The richness of reef fish community in an environmentally-friendly bioreeftech area of the Staring Bay, Indonesia

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Abstract. The reef fish community is strongly influenced by the artificial reefs as they play an important role in providing a new habitat. The bioreeftech's physical structure and technology serves as a rearing media for planula larvae and as a fishing zone. The objective of the study was to determine the richness of the reef fish community in the area of a nature-friendly bioreeftech in the Staring Bay, South Konawe. Data was collected between June 2018-June 2019, using the Underwater Visual Census (UVC) and the line intercept transect method. Prior to the bioreeftech placement, 69 fish species were identified in the study area, representing 14 families. There was an increase in the number of fish species residing the area after the placement of the bioreeftech: 141 species were identified, representing 24 families and comprising 33 commercial species, 23 indicator species, and 85 major species. Fish richness was dominated by commercial species: *Caesio cuning*, *Siganus vulpinus* and *Ctenochaetus striatus*. The indicator species were dominated by *Chaetodon octofasciatus*, while the major species were dominated by *Pomacentrus smithi*, *Chrysiptera rollandi*, *Chrysiptera springeri* and *Pomacentrus alexanderae*. The biodiversity index and the margalef dominance index were in the range of 1.36-3.23 and 4.74-8.66, respectively. In conclusion, bioreeftech contributed to the coral growth and to the increase of the fish species richness, providing a new habitat in the Staring Bay, South Konawe, Indonesia.
Key Words: reef fish community, diversity, abundance, artificial reef, bioreeftech.

Introduction. Starring Bay is one of the most valuable natural resources in South Konawe, SE Sulawesi, Indonesia. It sits geographically in 4°02'40"-4°08'53" South and 122°40'03"-122°48'02" East. The bay plays a critical role for communities around the area. Administratively, there are three sub-districts surrounding Staring Bay i.e. North Moramo, Moramo and Laonti. The area is composed of some ethnic groups residing along the bay, including: Bajonese, Tolakinese, Munanese and Butonese, and whose livelihoods depend on fishing and aquaculture (Nadia et al 2018).

In addition, Starring Bay is central to the marine culture activities, like seaweed and grouper farming, and for demersal fish catching. This area is also prone to natural disasters such as: cyclones, the issue of sea silting due to sedimentation, waves and sea level rise. Some residential activities have been destructive to corals and to the coastal condition, such as bombing or the use of potassium cyanide for fishing, and the reef exploitation for home construction and lime manufacturing. Such activities led to the coastal degradation, contributed to the destruction of the coral ecosystem and lowered the residents' income from fishing activities by up to 40% (Rahman & Mansyur 2016).

Coral reefs are widely used by marine organisms as food supply areas, development areas, foster and protected areas (Supriharyono 2007). However, in recent

years, coral reefs are being threatened by human activity. Rapid development in coastal area, environmentally unfriendly and destructive fishing have caused the degradation of these habitats. The increasing CO_2 has additionally caused increasing sea surface temperature which could trigger some environmental impacts such as sea level rise and more frequent coral bleaching (Wilkinson 2008). Bleaching of coral and destructive fishing has caused extensive loss of coral reefs, which reached 54.2% (Palupi et al 2012).

Nadia et al (2016) stated that coral cover in Staring Bay ranged from 32 to 35.4%. This value has an impact on the reef fish ecology index. Adrim (2012) also stated that the condition of coral substrate correlates with the presence of reef fish.

Research on the existence of fish in coral reef areas has been widely carried out. Many scientists always try to develop new technique for coral reef rehabilitation through an artificial reef. Research studies already reported on: the abundance of reef fish in artificial coral reefs (Risamasu 2003), the effect of the existence of artificial coral reefs (Mulatsih 2004), the development of reef fish community structure (Yunaldi et al 2011), the fish community related to 3 artificial modules (Yanuar & Aunurohim 2015), the fish preserving with artificial corals (Mujiyanto & Hartati 2016) and the nocturnal fish community structure (Prasetya 2016). However, information about the species richness in the bioreeftech area have not yet been reviewed.

