Research Article
Turkish Journal of Maritime and Marine Sciences

DOI: 10.52998/trjmms.1705965
Volume: XX Issue: XX (20XX) XX-XX

Impact of Bioreef Block Application on Coral Fish Community Structure in Tanjung Seloka Waters, Kotabaru, South Kalimantan Indonesia

Endonezya, Güney Kalimantan, Kotabaru, Tanjung Seloka Sularında Biyoreef Blok Uygulamasının Mercan Balık Topluluğu Yapısına Etkisi

Türk Denizcilik ve Deniz Bilimleri Dergisi

Cilt: XX Sayı: XX (20XX) XX-XX

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ABSTRACT

The Tanjung Seloka Sea waters, located in Pulau Laut Selatan District, Kotabaru Regency, South Kalimantan, serve as one of the selected locations for the application of Bioreef Block technology by PT State Electricity Company (Persero) East Kalimantan Development Unit. This innovation functions as a substrate for coral planula larval attachment and provides shelter for reef fish, utilizing Fly Ash and Bottom Ash as environmentally friendly construction materials. The objective of this study was to analyze the structure of the coral fish community associated with the Bioreef Block in the Tanjung Seloka waters. Data collection was conducted using the Underwater Visual Census (UVC) method. Research variables included fish species abundance, diversity, evenness, dominance, and water quality parameters such as temperature, salinity, pH, dissolved oxygen (DO), current velocity, brightness, and depth. In-situ measurements were carried out to obtain accurate environmental data. Findings indicated a notable increase in fish abundance and species richness following the installation of Bioreef Block. The target fish group was dominant, comprising 10 groups, followed by one major group and one indicator group, resulting in a total abundance of 3,160 individuals. Despite a low diversity index (H'), which suggests environmental stress, the high evenness index (E') reflects a stable fish community. Favorable environmental parameters also supported the success of the Bioreef Block in enhancing reef fish habitat and sustainability.

Keywords: Bioreef block, Coral fish, Structure, Tanjung seloka

Article Info
Received: 25 May 2025
Revised: 02 July 2025
Accepted: 07 July 2025

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To cite this article: Tony, F., Muhammad, M.M., Iskandar, R., Firzatullah, M. (20XX). Impact of Bioreef Block Application on Coral Fish Community Structure in Tanjung Seloka Waters, Kotabaru, South Kalimantan Indonesia, *Turkish Journal of Maritime and Marine Sciences*, XX (XX): XX-XX. doi: 10.52998/trjmms.1705965.

ÖZET

Güney Kalimantan, Kotabaru Naipliği, Pulau Laut Selatan Bölgesi'nde bulunan Tanjung Seloka Denizi suları, PT Devlet Elektrik Şirketi (Persero) Doğu Kalimantan Geliştirme Birimi tarafından Bioreef Block teknolojisinin uygulanması için seçilen yerlerden biri olarak hizmet vermektedir. Bu yenilik, mercan planula larvalarının tutunması için bir alt tabaka görevi görüyor ve resif balıkları için barınak sağlıyor; çevre dostu yapı malzemeleri olarak Uçan Kül ve Dip Külü kullanılıyor. Bu çalışmanın amacı Tanjung Seloka sularında bulunan Bioreef Block'a bağlı mercan balığı topluluğunun yapısını analiz etmektir. Veri toplama işlemi Sualtı Görsel Sayımı (UVC) yöntemi kullanılarak gerçekleştirilmiştir. Araştırma değişkenleri arasında balık türlerinin bolluğu, çeşitliliği, dengeliği, baskınlığı ve sıcaklık, tuzluluk, pH, çözünmüş oksijen (DO), akıntı hızı, parlaklık ve derinlik gibi su kalitesi parametreleri yer almaktadır. Doğru çevresel verilerin elde edilmesi amacıyla yerinde ölçümler yapılmıştır. Bulgular, Bioreef Block'un kurulumunun ardından balık bolluğunda ve tür zenginliğinde belirgin bir artış olduğunu göstermiştir. 10 hedef türün baskın olduğu tespit edilmiştir. Bunları bir ana grup ve bir indikatör grub takip etmiş olup, toplam 3.160 bireylik bollukla tespit edilmiştir. Düşük çeşitlilik indeksi (H') çevresel stresi gösterirken, yüksek eşitlik indeksi (E') istikrarlı bir balık topluluğunu yansıtır. Uygun çevresel parametreler de Bioreef Block'un resif balıklarının yaşam alanlarını iyileştirme ve sürdürülebilirliğini sağlamadaki başarısını desteklemiştir.

