Macrobenthos community structure in coral reef ecosystem around Pramuka Island, Jakarta

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Abstract. Macrobenthos are organisms that live crawling, sessile, and digging holes in substrates such as sand, silt, rock, coral fragments, or dead coral. Benthos have low mobility, easy to catch, have a long life, and sensitive to some pollutants so that it can mean that benthic community structure can be used as a parameter of condition the current ecosystem of a particular area and also as information about wealth contained in the aquatic area. The study was conducted on 6-14 September 2018 in the Pramuka Island area, Kepulauan Seribu district, Indonesia. The collection of ecological data was carried out at seven different observation stations. Along with the rapid development of facilities on this island, there are threats both directly and indirectly to the preservation of the coral reef ecosystem around the Pramuka Island. The method used in collecting macrobenthos data is the Belt Transect method and collecting diversity index, evenness index, dominance index, and density. During the observation at the seven observation stations, 94 species of the seven macrobenthos phylum with the highest phylum were found, namely the Chordata phylum. The species most commonly found is Atriolum robustum. Diversity Index at each station is in shallow depth and in the medium category. The evenness value obtained indicates a stable community condition. The highest index of dominance occurred at Pramuka Island Dock. Macrobenthos conditions from seven observation stations on Pramuka Island and its surroundings are still relatively good.

1. Introduction

Pramuka Island is one of the small islands in the Kepulauan Seribu district, Indonesia. Island with an area of 16.54 hectares is designated as the capital of the Kepulauan Seribu district. Along with the establishment, many facilities were built to support its function as the capital. The development can be seen from the construction of ports, regional public hospitals and the development of tourism facilities such as hotels and game rides [1]. Along with the rapid development of facilities on this island, there are threats both directly and indirectly to the preservation of the coral reef ecosystem around the Pramuka Island. Macrobenthos are organisms that live crawling, sessile, and digging holes in...
substrates such as sand, silt, rock, coral fragments, or dead coral [2]. Macrobenthos have low mobility, easy to catch, have a long life, and sensitive to some pollutants so that it can mean that benthic community structure can be used as a parameter of condition the current ecosystem of a particular area and also as information about wealth contained in the aquatic area [3]. Polluted waters will affect survival macrobenthos because macrobenthos is an aquatic organism that is easily affected by the presence of pollutants, both physical and chemical pollutants. Characteristics of the macrobenthos settled at the bottom and its slow movements, making macrobenthos have a good ability to respond to water quality continuously [4]. Therefore, macrobenthos can be used as a condition parameter for the waters of the coral reef ecosystem.

2. Methodology

2.1. Time and Location
The study was conducted on 6-14 September 2018 in the Pramuka Island area, Kepulauan Seribu district, DKI Jakarta province, Indonesia. The collection of ecological data was carried out at seven different observation stations that are West Panggang Island, West Pramuka Island, Pramuka Island Dock, South Air Island, South Panggang Island, North Pramuka Island, and North Sekati Island (Figure 1).

![Figure 1. Location map of seven observation stations on Pramuka Island and surroundings.](image-url)

2.2. Method
The method used in collecting macrobenthos data is the Belt Transect method [5]. This method is done by stretching transect along 20 m with three replications and a 5 m pause on each repetition. Data is collected by zig-zag by sweeping 1 m to the right and left. The data taken are species, number,
size for macrobenthos that are classified as economically important. Data is collected at two depths of 3 meters (shallow) and 10 meters (deep) in a direction parallel to the coastline. The tools used in the collection and analysis of macrobenthos data are SCUBA sets, slates, mechanical pencils, sewing meters, roll meters, water-resist paper, and underwater cameras, Tropical Pacific Invertebrate identification books, and Microsoft Excel applications.

2.3. Data Analysis

2.3.1. Diversity Index ($H'$). The Diversity Index ($H'$) describes the nature of a community which shows the diversity of the community, the evenness of individual abundance and the stability of the ecosystem [6].

$$H' = -\sum_{i=1}^{n} (p_i)(\log_2 p_i)$$

Information:

$H'$ = diversity index
$p_i$ = proportion of individual i-th species per total number of individuals
$i$ = 1, 2, 3, ...., n (ni / N)

Diversity Index value ($H'$):

$H' < 1$ = low species diversity
$1 \leq H' \leq 3$ = medium species diversity
$H' > 3$ = high species diversity

