Distribution, abundance and dominance of Echinodermata in Tombariri waters, North Sulawesi, Indonesia

[1]Erly Y. Kaligis, [1]Stenly Wullur, [2]Calvyn F. A. Sondak

[1] Marine Science Study Program, Sam Ratulangi University, Jl. Kampus Unsrat, Bahu, Manado, North Sulawesi, Indonesia; [2] Aquatic Science Magister Study Program, Sam Ratulangi University, Jl. Kampus Unsrat, Bahu, Manado, North Sulawesi, Indonesia. Corresponding author: E. Y. Kaligis, erly_kaligis@yahoo.co.id

Abstract. Echinoderms are one of the marine organisms that inhabit intertidal areas and have an important ecological role in marine ecosystems. The distribution of echinoderms in intertidal areas can give an idea of the condition of echinoderm communities. The purpose of this study is to determine the types of echinoderms and the abundance and dominance of echinoderms in Tombariri waters, North Sulawesi, Indonesia. The method used in this study is the quadratic transect method. The specimens obtained were preserved with 70% formalin and taken to the Marine Biology laboratory of the Faculty of Fisheries and Marine Sciences of UNSRAT for identification. Based on the results of the study, 12 species of echinoderms were identified, namely *Linckia laevigata*, *Protoreaster nodosus*, *Archaster typicus*, *Echinometra mathaei*, *Echinothrix calamaris*, *Tripneustes gratilla*, *Holothuria atra*, *Holothuria scabra*, *Holothuria leucospilota*, *Ophiomastix annulosa*, *Ophiocoma erinaceus*, and *Ophiocoma scolopendrina*. This type of *Ophiocoma erinaceus* has the highest density, which is 31.52%. Station 2 has a dominance value of 0.316 which is higher than stations 1 and 3.
Key Words: biodiversity, density, intertidal.

Introduction. Indonesia is known for its marine biodiversity so that it has become one of the marine mega biodiversity areas in the world (Setiawan et al 2018). One of Indonesia's regions rich in marine biodiversity is the Bunaken National Park Area (TNLB) located in North Sulawesi Province. This conservation area has been widely known as a marine ecotourism location because it has a diversity of coral reefs (around 380 species) and is inhabited by various marine animals (Newman & LeDrew 2005; Sela et al 2022). Bunaken Marine National Park centered on Bunaken Island covers a large area from Manado Bay to the southern part of Tombariri waters which have complete marine ecosystems such as coral reefs, seagrass beds, mangroves and coastal ecosystems. However, not much has been revealed about biodiversity, specifically marine animals in these waters.

Echinoderms include benthic animals that occupy various zones in areas of seagrass, seaweed and coral reefs (Clark & Rowe 1971). Echinoderms can even be found in almost all coastal waters, ranging from tidal areas to deep waters. In general, each type of this phylum has a specific habitat, for example, *Holothuria scabra* which is often found in sandy areas or muddy sand overgrown with seagrass. Clark and Rowe (1971) state that echinoderms are stenohaline animals. The number is only limited according to osmoregulation ability, so echinoderms mostly live only in marine environments.

Phylum Echinodermata include invertebrate animals that are divided into five classes, namely Crinoidea, Echinoidea, Holothuroidea, Asteroidea, and Ophiuroidea. The body shape features of the whole class are bilaterally symmetrical when larvae and radially symmetrical after adulthood. They have a chalk substance in their endoskeleton and vascular system. In addition, echinoderms can regenerate lost or damaged body parts (Schories & Kohlberg 2016).

Ecologically, echinoderms act as eaters of organic waste or detritus derived from animal and plant residues to clean organic waste in the ocean. This group of marine animals also acts as a bioindicator of the quality of an ecosystem in the sea. Echinoderms occupy various positions in food webs, including carnivores, herbivores, and detritus eaters (Suryanti & Ruswahyuni 2014).

It is estimated that there are about 6,500 species of echinoderms and more than 13,000 fossil species in many classes have become extinct (Hendler et al 1995). According to Yusron (2013), the abundance of echinoderms in Indonesia and its surroundings (West Indo-Pacific region) is around 141 species of Holothuroidea, 91 species of Crinoidea, 142 species of Ophiuroidea, 87 species of Asteroidea, and 84 species of Echinoidea.

