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Length weight relationship, food habit and sex ratio of narrow-barred Spanish mackerel (*Scomberomorus commerson* Lacepede 1800) in Bone Bay waters, South Sulawesi Indonesia

Achmar Mallawa and Faisal Amir

Department of Fishery Faculty of Marine Sciences and Fishery, Hasanuddin University, **Indonesia**

***Correspondence:** achmar_mallawa@yahoo.co.id **Received 21-04-2020, Revised: 20-07-2020, Accepted: 30-07-2020 e-Published: 18-08-2020**

The narrow-barred Spanish mackerel is one of the important fishery commodities in the Fisheries Management Area 713, especially in the Bone Bay waters, but research on these fish is still lacking. This research conducted in 2018 for 10 months in the Bone Bay waters aimed at analyzing several aspects of biology including growth patterns, condition factor, sex ratio, food habits and sex ratio. Primary data collected through direct observation in the field. The length-weight relationship was analyzed using cubic equation, condition factor by Froese equation, food habit by the Index of Relative Importance, and sex identification and sex ratio by morphological method and chi square. The results of the study showed that the growth patterns of narrow barred Spnaish mackerel in Bone Bay waters is negative allometric, condition factor was 1.138, the food consisted of teleost, shrimp and mollusk and importance food are *Stelophorus* sp, *Rastrelliger* sp and *Sardinella* sp, the number of males and females in balance.

Keywords: Scomberomorus, growth pattern, importance food, sexes-ratio

INTRODUCTION

In Indonesian waters area there are two species of mackerel, the Indo Pacific King mackerels (*Scomberomorus guttatus*) and narrow-barred Spanish mackerel (*Scomberomorus commerson*), spread almost throughout Indonesian waters.

The Directorate General of Capture Fisheries of the Ministry of Maritime Affairs and Fisheries (2014) reported that one of Indonesia's waters that has a high potential for narrow-barred Spanish mackerel is the Indonesian Fisheries Management Area 713 where Bone Bay is included. The Indian Ocean Tuna Committee, IOTC (2017) explained that based on the average catch data of mackerel fish from 2013 to 2017 of several countries in the Indian Ocean, Indonesia occupies the top position with a total catch of 39,000 tons per year or 24% of the total catch. Next followed India, Islamic Republic of Iran, United Arab Emirates, Myammar, Pakistan, Saudi Arabia, Yemen, and others. Suman et al., (2016) report that in the Indonesian Fisheries Management Area 713 large pelagic fishes including narrow-barred Spanish mackerel already full exploited and even over exploited. This is in line with the IOTC (2018) that since 2015 the narrow-barred Spanish mackerel stock in Indian Ocean waters is in a condition subjected to overfishing ($F_{2015}/F_{MSY}>1$) and stock overfished ($SB_{2015}/SB_{MSY}<1$). Furthermore, the IOTC explained that in order to the properly manage the narrow-barred Spanish mackerel procurement several data such as nominal catch, catch and effort, discards catch, and biological data are very

important. Research on narrow-barred Spanish mackerel in Indian Ocean waters has been widely reported namely about the relationship of length weight (Mackie et al. 2005; Govender et al., 2006; Shojeai et al., 2007; Motlagh et al., 2008; Sadeghi et al., 2009; Motlagh & Shojeai 2009; Kaymaran et al., 2010; Kazemi et al., 2013; Fakhri et al., 2015). About the sexes ratio (Claereboudt et al., 2005; Grandcourt et al., 2005; Sadhegi et al., 2009; Kaymaran et al., 2010; Johnson et al., 2014), and related to food habit (Mackei et al., 2005; Rose et al., 2006; Bakhoum 2007; Darvishi et al., 2013; Johnson et al., 2013; Rajesh et al., 2017; Niamaimandi et al., 2017). Research on narrow-barred Spanish mackerel in Indonesia is still lacking, research on biological aspects and population dynamics in the Kwandang waters of Sulawesi Sea (Nugroho et al., 2014 and 2018), length-weight relationships in the Java Sea (Santoso and Soesilo 2016), and exploitation rates (Yuliana and Nurhasanah 2017). About fisheries aspects in the Natuna Sea (Jumrizal et al., 2014) and about gonad maturity and sex ratio in Sunda Strait (Oktavia and Hidayati 2017).

