The abundance and diversity of benthic community in Krueng Cut estuary, Banda Aceh, Indonesia

Muhammad IRHAM1,2*, Muhammad IHSAN1, Chitra OKTAVINA1, Sugianto SUGIANTO3, Firman M. NUR1 and Agung Setia BATUBARA1

1. Faculty of Marine and Fisheries, Syiah Kuala University, Banda Aceh 23111, Indonesia.
2. Center for Marine and Fisheries Study, Syiah Kuala University, Banda Aceh 23111, Indonesia.
3. Doctoral Program in Mathematics and Sciences Application (DMAS), Graduate Program, Syiah Kuala University, Banda Aceh 23111, Indonesia.

* Corresponding author, M. Irham, E-mail: irham@unsyiah.ac.id

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Abstract. Benthos are sensitive organism to water pollution, they can be used as a bioindicator to determine the health status of an estuarine ecosystem. Therefore, the purpose of the study is to identify the abundance and diversity of benthic community in Krueng Cut estuary in Indonesia. The study used purposive sampling method by applying seven station sampling along the study area. The sampling was done in three places within one station that were in the left bank, center of the channel, and right bank. Benthos samples were taken using Ponal Grab, whose size is 23cm x 23cm with ± 20 kg weight and sieved from the substrate using a mesh filter of 0.1 mm in size. The result showed that Krueng Cut estuary has 347 ind/m² density index from 7 benthos species. It was found that the most abundance of benthos is Balanus sp., while the least are Nacula nucleus, Olivella volutella, and Uca sp. This result informs that the diversity index is categorized as low and on the other hand the dominance index level is high.

Key words: abundance, diversity, dominance, estuary ecosystem, Krueng Cut.

Introduction

Krueng Cut estuarial area is located in the village of Alue Naga, Banda Aceh. The estuary is one of the multifunctional waters around Banda Aceh city, which becomes a slippway of small fishing boats and economic resources of its community looking for oysters and crabs (Maldini et al. 2017, Kasmini et al. 2019). In addition to functioning economically for the surrounding community, the bed of the water (substrate) in this area is also a place of living organism that serves to decompose organic compounds namely benthos. Benthos also serve to accelerate the process of decomposition and mineralization of organic materials entering the waters (Sarong et al. 2015).

According to their size, benthos are divided into zoo-benthos whose size is between 0.1 to 1.0 mm and macrobenthos that is larger than 3 mm (Blackwell 2013). Macrobentos (benthic macroinvertebrate), according to Colen et al. (2013), is an indicator of the quality of an aquatic environment. These faunas live in sediments having direct contact with the ground (Burd et al. 2014) and expose to water by entering the pores of the sediment (Burd et al. 2013). When the sediment is polluted because of water contamination that lasts in the long run, these types of benthos will be disrupted and unable to adapt (Baron et al. 2014). Furthermore, zoo-benthos is also best used as a bioindicator in waters because of its relatively fixed habitat of life. The change in water quality, abundance, and diversity is highly depended on the level of these organisms sensitivity and tolerancy to the environment conditions (Urbanic 2012), which vary across the species.

Data on benthic abundance and diversity in the estuary of Krueng Cut is very limited and research has not been conducted yet. Therefore, a study of the macrozoobenthic community structures is necessary. In addition, the results of the study can be used as information for the management of water quality in the area because benthos has a function as a bio-indicator of water quality (Mathers et al. 2014) and becomes a nutrient decomposer on the substrate (Urbanic 2012). According to Pavlin et al. (2011), as an organism that has a relatively fixed habitat of life, changes in water quality and substrate affect the benthic community composition and its abundance (Huettel et al. 2014). Therefore, the assessment of macrozoobenthos composition can give an overview in looking at the quality of the waters. Thus, the purpose of this research is to know the level of abundance and diversity of Benthos communities located in the waters of Krueng Cut of Alue Naga village, Syiah Kuala Sub District, Banda Aceh in Indonesia. The results of this study can provide information about the abundance and diversity of Benthos communities in the estuarine waters.

