Kuroshio Science 17-1, 14-21, 2023

Symposium Proceedings

Maturity and spawning period of shortfin scad, *Decapterus macrosoma* (Bleeker, 1851, Perciformaes: Carangidae) in Babuyan Channel, Philippines

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Abstract
Decapterus macrosoma locally known as "galunngong" is one of the top species with great economic importance for Filipinos. The study was conducted to generate information on the spawning period, gonadosomatic index and length at maturity of *D. macrosoma* in Babuyan Channel, Philippines which is vital input for policy formulation for the management of shortfin scad in the fishing ground. Data was collected from April 2018 to March 2020 in the established NSAP landing centers within Babuyan Channel. Standardized method of the National Stock Assessment Program (NSAP) was used in the collection of samples. There were 1414 samples collected during the study period with total lengths ranging from 11.5 cm to 28.5 cm. Male *D. macrosoma* dominated the catch which means that in every male there are 0.95 (year^1) and 0.86 (year^2) female. Landings are affected by environmental conditions, monsoon season and the seasonality of fishing gears used. The peaks of spawning period occur in October, January and February (year^1) and May and September (year^2) showing a prolonged spawning season in fishing ground. Moreover, length at maturity for female is 15.31 cm TL and 15.02 cm TL for male. The species are already mature before being caught.

Key words: length at maturity, gonadosomatic index

INTRODUCTION

Shortfin scad or round scad locally known as "*galunggong*" is one of the most essential pelagic fish caught in large quantities in the Philippine waters most of the year (Pastoral et al. (2000) contributing 4.9% (47,350.64MT) of the municipal and 15.2% (141,652.58MT) commercial landings in the country (DA-BFAR Fisheries Profile, 2019). It is one of the top species and of great economic importance in Cagayan Valley Region since it is one of the most consumed pelagic fish and the cheapest source of animal protein in the locality. However, volume of landings of shortfin scad in Cagayan Valley Region is minimal compared to other major fishing grounds in the country like Palawan, Zamboanga, and Davao Peninsula.

In recent years, landings of *D. macrosoma* in the Babuyan Channel show an unexplained decline. In the year 2007, the recorded total laded catch was 80.30 MT but continues decline was observed in succeeding years to only 21.51 MT in 2014 and a further decline in 2019 with 3.81 MT (DA-BFAR-NSAP R02 Database, 2021). Similar observations were also documented in some areas of the country where the species is increasingly becoming scarier (Ani 2016) and a decrease in country's volume production was noted in the last six years from 270.80 MT in 2013 down to 182.10 MT in 2017 (Bersales and Bautista, 2018) to only 171.3 MT in 2018 (Mapa and Bautista 2019).

Babuyan Channel is one of the traditional and major fishing grounds in the country located along the Kuroshio Current and has a multi-gear and multi fishery where *D. macrosoma* is easily caught using gill nets, beach seine, multiple hook and line, and ring net. The stock is being shared by almost 7, 101 (DA-BFAR-BOATR, 2020) units of municipal fishing boats and 174 units of commercial boats using different types of gears (DA-BFAR-NSAP R02 Boat and Gear Inventory, 2020).

Despite its economic importance little is known on the biological studies of the species in the fishing ground, particularly on its reproductive parameters like sex ratio,

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gonadosomatic index, length at maturity, and spawning season. The result of these parameters will provide scientific advice for the proper management and conservation of the stock as there are no available management strategies being implemented in the fishing ground with regards to the species.

