Potential of yellowfin tuna catch in East Java-Indian Ocean based on length frequency and age distribution

D Hidayati, R Herlambang, N Jadid, N N Sa'adah, N Maulidina and A P D Nurhayati
Biology Department, Institut Teknologi Sepuluh Nopember (ITS) Surabaya-Indonesia
E-mail: dewi_hidayati@ymail.com

Abstract. Tuna’s catch in Indonesia is the largest in the world, which contributing approximately 16 percent of the world’s tuna supply. Investigation of tuna length frequency distribution that caught in Indian ocean has conducted to know the Indonesian’s fisheries potential included yellowfin tuna (YFT). The result study provide useful data for estimating fish growth as a fundamental for YFT stock assessments and managing exploitation. The 203 YFT samples were collected from fish landing area at Sendang Biru Malang, East Java Indonesia during April and May 2017. The research found that YFT in East Java - Indian ocean was dominated with length group of 151-180 cm (53.2 %) and followed by with length group of 121 – 150 cm (33.5%) with estimated age of 4.1 – 6.0 years and 3.1- 4.0 years respectively. There were 17 individual YFT at juvenile size in group length of 31-60 cm was found 8.4%, while the maximum group size (181-120 cm) was reported at level of 4.4%. The variation of YFT length and age indicates the variation of trophic level in East Java -Indian ocean water which very important for sustainable fisheries.

1. Introduction
Indonesia is the archipelago country that dominated with the sea area (76.94 %) or 6,653,341,439 km² [1], therefore opens great opportunities for the development of fisheries sector, including tuna. Indonesia’s tuna catch is the largest in the world which contributes about 16 % of the world’s total tuna supply [2].

As a top predators in the ocean, tuna plays an important role in marine ecosystems and provides the worldwide protein requirements [3]. The one of abundant and high economically value of tuna catch species in Indonesia is YFT (Thunnus albacares) which in 2014 reached 65.686 metric tons [2] and [4]. The geographic position of Indonesia included the East Java-Indian ocean is fits for YFT to breed hence supply high quality YFT across the global market. [5]. Moreover, YFT catch have increased in recent years. Due to its potential, the regulation of yellowfin exploitation has been issuing by Marine and Fisheries Ministerial to regulate capture and the Sustainable Fisheries Partnership (SFP) of Indian Ocean Longline Tuna [2]. Accordingly, the stock assessment for exploitation management of YFT in East Java-Indian Ocean is required. The study of length frequency and age distributions of catch may provide directly and useful information the condition of fish [6] and importantly used data for estimating fish growth as a fundamental for fish stock assessments and managing exploited species [7] and [8], as well as to predict the future yields, the sustainability of biomass levels and value of the catch [9]. Furthermore, this study provides fisheries data that has importantly contribution for the sustainable YFT catch in Indonesia.
2. Methods

2.1. Time, Place and Research Sample
Site sampling determination were conducted based on current information of forecast map of fishing area of Java, Bali and Nusa Tenggara Region that produced by the Ministry of Marine Affairs and Fisheries (KKP) in 2017. The site sampling determined the location of the study covering the South Coast of East Java and technically considering the basis of accessibility or accessibility aspects. In this study this criteria was represented by Sendang Biru coastal area, Malang Regency, East Java Indonesia (Figure 1). Sendang Biru is well-known fisheries area that produces the best handline tuna in Indonesia [10] Samples of YFT were collected from fish landing area at Sendang Biru during April and May 2017.

![Figure 1](https://www.google.co.id/maps/place/Indonesia)

**Figure 1.** Sampling site of YFT: A. Map of Indonesia, the dashed square is region of East Java; B: YFT sampling site at coastal area of Sendang Biru, East Java (balloon mark). Source with modification: https://www.google.co.id/maps/place/Indonesia [11] https://afebrianas.files.wordpress.com/2015/02/map-sendang-biru-jpg-e1423730834224 [12]
2.2. Analysis of YFT body length and age frequency distribution
The body length measurement was conducted based on morphometric method adopts the usual measurement method used in fisheries research [13]. The measurement of body length, and weight of YFT were obtained on site of fish landing area at Sendang Biru. The correlation among biometric data were analyzed using scatter plot in excel. Meanwhile, the incomplete data of YFT length/weight were estimated using the length-weight relation analysis according to Costa et al. [14], with the following formula:

\[
\text{Weight} = 2 \times 10^{-5} \times \text{Length}^{2.932}
\]

The observed and estimated of length-weight data were then analyzed using Frequency function within Excel in Microsoft Office. Frequency of data that determined within a certain range, then used for created a graph which shows the frequency distribution of YFT body length. Moreover, the frequency distribution of YFT body length were used for age estimation that calculated according to YFT growth equation that made by to Costa et al. [14].

