Habitat characteristic of two selected locations for sea cucumber ranching purposes

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Abstract. Sea cucumbers face heavily overfished because of their high prices and very strong market demand. One effort suggested to overcome this problem is sea ranching. The objectives of present works were to determine biological, physical, and chemical characteristics of prospective location for sea ranching of sea cucumber *Holothuria atra*. Two location at Jepara Waters (Teluk Awur and Bandengan WateRs of Jepara Regency) were selected. The determination of chemical (salinity, temperature, dissolved oxygen of water, phosphate, nitrate, nitrite and ammonium of water and sediment, organic matters of sediment), physical (transparancy, sedimen grains size, water current direction and its velocity), biologycal characteristic (coverage of seagrass and its macroalgae associated, phytoplankton as well as chlorophyl-a and phaeopytin of water and sediment) ware determined. The result of present work showed that some characteristic were matched with requirement as sea ranching location of sea cucumber because the density of sea cucumber in the sea is a function of habitat features. For sediment feeding holothurians of the family Aspidochirotida, the biologycal characteristic act as very important considerations by providing sea cucumber food. High cholophyl-a and phaeopytin in sediment also represent a prosperous habitat for sea cucumber ranching.

Keywords : sea cucumber, habitat, characteristic, sea ranching

1. Introduction

Sea cucumbers, known as ‘beche-de-mer’ or ‘trepang’, are generally consumed in Asia, where it is regarded as traditional medicine, a delicacy and an aphrodisiac. The rising demand in these markets prompted declines of many holothurian populations worldwide. The stocks of many tropical species are reportedly over-harvested [1][2][3]. Sea cucumbers being defenceless animals offer no resistance at the time of capture and are indiscriminately fished out. They also do not make any attempts to move away like fish or prawns. This has resulted in large scale capture of sea cucumbers including small and immature forms. In Indonesia, the sign of depleted stock was also very prompted. It showed by decreased production, reduced size of individual catch, farther and deeper fishing area, and more new species introduced in the market [4][5][6].

Sea ranching could be proposed when natural populations in the sea have been depleted due to overfishing. Sea cucumber lend themselves well for sea ranching since they immediately settle down to the bottom and also remain at the same place where they are sea ranched since sea cucumbers have limited movements [7]. Also young forms are known to live among coral reefs and seagrass bed for protection. This habit also helps them to survive better and contribute to the fishery. As in the sea ranching the processes between release and harvest are largely left to nature

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and the level of care that can be offered to sea cucumber throughout the growth process is reduced, yet still able to produce marketable size of sea cucumber, therefore it is important first to select a suitable site where natural populations are distributed.

Holothuria atra commonly known as black sea cucumber, is one of the most abundant and widely distributed sea cucumber species in most parts of the Indo-Pacific region [8][9]. They inhabit a wide range of depths and a broad variety of habitat ranging from rocky reefs to mudflats [10]. For sea ranching purposes, the objectives of present works were to determine biological, physical, and chemical characteristics of prospective location for sea ranching of sea cucumber *Holothuria atra*.

2. Materials and Methods

Teluk Awur (06°37.437'S, 110° 38.317'E-06°37.142'S, 110° 38.290'E) and Bandengan Waters (06°33.905'S, 110° 39.315'E-06°33.762'S, 110°39.142'E-) of Jepara Regency were surveyed on dry season (June 2016) to assess their suitability as sea raching location of sea cucumber *H. atra.* There were 5 line layed on each location, and 3 transect were plotted in each line for sampling of biotic and abiotic factors.

Biotic environment factor in each proposed location were assesed include seaweed and sea grass associated communities, epiphytes on the seagrass and phytoplankton.

Five transect line and three transect was established at each site running perpendicular to the shore and ending at approximately 500 meters deep edge of the bed. The edge of the bed was defined as the furthest growing sea grass from shore. The quadrat consisted of 1-m^2 of PVC-pipe separated into 100 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 [11]. The number colony of macroalgae found in each quadrat was also recorded. A sample of each species was saved for later identification in the lab. Ten or more blades of seagrass were selected at random, the epiphytes were carefully scraped from these blades, identified and counted.

Phytoplankton was collected from sea water samples which were taken from the surface waters (0.5-1 m depth) using a plankton net with a 100-µm mesh and a 20-cm opening. The net was pulled behind a boat at the end of a 10-m-long nylon rope for 10 minutes. The distance covered was about 500 m and the volume of seawater filtered for each plankton haul was 350 m^3. After each haul, the sample was taken to the laboratory where it was set in 5% buffered formalin. Phytoplankton identification based on [12]. Phytoplankton cell counting was done using a haemocytometer under a compound microscope.

