Biological aspects of shortfin scad (*Decapterus macrosoma*) in Bulukumba Regency, Gulf of Bone, Indonesia based on purse seine catch

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Abstract. Small pelagic schooling fish such as the shortfin scad (*Decapterus macrosoma*) are targeted by purse seine fisheries. The purpose of this study was to analyse some biological aspects of the shortfin scad caught by purse seine fisheries in the waters of Gulf of Bone, including length-weight relationship, length-frequency distribution, sex ratio, condition factor, and stages of gonad development. The study was conducted from March to April 2019 in Herlang, Bulukumba Regency, South Sulawesi, Indonesia. All data were analysed using the statistics tools in MS Excel 2010. The growth pattern of the shortfin scad was allometric positive. The dominant size class (fork length) was 21.01-22.50 cm (mean 21.75 cm). The sex ratio was female-biased with almost 70% comprised of females. The catch was dominated by immature and maturing fish (76.5%) with a very low percentage of fish that had reproduced. The condition factor range was 0.94 to 1.04 for females and 0.84-1.06 for males. These results indicate abundant food sources capable of supporting the survival and growth of this species.
Key Words: *Decapterus macrosoma*, length-weight relationship, length-frequency, condition factor, reproductive biology.

Introduction. The shortfin scad, *Decapterus macrosoma*, has long been an important food fish in Indonesia (Ono et al 2013), and is an economically important species in southeast-Asian fisheries targeting small pelagic fishes (Borsa 2003). It is commonly caught in the waters around South Sulawesi (Asni et al 2019), including the Gulf of Bone. Purse seines are one of several gears used to catch *D. macrosoma*. The adoption of purse seine began during the mid 1950s to catch tuna (Hall & Roman 2013). Species targeted by purse seines are typically schooling pelagic fishes of all sizes from small sardines to large tunas (FAO 2001-2020). The shortfin scad, a relatively small schooling pelagic fish, is mostly caught around 20-30 miles from shore (Prihartini et al 2007).

Purse seine fisheries in Indonesia tend to ignore the principles of sustainable fishing designed to ensure the continuity of the fisheries business (Atmaja & Haluan 2003). In particular, there is a worrying trend towards catching small-sized fishes and juvenile fish in purse seine fisheries. Considering that *D. macrosoma* is an economically important commodity, fishing effort needs to be controlled in order to avoid exploitation levels and patterns which could threaten the sustainability of the fishery and damage the economic potential *D. macrosoma* stocks.

There have been several studies on biological aspects of shortfin scads in Indonesia (e.g. Dahlan et al 2015; Liestiana et al 2015; Asni et al 2019; Ahmadi 2020). However, the specimens in these studies were collected from fish landing sites without a clear explanation regarding the fishing gear used to catch them. Other studies on shortfin scad used specimens caught using purse seines (e.g. Prihartini et al 2007; Senen & Sulistiono 2011; Bintoro et al 2019; Faizah & Sadiyah 2020), but none of these studies were conducted in the Gulf of Bone. Therefore, this study aimed to analyse biological aspects of *D. macrosoma* caught by purse seines in the waters around Herlang in the Gulf of Bone. The biological aspects addressed included the length-weight relationship, length-frequency distribution, sex ratio, condition factor, and gonad development stage.

Material and Method. This study was conducted from March to April 2019 in Herlang District, Bulukumba Regency, South Sulawesi, Indonesia. A random sample of 1000 *D. macrosoma* were collected through fortnightly sampling at a fish landing site in Tanuntung Village, Herlang District (Figure 1). These specimens were caught in the coastal waters of Herlang by local fishermen operating a purse seine vessel as their main source of income. The vessel was made of wood with a length over all of 20.60 m, a beam of 4.65 m, and a draught of 1.50 m. The purse seine fishing gear was 250 m long and 60 m in depth, made of polyethylene (PE) net with a 1” mesh size.

