LENGTH-WEIGHT RELATIONSHIP, SIZE DISTRIBUTION AND ANNUAL CPUE's OF ALBACORE IN EASTERN INDIAN OCEAN

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ABSTRACT

Albacore (*Thunnus alalunga*, Bonnaterre, 1788) is one of the tropical tuna species in the Eastern Indian Ocean incidentally caught by the Indonesian tuna longliner. Scientific observer series data during the period of 2005 – 2012 showed that the catches were geographically distributed within the area bordered by 5 – 35^0 S and 75 – 130^0 E. High CPUE mainly occurred in sub area between 25^0 and 35^0 S. Some biological observations indicated that immature albacore specimens were mainly recorded in areas of south of 25^0 S while mature albacore were concentrated in the area between 10^0 S and 25^0 S. Length – weight measurements for pooled male and female was $W= 0.00008FL^{2.7271}$. The hook-rates from onboard observation showed that increasing rates occurred during 2009 to 2012. The annual landing showed that that highest occurred in 2008 and the lowest in 2011 with overall tend to decrease until 2011 and increased slightly in 2012. Series number of length frequency measurements (2005 - 2012) showed that the albacore were caught within the range of 40 – 135 cm FL and there was a tendency that the average size decreased gradually from 103 cmFL (2005) to 84 cmFL (2012). As a preliminary finding these estimates contribute as important element for consideration in the national and regional tuna fisheries management in the area.

KEYWORDS: Scientific observer, length-weight relationship, size distribution, hook-rates.

INTRODUCTION

Tuna species is an important fishery resource shared by several nations bordering the Indian Ocean. Several type of fishing gear were employed in tuna fisheries. Longline fisheries commercially commenced in late 1965 (Simorangkir, 2000), while the small scale tuna fisheries with various type of fishing gear and species already exist in previous decades. There are several tuna species landed along the coast of western Sumatra and southern Java Islands of East Indian Ocean region. Statistically, the tuna species were formally recorded since 1977, however the breakdown statistics of tuna species including albacore were available since 2004 (DGCF, 2006).

This species distributed widely across the oceanic waters from latitude of 50^0 N to 40^0 S in the Indian Ocean (Yoshida & Otsu, 1983; Collette & Nauen, 1983). The states of albacore in IOTC (Indian Ocean Tuna Commission) region indicated that the stocks is subject to overfishing. Fishing mortality needs to be reduced at least 20% to ensure that spawning biomass is maintained at MSY level (IOTC, 2013). Maintaining or increasing effort in the core of albacore fishing grounds is likely to cause further decline in albacore biomass, productivity and CPUE (IOTC, 2013).

Since Indonesia becomes a full member of IOTC, research activities on several tunas species were developed. Albacore (*Thunnus alalunga*, Bonnaterre, 1788) is one of the common large pelagic highly migratory species (UNCLOS, 1982) that incidentally caught by tuna longliner operating mainly in south of Java. As a part of national research activities to provide scientific information, several onboard scientific observer program supervised by several regional organization (IOTC, CSIRO) were carried out since 2005. This regular activity aimed to collect a real time catch and effort data from commercial tuna long liner including some basic biological data. The landing were also recorded through regular enumeration in selected tuna fishing company.

This paper presents some information regarding some biological aspects such as length-weight relations, distribution on size and catch, estimation of catch per unit of effort. Data were collected from commercial tuna longline vessels that observed during period of 2005 – 2012. This study contributes for the strenghthening of biological and fisheries data that will be useful for managing this important highly migratory oceanic fish resources.

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MATERIALS AND METHODS

Study area and sampling

Study focused on longline fisheries. There were two types of data that have been collected; first was the specimens caught on onboard longliner through scientific observer program in which every fish caught was measured. The data were collected from October 2005 to November 2012 comprising of a total of 66 trips with an average of 55 days/trip. These data were plotted on a 5x5-degree square basis according to vessel, period of fishing, location of deployment, number of operated hooks in daily deployed, catch in number and length (FL). The second type of data were collected from port-based monitoring program, from January 2010 to December 2012 in 14 processing plants based on Port of Benoa. Daily Sampling was done randomly on the basis of enumerator availability and unpredicted landing of fishing fleets. The biological data consisted of length frequency (FL) and weight (Kg) and were collected based on IOTC sampling protocol (IOTC, 2002).

