Population dynamics and feeding habits of *Euthynnus affinis*, *Auxis thazard*, and *Auxis rochei* in South Coast of East Java waters

Tri Djoko Lelono and Gatut Bintoro
Faculty of Fisheries and Marine Science Universitas Brawijaya, Malang, Indonesia

E-mail: t.djoko@ub.ac.id

Abstract Little tuna landed there are three types: *Euthynnus affinis*, *Auxis thazard*, *Auxis rochei*. The analysis shows the condition of the resource indicates the condition Over Exploited. Length and weight relationship tuna (*Auxis thazard*) total positive allometric Length of first caught fish (Lc) of 27.08 cm, The length at first maturity (Lm) 28.39 cm/t, total mortality (Z) = 4.08 per year, Fishing mortality (F) = 2.91 per year, natural mortality (M) = 1.17 per year, with the Exploitation rate (E) = 0.71 per year which, if E> 0.5 is overfishing. The relationship between length and weight of Tuna (*Euthynnus affinis*) was unsexed W = 0.1078 Lt 3.48. The value of Lc and Lm were 37.51 cm, 38.43 cm, and 40.17 cm respectively. Von Bertalanffy growth *L* = 72.50 [1 − e−0.11(t + 0.27)] equation of this study was. The rate of total mortality (Z), natural (M), and catch (F) were respectively 0.56, 1.74 and 0.01. The peak season tuna catch in PPN Prigi was occurred in September (515.865%) with the low season occurred in January (1.24%). As for UPT PP Muncar, the peak season cob arrest took place in March (316.315%) with famine in February (6,651%). Little Tuna food was consist of 7 groups, namely: small fish, shrimp, Ascomycota, Chloromonadophyta, Chyanophyta, Chrysophyta, and Chlorophyta.

1. Introduction
There are three types of tuna caught by fishermen on south coast of East Java, the species of tuna fish are *Auxis thazard* (Lacepede, 1800), *Auxis rochei* (Risso, 1810), and Mackerel tuna (or kawakawa; *Euthynnus affinis*) are medium-sized schooling pelagic fish distributed throughout the Indo-West Pacific between latitudes 35°N and 25°S, longitudes 40°E and 137°W, in water temperatures of 18–29°C [1]. Information on fish biology, in general, can explain the condition of fish stocks, because the fish biology, discusses mainly fish growth, influenced by the size of fish stocks, the food habit. More. Several methods are used to identify fish species, including traditional morphological identification, electrophoresis, isoelectric focusing, liquid chromatography, immunoassay, and biological technologies [2,3].

Around 80% of the world’s exploited fish stocks are currently considered to be overexploited. Recent reanalysis of worldwide catch data indicates an advancing in the percentage of overexploitation, depletion,
stock improvement, and trends reduction in the property of underexploited and moderately exploited stocks [4].

Stock identification is a central theme in fisheries science that involves the recognition of self-sustaining components within natural populations. Stock identification is a prerequisite for the task of stock assessment and fishery management because most applied population models assume that the group of individuals has homogeneous vital rates (e.g., growth, maturity, mortality) and a closed life cycle, in which young fish in the group was produced by previous generations within the same group [5]. Introduction Stocks are a random group of fishes that are essentially self-reproducing, with members of each group having similar life history features. Stock identification is a basic requirement to describe the stock status and to support the better stock assessment of fishery. Stock identification involves recognition of self-sustaining components within natural populations. Moreover, fish populations are assumed to be partially reproductively isolated and comprise of subpopulations [6–9].

The food web context can be important in assessing the population viability of endangered species. For example, the dependence of a species on different food sources can strongly influence whether and what changes in the food web could affect populations over an extended time period. The ability of fish species to subsist on a diet consisting mostly of detritus can impact the population’s ability to survive times with low availability of other food [10]. Research on marine food webs describes the key processes of ecological communities, such as energy and bio-element pathways [11,12] the purpose of this study was to determine the growth of food types in Little tuna.

