JIPK. Volume 12 No 1. April 2020
Sinta 2 (Decree No: 10/E/KPT/2018)
e-ISSN:2528-0759; p-ISSN:2085-5842
DOI=10.20473/jipk.v12i1.15460
Available online at https://e-journal.unair.ac.id/JIPK/index

SCIENTIFIC JOURNAL OF FISHERIES AND MARINE

JIPK
(JURNAL ILMIAH PERIKANAN DAN KELAUTAN)

Research Article

Study on Community Structure of Commercial Sea Cucumber in Intertidal Zone, Southeast Moluccas, and Tual, Moluccas

Jasmadi, Ismiliana Wirawati, Indyaswan Tegar Suryaningtyas, Sandi Permadi

Research Division for Natural Product Technology, Indonesian Institute of Sciences. Indonesia

OPEN ACCESS

ARTICLE INFO

Received: October 25, 2019
Accepted: December 22, 2019
Published: March 13, 2020

*) Corresponding author:
E-mail: jasmadi.ipb06@gmail.com

Keywords:
population
Sea cucumber
moluccas
tual
intertidal

Abstract

A study on the community structure of sea cucumber in Southeast Moluccas and Tual needs to be done due to the important role of sea cucumber in both ecologically and economically sustainability. This study aimed to investigate the community structure of sea cucumber in this region as one of the supporting information for the utilization and management of the resources. A survey was conducted by sweeping the target area, by walking and also snorkeling. The location where each sea cucumber found was marked using a GPS, the specimen was weighed, and some were preserved for species analysis. Water quality was measured at each location, while the substrate and vegetation were recorded. This study revealed different composition of species in the investigated area. As many as 8 species of sea cucumber were found, in which four were of genus Holothuria, three were of genus Stichopus and the rest were of genus Bohadschia. Species *H. atra* has the highest density. In general, the diversity index was relatively low (< 2), the evenness index was 0-81 indicating that the community was depressed. Certain species dominated at most of the investigated sites (0.50-1), and a low margalef index is 0-1.7. To conclude, the community structure of sea cucumber in Tual and Southeast Moluccas was in a depressed condition.

Cite this as: Jasmadi, Wirawati, I., Suryaningtyas, I. T., & Permadi, S. (2020). Study on Community Structure of Commercial Sea Cucumber in Intertidal Zone, Southeast Moluccas, and Tual, Moluccas. *Jurnal Ilmiah Perikanan dan Kelautan*, 12(1):31–47. http://doi.org/10.20473/jipk.v12i.15460

1. Introduction

High economic value and market demand of some commercial sea cucumbers causing a high level of exploitation. As Anderson *et al*., 2011 noted in recent decades, invertebrate fishing activities have been increasing, one of which was class Holothuroidea, which had high values in Asia. Demand for sea cucumbers by China had a major role in the trade of sea cucumbers in the Indo-Pacific region for more than 100 years. It was noted that Indonesia was a major producer and exporter of sea cucumber in the world. Based on national statistical data, Indonesian production had reached around 4,700 tons/year since 1987 (Conand & Byrne, 1993).

This high market demand for sea cucumbers attracts the traders to fulfill the demand by exploiting from nature, without considering the importance of maintaining the populations. So far there have not been many regulations for sea cucumber fisheries so that control to prevent overfishing is not effective. Easier capture process, low growth, and the low recovery rate are some reasons that sea cucumber populations are very vulnerable to overfishing (Bruckner *et al.*, 2003; Uthicke, 2004). At present studies showed that some of sea cucumber-related fishery activities in the world have been declared to be overfishing (Conand, 2004; Nash & Ramofafia, 2006), including species *Holothuria scabra* in Indonesian waters, Sulawesi (Massin, 1999). This was allegedly due to the lack of specific conservation and management plans (Choo, 2008).

The conservation plan is an inseparable part of the efforts to manage the natural resources in an area, so a balance between human needs and environmental sustainability is to be met. Various government regulations have been issued as a legal basis to support natural resource management activities in an area. Acts No. 31 of 2004 on Fisheries, Acts No. 27 of 2007 on Management of Coastal Areas and Small Islands and Government Regulation of the Republic of Indonesia Number 60 of 2007 concerning Conservation of Fish Resources are several regulations that have been made to oversee the management of the natural resources in Indonesia. Base on that regulations, Southeast Moluccas and the City of Tual whose territory is mostly surrounded by coastal waters need to implement conservation effort as well.

As a region with a strong traditional culture, the local wisdom of the Indonesian archipelago can be used to manage fish resource utilization (Solihin, 2011). Sea cucumbers which are currently categorized as scarce compared to a few decades ago (private communication), are one of the commodities that become a concern to local management of Southeast Moluccas and Tual. The scientific data obtained from research is needed as an information source that is expected to support the implementation of a region's conservation plan. Several studies have been carried out in the previous decades regarding the existence of sea cucumbers in Southeast Moluccas (Radjab, 1996; Yusron, 2001; Yusron & Widianwari, 2004). These studies revealed that generally, study areas had a high density of sea cucumber (> 0.1 ind/m^2 on the average). This present study tends to have coverage areas that a bit different from previews studies. Previews studies carried out more than a decade ago, so further study needs to do to obtain new reference regarding sea cucumber population. Along with the development of fisheries, lifestyles of coastal communities and changes in environmental conditions make the present study of sea cucumber community structure needs to be done as baseline information and then to be used as a consideration in planning coastal management. This study is intended to know the structure of sea cucumber communities in several sites of Southeast Moluccas and Tual waters as one of the supporting information for the utilization and management of sea cucumber resources. Traditional management such as makes a fishing restricted area during a certain period is a system that uses to undertaken by the local community recently, called "sasi". For good management they require actual scientific information about sea cucumber resource, hence this study needs to be executed.

2. Materials and Method

2.1 Study area

The survey was conducted in the waters of Southeast Moluccas and Tual, Moluccas Province at six different stations. The station location was chosen based on information about the existence of sea cucumbers which are still relatively easy to find in the Southeast Moluccas region (Figure 1). In general, study areas were intertidal zone, covered by seagrass, sandy or dead coral and sometimes mangroves were distributed around of mainland coast. Sometimes there are macroalgae in the study site. Difur is in a bay where the waters are quite calm and protected, where the waters are quite calm and protected, so wave energy relatively low. Ibra was closer to the mainland and covered by mangrove plants (difficult to access). Ohoidertom was a restricted area for