Whole weight (RW) was measured with mechanical scales to the nearest 0.5 kg. Estimations of catch landed were calculated from port-based monitoring program in the processing plant in Benoa Port. This program is well-established and it contributes more than 60% of Indonesian tuna catch (Satria *et al*., 2011). The estimated annual landings were derived from the following formula proposed by IOTC (2002):

$$C_m = L_m * AV_m \quad \text{..} \quad (1)$$

Where :
C_m- total catch per month (in Ton),
L_m- total landing per month (in Ton) and
AV_m- average catches per month.

Length-weight relationship.

Length-weight data were also obtained from port-based monitoring program in Oceanic Fishing Port of Cilacap from January to December 2011. The specimens were randomly sampled from every catch landed. For each sampled fish, fork length (FL) was measured to the nearest 1 cm and weighted (RW) were measured with mechanical scales to the nearest 0.5 kg. The length – weight relationship was quantified using simple power function:

$$W = a * L^b \quad \text{..} \quad (2)$$

Where: W - round weight (in kg),
L - fork length (in cm),
a and b - parameters to be estimated.

In order to confirm whether b-values obtained in the power regressions were significantly different from the isometric value (3), Student's t-test (H_0: b = 3) was applied. The length frequency were plotted by year and the average length were analyzed throughout the period of observation. The nominal fishing effort of tuna longline fishery was described as the number of hooks used on certain area of fishing, while hook rates (CPUE) calculated as number of fishes caught per 100 hooks (Klawe, 1980). Range of hook rates on each hauls were pooled and plotted within 5° square georeference to describe the geograpical distribution of albacore.

RESULTS AND DISCUSSION

RESULTS

Length and Weight Relationship

Another set of data were collected regularly from port-based monitoring program in Cilacap between January to December 2011, a total of 497 specimens were measured. Individual Specimens ranged from 80 – 105 cmFL with 15 – 27 kg of weight. The student's t-test showed that regression coefficients explained significant deviations from isometric value of 3 (t_{value} = 2.1912; P < 0.001), with b = 2.7271 (Figure 1). To compare the recent findings, several previous findings on Length-Weight by authors were shown in Table 1.

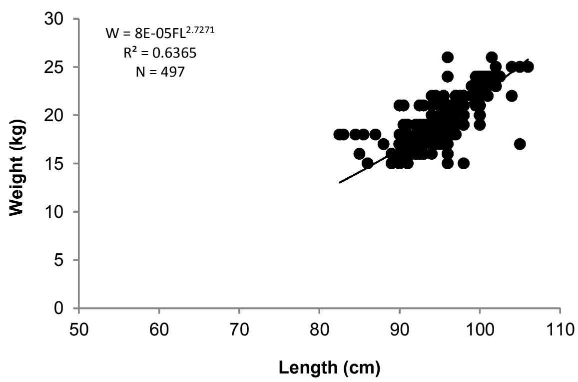

Figure 1. The scatter plot of 497 pairs of length-weight of albacore from the Indian Ocean based on Cilacap port-based monitoring program in 2011.

Several previous findings on length weight relationship showed that both slope and intercept slightly difference. The highest intercept and the lowest slope found in Zhu *et al*. (2010) based on the data collected in different fishing ground in Atlantic, Indian and Pasific Oceans, while Triharyuni *et al* (2012) give the lowest intercept and slope relatively in the same fishing ground. No clear evidence to explain this difference.

