Original Research Article

Diversity of Echinoderm in The Subtidal Zone of Sintok Island, Karimunjawa National Park, Jepara, Indonesia

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ABSTRACT

Aims: to determine the diversity of Echinoderms in the subtidal zone of Sintok Island.
Study design: This study applied a purposive sampling method.
Place and Duration of Study: Sintok Island, Jepara, Indonesia, November 2019.
Methodology: Thebelt transect method was used. The transect was drawn 200 m perpendicular from the coastline to the sea. The echinoderms in the 2m area along the transect line are observed for their diversity, the number of individuals from each species is counted, and the substrate is observed.The diversity index of Shannon-Wiener, evenness (uniformity), and dominance indices were analyzed.
Results: The results showed 11 species belonging to 3 classes of Echinoderms found in Sintok Island. Holothuroidea class consisted of *Holothuriaatra*, *H. coluber*, *H. edulis*, *H. impatiens*, *Pearsonothuriagraeffei*, and *Synaptamaculata*. Asteroidea class consisted of *Culcitanovaeguineae*, *Linckia laevigata*, and *Protoreasternodosus*. The Echinoidea class consists of *Diademasetosum* and *Laganumlaganum*. *H. atra* was the most abundant species (0.70 ind.m^{-2}). The diversity index value (H') of Echinoderm was in the range of 1.21 to 2.01, classified as a moderate condition.
Conclusion: The echinoderm species in subtidal areas on Sintok Island could be a good tourist attraction in this national park.

Keywords: [Holothuroidea, Asteroidea, Echinoidea, tourism, diversity, Sintok, Karimunjawa]

1. INTRODUCTION

Sintok is one small inhabited island of the Karimunjawa Archipelagos, located in the Northwest of Jepara Regency, Central Java, Indonesia. It comprises beach forest vegetation with a coral barrier in the outer subtidal area rich with seagrass and coral ecosystems. As the beach was white sand, Sintok Island became a tourist destination in Karimunjawa National Park[1]. Tourism activity in Sintok Island is mostly carried out in the subtidal zone. The subtidal zone is the zone close to shore but constantly submerged. Coastal waters, i.e., the intertidal and subtidal zones, experience the most extreme changes due to land processes. For example, the salinity can fluctuate between high salinity in hot, dry winds and low salinity during heavy rain and runoff. Temperature extremes can also exist, as the air temperature changes seasonally. The subtidal communities are less affected than intertidal communities but still experience these changes[2]. In contrast to the other zones, this provides a good habitat for a high diversity of marine plants and animals, including Echinoderm.

Echinoderms are distributed widely and can be found in varied habitats, from intertidal zones to deep seas [3]. Echinoderms can regenerate their body, either broken or damaged by predators. Most animals in this class have a radially symmetrical body and a calcareous endoskeleton with spines. The main group of Echinoderms consists of five classes: Asteroidea, Ophiuroidea, Echinoidea, Crinoidea, and Holothuroidea [4].

Generally, echinoderms live in clear, calm waters and play numerous ecological roles. Sand dollars and sea cucumbers burrow into the sand, providing more oxygen at greater depths of the sea floor and allowing more organisms to live there. In addition, starfish prevent the growth of algae on coral reefs [5]. This allows the coral to filter-feed more easily. Many sea cucumbers provide a habitat for commensal biota, such as fish, crabs, worms, and snails. Echinoderms are also important in the ocean food chain [6]. According to Setyastuti et al. [7], the highest diversity of Echinoderms can be found on coral reefs and shallow beach habitats. Echinodermata has a variety of shapes, sizes, and colors. Often with five or multiple arms, sometimes their arms were less than five [8]. Echinoderms are also colorful, so they attract tourists to observe them. This activity can be used for education and tourism in the area [9]. Research on diverse echinoderms on several islands in the Karimunjawa National Park has been conducted, such as on Cemara Besar Island [10], in Indoor Wreck, Kemujan Island [11], Cemara Kecil Island [12], in Menjangan Kecil, Karimunjawa, and Kemujan Island [13] [14]. One of the locations designated for tourism destinations is the waters of Sintok Island, Karimunjawa National Park. However, there is no data or information about the Echinoderms that inhabit there. Therefore, the present study aims to identify and determine the community structure of echinoderm in the subtidal one of Sintok Island.

2. MATERIAL AND METHODS

This research was conducted in November 2019 in the subtidal area of Sintok Island, Karimunjawa, Jepara Regency. There were four station observation and the geographical positions were as follows: Station 1 (5˚47'7.71" S; 110˚30'45.65" E), Station 2 (5˚46'59.37" S; 110˚30'35.81" E), Station 3 (5˚46'48.08" S; 110˚30'40.28" E) and Station 4 (5˚47'1.58" S; 110˚30'53.36" BT) (figure 1).