Anahtar sözcükler: Bioreef bloğu, Mercan balıkları, Yapı, Tanjung seloka.

1. INTRODUCTION

Tanjung Seloka is a village in Pulau Laut Selatan District, Kotabaru Regency, South Kalimantan Province, which is geographically located in the south of Kotabaru Regency and one of the many villages located at the tip of the mainland of Pulau Laut. Administratively, Tanjung Seloka village is divided into two areas, namely North Tanjung Seloka and South Tanjung Seloka. The location is far from the center of government of Kotabaru Regency, especially from the center of government of South Kalimantan Province, making this village rarely a topic of attention in environmental research issues (Tony *et al.*, 2021). This is also due to the fact that access to Tanjung Seloka village is not easy, apart from the long distance, also the inadequate road conditions. Researchers from universities and others are rarely interested in conducting research there and this results in little information being available, especially from the coastal environment and marine resources sector.

The Tanjung Seloka Sea waters, are one of the locations selected by PT State Electricity Company (Persero) East Kalimantan Development Main Unit for the implementation of Bioreef Block technology in 2024. This technology functions as a medium for attaching coral planula larvae as well as a habitat for reef fish, using basic concrete blocks from Fly Ash and Bottom Ash (FABA) waste. Bioreef Block itself is a green technology-based media that utilizes natural materials such as coconut shells, and is designed in the form of a hollow cube frame that functions as a shelter for fish (Tony *et al.*, 2021).

The application of Bioreef Block technology is also in line with the importance of understanding the condition of marine ecosystems as a whole in order to ensure sustainable use of marine resources and protection of their existence from various environmental threats (Coralwatch, 2011). The results of this method will strengthen understanding of the dynamics of coral reef ecosystems, and become the basis for designing management policies based on scientific data (Oktarina *et al.*, 2014). This approach is expected to support sustainable conservation efforts by considering the overall condition of the ecosystem and its potential for recovery through environmentally friendly technological interventions.

The purpose of this research is to analyze the structure of the fish community in the Bioreef Block in the waters of Tanjung Seloka Sea so that it is expected to provide more benefits to the community, especially fishermen, as a medium of information and support conservation efforts and sustainable management of marine resources in Kotabaru Regency, especially in Tanjung Seloka Village, as well as increase public awareness of the importance of coral reef conservation and environmentally friendly fishing.

2. MATERIALS AND METHODS

The research was conducted in the Tanjung Seloka Sea Waters in Pulau Laut Selatan District, Kotabaru Regency, South Kalimantan Province. The location of the coral fish research is based on the location of the Bioreef Block at a depth of 6-8 meters. The following is a map of the research location (Figure 1).

