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RESEARCH ARTICLE

Size distribution, length-weight relationship, and catch per unit effort of frigate tuna, *Auxis thazard* (Lacepède, 1800) in Tawi-Tawi waters, southern Philippines, caught using multiple handline

Jaro Omar Ajik[1] • Albaris Beteh Tahiluddin [1,2*]

[1] *Mindanao State University-Tawi-Tawi College of Technology and Oceanography, College of Fisheries, Marine Fisheries Department, Sanga-Sanga, Bongao, 7500 Tawi-Tawi, Philippines*

[2] *Kastamonu University, Institute of Science, Department of Aquaculture, 37200 Kastamonu, Turkey*

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ABSTRACT

Frigate tuna *Auxis thazard* (Lacepède, 1800) is the most dominant species caught by the multiple handline in the coastal and offshore fishing grounds of Tawi-Tawi, southern Philippines. In this study, we investigated the size distribution, length-weight relationship, and catch per unit effort of frigate tuna (*A. thazard*) in Tawi-Tawi waters, southern Philippines, caught using multiple handline. A total of 383 frigate tuna fish were sampled with a size distribution (total length) ranging from 16.5 to 34 cm. The length-weight relationship of frigate tuna was $W = 8 \times 10^{-3} \times TL^{3.139}$, where the b value of 3.139 indicates a positive allometric growth pattern. The catch per unit effort of the used gear was 2.49±0.52 kg/hr.

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Introduction

Frigate tuna, *Auxis thazard* (Lacepède, 1800), is a pelagic-neritic tuna species that belongs to the Scombridae family, which is distributed globally both in tropical and subtropical waters (Liu, 2008; Tao et al., 2012). This species is highly migratory, thrives in the marine waters with 50 m depth with an optimum temperature ranging from 27 to 28 °C (Maguire et al., 2006; Herrera & Pierre, 2009). Previous studies of frigate tuna across many oceans and seas showed that the biological aspects of this species vary. For instance, the length sizes (total, standard, fork length) of frigate tuna (*A. thazard*) reported to

* Corresponding author
E-mail address: albarist20@gmail.com (A. B. Tahiluddin)

be as low as 21 cm to as high as 40 cm (Noegroho et al., 2013; Tampubolon et al., 2016; Mudumala et al., 2018; Herath et al., 2019), with maturity stage starts at around 30 cm in length (Ghosh et al., 2012). Frigate tuna has a sex ratio of 1:1 sampled in the Eastern Indian Ocean (Noegroho et al., 2013). In Taiwan Strait, the dominant age of frigate tuna was two years (Tao et al., 2012). Numerous studies conducted in different parts of the world oceans revealed that this tuna species showed positive allometric growth (Ghosh et al., 2012; Tampubolon et al., 2016; Mariyasingarayan et al., 2018; Mudumala et al., 2018; Petukhova, 2019; Lelono & Bintoro, 2019; Herath et al., 2019).

Fishing this tuna species is important in many countries, especially in the purse seine fishery industry (Ahusan & Adam, 2011; Tao et al., 2012). Other fishing gears used to catch frigate tuna are gillnets, haul seine, ring net, beach seine, multiple handline, trolling, and pole and line (Haputhantri, 2016; Calicdan-Villarao et al., 2017; Mamalangkap et al., 2018; Sulistyaningsih et al., 2020).

Frigate tuna is one of the economically important tuna species caught in the Philippine waters. According to BFAR (2019), nearly 6% of municipal (approximately 54,000 metric tons) and commercial catch (approximately 58,000 metric tons) fish species in 2018 were contributed by frigate tuna. Tawi-Tawi waters are part of the Sulu Sea – one of the Philippines' richest fishing grounds and a home for most neritic and pelagic tunas, including frigate tuna (Mamalangkap et al., 2018).