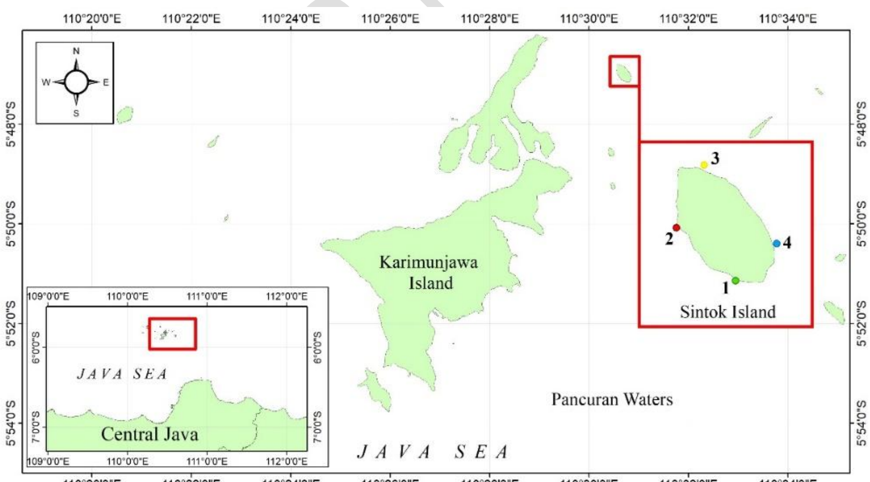

Fig. 1. Map of sampling stations of Sintok Island, Karimunjawa National Park, Jepara, Central Java, Indonesia

The observation used the belt transect method [15]. The transect was drawn 200 m perpendicular from the coastline to the sea. After the roll meter is installed, the echinoderms in the 2m area along the transect line are observed for their diversity, the number of individuals from each species is counted, and the substrate is observed. Echinoderms were recorded starting from 0 to 200 m with an observation width of 1 m to the left and right of the transect line so that the observation area was 400 m2 (figure 2).

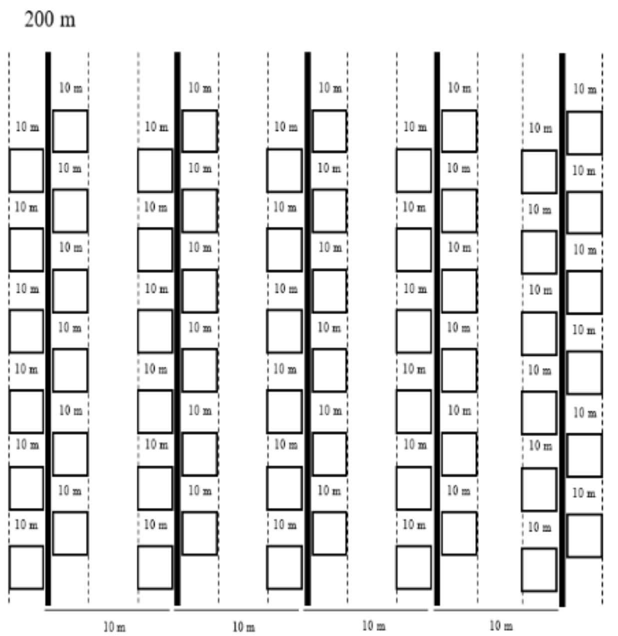

Fig. 2. The transect line position is in each research location on Sintok Island.

The identification of echinoderm is based on [16][17][18][19][20]. Based on each species' abundance data, the echinoderm community structure was determined as follows. The diversity index of Shannon-Wiener, evenness (uniformity), and dominance indices [21] [22] were calculated using the formula below. The benchmark value of diversity, dominance, and evenness was assessed using the criteria of Sumekar and Widayat [23].

$$H' = -\sum_{i=I}^{S} P_i log_2 P_i$$

H': Shannon-Wienner Index of Diversity
S: Number of species
P_i:= No. of indv. of spesieske-i /no.totalindv. (ni/N)

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

E: Eveness Index
H': Diversity Index of Shannon – Wienner
H_{max}: Maximum Diversity Index (log S)
S: Number of species

$$D = \frac{\sum ni\ (ni\ -1)}{N\ (N\ -1)}$$

D: Dominance Index
n_i: Number individual per species
N: Total individual per species

3. RESULTS AND DISCUSSION

3.1. Spesies composition of Echinoderms

Three classes of Echinoderm were found in the four stations of the subtidal zone of Sintok Island, namely Holothuroidea, Asteroidea, and Echinoidea. The number of Echinoderms in the subtidal zone of Sintok Island waters was 416 individuals, consisting of 11 species, i.e., *Holothuriaatra*, *H. coluber*, *H. edulis*, *H. impatiens*, *Pearsonothuriagraeffei*, and *Synaptamaculata* (Holothuroidea), *Culcitanovaeguineae*, *Linckia laevigata*, *Protorasternodosus* (Asteroidea), *Diademasetosum*, and *Laganumlaganum* (Echinoidea) (Figure 3).