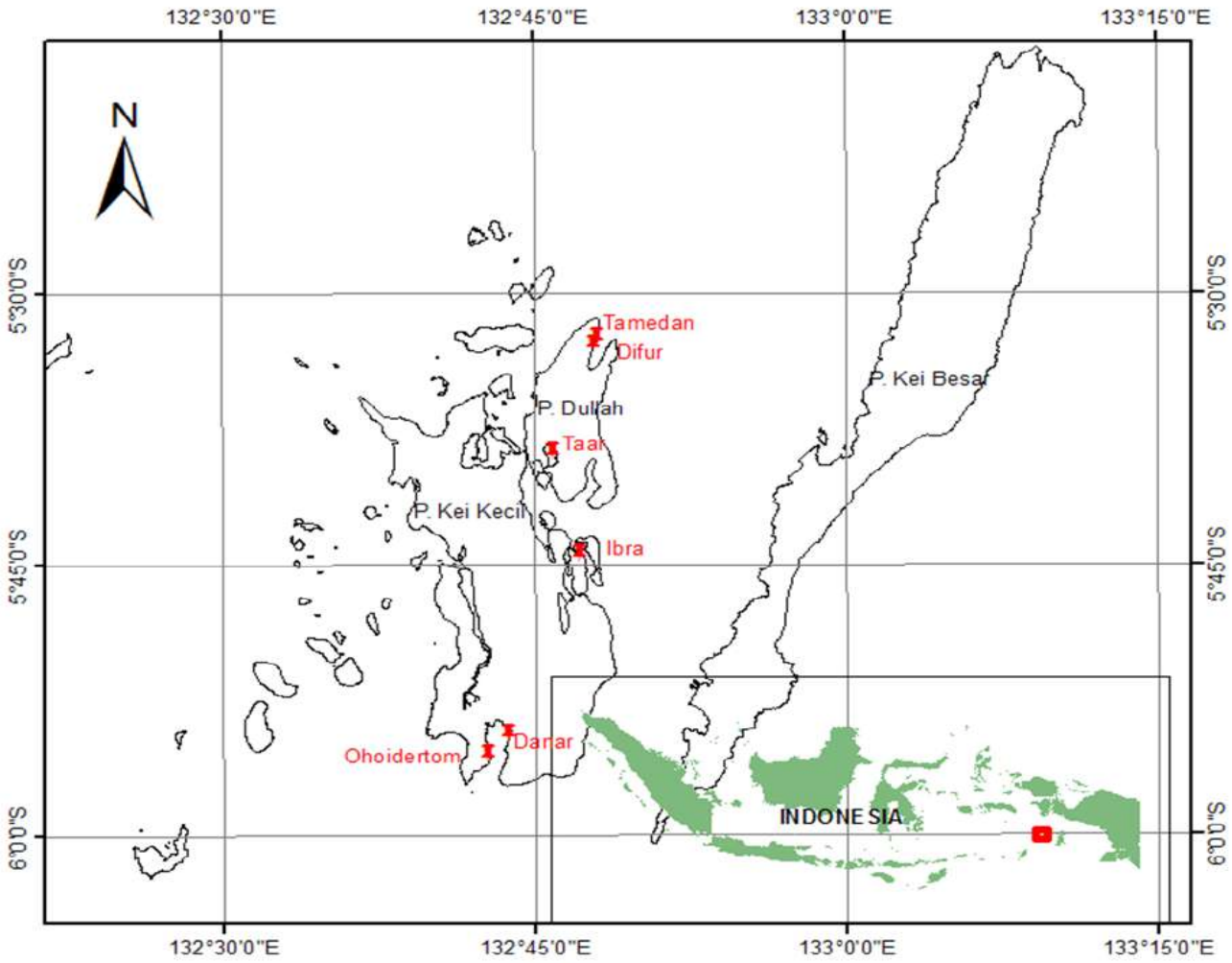

Figure 1. Locations for sea cucumber survey in Tual and Southeast moluccas

fishing as local consensus, named by "sasi". In general, sasi has been enforced in Ohoidertom so that people (whoever) couldn't harvest sea cucumber till a for a specific period of time, sometimes it is up to 5 years depending on their covenant. They could do anything through that site as usual except defying of agreement, exploiting or something that potentially damaging the site. Taar was bay, its shape which was more like a lake and a narrowing bay door allows for freshwater to be accommodated long enough in low tide conditions.

2.2 Sampling

The study focused on intertidal zones or intertidal areas where most of the locations were covered with seagrass or macroalgae with various substrates. These study areas were several habitat characteristics for sea cucumbers, moreover the survey covering area was adjusted considering the condition of the location and safety. The survey was carried out in August-October 2016 during the dry season when the water is receding. The surveys were done by sweeping the target area to search sea cucumber visually conducted by 6-12 people. The species names of sea cucumber were recorded, and then catch location coordinates were noted using the GPS (Global Positioning System) "Garmin 62sc" and "Garmin 60" and then the weight specimens were measured. Before weighing the samples were left for about 5 minutes and then dried using a sponge cloth. Sea cucumber was weighted with digital scales with an accuracy of 0.1 g, then released again. Several sea cucumber samples were documented, anesthetized with $MgCl_2$ and preserved with 70% alcohol, then morphological and ossicle analyses were performed to ascertain the species. Animal samples from the field were then deposited in the laboratory at Research Center for Oceanography (RCO), Indonesian Institute of Sciences, Jakarta. The seagrass species, macroalgae species, and substrate type at each location were recorded as habitat

conditions. Water quality at each location was measured by Wissenschaftlich - Technische Werkstätten (WTW) Multi 3430 SET-F Water Quality Checker. Temperature, salinity, total dissolved solids (TDS), pH, dissolved oxygen were measured in situ at each location.

2.3 Species identification

Species analysis was carried out in the RCO laboratory. Species identification was using morphology and ossicle characteristics. Ossicles were examined from the dorsal body wall, ventral body wall, tentacle, tube feet, and dorsal papillae. Small pieces of tissue are inserted in a microtube (1.5ml), commercial bleaching solution that contains 5.2% NaClO was added until the sample was submerged. After 10 minutes, the ossicles began to escape from the tissue, then NaClO was removed and aquadest was added twice for rinsing. If needed, 70% of alcohol was added for storage. The ossicles then observed using a compound microscope with a magnification of 100-200x. Species name were determined based on morphological characteristics along with the references to (Clark and Rowe, 1971; Massin, 1996a, 1996b; Ong *et al*, 2016; Rowe, 1969; Samyn, 2003; Samyn *et al*., 2006; Wirawati *et al*., 2007)

2.4 Data analysis

Data analysis including Shannon Index (H'), Evenness Index (J), Simpson's Index (D), Margalef Index were applied. The density of sea cucumbers were determined using formulas described by (Rogers, 2013), Species diversity in the sampling area was analyzed using Shannon-Weiner index (H') species variety index (e) (Odum (1975) in (Selanno *et al*., 2014), Dominating index was determined by Odum formula (1993) in (Gasango *et al*., 2013), Index Margalef, Gross 1992 in (Yusron, 2016). Those analyses were used to evaluate the sea cucumber community structure in this present study.

3. Result and Discussion

3.1 Species description

In total eight species were found in Southeast Moluccas and Tual, including four species of the genus Holothuria, three from the genus Stichopus and the rest was from the genus Bohadschia.

1. Bohadschia marmorata Jaeger, 1833

Systematic Account

Phylum : Echinodermata

Class : Holothuroidea

Ordo : Holothuriida

Family : Holothuriidae

Genus : Bohadschia

Species : *Bohadschia marmorata* (Jaeger, 1833)

*B. marmorata (*Jaeger*, 1833):* 18, pl. 3, fig. 9; (Clark and Rowe, 1971): 176, pl. 27, fig. 8; (Rowe & Doty, 1977): 132, pl. 22, fig. a-i; (Cherbonnier, 1988): 36 fig. 11A-L; (Samyn and Berghe, 2000): 21; (Samyn, 2003): 203, pl. 1H, fig. 8A-E, 51H; (Purcell *et al.*, 2012): 32.