Bioreeftech is a type of artificial reef, a green technology that utilizes natural materials (coconut shell) as a medium for attachment of coral planula larvae to form new colonies or coral reefs (Research Center for Marine and Observation 2016). The objective of this study was to determine the richness of reef fish community in the bioreeftech artificial reef area in Staring Bay, South Konawe Indonesia.

Material and Method

Data collection. Staring Bay is located at coordinates 122^{0}40 '52.5 E and 04^0 01' 31.4" S (Figure 1). Data was collected for 1 year, from June 2018 to June 2019. The placement area of the bioreeftech is around 10,000 m^2. Three categories of reef fish species were collected: commercial, indicator and major. Their presence was an indicator of the success of bioreeftech as a new habitat and a fish bank area. Data were collected according to the Underwater Visual Census (UVC), using the 50 m line intercept transect method developed by UNEP (1993). Photographic recording of reef fish was also applied in each location. The recorded fish species were then identified by referring to Allen et al (2003), Allen (1997), Myers (1991), Randall et al (1996), Kuiter & Tonozuka (2001).

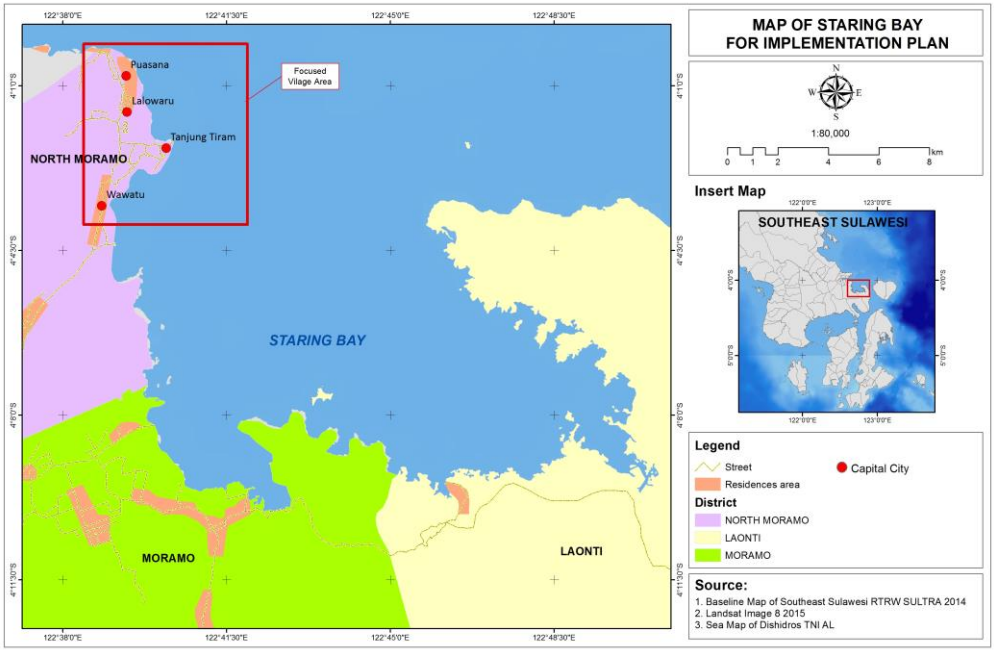

Figure 1. Map of study location.

Data analysis. The parameters observed were species composition, fish abundance, diversity index (H), uniformity index (E) and dominance index (D). Species composition refers to Greenberg (1992):

$$SC = \frac{ni}{N} 100\%$$

Where:
SC - species composition;
Ni - number of individuals per species;
N - total number of individuals.

The abundance of an organism can be expressed as the number of individuals per area (Odum 1993). Fish abundance was calculated by the formula:

$$A = \frac{Xi}{ni}$$

Where:
A - individual abundance (ind m^{-2});
Xi - number of individuals of the i^{th} species;
Ni- number of quadrants of i^{th} species.

The diversity index (H) was calculated by using the Shannon-Wiener equation (Odum 1993):

$$H' = -\sum_{i=1}^{s} Pi \ln Pi$$

Where:
H` - Shannon-Wiener diversity index;
Pi - number of proportion of the individual species i to the number of individuals;
Total Pi = ni/N, with ni - number of species-i, N - total species.

