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# THE SEASONAL VARIABILITY OF CPUE AND CATCH-AT-SIZE DISTRIBUTION OF TROLL AND HANDLINE TUNA FISHERIES LANDED IN LABUHAN LOMBOK

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## ABSTRACT

Troll and hand line tuna fisheries is one of the major fishing gears landed in Labuhan Lombok coastal fishing port (PPP Labuhan Lombok) west Nusa Tenggara Barat province. Both fisheries are strongly associated with fish aggregating devices (FAD's). The main fishing ground is Indian Ocean southern part of this province. Several source of data have been collected regularly. Data analysis comprised of monthly catch and effort data samples based on port monitoring program during 2012 to 2015. The result showed the dieclining of CPUE of yellowfin and skipjack tuna presumably related to fishing intensity of fleets and its variability that landed in PPP Labuhan Lombok. The increasing CPUE of skipjack tuna in 2014 was predicted due to increasing aggregation around the FADs. Contrasting seasonal fishing index pattern between yellowfin and skipjack tuna found in 4-month cycles, started in January. A length-weight relationship suggested that yellowfin tuna caught by small-scale fisheries were performing allometric growth pattern (b=2.963, $r^2$=0.9737).

**Keywords: Troll and handline fisheries; FADs; fishing season; Labuhan Lombok**

## INTRODUCTION

Approximately 35 million people worldwide are involved in fishing and fish processing and 80% of those are associated with small-scale fisheries (SSF) (Béné, 2006). The number of coastal communities increased to almost 200 million when family unit is added as estimation variable (McGoodwin, 2001). Indonesia known as the second longest coastline after Canada and about 80% of fishing activities are considered as small-scale fisheries (Mous *et al*., 2005) with various type of fishing gears (from traditional to modern technology) were applied to exploit the fish resources (Sumiono, 1997).

As compensation of the limited capacity of their fleets and local knowledge on predicting fish distribution, most of small-scale fisheries rely on the use of Fish Aggregating Device (FADs). This aggregating device historically has been used in eastern Indonesian since in 1980s (Nasution *et al*., 1986). Nevertheless, other information described that artisanal fishers in the Southeast Asia and the western and central Pacific Ocean (WCPO) have been using FADs for hundreds to thousands of years (Kakuma 2000). Monintja & Mathews (1999) mentioned that pole and line fishing on tuna aggregation around FADs increased catch ability by more than 40% compared to free swimming tuna. Despite of it advantages it should be considered that uncontrollable investment on new FADs could be an obstacle for recruitment overfishing, altering migration paths, growth and predation rates for pelagic species (Taquet *et al.*, 2000; Marsac *et al.*, 2000; Davies *et al.*, 2014).

Nusa Tenggara Barat is one of the examples for existing small-scale deep sea hand line tuna fisheries in Indonesia. The estimate total volume of large pelagic fishes landed from small-scale tuna fisheries contributed up to 27,573 tons in 2014 and the fisheries can lead to estimated production value up to IDR 444,272,623 (DGCF, 2015). This value contributed a significant amount of earning to the society to support their livelihood.

Several in-house research of small-scale tuna fisheries in coastal and EEZ of Indian ocean south of Java have been conducted i.e. Nurdin *et al.* (2012)

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which focused on tuna hand line fisheries in Prigi, East Jawa, Faizah & Aisyah (2011) in Sendang Biru, Jawa Timur, Nurdin *et al.* (2015) in Palabuhanratu, Jawa Barat and Sulistyaningsih *et al.* (2011) in Kedonganan Bali. Nurdin *et al.* (2012) described in details of fisheries aspects of small-scale tuna in Prigi, Trenggalek, East Java, while Muhammad & Barata (2012) reported the size structure of hand line catch around fish aggregating device (FADs) in south of Bali and Lombok. Nevertheless, the previous studies were mostly deal with biological parameters, while the fisheries aspect such as seasonal variability and catch per unit of effort (CPUE) are still not well discussed. The only publication related to this subject was from Nurdin *et al.* (2015) in Palabuhan Ratu. The objectives of this study are to provide detail information on fisheries aspects such as CPUE, seasonality and catch-at-size distribution from small-scale fisheries mainly caught using troll and hand line gear. The expected output of this research could be considered as an input in management measures of small-scale tuna fisheries in the area.

