Assessment of coastal water productivity of Fitu Village, Ternate Island based on its zooplankton community structure

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Abstract. Zooplankton has an important role in waters, especially in the food chain, this organism is the first consumer that plays a major role in bridging the transfer of energy from the main producers to living things at a higher trophic level. The aim of the study was to analyze the coastal waters condition of Fitu Village, Ternate Island based on zooplankton community structure, carried out at 4 stations, and 4 sampling periods. Zooplankton samples were taken by filtering method. The results showed that there were 10 zooplankton genera from 4 classes, namely Ciliates (3 genera), Crustacea (4 genera), Hydrozoa (1 genus), and Rotifera (2 genera). The abundance of zooplankton found ranged from 2271 to 11562 ind.l⁻¹, the highest at station 1 period IV and the lowest at station 4 period I. The value range of zooplankton biological indices were diversity index (H') = 1.12 - 1.87, evenness index (E) = 0.64 - 0.93, and the dominance index (D) = 0.17 - 0.42. The waters of Fitu are included in the category of waters that have a low fertility level with a diversity index value (H') of 1.12 - 1.87.

1. Introduction

Plankton is all collections of organisms in water, both in the form of animals and aquatic plants that have microscopic sizes and live to float following the movement of currents [1]. The grouping of plankton consists of 2, namely phytoplankton which has a role as the main producer of organic substances in the waters, and zooplankton which does not have the ability to produce organic substances so that they must get additional organic matter from their food [2].

Zooplankton and phytoplankton have a relationship pattern in the shape of a series of relationships between predators and prey, this pattern then forms a food chain path in the waters. Primary producers (phytoplankton) are consumption by zooplankton, then zooplankton is eaten by small fish at higher trophic levels [3]. This event illustrates that there is a very close dependence relationship between phytoplankton and zooplankton [2] [4] which has an impact on the abundance of these two organisms in the water. In addition, plankton including zooplankton can be used as one of the biota indicators to determine the condition of waters. Information about the condition of waters is very necessary related to the utilization of coastal and marine resources concerned.

The waters of Fitu are coastal waters in Ternate Island. These waters have an important location and role in supporting the economy in Ternate, and North Maluku in general. The waters of Fitu have are important in the Ternate because of the areas that can be used for the development of marine tourism, fishing locations, and marine culture in North Maluku. Therefore, in an effort to support this location as an economic potential area in Ternate City, it is necessary to conduct comprehensive research in the Fitu coastal waters in an effort to provide a database of its water quality. In this regard, data on the abundance of zooplankton is the important data. Until now, there has been no research...
conducted by researchers related to the condition of Fitu coastal waters. Thus, this research becomes important and has a large role in the effort to use and develop this location in supporting the provision of aquatic resources. The research aims to determine the condition of the coastal waters of Fitu based on the zooplankton community structure.

2. Materials and methods

2.1 Materials

This study was conducted from March to April 2018 in the waters of Fitu, Ternate City, North Maluku Province at 4 (four) stations (Figure 1). Sampling was carried out 4 (four) times with a sampling period of 1 (one) week.

![Figure 1](image)

**Figure 1.** Research location in the waters of Fitu Ternate, North Maluku.

2.2 Methods

A total of 30 liters of water were filtered using a 25 m plankton net for zooplankton specimens. The filtered water was put into a sample bottle with a volume of 110 ml and preserved using 4% Lugol's solution. The water sample identification was carried out at the Aquaculture System and Technology Laboratory of Fisheries and Marine Science Faculty, Khairun University, with reference to the plankton identification book from [5], [6], [7], [8]. The abundance of zooplankton species is calculated based on the equation according to [9].

\[
N = \frac{O_t}{O_p} \times \frac{V_r}{V_o} \times \frac{1}{V_s} \times \frac{n}{p}
\]  

Where, N; Number of individuals per liter, \(O_t\), area of the cover glass \((\text{mm}^2)\), \(O_p\), Area of one field of view \((\text{mm}^2)\), \(V_r\), Volume of filtered water \((\text{ml})\), \(V_o\), Observed water volume \((\text{ml})\), \(V_s\), Volume of filtered water \((\text{L})\), \(n\), Plankton number in the entire field of view, and \(p\), Observed number field of view.
The Shannon-Wiener index is used to calculate the species diversity index, the evenness index, and the dominance index is calculated according to [1] with the following formula:

1. Diversity index of Shannon-Wiener:
   \[ H' = - \sum_{i=1}^{S} \left( \frac{n_i}{N} \right) \ln \left( \frac{n_i}{N} \right) \] (2)

2. Evenness index:
   \[ E = \frac{H'}{H_{\text{max}}} \] (3)

3. Dominance index:
   \[ D = \sum_{i=1}^{S} \left( \frac{n_i}{N} \right)^2 \] (4)

Where, \( H' \) = diversity index of Shannon-Wiener, \( E \) = evenness index, \( D \) = Simpson dominance index, \( n_i \) = number of individuals of the \( i \)th genus, \( N \) = Total number of individuals of all genera, \( H_{\text{max}} \) = maximum diversity index (= \( \ln S \), where \( S \) = Total type).