Seawater and sediment samples were taken to measure chlorophyll a and total chloropigments to determine the phytobenthic biomass. Sediments were taken using a 60ml syringe with the top section cut off as a mini-corer, analysing only the top 1 cm of the sediment. Chlorophyll extraction used a standard ethanol extractions and pre- and post-acidification measurements [13]. A Perkin-Elmer Lambda 3BUV/VIS spectophotometerwith a 1 nm spectral bandwidth and optically matched 4 cm micro-cuvettes are used in the present work. Total chloropigments was calculated as the sum of chlorophyll a and phaeophytin.

Abiotic environmental factors, such as depth, salinity, pH, dissolved oxygen and temperature were measured in situ using a multi-probe meter. The depth of the light penetration was measured using the Secchi disc and was recorded to the nearest 5 cm.. The sample of sea water and sediment/substrates were taken for analyses of nitrate, nitrite, phosphat, ammonia, organic matter and carbon content, while sediment were also for physical characteristic (texture) analyses.

3. Results and Discussion

Selection of suitable site is the most important for the success of the sea ranching programme for *H. atra*. They prefer lives in coastal sea grass beds, soft and hard substrates of coral reefs as have been previously reported by [14][15][16][17]. Teluk Awur and Bandengan waters were chosen as proposed sea ranching of *H. atra* since they may have such characteristics.

3.1. Seagrass and Seaweed community

Seagrass are flowering plants growing in shallow coastal waters of tropical seas. They occupy a wide range of habitats from coarse sands and coral rubble to soft muddy bottroms, and from the intertidal zone down to 20 m water depth (or more). Altogather there are 12 species of seagrass inhabit Indonesia waters [18], while in present work, there were 5 species found in Bandengan waters (Table 1) namely *Thalassia hemprichii, Enhalus acoroides, Halodule pinifolia, Cymodocea serrulata, Cymodocea rotundata.* The range average shoot density were 2,8-13,6 shoot/m2 and the seagrass in line transect L2 and L3 were more dense. The cover persentage of seagrass was 23,4-56,3. The highest coverage was *C. serrulata* (75%).

There were found 7 species in Teluk Awur Waters (Table 2), i.e. *T. hemprichii, E. acoroides, Syngirodium isoetifolium, H pinifolia, C. serrulata, C. rotundata, and H. ovata.* The species composition is more varied, there were more line with more seagrass species. ***E. acoroides*** and ***T. hemprichii*** found in all line transect while *C. serrulata, C. rotundata* found in four line out of five. Average density was range from 13,2-39,9 shoot/m^2 with covarage of 21,3-39,9 %/m^2. The highest coverage was ***Thalassia hemprichii*** (44,3%).

There were also seaweed found in the same location of sea grasses. There were two species (*Halimeda opuntia* and *Udotea argentea)* lived in Bandengan waters and more varied species in Teluk Awur waters. *There were 9 species of seaweed in teluk Awur waters i.e. Padina australis, Halimeda opuntia, H. macroloba, Halimeda sp., Caulerpa racemosa C. Serullata, Dyctiota sp., Udotea argentea and Sargassum cristaefolium.*

Seagrass serves as diverse habitat for many marine species including fish and many invertebrates. It also serves as a protection for juvenile marine species and a source of nutrient that helps to sustain many complex food chains and recognised as one of the most productive marine ecosystems [19]. One group of marine invertebrates that inhabit seagrass beds is Echinoderms such as Holothuroidea (sea cucumbers) [20].

In shallow water and on intertidal shores, like in Teluk Awur and Bandengan Waters, seagrasses and microalgae growing directly on the sediment surface, whereas macroalgae are a relatively minor component due to the often turbid water and the difficulty of attaching in a fluid sedimentary environment. But too much of vegetation like algal beds are also not suitable as sea ranching sites [7].

