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PREFACE

Indonesian Fisheries Research Journal (IFRJ) in 2016 entered the Volume 22. The process of publishing this journal is funded by Center for Fisheries Research and Development of the fiscal year 2016. All submissions should be published through the process of evaluation by the Editorial Board, Peer-Reviewers and editing by Editorial Office.

Management of Indonesian Fisheries Research Journal (IFRJ) in 2016 began referring to the Open Journal Systems (OJS). In terms of appearance there were some minor changes, namely:
1. Inclusion of p-ISSN and e-ISSN in the upper right corner on the face skin page, title page and table of contents page of issue, without colons
2. Inclusion of numbered lists or ISSN barcode in the lower right corner on the back cover
3. Special Sheets for Peer-Reviewers
4. Sheet gratitude for Peer-Reviewers involved in the review of each number
5. Each title sheet no additional information on the website, email address and information about the IFRJ, as well as the logo and the cover on the left and right. This change information is displayed on each foreword for 2 (two) publications.

The IFRJ Volume 22 Number 2 2016 presented seven fisheries research articles. Those seven articles are: The effect of depth of hooks, set and soak time to the catch per unit of effort of tuna in The Eastern Indian Ocean; The influence of swimming layer and sub-surface oceanographic variables on catch of labacore (Thunnus alalunga) in Eastern Indian Ocean; Estimation of yellowfin tuna production landed in Benoa Port with weight-length, length-weight relationship and condition factor approaches; Inter-specific competition and fishing effect to population dynamic of Bali Sardine (Sardinella Lemuru); The distribution and abundance of decapod and fish communities in Cleveland Bay, Australia; Catch composition and some biological aspects of sharks in Western Sumatera Waters of Indonesia; Diversity of reef fish fungsional groups in terms of coral reef resiliences.

Those scientific papers are expected to contribute to policy makers and managers of fisheries resources in Indonesia. Editor would deliver sincere thanks to reseachers from the Center for Fisheries Research and Development and outside for their active participation in this edition.

Editor in Chief
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THE EFFECT OF DEPTH OF HOOKS, SET AND SOAK TIME TO THE CATCH PER UNIT OF EFFORT OF TUNA IN THE EASTERN INDIAN OCEAN

Bram Setyadji
IFRJ, Vol. 22 No. 2, Page: 61-68

ABSTRACT

Yellowfin (Thunnus albacares) and bigeye (T. obesus) tuna have been intensively exploited by longline fleets since 1980’s, however, a large proportion of zero catch per set of target species still occurred. Zero catch data contributed significantly to the low catch per unit of effort (CPUE) compared to other countries at the same fishing area. Therefore, understanding the factors contributed to the CPUE of tuna is essential, in order to improve longline fishing efficiency. A total of 2.115 set-by-set data were obtained from Indonesian Scientific Observer Program. The onboard observations were carried out at commercial tuna longline operated in Eastern Indian Ocean from August 2005 to December 2014. Several analytical approaches were conducted in this paper. First, General Linear Model (GLM) was applied in order to model the relationship between CPUE with all the variables involved. Second, boxplot diagram, polynomial and linear regression were applied to fit the relationship between CPUE with set time, soak time and depth (represented by hook position) respectively. The result showed that, there was no significant relationship between set time and CPUE of bigeye and yellowfin tuna. Soak time was positively related with CPUE of yellowfin and affect adversely on bigeye. Depth also have significant relationship with CPUE of tuna, where catch of yellowfin decreased linearly with hook depth, whereas catch of bigeye was performed the opposite. Improvement in tuna longline fishery in eastern Indian Ocean can be achieved through implementation of the specific soak time and hook depth for each target species, i.e. yellowfin and bigeye tuna.

