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Community Structure of Sea Urchin (*Echinoidea*) in Seagrass Ecosystem at Batu Jimbar Sanur Beach Denpasar

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Abstract

This study aims to determine the intensiveness of sea urchins (Echinoidea) and the community structure of sea urchins in the seagrass ecosystem at Batu Jimbar beach, Sanur. Sampling was carried out at the lowest tide at the three stations. The research results were found 8 types of sea urchins were found consisting of 4 families, namely the Diadematidae family (Echinothrix calamaris, Diadema setosum, Diadema savignyi and Diadema palmeri), Toxopneustidae family (Tripneustes gratilla and Pseudoboletia maculata), Echinometridae family ((Echinometra mathaei) and Stomopneustidae family (Stomopneustes variolaris).The highest density of sea urchins was in Diadema setosum as many as 149 individuals from the three stations with a density value of 0.40 individuals / 375 m2 , while the lowest density for sea urchins was 1 individual / 375 m2 . The highest relative density was in the type of Diadema setosum as much as 149 individuals / 375 m2 and the lowest relative density was in the type of Diadema palmeri as many as 1 individual / 375 m2. The structure of the sea urchin community on Batu Jimbar beach, Sanur shows that from all stations, the value of diversity is moderate with a value of 1.65, the uniformity value is not evenly distributed with a value of 0.00349 and a dominance value of 0.22 it can be concluded that there are no species which dominates at Batu Jimbar beach in Sanur.

Keywords: Echinoidea, community structure, Batu Jimbar, Sanur beach

1. Introduction

There are about 6000 species of Echinoderms in the world and an estimated 950 species of which are sea urchins, which are divided into 15 orders, 46 families, and 121 genera [1,2]. In Indonesia, there are approximately 84 species of sea urchins from 31 families and 48 genera [3]. Each type of sea urchin has a specific habitat distribution. Sea urchins are spread from shallow intertidal areas to deep seas [4]. Sea urchins generally inhabit coral reef ecosystems and seagrass and prefer a slightly hard substrate, especially the substrate in the field seagrass which is a mixture of sand and coral rubble [5,6].

The Echinoderms group is one of the inhabitants of the seagrass beds which is quite prominent and the Echinoidea (sea urchin) class is included in it [7,8]. Seagrass beds are inhabited and used for seeking food and shelter during critical times in their life cycle, especially when they were still larvae [7,9]. Based on their function Ecologically, seagrasses form associations with various marine biota as a feeding ground, nursery ground, and spawning ground, so the seagrass ecosystem has a high diversity of marine biota. [10,11]. Sanur Beach, Denpasar is one of the water areas in Bali which can be found in seagrass beds. Sanur beach is used as a place placing fishing boats and boats for tourism (speedboats and sailing boats) so that it is thought to have an influence on the natural community of biota on the coast [12,13]. In addition, there are also community activities taking sea urchins for economic purposes have been going on for a long time, and it can lead to a decrease in the population of sea urchins [14,15].

2. Materials and Methods

This research is located in the seagrass area of Batu Jimbar Beach, Sanur, Denpasar, Bali. This research was conducted from 17 to 18 February 2021. Sample identification is carried out directlyin the field (in situ). The tools used in this study are snorkeling tools, GPS, Roll meter, transects, stationery, underwater camera, pH meter, thermometer, salinometer and DO meter. This research is a descriptive study using the survey method This research has four stages, namely stages preparation, the observation stage, the stage of determining the location and research station, and the stage observation.

Determination of the location and research station was carried out after the observation stage. In this study, the station is determined based on the distribution and cover of seagrass so that there arethree stations, namely station I is located at the coordinate point 115 ° 15'58.17 "E - 8 ° 41'52.87" S, while station II is located at the coordinate point 115 ° 15'59.34 " E - 8 ° 41'48.15 "S, and Station III is located at coordinates 115 ° 16'0.16"E - 8 ° 41'43.42 "S. Observations were made at low tide with the help of snorkeling equipment. Observation and sampling of sea urchins were carried out using the observation method and the quadratic transectmethod. A quadratic transect measuring 5 x 5 m is installed along the station area parallel to the coastline and 50 m from the coast to the sea with a distance between Station I, II and III of 150 m (Figure 1). Transect measuring 5 x 5 m placed on the edge / side of the transect line and, takingthe abundance data of sea urchins (*Echinoidea*) in the transect quadrant frame measuring 5 x 5 malong 50 m with 2x repetitions [16,17].

