Fish diversity and abundance in GROPOZAG construction in Ujong Batee waters, Aceh Besar District, Indonesia

I Dewiyanti1,2*, R Syahputra1, M Ulfah1,2, Y Yunita2

1Marine Biology Laboratory, Faculty of Marine and Fisheries, Universitas Syiah Kuala, 23111, Indonesia
2Marine and Fisheries Research Center, Universitas Syiah Kuala, Indonesia
3Faculty of Mathematics and Natural Sciences, Universitas Syiah Kuala, 23111, Indonesia

*E-mail: irmadewiyanti@unsyiah.ac.id

Abstract. The community structure of fish species including diversity index and abundance is important to be studied as one of the secondary productivity indicators in any ecosystem. Furthermore, species richness and density can be used for conservation and management purposes. GROPOZAG (Groin Porous Zig-Zag Type) is a breakwater building construction designed in the form of cube blocks with holes and arranged zigzag. The purposes of the present study were to assess the abundance and diversity of fish species in GROPOZAG construction area in Ujong Batee water, Aceh Besar. This research was conducted from January to March 2018. The method used in this research was belt transect using visual census. Fish data collection was carried out once a month for three months at the highest tide with a depth 2-4 m and each observation was done three replications. The result of this research found nine families of fish divided into 13 species. Some species were always found in each sampling i.e. *Acanthurus auranticavus*, *Abudefduf vaigiensis*, *Monodactylus argenteus*, and *Arothron manilensis*. The highest fish abundance was *Monodactylus argenteus* with an average of 41 individuals/80m². Most fish species in the GROPOZAG construction were herbivorous fish (62%) and followed by omnivorous (33%), and carnivorous was 5%. The average of fish abundance was 129 individuals/80m². The value of diversity index (H’) ranged from 1.15 to 1.79 categorized into medium category and evenness index ranged from 0.76 to 0.83 (high category). GROPOZAG construction is affective as a new habitat for aquatic organisms such as fishes.

1. Introduction

Biodiversity of a certain community is urgent and important for the future sustainability of marine resources included commercial fisheries. Fisheries that catch several species or populations may have more stable catches than fisheries that conquer a single species [1, 2]. Ecologically, fish community is very important as bio indicator of secondary productivity in the marine ecosystem. Fishes is a relatively more complex organism which is many biological aspects and behaviors can be used to measure their sustainable habitat [3]. Some species of fish have become bio indicators of water fertility, where the high diversity and abundance of certain fish can explain the water quality. Fishes are very important for fishermen and surrounding communities for sources of income or as food for daily consumption [4]. Indicators that can be used to assess processes and changes occurred in ecosystems over time are the abundance and diversity of aquatic organism. Some reasons for choosing
fish as an indicator because fish is an integral part of marine life, sufficient nature and flexibility can reflect the damage or support the ecosystem [5].

Aceh has high biodiversity that remains one of the longest coastal line provinces in Indonesia. Due to this strategic area, Aceh has high biodiversity including marine flora and fish fauna [6]. Ujung Batee waters located in Mesjid Raya District, Aceh Besar categorized as sandy and rocky beach and it has strong waves and currents. In Ujung Batee waters, there were no coral reef ecosystems found because the condition of sandy substrates and strong currents did not allow coral larvae to stick to the bottom of the waters. In addition, strong current or wave in this area can also result in coastal abrasion at Ujung Batee Beach. Therefore, it is necessary to reduce beach abrasion activities. Porous zig-zag type (GROPOZAG) are environmentally friendly breakwater construction. GROPOZAG construction formed on cube blocks with holes and arranged zigzag can reduce wave and it was significantly reducing coastal erosion [7]. The GROPOZAG prototype is made of concrete material and it does not damage the surrounding environment by its existence [8]. Furthermore, this construction can also function as a new habitat for organisms in these waters, for example fish. Considering the importance of present fishes to support the productivity of aquatic fauna in coastal areas, it is necessary to obtain the diversity and abundance of fishes in the GROPOZAG construction area at Ujung Batee water, Aceh Besar District.

2. Materials and Methods

2.1 Study area

This research was conducted from January to March 2018 in the GROPOZAG construction in Ujung Batee water at the east coastal waters area, Aceh Besar District. The purposive sampling method was used to determine the characteristics of the observation site. The location of the research can be seen in Figure 1. Tools and materials used in this study were underwater stationery, SCUBA, GPS, underwater cameras, hand refractometer, pH meter, thermometer, fish identification books, bucket and drop pipettes.

![Figure 1](image_url). The map of study sites located in Aceh Besar.

