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STUDY ON SPECIES COMPOSITION OF JUVENILE TUNA CAUGHT BY PURSE SEINE FLEET LANDING IN TAMPERAN FISHING PORT, SOUTH JAVA, INDONESIA

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ABSTRACT

Juvenile yellowfin tuna (*Thunnus albacares*) and bigeye tuna (*T. obesus*) are very similar in morphological characteristics, hence it is difficult to distinguish between these two species, especially when they are landed in frozen or defect conditions. The presence of juvenile bigeye tuna in yellowfin catch was first noticed in the 1980s from pole and line fisheries in Maldives. We analyzed the monthly composition structure of juvenile tuna caught by purse seine fleet operating in the South Indian Ocean. Tamperan fishing port was chosen for benchmarking to other small-scale fisheries. The result is expected to be used as an index for increasing the accuracy of juvenile tuna proportion for national catch statistics. A total of 4760 juvenile tunas were examined during monitoring activities. The length ranged 19-65 cm FL with median 40 cm FL for juvenile yellowfin tuna and 44 cm for juvenile bigeye. The whole weight of juvenile tuna ranged from 5 to 7 kg. The length-weight conversion for both species are $W = 0.0184{*}FL^{3.0086}$ ($R^2 = 0.95$, n = 4144) for juvenile yellowfin tuna and $W = 0.018{*}FL^{3.0047}$ ($R^2 = 0.93$, n = 346) for juvenile bigeye tuna. It can be inferred from the study that in terms of catch proportion of juvenile tuna, it consists of ratio 10:1, whereas for every 10 kg of juvenile tuna contains approximately one kg of bigeye tuna. Besides, the length-weight equation for both species is interchangeable, which means either equation can be performed to convert length to weight for both juvenile yellowfin and bigeye tuna.

Keyword: Juvenile tuna; length-weight; length-structure; purse seine

INTRODUCTION

Yellowfin tuna, *Thunnus albacares* (Bonnaterre, 1788) and bigeye tuna, *Thunnus obesus* (Lowe, 1983) are target species for many fisheries in the world (Pedrosa-Gerasmio *et al.,* 2012). Based on a review of global tuna fisheries, Indonesia is one of the world's 10 largest tuna-producing countries and the largest in the world with a 2014 landing estimate of 620,000 tonnes (Wibowo *et al.,* 2016), contributing 16% of world tuna production (Firdaus, 2018). His study illustrates that 40% of landing catches in Indonesia were generated from purse seine fisheries, while the rest were landed by other fishing fleets, such as tuna longline, handline, and gillnets, that are operating in the western Pacific Ocean and Indian Ocean.

It is generally known that juvenile tuna are more likely caught around Fish Aggregating Devices (FAD) and composed of a smaller size school compared to free schooling tuna (Dagorn *et al.,* 2013). Furthermore, gear characteristics may influence catch composition because the different species of tuna typically inhabit different depths around FADs (Lennert-Cody *et al.,* 2008; Matsumoto *et al.,* 2006). To facilitate effective management measures that reduce the fishing impact on juvenile tuna stocks, it is necessary to determine the catch proportion between the two main large tuna species, yellowfin tuna and bigeye tuna for each gear type, especially for purse seine fleets where most juvenile tunas are caught. Juvenile yellowfin and bigeye tuna are very similar, hence are very difficult to distinguish from each other, especially when landed in frozen or defect condition. These juvenile tunas are often recorded as "baby tuna", and it is often assumed that all baby tuna are yellowfin tuna. Thus, this practice causes overestimation on the total catch for yellowfin tuna and underestimation for bigeye tuna. The presence of juvenile bigeye tuna in the yellowfin catch was first noticed in the 1980s from pole and line fisheries in Maldives (Anderson & Hafiz, 1991). A review of data up to 1990 showed that the proportion of bigeye to yellowfin tuna was higher in the south than in the north (Anderson, 1996). A previous study from Hartaty *et al.* (2012) in Pacitan, East Java, suggested that the composition of juvenile bigeye tuna comprised only around 5% from the total catch.

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However, the result should be handled carefully since it only relied on the statistical report.