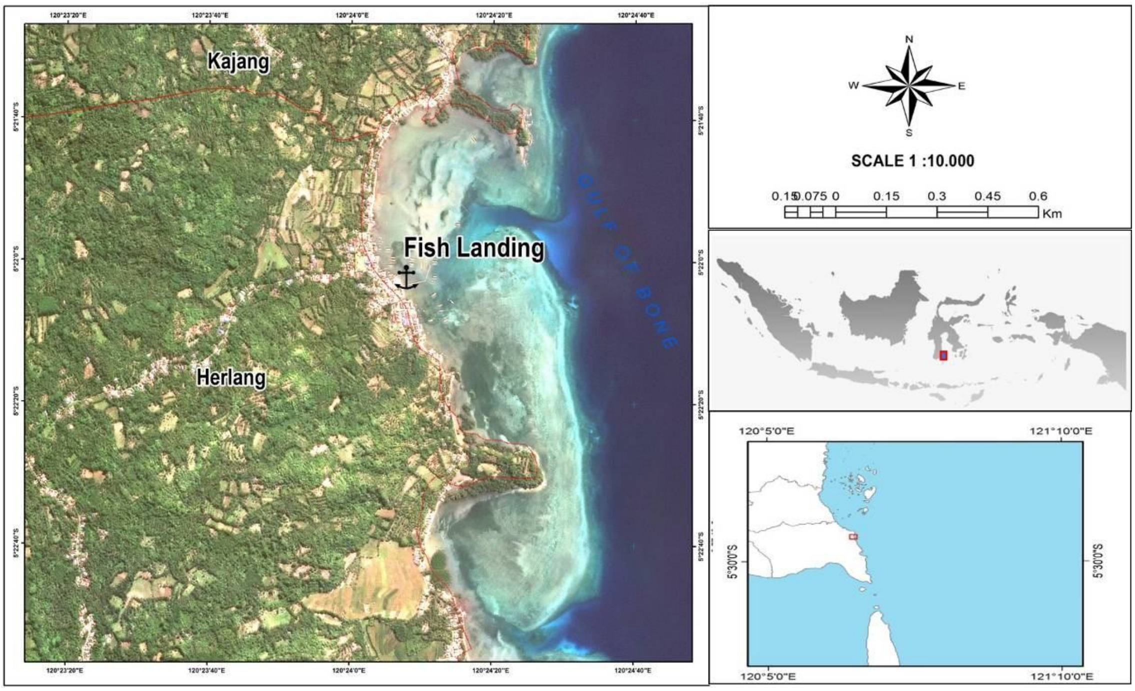

Figure 1. Map of the study area in the Gulf of Bone, in Herlang District, Bulukumba Regency, South Sulawesi Province, Indonesia (Source: Google Earth & INA-Geoportal). The red marker shows the fish landing site in Tanuntung Village where *Decapterus macrosoma* samples were collected.

The fork length (FL) of each specimen was measured (precision 0.1 cm) from the tip of the snout to the end of the middle caudal fin using a fish measuring board. The specimen was then weighed using electronic scales (precision 0.1 g). The data were grouped into length classes with an interval of 1.5 cm. The relationship between length and weight of a fish is usually expressed by the equation $W = a \cdot Lb$, where W is body weight (g), L is total length (cm), a is a coefficient related to body form and b is an exponent indicating isometric growth when equal to 3 (Froese 2006). The values of the exponent b provide information on fish growth pattern, which is isometric if b is equal to 3 (proportional increase in length and weight); allometric positive if b is higher than 3 (weight increases faster than length) and allometric negative if b is less than 3 (weight increases more slowly than length) (Kuriakose 2014). Student’s t-test was used to test whether b differed significantly from 3 for male and female *D. macrosoma*.

The relative condition factor (Kn) is expressed as the ratio between actual weight (observed weight) and the calculated weight according to the length-weight equation (Le-Cren 1951). The data used for length-weight relationships were also used to calculate the relative condition factor (Kn) using the formula: $Kn = \frac{W}{W'}$, where W is observed weight and W’ the computed weight as determined from the length-weight equations. After being measured and weighed, each specimen was dissected and the gonads were observed *in situ* and then removed. The sex of each sample was identified by examining the gonads. The sex ratio was given as males:females (M:F), calculated through division by the total number of males. The gonad development stage (GDS) of female and male specimens was identified based on the macroscopic descriptions of the various reproductive phases in Table 1 (Brown-Peterson et al 2011).