## MATERIALS AND METHODS

### *Study Area*

Labuhan Lombok Fish Landing Center Labuhan Lombok was selected due to the largest tuna landing site in West Nusa Tenggara Province and geographically located between two straits (Lombok strait on the west and Alas strait on the east) which presumably as an appropriate location regarding FAD's placement (Figure 1). This landing center has organized fisheries database over the years and become pilot project from NGOs (Non-Government Organization) and Universities for sustainable small-scale fisheries program. Previous study showed that the type of gears used are troll line and hand line (more than 80%) with deep FADs as the main fish attractor (Setyadji & Nugraha, 2015). It also understood that the composition of the fishers is mostly came from Sulawesi Selatan, i.e. Mandar, Sinjai, Polewali, Bone and Majene.

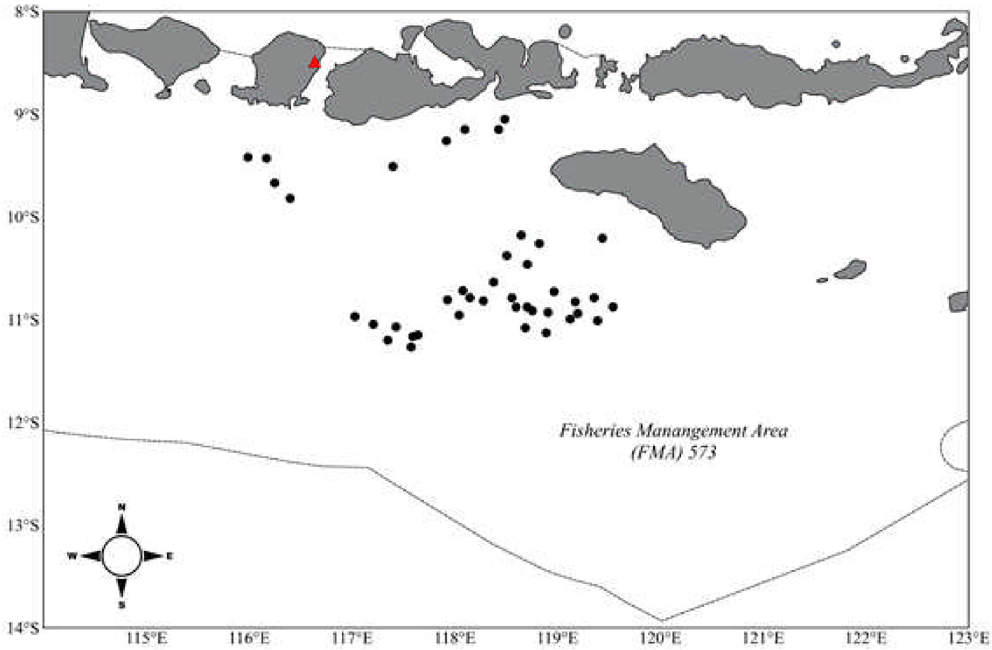


Figure 1. Study area and known FADs from small-scale tuna fisheries based in PPP. Labuhan Lombok (remarks: actual number FADs might be higher).

### *Data Source*

The Main source of data used for analysis derived from daily landing activity at fish auction center (TPI) in Labuhan Lombok, Nusa Tenggara Barat. Sampling was collected regularly during period of May 2012 to December 2014. The biological data consisted of fork length (cm), weight (kg) for each species. Secondary data was retrieved from SL3 provided by the local authority from 2007-2014. This serial fisheries data was analyzed in order to describe the variability of catch and effort data from previous years for CPUE estimation and its seasonality analysis. Catch-at-size data was obtained from port landing monitoring program conducted since May 2012, managed by Research Institute for Tuna Fisheries.



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One should be considered that this paper did not segregate the catch between troll line and hand line since both gears were used simultaneously during the fishing activity targeting the same species. The analysis covered within Fisheries Management Area (FMA) 573 that focused in Indian Ocean south of Java, Bali and Nusa Tenggara. Skipjack tuna (*Katsuwonus pelamis*) and yellowfin tuna (*Thunnus albacares*) were used as a baseline data since both are become the main target for all FAD's associated fisheries in Indian Ocean.