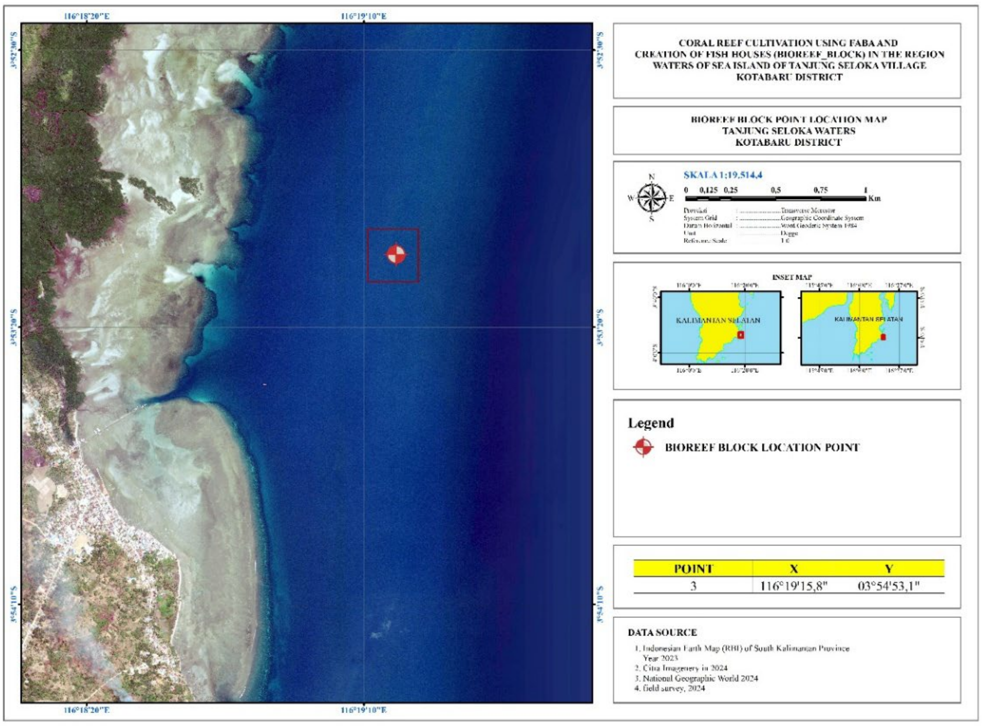

Figure 1. Map of Research Location

2.1. Data Collection Method

The method of collecting coral fish data (monitoring) used the Underwater Visual Census method over a period of 6 months which is one of the methods developed to monitor living coral fish in a coral reef location in an easy way and in a short time to estimate the coral fish community (English *et al.*, 1997). The research material includes analysis of species abundance, diversity, uniformity, dominance of coral fish and water quality in the Tanjung Seloka Sea waters. Data to be obtained in-situ include the following parameters: reef fish (underwater visual census using snorkeling or SCUBA), temperature (measured using a digital thermometer or water quality multiparameter probe), salinity (refractometer or conductivity meter), pH (pH meter), dissolved oxygen/DO (DO meter), current (current meter or drogues), brightness (Secchi disc), and depth (depth meter or portable depth gauge).

2.2. Data Analysis Method

2.2.1. Abundance of Coral Fish

The abundance of coral fish was calculated using the equation below (English *et al.*, 1997):

$$N = \frac{n_i}{A} \quad (1)$$

Description:

N is the abundance of fish (individual/m^2)
n_i is the number of individuals I; and
A is the area (m^2)

2.2.2. Diversity Index (*H'*)

The diversity index is calculated using the criteria according to Brower and Zar (1977):

$$H' = \sum_{i=1}^{s} p_i \ln p_i \quad (2)$$

Description:
H' = diversity index.
s = number of reef fish species.
p = proportion of individuals in reef fish species.
a. $H' \leq 2.30$: low diversity, very strong environmental pressure.
b. $2.30 < H' \leq 3.30$: moderate diversity, moderate environmental pressure
c. $H' > 3.30$: high diversity, ecosystem balance occurs

2.3. Uniformity Index (*E*)

$$E = \frac{H'}{H_{\max}} \quad (3)$$

Description:
E = uniformity index
H_{max} = species balance in maximum equilibrium = ln s
The index value ranges from 0 – 1 with the criteria (Brower & Zar, 1977):
• $E \leq 0.4$: low uniformity, stressed community
• $0.4 < E \leq 0.6$: moderate uniformity, unstable community
• $E > 0.6$: high uniformity, stable community

2.4. Dominance Index (*C*)

$$C = \sum_{i=1}^{s} p_i^2 \quad (4)$$

Description:
C = dominance index
p_i = proportion of the number of individuals in a coral fish species
s = number of coral fish species

Odum (1993) the dominance index value ranges from 0-1 with the criteria that if the dominance index approaches zero it means that there is no species that dominates the station or is in a stable state, if the dominance index approaches 1 then there is a species that dominates the station or the state is unstable.