Tawi-Tawi's local fisherfolks used ring net (*Kulibo*) to catch small pelagic fishes, usually done at night. In addition, small pump boat operators used multiple handline locally known as "bira-bira" to catch small tuna species such as frigate tuna, bullet tuna, eastern-little tuna, and other small pelagic tuna-like fishes. Using multiple handline to fish tuna has been practiced since the 1990s to the present, but with some innovation on the colors of artificial lures and the number of hooks of the gear to be used. Despite this tuna fishing practice, frigate tuna and other small tuna-like fish resources still sustain. However, to date, there is no available information about the size distribution, length-weight relationship, and catch per unit effort of frigate tuna in Tawi-Tawi. Hence, in this study, we determined the size distribution, length-weight relationship, and catch per unit effort of frigate tuna in Tawi-Tawi waters, southern Philippines, using multiple handline.

Materials and Methods

Study Site

The study was conducted in Tawi-Tawi waters, southern Philippines, particularly in Bongao municipal waters (Figure 1), from March 15, 2020 to April 27, 2020. Fishing operation, targeting frigate tuna, was done using multiple handline (Figure 2) and a motorized banca powered with Honda 13 HP gasoline engine.

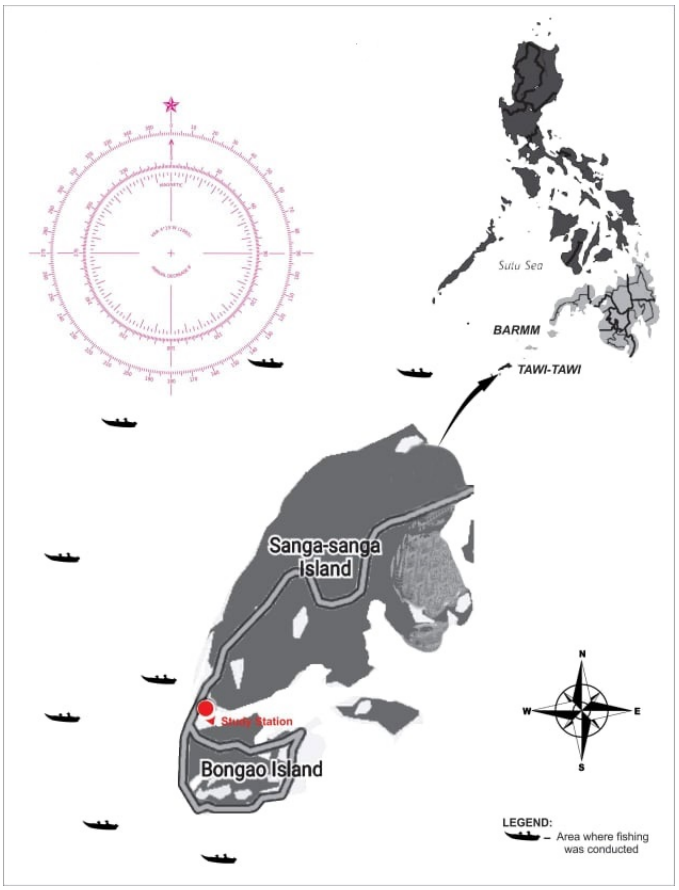

Figure 1. Map showing the study site

Figure 2. Multiple handline (bira-bira) used in the study

Size Distribution and Length-Weight Relationship

The total length and weight of frigate tuna were measured and weighed to the nearest 0.5 g/cm. Then, the relation between the number of catch and its corresponding length were investigated using the correlation analysis. For the length-weight relationship, the formula $W = aL^b$ was used to calculate the relationship between the body length of the fish and its body weight, where W is the fish weight, L is the total length of the fish, a is the intercept, and b is the slope of the linear regression (Petukhova, 2019).