Research on echinoderms in North Sulawesi waters has been reported several times. Studies in several locations have been reported by Supono and Arbi (2010) who found 31 species of echinoderms in the waters of Kema, Bitung, and Talise waters, North Minahasa. Research in the Meras water site has also been reported by Rompis et al (2013) who found 8 species of echinoderms. Bengkal et al (2019) also reported the results of research in Tongkeina waters and found 21 species of echinoderms representing 5 species of Holothuroidea, 5 species of Asteroidea, 4 species of Echinoidea and 7 species of Ophiuroidea. Christianti et al (2023) reported the results of research in the waters of Lembeh Bitung Island Shower and found as many as 18 species of echinoderms consisting of 7 species of class Asteroidea, 5 species of class Echinoidea, 2 species of class Holothuroidea and 4 species of class Ophiuroidea. Specifically, about the Echinoidea and Asteroidea classes, research has been carried out in the waters of Molas, Bahowo and Tongkeina and found 5 classes of Echinoidea and 4 species of class Asteroidea (Kaligis et al 2023).

Recent economic developments have shown an increase in community activities that have caused negative impacts on benthic biota communities including echinoderms. Therefore, efforts are needed to manage these aquatic biological resources from the impact of reduced diversity in the future. Tombariri waters in the Bunaken National Park area have differences with the more crowded northern waters. Ecotourism and anthropogenic activities in Tombariri waters are relatively less and this condition causes these waters to be maintained as a habitat for benthic animals. On the other hand, there is still limited information about the phylum Echinodermata, so it is necessary to conduct research on various types of echinoderms and their populations in the intertidal zone of Tombariri Beach.

Material and Method. The study was conducted from April to August 2023. Echinoderm data collection was carried out in the intertidal zone of Tambala, Teling, and Kumu Waters, Tombariri District, Minahasa Regency. The location of the study is located at the coordinate points: 1°24'24"N 124°41'07"E (Tambala), 1°25'07"N 124°36'43"E (Teling), and 1°24'20"N 124°35'34"E (Kumu). Research location can be seen in Figure 1.

Figure 1. Research locations: Tambala (right red mark), Teling (middle red mark), Kumu (left red mark), map of Sulawesi Island (top left) (map generated using Google Earth 2024).

The research method used the line transect method using three stations, namely Station 1 (Tambala), Station 2 (Teling) and Station 3 (Kumu). At each station, 3 transects are made by drawing 3 straight lines from the lowest low tide point along 100 m towards the sea. The distance between each transect is 100 m. On each transect line 10 squares are placed with a distance of 10 meters from each other. The square used measures 1x1 meter made of cylindrical pipes measuring 1 meter in length and half an inch in diameter. Five random quadrants per transect were selected for further analysis.

Data collection is carried out when the sea water recedes, around 05:00 to 11:00 WIB so that it is easier when observing samples at the research site. Echinoderm samples that were in squares were counted and several samples of each different type were documented. The captured sample is put into a sample plastic bottle to be preserved with 70% formalin. Then the sample was taken to the Marine Biology laboratory of the Faculty of Fisheries and Marine Sciences UNSRAT for identification.

Echinodermata identification is done visually by looking at the morphological characteristics based on body size, shape and completeness of organs and body colour. Morphometric measurements include body length and width using callipers. The process of identifying Echinodermata types uses the Echinodermata identification guidebooks from Clark and Rowe (1971), Colin and Arneson (1995), Raghunathan et al (2013), and the WoRMS (2023) website. The data obtained was analyzed descriptively and then explained in the form of tables and figures. For population data analysis, the relative abundance index formula and species dominance index are used (Odum 1971).

Results. The research results show that in the intertidal zone of Tambala, Teling and Kumu beaches there are 12 species of Echinodermata. Of these, 3 species belong to the Asteroidea class, 3 species to Echinoidea, 3 species to Holothuroidea and 3 species to Ophiuroidea. All echinoderm species found can be seen in Table 1.