Table 1. Length – weight relationship of albacore in the Indian Ocean

No	Author	N	FL Range (cm)	Intercept (a)	Slope (b)	R^2	Gears
1	Setyadji *et al.* (2014)	497	83 – 106	0.00008	2.7271	0.6365	Longline
2	Triharyuni *et al* (2012)	817	94 – 113	0.000006	3.4205	0.8585	Longline
3	Zhu *et al.* (2010)	88	93 – 119	0.00043	2.3428	0.7644	Longline

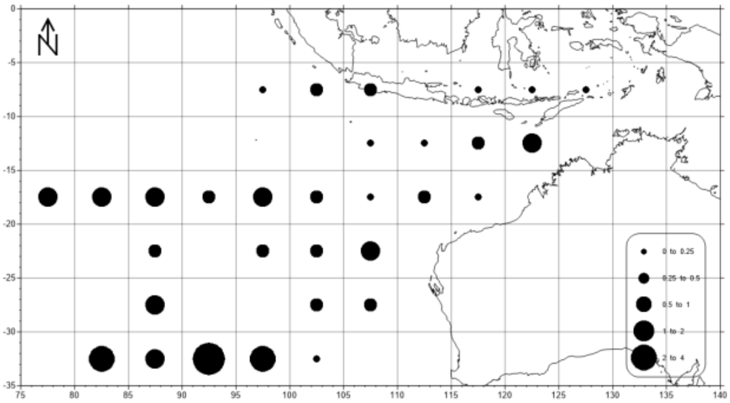

Figure 2. The distribution of average CPUE of albacore based on observer data collected from longline fishery in Indian Ocean (2005 – 2012).

Remarks : Black circle legend represents quantiles of CPUE.

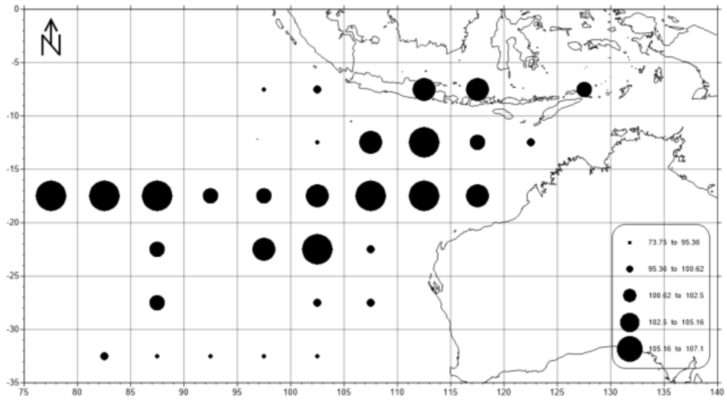

Figure 3. The distribution of mean length of albacore from selected onboard observer longline fishery in the Eastern Indian Ocean (2005 – 2012).

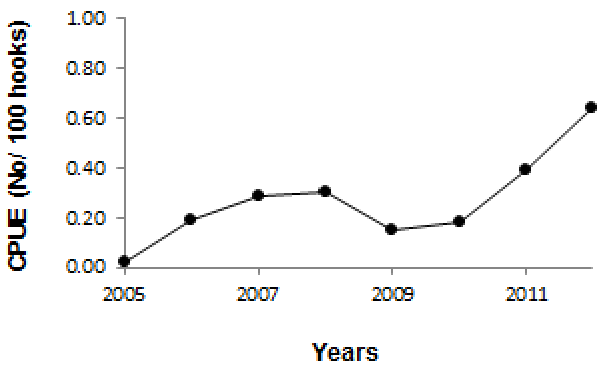

Figure 4. Development of nominal CPUE based on onboard observation between 2005 and 2012.

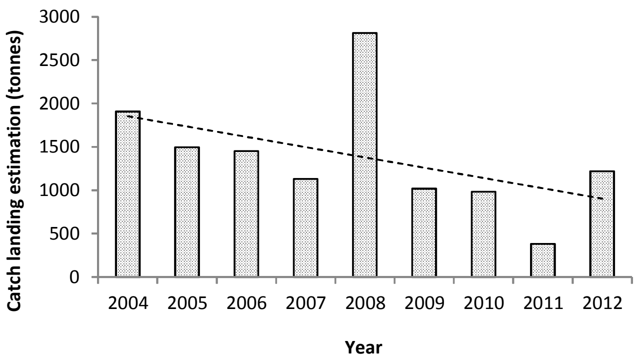

Figure 5. Estimation of annual catch (in metric tones) of albacore by longline landed at the port of Benoa. The dashed line was the predicted trend over years.