Table 1. Seagrass and seaweed associated composition, shoot or colony density abundance (A = shoot or coloni/m^2) and coverage (B=%/m^2) in Bandengan Waters of Jepara

No.	Seagrass species	L1		L2		L3		L4		L5	
		A	B	A	B	A	B	A	B	A	B
1	*Enhalus acoroides*			12	44,5	8,8	21,9			1,6	9,4
2	*Thalassia hemprichii*	4	37,5	13,6	37,5	7,2	37,5	6,4	37,5	4	37,5
3	*Halodule pinifolia*			7,2	20,3						
4	*Cymodocea rotundata*	4	37,5								
5	*Cymodocea serrulata*			2,4	18,8	8	28,1	8,8	75		
	Average	4	37,5	8,8	30,3	8	29,2	7,6	56,3	2,8	23,4
	Seaweed species										
1	*Halimeda opuntia*			3,2		3				5	
2	*Udotea argentea*					2					
	Average			3,2		2,5				5	

Table 2. Seagrass and seaweed associated composition, , shoot or colony density abundance (A = shoot/m^2 or coloni/m^2) and coverage (B=%/m^2) in Teluk Awur Waters of Jepara

No.	Seagrass species	L1		L2		L3		L4		L5	
		A	B	A	B	A	B	A	B	A	B
1	*Enhalus acoroides*	16	16,4	21,6	39,1	19,2	17	16,8	16,2	33,6	31,8
2	*Thalassia hemprichii*	25,6	44,3	8,8	17,2	20	20,3	13,6	16,2	22,4	29,1
3	*Halophila ovata*	11,2	30,5	11,2	19,8	8	14,8				
4	*Halodule pinifolia*			10,4	19,8	11,2	14,1				
5	*Cymodocea rotundata*	12,8	35,2	10,4	24,2	10,4	37,5			8	37,5
6	*Cymodocea serrulata*	5,6	14,6	13,6	39,8	14,4	37,5	14,4	37,5		
7	*Syringidium isoetifolium*	8	75							10	75
	Average	13,2	36	12,7	26,7	15	23,5	13,2	23,3	21,3	39,9
No.	Seaweed species										
1	*Padina australis*			1		3		5			
2	*Halimeda opuntia*	2,5		2,5		3		2,3		3,3	
3	*Halimeda macroloba*			4		3		2,5			
4	*Halimeda sp.*	1								6	
5	*Caulerpa racemosa*			2		4,7		2		4,5	
6	*Caulerpa serullata*					8		2		3,5	
7	*Dyctiota sp*			4							
8	*Udotea argentea*					2,3		3			
9	*Sargassum cristaefolium*	1,5		1		5		4		7	
	Average	5		14,5		29		21,8		24,3	

3.2. Epiphytes

Many tropical seagrass species have high primary production rates [21] and provide a substantial proportion of the primary productivity for associated ecosystems. Epiphytes density and number of genera found in each species of sea grasses were presented in Table 3 and 4.

Table 3. Average epiphytes density (cell/cm^2) and number of genera (n) in seagrass blades in Bandengan Waters

No.	Sea grass species	Chrysophyta	Chlorophyta	Cyanophyta	Total Density (No. of genera)
1	*Enhalus acoroides*	3.727 (23)	443 (3)	1.489 (5)	5.659 (31)
2	*Thalassia hemprichii*	1.097 (16)	125 (3)	646 (5)	1.867 (24)
3	*Halodule pinifolia*	670 (11)	43 (2)	818 (5)	1.531 (18)
4	*Cymodocea rotundata*	810 (15)	28 (3)	470 (4)	1.307 (22)
5	*Cymodocea serrulata*	1.261 (25)	88 (2)	913 (5)	2.262 (25)

Table 4. Average epiphytes density (cell/cm^2) and number of genera (n) in seagrass blades in Teluk Awur Waters

No.	Sea grass species	Chrysophyta	Chlorophyta	Cyanophyta	Total Density (No. of genera)
1	*Enhalus acoroides*	2.946 (23)	234 (4)	1.227 (5)	4.407 (32)
2	*Thalassia hemprichii*	1.012 (14)	111 (2)	643 (2)	1.765 (20)
3	*Halophila ovata*	1.131 (16)	48 (1)	446 (5)	1.625 (22)
4	*Halodule pinifolia*	670 (11)	64 (2)	818 (5)	1.552 (18)
5	*Cymodocea rotundata*	1.011 (15)	33 (3)	601 (4)	1.645 (22)
6	*Cymodocea serrulata*	1.131 (16)	48 (3)	678 (4)	1.857 (23)
7	*Syringidium isoetifolium*	739 (6)	-	537 (4)	1.275 (10)

3.3. Phytoplankton

Phytoplankton was determined for their composition and abundance. Therewere 12 and 9 genera found in Bandengan and Teluk Awur waters respectively, all belong to Division of Chromophyta and Cyanophyta. Total of 5,86 x 10^5 cell/L in Bandengan waters was quite higher compare to 3,76 x 10^5 cell/L in Teluk Awur waters (Table 5).