MATERIALS AND METHODS

Data collection

A total of 1,414 samples were collected and dissected from April 2018 to March 2020 from the established NSAP observation sites within Babuyan Channel area (Fig. 1). *D. macrosoma* samples were randomly collected from ring net, hook and line, gillnet, and beach seine. Collection of samples was done every other two days with a minimum sample of 50 pcs per sampling day per gear. However, there are sampling days that the species is not present or very minimal in catch wherein the enumerators can only sample an average of five pcs per sampling day. The total length of individual fish with the corresponding body weight were recorded prior to dissection. Dissection was done by opening the abdominal cavity of the fish to determine the sex and degree of gonad maturity using the five-point scale of maturity of Ismen (2002). All gonads with stages II to V were weighed to the nearest 0.01 g. Dissection of the samples was conducted to identify the sex and the gonad condition using the five scale of sexual maturity. Individual gonad weights (GW: weight of both lobules) were recorded in grams (g) and parts of the gonads were fixed in 10% formalin solution for fixation and later transferred to 70% alcohol solution. The sexual stages were classified using the five-point scale developed by Ismen (2002).

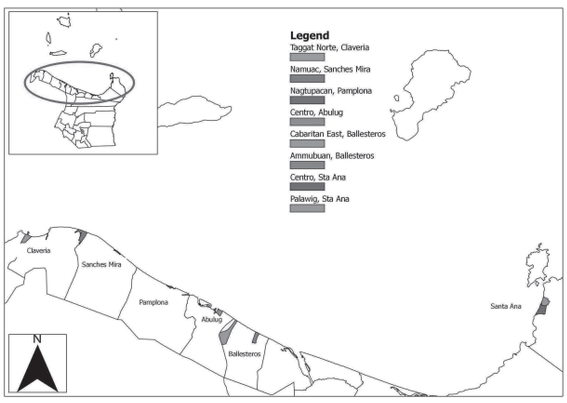

Fig. 1. Map of Babuyan Channel, Philippines showing the location of collection sites.

Data analysis

Sex ratio

The sex ratios by month were expressed as the proportion of females to the total numbers of juvenile and male (Sheung-Ping et al. 2003):

$$\text{Sex Ratio} = Fn/n \qquad \text{(Equation 1)}$$

Where Fn is the monthly count of female, n is the monthly total number of samples.

Seasonality

The monthly total catch of the species was computed and used to determine the seasonality.

Spawning period

Spawning period was computed using the Gonadosomatic index (GSI) equation used by Bothakur (2018).

$$GSI = (GW/(BW\text{-}GW) \times 100 \qquad \text{(Equation 1)}$$

where GW is the total wet weight of gonad, BW is the total body weight of the fish with intact gonad. Individual GSI were averaged monthly both for male and female to determine the peak of spawning.

Length at first maturity

Length at maturity was computed for male and female *D. macrosoma* following the five-point scale of gonadal maturity (Table 1) of Ismen (2002).

Length at which 50% of all individuals are sexually mature (Lm) was estimated from the proportion of mature individuals in each of 0.5 cm length class interval in the fitted logistic curve (Sparre and Venema, 1992) as follows:

Table 1. Five point scale of gonad maturity by Ismen (2002).

Maturity Stages	Classification	Distinguishing Characteristics
Juvenile	Juvenile	Fish samples are very small in sizes and have not yet engaged in reproduction;
Stage I	Immature/Virgin	Young individuals have not yet engaged in reproduction; gonads are very small.
Stage II	Developing/ Maturing	Sexual products have not yet begun to develop; gonads are very small in size; eggs are not distinguishable to the naked eye.
Stage III	Mature/ Developed	Female- Eggs are distinguishable to the naked eye; very rapid increase in weight of the gonads is in progress. Male- testes change from transparent to pale rose color.
Stage IV	Gravid and Spawning	Sexual products are ripe; gonads have achieved its maximum weight; sexual products are extruded in response to light pressure on the belly; weight of the gonads decreases rapidly from the start of the spawning to its completion.
Stage V	Spent or Resting	The sexual products have been discharged; the genital aperture is inflamed; gonads have the appearance of deflated sacs; the ovaries contain a few leftover eggs and the testes had some residual sperms. And finally on the resting stage, inflammation on the genital aperture has subsided; gonads are very small; and the eggs are not distinguishable to the naked eye.

$$P = \frac{1}{1 + \exp(S_1 + S_2 \times L)} \quad \text{(Equation 2)}$$

where P is the proportion of mature individuals within a length class, S_1 is the intercept, S_2 is the slope, and L midpoint length.

