Fish community structure in the seagrass ecosystem of Tidung Besar Island, Seribu Islands

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Abstract. Seagrass plays an important role as a habitat for spawning, nurturing, protecting, and foraging marine biota such as fish. However, the fish community structure in the seagrass ecosystem of Tidung Besar Island has not been studied. This study aimed to analyze the structure of fish communities in the seagrass ecosystem of Tidung Besar Island during high- and low-tide conditions. Fish sampling was carried out for three months from October to December 2023 using gillnets with four different mesh sizes, lengths, and widths. The fish samples were analyzed in the laboratory. During the study, 1144 individuals were collected, consisting of 12 orders, 30 families, and 70 species. The fish composition was dominated by *Dischistodus chrysopoecilus* (white-spot damsel) at 612 Ind/m^2. The abundance and dominance of species were higher at high tide, whereas species richness, diversity, and evenness were higher at low tide. Fish diversity on Tidung Besar Island is included in the medium category, with conditions that tend to be stable.

1. Introduction

Tidung Island is one of the islands inhabited by the Seribu Islands. The Island is divided into two islands, namely, Tidung Besar Island and Tidung Kecil Island, which are connected by the Love Bridge. Tidung Besar Island has an area of 50.13 Ha, while Tidung Kecil Island is 17.40 Ha. Tidung Besar Island is used as a residential area, whereas Tidung Kecil Island is used as a conservation area [1].

The Tidung Besar Island has great tourism potential because of its diverse biota. This potential needs to be studied further to obtain the correct management steps. The strategic location of Tidung Island has its own advantages, especially for the utilization of shallow seawater areas, because the island is easy to reach. In addition to having a strategic location,

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the island has three types of coastal ecosystems with high biodiversity: coral reefs, seagrass, and mangroves. The high species biodiversity on the island can be utilized for fishery activities [2].

Seagrass ecosystems play an important role in marine ecosystems. Seagrass plays an important role as a primary producer, sediment trapper, and nutrient recycler [3]. The seagrass ecosystem also plays an important role as a shelter, spawning, nursery ground, and a place to find food for the biota who live on it [1]. Various biota are associated with seagrass, such as herbivorous fish, reef fish, and various species of macrozoobenthos from the classes Gastropoda, Bivalvia, Echinoidea, and Holothuroidea [4].

Community structure can be interpreted as a concept that discusses the arrangement or composition of species and their abundance in a community [5]. Community structure refers to an ecological term that studies the types and numbers of species found in an ecosystem. Community structure consists of ecological indices that reflect the dominance, evenness, and richness of an organism [6]. However, there has been no research related to the structure of fish communities in the seagrass ecosystem of Tidung Besar Island, so this research needs to be carried out on fish structure communities so that the abundance, richness, diversity, and evenness of fish in the seagrass ecosystem of Tidung Besar Island can be known so that it can be used as a basis for sustainable fisheries management.

2. Materials and Methods

2.1 Time and Location

The study was conducted from October to December 2023, with a sampling interval of one month, in the seagrass ecosystem of Tidung Besar Island, Seribu Islands (Figure 1).

Fig. 1. Research areas at Tidung Besar Island of Seribu Island, Jakarta

The determination of sampling points was based on the percentage of different seagrass density levels and different regional conditions. The seagrass density at Station 1 was 8,9394 stands/m^2. Station 1 is a residential area that is widely used as a homestay for tourists. The seagrass density at Station 2 is 18,6364 stands/m^2. Station 2 is also a residential area, but in the northern area, people are still less aware of marine cleanliness, so there is still a lot of garbage and many people still dispose of their waste directly into the sea. Most of the people in the northern part were fishermen. This caused them to anchor their ships or boats directly in front of their houses. The seagrass density at Station 3 was 8,9394 stands/m^2. Station 3 is an area that is not used in any place and there is mangrove planting in the area.

2.2 Data Collection

Samples of fish caught came from three stations on Tidung Besar Island during high- and low-tide conditions. It was conducted three times at each station in October, November, and December 2023. Based on rainfall data from the Indonesian Agency for Meteorological, Climatological, and Geophysics, October and December were included in the dry season, while November was included in the rainy season. The catchment area is determined by a line transect 50 – 100 m long and 5 – 10 m wide. Fish samples were caught using gillnets with a total catchment area of 500 m^2. The catch time ranged from two to three hours per station for each condition at high and low tides.

The gillnet has a float attached to the top so that the net can float and an anchor located at the bottom to maintain the position of the fishing gear [7]. The nets used in this study consisted of four types of different mesh sizes, lengths, and widths. First gillnet has a mesh of 0,5 inches with a length of 20 m and a width of 1,5 m, the second gillnet has a mesh of 1,75 inches with a length of 40 m and a width of 1 m, the third gillnet has a mesh of 1,5 inches with a length of 40 m and a width of 1 m, and the fourth gillnet has a mesh of 2 inches with a length of 30 m and a width of 1 m.

Samples of the caught fish were collected in the box. The fish were sorted based on their shape and color, which tended to be the same. After sorting, the fish samples were placed in medium – sized plastic bags that had been perforated in several parts so that the fish samples could be completely submerged. The fish samples were placed in a coolbox. Two coolboxes were used: a coolbox containing 20 liters of 10% formalin and a coolbox containing 20 liters of 96% alcohol. The first fish was preserved in formalin for 24 – 48 h. After 24 – 48 h, the fish samples were cleaned using clean water, transferred into a coolbox containing 96% alcohol, and soaked again until they were identified.

The preserved fish samples were identified by class and species. Identification was carried out using several reference books (Allen, 1997); Carpenter and Niem (2001); Allen *et al*. (2003); Allen and Erdmann (2012). Each identified species was counted as number of individuals. Furthermore, the length of the fish body was measured using a scale and the weight of the fish was measured using a balance. The identification results are listed in a table that also contains data related to the order, family, species, local name, number, length distribution, weight distribution, station where the fish were found, resident status, economic value, and IUCN status.

The density of seagrass was determined by stretching a 100-meter line transect. Within a 100-meter distance, the density was measured using a quadrant transect divided into four boxes. Each box was calculated for seagrass stands, and each type of seagrass was identified. After the data were collected, the density of seagrass at each sampling point was analyzed.