2.3.2. Evenness Index ($E$). Evenness Index is the composition of the number of individuals in each genus contained in the community. Evenness is obtained by comparing the diversity index with its maximum value [6]

$$E = \frac{H'}{H'_{max}}$$

Information:

$E$ = evenness index
$H'$ = diversity index
$H'_{max}$ = maximum diversity index

Evenness Index value (E):

$E < 0.4$ = low population evenness
$0.4 \leq E \leq 0.6$ = medium population evenness
$E > 0.6$ = high population evenness

2.3.3 Dominance Index ($C$). Dominance index is used to obtain information about the species that dominate in a community in each habitat [6].

$$C = \sum_{i=1}^{s} \left(\frac{ni}{N}\right)^2 = \sum_{i=1}^{s} p_i^2$$

Information:

$C$ = index of dominance
$ni$ = number of i individual types
$N$ = number of individuals of all species
The Dominance Index value approaches one (1) if the community is dominated by certain species and close to zero (0) then no species dominates [6].

2.3.4. Density (D). Macrobenthos density is calculated based on the number of individuals per area (ind / m²) [6].

\[ D = \frac{n_i}{A} \]

Information:
- \( D \) = density
- \( N_i \) = number of i individual types
- \( A \) = area of data collection

3. Result and discussion

3.1. Density of macrobenthos species in shallow and deep depth

Based on observations, obtained ten species with the highest species density taken from seven different stations (Figure 2 & 3). At shallow depths, the ten species with the highest density are *Atriolum robustum*, *Bispira* sp., *Comanthus wahlbergi*, *Ophiothrix nereidina*, *Pedum spondyloideum*, *Didemnum molle*, *Didemnum mosleyi*, *Diplosoma virens*, *Petrosia* sp., and *Mitra papalis*. Species with the highest density is *Atriolum robustum* with an average value of 24.9167 Ind/40m² and error value of ± 5.8742, while species with the lowest density namely *Mitra papalis* with an average value of 2,333 Ind/40m² and an error value of ± 2.3333.

At deeper depth, there were ten species with the highest density are *Comanthus parvicirrus*, *Atriolum robustum*, *Lytocarpus phoeniceus*, *Rhopalaea circula*, *Bispira* sp., *Pedum Spondyloideum*, *Comanthus wahlbergii*, *Aaptos suberitoides*, *Comaster schlegelii*, and *Didemnum molle*. The species with the highest density, *Comanthus parvicirrus*, has an average value of 9.8778 Ind / 40m² and an error value of ± 2.4267. The species with the lowest density, *Didemnum molle*, has an average value of 5.3333 Ind/40 m² and error value ± 1.6777.

*Atriolum robustum* belongs to the Chordata subphylum Class Asciidiacea which has a body shape such as small pockets and generally lives in ocean waters. The bodies are covered by the mantle (tunic) formed from protein compounds and polysaccharides that are of a nature filter feeder that will take the food needed [7]. *Atriolum robustum* is the highest species density of all observation stations at shallow depth and deep. The number of coral fractures (rubble) is a factor in this species abundant, in conditions of waters that are relatively protected from organic materials and high sedimentation. Therefore, ascidians are often used as indicators waters [8].

Figure 2. Species density in shallow depth.
Figure 3. Species density in deeper depth.

*Bispira* sp. is one of the species of phylum Annelida that has the second-highest composition of all observation stations. This species often known as fan worms this is a sessile organism that is only found in saltwater and hermatypic coral tropical and subtropical waters that are considered as ornamental on the coral reef ecosystem for diving lovers.

The species that has the third-highest density is *Comanthus wahlbergii*, this species of Echinoderms phylum is one of the most important animals in the marine ecosystem and it is useful as one component of the food chain [9]. This species, known as the sea lily, has various colors. More sea lilies are found in deeper depths, this in accordance with Aziz (1994) statement which states that salinity very affects the life of sea lilies. This species avoids estuarine waters and the coral reef flat zone to avoid extreme changes in salinity, therefore more sea lilies are found on the slopes of coral reefs.

3.2. Composition of the macrobenthos phylum

Based on phylum composition diagrams, at deep depths (Figure 4) phylum composition with the highest percentage is Chordata with a percentage of 28.56% and at shallow depth (Figure 5), the phylum composition with the lowest percentage is Platyhelminthes with a percentage of 0.63%. While at shallow depths, the composition of phylum with the highest percentage is the percentage of chordates with 38.16% and at shallow depths phylum composition with the lowest percentage is flatworm with a percentage of 0.35%.