3. RESULTS

Bioreef Block is an innovation in coral reef rehabilitation efforts designed to provide a place or home for fish. Analysis of the impact of Bioreef Block on abundance, diversity and uniformity and dominance. The results of the research conducted in general showed that the largest group of fish was from the target fish group, namely 10 groups consisting of Caesionidae (3 Species), Centriscidae (1 Species), Diodontidae (1 Species), Haemulidae (1 Species), Latidae (1 Species), Lutjanidae (2 Species), Nemipteridae (1 Species), Serranidae (1 Species), Siganidae (1 Species), Tetraodontidae (1 Species), (1 Species), while for the manor fish and indicator fish groups, there is still 1 (one) Group each, namely Pomacentridae (1 Species) and Chaetodonthidae (1 Species) with a total abundance of 3160 individuals. The abundance and presence of individual fish in each monitoring can be seen in Table 1.
Significant fish abundance after 1 month since the initial placement of Bioreef Block in October 2024, namely from 0.17 ind/m2 to 4.15 ind/m2 on average in December 2024, which can be seen in Figure 2.

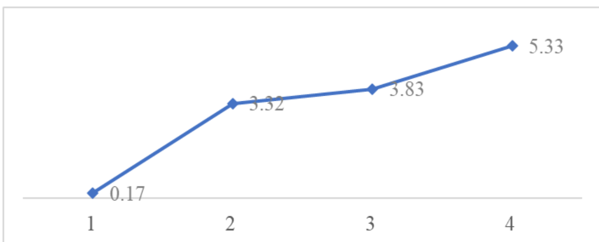

Figure 2. Abundance of individuals/m^2 in each monitoring.

Table 1. Abundance and presence of individual fish at each monitoring.

No	Name of tribe and type of fish	Monitoring				Abundance
		1	2	3	4	
I	Major group					
	Pomacentridae					1015
	Neoglyphidodon nigroris	13	98	82	109	
	Neopomacentrus taeniurus	4	112	93	125	
	Plectroglyphidodon imparipennis	-	134	113	132	
II	Target species					
	Caesionidae					798
	Caesio teres	9	102	131	158	
	Caesio cuning	-	47	48	92	
	Caesio xanthonota	4	58	62	87	
	Centriscidae					59
	Aeoliscus strigatus	-	14	18	27	
	Diodontidae	-				26
	Diodon holocanthus	-	7	7	12	
	Haemulidae					208
	Plectorhincus picus	-	54	69	85	
	Latidae					162
	Late calcarifer	-	33	57	72	
	Lutjanidae					147
	Lutjanus lemniscatus	-	13	17	44	
	Lutjanus sebae	-	6	14	53	
	Nemipteridae					204
	Scolopsis affinis	6	37	49	112	
	Serranidae					150
	Platax boersii (Golden Spadefis - Juvenile)		31	52	67	
	Siganidae					155
	Siganus javus (baronang)	3	47	59	46	
	Tetraodontidae					88
	Arothron immaculate	-	17	28	43	
III	Species indicators					
	Chaetodonthidae					148
	Chaetodon octofasciatus	3	-	21	32	
	Chelmon rasstratus	-	11	19	24	
	Heniochus acuminatus	-	8	18	12	
				Total		**3160**

Addition of the number of individuals and the number of species in each monitoring, in Figure 3 below. The number of fish and the number of species that are different at all observation times, both major fish categories, target fish, or indicator fish except for the 3rd and 4th monitoring which have the same number of species, namely 19 species. The 4th monitoring has the highest number of 1332 individuals with 19 species, while when the Bioreef Block was just placed, namely the 1st monitoring, there were only 42 individuals with 7 species.

The results of the Diversity Analysis (H), Uniformity (E) and Dominance Index (C). The results of the analysis of diversity (H), uniformity (E) and dominance index (C) with reference to the respective criteria values can be concluded that at the location where the Bioreef Block is located there is low diversity with very strong environmental pressure, but has high uniformity and a stable community with no dominant fish species at the Bioreef Block location. This is in line with previous research on the effectiveness of Bioreef Block technology on the diversity of coral fish in the marine waters of Sungai Cuka Village, Kintap Regency, Tanah Laut Regency, South Kalimantan Regency, that there was an increase in fish abundance at each data collection, as well as a small diversity index value (H') with very strong environmental pressure, but at each observation there was an increase in diversity. The uniformity index (E) before the presence of Bioreef Block was small with a depressed community, but after the presence of Bioreef Block in the first month there was a moderate increase in uniformity, with a non-labile community, and in the following month of observation there was high uniformity with a stable community. Dominance index (C) of coral fish, there are no dominant fish criteria. (Tony *et al*., 2021).