Table 1

Type and number of echinoderms found in the intertidal zones of Tombariri waters

Class	*Species*	*Station 1 Tambala*	*Station 2 Teling*	*Station 3 Kumu*
Asteroidea	*Linckia laevigata*	3	2	5
	Protoreaster nodosus	-	7	9
	Archaster typicus	-	3	4
Echinoidea	*Echinometra mathaei*	9	8	15
	Echinothrix calamaris	-	-	6
	Tripneustes gratilla	-	3	3
Holothuroidea	*Holothuria atra*	5	10	3
	Holothuria scabra	1	7	11
	Holothuria leucospilota	3	-	1
Ophiuroidea	*Ophiomastix annulosa*	10	9	5
	Ophiocoma erinaceus	38	29	26
	Ophiocoma scolopendrina	18	14	22

A description of each species found during the research in Tombariri waters is presented in the next section of the article.

Linckia laevigata (Linnaeus 1758) (Figure 2) is a sea star that is easily recognized because it is blue. This species has characteristics of a radially symmetrical body shape with a rough body surface, a body size of about 3 cm in diameter (Fitriansyah et al 2018), slender arms with blunt ends, generally blue, and is most often found on reef flats and shallow areas (Clark & Rowe 1971).

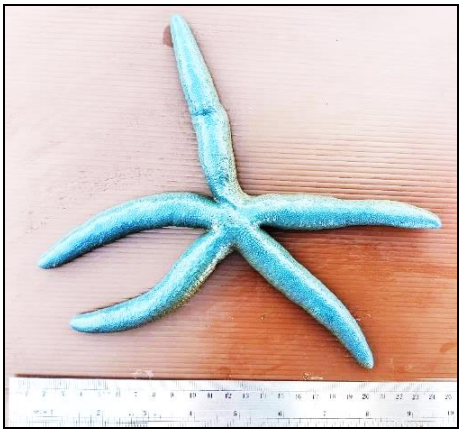

Figure 2. *Linckia laevigata* (original image).

Protoreaster nodosus (Linnaeus, 1758) (Figure 3) has colour characteristics in colour from dark red, pink, pale brown, green, and blue to white, body size ranges from 12-17 cm, medium disc size with cranial plates that are shaped like pads, with a flat shape (Clark & Rowe 1971). It lives in seagrass beds about 2 m (6 ft) deep (Colin & Arneson 1995).

Figure 3. *Protoreaster nodosus* (original image).

Archaster typicus (Müller & Troschel, 1840) (Figure 4) has 5 arms, having tube feet along the arms, the marginal plate is visible and there is a primary spine, generally light grey and is usually burying itself in the sand (Clark & Rowe 1971; Fortaleza et al 2020).

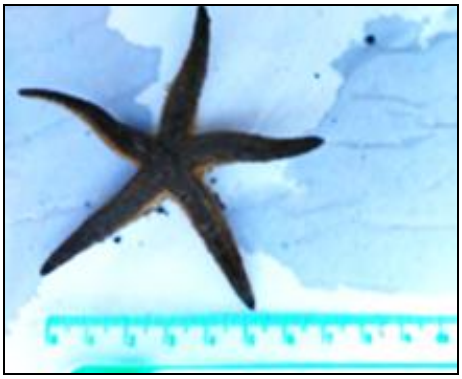

Figure 4. *Archaster typicus* (original image).

Echinometra mathaei (Blainville, 1825) (Figure 5) has a characteristic oval-shaped body and a yellow colour. Body diameter is around 3.2 – 4.4 cm. According to Raghunatan et

al (2013), the *Echinometra mathaei* species has green, brown, red, pink, yellow and white colours, and its spines usually have a white ring around them.

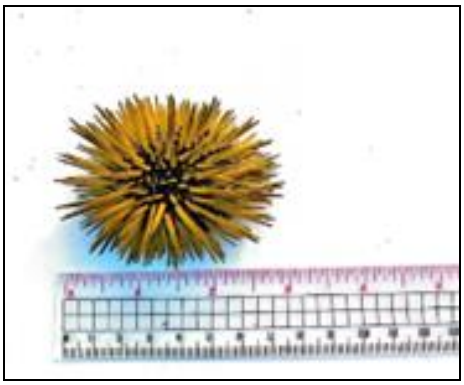

Figure 5. *Echinometra mathaei* (original image).

Echinothrix calamaris (Pallas, 1774) (Figure 6) has the characteristics of long, black and white striped spines, thick spines with blunt and brittle tips, and lives in coral rubble areas. This characteristic is generally in accordance with the report from Alwi et al (2020).

