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Length-Weight Relationships and Condition Factors of Three *Epinephelus* Grouper (Epinephelidae) Harvested in the Northern Coast of Aceh, Indonesia

Nur Fadli[1*], Adrian Damora[1], Zainal Abidin Muchlisin[1], Irma Dewiyanti[1], Mutia Ramadhaniaty[1], Nanda Muhammad Razy[1], Edison D. Macusi[2], Mohd N. Siti-Azizah[3]

[1] Faculty of Marine and Fisheries, Universitas Syiah Kuala, Banda Aceh 23111, Indonesia
[2] Institute of Agriculture and Life Sciences (IALS), Davao Oriental State University (DOrSU), Mati City, Davao Oriental 8200, Philippines
[3] Institute of Marine Biotechnology, Universiti Malaysia Terengganu, Terengganu 21030, Malaysia

Corresponding Author Email: nurfadli@unsyiah.ac.id

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ABSTRACT

The current research reports the length-weight relationships (LWRs) and Fulton's condition factor (K) of three grouper species, namely: areolate grouper (*Epinephelus areolatus*), blacktip grouper (*Epinephelus fasciatus*), and honeycomb grouper (*Epinephelus merra*) harvested in the northern coast of Aceh, Indonesia. The fish samples were gathered from Pelabuhan Perikanan Samudera (PPS) Lampulo, Kuta Alam District, Banda Aceh, Aceh from June - December 2020. In total, 571 grouper specimens were collected during the study period (186 of *E. areolatus*, 205 specimens of *E. fasciatus*, and 180 *E. merra*). The total length (TL) of each fish species ranged from: 125.9-302.5 mm (mean 222.5 ± 30.3) (*E. areolatus*), 113.3-268.6 mm (mean 196.6 ± 26.9) (*E. fasciatus*) and 111.1-215.4 mm (mean 162.9 ± 21.7) (*E. merra*) with weight (W): 25.5-367.6 g (mean 145.8 ± 64.6) (*E. areolatus*), 24.0-290.9 g (mean 130.3 ± 56.2) (*E. fasciatus*) and 24.0-290.9 g (mean 130.3 ± 56.2) (*E. fasciatus*). In addition, the observed Fulton (K) condition factor and Ws values for all the three species were above 100 and 1. Furthermore, the LWRs analysis results revealed that all three fish species showed the b value of 3.0548 (r^2=0.97), 3.0466 (r^2=0.94) and 3.1681 (r^2=0.97) for *E. areolatus, E. fasciatus* and *E. merra*, respectively, indicating that the three observed fish species had a positive allometric growth pattern and had a solid relationship between body weight and total length. This study delivers a reference point of several biological characteristics of the observed grouper species that will benefit and improve the fisheries management in the region.

1. INTRODUCTION

Northern Aceh region is situated in Indonesia's western most area, an area endowed with high marine biodiversity, e.g., coral reefs [1, 2], reef fishes [3], macroinvertebrates [4], gastropods and bivalve [5], etc. Like other coastal regions, capture fisheries play a vital role in the fisheries industry in this area, with increasing annual fish production (DKP Aceh, 2021). The region is also known as one of the most extensive fishing grounds in Aceh [6]. One of the targeted fish groups in the capture fisheries industry in the region is the grouper (family Epinephelidae) [3].

Epinephelus is one of the genera within the Epinephelidae family [7]. The genera are the main genus (covered 58%) of commercial groupers found in many Aceh fish landing sites. Out of 26 grouper species, *Epinephelus areolatus*, *E. fasciatus,* and *E. merra* are among the common *Epinephelus* species found in Aceh [8]. The fishes are categorized as Least Concern (LC) by IUCN [9]. Despite their commercial importance, there is still incomplete information on their biological aspects, especially for the groupers that fished on the northern Aceh coast.

There have been limited comprehensive studies of groupers in Indonesia, especially in the Aceh area and its nearby region. The majority of these researches had concentrated on inventory studies of the groupers using both traditional methods [10] and molecular approaches [8, 11]. Among essential biological information needed in fisheries management are the length-weight relationships and condition factors. The LWRs and condition factors data are had been extensively described in many grouper studies worldwide, for example, Haifa grouper (*Hyporthodus haifensis*) and mottled grouper (*Mycteroperca rubra*) harvested from the North-Eastern Mediterranean Sea [12], Pacific goliath grouper (*Epinephelus quinquefasciatus*) fished in Colombia [13], white-spotted grouper (*Epinephelus coeruleopunctatus*) in Padang waters [14], goldblotch grouper (*Epinephelus costae*) and dusky grouper (*Epinephelus marginatus*) in Tripoli-El Mina, North Lebanon [15].