Water quality parameters were measured using several tools. A pH meter was used to measure salinity, a refractometer was used to measure dissolved oxygen, a DO meter was used to measure temperature, a thermometer was used to measure depth, and a graduated stick was used to measure depth. For the pH, salinity, temperature, and dissolved oxygen parameters, three repetitions were performed to obtain the average.

2.3 Data Analysis

2.3.1 Species Abundance

Species abundance was calculated as the number of individuals found per unit area of the observation area. Species abundance was calculated using the following formula [12]:

$$K_i = \frac{n_i}{A}$$

Description:
K_i : Species abundance (Ind/m^2)
n_i : Number of individuals of species (Ind)
A : Observation area (m^2)

2.3.2 Richness Index (D)

Fish species richness can be calculated using the Margalef species richness index model [13].

$$\left[D = \frac{S-1}{\ln N}\right]$$

Description:
S: Amount of species
N: Amount of individuals of all species
The following are the criteria for assessing the species richness index [13]:
$D < 3.50$: Low species richness
$3.50 \leq D \leq 5.00$: Medium species richness
$D > 5.00$: High species richness

2.3.3 Diversity Index (H')

According to [14], the diversity index is used to measure the relative abundance based on the number of species and individuals of each species. There is a Shannon-Wiener diversity index formula is as follows [15]:

$$\left[H' = \sum_{i=1}^{n} p_i \ln p_i\right]$$

$$p_i = \frac{n_i}{N}$$

Description:

p_i: Proportion of the amount of individuals
n_i: Amount of individuals for each species
According to [12], there are criteria for the diversity index that include
H' < 1: Low diversity
1 ≤ H' ≤ 3: Medium diversity
H' > 3: High diversity

2.3.4 Evenness Index (E)

The magnitude of similarity in the distribution of the number of individuals of each type can be calculated using a method called the uniformity index according to [15]. The formula used is as follows:

$$\left[E = \frac{H'}{\ln S}\right]$$

Based on [16], the uniformity index criteria are as follows:
0 ≤ E ≤ 0.5: The community is in a depressed condition
0.5 ≤ E ≤ 0.75: The community is in an unstable condition
0.75 ≤ E ≤ 1: The community is in a stable condition

2.3.5 Dominance Index (C)

The dominance index describes whether a dominant species exists in an ecosystem. The dominance index formula is as follows [17].

$$\left[C = \sum_{i=1}^{n} {p_i}^2\right]$$

According to [18], the dominance index criteria are as follows:
0.00 < C ≤ 0.50: Low dominance
0.50 < C ≤ 0.75: Medium dominance
0.75 < C ≤ 1.00: High dominance

2.3.6 Seagrass Density (Ki)

Seagrass density was used to calculate the number of seagrass species in a given area [19]. According to [20], the formula for the density of seagrass species is as follows:

$$K_i = \frac{\Sigma n_i}{A}$$

Description:
K_i: Density of the i-th species (stand/m^2)
Σn_i: Number of individuals or stands in the i-th transect
A: Sampling area (m^2)

2.3.7 Similarity Analaysis

One of the analyses that can be used for similarity is the Bray–Curtis similarity analysis. It was used to determine the similarities between research stations based on the number of individuals and the number of species at each station using a grouping system. The grouping principle is carried out by determining the correlation value between stations, which is continued by compiling a matrix called the Bray Curtis similarity matrix [21]. Bray Curtis similarity analysis can be performed using the PAST (Paleontological Statistics) software [22]. The Bray Curtis similarity analysis was based on two variables: the number of individuals and the number of species found at each station. The results are presented as a dendrogram that forms several clusters. Based on the clusters formed, further analysis was carried out to determine the relationship between the influencing variables and the influenced variables.

2.3.8 Principal Component Analysis (PCA)

Principal Component Analysis (PCA) is an analysis that can provide information on the relationship between environmental parameters such as pH, temperature, dissolved oxygen that can affect the abundance and diversity of fish [23]. Principal Component Analysis was performed using the XLSTAT software, which can be connected to Microsoft Excel. This software can assist with statistical data processing, such as identifying several characteristics and classifying variability [24].

3. Results

3.1 Fish Composition

The fish samples collected were 1144 individuals, consisting of 393 individuals in October, 252 individuals in November, and 499 individuals in December. Individuals were caught in the Actinopterygii class (consisting of 12 orders, 30 families, and 70 species). The order Perciformes is the order with the highest number of families and species, consisting of 11 families and 46 species.

Table 1. Composition of fish catches

Order/Family	Species	Common Name	Amount	Weight Range (gr)	Long Range (cm)	Station			Resident Status	Economic Values			IUCN Status
						1	2	3		C	F	D	
ACANTHURIFORMES													
Acanthuridae	*Acanthurus xanthopterus*	Yellowfin surgeonfish	1	87,8835	15,7			✓	OV	✓			LC
Chaetodontidae	*Chaetodon octofasciatus*	Eightband butterflyfish	3	14,1748 - 28,2495	7,5 - 9,6	✓			OV	✓		✓	LC
	Chaetodon trifasciatus	Melon butterflyfish	2	36,8544 - 59,5340	10,9 - 12,1			✓	OV	✓		✓	LC
Siganidae	*Siganus fuscescens*	Mottled spinefoot	12	42,5243 - 192,7766	14,1 - 22,2	✓	✓	✓	TR	✓			LC
	Siganus virgatus	Barhead spinefoot	17	22,6796 - 96,3883	11,7 - 18,0	✓	✓	✓	TR	✓			LC