Benthos are organisms that inhabit the bottom of waters and live in bed sediments (infauna) as well as the surface of bed sediments (epifauna) (Counihan et al. 2014). In general, benthos are divided into three groups namely macrobenthos (Xie et al. 2016) whose size is 1 mm, meiobenthos (Sinh et al. 2014) whose size is between 0.1 - 1.0 mm, and microbenthos (Rubino et al. 2015) whose size is smaller than 0.1 mm. Benthos are animals that spend a part or all of their life cycle at the bottom of the water body moving by crawling and digging holes. Some of these animals have important roles in the ecosystem such as in the process of decomposition (Quillien et al. 2015) and mineralization of organic materials (Bletter et al. 2014) and occupy some trophic levels in the food chain (Riisgard & Larsen 2017).
process of the animal physiology particularly metabolism, the reproductive cycle, and the solubility of oxygen required by animals for the respiration process (Holtappels et al. 2013). Water temperature also affects the existence of benthos physiologically and ecologically (Mathers et al. 2014). Physiologically, the water temperature differences affect greatly the productiveness, length of life, and the size of adult macrozoobenthos (Rolet et al. 2015). Ecologically, temperature changes cause differences in the composition and abundance of macrozoobenthos (Signa et al. 2015). Meanwhile, dissolved oxygen (DO) is a gas for respiration, which is often a limiting factor in the aquatic environment (Holtappels et al. 2013). In terms of ecosystem, dissolved oxygen levels determine the rate of metabolism and respiration (Hume et al. 2011) and are essential for the survival and growth of aquatic organisms (Rubino et al. 2015). Meanwhile, dissolved oxygen (DO) is a gas for respiration, which is often a limiting factor in the aquatic environment (Holtappels et al. 2013). In terms of ecosystem, dissolved oxygen levels determine the rate of metabolism and respiration (Hume et al. 2011) and are essential for the survival and growth of aquatic organisms (Rubino et al. 2015). Holtappels et al. (2013) stated that the relationship between DO and temperature is very significant. If the water temperature increase then the DO will decrease.

Salinity is another limiting factor in the spread of macrozoobenthos in waters (Berg et al. 2013). Species of holoplankton and meroplankton at certain stages of their life cycle have different ways of adapting to salinity changes (Mathers et al. 2014). The distribution of salinity at sea and estuarial areas are influenced by various factors such as patterns of water circulation, evaporation, rainfall, and river flow (Irham & Setiawan 2017).

The aquatic substrates are the habitats of plants and animals that live on the bottom of the waters (Bletter et al. 2014). The type of substrate determines the density and composition of benthos (Ford et al. 2017). The substrate type is related to the oxygen content and the availability of nutrients in the sediment (Clare 2016). In sandy substrates, the oxygen content is relatively higher compared to the muddy substrates because there are air pores that allow more intensive mixing with water on it (Huettel et al. 2014). However, the nutrients in sandy substrates are not much (Clare 2016). In contrast to sandy substrates, a muddy sediment is lack of oxygen but the available nutrients are considerably higher (Colen 2014).

Materials and methods

The research was conducted in Krueng Cut waters of Alue Naga village, Syiah Kuala sub-district, Banda Aceh (Figure 1) from March to April 2017. Meanwhile, for benthos identification, it was observed in the Biology Laboratory of Faculty of Marine and Fisheries of Syiah Kuala University. The method used in this research was field sampling method and then the samplings were identified and analyzed in the laboratory. To represent the study area, the purposive sampling method was used to conduct the work.

Field sampling implementation

The sampling was conducted in 7 stations and each station had three points for the sample to be collected, which were on the left, center, and right (distance of 50 m) of the water channel. Samples were taken by using Ponar Grab whose size is 23cm x 23cm with ± 20 kg weight. The samples were then sieved from the substrate using a mesh filter of 0.1 mm size. The sieve results, benthos organisms, were placed in the plastic of sample, which contained 70% of alcohol for preservation. The samples that had been collected were taken to the laboratory to be then identified and analyzed by using identification books.

Data analysis

Benthos density: Density is the amount obtained by calculating the number of individuals that are divided by the area as shown in the following formula:

\[
D_i = \frac{N_i}{A}
\]

where: \( D_i \) is the density of macrozoobenthos (idm/m²), \( N_i \) is the number of individual (idm), \( A \) is the area (m²).