Size composition by gear

Comparison of minimum and maximum length ranges of same species caught by the different fishing gear was recorded to determine the type of fishing gear which is sustainable and those catching small/juvenile sizes prior to the first maturity.

RESULTS

A total of 1,414 samples were collected and dissected during the study period. Out of 1,414 samples, there were 643 (45.47%) males, 665 (47.03%) females, and 106 (7.49%) undetermined sex.

Sex ratio

Table 2 shows the sex ratio of *D. macrosoma* by month as the proportion of females to males. As observed, females were dominant from April to June, September, and January while males were dominant during the rest of the months. An equal sex ratio was noted in the month of May and September 2019.

Notably, male *D. macrosoma* dominated the catch during the study period. The mean sex ratio value computed was 0.95: 1 in year[1] and 0.86:1 in year[2] which means that in every male there is 0.95 female in year[1] and 0.86 female in year[2].

Seasonality

Figure 2 shows the catch seasonality of *D. macrosoma* caught in Babuyan Channel during the study period. A total of 88.44 kilograms were landed. The peak of catch for the species varies during the study period. The highest peak was observed in the month of August in year[1] and February in year[2].

Spawning period

The spawning period was identified based on the GSI and the five (5) stages of gonadal development by Ismen (2002). The monthly mean GSI for female ranged from 0.0044 to 4.858 and 0.0006 to 2.756 for male. Maximum mean GSI value for females was observed during the month of October (3.49), January (2.3) and February (3.19) (year[1]) and May (2.91) and September (2.1) (year[2]) (Fig. 3). While the highest GSI value for males was observed during February (1.97) and July (1.74) (year[1]) and only less than 1 GSI value in year[2].

Generally, the highest GSI value was observed for females than male *D. macrosoma* in Babuyan Channel.

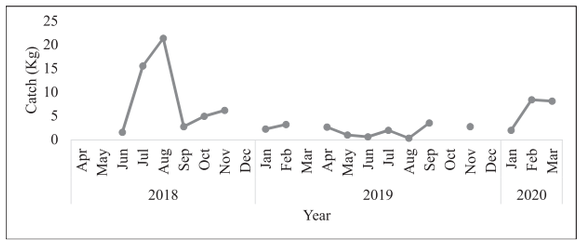

Fig. 2. Seasonality of *Decapterus macrosoma* (2018-2020) in Babuyan Channel, Philippines.

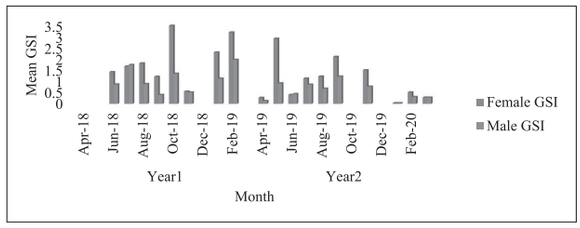

Fig. 3. Monthly changes in the mean gonadosomatic index of female and male *Decapterus macrosoma* in Babuyan Channel, Philippines.

Table 2. Sex ratio of *Decapterus macrosoma* in different months in Year 1 and Year 2.

Year 1				Year 2			
Months	**Female**	**Male**	**Sex Ratio (F:M)**	**Months**	**Female**	**Male**	**Sex Ratio (F:M)**
18-Apr				**Apr-19**	37	23	1.61:1
18-May				**May-19**	9	9	1:1
18-Jun	18	12	1.50:1	**Jun-19**	10	7	1.43:1
18-Jul	51	58	0.88:1	**Jul-19**	21	35	0.6:1
18-Aug	140	149	0.94:1	**Aug-19**	2	3	0.67:1
18-Sep	18	8	2.25:1	**Sep-19**	41	41	1:1
18-Oct	41	48	0.85:1	**Oct-19**			
18-Nov	111	113	0.98:1	**Nov-19**	15	34	0.44:1
18-Dec				**Dec-19**			
19-Jan	21	18	1.17:1	**Jan-20**	24	16	1.5:1
19-Feb	18	34	0.53:1	**Feb-20**	46	72	0.64:1
19-Mar				**Mar-20**	39	45	0.87:1
Total	**418**	**440**	**0.95:1**	**Total**	**244**	**285**	**0.86:1**