2.2 Sampling procedures

2.2.1 Fish data collection and fish amount calculation

Fish data collection using a belt transect method by visual census [9]. Data collection was carried out along the 16 meters long of GROPOZAG construction with 2.5 meters right and 2.5 meters left (Figure 2). Fish data collection was carried out once a month for 3 months at the highest tide with a depth 2 - 4 m and each observation was done 3 replications.
Fish data collection was using belt transect method

Technical data to record the number of schooling fish to facilitate observer in calculating the number of fish estimated by dividing into 4 parts of the total fish number. The observer only needs to calculate one part of the total number of fish, then the sum of one part multiplied by 4 so the result is the total number of fish seen. Whereas for solitary fish, simply count the number of individual fish that enter the transect area [10]. Figure 3 showed the technically fish counting in the schooling fish.

2.3 Data Analysis

Abundance of Fishes was calculated using the formula as follows [11].

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

(1)

Where, \(X_i\) is Fish abundance (individuals/m\(^2\)), \(N_i\) is the total of Fish (individuals), and \(A\) is transect sampling area (m\(^2\))

The Shannon index of diversity (\(H'\)) is a measure of species weighed by the relative abundance [11]. Shannon index of diversity (\(H'\)) was calculated using the formula:

\[
H' = -\sum_{i=1}^{S} P_i \ln P_i
\]  

(2)

Where, \(H'\) is diversity index, \(P_i\) is the proportion of individuals in the \(i^{th}\) species. Shannon index was used to indicate diversity of fishes at different sampling sites.

Evenness index was calculated by using the formula as follows [12]:

\[
E = \frac{H'}{H_{\max}}
\]  

(3)

Where \(E\) is Evenness index, \(H'\) is diversity index, \(H_{\max}\) is Ln S, and \(S\) is the number of species.
3. Results and Discussions

3.1 Species Composition and Abundance

The results of the present study showed that there are 13 fish species included 9 families in the GROPOZAG construction, Ujung Batee waters, Mesjid Raya subdistrict, Aceh Besar District. The fish composition based on the number of species recorded that Acanthuridae was the highest species composition in the GROPOZAG construction area which was 23%, and followed by Siganidae (15%) and Lutjanidae (15%). The total family composition showed in Figure 4. There were three species of Acanthuridae i.e. Acanthurus auranticavus, Acanthurus triostegus, and Acanthus xanthesperus. A total of 20 types of reef fish from 10 families were found in the waters of Legon Boyo, Karimunjawa, namely Acanthuridae, Apogonidae, Chaetodontidae, Gobidae, Mulidae, Pomacanthidae, Pomacentridae, Serranidae, Scaridae, Siganidae [13]. Acanthuridae characterized as herbivorous fish that were often found and widely distributed in tropical waters [14]. The high percentage of Acanthuridae correlated to algae growth on the surface of GROPOZAG construction. This was supported by the statement of Ghiffar [15], generally herbivorous fish are algae feeders that can affect the abundance of diversity of fish. Moreover, Acanthuridae is mostly classified as an indicator of algae growth in waters.

The results explained that the number of fish species was increasing from January to March 2018. The enhancement was not only in terms of the number of individuals but also in the number of fish families and species in the GROPOZAG construction. The highest fish species were found in March with an abundance average of 166 individuals/80m² while the least abundance of fish was found in January (76 Individuals/80m²) (Table 1).

The most common fish species was Monodactylus argenteus with a total abundance of 124 individuals/80m² during the observation period and the average was 41 individuals/80m² (Table 1). M. argenteus (Monodactylidae) was always found in every observation. According to Kottelat [16] mentioned that Monodactylidae is fish that live in waters near the coast or the estuary area with a depth of 1-12 meters and schooling. Furthermore, M. argenteus is an omnivorous fish (plankton, algae and detritus feeders) [17]. In total, the abundance of fish was 387 individuals/m². High abundance in sampling location was because the environmental supported by water temperature ranged from 29 ºC to 31 ºC, Monodactylus argenteus lives in a tropical climate with temperature ranged from 25 ºC to 32 ºC [17]. These fish is generally solitary and can inflate their bodies as a form of self-defense from predator attacks. According to Setiawan [18], Tetraodontidae family live in the cracks of rocks and open sea waters.