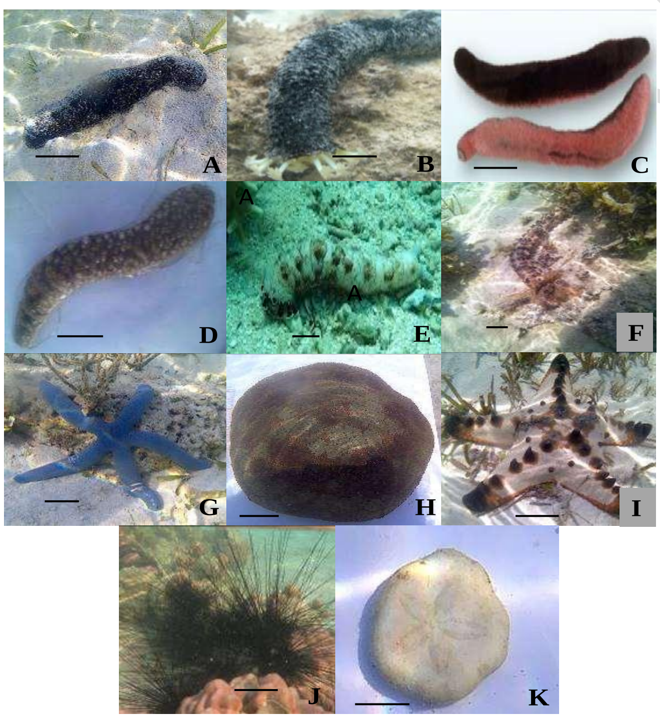

Fig.3.Echinoderm species found in the sub-tidal zone of Sintok Island (A. *Holothuriaatra* B. *H. coluber*, C. *H. edulis*, D. *H. impatiens*, E. *Pearsonothuriagraeffei*, F. *Synaptamaculata*, G. *Culcitanovaeguineae*, H. *Linckia laevigata*, I. *Protorasternodosus*, J. *Diademasetosum*, K. *Laganumlaganum*; black line is 1 cm)

There were two families of Holothuroidea inhabited in the subtidal zone of Sintok Island, namely the Holothuroiidae and Synaptidae family. Their integument structure could differentiate them. The Holothuriidae family had a structured and strong integument, while the Synaptidae family had a limp integument, and all parts of their body were very sticky when touched. According to Hartati and Widianingsih[24], the Holothuriidae family had rounded body cross-sections and tube feet for locomotors, while the Synaptidae family have no tube feet, tentacle ampullae, retractor muscles, respiratory trees, or cuvierian tubules [25]. The body of the latest family was like a worm, and the body walls were thin. Hartati et al. [24] stated that the body surface of sea cucumbers is generally rough due to spicules on the skin walls. The spicula was an endoskeleton that had been reduced to microscopic sizes and was embedded in the dermis layer of the sea cucumber body wall. The shape of the spicula varies and is unique to each species. Therefore, spicules can characterize sea cucumbers' genera and species [27].

Six species of Holothuroidea, namely *H.atra, H. coluber, H. edulis, H. impatiens, P.graeffei,* and *S.maculata*, were encountered in the subtidal area of Sintok Island. They had different characteristics. *H. atra* has an elongated body shape and is generally soft in black [26]. There were short papillae. Observations on Sintok Island show that this species is found in seagrass and sand substrates. Its body was often found covered in sand. It is thought to be an effort to defend itself. *H. coluber* had the characteristics of a black body with a cylindrical shape and thick integument. This species had papilla on its dorsal, which is longer than the *H. atra*, so it has a coarser texture [28]. There were tentacles in the mouth located in the ventral. The tips on the tentacles were light-colored, as were the papillae. [29] stated that the length of H. coluber was 18-40 cm. Its body color was black even though it was soaked in alcohol. It has a yellowish-white dorsal papilla, scattered irregularly. The integument was thick and hard, and the mouth was at the ventral and the anus at the terminal. The tentacles on its shield-type mouth were yellow. The tube feet were white and arranged in rows on the ambulacral and interambulacral ventral bodies.

The body of *H. edulis* had a different coloration on the dorsal and ventral sides. On the dorsal part, H. edulis is black, while on the ventral part, it is bright pink. It had black papillae on the dorsal side [28]. Morphologically, *H. edulis* had a round cross-body section, the ventral side tends to be flat, and the anal canal is round. Another Holothuroidea species was *H. impatiens*, characterized by a rough round body texture due to its prominent papillae. Its body shape was cylindrical with flexible integument in the body [24]. The body is grayish-yellow with bright papilla tips and a blackish-brown patch in the dorsal part. The ventral mouth is surrounded by 20 tentacles which are in turn surrounded by a ring of very small conical papillae; the anus terminal with five conical papillae [29]. *H. impatiens* is commonly found under rocks and sometimes in seagrass areas.

P. graeffei was also found in the subtidal zone of Sintok Island, it had a light brown color with red-black spots. *P graeffei* has a rough texture due to the large papillae on its body with light-colored tips [30]. According to Prescott et al. [31], it was characterized by a cream-to-brown body with black spots scattered. It has an oval-shaped body with an abdomen, a transverse fold, and tentacles on the mouth. It was a scavenger and roamed around on the seabed, sifting through the sediment with its feeding tentacle.