2. Materials and methods

2.1. Population dynamic
Total Length and weight data were collected randomly from two fish landing sites: place puger coast, and the coast of Prigi (figure 1). Samples were taken every month during the period of April-December (2016) and May - June (2017) from the fishing fleet using purse seine, gillnet and trolling lines. Identification was carried out based on the identification key of Whithead (1985) and FAO Species Identification Sheet (1984). The parameters of the length-weight relationship were estimated through logarithmic transformations. If the calculated number of "b" does not have a significant difference with 3, the species has isometric growth. The below equation was used to test this difference.
Figure 1. Landing sites for the sampling of *E. affinis*, *Auxis thazard*, and *Auxis rochei*

The data were analyzed using FiSAT II software (FAO-ICLARM Stock Assessment Tools) [13]. The fitting of the best growth curve was based on the ELEFAN 1 program [14], which allows the fitted curve through the maximum number of peaks of the length-frequency distribution. The von Bertalanffy growth equation for length was taken in the form of:

\[ L_t = L_\infty \left(1 - \exp\left(-K (t-t_0)\right)\right) \]  

Growth parameters \((K, L_\infty)\) and total mortality \((Z)\) were estimated by using Shepherd's method (scan of \(K\) value) and lengthconverted catch curve methods [15].

2.2. Analysis of the stomach contents of fish

2.2.1. The length of the intestine relative. Analysis of the relative length of the intestines was conducted to determine the type of food consumed by fish. The formula used to calculate the length of the colon relative by [16]:

Relative according to is:

\[ R.L.G = \frac{L_G}{L} \times 100 \]

R.L.G = Relative Length of Gut
L.G = Lenght of Gut (cm)

2.3. Method of the frequency of occurrence

\[ f_k = \frac{n_i}{N} \times 100 \]

Fk = percentage frequency of occurrence of these foods
Ni = number of occurrences of food to-i
N = the number of the stomach containing food
2.4. The section Index (Index of preponderance) (ILP)
Analysis largest share index (Index of preponderance) is a combination of methods of the frequency of occurrence and volumetric methods. This is done to determine the composition of the food contained in the stomach of fish with the calculation formula according to [17].

\[
ILP = \frac{V_i \times O_i}{\sum (V_i \times O_i)} \times 100
\]

Information:
ILP = index largest proportion (index of preponderance)
Vi = the percentage of the volume of food to-i
Oi = the percentage frequency of occurrence of food to-i

To determine the eating habits of the fish, then the food order can be distinguished to three categories, which are the main food with IP values> 40%, complementary foods with IP values of between 4% to 40%, and food additives with IP value <4.

3. Results and discussion

3.1. Result
In Indonesia especially WPP 573, generally the type of tuna in includes Tongkol Komo (Euthynnus affinis), Tongkol Krai (Auxis thazard) and Tongkol Lingsong (Auxis rochei). Here is the local name of little tuna in some areas can be seen in Table 1: Based on the logbook of fisheries statistic board of East Java Province, little tuna was only recorded as Euthynnus sp. However, according to its characteristic, the fish consisted of three species, namely Abon/Pengpeng (Euthynnus affinis), Glondong (Euthynnus alletteratus), and Rengi (Euthynnus lineatus). Lack of data and ability to identify each species would lead to management of fisheries resource [18].

Table 1. Kinds of Little Tuna caught in the South Eastern Java

| Common Name          | Local Name                  | Scientific Name | International Name |
|----------------------|-----------------------------|-----------------|--------------------|
| Mackerel Tuna        | Abon Peng-peng (Trenggalek), Komo (Treanggalek, Sendang Biru) | Euthynnus affinis | Little Tuna        |
| Mackerel Tuna        | Lisong, Rengis (Treanggalek), Locok (Jember, Madura, Sendang Biru) | Auxis rochei    | Bullet Tuna        |
| Mackerel Tuna        | Krai (Trenggalek)           | Auxis thazard   | Frigate Tuna       |

Total length relationship in weight of the Euthynnus affinis is \( W = 0.1078 L^{3.48} \) where as total length of correlation and the weight Auxis thazard then obtained a growth pattern \( W = 4.8105 L^{3.1096} \) mean Growth Length greatly affects the weight growth likely due to by two factors, are availability of food resources for Euthynnus affinis (table 2 and 3) and body shape of the fish came from Furthermore, according to [19] says that the composition of stomach contents tunny (Euthynnus affinis) is largely dominated by small fish, crustaceans and shellfish.

