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Research Article

Food Preference of Bullet Tuna (*Auxis rochei* Risso, 1810) in Prigi Coast of Trenggalek Regency, East Java

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ABSTRACT
As a commercial fish, bullet tuna is constantly caught in purse seine fisheries to provide economic benefits for coastal communities. Biological information such as food preference has to be known due to their sustainability in the future. This research aims to figure out the food composition and preference of bullet tuna (*Auxis rochei* Risso, 1810) in Prigi Coast, Trenggalek Regency East Java. A total of 294 fish landed by purse seine fishermen have been collected from March up to May 2018. Each individual was measured in its total length and weight, then was dissected for sex determination, measured the length of intestine, and analyse the stomach content. The data analysis encompasses frequency distribution of total length, relative gut length, frequency of occurrence, index of preponderance, trophic level, niche breadth, and food overlapping. The research result indicates that the main foods of *Auxis rochei* are fish and crustacean, while the complementary and additional foods were copepod, mollusc, annelid, and debris. Bullet tuna was a carnivorous fish with the trophic level of 3.7 and shows the existence of competition for food resources. Overlapping of feeding occurred in the 19-20 cm long group against the 23-24 cm long group in male fish and the 19-20 cm size group against the 21-22 cm length group in female fish. Bullet tuna use the same feed resources among the size groups of fish, where females use feed over a wider area than males.

INTRODUCTION
Tunas belonging to the genus Auxis has a wide distribution in tropical and oceanic sub-tropic oceans (Uchida 1981). Bullet tuna (*Auxis rochei*, Risso 1810) is one of the epipelagic neritic tuna found in the equator ocean and migrate as schooling (Pillai & Satheeshkumar 2012; IOTC 2017; Herath et al. 2019). Bullet tunas are commonly caught by gillnet, handline, and trolling, but it is a potential purse seine commodity (IOTC-WPNT09 2019) and also usually by-cached in pelagic fishery using danish seine, purse seine, drifting gillnet, lift net, pole, and line, as well as hand lines (Widodo et al. 2014). Prigi fishing port reported total catch of purse seine fishermen dominated by bullet tuna reached 500 tons in a day with a production value of about 2 billion to 3.5 billion rupiahs (Prigi Fishing Port 2022).

Fishery activities in Prigi bay are known as one of the main capture fisheries dominated by purse seine fishery. Fishery capture data from

Ministry of Marine Affair and Fisheries of Indonesia (MOMAF 2018) showed that almost 93.9% of purse seine had dominated the total fish catch landing in Prigi bay. At the Prigi Coast, the fishes caught using purse seine and dominated by small and big pelagic fish, followed by demersal fish. In 2018, fish capture using purse seine was dominated by bullet tuna and shortfin scad with 18,317 tons (66.08%) and 6,001 tons (21.65%), respectively (MOMAF 2018). Bullet tuna is one of the essential and potential pelagic fish resources in Prigi bay and has a valuable economic contribution to the local community.

Bullet tuna has not been massively exploited yet in several fishing areas because of its relatively small size. Nevertheless, frigate tuna species decline will increase bullet tuna exploitation (Collette et al. 2011). Bullet tuna resources on the west coast of Sumatera (Noegroho & Chodrijah 2015) and Prigi bay, East Java (Agustina & Rachman 2019) have been actively exploited. Intensive and continuous fishing could potentially endanger the sustainability of fish resources in the future. Therefore, appropriate management of bullet tuna is needed to ensure its sustainable fish stock and population. Good fisheries management should be based on the bio-ecological information of the fish; one of them is related to the food and feeding habits. Food preference can be used to determine the fish's natural nutrition and the interaction between the fish as well as its environments such as feeding habits, forms of predation, competition, and trophic level through the food chain (Effendi 2002). A few numbers of stomach contents analyses of bullet tuna were collected from different waters, namely Philippine waters, Tunisian waters, Indian waters and Makassar strait (Jasmine et al. 2013; Baeck et al. 2014; Hajjej et al. 2018; Kantun et al. 2019). These studies found that Bullet tuna commonly consume crustaceans, small fishes, and molluscs (Jasmine et al. 2013). Bullet tuna caught in Makassar Strait feed on crustaceans and cephalopods (Kantun et al. 2019), whereas on the west coast of Sumatera, the bullet tuna feed on anchovies (*Stolephorus* sp.) (Noegroho et al. 2013). Previous studies indicate that there are different types of food consumed by fish that might be controlled by food availability in the habitat and feeding behaviour. Up to now, there is still a scarcity of information on the food preferences and feeding habits of bullet tuna in the Prigi Coast. Therefore, this research aims to determine the food composition and preference of bullet tuna in Prigi Coast, Trenggalek Regency, East Java.