S. maculata was the only member of the Synaptidae family found in the subtidal areas of Sintok Island waters. This species had very distinct characteristics compared to other Holothuroidea species. Its body shape resembled a snake. Because the integument is so thin that the body is limp. The rest of the body was typically wrinkled, and its color was a semi-transparent white to pale or yellowish-grey, with a low density of ochre-colored spicules [32]. The anterior part was yellow-brown longitudinally, with white and brown stripes and transversal dark grey blotches, and exhibited dense patches of spicules. The sea cucumber species found in this work were less than those found by [27] and [33].

The composition of the Asteroidea class consists of two families, i.e., Ophidiasteridae (*L. laevigata*) and Oreasteridae (*P.nodosus* and *C.novaeguineae*). This class has a total of 30 individuals spread over four stations. The blue sea star, *L. laevigata*, is approximately 15 cm long and has five cylindrical and slender arms. Its body was sturdy because of its calcium carbonate skeleton. These organisms usually live on coral reefs, sand, and seagrass beds [34]. Adults are pentamerous radial symmetrical and possess short, yellow tube feet for locomotion [35]. Another sea star with an interesting body form found was *C. novaeguineae*, i.e., large, bulky, and puffed-up cushion star with a pentagonal shape and 5 almost absent arms [36]. Its color can vary widely from red to green and brown. Yokley [37] stated that *C. novaeguineae* has a pentagonal body shape with five short arms and a sturdy structure. This cushion-like body-shaped sea star was also known as a Cushion star. *P. nodosus* was also found during the present study; it possessed rows of spines or "horns" in the aboral, which was used to scare away possible predators. This starfish also had five sturdy shape arms. Each end of the arm was bent upwards. Jonathan et al. [3] stated that the most dominant color of *P. nodosus* was orange, with black blunt spines on its body. This species usually lives in sandy areas [38].

The echinoidea in the subtidal zone of Sintok island consisted of two families, i.e., Diadematidae (*D.setosum*) and Laganidae (*L.laganum*). This class has a total of 40 individuals in all stations. Sea urchins from Diadema are some of the most widespread, abundant, and ecologically important echinoids in tropical regions [39]. *D. setosum* had a black, round body surrounded by moveable, sharp black spines [40]. It is a typical sea urchin with extremely long, hollow, mildly venomous spines [41]. Besides protecting themselves from predators, these spines were also used for movement apparatus [42]. In the aboral part of this echinoid, there was an orange anal ring and a blue or green color on the genitals, while on the oral part, there is a mouth. *D. setosum* is commonly associated with coral reefs but is also found on sand flats and seagrass beds [39]. Sand dollar (*L. laganum*) was found on a sandy substrate. This species had a light brownish gray color flat body but changed into white when it died. Small thorns were on the body, and its habitat was sandy or muddy [43]. *L. laganum* also was found in Cemara Besar Island of Karimunjawa Archipelago [10].

The previous study in Karimunjawa National Park found several echinoderm species. [3] Hartati et al. [3] found six species of Asteroidea, i.e., *L. laevigata, L. multifora, Neoferdifla ocellata* (Family Ophidiasteridae), *Luidia alternate* (Family Luidiidae), *C. novaeguineae* (Family Oreasteridae) and *Acanthaster plancii* which belongs to Family Acanthasteridae. and *D. setosum, D. antillarum, D. savignyi,* and *Echinothrixcalamaris* (Family Diadematidae). A study byHadi et al. [11] in Indonoor Werk of Kemujan Island revealed more diverse echinoderm and found 3 crinoid species since it lay at 12-15 meters depth. Several Holothurian species have inhabited Karimunjawa Island, such as *H. atra, H. scabra, H. fuscocinerea, Stichopus vastus, Bohadschia marmorata*, and *P. graffei* [45], and *S. monotuberculatus*[46] [14]. In 2021, Hartati et al. [33] found more sea cucumber species diversity in a deeper sea of Nyamuk Island of Karimunjawa National Park, which belonged to two genera (Stichopus and Thelenota), i.e., *S. horrens, S. pseudohorrens, S. naso, S. vastus, S. chloronatus, S. herrmanni, S. monotuberculatus, S. ocellatus, S. quadrifasciatus, Thelenotaanax,* and *T. ananas*.

There were 161, 161, 32, and 71 individuals of echinoderm inhabiting 400 meter^2 area in Stations 1, 2, 3, and 4, respectively, and their abundance was shown in Figure 4. Holothuroidea, especially *H.atra*, was the most abundant (10-114 individuals per station) compared to other classes. This was related to sandy and seagrass beaches as their specific habitat [26]. According to de Guzman and Quiñones [47], the difference in sea cucumber densities may affected by habitat type, time of sampling, or fishing patterns. In the subtidal area, sea cucumbers could be found more easily in seagrass beds as they are usually exposed than in coral reefs of deeper water, except during extreme ebb tides or whenever they are burrowed [48]. The high density of *H. atra* is also found in the Mindanao Area of the Phillippines [49]. The low density of each species in the subtidal area of Sintok Island confirms the resulting study of Sobczyk et al. [8] that the tropical echinoderm communities have high patchiness and low abundance, which is influenced by increased microhabitat diversity and food availability.

