28 Biomonitoring on Integrated Multi-Thropic Aquaculture (IMTA) activities using macrobenthic mollusks on Tembelas Island, Kepulauan Riau Province

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Journal of Physics: Conference Series

PAPER • OPEN ACCESS

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To cite this article: M Abyan Syuja' *et al* 2018 *J. Phys.: Conf. Ser.* **1025** 012083

Biomonitoring on Integrated Multi-Thropic Aquaculture (IMTA) activities using macrobenthic mollusks on Tembelas Island, Kepulauan Riau Province

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Abstract. Macrobenthic mollusks are considered a good aquatic bioindicator for environmental biomonitoring. This study was conducted in Tembelas Island, Karimun District, Kepulauan Riau Province, at 103°29'47' - 103°29'90' BT and 0.991°16'63' - 0.989°06'37' LS. The objective was to compare the quality of water and sediment at Integrated Multitrophic Aquaculture (IMTA) sites, monocultural sites and reference sites using the community structure of mollusks, and to assess the potential of mollusks as bioindicator. The research was conducted in June and October of 2016. Data of abiotic parameters included the composition of sediment substrate and DO, pH, salinity, temperature and turbidity. The sampling procedure was performed with the use of an Ekman Grab. The animals obtained were 1 mm size-sieved and were fixed using 10% formalin for further analysis. In total there were 49 species and 2 classes obtained (Gastropods and Bivalves). The most prevalent genus were *Costoanachis* sp (Fam. Collumbellidae) and *Anodontia* sp (Fam. Lucinidae). The values of outcomes from indices used were considered low, ranging from 1.34 to 2.54 for diversity (H'), from 0.86 to 0.96 for evenness, and from 0.11 to 0.31 for dominance (C). Further analysis consisting of a multivariate approach and graphical methods of cluster analysis and Non-Metric Multidimensional Scaling (NMDS) ordination showed differences between the assemblages in the aquacultural areas and the reference area. However, the tendency of grouping the stations between IMTA and monocultural sites did not occur, implying both sites have relatively similar structures of macrobenthic mollusks. Based on the data obtained, sediment composition at the KJABB IMTA, monocultural areas and the reference area were dominated by silt, with the highest value being 92.06% found in the KJABB IMTA area. Clay, silt and nitrogen levels were the abiotic factors influencing structure of macrobenthic mollusks (BIO-ENV-Primer 6.1.5; r = 0.571).

Keywords: *Macrobenthic mollusks, KJABB IMTA, Tembelas Island, Abiotic Component, Sediment*

1. Introduction

Aquaculture in Indonesia can be done by using ponds or Floating Net Cages (KJA). A pond is a system that is made deliberately as a container of aquaculture, usually located near a beach. Ponds are often filled with brackish water because its water sources near coasts tend to be so. The Floating Net Cage is a type of aquacultural containers that is usually placed on large water current such as lakes, rivers, and sea. The use of KJA is proven to benefit the community due to more efficient use of land and feed, and how easy it is to harvest, either selectively or totally. Unlike ponds, they do not require special water management. [1] Floating Net Cages in Indonesia can be deployed as both monocultural and polycultural systems. The monocultural system is the cultivation of a single species of fish in one place, whereas the polycultural system contains various species of fish in one pond that each require a different food source to prevent competition in the search for food [2]. The benefits gained from aquaculture are great, but fishery aquaculture can have an impact on the eutrophication or enrichment of organic matter. If the activity is not matched by the application of good environmental management, organic material resulting from aquacultural activities may cause ecological imbalance in the area, which in turn may threaten the sustainability of aquaculture itself.

Tembelas Island is one of the islands located in Karimun Regency, Riau Islands. This island does aquaculture with ponds by deploying the Floating Net Cage (KJA) IMTA system. As a result of these activities, water conditions can change. According to Dahuri [3], changes in the quality of a waters greatly affect the life of biota living in these waters. One of these biotas are macrobenthos.