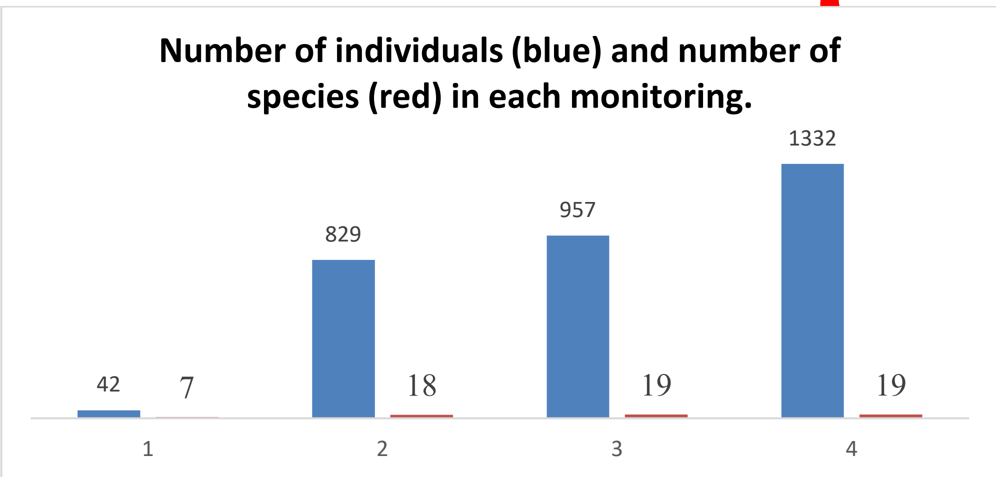

Figure 3. Number of individuals (blue) and number of species (red) in each monitoring.

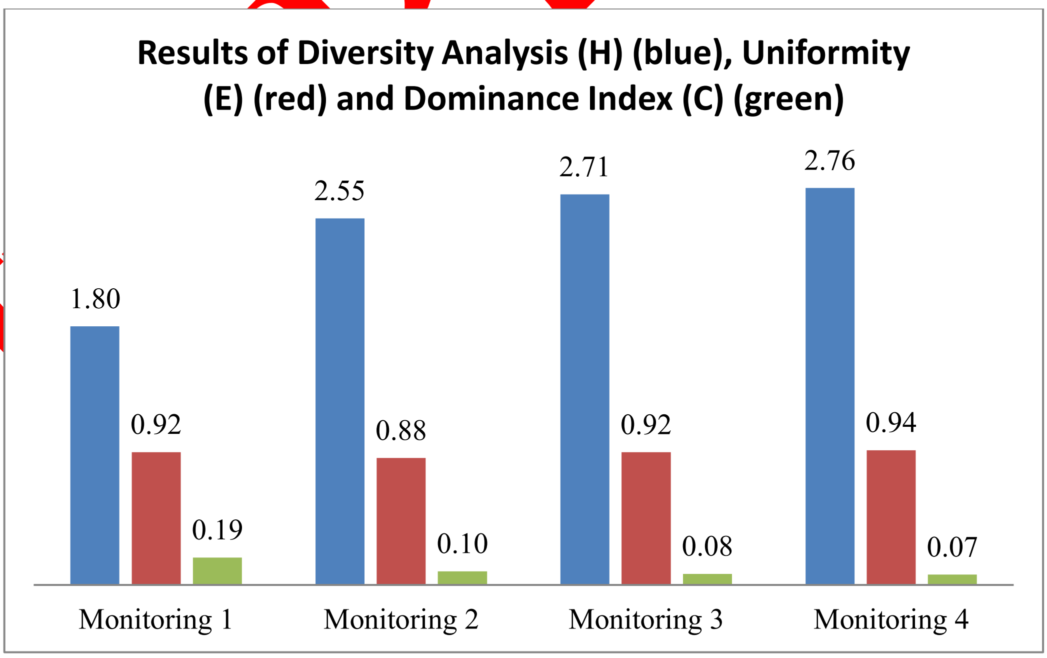

Figure 4. Results of Diversity Analysis (H) (blue), Uniformity (E) (red) and Dominance Index (C) (green)

Table 2. Criteria values for Diversity (H), Uniformity (E) and Dominance Index (C)