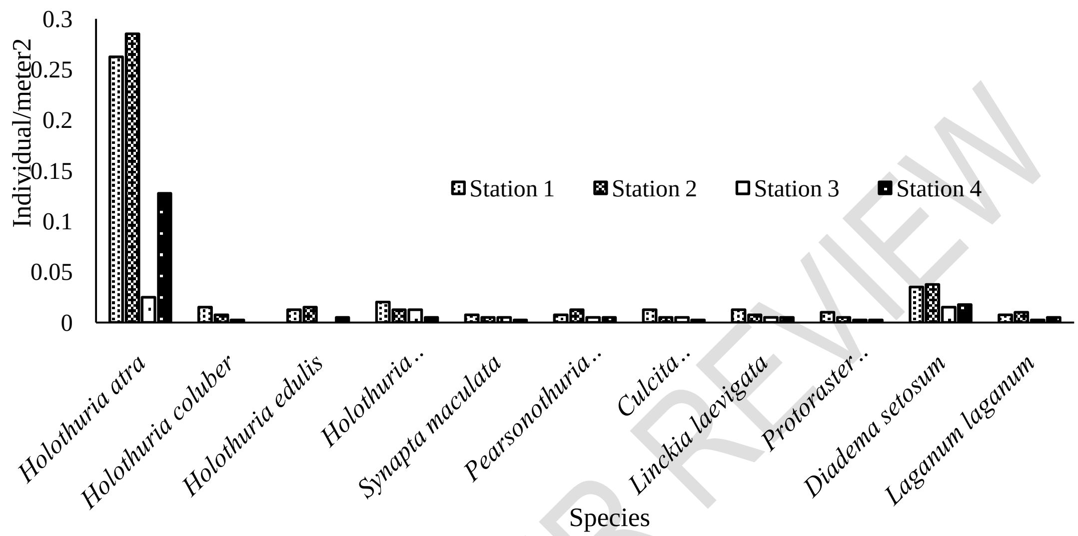

Fig.4. The abundance of echinoderm species (individual.m-2) found in the subtidal zone of Sintok Island

3.2. Diversity, Evenness, and Dominance Index

Diversity (H '), Evenness (E), and dominance (D) indexes were used to estimate the condition of the aquatic environment based on its species composition. The value of the diversity index, uniformity, and dominance at the four stations in the waters of Sintok Island is presented in Figure 5 below.

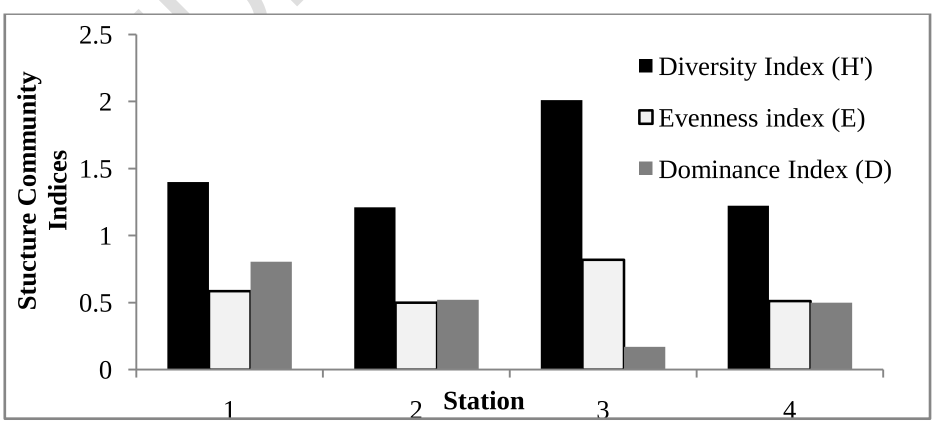

Fig.5. The Echinoderm's species Diversity, Evenness and Dominance Index in the subtidal zone of Sintok island.

The diversity index value (H') was varied with the station, which showed the species abundance. The distribution of individuals of each species influenced this. The highest diversity index value was 2.01 at Station 3, and the lowest was 1.21 at Station 2. This value could be affected by several factors, such as the number of individuals per species or the number of species found in an area [50]; it included a medium condition, which indicated the echinoderm community stability in the subtidal zone of Sintok Island. The presence and role of echinoderms as bioturbators in the subtidal area may increase the abundance of other invertebrates or cause shifts in species composition [51].

The four stations' evenness index value (E) was 0,5-0.84; the highest was found in Station 3 According to Siburian et al. [52], the evenness index value can describe the stability of a community. A community was stable if it had a species evenness index value close to 1 and vice versa if it had a species evenness index value close to 0. Among the four stations, station 2 has a value close to 0 due to the high H. atra abundance value.

The dominance index value (D) of four stations shows varied values, in which Stations 1, 2, 3, and 4 were 0.81, 0.52, 0.17, and 0.50 respectively. Station 1 has the highest dominance index, namely 0.81. According to Yusron[53], the dominance value (D) is in the range of values from 0 to 1. If the dominance index value was close to 1, then there was a relatively abundant (dominant) species, i.e., *H. atra*. The value of diversity, evenness, and dominance indices showed that the subtidal zone of Sintok Island was still a good habitat for echinoderm. The species in subtidal areas could be a good tourist attraction in this national park.