Table 1

Macroscopic descriptions of female and male gonad maturity stages

Stage	*Female*	*Male*
I. Immature	Small ovaries, often clear, blood vessels indistinct.	Small testes, often clear and threadlike.
II. Developing	Enlarging ovaries, blood vessels becoming more distinct.	Small testes but easily identified.
III. Spawning capable	Large ovaries, blood vessels prominent. Individual oocytes visible macroscopically.	Large and firm testes. Actively spawning sub-phase (macroscopic): milt released with gentle pressure on the abdomen.
IV. Regressing	Flaccid ovaries, blood vessels prominent.	Small and flaccid testes, no milt release with pressure.
V. Regenerating	Small ovaries, blood vessels reduced but present.	Small testes, often threadlike.

All data were tabulated and analysed in Microsoft Excel 2010. In statistical analyses, significance was assessed at the 95% confidence level (α = 0.05).

Results and Discussion

Length-weight relationship. The fork length (FL) of *D. macrosoma* specimens ranged in size from 12 to 27 cm, comprising 697 females and 303 males. The values of *b* in the length-weight relations for male and female *D. macrosoma* (Figure 2, Table 2) show that females exhibited allometric positive growth (Figure 2A) while males exhibited isometric growth (Figure 2B). The correlation coefficients of the regression equations for both sexes were over 0.9, indicating a very strong correlation with relatively little variation between individuals while in males the body weight increases in proportion with the length of the fish. This difference implies that, at a given length, females gain weight at a faster rate compared to males.

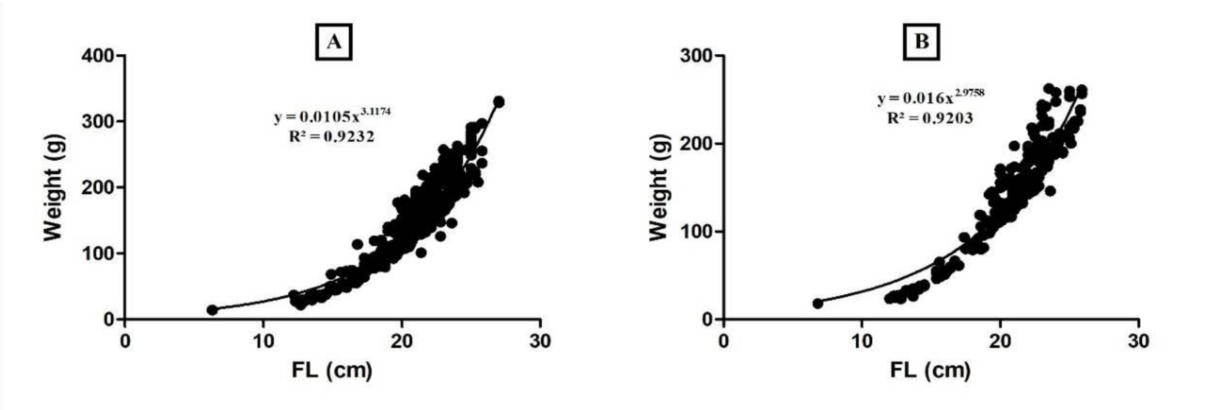

Figure 2. Length-weight relationship of female (A) and male (B) *Decapterus macrosoma*.

Table 2

Estimated length-weight parameters of female and male *Decapterus macrosoma* caught by purse seine in Herlang Waters, Gulf of Bone, South Sulawesi, Indonesia

Sex	*a*	*b*	*r*	R^2	*t-test*[a]	*Growth pattern*
Female	0.0105	3.1174	0.9608	0.9232	*	A+
Male	0.016	2.9758	0.9593	0.9203	ns	I

[a] * = significantly different from 3; ns = not significantly different from 3; [b] A+ = allometric positive; I = isometric.

According to Le-Cren (1951), female fish can be heavier than males of the same species at a given length due to differences in fatness and gonadal development. A similar growth pattern in female *D. macrosoma* was also found in the Makassar Strait (Asni et al 2019). Meanwhile, the growth pattern of male *D. macrosoma* in this study is similar to that reported by Ahmadi (2020) based on specimens from Banjar Masin Fishing Port, while Randongkir et al (2018) found an allometric negative growth pattern for male *D. macrosoma* landed at the PPI Sanggeng Fish Landing Port, Manokwari, West Papua. In contrast, Asni et al (2019) found an allometric positive growth pattern in male *D. macrosoma* from the Makassar Strait. Other studies report differing growth patterns between female and male *D. macrosoma* (Table 3). These variations between sex and between sites might be due to several factors that were not controlled for in this study, such as feeding habits, seasonal effects, sexual maturity, and environmental conditions (Khatib et al 2018).

