



## BIOLOGICAL ASPECT OF BULLET TUNA *Auxis rochei* (Risso, 1810) IN THE MAKASSAR STRAIT, WEST SULAWESI, INDONESIA

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### ABSTRACT

The objectives of the present study were to determine the size distribution, growth pattern, feeding habit and stomach fullness index of bullet tuna *Auxis rochei* in the Makassar Strait, West Sulawesi. The research was conducted for six months between March and August 2017. Sampling collection was carried out using the handline technique. A total of 2160 fish were caught. Their total length ranged from 15.8 to 28.5 cm and weight ranged from 52.3 to 366.5 g. The total length of male fish ranged from 18.5 to 28.5 cm and weight ranged from 77.5 to 366.5 g. The total length of female fish ranged from 15.8 to 27.5 cm and weight ranged from 52.3 to 328.8 g. The growth pattern of bullet tuna for both male and female fish was classified into a positive allometry ( $b > 3$ ); the type of food found in the fish gut consisted of crustacean (12.50% to 25.64%), chepalopods (7.32 to 34.80%) and unidentified (47.69 to 64.51%), respectively. Nonetheless, the predominant food condition was not identified and in the gut there was generally no food present. The stomach fullness index ranged from 1.13% to 7.18%,  $\frac{1}{4}$  (12.11 to 15.74%),  $\frac{1}{2}$  (12.27 to 23.14%) and empty (59.26 to 65.74%). The length size distribution of male bullet tuna was larger than the female with a positive allometric growth pattern. However, the growth pattern of male and female bullet tuna statistically showed no difference.

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## INTRODUCTION

Bullet tuna *Auxis rochei* has been a sought-after commodity due to its high economic value on both the domestic and international market. It leads to a high exploitation of wild population of bullet tuna leading to the decline of its stock in the wild. Babana in central Mamuju Regency of West Sulawesi has been known as one of the central producers of bullet tuna in Indonesia. Traditional and modern fishing gear has been applied for fishing activity by the local fishermen in Indonesia. The gillnet and hand-line are used for catching bullet tuna. Nonetheless, fishing activity is dominated by the hand-line technique.

Several studies on aspects of bullet tuna have been documented in the Makassar Strait. The study on the fishing of bullet tuna was based on time, depth and type of bait (Kantun, 2016), length and weight relationship, reproductive season, growth pattern, feeding ecology (Plandri et al., 2009), feeding habits of bullet tuna *Auxis rochei* in the southern Tyrrhenian Sea (Mostarda et al., 2007), stocks assessment for tuna fish (Melmambessy, 2010), the parameters of chlorophyll-a, the abundance of phytoplankton and zooplankton, primary production, number of fish catches and feeding habits (Kaswadji et al., 2009), the stock assessment on the potential, pattern and level of utilization in the Flores Sea (Mallawa et al., 2006). Research on tuna in other regions has also been carried out, for instance, the potential and exploitation level of mackerel tuna *Euthynnus affinis* and frigate tuna *Auxis thazard* (Piscandika et al., 2012), the relationship and integrated marketing of tuna between two fish landings (Lubis and Pane., 2017), the fishing ground of tuna (Girsang, 2008) and the feeding habits of tuna (Aswir et al., 2004). However, there is no study on biological aspect of bullet tuna carried out in the Makassar Strait, particularly in West Mamuju waters. The study aimed to determine the length size distribution, the growth pattern, feeding habits and the stomach fullness index of bullet tuna in the Makassar Strait, West Sulawesi.

## MATERIALS AND METHODS

### Study sites

This study was conducted in the Makassar Strait, West Mamuju waters. The study site is an administrative part of West Sulawesi province, Indonesia, located between the Islands of Kalimantan (Borneo) and Sulawesi. West Mamuju waters have a typical tropical climate that consists of the dry season and rainy season. There are several fishing activities in the location such as commercial fishing, fishing activity by local people using the gill nets, fish traps and various other types of fishing gear. In addition, the Makassar Strait has become a home for many marine species such as large, small pelagic fish, demersal fish and reef fish.

### Fish sampling

Fish sampling was carried out twelve times for 6 months between March and August 2017 in shallow Fish Aggregating Device (FAD) and deep FADs (Figure 1). Fish sampling was performed using hand-line fishing gear of number 10 and 12 size, deployed in both shallow and deep FAD locations.