Tabel 5. The average abundance of phytoplakton (cell/L) number of genera (n) found in Bandengan and Teluk Awur waters

Division	Bandengan Waters	Teluk Awur Waters
Chromophyta	325.000 (32)	554.000 (34)
Cyanophyta	45.000 (4)	56.000 (4)
Abundance (cell/L)	370.000 (36)	610.000 (38)

For deposit feeder such as *H. atra*, phytoplankton do not have direct effect but the increasing temperature, as well as of the extent and intensity of daylight, implying an increase in phytoplankton biomass and, in turn, a larger supply of food for sea cucumbers [22]. In the other hand, the phytoplankton plays very important role on feeding of holothurian planktonic larva.

3.4. Cholophyll-a and phaeophytin

Estimating the concentration of chlorophyll-*a* remains the most common method for assessing algal biomass. The concentration of chlorophyll-*a* has also been shown to relate to primary productivity and can be used to assess the physiological health of algae by examining its degradation product, phaeophytin. This degradation product has been shown to contribute 16-60% of the chlorophyll-*a* content in seawater and freshwater. Chlorophyll-a concentration in Bandengan sea water was slightly higher than Teluk Awur waters (Table 6) but the consentration of phaeophytin and total chloropigments of both location was almost the same.

Tabel 6. The content of chlorophyll-a, Phaeophytin and Total chloropigments in the seawater and sediment of Bandengan and Teluk Awur waters

	Bandengan waters		Teluk Awur Waters	
Pigment	Seawater	Sediment	Seawater	Sediment
Klorofil-a (µg/l)	0,002421	0,005160	0,001783	0,018556
Phaeophytin (µg/l)	0,059220	0,123888	0,060140	0,143882
Total chloropigments (µg/l)	0,061641	0,129048	0,060923	0,162438

Chlorophyll-a in sediment could be representative of microphytobenthos, i.e. benthic microalgae which are important and resilient ecosystem modifiers and are also important in coastal food webs because of their high accessibility to consumers, such as sea cucumber. The chlorophyll-a, phaeophytin and total chloropigment in sediment of Teluk Awur was higher than Bandengan waters. It may due to high abundance of microphytobenthic organisms.

Both chemosynthetic and photosynthetic bacteria in the sediment contribute substantially to primary production [23]. In addition to their role in primary production, the microphytobenthos (photosynthetic algae and bacteria) structure the physical environment by mediating oxygen and nutrient flux and stabilizing the sediment[24][25].

3.5. Water quality and nutrient content of the sea water and sediment

Water quality such as temperature, salinity, pH, dissolved oxygen, light transparancy were measured in situ and the value was presented in Tabel 7. Sea cucumbers being stenohaline cannot tolerate wide ranges is salinity. Therefore river mouth, estuaries and other bays where the salinity goes down below 10 ppt during the monsoon season have to be avoided [7]. The salinity both location (Bandengan and Teluk Awur waters) were 22-32 and 23-33($^{o}/_{oo}$) and suitable for sea cucumber life.

The seawater temperature of Bandengan and Teluk Awur waters ranged of 27-34 and 28-35 ^{o}C. H. *atra* is unusually tolerant of heat, and is almost the only macroscopic organism living in these warm pools at low tide on the warmest days. H. *atra* face high temperature of the environment by coating of light-colored sand with which it habitually covers its body, enabling it to retain a slightly lower body temperature than it does when not sand-coated. H. *atra*, are negatively phototropic since protect themselves from strong light by its sand coating. They usually react to

quick changes in light intensity, as by withdrawal of tentacles when covered by a shadow during feeding.

