark, there is a need for catch quotas and restrictions on catch size and monitoring of shark fishing areas which are indispensable in efforts to manage bigeye thresher shark conservation.

Key words: *Bigeye thresher shark, Length-weight relationship, Conservation, Cilacap Ocean Fishing Port*

1. INTRODUCTION

Sharks are one of the species of the elasmobranch sub-class that are of global concern due to the high exploitation rate of their capture [8]. A quarter of shark and ray populations worldwide are estimated to be in decline [9]. The demand for shark products in the form of fins, meat, cartilage, oil and skin drives the exploitation of sharks around the world [2]. The capture of sharks, which are apex predators in the food chain, can affect the balance of the ecosystem and the sustainability of their populations in nature. The decline in their population has made sharks a global conservation priority [13].

One of the target biodiversity conservation areas is Indonesia. Indonesia has 20% of the global elasmobranch diversity [13], one of which is from the Alopiidae family (thresher sharks). The Alopiidae family consists of three species including the common thresher shark (*Alopias vulpinus*), bigeye thresher shark (*Alopias superciliosus*), pelagic thresher shark (*Alopias pelagicus*) [7]. Two species have been identified in Indonesian waters, including *Alopias superciliosus* and *Alopias pelagicus* [3].

Bigeye thresher shark (*Alopias superciliosus*) is characterized by large eyes and a long tail that is almost half the length of its body. Bigeye thresher sharks are a migratory pelagic shark group, and are found in high seas habitats. Bigeye thresher shark distribution is found in tropical climates and warm temperatures to a depth of 955 m [15]. Bigeye thresher shark has a slow growth rate, long life cycle slow sexual maturity and low fecundity [19]. Bigeye thresher shark is listed by the IUCN globally as a species vulnerable to extinction [15].

Cilacap Ocean Fishing Port (OFP) is a fishing port with classification A located on the south coast of Central Java Island. Cilacap OFP is designated as one of the marine and fisheries economic development areas (minapolitan) based on capture fisheries based on

the principles of integration, efficiency and acceleration [12]. Cilacap OFP is a fisheries management area (WPP) 573 whose fishing grounds are in Indian Ocean waters. WPP 573 has abundant and diverse marine fisheries potential.

Information regarding the population of *Alopias spp*. including bigeye thresher shark is limited. Knowing the biological characteristics of different geographical locations can provide basic information in developing a database of sharks exploited from Indonesian territory caught in Indian Ocean waters. This study aims to determine the biological condition of bigeye thresher shark (*Alopias superciliosus*) length at first capture (Lc), length at first maturity (Lm) in male sharks, length-weight relationship to growth patterns, condition factors, sex ratio and sexual maturity in male bigeye thresher sharks.

2. MATERIAL AND METHODS

Study area

This research was conducted at the Cilacap Ocean Fisheries Port (OFP) Fish Landing Site with a geographical reference of 7°43'25.59"S-109°1'22.53"T, Cilacap Regency, Central Java Province, Indonesia. The research was conducted from March to April 2023, which is the first transitional season in the south of Java Island.

Procedures

Sampling bigeye thresher shark by purposive selective sampling. Landed bigeye thresher shark were mostly caught using longline, handline and gillnet gear. Samples were collected twice a month from March to June 2023. The number of samples taken was 183 individuals. Vessel samples were determined by accidental sampling. Measurements of bigeye thresher shark length were taken based on the length of the fork (FL), because the condition of the shark landed is often not intact and the tail is not straight and folded, making it difficult to get an accurate total length measurement. Shark weights were measured with digital scales. The sex of the bigeye thresher shark was determined by observing the presence or absence of a claspers on the anus, which indicates the genitals of male sharks [11]. The level of sexual maturity was determined by looking at the condition of the genitalia and measuring the length of the claspers.

Data analysis

The population length-weight relationship (LWR) equation [5] was used as follows: $W = aL^b$, where W: weight (kg); a and b are linear regression constants. If a logarithmic transformation is made, the equation is obtained: Log W = Log a + b Log L. The average length at first capture (Lc) was obtained from the calculation of a sigmoid-shaped logistic curve, by plotting the 50% intersection point of the cumulative frequency curve with the length of the shark [16]. Condition factor (K) was obtained based on Effendi's (2002) equation: $FK = W*10^5//L^3$ if the growth pattern is isometric and $FK = W/aL^b$ if the growth pattern is allometric, where FK: condition factor, W: weight (kg); a and b linear regression constants; L: fork length (cm). A constant value of b = 3 indicates an isometric growth pattern, while a constant b ≠ 3 indicates an allometric growth pattern. Sex ratio was analyzed with the equation [17] as follows: $NK = N_{bi}/N_{ji}$, where NK: sex ratio, Nbi: number of female fish, and Nji: number of male fish. Then tested with chi-square statistics with an alternative hypothesis: H0 if the sex ratio of males and females is balanced and H1 hypothesis if the sex ratio of males and females is in an unbalanced condition. Sexual maturity was analyzed from the observation of the condition of the clamp and then grouped based on the maturity level of the clamp, where there was no calcification (NC), there was calcification (NFC) and the clamp was filled with lime (FC) [11].