However, only a few studies have recorded biological aspects of groupers in Aceh. For example, the study by Ramadhani et al. [16] that reported the variation of the growth pattern of the leopard coralgrouper (*Plectropomus leopardus*), blacksaddled coralgrouper (*P. laevis*), brown-marbled grouper (*E. fuscoguttatus*), and duskytail grouper (*E. bleekeri*) harvested in Aceh northern coast. This study noted that out of five observed grouper species, four species had negative allometric growth pattern (*P. leopardus*, *P. laevis, E.*

fuscoguttatus, and *E. bleekeri*), while *P. Maculatus* had positive allometric. In another, Fadli et al. [17] observed a positive allometric growth pattern of the golden hind grouper (*Cephalopholis aurantia*) fished in the northern Aceh coast. In addition, Fadli et al. [18] also reported the LWR analysis of the orange-spotted grouper *(Epinephelus coioides*) and noted a negative allometric growth pattern. Furthermore, Damora et al. [19] also reported the same growth pattern (negative) for the White-edged lyretail (*Variola albimarginata*) from northern Aceh waters. Nevertheless, comparable data are not presented for *Epinephelus areolatus, Epinephelus fasciatus* and *Epinephelus merra* in the northern Aceh region. Hence, the objective of the current study was to provide the length-weight relationships and condition factors of *Epinephelus areolatus, Epinephelus fasciatus,* and *Epinephelus merra* harvested in the region.

2. MATERIALS AND METHOD

The research was conducted from June - December 2020. The grouper samples were gathered from Pelabuhan Perikanan Samudera (PPS) Lampulo, Kuta Alam District, Banda Aceh, Aceh (Figure 1). The grouper species examined in this study were the common grouper fished by handlines and bottom longlines in northern Aceh region, that is, *Epinephelus areolatus*, *E. fasciatus*, and *E. merra*. A stratified random sampling method was used to select the fish samples, and at least 30 fish samples were collected from each species every month during the study period. Overall, 571 grouper specimens were collected during the study (composed of 186 *E. areolatus*, 205 specimens of *E. fasciatus,* and 180 *E. merra*). The fish samples were identified based on Craig et al. [7]. Several biological parameters were measured: total length (TL), body weight (W), gonad weight (w), sex, maturity level, etc. The TL was assessed to the nearest mm using a digital caliper ruler with an accuracy of 0.1 mm. The body weight was assessed using a digital balance with an accuracy of 0.1 gram, while the gonad weight was measured using a digital balance to nearest the nearest gram with an accuracy of 0.01 g. All procedures were conducted at the Genetics and Biodiversity Laboratory in the Faculty of Marine and Fisheries, Universitas Syiah Kuala.

The length-weight relationship (LWR) was estimated using the linear allometric model (LAM) following De Robertis and Williams [20] and Muchlisin et al. [21] as follows: $W = e^{0.56}(aL^b)$, where W is the fish weight (g), L is the total length of fish (mm), a is the regression intercept, b is regression coefficient, e is the variant of residual from LAM, and 0.56 is the correction factor. A simple linear regression equation was made first with the following equation: Ln W = a + bLn TL. Then T-test was conducted to test the isometric or allometric growth pattern.

In addition, two different condition factors were calculated in this research: Fulton's condition (K) and Relative weight (Wr). Fulton's condition is a value that used to assess the fish condition/health calculated based on its weight and length [22] and has been used in many fisheries studies [21, 23, 24]. Fulton's condition (K) was calculated based on Blackwell et al. [25] as follows: $K=WL^{-3}\times100$, where K is Fulton's condition factor, W is the bodyweight of fish (g), and L is the total length of fish (mm). Predicted weight (Ws) and Relative weight (Wr) were calculated as follows: Wr = (W/Ws) × 100, where Wr is the relative weight condition factor, W is the bodyweight of direct fish measurement, Ws is the predicted weight of fish [26].

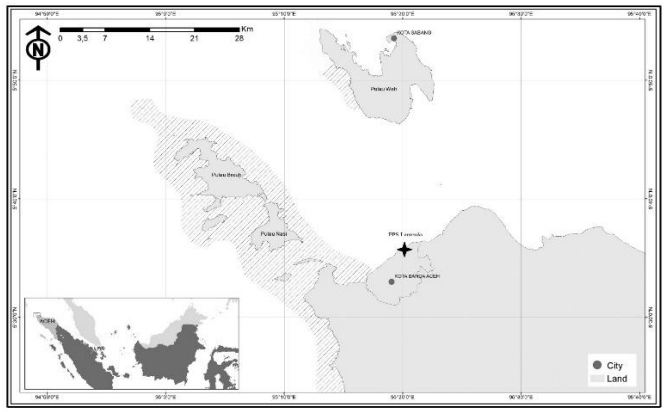


Figure 1. Northern Aceh region and its fishing ground (dashed line) (black star: PPS Lampulo)