Tabel 7. Water quality parameters of Bandengan and Teluk Awur Waters

Locations	Station	Temperature (°C)	Salinity (‰)	pH	Dissolved oxygen (ppm)	Light intensity (Cm)	Depth (Cm)
Bandengan Waters	L1	28-30	25-32	7-8	4-6	102-115	102-115
	L2	27-33	26-31	7-8	3,54-6	98-110	98-110
	L3	28-34	28-30	7-8	4-6	107-109	107-109
	L4	28-33	26-30	7-8	2,5-6	110-116	110-116
	L5	28-30	22-29	7-8	4-6	100-120	100-120
Teluk Awur Waters	L1	28-33	28-30	7-8	4-6	115-120	115-120
	L2	29-30	28-30	7-8	4-6	110-120	110-120
	L3	29,5-35	29-33	7-8	4-6	104-125	104-125
	L4	29-32	23-32	7-8	4-6	115-130	115-130
	L5	30-32,5	24-32	7-8	4-6	110-150	110-150

Nitrogen (N), one of the primary nutrients that mediate bottom-water hypoxia, can be removed from beach through biological uptake, denitrification, or permanent burial in sediments. Denitrification is the bacterial conversion of nitrates (NO_3^-) in watersheds to gases (N_2 and N_2O) that can enter the atmosphere. The concentration of NH_3-N, NO_3-N, $N0_2$-N, and PO4-P presented in Tabel 8 and 9.

Tabel 8. The nutrient content in the sedimen of Bandengan and Teluk Awur Waters

		Nutrients (mg/gr)			
Locations	Station	NH3-N	NO3-N	N02-N	PO4-P
Bandengan Waters	L1	0,004	0,6638	0,0080	0,2402
	L2	0,002	1,0170	0,0019	0,2042
	L3	0,002	0,2894	0,0008	0,1197
	L4	0,002	0,0468	0,0020	0,1241
	L5	0,002	0,2145	0,0065	0,9234
Teluk Awur Waters	L1	0,098	0,1660	0,0115	2,1580
	L2	0,002	0,1702	0,0069	1,7942
	L3	0,002	0,3319	0,0054	0,8937
	L4	0,002	0,1787	0,0020	0,3046
	L5	0,002	0,2340	0,0026	0,3621

Tabel 9. The nutrient content in the sea water of Bandengan and Teluk Awur Waters

		Nutrients (mg/gr)			
Locations	Station	NH3-N	NO3-N	N02-N	PO4-P
Bandengan Waters	L1	0,033	0,0145	0,0013	0,0136
	L2	0,007	0,0123	0,0009	0,0132
	L3	<0,002	0,0158	0,0007	0,0112
	L4	<0,002	0,0026	0,0017	0,0054
	L5	0,006	0,0111	0,0012	0,0012
Teluk Awur Waters	L1	<0,002	0,0004	0,0018	0,0136
	L2	<0,002	0,0023	0,0012	0,0172
	L3	<0,002	0,0013	0,0014	0,0116
	L4	<0,002	0,0026	0,0014	0,0078
	L5	0,0022	0,00045	0,0021	0,0023

3.6. Sediment characteristics

According to [26], bottom sediment characteristics are one of the crucial components affecting the habitat preference of sea cucumbers and hence studies on ecology of sea cucumber beds are essential. The sediment character of Bandengan and Teluk Awur Waters is presented in Tabel 10. The presence of sediment reduces the stress impacts as limited growth rate caused by the handling and fluctuation in environmental parameters by allowing sea cucumbers to bury in accordance with their diurnal cycle and in response to stress conditions.

Tabel 10. The sediment character of Bandengan and Teluk Awur Waters

Location	Station	Percentage (%)					Organic matter (%)
		Gravel	Coarse sand	Fine sand	Silt	Clay	
Bandengan Waters	L1	10,15	21,15	66,85	1,85	0,00	3,34
	L2	2,20	6,60	90,90	0,30	0,00	4,03
	L3	2,15	7,65	89,75	0,45	0,00	4,02
	L4	2,30	7,60	89,85	0,25	0,00	4,03
	L5	0,00	36,10	60,20	3,70	0,00	2,77
Teluk Awur Waters	L1	2,00	32,20	62,20	3,60	0,00	4,93
	L2	11,40	21,20	65,00	2,40	0,00	4,71
	L3	11,00	24,10	61,35	3,55	0,00	4,20
	L4	10,20	20,20	67,90	1,70	0,00	4,24
	L5	24,20	21,00	42,70	12,10	0,00	4,95