Order/Family	Species	Common Name	Amount	Weight Range (gr)	Long Range (cm)	Station			Resident Status	Economic Values			IUCN Status
						1	2	3		C	F	D	
ATHERINIFORMES													
Atherinidae	*Atherinomorus endrachtensis*	Endracht hardyhead	7	2,8350 - 2,840	6,9 - 7,6	✓			RV		✓		N/A
BELONIFORMES													
Belonidae	*Tylosurus crocodilus*	Crocodilian longtom	1	323,1843	58,7	✓			OV	✓			LC
Hemiramphidae	*Hemiramphus far*	Barred garfish	1	221,1261	32,7	✓			OV	✓		✓	N/A
Zenarchopteridae	*Zenarchopterus buffonis*	Buffon's river-garfish	2	2,8349 - 2,8540	12,2 - 13,6	✓			RV	✓		✓	LC
CARANGIFORMES													
Carangidae	*Carangoides coeruleopinnatus*	Coastal trevally	1	87,8835	18,3			✓	OV	✓			DD
	Decapterus macarellus	Mackerel scad	1	53,8641	18,1			✓	OV	✓			LC
	Selaroides leptolepis	Yellowstripe scad	2	25,5146 - 70,8738	13-17,5			✓	OV	✓			LC
CENTRARCHIFORMES													
Kyphosidae	*Kyphosus vaigiensis*	Brassy chub	1	62,3689	15,3			✓	OV	✓			DD
GOBIIFORMES													
Gobiidae	*Acentrogobius nebulosus*	Shadow goby	1	1,5025	4,9		✓		RV	✓	✓	✓	LC
	Amblygobius bynoensis	Freckled goby	1	8,5049	6,5		✓		RV	✓	✓		LC
HOLOCENTRIFORMES													
Holocentridae	*Sargocentron rubrum*	Red squirrelfish	1	79,3786	16,4	✓			OV	✓			LC
KURTIFORMES													
Apogonidae	*Cheilodipterus quinquelineatus*	Five-lined cardinalfish	1	17,0097	10,9	✓			RV		✓	✓	LC
	Fibramia lateralis	Humpback cardinal	6	2,1262 - 5,6699	5,4 - 6,6	✓			RV		✓		N/A
PERCIFORMES													
Epinephelidae	*Epinephelus quoyanus*	Longfin grouper	8	42,5243 - 68,0388	13,9 - 16,8	✓	✓	✓	OV	✓			LC
Gerreidae	*Gerres erythrourus*	Deepbody silverbiddy	1	73,7087	13	✓			TR	✓	✓		LC
	Gerres oyena	Common silver-biddy	202	22,6796 - 36,8544	11,1 - 13,2	✓	✓	✓	TR	✓	✓		LC
Labridae	*Cheilinus oxycephalus*	Snooty wrasse	5	34,0194 - 45,3592	13,0 - 13,8	✓	✓	✓	OV	✓			LC
	Cheilinus trilobatus	Tripletail wrasse	1	56,699	13,7	✓			OV	✓		✓	LC
	Choerodon anchorago	Orange-dotted tuskfish	89	1,1340 - 121,9029	5,3 - 17,9	✓	✓	✓	RV	✓			LC
	Halichoeres argus	Argus wrasse	3	48,1942 - 56,6990	14,3 - 15,9	✓		✓	RV	✓		✓	LC

Order/Family	Species	Common Name	Amount	Weight Range (gr)	Long Range (cm)	Station			Resident Status	Economic Values			IUCN Status
						1	2	3		C	F	D	
	Halichoeres chloropterus	Pastel-green wrasse	19	2,8350 - 14,1748	5,8 - 10,5	✓	✓		RV	✓	✓		LC
	Halichoeres richmondi	Richmond's wrasse	3	2,8350 - 2,8401	6,8 - 7,4		✓		RV			✓	LC
	Halichoeres scapularis	Zigzag wrasse	4	2,8350 - 45,3592	7,2 - 14,2		✓		RV	✓			LC
	Hemigymnus melapterus	Thick-lipped wrasse	19	39,6893 - 167,2671	12,9 - 21,5	✓	✓	✓	PR	✓			LC
	Stethojulis trilineata	Three-lined rainbowfish	5	36,8544 - 42,5243	12,4 - 13,0		✓	✓	OV			✓	LC
	Lethrinus atkinsoni	Pacific yellowtail emperor	1	25,5146	11,1	✓			OV	✓	✓		LC
Lethrinidae	*Lethrinus harak*	Thumbprint emperor	4	39,6893 - 62,3689	13,9 - 16,4	✓	✓	✓	TR	✓	✓		LC
	Lethrinus lentjan	Pink ear emperor	36	31,1845 - 51,0291	11,4 - 15,2	✓	✓	✓	TR	✓	✓		LC
	Lutjanus carponotatus	Spanish flag snapper	12	62,3689 - 141,7475	15,0 - 20,3	✓	✓	✓	TR	✓	✓		LC
Lutjanidae	*Lutjanus decussatus*	Checkered snapper	4	56,6990 - 68,0388	14,9 - 15,8	✓		✓	PR	✓			LC
	Lutjanus fulviflamma	Dory snapper	2	48,19415 - 56,6990	14,0 - 15,1		✓		OV	✓	✓		LC
	Nemipterus furcosus	Rosy threadfin bream	1	73,7087	17,9	✓			OV	✓			LC
	Pentapodus trivittatus	Three-striped whiptail	40	11,3398 - 133,2427	9,8 - 21,0	✓	✓	✓	RV	✓			LC
	Scolopsis aurata	Yellowstripe monocle bream	4	34,0194 - 87,8835	12,7 - 17,3	✓		✓	OV	✓			LC
Nemipteridae	*Scolopsis ciliata*	Whitestreak monocle bream	14	28,3495 - 53,8641	12,9 - 15,9		✓	✓	OV	✓			LC
	Scolopsis lineata	Striped monocle bream	19	17,0097 - 113,3980	10,4 - 19,3	✓	✓	✓	OV	✓			LC
	Scolopsis margaritifera	Pearly monocle bream	5	34,0194 - 53,8641	13,4 - 14,8		✓	✓	OV	✓			LC
Pomacanthidae	*Pomacanthus sexstriatus*	Sixbar angelfish	1	34,0194	10,1			✓	OV			✓	LC
	Abudefduf bengalensis	Narrow-banded sergeant major	14	17,0097 - 73,7087	10,3 - 14,3	✓	✓	✓	OV			✓	LC
Pomacentridae	*Abudefduf sexfasciatus*	Scissortail sergeant	5	19,8445 - 62,3689	10,5 - 14,2	✓	✓		OV			✓	LC
	Abudefduf sordidus	Blackspot sergeant	1	39,6893	11	✓			OV	✓	✓		LC