Based on these facts, it is very important to conduct research on narrow-barred Spanish mackerel especially those related to aspects of biology. The research aims to analyze the biological aspects such as length-weight relationship, condition factor, sex ratio, and food habit of narrow-barred Spanish mackerel in the Bone Bay waters, Indonesia. The results of the study expected to be additional information for policy-makers related to the management and utilization of narrow-barred Spanish mackerel, especially in the waters of Bone Bay and Indonesian waters. In addition, the results of the study expected to be one of the references for researchers on biological aspects of narrow-barred Spanish mackerel.

MATERIALS AND METHODS

Sampling site

A total 515 specimens of narrow-barred Spanish mackerel captured by drift surface gill net, trolling line, hand line and boat lift net was collected by Stratified Random Sampling, monthly from February to November 2018 in the Bone Bay waters, 2°30 ' North Latitude to 6° South Latitude and 120° West Longitude to 122°East Longitude (Fig.1)

Data on the length (Fork length in cm) and weight (body weight in gram) obtained through direct by measuring board and weighing by portable balance on the fishing boats. Simultaneously a 100 fish gut specimen taken to observe the kinds of food and main food for this fish. For laboratory observe the fish gut specimen were preserved in 10% formalin solution. Kinds of preys were determined on the lowest possible taxon, and the occurrence, number and weight of different prey in fish gut also recorded.

Data analysis

Length-weight relationship

The lengths-weights relationship of narrow-barred Spanish mackerel analyzed using the cubic equation that the weight of the fish as the power of three of its length as follows:

$$W = aL^b$$

Where individuals body weight in gram, L is fork length in cm, “a” is intercept the y-axis, “b” is regression coefficient. .Based on the “b” value obtained, it can seen the growth pattern of the fish, namely if the value of “b” is equal to 3.0, the growth pattern is isometric, if the value of “b” is greater than 3.0 the growth pattern is positive allometric, and if the value of “b” is smaller than 3.0 the growth pattern negative allometric. To find out whether the value of “b” is equal to the 3.0, a Student t-test carried out at a confidence level of 95% (Steel & Torrie, 1993).

Condition factor

For fish where the length-weight relationship was allometric, the condition factor (C_F) could be count by equation of Froese (2006) as follow:

$C_F = (Wb/aL^b)$ or $CF=Wb/W^*$,

$Wb = (W1+W2+W3+ Wn)/n$, and $W^*=aL^b$,

Where W is the average weight (gram) of fish in a length class, L is average length (cm) in a class length.

Food habit

To find out what kinds of important food of narrow-barred Spanish mackerel has used the Index of Relative Importance method, IRI (Effendi, 1997) with the equation:

$IRI = (N+ W)\times F$,

Where N is percentage of number of a type of food, W is percentage of weight of type of food, and, F = percentage of occurrence of type of food.