Benthic animals spend part or all of their lifecycle at the bottom of waters, either crawling or digging holes. Benthic animals fulfill a role in the process of decomposition and mineralization of organic materials in waters. They also occupy several levels of thropic groups in the food chain. [4] [5]

Benthic animals are subclassed as the small microbenthos and the larger macrobenthos. Macrobenthos generally cannot move quickly. Due to their size it is easy to be identified in its habitat in and at the bottom of waters [4]. Changes in water quality and substrate greatly affect macrobenthos abundance and diversity. This abundancy and diversity is highly dependent on tolerance, activity and sensitivity to environmental change. The tolerance to environmental change differs among the different macrobenthic species [6]. One species that is considered a reliable aquatic bioindicator is the Mollusca. A Mollusca is an invertebrate that can serve as a bioindicator for water pollution due to its sensitivity to pollutant compounds that exist in the ecosystem. Therefore, it is necessary to do research on the diversity of Mollusca at Tembelas Island.

The use of mollusks as a biological indicator for aquatic quality is not a new phenomenon. Benthic animals have a range of properties that can be used as bioindicators, such as benthic animals that are ubiquitous. Other species can provide a spectrum of responses to environmental stress. Sedentary living habitats and long life cycles can aid in indicating spatial changes and temporal changes respectively [7] [8]

2. Methods

The materials used in this study were Mollusca animal samples as biotic parameters, sediment and water samples as abiotic parameters, 4% formalin solution and 70% ethanol solution for preservation.

Additionally, for this study the following tools were used: an *Ekman Grab*, a water checker, a 1 mm mesh strainer screen, a sample bottle, tweezers, gloves, a mask, a label, a camera, a petri dish, an oven and a plastic bag.

Finally, physical and chemical aspects of water that were measured include pH, temperature, DO, turbidity, conductivity and salinity. This was done using a water checker, a Lux meter, a TDS meter and a refractometer. Mollusca sampling was done with the aforementioned Ekman Grab tool. The sediment samples that have been taken were given 4% formalin solution for fixation. The sediment samples were then examined in the laboratory to identify the presence of Mollusca and to analyze the substrate grain composition as well as the carbon and nitrogen content.

The sediment samples were then sieved with a benthic filter with a net measuring 1 mm. The results were then washed under water and sorted. The sorted results were then put into a bottle containing 70% ethanol solution and were labeled. During the next stage the data was identified and analyzed.

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The correlation between the biotic and abiotic components were calculated by the use of BIO-ENV in PRIMER software V.6.1.5. The first biotic data were transformed using log (X + 1) and then were tested using the similarity of Bray Curtis so it can be seen grouping data by using Non-Multidimensional Scaling (NMDS). A square root transformation was applied to the abiotic data. The result of the transformation in the first normalization was then performed the tabulation of the distance matrix using Euclidean Distance so that it can be seen grouping data by using Principle Component Analysis (PCA). The result of the normalization then goes through the BIO-ENV test with biotic data that has been tested with Bray Curtis similarity so that the result is a correlation between biotic and abiotic component.

3. Results and Discussion

From the observations of both the first and second sampling in the KJAB area of the IMTA system on Tembelas Island, the aquaculture of monocultural cage fishery systems and reference areas identified 49 species of Mollusca in total. The KJAB area contained 9 of these families and 11 species. The monocultural area contained 12 families and 16 species and the reference area contained 30 families and 38 species. The Mollusca at the study sites consisted of two classes: Bivalves (15 species) and Gastropoda (34 species).

Table 1. Mollusca Abundance

No.	Makrozoobentos Taxa	Species
1	Bivalves	15 species
2	Gastropoda	34 species

The Gastropoda class has the highest abundancy. At each sampling location (the KJAB IMTA system on Tembelas Island, where aquaculture is done with the monocultural cage fishery system, and the reference area), Gastropoda were always found in larger quantities of families and species than the Bivalvia class. This is due to Gastropoda living and growing on more varying sedimentary structures and having more movement capabilities than bivalves [9].

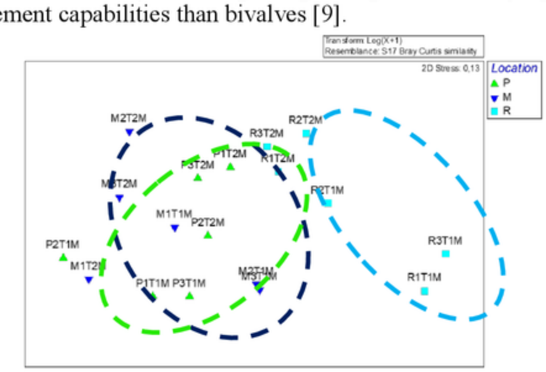

Figure 1. Results of 2D ordinations by Non-matrix Multidimensional Scaling (NMDS) showing Mollusca abundance.