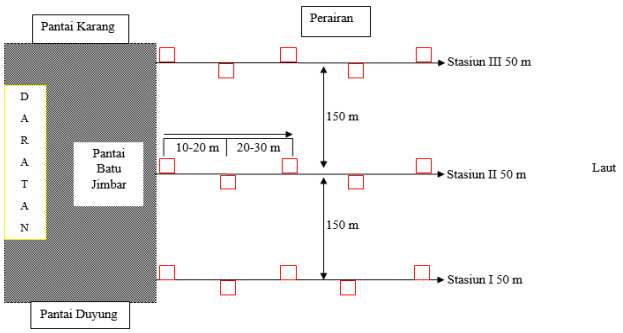

Figure 1.
Transect position in the study

Identification of sea urchins by matching or comparing the body shape (regular and irregular), the diameter of the spicules (test), the color pattern of the spines, the color pattern ofthe anus or periprok, the character of the spines (length and tip of the spines) of sea urchins using the reference [4,18] . Water quality includes taking temperature, salinity, pH, and dissolved oxygen (DO). Water quality measurements are carried out on one line transect at each the observation station is as much as 2 times the data collection. Water quality variable measured, namely: temperature, salinity, pH and DO.

Data analysis

The type composition is the ratio between the number of individuals type against the number of individuals as a whole. The type composition is calculated by using the formula [16].

$$Ki=\frac{ni}{N}X\ 100\%$$

Which's:
Ki = Composition of species i (%)
ni = Number of individuals of type - i (ind)
N = Total number of individuals (ind)

Density of the number of individuals per unit area [19] can known by the following formula as used by other researchers:

$$D\boldsymbol{i}=\frac{\boldsymbol{ni}}{A}$$

Which's:
Di = Density for species i
ni = Number of individuals for each species
A = Total area of the sampled habitat (ind / m2)

Relative species density (RSD) is the proportion of the number of individuals of a species against the number of individuals of all species [20].

$$RSD\boldsymbol{i}=\frac{D\boldsymbol{i}}{\sum D}$$

Which's:
RSDi = Relative density of i – species
Di = Density of the - i species
ΣD = Total density of all species

The calculation of the diversity of this species is done using Shannon - Wienner Diversity Index which is based on base logarithms two [16] with equation (3).

$$H'=-\sum p\boldsymbol{i}\ log2\ p\boldsymbol{i}\ \text{dimana}\ p\boldsymbol{i}=\boldsymbol{ni}/N$$

Which's:
H' = Shannon's diversity index
Pi = Proportion of abundance from individual to I (ni / N)
ni = Number of individuals for each species
N = Total individuals of all speciesWith the following criteria:
H' < 1 : Low diversity
1 < H' < 2 : Moderate diversity
H' > 3 : High diversity

The uniformity of sea urchins at each station was calculated using the Shannon - Winner formula [20].

$$E = H' / Log2\ S$$

Which's:
E = Uniformity index
H' = Diversity index
S = Number of species
With the following criteria:
E approaches 0 : The distribution of types is uneven
E approaches 1 : The distribution of species is relatively even

The dominance index shows the balance in a division the number of individuals of each type and calculated by the Simpson dominance index [21].

$$D = \sum ni\ (ni-1) / N\ (N-1)$$

Which's:
D = Simpson dominant index
ni = Number of individuals of each speciesN = Total individuals of all species
With the following criteria:
D is close to 0 (D <0,5) : Neither type predominates
D approaches 1 (D > 0.5) : there are types that dominate

3. Results and Discussion

3.1 Result

1. Types of sea urchins (Echinoidea) at Batu Jimbar Beach, Sanur

The types of sea urchins (Ehinoidea) obtained during the study were obtained seen in the following 1.

Table 1
The types of sea urchins found on Batu Jimbar beach, Sanur

Types / Species	Number of Sea Urchins (Echinoidea)			
	Station I	**Statoin II**	**Statoin III**	**Statoin IV**
1 *Echinothrix calamaris*	46	14	73	133
2 *Tripneustes gratilla*	27	5	3	35
3 *Diadema setosum*	9	45	95	149
4 *Echinometra mathaei*	46	1	28	75
5 *Stomopneustes variolaris*	28	2	7	37
6 *Diadema savignyi*	5	10	27	42
7 *Diadema palmeri*	1	0	0	1
8 *Pseudoboletia maculata*	2	0	0	2
Average	**164**	**77**	**233**	**474**

Eight species of sea urchins were found consisting of four families, namely the Diadematidae family (Echinothrix calamaris, Diadema setosum, Diadema savignyi and Diadema palmeri) family Toxopneustidae (Tripneustes gratilla and Pseudoboletia maculata) family Echinometridae (Echinometra mathaei) and the family Stomopneustidae (Stomopneustes variolaris).

2. Values at Station I, II, III, All Stations and Quality Parameters Water on Batu Jimbar Beach, Sanur T

The values of species composition, density, relative density, H ', E, D at station I can be seen in Table 2.