Benthos diversity: Diversity index (H') describes the condition of benthos populations mathematically in order to make it easier to analyze the information of individual number of each species in a community. To calculate the diversity, the equation of Shannon -
The abundance and diversity of benthic community

The abundance and diversity of benthic community. The dominance of organism within a community. The value shows the dominance index obtained from the research station is presented in Table 2. The dominance of species of Balanus sp. with a density index of 59%. The highest abundance of Balanus sp. is caused by its living habits in which their shells are directly attached to the boulders at the bottom of the substrate. The species of Balanus sp. lives in intertidal waters in tropical regions (Clare 2016). This is consistent with those found in the research stations where Balanus sp. was found attached to the boulders of rocks and the station is also located at intertidal area. According to Bletter et al. (2014) Balanus sp. has a habit of living by sticking itself to floating objects such as plastic wastes and broken rods. At station 4, the highest abundance of species of Balanus sp. was found. This is because of many chunks of rocks and rods existence in that area. Thus, it can be said that

### Table 1. Number of individual benthos organism (Ni = ind) and its density (Di = ind/m²) in Krueng Cut estuary.

<table>
<thead>
<tr>
<th>Species/Family</th>
<th>St.1 Ni</th>
<th>St.2 Ni</th>
<th>St.3 Ni</th>
<th>St.4 Ni</th>
<th>St.5 Ni</th>
<th>St.6 Ni</th>
<th>St.7 Ni</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anadara grunosa</td>
<td>0.3</td>
<td>5.8</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>5.8</td>
</tr>
<tr>
<td>Balanus sp.</td>
<td>0.7</td>
<td>13.4</td>
<td>0.3</td>
<td>5.8</td>
<td>0.4</td>
<td>7.7</td>
<td>1.2</td>
<td>23.1</td>
</tr>
<tr>
<td>Mactra dissimilis</td>
<td>-</td>
<td>-</td>
<td>0.1</td>
<td>1.9</td>
<td>-</td>
<td>0.1</td>
<td>1.9</td>
<td>6.7</td>
</tr>
<tr>
<td>Nucula nucleus</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.1</td>
<td>1.9</td>
<td>-</td>
</tr>
<tr>
<td>Olivella volutella</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.1</td>
<td>1.9</td>
<td>-</td>
</tr>
<tr>
<td>Rissoina celtata</td>
<td>0.2</td>
<td>3.8</td>
<td>-</td>
<td>0.1</td>
<td>1.9</td>
<td>-</td>
<td>-</td>
<td>5.8</td>
</tr>
<tr>
<td>Uca sp.</td>
<td>0.1</td>
<td>1.9</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>5.8</td>
</tr>
<tr>
<td>Total</td>
<td>1.3</td>
<td>25.0</td>
<td>0.4</td>
<td>7.7</td>
<td>0.5</td>
<td>9.6</td>
<td>1.4</td>
<td>26.9</td>
</tr>
</tbody>
</table>

Weiner was applied using the formulation as follows:

\[ H' = - \sum_{i=1}^{n} p_i \log_2 p_i \]

where: \( H' \) is Shannon-Wiener diversity index, \( p_i \) is Number of individual \( i \) divided by total number of individuals, \( \log_2 \) is 3.3219.

**Benthos dominance:** Dominance index is calculated by the formula of Dominanze of Simpson.

\[ C = \sum (n_i/N)^2 \]

where: \( C \) is Index of dominance, \( n_i \) is Number of individuals of each type, \( N \) is Total number of individuals.

### Results

Results of the study shows that there are 7 individuals of benthos found which spreading in all the 7 stations of observation with the total abundance of 694 ind/m². The density ranges of individual benthos are 13 - 186 ind/m² out of 7 stations, where the lowest density is located at station 5 and the highest is at station 4. The percentage of benthos abundance at each research station is shown in Figure 2 and Table 1.