Keywords: Yellowfin tuna; bigeye tuna; set time; soak time; hook depth; Indian Ocean

THE INFLUENCE OF SWIMMING LAYER AND SUB-SURFACE OCEANOGRAPHIC VARIABLES ON CATCH OF ALBACORE (Thunnus alalunga) IN EASTERN INDIAN OCEAN

Fathur Rochman
IFRJ, Vol. 22 No. 2, Page: 69-76

ABSTRACT

This study was highlighted the content of albacore’s number catch, swimming layer and sub-surface oceanographic variables (SSOV) at Eastern Indian Ocean include temperature, dissolved oxygen, salinity, nitrate, phosphate and silicate. Hopefully the information would be useful for the longliners to understand the ALB behaviour, environment and the best techniques on how to catch this fish. Data in this study were based on the Research Institute for Tuna Fisheries (RITF) observer program in Benoa from 2010-2013. Data analysis was base on primary data and secondary data. Primary data are albacore’s (ALB) swimming layer data which are measured by minilogger. Secondary data is SSOV data which extracted from World Ocean Atlas 2009 (WOA09). The results show that the optimum catch of albacore occurred at depth of 118 to 291 m with the average temperature between 12.41-20.47 °C, dissolved oxygen 3.24-4.68 ml/l, salinity 34.78-35.01 psu, nitrate 6.78-17.50 µ mol/l, phosphate 0.62-1.27 µ mol/l and silicate 10.06-24.77 µ mol/l. The highest catch of ALB was mostly at depth of 156 m (hook number 2 and 11) with the average temperature 18.71°C, dissolved oxygen 4.68 ml/l, salinity 34.78 psu, nitrate 10.71 µ mol/l, phosphate 0.86 µ mol/l and silicate 15.95 µ mol/l. The highest influence of swimming layer and sub-surface oceanographic variable to the number of ALB catch happened at depth of 291 m of ALB swimming layer with coefficient correlation (r) of 0.934 and determination coefficient (R²) of 0.872. The lowest influence of swimming layer and sub-surface oceanographic variable to the number of ALB catch happened at depth of 156 m of albacore swimming layer with coefficient correlation (r) of 0.528 and determination coefficient (R²) of 0.279. The relationship between swimming layer and sub-surface oceanographic variable on catch of ALB tuna was low (<0.500).

Keywords: Swimming layer; sub surface oceanographic variable; albacore; Eastern Indian Ocean
ESTIMATION OF YELLOWFIN TUNA PRODUCTION LANDED IN BENOA PORT WITH WEIGHT-WEIGHT, LENGTH-WEIGHT RELATIONSHIPS AND CONDITION FACTOR APPROACHES

Irwan Jatmiko
IFRJ, Vol. 22 No.2, Page: 77-84

ABSTRACT

Yellowfin tuna (Thunnus albacares) is one of the important catch for the fishing industry in Indonesia. Length-weight relationship study is one of important tools to support fisheries management. However it could not be done to yellowfin tuna landed in Benoa port since they are in the form of gilled-gutted condition. The objectives of this study are to determine the relationship between gilled-gutted weight (GW) and whole weight (WW), to calculate length weight relationship between fork length (FL) and estimated whole weight (WW) and to assess the relative condition factor (K) of yellowfin tuna in Eastern Indian Ocean. Data were collected from three landing sites i.e. Malang, East Java; Benoa, Bali and Kupang, East Nusa Tenggara from January 2013 to February 2014. Linear regression analysis applied to test the significance baseline between weight-weight relationships and log transformed length weight relationship. Relative condition factor (K) used to identify fish condition among length groups and months. The results showed a significant positive linear relationships between whole weight (WW) and gilled-gutted weight (GW) of T. albacares (p<0.001). There was a significant positive linier relationships between log transformed fork length and log transformed whole weight of T. albacares (p<0.001). Relative condition factor (K) showed declining pattern along with length increase and varied among months. The findings from this study provide data for management of yellowfin tuna stock and population.