3. RESULTS AND DISCUSSION

Length at first capture (L_C)

Bigeye thresher shark landed at fish landing site Cilacap OFP during March-June 2023 had a length class interval ranging from 88-294 cmFL. Male bigeye thresher shark had a length class interval of 88-294 cmFL while female bigeye thresher shark had a length class interval of 91-243 cmFL. The size of bittern sharks caught on the Southeast coast of India ranged from 108-265 cmTL [7]. Research [14] revealed that bitter sharks landed at Cilacap OFP in February-December 2022 had a size interval of 67-243 cmFL with the dominant size caught being 157-171 cmFL.

The results of the study during March-June 2023 showed that the length at first capture (Lc) in female, male and combined bigeye thresher shark was 142 cmFL, 150 cmFL and 154 cmFL (Figure 1). [14] in his research in February-December 2022 showed the Lc value in the combined bigeye thresher shark was 153. While the Lc value in research [1] on female and male bigeye thresher sharks is 147 cmFL and 154 cmFL. Differences in size variation can be influenced by the selectivity of fishing gear, season and fishing area [18,3].

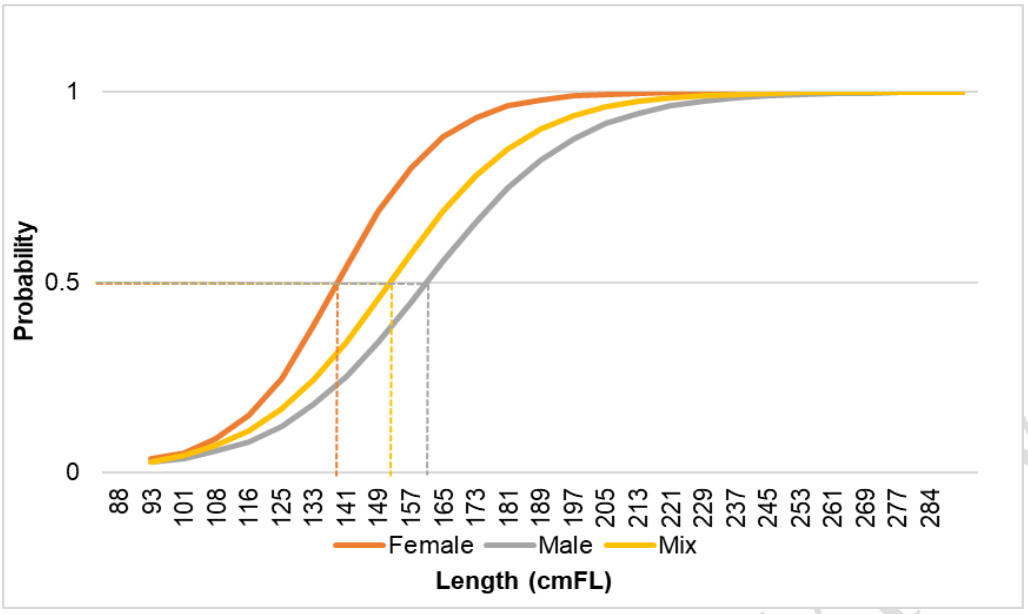

Figure 1. length at first capture (Lc) in combined bigeye thresher shark. (Source: Primary data 2023)

Length at first maturity (L_m)

The length at first maturity was estimated based on the size of the claspers in male sharks. The results of the study during March-June 2023 showed that the length at first maturity (Lm) in male bigeye thresher sharks was 142 cmFL (Figure 2). Similar research [14] in February-December 2022, which showed Lm values around 160 cmFL. The difference in Lm value was influenced by the time of observation in the field related to the season and the number of samples analyzed.

Based on Figure 2, the length at first capture (Lc) in male bigeye thresher shark is greater than the length at first maturity (Lm). This condition indicates the capture of fish that have matured. In contrast to the results of [14], the value of Lc is smaller than the value of Lm, which indicates that the bigeye thresher shark capture is immature in length. Differences in these conditions can be caused by differences in fishing areas or selectivity of fishing gear.