3. RESULTS AND DISCUSSION

The present study records the length-weight relationships (LWRs) and Fulton's condition factor (K) of three grouper species harvested in the northern Aceh region. In total, 186 specimens of *E. areolatus*, 205 specimens of *E. fasciatus,* and 180 *E. merra* were collected during the study period, respectively. The total length (TL) of each fish species varied from: 125.9-302.5 mm (mean 222.5 ± 30.3) (*E. areolatus*), 113.3-268.6 (mean 196.6 ± 26.9) (*E. fasciatus*) and 111.1-215.4 (mean 162.9 ± 21.7) (*E. merra*) with weight (W): 25.5-367.6 g (mean 145.8 ± 64.6) (*E. areolatus*), 24.0-290.9 g (mean 130.3 ± 56.2) (*E. fasciatus*) and 24.0-290.9 g (mean 130.3 ± 56.2) (*E. fasciatus*). The Fulton (K) condition factor ranged from 2.86-3.31 (mean 3.10 ± 0.06) for *E. areolatus,* 2.76-3.42 (mean 3.25 ± 0.08) for *E. fasciatus* and 2.86-3.40 (mean 3.22 ± 0.10) for *E. merra,* respectively. In addition, the average Ws values for all three species were above 100. The Ws values ranged from 23.99 to 348.87 g (mean 144.48 ± 60.42) for *E. areolatus*, 22.86-317.13 (129.77 ± 55.19) for *E. fasciatus,* and 29.11-237.13 (mean 104.10 ± 41.69) for *E. merra*. Additionally, the relative weight value (Wr) for *E. areolatus* varied from 74.50 to 125.57 (mean 99.94 ± 7.70), 78.70 to 217.48 (mean 100.69 ± 12.99) for *E. fasciatus* and *E. merra* ranged from 109.77-160.43 (mean 135.15 ± 9.90) (Table 1).

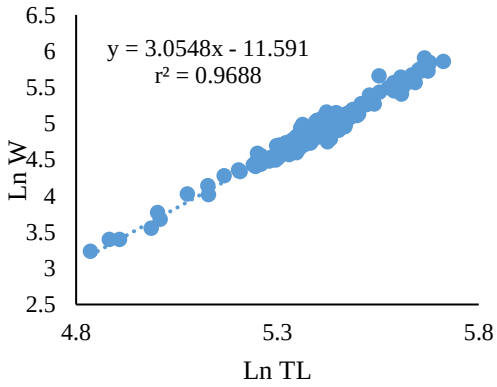
Regressions of LWRs for all three fish species showed that the b value for *E. areolatus, E. fasciatus,* and *E. merra* were 3.0548 (r^2=0.97), 3.0466 (r^2=0.94) and 3.1681 (r^2=0.97), respectively, indicating that three observed fish had a positive allometric growth shape and had a strong correlation between body weight and total length (Figure 2). In addition, the regression model for the three observed fish revealed a comparable growth pattern between the observed and the predicted (Figure 3).

In general, the growth pattern of all the collected species showed a positive allometric pattern. This growth pattern is similar with earlier studies of several grouper species, for example, the golden hind grouper (*Cephalopholis aurantia*) [17] and *P. maculatus* [16] harvested in northern Aceh, haifa grouper (*Hyporthodus haifensis*), and mottled grouper (*Mycteroperca rubra*) from the North-Eastern Mediterranean Sea [12], Pacific goliath grouper (*Epinephelus*

quinquefasciatus) fished in Colombia [13], goldblotch grouper (*Epinephelus costae*) and dusky grouper (*Epinephelus marginatus*) in Tripoli-El Mina, North Lebanon [15]. In contrast, Ramadhani et al. [16] and Bulanin et al. [14] found that growth pattern of groupers (*Plectropomus leopardus, P. laevis*, *E. fuscoguttatus,* and *E. bleekeri*) in northern Aceh and *E. coeruleopunctatus* harvested in the coastal waters of Padang City, respectively, displayed negative allometric pattern. In another study, Fadli et al. [18] and Damora et al. [19] also reported negative allometric patterns for *E. coioides* and white-edged lyretail (*Variola albimarginata*) harvested in northern Aceh.