Keywords: Weight-weight relationships; length-weight relationships; condition factor; yellowfin tuna; Eastern Indian Ocean

INTER-SPECIFIC COMPETITION AND FISHING EFFECT TO POPULATION DYNAMIC OF BALI SARDINE (SARDINELLA LEMURU)

Andhika Prima Prasetyo
IFRJ, Vol. 22 No.2, Page: 85-90

ABSTRACT

Spatial and temporal variations in the fish and decapod communities were investigated at three stations in Cleveland Bay along with other zooplankton and phytoplankton communities. The linkage between biological assemblages and physical properties of the ocean was explained to develop better understanding of population dynamic of planktonic communities. Biological and physical properties data were gathered in 3 stations by 6 different trips. The results show that there is a significant association between daytime and tidal period to the abundance of planktonic communities (P < 0.05). Spatial distribution of fish and decapod communities are likely explained by “predator pit” and “match/mismatch” concepts to increase the survival probability along with physical properties of the ocean.

Keywords: Biological oceanography; decapod and fish communities; Cleveland bay

CATCH COMPOSITION AND SOME BIOLOGICAL ASPECTS OF SHARKS IN WESTERN SUMATERA WATERS OF INDONESIA

Dharmadi

ABSTRACT

This study was conducted in western Sumatera and since October 2013 to June 2014. The sampling locations in Banda Aceh and Sibolga-North Sumatera which were the largest base of fisheries in western Sumatera region. Shark landing recorded by enumerators was used as sampling data daily. This research aim to describe sex ratio, size composition, catch composition of sharks, and length at first maturity. In Banda Aceh, the sharks as target fish collected by sorting the bycatch from tuna longlines and tuna handlines. In Sibolga, sharks is bycatch from fish net, bottom gillnet and purse seine. Overall, there were 20 species of shark caught in west Indian Ocean and landed at those fish landing sites, dominated by Spot tail shark (23%) and Silky shark (13%).
whereas Hammerhead shark contributed about 10% and Oceanic whitetip shark was only less than 1%. Almost of Spot tail shark, Silky shark, and Scalloped hammerhead that caught in that area were immature, while for the almost part of Tiger shark and Pelagic thresher were matured. The sex ratios for Spot tail shark, Silky shark, Tiger shark, Pelagic thresher, and Scalloped hammerhead caught and landed at Lampulo and Sibolga fish landing sites were not balance. The length at first maturity for Spot tail shark was Lm=87.1 cm and Lm = 213.2 cm total length for Tiger shark.

**Keywords:** Sharks; biology; fisheries; western sumatera

**DIVERSITY OF REEF FISH FUNCTIONAL GROUPS IN TERMS OF CORAL REEF RESILIENCES**

Isa Nagib Edrus

**ABSTRACT**

Infrastructure development in the particular sites of Seribu Islands as well as those in main land of Jakarta City increased with coastal population this phenomenon is likely to increase the effects to the adjacent coral waters of Seribu Islands. Chemical pollutants, sedimentation, and domestic wastes are the common impact and threatening, the survival of coral reef ecosystem. Coral reef resiliences naturally remained on their processes under many influences of supporting factors. One of the major factor is the role of reef fish functional groups on controlling algae growth to recolonize coral juveniles. The aim of this study to obtain data of a herbivory and other fish functional groups of reef fishes in the Pari Islands that are resiliences indicators, or that may indicate the effectiveness of management actions. A conventional scientific approach on fish diversity and abundance data gathering was conducted by the underwater visual cencus. Diversity values of the reef fish functional groups, such as the abundance of individual fish including species, were collected and tabulated by classes and weighted as a baseline to understand the resiliences of coral reef based on Obura and Grimsditch (2009) techniques. The results succesfully identified several fish functional groups such as harpivores (21 species), carnivores (13 species) and fish indicator (5 species) occurred in the area. Regarding the aspects of fish density and its diversity, especially herbivorous fish functional group, were presumably in the state of rarely available to support the coral reef resiliences. Resilience indices ranged from 1 (low level) to 3 (moderate level) and averages of the quality levels ranged from 227 to 674. These levels were inadequate to support coral reef recolonization.