Material examined

There is 1 specimen, Diffur (132.047'54.07"S and 50.32'43.36"E), September 10th, 2016.

Diagnosis

Body size 20 cm length and 2.5 cm width, cylindrical and stout; body wall very thick and soft. Dorsal color beige with dark brown dorsolateral ribbon-like patterns, sometimes with the various brown shape of blotches (Figure 2A). Ventral color white or light brown (Figure 2B). Dorsal papillae are small and densely arranged in the dorsal surface, dark brown spots present on the base of the papillae. Tube feet white, small, long, and scattered densely on the ventral surface. Mouth ventral and anus dorsolateral.

Remarks

These species have a color pattern that very similar to *B. koellikeri* and *B. vitiensis*. *B. marmorata* has a distinct dark color of various shape blotches and/or ribbon-like patterns. While *B. koellikeri* and *B. vitiensis* have the overall light-brown and irregular blotches (Kim *et al*., 2013), these species are also harvested from the sea and known as *trepang* (Setyastuti and Purwati, 2015).

Distribution

Relatively restricted to the West Indo-Pacific, including Indonesia (Kim *et al*., 2013) (Figure 2)

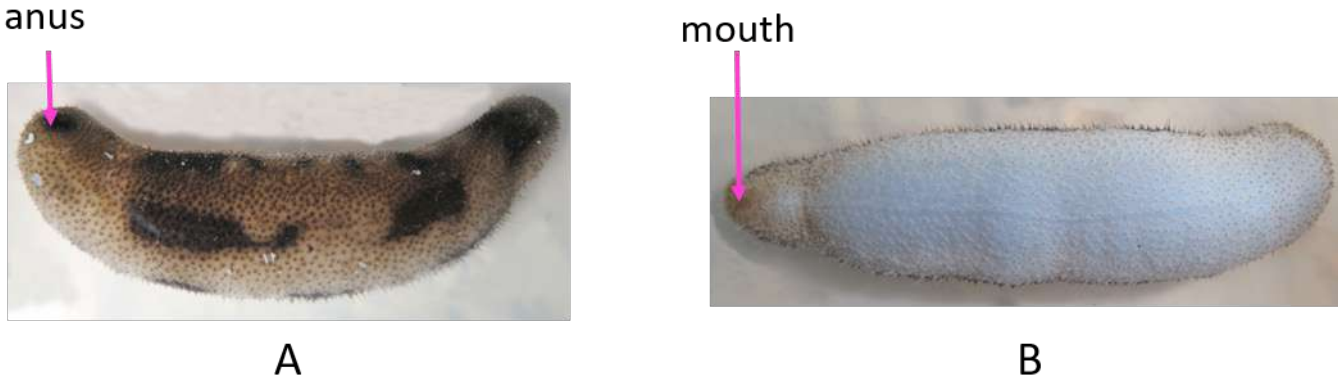

Figure 2. Morphology of *B. marmorata* Jaeger, 1833. A: Dorsal, B: ventral.

2. Holothuria (Halodeima) atra Jaeger, 1833

Systematic Account

Phylum : Echinodermata
Class : Holothuroidea
Ordo : Holothuriida
Family : Holothuriidae
Genus : Holothuria
Species : *Holothuria atra* (Jaeger, 1833)

H. atra; (Cherbonnier, 1988): 73, fig. 28A-J; (Massin, 1996b): 18, fig. 10A-E; (Massin, 1999): 20, fig. 13; (Samyn & Berghe, 2000): 22; (Samyn, 2003): 212, pl. 2E, fig. 14A-D; (Purwati & Wirawati, 2009): 7, fig. 6a-b; (Setyastuti, 2009): fig. 8a-b, 9a-e; (Purcell *et al.*, 2012): 42; (Purwati and Wirawati, 2012): 244, fig. 4, 5A-G.

Material examined

There are 2 specimens, Danar (50.54'16.54"S and 132.043'45.68"E), 8 September 2016; Ibra (132.047'12.11"S and 50.44'21.16"E), September 17th, 2016.

Diagnosis

Body size 10.5 cm length and 1.5 cm width, cylindrical; body wall thick and hard. Body-color uniformly black with long, small, and black dorsal papillae densely covered the dorsal surface. Tube feet similar shape and color with dorsal papillae, also densely covered ventral surface. Mouth ventral and anus terminal (Figure 3A and 3B).

Remarks

These species is very similar to *H. leucospilota*. The differences with *H. leucospilota* are that these species have a thicker body wall, shorter dorsal papillae, and no tubulous cuvier.

Distribution

These species are widely distributed in tropical shallow waters Indo-Pacific, including Indonesia (Purcell *et al*., 2012).

3. Holothuria (Metriatyla) albiventer Semper, 1868

Systematic Account

Phylum : Echinodermata
Class : Holothuroidea
Ordo : Holothuriida
Family : Holothuriidae
Genus : Holothuria
Species : *Holothuria albiventer* (Semper, 1868)

H. albiventer (Semper, 1868): 248, 277, pl. 30, fig. 14. Holothuria (Metriatyla) albiventer; (Rowe, 1969): 160; (Clark & Rowe, 1971): 176, pl. 28, fig. 2; (Cherbonnier, 1988): 129, fig. 52A-I; (Samyn, 2003),

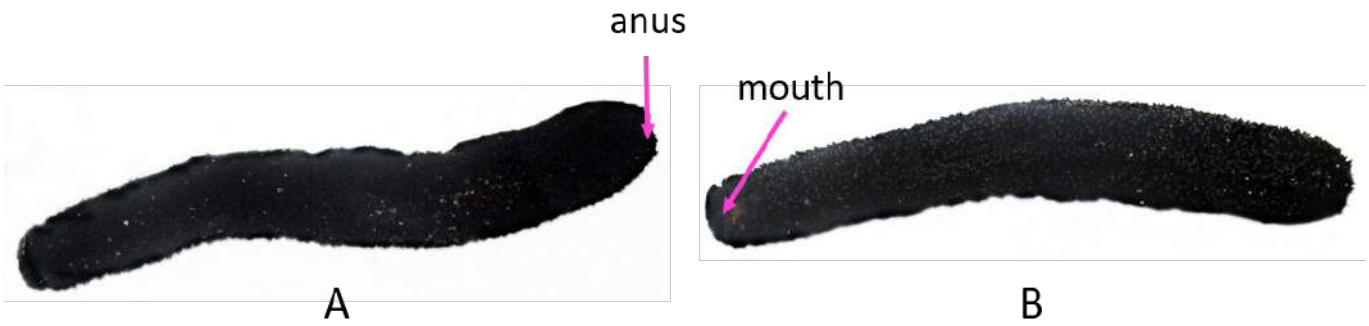

Figure 3. Morphology of *Holothuria (Halodeima) atra* Jaeger, 1833. A: Dorsal, B: ventral.

2003: 222, pl. 2H, fig. 18A-E, 53C; (Purwati & Wirawati, 2009): 14, fig. 11a-b; (Setyastuti, 2009): 375, fig. 4a-b, 5a-f.

