Growth patterns and condition factor of fish live in Kuala Gigieng waters of Aceh Besar as the basic for sustainable fisheries development

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Abstract. Information on the growth pattern and condition factor is crucial for fisheries management. Hence, the objectives of the present study were to determine the growth patterns and condition factor of three fish species dominated and harvested in Kuala Gigieng waters, Aceh Besar. The observation was carried out from April to May 2019, and the determination of sampling location was conducted using the random stratified sampling method, which was thought to represent Kuala Gigieng waters. There were three repetitions in each sampling location (station). Based on the results of the study, three dominant fish species harvested in the Kuala Gigieng waters were belanak (\textit{Mugil cephalus}), kerong-kerong (\textit{Terapon jarbua}), and bolo-bolo (\textit{Atherinomorus lacunosus}) as many as 48, 35, and 54 individuals, respectively. The growth pattern in all three fish species were negative allometric (b<3), which means that the increase in fish body length was faster than the fish body weight. The results also showed the correlation coefficient (r) ranged from 0.716 to 0.852. A high correlation coefficient indicated a close relationship between weight gain and length. The value of the condition factor of the three fishes based on the relative weight value (Wr) was above 100, meant that adequate food availability or low predator density and showed the condition of Kuala Gigieng waters was still in balance environmental condition. Generally, the condition of the Kuala Gigieng waters was relatively good and it could support fish growth as well.

1. Introduction
The Kuala Gigieng Waters, located in Aceh Besar District, Aceh Province, has potential fisheries sector, including marine and brackish fisheries, ponds, and river. Some economically fish that often caught by local fishermen in this area were \textit{Mugil cephalus}, \textit{Ambassis koopsii}, and \textit{Leiognathus fasciatus} [1]. Nowadays, the Kuala Gigieng Waters received a lot of impact from human activities such as fish landing port, mangrove degradation, housing, and breakwater construction. Those impacts will influence the fish’s live and water environmental conditions such as growth patterns and feeding habits. The growth pattern indicates relative growth, which means it is possible to change over the time. If there is a change in the environment and food availability, it is estimated that the value of the length-weight relationship will be changing.
The relationship between length-weight and condition factor is important to know in efforts to manage fisheries resources continuously. According to Richter [2], the study of length and weight relationships is critical because this information can explain fish growth patterns, habitat of fishes, water productivity, physiological conditions of fish, and the level of fish health in general. Furthermore, Muchlisin et al., [3] stated that length-weight relationship is one of the crucial data to evaluate the ecological relationship among aquatic organisms and fish growth patterns in the habitat as primary data to compare their condition in aquaculture system. Length-weight relationships can differ between species, between stocks of different fishing areas, and even between the sexes of the same species [4]. Meanwhile, the condition factor is a parameter used to compare the wellbeing of a species between populations, and described the physiological status of fish itself influenced by intrinsic and extrinsic factors [5,6].

Research on the fishes length-weight relationship and factor conditions in the waters of Aceh have been carried out on several species, including tufts fish (Zenarchopterus dispar) in the waters of the North coast of Aceh [7], mullet fish (Mugil cephalus) in the Estuary waters of Banda Aceh and Aceh Besar [8], three types of fish harvested in the waters of Kuala Gigieng, Aceh Besar [1], and two threatened fishes species, Rasbora tawarensis and Poropuntius tawarensis in Lake Laut Tawar, Aceh Province [3]. Therefore, the objective of the present study was to examine the growth pattern and condition factor of three dominant species harvested from Kuala Gigieng, Aceh Besar District, Indonesia.

2. Materials and Methods

2.1. Study area

This research was conducted from April to July 2019 in Kuala Gigeng waters, Aceh Besar, Aceh Province, while the sample analysis was carried out in the Marine Biology Laboratory, Faculty of Marine and Fisheries, Universitas Syiah Kuala. Determination of site was carried out by a stratified random sampling method where the location selected by several characteristic from specific areas assessed according to the objectives or research problems [9]. Data collection was conducted in five stations considered to represent the waters of Kuala Gigieng (Figure 1), and at each station, there are three repetitions. Determination of 1st station was taken at the entrance of the seawater to Kuala Gigieng, 2nd station was near the sand quarry, 3rd station was at the body of the estuary from Kuala Gigieng waters, 4th station was the area where mangroves live and the 5th station was taken at the back of the community settlement.