Table 3

Length-weight relationship parameters of shortfin scad (*Decapterus macrosoma*) from studies conducted at sites across Indonesia

Study area	*Province*	*Sex*[a]	*n*	*b*	*Growth pattern*[b]	*References*
Herlang, Gulf of Bone	South Sulawesi	F	695	3.12	A+	Present study
		M	305	2.98	I	
Banjarmasin Fishing Port	South Kalimantan	F	135	2.96	I	Ahmadi (2020)
		M	178	3.03	I	
Western Java Sea	Central Java	P	610	2.98	I	Prihartini et al (2007)
Makassar waters	South Sulawesi	F	169	3.73	A+	Asni et al (2019)
		M	201	3.37	A+	
PPI Sadeng, Gunung Kidul	Yogyakarta	p	1324	2.88	A-	Liestiana et al (2015)
PPI Sanggeng, Manokwari	West Papua	M	222	1.84	A-	Randongkir et al (2018)
		F	278	2.03	A-	
Banda Nera Island	Maluku	P	1134	3.19	A+	Senen & Sulistiono (2011)
Ambon Island	Maluku	P	1018	3.59	A+	Pattikawa et al (2017)

[a] F = female; M = male; P = whole population (males and females); [b] A+ = allometric positive; A- = allometric negative; I = isometric.

The *D. macrosoma* length-frequency histogram (Figure 3) shows that males and females had a similar length-frequency distribution. This was confirmed by a two-sample F-Test for variance which showed no significant between-sex difference ($p > 0.05$). The most common size at capture was the 21.75 cm mid-length class (34.00% of females and 30.36% of males). This contrasts with the results of Randongkir et al (2018) who found that male *D. macrosoma* landed at the Sanggeng landing site in Manokwari had a length-frequency peak in the 16.8-18.1 cm range, while the peak range for female *D. macrosoma* was 16.2-17.6 cm. Irrespective of the between-sex difference in Manokwari, these results indicate that the *D. macrosoma* caught in the Gulf of Bone waters around Herlang tend to be larger than those caught in the waters around Manokwari.

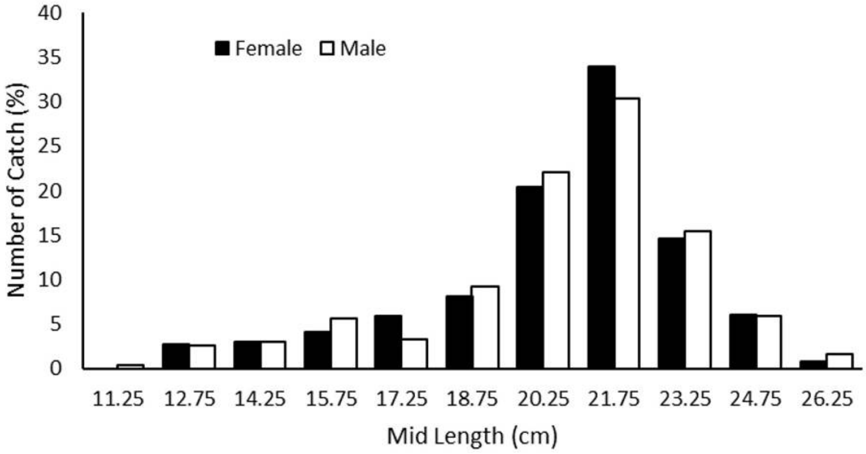

Figure 3. Length frequency distribution of *Decapterus macrosoma* landed in Herlang, Gulf of Bone.

Sex ratio*.* The *D. macrosoma* sample from Herlang, Gulf of Bone comprised 1000 specimens, with 697 females (69.7%) and 303 males (30.3%). The sex ratio or ratio of males to females (M:F) was therefore 1:2.3. This suggests that the sex ratio of the *D. macrosoma* stock in Herlang waters was female-biased, differing substantially from the balanced ratio (1:1). Information on the sex ratio is important for understanding the relationship between individuals, the environment, and the state of the population (Vicentini & Araújo 2003). Differences in sex ratio can occur due to spawning behaviour, and can change before and during spawning. According to Nikolsky (1978), the ratio of males and females regularly changes in spawning fish; initially, there would be more male fish, then the sex ratio changes to 1:1, followed by a dominance of females. Differences in the numbers of individuals of one of the sexes in the population can also be affected by differences in growth patterns, age difference, timing of first maturity, and the addition of new fish species (Nikolsky 1978; Oliveira et al 2015).

