

DISTRIBUTION AND BIOLOGICAL ASPECT OF YELLOWFIN TUNA (*Thunnus albacares*) CAUGHT BY INDONESIAN TUNA LONGLINE IN THE EASTERN INDIAN OCEAN

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ABSTRACT

Yellowfin tuna or YFT (*Thunnus albacares*) is one of the important catch for the fishing industry in Indonesia. The aim of this study is to determine the spatial and temporal distribution of YFT in the Eastern Indian Ocean. Scientific observers on commercial tuna longline conducted data collection, mainly based in Benoa, Palabuhan Ratu and Bungus from August 2005 to November 2013. Total of 2,250 YFT were caught and as many as 2,227 of them measured in length. Distribution of YFT caught by Indonesia tuna longline scattered from 0-34°S and 76-133°E where hook rates around Mentawai Islands and along Eastern Java to West Nusa Tenggara tend to be high (> 0.12 fish/100 hooks). A wide size group represented the fishery with the fork length of YFT measuring from 30 cm to 179 cm with mean length was 101.65 cm and modes at 106-110 cm. Mostly YFT has larger size than Lm (100 cm) with percentage 81.04% and caught in most area of the Eastern Indian Ocean. Males were dominant with a female_ -: male ratio of 1:1.45. Meanwhile, female proportion slightly decreased at larger size (> 150 cm) described as equation as $1.8013 - 0.0099 FL$. Food contents consisted of a variety of prey animals where fishes (bony pelagic fishes), molluscs (squids) and crustaceans (shrimps) were the major prey groups. This research also recommends that fisher should conduct fishing operations in areas that have a high percentage of YFT length > 100 cm (Lm), to provide opportunities for the species to spawn at least once throughout their life. It is important to maintain the sustainability of YFT resources in the Eastern Indian Ocean.

INTRODUCTION

Yellowfin tuna or YFT (*Thunnus albacares*) is an important commodity which has the highest catches compared to other tuna species in Indonesia. Four tuna species caught by Indonesia during 2004-2011 totally reached 1,297 metric ton where dominated by YFT up to 69% of total catch. Furthermore, the catch followed by BET (*Thunnus obesus*) 24%, ALB (*Thunnus alalunga*) 6%, and less than 1% of SBT (*Thunnus maccoyii*) (Directorate General of Capture Fisheries, 2012).

YFT is one of the highly migratory species, which distributed worldwide from tropical to sub-tropical ocean and abundance in surface waters with temperature ranged between 15-31°C (Collette & Nauen, 1983). This species also can be found in Atlantic, Indian, and Pacific Ocean but not found in the Mediterranean Sea (Collette & Nauen, 1983; FAO, 1994). YFT distribution in Indonesia stretched from western and southern part of Sumatra, Java, Bali and Nusa Tenggara, Banda Sea and its adjacent area, Sulawesi Sea, Tomini Bay, around Maluku and western part of Papua, and northern of Papua (Pacific Ocean) (Uktolseja *et al.*, 1991; Wudianto & Niki Juluw, 2004).

Conditions of YFT stock in the Indian Ocean generally in good condition as indicated not overfished and overfishing was occurring (IOTC, 2013; ISSF, 2013). However, the demand of tuna from the worldwide market is slightly increase in the last few years, resulted in expanding of the ~~effort~~ effort that could threat the sustainability of tuna species. Therefore, the right and responsible management is a necessity (FAO, 2012). Information of species distribution related to its environmental factors is important on determining the exploitation level and stock assessment, especially for highly migratory species (Lehodey, 2001). On the other hand, biological aspect also needed for comprehensive management measures. The objective of this paper is to analyze both distribution and biological aspect of YFT that collected from scientific observer program on commercial Indonesian tuna longline during 2005 – 2013.