Table 1. The value of biological parameters, the relationship between length and weight, and condition factor for *Epinephelus areolatus, Epinephelus fasciatus,* and *Epinephelus merra* harvested on the northern coast of Aceh

Parameters	Species		
	E. areolatus	***E. fasciatus***	***E. merra***
Total length (mm)	125.9-302.5 (222.5 ± 30.3)	113.3-268.6 (196.6 ± 26.9)	111.1-215.4 (162.9 ± 21.7)
Body weight (g)	25.5-367.6 (145.8 ± 64.6)	24.0-290.9 (130.3 ± 56.2)	20.8-185.3 (77.3 ± 30.4)
Fulton's condition (K)	2.86-3.31 (3.10 ± 0.06)	2.76-3.42 (3.25 ± 0.08)	2.86-3.40 (3.22 ± 0.10)
Prediction weight (Ws) (g)	23.99-348.87 (144.48 ± 60.42)	22.86-317.13 (129.77 ± 55.19)	29.11-237.13 (104.10 ± 41.69)
Relative weight (Wr) (g)	74.50-125.57 (99.94 ± 7.70)	78.70-217.48 (100.69 ± 12.99)	109.77-160.43 (135.15 ± 9.90)
b Value	3.0548	3.0466	3.1681



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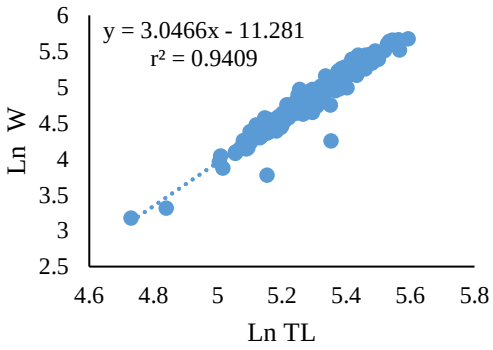

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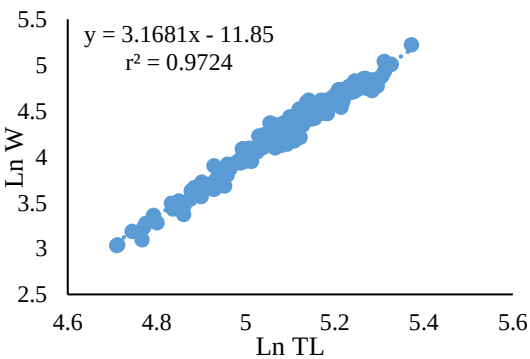
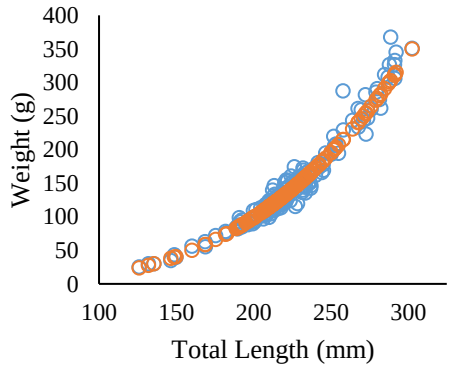
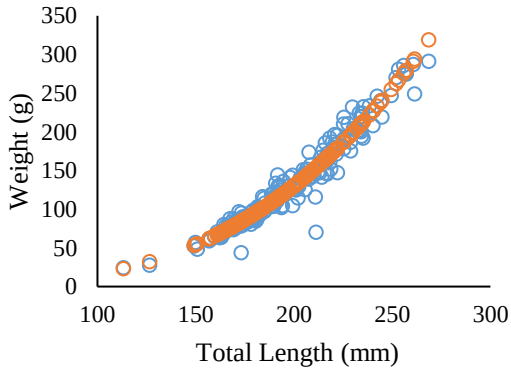


(c)

Figure 2. The length-weight relationships of *E. areolatus* (a), *E. fasciatus* (b), and *E. merra* (c) harvested in Aceh's northern coast



(a)



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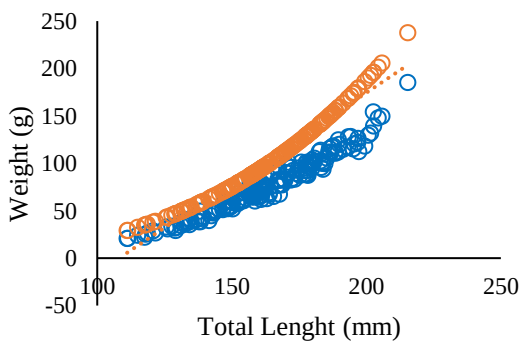

(c)

Figure 3. Comparison of observed (blue circle) and predicted (orange circle) growth of *E. areolatus* (a), *E. fasciatus* (b), and *E. merra* (c) harvested in Aceh's northern coast