The highest phylum in both deep and shallow depth is the Chordata. Fifteen species of Chordata phylum are found from this observation with a total of 956 individuals. Chordata phylum belongs to subphylum Tunicate, class Asciida. Tunicates are aquatic invertebrates that have body shapes such as pockets, mantle, transparent, thick, has a notochord and generally silent (not moving) or sticky life (sessile) [10]. These animals are often found in aquatic habitats that are protected from contamination of organic materials [11]. However, some of these animals are also found to abundantly colonize in extreme aquatic environments. This is suspected because this animal could survive in environmental changes such as temperature fluctuations, salinity, organic pollution, and an organic, seawater acidification, and predation despite these animals produce secondary metabolite that produced from the outer layers of cellulose and bacteria symbiotic that live inside the Ascidian tunic, so that these animals can defend themselves against environmental changes [12]. The existence of coral reefs substrate condition also influences the existence of Ascidians in accordance with the statement of Edgar et al. [13] that Ascidians are found in living and dead coral reef, sand, silt substrate, coral fragments, mollusk shells, and ship hulls. Pramuka Island and its surrounding island have a moderate
category of coral reef composition with substrate condition cover in the form of sand substrate, coral fragments, and dead coral.

**Figure 4.** Macrobenthos phylum composition at deep depth.

**Figure 5.** Macrobenthos phylum composition at shallow depth.
The lowest phylum based on observations in both deep and shallow depth is the Platyhelminthes phylum. Platyhelminthes found as many as 4 types of species with a total of 14 individuals. Flatworms have a small size, beautiful color and pattern diverse, soft bodies, flat in the ventral-dorsal region, and hermaphrodite [14]. These animals are often found beneath or crack of rock, and occasionally come out towards sand substrate on a level of coral reefs and lagoons. Low phylum composition Platyhelminthes allegedly because this animal can camouflage well from color patterns his body and its small size [15]. Apart from that, these animals usually do active at night compared to during the day, out of hiding under or a crack in the rock to find food.

3.3. Bioindicator macrobenthos

Macrobenthos are aquatic invertebrates that are commonly used as an indicator of changes in water quality due to the relatively silent (not moving) or low mobility, so it has a lot of influence from the environment around it [16]. Sea sponges and ascidians are commonly found because of their nature which is dominant in the benthic community. As filter feeders, sponges and ascidians often exposed by pollutants in the waters, so they can collect dirt phytoplankton or other suspended content [9].

Sponges are sessile invertebrates that belong to the metazoan class which primitive and simple. Its low mobility causes sponges to have high adaptability to environmental changes. Porifera is known as a filter feeder that capable to pump water in an average of 10 times the volume of his body within 1 minute. Water that contains food particles and microbes will be filtered and digested from the entire surface of the body porifera and the rest of its metabolism will be issued through the osculum [17]. As a filter feeder, the sponge accumulates pollutants from its environment. Therefore, the sponge can be used as a tool to detect heavy metal pollution and chemical wastes that are non-biodegradable [18]. Figure 6 is a picture of one Porifera's phylum, hat is Xestospongia sp. Symbiotic bacteria on the surface and the inside of the sponge Xestospongia sp. is known to be an indicator of metal nickel in waters [19].

**Figure 6.** Xestospongia sp., one of sea sponge species (Porifera phylum) which found during observation.

**Figure 7.** Acanthaster planci, one of Echinoderm phylum which found during observation.

Besides Porifera (sponge), Echinoderms are one of the very important animals in marine ecosystems. They are seston eaters or detritus eaters. Its role in the ecosystem is to remodel the rest of the organic material that does not used by other species. The more important thing is it has a role as an environmental cleaner of the marine ecosystem, especially at the beaches [9]. Figure 7 is a picture of one member of the Echinoderms phylum which is a species of starfish, Acanthaster planci. Acanthaster planci abundance can be made as a health indicator of the coral reef ecosystem. A high number of Acanthaster planci will become pests and cause an unhealthy coral reef [20]. Acanthaster planci is a threat to coral reefs because their presence to become excessive predators of coral will be very detrimental to the coral reef ecosystem. This ‘thorny’ starfish known as the Crown of Throne
Starfish is a predator for the coral reef. They prey on coral by covering the surface of the coral reef with his stomach and producing digestive enzymes that damage coral soft tissue [21].

3.4. Diversity Index (H'), Evenness Index (E), and Dominance (C)

The following is the result of the Diversity Index, Evenness Index, and Dominance of macrobenthos at shallow and deep depths on Pramuka Island and around it.

