Mar. Res. Indonesia Vol. 39, No. 2, 2014: 51−61

ECHINODERM FAUNA OF THE LEMBEH STRAIT, NORTH SULAWESI: INVENTORY AND DISTIBUTION REVIEW

Supono[1*], David John William Lane[2] and Susetiono[3]

[1]Bitung Technical Implementation for Marine Life Conservation-North Sulawesi
Jl. Tandurusa, Kodya Bitung, Sulawesi Utara, 95527
[2]Department of Biology, Faculty of Science, Universiti Brunei Darussalam
Jl. Tungku Link Gadong BE 1410
[3]Research Center For Oceanography
Jl. Pasir Putih 1, Ancol Timur, Jakarta Utara 14430
[*]E-mail: Supono_lipi@yahoo.com

Received: July 2013 Accepted: May 2014

ABSTRACT

Indonesia is particularly rich in Echinoderms and North Sulawesi lies at the geographic centre of this biodiverse marine realm. While further studies on Sulawesi Echinodermata are required in order to obtain full understanding of current biodiversity status, preliminary SCUBA and intertidal surveys in early 2012 in the vicinity of the Lembeh Island, a region little explored previously, recorded a total of 76 species of 4 classes (Asteroidea, Ophiuroidea, Echinoidea and Holothuroidea) from shallow waters (0-40 m) at 36 sites (sea grass, coral rubble and reef). The class Crinoidea is not reported here. A review of Echinoderm literature for North Sulawesi noted that there are 114 species belonging to 5 classes of Echinodermata.

Keywords: Biodiversity, Echinoderm, Indonesia, North Sulawesi

INTRODUCTION

The echinoderm fauna is a major part of marine biodiversity, particularly in terms of biomass and these conspicuous macroinvertebrates generally play an essential role in ecosystem functioning. Echinoderms are affected by human activity since some species have a high commercial value and are heavily exploited. In order to manage and conserve this fauna, research at several levels is needed including, for example, taxonomy, ecology and fauna composition of the species assemblages.

The earliest information on marine biota in Indonesia comes from the work of Rumphius (1705), in Ambon. In recognition of his pioneering work a number of Rumphius biohistorical expeditions to the Ambon region have subsequently described a variety of echinoderms. Our knowledge of Indonesian and Indo-Pacific Echinodermata is, however, mainly due to various expeditions such as the Challenger Expedition (1873-1874), Albatross Expedition (1908-1910), Deutchen Tiefsee-Expedition (1902-1903), Snellius Expedition (1929), John Murray Expedition (1933-1934) and the Danish Deep Sea Expedition (1950-1952). The results of several echinoderm investigations in Indonesia are reported separately for echinoderm classes, for example, several works dealing with Indonesian holothurians have been published (Selenka, 1867; Semper, 1868; Ludwig, 1882; 1888; Theel, 1886; Sluiter, 1890; 1894; 1895; 1901; Koehler, 1895; Heding, 1928; Rowe, 1983, Massin 1996; 1999). Guille & Wolff (1984) reported 37 species of brittle stars collected during the Snellius Expedition, Massin (1996) and Fujita and Marsh (2004) reported 27 sea cucumbers and 26 seastars respectively from Ambon, and recently Purwati & Lane (2004) recorded 27 species of sea

DOI : 10.14203/mri.v39i2.85

stars during the Anambas Expedition in 2002 in Anambas and Natuna Islands. Clark and Rowe (1971) published a monograph of the shallow-water Indo-Pacific echinoderms including all species known from Indonesia at that time. This work remains as one of the most comprehensive works on the shallow-water Indonesian echinoderm fauna (Hutomo and Moosa, 2005). Further echinoderm studies in Indonesia are required in order to obtain a comprehensive database, and recent research in North Sulawesi has been undertaken to provide additional information for echinoderm species lists and their distribution.

The North Sulawesi Peninsula, stretching between the Sulawesi Sea and the Maluku Sea, lies centrally within an area known worldwide as the center of maximum marine biodiversity linking the Indian and Pacific Oceans (Sheppard and Wells, 1988; Muller,1997; Tomascik *et al.*,1997; Edinger *et al.*, 1998). Echinoderms have been reported in several localities for this area *i.e.* Pasige, Tagulangang and Ruang Island (Darsono and Aziz, 2002), Bunaken (Lane, 1999), Wori (Supono and Susetiono, 2010), Likupang Timur (Supono, 2011), Lembeh Strait (Yusron, 2009), Tanjung Merah (Yusron and Susetiono, 2005) and Kema (Supono and Arbi, 2010). However, comprehensive information on echinoderms in this area is lacking. In the present study, we investigated the echinoderm fauna in the shallow waters in Lembeh Strait, North Sulawesi. This preliminary study aims to update knowledge of the distribution of echinoderms in North Sulawesi waters.