The range of reef fish diversity indexes are: H<1 (low species diversity category), 1.0<H'<3.0 (medium species diversity category), and H>3.0 (high species diversity category). The uniformity index (E) value indicates the uniformity and evenness of the species mutual distribution. The uniformity index formula (E) was calculated using the evenness index (Odum 1993):

$$E = \frac{H'}{lnS}$$

Where:
E - uniformity index;
H - diversity index;
S - number of species;
ln - natural logarithm.

The dominance index (C) is used to determine the dominance of one species of fish in the area. If the dominance index is 0, it means that there are almost no species which dominate the population. If the dominance index value approaches 1, it means that there was one type of reef fish dominates the population. The dominance index is calculated by the index formula (Odum 1993):

$$C = \sum \left(\frac{ni}{N}\right)^2$$

Where:
C - index of dominance;
ni - number of individuals of each species;
N - number of individuals of all species.

Results

Species composition and abundance. Prior to the placement of bioreeftech, 69 fish species were identified in the study area, representing 14 families. There was an increase in the number of fish residing the area after the bioreeftech placement. 141 species were identified, representing 24 families. The fish community comprised 33 commercial

species, 23 indicator species, and 85 major species. This research also defined a cluster of 25 species of economical importantanceand a cluster of 116 species of non-economic importantance, in the bioreeftech artificial reef. The food/commercial group of fish was dominated by *Caesio cuning*, *Siganus vulpinus* and *Ctenochaetus striatus* species. The most dominant species in the indicator fish group was *Heniochus singularius*. The dominant species in the major group were *Cheilodipterus isostigmus*, *Pomacentrus smithi*, *Chrysiptera rollandi*, *Dischistodus prosopotaenia*, *Dascyllus aruanus* and *Pomacentrus alexanderae*. Species composition and abundance of reef fishes in the bioreeftech artificial reef was presented in Table 1.

Table 1

Species composition and abundance of commercial fish in the bioreeftech

Family	*Species*	*Abundance (Ind)*	*Species composition (%)*
Acanthuridae	*Acanthurus lineatus*	32	4.0
	Acanthurus pyropherus	23	2.8
	Acanthurus thompsoni	13	1.6
	Ctenochaetus cyanocheilus	21	2.6
	Ctenochaetus striatus	98	12.1
	Naso lituratus	5	0.6
	Naso brevirostris	5	0.6
	Zebrasoma veliferum	18	2.2
Caesionidae	*Caesio cuning*	121	15.0
	Caesio xanthonota	26	3.2
Haemulidae	*Plectorhinchus chaetodontoides*	21	2.6
	Plectorhinchus goldmanni	17	2.1
	Plectorhinchus lessonii	7	0.9
Labridae	*Coris batuensis*	33	4.1
	Pteragogus guttatus	18	2.2
Lutjanidae	*Lutjanus biguttatus*	23	2.8
	Lutjanus quenquelineatus	27	3.3
	Macolor macularis	11	1.4
Mullidae	*Parupeneus barberinus*	32	4.0
	Parupeneus multifasciatus	16	2.0
Nemipteridae	*Pentapodus trivittatus*	12	1.5
Scaridae	*Chlorurus ble ekeri*	12	1.5
	Scarus bicolor	12	1.5
Serranidae	*Anyperodon leucogramicus*	20	2.5
	Cephalopholis boenak	8	1.0
	Cephalopholis cyanostigma	12	1.5
	Cephalopholis miniata	3	0.4
	Epinephelus merra	21	2.6
	Epinephelus coralticola	4	0.5
	Epinephelus sexfasciatus	2	0.2
	Variola albomarginata	3	0.4
Siganidae	*Siganus javus*	8	1.0
	Siganus puellus	21	2.6
	Siganus punctatissimus	12	1.5
	Siganus virgatus	5	0.6
	Siganus vulpinus	87	10.8
Total		809	100.0

Indicator fish. The highest value in indicator species composition was calculated for *Parachaetodon ocellatus*: 15.4%, with an abundance of 18 individuals, while the lowest

value, of 0.9%, was found in 6 species, namely: *Chaetodon lineolatus*, *Chaetodon vagabundus*, *Chaetodon baronessa*, *Chaetodon ornatissimus*, *Chaetodon unimaculatus* and *Coradion altivelis* (1 individual for each solitary species). The indexes for the indicator fish group were presented in Table 2.