**Table 1.** Diversity Index (H'), Evenness Index (E), and Dominance (C) in seven observation location.

| Station                  | Shallow | Deep |
|--------------------------|---------|------|
|                          | H'      | E    | C    | H'    | E  | C  |
| West Panggang Island     | 3.23    | 0.77 | 0.13 | 3.75  | 0.78| 0.10|
| West Pramuka Island      | 3.95    | 0.84 | 0.09 | 3.48  | 0.79| 0.12|
| Pramuka Island Dock      | 2.77    | 0.75 | 0.23 | 4.11  | 0.85| 0.09|
| South Air Island         | 3.89    | 0.85 | 0.10 | 3.36  | 0.75| 0.14|
| South Panggang Island    | 4.60    | 0.86 | 0.06 | 4.68  | 0.91| 0.06|
| North Sekati Island      | 1.68    | 0.43 | 0.53 | 4.83  | 0.86| 0.05|
| North Pramuka Island     | 4.08    | 0.87 | 0.07 | 3.64  | 0.86| 0.10|

At shallow depth, the highest Diversity Index (H') is in the South Panggang Island with a value of 4.5986 and the lowest is in the North Sekati Island with a value of 1.6793. The highest evenness index (E) is in North Pramuka Island the value is 0.8677 and the lowest is in North Sekati Island with a value of 0.4298. The highest dominance (C) index is in Pramuka Island Dock with a value of 0.2314 and the lowest is in the South of the Baked Island with a value of 0.0576. At deep depths, the highest Diversity Index (H') was in North Sekati Island with a value of 4.8271 and the lowest is in South Air Island with a value of 3.3614. For Evenness Index (E), the highest is in South Panggang Island with a value of 0.9129 and the lowest is in South Air Island with a value of 0.7538. The highest dominance index (C) is in South Air Island with a value of 0.1372 and the lowest is in North Sekati Island with a value of 0.0465.

Diversity Index is a value that can show the balance of diversity in the distribution of a number of individuals for each type, and see the level of diversity of species [6]. *Atriolum robustum* species tend to dominate, thus affecting the value of the North Sekati Island station diversity index to become unstable. The higher dominance value in water will make the lower diversity index value. This species is able to withstand extreme changes in the aquatic environment, and it’s commonly found in waters that are protected from contamination of organic material [11]. The level of diversity will be high if the value is close to 3, so this shows the condition of the waters is classified as good.

Evenness values (E) obtained at the observation station on Pramuka Island and its surroundings at shallow depths and deep depths range between 0.4 - 0.9, indicating a stable condition of the community. The lowest evenness value is 0.4 at North Sekati Island, and the highest evenness value is 0.9 at South Panggang Island. A stable community indicates that the ecosystem in these waters has high diversity, there is no dominant species and the distribution of the number is classified equally [6]. At the North Sekati Island in the shallow depth, the evenness value is 0.4 and it is the lowest if it’s compared to other dive stations. According to Odum [6] the value of the Evenness Index (E) ranges between 0-1, where the value approaches 0 means that evenness is low because there is a species that dominates, and if the value is close to 1, then the evenness value is high and illustrates that there is no species dominating so the division of the number individuals of each type of species are very uniform or evenly distributed. From these data, it can be concluded that the value of evenness in Pramuka Island and its surroundings at shallow depth and depth has a high evenness.

Dominance Index (C) indicates that the ecosystem has a high diversity, there is no dominant species and the distribution of the number of individuals is evenly distributed [6], and shows the
wealth of types of communities and the balance of the number of individuals of each type. Based on data obtained from the dive station on Pramuka Island and its surroundings, the dominance value at shallow depth and depth is 0.04 - 0.23. This shows that the dominance value is relatively low. The dominance index value ranges from 0-1, if the dominance index value approaches 1, it means that there is no individual dominating the waters and generally followed by a large evenness value. If the dominance index value = 1 means one of the individuals who dominate and the evenness value will be smaller [6]. The low dominance value indicates that water has a high species richness with an even distribution.

4. Conclusion
During the observation at the seven observation stations, 94 species of the seven macrobenthos phylum with the highest phylum were found, namely the Chordata phylum. The species most commonly found is Atriolum robustum. Diversity index at each station are in shallow depth and in the medium category. The evenness value obtained indicates a stable community condition. The highest index of dominance occurred at Pramuka Island Dock. Macrobenthos conditions from seven observation stations on Pramuka Island and its surroundings are still relatively good.

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