4. CONCLUSION

The diversity of Echinoderms found in the subtidal zone of Sintok Island consisted of 3 classes, namely Holothuroidea, Asteroidea, and Echinoidea. The species consisted of *Holothuriaatra, H. coluber, H. edulis, H. impatiens, Pearsonothuriagraeffei, Synaptamaculata, Linckia laevigata, Culcitanovaeguineae, Protoreasternodosus, Diademasetosum*, and *Laganumlaganum. H. atra* was found to be the most abundant compared to other species. The average diversity index was 1.46, belonging to moderate conditions. The habitat was still good for the echinoderm habitat

REFERENCES

1. Yuliana E, Fahrudin A, Boer M, Kamal MM, Pardede ST. 2016. The effectiveness of the zoning system in the management of reef fisheries in the marine protected area of Karimunjawa National Park, Indonesia. AACL Bioflux. 2016;9(3):483-497.
2. Elizabeth K. OCEAN-101: Fundamentals of Oceanography. Open Education Resource (OER) LibreTexts Project. Diablo Valley College. 2023.

3. Jonathan TYH, Tan R, Sheng LK. Juvenile knobbly sea stars on Singapore shores. Singapore Biodiversity Records. 2016;48-52

4. Espinoza-Rodríguez N, Pernía Y, Severeyn H, de Severeyn YG, BarriosGarridoH.. Echinoderms from the Gulf of Venezuela, NorthWestern Coast of Venezuela. Pap Avulsos Zool. 2021;61: e20216151. DOI: 10.11606/1807-0205/2021.61.51

5. Hermosillo-Nuñez B, Rodríguez-Zaragoza F, Ortiz M, Galván-Villa C, Cupul-Magaña, A, Ríos-Jara E. Effect of habitat structure on the most frequent echinoderm species

inhabiting coral reef communities at Isla Isabel National Park (Mexico). Community Ecology. 2015; 16(1):125-134. DOI: 10.1556/168.2015.16.1.14

6. Radjab AW, Rumahenga SA, Soamole A, Polnaya D, Barends W. Diversity and abundance of echinoderm in Weda Bay of North Maluku. JurnalIlmu dan TeknologiKelautanTropis. 2014; 6(1):17-30. (Indonesian)

7. Setyastuti A, Purbiantoro W, Hadiyanto. Spatial distribution of echinoderms in littoral area of Ambon Island, Eastern Indonesia. Biodiversitas. 2018;19(5):1919-1925. DOI: 10.13057/biodiv/d190544

8. Sobczyk R, Presler P, Czortek P, Serigstad B, Pabis K. Diversity, distribution patterns and indicatory potential of echinoderm communities of the tropical East Atlantic (Gulf of Guinea): Influence of multiple natural and anthropogenic factors along a 25–1000 m depth gradient. Ecological Indicators. 2023;156, 111108. https://doi.org/10.1016/j.ecolind.2023.111108

9. Fitriana N. Sea Star Identification (Echinoderm: Asteroidea) on Pari Island Coast of Seribu Archipelago. Faktor Exacta. 2015;3(2):167-174. (Indonesian)

10. Dian A, Hartati R, Ambariyanto. Identification of Sand Dollar and its habitat characteristic in Cemara Besar Island of Karimunjawa Archipelago. ILMU KELAUTAN: Indonesian of Marine Science. 2005;10(1):1-10. DOI: https://doi.org/10.14710/ik.ijms.10.1.1-10

11. Hadi A, Hartati R, Widianingsih W. Fauna Echinodermata di Indonoor Wreck, PulauKemujan, KepulauanKarimunjawa. ILMU KELAUTAN: Indonesian Journal of Marine Sciences. 2011;16(4):236-242. doi:10.14710/ik.ijms.16.4.236-242)

12. Suryanti, Muskananfola MR, Simanjuntak KE. Sand Dollars distribution pattern and abundance at the Coast of Cemara Kecil Island, Karimunjawa, Jepara, Indonesia. JurnalTeknologi. 2016;78 (42):239-244. https://doi.org/10.11113/jt.v78.8215

13. Sulardiono B. Potential Use of Sea Cucumbers (Holothurians) in Karimunjawa Waters, Jepara Regency, Java Province. BuletinOseanografi Marina. 2016;5(1):64–72

14. Sulardiono B, Hartoko A, Aini AN, Wulandari D, Budiharjo A. Genetic diversity of commercial sea cucumbers Stichopus (Echinoderm: Stichopodidae) based on DNA Barcoding in Karimunjawa, Indonesia. BIODIVERSITAS. 2022;23(2):922-927 DOI: 10.13057/biodiv/d230234

15. Llacuna MEJ, Walag AMP, Villaluz EA. Diversity and dispersion patterns of echinoderms in Babanlagan, Talisayan, Misamis Oriental, Philippines. Environmental and Experimental Biology. 2016;14: 213–217 DOI: 10.22364/eeb.14.28.