The results of density level in Krueng Cut estuary is shown in Table 2. Based on the results, the index of diversity in the Krueng Cut falls to the low density category ranging from 0 to 1.67 (Figure 3). The results show that 7 species of benthos are distributed in 7 stations of observation with a total dominance of 694 ind/m². Benthos dominance at each research station is presented in Table 2. According to the profile above, the dominance index obtained from the research varies from 0.57 to 1.00 (Figure 3). The value shows the indication of dominance of organism within a community. The dominance in the highest category is found in Station 5 with the species of Olivella volutella and Station 6 with the species of Mactra dissimilis.

### Discussion

The result shows that the highest number of benthos species is Balanus sp. with a density index of 59%. The highest abundance of Balanus sp. is caused by its living habits in which their shells are directly attached to the boulders at the bottom of the substrate. The species of Balanus sp. lives in intertidal waters in tropical regions (Clare 2016). This is consistent with those found in the research stations where Balanus sp. was found attached to the boulders of rocks and the station is also located at intertidal area. According to Bletter et al. (2014) Balanus sp. has a habit of living by sticking itself to floating objects such as plastic wastes and broken rods. At station 4, the highest abundance of species of Balanus sp. was found. This is because of many chunks of rocks and rods existence in that area. Thus, it can be said that...
the rocks and rods are used by Balanus sp. to live and stick on. The lowest density of benthos is Nucula nucleus, Olivella volutella, and Uca sp. with a density index of 13 ind/m². This is allegedly due to the disruption of the habitats of the three species caused by the construction process of the Lamnyong Bridge and the absence of trees or mangroves where the species to live in. The low density of Uca sp. could be caused by the environment of the study area. Uca sp. has a living habit in the substrate holes Rubino et al. (2015). Uca sp. digs holes in the substrate and eats the foliage of mangrove to survive. However, due to many chunks of rocks and rods from the construction, the living substrate used by Uca sp. has decreased.

Based on the results, the index of diversity in the Krueng Cut falls to the low density category ranging from 0 to 1.67 (Figure 3). The main factors that affect the low diversity is environmental (Burd et al. 2013), which greatly affect the level of diversity in the area. At the time of the study, the study area was slightly polluted due to the construction carried out in the Krueng Cut area which make the area less suitable for benthos habitat. Another factor that influence a lot is the study area that is barren with no mangrove trees that is the major factor of low benthos diversity in the area.

The low level of benthos diversity in this area suggests the ecosystem of Krueng Cut. Counihan et al. (2014) states that the higher index of diversity in an ecosystem will create higher stability and balance of ecosystem. In addition, the lower diversity of an ecosystem indicates that the ecosystem is increasingly depressed or the quality of environment is degraded (Hume 2011). The high value of the diversity index is influenced by the substrate, temperature, salinity, acidity, and dissolved oxygen (DO) (Holtappels et al. 2014). Benthos organisms, especially macrozoobenthos, have a range of tolerances to be able to live well in certain aquatic place where the physical and chemical factors of the area are suitable for them to survive.

The dominance index obtained from the research varies from 0.37 to 1.00 (Figure 3). The dominance in the highest category is found in Station 5 with the species of Olivella volutella and Station 6 with the species of Mactra dissimilis. Environmental conditions with muddy-sand correspond to the habitats required by both species. Rizkya et al. (2012) classified that these species fall into suspension-feeding group, excavator and deposit eaters. Hence, the numbers tend to cluster in the soft mud sediments. Another cause of high dominance of these species within a community is the low value of species diversity in the area. Dominance is inversely proportional to the diversity of a species, where the more diverse species found in a region, the lower the dominance of a species will be. The high dominance according to Nirmalasari (2011) can lead to a high competition between species and result in inability to adapt.

The highest density of benthos living in Krueng Cut estuarial area is Balanus sp. with its density index of 206.7 ind/m². Meanwhile, the lowest abundance is the Nucula nucleus, Olivella volutella, and Uca sp. with their abundance index of 6.7 ind/m². The diversity index based on field observations varies from 0.0 to 1.67, which are categorized as low index. The main factors that affect the diversity is environmental factors and lack of mangrove forest. Furthermore, the dominance index obtained from the present results varies between 0.37 and 1.00 means that the area has low level of benthos density due to lack of stable environment.

References