MATERIALS AND METHODS

In total, 294 samples of bullet tuna were collected once a month using the catch of purse seine fisherman from March up to May 2018 in Prigi Coast, Trenggalek Regency East Java (Figure 1). Each individual collected was measured in its total length (± 0.1 cm) and weighed using electric balancing (± 0.1 g). The specimens were dissected for visual inspection of their gonad for sex determination.

The digestive tract of fish is separated from the intestine and stomach. The length of the fish intestine was measured, while the fish stomach was separated and preserved using solution of formalin 4% (Berg 1979) in bottles labeled with the time of sampling. Samples of stomach contents only came from fish stomachs. Stomachs were dissected and the contents were added to the graduated test tube filled with distilled water. The volume of the sample of stomach contents was taken using a dropper and placed in Sedgwick rafter counting chamber containing a small of 2 x 2 x 1 mm^3 box. Sedgwick rafter is used to measure the volume of each food items. The larger food items were identified visually, whereas the small-sized food items were identified using dissecting microscope (Olympus CX 21, magnification 4× and 10×). The frequency of occurrence method

analyzed each type of food items found in the stomach, and the volume of each food items was analyzed by the volumetric method (Effendie 2002). The obtained data were analyzed based on the following formulas:

Relative gut length describes the type of fish food based on the ratio of the length of the intestine to the length of the fish's body. It was calculated as (relative gut length = total gut length (cm)/total length (cm)). Relative gut length is categorized as follows: carnivore < 1, omnivore 1-3, herbivore > 3

The frequency of food occurrence determined the presence of each type of feed contained in the stomach of the fish containing the food in their stomach. The frequency of occurrence was calculated as (% Oi = Ji/ p x 100),

Where:
Ji = number of fish containing food items
p = number of fish with food in their stomach

Volumetric method (% Vi), the percentage volume of the prey component i was calculated as:

$$\%V_i = \frac{\text{Number of points allocated to component } i}{\text{Total points allocated to subsample}} \times 100$$

Index of Preponderance describes the relative abundance of different organisms in the fish diet and is calculated as: (Biswas 1993)

$$IP = \frac{VixOi}{\sum_{i=1}^{n} VixOi} x100\%$$

where:
IP = index of preponderance
Vi = percentage of fish food volume type i
Oi = percentage of occurence frequency of food type i
N = number of fish food organism (i = 1, 2, 3,.....n)
Index of preponderance is classified into three categories as follows: main food = IP > 25%, complementary food = 5% ≤ IP ≥ 25%, additional food = IP < 5%.

Trophic Level describes whether the fish species is classified as carnivore, omnivore or herbivore, and calculated as:

$$Tp = 1 + \sum \left\{ \frac{Ttp x Ip}{100} \right\}$$

where:
Tp = trophic level
Ttp = trophic level of food type p
IP = index of preponderance of food type p
Trophic level is categorized as follows: trophic level 2 = herbivore; trophic level 2.5 = omnivore; trophic level 3 = carnivore.

Niche Breadth shows the adaptation of fish species to the food availability in the habitat, and is calculated as:

$$BA = \frac{1}{n-1}\left[\frac{1}{\sum Pij^2} - 1\right]$$

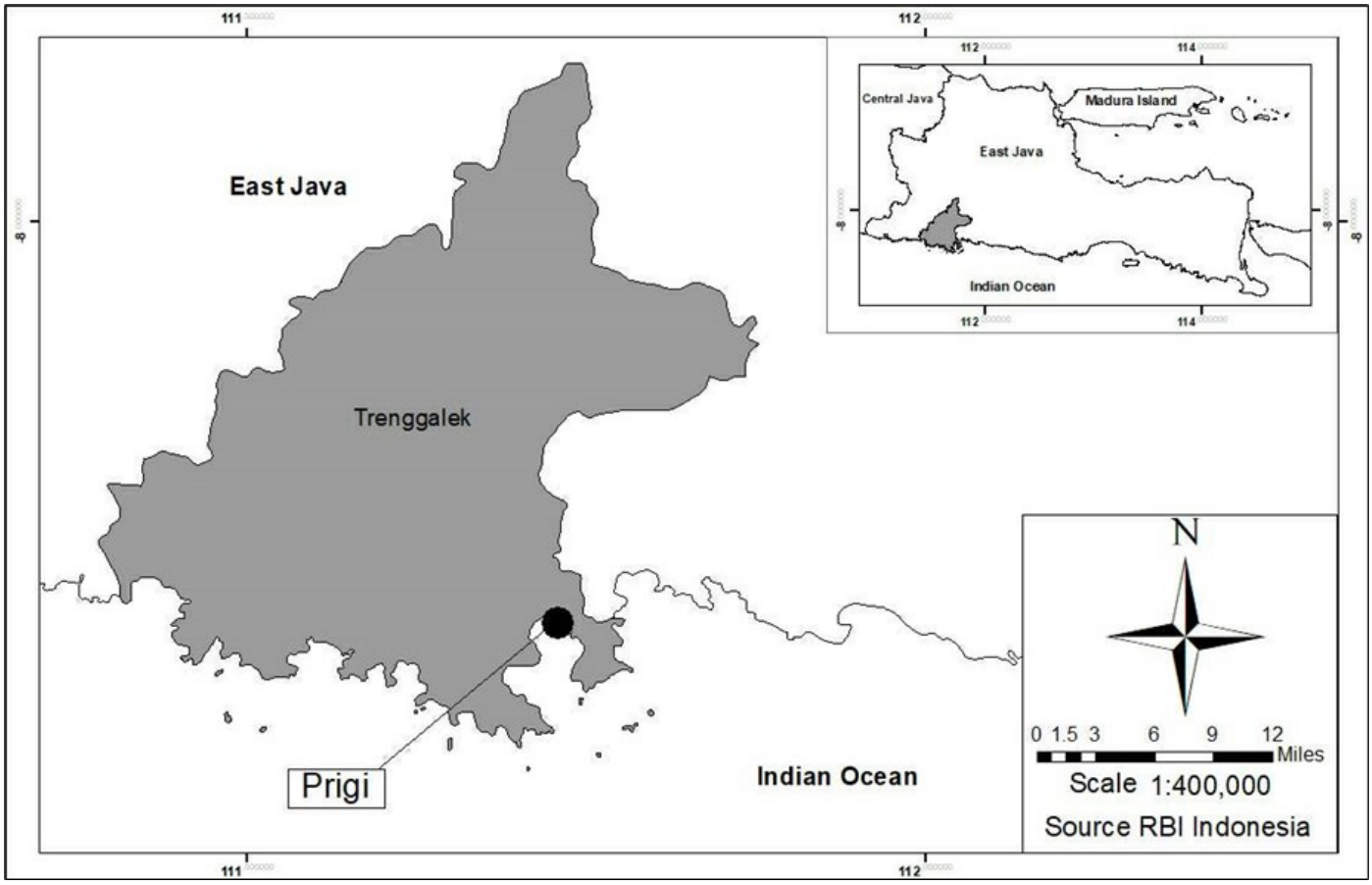

Figure 1. Landing site of bullet tuna (*Auxis rochei*) in Prigi Coast Trenggalek Regency East Java.

where:
BA = niche breadth of fish size i toward food resource j
Pij = proportion of fish size I that is related to food resource j
n = number of food of fish size (i=1, 2, 3,.....n)
Niche breadth values are considered as: high when BA > 0.6, moderate when 0.6 < BA > 0.4, low when BA < 0.4.

Food Overlapping describes multiple shared food sources, and is calculated as follows:

$$Ch = \frac{2\sum PijxPik}{\sum P^2ij + P^2ik}$$

where:
Ch = simplified Morisita Index between fish size j and size k
Pij, Pik = proportion of resource I from total resource used by fish size j and k (i = 1, 2, 3,.....n)

RESULTS AND DISCUSSION

Results

Food composition and preference of bullet tuna

The total of bullet tuna collected in Prigi Coast were 294 fishes and filled -stomach samples were 271 fishes (92.17%). Specimens of bullet tuna ranged between 17.3 - 27.4 cm in total length, which were consisted by male 52.38% and female 47.62%. Male and female fish were commonly found in the 19 - 20 cm length group. Most male fish were found in the length group of ≤ 18 cm, 23 - 24 cm, and 25 - 26 cm , while the least is ≥ 27cm. Most female fish were found in the length group of 23-24 cm and ≤ 18 cm, while ≥ 27 cm were not found.