***Data Analysis***

Analysis on seasonal variability of yellowfin and skipjack tuna was performed using average percentage method (Spiegel, 1961). Noting that juvenile yellowfin and bigeye were difficult to identify and always lumped together, it was not included in the analysis thus only large yellowfin tuna (identifiable) which take into account. Catch per unit of effort (CPUE) was the main variable on this calculation. It was extracted from warrant of seaworthy form (SL3), provided by local fisheries authority from 2009-2014 (5 years). Steps of fishing season indices analysis are presented below:

1. Calculation of monthly CPUE ($U_i$) and average of monthly CPUE in a year ($\bar{U}$).

$$\overline{U} = \frac{1}{m}\sum_{i=1}^{m} U_i \quad \text{.........................................} \; (1)$$

where,
$\bar{U}$ : Average of monthly CPUE in a year (kg/trip)
$U_i$ : Monthly CPUE (kg/trip)
*m* : Number of months in a year (12)

2. Calculation of $U_p$ which is the ratio of $U_i$ towards $U$ (in percent):

$$U_p = \frac{U_i}{U} x100\% \quad \text{......................................} (2)$$

3. Calculation of fishing season indices (FS)

$$FS_i = \frac{1}{y}\sum_{i=1}^{y} U_p \quad \text{.........................................} \; (3)$$

where,
$FS_i$ : The indices at particular season (*i*)
*y* : Number of year calculated

4. If the sum of $FS_i$ in a year doesn't equal 1,200%, adjustment should be made with the following formula:

$$AFS_i = \frac{1200}{\sum_{i=1}^{y} FSi} X \; FS_i \quad \text{..........................} \; (4)$$

where,
$AFS_i$ : Adjusted fishing season indices

5. If there is any extreme value of $U_p$ , it would not include on the calculation of FS, instead the median value (*Md*) of the FS would be used. If the total sum of the median value doesn't equal with 1,200%, another adjustment should be made as follow:

$$AMFS_i = \frac{1200}{\sum_{i=1}^{y} Md_i} \text{X} \; Md_i \quad \text{......................} \; (5)$$

where,
$AMFS_i$ : Adjusted median fishing season indices

6. Hypothetically, high fishing season is when index FS > 100 (above average); low fishing season is when FS < 1 (below average); and if index FS=100 it means the season reach its equilibrium.

Individual dressed weight (DW) was recorded to the nearest kilogram for yellowfin tuna, as for skipjack tuna, no weight data recorded due to the unloading speed in the port. Weight and length were fitted by non-linear regression (power function) using DW as the dependent variable, where $DW=\alpha FL^b$ (á and b are parameters). To test b=3 or b$\neq$3 we used Student's t-test under the R stats package 2.3.2, testing the hypothesis $H_0$: $\beta$ =3 (isometric) dan $H_1$: $\beta \neq 3$ (alometric). The t-statistic was calculated as t=(b-3)/$S_b$, where $S_b$=standard error of 'b'; $S_b$=Ö(1/(n-2))*[($S_y$/$S_x$)2-$b^2$]. $S_y$ and $S_x$ are the standard deviations of y and x respectively. The significance of t-value was calculated at 1% and 5% level of significance with (n-2) degrees of freedom (Sawant *et al.,* 2013).

## RESULTS AND DISCUSSION

### Results

***Annual Trend of CPUE***

Mean CPUE of yellowfin tuna reached its maximum in 2010, accounted about 96,799 kg/trip, but then gradually decreased during the following years. The mean CPUE of skipjack has similar trend, reached its first peak in 2011, accounted about 81,930 kg/trip then decreased into its lowest in 2013 with only 53,579 kg/trip. It was then followed by strong increase of mean CPUE at 94,172 kg/trip (more than 90%) in 2014 (Figure 2).