2.3. Additional data of Tuna catch fisheries
Monthly and annual data of tuna catch were analyzed based on the secondary fisheries data from local institution i.e. Pondok Dadap Office of Maritime Affairs and Fisheries. The data of YFT fishing equipment that used in Sendang Biru as well as tuna catch location were obtained by interview with the fishermen that landing at Sendang Biru.

3. Result and Discussion
3.1. The trend of YFT catch at Sendang Biru
The tuna catch report at East Java-Indian ocean refer to Pondok Dadap Office of Maritime Affairs and Fisheries from year of 2013, 2015 and 2016 showed fluctuated total weight production i.e. 811.176 ton; 745.420 ton and 918.393 ton respectively.

Refer to Figure 2, there similarity trend showed between year of 2015 and 2016. During April to August the catch was showed increasing trend with the peak catch found at June (at 2015= 304.84 ton; at 2016=282.742 ton). January found as the lowest month of YFT tuna catch in 2015 as well as at 2016 (0 ton), Another study by Isfandiary [15] also reported that in 2015 there was no capture of
YFT (0 ton / trip). Meanwhile, data of 2013 indicated two peaks of YFT catch i.e. on May (158.469 ton) and August (181.462 ton).

Indonesia has two seasons, wet and dry season. In Java, the wet season occurs between September to March and the dry season is from March to September. The average annual rainfall for Indonesia approximately in level of 3,175 mm, however in the eastern tip of Java tend to be dry until the rainfall decrease less than 1,000 mm [16]. These trend differences might be affected by disruption of the physical environment due to the climate patterns, which then impact natural stock behaviors such as migration, egg spawning hence decreasing the fish juveniles each year. For example, the annual fish stock in Pacific hake were different more than 100 times from year to year [17]

3.2 The correlation between body length and weight of YFT catch

The analysis of length-weight correlation that calculated using completely data of length-weight from 80 individual YFT samples presented at Figure 3. It is demonstrated the strong positive correlation between body length and weight (R² = 0.92). According to ICCAT was known that there is no significant size-weight difference between sexes, hence the length-weight applied for both sex. Length-weight relationships have been devised to obtain better estimates of catches in round weight from landed and processed catches [18]). Meanwhile, 123 individual YFT samples that were not completely yet measured (only consist of one data of length or weight) were estimated using length-weight correlation according to Costa et al [14]

![Figure 3. The correlation between body length and weight of YFT catch](image)

3.3 YFT body length and age frequency distribution

Bard et al. and ICCAT reported there are three age categories: juveniles (50-65 cm), pre-adults (65-110 cm) and adults (110-170 cm). The YFT fork length of 50 cm is remain in the coastal areas, and show moderate migratory habits (30 miles). Pre-adult YFT migrates with similar patterns to that of juvenile, while adults make trophic migrations towards higher latitudes during the summer and migrations across the ocean [19].

The percentage of body length and age frequency distribution from 203 individual YFT samples showed at Figure 4 and table 1.
The research found that YFT in East Java-Indian ocean was dominated with length group of 151-180 cm (53.2 %) and followed by with length group of 121 – 150 cm (33.5%) with estimated age of 4.1 – 6.0 years and 3.1 - 4.0 years. The both groups were categorized at adult size (table 1). There were 17 individual YFT at juvenile size in group length of 31-60 cm was found 8.4%, while the adult maximum group size (181-120 cm) was found at level of 4.4%.

Table 1. Frequency distribution of Body Length and Age of YFT catch

| Range size | No of ind. | Percentage | Estimated age (years) | Age category (Bard et al. 1991) |
|------------|------------|------------|-----------------------|----------------------------------|
| 31-60      | 17         | 8.4        | 0.5 - 1.5             | Juvenile                        |
| 61-90      | 0          | 0.0        | 1.6 - 2.5             | Pre adult                        |
| 91-120     | 1          | 0.5        | 2.6 - 3.0             | Pre adult/adult                 |
| 121-150    | 68         | 33.5       | 3.1 - 4.0             | Adult                           |
| 151-180    | 108        | 53.2       | 4.1 - 6.0             | Adult                           |
| 181-210    | 9          | 4.4        | 6.1-7.0               | Adult                           |

As previously described, that each age category have trophic migration at different area and possibly intersection area. According to the interview data with local tuna fishermen was known that they do fishing generally at approximately 30 miles, which available to find mostly adult YFT. The variation of YFT length and age indicates the variation of trophic level in East Java-Indian ocean water which very important for sustainable fisheries. The length frequencies data may use to estimate catch-at-age which is to be the one of important component in fisheries assessment [20]. Moreover, the age distribution of the fish is an important aspect of stock predictions included the sexual maturity, the numbers of parent and young fish stock as well as estimates and manages the condition of fish populations in future years. Fish stock assessments providing the information that necessary to make sound decisions, therefore support sustainable fisheries [16] and [21].