(P1T1M) The first station KJABB IMTA sampling period first, (P2T1M) 2nd stations KJABB IMTA sampling period first, (P3T1M) 3rd stations KJABB IMTA sampling period first, (P1T2M) The first station KJABB IMTA sampling period two, (P2T2M) 2nd stations KJABB IMTA sampling period two, (P3T2M) 3rd stations KJABB IMTA sampling period two, (M1T1M) the first station monoculture sampling period first, (M2T1M) 2nd stations monoculture sampling period first, (M3T1M) 3rd stations monoculture sampling period first, (M1T2M) the first station monoculture sampling period two, (M2T2M) 2nd stations monoculture sampling period two, (M3T2M) 3rd stations monoculture sampling period two, (R1T1M) the first station reference period first sampling, (R2T1M) 2nd station the reference

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period first sampling, (R3T1M) 3rd station reference first sampling period, (R1T2M) the first station a second sampling reference period, (R2T2M) 2nd stations sampling the second reference period, (R3T2M) T3rd station the second sampling reference period.

The NMDS graphs show that based on the abundance and diversity of Mollusca, there was a grouping between the reference area and the aquacultural area. Comparing KJABB IMTA with monoculture does not show significant grouping. However, if given an auxiliary line for each area group, KJABB IMTA and the reference area have a higher level of similarity than the monocultural area with the reference area. The distribution of each point that is mutually clustered to each other between the reference area and KJABB IMTA shows this. Based on the graph it can be said that the area of KJABB IMTA and the monocultural area have similar Mollusca abundance between the two. This is a natural phenomenon since both areas are cultivated areas that have the potential to experience the sedimentation of organic matter. Based on the aforementioned abundance similarity data, it can be said that KJABB IMTA has the characteristics of an area that is closer related to the reference area than the monocultural area is. According to Putro [10], it can cause the accumulation of feed to the bodies of water / sediment substrate. The presence of high organic matter can trigger the growth of toxic microalgae and pathogenic bacteria in these waters.

The water around Tembelas Island, Kepulauan Riau, measured values of pH (7.6-8.5), DO (4.3-7.4 mg / l), turbidity (25- 59.3 mg / l), conductivity (74.3-89.2 ms / cm), temperature (29.9-31.6 ^{o}C) and salinity (30-32.67%). The range of pH values that benthic animals will tolerate is 6.5-8.5 [11]. The pH value of Tembelas Island at the reference area, of monoculture and of IMTA, are all within acceptable ranges for Mollusca to live in.

The range of salinity that benthic animals will tolerate is 25-40%, according to Hubarat [12]. The acceptable salinity range depends on the tolerance level of each Mollusca species. Reference areas, monoculture areas and KJABB IMTA areas have high, yet acceptable salinity levels for Mollusca. The temperatures that benthic animals will tolerate are 20-30 ^{o}C, according to Efendi [11]. Temperatures in all three areas are also fairly normal and tolerable for Mollusca. The optimum Oxygen Content (DO) for benthic animals is > 4.0 mg / l, according to Hubarat [12]. DO levels in all three areas have a minimum value above 4.0 mg / l and is therefore suitable for benthic animals.