This study focused on analyzing the monthly composition and length-weight relationship of juvenile tuna caught by purse seine fleet based on daily scientific port sampling activity. Tamperan Coastal Fishing Port was chosen as it is the representative of other small-scale fisheries operating in the south eastern Indian Ocean. The purse seine fisheries that operate in Tamperan have length size range 17-28 m, width 6-7 m, height 2-3 meter, and are made of wood. The purse seiners vary between 28 and 45 GT in size with vessel crew capacity 30-35 people (Hartaty *et al.,* 2012). The result is expected to be utilized as an index for increasing the accuracy of juvenile tuna proportion for national catch statistics, especially from purse seine fleets in the Indian Ocean area (Fisheries Management Area 572 and 573).

MATERIALS AND METHODS

Data Collection

Data collection took place from January to December 2016, at Tamperan Coastal Fishing Port, Pacitan, South of East Java (Figure 1). To get an accurate estimate of the proportion of juvenile yellowfin and bigeye tuna, the samples were obtained using stratified random sampling. For each month, the well-trained enumerators sampled at least 50% of the landings. At Tamperan Fishing Port, fishers separate juvenile tuna from skipjack tuna, and researchers examine, validate, determine species, length, and weight of at least ± 400 randomly selected juvenile tuna then compile the data at the end of each month. Since not all samples have weight information, a length-weight conversion is needed to transform length data into estimated individual weight.

The fork length (FL) was measured from the tip of the snout to the fork tail using metal tape with 1 mm accuracy. Weight measurement was conducted using a digital scale with 0.1 gram accuracy. The length-weight data was tabulated in a 1 cm FL interval. Also, the total number of landing catch and sampled fishes were collected. The sampling coverage at least 50% the catch of total vessels landed that is used later for extrapolation.

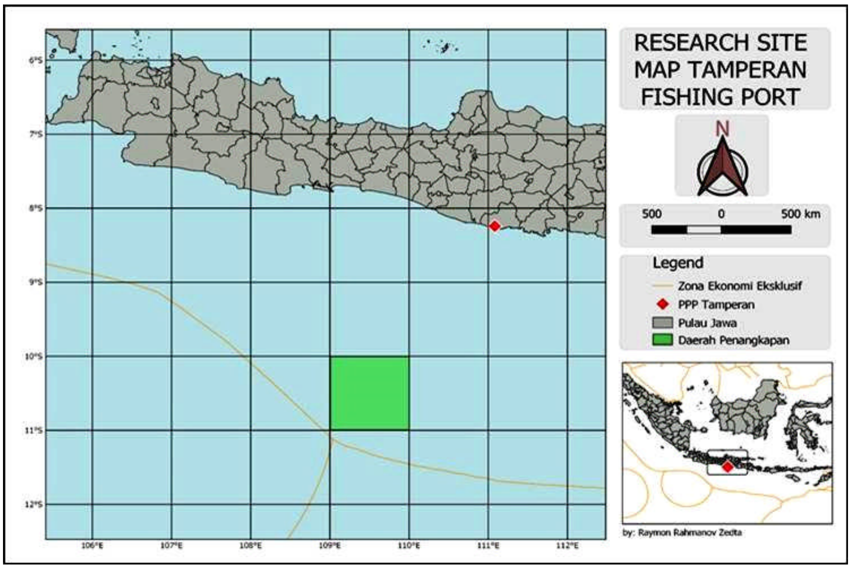

Figure 1. Map of purse seine fleet operation in the southern Indian Ocean in 2016.

Data Analysis

Length-weight data were analyzed using the equation: $W = aL^b$, whereas W is body weight (kg), L is fork length (cm FL), a is a coefficient related to body form, and b is an exponent with a value that is usually close to 3 (Ricker, 1979). Weight and length are transformed into a logarithm to examine the significance between these two variables. The value of the exponent b informs about fish growth type, which is if the value of variable b = 3, accretion in weight is higher than length (called isometric). When the value of b is other than 3, the weight increase is allometric, (positive allometric if $b>3$, negative allometric if $b<3$). The null hypothesis of the isometric growth ($H0: b=3$) was analyzed using a t-test (Morey *et al.,* 2003).

Juvenile tuna composition structure was analyzed by estimating the total length-weight proportion from two species sampled daily into a monthly gross catch. It can be obtained by raising the catch composition of each vessel sampled to gross catch by multiplying it with the total landing vessel for each month. The calculation refers to the following formula (IOTC, 2002):

CM = LM * AVM .... (1)

Where:
CM : Total catch per month (in kg)
LM : Total landing per month (in kg)
AVM : Average catches per month (catches sample/ landing sample)

Length frequency data for both species are presented in the histogram with 1 cm length class. There were no particular methods for determining the size class such as Bhattacharya method (Sparre & Venema, 1998). Instead, the 1 cm size class is considered to give a more general description of the size distribution.