Table 2
The total score at station I

No	Jypes / Species	Total Area of Sampled Habitat (m2)	Number (Ni)	Composition Type (Ki=Ni/Nx100%)	Type density	Relative Densi RSDi=Di/ΣD	Diversity Index (H')	Uniformity Index (E)	Index Dominance (D
1	*Echinothrix calamaris*		46	0.28	0.37	0.28	0.36	0.002	0.07867
2	*Tripneustes gratilla*		27	0.16	0.22	0.16	0.30	0.002	0.02710
3	*Diadema setosum*		9	0.05	0.07	0.05	0.16	0.001	0.00301
4	*Echinometra mathaei*	125	46	0.28	0.37	0.28	0.36	0.002	0.07867
5	*Stomopneustes variolaris*	28		0.17	0.22	0.17	0.30	0.002	0.02915
6	*Diadema savignyi*	5		0.03	0.04	0.03	0.11	0.001	0.00093
7	*Diadema palmeri*	1		0.01	0.01	0.01	0.03	0.000	0.00004
8	*Pseudoboletia maculata*	2		0.01	0.02	0.01	0.05	0.000	0.00015
	Average	164		1.00	1.31	1.00	1.66	0.010	0.21773

The values of species composition, density, relative density, H ', E, D at station II can be seen in Table 3.

Table 3
The total score at station II

No	Jypes / Species	Total Area of Sampled Habitat (m2)	Number (Ni)	Composition Type (Ki=Ni/Nx100%)	Type density	Relative Densi RSDi=Di/ΣD	Diversity Index (H')	Uniformity Index (E)	Index Dominance (D
1	*Echinothrix calamaris*		14	0.18	0.11	0.18	0.31	0.004	0.03306
2	*Tripneustes gratilla*		5	0.06	0.04	0.06	0.18	0.002	0.00422
3	*Diadema setosum*		45	0.58	0.36	0.58	0.31	0.004	0.34154
4	*Echinometra mathaei*	125	1	0.01	0.01	0.01	0.06	0.001	0.00017
5	*Stomopneustes variolaris*	2		0.03	0.02	0.03	0.09	0.001	0.00067
6	*Diadema savignyi*	1		0.13	0.08	0.13	0.27	0.003	0.01687
7	*Diadema palmeri*	0		0.00	0.00	0.00	0.00	0.000	0.00000
8	*Pseudoboletia maculata*	0		0.00	0.00	0.00	0.00	0.000	0.00000
	Average	**77**		**1.00**	0.62	1.00	1.22	0.016	0.39653

The values of species composition, density, relative density, H ', E, D at station III can be seen in Table 4.

Table 4

The total score at station III

No	Jypes / Species	Total Area of Sampled Habitat (m2)	Number (Ni)	Composition Type (Ki=Ni/Nx100%)	Type density	Relative Densi RSDi=Di/ΣD	Diversity Index (H')	Uniformity Index (E)	Index Dominance (D
1	*Echinothrix calamaris*		73	0.31	0.58	0.31	0.36	0.002	0.09816
2	*Tripneustes gratilla*		3	0.01	0.02	0.01	0.06	0.002	0.00017
3	*Diadema setosum*		95	0.41	0.76	0.41	0.37	0.002	0.16624
4	*Echinometra mathaei*	125	28	0.12	0.22	0.12	0.25	0.001	0.01444
5	*Stomopneustes variolaris*		7	0.03	0.06	0.03	0.11	0.000	0.00090
6	*Diadema savignyi*		27	0.12	0.22	0.12	0.25	0.001	0.01343
7	*Diadema palmeri*		0	0.00	0.00	0.00	0.00	0.000	0.00000
8	*Pseudoboletia maculata*		0	0.00	0.00	0.00	0.00	0.000	0.00000
	Average		233	1.00	1.86	1.00	1.40	0.006	0.29334

The values of species composition, density, relative density, H ', E, D for all station can be seen in Table 5.

Table 5

Total scores for all stations

No	Jypes / Species	Total Area of Sampled Habitat (m2)	Number (Ni)	Composition Type (Ki=Ni/Nx100%)	Type density	Relative Densi RSDi=Di/ΣD	Diversity Index (H')	Uniformity Index (E)	Index Dominance (D
1	*Echinothrix calamaris*		133	0.28	0.35	0.28	0.36	0.001	0.07873
2	*Tripneustes gratilla*		35	0.07	0.09	0.07	0.19	0.000	0.000545
3	*Diadema setosum*		149	0.31	0.40	0.31	0.36	0.001	0.09881
4	*Echinometra mathaei*	375	75	0.16	0.20	0.16	0.29	0.001	0.02504
5	*Stomopneustes variolaris*		37	0.08	0.10	0.08	0.20	0.000	0.00609
6	*Diadema savignyi*		42	0.09	0.11	0.09	0.21	0.000	0.00785
7	*Diadema palmeri*		1	0.00	0.00	0.00	0.01	0.000	0.00000
8	*Pseudoboletia maculata*		2	0.00	0.01	0.00	0.02	0.000	0.00002
	Average		474	1.00	1.26	1.00	1.65	0.003	0.22000

Composition analysis results of sea urchins (Ehinoidea) at Batu Jimbar beach can be seen in the following figure 1.