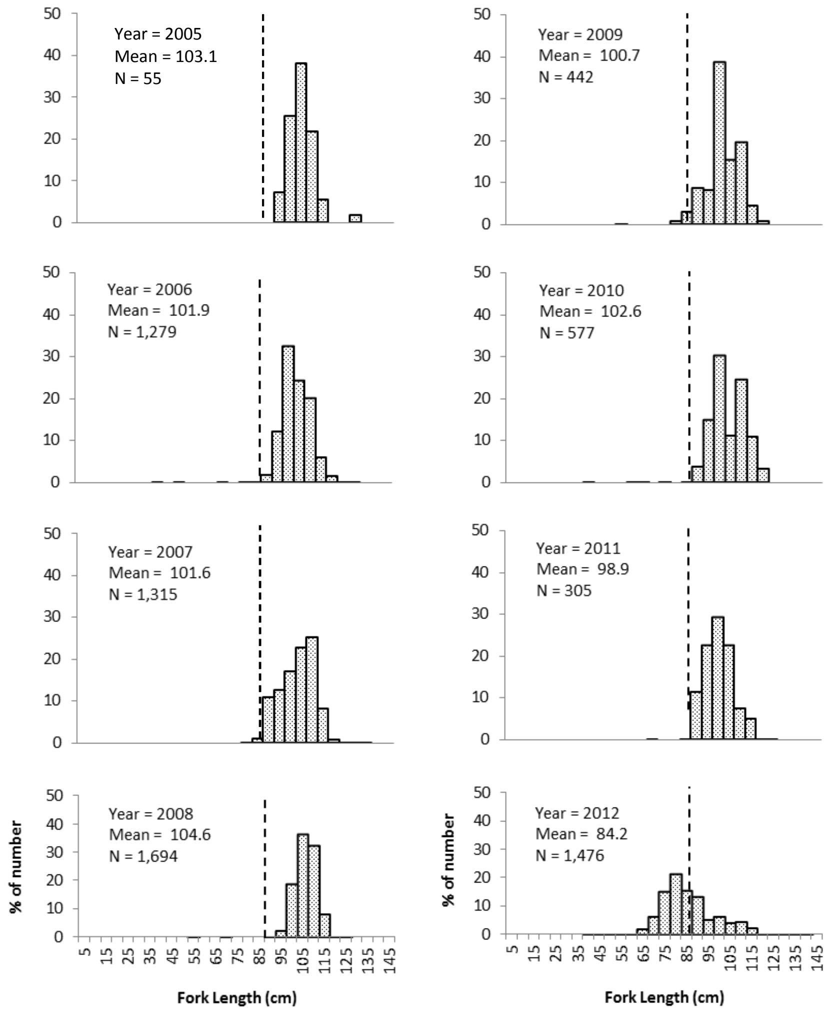

Figure 6. Annual length distribution of albacore caught by Indonesian tuna longline fleets in Eastern Indian Ocean. The dashed line showed the Lm for albacore as proposed by Wu & Kuo (1983).

Catch and CPUE Distribution

The annual catch distribution based on onboard observer program during 2002-2008 showed that the albacore mostly occurred from 5 – 35^0 S and 75 – 130^0 E (Figure 2). Looking at the distribution of the catch, the hook rates tend to be higher south of 30^{0}S and west of 100^0 E with sub fishing area with high CPUE (1 – 5/ 100 hooks) occurred between 25^0 and 35^0 S with small extent in the area 10^0 – 15 0 S.

The annual average of CPUE of onboard observer data varied among years, but showing progression trends over the years, the lowest catch was recorded in 2005 with an average of 0.02 fish/100 hooks and the highest was in 2012, with 0.64 fish/100 hooks (Figure 4). No sufficient data to explain the trend, and the increasing trend of CPUE probably due to the limited data collected from the vessel as it covers only few trips. On the other side the estimation of annual total catch during 2004 – 2012 shows gradual decline over years (Figure 5.). The highest landing (2811 metric tons) occurred in 2008 and the lowest (384 metric tons) in 2011, which is around 13% compared to 2008 or 20% of 2004 landings. The estimated landing was based on a serial data collected in port based monitoring program.