### Length and weight measurements.

The captured fish was first placed in the buckets. A ruler with an accuracy of 0.1 cm was used to measure the fork length of fish. The digital balance with 0.01 g accuracy (Sartorius Brand) was used to obtain the fish weight.

### Stomach observation

The stomach fullness index of fish sampled was observed by dissecting the stomach of tuna (cardiac, body mid portion and pylorus part) and then the contents were observed, including type of food and the condition of the stomach. A total of 60 fish samples were collected for six months or 10 fish per trip.

### Data analysis

#### Fish distribution

Fish size distribution was calculated according to Munira (2010) as follows: (1) by determining the number of classes using the "sturgess law" rule with the formula  $K$  (number of classes) =  $1 + (3.32 \log n)$ ; (2) by determining the interval (class interval width) with the LK formula (class width) = data range divided by class; (3) by determining the frequency of each class by entering the length of each sample into the specified class interval.

### Growth pattern

The growth pattern of fish was measured using equation:  $W = aL^b$  (Effendie, 2002). Note:  $W$  = fish weight (g),  $L$  = fork length (cm), constants  $a$  and  $b$ , obtained from regression analysis.

### Stomach fullness index

The stomach content of fish was analyzed using Index of Preponderance modified by Biswas (1993) below:

$$IP = ((v_i \times o_i)) / (\sum (v_i \times o_i)) \times 100\%$$

Notes:

IP: Preponderance Index

$v_i$ : Food weight

$o_i$ : the frequency of type of food obtained in the stomach.

The stomach fullness observation method was modified from Bapal and Bal (1958) where the fullness level of stomach was 1/4, 2/4, 3/4 and 4/4.