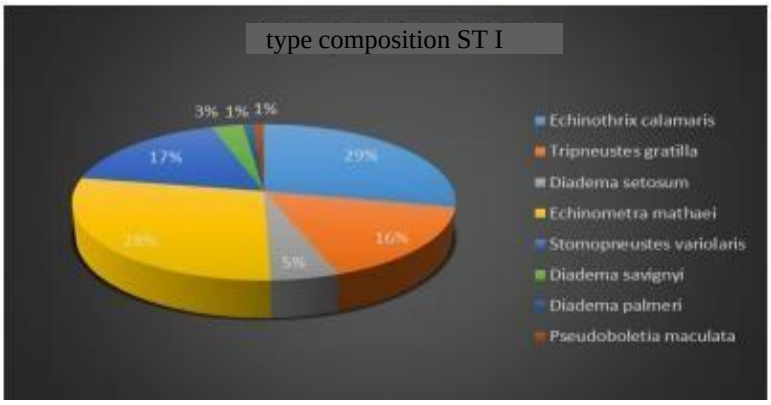

Figure 1
Composition of sea urchins (Echinoidea) STI

Based on the results of the study, it was shown that the composition of the type of sea urchin (Echinoidea) was highest in the research at station I, namely Echinothrix calamaris of 29% (46 ind/125 m^2) and the smallest type was Diadema palmeri and Pseudoboletia maculata 1% (1 ind / 125 m^2). Composition analysis results of sea urchins (Ehinoidea) at Batu Jimbar beach can be seen in the following figure 2.

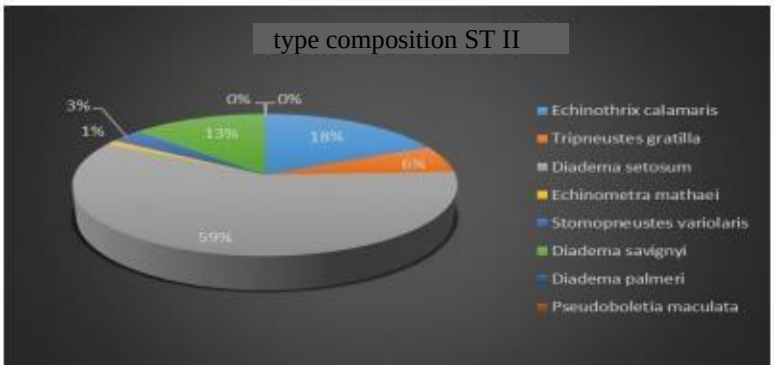

Figure.2
Composition of sea urchins (Echinoidea) STII

At the second station the research results showed that the highest composition of sea urchins (*Echinoidea*) found in the study at station II was Diadema setosum 59% (45 ind / 125 m^2) and the smallest type was Echinometra mathaei 1% (1 ind / 125 m^2).

Composition analysis results of sea urchins (*Ehinoidea*) at Batu Jimbar beach can be seen in the following figure 3.

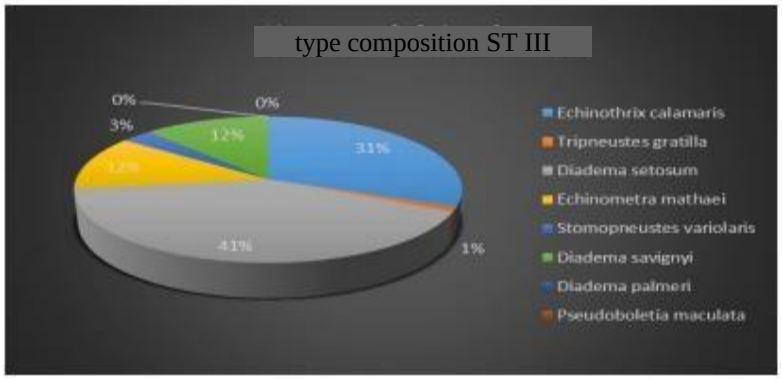

Figure 3.
Composition of sea urchins (Echinoidea) STIII

Whereas at the third station the research results showed that the highest composition of sea urchins (Echinoidea) found in the study at station III was the highest type of Diadema setosum 41% (95 ind / 125 m^2) and the smallest type was Tripneustes gratilla 1% (3 ind / 125 m^2). At these three stations, the highest type is from the Diadematidae family.

3. Density of Sea Urchin (Echinoidea) at Stations I, II and III

Density analysis results of sea urchins (Echinoidea) at Batu Jimbar beach can be seen in the following Figure 4.

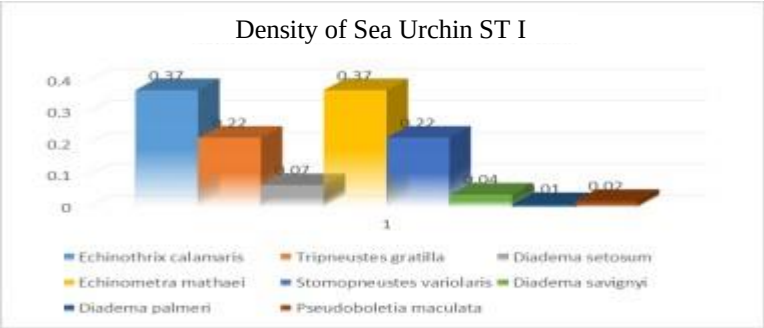

Figure 4.
Density of sea urchins (Echinoidea) ST I

Based on the results of the study, it was shown that the highest density of sea urchins (*Echinoidea*) found in research at station I was Echinothrix calamaris and Diadema setosum of 0.37 Di (46 ind / 125 m^2), and the smallest was Diadema palmeri, namely 0, 1 In (1 ind / 125 m^2).