MATERIAL AND METHODS

The data including set position, number of catch and hooks, length in centimeter, and sex obtained from scientific observer program on commercial logline vessel, conducted by Research Institute for Tuna Fisheries, from August 2005 to November 2013 in the Eastern Indian Ocean. Mostly the longline vessel based in Bena Fishing Port, but also in Palabuhan Ratu and Bungus. These data were plotted according to longitude, latitude, period of fishing, location of setting, number of operated hooks in daily deployed, catch in number, sex, stomach content and length (FL). The length frequency was aggregated and compared with length at first maturity of YFT (L_m) = 100 cm (Zhu et.al, 2008; IOTC, 2013). The nominal fishing effort of tuna longline was described as the number of hooks used on certain area of fishing, while hook rates calculated as number of fishes caught per 100 hooks. Range of hook rates on each hauls, length distribution and sex proportion were pooled and plotted according to $5 \times 5^\circ$ square of latitude and longitude map to illustrate the spatial distribution of YFT.

The hook rates were calculated using an equation for every 100 hooks. Chi-Square analysis with 95% of confidence interval also implemented to determine sex ratio between male and female. Hypothesis in this study that sex ratio of male and female is equal. The relationship between length and female ratio was calculated using regression formula followed Nootmorn et.al (2005).

RESULT AND DISCUSSION

Fishing ground

Observed fishing ground in the Eastern Indian Ocean scattered from $0-34^\circ\text{S}$ and $76-133^\circ\text{E}$ (Figure 1). The observed longline vessel that based in Bena Fishing Port sets were concentrated within the area between $8^\circ - 18^\circ\text{S}$ and $107^\circ - 122^\circ\text{E}$. On the other hand, longline vessel that based in Palabuhan Ratu fishing in the southwestern Sunda Strait, while the other vessel based in Bungus fishing in the western part of Mentawai Islands

waters. The furthest location of these sets occurred in period 2006-2008 and 2012. Fishing ground distance is related with the fishes targeted (either fresh or frozen), wherein all of fishes caught by a vessel that fishing in far distance being landed mostly in frozen rather than fresh condition.