Catch per Unit Effort (CPUE)

Catch per unit effort (CPUE) is defined by the total weight of fish caught divided by the total number of fishing hours. Researchers used two separate boats (corresponding to two fishers using the same fishing gear), fishing for two hours each trip, including time travel to the fishing ground, with a total of 18 fishing trips. The basis for the fishing time was based on the fishers' practice in the area. The total weight of the caught frigate tuna was recorded. Then, CPUE was calculated by diving the total fish caught with the total number of fishing hours.

Results and Discussion

A total of 383 frigate tuna were caught and sampled. Total length ranged from 16.5 to 34 cm, and body weight ranged from 45 to 451 g (Table 1).

Size Distribution and Length-Weight Relationship

The size distribution of frigate tuna categorized according to the number of fish caught to its total length (cm) is shown in Figure 3. The highest size category of frigate tuna was recorded on the size range of 26.5 to 30.5 cm with 227 fish, followed by the size range of 21.5 to 25.5 cm with 128 fish, and the size range of 16.5 to 20.5 cm with 16 fish. The lowest catch of the size category was 31.5 to 35.5 cm with 12 fish. The average total length of caught frigate tuna was 27.28±0.12 cm (Table 1). Our results are parallel to the study of Tampubolon et al. (2016), where they reported that the highest size distribution of frigate tuna ranged from 26 to 31 cm sampled from West Coast Sumatera, Eastern Indian Ocean. Also, the mean length of frigate tuna collected from the Northwest Coast of India was 32.35 cm (Mudumala et al., 2018). In Sri Lanka, the average standard length of frigate tuna ranged from 28 to 32 cm (Herath et al., 2019).

Table 1. Total length and weight of frigate tuna

Size Distribution	Descriptive Statistics		
	Minimum	*Maximum*	*Mean±SE*
Total length (cm)	16.5	34	27.28±0.12
Weight (g)	45	451	244.65±12.5

The length-weight relationship of frigate tuna was $W = 8 \times 10^{-3} \times TL^{3.139}$, wherein the b value was equal to 3.139, indicating positive allometry (b>3, t-test, $P < 0.05$), which implies that frigate tuna has a systematic pattern of growth such that the weight of the fish is proportional to its body length (Figure 4). This result is not so different from the study of Tampubolon et al. (2016), where the b value was 3.1489 of the same species in Indonesian waters. Also, Petukhova (2019) reported that the length-weight relationship of *A. thazard* was likewise showed positive allometry (b value of 3.240) collected from Northeast Atlantic. Besides, frigate tuna caught from the Northwest Coast of India showed positive allometry with an r-value of 0.9576 (Mudumala et al., 2018). Furthermore, positive allometric growth patterns (b values = 3.3385 and 3.48) were also reported for *A. thazard* in the South Coast of East Java waters, Indonesia (Lelono & Bintoro, 2019) and in the coastal waters of Sri Lanka (Herath et al., 2019), respectively. The correlation coefficient of determination "r^2" found in the present study was equal to 0.9005, indicating a strong correlation and highly statistically significant that the length of frigate tuna is proportional to its body length. Our result on the correlation coefficient of frigate tuna is relatively similar to the findings of Mariyasingarayan et al. (2018) collected from Parangipettai, Southeast Coast of India.

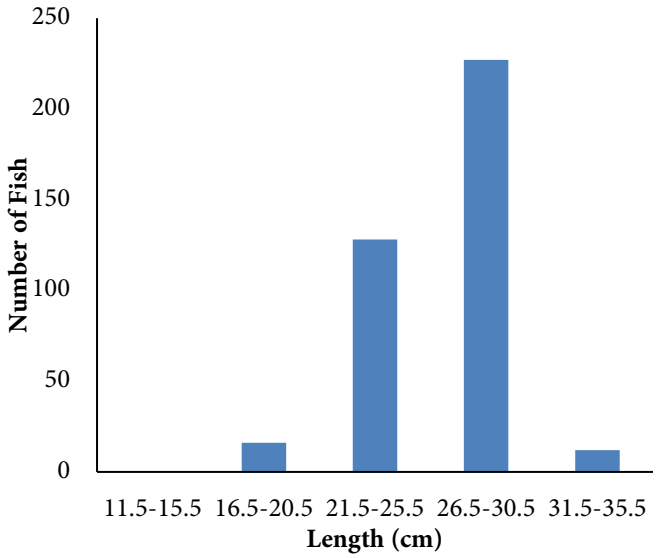

Figure 3. Size distribution of frigate tuna (*A. thazard*)