The results of the density analysis of sea urchins (Echinoidea) at Batu Jimbar beach can be seen in Figure 5.

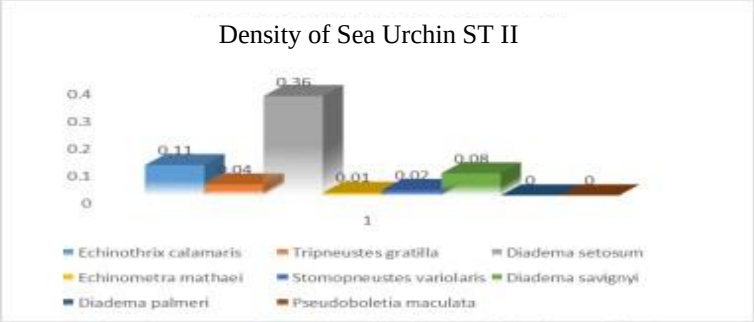

Figure 5.
Density of sea urchins (Echinoidea) ST II

At the second station the research results showed that the highest composition of sea urchins (Echinoidea) found in the study at station II was the highest type of Diadema setosum 0.76 Di (45 ind / 125 m^2) and the smallest type was Echinometra mathaei, namely 0, 01 In (1 ind / 125 m^2).

The results of the density analysis of sea urchins (Echinoidea) at Batu Jimbar beach can be seen in Figure 6.

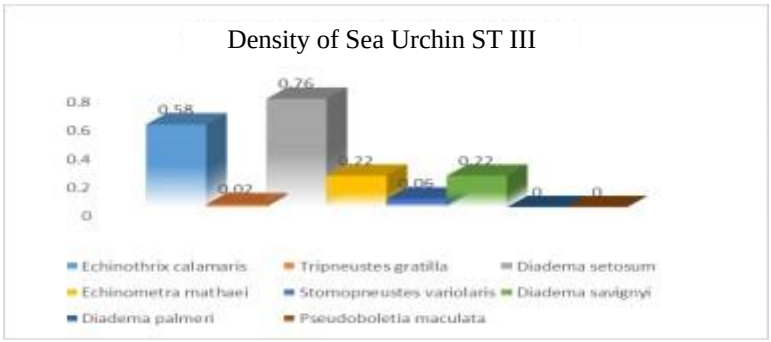

Figure.6.
Density of sea urchins (Echinoidea) ST III

Whereas at the third station the research results showed that the highest density of sea urchins (Echinoidea) found in the study at station III was the highest type of Diadema setosum, namely 0.76 Di (95 ind / 125 m^2) and the smallest type was Tripneustes gratilla, namely 0.02 Di (3 ind / 125 m^2).

4. Relative Density of Sea Urchin (Echinoidea) at Stations I, II and III

The results of the analysis of the relative density of sea urchins (Echinoidea) at Batu Jimbar beach can be seen in the following figure 7.

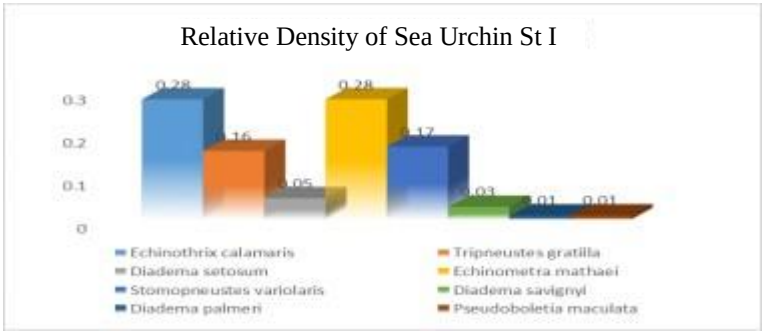

Figure 7
Relative density of sea urchins (Echinoidea) ST I

Based on the results of the study, it was shown that the highest relative density of sea urchins (*Echinoidea*) found in the study at station I was Echinothrix calamaris and Echinometra mathaei 0.28 RSDi (46 ind / 125 m^2), and the smallest was Diadema palmeri, namely 0, 1 In (1 ind / 125 m^2).

The results of the analysis of the relative density of sea urchins (*Echinoidea*) at Batu Jimbar beach can be seen in Figure 8.