Order/Family	Species	Common Name	Amount	Weight Range (gr)	Long Range (cm)	Station			Resident Status	Economic Values			IUCN Status
						1	2	3		C	F	D	
	Abudefduf vaigiensis	Sergeant-major	16	19,8445 - 138,9126	9,7 - 12,0	✓	✓		TR			✓	VU
	Dischistodus chrysopoecilus	White-spot damsel	306	1,9845 - 87,8835	4,1 - 15,7	✓	✓	✓	PR		✓		LC
	Dischistodus fasciatus	Banded damsel	1	28,3495	10,3	✓			OV	✓	✓		N/A
	Dischistodus perspicillatus	White damsel	90	2,83495 - 93,5534	6,4 - 16,2	✓	✓	✓	OV		✓		LC
	Dischistodus prosopotaenia	Honey-head damsel	1	28,3495	11,5		✓		OV	✓	✓		LC
	Pomacentrus javanicus	Java damsel	1	76,54365	14,7	✓			OV	✓	✓		N/A
	Pomacentrus littoralis	Smoky damsel	9	22,6796 - 82,2136	9,5 - 14,7	✓		✓	TR		✓		N/A
	Stegastes nigricans	Dusky farmerfish	1	85,0485	16,2			✓	OV		✓		LC
	Calotomus spinidens	Spinytooth parrotfish	3	48,1942 - 59,5340	12,8-15,0	✓	✓		OV	✓			LC
	Hipposcarus harid	Candelamoa parrotfish	2	59,5339 - 79,8738	15,7 - 16,9	✓		✓	PR	✓			LC
	Scarus ghobban	Blue-barred parrotfish	38	8,50485 - 136,0776	7,9-18,5	✓	✓	✓	TR	✓			EN
Scaridae	*Scarus psittacus*	Palenose parrotfish	45	36,85435 - 85,0485	12,5 - 16,3	✓	✓	✓	OV	✓			DD
	Scarus quoyi	Quoy's parrotfish	19	45,3592 - 70,8738	12,3-14,6	✓	✓	✓	OV	✓			LC
	Scarus rivulatus	Surf parrotfish	6	65,2039 - 153,0873	14,1 - 20,6		✓	✓	OV	✓			DD
	Scarus spinus	Greensnout parrotfish	1	56,699	14		✓		OV	✓			LC
Scorpaenidae	*Scorpaenopsis diabolus*	False stonefish	1	249,4756	20,2			✓	OV	x	x	x	N/A
Sphyraenidae	*Sphyraena jello*	Pickhandle barracuda	1	269,3203	37		✓		OV	✓			N/A
Synanceiidae	*Synanceia horrida*	Estuarine stonefish	1	464,9318	16,6			✓	OV	x	x	x	LC
SCOMBRIFORMES													
Scombridae	*Rastrelliger kanagurta*	Indian mackerel	1	45,3592	16,4			✓	OV	✓			LC
SYNGNATHIFORMES													
Centriscidae	*Aeoliscus strigatus*	Razorfish	2	0,6804	12,9			✓	PR				DD
TETRAODONTIFORMES													
Balistidae	*Balistoides viridescens*	Titan triggerfish	1	48,1942	12		✓		OV	✓			LC
Monacanthidae	*Acreichthys tomentosus*	Bristle-tail file-fish	6	8,5049 - 170,0970	7,4 - 9,3	✓	✓		RV		✓		LC

Order/Family	Species	Common Name	Amount	Weight Range (gr)	Long Range (cm)	Station			Resident Status	Economic Values			IUCN Status
						1	2	3		C	F	D	
Ostraciidae	*Ostracion cubicum*	Yellow boxfish	7	36,8544 - 215,4562	9,2 - 19,0	✓	✓	✓	PR	✓		✓	N/A
Tetraodontidae	*Arothron mappa*	Map puffer	2	291,9998 - 1312,5819	18,8 - 34,1			✓	TR			✓	LC

**Note: PR: permanent resident, TR: temporary resident, RV: regular visitors, OV: occasional visitors, C: consumption, F: feed, D: decorative, LC: least concern, DD: data deficient, VU: vulnerable, EN: endangered, N/A: no data found on IUCN.*

3.2 Abundance and Richness Index

Species abundance showed varying results at each station. In October – November, fish species abundance was not significantly different, whereas in December, a significant difference was observed. The highest and lowest fish abundances were found at Station 3 in December under high- and low-tide conditions, respectively.

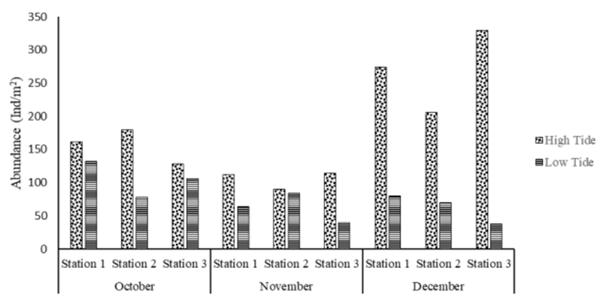


Fig. 2. Fish abundance during high and low tide conditions in Tidung Besar Island, Seribu Islands

The comparison between the richness values based on the amount and biomass of fish showed an insignificant difference. The highest richness of fish species was found at Station 2 in October during low-tide conditions, which were included in the high category. The lowest richness of fish species was found at Station 2 in November during high-tide conditions, which were included in the low category.

(a) (b)

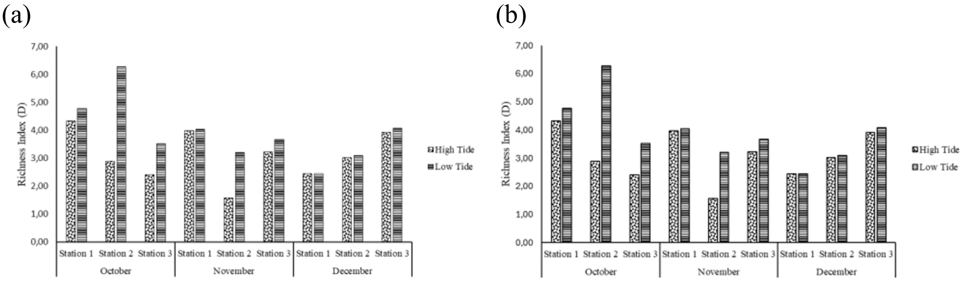


Fig. 3. Fish richness based on number (a) and biomass (b) in Tidung Besar Island, Seribu Islands

3.3 Diversity, Evenness, and Dominance Index

Fish diversity based on the amount and biomass was highest at Station 2 in October during low tide. The lowest diversity of fish species was observed at Station 1 in December during high tide. The highest and lowest diversity of fish species were included in the moderate category. Differences were observed in the values at Station 1 in October and Station 3 in December. Based on the number of fish, Station 1 in October and Station 3 in December had higher diversity values during low tide, while based on fish biomass, the diversity value of fish was higher during high tide.