The popularity is highest in foods anchovy that is for Southern waters east Java amounted to 80.59% and 96.71% at 713. Table 3 This means that the anchovy is the main food of tuna as a percentage of the value of LSI is greater than 40%.type of food has a value Largest Section Index (LSI) > 40%, the types of food are the main food and if the value of 4% ≤ LSI ≥ 40% was included complimentary foods whereas if
the value of LSI <4%, the types of food, including food additives. The other category is the replacement foods are foods consumed at the time of main meals not

Table 2. Composition type food fish little tuna

| Fish   | Food                   | Type of food                         |
|--------|------------------------|--------------------------------------|
| E. affinis | Stelophorus sp         | Fish Species that is unknown          |
|        | Loligo sp              | Engraulidae                          |
|        | Ascomycota, Chloromonadophyta, Chyanophyta, Chrysophyta, Phytoplankton | Chlorophyta.                      |

Flores sea

| E. affinis | Stelophorus sp         | Engraulidae                          |
| Clupeidae  | Sardinella sp          | Crustacea                            |
| destruction Fish | Types of fish that can not be identified because it has been digested (broken) |

The popularity is highest in foods anchovy that is for Southern waters east Java amounted to 80.59% and 96.71% at 713.(table 3) This means that the anchovy is the main food of tuna as a percentage of the value of LSI is greater than 40%. type of food has a value Largest Section Index (LSI) > 40%, the types of food are the main food and if the value of 4% ≤ LSI ≥ 40% was included complimentary foods whereas if the value of LSI <4%, the types of food, including food additives. The other category is the replacement foods are foods consumed at the time of main meals not available [17]

Table 3. Data Analysis Little Tuna Fish

| Type of food         | Vol. type of food | Volumetric percentage (Vi) | Percentage frequency of occurrence (Oi) | Vi x Oi | Largest Section Index (LSI) |
|----------------------|-------------------|----------------------------|----------------------------------------|--------|-----------------------------|
| Fish                 | 15                | 10.87                      | 11.11                                  | 120.77 | 3.99                        |
| Engraulidae          | 101               | 73.19                      | 33.33                                  | 2439.61| 80.59                       |
| Loliginidae          | 10                | 7.25                       | 11.11                                  | 80.52  | 2.66                        |
| Unidentify           | 12                | 8.70                       | 44.44                                  | 386.47 | 12.77                       |
| Engraulidae          | 252               | 89.36                      | 100.00                                 | 8936.17| 96.71                       |
| Sardinella sp        | 5                 | 1.77                       | 28.57                                  | 50.66  | 0.55                        |
| destruction Fish     | 23                | 8.16                       | 28.57                                  | 233.03 | 2.52                        |
| Crab larvae          | 2                 | 0.71                       | 28.57                                  | 20.26  | 0.22                        |

The total length first captured Euthynus affinis (Lc) 37.31 cm (size catch 15.5 - 64.5 cm, TL). Meanwhile, in the waters of the Sunda strait Lc = 55 cm. (50-60 from [20,21] One reason that is different from the territorial waters, the waters are also different characteristics so that the catches obtained also different. The different Lc of the same species found was due to the environment of the Indian ocean. Von Bertalanffy growth equation of E. affinis is $L_t = 72.50 \left[ 1 - e^{-0.11(t + 0.27)} \right]$. Von Bertalanffy growth equation of (Auxis thazard) is $L_t = 35.40 \left[ 1 - e^{-0.58(t + 0.26)} \right]$. The length of the E.affinis on the long infinitive (L∞ of E. affinis)
was achieved at the age of 150 months or 12.5 years. *E. affinis* growth rate tended to be faster with the high rate of intrinsic growth rate. This high rate led to a logarithmic growth curve. At the field, the *E. affinis* length was 64.5 cm. While the maximum length of fish supposed to be 90% of $L_\infty$ so that the $L_{\text{max}}$ value was 64.09 cm with age less than 21 months or 7/4 years. Age *Auxis thazard* is suspected at the time $t = 0$ years of age has a 5.07 cm long, while the age of the fish at the time of a maximum length of 33.63 cm was estimated to be (t mak) 4.8 years.

3.2. Discussion

The composition is similar to the composition of the stomach contents of tuna (*Katsuwonus pelamis*). So skipjack (*Katsuwonus pelamis*) and tuna (*Euthynnus affinis*) compete for the same food. Besides, Griffiths et al. (2007) and Griffiths et al. (2009) [22,23] mentions that following food consumption and the ratio of mackerel tuna (*Euthynnus affinis*) was studied in the waters neritic Australia. All consisted of 43 prey were identified from 271 bellies of the fish. Clupeoid entails are pelagic (wt weight 78%; 71% frequency of occurrence) and demersal fish (19% of wt weight; 32% frequency of occurrence). In general, families Scombroidae swimming at night time and return to the deeper layers of in the afternoon. This follows the vertical migration of the movement of plankton and small fish they eat. Little Tuna is a pelagic fish that lives in groups.