The relative gut length of fish showed in Table 1 is used to describe the type of food fish ate. The intestine of bullet tuna is about 7 - 12 cm, with a relative gut length of about 0.37 - 0.43. Based on the relative gut length of the intestine, the bullet tuna is a carnivorous fish. The food composition of bullet tuna consists of fishes (39%), shrimps (25%), copepods (6%), molluscs (4%), annelids (1%), and debris (25%). Only fish pieces, fish spines, and fish scales were found in the fish food item. The food composition of bullet tuna in Prigi Coast showed in Figure 2.

Table 1. Gut length size of bullet tuna in Prigi Coast.

Length Size Group (cm)	Q (species)	Mean of Gut Length	Relative Gut Length
≤ 18	39	7.86	0.43
19-20	145	8.35	0.42
21-22	26	9.09	0.42
23-24	42	8.81	0.37
25-26	40	10	0.39
≥ 27	2	11.85	0.43

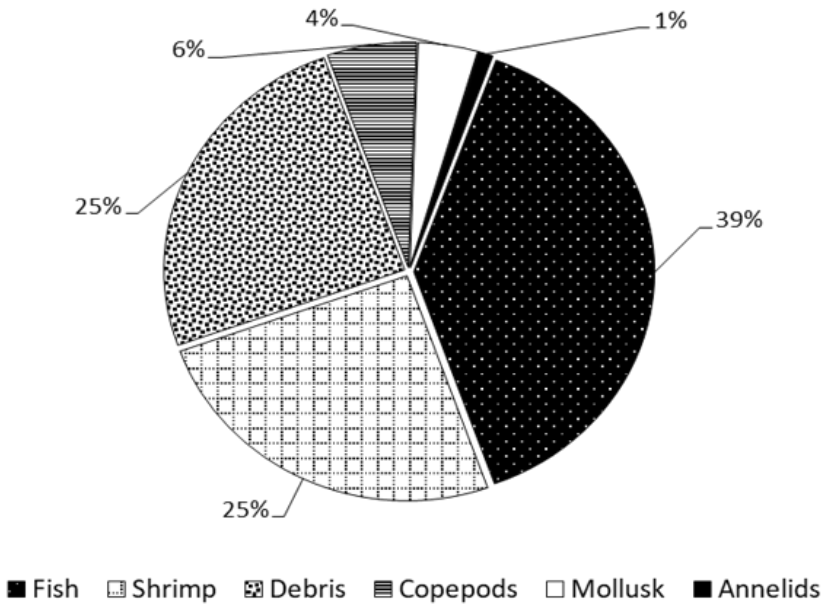

Figure 2. Food composition of bullet tuna in Prigi Coast.

The frequency of fish was mainly found in bullet tuna stomachs. The most common types of fish (87.80%) were found in male fish, while shrimp (83.33%) and fish (72.22%) were most commonly found in female fish. The frequency of occurrence of debris (53.66%) and shrimp (23.17%) is rarely found in male fish. Copepods and mollusks were also found in fish stomachs with less frequency. Annelids are most rarely found in male and female fish.

Food composition indicates bullet tuna as a carnivore. Index of preponderance (IP) shows the percentage of the greatest amount of food contained inside fish's stomach. Bullet tuna's index of preponderance based on their sex can be seen in Table 2 and 3 as follows.

Table 2. Index of preponderance (IP) of male bullet tuna (*Auxis rochei)* in Prigi Coast.

Type	IP	Category
Fish	39.66	Main food
Crustacean	14.7	Complementary food
Mollusca	0.79	Additional food
Annelids	1.58	Additional food
Copepods	3.21	Additional food
	40.05	-

Table 3. Index of preponderance (IP) of female bullet tuna (*Auxis rochei*) in Prigi Coast.

Type	IP	Category
Fish	26.51	Main food
Crustacean	29.93	Main food
Mollusca	2.68	Additional food
Annelids	0.29	Additional food
Copepods	6.58	Complementary food
Debris	40.05	-

Fish was the main food of male bullet tuna (39.66%), while crustacean was the complementary food (14.7%). A similar result was presented in female bullet tuna. The main food of female bullet tuna is fish (26.51%) and crustacean (29.93%), while copepods become the complementary food (6.58%).

Trophic level indicates the position of organisms in a food chain. In Prigi Coast, bullet tuna is categorized as a carnivore (3.6 - 3.8) (Table 4). Small to adult bullet fish do not experience any shift of food type.