RESULTS AND DISCUSSION
Results

A total of 4,761 juvenile tunas were examined during monitoring activities. The length ranged between 19-65 cmFL with a median 40 cmFL for juvenile yellowfin tuna, and 44 cmFL for juvenile bigeye. The whole weight of juvenile tuna ranged from 5 to 7 kg. The length-weight conversion for both species are presented as follows:

Juvenile yellowfin tuna, $W = 0.0184^{3.0086}$ ($R^2 = 0.95$, n = 4144)

Juvenile bigeye tuna, $W = 0.018^{3.0047}$ ($R^2 = 0.93$, n = 346)

Both species resembled each other in both aspects (length and weight), hence each parameter was quite similar. The following t-test showed that both *b* values were not significantly different, whereas the F for juvenile yellowfin tuna was 89011.14 (df=4462, P<0.001), and for bigeye tuna was 4277.37 (df=295, P<0.001) (Figure 2). In other words, the length-weight equation for both species is interchangeable.

Sampling coverage varied from 41.2% to 97.7%, with a monthly average of around 65%. The lowest catch occurred in November (9.85 tons), while the peak seasons were recorded during May-June (126.22 tons and 151.11 tons, respectively). The total catch estimation for a single calendar year was about 537.11 tons (Table 1).

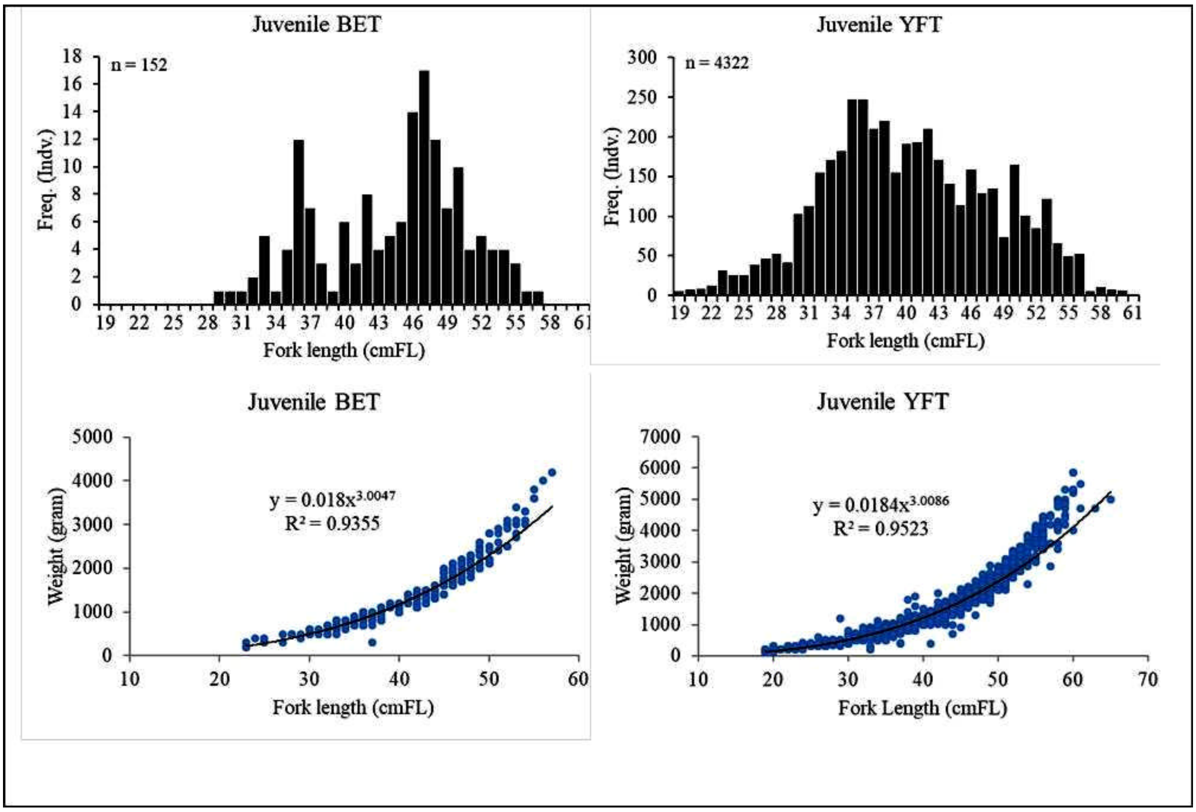

Figure 2. Length frequency of juvenile yellowfin and bigeye tuna (upper graphs) and length-weight relationships of juvenile yellowfin and bigeye tuna (lower graphs) caught by purse seine landed at Tamperan Fishing Port, Pacitan 2016.

