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The abundance of *Holothuria (Halodeima) atra* (Jaeger, 1833) in Karimunjawa and Sintok Island, Karimunjawa National Park, Jepara, Indonesia related to density of seagrass

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ABSTRACT

Seagrasses have been known as one of the most important marine resources. They provide a great ecological important marine ecosystem service. They also have function to provide habitat for a variety of life forms in coastal waters as well as serving as nursery, shelter and feeding area for many species, including sea cucumber. The objectives of the present work was to determine the relationship between *Holothuria (Halodeima) atra* (Jaeger, 1833) abundance and seagrass density in Alang-alang waters and Pancuran waters of Karimunjawa and Sintok Island of Karimunjawa National Park. Quadrant transects of 50x50 cm^2 were applied to observe the seagrass species, density and coverage as well as to determine the abundance of *H. atra* in different locations with dense, medium, low density of seagrass. The results showed that there were medium coverage conditions of seagrass in research locations, where in Pancuran waters found more percentage coverage than other locations. It also had more (8) species of seagrass, i.e. *Enhalusacoroides*, *Thalassia hemprichii*, *Halophila ovalis*, *Halodule uninervis*, *Halodule pinifolia*, *Cymodocea rotundata*, *Cymodocea serrulata*, and *Syringodium isoetifolium* while in Alang-Alang and Sintok Waters found only five species. Based on density of seagrass the denser seagrass the more abundance the *H. atra*. So that in Karimunjawa National Park, the abundance of *H. atra* found to have strong to very strong relationship with seagrass density that showed its importance as habitat as well as food source for *H. atra* populations.

***Key words** : Alang-alang waters, Habitat, Holothuriaatra, Pancuran Waters, Sintok waters*

Introduction

Situated some 90 km northwest off the northern coast of Jepara Regency in CentralJava Province, Indonesia, the Karimunjawa Archipelago consists of numerous islands and outspread reefs and seagrass ecosystem. The Karimunjawa National Park (KNP), a nature reserve which has an originale cosystem and a richly diverse coral reef, seagrass, and mangrove, is managed by Karimunjawa National Park Authority (KNPA). In 2001, all marine waters of KNP were designated as a marine conservation area by the Ministry of Forestry Decree No.74/Kpts-II/2001 (KNPA, 2014; Campbell *et al*., 2013). The KNP area is divided into nine zones which have different functions and allocations, i.e. core (444.63 ha), forest (1,451.77 ha), marine protection (2,599.77 ha), land utilization (55.99 ha), marine tourism utilization (2,733.74 ha), mariculture (1,370.73 ha), religious, cultural, and historical (0.86 ha), rehabilitation (68.33 ha), and traditional fisheries zone (102,899.25 ha) (Yuliana *et al.,* 2016).

The Karimunjawa Islands have high biodiversity natural resources from land to waters that need to be maintained and utilized sustainably and wisely (BTNKJ, 2018). There are three important ecosystems to maintain balance in the coastal areas, namely seagrass, mangrove and coral reef ecosystems. As one of the important ecosystems, seagrass beds have primary productivity as autotrophic plants that bind carbon dioxide into energy in the food chain which will be eaten by herbivorous animals and through decomposition as litter, it also plays a role in nutrient recycling, as a food source that contains nutrients, as a shelter from predators **(**Kawaroe *et al.,* 2016). Many marine biotas are associated with this ecosystem, one of them is sea cucumber which uses the seagrass meadow a place of refuge, spawning and foraging. Sea cucumber prefers habitat with fine sandy substrates that are overgrown with protective plants, such as seagrass (Tanita and Yamada, 2019). The existence of sea cucumbers in nature is influenced by the availability of food. *H. atra* can be found in areas containing organic material from microphytobenthic organisms (Hartati *et al*., 2020b). Ecologically, sea cucumbers have an important role as a deposit feeder that can process the substrate in their environment and provide food in the form of eggs, larvae and juveniles for another marine biota.