The observed typical Fulton's condition factor (K) was greater than 1 for the three species (*Epinephelus areolatus*: 3.10 ± 0.06*, Epinephelus fasciatus*: 3.25 ± 0.08 and *Epinephelus merra*: 3.22 ± 0.10). The K value observed in this study is in similar with earlier grouper studies in Indonesian waters [14, 16] and worldwide [27]. For example, Bulanin et al. [14] reported that the K value of the white spotted grouper *E. coeruleopunctatus* caught in Padang waters was 3.13 ± 0.05 (male fish) and 3.20 ± 0.10 (female fish), respectively. In another study, Ramadhani et al. [16] observed K > 1 for the leopard coral grouper *Plectropomus leopardus* (1.79 ± 0.13), black saddled coral grouper *P. laevis* (2.06 ± 0.09), *P. maculatus* (1.95 ± 0.07), brown-marbled grouper *E. fuscoguttatus* (1.82 ± 0.13) and dusky tail grouper *E. bleekeri* (1.77 ± 0.10) harvested in northern Aceh region. The observed K value in this research was also greater than the K value of white grouper, *E. aeneus* from the southwest coast of Senegal, West Africa (1.212-1.361) [27]. Furthermore, the K value observed in this study is also higher than the K value reported in the other marine fishes studies. For example, Jin et al. [22] reported that the skipjack tuna (*Katsuwonus pelamis*) in the western and central Pacific Ocean was 0.65 to 1.86. In another study, Sabbir et al. [28] reported the K values varied from 0.56 to 1.12 (males) and 0.60 to 1.45 (females), respectively, of Hooghly croaker (*Panna heterolepis*) harvested from the Bay of Bengal (Southwestern Bangladesh).

Moreover, the average relative weight was above 100 for *Epinephelus fasciatus* (100.69 ± 12.99) and *Epinephelus merra* (135.15 ± 9.90) while <100 for *Epinephelus areolatus* (99.94 ± 7.70). The relative weight value displayed in this research corresponds with previous grouper studies. For example, Fadli et al. [17] and Fadli et al. [18] reported that the Wr value of the golden hind grouper (*Cephalopholis aurantia*) and the orange spotted grouper (*E. coioides*) fished in northern Aceh waters were 100.23± 7.13 and 100.08± 4.20, respectively. Comparable results were also described in several marine fishes studies. For example, the snapper (*Lutjanus russellii*), ponyfish (*Aurigequula fasciata*), and white-spotted spinefoot (*Siganus canaliculatus*) fished from Ulelhee Bay, Banda Aceh City, Indonesia, had an average relative weight of higher than 100 [29]. In addition, in their study in the Lambada Lhok, Aceh Besar, Yulianto et al. [30] also reported that the Wr value of the two mullets fish was 100.11 (*Liza macrolepis*) and 101.08 (*Moolgarda engeli*), respectively. The K and Wr values noted in this study indicated that the populations of *Epinephelus fasciatus, Epinephelus merra,* and *Epinephelus areolatus* harvested on the northern coast are still in good condition. A fish population is in a good state when the K value is higher than 1, while a Wr value > 100 shows a surplus of prey [23].

Abiotic (environmental conditions, water quality, seasons, etc.) and biotic (the availability of prey/feed, fish behavior and predator density, etc.) factors have been recognized as the significant factors affecting fish condition factors and growth patterns [21, 25, 28-30]. For example, environmental conditions in Ulelhee Bay, Banda Aceh had been reported to provide more favorable environment for the snapper (*Lutjanus russellii*) than the Ponyfish and spinefoot as indicated in its growth patterns [29]. The high *b* value detected in this study could indicate that the environment in the northern Aceh region still provides favorable habitat for the groupers. The northern coast of Aceh is bequeathed by a healthy coral reef environment [1, 31], and it offers food, protection, and breeding areas for the fish. Since 2018, the Government of Aceh has declared several areas of the northern Aceh region as a marine protected area (Decree No. 523/1297/2018) to prevent the reefs from further destruction. Most groupers are reef-associated fishes, and their survival depends on the coral reef ecosystem [7]. In addition, the high *b* value noted in this study could be related to their behavior. Most of the groupers are passive swimming fish [32]. Passive swimming fish typically had higher *b* value than mobile swimming fish [21]. Furthermore, in their study, Sabbir et al. [28] reported that the temperature influenced the condition factor of *Panna heterolepis* harvested from Southwestern Bangladesh. Moreover, food availability also plays a vital role in determining fish condition factors, as reported by Yulianto et al. [30] for the mullets obtained from Lambada Lhok waters in Aceh Besar, Indonesia.

However, this study also revealed an alarming finding. The sizes of the three observed species were smaller than their maximum size. Froese [32] noted that the TL of *Epinephelus areolatus*, *E. fasciatus,* and *E. merra* could reach a maximum size of 470 mm, 400 mm, and 320 mm with a typical length of 350 mm, 220 mm, and 200 mm, respectively. However, individuals obtained in this study had relatively lower TL, and W. Like other typical reef fish fisheries, the fishermen in Aceh catch all fish species with a market value, irrespective of the size. Nevertheless, harvesting small and immature fishes from the populations reduces the breeding population size [8]. Without immediate management strategies, the fisheries may collapse [33]. Several studies have shown that the grouper populations are already overfished in several Indonesian regions [8, 14, 34, 35]. The same situation is occurring globally. For example, in their study, Ketchum et al. [36], reported three grouper species (*Epinephelus coioides, Epinephelus areolatus,* and *Epinephelus bleekeri*) in the United Arab Emirates already experienced overfished. Similar conditions were also reported in grouper fisheries in the Philippines [37] dan Malaysia [38]. With no appropriate managing plan, there is a high risk that the grouper catches in Aceh will severely decrease due to overutilization.