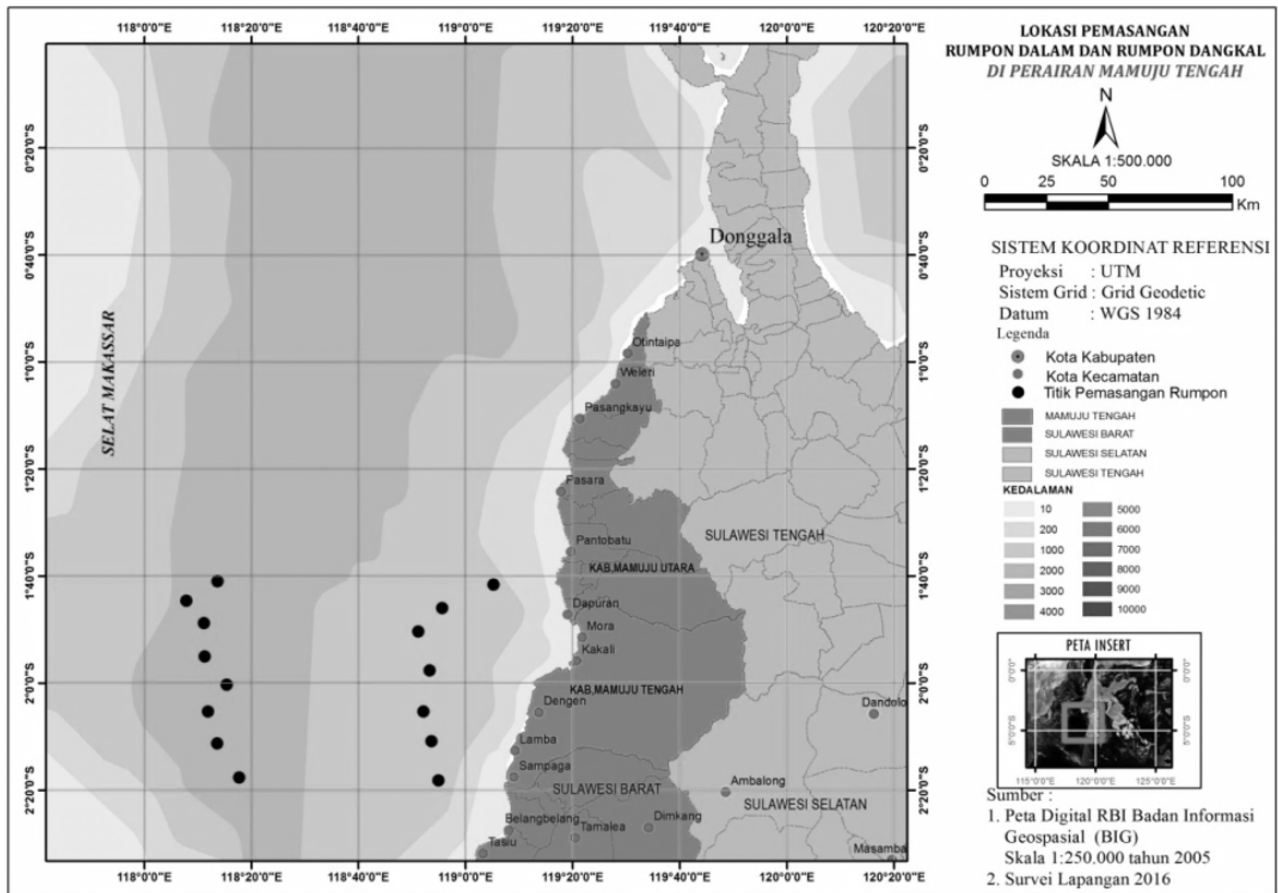


Fig 1. Fishing ground of bullet tuna in the Makassar Strait, West Sulawesi

### Statistical analysis

A t-test was performed using IBM version 22 for the significant difference between the growth patterns of bullet tuna both male and female.

## RESULTS

### Size distribution

A total of 2160 fish was obtained during the study period, consisting of 1216 female and 944 male bullet tuna. The size distribution of female and male bullet tuna varied. The female bullet tuna length and weight distribution ranged from 15.8-27.5 cm ( $23.7 \pm 0.54$  cm) and 52.8-261.3 g ( $190.8 \pm 16.01$  g). While male tuna fish length and weight ranged from 18.5-28.5 cm ( $23.6 \pm 0.52$  cm) and 77.5-366.5 g ( $178.4 \pm 16.02$  g), respectively (Figure 2). The frequent size distribution of female bullet tuna based on the class size was 24.0-24.5 cm or 175 fish (14.39%), while the male was 23.5-24.0 or 119 fish (12.69%).

### Growth pattern

In the present study, the type of growth of bullet tuna is shown in Figure 3. Growth patterns of female bullet tuna

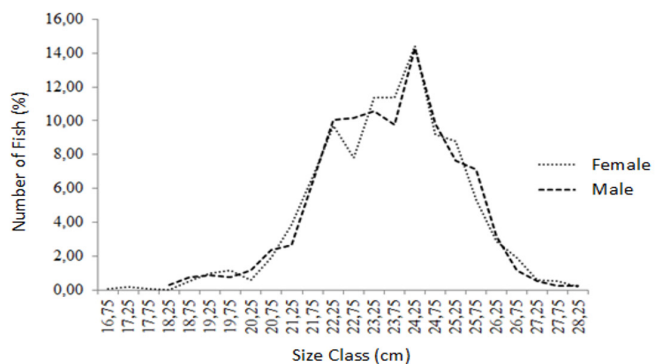


Fig 2. Size distribution of bullet tuna based on sex between March and August 2017

( $n = 1216$  fish) obtained  $b$  value (3.246 with  $r^2$  of 0.5142) or positive allometric growth ( $b > 3$ ) (Figure 3A). The growth pattern of bullet tuna for male ( $n = 944$  fish) obtained  $b$  value (3.4934 with  $r^2$  of 0.5922) or positive allometric growth ( $b > 3$ ), whereas the equation of female and male growth was  $W = 0.0059L^{3.246}$  and male  $W = 0.0027L^{3.4934}$  (Figure 3B). The t-test analysis suggested that the growth patterns of bullet tuna, both male and female, are not different from positive allometric patterns or greater weight gain compared to length gain.