2.2. Data collection procedure

Fish sampling was carried out with 4 m high gill nets, 200 m long nets with 5/8 to 4.5 inches mesh. The net was installed in the morning before high tide and then was taken at low tide, and it was checked periodically. Fish samples obtained were grouped according to the catching area, sexes (male-female), and fish species, then the fish samples were inserted into a styrofoam. Furthermore, fish samples were analyzed in the Marine Biology Laboratory of the Marine and Fisheries Faculty, Syiah Kuala University. Measurement of the length and weight of fish was done on the same day, and directly after the fish was harvested. In measuring the total length of the fish were measured from the front end of the head to the tip of the rear tail fin using a caliper. The body weight of the fish was measured as a whole by calculating the total weight of the fish using a digital scale of 0.01 g accuracy.
2.3. Data analysis

2.3.1. Length weight data. The Linear Allometric Model (LAM) was used to calculate parameters $a$ and $b$ through the measurement of changes in weight and length. The bias correction on the change in mean weight of the logarithmic unit was used to predict the weight of the length parameter according to the following allometric equation [10].

$$W = e^{0.56(aL^b)} \tag{1}$$

Where, $W$ is total body weight (g), $L$ is a total length (mm), $a$ is an intercept regression, $b$ is the regression coefficient, $e$ is a residual variant of the regression, $0.56 = $ correction factor.

Based on the $b$ value of the regression coefficient, the growth rate of the fish was divided into three categories, namely; allometric positive when the $b$ value > 3.0, allometric negative when the $b$ value > 3.0, and isometric when the $b$ value = 3.0.

2.3.2. Condition factor. The condition factors analyzed in this study include the Fulton condition factor ($K$) and the relative weight condition factor ($W_r$). The relative weight condition factor ($W_r$) refers to [11].

$$W_r = \left( \frac{W}{W_s} \right) \times 100 \tag{2}$$

Where: $W_r$ is a factor of relative weight conditions, $W$ is the weight of fish (g), $W_s$ is the standard weight (g) is the standard weight predicted from the same sample because it is calculated from the combined length-weight regression through distances between species.

$$W_s = aL^b \tag{3}$$

Furthermore, the Fulton ($K$) condition factor analysis was analyzed, referring to [12].
\[ K = WL^{-3} \times 100 \]  

Where: \( K \) is a Fulton condition factor, \( W \) is the weight of fish (g), \( L \) is the total length of fish (mm), -3 is a correction factor for the length coefficient leading to number one.

3. Results and discussion

3.1. Growth pattern

Based on the results, there were three dominant fishes species caught in the waters of Kuala Gigieng, namely bolo-bolo fish (\textit{Atherinomorus lacunosus}), belanak fish (\textit{Mugil cephalus}), and kerong-kerong fish (\textit{Terapon jarbua}) as many as 54, 48 and 35 individuals, respectively. The total length of \textit{A. lacunosus} was ranged from 56.3 mm to 71.3 mm, and weight was ranged from 5 g to 8 g. The total length of \textit{M. cephalus} was ranged from 74.5 mm to 190 mm, and weight was ranged from 11 g to 66 g. The total length of \textit{T. jarbua} was ranged from 37.3 mm to 128.7 mm, and weight was ranged from 3 g to 30 g (Table 1). This is different from Mulfizar et al. [1], which mentions the dominant fish in Kuala Gigieng waters were belanak fish (\textit{M. cephalus}), petek fish (\textit{Leiognathus fasciatus}) and seriding fish (\textit{Ambasis koopsii}). The amount of fish was decreasing if compared with the result found by Mulfizar et al. [1], which was \textit{M. cephalus} as many as 98 individuals. It is assumed that there were any changing environmental conditions because of human activities around the area. Mullet fish (\textit{M. cephalus}) found at all repetition points, and this indicated that mullet fish is one of the inhabitants of the mangrove ecosystem. This is consistent with the results found by Puteri et al., [13], Redjeki [14] Ezekiel [15], which states that the Mungilidae family has the most extensive distribution of compositions in estuarine areas, including mangroves. Mungilidae family lives in a wide range of salinity because it can live in freshwater, brackish water, and the sea. Belanak fish (\textit{M. cephalus}) are generally small, has torpedo body shape, and suitable for foraging in surface water areas. The shape of the forked tail can support the movement of fish against currents [16].

\[ B = \frac{W}{L^b} \]  

Where: \( B \) is the weight-length relationship obtained, \( W \) is the weight of fish, \( L \) is the total length of fish, and \( b \) is the exponent growth pattern. The exponent value \( b \) can be obtained by each fish by environmental factors, which are supported by food, geographical location, and sampling techniques as well as the time is taken. Fish in the floodplains are more abundant in the rainy season and increase fish growth [18]. In general, the value of \( b \) depends on biological information related to food and gonad development. Muchlisin [3], stated that the low \( b \) value can be resulted from the behavior of fish; for example, inactive swimming fish shows a lower amount of \( b \) than active fish. Okgerman [12], also mentioned that \( b \) value can be determined by differences in the number and variations of fish considered.