**Keywords:** Resiliences; reef fishes; Pari Islands
ESTIMATION OF YELLOWFIN TUNA PRODUCTION LANDED IN BENOA PORT WITH WEIGHT-WEIGHT, LENGTH-WEIGHT RELATIONSHIPS AND CONDITION FACTOR APPROACHES

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ABSTRACT

Yellowfin tuna (Thunnus albacares) is one of the important catch for the fishing industry in Indonesia. Length-weight relationship study is one of important tools to support fisheries management. However it could not be done to yellowfin tuna landed in Benoa port since they are in the form of gilled-gutted condition. The objectives of this study are to determine the relationship between gilled-gutted weight (GW) and whole weight (WW), to calculate length weight relationship between fork length (FL) and estimated whole weight (WW) and to assess the relative condition factor (K) of yellowfin tuna in Eastern Indian Ocean. Data were collected from three landing sites i.e. Malang, East Java; Benoa, Bali and Kupang, East Nusa Tenggara from January 2013 to February 2014. Linear regression analysis applied to test the significance baseline between weight-weight relationships and log transformed length weight relationship. Relative condition factor (Kn) used to identify fish condition among length groups and months. The results showed a significant positive linear relationships between whole weight (WW) and gilled-gutted weight (GW) of T. albacares (p<0.001). There was a significant positive linearer relationships between log transformed fork length and log transformed whole weight of T. albacares (p<0.001). Relative condition factor (Kn) showed declining pattern along with length increase and varied among months. The findings from this study provide data for management of yellowfin tuna stock and population.

Keywords: Weight-weight relationships; length-weight relationships; condition factor; yellowfin tuna; Eastern Indian Ocean

INTRODUCTION

Tuna is one of important export commodity in Indonesia with total production reaches 1.352.802 tons from 2005 to 2012. Yellowfin tuna is the highest percentage with 72% from total big tuna group production, followed by bigeye tuna (21%), albacore (6%) and southern bluefin tuna (1%) (DGCF, 2015). Yellowfin tuna (Thunnus albacares) is highly migratory species with distribution in tropical and temperate water. This species can be found in Atlantic, Hindian and Pacific Ocean (Collette & Nauen, 1983). In Indonesia, the distribution of this species spreading from west and south Sumatera; south of Java, Bali and Nusa Tenggara; Banda and Sulawesi Sea; and west of Papuan waters (Uktolseja et al., 1991).

Length-weight relationship study is one of an important tool to support fisheries management. This information can estimate the average weight from known fish length which can then be used to estimate the biomass of fish population (Froese, 2006). Furthermore, length-weight relationships and condition factor studies were applied to support stock assessment of population (Ricker, 1979) and also valuable to understand the life history including reproduction aspect and general health of the species (Pauly, 1993).

One of the important tuna landing site in Indonesia is located in Benoa port, Bali. Different with albacore that landed in whole condition in this port, three other species of tuna were processed onboard (removing gill and stomach content) and landed in gilled-gutted condition. This process performed to maintain the quality of the fish for export destination. However, this procedure affects the loss of fish weight due to gill and gutted removal. The objectives of this study are
to determine the weight-weight relationship between gilled-gutted weight (GW) and whole weight (WW), to calculate length weight relationship between fork length (FL) and whole weight (WW) and to assess the relative condition factor ($K_n$) of yellowfin tuna in Eastern Indian Ocean. The finding of this study be able to become data base for the estimation of yellowfin tuna production. Moreover, the results from this study can be used to determine the quota for yellowfin tuna in the Regional Fisheries Management Organization (RFMO).