(a) (b)

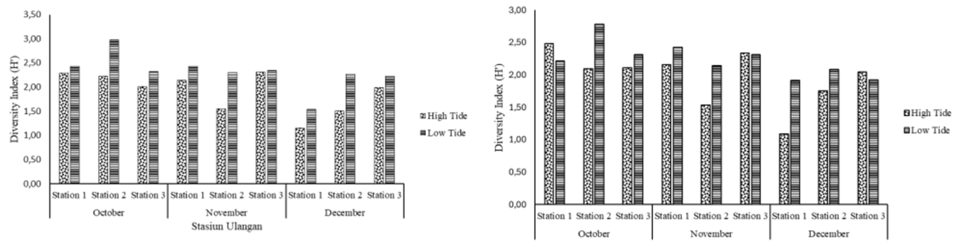


Fig. 4. Fish diversity based on number (a) and biomass (b) in Tidung Besar Island, Seribu Islands

The highest fish evenness was found at Station 3 in November during low-tide conditions, which were included in the stable category. The lowest evenness of fish species was found at Station 1 in December during high-tide conditions, which were included in the depressed category. There were differences in the values at stations 1 and 3 in October. Based on the number of fish, Stations 1 and 3 in October had higher evenness values during low tide conditions, while based on fish biomass, during high tide conditions the evenness values of fish were higher.

(a) (b)

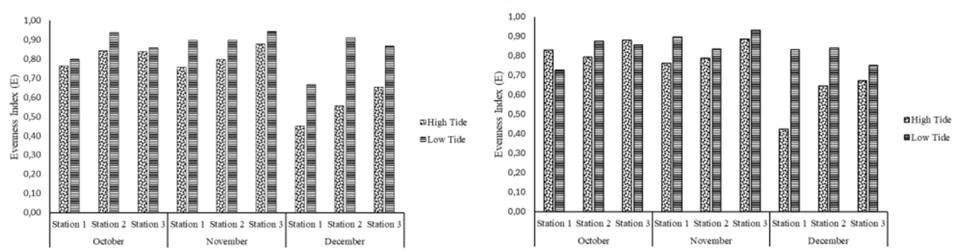


Fig. 5. Fish evenness based on number (a) and biomass (b) in Tidung Besar Island, Seribu Islands

The dominance values at Stations 1, 2, and 3 in October – November showed no very different results between high and low tide conditions. In contrast to October and November, at Stations 1, 2, and 3 in December, the difference in dominance values was significant between high and low tides. The highest dominance was observed at Station 1 in December, when high tide conditions were included in the moderate category. A comparison between dominance values based on the amount and biomass of fish showed significant differences. Based on the number of fish, Station 1 in October had a higher dominance value during high tide conditions, whereas based on fish biomass, the fish dominance value was higher during low tide conditions.

(a) (b)

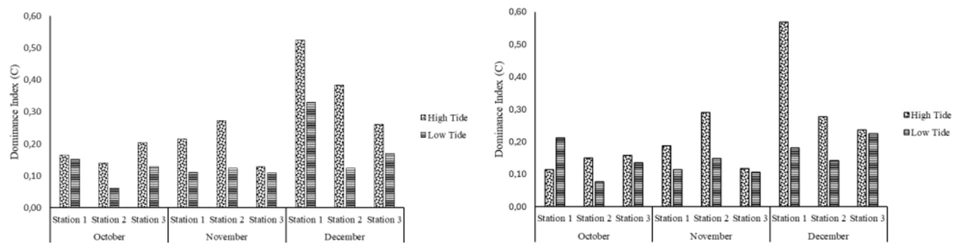


Fig. 6. Fish dominance based on number (a) and biomass (b) in Tidung Besar Island, Seribu Islands

3.4 Types and Density of Seagrass

There were four types of seagrass found in the observation area. These four species were *Enhalus acoroides*, *Thalassia hemprichii*, *Cymodocea rotundata*, and *Halophila ovalis*. The dominant seagrass type on Tidung Besar Island was *T. hemprichii* with a species density value of 93,58 stands/m^2. The highest total density was observed at Station 3, which was 19,15 stands/m^2.

Table 2. Types and density of seagrass of Tidung Besar Island, Seribu Islands

Types of Seagrass	Density (Ind/m^2)			
	Station			Density of type
	1	2	3	
Enhalus acoroides	3,52	3,52	57,70	64,73
Thalassia hemprichi	31,39	43,27	18,91	93,58
Cymodocea rotundata	0,00	16,24	0,00	16,24
Halophila ovalis	0,85	11,52	0,00	12,36
Total	35,76	74,55	76,61	
Average	8,94	18,64	19,15	

3.5 Water Quality Parameters

The results of the measurements of physicochemical parameters, including temperature, depth, pH, salinity, and dissolved oxygen, are presented in Table 3. The physicochemical parameters of water vary both spatially and temporally.

Table 3. Water quality parameters at Tidung Besar Island, Seribu Islands

Condition	Water Quality Parameters				
	Physical Parameters		Chemical Parameters		
	Temperature	Depth	pH	Salinity	Dissolved Oxygen
High Tide	29,6 - 32,3	70,5 - 126,4	6,76 - 8,08	34 - 36	4,5 - 6,4
Low Tide	29,9 - 33,2	48,2 - 90,4	6,93 - 8,05		4,1 - 5,1

3.6 Similarity Analysis

A similarity analysis was conducted based on data on the number of individuals and the number of species found at each station. This is because the t-test that has been conducted showed that the differences in seasons in October, November, and December were not significant, so it can be categorized into one season. The clustering results based on Bray-Curtis analysis showed that the number of individuals and species on Tidung Besar Island were divided into four clusters. This grouping was based on 80 value of the data.