Table 2

Species composition and abundance of indicator fish in in the bioreeftech

Family	*Species*	*Abundance (Ind)*	*Species composition (%)*
Chaetodontidae	*Chaetodon octofasciatus*	2	1.7
	Chaetodon trifasciatus	3	2.6
	Chaetodon kleinii	9	7.7
	Chaetodon lineolatus	1	0.9
	Chaetodon melannotus	9	7.7
	Chaetodon ocellicaudus	4	3.4
	Chaetodon auriga	11	9.4
	Chaetodon adiergastos	2	1.7
	Chaetodon vagabundus	1	0.9
	Chaetodon baronessa	1	0.9
	Chaetodon ornatissimus	1	0.9
	Chaetodon unimaculatus	1	0.9
	Chaetodon vagabundus	5	4.3
	Chelmon rostratus	2	1.7
	Coradion altivelis	1	0.9
	Coradion chrysozonus	2	1.7
	Forcipiger flavissimus	6	5.1
	Forcipiger longirostris	5	4.3
	Heniochus chrysostomus	9	7.7
	Heniochus varius	11	9.4
	Heniochus singularius	12	10.3
	Heniochus acuminatus	1	0.9
	Parachaetodon ocellatus	18	15.4
	Total	117	100.0

Major fish. 85 major fish groups from 11 families were recorded. The most important families were *Apogonidae* (8 species), *Balistidae* (4 types), *Bennidae* (4 types), *Gobidae* (8 types), *Centricidae* (3 types), *Holocentridae* (7 types), *Pomacentridae* (36 types), *Scaridae* (6 types), *Tetraodontidae* (5 types) and *Zanclidae* (4 types). *Dischistodus perspicillatus* from the *Pomacentridae* family wasdominant, with a total abundance of 96 individuals and a species composition 13.9%.

Table 3

The number of species for each family of major fish groups at the bioreeftech

Family	*Number of type*	*Number of individuals*
Apogonidae	8	1,021
Balistidae	4	98
Blennidae	4	456
Gobidae	8	120
Centricidae	3	30
Holocentridae	7	77
Pomacentridae	36	2,076
Scaridae	6	89
Tetraodontidae	5	98
Zanclidae	4	43
Total	85	4,108

The number of species for each family of major fish groups at the bioreeftech area was presented in Table 3. Furthermore, the species composition and abundance, based on the number of individuals of the dominant fish species, were presented in Table 4.

Table 4

Species composition and abundance of major fish in the bioreeftech

Species	*Abundance (Ind)*	*Species composition (%)*
Cheilodipterus isostigmus	512	12.5
Pomacentrus smithi	406	9.9
Chrysiptera rollandi	387	9.4
Dischistodus prosopotaenia	289	7.0
Dascyllus aruanus	287	7.0
Pomacentrus alexanderae	211	5.1
Chrysiptera springeri	112	2.7
Meiacanthus grammistes	111	2.7
Amblyglyphidodon leucogaster	103	2.5
Chromis ternatensis	98	2.4
Other types (75 types)	1,592	38.8
Total	4,108	100

The monthly increase of the number of commercial (target fish), indicator and major s of species can be seen in the Figure 2.