Material examined

There is 1 specimen, Danar (50.54'16.54"S and 132.043'45.68"E), September 8th, 2016.

Diagnosis

Body size 10 cm length and 2 cm width, cylindrical and tapering on the anterior and posterior; body wall thin and paper-like. Dorsal color beige with white or yellowish small dots scattered on dorsal surface; a few large dark brown spots present vertically on both sides of the dorsal surface. Ventral color uniformly dark grey with white large conical from the base of tube feet. Dorsal papillae are white and large with conical on the base, scattered on the dorsal surface. Lateral papillae with larger conical that look like a wing on both side of the body. Mouth ventral and anus terminal.

Remarks

These species have a few color variations. Specimens from West Lombok have distinct large dark brown spots vertically on both sides of the dorsal surface (Purwati and Wirawati, 2009). While specimens from the Moluccas have dark green-brown body color on the dorsal (Setyastuti, 2009). The specimen from Tual in this study also have similarity to Moluccas specimens.

Distribution

This species recorded rom Indo-West Pacific, Including Indonesia (Rowe, 1969).

4. Holothuria (Fistularia) hilla Lesson, 1830

Systematic Account

Phylum : Echinodermata
Class : Holothuroidea
Ordo : Holothuriida
Family : Holothuriidae
Genus : Holothuria
Species : *Holothuria (Fistularia) hilla* (Lesson, 1830)

H. hilla (Lesson, 1830): 226, pl. 79. Holothuria (Mertensiothuria) hilla; (Rowe, 1969): 147; (Clark and Rowe, 1971): 178, pl. 28, fig. 9; (Cherbonnier, 1988): 85, fig. 34A-L; (Massin, 1996b): 30, fig. 20A-G; (Massin, 1999): 55, fig. 44, 111d; (Samyn & Berghe, 2000), 2000: 28; (Samyn, 2003): 84, fig. 5A-E, 11C, 12F; (Purwati and Wirawati, 2009): 9, fig. 8a-b; (Setyastuti, 2009): 378, fig. 10a-b, 11a-e; (Purcell *et al*., 2012): 58.

Material examined

There is specimen, Tamedan (132048'2.23"S and 5032'22.48"E), September 19th, 2016.

Diagnosis

Body size 20 cm length and 1.5 cm width, cylindrical with anterior narrower; body wall thin and soft. Body-color uniformly reddish-brown with white conical on the base of the dorsal papillae, scattered on the dorsal surface. Ventral with light reddish-brown to yellow and also with white conical on the base of the tube feet, scattered on the ventral surface. Mouth ventral and anus terminal.

Figure 4. Morphology of *Holothuria (Metriatyla) albiventer* Semper, 1868. A: Dorsal, B: ventral.

Figure 5. Morphology of *Holothuria (Mertensiothuria) hilla* Lesson, 1830. A: Dorsal, B: ventral.

Remarks

These species are often found under the rock or coral debris in the intertidal seagrass bed or sandy flat. Body-color varied from yellowish-brown, light brown, reddish-brown to dark brown with white or yellow conical sometimes merge into line, arranged vertically (Massin, 1999; Purcell *et al*., 2012; Purwati and Wirawati, 2009; Setyastuti, 2009).

Distribution

These species are widely distributed in the Indian Ocean, western central Pacific, to eastern Central America (Purcell *et al*., 2012).

5. *Holothuria scabra* Jaeger, 1833

Systematic Account

Phylum : Echinodermata
Class : Holothuroidea
Ordo : Holothuriida
Family : Holothuriidae
Genus : Holothuria
Species : *Holothuria scabra* (Jaeger, 1833)

H. (Metriatyla) scabra; (Rowe, 1969): 160, fig. 60; (Clark & Rowe, 1971): 178, pl. 15, fig. 15; (Cherbonnier, 1988): 135, fig. 55A-O; (Massin, 1996b): 25, fig. 16A-F, 17A-D; (Massin, 1999): 30, fig. 22a-l, 23, 110f; (Samyn and Berghe, 2000): 24; (Samyn, 2003),: 223, pl. 3A, fig. 19A-E, 53D; (Purcell *et al*., 2012): 80.

Material examined

In total 4 specimens, Ohoidertom (50.55'22.63"S and 132.042'47.99"E) September 7th, 2016; Tamedan (132.048'2.23"S and 5032'22.48"E), September 19th, 2016; Danar (50.54'16.54"S and 132.043'45.68"E), September 8th 2016; Difur (132.047'54.07"S and 50.32'43.36"E) September 10th, 2016.

Diagnosis

Body size 12 cm length and 4 cm width, cylindrical and stout; body wall thick and hard with a few horizontal folds. Body-color light greyish-brown to dark greyish-brown with black stripes arranged horizontally on the dorsal surface. Ventral color is uniformly white to a lighter grey. Dorsal papillae dark brown, small and densely scattered on the dorsal surface. Tube feet white, small and densely scattered on the ventral surface. Mouth ventral and anus terminal.

Distribution

These species are widely distributed in tropical Indo-West Pacific, including Indonesia (Massin, 1999).

6. Stichopus chloronotus Brandt, 1835

Systematic Account

Phylum : Echinodermata
Class : Holothuroidea
Ordo : Synallactida
Family : Stichopodidae
Genus : Stichopus
Species : *Stichopus* (*Perideris*) *chloronotos* (Brandt, 1835)

Figure 6. Dorsal side of *Holothuria (Metriatyla) scabra* Jaeger, 1833. A: Dorsal, B: ventral.

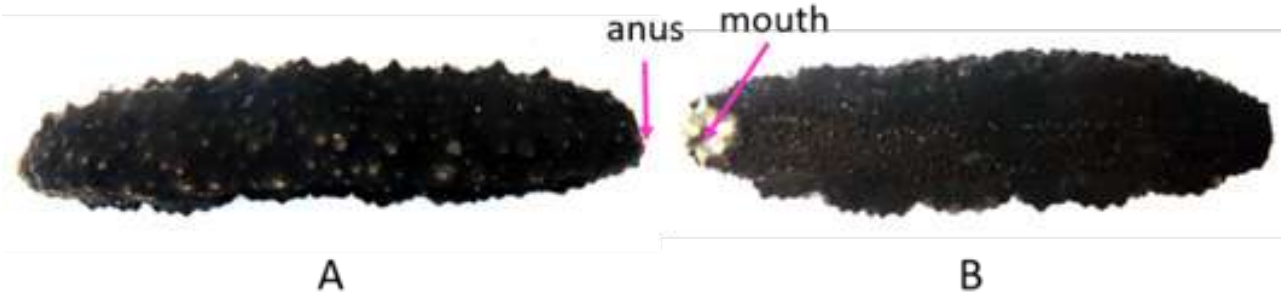

Figure 7. Morphology of *Stichopus chloronotus* Brandt, 1835. A: Dorsal, B: ventral.

S. chloronotus; (Cherbonnier, 1988): 146, fig. 60A-O; (Massin, 1996b): 34, fig. 23A-L; (Samyn, 2003): 247, pl. 4A, fig. 35A-F, 55B; (Wirawati *et al*., 2007): 359, fig. 3A-B, 4A-F; (Purcell *et al*., 2012): 100.