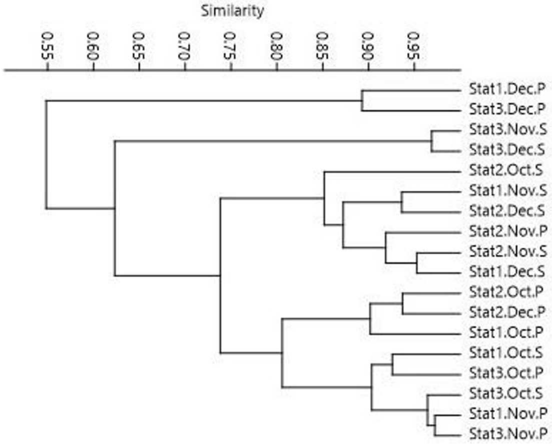
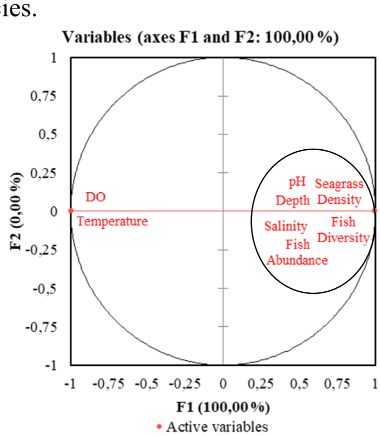


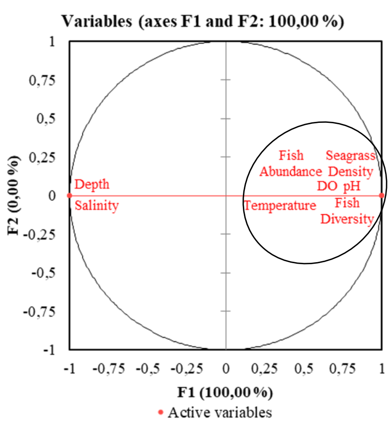
Fig. 7. Similarity of number of individuals and species between stations in Tidung Besar Island, Seribu Islands

3.7 Principal Component Analysis

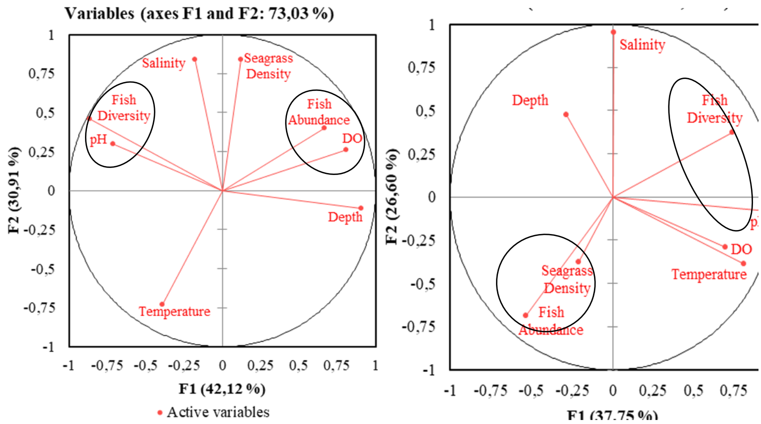
The relationship between the abundance of fish species and diversity and environmental parameters is shown in Figure 7. Results of the principal component analysis were divided into four clusters. F1 and F2 in each biplot are factorial axes that represent linear combinations of the original variables. The total percentages of F1 and F2 illustrate the magnitude of the influence of environmental parameters on the abundance and diversity of fish species.



Cluster 1



Cluster 2



Cluster 3 *Cluster* 4

Fig. 8. Relationship between environmental factors, species abundance, and fish diversity at Tidung Besar Island, Seribu Islands

4. Discussion

The composition of fish species included the number of individuals, species, families, and orders recorded during the study period. Perciformes had the highest number of families and species compared to the other orders. This is supported by the statement in [25], where Perciformes is the order with the highest number of species in the fish world. This causes Perciformes to be found in many aquatic ecosystems and has cosmopolitan properties. Other orders found in the seagrass ecosystem of Tidung Besar Island include Acanthuriformes, Beloniformes, Carangiformes, Tetraodontiformes, Kurtiformes, Gobiiformes, Athiriniformes, Centrachiformes, Holocentriformes, Scombriformes, and Syngnathiformes. One of the families in Perciformes is the Pomacentridae family, which has the highest number of species. Compared to other families that have only one to nine species, Pomacentridae consists of 12 species. This is supported by research conducted by [26], which states that Pomacentridae has a worldwide distribution. Pomacentridae prefers tropical habitats both on the edges of waters such as seagrass and mangrove ecosystems, as well as around coral reefs or lagoon ecosystems. The species with the highest number of individuals obtained during the study was *Dischistodus chrysopoecilus* (white-spot damsel), which came from the Pomacentridae, with a total of 306 individuals. In addition to *Dischistodus chrysopoecilus*, *Gerres oyena* (common silver-biddy), which belongs to the order Gerreidae, also obtained a high number of individuals, namely 202 individuals. *Dischistodus chrysopoecilus* and *Gerres oyena* were obtained from Perciformes. This is supported by the statement of Kholis *et al.* that the types of fish found in the seagrass ecosystem generally come from the families Lutjanidae, Gerreidae, Haemulidae, Pomacentridae, Labridae, Sparidae, Atherinidae and Leiognathidae [27].

Based on the data obtained, *Dischistodus chrysopoecilus* and *Gerres oyena* were found at almost every station during high and low tides. This is because of the characteristics of fish from the Perciformes (*Dischistodus chrysopoecilus* belongs to the Pomacentridae family and *Gerres oyena* belongs to the family Gerreidae). This correlates with the seagrass ecosystem, which acts as a shelter, feeding ground, spawning ground, and nursery ground for marine biota [28]. The Pomacentridae is included in the temporary residents (TR) of the seagrass ecosystem, which only occupies the seagrass ecosystem in the juvenile phase [29], whereas the Gerreidae family uses the seagrass ecosystem as a spawning ground. In general, the spawning period for fish of the Gerreidae family occurs throughout the year with two peak spawning periods, namely in March and October – December [30].