Monitoring	Diversity		Uniformity		Dominance	
	Value H'	Value Criteria	Value E'	Value Criteria	Value C'	Value Criteria
1	1.80	Low diversity, very strong environmental pressure	0.92	High Uniformity, Stable Community	0.19	No dominant type
2	2.55	Low diversity, very strong environmental pressure	0.88	High Uniformity, Stable Community	0.10	No dominant type
3	2.71	Low diversity, very strong environmental pressure	0.92	High Uniformity, Stable Community	0.08	No dominant type
4	2.76	Low diversity, very strong environmental pressure	0.94	High Uniformity, Stable Community	0.07	No dominant type

3.1. Physical and Chemical Parameters of Water

The physical parameters of the waters observed in the waters where the Bioreef Block is located are Temperature, Brightness and Current where the Average Temperature in the water area ranges from 30.1 °C to 30.6 °C and for the brightness parameter ranges from 4 meters to 8 meters while for the current speed parameter ranges from 0.0075 m/s to 0.0083 m/s. Chemical parameters that Salinity is in the range of 36 ‰ to 40 ‰, the acidity parameter (pH) ranges from 7.3 to 8.4 and for dissolved oxygen in water (DO) is in the range of 6.5 (mg/l) to 8.3 (mg/l).

Table 3. Results of Water Physics and Chemistry

Parameter	Monitoring to - Sampling time (WITA)			
	1	**2**	**3**	**4**
	14.29	15.34	14.39	15.08
Temperature °c	30.3	30.1	30.6	30.6
Brightness (m)	8	4.5	5	4
Current Speed (m/s)	0.0075	0.0077	0.0076	0.0079
pH	7.01	6.9	6.57	7.14
DO (mg/l)	5.4	5.2	5.5	5.3
Salinity (‰)	27.5	28.4	27.7	28.1

4. DISCUSSIONS

The installation of Bioreef Block in Tanjung Seloka waters has a significant positive impact on the abundance, number of species, and diversity of reef fish. Data shows that fish abundance increased sharply from an average of 0.17 individuals per square meter at the beginning of installation (October 2024) to 4.15 individuals per square meter within two months (December 2024). The number of fish species also increased from 7 to 19 species, indicating a positive ecological response from the fish community to the presence of this artificial structure. Nybakken (2000) stated that fringing reefs that develop in shallow waters near the coast provide optimal habitat for various types of fish and other marine biota. The Bioreef Block structure functions to resemble a natural habitat, providing shelter, feeding areas, and reproductive space for reef fish.

The ecological conditions at the research location, which are dominated by sand and mud substrates at depths of more than 8 meters, cause the growth of hard corals to be very limited. The installation of Bioreef Block is a relevant solution in enriching habitat structures in areas with low hard coral cover. The live coral cover in Tanjung Seloka waters only reached 46.38%, which is categorized as moderate and indicates ecological pressure that needs to be mitigated immediately. The dominance of massive and encrusting coral species at this location indicates coral adaptation to water conditions that may have experienced physical disturbance or environmental degradation. The condition of coral cover ranging from moderate to good has also been reported by Tony *et al*. (2025), which emphasizes the importance of continuous monitoring to maintain the stability and function of coral reef ecosystems. The coral cover status in Tanjung Seloka strengthens the urgency of implementing the Bioreef Block installation as an effort to increase habitat complexity and support long-term data-based conservation programs (Tony *et al*., 2021).

Analysis of the (H'), (E), and (C) in the fish community around the Bioreef Block structure showed early signs of ecosystem stability. The diversity index value H' increased from 1.80 to 2.76, although it is still relatively low (<3), which reflects the presence of environmental pressure that is still quite high. However, this increasing trend is a positive indicator that ecosystem conditions are starting to improve gradually. Souhoka (2020) live coral cover in the area ranged from 15.42% to 80.80%, with a species diversity index (H) between 1.09 and 1.29, a species evenness index (j) of 0.80 to 0.92, and a species dominance index (D) of 0.06 to 0.13. These conditions indicate that in general the coral reef ecosystem in the area is in a good category, with 117 hard coral species from 16 families successfully identified, including species such as Heliofungia actiniformis, Galaxea astreata, Pocillopora verrucosa, Hydnophora rigida, Acropora hyacinthus, Acropora formosa, and Seriatopora hystrix.