Feeding habits and food is one aspect that is the basis for the study of interactions between species, either through study relationship between predator-prey or food competition). Feeding habits and interactions between species of fish as one of the bases for the management of fish resources related to the multi-species. By knowing feeding habits, it can be seen ecological relationships between organisms in surface waters, such as forms of predation, competition, and the food chain. Therefore, the food can be a determining factor for population growth and condition of the fish. While this type of food every species of fish usually depends on the age, place and time

In addition, according to the FAO Fisheries Department (1994), the spread little tuna spread in the waters of the Indo - West Pacific, in the warm waters including islands - islands of the ocean and islands. Some species there are migration and the Middle East gathered in the Pacific. Sometimes *Euthynnus affinis* is also found in Australia known as the mackerel tuna originating from the mid-coast of Western Australia, explore tropical countries north and back to the east coast to the south of New South Wales. Also found a small tuna *Euthynnus alletteratus* is one of three species of the genus Euthynnus found in tropical and subtropical coastal waters in the world [17]. Distribution of small tuna on the inner side of the Atlantic, including the Mediterranean Sea; *Euthynnus affinis* overall found numerous in the Indian Ocean - the Pacific Ocean and its own limited *Euthynnus lineatus* tropical regions of the Pacific Ocean. Generally, the three species occur between 35 and 35 OLS Olu and no more than 100 miles from land.

Waters with their different characteristics will influence the catch obtained. Another possible cause was the time of data collection. When the data were collected at the time of fish scarcity, the catch would be dominated by small fish and the $L_c$ value tended to decrease. The length of the fish at the first caught ($L_c$) is required to determine the mesh size of fishing gears, whether it has the aspect of environmental sustainability or not. The value of $L_c$ should be compared with the value of $L_m$. If $L_c < L_m$, the mean mesh size nets have supported the aspects of environmental sustainability. However, if $L_c > L_m$, the mesh size nets were not in accordance with environmental sustainability. Therefore the mesh size should be enlarged and it would give the fish a chance to spawn. In this study, the fish length at the first mature gonads ($L_m$) was 40.17 ± 6.5 cm or ½ months of the year. Therefore in the Prigi waters the value of $L_c$ was <$L_m$. It means that the little Tuna fishery has not been fulfilled the aspect of environmental sustainability. In this study the most caught fish were immature, therefore growth overfishing occurred. Studies showed that most of Indonesia’s capture and fisheries are either fully or over-exploited [24]. This suggests that the tuna fishery has not been in accordance with the regulations in fishing management.
Ideally, the value of $L_c > L_m$ which means that the fish are caught by the fishermen had already mature and the sustainability of fish stock can be maintained. Length at first Catch ($L_c$) whereas Length at first catch ($L_c$) *Auxis thazard* Lacepede, 27.08 cm in length was first cooked fish gonad ($L_m$) of 28.39 cm, while according to Ghosh et al. (2012) [24] *Auxis thazard* captured first ($L_c$) in the waters of 32.83 cm Length at first maturity ($L_m$) 30.8 cm water India.

### 4. Conclusion

The results of the analysis of the tuna hull show that the types of food eaten by tuna include the types of surface small fish and cephalopods. The observation of the tuna hull composition shows that the unknown type of surface fish is 51.72% while the type of food not identified is 48.28% for the Pondokdadap area. In the Puger area, anchovy was found with the presentation of IP values of 96.81% and squid at 3.19%. Next to the Maumere region, the type of food found in all samples is anchovy with an IP value of 100%. Von Bertalanffy growth equation of *E. affinis* (Total Length) $L_c = 72.50 \left\{ 1 - e^{-0.11(t + 0.27)} \right\}$ Von Bertalanffy growth equation of (*Auxis thazard*) is (Total Length) $L_c = 35.40 \left\{ 1 - e^{-0.58(t + 0.26)} \right\}$