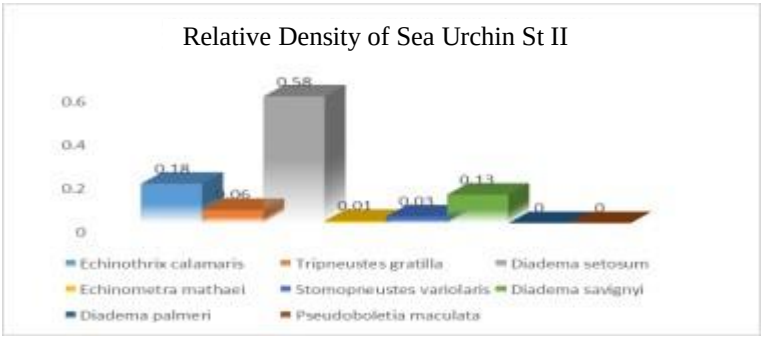

Figure 8.
Relative density of sea urchins (Echinoidea) ST II

At the second station the research results showed that the highest relative density of sea urchins (*Echinoidea*) found in the study at station II was the type of `Diadema setosum, namely 0.58 RSDi (45 ind / 125 m^2), and the smallest type was Echinometra mathaei, namely 0.01 RSDi (1 ind / 125 m^2).

The results of the analysis of the relative density of sea urchins (Echinoidea) at Batu Jimbar beach can be seen in figure 9.

Figure 9.
Relative density of sea urchins (Echinoidea) ST III

Whereas at the third station the research results showed that the highest relative density of sea urchins (*Echinoidea*) found in the study at station III was the highest type of Diadema setosum 0.41 RSDi (95 ind / 125 m^2) and the smallest type was Tripneustes gratilla, namely 0, 01 RSDi (3 ind / 125 m^2).

5. Diversity Index, Uniformity and Dominance of Sea Urchin (Echinoidea) At Stations I, II and III

Diversity index value, uniformity index and dominance index in Batu Jimbar beach can be seen in the following figure 10.

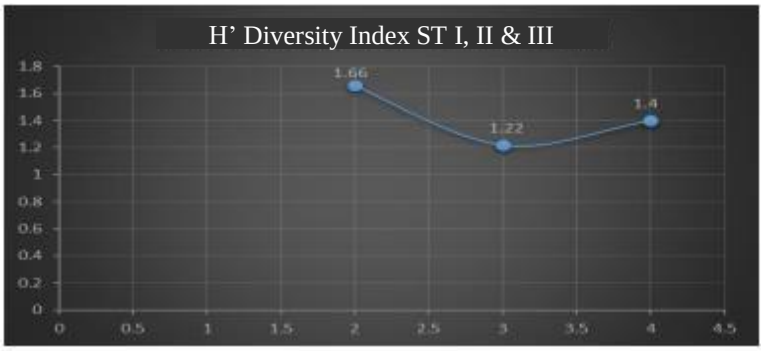

Figure 10.
H 'index of sea urchins (Echinoidea) at ST I, II & III

The analysis results obtained for the diversity index at Batu Jimbar beach are at station I at 1.66 H ', station II at 1.22 H', while at station III at 1.4 H '. Based on the results of the analysis of the diversity index according to Odum (1971) if 1 <H '<2 then the diversity is moderate. From the diversity value above shows that at the research location the value of diversity is moderate because the H 'value of the three stations is less than 2.The freshness index value at Batu Jimbar beach can be seen in figure 11.

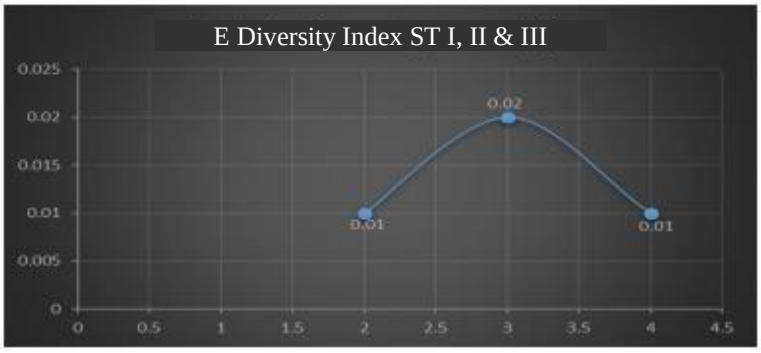

Figure 11.
E index of sea urchins (Echinoidea) at ST I, II & III

The analysis results obtained for the uniformity index at Batu Jimbar beach are at station I of 0.01, station II 0.02 E and station 0.01 E. The uniformity index value of sea urchins at the three stations is categorized as uneven because it is close to 0. This indicates that the abundance of organisms in the community is very low in population uniformity so that the types of sea urchin species tend to be non- uniform. The dominance index value, at Batu Jimbar beach can be seen in Figure 12.