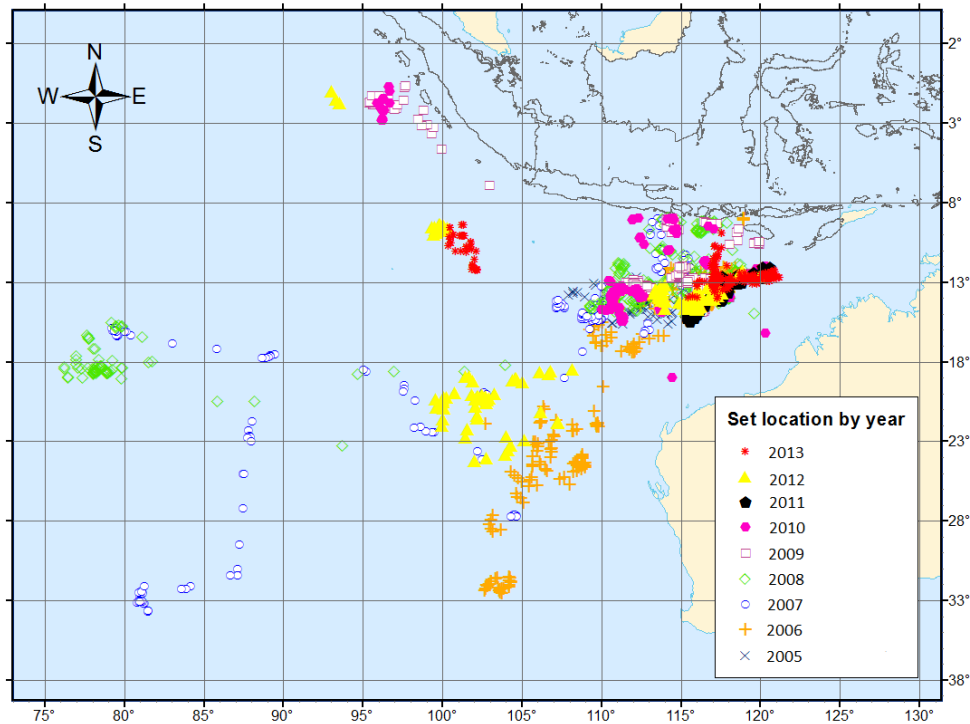


Figure 1. Distribution of observed setting for tuna longline from 2005 to 2013

Hook rates

Annually average of YFT hook rates distribution caught by Indonesia tuna longline was varied where the highest occurred in 2006 (0.11 fish/100 hooks), while the lowest one in 2005 (0.011 fish/100 hooks) as illustrated in Figure 2. However, in 2005 scientific observer program has just began and still in preliminary level, so the case in 2005 could be an exception. In addition, the second lowest of hook rates also occurred in 2011 (0.06 fish/100 hooks). Spatially hook rates also determined by 5x5° degree of latitude and longitude where the result showed that hook rates around Mentawai Islands and along Eastern Java to West Nusa Tenggara tend to be high (> 0.12 fish/100 hooks). On the other hand, a lower hook rate has occurred in western part of Bengkulu waters and southern part of Java Island (Figure 3).