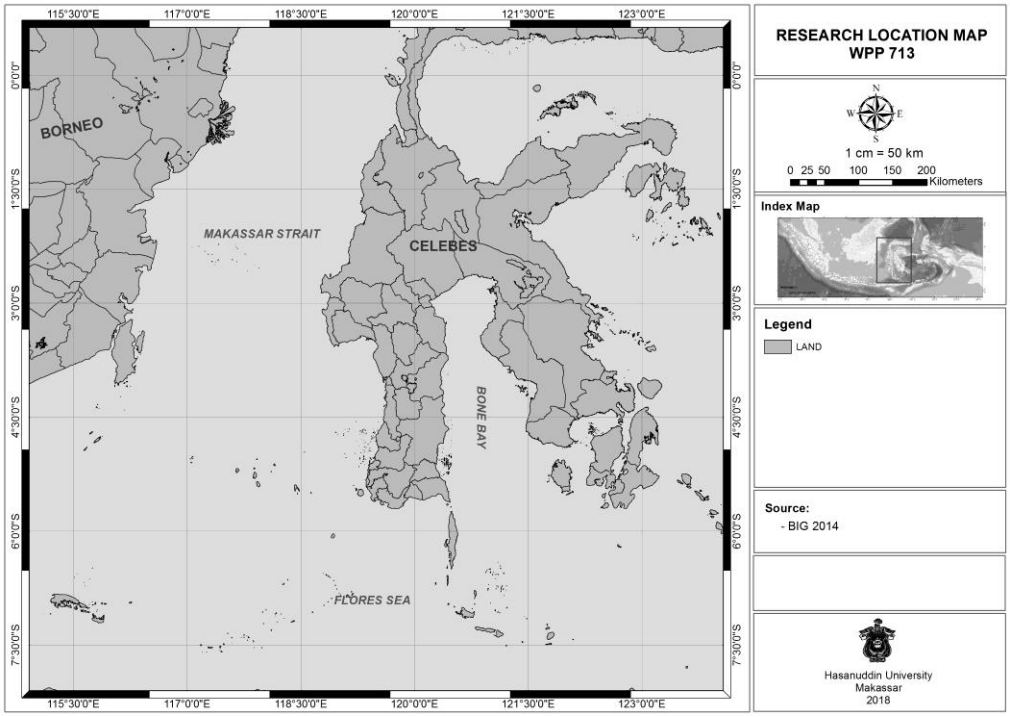

Figure 1: Research Location (Bone Bay Waters)

Sexes-Ratio

Specimens sexed by macroscopic observation. Sexes-ratio is calculated by comparing the number of the females and males in the fish samples and to find out whether the number of males and females is comparable, chi-square test ($p>0.05$) is carried out.

RESULTS

Length-Weight Relationship and Growth Pattern

The measurement results of 515 fish samples found that the length of the fish ranged from 57-135 cm and the weight ranged from 0.5 to 11 kg. Mapping the length of the fish as the x-axis and the weight of the fish as the y-axis (Figure 1) results in the equation of the length-weight relationship is:

$W = 0.050466. L^{2,562}$

the equation $W = a L^{b}$ in Bone Bay waters

The t-student test result that the value of "b" 2.562 is significantly difference with 3.0 (t calculated 2.3449>t table 1.960, at $p > 0.05$), where the value of "b" is smaller than the 3.0. It means that the growth pattern of narrow-barred Spanish mackerel in the Bone Bay waters is negative allometric, or the increase in length is faster than the weight gain.

Condition factor

The result of analysis showed that the condition factor value varies according to length class, the smallest value was 0.383 in 147-152 cm length class, and the highest was 1.138 in 42-47 cm length class.

Food habit

Diet analysis indicated that food composition of narrow-barred Spanish mackerel in Bone Bay waters consist of fish (teleost), crustacean, and mollusk. Kinds of food item indentified in the stomach includes anchovy (*Stelophorus* sp), sardine (*Sardinella*spp), Indian mackerel (*Rastrellliger* spp), bonyfish (*Leiognathus spp*), shrimps, squid (*Loligo* sp). The IRI analysis result revealed that anchovy, sardine and Indian mackerel were the most important food item to the diet of narrow-barred Spanish mackerel in Bone Bay waters. Bonyfish, shrimps and squid were the less important component to the diet of narrow-barred mackerel (Table 1).

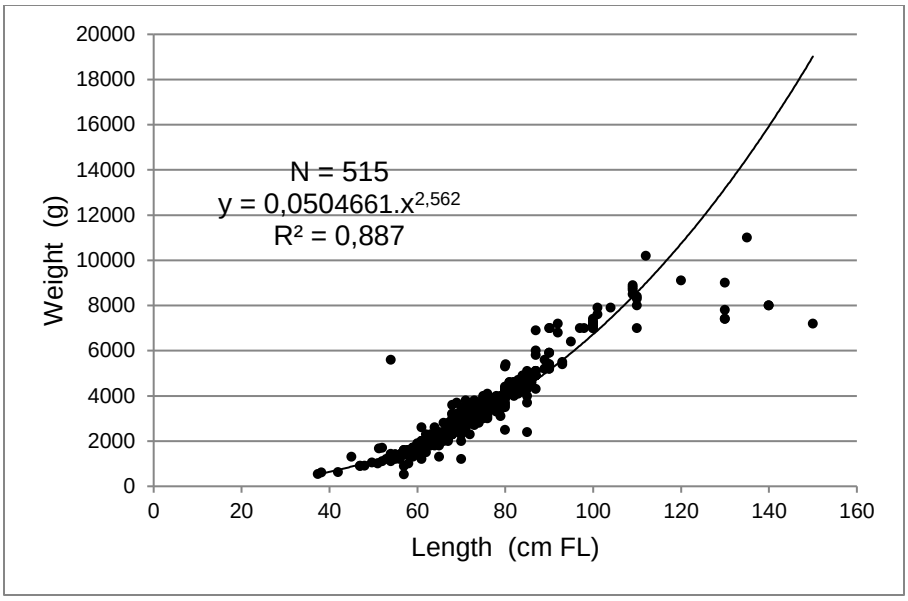

Figure 2: The length-weight relationship of narror-barred Spanish mackerel mackerel uses