Material examined

There is 1 specimen, Tamedan (132.048'2.23"S and 50.32'22.48"E), September 19th, 2016.

Diagnosis

Body size 13 cm length and 2.5 cm width, trapezoid in cross-section with ventral sole flat; body wall thick, soft, and delicate. Body-color uniformly black with orange dorsal papillae, black with white tip tube feet, and white tentacle. Dorsal papillae densely scattered with conical on its base; very large conical present and vertically arranged on both lateral sides, forming wing-like appearance. Tube feet limited on ambulacral. Mouth ventral and anus terminal.

Remarks

The dorsal papillae in this specimen arrange densely not only on the ambulacral area but also on interambulacral. This characteristic is slightly different from the specimens from another area in Indonesia that the dorsal papillae arrange densely only on the ambulacral area (Massin, 1996b; Setyastuti, 2013; Wirawati *et al*., 2007).

Distribution

These species are widely distributed in the tropical Indo-West Pacific (Massin, 1996b; Purcell *et al*., 2012).

7. Stichopus cf. *monotuberculatus* Quoy and Gaimard, 1833

Systematic Account

Phylum : Echinodermata
Class : Holothuroidea
Ordo : Holothuriida
Family : Holothuriidae
Genus : Holothuria
Species : *Holothuria monotuberculata* (Quoy and Gaimard, 1833)

H. monotuberculata (Quoy and Gaimard, 1833): 131, pl. 432 fig. 1. Stichopus monotuberculatus; (Massin, 1996a): 163, pl. 1C-D, fig. 9-10; (Purcell *et al*., 2012): 106. Stichopus cf. monotuberculatus; (Samyn, 2003): 31, pl. 2E.

Material examined

There is 1 specimen, Taar (132.045'54.44"S and 50.38'40.96"E) September 22nd, 2016.

Diagnosis

Body size 13 cm length and 2.5 cm width, trapezoid in cross-section; body wall thick, soft, and delicate. Body-color brownish-green with irregular light brown area scattered unevenly on dorsal and surface; dark green blotches, sometimes combining into line arranged vertically on each dorsal interambulacral area and arranged unevenly on the ventral surface. Dorsal papillae prominent with large conical at the base, tip of the conical or base of the papillae have a dark green color and scattered densely on dorsal surface; the tip of the papillae white. Tube feet white, long, and densely arranged on the ambulacral area. Mouth ventral and anus terminal.

Remarks

Stichopus monotuberculatus is one of the cryptic species in *Stichopus* genera. Many of previous studies determined as different species that have the similarity with *S. monotuberculatus*, such as identified as *Stichopus monotuberculatus* of Purcell *et al*., (2012) not Quoy and Gaimard (1833) because of the longer dorsal papillae; (Samyn and Berghe, 2000) and (Setyastuti, 2013) identified as *Stichopus* cf. *monotuberculatus* because of the differences on the coloration and pattern of the body wall; (Ong *et al*., 2016) identified as *Stichopus* aff. *monotuberculatus* because of the red tip of the dorsal papillae. This specimen had similar body color and white color of the tip of the dorsal papillae, but the rest of the pattern was different from what (Massin, 1996a) described. This specimen was more similar morphologically with the description of *Stichopus monotuberculatus* of Purcell *et al*., (2012), not Quoy and Gaimard, (1833), but we did not compare it with the ossicles; therefore we determined it as *Stichopus* cf. *monotuberculatus*.

Distribution

Wide distribution through the Indo-Pacific, including Indonesia (Massin, 1996a; Purcell *et al*., 2012).

8. Stichopus vastus Sluiter, 1887

Systematic Account

Phylum : Echinodermata
Class : Holothuroidea
Ordo : Synallactida
Family : Stichopodidae
Genus : Stichopus
Species : *Stichopus vastus* (Sluiter, 1887)

Figure 8. Morphology of *Stichopus monotuberculatus* Quoy & Gaimard, 1833. A: Dorsal, B: ventral.

Figure 9. Morphology of *Stichopus vastus* Sluiter, 1887. A: Dorsal, B: ventral

S. vastus (Sluiter, 1887): 198, pl.2 figs 46-48; (Massin, 1999): 71, fig. 57a-l, 58a-m, 60a-d, 61, 112d-e; (Wirawati *et al*., 2007): 367, 11A-B, 12A-J; (Purcell *et al*., 2012): 114.

Material examined

There are 2 specimens, Taar (132.045'54.44"S and 50.38'40.96"E), September 22nd, 2016; Tamedan (132.048'2.23"S and 50.32'22.48"E), September 19th, 2016.

Diagnosis

Body size 30 cm length and 7 cm width, quadrangular in cross-section with ventral sole flat; body wall thick, soft, and delicate. Body-color light brown with numerous dark brown stripes arranged densely on the dorsal and conical surface. Ventral color uniformly reddish-brown. Dorsal papillae cream-colored with large and small conical. Large conical densely arrange on the ambulacral area vertically, small conical scattered on the dorsal surface. Tube feet dark brown and arranged in the ambulacral area. Mouth ventral and anus terminal.

Remarks

The dark lines pattern varied among the species, some more intense than the other (Massin *et al*., 2002). This species found in the intertidal area, especially seagrass beds and sandy, coral rubble substrates (Purcell *et al*., 2012; Setyastuti *et al*., 2018; Wirawati *et al*., 2007).

Distribution

Indonesia, Philippines, Papua New Guinea, Palau Islands, Yap (Federated States of Micronesia), and northeastern Australia (Purcell *et al*., 2012).

3.2 Density

Holothuria atra in Ibra (0.50781 ind/m^2) had the highest density among other species followed *by H. scabra* in Ohoidertom (0.19058 ind/m^2) and *Stichopus vastus* in Taar (0.00981 ind/m^2) (Figures 10 and 11). *H. atra* in Ibra was found gathering in large numbers at the same location with an average weight of 88.95 g, this location was closer to the mainland and covered by mangrove plants (difficult to access). This location was thought to be a rearing site of *H. atra*; this was confirmed by the finding of only one type species with almost relatively uniform size. Also, (Mercier *et al*., 1999) in his research stated that there was a relationship between sea cucumber *H. scabra* that are found in a group with the reproduction cycle of sea cucumbers. That location was protected by mangroves, the condition of sandy substrate and coral fragments provide sufficient food for *H. atra*. Although the area was not too large, this location was quite protected even from predators or humans for breeding grounds. As stated by Elfidasari *et al*., 2012, the gathering of certain sea cucumbers in their habitat could be influenced by food sources at these locations.

Sea cucumber density at Ohoidertom was quite high, and only one type of sea cucumber was found, namely *H. scabra*. This location was generally sandy and dense with seagrass species *Thalassia hemprichii* (Table 1). In the natural habitat, *H. scabra* tends to prefer this type of location characteristic (Mercier *et al*., 2000; Tuwo *et al*., 2012). The relatively high density of *H. scabra* in this location might be caused by village regulation that banned fishing (including sea cucumber) for more than two years (personal communication). This prohibition made sea cucumbers only exploited minimally by the local community so that they could develop and grow densely in this area. As information, in the context of managing and exploit marine biota, the people of Southeast Moluccas have already practiced the local prohibition system in a traditional *sasi* manner. *Sasi* is an local indigenous tradition for the management and conservation efforts of fisheries resources in the Moluccas (Novaczek *et al*., 2001; Persada *et al*., 2018). *Sasi*, which considers the sustainability of the environment, has a positive impact on the ecosystem's health that is being maintained.