H. atra commonly known as black sea cucumber, is one of the most abundant and widelydistributed sea cucumber species in most parts of the Indo-Pacific region (Conand, 2008) as well as in Indonesia, especially in Karimunjawa Islands (Purwanti *et al*., 2010; Mustagpirin and Hartati, 2016). They inhabit a wide range of depths and a broad variety of habitat ranging from rocky reefs to mudflats (Conand, 2008; Purcell *et al*., 2009). Before exploitation went to high-value sea cucumber, but recently shifted towards low value species (Anderson *et al.,* 2011),such as *H. atra* (Purwanti *et al*., 2010; Hartati *et al*., 2019). *H. atra* preferably lives in coastal seagrass beds, soft and hard substrates of coral reefs as having been previously reported by Dissanayake and Stefansson (2012); Setyastuti (2014), Asha *et al*. (2015) and Hartati *et al*. (2017). Asdeposit feeder, *H. atra* consume detritus, uneaten food, and algae in the substrate (Hartati *et al*., 2017; 2020a, b). It also ingests and grains, digests the nutrient, and then expels and pellets both in day and night time. Hartati *et al*., (2020b) found that in Panjang Island, Jepara, *H. atra* had efficiency in feeding by taking advantage of the high TOM content and high abundance of microphytobenthic organisms which is related to their natural microhabitats with different seagrass coverage. Buckius *et al*. (2010) also emphasized that MPAs have the ability to maintain higher sea cucumber abundance; therefore the present research was aimed to establish the relationship between the abundance of *H. atra* with the density of seagrass in different waters of Karimunjawa and Sintok Island, in Karimunjawa National Park.

Materials and Methods

The research was conducted in Karimunjawa National Park, i.e., in Alang-alang and Pancuran Waters of Karimunjawa Island and Sintok Waters of Sintok island, Jepara Regency, Indonesia during October 2019. The sampling map is presented in Figure 1 and the position of each location is presented in Table 1.

Sea cucumber of *Holothuria (Halodeima) atra* (Jaeger, 1833) samples were observed and determined along with seagrass observations in different density and no seagrass (none) location as control. Seagrass density was categorized based on Rahmawati *et al*. (2014), i.e. Seagrass percent cover of 0-25, 26-50, 51-75 and 76-100% as low, medium, dense, and very dense, respectively. The quadrat consisted of 50 × 50 cm^2 of PVC-pipe separated into 50 squares. If any seagrass was found in a square, then it was identified and counted for their shoot. Percent cover for each species was calculated from the shoot density according to Rahmawati *et al*. (2014); McCloskey and Unsworth (2015). Sea cucumber found in the same seagrass transect were counted as abundance of sea cucumber. A regression analysis was applied in order to establish the relationship between abundance of sea cucumber *H. atra* and density of seagrass in three different locations in Karimunjawa National Parks.

Water quality were measured in situ, temperature with hand termometer, salinity with Atago N1 *Hand Held Refractometer*, pH with Ohaus ST10 *Starter*