Condition factor Kn*.* Table 4 shows the mean relative condition factor for females and males differed between size classes. Similar patterns were found by Senen & Sulistiono (2011) who also found that the condition factor of *D. macrosoma* in Banda Aceh fluctuated between months, with the values in the range of 0.91-1.11.

Table 4

Mean value of *Decapterus macrosoma* relative condition factor (Kn) by length class

The length size range (FL)	*Mid-length*	*Kn*			
		n	*Female*	*n*	*Male*
10.51-12.00	11.25	0	0	9	0.90
12.01-13.50	12.75	19	0.96	9	0.89
13.51-15.00	14.25	21	0.95	17	0.84
15.01-16.50	15.75	29	0.94	10	0.91
16.51-18.00	17.25	41	0.96	29	0.96
18.01-19.50	18.75	57	1.00	67	1.06
19.51-21.00	20.25	142	1.04	67	1.04
21.01-22.50	21.75	237	1.00	92	1.01
22.51-24.00	23.25	102	1.03	47	1.05
24.01-25.50	24.75	42	0.98	18	0.94
25.51-27.00	26.25	6	1.02	5	0.96

The data in Table 4 indicate that the relative condition factor Kn tends to increase as the fish grow larger. The highest Kn values were observed in females and males in the length classes 19.51-21.00 cm to 22.51-24.00 cm and could most likely be attributed to good feeding. The increase in Kn values from the length class 18.01-19.50 cm to 19.51-21.00 cm indicates that the process of gonad maturation begins at around 18.01-19.50 cm.

After the length size range 24.01 to 25.50 cm, the Kn value increased more rapidly indicating the possibility of recovery after spawning. The effect of the Kn value is more significant in females than males. After a drop in Kn for the length class 24.01 to 25.50 cm, the Kn value increased again, which could possibly indicate spawning followed by recovery after spawning. The variation in Kn value was more marked in females than in males.

Gonad development stage (GDS). The majority of the *D. macrosoma* sampled (females and males) were in gonad development stage (GDS) I and II. This suggests that most of the *D. macrosoma* sampled (76.5%) were immature or maturing fish.

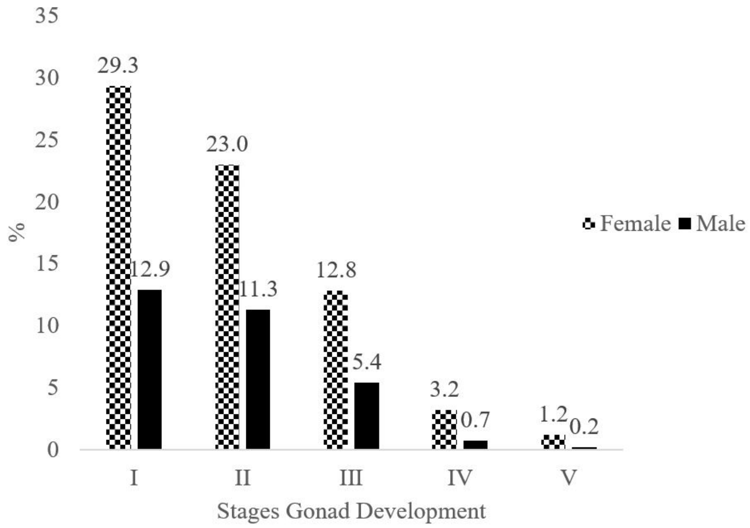

Figure 5. *Decapterus macrosoma* gonad development stage (GDS) by sex.

The gonad development stage (GDS) by length class (Table 5) shows that fish in the dominant size class (21.01-22.50 cm) were mostly in GDS I, II, and III. Male and female fish had different GDS distributions, with very few fish in GDS IV and V.