4. Conclusion
The YFT in East Java-Indian ocean was dominated with adult sizes (91.1%) included the varied adult size groups: 151-180 cm (53.2 %); 121 – 150 cm (33.5%) and (181-120 cm). There rest of YFT catch (8.9%) were composed of varied size of juveniles and pre-adult. The diversity of size and age, the high frequency of adult YFT and small frequency of YFT juvenile/pre adult reflects the YFT catch sustainability at economically and ecology prospective.
References

[1] Ramdhan M and Arifin T 2013 Aplikasi sistem informasi geografis dalam penilaian proporsi luas laut Indonesia. (Application of Geographic Information System for Assessment of Indonesia Marine Proportion) Jurnal Geomatika 19 141-146

[2] CEA (California Environmental Associates) 2016 Indonesia Fisheries: 2015 Review: A report on trends in coastal marine resources and fisheries management in Indonesia. Prepared for The David and Lucile Packard Foundation

[3] FAO (Food and Agriculture Organization of the United Nations) 2011 Tuna and tuna-like species, in: Review of the state of world marine fishery resources. FAO Fisheries and Aquaculture Technical Paper 569 227-243.

[4] Albaina A, Iriondo M, Velado I, Laconcha U, Zarraonaindia I, Arvizualalaga H, Pardo M A, Lutcvage M, Grant WS and Estonba A 2013 Single nucleotide polymorphism discovery in albacore and Atlantic bluefin tuna provides insights into worldwide population structure. Animal Gener 44 678-692

[5] Ikhwon F B 2015 Export New Indonesia: Yellowfin Tuna. Directorate General of National Export Development Ministry of Trade of The Republic of Indonesia Ditjen PEN/MJL/XXV/11/2015.

[6] Erismana B E, Ashley M, Apel, Alec MacCall D, Románd M J and Fujita R 2014 The influence of gear selectivity and spawning behaviour on a data-poor assessment of a spawning aggregation fishery. Fisheries Research 159 75–87

[7] Francis R I C C 1988 Are growth parameters estimated from tagging and age-length data comparable? Can. J. Fish. Aquat. Sci 45 936–942

[8] Gulland, J. A. 1988. Fish population dynamics: the implications for management, 422 p. John Wiley and Sons Ltd., New York.

[9] Sparre P and Venema S. C. 1998. Introduction to Tropical Fish Stock Assessment - Part 1: Manual. FAO fisheries technical paper 306/1 Rev. 2

[10] Arifin Z 2016 Capture Fisheries Assistant For Tuna Fisherman Community Engagement WWF-Indonesia).

[11] https://www.google.co.id/maps/place/Indonesia

[12] https://afebrianas.files.wordpress.com/2015/02/map-sendang-biru-jpg-e1423730834224 [8

[13] Gayanilo F C and Pauly D 1997 The FAO ICRLAM Stock Assessment Tools (FISAT) reference manual. FAO Computer Information Series

[14] Costa F E S, Braga F M S, Amorim A F and Arfelli C A 2005 Fishery biology of the YFT, Thunnus albacares in southern Brazil. Col. Vol. Sci. Pap. ICCAT 58 (1) 309-349

[15] Isfandiary X.I 2016 Pola Produksi Penangkapan Ikan Tuna Sirip Kuning (Thunnus alalunga) di Perairan Selatan Jawa Timur Berdasarkan Hasil Tangkapan Yang Didaratkan di Instalasi Pelabuhan P. Sarjana thesis, Universitas Brawijaya.

[16] Hays J 2015 Weather and climate in Indonesia http://factsanddetails.com/indonesia/ Nature_Science_Animals/sub6_8a/entry-4079.html

[17] NOAA 2012 Science Advisor for Stock Assessments: Fish Stock Assessment 101 Series: Part 1—Data Required for Assessing U.S. Fish Stocks http://www.nmfs.noaa.gov/stories/2012

[18] ICCAT 2006 ICCAT Manual CHAPTER 2.1.1: Yellowfin tuna. author: iEO https://www.iccat.int/Documents/SCRS/Manual/CH2/2_1_1_YFT_ENG.pdf

[19] BARD, F.X. and Scott. E.D 1991. Sept traverses transatlantiques d’albacores marques thons migrateurs ou sédentaires? Collect. Vol. Sci. Pap, ICCAT 36 (1) 205-222.

[20] Andrade H A and Kinas Paul G 2004 Estimation of birthdates and catch-at-age using length frequency analysis (LFA), with application for skipjack tuna (Katsuwonus pelamis) caught in the Southwest Atlantic. ICES Journal of Marine Science 61 798-811. doi: 10.1016/j.icesjms.03.002

[21] WOR2 (World ocean review) 2013 Living with the oceans. Published by maribus in cooperation with 2 The Future of Fish – The Fisheries of the Future