The lowest sea cucumber density was in Difur with 0.0005 ind/m^2, where *H. scabra* was more dominant than other species (Figure 10). Sandy substrate, overgrown with seagrasses, and also macro algae indicate that this site was very attractive for sea cucumber habitat. Besides that, this location is in the bay where the waters are quite calm and protected. Based on information from the local community, Difur and Tamedan were locations where many sea cucumbers could be found, especially the species with high economic value, *H. scabra.* It matched the data obtained that *H. scabra* was found more in Difur, compared to other species. However, it was still relatively low compared to *H. scabra* in Ohoidertom. Difur and Tamedan locations were very open for fishermen to catch and harvest sea cucumbers with economic value; there were no restrictions or formal local rules which caused the low density of sea cucumbers. Personal communication with the local community (Difur) revealed that the number of sea cucumbers found was likely to be higher if the sampling was held at night (Personal communication; (Wisesa *et al*., 2018). It was stated by (Tanduyan *et al*., 2013) that *H. scabra* had a frequency found twice as much at night compared to daytime.

In general, the density of sea cucumber found in some of these observations sites was 0.00003 - 0.5078 ind/m^2. It was lower than reported by (Ardiannanto *et al*., 2014) 0.0800-1.0733 ind/m^2, and in Nyaregilaguramangofa Island, North Moluccas with density of 0.01-0.009 ind/m^2 (Husain *et al*., 2017), also in Tual and Southeast Moluccas with 0.12-1.74 ind/m^2 (Yusron, 2001), and North Moluccas Kakara Village 0.1-0.226 ind/m^2 (Gasango *et al*., 2013). Exploitation rate is considered to be the reason for the low density of sea cucumber in this study. Harvesting without ecological balance consideration led to a declining sea cucumber population in Indonesia (Aziz, 1997). On the other hand, the trade data (Fish Quarantine and Inspection Agency, a representative for Tual) showed that dry weight sea cucumber trade increased from 29,191 kg (in 2013) to 33,379 kg in 2016. However, in this time-specific value data of sea cucumber exploitation is still lack. *H. atra* was species that are generally most easily found and had a higher density compared to other types, both in the present and previous research. The high adaptability in their habitat, ability to reproduce asexually (through fission in stressful circumstances), suitable environment and low economic value may be allowing this species more abundant than

Table 1. Substrate and vegetation in sites

Locations	Habitat		
	Substrate	**Seagrass**	**Macro algae**
Ohoidertom	Sandy	Dominated by *Thalassia hemprichii*	-
Danar	Muddy Sand	Dominated by *Thalassia hemprichii*	
Ibra	Dead coral	-	Dominated by *Halimeda* sp.
Taar	Sandy, Dead coral	Dominated by *Enhalus acroides*	Dominated *Padina australis*
Difur	Sandy	*Cymodocea rotundata* and *Thalassia hemprichii*	*Padina australis*
Tamedan	Sandy	Dominated by *Thalassia hemprichii*	Dominated by *Padina australis*

others. Local communities tended to exploit high-valuesea cucumber species than others. Furthermore, it might be associated with an ability to adapt to various habitat from intertidal to a subtidal area or called as a habitat generalist species (Sanvicente *et al*., 2017).

S. vastus from Taar was a species of sea cucumber to be the largest 746.02 g (± 270 mm) compared to other species (Figure 11). In previous research in Karimun Jawa (Sulardiono *et al*., 2012), the biggest *S. vastus* found was 300 mm; the size of this species can reach 400 mm (Massin *et al*., 2002), followed by *S*. cf. *monotuberculatus* 426.00 g. *S. vastus* found in Taar was five times larger in size compared to those found in Tamedan (141g). Taar was a bay that is quite closed or protected from outside waters. This location was suspected to be a spawning ground for them, especially when it was discovered in September, with averages on mature size. This is supported by (Sulardiono, 2011) who stated that the mature size of *S. Vastus* is 269-286 mm and September was considered as the month with most frequent gonadal maturity. With this alleged spawning ground location, local government is encouraged to do further study as a basis for the sea cucumber management in Taar. It is known that *S. vastus* has a high economic value for the local community (Setyastuti & Purwati, 2015; Sulardiono *et al*., 2012). As information, Taar was also a watershed area that was imposed "sasi" by residents. At least sasi had a positive impact on ecosystems rehabilitation and conservation because it allowed sea cucumbers and natural biota to develop naturally with little interference from exploitation activities. On the other hand *H. scabra* size was not significantly different from each location, ranging between 58.50g (± 100 mm) (Danar) to 72.37g (± 120 mm) (Ohoidertom).

3.3 Diversity Index and Dominancy Index

The diversity index (Shannon Index, H', Figure 12) of sea cucumber in Southeast Moluccas and Tual was relatively low (Nirwana *et al*., 2016), which ranged from 0 in Ohoidertom as well is in Ibra, and up to 0.86 in Danar, compared to other locations such as Kei Besar, Southeast Moluccas (2.2-2.5) (Yusron and Widianwari, 2004), Panjang Island, Jepara 0.64-0.68 (Satria *et al*., 2014); Kakelo Tobelo Beach 1.95 (Gasango *et al*., 2013); Odong Siau Beach Tagulandang Biaro 1,718 (Lagio *et al*., 2014); and Sawapudo Konawe waters 2.77-2.96 (Nirwana *et al*., 2016). Low diversity index might be caused by several factors, including the existence of essential ecosystems such as mangrove, seagrass beds, and coral reefs as their habitat, the number of individual species found, certain abundant species, and homogeneity of the substrate (Supono and Arbi, 2010; Yusron, 2016). Low diversity could also be influenced by periodic or seasonal disturbance by humans or nature (Gasango *et al*., 2013). It was well known that sea cucumbers are commodities that have high economic value in Southeast Moluccas and Tual, so that exploitation