Table 5

Decapterus macrosoma gonad development stage (GDS) percentage by length class

Length class (FL, cm)	*Class mid-length*	*GDS I*		*GDS II*		*GDS III*		*GDS IV*		*GDS V*	
		F	*M*	*F*	*M*	*F*	*M*	*F*	*M*	*F*	*M*
10.51-12.00	11.25	0	0.1	0	0	0	0	0	0	0	0
12.01-13.50	12.75	1.6	0.6	0.3	0.1	0	0.1	0	0	0	0
13.51-15.00	14.25	1.7	0.9	0.1	0	0.2	0	0	0	0.1	0
15.01-16.50	15.75	2.2	1.4	0.4	0.3	0.3	0	0	0	0	0
16.51-18.00	17.25	2.9	0.7	0.4	0.1	0.5	0.2	0.3	0	0	0
18.01-19.50	18.75	3.1	1.8	1.9	0.9	0.4	0.1	0.2	0	0.1	0
19.51-21.00	20.25	6.7	3.2	5.3	2.9	1.6	0.6	0.2	0	0.4	0
21.01-22.50	21.75	7.7	2.8	8.9	4.1	6.1	2.1	0.8	0.2	0.2	0
22.51-24.00	23.25	2.5	0.7	4.2	2.2	2.1	1.3	1.2	0.4	0.2	0.1
24.00-25.50	24.75	0.8	0.3	1.3	0.5	1.6	0.9	0.4	0	0.1	0.1
25.51-27.00	26.25	0.1	0.1	0.2	0.2	0	0.1	0.2	0.1	0.1	0

The data in Table 5 indicate that the majority of the *D. macrosoma* population caught in the Gulf of Bone had not yet reproduced. Fish with mature gonads but who had not yet reproduced (GDS III) comprised 18.2% of the catch, while fish that had reproduced (GDS IV and V) comprised only 5.4% of the catch. These results confirm previous indications of juvenile fishing in *D. macrosoma* fisheries. To ensure optimal and sustainable production of the shortfin scad (*D. macrosoma*) in the Gulf of Bone, and especially in the waters around Herlang, appropriate fisheries management measures are essential. These should include controls on fishing gears, patterns and intensity, and or the creation of conservation areas, to maintain stocks and thereby maintain or improve the catch per unit effort (CPUE).

Conclusions. Fishing control measures for scads in general, and the shortfin scad *Decapterus macrosoma* should be considered a priority to ensure sustainable benefits from these important small pelagic fish stocks. The high level of juveniles caught in the purse seine fishery in the waters off Herlang District in the Gulf of Bone is a particular cause for concern. The controls should aim to maintain or improve the catch per unit effort (CPUE) through a rational intensity of fishing in the area, including measures to reduce juvenile catch. Creating conservation areas could also contribute to preventing population declines due to overexploitation.

References

Ahmadi, 2020 Length-weight relationship, body condition, and fishing gear selectivity of shortfin scad (*Decapterus macrosoma*) landed in Banjarmasin fishing port, Indonesia. Fisheries and Aquatic Life 28:113-124.

Asni A., Hamsiah, Rustam, Ilmiah, 2019 Biological aspects of shortfin scad (*Decapterus macrosoma*) in Makassar waters, South Sulawesi, Indonesia. IOP Conference Series: Earth and Environmental Science 253:012008.

Atmaja S. B., Haluan J., 2003 [The change of sustainable yield of pelagic fishes in Java Sea and its surrounding waters]. Buletin PSP 12(2):47-59.

Bintoro G., Rudianto, Lelono T. D., Syehbiarachman H., 2019 Biological aspect of Indian scad (*Decapterus russelli*) caught by purse seine in north coast of Sumenep waters, East Java. IOP Conference Series: Earth and Environmental Science 239:012016.

Borsa P., 2003 Genetic structure of round scad mackerel *Decapterus macrosoma* (Carangidae) in the Indo-Malay Archipelago. Marine Biology 142:575-581.

Brown-Peterson N. J., Wyanski D. M., Saborido-Rey F., Macewicz B. J., Lowerre-Barbieri S. K., 2011 A standardized terminology for describing reproductive development in fishes. Marine and Coastal Fisheries 3(1):52-70.

Dahlan M. A., Omar S. B. A., Tresnati J., Nur M., Umar M. T., 2015 [Several aspects of scad (*Decapterus macrosoma* Bleeker, 1841) reproduction caught by lift net in Barru coastal waters, South Sulawesi]. Jurnal IPTEKS Pemanfaatan Sumberdaya Perikanan 2(3):218-227. [in Indonesian]

Faizah R., Sadiyah L., 2020 Some biology aspects of Indian scad (*Decapterus russelli*, Rupell, 1928) in Pemangkat Fisheries Port, West Kalimantan. IOP Conference Series: Earth and Environmental Science 429:012063.