The highest abundance was found at Station 3 in December during high tide, with a value of 330 Ind/m^2. This was evidenced by the number of catches at Station 3 in December during high tide, which reached 165 individuals. One of the factors that can cause high fish abundance in an ecosystem is temperature. Beroperai *et al*. stated that if a body of water has a temperature that tends to be low and higher in nutrient availability, the abundance value will be higher when compared to waters that have a higher temperature and insufficient food availability [31]. According to Latuconsina and Rappe, the high and low abundances of fish in an aquatic ecosystem can be influenced by high and low oceanographic parameters such as turbidity, temperature, salinity, pH, and dissolved oxygen [31]. In addition to high and low oceanographic parameters, fish abundance can also be influenced by human activities, such as overfishing, the use of environmentally unfriendly fishing gear, and no size selection in fishing activities [32]. As shown in Figure 3, fish abundance is higher at high tide than at low tide, according to Hutami *et al*., because at high tide, the nutrients in the waters tend to be higher than at low tide [33].

The richness index was positively correlated with the diversity index, which caused diversity at Station 2 (in October) when the low tide was also high. This is evidenced by the number of diverse species of 24 species from 39 individuals obtained, where the richness index value at this station was 6,2780, which was included in the high category, and the diversity index value was 2,9817, which was included in the medium category. High and low diversity cannot be separated from the influence of environmental conditions and human activities such as fishing, presence of invasive species, and habitat destruction [34]. The water quality in the seagrass ecosystem of Tidung Besar Island is included in the good category; however, the high fishing activity of local fishermen is the cause of the diversity value of all observed stations being included in the medium category.

The highest evenness value was found at Station 3 in November when the low tide had a value of 0,9440 which means that the fish community at that station was in a stable condition. This is in accordance with the catch results, which only contained 20 individuals but had a total of 12 species. This high evenness value in a community indicates that the waters have a large community balance; conversely, if the evenness value is low, then there are fish species that have a relatively large number of individuals, whereas other species have a relatively small number of individuals. This can be seen at Station 1 (in December) during high tide conditions where the number of catches was 137, but was dominated by the *Dischistodus chrysopoecilus* species of 97 individuals. There were differences in the structure of the fish community at high tide and low tide. During high tide, abundance and dominance were higher, while during low tide, diversity and evenness were higher. This is because of the different daily rhythms of fish and differences in fish orientation to find food and shelter [35]. The dominance index was used to determine the most commonly found species from a given location [36].

The highest dominance was found at Station 1 in December when the tide conditions had a value of 0,5233 which was included in the medium dominance category. This is evidenced by the high catch of 137 individuals, but only 13 species. According to Yohanista, if a community has a high dominance value, it means that the dominance in the community is only centered on one species, whereas if the dominance value is low, the dominance is centered on several species [37]. This proves the dominance at Station 1 (in December) when the tide conditions were centered on the species *Dischistodus chrysopoecilus*. This dominance index has a negative correlation with diversity; the higher the dominance value, the lower the diversity value in a community. In accordance with the results shown in Figures 4 and 6, the highest dominance value and the lowest diversity were found at Station 1 in December when the tide conditions were.

Fish abundance obtained during the study cannot be separated from the ecosystem factor itself, namely, the seagrass ecosystem. The seagrass ecosystem is one of the ecosystems that is a habitat for fish found in the sea. Station 1 had the physical characteristics of sediments dominated by sandy substrates mixed with dead coral. Three types of seagrass vegetation were found (*Enhalus acoroides*, *Thalassia hemprichii*, and *Halophila ovalis*). Station 2 had the physical characteristics of sediment dominated by muddy sand substrates mixed with dead coral. Four types of seagrass vegetation were found (*Enhalus acoroides*, *Thalassia hemprichii*, *Cymodocea rotundata*, and *Halophila ovalis*). Station 3 had the physical characteristics of sediments dominated by sandy substrates mixed with dead coral. Two types of seagrass vegetation were identified (*Enhalus acoroides* and *Thalassia hemprichii*).

Fish associated with the seagrass species *Enhalus acoroides* generally come from the families Pomacentridae, Siganidae, Sphyraenidae, Nemipteridae, Acanthuridae, and Labridae. The identification results showed that the fish from Pomacentridae had the largest number. This may indicate that fish of the Pomacentridae family are closely associated with seagrass. Pomacentridae use seagrass as a shelter from predators during the juvenile phase. The types of fish from Siganidae depend on the seagrass species *Enhalus acoroides* for their livelihood [38]. This is supported by research by Latuconsina *et al*., who found that fragments of *Enhalus acoroides* seagrass dominated the stomach contents of fish from the Siganidae family [32].

Acanthuridae, Kyphosidae, Hemiramphidae, and Siganidae are fish families strongly associated with *Thalassia hemprichii* seagrass. Fish from these families use *Thallassia hemprichii* as a food source. This was evidenced by the discovery of this type of seagrass in the stomachs of these fish in a study conducted by Adrim [39]. Fish of Apogonidae are one of the fish that spend most of their lives in seagrass, either for spawning, foraging, or sheltering [40]. Fish of Siganidae prefer *Thallassia hemprichii* and *Enhalus acoroides* because they tend to be larger and wider, respectively. With this shape, these two types of seagrass can provide an ecological niche for fish as a nursery area.

Bray-Curtis clustering divides clustering into four main clusters. This clustering was based on data on the number of individuals and species at each station. The formation of these four clusters was due to the high similarity between the stations in each cluster. This means that between stations in each cluster, there is high similarity based on the number of individuals and the number of species at each station. The grouping into four clusters indicated that there was a relatively low similarity between clusters.

The environment plays an important role in the marine biota. Environmental parameters, such as seagrass density, pH, salinity, and depth, had a strong effect on the abundance of fish species and diversity (Cluster 1). Environmental parameters, such as seagrass density, dissolved oxygen, temperature, and pH, have a strong effect on the abundance of fish species and diversity (Cluster 2). In contrast to clusters 1 and 2, DO and seagrass density in clusters 3 and 4 had a strong effect on the abundance of fish species, while pH had a strong effect on the value of fish diversity.