Gonadal frequency pattern

Figure 4 shows the gonadal frequency of *D. macrosoma* in different months during the study period. The five-point scale gonadal frequency was observed. However, there are months when samples are not available. It can be noted that Stage I (Immature/Virgin) and Stage II (Maturing/Developing) samples were the most dominant in year[1] and Stage II and Stage III (Mature) in year[2] of the study compared to other five-point scales gonadal maturity. The highest gonadal frequency for Stage I was observed during the month of November and August for Stage II in year[1]. While in year[2], the highest gonadal frequency for Stage II and Stage III were in the months of September and February, respectively. Mature individuals were observed all throughout the study period with highest peak in July (year[1]) and September (year[2]).

Length at first maturity

The observed total length of female and male *D. macrosoma* range from 12.1 cm to 27.5 cm and 12.2 cm and 28. 5 cm, respectively. Following the logistic curve, the computed length at first maturity (L_m) of female *D. macrosoma* in Babuyan Channel was 15.31 cm (Fig. 5) having an intercept value of 23.88, slope value of 1.56, r squared of 0.99, and standard deviation of 7.69 (Table 3).

Meanwhile, the computed L_m of D. male *D. macrosoma* in the fishing grounds was 15. 02 cm (Fig. 5) having an intercept of 16.99, a slope of 1.13, r squared of 0.95, and standard deviation of 7.66 (Table 2). Both sexes obtained a midpoint (L) of 17.5 cm TL.

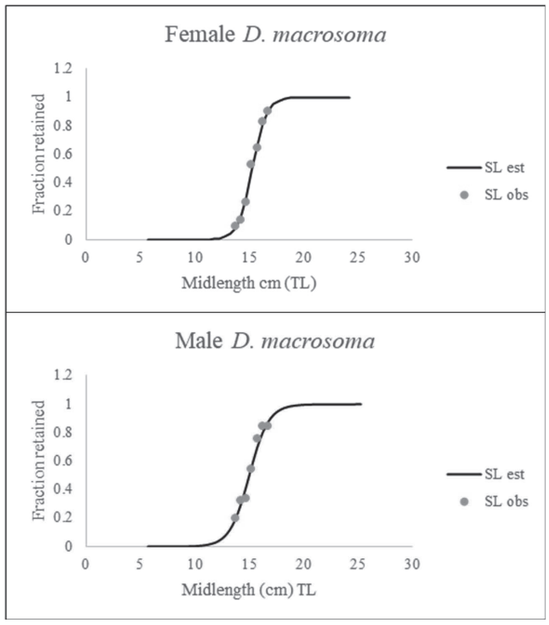

Fig. 5. Observed length at first maturity (L_m) for female (a) and male (b) *Decapterus macrosoma* in Babuyan Channel, Philippines.

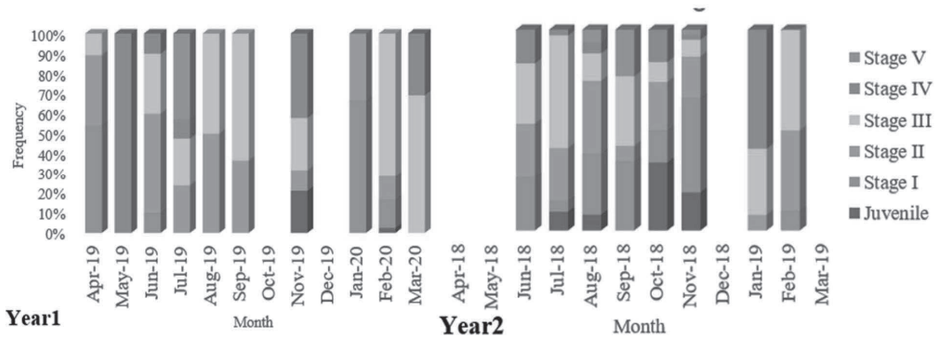

Fig. 4. Frequency of occurrence of gonadal stage of maturity of *Decapterus macrosoma* in different months during year[1] and year[2] in Babuyan Channel, Philippines.

