The comparison of distribution patterns of macrobenthic assemblages adjacent floating net cage areas at Karang Lebar Island, Jakarta: a multivariate approach

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Abstract. Water and sediment ecosystems are often influenced by fish farming activities especially organic matter that lead to organic enrichment. The macrobenthic community is one of the benthic organisms that can be used as bioindicator to detect disturbances in aquatic environments. The purpose of this study was to compare the distribution patterns of macrobenthic assemblages adjacent to floating net cages situated at Karang Lebar Island, Jakarta using a multivariate approach. Three sampling locations were assessed, each with three stations and three replicates. Each location consisted of a floating net cage of monoculture, a floating net cage of IMTA (Integrated Multi-Trophic Aquaculture), and a reference site at Karang Lebar Island, Kepulauan Seribu, DKI Jakarta. All data concerning macrobenthic presence was expressed using diversity (H’), evenness (e) and dominance (C) indices. Further analysis done using multivariate analysis was presented as 2D-ordination by Non-metric Multi-Dimensional Scaling (NMDS). The composition of macrobenthic assemblages was dominated by gastropods (18 species), bivalves (9 species) and Polychaeta (7 species). Based on NMDS ordination, there was a tendency of grouping stations by sampling time. It is particularly so between sampling times II and III, and between sampling times I and III. However, this grouping did not occur between sampling times I and II. It may indicate that the macrobenthic assemblages were influenced by certain annual seasons. Meanwhile, depending on sampling locations, the assemblages were influenced by environmental variability. The stations were grouped by the aquacultural areas and reference area on the ordination with some overlapping stations positioned among them. However, the tendency of grouping the stations between IMTA and monocultural sites did not occur, implying both farming practices have a relatively similar impact on the structure of macrobenthic assemblages.
1. Introduction
Macrobenthic are organisms that live in mud, sand, gravel, stone or organic waste on the basis that the aquatic environment is capable of settling and getting stuck on the bottom of the water [1]. The structure of macrobenthic communities has been used as indicators for determining various environmental disturbances both in farming [2,3]. Therefore, macrobenthic are organisms which are difficult to escape from environmental disturbance.

Macrobenthic organisms fulfill a variety of roles, among which is being part of the aquatic food chain and improving the structure of sediment through the activity of digging, drilling, bioturbation, and excretion. Macrobenthic can be used to determine the quality of water by observing the structure and dominance of taxa [4]. Macrobenthic can respond quickly to changes in the environment expressed as changes in structure and abundance. According to Ref [2], spatial and temporal variability of taxa richness, evenness, diversity, the abundance of macrobenthic assemblages occurred, both at fish farming and reference areas, owing to differences in sediment properties.

The distribution of these macrobenthic communities is highly correlated with the type of sediment. The latter of which is related to a wider set of environmental conditions, such as current speed and organic content of the sediment [5]. Due to this, macrobenthic assemblages might be expected. Because of the important ecological function macrobenthic organisms fulfill within the marine ecosystem, knowledge, and understanding of the macrobenthic diversity patterns is indispensable for identifying priority areas for conservation and the adjustment of human activities in marine zones [6].

Fish cultivation activities using floating net cages in the waters of Karang Lebar Island reduce the quality of water with fish feed residues. These residues exist of organic materials, namely remaining fish feed, feces, and the results of fish metabolic activities. This study aims to compare the distribution patterns of macrobenthic assemblages adjacent to floating net cage areas at Karang Lebar Island, Kepulauan Seribu, Jakarta, using a multivariate approach.

2. Research Methods
2.1. The study sites
The sampling sites were located at Karang Lebar Island, Kepulauan Seribu, DKI Jakarta. The sampling locations have been assessed with three replicates (S1, S2, S3) and three time sampling (T1, T2, T3) for each location. These replicates are the floating net cage of monoculture, floating net cage of IMTA, and reference area.

2.2. Sampling procedures
The base sediments have been taken from three locations using an Ekman Grab excavation tool. Then the sample was placed into a plastic bottle containing a 4% formalin solution. Macrobenthic animal samples were rinsed, sorted and preserved in a 70% ethanol solution.

2.3. Identification
Macrobenthic identification was performed using identification books [7], after which the amount of types was calculated, tabulation and calculation was conducted.

2.4. Data analyses
The diversity of the macrobenthic assemblages was analyzed using a Shannon-Wiener index (H'). An evenness (e) index was used to express similarity [8]. Dominance within macrobenthic assemblages was analyzed using a Simpson index (C) [9]. The graphical method of NMDS ordination (software Primer 6.1.1) of Bray-Curtis similarities on log (X + 1) transformed data was used to provide a 2D-visual representation of differences between sites. The NMDS ordination was used to determine the extent of changing patterns of macrobenthic structure and abundance at each sampling station in space and time.