Figure 6. *Echinothrix calamaris* (original image).

Tripneustes gratilla (Linnaeus, 1758) (Figure 7) has characteristic small, smooth orange and white spines. Sese et al (2018) stated that this species has a flat, round shape with spines that are relatively the same size throughout the shell.

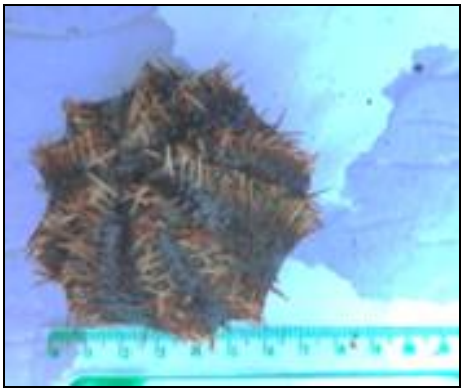

Figure 7. *Tripneustes gratilla* (original image).

Holothuria atra (Jaeger, 1833) (Figure 8) has a characteristic elongated round body. The entire surface of the body is black and has fine spots, and the body length is around 12

cm. According to Carpenter and Niem (1998), *Holothuria atra* has black body colour throughout its body, its ventral mouth is surrounded by 20 black tentacles.

Figure 8. *Holothuria atra* (original image).

Holothuria scabra (Jaeger, 1833) (Figure 9) has a characteristic elongated round body shape. The dorsal part is grey with transverse stripes and between the stripes is white. The ventral colour is whitish with small black spots. Carpenter and Niem (1998) stated that the body colour of *Holothuria scabra* varies greatly. The dorsal part is whitish to dark brown, while the ventral part is generally white.

Figure 9. *Holothuria scabra* (original image).

Holothuria leucospilota (Brandt, 1835) (Figure 10) has a characteristic black body with black spots. Body length is usually around 20 cm. Carpenter and Niem (1998) stated that *Holothuria leucospilota* has a black body, with a body length reaching a maximum of 55 cm.

Figure 10. *Holothuria leucospilota* (original image).

Ophiocoma erinaceus (Müller & Troschel, 1842) (Figure 11) has a characteristic black body. The disc is pentagonal with an interradial shape on each side. There are five arms with arms that are thicker and sharper at the end. Raghunathan et al (2013) stated that *Ophiocoma erinaceus* is uniformly black, with arms up to 12 cm long.

Figure 11. *Ophiocoma erinaceus* (original image).

Ophiocoma scolopendrina (Lamarck, 1816) (Figure 12) has a dark brown disc and there are light spots on the dorsal side while the ventral side is paler. Another characteristic is it has five simple unbranched arms. Arm length reaches 13 cm. These characteristics are generally consistent with reports from Clark and Rowe (1971) and Cabahug and Sotto (2006).

Figure 12. *Ophiocoma scolopendrina* (original image).

Ophiomastix annulosa (Müller & Troschel, 1842) (Figure 13) has a distinctive characteristic, namely a red and grey body, with white and blackish-grey striped spines resembling a ring motif (Figure 14). Clark and Rowe (1971) and Cabahug and Sotto (2006) stated that this species has a rusty red base colour with a bright pattern on the dorsal part while its spines are grey and black. Its living area is in rocky sand areas and coral reefs.

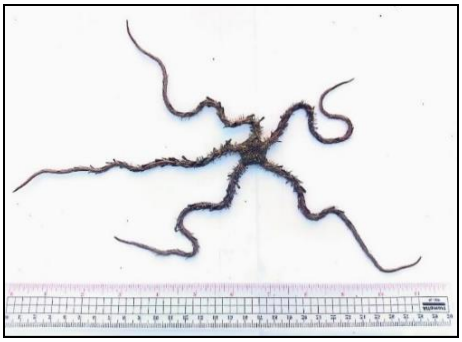

Figure 13. *Ophiomastix annulosa* (original image).

The results of the relative abundance analysis showed that the highest relative abundance value was 31.52%, namely *Ophiocoma erinaceus* at Station I (Tambala). This type of echinoderm was also found most frequently in the other two research locations, namely the relative abundance value was 23.63% at Station 2 (Teling) and 31.52% at Station 3 (Kumu). The species with the lowest relative abundance value is *Holothuria leucospilota*. The relative abundance value for this species is 0.91% (Figure 14).