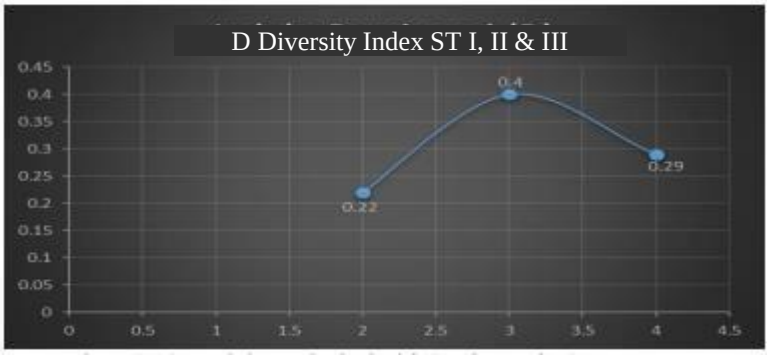

Figure 12.
D index of sea urchins (Echinoidea) at ST I, II & III

The analysis results obtained for the dominance index of sea urchins at each station on Batu Jimbar beach, namely at station I is 0.22 D, station II is 0.4 D, while at station III it is 0.29. The station is stated that there is no species that dominates because the value obtained from the three stations is 0.29 the highest. In accordance with the dominance criteria according to Magguran [21] if D is close to 0 it means that no species dominates and if D approaches 1 it means that one species is dominating.

6. Average Value of All Stations at Batu Jimbar Beach, Sanur

Average Value of Stations I, II and III at Batu Jimbar Beach, Sanur can be seen in the following Figure.13.

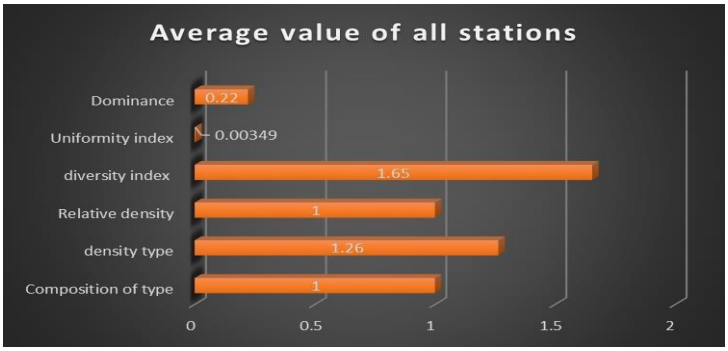

Figure 13.
The average value of stations I, II and III

Diadema setosum is the most common type found at the study site. Bulleri et al. [22] stated that the habitat of Diadema setosum is located in a shallow area close to the intertidal, and must be able to tolerate the action of harsh waves. The large number of Diadema setosum is thought to have been influenced by the condition of the aquatic habitat, where this species is often found in rocky zone areas because it is influenced by food and dietary factors [23,24]. The observation results show that Station I and Station III have a fairly high number of individuals, in comparison to Station II which is lower.

Based on the conditions of the aquatic environment that have been described previously, it is known that station I and station III have rougher substrate conditions, or in other words have a hard bottom compared to station II which is more on a muddy sand substrate. The condition of the coarse substrate is very supportive of the survival of Echinoidea species, especially Diadema setosum.

7. Measurement of Water Quality Parameters

Water quality parameters measured in the study are parameters physics and chemistry which includes: temperature, salinity, degree of similarity (pH) and oxygen dissolved (DO). It can be seen in the following Table 6.

Table 6.
Seawater quality parameters at Batu Jimbar beach, Sanur

No	Parameters	Unit	Station			Average	Sea Water Quality Standards
			I	II	III		
1	Temperature	°C	27	30	31.16	29.4	20 - 30 (c)
2	Salinity	‰	29	31	32	30.7	33 - 34 (e)
3	pH	–	7.8	7.4	7.9	7.7	7 - 8,5 (d)
4	DO	ppm	3.8	4.6	4.2	4.2	> 5

Water Quality Standards Sea according to Kep.Men LH No: 51 of 2004 is a measure of the limit or level living things, substances, energies or components that exist or must exist and or elements tolerable pollutants in seawater. Pollution Index (PI) is an assessment value to state the level of pollution [23,25].

4. Conclusion

Composition of sea urchins found on Batu Jimbar beach, Sanur as many as 8 types consisting of 4 families, namely the Diadematidae family (Echinothrix calamaris, Diadema setosum, Diadema savignyi and Diadema palmeri) family Toxopneustidae (Tripneutes gratilla and Pseudoboletia maculata) family Echinometridae (Echinometra mathaei) and family Stomopneustidae (Stomopneustes variolaris). The highest density of sea urchins on Batu Jimbar beach, Sanur by type Diadema setosum with an average density value of 0.40 Di (149 ind / 125 m2), while the lowest density of sea urchins is from species Pseudoboletia maculata 0.01 in (2 ind / 125 m2). Based on the results of the data analysis from all stations, namely the valu 1.65 H 'moderate diversity, the value of 0.00349 E is uneven uniformit and a value of 0.22 D, it can be concluded that there are no species that dominate on the Batu Jimbar beach in Sanur.

References

[1] Clark A, Rowe F. (1971). Monograph of Shallow-water Indo-West Pacific Echinoderms. London: London Muesum,. 238 p.