This study has highlighted several preliminary aspects of the areolate grouper, blacktip grouper, and honeycomb grouper of the northern Aceh region, which be applied to create a practical and effective fisheries management of the species in this region. In addition, the data provided in this research could be used as baseline data for future related studies.

4. CONCLUSIONS

This study provides baseline data of TL, length-weight relationship, and condition factors of the areolate grouper (*Epinephelus areolatus*), blacktip grouper (*Epinephelus fasciatus*), and honeycomb grouper (*Epinephelus merra*) harvested in the northern coast of Aceh, Indonesia. The three observed fish had a positive allometric growth pattern. The northern coast of Aceh is still providing a healthy habitat for the species as indicated by the average Fulton's condition and the average relative weight value.

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REFERENCES

[1] Baird, A.H., Campbell, S.J., Fadli, N., Hoey, A.S., Rudi, E. (2012). The shallow water hard corals of Pulau Weh, Aceh Province, Indonesia. Aquaculture, Aquarium, Conservation & Legislation, 5(1): 23-28.

[2] Fadli, N., Muchlisin, Z.A., Pratama, F.O., Mustari, T.R., Dewiyanti, I., Purnawan, S., El-Rahimi, S.A., Sofyan, H., Affan, M., Siti-Azizah, M.N. (2019). The composition of coral reefs in Ulee Lheue breakwater, Banda Aceh, Aceh, Indonesia. IOP Conference Series: Earth and Environmental Science, 348(1): 012077. https://doi.org/10.1088/1755-1315/348/1/012077

[3] Fadli, N., Mohd Nor, S.A., Othman, A.S., Sofyan, H., Muchlisin, Z.A. (2020). DNA barcoding of commercially important reef fishes in Weh Island, Aceh, Indonesia. PeerJ, 8: e9641. https://doi.org/10.7717/peerj.9641

[4] Fadli, N., Muchlisin, Z.A., Soraya, I., Dewiyanti, I., Purnawan, S., El-Rahimi, S.A., Sofyan, H., Affan, M., Siti-Azizah, M.N. (2019). The diversity of marine macroinvertebrates in Aceh Besar waters, Aceh, Indonesia. IOP Conference Series: Earth and Environmental Science, 348(1): 012076. https://doi.org/10.1088/1755-1315/348/1/012076

[5] Irma, D., Sofyatuddin, K. (2012). Diversity of gastropods and bivalves in mangrove ecosystem rehabilitation areas in Aceh Besar and Banda Aceh districts, Indonesia. Aquaculture, Aquarium, Conservation & Legislation, 5(2): 55-59.

[6] Haridhi, H.A., Rizal, S., Nanda, M., Muhammad, Wilson, C.R. (2021). Identification of fishing ground hotspot of traditional purse seine fisher at northern waters of Aceh-A community-based data collection approach. IOP Conference Series: Earth and Environmental Science, 674(1): 012063. https://doi.org/10.1088/1755-1315/674/1/012063

[7] Craig, M.T., Sadovy de Mitcheson, Y., Heemstra, P.C. (2011). Groupers of the world: A field and market guide. Grahamstown, South Africa: NISC, 356.

[8] Fadli, N., Muchlisin, Z.A., Siti-Azizah, M.N. (2021). DNA barcoding of commercially important groupers (Epinephelidae) in Aceh, Indonesia. Fisheries Research, 234: 105796. https://doi.org/https://doi.org/10.1016/j.fishres.2020.105796

[9] IUCN. The IUCN Red List of Threatened Species. Version 2019-1. http://www.iucnredlist.org.2019.