Figure 2 shows the correlation between the length and weight of three fishes species harvested in Kuala Gigieng Waters. The results showed that the correlation coefficient (\( r \)) was ranged from 0.716 to 0.852. High correlation coefficient values indicate a close relationship between weight and length. The determination coefficient value (\( R^2 \)) was ranged from 0.513 to 0.727 which means that 51% to 72% of the total shows a close relationship between these variants, each found in bolo-bolo fish (\textit{A. lacunosus}), and belanak fish (\textit{M. cephalus}) respectively. If the \( R^2 \) value is close to 1, then the total length of the fish will increase as the bodyweight of the fish increases [19]. Correlation coefficient values indicated that each additional weight of fish will be accompanied by additional length each time of observation [20].
The results of the regression analysis and weight length relationship in Figure 2 (a) 1 have a regression equation $y = 2.067x - 6.622$ with the coefficient of determination is $R^2 = 0.727$. This means that 73% of fish body weight gain occurred due to fish body length increase, while 27% of fish body weight gain was caused by other factors such as environmental and age factors. It shows that the total length of the fish body is a hefty total mullet fish ($Mugil cephalus$). The graph of analysis results (Figure 2) growth pattern of mullet fish ($Mugil cephalus$) has a similar growth pattern between the results of observations and prediction results.

In comparing prediction growth versus observation growth, both showed a similar trend (Figure 3). It was indicated that $Atherinomorus lacunosus$, $Mugil cephalus$, $Terapon jarbua$ in Kuala Gigieng waters is growing well.

**Figure 2.** Correlation between length and weight of (a) $Atherinomorus lacunosus$ (b) $Mugil cephalus$, and (c) $Terapon jarbua$ from Kuala Gigieng waters.
Figure 3. Comparing prediction growth and observation growth of (a) Atherinomorus lacunosus (b) Mugil cephalus, and (c) Terapon jarbua in Kuala Gigieng waters.

Table 1. Length, weight, growth pattern and condition factor of Atherinomorus lacunosus, Mugil cephalus, and Terapon jarbua in Kuala Gigieng waters.

| No. | Variables                  | Bolo-bolo fish (Atherinomorus lacunosus) (n=54) | Belanak fish (Mugil cephalus) (n=48) | Kerong-kerong fish (Terapon jarbua) (n=35) |
|-----|----------------------------|-----------------------------------------------|-------------------------------------|--------------------------------------------|
| 1   | Total length (TL) (mm)     | 56.3-71.3                                     | 74.5 – 190                          | 37.3-128.7                                 |
| 2   | Weight (W) (g)             | 5 – 8                                         | 11 – 66                             | 3 – 30                                     |
| 3   | Body weight prediction (Wr) | 76.52 - 118.34                                | 64.09-185.94                        | 23.38- 138.13                              |
| 4   | Fulton condition factor (K) | 2.51 - 2.87                                   | 2.59- 3.65                         | 2.32- 3.54                                 |
| 5   | Determination coefficient (R²) | 0.51                                        | 0.73                                | 0.6                                        |
| 6   | Correlation coefficient (r) | 0.72                                          | 0.85                                | 0.77                                       |
| 7   | b Value                    | 1.85                                          | 2.067                               | 1.126                                      |
| 8   | Regression equation        | y = 1.850x - 5.837                            | y = 2.067x - 6.622                  | y = 1.126x - 2.396                         |
| 9   | Growth pattern             | Negative allometric                          | Negative allometric                | Negative allometric                        |

3.2. Condition factor
Condition factor of *A. lacunosus*, *M. cephalus*, and *T. jarbua* were ranged from 2.51- 2.87, 2.59- 3.65, and 2.32- 3.54, respectively. The value of body relative weight condition (Wr) of three species harvested in the location were 100.51 (*A. lacunosus*), 104.31 (*M. cephalus*), and 103.03 (*T. jarbua*). The value of relative weight (Wr) was above 100, indicated the excess availability of prey or low density of a predator. It showed that Kuala Gigeng waters provide sufficient food or low predator density. This is consistent with Effendi's [21] statement that estuary waters have a varying salinity gradient, depending on freshwater supply from the river and seawater through the tidal condition.

Besides the availability of feed or predators, biotic, abiotic, and management factors, fisheries can also influence a variety of condition factors [22,23]. Variations in feed supply that occur between seasons can change factors in seasonal conditions [24]. If the relative weight value (Wr) is below 100 parts an individual or population indicate problems such as low availability of prey or high density of a predator [25]. The factor values for the three types of fish studied were not significantly different. However, fish that have higher condition factor values are expected to have higher fecundity than fish that have lower condition factor values. Moreover, it is in accordance with the statement of Sulistiyarto [18], who stated that mullet fish belongs to a group of fish that has a reasonably high fecundity that these fish are capable to maintain its population in nature. Condition factors were calculated to assess the health of fish in general, productivity, and physiological conditions of fish populations [2,23]. These condition factors reflect the morphological characteristics of the body, lipid content, and growth rate [11,26,27].

4. Conclusion

Three dominant fishes species harvested in Kuala Gigieng waters were mullet fish (*M. cephalus*), kerong kerong fish (*T. jarbua*), and bolo-bolo fish (*A. lacunosus*). The length-weight relationship of those fishes showed negative allometric growth patterns based on the value of b (b<3). The condition factor value of the three types of fish, based on the relative weight (Wr), was above 100 indicated the availability of sufficient food or low predator density. The value of the Fulton condition factor (K) was not significantly different, and the value showed the conditions of the waters was relatively good and supported the growth of the three dominant fish species in the Kuala Gigieng waters.

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