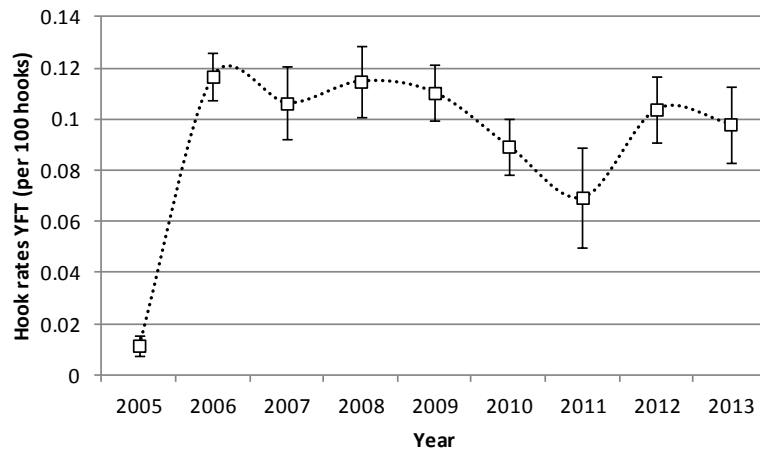


Figure 2. Annually average of YFT hook rates caught by Indonesia tuna longline

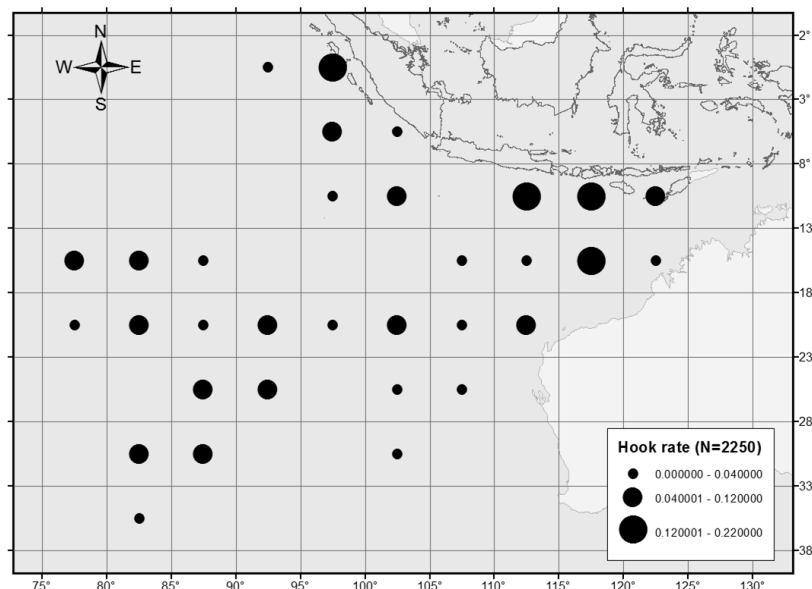


Figure 3. Spatially distribution of YFT hook rates by Indonesian tuna longline

Length distribution

YFT that caught by Indonesian tuna longline during 2005-2013 totaled 2,250 fishes, but only 2,227 of those that can be measured. Range of length distribution of male YFT were from 43 to 178 cm (mean 135.3 cm), female ranged from 30-170 cm (mean 130.80 cm), and unsexed YFT range from 30-179 cm (mean 101.65 cm). Length distribution also analyzes by monthly indicated that the longest mean occurred in May (130.37) and the lowest in February (95.33 cm). Mostly YFT (81.04%) were caught by longliner has larger size than its length at first maturity ($L_m = 100$), otherwise 18.96% YFT has smaller compare with L_m (Figure 4). YFT that is larger than 100 cm caught in

most area of the Eastern Indian Ocean, while YFT smaller than 100 cm caught in the western part of Bengkulu waters and central-Eastern Indian Ocean (Figure 5).

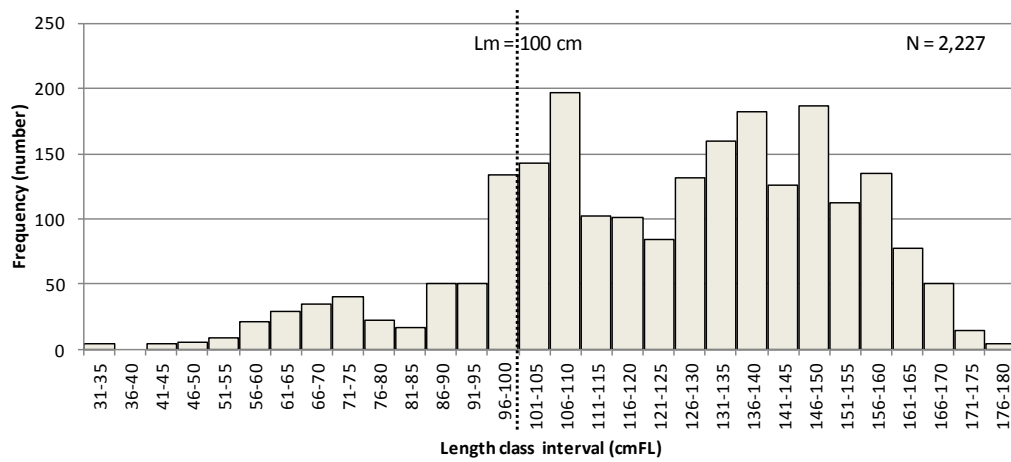


Figure 4. Length distribution of YFT were caught in Eastern Indian Ocean.