Table 1: Index of relative importance (IRI) of each food in the diet of *S.commerson*

Food Items	%F	%N	%W	IRI
A-Teleost	65.63	78.50	80.74	10,450.92
Stelophorus sp	40.12	43.80	30,74	2,990.54
Sardinella sp	20.15	19.10	23,77	863.83
Rastrelliger sp	20.23	19.90	25,91	926.74
Leiognathus sp	5.16	4.90	3,64	44.07
B-Crustacean	3.46	10.50	1.88	42.83
Shrimps	3.46	10.50	1.88	42.83
C-Mollusc	15.06	5.50	9.3	222.89
Loligo sp	15.06	5.50	9.3	222.89
C-Unknown	15.85	5.50	8.08	215.24

Sex Ratio

The macroscopic observations of 100 gonad samples obtained as many as 53 females and 47 males or sexes-ratio 1.13 : 1,00. The chi square test result showed that the number of male and females was not significantly different (chi-square cal 0.98 < chi square table 3.841, α=0.050) which meant the proportion of males and females in the population was not significantly different.

In general, the parameter value “b” of the length-weight relationship influenced by the composition of the size of the fish observed, the physical chemical factors of the aquatic environment, the availability of food, and the level of maturity of the fish. Normally, in young fish the increase of length is usually faster than weight gain. In adult fish where the gonad development begins, weight gain is faster than length gain. Several researcher had been described that length-weight relationship was isometric (Grandcourt et al., 2005; Govender et al., 2006; Shojeai et al., 2007; Thagari et al. 2008; Sadhegi et al., 2009; Kaymaran et al., 2010; Fakhri et al., 2015). On the other side, some researchers have obtained negative allometric growth patterns (Mackie et al., 2005; Motlag & Shojeai 2009; Kazemi et al., 2013; Santoso & Susilo 2016; Sougueh et al., 2018). The growth patterns of narrow-barred Spanish mackerel according to researchers and the areas presented in Table 2.

Table 2: Length-weight relationship of narrow barred Spanish mackerel in the Indonesian and Indian Ocean waters.

Fishing Area	Fork length (cm)	Weight (gram)	Intercept a	Slope b	Growth pattern	References
Australia waters	5.8-172	0.0015–40.6	3.4×10^{-9}	3.12	Allometric positive	Mackie et al., 2005
South Arabia Sea	nd	nd	9×10^{-6}	2.96	Isometric	Grandcourt et al., 2005
Oman waters	nd	nd	3.53×10^{-3}M 5.3×10^{-3}F	3.17M 3.09 F	Isometric	Govender et al., 2006
Iran Sea	55-132	nd	0.076	2.98	Isometric	Shojeai et al., 2007
Oman waters	Nd	nd	0.0153	2.83	Isometric	Thaghari et al., 2008
Coastal waters of Iran	29-128	nd	0.0194	2.86	Isometric	Sadeghi et al.,2009
Gulf of Persia Iran	30-156	nd	0.0244	2.73	Allometric negative	Motlagh & Shojeai 2009
Gulf of Persia and Oman Sea	29-154 (F) 35-144 (M)	nd	0.0119 (F) 0.0113 (M)	2.9 (F) 2.9 (M)	Isometric	Kaymaran et al., 2010
Gulf of Persia and Oman Sea	35-154	0.11 – 2.41	0.044	2.59	Allometric negative	Kazemi et al,.2013
Northern of Persia Gulf	20-139	0.15 – 18.0	0.018	2.93	Isometric	Fakhri et al., 2015
Djibouti Red Sea	45-110	nd	$5x10^{-4}$	1.55	Allometric negative	Sougueh 2018
Java Sea	nd	nd	-4.51	2.73	Allometric negative	Santoso & Susilo 2016
Bone Bay	39.5 – 149.5	0.57 – 8.70	-0.4107	2.4576	Allometric negative	This research

*) F=females, M=males, nd = no data

The value of condition factors generally ranges from 2-4 for fish that have elliptical or torpedo shaped bodies and 1-3 for fish that are slightly flat bodies. Condition factor values can vary between species and inter species caused mainly by the presence fof food, fish age, sex and gonadal maturity. The value of the condition factor of narrow-barred Spanish mackerel in Bone Bay waters obtained in this study is 1.138 categorized as normal in accordance with the torpedo shaped body.