Table 4. Trophic level of bullet tuna (*Auxis rochei*) in Prigi Coast.

Length (cm)	Trophic level	Description
≤ 18	3.8	Carnivore
19 - 20	3.8	Carnivore
21 - 22	3.6	Carnivore
23 - 24	3.7	Carnivore
25 - 26	3.6	Carnivore
≥ 27	3.7	Carnivore

Niche breadth indicates the selectivity of intraspecies fish from a certain size class toward the availability of food resources. Female bullet tuna has a broader range of niche breadth than the male one. Table 5 shows the detailed niche breadth of male and female bullet tuna in the Prigi Coast.

The niche breadth of male bullet tuna is ranged between 2.26 -3.28, with a range of standardization between 0.27 - 0.46. Male bullet tuna which sized ≥ 27 cm, consumes more various food than the others of smaller size. The niche breadth of female bullet tuna ranged between 2.78 - 4.63, with standardization ranging between 0.35 - 0.73. The broadest niche breadth of female bullet tuna ranged between 25 - 26 cm.

Food overlapping refers to the similarity of food type consumed by male and female bullet tuna, and also by bullet tuna of several length classes. The food overlapping of male and female bullet tuna can be seen in Table 6 and 7.

Table 5. Niche breadth of bullet tuna.

Length Size Class (cm)	Male		Female	
	Niche Breadth	Standardization	Niche Breadth	Standardization
≤ 18	2.66	0.33	2.78	0.35
19 - 20	2.35	0.27	2.84	0.37
21 - 22	3.26	0.45	3.05	0.41
23 - 24	2.82	0.36	4.05	0.61
25 - 26	2.82	0.36	4.63	0.73
≥ 27	3.28	0.46	-	-
Average	2.86	0.37	3.47	0.49

Table 6. Food overlapping of male bullet tuna (*Auxis rochei*) in Prigi Coast.

Length Class (cm)	≤ 18	19 - 20	21 - 22	23 - 24	25 - 26	≥ 27
≤ 18	1	0.97554	0.91612	0.96799	0.9788	0.94536
19 - 20		1	0.93175	0.99098	0.98122	0.91237
21 - 22			1	0.95718	0.9669	0.94046
23 - 24				1	0.98435	0.92223
25 - 26					1	0.96959
≥ 27						1

Food overlapping of male bullet tuna is ranged between 0.91612 - 1. The highest number of food overlapping was in length class 19 - 20 cm toward length class 23 - 24 cm. Thus there is a similarity of food resources consumed by bullet tuna of both length classes.

Table 7. Food overlapping of female bullet tuna (*Auxis rochei*) in Prigi Coast.

Class (cm)	≤ 18	19 - 20	21 - 22	23 - 24	25 - 26
≤ 18	1	0.91932	0.89838	0.88799	0.8462
19 - 20		1	0.99148	0.5513	0.86972
21 - 22			1	0.94833	0.89655
23 - 24				1	0.98653
25 - 26					1

Food overlapping of female bullet tuna is ranged between 0.5513 - 1. The highest number of food overlapping is indicative in length class 19 - 20 cm toward length class 21 - 22 cm. Both of these length classes consumed the same food resources.

Discussion

Bullet tuna in this study has a smaller length than in the South Tyrrhenian (Mostarda et al. 2007) and the Mediterranean (Morote et al. 2008). Lisong tuna has a total length of up to 50 cm with a length of 35 cm at the first maturity of the gonads (Fishbase 1993). The relative gut length is used to see the natural food consumed by fish. The length of the digestive tract of fish depends on the natural food consumed (Biswas 1993). Bullet tuna is categorized as a carnivorous fish based on the relative gut length. The relative gut length varies from one species to another and in the same species at different life stages.