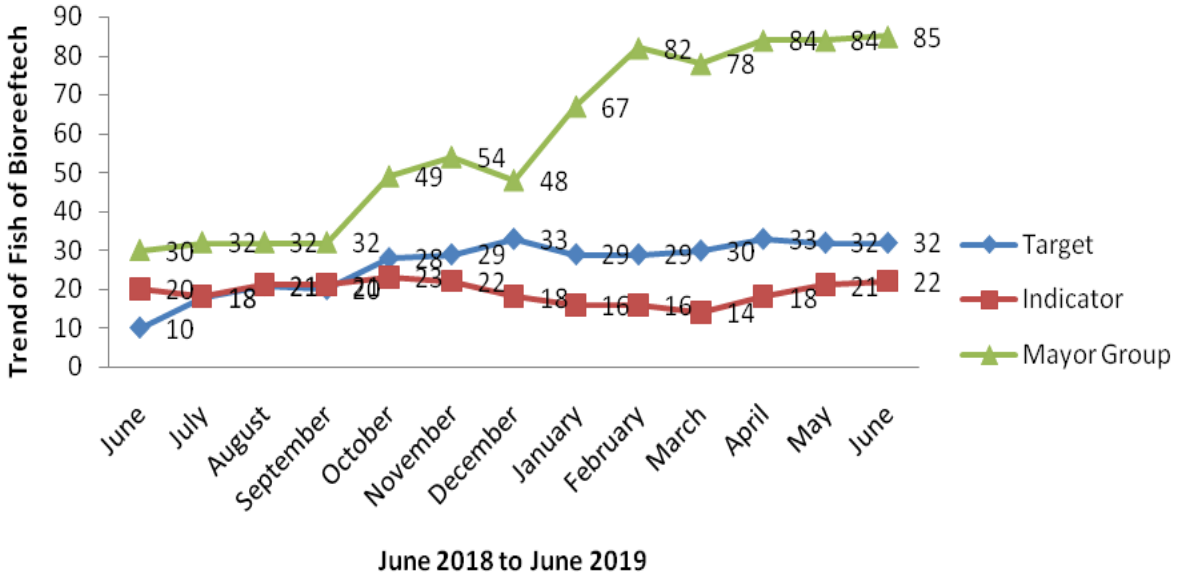

Figure 2. The increase of the number of species in each month, from June 2018 to June 2019.

Diversity index (H), uniformity index (E) and dominance index (D). The diversity, uniformity and dominance indexes showed the richness of the species and the balance of the distribution of the number of individuals for each (Odum 1971). The results of analysis for the diversity index (H'), uniformity index (E) and dominance index (D) of reef fish found during the study at the bioreeftech artificial reef area can be seen in Figure 3.

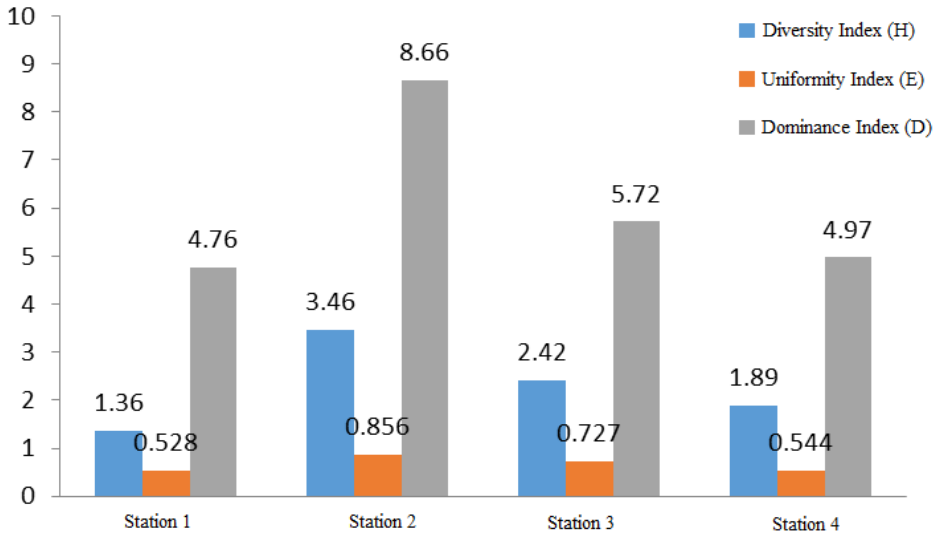

Figure 3. Diversity index (H'), uniformity index (E) and dominance index (D) of the reef fish found at the bioreeftech artificial reef area.

Discussion. Based on the results, the commercial fish group at the bioreeftek artificial reef area consisted of the following families: *Acanthuridae* (8 species), *Caesionidae* (2 species), *Haemulidae* (3 species), *Labridae* (2 species), *Lutjanidae* (3 species), *Mullidae* (2 species), *Nemipteridae* (2 species), *Scaridae* (2 species), *Serranidae* (8 species), and *Siganidae* (6 species), and it was relatively larger, compared with the research of Adrim et al (2012) on the natural habitats in Kendari Seawaters, with 31 species from 11 families. A commercial reef fish family commonly found in coral reef areas was the Lutjanidae: it was also found in Bunaken Marine Park, with 13 species (Makatipu et al 2010), in Wetar (unexploited area), with 14 species (Adrim 2007), and on Enggano Island (exploited area) with 9 types (Adrim 2007). In the current study, the species composition and their abundance was relatively higher, compared to other researches.