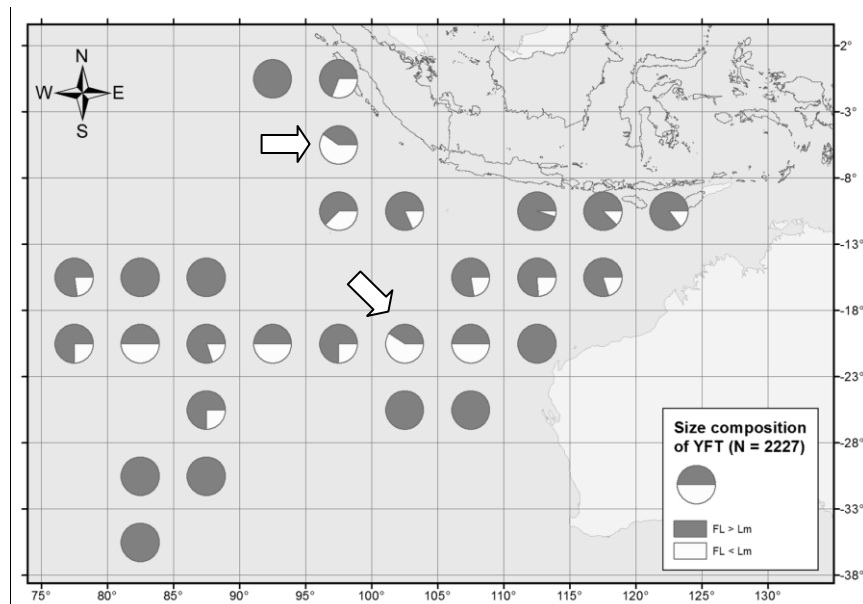


Figure 5. Spatially-size distribution of yellowfin tuna compared its length at first maturity (L_m) in the Eastern Indian Ocean

Sex ratio

Sex ratio over all YFT size for female and male was 1:1.45 respectively. Chi square test with 95% confidence interval also implemented and there were showed that is not equal condition where male was dominated rather than female. Similar result also gathered from previous study i.e. [Rohit & Rammohan \(2009\)](#) in Andhra waters (India); [Kar et.al \(2012\)](#) in Andaman and Nicobar waters; [Zhu et.al \(2008\)](#) in Central and Western Indian Ocean; and [Marsac et.al \(2006\)](#) whose reported that male was predominantly than female.

Proportion of male was dominant in every length class interval meanwhile female proportion slightly decreased at larger size (> 150 cm). Even, female fish disappeared over 170 cm fork length. Males are increasingly dominant at sizes greater than 140 cm, reaching levels close or over 80% of males at 160 cm in every ocean (Fonteneau, 2005). The relationship between female ratio and fork length described as regression equation as illustrated in Figure 7a. However, monthly female proportion indicated in equal condition in 95% confidence interval occurred in March, August, September and October (Figure 7b). Sex ratio, the monthly proportion of male and female was used to expect the spawning capability of fish (Hamano & Matsuura, 1987 cited in Nootmorn, 2005). YFT with size over than 100 cm were caught around Indonesia archipelago waters are dominated by male (63.94%) than female (36.06%). Nevertheless, large-sized YFT caught in East Java waters indicated in equal condition between male and female (Figure 8).