The relatively low diversity in aquatic ecosystems is often influenced by the physical-chemical conditions of the waters and the presence of coral reefs as the main habitat for reef fish (Iskandar *et al*., 2020). The stability of a community can be measured through the species evenness index which is close to 1, where this value indicates an even distribution of species (Arbi, 2012). The smaller the evenness index value indicates that the distribution of species is uneven, which reflects ecological pressure or disturbance to the habitat. The existence of Bioreef Block which is able to increase the complexity of artificial habitats can be an effective solution to encourage the recovery and stability of coral fish communities in the waters of Tanjung Seloka, while also supporting the sustainability of the wider coral reef ecosystem.

The high uniformity index value (E), ranging from 0.88 to 0.94, indicates a relatively even distribution of individuals between fish species around the Bioreef Block structure. This condition indicates that the fish community is not only starting to show balance, but also shows stable population dynamics, where no one species significantly dominates the number of individuals compared to other species. According to Brower and Zar (1977), a uniformity index value above 0.6 is considered high and reflects good community stability. The same thing was also stated by Sarbini *et al*. (2016) who stated that the higher the uniformity value of a biota community, the more stable the community is because there is no striking dominance by one type of organism. The low dominance index value (C), which is between 0.07 and 0.19, further confirms that there are no fish species that significantly dominate the ecosystem around the Bioreef Block. This condition describes a healthy community structure that is not suppressed by specific dominance, so that the balance of the ecosystem can be maintained properly. Odum (1993) explained that a dominance index value approaching zero indicates the absence of excessive dominant species, allowing for balanced ecological interactions in the community. Howard *et al*. (2009) confirmed a positive correlation between low dominance values (<0.5) and high uniformity values and stable ecosystem conditions.

Coral reef damage that occurs in various regions, including Tanjung Seloka, can be caused by two main factors, namely natural factors such as storms, high waves, and extreme temperature changes, as well as anthropogenic factors such as destructive fishing, pollution, and uncontrolled coastal development (Manginsela *et al*., 2016). Coral reef rehabilitation efforts are very important to restore disturbed ecological functions. The existence of Bioreef Block as an artificial structure has been shown to make a positive contribution to improving the quality of fish habitat, both in terms of diversity and population distribution, thus acting as an effective alternative in rehabilitating damaged coral reefs (Iskandar *et al*., 2020).

Artificial reefs such as Bioreef Block provide habitat, feeding areas, and breeding spaces for various fish species, which ultimately support sustainable biodiversity enhancement. The coral reef basement community consisting of hard and soft corals is very important for ecosystem stability, where their competition for living space is influenced by environmental factors such as nutrient levels, wave strength, and water temperature (Rustam *et al*., 2016). The implementation of the Bioreef Block installation not only functions as a conservation effort, but also as an integral part of a broader and more sustainable marine ecosystem rehabilitation strategy.

The relatively stable physical and chemical conditions of the waters at the research location also supported the success of the Bioreef Block installation. The water temperature in the range of 30.1–30.6°C is within the optimal limit for fish metabolism and coral calcification processes, while the water clarity ranges from 4–8 meters with a current of around 0.0075–0.0083 m/s allows sufficient light penetration for photosynthesis of symbiotic algae in corals. Other parameters such as salinity, pH, and dissolved oxygen are also generally within the ecological tolerance threshold for tropical marine biota. Salinity values that slightly exceed the limits according to the Decree of the Minister of Environment No. 51 of 2004 and fluctuations in water clarity are important indicators that need to be considered in managing habitats and the quality of the aquatic environment (Iskandar *et al*., 2025)

The average current speed of 0.07 m/s with a peak of 0.10 m/s at the research location is higher than the Value in other coastal areas such as Angsana, Tanah Bumbu (Iskandar and Tony, 2013). This moderate current speed plays a vital role in supporting coral growth by providing nutrient and oxygen distribution and cleaning coral polyps from suspended particles (Dahuri, 2003). These adequate current conditions create a more stable and healthy environment for the coral community, as seen in the Acropora coral cover ranging from 26.76% to 52.76% indicating moderate to good reef conditions. Sedimentation and suspended material factors still need to be monitored because they can inhibit coral growth by covering polyps (Babcock and Smith, 2000), but the presence of Bioreef Block is believed to contribute positively to the recovery and sustainability of coral reef ecosystems (Tony *et al*., 2021).