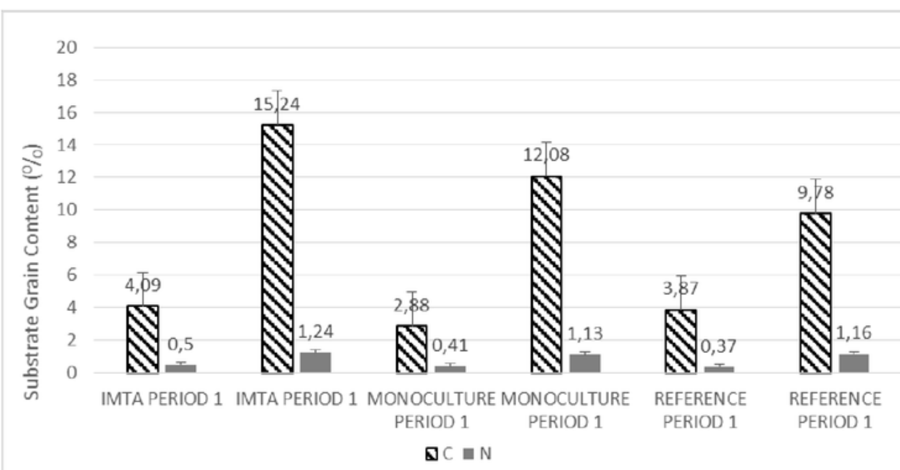

Figure 2. Carbon and Nitrogen Levels on Substrates Basic Water

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Substrate organic content is a food source for a variety of organisms and for macrobenthic animals in particular [13]. Based on the analysis, the average carbon content ranged from 2.88 to 15.24% and the nitrogen content ranged from 0.05 to 1.24%. The highest carbon content was in the KJABB IMTA area during the second sampling session, where it was 15.24%. The lowest levels were measured in the monocultural area during the first sampling session, where it was 2.88%. Carbon levels during the first and second sampling sessions at all three locations were considerably different. This is thought to be the effect of the intervals between the first and second sampling sessions during which organic matter was influenced by aquacultural activities as well as by strong currents that can deliver organic matter causing accumulation in the area. The average nitrogen content ranged from 0.37 to 1.24%. The highest nitrogen content was in the KJABB IMTA area during the second sampling session, as it was measured at 1.24%. The lowest concentration of nitrogen was measured in the reference area during the first sampling session, at 0.37%. The nitrogen content in the KJABB IMTA, monocultural and reference areas tended to be stable between the first and second observations.

The PCA-graph of environmental conditions in the reference area and KJA polyculture is made with the use of Euclidean Distance Index equations in PRIMER software V.6.1.5. Euclidean Distance is used to calculate the similarity of two objects observed by their abiotic components [14]. The abiotic components measured were pH, salinity, DO, temperature, C- and N-levels, as well as the substrate grain composition.

From the CPA-graph similarities in the abiotic values measured at each location can be seen by looking at the distribution of each point of mutual interest between KJABB areas, the monocultural area and the reference area. Based on the graph it can be said that the two locations have quite a clear difference of abiotic components based on time.

The relationship between the biotic and abiotic components of the KJABB IMTA, monocultural and the reference area can be seen in the table below:

Table 2. Results of analysis of the relationship of biotic and abiotic components

No.	Relationhip	Variabl	Variable
1	0.571	8,9,11	3
2	0.559	8	1
3	0.557	4,8,11	3
4	0.555	2,8,9,1	4
5	0.551	7,8	2
6	0.535	8,11	2
7	0.531	7-9	3
8	0.529	2,4,8,9,	5
9	0.527	2,8,9	3
10	0.524	7-9,11	4

1) DO, 2) Salinity, 3) pH, 4) EC, 5) Temperature, 6) Turbidity, 7) Sand Level, 8) Silt Level, 9) Clay Level, 10) C Level %, 11) N Level %

The relationship between physicochemical factors, substrate grain composition and carbon and nitrogen content with Mollusca abundance was analyzed with BIO-ENV in PRIMER software V.6.1.5. Table 2 shows the highest correlation value by correlating some random variable. Based on table 2 the abundance of Mollusca with silt content, clay content and N-content has the largest correlation, namely 0.571. This indicates that the value of silt content, clay content and N-content is the most influential abiotic component of the abundance of Mollusca at Tembelas Island.

DO levels in the waters are important for organic life. This goes for Mollusca in particular, because they require oxygen to breathe and metabolize. The quantity of oxygen in water can cause the death of benthic organisms. Salmin [15] states that dissolved oxygen plays an important role as a biological indicator because it plays a role in the oxidation process and reduction of organic and inorganic materials. Carbon and nitrogen levels are very important for Mollusca. This is in accordance with the statement of Nurrachmi and Marwan [16]. The presence of Benthic animals is closely related to the availability of organic material contained in the substrate because it is a source of nutrients for biota that generally live on the basic substrate. Organic matter on a substrate at a certain level is a food source for mollusks, whereas an overabundance of it can be toxic to benthic organisms. According to Putro [13], in certain concentrations the content of organic substrates is necessary as a food source for certain organisms, in particular macrobenthic animals.

4. Conclusion

This study shows that there are differences in Mollusca structure at the presence of KJABB IMTA culture, monoculture and the reference area indicated by the grouping on ordination shown between areas and between sampling periods by nMDS analysis and PCA analysis. There is no noticeable difference between KJABB and monoculture but there is a marked difference between the aquacultural area and the reference area. The primary abiotic factors affecting the mollusk community structure are DO, carbon content (% C) and nitrogen (% N) (BIO-ENV: *r=0,571*).

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