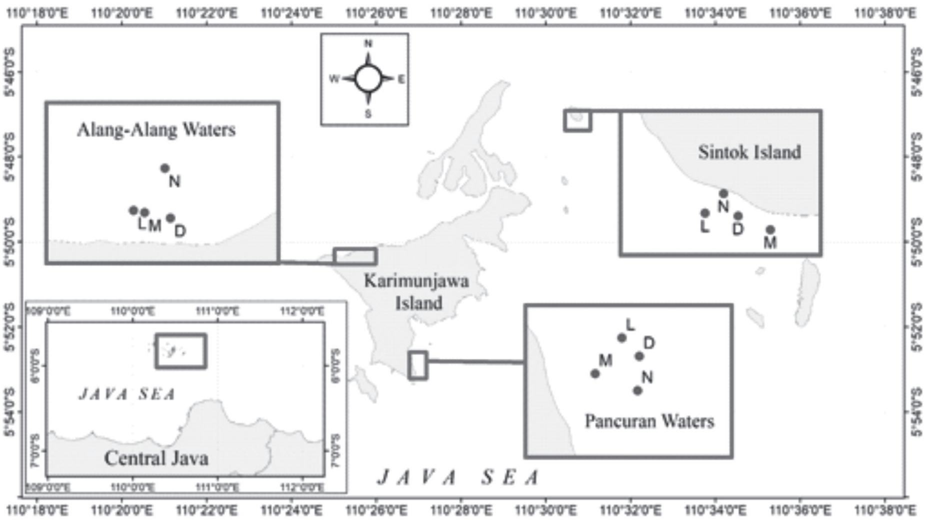

Fig. 1. Map of sampling stations of Karimunjawa and SintokIsland, Karimunjawa National Park, Jepara, Central Java, Indonesia

pH meter, dissolved oxygen with HANNA HI 91466 DO meter. Sediment sample was taken using sediment *core* with the depth of 20 mm for organic matter and chlorophyll-a analysis. Total Organic Matter (TOM) analysis was done using the 'ash method' (Wang *et al.* (2011)). Biomass of microphytobenthic was measured as concentration of chlorophyll-a following procedures of DeJonge *et al*. (2012) and Johan *et al*., 2015) using a Perkin-Elmer Lambda 3BUV/VIS spectrophotometer. The chlorophyll-*a* concentrations were calculated with the formula of Montani *et al*. (2012).

Results and Discussion

In the Karimunjawa National Park, the research was conducted in Alang-Alang and Pancuran Waters of Karimunjawa Island and in Sintok Waters of Sintok Island. Alang-Alang waters were located close to residential areas, so the water quality was influenced by the activities of coastal community which can have an impact on the surrounding ecosystem and can cause a decrease in the potential for biodiversity. Pancuran waters were one of tourist destination with quite rich seagrass beds and coral reef ecosystems. Meanwhile, the Sintok Island is being designed as tourist destination; many biotas found and associated with seagrass ecosystems and coral reef ecosystems. As seagrass bed in Sintok waters located in piers, this location has potential damage to due to influence of ship traffic activities.

Table 1. Geographical position of sampling locations in Karimunjawa and SintokIsland, KarimunjawaNational Park, Jepara, Central Java, Indonesia

Locations	Seagrass Density	South	East
	Low (L)	5º50'17,57"	110º25'08,29
Alang-Alang Waters	Medium (M)	5º50'17,72"	110º25'09,06"
Karimunjawa Island	Dense (D)	5º50'18,11"	110º25'10,89"
	None (N)	5º50'14,58"	110º25'10,50"
	Low (L)	5º52'52,04"	110º26'56,84"
PancuranWaters	Medium (M)	5º52'54,57"	110º26'54,94"
Karimunjawa Island	Dense (D)	5º52'53,33"	110º26'58,07"
	None (N)	5º52'55,76"	110º26'57,94"
	Low (L)	5º47'07,86"	110º30'41,47"
Sintok Waters	Medium (M)	5º47'09,67"	110º30'45,91"
Sintok Island	Dense (D)	5º47'08,54"	110º30'43,28"
	None (N)	5º47'06,30"	110º30'42,73"

Overall, the seagrass coverage in research locations varied, i.e. their average value in Alang-Alang, Pancuran and Sintok waters was 34.92, 51.5% and 41.59% respectively. According to Rahmawati *et al.* (2014), this condition belonged to moderate conditions. There were eight species of seagrass were found in the research location, i.e. *Enhalusacoroides*, *Thalassia hemprichii*, *Halophila ovalis*, *Halodule uninervis*, *Halodule pinifolia, Cymodocearo tundata, Cymodocea serrulata,* and *Syringodium isoetifolium*, in which Pancuran waters have more species of seagrass than two other locations. Five species of seagrass were found in the dense seagrass bed at all locations, i.e. *E. acoroides, T. hemprichii H. ovalis, H. uninervis, and C. rotundata* (Table 3). Density of *T. hemprichii* showed higher (172-781 ind.m^{-2}) than other species in all locations. This seagrass species is able to grow in any condition (Riniatsih, 2016). The composition of the types of seagrass density (ind.m^{-2}) and the abundance of *H. atra* (ind.m^{-2}) in Alang-Alang, Pancuran and Sintok waters were showed in Table 2.