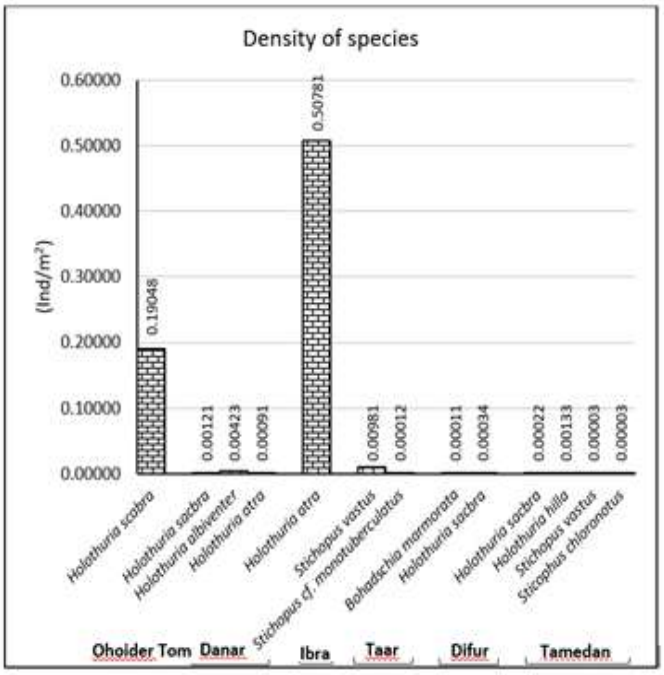

Figure 10. The density of species each station

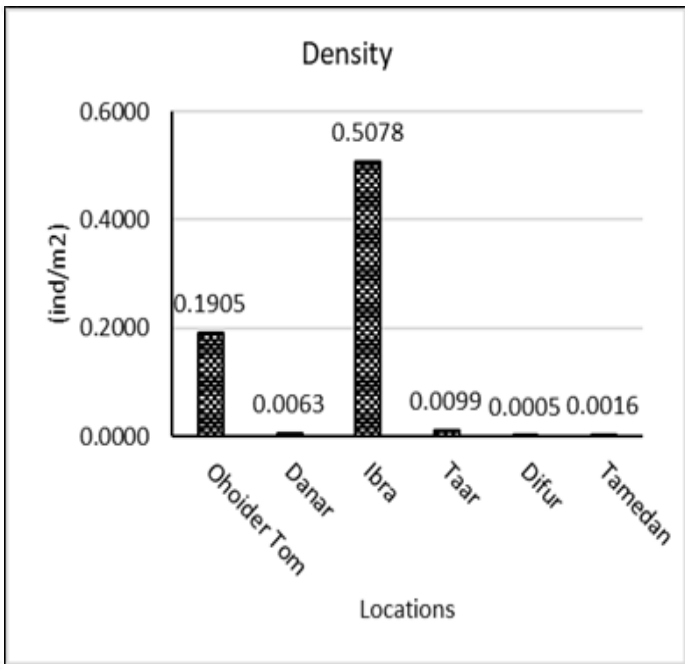

Figure 11. Sea cucumber density each station

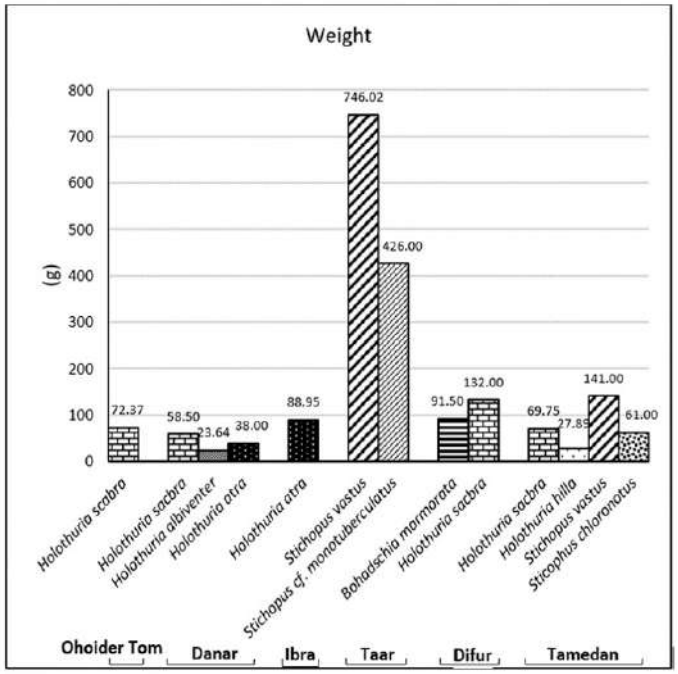

Figure 11. The average weight of sea cucumber founded in each station

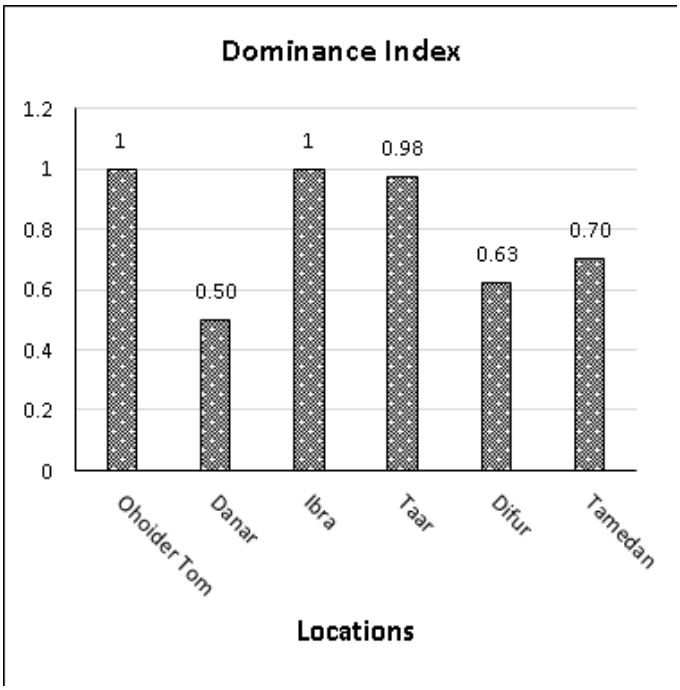

Figure 13. Dominance Index of sea cucumber in each location

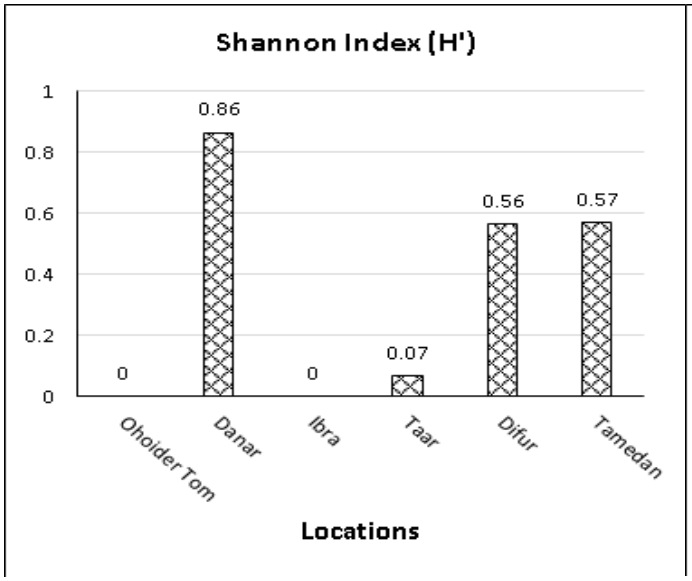

Figure 12. Shanon Index of sea cucumber in each location

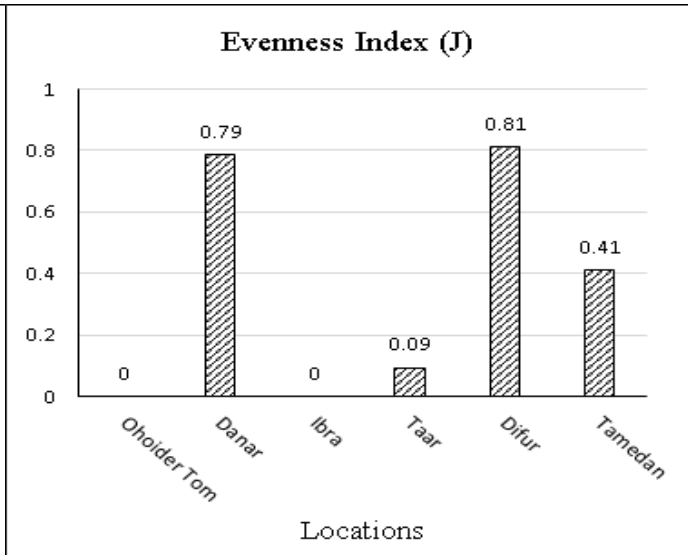

Figure 14. Evenness Index of sea cucumber in each location

activities by the local community were one of the factors affecting species diversity at this location. . In general, inhabitants usually harvested valuable species for their benefit for instan, *H. scabra* and *S. hermani,* etc.