MATERIALS AND METHODS

Data Collection

Yellowfin tuna data were collected from three landing sites i.e. Malang, East Java; Benoa, Bali and Kupang, East Nusa Tenggara (Figure 1). For weight-weight relationships study, the fish samples gained from August 2013 to February 2014 in Malang, East Java and Kupang, East Nusa Tenggara. The fork length (FL) of fish was measured (±1 cm), weighing whole weight (WW) and gilled-gutted weight (± 0.01 kg) with a digital balance. The yellowfin tuna from these sites were caught by handline fishing. For length-weight relationships and condition factor study, other fish samples were measured monthly by enumerator from January to December 2013 in Benoa, Bali. The fork length (FL) of fish was measured (±1 cm), weighing gilled-gutted weight (± 1 kg) with a regular balance. The yellowfin tuna from this site was caught by longline fishing.

The first survey conducted from August 2013 to February 2014 collected 79 samples with fork length ranged 26-68 cm, whole weight (WW) ranged 0.32-6.40 kg and gilled-gutted weight (GW) ranged 0.27-5.80 kg. The second survey covered a period of 12 consecutive months from January to December 2013. A total of 7,254 measured samples of $T. albacares$ were examined with fork lengths (FL) ranging from 77 to 180 cm and gilled-gutted weight (GW) ranged 8-103 kg (Table 1).

Figure 1. Sampling site in Malang, East Java (circular), Benoa, Bali (triangle) and Kupang, East Nusa Tenggara (square).

Table 1. The summary of descriptive statistics of $T. albacares$ samples.

<table>
<thead>
<tr>
<th>Survey</th>
<th>N</th>
<th>Fork length (cm)</th>
<th>Whole weight (kg)</th>
<th>Gilled-gutted weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Range</td>
<td>Mean ± SE</td>
<td>Range</td>
</tr>
<tr>
<td>I</td>
<td>79</td>
<td>26-68</td>
<td>41.73±1.05</td>
<td>0.32-6.40</td>
</tr>
<tr>
<td>II</td>
<td>7254</td>
<td>77-180</td>
<td>132.53±0.20</td>
<td>-</td>
</tr>
</tbody>
</table>
Data Analysis

Relationships between whole weight (WW) and gilled-gutted weight (GW) was analyzed using linear regression model \( Y = a + bX \), where \( a \) is intercept and \( b \) is slope. Linear regression analysis performed to determine the amount of deviation in \( Y \) variable explained by \( X \) variable. Test for linear regression was conducted to examine the significance between two variables (Barnett, 2003). This relationship was used to convert from gilled-gutted weight data into estimated whole weight data to generate length-weight relationships.

The relationships between the length and estimated whole weight of a fish calculated using equation, \( W = aL^b \). Where \( W \) is body weight (kg), \( L \) is fork length (cm), \( a \) is a coefficient related to body form and \( b \) is an exponent indicating fish growth (Ricker, 1979).

Log transformed length and log transformed weight were plotted in order to examine the significance between these two variables. Values of the exponent \( b \) provide information on fish growth. When \( b=3 \), increase in weight is isometric. When the value of \( b \) is other than 3, weight increase is allometric, (positive allometric if \( b>3 \), negative allometric if \( b<3 \)). The null hypothesis of the isometric growth \( (H_0: b=3) \) was tested using \( t \)-test (Morey et al., 2003).

RESULTS AND DISCUSSION

Results

Whole Weight (WW) and Gilled-gutted Weight (GW) Relationship

There was a significant positive linear relationships between whole weight (WW) and gilled-gutted weight (GW) of \( T. \) albacares \( (F_{1,77} = 80.383.60, p<0.001, R^2 = 0.999) \). As gilled-gutted weight increases, the whole weight of \( T. \) albacares increases. Gilled-gutted weight explained 99% variation in the whole weight of \( T. \) albacares with equation \( \text{WW} = 1.1167 \text{GW} + 0.0266 \) (Figure 2).