Catch per Unit Efforts (CPUE)

CPUE is one way of measuring the efficiency of particular fishing gear in terms of catch and likewise can be used as a fish abundance index (Mamalangkap et al., 2018). In this study, the average CPUE of frigate tuna for the whole fishing trip was 2.49±0.52 kg/hr. The CPUE of frigate tuna by the total weight of all the species is shown in Figure 5. The highest CPUE of frigate tuna was recorded on the second fishing trip with 8.87 kg/hr and followed by 5.44 kg/hr recorded on the first fishing trip. In Zambales, Philippines, the average annual (2003 to 2012) CPUE of multiple handline in catching tuna species, including frigate tuna, was 63 kg/hr (Yutuc et al., 2018).

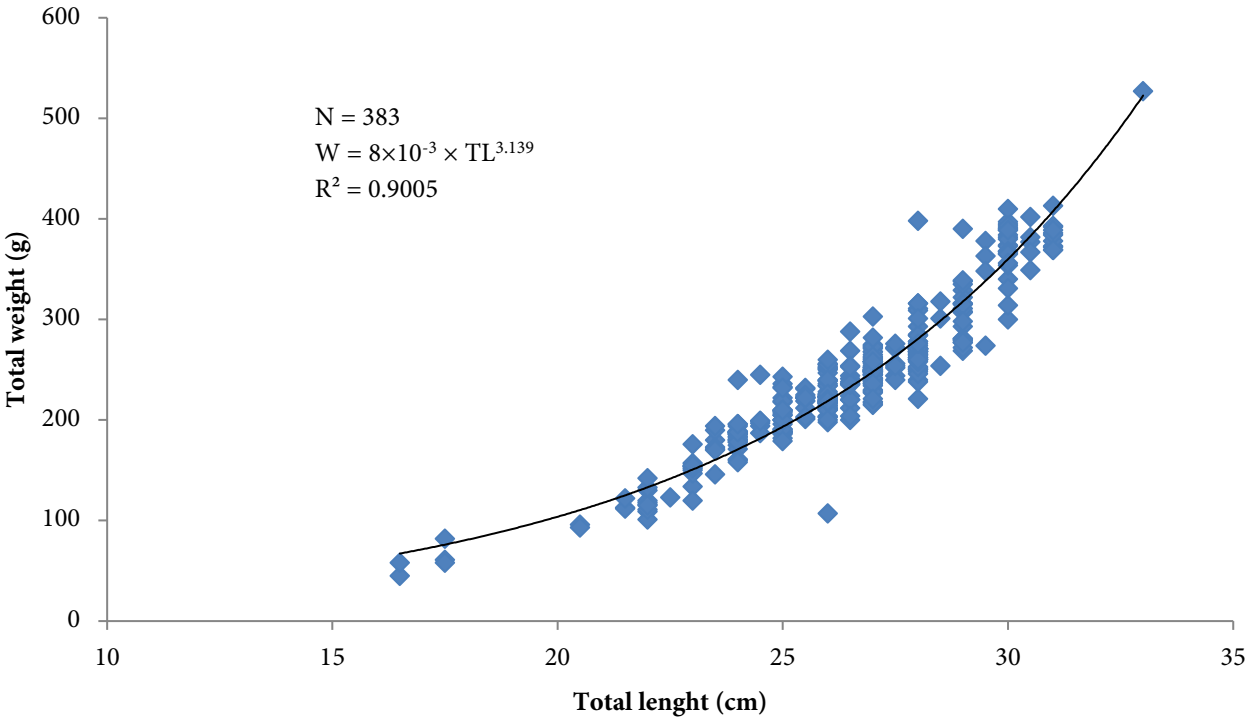

Figure 4. Length-weight relationship of frigate tuna (*A. thazard*)