3.2 Percentage of Fish Based on the Type of Food

Most fish species found in GROPOZAG construction were herbivorous (62%), followed by omnivorous (33%) and Carnivorous (5%). Herbivorous fish (62%) in the sampling site was generally as algae feeders. Figure 5 showed the percentage of total number each species according to the type of food.
Table 1. The Average of Fish Abundance in Sampling Area

| Families      | Genus                  | Abundance (individuals/80m²) | Total | Average |
|---------------|------------------------|-----------------------------|-------|---------|
|               |                        | January | February | March    |         |
| Acanthuridae  | Acanthurus auranticavus | 21      | 40       | 42       | 103     | 34      |
|               | Acanthurus triostegus  | 0       | 12       | 5        | 17      | 6       |
|               | Acanthurus xanthopterus| 0       | 6        | 6        | 12      | 4       |
| Carangidae    | Caranx sexfasciatus    | 0       | 0        | 3        | 3       | 1       |
| Chaetodontidae| Chaetodon decussatus   | 0       | 0        | 2        | 2       | 1       |
| Lutjanidae    | Lutjanus rivulatus     | 0       | 6        | 3        | 9       | 3       |
|               | Lutjanus ehrenbergii   | 0       | 0        | 3        | 3       | 1       |
| Monodactylidae| Monodactylus argenteus | 27      | 40       | 57       | 124     | 41      |
| Mulidae       | Parupeneus indicus     | 0       | 0        | 3        | 3       | 1       |
| Pomacentridae | Abudefduf vaigiensis   | 27      | 40       | 36       | 103     | 34      |
| Siganidae     | Siganus vermiculatus   | 0       | 0        | 2        | 2       | 1       |
|               | Siganus javus          | 0       | 0        | 3        | 3       | 1       |
| Tetraodontidae| Arothron manilensis    | 1       | 1        | 1        | 3       | 1       |
| **Total**     |                        | **76**  | **145**  | **166**  | **387** | **129** |

Figure 5. Grouping Fish Found based on food type in Observation site

According to Yuliana [19], the availability of food sources is an important factor for the growth of fish which are generally food sources from algae, mollusk and crustacean. In additional, algae are one of the foods for several species of fish [20]. The high percentage of herbivorous due to an increasing the growth of algae that lives on the GROPOZAG surface construction. The growth of algae is also one of the main factors increasing the number of individual fish in the GROPOZAG construction area.

3.3 Fish Abundance Based on its role In the Ecosystem

The results gained showed that the abundance of major fish was higher than the target fish and indicator fish (Figure 6). The abundance of major fish in the GROPOZAG construction ranged from 55-97 individuals/80m², and the fish target and fish indicator were 6-15 individuals/80m² and 22-55 individuals/80m², respectively. Major fish is a group of common fish that is high in abundance because the major fish are fish that have a clustered life (schooling) [21].
3.4 Biological Indices

The diversity index (Shannon index) has varied from 1.15 to 1.79 indicating medium value. Table 2 showed the average of diversity index and evenness index of fish in sampling location. The highest diversity index (H’) was in March 2018 and classified in the medium category. According to Odum [11], if the diversity index is 1 < H’ < 3 categorized as medium category, the category can explain the fish ecosystem is relatively stable condition. The lowest diversity value was in January 2018 and it classified as medium. Diversity index was increasing every observation due to the number of fish families and species was also increasing from January to March 2018. The increasing value of diversity occurs when the amount of a species increases and is balanced or evenly distributed from individuals in each type [22]. Furthermore, high diversity indicates a stable condition of ecosystem and species diversity is high when in a certain area there are many species found, species diversity being a biological index of the relation between the number of species and the number of individuals [23]. Biodiversity is urgent for the future sustainability of marine natural resources included commercial fisheries [24].

Evenness index (E) explained the distribution number of individuals in each species. The Evenness index ranged from 0.76 to 0.83 classified into high value, it showed that the number of individual each species was equal and there was probably no particular species dominate in study area. Evenness value of 0.75 < E ≤ 1 explained that distribution of species of each individual is evenly distributed and no species dominates [13]. Noor [22] stated that if an ecosystem has a high evenness value, then it is very beneficial in terms of the food chain and space for fish in the ecosystem.