Table 3. Statistical Values in the computation of length at maturity (L_m) of *D. macrosoma* in Babuyan Channel, Philippines.

Statistical Values	Male	Female
Slope	-1.13	-1.56
Intercept	16.99	23.89
Midpoint (L)	17.5 cm	17.5 cm
R squared	0.95	0.99
Standard Deviation	7.66	7.69
Std Error	0.29	0.17

Size composition by gear

Figure 6 shows the length frequency distribution for *D. macrosoma* caught by ring net (RN), multiple hook and line (MHL), surface set gillnet (SSGN), bottom set gillnet (BSGN) beach seine (BS), and tuna gillnet (TGN). The presentation of size composition includes the juveniles and the undetermined sex of *D. macrosoma*. Pooling the length frequency for year[1] and year[2] of the study, the length of fish caught by ring net ranges from 15.1 cm to 19.7 cm, 13.6 to 27.6 cm using multiple hook and line ranges, 16 cm to 22.6 cm for surface set gillnet, 15 cm to 28.5 cm for bottom set gillnet, 11.5 cm to 27.1 cm for beach seine and 20.2 cm to 21.4 cm for tuna gillnet. The observed minimum and maximum lengths recorded for *D. macrosoma* for all gears in year[1] were 11.5 cm and 28.5 cm, respectively, and 13.2 cm and 22.5 cm for the year[2], respectively.

DISCUSSION

The obtained sex ratio for *D. macrosoma* is in agreement with the results obtained by Widodo (1991), Asni et al. (2008), and Rada et al. (2019) on shortfin scad in Philippine waters. However, this is in contrast to the result of Tiews at al. (1971) in Manila Bay where female *D. macrosoma* were found to be more slightly numerous than males. This observation of Tiews et al. (1971) indicates that the sex ratio differs with area and species. Hence, it can be presumed that the species in Babuyan Channel differs from the other fishing grounds because of its location and the condition of the environment. The species was documented to be present throughout the year from municipal and commercial catches based on the studies of Calvelo (1992) and Gaerlan et al. (2018). However, the landed catch in Babuyan Channel can only be observed in some months. This could be due to the seasonality of the fishing gears being used in the fishing ground. In addition, fishing activities become limited starting at the onset of the northeast monsoon wherein frequent unfavorable weather conditions are being experienced thereby limiting the fishing activity of fishers. As observed, it is only during the summer season that landings are abundant since these are the only months when the peak of fishing activities in the fishing ground usually occur. Trinidad et al. (1993) cited that the Philippines is a tropical country where primary and secondary production does not show strong seasonal fluctuations (Yesaki, 1983), the biological production of small pelagics is highly seasonal, being influenced by environmental conditions most probably by monsoon winds (Pauly and Navaluna, 1983;