[2] Andilala N, Khalallia FBR, Maharani SE, Ramadhani PH, Huda AM, Putri AF, et al. (2020). The diversity of Echinoderm in Sarangan beach , Gunung Kidul , Yogyakarta The diversity of Echinoderm in Sarangan beach , Gunung Kidul ,. IOP Conf Ser Earth Environ Sci.404(1).

[3] Suwignyo S, B W, Y W, M K. 2005. Avertebrata Air Jilid 1. Jakarta: Swadaya.

[4] Jeng M. (1998). Shallow – Water Echinoderms of Taiping Island in the South China Sea. Zoological Studies.

[5] Aziz A. (1994). Tingkah Laku Bulu Babi di Padang Lamun. Oseana, 19(4), 35–43.

[6] Ilman Huda MA, Sudarmadji S, Fajariyah S. (2017). Keanekaragaman Jenis Echinoidea di Zona Intertidal Pantai Jeding Taman Nasional Baluran. Berk *Sainstek*, 5(2):61.

[7] Aswandy I, Azkab H. (2000). Hubungan Fauna dengan Padang Lamun. 25(3), 19–24.

[8] Istiqlal BA, Kasa IW, Yusup D. (2018). Invertebrates Diversity of Merta Segara and Nyangnyang Beach : Comparison Invertebrates Diversity of Merta Segara and Nyangnyang Beach : Comparison Study of Two Beaches with Different. *J Adv Trop Biodivers Environ Sci*, 2(2).

[9] Latuconsina H, Padang A, Ena AM. (2019). Iktiofauna di Padang Lamun Pulau Tatumbu Teluk Kotania , Seram Barat – Maluku (*Ichthyofauna in Seagrass Beds of Tatumbu Islands Kotania Bay , West Ceram - Mollucas*), 12(1), 93–104.

[10] Supono AU. (2010). Struktur Komunitas Ekinodermata di Padang Lamun Perairan Kema, Sulawesi Utara. Oseanology dan Limnol Indones, 36(3), 329–41.

[11] Toha AHA, Sumitro SB, Hakim L, Widodo N, Binur R, Anggoro AJIW. (2017). Review : Biology of the commercially used sea urchin Tripneustes gratilla (Linnaeus , 1758) (Echinoidea : Echinodermata), 1(1), 1–10.

[12] Moreira J. (2006). Pattern of Occurrence of Grazing Mollusks on Sandstone and Concrete Seawalls in Sydney, Harbour (Australia). *Molluscan Res*, 26(1), 51–60.

[13] Green DS, Chapman MG, Blockley DJ. (2012). Ecological consequences of the type of rock used in the construction of artificial. Ecol Eng [Internet], 46:1–10. Available from: http://dx.doi.org/10.1016/j.ecoleng.2012.04.030

[14] Yulianto A. (2010). Pemanfaatan Bulu Babi Secara Berkelanjutan Pada Kawasan Padang Lamun. Program Pascasarjana. Universitas Indonesia.

[15] Luthfi OM, Dewi CS, Sasmitha RD, Alim DS, Putranto DBD, Yulianto F. (2018). Kelimpahan invertebrata di pulau sempu sebagai indeks bioindikator, ekonomis penting konsumsi, dan komoditas koleksi akuarium. *JFMR (Journal Fish Mar Res)*, 2(3).

[16] English S, Wikinson C, Baker V. (1994). Survey Manual for Tropical Marine Resources. Queensland: Australian Institute of Marine Science. 390 p.

[17] Gibson R, Atkinson R, Gordon J. A (2016). Review of underwater stereo-image measurement for marine biology and ecology applications. *Oceanography and marine biology: an annual review*, 47,257–92.

[18] Colin P., Charles A. (1995). Tropical Pacific Invertebrates. USA: Coral Reef Press.
[19] Brower J., Zar J., Von Ende C. (1998.). Field and Laboratory Methods for General Ecology. Fourth Edi. New York: The McGraw-Hill companies.
[20] Odum P. (1993). Dasar – Dasar Ekologi. Diterjemahkan dari Fundamental of Ecology oleh T. Samingan. Yogyakarta: Universitas Gadjah Mada Press.
[21] Magurran A.(1998). Ecological Diversity And Measurement. USA: Chapman and Hall.
[22] Bulleri.(2002). Klasifikasi Echinoidea. Jakarta: Penerbit Djambatan.
[23] Thamrin T, Setiawan YJ, Siregar S. (2011). Analisa Kepadatan Bulu Babi Diadema Setosum pada Kondisi Terumbu Karang Berbeda di Desa Mapur Kepulauan Riau. *J Ilmu Lingkung*an, 5(1), 45–53.
[24] Lubis SA, Yolanda R, Purnama AA, Karno R. (2016). The Sea Urchin (Echinoidea) from Panjang Island Water, Bangka Belitung Province. *Omni-Akuatika*, 12(2).
[25] Kementrian Lingkungan H. Keputusan Menteri Negara Lingkungan Hidup Nomor : 115 Tahun 2003 Tentang Pedoman Penentuan Status Mutu Air Tahun 2003.