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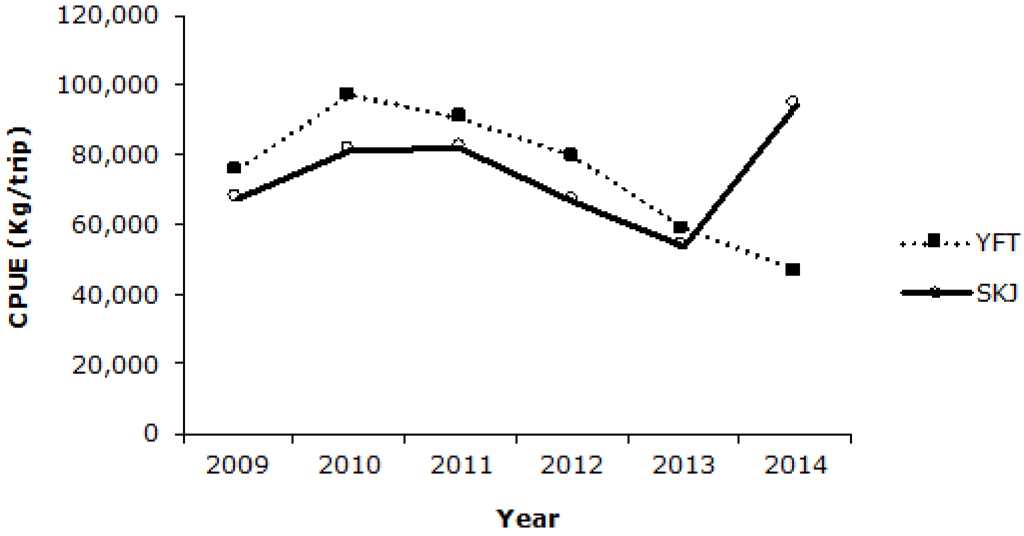
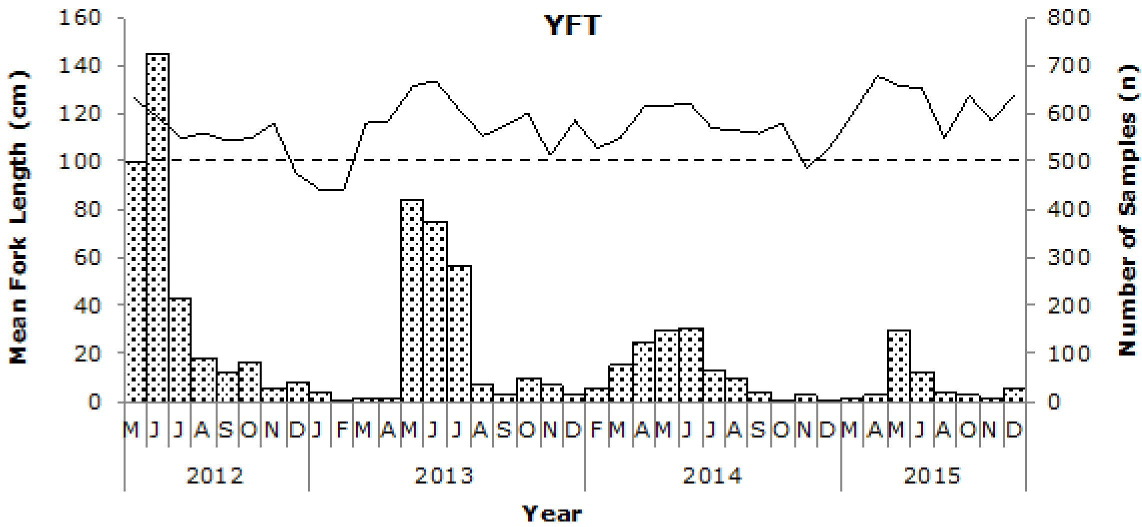



Figure 2. Development of average nominal annual CPUE of yellowfin (YFT) and skipjack (SKJ) landed in PPP Labuhan Lombok from 2009-2014.