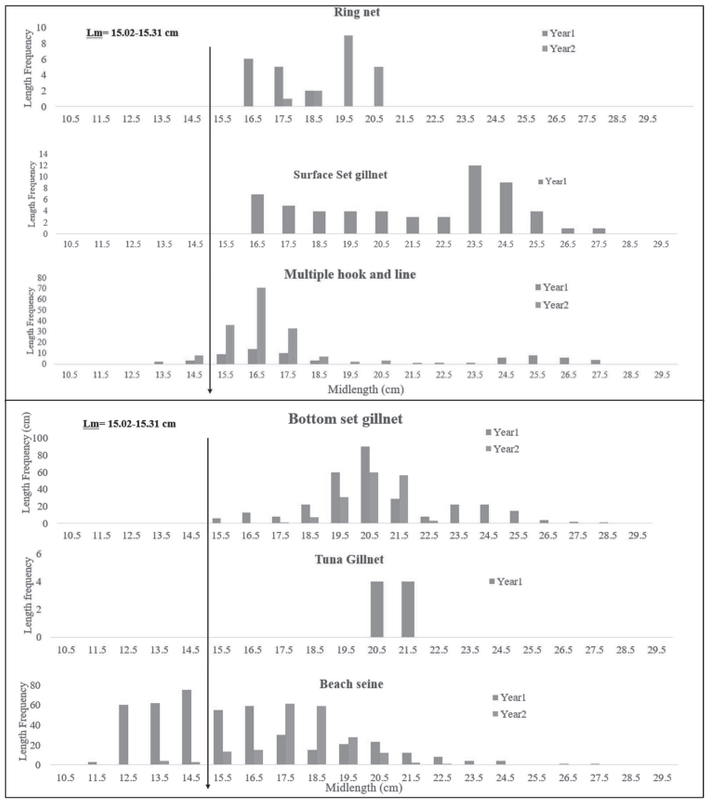

Fig. 6. Length frequency distribution of *Decapterus macrosoma* caught by ring net, surface set gillnet, multiple hook and, bottom set gillnet, tuna gillnet, and beach seine in Babuyan Channel, Philippines.

Navaluna and Pauly, 1998; Dalzell and Corpuz, 1990). The seasonality of the species is not pronounced due to unavailability of samples in some months. However, it can be noted that highest production was observed during summer months. According to Trinidad et al. (1993), the production peak of roundscad occurs between March and June i. e. following the end of the northeast monsoon and the beginning of southwest monsoon.

Meanwhile, it can be noticed in Babuyan Channel that the spawning time of the species comes into two seasons that is during northeast and southwest monsoon particularly in the months of February to May and July to November, respectively. The spawning of the species in the fishing ground is one (1) month earlier than the spawning of *D. macrosoma* in Palawan waters, Philippines and two (2) to three (3) months earlier than the spawning of the species in Manila Bay, Philippines. Hence, it can be presumed that the spawning time of *D. macrosoma* is earlier in the Northern part of the country. This could be due to the environmental condition of the habitat of the species in the fishing ground. Previous studies on the genus *Decapterus* showed that reproductive characteristics differ among habitats (Ohshimo et al., 2006) and some studies indicated that environmental factors have influence on the biological characteristics of the species (Yoneda, 2006). It can also be observed that female has the highest GSI compared to males where the result is also similar to the result obtained by Shiraishi et al. (2010). Monthly mean GSI values obtained in the study conforms to the monthly mean GSI values for male and female *D. macrosoma* obtained by Rada et al. (2019) in the coastal waters of San Fernando, Romblon, Philippines. Therefore, it was presumed that these months are the peak of spawning period for the species in Babuyan Channel. The presence of five-point scale gonadal maturity for *D. macrosoma* throughout the year could be attributed to the biological characteristic of the species having flexible reproductive strategy.

The prolonged spawning season observed for the species may be associated with the availability of plantonic prey (Chang et al., 2009; Jose et al., 2015), other nutrients present in the fishing ground and the zooplankton biomass and composition in the area could possibly influence continues spawning of the species.