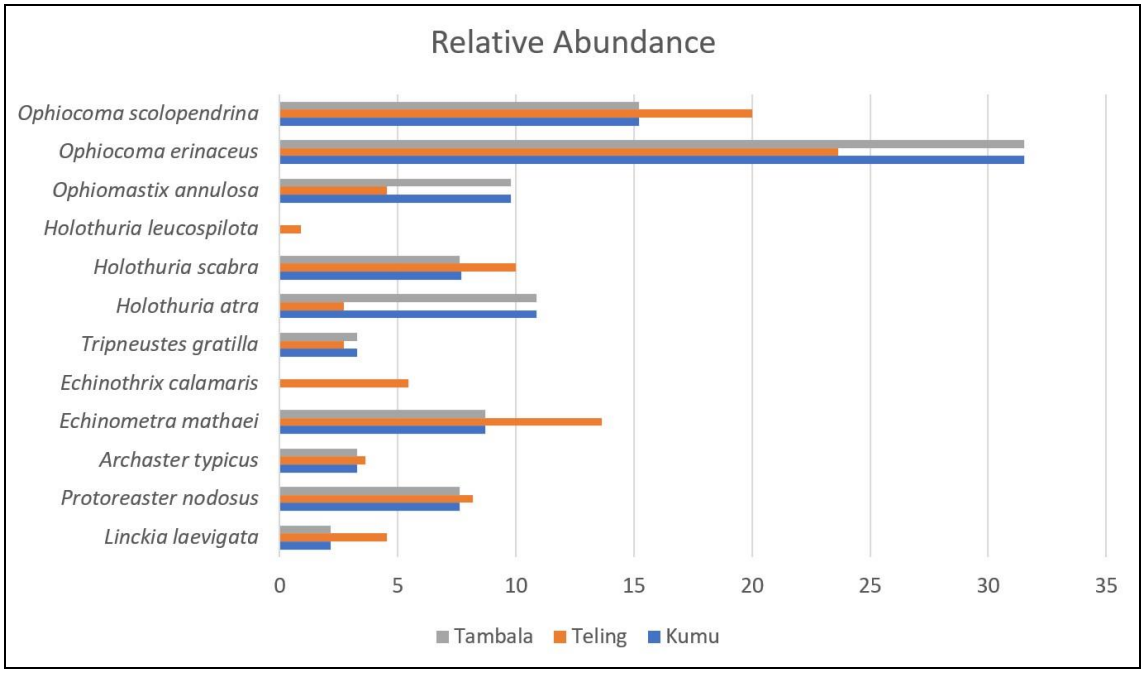

Figure 14. Relative abundance value of echinoderms at each research location.