Seagrasses have been known as one of the most important marine resources. They provide a great ecological and economic important marine ecosystem services, including their capacity in sediment stabilization, water quality improvement, and their role in carbon and nutrient cycling (Nadiarti *et al.*, 2012). They also have function to provide habitat for a variety of life forms in coastal waters as well as serving as nursery, shelter and feeding area for many species, including sea cucumber (Dissanayakea and Stefanssona, 2012**)**.

One of the marine organisms associated with seagrass ecosystem is black sea cucumbers, *H. atra.* It had characteristic of elongated body, medium flesh, and reddish black color (Purcell *et al.*, 2014). The whole body was covered with long, small, tight papillae on the dorsal surface, and long densely small tube feet on the ventral surface of the body. The sea cucumbers found in Alang-Alang, Pancuran and Sintok waters in this study were relatively low. The research was conducted in the morning until noon, *H. atra* was probably buried itself in the sand,

Table 2. Seagrass composition and density of seagrass (ind.m^{-2}) and abundance of *H. atra*(ind.m^{-2}) in Alang-Alang, Pancuran waters (Karimunjawa Island) and Sintok Waters (Sintok Island)

Seagrass species	Dense Ind.m^{-2}	Medium Ind.m^{-2}	Low Ind.m^{-2}	None Ind.m^{-2}
Alang-Alang Waters, Karimunjawa Island				
Enhalus acoroides	122	39	2	0
Thalassia hemprichii	770	210	64	0
Halophila ovalis	148	18	0	0
Halodule uninervis	193	0	0	0
Cymodocea rotundata	30	8	0	0
Pancuran Waters, Karimunjawa Island				
Enhalus acoroides	66	11	0	0
Thalassia hemprichii	781	147	54	0
Halophila ovalis	119	25	0	0
Halodule uninervis	37	0	0	0
Cymodocea rotundata	740	197	27	0
Cymodocea serrulata	89	0	0	0
Syringodium isoetifolium	27	0	0	0
Halodule pinifolia	95	0	0	0
Sintok Waters, Sintok Island				
Enhalus acoroides	5	0	0	0
Thalassia hemprichii	172	158	47	0
Halophila ovalis	48	23	17	0
Halodule uninervis	11	16	19	0
Cymodocea rotundata	1508	145	26	0
Sea cucumber *H. atra*				
Alang-Alang Waters	2.67	1.23	0.36	0.18
Pancuran Waters	4.0	2.25	0.85	0
Sintok Waters	1.43	1.23	0.31	0

so that the number of *H. atra* was relatively low. According to Dissanayakea and Stefanssona (2012), most sea cucumbers were active foraging at night and hiding during the day and according to Setyastuti (2014) sea cucumbers usually live immersing themselves in sand.