2.3 Statistical analysis

Several water physicochemical parameters that affect the growth and development of zooplankton were measured as supporting data. Measurements of several water quality parameters such as temperature, salinity, and pH were carried out in situ [9]. All data obtained from this study were presented in the form of tables and graphs, and specifically for the supporting data group were analyzed descriptively. The condition or level of fertility of the waters of Fitu was determined by calculating the value of zooplankton abundance and the Shannon-Wiener diversity index. Furthermore, the data from the calculation of the diversity index value were compared with the level of water fertility based on the criteria of Wilhm and Dorris. Excel Stat Pro 5.0 and Minitab 18 Program were used to facilitate calculations in analysis.

3. Results and discussion

3.1. Species composition and abundance

Zooplankton obtained during the study had a composition of species and the number of genera that varied between each station and the time of observation. The number of genera obtained has a range of values between 4 - 9 genera. Overall, there were 10 zooplankton genera from 4 (four) classes, namely Ciliata class (3 genera), Crustacea class (4 genera), Hydrozoa class (1 genus), and Rotifera class (2 genera). The found genus has fewer numbers when compared to the study of [10] in the waters of Bunaken Manado, research by [11] on the southwest coast of Nigeria, as well as research by [12] in the coastal waters of Keffing Island, Seram Regency, each of which found 28 species. However, it is higher than [13] study in the waters of Jailolo, West Halmahera, and the research of [14] in the waters of Bunaken Island which found 7 genera of zooplankton. The class found at all locations, and time of observation was Ciliata, while the Hydrozoa class was only found at station 4 period I. This indicates that the Ciliata class has a wider distribution than the other classes in the waters of Fitu. This is different from that found by [15] that the Crustacea class that dominated zooplankton in the coastal waters of Tangerang, as well as research by [12] in the coastal waters of Keffing Island, Seram Regency which found that Copepods dominated zooplankton in those areas.
When examined further, it was found that the genus Rabdonella (Ciliata) was found at all stations, and observation periods. Meanwhile, the genus Eperelmus (Hydrozoa) was only found at station 4 in period I. This indicates that the genus Rabdonella had a wider distribution than other zooplankton genera. The composition of zooplankton species based on the observation period. Further, it was found that the Ciliata class dominated over other classes in periods I and II, while in periods III and IV zooplankton class was dominated by the Crustacea class. Meanwhile, Hydrozoa class is only found in the first period (Figure 2).

Abundance of zooplankton varied among station and observation times (periods). The abundance of zooplankton obtained had a range of values between 2271 and 11562 ind.l⁻¹, the highest abundance was at station I period IV with a value of 11562 ind.l⁻¹, and the lowest was at station 4 period I with an abundance value of 2271 ind.l⁻¹ (Figure 3). If the value of zooplankton abundance obtained was compared to research result of [16] in Badik Pangkep Island which obtained an abundance of zooplankton ranging from 55 to 225 ind.l⁻¹, it was found that the abundance value in these waters was higher. However, it is lower than the research by [17] at Buli Bay which obtained an abundance of zooplankton of 4568 - 19322 ind m⁻³, the research of [15] at Bali Strait which found an abundance of zooplankton with a range between 33098 and 1413069 ind.m⁻³, and as well as research by [12] in the coastal waters of Keffing Island, Seram Regency which obtained an abundance of zooplankton with values ranging from 351 to 1190 ind.m⁻³.
Figure 3. The abundance of zooplankton at each station and period of observation in Fitu waters, Ternate

The results of a more in-depth analysis by genus found that during the research in the waters of Fitu, the genus *Rhabdonella* (Ciliata) had the highest abundance value of 20233 ind. l\(^{-1}\) compared to other species. Meanwhile, the lowest abundance was the genus *Eperelmus* (Hydrozoa) with an abundance of 206 ind l\(^{-1}\). This result is different from the results of research from [18] in Prince William Sound, Alaska which found that the commonly found (dominant) species were *Oithona similis, Limacina helicina, Pseudocalanus* spp., and *Acartia longiremis*.