Meanwhile, length at maturity obtained in the study was close to the values of length at maturity obtained by Rada et al. (2019) in Romblon, Philippines in 2016 to 2017 with 15.29 cm (TL) for female and 17.22 cm (TL) for male. The values obtained were also close to the data from Palawan, Philippines wherein the length at maturity of *D. macrosoma* in 2013 to 2014 was 16.39 cm, 17.85 cm in 2015 to 2016, and 19.39 cm in 2016 to 2017 (DA-DILG, 2015 cited by Rada et al., 2019). Further, various researches conducted in other countries have come up with values on FL size at first maturity for female *D. macrosoma* which is 17. 7 cm in Indonesian waters (Tampubolon and Merta, 1987) 17. 2 cm in Thailand (Sutthakorn and Saranakomkul, 1987), and 19.7 cm in Java Sea (Atmaja and Sadhotomo, 2005). Widodo (1991) also obtained length at maturity for female *D. macrosoma* at 15.5 cm (FL) and 14.8 cm (FL) for males in Java Sea. These values were much higher than the observed maturity values in this study. The variations of length at maturity observed in different studies could be attributed to environmental factors, habitat of the species and its biological characteristics and the intensity of fishing activities that causes fishing pressure to the species

McBride et al. (2002) and Ohshimo et al. (2006) showed that growth and reproductive characteristics of *Decapterus* species differ among habitats and the influence of environmental factors on biological characteristics could also contribute to the variations of L_m observed. Brander (1994) and Campana et al. (1995) cited by Rada et al. (2019) confirmed that the growth of fishes in areas of high water temperature (low latitude regions) is faster and the size at sexual maturity is smaller than the areas with low water temperature (high latitude regions) particularly the Atlantic cod (*Gadus morhua*). Other species like *Trachurus japonicus* in the waters off Nagasaki spawns earlier in the recent years compared from the 1950s and 1960s due to influence of the increase of temperature of the surface layer (Ohshimo et al., 2004). Therefore, variations in water temperature and trophic conditions influence the maturation rate and spawning period of the species (Shiraishi et al., 2010). The observations of the authors on the influence of these factors seems to be true in the country since it is a tropical region with warmer average seawater temperature, thus influencing the sexual maturity of *D. macrosoma* at shorter lengths compared to high-latitude regions.

Notably, length ranges in this study were wider compared to the studies conducted in other parts of the country. This may be due to the various types of fishing gears being used, samples obtained at different landing centers and random collection of samples. Based on the collected samples and using the L_m generated in this study which is 15.02 cm (male) to 15.31 (female) cm, the catch of bottom set gillnet, surface set gillnet, tuna gillnet, and ringnet were 100% mature while multiple hook and line was 94.29% mature with only 5.71% juveniles, and beach seine was 67.2% mature with 32.8% juveniles. These results were closer to the values reported by Rada et al. (2019) and Widodo (1988) as cited by Pattikawa et al. (2017) with a total length ranging from 11.50 cm to 22 cm and 13.50 cm to 25.30 cm, respectively. However, there are also studies showing total length ranging from 13.30 cm to 31.50 cm in Eastern waters of Ambon Island, Indonesia (Pattikawa et

al., 2017), 7.50 cm to 31.50 cm in Banda Neira waters, Maluku Province, Indonesia (Senen et al., 2011), and 12.10 cm to 29. 50 cm in Bone Bay waters, South Sulawesi, Indonesia (Suwarni et al., 2015).

CONCLUSION

Landed catch of *Decapterus macrosoma* in Babuyan Channel, Philippines could be highly affected by the seasonality of the fishing gears, weather conditions, and monsoon season. It can be shown that the spawning season of *D. macrosoma* occurred in two peaks, one during the northeast monsoon and another peak during southwest monsoon. It was further noted that the species has a prolonged spawning in the fishing ground as reflected in the gonadal pattern of the species. The spawning of the species in the fishing ground is earlier than the spawning of *D. macrosoma* in Palawan waters and Manila Bay in the Philippines. Hence, it can be concluded that the spawning time of the species is earlier in the Northern part of the country. This could be due to environmental conditions and the habitat of the species in the fishing ground. Variations in length ranges of *D. macrosoma* in the study could be due to different types of fishing gears used, samples obtained at different landing centers, and random collection of samples and other environmental and biological factors that affect the growth of the species being located along the Kuroshio Current. Using the Lm generated in this study it can be concluded that species of *D. macrosoma* in Babuyan Channel already attained its maturity before being caught by the gear.

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