Habitats with different density seagrasses revealed to have varied *H. atra* abundance. The abundance of *H. atra* was varied among the locations and densities of seagrass bed in the range of 0.31-4.0 ind.m^{-2}. The higher abundance found in Pancuran water over the different density of seagrass. As same location of marine protected area, it is almost the same abundance of *H. atra* of Cabansag *et al.* (2014) studies in MPAs of Guiuan Eastern Samar and Palompon Leyte, Philippines. It is said that *H. atra* are found to show preference for specific habitat characteristics that are associated with their feeding and protection (Dissanayakea and Stefanssona, 2012). The relationship between abundance of *H. atra* and density of seagrass were presented in Figure 2. Abundance of *H. atra* and density of seagrass in different locations were connected in a linear equation. In Karimunjawa Island (Alang-alang and Pancuran Waters) abundance of *H. atra* had very strong positive relation with density of seagrass (range of 0.91-0.93) and there was strong relationship between the min Sintok Waters with correlation coefficient of 0.78 (Figure 2). So the abundance of *H. atra* in three locations showed higher in denser seagrass than lower density seagrass (Table 3). Even in open none seagrass area, *H. atra* was only found in one location, i.e. in Alang-alang waters. These results indicate the important role of seagrass for the life of the associated biota, especially sea cucumbers as a shelter. Denser seagrass is preferred place by sea cucumbers, so they use them as shelter from predators, waves and as a place foraging. In accordance with Tanita and Yamada (2019) sea cucumbers like a soft sandy base that is covered with protective plants, such as seagrass and the like and is free from the waves. The factors that influence the high abundance of sea cucumbers in Pancuran are thought to be due to the location that lacks local activity, tourist sites that are visited by few tourists, these waters are overgrown with various types of seagrass with sand substrate types and chemical physics factors that support sea cucumber life. In accordance with Asha *et al.* (2015), sea cucumbers were adaptive to change of chemical physicals environmental factors that support sea cucumber life. In Alang-Alang waters and Sintok Island waters, the abundance of sea cucumbers was lower than in Pancuran waters, presumably due to ecological pressure or disturbances from the surrounding environment, such as community and boat traffic activities which disturb the seagrass beds and associated biota, so that the density and type of seagrass in these waters is relatively low. In accordance with Kawaroe *et al.* (2016) the seagrass ecosystem is dynamic, which is influenced by changes in environmental conditions, if there is a decline, indicating a pressure or threat to the ecosystem.

Water quality in the form of physical and chemi-

Table 3. Water quality parameter of Karimunjawa and Sintok Island, Karimunjawa National Park, Jepara, Indonesia

Parameter	Seagrass density	Alang-Alang waters	Pancuran Waters	Sintok Waters
Temperature (°C)		31.9 ± 2	30.5 ± 2	31.2 ± 2
pH		8.13 ± 2	7.76 ± 2	7.36 ± 2
Salinity (ppt)		28.67 ± 2	30.33 ± 2	33.67 ± 2
Dissolvedoxygen (mg.L^{-1})		5.13 ± 2	5.57 ± 2	6.1 ± 2
Transparency (%)		100	100	100
Depth (cm)		85-105	88-100	80-110
Sediment		Sandy	Sandy	Sandy
Organic matter (%)in seagrass density	Low	7.57	6.16	6.86
	Medium	6.01	5.19	7.18
	Dense	6.85	5.28	7.54
	None	5.92	6.39	5.82
Chlorophyll- a (mg.g^{-1})in seagrass density	Low	0.23	1.15	0.51
	Medium	0.63	1.01	0.72
	Dense	0.70	0.55	0.69
	None	1.59	0	0

cal parameters was presented in Table 3. The bottom substrate of different seagrass densities in all locations were dominated by sand which is preferred by sea cucumbers. According to Tanita and Yamada (2019), *H. atra* preferred seagrass beds with a sand-based substrate. Apart from being influenced by the seagrass ecosystem, the availability of food in the ecosystem also affects the abundance of sea cucumbers. According to Hartati *et al*. (2020a), ecologically, *H. atra* were deposit feeders also acted as bioturbator or sediment processor in shallow ecosystem waters. The organic matter and chlorophyll-a in Alang-Alang, Pancuran and Sintok waters at different seagrass densities tended to be low and medium, ranging from 5.19- 7.57%. Low and moderate organic matter content is thought to have been used by sea cucumbers as a food source. According to Hartati *et al*. (2017), black sea cucumbers were also omnivorous, ate algae, detritus (non-living matter). *H.atra* were usually found in habitats with