Size Distribution

The average length (cmFL) of specimens caught indicated that the fish adversely distributed with CPUE, even if still not clearly distinct. There is a tendency that fish with smaller size mostly found in the area between 25 - 35^0 S, while bigger size were recorded in shorter distance from the fishing base of 10 – 25^0 S (Figure 3).

Total specimens collected were 7,143 from onboard observation program from 2005 – 2012 which covered part of the Eastern Indian Ocean. The minimum length was recorded at 38 cm, and maximum length 138 cm with an average of 99 cm. Overall, most of the catch was above its predicted size of first maturity (L_m) of 90 cm length (Wu & Kuo, 1983).

The annual average size of specimens ranged between 84.2 – 104.6 cm with tends to become gradually smaller in the latest year (Figure 5). This probably due to shifting fishing ground toward the southern waters in which most of the catches consisted of smaller and immature fish.

DISCUSSION

Distribution pattern of CPUE albacore in this study were similar to those found based on Taiwanese fleets where areas of high CPUE obtained usually between 25^0 – 45^{0}S (Huang *et al*., 2003; Chen *et al*., 2005) which likely influenced by environmental factors such as temperature, salinity and dissolved oxygen (Chen *et al*., 2005). An interesting fact shown that the catch in the area between 10^0 – 15^0 S, 90% of the fish caught were relatively low in number but dominated by mature albacore (> 90 cm), while in fishing ground south of 15^0 to 35^0 S, the number of catch were significantly higher but dominated by immature fish. It was relevant with distribution theory proposed by Chen *et al.,* (2005) where immature albacore in the Indian Ocean were mainly distributed in areas south of 30^0 while the mature fish, mainly concentrated between 10^{0}S and 30^{0}S. Additional information shown that area from 5^0 N to 25^{0}S is the distribution area for adult fish, in which spawning area exists in the area from 10^0 S to 25^0 S and feeding water from 30^0 S to 40^0 S (Nishida & Tanaka, 2008).

Length class interval is one of the main components in constructing catch-at-size data for stock assessment purpose (Herrera & Pierre, 2011). These do not clearly showed that there was significant shifting on range of average length frequency over years until 2012 which more immature albacore were landed (27%). This phenomenon exist probably due to the intensity of fishing which is increasing over years, and probably linked to also due to shifting fishing ground, and its strategy, from targeting fresh to frozen tuna to maximize the benefit. To raise the commercial catch of albacore, the fisher has to go further to the southern fishing grounds.

The length – weight relationship analysis showed that the growth pattern of albacore landed performed negative allometric, where growth in length is faster than growth in weight. The slope was lower compared to other results in the Indian Ocean namely from the Taiwanese gillnet fishery (Hsu,1999) and tuna landing analysis from Cilacap Port monitoring program (Triharyuni *et al*.,2012) but higher than the Chinese longline vessels (Zhu *et al*., 2010). Low value of R^2 found in this paper compared to other authors was caused by outliers, which always distort the curves much more towards themselves (Sen & Srivastava, 1990), even though the outliers may not be relevant to the large sample sizes in regression analysis (Hsu, 1999). This discrepancy also may be due to the different sample sizes, different gears and estimation methods, especially when the samples came frozen, so the weight might be bias. Direct measurement onboard is preferred in order to get more accurate weight information even though it had never been practised in Indonesian commercial tuna longline vessels.

CONCLUSION

Catch of albacore distributed from 5 – 35^0 S and 75 – 130^0 E, subarea of high CPUE occurred between 25^0 and 35^0 S. Immature fish were mainly distributed in areas south of 25^{0}S while the mature fish, mainly concentrated between 10^0 S and 25^0 S. The length – weight relationship was expressed as $W= 0.00008FL^{2.7271}$ and showed negative allometric relationship, where growth in length is faster than growth in weight. Observation on bio-reproduction aspects clearly showed that most of the fish landed by the tuna fleets operated in 10-15^o S latitude were mature fish while the fish caught within the area of 25-35^o S were mostly smaller size and in immature stages.