The abundance of species (Ki) and diversity of fish (H') can be influenced by factors such as temperature, pH, salinity, dissolved oxygen, and water depth. As shown in Figure 7, the abundance of species and the diversity of fish in this study were greatly influenced by factors such as temperature, salinity, pH, depth, and dissolved oxygen. The magnitudes of temperature, salinity, pH, and dissolved oxygen obtained during the study were included in the good category, which is suitable for the life of marine biota in accordance with seawater quality standards in accordance with Government Regulation of the Republic of Indonesia Number 22 of 2021 concerning the Implementation of Environmental Protection and Management. This is in accordance with the function of seagrass as a place for spawning, shelter, foraging, and nurturing fish, which causes the diversity of fish in the seagrass ecosystem of Tidung Besar Island to be included in the moderate category. The parameters of water depth and dissolved oxygen are interrelated, which means that as the depth increases, it will affect the entry of light into the water, which will affect seagrass photosynthesis and the level of dissolved oxygen present [41]. The depth level in the seagrass ecosystem of Tidung Besar Island has a range of values of 48,2 cm at low tide – 137,6 cm at high tide. This value is neither too low nor too high, which means that the seagrass ecosystem of Tidung Besar Island can support the life of biota.

Based on the data obtained, Tidung Besar Island experienced two different types of tides. In October – November, there is a mixed tide prevailing semi-diurnally, while in December there is a diurnal tide. Mixed tide prevailing semi-dirunal is a type of tide that occurs twice in one day and twice in one day with different wave heights, whereas diurnal tide is a type of tide that only occurs once in one day [42]. Sea tides influence the presence of fish in the seagrass ecosystem of Tidung Besar Island. Generally, seagrass is located in shallow waters, which causes water quality, movement, and depth to be influenced by the rhythm of the tides within a certain time span. In addition, food availability, shelter quality, and other environmental factors also occur during the tidal cycle.

These tidal changes can affect animal migration patterns in one ecosystem. During high tide, there will generally be more fish entering shallower waters, such as seagrass. Likewise, when the water starts to recede, fish generally leave shallower waters to avoid the increase in temperature or salinity that occurs and the risk of predation. For example, *Siganus fuscences* and *Siganus virgatus* were found at Stations 1, 2, and 3 to find food because these are herbivorous fish that eat seagrass leaves. These fish, which belong to the Siganidae family, come to seagrass during high tide.

Community structure in an ecosystem is not only influenced by factors such as relationships between species, but also by the relative number of organisms of the species, so that the relative abundance of a species will affect the function of the community, the distribution of individuals in a community, the balance of a community, and the stability of the community [43]. The abundance, richness, diversity, evenness, and dominance indicate different values every month because they are caused by changes in the environmental conditions of the water. The physicochemical parameters of the waters in the seagrass ecosystem of Tidung Besar Island change every month, although the changes are not significant. This is caused by changes in weather and season. According to Patty, seasonal changes can affect changes in temperature and salinity distribution patterns [44]. This is in accordance with data from the Indonesian Agency for Meteorological, Climatological, and Geophysics, which states that October and December 2023 are the dry seasons, while November 2023 is the rainy season. However, the results of the t – test showed that there was no significant difference between the rainy and dry seasons; therefore, the three months can be categorized as transitional seasons.

The fish community structure in the seagrass ecosystem of Tidung Besar Island had varying values for each station and month. Based on these results, this variation is caused by factors such as the environmental conditions of the ecosystem and the correlation between ecosystems. Stations 2 and 3 have seagrass ecosystems and coral reef ecosystems that are close together so that the two ecosystems have strong connectivity, whereas Station 1 has seagrass, mangrove, and coral reef ecosystems that are close together to create connectivity between habitats. This is supported by Adrim's research showing that the diversity of fish species in the seagrass ecosystem is supported by the correlation between ecosystems [39].

Stations 1 and 2 have seagrass beds close to coral reefs. According to Latuconsina *et al.*, there are families of fish typical of coral reefs that can be found in seagrass beds, such as Labridae, Serranidae, Scaridae, Siganidae, Lutjanidae, Lethrinidae, and Pomacentridae [35]. This is in accordance with the findings at Stations 1 and 2, namely that there are fish species such as *C. oxycephalus*, *C. trilobatus* (Labridae), *S. ghobban* and *S. quoyi* (Scaridae), *L. carponotatus* and *L. decussatus* (Lutjanidae), *L. harak* and *L. lentjan* (Lethrinidae), *A. bengalensis* and *A. sordidus* (Pomacentridae). The discovery of typical coral fish at stations 1 and 2 proves that there is habitat connectivity between seagrass and coral reefs. Typical coral reef fish found in seagrass tend to use seagrass beds as a place to find food and as a nursery and protection area as found by Latuconsina *et al*. in the seagrass ecosystem of the Ambon Dalam Bay waters [32].

Station 3 had a seagrass bed located close to the coral reefs and mangroves. According to Latuconsina *et al.*, several typical mangrove families found in seagrass are Carangidae, Sphyraenidae, and Gerreidae [35]. This is in accordance with the findings at Station 3, namely that there are fish species, such as *C. coeruleopinnatus* (Carangidae), *S. jello* (Sphyraenidae), and *G. oyena* (Gerreidae). According to Kimirei *et al.*, the presence of typical coral reefs and mangrove fish in seagrass proves the high connectivity found in the three ecosystems [45]. This is related to the ontogenetic distribution patterns of these fish. Generally, ontogenetic habitat patterns shift from shallower waters, such as seagrass and mangroves, to deeper waters, such as coral reefs.

The presence of typical fish from coral reefs and mangrove ecosystems proves that the richness of fish species in the seagrass ecosystem on Tidung Besar Island is influenced by the presence of coral reefs and mangrove ecosystems that are correlated with each other. It is important to maintain the stability of each habitat in order to create stable water conditions. The seagrass ecosystem on Tidung Besar Island can be categorized as quite good when viewed from the perspective of the diversity of existing fish. Good environmental conditions support the presence of existing fishes. Human activities, such as throwing garbage into the sea and anchoring ships in areas where there is seagrass, need to be avoided to reduce the risk of habitat damage. Fishermen's fishing activities must also be monitored. This is because there are still many fishermen who carry out fishing activities with endangered status, namely, *Scarus ghobban* (based on IUCN data).

5. Conclusion

The diversity of fish on Tidung Besar Island is included in the moderate category, with conditions that tend to be stable. The abundance of species and dominance mostly had higher values during the high tides. Richness, diversity, and dominance mostly had higher values during the low tides. The structure of the fish community in the seagrass ecosystem of Tidung Besar Island is influenced by the type and density of the seagrass.

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