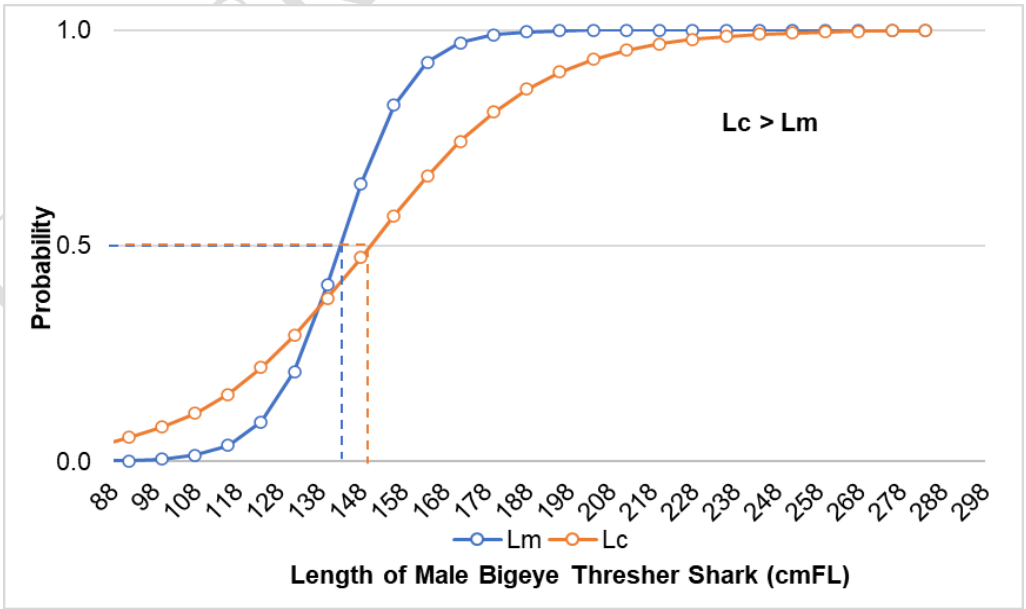

Figure 2. Length at first maturity (Lm) in male bigeye thresher sharks. (Source: Primary data 2023)

Based on the condition of the adult bigeye thresher shark, monitoring of the fishing grounds is required. It is estimated that the fishing grounds are spawning grounds, feeding grounds and/or nursery grounds. The Lc and Lm values obtained from the study are useful as information in supporting regulations to limit overfishing exploitation.

Length-weight relationship (LWR)

The bigeye thresher shark length-weight relationship showed the equation $W = 0{,}00003\ L^{2{,}805}$ (Figure 3). The constant value of b was 2,805 the value of b obtained was then tested at 95% confidence interval. The t test results show that $t_{hit}(2.45) > t_{tab}(1.97)$ then H0 is rejected and accept H1, which indicates a negative allometric growth pattern (b < 3), where the increase in length is faster than the growth in weight. The R^2 value of bigeye thresher shark is 0,87 which shows 87% of the growth rate is relatively slower and the size of the shark's body diameter is in the thin category, while 13% is influenced by other factors such as environmental factors and fish age.

The growth pattern has similarities with studies [10] in the Arabian Sea, [7] in the Indian Sea and [14] in February-December 2022 at fish landing site Cilacap OFP which showed a negative allometric growth pattern. However, it has a difference in research [3] in the period May 2015 to November 2016 at fish landing site Cilacap OFP showing a positive allometric growth pattern in female bigeye thresher shark and isometric growth pattern in male bigeye thresher shark. Differences in growth patterns can be caused by differences in research time and the number of samples used.

Condition factor values based on negative allometric growth patterns of length-weight relationships ranged from 0,23-2,29. The condition factor value indicates the suitability of environmental factors for shark growth [9]. Similarly, [3] stated that differences in environmental conditions affect fish growth.

Length-weight relationships can provide information to predict the weight of bitterness sharks based on their length at sea. This is a form of supporting regulations that limit the capture of bitterness sharks, one of which is in the KP Regulation. Number Per.12/Men/2012 concerning capture fisheries business on the high seas. Based on the size of the estimated length of the catch at sea.