The species from the Serranidae family, recorded at the study site, were generally still of the size of tillers. Based on this research, the *C. cuning*, an indigeneus species of the coral reefs, had various sizes, ranging from tillers to the suitable size for consumption. Within the economically important clusters, the commercial species found at the study site were: *C. cuning*, grouper fish (*Epinephelus merra*, *Epinephelus sexfasciatus*, *Cephalopholis cyanostigma* and *Variola albomarginata*), *Siganus virgatus*, and *Lutjanus biguttatus* (snapper). These species of reef fish have commonly been used by fishermen for local consumption and were traded locally. Nadia et al (2016) showed that the economically important cluster of reef fish, such as groupers and snappers, was found in the coral reef area in Tobea Island, with a species composition 16.4-18.9%. Besides, *C. cuning* has also been used for trade purposes, at both consumption and seed sizes. The existence of the bioreeftech greatly contributed to for the abundance of reef fish, especially of the economically important clusters of fish.

The number of indicator species at the study site was very high, due to the location of the bioreeftech close to natural coral reefs of different conditions (damaged, moderate and good). Palupi et al (2012) stated that indicator fish were generally found in damaged coral areas and had a high tolerance, being able to adapt to various coral reef habitat conditions because of their omnivorous feeding characteristic. Adrim (2011) stated that the *Chaetodontidae* family had strong associations with corals and can be used as indicators of coral health. Froese et al (2008) stated that the number of individuals from the *Chaetodontidae* family can be used as indicators for artificial reef areas. *Chaetodontidae* family was coral corallite-eating fish. This fish group was a family of reef fishes which often found in Indo-Pacific Seawaters (Kulbicki et al 2005).

Generally, the major fish species have small-sized phenotypes, being commonly used as ornamental fish. The semi-quantitative recording was applied to record this fish group, due to its schooling characteristic. Arham (2013) stated that the number of major

fish has the highest abundance, their high composition being normal in coral reef areas. This group was dominant, both the in the number of species and abundance. The diversity index of the reef fish observed at each research station ranged from 1.36 to 3.46. The highest diversity index was found at station 2 (Lalowaru Village) with 3.46 while the lowest found at station 1 (Puasana Village) with 1.36, indicating either stable conditions or a moderate diversity. The uniformity index illustrated whether the distribution of the individuals of each species was balanced and ranged from 0.528 to 0.856, at all locations (Figure 3). The dominance index of reef fish species ranged from 4.76 to 5.72. These values were classified as moderate. The three index of reef fish communities indicated that the diversity of reef fish was quite diverse. The uniformity index values range from 0 to 1, a value approaching 0 indicates a higher density of certain species, in number of individuals (Setyobudiandi et al 2009).

In this study, the number of individuals in each species was quite similar. Fachrul (2007) stated that if the uniformity index is relatively high, the species of fish in seawaters is equally distributed. Purwanti (2004) also stated that the availability of food for reef fish in their habitat greatly affects the level of competition between species. In the current research, the low dominance index value was caused by a high food availability, therefore all fish species can grow well. An increasing number of reef fish populations, suggested a sustainable environment in the bioreeftech area. The indicators had a positive correlation with the environmental quality.

Conclusions. Prior to the placement of bioreeftech, 69 fish species were identified in the study area, representing 14 families. The number of fish species residing in the area significantly increased after the bioreeftech installation, reaching 141 species, which represented 24 families. The species richness of the commercial category (target fish) was dominated by *C. cuning*, *S. vulpinus* and *C. striatus*. The dominant fish species of the indicator category was *C. octofasciatus* while the dominant species of the major category were *P. smithi*, *C. rollandi*, *C. springeri* and *P. alexanderae*. The diversity index values ranged from 1.36 to 3.23 and the dominance index ranged from 4.74 to 8.66. The Staring Bay bioreeftech was validated as an appropriate habitat for reef fish species.

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Conflict of interest. The authors declare no conflict of interest.

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