Table 1. Juvenile tuna sampling percentage of purse seine in Tamperan Fishing Port 2016

Month	(a) Catch per vessel (tons)	(b) Total Landing (unit)	(c) Total Sampled (unit)	Sampling coverage (%)	Total Catch Estimation (a/c*b)
January	32.25	36	29	80.6	40.03
February	19.27	30	29	96.7	19.93
March	36.41	43	42	97.7	37.27
April	26.45	34	14	41.2	64.23
May	91.05	61	44	72.1	126.22
June	70.93	81	38	46.9	151.19
July	25.11	33	29	87.9	28.58
August	6.83	47	22	46.8	14.58
September	8.97	45	22	48.9	18.35
October	8.55	43	28	65.1	13.13
November	6.35	45	29	64.4	9.85
December	8.02	36	21	58.3	13.75
Total	**340.19**	**534**	**347**	**67.22**	**537.11**

Juvenile yellowfin tuna was present throughout the year, on the other hand, juvenile bigeye tuna can only be seen in certain months. Catch ratio between both species almost resembles 10:1, whereas for every 10 kgs of juvenile tunas at least consist of approximately a kilogram of bigeye tuna (Table 2).

Tabel 2. Estimated percentage of juvenile yellowfin and bigeye tuna caught by purse seine that landed in Tamperan Fishing Port 2016

Month	Catch (kg)		Catch ratio (%)		Total (kg)
	juvenile BET	juvenile YFT	juvenile BET	juvenile YFT	
January	170	194	46.80	53.20	364
February	182	306	37.31	62.69	489
March	104	1299	7.42	92.58	1403
April	0	425	0.00	100.00	425
May	0	1452	0.00	100.00	1452
June	43	1229	3.41	96.59	1272
July	0	229	0.00	100.00	229
August	0	6150	0.00	100.00	6150
September	0	2368	0.00	100.00	2368
October	0	273	0.00	100.00	273
November	0	266	0.00	100.00	266
December	0	257	0.00	100.00	257
Mean			**7.91**	**92.09**	**14948**

Juvenile bigeye tuna most likely appeared during January-March and sometimes in June with the highest proportion between the first two months (Figure 3). Besides, the size of juvenile yellowfin tuna was relatively bigger in the first semester compared to the second semester as shown in a distinctive pattern. In contrast, comparatively bigger juvenile bigeye tuna were found towards the end of the monitoring (Figure 4).

Figure 3. Estimated monthly percentage ratio of juvenile yellowfin and bigeye tuna caught by purse seine based in Tamperan Fishing Port (2016).