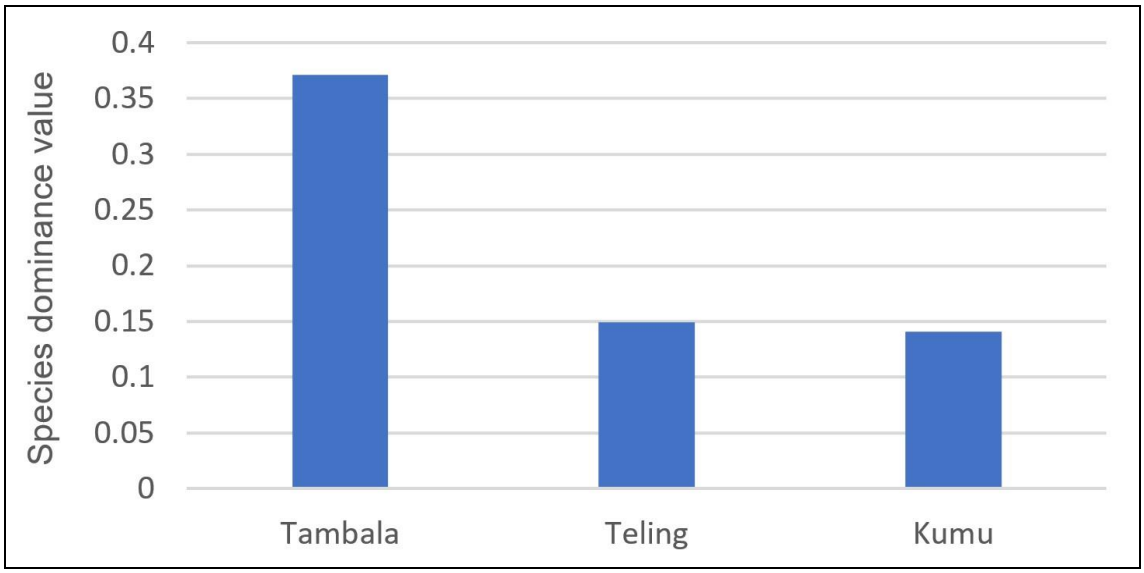

Figure 15. Echinodermata species dominance value from each research location.

The highest species dominance value is at Station 1 (Tambala) with 0.371, while the other 2 stations show lower values. The species dominance value at Station 2 (Teling) is 0.149, and at Station 3 (Kumu) the species dominance value is 0.141 (Figure 15).

Discussion. Based on the results of observations, 12 species of members of the phylum Echinodermata were found, namely *Linckia laevigata*, *Protoreaster nodosus*, *Archaster typicus*, *Echinometra mathaei*, *Echinothrix calamaris*, *Tripneustes gratilla*, *Holothuria atra*, *Holothuria scabra*, *Holothuria leucospilota*, *Ophiomastix annulosa*, *Ophiocoma erinaceus*, and *Ophiocoma scolopendrina.* All species belong to the 4 classes of Echinodermata, namely Asteroidea, Echinoidea, Holothuroidea, and Ophiuroidea. Each Echinodermata class consists of 3 species and species from the Ophiuroidea class are found at all research stations. Compared to previous research reports by Christianti et al (2023) in the intertidal zone of Pancuran village, Lembeh Island, 18 species from 4 Echinodermata classes were found and the identification results showed that the highest number of species was 7 species belonging to the Asteroidea class. The Crinoidea class is

also not found because its habitat is generally in the subtidal zone or deeper waters. Species from this class are more often found on coral reef slopes that have relatively strong sea currents and are classified as filter feeder organisms (Suryanti 2019).

The results of the relative abundance index analysis show that the *Ophiocoma erinaceus* species is the most abundant compared to other types of echinoderms. The highest relative abundance value of *Ophiocoma erinaceus* was 31.52% at Station 1 (Tambala). This type of brittle starfish was found most abundantly at Station 2 and Station 3 as well. In general, the results of the highest relative abundance index in this study can be said to have a lower value when compared to research conducted by Jambo et al (2021) in the intertidal zone of Molas Village, Bunaken District, where the highest relative abundance is for *Diadema setosum* with a value of 55.42%.

The abundance of echinoderms in a body of water can be caused by several factors such as differences in the number of species and the number of individuals. Apart from that, substrate composition also determines the abundance and diversity of Echinodermata species (Setyastuti et al 2018). In this study, the characteristics of the research location were mostly dead coral zones. This type of dead coral substrate is a suitable habitat for Ophiuroidea (Aziz 1991). The *Ophiocoma erinaceus* species is classified as a benthic animal which has a dwelling habit among corals. This causes the ecological pressure on *Ophiocoma erinaceus* to be relatively low compared to other types of echinoderms which are easily caught by humans. According to Stöhr et al (2012), Ophiuroidea are mobile marine biota, that look for a safer place when disturbed.

The dominance index shows the presence or absence of the species that has the most dominant number of individuals in the community. At the three research locations, the dominance index value was in the low category ($C = 0 < C < 0.5$), or the species dominance value was less than 0.5 (Odum et al 1971). The low dominance index at the three research locations was due to the absence of a dominant species. The dominance value and species diversity are related. If dominance is high, diversity tends to be low. The results of this study indicate that species dominance at the three research locations is low, or species diversity is high.