In the present study, the bullet tuna in Prigi Coast preferred to eat fish and crustacean as main foods with additional foods ítems were copepods, molluscs, and annelids. Our results are similar to those mentioned by Hejjej et al. (2018), where *Sardinella aurita* are the most important prey species found in the majority of bullet tuna's stomachs, while crustaceans and molluscs are secondary food types. Feeding habit study of *A. thazard* by Mariyasingarayan et al. (2018) collected from Southeast coast of India reported the presence of fishes and crustacean (88% and 12%, respectively) with the dominant fish species were *Anchoviella* spp. and *Leiognathus* spp. Based on the food preference, the bullet tuna was a non-selective feeder, which mainly prefers the crustaceans, small fishes, and molluscs (Jasmine et al. 2013). Another study reported that the food type of bullet tuna in Makassar Strait consisted of unidentified food, cephalopods, crustaceans, and small fishes (Kantun et al. 2019). Bullet tuna on the west coast of Sumatera preferred the anchovies' group as the main food (Noegroho et al. 2013). As a comparison, the bullet tuna in the Southern Tyrrhenian Sea mostly consumes crustacea, fish, mollusc, polychaeta, siphonophora, chaetognatha, and urochordate (Mostarda et al. 2007), while the Indian Sea, the main food of bullet tuna is fish (Clupeidae), crustacea, dan mollusc (Kumaran 1964). Plandri et al. (2009) recorded that the dominant prey of bullet tuna from the Ligurian sea were fish and euphasiid crustaceans, while Jasmine et al. (2013) reported the common food of bullet tuna collected from Indian waters were fish, crustaceans and zooplankton. Bullet tuna in Philippines waters are epipelagic feeder that ate fish as dominant food and prey for others like crustacean, copepods, crab larvae, amphipods, and cephalopods (Baeck et al. 2014).

The food type of bullet tuna can easily change. Besides, due to the preference of a particular prey, the main food of fish seems to depend on the availability of prey in the habitat where the fish live. The prey items of *A. rochei* studied from Prigi Coast are in accordance with the feeding patterns of this species from different coastal areas. The tendency of fish to consume a certain type of food is highly influenced by several factors such as food size, color, taste, texture, and appetite, and also the availability of food in a particular sea (Effendie 2002). Bullet tuna consume prey based on their availability in the environment and geographic abundance (Baeck et al. 2014). The variation of the food type of bullet tuna is used as the optimal quality water indicator and food availability in the fishing ground of bullet tuna (Kantun et al. 2019).

The **trophic level** estimated of bullet tuna in Prigi Coast is 3.7, positioning it as a carnivore that opportunistically eats various food types and preferred ate fish and cructacean. Fatah and Adjie (2015) state that fish catching is capable of altering the spatial distribution and fish abundance, which will affect species interaction and trophic structure in general. The **trophic level** of a particular fish can be affected by life expectancy (size), gonads, ecomorphology, behavior, intraspecies and interspecies competition, as well as distribution of resources and parasites (Elliot & Hemingway 2002).

Female bullet tuna has a broader range of **niche breadth** than the male one. Therefore, female bullet tuna consumes many kinds of food. The difference in niche breadth can be caused by food availability, food abundance, and habitat of the fish. The organism that consumes several kinds of food resources, its niche breadth will increase even though the availability of food resources is low (Anakotta 2002). The niche breadth of bullet tuna is different in each class. Body length and a great variety of food do not guarantee a broad niche because niche breadth is also deter-

mined by the fish's capability of using the available resources. Fish capability to use the food variation in the water is not determined by fish length (Ariasari et al. 2018). Bullet tuna in Philippine waters has narrow niche and as a specialized feeder which dominantly ate fish as dominant prey (Baeck et al. 2014). The niche breadth of bullet tuna in Prigi Coast is ranged between 2.35 - 4.63. The total and food type consumed by a particular fish species generally depends on age, place, and time (Effendie 2002).

Food overlap reveals the occurrence of similar foods that fish consume. The highest proportion of foods overlapped by male 19 - 20 cm bullet tuna is 0.99098. The largest value of foods overlapped by female 21 - 22 cm bullet tuna is 0.99148. These findings demonstrate that certain length classes of bullet tuna have a similar type of diet. Thus there is a competition in obtaining food resources between these two length classes of female bullet tuna. Thus it induces competition among length classes. The high number of competitions is affected by the high number of similarities in using niche and the same space. In general, fish will undergo food type shifting along with the increase in fish length. It is influenced by various factors such as competition of obtaining food resources, food abundance, and tendency level toward the prey.

CONCLUSIONS

Fish and crustacean are the main food of *Auxis rochei* in Prigi Coast (39% and 25%, respectively), while the complementary and additional foods are copepod, mollusc, annelid, and debris. Bullet tuna was a carnivorous fish with the trophic level of 3.7, and shows existence of competition for food resources, especially between different fish sizes. Bullet tuna female has a wide area of consumed food resources than male.

AUTHOR CONTRIBUTION

B.P.A collecting data and analysis, A.A. analysed the data and wrote the manuscript, T.B.S. wrote the manuscript, E.S. designed the research, wrote the manuscript and supervised all the process.

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CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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