### References

[1] Froese R and Pauly D 2010 FishBase
[2] O’reilly P and Wright J M 1995 The evolving technology of DNA fingerprinting and its application to fisheries and aquaculture *J. Fish Biol.* 47 29–55
[3] Osman M A, Ashoor S H and Marsh P C 1987 Liquid chromatographic identification of common fish species *Journal-Association Off. Anal. Chem.* 70 618–25
[4] Froese R, Zeller D, Kleisner K and Pauly D 2012 What catch data can tell us about the status of global fisheries *Mar. Biol.* 159 1283–92
[5] X. C S and Lisa A. Karr1 Stefano Mariani3Stock Identification Methods: An Overview. Stock Identification Methods
[6] Hilborn R and Walters C J 1992 Quantitative fisheries stock assessment: choice, dynamics and uncertainty *Rev. Fish Biol. Fish.* 2 177–8
[7] Cadrin S X, Kerr L A and Mariani S 2013 Stock identification methods: applications in fishery science (Academic Press)
[8] Hallerman E M 2003 Population genetics: principles and applications for fisheries scientists
[9] Marcil J, Swain D P and Hutchings J A 2006 Genetic and environmental components of phenotypic variation in body shape among populations of Atlantic cod (Gadus morhua L.) *Biol. J. Linn. Soc.* 88 351–65
[10] Herwig B R and Zimmer K D 2007 Population ecology and prey consumption by fatminnows in prairie wetlands: importance of detritus and larval fish *Ecol. Freshw. Fish* 16 282–94
[11] Bukovinszky T, van Veen F J F, Jongema Y and Dicke M 2008 Direct and indirect effects of resource quality on food web structure *Science (80-. ).* 319 804–7
[12] Yen J D L, Cabral R B, Cantor M, Hatton I, Kortsch S, Patricio J and Yamamichi M 2016 Linking structure and function in food webs: maximization of different ecological functions generates distinct food web structures *J. Anim. Ecol.* 85 537–47
[13] Gayanilo F C, Sparre P and Pauly D 2005 Stock Assessment Tools (FISAT II) on line User’s Guide The Food and Agriculture Organization of the United Nations
[14] Pauly D 2010 5 easy pieces: how fishing impacts marine ecosystems
[15] Sparre P 1998 Introduction to tropical fish stock assessment. Part 1. *Manual FAO Fish. Tech. Pap.* 306 1–407
[16] Roos S C and Aizam Z A 1983 Some aspects of the biology of ‘Ikan Kelabau” Osteochilus
melanopleura (Bleeker)

[17] Natarajan A V and Jhingran A G 1961 Index of preponderance—a method of grading the food elements in the stomach analysis of fishes *Indian J. Fish.* **8** 54–9
[18] Jiao Y, Hayes C and Cortés E 2008 Hierarchical Bayesian approach for population dynamics modelling of fish complexes without species-specific data *ICES J. Mar. Sci.* **66** 367–77
[19] Al-Zibdah M and Odat N 2007 Fishery status, growth, reproduction biology and feeding habit of two scombrid fish from the Gulf of Aqaba Red Sea *Leban. Sci. J.* **8** 3–20
[20] Djamali A 1987 *Estimation of Tuna Fish Growth Rate (Euthynnus affinis and Auxis thazard) from Sunda Strait Waters, West Java* (Jakarta: Center for Research and Development of Oceanology LIPI)
[21] Lelono T D 2012 *Resource Management (Euthynnus sp.) In the waters of Prigi East Java* (Universitas Brawijaya Malang)
[22] Griffiths S P, Fry G C, Manson F J and Pillans R D 2007 Feeding dynamics, consumption rates and daily ration of longtail tuna (Thunnus tonggol) in Australian waters, with emphasis on the consumption of commercially important prawns *Mar. Freshw. Res.* **58** 376–97
[23] Griffiths S P, Kuhnert P M, Fry G F and Manson F J 2009 Temporal and size-related variation in the diet, consumption rate, and daily ration of mackerel tuna (Euthynnus affinis) in neritic waters of eastern Australia *ICES J. Mar. Sci.* **66** 720–33
[24] Ghosh S, Sivadas M, Abdussamad E M, Rohit P, Koya K P, Joshi K K, Chellappan A, Margaret Muthu Rathinam A, Prakasan D and Sebastine M 2012 Fishery, population dynamics and stock structure of frigate tuna Auxis thazard (Lacepede, 1800) exploited from Indian waters *Indian J. Fish.* **59** 95–100