[10] Astuti, R., Yonvitner, Kamal, M.M. (2016). Community structure of grouper fish (Serranidae) landed in Peukan Bada Subdistrict, Aceh Province. Jurnal Ilmu dan Teknologi Kelautan Tropis, 8(1): 73-84. https://doi.org/10.29244/jitkt.v8i1.12497

[11] Jefri, E., Zamani, N.P., Subhan, B., Madduppa, H.H. (2015). Molecular phylogeny inferred from mitochondrial DNA of the grouper *Epinephelus* spp. Indonesia collected from local fish market. Biodiversitas, 16(2): 254-263. https://doi.org/10.13057/biodiv/d160221

[12] Özvarol, Y., Gökoğlu, M. (2015). Length–weight relationship of *Hyporthodus haifensis* and *Mycteroperca rubra* (Pisces; Serranidae) from the North-Eastern Mediterranean Sea, Turkey. Journal of Applied Ichthyology, 31(6): 1165-1167. https://doi.org/10.1111/jai.12837

[13] Baos, R., Castellanos-Galindo, G.A., Chong-Montenegro, C., Tompkins, P., Zapata, L.A. (2016). Length–weight relationship of the Pacific goliath grouper, *Epinephelus quinquefasciatus* (Bocourt, 1868). Journal of Applied Ichthyology, 32(4): 727-728. https://doi.org/10.1111/jai.13101

[14] Bulanin, U., Masrizal, M., Muchlisin, Z.A. (2017). Length-weight relationships and condition factors of the whitespotted grouper *Epinephelus coeruleopunctatus* Bloch, 1790 in the coastal waters of Padang City, Indonesia. Aceh Journal of Animal Science, 2(1): 23-27. https://doi.org/10.13170/ajas.2.1.6570

[15] Jisr, N., Younes, G., Sukhn, C., El-Dakdouki, M.H. (2018). Length-weight relationships and relative condition factor of fish inhabiting the marine area of the Eastern Mediterranean city, Tripoli-Lebanon. The Egyptian Journal of Aquatic Research, 44(4): 299-305. https://doi.org/10.1016/j.ejar.2018.11.004

[16] Ramadhani, A., Muchlisin, Z.A., Sarong, M.A., Batubara, A.S. (2017). Hubungan panjang berat dan faktor kondisi ikan kerapu famili Serranidae yang tertangkap di Perairan Pulo Aceh Kabupaten Aceh Besar, Provinsi Aceh. DEPIK Jurnal Ilmu-Ilmu Perairan, Pesisir dan Perikanan, 6(2): 112-121. https://doi.org/10.13170/depik.6.2.7017

[17] Fadli, N., Damora, A., Muchlisin, Z.A., Dewiyanti, I., Ramadhaniaty, M., Hanif, A., Zahara, C.S., Rusdi, M., Nur, F.M., Batubara, A.S., Siti-Azizah, M.N. (2021). Some biological aspects of the golden hind grouper (*Cephalopholis aurantia*) harvested in the northern coast of Aceh, Indonesia (a preliminary study). IOP Conference Series: Earth and Environmental Science, 674(1): 012084. https://doi.org/10.1088/1755-1315/674/1/012084

[18] Fadli, N., Damora, A., Muchlisin, Z.A., Dewiyanti, I., Ramadhaniaty, M., Zhelfi, Z., Roka, N.F., Fitriani, F., Rusdi, M., Nur, F.M., Batubara, A.S., Siti-Azizah, M.N. (2021). A preliminary study on biological aspects of the orange-spotted grouper (*Epinephelus coioides*) harvested in the northern coast of Aceh, Indonesia. IOP Conference Series: Earth and Environmental Science, 674(1): 012085. https://doi.org/10.1088/1755-1315/674/1/012085

[19] Damora, A., Fadli, N., Muchlisin, Z.A., Dewiyanti, I., Batubara, A.S., Nur, F.M., Zhelfi, Z., Roka, N.F., Fitriani, F., Siti-Azizah, M.N. (2021). White-edged lyretail (*Variola albimarginata*): A preliminary study on some biological aspects. IOP Conference Series: Earth and Environmental Science, 674(1): 012091. https://doi.org/10.1088/1755-1315/674/1/012091

[20] De Robertis, A., Williams, K. (2008). Weight-length relationships in fisheries studies: the standard allometric model should be applied with caution. Transactions of the American Fisheries Society, 137(3): 707-719. https://doi.org/10.1577/t07-124.1

[21] Muchlisin, Z.A., Musman, M., Siti Azizah, M.N. (2010).

Length-weight relationships and condition factors of two threatened fishes, *Rasbora tawarensis* and *Poropuntius tawarensis*, endemic to Lake Laut Tawar, Aceh Province, Indonesia. Journal of Applied Ichthyology, 26(6): 949-53. https://doi.org/10.1111/j.1439-0426.2010.01524.x

[22] Jin, S., Yan, X., Zhang, H., Fan, W. (2015). Weight–length relationships and Fulton's condition factors of skipjack tuna (*Katsuwonus pelamis*) in the western and central Pacific Ocean. PeerJ, 3: e758. https://doi.org/10.7717/peerj.758

[23] Morton, A., Routledge, R.D. (2006). Fulton's condition factor: is it a valid measure of sea lice impact on juvenile salmon? North American Journal of Fisheries Management, 26(1): 56-62. https://doi.org/10.1577/m05-068.1