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REFERENCES

Chen, I.C., Lee, P.F. & Tzeng, W.N. 2005. Distribution of albacore (*Thunnus alalunga*) in the Indian Ocean and its relation to environmental factors. *Fish. Oceanogr*. 14 (1): 71 - 80

Collette, H.B. & Nauen, C.E. 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. 2006. Capture Fisheries Statistics of Indonesia. Directorate General of Capture Fisheries. Ministry of Marine Affairs and Fisheries. 181 p.

Hsu, C.C. 1999. The length-weight relationship of Albacore, *Thunnus alalunga*, from the Indian Ocean. *Fisheries Research*. 41 (1999): 87-92

Huang, H.W., Hsu, C.C., Lee, H.H. & Yeh, Y.M. 2003. Stock assessment of Albacore, *Thunnus alalunga*, in the Indian Ocean by Surplus Models with a New Relative Abundance Index. *TAO*. 14(2): 201-220

Herrera, M. & Pierre, L. 2011. Preparation of catch-at-size and catch-at-age files for the stock assessments of tropical tunas. IOTC-2011-WPTT13-07a. Thirteenth Working Party on Tropical Tunas, Maldives, 16–23 October 2011. 44 pp.

Indian Ocean Tuna Commission (IOTC). 2013. Executive summary: albacore. Appendix VIII. IOTC – 2013 – SC16 – R [E]. 11p.

Indian Ocean Tuna Commission (IOTC). 2002. Field manual for data collection on tuna landings from longliners. IOTC Technical Report 02/02. IOTC – Seychelles, July 2002.

Klawe, W.L. 1980. Long lines catches of tunas within the 200 miles economic zones of the Indian and Western Pasific Ocean. *Dev. Rep. Indian Ocean Prog*.48: 83 pp.

Nishida, T. & Tanaka, M. 2008. General review of Indian Ocean Albacore (*Thunnus alalunga*). IOTC-2008-WPTe-INF03. 8 pp.

Satria, F., Wudianto, Nugroho, D., Sadiyah, L., Nugraha, B., Barata, A. & Suryanto. 2011. National report Indonesia southern bluefin tuna fisheries. Bali, Benoa, 19 - 28th July 2011. CCSBT – ESC/1107/SBT FISHERIES – Indonesia (revised).

Sen, A.K. & Srivastava, M.S.1990. Regression Analysis: Theory, Methods and Applications. Springer. New York. 355p.

Simorangkir, S. 2000. Indonesian Fisheries. Bali Post. 294 pp (In Indonesian)

Triharyuni, S., Sulaiman, P.S. & Rianto, J. 2012. Length weight relationship, exploration rate, and catch fluctuation of albacore (*Thunnus alalunga*, Bonnaterre) in the Indian Ocean (in Bahasa Indonesia). *J. Lit. Perikan. Ind*.18 (1). 35 – 41. (In Indonesian)

Wu, C.L. & Kuo, C.L. (1993) Maturity and fecundity of albacore, Thunnus alalunga (Bonnaterre), from the Indian Ocean. *J. Fish. Soc. Taiwan* 20:135–151.

Yoshida, H.O. & Otsu, T. 1963. Synopsis of Biological Data on Albacore *Thunnus germo* (Lacepede), 1800 (Pacific and Indian Oceans). Species Synopsis No. 9. *FAO Fisheries Biology Synopsis* No.52. 274 - 318

Zhu, G., Xu, L., Zhou, Y. & Dai, X. 2008. Length-frequency compositions and weight-length relations for big-eye tuna, yellowfin tuna, and albacore (Perciformes: Scombridae) in the Atlantic, Indian, and Eastern Pacific Oceans. *Acta Ichthyologica et Piscatoria*. 38 (2): 157 - 161 p. DOI: 10.3750/AIP2008.38.2.12.