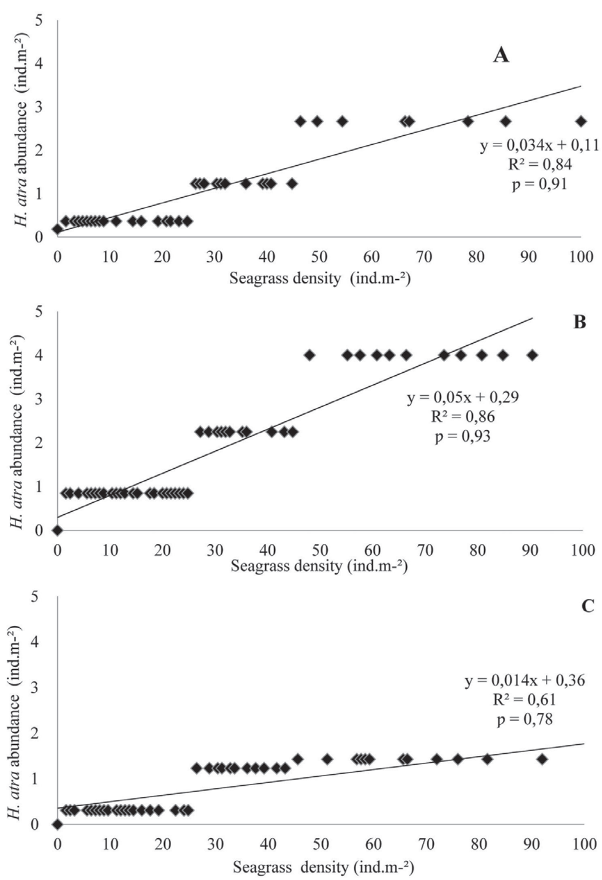

Fig. 2. The relationship between abundance of *H. Atra* with density of seagrass in Alang-Alang Waters (A) and Pancuran Waters (B) in Karimunjawa Islanddan Sintok Waters in Sintokisland (C).

organic matter content of 2.1-2.9% (Asha *et al*., 2015). The chlorophyll-a content in the three study sites with different seagrass densities showed low value which were thought to have been eaten by sea cucumbers. According to Hartati *et al.* (2017), in addition to organic matter, chlorophyll-a can represent algal biomass and microphytobenthic which are a source of food for sea cucumbers. Water quality parameters also affect the condition of sea cucumber habitat in seagrass ecosystem. The water temperature in research locations were 30.3-32°C. According to Asha *et al*. (2015), sea cucumbers can adjust to sea water temperatures between 28-32°C. Salinity in the research locations were in the range of 26.67-35.67°/oo which was still suitable for the life of sea cucumbers (Sun *et al*., 2018). High temperatures cause an increase in oxygen consumption by biota, but dissolved oxygen content was still good for *H. atra*. Transparency of water was 100% meant that the sunlight was down reached the bottom and it allowed microphytobenthic to do photosynthesis and grow that will support the sea cucumbers (Pitt and Duy, 2004). As the water quality of Alang-Alang, Pancuran waters in Karimunjawa Island and Sintok Waters in Sintok Island were not varied much and in acceptable level of *H. atra*, so it did not influence the abundance of *H. atra* therefore it confirmed the relation with density of seagrass.

Conclusion

The seagrass coverage in Alang-Alang, Pancuran (Karimunjawa Island) and Sintok waters (Sintok island) of Karimunjawa National Park showed in moderate condition (34,92-51.5%) consisted of eight species, i.e. *Enhalu sacoroides*, *Thalassia hemprichii*, *Halophila ovalis*, *Haloduleuninervis*, *Halodule pinifolia*, *Cymodocea rotundata*, *Cymodocea serrulata*, and *Syringodium isoetifolium.* The abundance of *Holothuriaatra* found to have strong to very strong relationship with seagrass density that showed its importance as habitat as well as food source for *Holothuriaatra* populations.

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