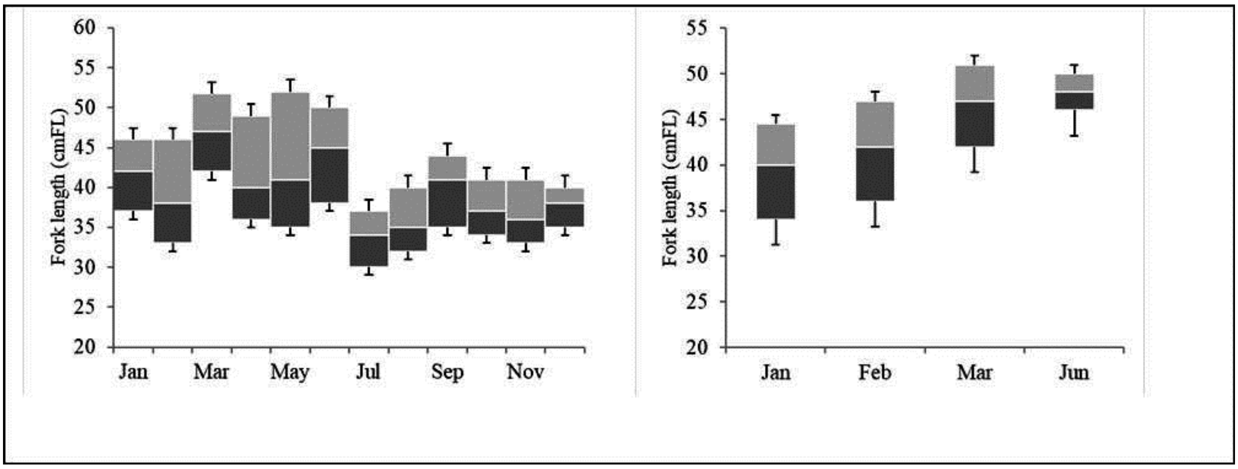

Figure 4. Box plots of the variation in length distribution over the months January - December for yellowfin tuna (left) and bigeye tuna (right) caught by Tamperan Purse seine. Note that bigeye tuna were only present in January - March and June.

Discussion

Purse seine fleets mainly target skipjack tuna (*Katsuwonus pelamis*), whether chasing free schooling or associated with fish aggregating devices (FADs). However, the latter approach often results in significant catches of juvenile tunas as by-catch, which mainly consist of yellowfin and bigeye tuna (Hartaty *et al.,* 2012). Usually, the sizes range at interquartile (IQR) of 49-69 cmFL and 47-73 cmFL for juvenile yellowfin and bigeye tuna, respectively (Phillips *et al.,* 2017), which are relatively similar to the finding on this study for both species. In general, the catch-at-size of skipjack tuna exploited in the Indian Ocean ranged from 30 cm to 180 cmFL, where juvenile tunas (<30 cm) form mixed schools with skipjack tuna that are mainly limited to surface tropical waters, while larger fish (>30 cm) are mostly found in sub-surface waters (IOTC, 2018). Juvenile tunas inhabit water columns down to approximately 300 m (Nootmorn *et al.,* 2005).

Purse seine selectivity tends to selects smaller tuna than longline gear (Campbell *et al.,* 1995; Bertignac *et al.,* 2000; Sun *et al.,* 2017). Tuna purse seiners usually perform three types of sets; sets on associated with dolphins, associated with floating objects (such as FADs), and sets on tuna in unassociated schools. In general, the first type of set, catch is dominated by large yellowfin tuna and the later type of sets, the catch usually consist of skipjack and small bigeye and yellowfin tuna. Longline vessels catch large yellowûn and large bigeye on the other hand, longline.

Both length-weight relationships (yellowfin and bigeye tuna) performed similar equations, which indicated an allometric growth type, whereas its length grew faster than its weight (Figure 2). The finding is similar to Tantivala (2000) in Maldives, where for juvenile bigeye tuna *b*=2.6480, R^2 = 0.99, *n* = 232, as for juvenile yellowfin tuna *b*=2.8580, R^2=0.97, *n*=368. The growth pattern is mostly affected by several factors, including season, habitat, food availability, feeding rate, gonad development, sex, spawning period, health, preservation techniques, and locality (Zhu *et al.,* 2010). Also, it is an interesting finding where both equations are interchangeable, which means either equation can be performed to convert length to weight for both juvenile yellowfin and bigeye tuna.

The proportion of juvenile yellowfin and bigeye tuna was approximately 10:1. Further studies across gears and locations are required. However, this finding could be useful for converting the huge proportion of juvenile tuna caught by purse seine fleets based in Tamperan Fishing Port, Pacitan. According to port statistics, the total catch of juvenile tuna, yellowfin tuna, and bigeye tuna from purse seine fleets in 2016 recorded 704,136 kg, 17,771 kg, and 3,669 kg, respectively. Besides, Tamperan Fishing Port authorities usually record a mix of juvenile tuna (yellowfin and bigeye) as "yuwana tuna", while tuna that is larger than 20 kg is surely separated by species. If we apply the conversion ratio according to this study, then the final total catch estimation for yellowfin and bigeye tuna are 665,576 kg and 60,000 kg, respectively. Such the result is very useful in determining the stock status for both species globally since both species were under the responsibility of Indian Ocean Tuna Commission (IOTC). It also gives more confidence for the managers to decide on any management measures since the juvenile tuna can be scientifically distinguished.

CONCLUSION

It can be inferred from the study that in terms of catch proportion of juvenile tuna, it consists of ratio 10:1, whereas for every 10 kg of juvenile tuna contain approximately a kilogram of bigeye tuna. Also, the length-weight equation for both species is interchangeable, which means either equation can be performed to convert length to weight for both juvenile yellowfin and bigeye tuna.

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