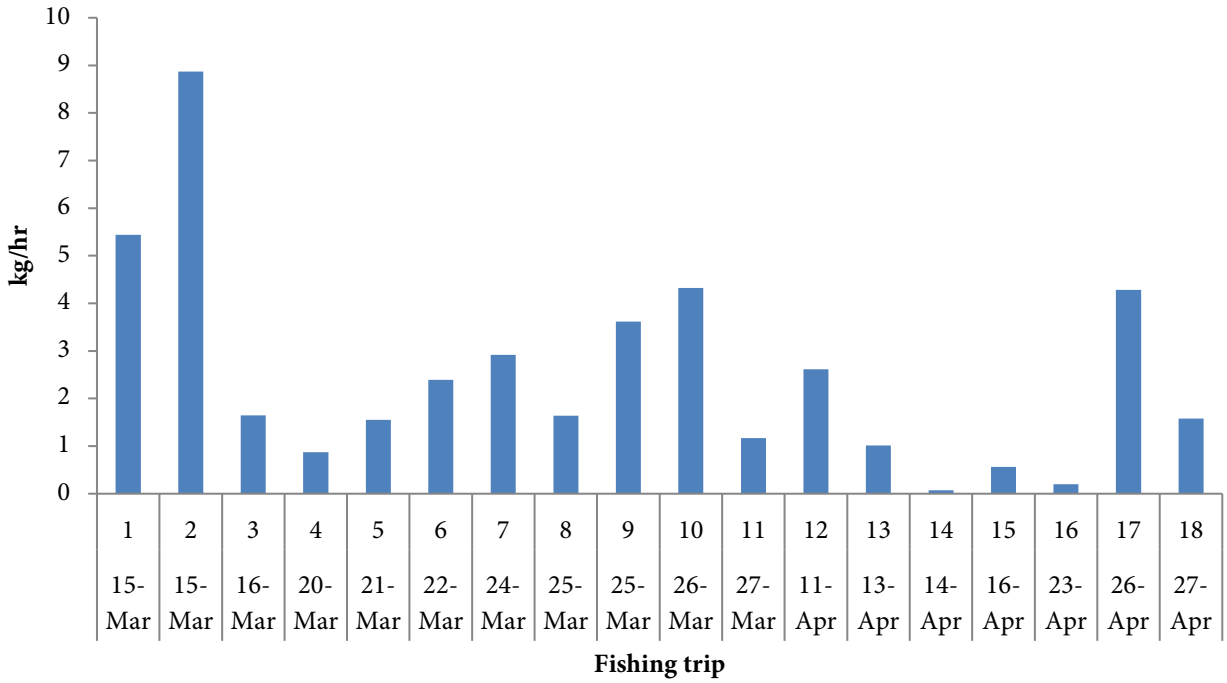

Figure 5. Catch per unit effort of frigate tuna using multiple handline

Conclusion

In conclusion, the size distribution of frigate tuna (*A. thazard*) was within the size range reported by the literature. Furthermore, the length-weight relationship of frigate tuna showed a positive allometric growth indicating that the fish live in the normal environment suitable for their growth. Based on the catch per unit effort result, we can still say that the multiple handline is relatively efficient to catch frigate tuna. Therefore, frigate tuna fishing in Tawi-Tawi waters, southern Philippines, is one of the important sources of food and livelihood for many local fishers.

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Compliance With Ethical Standards

Authors' Contributions

Both authors have contributed equally to this paper. In addition, both authors read and approved the final manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Approval

For this type of study, formal consent is not required.

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