The role of salinity is very important in aquatic ecosystems, because it is closely related to the tolerance of aquatic organisms to environmental changes (Kültz, 2015). The salinity value at the research location ranged from 26.5 to 27.2 ‰, although slightly lower than the optimal range of 30–40 ‰, influenced by rainfall factors and freshwater flow from the mainland through the Cuka River. Lehtonen *et al*. (2016) this salinity range can still be tolerated by coral reefs and related marine biota, but remains a special concern in environmental management to maintain ecosystem balance (Smyth and Elliott, 2016). The pH value ranged from 6.63 to 7.43, although slightly below the optimal range of 7.0–8.5 (Decree of the Minister of Environment No. 51 of 2004), in general the carbon dioxide buffer system in water is able to maintain pH stability in tropical marine waters (Feely *et al*., 2009; Putri *et al*., 2015).

Dissolved oxygen (DO) concentrations measured in the range of 5.3 to 5.6 mg/L support the survival of aquatic organisms in the research area, although they are still relatively lower compared to several other locations in the surrounding area such as Pulau Laut Village and Halang Melingkau Island (Tony *et al*., 2021). The DO value is still above the critical threshold of 3 mg/L which can cause organism death. Potential indirect effects, such as increased pollutant toxicity due to less than optimal DO conditions, which can ultimately harm marine biota (Rahayu, 1991). Comprehensive water quality monitoring and pollution mitigation measures are important parts of maintaining the health of coral reef ecosystems and fish communities at the Bioreef Block location (Faturohman *et al*., 2016).

The integration between supportive oceanographic conditions and the application of artificial habitat technology such as Bioreef Block is a strong foundation for effective and sustainable coral reef ecosystem restoration efforts (Iskandar *et al*., 2025). This success also emphasizes the importance of a multidisciplinary approach that combines biological, physical, and chemical aspects of water in the management of tropical marine ecosystems. Bioreef Block not only functions as a supporting structure for biodiversity, but also as a key element in conservation and adaptation strategies to future environmental changes (Tony *et al*., 2021).

5. CONCLUSIONS

The structure of the fish community in the Tanjung Seloka Sea waters showed a significant increase after the installation of Bioreef Block, both in terms of the number of individuals and species. The target fish group dominated with 10 groups, followed by the major and indicator groups with one group each, resulting in a total abundance of 3,160 individuals. The diversity index (H') is in the low category, indicating strong environmental pressure, but the high evenness index (E') indicates a stable fish community that is not dominated by certain species. Bioreef Block was effective in creating a habitat that supported the recovery of coral fish populations sustainably. Environmental parameters of the waters such as stable temperature (30.1–30.6°C), salinity 36–40‰, neutral to slightly alkaline pH, and adequate DO levels, also supported the success of Bioreef Block.

ACKNOWLEDGEMENTS

Thanks to PT State Electricity Company (Persero) East Kalimantan Main Development Unit, which provided support and facilitation for this research. The author would also like to thank the Indonesian Subaquatic Sport Association, South Kalimantan, the Dean of the Faculty of Agriculture, Achmad Yani University, Banjarmasin, the Dean of the Faculty of Fisheries and Marine Sciences, Lambung Mangkurat University, as well as the Village Head and the entire community of Tanjung Seloka Village for their contributions, cooperation, and support. Gratitude is also expressed to all parties who have helped, both directly and indirectly, so that this activity can be carried out well and achieve the expected results. Hopefully this effort will provide sustainable benefits for society and the environment.

AUTHORSHIP CONTRIBUTION STATEMENT

Frans TONY: Sampling, Writing-Review and Editing, Supervision.

Maulana Malik MUHAMMAD: Sampling and Data Analysis.

Rina ISKANDAR: Conceptualization, Visualization, Writing-Original Draft, Writing-Review and Editing.

Muhammad FIRZATULLAH: Sampling and Data Curation

CONFLICT OF INTERESTS

The author(s) declare that for this article they have no actual, potential or perceived conflict of interests.

ETHICS COMMITTEE PERMISSION

No ethics committee permissions is required for this study.

FUNDING

No funding was received from institutions or agencies for the execution of this research.

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