*Size-at-catch distribution*

Total catch-at-size data measured from port landing monitoring program during May 2012 until December 2015 was 3,990 individuals for yellowfin tuna and 11,902 individuals for skipjack tuna. The smallest size for yellowfin tuna was 51 cm and the largest was 174 cm. Larger size were mostly found during May to July, while smaller individuals appeared during December to January. The high proportion (>95%) of yellowfin tuna caught was above the $Lm_{50}$ threshold or equal to 100 cm (IOTC, 2014) which mean most of the yellowfin caught by handline were mature and/or at least already spawned. As for skipjack tuna caught during the same period showed that the average size was in between the $Lm_{50}$ threshold, 41-43 (IOTC, 2014). The smallest size for skipjack recorded on the dataset was 14 cm that usually found on May to June and the largest was 82 cm. Large size (above the threshold) are usually found on November to January (Figure 3).



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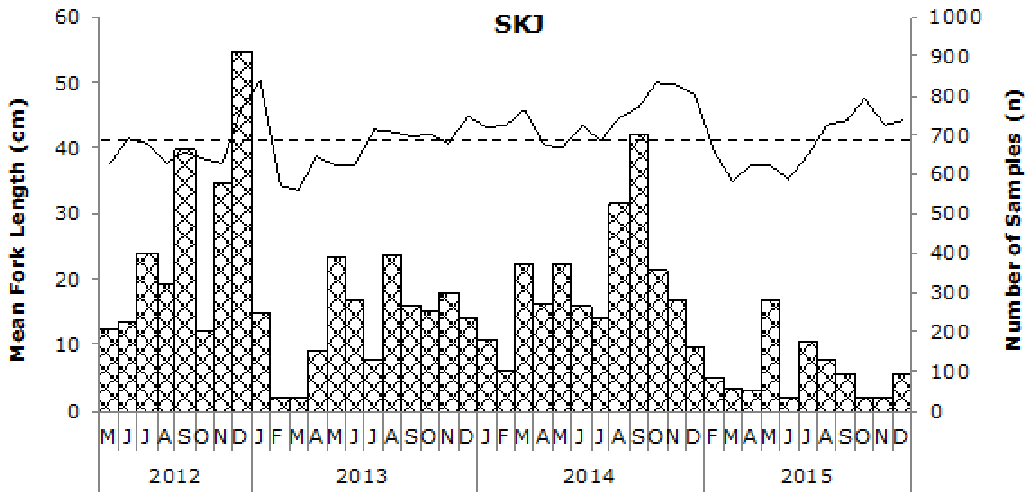


Figure 3. Mean fork length distribution of yellowfin (YFT) and skipjack tuna (SKJ) landed in PPP Labuhan Lombok from 2012-2015 (Remark: Zero catch per month was not included).

*Seasonal Fishing Index (SFI)*

Interesting pattern of the adjusted fishing season indices occurred for yellowfin and skipjack tuna. It performed contrasting interaction, which the fishing season for yellowfin tuna started in April and reached its peak season on June, gradually decreased afterward and started to appear again in small amount in October to December. Skipjack tuna were found throughout the year, but the fishing season started in January, reached the first peak in February then decreased until its lowest season in June. The main fishing season for this species occurred in September when the number of yellowfin tuna were at the second lowest of the season after February (Figure 4).