Each species can be influenced either directly or indirectly by various factors. For example, predation has a direct effect and changes in habitat structure have an indirect effect. These factors will have an impact and influence on determining the dominant species (Levin 2013). Changes in habitat structure in coral communities cause an increase in excessive nutrients which causes a shift in the dominant species in the ecosystem. The intertidal zone of Tambala, Teling and Kumu beaches is a zone with habitat characteristics that are suitable for echinoderm life, because there are several different substrates such as seagrass, rocks, coral fragments and sand. However, efforts are needed to maintain the habitat structure so that it does not have a negative impact on species diversity.

Conclusions. The Echinodermata phylum is represented in the research area by four classes, namely the Asteroidea, Echinoidea, Ophiuroidea, and Holothuroidea classes with a total of 12 species. Based on the relative abundance index, the brittle star *Ophiocoma erinaceus* was found to be the most abundant, while the Echinodermata dominance value showed that at the three stations the results were relatively low.

Conflict of interest. The authors declare that there is no conflict of interest.

References

Alwi D., Muhammad S., Tae I., 2020 [Morphological characteristics and ecological index of sea urchins (Echinoidea) in the waters of Wawama Village, Morotai Island Regency]. Jurnal of Sumberdaya Akuatik Indopasifik 4(1):23-32. [In Indonesian].

Aziz A. Z. N. A. M., 1991 [Some notes of brittle stars (Ophiuroidea) as benthic biota]. Oseana 16(1):13-22. [In Indonesian].

Bengkal K. P., Manembu I. S., Sondak C. F. A., Wagey B. T., Schaduw J. N. W., Lumingas L. J. L., 2019 [Identify seagrass and echinoderm diversity in conservation efforts]. Jurnal Pesisir dan Laut Tropis 1(1):29-39. [In Indonesian].
Cabahug E. J., Sotto F. B., 2006 Shallow-water Ophiuroids (Echinodermata: Ophiuroidea) of Mactan Island, Central Philippines and the neighboring island. Journal of Aquatic Sciences 3:41–55.
Carpenter K. E., Niem V. H., 1998 FAO species identification guide for fishery purposes. The living marine resources of the Western Central Pacific. Vol. 2. Cephalopods, Crustaceans, Holothurians and Sharks. Rome, FAO. 687-1396 pp.
Christianti Y., Boneka F., Kaligis E., Wagey B. T., Sinjal C. A. L., Lasabuda R., 2023 [Diversity and abundance of echinoderms in Pancuran Beach, Lembeh Island]. Jurnal Ilmiah Platax 11(2):362–368. [In Indonesian].
Clark A. M., Rowe F. W. E., 1971 Monograph of shallow-water Indo-West Pacific echinoderms. Trustees of the British Museum (Natural History), London. 238 pp.
Colin P., Arneson C., 1995 Tropical Pacific Invertebrates: a field guide to the marine invertebrates occurring on tropical Pacific coral reefs, seagrass beds and mangroves. Coral Reef Press. 296 pp.
Fitriansyah M. Y. F., Arifin D., Biyatmoko, 2018 [Identification of echinoderms on the shores of Denawan Island, Pulau Sembilan District]. Proceeding Seminar Nasional Lingkungan Lahan Basah 3(1):157-163. [In Indonesian].
Fortaleza M. A., Lanutan J. J., Consuegra J. M., Nanola C. L., 2020 Diversity of echinoderms in intertidal and shallow-water areas of Samal Island, Philippines. Philippine Journal of Science 150:281-297.
Hendler G., Miller J. E., Pawson D. L., Kier P. M., 1995 Sea stars, sea urchins, and allies: echinoderms of Florida and the Caribbean. Smithsonian Institution Press, Washington, DC. 390 pp.
Jambo N. A., Kaligis E. Y., Kumampung D. R. H., Darwisito S., Schaduw J. N. W., Pratasik S. B., 2021 [Diversity and abundance of phylum Echinodermata on intertidal zone of Molas, Sub-district of Bunaken, Manado City]. Jurnal Pesisir dan Laut Tropis 9(2):104-114. [In Indonesian].
Kaligis E. Y., Ompi M., Sondak C. F. A., 2023 Echinoidea and Asteroidea diversity and abundance in Manado Bay waters, Indonesia. AACL Bioflux 16(3):1732-1743.
Levin S. A., 2013 Encyclopedia of biodiversity: second edition. Elsevier Inc, Princeton University, Princeton, New Jersey, USA. 5504 pp.
Newman C. M., LeDrew E., 2005 Towards community - and scientific-based information integration in marine resource management in Indonesia: Bunaken National Park case study. Environments Journal 33(1):5-24.
Odum E. P., 1971 Fundamentals of ecology. Philadelphia: W.B Sounders Company L, Philadelphia. 574 pp.
Raghunathan C., Sadhukhan K., Mondal T., Sivaperuman C., Venkataraman K., 2013 A guide to common echinoderms of Andaman and Nicobar Islands. Zoological Survey of India, Kolkata. 210 pp.
Rompis B. R., Marnix L., Katili D., Adelfia P., 2013 [Diversity of echinoderms on the Meras Beach, Bunaken District, North Sulawesi]. Jurnal Bios Logos 3(1):26-31. [In Indonesian].
Schories D., Kohlberg G., 2016 Sea urchins, Echinoidea. In: Marine wildlife King George Island Antarctica, 1st edition. Schories D., Kohlberg G. (eds). Dirk Schories Publications Rostock, Germany. 216-218 pp.
Sela J. J., Supardjo S., Prijadi R., 2022 [Bunaken Marine Park aquarium in Manado metaphor combination]. Jurnal Arsitektur DASENG 11(2):24-32. [In Indonesian].
Sese M. R., Annawaty, Yusron E., 2018 [Diversity of echinoderms (Echinoidea and Holothuroidea) on Bakalan Island, Banggai Islands, Central Sulawesi, Indonesia]. Scripta Biologica 5(2):73-77. [In Indonesian].
Setyastuti A., Purbiantoro W., Hadiyanto, 2018 Spatial distribution of echinoderms in littoral area of Ambon Island, Eastern Indonesia. Biodiversitas 19(5):1919-1925.