Zooplankton has the highest abundance at station 1 period IV with a value of 11562 ind. l\(^{-1}\). The high abundance at this location compared to other stations is caused by the value of the physicochemical parameters of the waters at the station and the observation time is in the appropriate range so that it can support the growth and development of zooplankton, which results in these organisms being at their maximum growth. Station 1 period IV has water physicochemical parameter values successively, namely temperature: 29.7°C, salinity: 30, and pH: 7.70. Another thing that causes the high abundance of zooplankton at this location and time of observation is the availability of food that suits the needs of these organisms. Phytoplankton as food for zooplankton is inadequate and sufficient conditions for the needs of zooplankton. If explored further, it was found that at station 1, observation period IV, the abundance value of phytoplankton was 33240 cell. l\(^{-1}\). The phytoplankton content is not included in the high category but is classified as low. The low content of phytoplankton indicates that there has been grazing of phytoplankton by zooplankton. This is in accordance with the research of [19] in the western part of the Black Sea who found that there was grazing of phytoplankton by zooplankton of 0.10 - 0.69 per day.

The lowest abundance (2271 ind. l\(^{-1}\)) found at station 4 period I was more due to the availability of inadequate and sufficient for the needs of the zooplankton so that zooplankton could not develop and grow optimally. Meanwhile, the content of the water physicochemical parameters at the station and the time of observation is not an inhibiting factor because it has a value that is not too different from other stations and observation times.

3.2 Biological indices
Diversity index (*H’*), evenness (*E*), and dominance index (*D*) are the biological indices of zooplankton observed in this study. From these biological indices, it can be studied and explored further about the
species richness in a community and the balance of the number of individuals of each species. The results of the calculation of the complete zooplankton biological indices are listed in Table 1.

The value of the diversity index (H') during the study at all stations and the time of observation, generally obtained a value with a range between 1.12 - 1.87 (Table 1). The diversity index value in the waters of Fitu is included in the medium category. This moderate diversity index indicates that the zooplankton community at the study site is experiencing environmental conditions that are not optimal or in other words that the environmental parameters that affect the growth and development of zooplankton are in a non-optimal range, but are still in a condition that can be tolerated by the environment, zooplankton for growth and development.

| Period | Station | Biological indices |
|--------|---------|-------------------|
|        |         | H'    | E       | D       |
| I      | 1       | 1.84  | 0.89    | 0.19    |
|        | 2       | 1.26  | 0.91    | 0.32    |
|        | 3       | 1.63  | 0.91    | 0.22    |
|        | 4       | 1.41  | 0.88    | 0.29    |
|        | 1       | 1.67  | 0.93    | 0.21    |
|        | 2       | 1.23  | 0.89    | 0.31    |
|        | 3       | 1.77  | 0.91    | 0.20    |
|        | 4       | 1.12  | 0.81    | 0.37    |
|        | 1       | 1.41  | 0.79    | 0.31    |
|        | 2       | 1.46  | 0.81    | 0.31    |
|        | 3       | 1.87  | 0.90    | 0.17    |
|        | 4       | 1.84  | 0.84    | 0.20    |
|        | 1       | 1.33  | 0.64    | 0.42    |
|        | 2       | 1.72  | 0.88    | 0.20    |
|        | 3       | 1.46  | 0.91    | 0.25    |
|        | 4       | 1.25  | 0.90    | 0.30    |

Description: H’ = Diversity Index, E = Evenness Index, and D = Dominance Index

The range of evenness index values (E) obtained during the study has a value of 0.64 - 0.93 (Table 1). If referring to [20] criteria, it can be explained that the community structure at the stations and the time of observation are in unstable to stable conditions. This indicates that the environmental conditions in the waters of Fitu are relatively unsuitable or unfit to support the growth and development of each genus of zooplankton optimally.

At all stations and observation times, it was found that the dominance index (D) ranged from 0.17 to 0.42 (Table 1). If traced further, it was found that at all stations and observation time, the dominance index value was close to 0 (below 0.5). Thus, it can be explained that in the zooplankton community structure being observed in the waters of Fitu, there is no genus that extremely dominates other genera, all types of zooplankton have the same opportunity and opportunity to grow and reproduce.

3.3 Waters condition of Fitu
The condition of waters can be known by conducting analysis/study on several physicochemical parameters of the waters concerned. Parameters that can be used include nitrogen and phosphorus
concentrations, chlorophyll-a content, and the presence of plankton. However, in this study, the condition of the waters at the research site was carried out using an approach to the zooplankton community structure and zooplankton biological indices.

Based on the species composition, only 10 genera from 4 classes of zooplankton were found. Likewise, with the value of biological indices, more specifically examined from the value of the zooplankton diversity index, it was found that Fitu waters are included in the category of waters that have a low fertility level with a diversity index value (H') of 1.12 - 1.87.

4. Conclusion
Based on the research that has been done, it can be concluded that the coastal waters of Fitu was in the category of waters with low fertility conditions/levels based on the value of the diversity index (H') of zooplankton.

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