To detect seasonal variations in the condition of the fish, relative condition factors \( (K_n) \) were calculated from monthly samples. The conditional factors can be calculated by comparing the mean weight of fish in a sample with the predicted weight of fish from a generalized length-weight relationship using equation (King, 2007):

\[
K_n = \frac{W_m}{W_p}
\]

Where:
- \( K_n \) = relative condition factor
- \( W_m \) = monthly of mean weight
- \( W_p \) = general predicted weight of fish from the same mean length

Figure 2. Weight-weight relationships between gilled-gutted weight (GW) and whole weight (WW) of \( T. \) albacares in Eastern Indian Ocean.
Length and Estimated Whole Weight (WW) Relationship

Monthly descriptive statistics and estimated parameters of length-weight relationships for *T. albacares* were shown in Table 1. Growth pattern of *T. albacares* showed that positive allometric growth occurred in January, March, April, October and December. Whereas the isometric growth appeared in February, May, June, July, August, September and November. Overall, the growth pattern of *T. albacares* in Eastern Indian Ocean is isometric (Table 2).

Length-weight analysis showed the equation $W = 0.00002 \times L^{3.0294}$ with coefficient determination ($R^2$) 0.9635. Fork length explained 96% variation in the weight of *T. albacares* (Figure 3).

### Table 2. Monthly growth pattern of yellowfin tuna caught in Indian Ocean southern of Java, Bali and Nusa Tenggara

<table>
<thead>
<tr>
<th>Month</th>
<th>N</th>
<th>Fork length (cm) Range</th>
<th>Mean±SE</th>
<th>Whole weight (kg) Range</th>
<th>Mean±SE</th>
<th>Parameters</th>
<th>Growth pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Range</td>
<td>Mean±SE</td>
<td>Range</td>
<td>Mean±SE</td>
<td>$a$</td>
<td>$b$</td>
</tr>
<tr>
<td>Jan</td>
<td>672</td>
<td>79-176</td>
<td>127.29±0.74</td>
<td>10-106</td>
<td>44.88±0.76</td>
<td>0.00001</td>
<td>3.0892</td>
</tr>
<tr>
<td>Feb</td>
<td>336</td>
<td>77-165</td>
<td>124.06±0.94</td>
<td>10-90</td>
<td>39.78±0.94</td>
<td>0.00002</td>
<td>3.0295</td>
</tr>
<tr>
<td>Mar</td>
<td>292</td>
<td>85-165</td>
<td>125.85±0.96</td>
<td>12-98</td>
<td>41.41±1.04</td>
<td>0.00001</td>
<td>3.1056</td>
</tr>
<tr>
<td>Apr</td>
<td>462</td>
<td>87-171</td>
<td>126.77±0.73</td>
<td>15-103</td>
<td>42.33±0.79</td>
<td>0.00001</td>
<td>3.1221</td>
</tr>
<tr>
<td>May</td>
<td>980</td>
<td>89-174</td>
<td>136.21±0.50</td>
<td>12-95</td>
<td>51.57±0.55</td>
<td>0.00002</td>
<td>3.0459</td>
</tr>
<tr>
<td>Jun</td>
<td>958</td>
<td>91-171</td>
<td>134.95±0.52</td>
<td>17-93</td>
<td>50.11±0.57</td>
<td>0.00002</td>
<td>3.0261</td>
</tr>
<tr>
<td>Jul</td>
<td>1337</td>
<td>81-172</td>
<td>136.13±0.46</td>
<td>11-90</td>
<td>50.95±0.47</td>
<td>0.00002</td>
<td>2.9555</td>
</tr>
<tr>
<td>Aug</td>
<td>257</td>
<td>94-162</td>
<td>133.42±0.89</td>
<td>13-86</td>
<td>46.27±0.89</td>
<td>0.00002</td>
<td>2.9565</td>
</tr>
<tr>
<td>Sep</td>
<td>328</td>
<td>81-165</td>
<td>128.67±0.73</td>
<td>10-88</td>
<td>43.98±0.74</td>
<td>0.00002</td>
<td>2.9985</td>
</tr>
<tr>
<td>Oct</td>
<td>369</td>
<td>80-180</td>
<td>129.98±1.05</td>
<td>9-115</td>
<td>48.14±1.08</td>
<td>0.000009</td>
<td>3.1779</td>
</tr>
<tr>
<td>Nov</td>
<td>600</td>
<td>80-169</td>
<td>133.63±0.82</td>
<td>10-102</td>
<td>50.41±0.81</td>
<td>0.00002</td>
<td>3.0217</td>
</tr>
<tr>
<td>Dec</td>
<td>663</td>
<td>85-173</td>
<td>134.88±0.62</td>
<td>11-105</td>
<td>51.38±0.66</td>
<td>0.00001</td>
<td>3.0700</td>
</tr>
<tr>
<td>All</td>
<td>7254</td>
<td>77-180</td>
<td>132.53±0.20</td>
<td>9-115</td>
<td>48.30±0.21</td>
<td>0.00002</td>
<td>3.0294</td>
</tr>
</tbody>
</table>