Table 2. The Average of Diversity Index and Evenness Index of Fishes in sampling location

| Biological Indices | Observation Period |
|--------------------|--------------------|
|                    | January  | Category | February  | Category | March     | Category |
| Diversity (H’)     | 1.15     | Medium   | 1.56      | Medium   | 1.79      | Medium   |
| Evenness (E)       | 0.83     | High     | 0.80      | High     | 0.76      | High     |

4. Conclusion

There were 13 fish species included nine families in the GROPOZAG construction. The highest fish abundance was *Monodactylus argenteus* with an average 41 individuals/80m². Most fish species in the Gropozag construction were herbivorous fish (62%), followed by omnivorous and carnivorous were 33% and 5%, respectively. The average of fish abundance was 129 individuals/80m². GROPOZAG construction is an affective as a new habitat for aquatic organisms such as fishes, and structure fish community in study area was stable condition showed medium diversity index and high evenness index.
Acknowledgment
We would like to express our gratitude to the Directorate General of Higher Education through Syiah Kuala University for providing research grant. Our deepest thanks to the local people in study area for their supporting and very good cooperation. Thanks to Maria, Rizki, Safruddin, Yunita for their field work during the research study.

References
[1] Dulvy N K, Sadovy Y, Reynolds J D 2003 Extinction vulnerability in marine population. Fish and Fisheries 4:25-64
[2] Hilborn R, Branch T A, Ernst B, Magnusson A, Minte-Vera C V, Scheuerell M D, Valero J L 2003 State of the world’s fisheries. Annual Review of Environmental Resources 28:359-399
[3] Jalal K C A, Azfar M A, John B A, Kamaruzzaman Y B, Shabbudin S 2012 Pakistan Journal of Zoology 44(1):181-187
[4] Rudi E, Taufiq I, Fadli N, Hidayat 2012 AACL Bioflux 5(5): 309-320
[5] Gomez E D, Yap H T 1984 Monitoring reef condition. In: Coral reef management handbook. Jakarta: Unesco Publisher
[6] Muchlisin Z A, Mauldinin M, Muhammadar A A, Putra D F 2016 Journal of Animal Science 1(2):58-61
[7] Fatimah E, Zourawaty A, Ariff, Ziana 2015 Jurnal Teknik Sipil Unsyiah 125-138, 2088-9321
[8] Fatimah E, Irawan E H 2012 Zig-Zag Shape Porous Groin for Beach Stabilization. 8th International Conference on Coastal and Port Engineering in Developing Countries Copied 2012, Iit Madras, Chennai, India
[9] English S C, Wilkinson, Baker V 1994 Survey manual for tropical marine resources
[10] Rudi E 2011 Ikan Karang Perairan Aceh dan Sekitarnya. Lubuk Agung: Bandung
[11] Odum E P 1971 Fundamental of Ecology .Toppan Company Ltd. M New York
[12] Krebs J C 1972 The Experimental Analysis of Distribution of Abundance. New York: Haper and Row Publisher
[13] Utomo S P R, Ain C, Supriharyono 2013 Diponegoro Journal of Maquares 2(4): 81-90
[14] Sale P F 1991 The Ecology of Fishes On Coral Reefs. Acedemic Press Inc. California
[15] Ghiffar M, Irham A, Harahap A, Kurniawaty S A 2017 SPERMONDE 2(3): 17-24
[16] Kottelat M 2001 Monodactylidae in Charpenter The living marine Resource of the western pacific. FAO Species Identification Guide of Fisheries Purpose. Rome
[17] Allen G R, Midgley S H, Allen 2002 Field guide to the fresh water Fishes of Australia. Western Australia Museum, Pert. Australia
[18] Setiawan F 2010 Identifikasi Ikan Karang dan Invertebrata Laut. Wildlife Conservation Society. Manado
[19] Yuliana E, Mennofatria B, Achmad F, Muklis K M, Efin M 2016 Jurnal penelitian perikanan Indonesia 22(1): 9-16
[20] Putra M I H, Saputra T A, Saputra J 2013 Studi Pengaruh Kesehatan Terumbu Karang Terhadap Biomassa dan kelimpahan Ikan Ekonomis dan Ikan Herbivora Di Taman Nasional Komodo, Kabupaten Manggarai, Nusa Tenggara Timur. Conference Paper
[21] Rani C, Burhanuddin, Atjo A A 2010 Sebaran dan Keanekeagaman Ikan Karang di Pulau Barranglombo: Kaitannya dengan Kompleksitas Habitat. Jurusan Ilmu Kelautan dan Perikanan Unhas.
[22] Noor M O 2013 Biodiversitas Ikan karang Diperaian Ujung Pancu Kabupaten Aceh Besar. Skripsi: Fakultas Kelautan dan Perikanan Universitas Syiah Kuala: Banda Aceh.
[23] Spellerberg I F 1991 Monitoring ecological change. Cambridge University Press, Cambridge, UK, 334 pp
[24] Thaib R, Taufik K N, Dewiyanti I, Sayyid A E, Dedi F P 2017 AACL Bioflux 10(5): 1180-1185