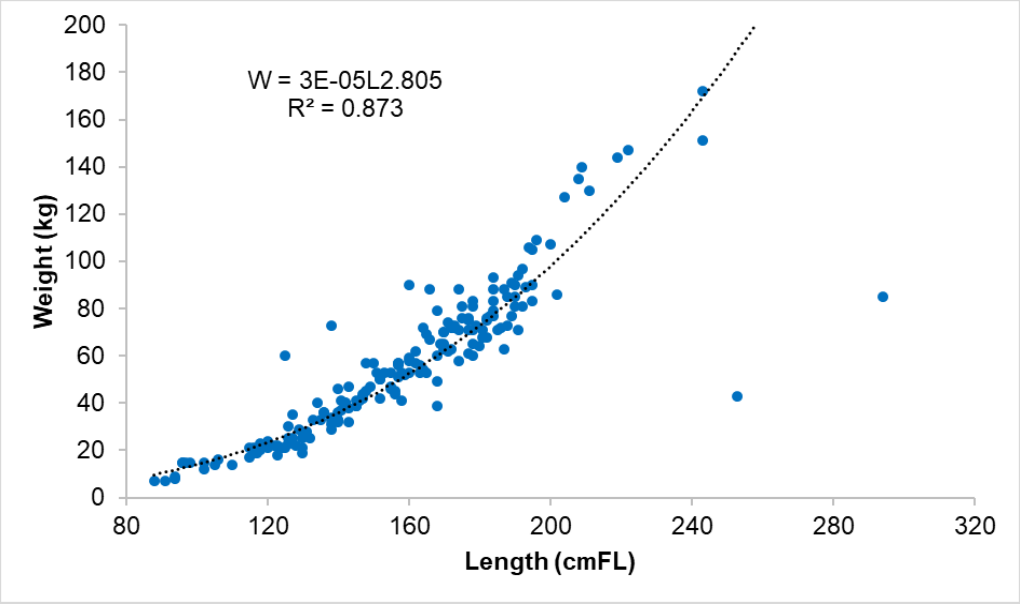

Figure 3**.** Length-weight relationship (LWR) of bigeye thresher shark during March-June 2023 (Source: Primary Data, 2023)

Sex Ratio

The results of research that has been done on 187 bigeye thresher shark samples during March-June 2023, it is known that the composition of female and male sharks is 1:

1,7. The results of the Chi-Square test on 187 female and male bigeye thresher sharks showed that the X^2_{hit} and X^2_{tab} values were 8,36 and 5,99, so H0 was rejected and H1 was accepted. Based on the Chi-Square test, the sex ratio of sharks is not balanced at the 95% level. The proportion of male sharks is more dominant than female sharks except in March 2023.

This has a difference in research [3] obtained a sex ratio of females and males of 1,02: 1 which means that the sex ratio of females and males is in a balanced condition. Sex ratio can be used in estimating the population size and as a control of the population size of the next generation [3]. The sex ratio of bigeye thresher shark during March-June 2023 is presented in table 1.

Table 1. Sex ratio of bigeye thresher shark

Month	Shark Count (Indv)			Sex Rasio	
	Female	Male	Total	Female	Male
March	21	20	41	1,05	1,00
April	23	65	88	1,00	2,83
May	0	0	0	0,00	0,00
June	22	32	54	1,00	1,45
Total	66	117	183	1,00	1,77

(Source: Primary Data, 2023)

Shark sexual maturity

The results showed that bigeye thresher shark landed at fish landing site Cilacap OFP was found to be immature with 14,5% in NC category and 19,7% in NFC category. However, most of them were in the Full-Calcified (FC) category with a percentage of 65,8%. This indicates that the claspers are mature and the sharks are ready to mate. Bigeye thresher shark is vulnerable to overfishing, due to its life cycle that takes a long time to reach sexual maturity and has a very low recruitment rate. Based on the biological information of bitterness shark landed at fish landing site Cilacap OFP, monitoring of fishing areas that are habitat for bigeye thresher shark is needed, regulation of utilization quota and limitation of catch size.

Table 2. Classification of sexual maturity in male bigeye thresher sharks

Classification	Clasper Length Range (cm)	Shark Count (indv)	Percentage (%)
NC	2-7 cm	17	14,5
NFC	8-18 cm	23	19,7
NF	14-26 cm	77	65,8
Total		117	100,0

(Source: Primary Data, 2023)

Sexual maturity can be influenced by high fishing pressure and selectivity in fishing gear, the lower the fishing pressure, the smaller the size of the fish capture [3]. Bigeye thresher shark is vulnerable to overfishing, because its life cycle takes a long time to reach sexual maturity and has a very low recruitment rate. Based on biological information of bigeye thresher shark landed at fish landing site Cilacap OFP, monitoring of fishing areas that are habitat for bigeye thresher shark, regulation of utilization quota and limitation of catch size are required.

4. CONCLUSION

The first capture size ratio (Lc) was greater than the first maturity size (Lm) indicating that the sharks caught were mature. The bigeye thresher shark length-weight relationship showed a negative allometric growth pattern (b<3). The sex ratio of female and male bigeye thresher sharks was 1:1,7, indicating an unbalanced sex ratio. The sexual maturity obtained shows that most of the sharks caught and landed at fish landing site Cilacap OFP during March-June 2023 are in a mature claspers condition and ready to mate. Based on these biological conditions, monitoring of fishing areas that become bigeye thresher shark habitat is needed, regulation of catch quotas and selectivity of shark sizes that can be utilized.

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