Figure 3. Length-weight relationships between fork length (FL) and whole weight (WW) of *T. albacares* in Eastern Indian Ocean. Whole weight data were estimated from weight-weight relationship.
Relative Condition Factor ($K_n$)

The relative condition factor ($K_n$) has been calculated for each 5 cm length groups. Generally, the relative condition factor ($K_n$) decreased along with the increasing of fork length. The highest value with 1.04 occurred at length group 80 cm then decreased significantly up to 0.83 at length group 110 cm. There has been slightly increased at length group 115 cm and tend to steady until length group 160 cm then decline drastically to 0.75 at length group 180 cm (Figure 4).

Monthly relative condition factor ($K_n$) of $T.\ albacares$ showed fluctuated during the year. The highest relative condition factor ($K_n$) occurred in March with 0.89 and the lowest appeared in August with 0.82 (Figure 5).

Figure 4. Variation of relative condition factors (mean±SE) of $T.\ albacares$ in Eastern Indian Ocean. Values on fork length are the upper limit of 5 cm length groups.

Figure 5. Monthly relative condition factors (mean±SE) of $T.\ albacares$ in Eastern Indian Ocean.
Discussion

Weight-weight relationships and length-weight relationships studies are important for fisheries management, for example in calculating yield and biomass (King, 2007). However, processing fish on board had consequences in the loss weight of the fish. This study showed that additional weight of T. albacares landed in Benoa port ranged from 1.2 kg at length class 80 cm to 10.2 kg at length class 180 cm. The additional weight increased along with the increase of length. The increasing length of fish leads the greater on the weight of the fish.

Length-weight relationship showed that $a$ value (intercept) is less influential than $b$ value (slope) to the equation because its value is very small (Table 3). The $a$ value in this study is 0.00002, relatively similar to other studies except in Indian Ocean, Sri Lanka waters with a value is 0.033 (Perera et al., 2013). The $b$ value in this study is 3.029 higher than other studies except in Pacific Ocean with $b$ value is 3.244 (Zhu et al., 2010). After t-test analysis the result showed that this value is not significantly different ($b=3$), ensuing that growth pattern of T. albacares is isometric. It means that growth occurred at the same rate for length and weight of the fish so that its shape is consistent throughout development or in the same dimension as the cube of length (Pauly, 1984). This growth pattern is different with other studies in Atlantic and Indian Ocean where the growth pattern is negative allometric and in Pacific Ocean where the growth pattern is positive allometric (Zhu et al., 2010). The variability of growth pattern of fish can be depend on the food availability, season and environmental conditions (Froese, 2006; Effendie, 2002) and the swimming activity of the fish (Muchlisin et al., 2010).

Table 3. Estimated parameters of length-weight relationships for T. albacares from various studies.