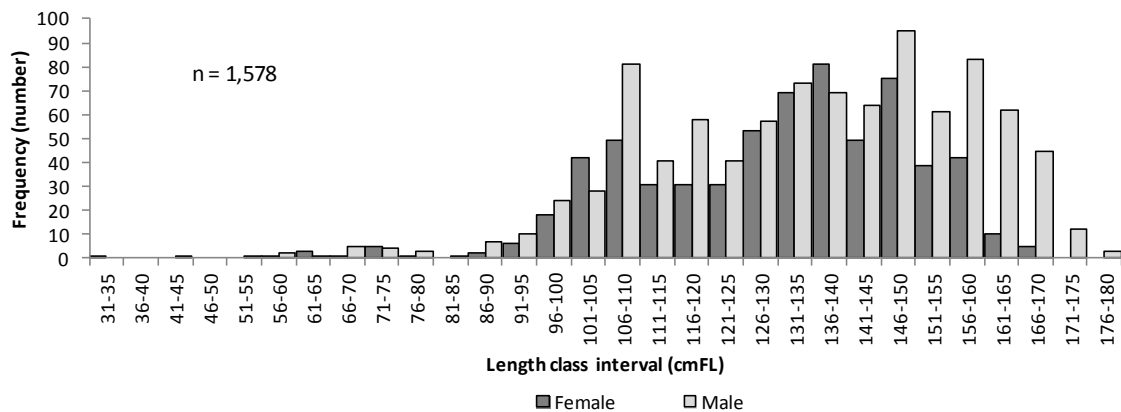


Figure 6. Sex ratio of YFT according to length class

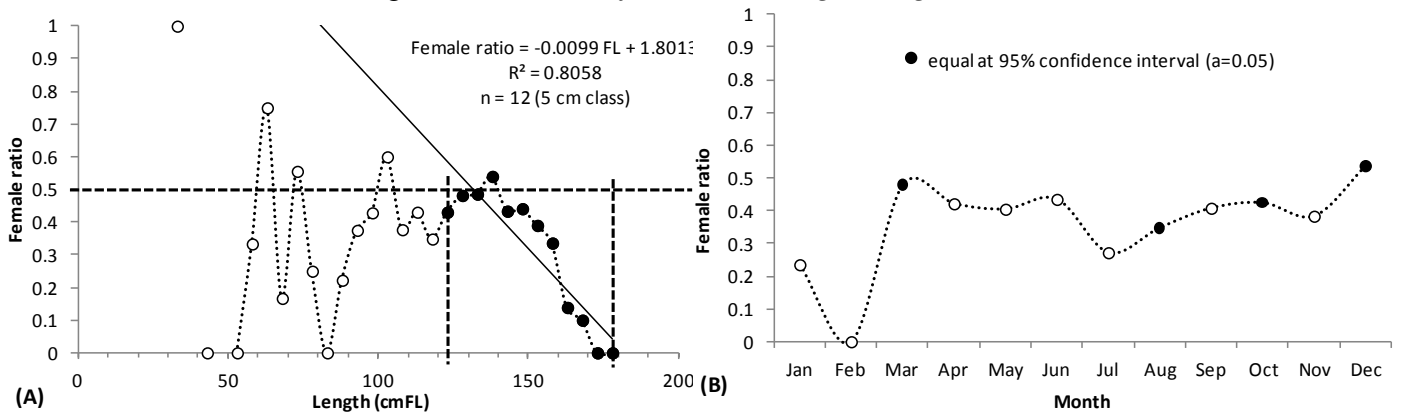


Figure 7. (a) Relationship between female ratio and fork length; (b) Monthly female ratio of YFT caught by Indonesian tuna longline in the Eastern Indian Ocean