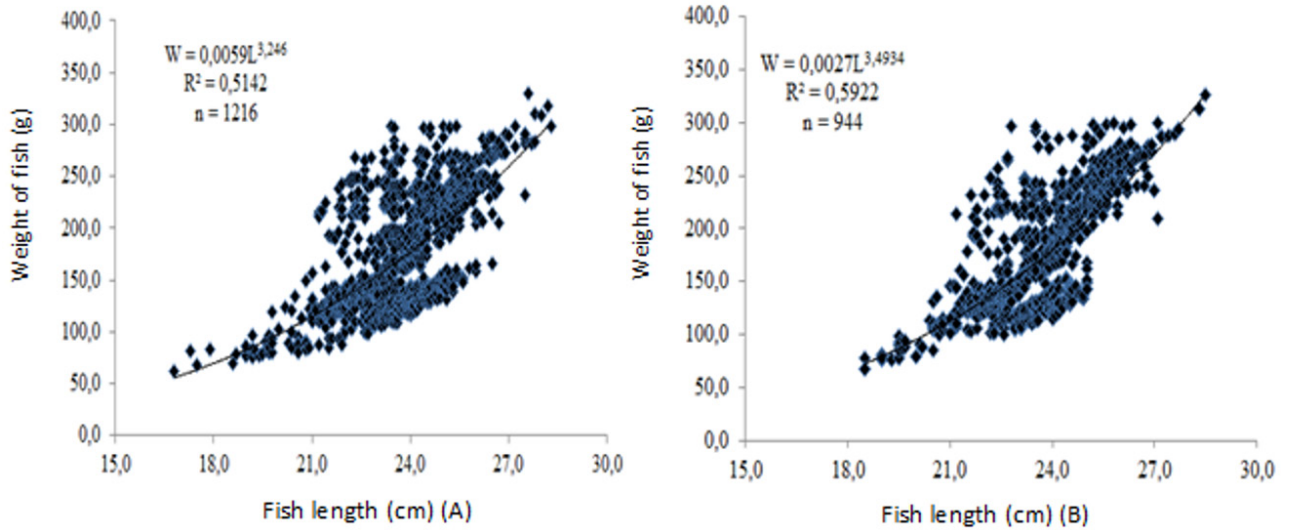


Fig 3. Growth pattern of bullet tuna for female (A) and male (B)

#### Feeding habit

In the present study, the type of food found in the bullet tuna gut was dominated by unidentified food (47.69 to 64.51% or average  $\pm$  56.1%), cephalopods (7.32 to 34.80% or average  $\pm$  21.06%), crustaceans 12.50-25.64% (average  $\pm$  19.07%) and fish species (14.98 to 22.9% or average  $\pm$  18.83%), respectively (Figure 4).

#### Level of stomach fullness

The level of stomach fullness of bullet tuna caught at FADs ranged from 59.26 to 65.74%. The lowest condition was 1.13-7.18% (Figure 5).