16. Clark AM, Rowe FWF. Monograph of Shallow Water IndowestPasific Echinoderms. London. 269p. 1971

17. Arnold PW, Birtles RA. Soft sediment invertebrates of Southeast Asia and Australia: A Guide to identification. Australian Institute of Marine Science. Townsville. 236p. 1971.

18. Massin C. Results of the Rumphius Biohistorical Expedition to Ambon (1990) Part. 4. The Holothurioidea (Echinodermata) collected at Ambon during the Rumphius Biohistorical Expedition Zool. Verh. 1996;307:1–53

19. Massin C. Reef-dwelling Holothuroidea (Echinodermata) of the Spermonde archipelago (south-west Sulawesi, Indonesia) (Germany: ZoologischeVerhandelingen) 1996.

20. Samyn Y, Vandenspiegel D, Massin, C. A new Indo-West Pacific species of Actinopyga (Holothuroidea: Aspidochirotida: Holothuriidae). Zootaxa. 2006; 138:53–68.

21. Magurran AE. Ecological Diversity and Its Measurement. Princeton, NJ: Princeton University Press. 1998.

22. Dhahiyat Y, Sinuhaji D, Hamdani H.. Reef fish community structure in the coral transplant area of Pari Island, Seribu Islands. JurnalIkhtiologi Indonesia. 2003;3. [Indonesian]

23. Sumekar Y, Widayat D. The effect of weed management on seed banks in paddy rice fields. Res. Sq.2021;12:1-12. DOI: .21203/rs.3.rs1047098/v1.

24. Hartati, R. and Widianingsih. Field guide of sea cucumber of Karimunjawa Island. Tiga media Utama. Semarang. 70 pages. 2024. In press.

25. Abrogueña JBR, Tanita I, Anton A, Maquirang JRH, Duarte C, Woo SP, Berković B, Roje-Busatto R, Yacoubi L, Doyle A, Konji H, Al-Johani T, Chen J, Lotfi J, Rabaoui LJ. Influence of environmental variables on the abundance of *Synaptamaculata* (Holothuroidea: Synaptidae) in a multi-species seagrass meadow in the southern Red Sea of Saudi Arabia. Regional Studies in Marine Science. 2023;66,103133, https://doi.org/10.1016/j.rsma.2023.103133.

26. Hartati R, Zainuri M, Ambariyanto A, Riniatsih I, Redjeki S, Nuraini RAT, Soegianto A, Widyaningsih. Density and population growth of the Black sea cucumber, Holothuria (Halodeima) atra (Jaeger, 1833) in two different microhabitats of Jepara Waters, Indonesia. Eco. Env. & Cons. 2020;26(3):1222-1227. http://www.envirobiotechjournals.com /journal_details.php?jid=3

27. Purwati P, Hartati R, Widianingsih. Eighteen sea cucumber species fished in Katimunjawa Islands, Java Sea. Marine Research Indonesia. 2010; 35(2):3-10.

28. Buccheri E, Matthias W, Foellmer MW, Christensen BA, Langis P, Ritter S, Wolf E, Freema AS. Variation in Righting Times of Holothuriaatra, Stichopuschloronotus, and Holothuria edulis in Response to Increased Seawater Temperatures on Heron Reef in the Southern GBR. Journal of Marine Science. 2019;2019, 6179705. https://doi.org/10.1155/2019/6179705.

29. Simone MD, Horellou A, Ducarme F, Conand C. Identification Guide Commercial Sea Cucumbers. PATRINAT-Centre d’expertise et de données sur le patrimoine naturel. 226 p. 2022.

30. Jontila JBS. The Sea Cucumbers of Palawan, Philippines: A Field Guide. Dolorosa RG (Ed). Western Philippines University, 92 pp. 2023.

31. Prescott AJ, Zhou S, Prasetyo AP. Soft bodies make estimation hard: correlations among body dimensions and weights of multiple species of sea cucumbers. Marine and Freshwater Research. 2015;66: 857–865. http://dx.doi.org/10.1071/MF14146

32. Bourjon P. Field observations on the regeneration in Synaptamaculata (Holothuroidea: Synaptidae). SPC Beche-de-mer Information Bulletin.2017;#37: 105-106.

33. Hartati R, Ambariyanto A, Widianingsih W, Mahendrajaya RT, Mustagfirin M, Prihatinningsih P. Stichopodidae (Holothuroidea: Echinodermata) from Nyamuk Island, Karimunjawa National Park, Central of Java, Indonesia. IOP Conf. Series: Earth and Environmental Science. 919 (2021) 012024 doi:10.1088/1755-1315/919/1/012024

34. Zamani NP. Coral conditions and its association with starfish (Linckia laevigata) in the Tunda island, Seram District, Banten province. JurnalTeknologiPerikanan dan Kelautan. 2015;6(1):1-10. https://doi.org/10.24319/jtpk.6.1-1.