Setiawan R., Atmowidi T., Widayati K. A., Purwati P., 2018 [Habitat preferences of Ophiuroidea species in the intertidal zone of Pancur Beach Alas Purwo National Park]. Jurnal Kelautan 11(2):151-166. [In Indonesian].
Stöhr S., O'Hara T. D., Thuy B., 2012 [Global diversity of brittle stars (Echinodermata: Ophiuroidea)]. PLoS ONE 7(3):e31940. doi: 10.1371/journal.pone.0031940.
Supono, Arbi U. Y., 2010 [Community structure of echinoderms in seagrass fields in Kema waters, North Sulawesi]. Oseanologi dan Limnologi di Indonesia 36(3):329-342. [In Indonesian].
Suryanti, Ruswahyuni, 2014 [Differences in the abundance of echinoideas on coral ecosystem and seagrass beds in Pancuran Belakang, Karimunjawa, Jepara]. Indonesian Journal of Fisheries Science and Technology 10:(1):62–67. [In Indonesian].
Yusron E., 2013 [Biodiversity fauna of echinoderms (Holothuroidea, Echinoidea, Asteroidea, and Ophiuroidea) in the waters of Lombok Island, West Nusa Tenggara]. Zoo Indonesia 22(1):1-10. [In Indonesian].
*** World Register of Marine Species (WoRMS), 2023 Marine Species. www.marinespecies.org [Last accessed on 18 December 2023].

Received: 20 February 2024. Accepted: 26 March 2024. Published online: 30 October 2024
Authors:
Erly Y. Kaligis, Marine Science Study Program, Sam Ratulangi University, Jl. Kampus Unsrat, Bahu, Manado, North Sulawesi, Indonesia, e-mail: erly_kaligis@yahoo.co.id
Stenly Wullur, Marine Science Study Program, Sam Ratulangi University, Jl. Kampus Unsrat, Bahu, Manado, North Sulawesi, Indonesia, e-mail : stenlywullur@unsrat.ac.id
Calvyn F. A. Sondak, Aquatic Science Magister Study Program, Sam Ratulangi University, Jl. Kampus Unsrat, Bahu, Manado, North Sulawesi, Indonesia, e-mail: calvynson@yahoo.com
This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution and reproduction in any medium, provided the original author and source are credited.
How to cite this article:
Kaligis E. Y., Wullur S., Sondak C. F. A., 2024 Distribution, abundance and dominance of Echinodermata in Tombariri waters, North Sulawesi, Indonesia. AACL Bioflux 17(5):2365-2375.