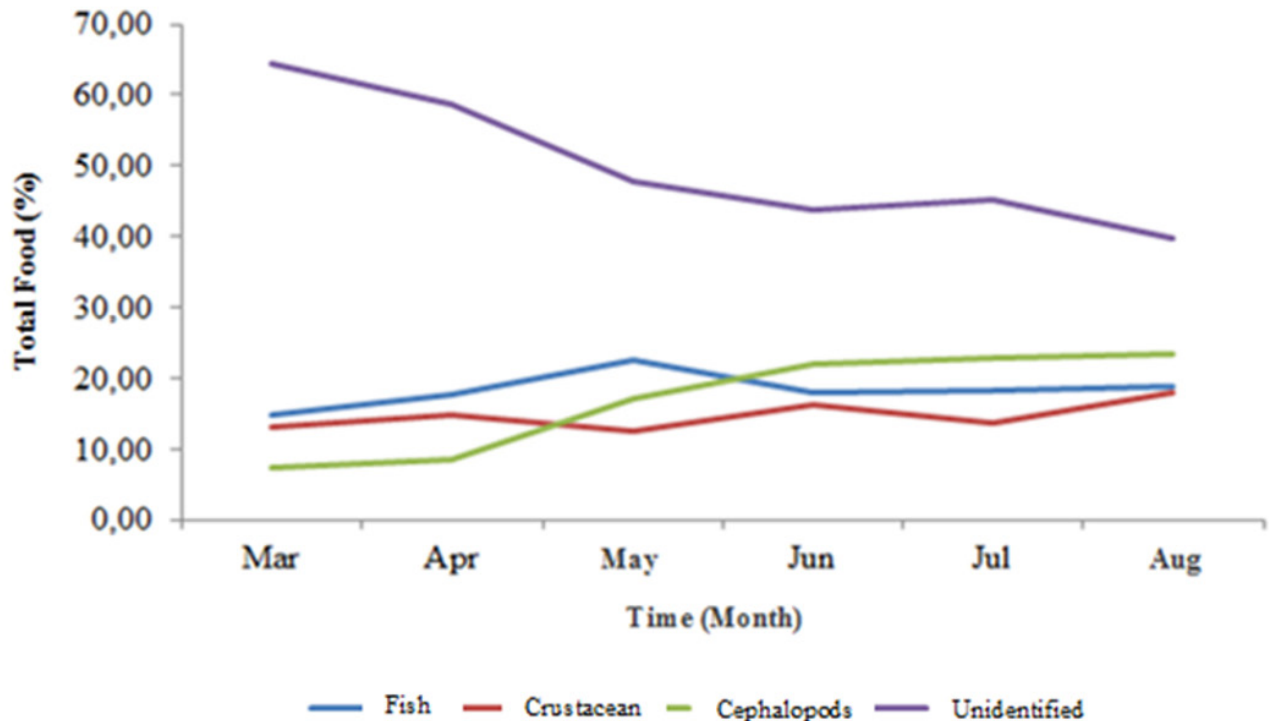


Fig 4. Growth pattern of bullet tuna for female (A) and male (B)

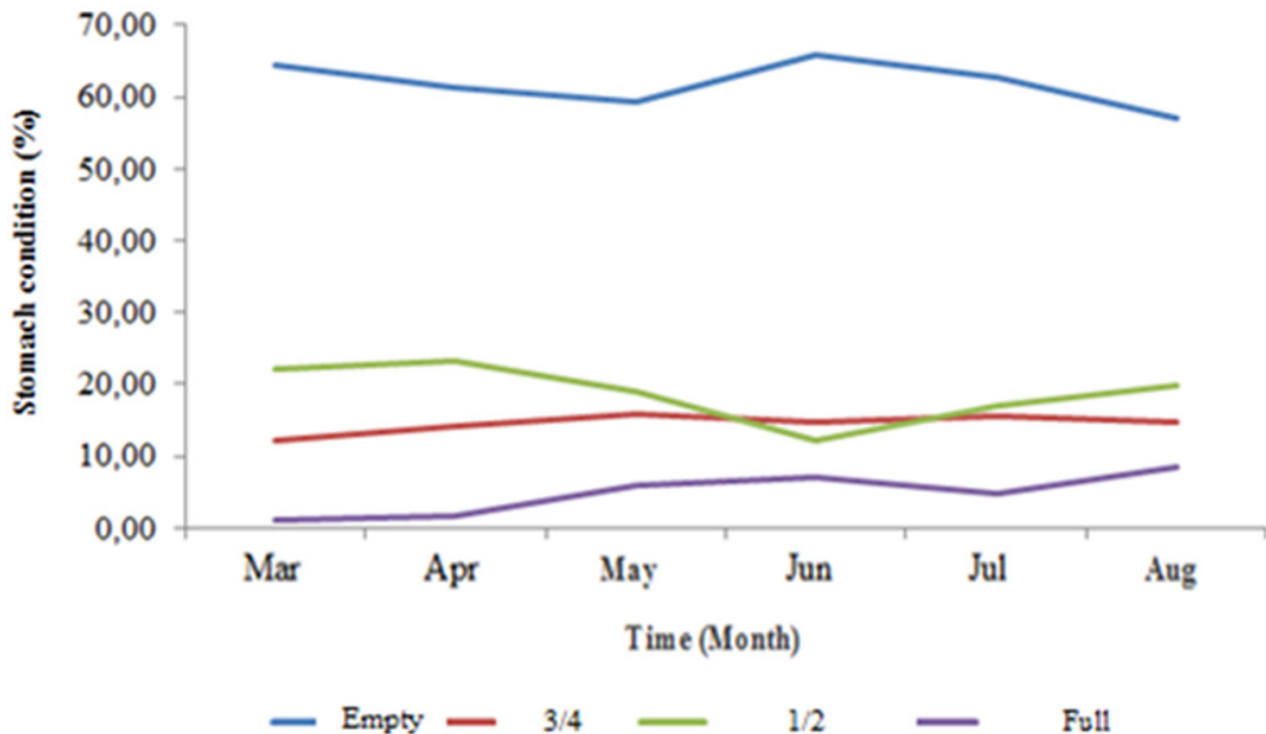


Fig 5. Level of stomach fullness of bullet tuna during the study period between March and August 2017