Holothurians can assimilate low content of organic matter as live diatoms, bacteria and detritus by passing sediment through their gut system. By feeding and movement characteristics, they grind organic material and sediment into finer particles, mix up the substrate and recycle the detrital material on the top layers of the sediment. Rocky beds have to be avoided since the sea cucumbers live on the mud or sand and fixed on the organic matter present in the same. *H. atra* are deposit-

feeders that ingest sediment with organic matter [28][29][30] and their gut contents are dominated by decaying materials from macroalgae and seaweed, shell fragments from mollusks, crustaceans and barnacles, echinoderm ossicles, many pelagic and benthic foraminifera and diatoms [31][32]. Some studies have also shown that sea cucumbers ingest feces of marine animals[33][34], even their own feces [35][36]. Sediment is an absolutely necessary material for not only feeding of sea cucumbers but also for burrowing and wellbeing of these benthic organisms. Robinson *et al.* (2013) suggested that the presence of sand improves the growth due to the increased surface area for the development of natural food as bacteria and microphytobenthic primary production. Also, diet digestion facilitates by the presence of sand for consumption

According to [15] in the shallow water (<10 m) *H. atra* prefer seagrass habitat with sediments characterized by 2–3.5% organic content, 15–25% of gravel and coarse sand (0.7–1.2 mm) but not silt–mud. Study of [37] also found that *H. atra* primarily in sand-dominated habitats. The preference towards the specific habitat characteristics seems to be associated with their feeding and protection. An understanding of habitat preference would be useful to improve the management of these sea cucumber populations and enable more precise stock assessment.

The present work is to conduct survey for natural beds in purpose to sea ranch the wild stock of sea cucumber. The other most important aspect in this programme is that the area where sea cucumber is sea ranched should be a protected area and free from activities of the fishermen and fishing operations [7]. If trawl net is operated over the area the stocked sea ranched will enter the net resulting in total failure of the programme. The fishing activity in Bandengan are more than in Teluk Awur Waters, since there were many fishing boat harbour in the beach. Another aspect to be borne in mind is that the area where the young or wild *H. atra* are left should be free from strong currents which will sweep away all the seed sea ranched. Teluk Awur can be more suitable for biological reserve for *H. atra*.

4. Conclusion

Based on biological, chemical, physical characteristic of natural beds of Bandengan and Teluk Awur Waters revealed that some characteristic were matched with requirement as sea ranching location of sea cucumber because the density of sea cucumber in the sea is a function of habitat features. For sediment feeding holothurians of the family Aspidochirotida, the biologycal characteristic act as very important considerations by providing sea cucumber food. High cholophyl-a and phaeopytin in sediment also represent a prosperous habitat for sea cucumber ranching

Acknowledgement

The author wish to thank to Rector of Diponegoro University for funding this research through scheme of International Research Publication of PNBP DIPA Universitas Diponegoro No. : SP DIPA-042.01.2.400898/2016, Date of 7 December 2015, Bugdet year of 2016

Referrences

[1]. Lovatelli A, Conand C, Purcell S, Uthicke S, Hamel J F, and Mercier A editors 2004 *Advances in sea cucumber aquaculture and management (FAO fisheries technical paper 463)* (Rome United Nations Food and Agriculture Organisation).
[2]. Bruckner A (editor) 2005 *The Proc. of the Technical workshop on the conservation of sea cucumbers in the families Holothuridae and Stichopodidae* (*NOAA Technical Memorandum NMFSOPR 44*) Silver Spring MD 239 pp
[3]. Uthicke S and Conand C 2005. *SPC Beche-de-mer Inf. Bull.,* **21** 9–14.