The number of species found at each location was four species. It was the most species found, while the least found was at Ibra as well as Ohoidertom which only one species, with H' value was 0. The observation sites at Ohoidertom and in Ibra show that the microhabitats formed were very by following the species found. For example, *H. scabra* was mostly found in Ohoidertom, and *H. atra* was mostly found in Ibra, compared to other locations. The values of diversity index in the two locations were inversely proportional to the high dominance by the species of sea cucumber found (Figures 12 and 13). The dominance index value of the two locations was 1. On average, the dominance index value of all of these research sites was 0.8017, categorized as high (Oktamalia *et al*., 2016), wherein some locations there was dominance by certain types.

This dominance could be caused by several

Table 2. Water quality parameter of stations

Locations	Dissolved Oxygen (ppm)	Salinity (ppt)	Temperature (°C)	pH	Total Dissolve Solid (ppm)
Ohoidertom	NA	30.5	30.2	8.45	26.5
Danar	NA	33.5	29.01	8.22	25.4
Ibra	6.64	33.2	31.32	7.9	25.1
Taar	7.33	28	30.6	8.15	21.6
Difur	NA	29.4	32.3	8.8	22.5
Tamedan	7.61	32.9	32.2	8.26	24.9

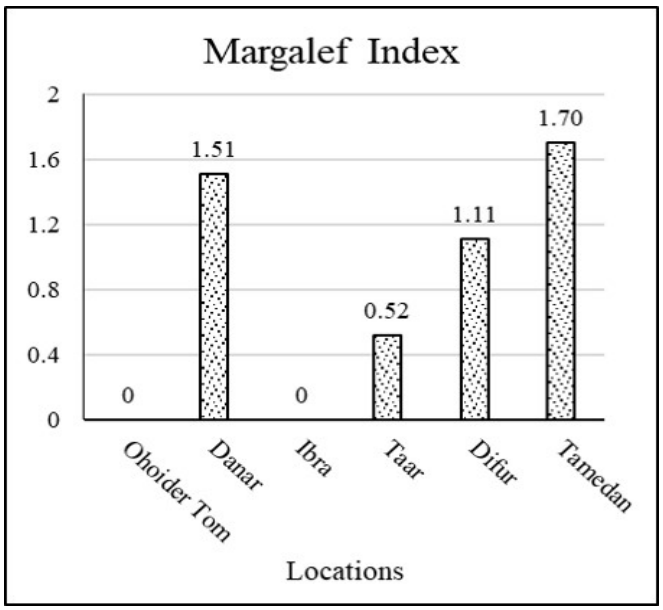

Figure 15. Margalef index of sea cucumber in each location

factors including habitat suitability, food availability, competitors, and predators, as well as anthropogenic activities as mentioned earlier that these locations were rarely accessed by the community because of the prohibition by local culture, or *sasi*. Specifically, for Ibra, this location was very protected by vegetation surroundings (mangrove) and relatively difficult to access.

3.4 Evenness Index and Species Richness Index

The evenness index in Danar and Difur was quite high, i.e. 0.79 and 0.81, respectively (Figure 14). While the lowest was 0 for Ohoidertom and Ibra. Based on the value of the closeness, the data showed that the sea cucumber community in Danar and Difur waters was categorized as stable, while others were categorized as depressed (Ardiannanto *et al*., 2014). As a comparison, the evenness index in Kei Besar, Southeast Moluccas was high (0.9-0.96) (Yusron and Widianwari, 2004); Nyalegilaguramangofa Island, North Moluccas was 0.834 (Husain *et al*., 2017), in North Sulawesi Vice District level 0.665 (Gustiani *et al*., 2018) and Kakara North Moluccas 0.939 (Gasango *et al*., 2013). The data in Figure 14 showed that if there were dominance by certain species at an observation location, it would have an impact on the low Evenness Index (Figure 14), as happened in Ohoidertom, Ibra, and Taar. Then the Margalef Index (Figure 15) at each station had different, the lowest is obtained at Ohoidertom and Ibra, which is 0, and the Margalef Index in Danar and Tamedan were 1.51 and 1.70, respectively. The richness of community types could be influenced by several interrelated factors, one of which is water quality, both chemical and physical (Yusron, 2013). In general, it could be said that the Margalef Index of species diversity at the observation locations was relatively low. It meant study areas had a low abundance of sea cucumber species.

Observed water quality data (Table 2) showed that environmental conditions were still normal, suiting the living needs of marine biota (KMNLH, 2004). There was a significant difference in salinity in Taar compare to other locations (28 ppt). In a certain month, this location had a fairly low salinity of around 28 ppt according to the results of (Jasmadi, 2016). Also, the water flow sources from the mainland to the observation sites also played an important role in decreasing the water salt content. The shape of the bay, which was more like a lake and a narrowing bay door, allows for freshwater to be accommodated long enough in low tide conditions. In accordance with this present study suggested that management strategy needs to be taken, one of them is by using local wisdom approach to maintain the stability of sea cucumber community structure.

4. Conclusion

In this study, eight species of sea cucumber were found which were of high and low economic low. From all of the samples found, four species where of the genus Holothuria, three were of genus Stichopus, and the rest were of genus Bohadschia. In general, the diver-

sity index was relatively low. The evenness index was also low, which indicates the community was depressed, there certain spesies dominate in most locations, and the Margalef Index was low. The community structure of sea cucumber in the Tual and Southeast Moluccas in observed sites was in a quite depressing condition so management strategy needs to be taken, one of them is by using a local knowledge approach to maintain the stability of sea cucumber community structure.

Acknowledgment

The author would like to thanks to the Conservation Unit for Tual Marine Life (Indonesian Institute of Sciences) for budget and facilities support for this research. Also, it also provided technicians and staff for this research.

Authors' Contributions

All authors have contributed to the manuscrip. Their contribution listed as follow, Jasmadi was the first author, responsible to research design, data collecting, proposal submission for research funding, research, data analysis, manuscript drafting. Ismi: co-author, responsible to data analysis, manuscript drafting. Tegar: co-author, responsible to data analysis, manuscript drafting. Sandi Permadi co-author, responsible to data analysis, manuscript drafting.

Conflict of Interest

The authors declare that they have no competing interests.

Funding Information

Our Research Project was fully funded by Loka Konservasi Biota Laut Tual LIPI with grant number 22/IPK.10/KP/I/2016.

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