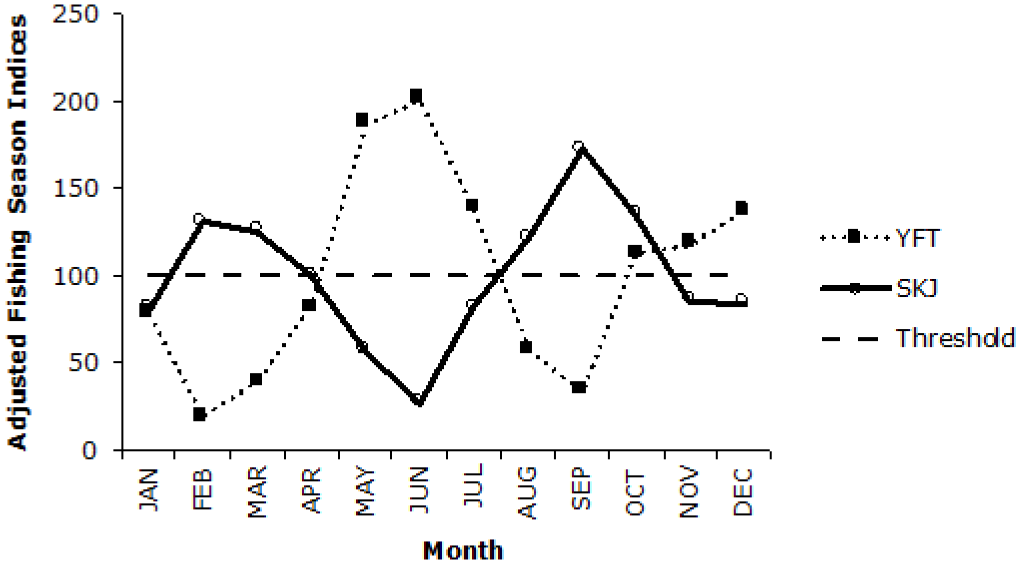


Figure 4. Adjusted fishing season indices of yellowfin (YFT) and skipjack tuna (SKJ) landed in PPP. Labuhan Lombok from 2008 to 2014.

Length-weight relationship for skipjack tuna was not included into the analysis because no weight data available. Growth pattern of yellowfin tuna, as shown by *b* value ranged from 2.826-2.993. Non-linear model analysis showed that samples taken in 2013 (1,221 individuals) resulted in allometric growth while the next two following years (n=687, n=507) were isometric even though the *b* value looked not significantly difference (Table 1). Overall the length-weight model shown negative allometric growth pattern (b=2.963, $R^2$=0.973, t-stat>t-table; 3.57>1.86).



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Table 1. Parameters of length-weight relationship of yellowfin tuna landed in PPP. Labuhan Lombok from 2013-2015.

| No | Year | n | FL Range (cm) | Intercept (a) | Slope (b) | $R^2$ | Growth Type |
|---|---|---|---|---|---|---|---|
| 1 | 2013 | 1,221 | 51 – 174 | 0.00005 | 2.826 | 0.929 | Allometric |
| 2 | 2014 | 687 | 81 – 165 | 0.00002 | 2.993 | 0.973 | Isometric |
| 3 | 2015 | 507 | 77 – 162 | 0.00002 | 2.993 | 0.976 | Isometric |

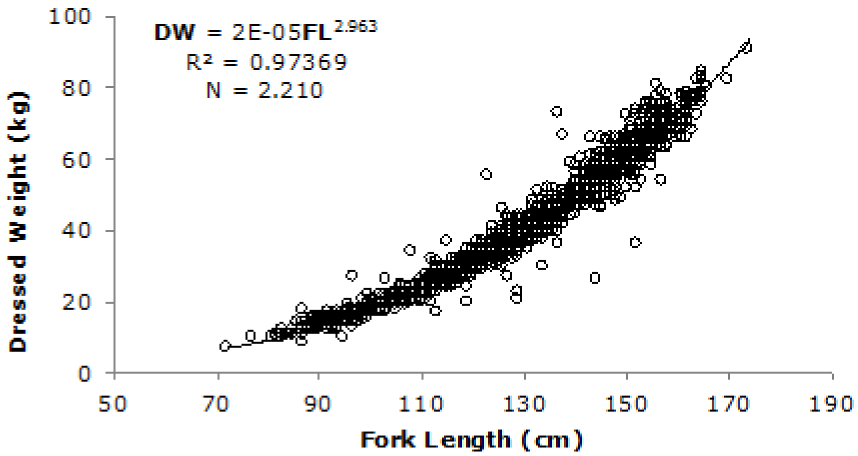


Figure 5. Length-weight relationship model for yellowfin tuna landed in PPP. Labuhan Lombok from 2013-2015.