## DISCUSSION

In the present study, the size distribution of the female bullet tuna was wider than of the male fish (Figure 2). However, this result differs from the size distribution found in Majene waters, the Makassar Strait which is narrower than the fish size distribution in Babana waters, central Mamuju (20.0-26.0 cm) (Kantun, 2016). Conversely, Kantun and Amir (2016) reported that the size distribution of bullet tuna found in Bone Bay was narrower (41-42 cm or 14.60%). Several studies on size distribution of bullet tuna are the following: Gibraltar, 47 cm (Rodriguez-Roda, 1966); Turkey waters, 28.5-44.5 cm (Bok and Oray (2001); Spanish Mediterranean southwest 33.4-47 cm (Macias et al., 2005); Southeastern Mediterranean 25-47 cm (Macias et al., 2006; Pacitan waters, 22-28.2 cm (Prayitno et al., 2017).

The type and size of fishing rods, including fishing technology and biological nature lead to the difference in fish size distribution. The size of the fishing rod affects the composition and size of the fish caught because it is associated with mouth openings of the fish. On the other hand, fish tends to swim in schools of fish of identical length and weigh, thus contributing to the distribution of fish size.

The growth pattern of male (3.4934 with  $r^2$  of 0.5922) and female (3.246 with  $r^2$  of 0.5142) bullet tuna was classified into a positive allometric pattern. In other words, the weight gain is faster than the length gain. If it is associated with the condition of resources in nature, then the level of

utilization of tuna in Central Mamuju is still relatively low. Nonetheless, the growth pattern of female bullet tuna in May showed a negative allometric growth pattern. This is due to a decrease in body weight of female bullet tuna associated with the occurrence of gonadal maturity and spawning season in the following month during the study period.

Differences in the value of  $b$  may occur between different populations of the same species or between the same population in different years related to biological and ecological conditions, such as the carrying capacity of the environment where the fish live. Changes in the environment and biological conditions of fish can cause changes in the relationship of long weights. These changes are caused by the condition of fish and they depend on food, age, sex and gonadal maturity.

Macias et al. (2006) reported that a positive allometric growth pattern ( $b = 3.292$ ) of bullet tuna *Auxis rochei* was obtained in the Mediterranean waters of Western Spain. Plandri et al. (2009) obtained a positive allometric growth pattern ( $b = 3.674$ ) in the Ligurian Sea. Noegoro et al. (2013) reported negative allometry of bullet tuna ( $b = 2.933$ ) in West Coast waters of Sumatra. Rodrigues-Roda (1966) reported positive allometry ( $b = 3.129$ ) in Spanish waters. The differences in growth patterns (value  $b$ ) are caused by fish behavior. Muchlisin (2010) argues that the size of  $b$  value can be influenced by the behavior of fish, such as active swimming fish showing a lower value of  $b$  when compared to fish that swim passively. This is related to the allocation of energy spent on movement

and growth. In addition, the general value of  $b$  depends on physiological and environmental conditions such as temperature, pH, salinity, geographical location, sampling techniques (Jenning et al., 2001), and biological conditions such as gonadal development and food availability (Froese, 2006). Moreover, Fafioye and Oluajon (2005) argue that fish growth is generally relative in nature which can change according to time. If there is a change in the environment and the availability of food, the value of length and weight will also change (Garcia-Arteaga et al., 1997). These changes are influenced by genetics, sex, age, temperature and food availability to support their lives (Effendie, 2002).

The results of observations of the stomach indicated that the gut of bullet tuna was dominated by unidentified food (47.69% to 64.51% or average  $\pm$  56.1%), cephalopods (7.32 to 34.80% or average  $\pm$  21.06%), crustaceans 12.50-25.64% (average  $\pm$  19.07%) and fish species (14.98 to 22.9% or average  $\pm$  18.83%), respectively. This is in line with Kumaran (1964) who determined 3 majors type of food for bullet tuna in the Indian Ocean. They are finfishes (*Sardinella* spp, *Anchoviella* spp, *Leiognathus* sp, and *Carangidae*), crustaceans (*Rhopolophthalmus* sp, *Hyperia bengalensis*, *Oxycephalus Clausi*, *Pseudophausia latifrons*, *Acetes erythreus*, *Squilla* larvae) and cephalopods. Noegroho et al. (2013) found the gut of bullet tuna in an empty condition (61%), filled with anchovy *Stolephorus* sp (28%) and unidentified fish (12%) obtained from 175 fish. Ghosh et al. (2010) found that the type of food in bullet tuna includes Crustacea, Mollusca, Annelida, Anthyphyta and some small pelagic fish such as *Stolephorus* spp. *Sardinella* spp. and trevally fish species, whereas Froese and Pauly (2009), Kahraman et al. (2010), Widodo et al. (2012) found the type of food obtained from the gut of bullet tuna such as small fish, anchovy, crustacean and squids. Similarly, Mostarda et al. (2007) claimed that the bullet tuna of 194 and 465 mm (FL) in size is more likely to prey on fish larvae, planktonic invertebrates and small-sized cephalopods.