35. Khalid, A.M., Primawati, S.N., Nofisulastri. 2021. Morphological characteristic of Asteroidea in the Coastal of Gili Gede. Cocos. Bio. 6(2): 68-75. (In Indonesia)

36. McKeon CS, Moore JM. Species and size diversity in protective services offered by coral guard-crabs. PeerJ. 2014; 2: e574. doi: 10.7717/peerj.574

37. Yokley AG. The thermal range of the cushion sea star, Culcitanovaeguineae, distribution, and its behavioral response to warmer waters. PeerJ Preprints. 2016;4: e2653v1 https://doi.org/10.7287/peerj.preprints.2653v1

38. Sew G, Yaakub SM. Knobblyseastar on the shores of Tanah Merah. Singapore Biodiversity Records.2015;2015:105.

39. Muthiga NA, McClanahan TR Diadema. In: Lawrence J M (Ed.). Sea Urchins: Biology and Ecology. Fourth Ed., Vol. 43. Elsevier B.V. 2020. https://doi.org/10.1016/B978-0-12-819570-3.00023-8

40. Bronstein O, Kroh A, Loya Y. Reproduction of the long-spined sea urchin Diademasetosum in the Gulf of Aqaba-implications for the use of gonad-indexes. Sci. Rep. 2016;6:29569. doi: 10.1038/srep29569.

41. Hui TH. Longspine sea urchins with commensal fish and shrimps: Zanzibar urchin shrimp, Tuleariocariszanzibarica; Urchin clingfish, Diademichthyslineatus. Singapore Biodiversity Records. 2014;2014: 179-180

42. Hughes AD, Brunner L, Cook EJ, Kelly MS, Wilson B. Echinoderms Display Morphological and Behavioural Phenotypic Plasticity in Response to Their Trophic Environment. PLoS ONE. 2012;7(8): e41243. doi:10.1371/journal.pone.0041243

43. Triana R, Elfidasari D, Vimono IB. Identification of Echinoderms in Southern Tikus Island, Pari Island, Seribu Archipelago, Jakarta. Prosiding Seminar Nasional Masyarakat Biodiversitas Indonesia(2015;1(3): 455-459. DOI: 10.13057/psnmbi/m010313

44. Hartati R, Meirawati E, Redjeki S, Riniatsih I, Mahendrajaya RT. Species of Starfish and Sea Urchins (Asteroidea, Echinoidea: Echinoderms) in the Cilik Island, Karimunjawa Islands. JurnalKelautanTropis. 2018;21(1):41–48. DOI: https://doi.org/10.14710/jkt.v21i1.2417. (In Indonesian)

45. Fadli M, Suryanti, Ruswahyuni. The Abundance of sea cucumbers species (Holothuroidea) on the coral reef flat and coral reef slope of PancuranBelakang Beach, Karimunjawa Islands, Jepara. DIPONEGORO JOURNAL OF MAQUARES. 2013;2 (3):288-297

46. Widianingsih W, Hartati R, Endrawati H, Mahendrajaya RT, Soegianto A. Redescription of Stichopusmonotuberculatus (Echinodermata, Holothuroidea, Stichopodidae) of Parang Island, Karimunjawa Archipelago, Central Java, Indonesia. Eco. Env. & Cons. 2021;27(2): 894-899

47. De Guzman AB, Quiñones MB. Sea Cucumbers (Holothuroidea) of Northeastern and Western Mindanao, Philippines: The Potential Role of Marine Protected Areas in Maintaining Diversity and Abundance. JEAR.2021;6:47–70.

48. Pitogo KME, Sumin JP, Ortiz AT. Shallow-water Sea Cucumbers (Echinodermata: Holothuroidea) in Sarangani Bay, Mindanao, the Philippines with Notes on Their Relative Abundance. Philipp. J. Sci. 2018;147(3):453–461.

49. Arriesgado EM, Sornito MB, Zalsos JD, BesoñaJFAlia LC, Cadeliña FA, Magcanta-Mortos MLM, Uy WH. Diversity and Abundance of Sea Cucumbers in Selected Areas of Mindanao, Philippines. Philipp. J. Sci. 2022;151(3): 863-877.

50. Husain G, Tamanampo JW, Manu GD. Community Structure of Sea Cucumber (Holothuroidea) in the Coastal Area of the Island of Jailolo Subdistrict Nyaregilaguramangofa South Halmahera Regency West of North Maluku. JurnalIlmiah PLATAX. 2017;5(2):17.

51. Lenihan HS, Peterson CH, Miller RJ, Koyal M, Potoski M. Biotic disturbance mitigates effects of multiple stressors in a marine benthic community. Ecosphere. 2018;9(2018), p.e02314

52. Siburian RHS, Tapilatu JR, Tapilatu ME. Discovery of habitat preferences and community structure of echinoderms in Kri, Raja Ampat, Indonesia. Biodiversitas. 2023;24: 3968-3976. DOI: 10.13057/biodiv/d240735

53. Yusron E. Community structure Echinoderms (Asteroidea, Ophiuroidea, Echinoidea and Holothuroidea) in the Marine National Park, East Sulawesi Wakatobi. JurnalIlmu dan TeknologiKelautanTropis. 2016;8(1):357-366. (In Indonesian)