[4]. Hartati R, Widianingsih, Purwati P 2009a *Teripang (Holothuroidea : Echinodermata) di Indonesia : Biologi, Budidaya dan Konservasinya.* (Yogyakarta Penerbit Navila Idea) 72 hal
[5]. Hartati R, Widianingsih, Pringgenies D 2009b *Pembenihan dan pembesaran Teripang Pasir (Echinodermata: Holothuroidea)* (Semarang Badan penerbit Universitas Diponegoro) 128 hal.
[6]. Purwati P, Hartati R dan Widianingsih 2012. *Mar. Res. Indonesia* **35(2)** 23-30
[7]. James D B 1993 Sea ranching of sea cucumber. Marine Fiseheries Information (*Tehnical and Extension Series 124*) (India Central marine Fisheries Research Institute Cochin, India) pp 15-17
[8]. Uthicke S 2001 *Mar Ecol Prog Ser* **210** 125–138.
[9]. Conand C 2008 Population status, fisheries and trade of sea cucumbers in Africa and the Indian Ocean. Sea Cucumbers. *A Global Review of Fisheries and Trade (FAO Fisheries Technical Paper 516)* ed Toral-Granda V, Lovatelli A, and Vasconcellos M (Rome FAO) pp 143–193
[10]. Purcell S W, Gossuin H and Agudo N S 2009. *SPC Beche-de-mer Infor Bull* **29** 3-6
[11]. English S, Wilkinson C, and Baker V 1994 *Survey manual for tropical marine resources* (Townsville North Queensland Australia Australian Institute of Marine Sciences) 390 pp.
[12]. Tomas C 1997 *Identifying Marine Phytoplankton* 1st Edition (London Academic Press) 858 p
[13]. Nusch E A 1980 *Arch Hydrobiol Beih Ergeb Limnol* 14 14–30
[14]. Kinch J, Purcell S, Uthicke S, and Friedman K 2008 Population status, fisheries and trade of sea cucumbers in the Western Central Pacific *A Global Review of Fisheries and Trade (FAO Fisheries Technical Paper 516)* ed Toral-Granda V, Lovatelli A, and Vasconcellos M (Rome FAO) pp 7–55
[15]. Dissanayake D C T, and Stefansson G 2012 *J. of the Mar. Biol. Ass. of the UK* **92(3)** 581-590
[16]. Setyastuti A 2014 *J. Ilmu Teknol Kelaut Trop* **6(1)** 31-39
[17]. Asha P S, Diwakar K, Santhanavalli G and Manissery M K 2015 *Indian J. Fish*. **62(1)** 52-57
[18]. Nienhuis P H, Coosen J and Kiswara W 1979 *Netherlands J of Sea Res* **23(2)** 197-214
[19]. Rasheed M A, Dew K R, Kerville S P, McKenzie L J and Coles R G 2006 Seagrass distribution, community structure and productivity for Orman Reefs, Torres Strait – March and November 2004. (*DPI Information Series QI06088)* (Cairns DPI) 38 pp
[20]. Tuapattinaja M A, Pattikawa J A, and Natan Y 2014 *AACL Bioflux* **7(5**) 351-356
[21]. Mateo M A, Cebrián J, Dunton K and Mutchler T 2006 Carbon flux in seagrass ecosystems. (*Seagrasses: Biology, Ecology and Conservation)* ed Larkum A WD, Orth RJ, and Duarte CM (Dordrecht The Netherlands Springer) pp 159-192
[22]. Benítez-Villalobos F, Avila-Poveda O H, and Gutiérrez-Méndez I S 2013. *Sex Early Dev Aquat Org.* **1** 13–24 doi: 10.3354/sedao00003
[23]. Valiela I 1984 *Marine ecologycal process* (New York Springer Science + Bussines Media LLC) 559 p.
[24]. Yallop M L, de Winder B, Paterson D M, and Stal L J 1994 *Est Coast Shelf Sci* **39** 333–344
[25]. MacIntyre H L, Geider R J, and Miller D C 1996 *Estuaries* **19(2A)** 186-201
[26]. Slater M J and Jeffs A G 2010 *J. Sea Res* **64** 241–249
[27]. Moriarty D J W 1982 *Aust J Mar Freshw Res* **33** 255–263
[28]. Uthicke S 1999 *B Mar Sci* **64** 129–141.
[29]. Michio K, Kengo K, Yasunori K, Hitoshi M, Takayuki Y, Hideaki Y, and Hiroshi S 2003 *Mar Pollut Bul.* **47** 118–125
[30]. Hauksson E 1979 *Sarsia* **64** 155-160
[31]. Zhang B L, Sun D L, and Wu Y Q 1995 *Mar Sci* **3** 11–13 (in Chinese with English abstract)
[32]. Yuan X T, Yang H S, Zhou Y, Mao Y Z, Zhang T, and Liu Y 2006. *Aquaculture* **256** 457–467
[33]. Zhou Y, Yang H S, Liu S L, Yuan X T, Mao Y Z, Liu Y, Xu X L, and Zhang F S 2006 *Aquaculture* **256** 510–520
[34]. Goshima S, Fujiyoshi Y, Ide N, Gamboa R U, and Nakao S 1994 *Suisanzoshoku* **42** 261–266 (in Japanese, with English abstract)
[35]. Kang K H, Kwon J Y, and Kim Y M 2003 *Aquaculture* 216 87–93
[36]. Bellchambers L M, Meeuwig J J, Evans S N, and Legendre P 2011 *Aquat Biol* **14** 57–66