[24] Wang, L., Wu, Z., Liu, M., Liu, W., Zhao, W., Liu, H., Zhang, P., You, F. (2017). Length-weight, length-length relationships, and condition factors of black rockfish Sebastes Schlegelii Hilgendorf, 1880 in Lidao Bay, China. Thalassas: An International Journal of Marine Sciences, 33(1): 57-63. https://doi.org/10.1007/s41208-017-0021-6

[25] Blackwell, B.G., Brown, M.L., Willis, D.W. (2000). Relative weight (Wr) status and current use in fisheries assessment and management. Reviews in Fisheries Science, 8(1): 1-44. https://doi.org/10.1080/10641260091129161

[26] Rypel, A.L., Richter, T.J. (2008). Empirical percentile standard weight equation for the Blacktail Redhorse. North American Journal of Fisheries Management, 28(6): 1843-1846. https://doi.org/10.1577/m07-193.1

[27] Ndiaye, W., Diouf, K., Samba, O., Ndiaye, P., Panfili, J. (2015). The length-weight relationship and condition factor of white grouper (*Epinephelus aeneus*, Geoffroy Saint Hilaire, 1817) at the South-West Coast of Senegal, West Africa. International Journal of Advanced Research, 3(3): 145-153.

[28] Sabbir, W., Hossain, M.Y., Rahman, M.A., Hasan, M.R., Mawa, Z., Tanjin, S., Ul-Hassan, H., Ohtomi, J. (2020). First report on condition factor of *Panna heterolepis* (Trewavas, 1977) in the Bay of Bengal (Southwestern Bangladesh) in relation to eco-climatic factors. Egyptian Journal of Aquatic Biology and Fisheries, 24(2): 591-608. https://doi.org/10.21608/ejabf.2020.87095

[29] Muchlisin, Z.A., Fransiska, V., Muhammadar, A.A., Fauzi, M., Batubara, A.S. (2017). Length-weight relationships and condition factors of the three dominant species of marine fishes caught by traditional beach trawl in Ulelhee Bay, Banda Aceh City, Indonesia. Croatian Journal of Fisheries, 75(3): 104-112. https://doi.org/doi:10.1515/cjf-2017-0014

[30] Yulianto, D., Indra, I., Batubara, A., Efizon, D., Nur, F., Rizal, S., Elvyra, R., Muchlisin, Z. (2020). Length-weight relationships and condition factors of mullets *Liza macrolepis* and *Moolgarda engeli* (Pisces: Mugilidae) harvested from Lambada Lhok waters in Aceh Besar, Indonesia. F1000Research, 9: 259. https://doi.org/10.12688/f1000research.22562.2

[31] Rudi, E., Campbell, S.J., Hoey, A.S., Fadli, N., Linkie, M., Baird, A.H. (2012). The coral triangle initiative: What are we missing? A case study from Aceh. Oryx, 46(04): 482-485. https://doi.org/10.1017/S0030605312000178

[32] Froese, R. (2010). FishBase. World Wide Web electronic publication. http://www.fishbase.org.

[33] Hilborn, R., Ovando, D. (2014). Reflections on the success of traditional fisheries management. ICES Journal of Marine Science, 71(5): 1040-1046. https://doi.org/10.1093/icesjms/fsu034

[34] Muttaqin, E., Yulianto, I., Mukminin, A., Susanto, H.A., S., Campbell, S. (2013). Spear gun fishing in shallow and deeper water of coral reefs in Weh Island, Aceh, Indonesia. Galaxea, Journal of Coral Reef Studies, 15(Supplement): 277-284. https://doi.org/10.3755/galaxea.15.277

[35] Yulianto, I., Hammer, C., Wiryawan, B., Palm, H. (2015). Potential and risk of grouper (*Epinephelus* spp., Epinephelidae) stock enhancement in Indonesia. Journal of Coastal Zone Management, 18(1): 1-9. https://doi.org/10.4172/2473-3350.1000394

[36] Ketchum, R.N., Dieng, M.M., Vaughan, G.O., Burt, J.A., Idaghdour, Y. (2016). Levels of genetic diversity and taxonomic status of *Epinephelus* species in United Arab Emirates fish markets. Marine Pollution Bulletin. 105(2): 540-545. https://doi.org/10.1016/j.marpolbul.2015.11.042

[37] Alcantara, S.G., Yambot, A.V. (2016). DNA barcoding of commercially important Grouper species (Perciformes, Serranidae) in the Philippines. Mitochondrial DNA Part A, 27(6): 3837-3845. https://doi.org/10.3109/19401736.2014.958672

[38] Mat Piah, R., Abdul Kadir, N.H., Kamaruddin, A., Azaman, M.N., Ambak, M. (2018). Analysis of historical landing data to understand the status of grouper populations in Malaysia. Malaysian Applied Biology, 47(3): 49-58.