The results of this study explain that fish groups become an important food of narrow-barred Spanish mackerel in the waters of the Gulf of Bone. This discovery is in line with all previous research about food habit in various waters, but the composition of the species is slightly different. Bakhoum (2007) reported that teleost such as *Engraulis encrasicolus*, *Gobius* spp, *Sardinella aurita, Sardina pichardus* were the most important food item, contributing 92.62% and shrimpsrepresented the second most important to the diet of *S.commerson* in the Egyptian Mediterranean coast. Darvishi et al., (2013) reported that the major food groups of narrow-barred Spanish mackerel Persian Gulf and Oman Sea were Ostheichthyes, Crustacea and Chephalopoda and basic foods in Octeischthyes group were Engraulidae and Clupeidae. Johnson & Tamatamah (2013) described that in the stomach of S.commerson in coastal watersof Dar es Salam Tanzania, identified fish includes *Atherina breviceps*, *Silago* spp, *Eutruthemes teres*, *Atherinomonus* spp, and *Sardinella ocelatus,* and *E. teres* was the dominant prey species. Niamaimandi et al., (2017) reported that fish found to be the main prey item of narrow-barred Spanish mackerel in the northern Persian Gulf. Furthermore, explained that Sardines were the most prevalent, accounted for 50-85% of the total weight of prey items in different months, while Indian mackerel (*Ratrelliger* spp), Ponyfish (*Leiognathus* sp.) and Halfbeak (*Hyporhamphus* sp.) were less essential components of diet of *S. commerson*. Rajesh et al., (2017) reported that the major food items identified based on the IRI values of narrow-barred Spanish mackerel in south-west coast of India were *S. longiceps*, *Decapterus ruselli*, whitebaits, *R. kanagurta*, and *Ephinepelus* spp.

In general, the fertilization process towards spawning of aquatic organisms is better at sex ratio was no significantly different from 1:1. In this study, the sex ratio was no significantly different from 1:1. Some studies that have been done previously show the same results, but also some studies show different results as presented in Table 3.

Based on the information in Table 3 that narrow-barred Spanish mackerel that live in the same waters do not show the same sex ratio. The sex ratio of mackerel in the same waters can be different according to the time of the study, but instead the same waters and different times can show the same sex ratio. Mackie et al., (2005) explain that the sex ratio of a species can differ according to the observed water location along with the observed age group changes. Variations in the sex ratio often occur due to three factors namely differences in reproductive behavior, environmental conditions, and fishing (Nugroho et al., 2018). The high level of exploitation of a population can affect the biological aspects of that population such as growth pattern, condition factor and sex ratio (Mallawa & Amir 2019).

Table 3: Sex ratio of narrow-barred Spanish mackerel in the Indian Ocean waters

Area	Sex Ratio			References
	Female	Male	Significantly	
Coastal waters of Oman	1	0.74	Different	Claereboudt et al., 2005
Nothern Australia waters	1.2	1	Different	Mackie et al., 2005
Quensland waters, Australia	1.2	1	Different	Rose et al., 2006
Coastal waters of Iran	1	0.97	Not different	Sadeghie et al., 2009
Persian Gulf and Oman Sea	1	0.97	Not different	Kaymaram et al., 2010
Persian Gulf and Oman Sea	1	0.97	Not different	Darvishi et al., 2011 and 2013
Nothern of Persia Gulf	1	0.6	Different	Niamaimandiet al., 2017
Kwandang Bay, Sulawesi Sea	1.2	1.0	Different	Nugrohoet al., 2018
Bone Bay	1.13	1.0	Not different	This research

CONCLUSION

The increasing of length of narrow-barred Spanish mackerel fish in Bone bay waters is fast than its weight gain. The value of the condition factor is in the range of the value of the fish that has an elongated round shape, the important food were anchovy, sardine and Indian mackerel, the ratio of the number of males and females in the population is considered normal.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

Add contribution of each author (with abbreviated name) here. For example WEP designed and performleed the experiments and also wrote the manuscript. EW, OA, and IDJ performed animal treatments, flow cytometry experiments, tissue collection, and data analysis. AS and MR designed experiments and reviewed the manuscript. All authors read and approved the final version.

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