2.4.1. Shannon-Wiener diversity index
The $H'$ value normally will not exceed 5 (five). In general, the greater the number of species in the community, the higher the value of the $H'$-index will be.

2.4.2. Evenness Similarity index

$$e = \frac{H'}{\ln S}$$

Specification:
- $H'$ = index of species diversity (species), *Shanon-Wiener*
- $\ln$ = exponential logarithm
- $S$ = number of species (types)

The higher the value of $e$, the higher the degree of similarity between communities will be.

2.4.3. Simpson dominance index

$$C = \sum Pi^2$$

Specification:
- $Pi$ = proportion of the total sample of the i-th species = $ni / N$

3. Results

3.1. Macrobenthic abundance

Based on the results from macrobenthic identification, all three locations were dominated by gastropods (18 species), bivalves (9 species) and polychaeta (7 species). At the S1 and S2 the macrobenthic group is dominated by the gastropods and bivalves classes and a small number of bivalves polychaeta were found. Each represents a balanced proportion of abundance between the two locations. The macrobenthic abundance proportions for S1 and S2 are shown in Figure 1 (a, b). At the S3 is dominated by gastropods and bivalves. Only a few pholychata were found as is shown in Figure 1c. The results from this study show a family of gastropods and polychaeta with high distribution in both sites. This is due to the environmental conditions being in accordance with their habitat, especially in the organically rich muddy sediment. Gastropods are animals that are able to live and breed well on various types of substrates that are rich in nutrition and contain chemical and physical factors that support their life. The cultivation area is likely to contain similar organisms, depending on the type of sediment [10, 11]. Both gastropods and polychaeta belong to the class of opportunistic taxa. An opportunistic taxon exploits disturbed conditions due to environmental stress by increasing the rate at which they reproduce so that their population increases substantially compared to other organisms which as a result may struggle to survive [4].
The macrobenthic abundance at floating net cages of monoculture (a), at floating net cages of IMTA (b), and at the reference area (c).

At the third location – the reference area – the macrobenthic groups that dominated were from the gastropods and bivalves class. The reference area is a location that is not directly affected by the activity of farming. This area is free from any cultivation farming resulting in macrobenthic organisms proliferating and surviving without interference leaving their structure unchanged [11].

3.2. The approach for distribution pattern with NMDS ordination

The NMDS ordination showed there was a tendency of grouping stations by sampling time. This was the case in particular between T2 and T3, and between T1 and T3. However, the grouping did not occur between T1 and T2. This may indicate that the macrobenthic assemblages were influenced by certain annual seasons (Figure 2a). This is not surprising as the seasons are one of the factors that affect macrobenthic abundance in waters. In the rainy season the nutrient concentration may be lower than during the dry season resulting in a considerably low macrobenthic abundance [12]. This condition to related lowering light penetration, salinity, temperature, and turbidity. This causes relatively high sedimentation, thus impacting macrobenthic assemblages.

Depending on the sampling location, the macrobenthic assemblages were influenced by environmental variability. The stations were grouped by aquaculture areas and reference areas on the ordination, with some overlapping stations positioned among them (Figure 2b). This is due to difference in the type of sediment substrate in the cultivation area compared to the reference area. However, the grouping of IMTA and monocultural stations did not occur, implying both farming practices have a relatively similar impact on the structure of macrobenthic assemblages.
3.3. Diversity index

Table 1. Value of diversity

| Index                        | S1   | S2   | S3   |
|------------------------------|------|------|------|
| **Shannon Wiener diversity (H’)** | 3.54 | 3.65 | 3.73 |
| **Evenness index (e)**       | 0.72 | 0.80 | 0.68 |
| **Simpson dominance (C)**    | 0.36 | 0.42 | 0.31 |

Table 1 shows the diversity index. At the three locations, the results for diversity ranged from 3.54–3.73 H’. Diversity is low when 0 < H’ < 2.30. When 2.302 < H’ < 6.907, the diversity is rated as medium. Finally, when H’ < 6.907, the diversity is high [8]. The results from S2 show a medium diversity. The results from the similarity index at all locations was high. Similarity is high when approaching 1. The high uniformity indicates that no species dominated [8]. Finally, the dominance index shows that at all locations, the results are close to 0. This means there is no dominant species at S3.

4. Conclusion

The NMDS ordination is approach for distribution pattern there is a tendency of grouping stations by sampling time and by sampling locations. The macrobenthic assemblages were influenced by environmental variability, as the stations were divided among the aquacultural areas and the reference area on the ordination with some stations having overlapping positions. From this study it can be concluded that the structures of macrobenthics can indicate a moderate disruption of the environment of the study sites.

Acknowledgement

This research was financially supported by Sim-Litabmas Directorate of Research and Community Service, Ministry of Research, Technology and Higher Education, Indonesia, through the *PUSN Project Batch I 2018.*

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