The types of food found in the stomach indicate that tuna are not classified as selective when searching for food. The unidentified type of food is due to the digestive process and the possibility that it had also been absorbed. The diversity of food types found in tuna was also an indicator of optimal water quality and food availability in the tuna fishing grounds. Interestingly, unidentified food tends to decline between May and August, during the study period. Decreasing the number of unidentified foods probably related to food absorption due to energy intake. A lot of energy intake is required during the gonadal maturation. In the present study, the highest spawning peak and gonadal maturity occurred in August. This suggests that the more fish gonads mature, the more food is needed to stimulate the development of gonadal hormones.

Noegroho et al. (2013) found that from 65 of *Auxis thazard* stomachs, the gut contained unidentified food (41%), no food (32%), sardines (*Sardinella* sp) (14%), crustaceans

(*Acetes* spp) (10%), anchovies (*Stolephorus* sp) (2%) and squids (Lolingidae) (1%). Furthermore, Noegroho et al. (2013) reported that out of 175 gut samples of bullet tuna *Auxis rochei*, empty stomach conditions were 61%, containing 28% anchovies (*Stolephorus* sp) and 12% of unidentified food because they were shattered. In addition, in kawakawa *Euthynnus affinis*, with 54 stomach samples analysed, gut empty condition (83%), unidentified fish (12%) and 5% of scads (*Decapterus* sp) were found. The fullness of stomach was highly affected by the digestive process and food availability.

## CONCLUSION

Variations in size distribution are caused by the size of the fishing rod, time of observation, fishing ground, fishing technology, cycle and the behavior of the fish. Growth patterns can be caused by fish behavior, physiological, biological conditions and food availability. The diversity of food types found in the stomach of tuna suggests the indicator of water quality and food availability in the fishing area. The condition of the stomach depends on the availability of food in nature, the duration of the digestion process and density of tuna population. Hand-line fishing gear for *Auxis rochei* bullet tuna fish promotes sustainable fish exploitation.

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## BIOLOŠKI ASPEKT TRUPCA *Auxis rochei* (Risso, 1810) U MAKASARSKOM TJESNACU, ZAPADNI SULAWESI, INDONEZIJA

## SAŽETAK

Ciljevi ove studije bili su utvrditi veličinu, rast, ishranu te indeks punoće želuca trupca *Auxis rochei* u tjesnacu Makassar, zapadni Sulawesi. Istraživanje je trajalo šest mjeseci u razdoblju od ožujka do kolovoza 2017. godine. Prikupljanje uzoraka provedeno je tehnikom ručnog ribolova udicom a ukupno je ulovljeno 2160 riba. Njihova totalna dužina (TL) je varirala od 15,8 do 28,5 cm, a masa (W) od 52,3 do 366,5 g. TL ženki kretala se u rasponu od 15,8 do 27,5 cm, a W od 52,3 do 328,8 g. Dužinsko-maseni rast mužjaka i ženki trupaca bio je pozitivno alometričan ( $b > 3$ ); vrsta hrane koja se nalazila u probavnom sustavu sastojala se od rakova (12,50% do 25,64%), glavonožaca (7,32 do 34,80%) i neidentificiranih organizama (47,69 do 64,51%). Unatoč tome, dominantna ishrana prema

vrstama nije utvrđena, a u crijevima uglavnom nije pronađena hrana. Indeks punoće želuca kretao se u rasponu od punog 1,13% do 7,18%,  $\frac{3}{4}$  (12,11 do 15,74%),  $\frac{1}{2}$  (12,27 do 23,14%) i prazan (59,26 do 65,74%). Prema raspodjeli veličine, mužjaci trupca su bili veći od ženki s pozitivnim alometrijskim rastom, međutim bez utvrđene statistički značajne razlike.

**Ključne riječi:** rasprostranjenost, rast, ishrana, stanje crijeva, *Auxis rochei*, vode Mamuju

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