FAO, 2001-2020 Fishing gear types. Purse seines. Technology Fact Sheets. In: FAO Fisheries Division [online]. Rome, Food and Agriculture Organisation of the United Nations. Available at: http://www.fao.org/fishery/geartype/249/en. Accessed: October, 2020.

Froese R., 2006 Cube law, condition factor and weight-length relationships: history, meta-analysis and recommendations. Journal of Applied Ichthyology 22(4):241-253.

Hall M., Roman M., 2013 Bycatch and non-tuna catch in the tropical tuna purse seine fisheries of the world. FAO Fisheries and Aquaculture Technical Paper No. 568, Rome, Food and Agriculture Organisation of the United Nations, 249 pp.

Khatib M., Azim M., Sarker S. M., Ali N. A. H., Arshad A., Yusoff F. M., 2018 Length-weight and length-length relationship models of four Carangid fishes from the Matang mangrove estuaries, Perak, Malaysia. Pertanika Journal of Tropical Agricultural Science 41(4):1659-1668.

Kuriakose S., 2014 Estimation of length weight relationship in fishes. In: Training manual on fish stock assessment and management. Kochi, Central Marine Fisheries Research Institute (CMFRI), pp. 215-220.

Le-Cren E. D., 1951 The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). Journal of Animal Ecology 20(2):201-219.

Liestiana H., Ghofar A., Rudiyanti S., 2015 [Biological aspects of the shortfin scad (*Decapterus macrosoma*) caught at Sadeng Fishing Base, Gunungkidul, Yogyakarta]. Diponegoro Journal of Maquares 4(4):10-18. [in Indonesian]

Nikolsky G. V., 1978 [The ecology of fishes]. Neptune NJ, TFH Publications Inc., 352 pp. [in Russian]

Oliveira M. R., Silva N. B., Yamamoto M. E., Chellappa S., 2015 Desenvolvimento das gônadas e reprodução da agulha-preta, *Hemiramphus brasiliensis* das águas costeiras do Rio Grande do Norte, Brasil. Brazilian Journal of Biology 75(2):324-330. [in Portuguese]

Ono R., Morrison A., Addison D. (eds), 2013 Prehistoric marine resource use in the Indo-Pacific regions. Canberra: Australian National University, E-Press, 214 pp.

Pattikawa J. A., Tetelepta J. M. S., Ongkers O. T. S., Unepputy P. A., Lewerissa H., 2017 Size distribution, length-weight relationship and age group of *Decapterus macrosoma* in eastern waters of Ambon Island, Indonesia. AACL Bioflux 10(4):969-976.

Prihartini A., Anggoro S., Asriyanto, 2007 Biological performance analysis of layang (*Decapterus* spp.) from the purse seine fishery at the PPN Pekalongan landing place. Jurnal Pasir Laut 3(1):61-75.

Randongkir Y. E., Simatauw F., Handayani T., 2018 [Growth aspects of scad *Decapterus macrosoma* on Fish Point Sanggeng-Manokwari Regency]. Jurnal Sumberdaya Akuatik Indopasifik 2(1):15-24. [in Indonesian]

Senen B., Sulistiono I. M., 2011 Beberapa aspek biologi ikan layang deles (*Decapterus macrosoma*) di Perairan Banda Neira, Maluku. Jurnal Pertanian-UMMI 1:34-40. [in Indonesian]

Vicentini R. N., Araújo F. G., 2003 Sex ratio and size structure of *Micropogonias furnieri* (Desmarest, 1823) (Perciformes, Sciaenidae) in Sepetiba Bay, Rio de Janeiro, Brazil. Brazilian Journal of Biology 63(4):559-566.

Received: 18 October 2020. Accepted: 21 January 2021. Published online: 12 March 2021.

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How to cite this article:
Jamal M., Ihsan, Sari D. P., Nadiarti N., 2021 Biological aspects of shortfin scad (*Decapterus macrosoma*) in Bulukumba Regency, Gulf of Bone, Indonesia based on purse seine catch. AACL Bioflux 14(2):746-753.