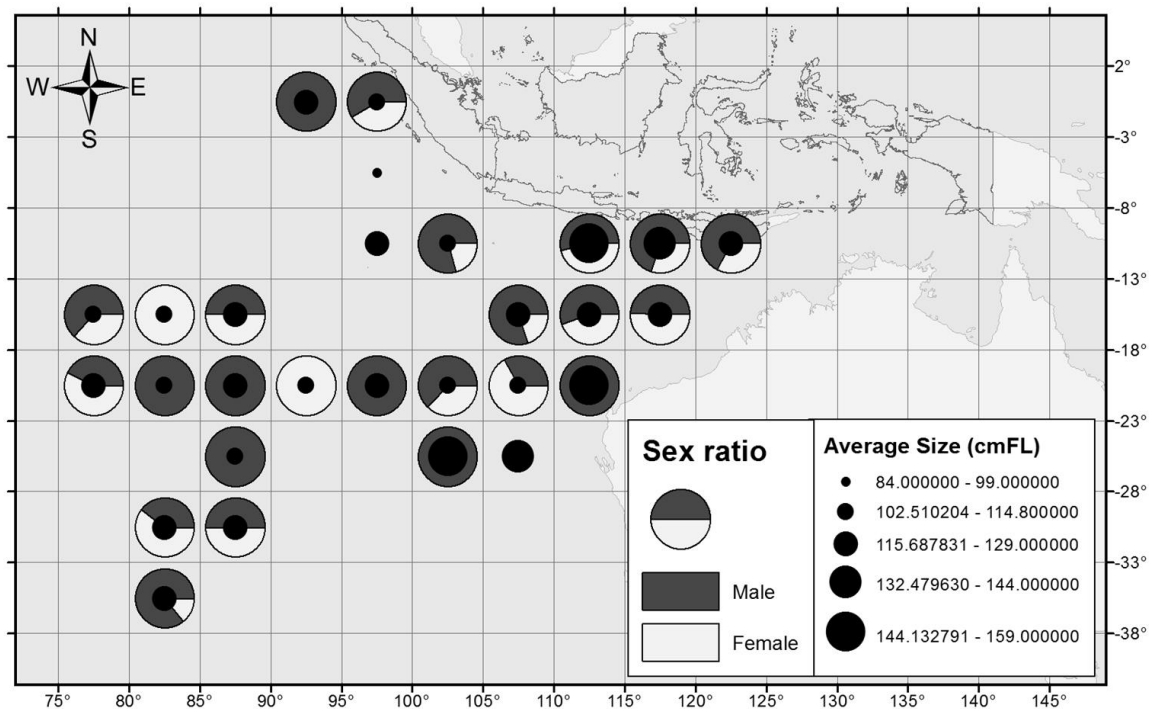


Figure 8. *Spatial distribution of sex ratio YFT accordance with size in the Eastern Indian*

Food habits

Disregarding the digested prey (15.5%), the diet proportion of YFT showed a domination of mackerel scad (53.9%), followed by lancetfish (7.9%), sardines (7.5%), mackerel (3.8%), anchovy (1.0%), sickle pomfret (0.2%), and finally followed by shrimps (2.1%) and squids (8.1%) (Figure 9). Fishes placed as main diet for YFT (67.7%), while cephalopods (1.5%) and crustacean (0.3%) as additional diet. Similar result reported by [Allain \(2005a\)](#) in Western and Central Pacific for albacore, bluefin, yellowfin and skipjack tuna where the important prey groups found in the stomachs (measured by weight) were dominated by fish (64–88%), mollusks (6–25%) and crustaceans (0.2–9%). Different result ~~occurred~~ occurred in the Bay of Bengal according to [Notmoorn et.al. \(2008\)](#), group of cephalopods were dominant in the diet composition for common tuna and tuna-like species, including YFT, with percentage 60.7%, followed by group of fishes (38.8%).

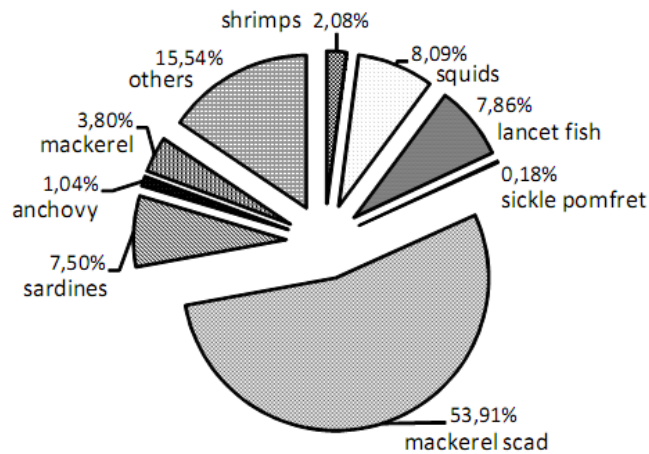


Figure 9. Diet composition of YFT caught by Indonesian tuna longline in the Eastern Indian Ocean.

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REFERENCE

- Allain, V. 2005. Diet of four tuna species of the Western and Central Pacific Ocean. SPC Fisheries Newsletter #114–July/September 2005. 20p.
- Collete, H.B. & C.E. Nauen. 1983. FAO species catalogue. Vol. 2. Scombrids of the world. An Annotated and illustrated catalogue of tunas, mackerels, bonitos, and related species known to date. FAO Fisheries Synopsis. No. 125, Vol. 2. Rome, Italy: FAO Press, 137 pp.
- DGCF (Directorate General of Capture Fisheries). 2012. Statistik Perikanan Tangkap Indonesia 2011. Kementerian Kelautan dan Perikanan, Jakarta. 190 pp.
- Fonteneau, A. 2005. An overview of yellowfin tuna stocks, fisheries and stock status worldwide. IOTC 7th Working party on tropical tunas Phuket-Thailand, 18-22 July 2005. 37 p.
- Food and Agriculture Organization. 1994. World review of highly migratory species and straddling stocks. FAO Fisheries Department. Technical Paper No. 337. Rome, FAO. 70 p.