**Discussion**

The nominal CPUE would explain very useful information on the condition of stock. In this research, CPUE of yellowfin tuna showed a negative trend especially after 2010. Intense catch from all over Indian Ocean region especially by purse seiners was probably become the main cause of the decline since they targeting mostly of schooling of undersize tuna around FAD/DFAD (IOTC, 2014; Fonteneau *et al.*, 2015). Since the yellow fin tuna belong to migratory species (UNCLOS, 1982) and the ecological connectivity of this species were under RFMO – IOTC, several related informations indicated that the average catch of yellowfin tuna in Eastern Indian Ocean ranged from 2010-2014 was 373,824 tons per year, while in 2014 the annual catch was 430,327 tons, which was above the proposed MSY (421,000 ton), this led to the conclusion that yellowfin tuna stock is determined to be overfished and subject to overfishing (IOTC, 2014). The following recommended action by IOTC was to reduce the catch by 20% from the current (2014) levels, in order to sustain the stock. The proposed action considered difficult to apply for some of the coastal country with mostly operating in small-scale area that strongly related to FAD. The declining trend of CPUE was affected skipjack, but in 2014 high catches were statistically recorded, almost double to the previous year. the high catches in 2014, should be taken with precautious approach due to possible increasing aggregation around the FADs instead of new recruitment.

Plotting catch-at-size data showed a strong seasonal linkage between large yellowfin and skipjack tuna. When large yellowfin occurred between May to July it followed by smaller group of skipjack tuna, adversely when smaller yellowfin appeared between November to January, bigger size of skipjack was found. This probably due to their feeding behavior, while juvenile tuna (<50 cm) was not a threat to skipjack, and mostly feed on fish larvae and other zooplanktonic organims, large yellowfin tuna switches their diet to teleost fishes, including scombridae family (Weng *et al*., 2015). This could affected skipjack in the same water column with large yellowfin tuna at the same time.

Fishing season mostly related to rainfall intensity and linked to the monsoon cycle. (DGCF, 2011; Surinati, 2009; Wiyono *et al.*, 2006). It usually started in late February or March (east moonsoon) when the intensity of rainfall is lower and sea condition is preferable. This occurred in small-scale tuna fisheries alongside Indian Ocean, as reported in Kedonganan, Bali (Sulistyaningsih *et al.*, 2011); Sendang Biru, Malang (Nurdin *et al.*, 2008) and Prigi, East Java (Nurdin *et al.*, 2012). The opposite seasonal fishing



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index interaction between large yellowfin and skipjack tuna was influenced by the present of FADs. Based on variability of monthly catch data, it could be predicted that the increasing abundance of large yellowfin tuna begin to exist in surrounding FADs on April, when the weather is suitable, and skipjack tuna finds this gap (January-April) as an opportunity to aggregate around FADs, this resulted in high catch of skipjack during low season of yellowfin tuna. As the skipjack stock tend to decline, the FADs was aggregated by yellowfin tuna. This shifting strategy on its abundance occurred during 4-month cycles.

The *b*-value of growth derived from length-weight non-linear regression ideally it range from 2.5-3.5 (Pauly, 1984). In this study, the *b*-value was 2.963 showing a negative allometric growth pattern. A previous study conducted by Jatmiko *et al.* (2014) using samples from longline fisheries gave slightly higher *b*-value (3.029) but resulted as isometric growth pattern. This result showed that yellowfin tuna caught from small-scale fisheries were seemingly to be slimmer compared to industrial using longline gear. The length-weight relationship is essential part in fisheries science and quite practical in term of defining: 1) the biomass estimation from length data; 2) explaining the condition factor of fish; 3) and comparing between life cycle differences and fish morphology on the same species with different area (Pauly, 1993; Petrakis & Stergiou, 1995).

## CONCLUSION

Intense fishing practice around FADs resulted in declining of tuna catch over the years and there was strong seasonal linkage between yellowfin and skipjack tuna with majority of yellowfin tuna caught were slender and slimmer.

Fishing season for skipjack occurred during February-March and August-October while yellowfin occurred during May-July, showing contrasting cycle pattern.

Most of yellowfin tuna landed by handline were at larger size of its predicted length at first maturity > 100 cm and this was indicated that deeper water column around FADs contain suitable and healthier stock of yellowfin tuna.

## ACKNOWLEDGEMENT

This paper is authors' part contribution to research on assessment of skipjack (*Katsuwonus pelamis*) fishing ground in the Indian Ocean south of Java, Bali, and Nusa Tenggara in 2012 and Research Institute for Tuna Fisheries port monitoring program 2013-2015. The Authors also would like to thank to WASKI, Labuhan Lombok Coastal Fishing Port and Harbormaster for their hospitality during the research and Rachmat Wijaya as enumerators for providing the data throughout the years.

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