<table>
<thead>
<tr>
<th>Location</th>
<th>$a$</th>
<th>$b$</th>
<th>$R^2$</th>
<th>Growth pattern</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pacific Ocean, Taiwan</td>
<td>0.00004</td>
<td>2.854</td>
<td>-</td>
<td>-</td>
<td>Wang et al., 2002</td>
</tr>
<tr>
<td>Pacific Ocean, Hawaii</td>
<td>0.00003</td>
<td>2.889</td>
<td>0.975</td>
<td>-</td>
<td>Uchiyama &amp; Kazama, 2003</td>
</tr>
<tr>
<td>Atlantic Ocean</td>
<td>0.00002</td>
<td>2.969</td>
<td>0.941</td>
<td>Negative allometric</td>
<td>Zhu et al., 2010</td>
</tr>
<tr>
<td>Indian Ocean</td>
<td>0.00002</td>
<td>2.985</td>
<td>0.969</td>
<td>Negative allometric</td>
<td>Zhu et al., 2010</td>
</tr>
<tr>
<td>Pacific Ocean</td>
<td>0.00004</td>
<td>3.244</td>
<td>0.945</td>
<td>Positive allometric</td>
<td>Zhu et al., 2010</td>
</tr>
<tr>
<td>Indian Ocean, Sri Lanka</td>
<td>0.033</td>
<td>2.848</td>
<td>0.918</td>
<td>-</td>
<td>Perera et al., 2013</td>
</tr>
<tr>
<td>Indian Ocean, Indonesia</td>
<td>0.00002</td>
<td>3.029</td>
<td>0.964</td>
<td>Isometric</td>
<td>Present study</td>
</tr>
</tbody>
</table>

Condition factor ($K_r$) was used to identify the condition of the fish. Study on salmonid fish showed that the higher $K_r$ value showed fish in good condition. On the contrary, the lower $K_r$ value showed poor condition (Barnham & Baxter, 1998). The similar results occurred in this study. The relative condition factor ($K_r$) of T. albacares showed high value for small fish and decreased along with the development of fish length. There was steep declining of relative condition factor ($K_r$) when fish reach 106-110 cm to 0.83. This decreased probably related with the reproduction strategies of yellowfin tuna which reach their length at 50% maturity ($L_{50}$) at 102 cm (Zudaire et al., 2013), 105 cm (Itano, 2000), 105 cm for male and 110 cm for female (Nootmorn et al., 2005) and 110-115 (Hassani & Stequert, 1991).

Monthly relative condition factor ($K_r$) showed high value from September to April with the highest value occurred in March with 0.89. On the other hand, it showed low value from May to August with the lowest value happened in August with 0.82. It means that the index of well-being of the fish from September to April was better than the condition of the fish from May to August. The variability of relative condition factor ($K_r$) among months allegedly due to seasonal variations which may vary with food availability and dietary habit (King, 2007; Saha et al., 2009).
Moreover, monthly condition factor also influenced by environmental condition (Froese, 2006; Effendie, 2002). Indian Ocean waters has distinctive characteristics that its environmental condition had influence from Indian Ocean Dipole-zonal Mode/IODM (Li et al., 2003), El Nino Southern Oscillation/ENSO (Reason et al., 2000) and monsoon (Yang et al., 2007). Monsoon can be categorized into four segments, which are west monsoon (Dec-Feb), transitional season I (Mar-May), east monsoon (Jun-Aug) and transitional season II (Sep-Nov). Monthly condition factor showed that well-being index of yellowfin tuna is better in west monsoon and transitional II. It was allegedly as this season occurred healthy of water fertility that have a positive impact on the availability of abundant food resources (Realino et al., 2010).

**CONCLUSION**

The strong positive linear relationship between whole weight and gilled-gutted weight resulted from this study indicated that the total weight of yellowfin tuna that landed in Benoa Port can be estimated from gilled-gutted weight (processed weight). Therefore, this finding can be used to determine the quota for yellowfin tuna in Regional Fisheries Management Organizations (RFMO's). The growth in weight and length of yellowfin tuna is proportional to each other with its relative condition factor tend to decrease along with the increasing of length.

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