- Food and Agriculture Organization. 2012. The State of World Fisheries and Aquaculture 2012. FAO Fisheries and Aquaculture Department. Rome, Italy. 230 pp.
- Indian Ocean Tuna Commission. 2013. Report of the Fifteenth Session of the IOTC Working Party on Tropical Tunas. San Sebastian, Spain, 23–28 October 2013. 93 pp.
- International Seafood Sustainability Foundation. 2013. ISSF Tuna Stock Status Update, 2013(2): Status of the world fisheries for tuna. ISSF Technical Report 2013-04A. International Seafood Sustainability Foundation, Washington, D.C., USA. 88 pp.
- Kar, A.B., L. Ramalingam, K. Govindaraj & G.V.A. Prasad. 2012. Study of the growth and population parameters of yellowfin tuna (*Thunnus albacares*) in the Andaman and Nicobar waters based on the length frequency data. IOTC 14th Working party on tropical tuna, Mauritius, 24-29 October 2012. 17p.
- Lehodey, P. 2001. The pelagic ecosystem of the tropical Pacific Ocean: dynamic spatial modelling and biological consequences of ENSO. *Progr. Oceanogr.*, 49:439-468.
- Marsac F, Potier M, Peignon C, Lucas V, Dewals P, Fonteneau A, Pianet R, Ménard F. 2006. Updated biological parameters for Indian Ocean yellowfin tuna and monitoring of forage fauna of the pelagic ecosystem, based on a routine sampling at the cannery in Seychelles. IOTC 8th Working party on tropical tuna, Seychelles, 24-28 July 2006. 15 p.
- Nootmorn, P., A. Yakoh, & K. Kawises. 2005. Reproductive Biology of yellowfin tuna in the Eastern Indian Ocean. IOTC 7th Working Party on Tropical Tuna, Phuket-Thailand 18-22 July 2005: 8 p.
- Nootmorn, P., Sumontha, M., Keereerut, P., Jayasinghe, R.P.P.K., Jagannath, N. & M.K. Sinha. 2008. Stomach content of the three large pelagic fishes in Bay of Bengal. IOTC-2008-WPEB-11.p.1-13.
- Rohit, P. & K. Rammohan. 2009. Fishery and biological aspect of yellowfin tuna *Thunnus albacares*. *Asian Fisheries Science* 22: 235-244.
- Uktolseja J.C.B., B. Gafa & S. Bahar. 1991. Potensi dan penyebaran sumberdaya ikan tuna dan cakalang. dalam: Martosubroto P., N. Naamin, B.B.A. Malik (editor). Potensi dan Penyebaran Sumberdaya Ikan Laut di Perairan Indonesia. Jakarta: Direktorat Jenderal Perikanan. Pusat Penelitian dan Pengembangan Perikanan. Pusat Penelitian dan Pengembangan Oseanologi. Jakarta. 29-43 pp.
- Wudianto & V.P.H. Nikijuluw. 2004. Guide to Invest on Fisheries in Indonesia. Directorate of Capital and Investment System. Ministry of Marine Affairs and Fisheries Republic of Indonesia. 17p.
- Zhu G, Xu L, Zhou Y, Song L. 2008. Reproductive biology of yellowfin tuna *T.albacares* in the west-central Indian Ocean. *Journal of Ocean University of China (English Edition)* 7: 327-332.