MATERIALS AND METHODS

The study was conducted by scuba diving, snorkelling and collecting intertidally from January to February 2012. A total of 36 sites (Fig. 1; Table 1), covering the length of the Lembeh Strait,

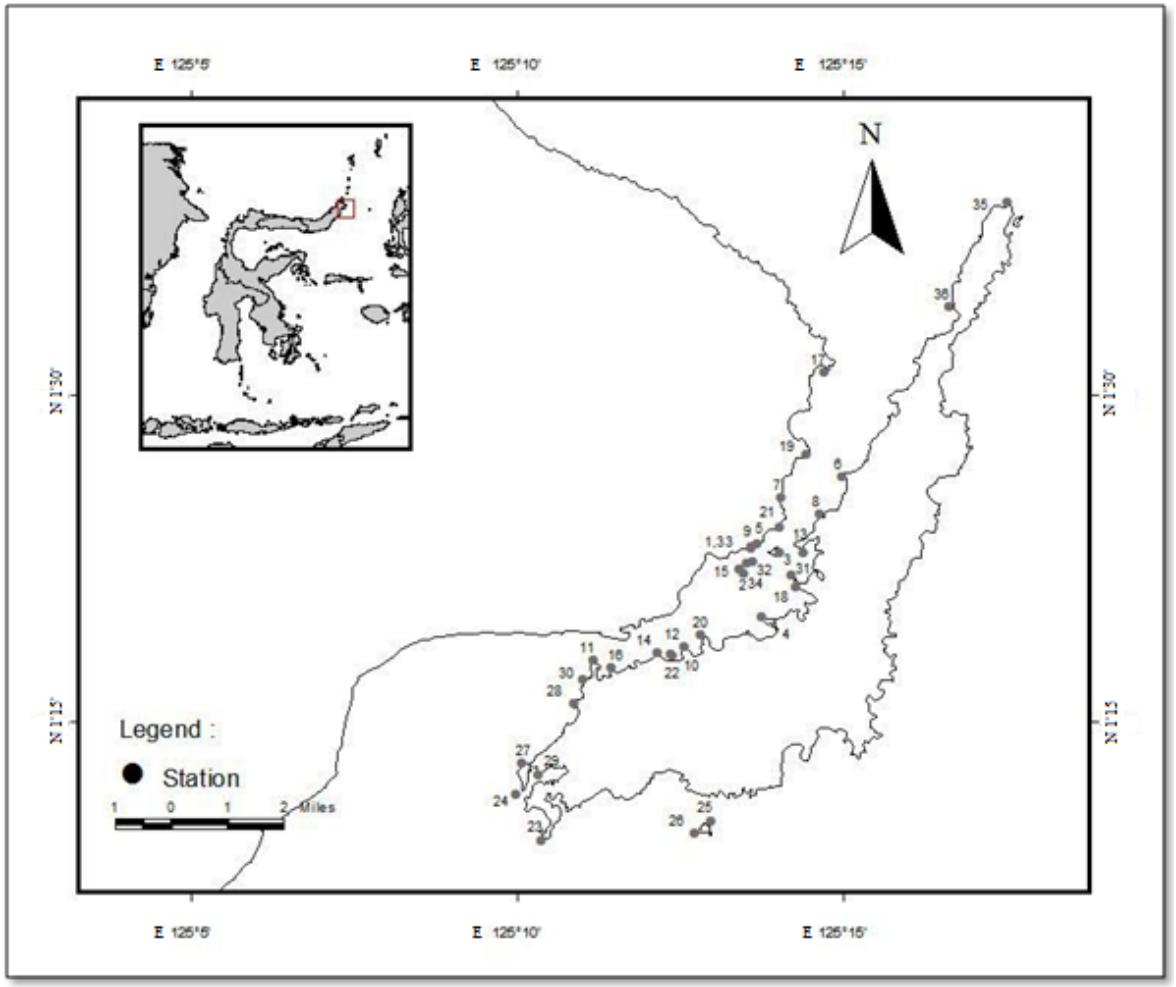

Figure 1. Map of dive localities of the Lembeh Strait, North Sulawesi

Table 1. Dive localities in Lembeh Strait, North Sulawesi

Station	Locality	Coordinate		Date	Max. Depth (m)	Habitat		
						Reef	Rubble	Seagrass
St 1	Tanjung Nanas I	N1° 27' 40.42"	E125° 13' 36.40"	30/jan/2012	20	+	+	-
St 2	(South East) Sarena Kecil	N 1° 27' 15.80"	E125° 13' 29.53"	30/jan/2012	18	+	+	-
St 3	(East) Sarena Besar	N 1° 27' 34.16"	E 125° 14' 1.89"	31/jan/2012	25	-	+	-
St 4	Tanjung Mawali	N 1° 26' 36.41"	E 125° 13' 45.98"	31/jan/2012	22	+	+	-
St 5	Tanjung Nanas II	N 1° 27' 43.66"	E 125° 13' 41.62"	1/feb/2012	23	-	+	-
St 6	Tanjung Kubur	N 1° 28' 44.68"	E 125° 14' 59.13"	1/feb/2012	18	-	+	-
St 7	Aer Perang	N 1° 28' 25.28"	E 125° 14' 2.54"	2/feb/2012	20	+	-	+
St 8	Pantai Perigi	N 1° 28' 10.01"	E 125° 14' 38.796"	2/feb/2012	15	+	-	-
St 9	Tanjung Nanas I	N 1° 27' 40.21"	E 125° 13' 36.40"	3/feb/2012	22	+	-	-
St 10	Pulau Abadi	N 1° 26' 0.74"	E 125° 12' 22.60"	3/feb/2012	20	+	-	-
St 11	Tanjung Labuhankompeni	N 1° 25' 55.84"	E 125° 11' 10.64"	4/feb/2012	30	+	-	-
St 12	Kelapa Dua	N 1° 26' 8.37"	E 125° 12' 34.09"	4/feb/2012	25	+	+	-
St 13	Baturiri	N 1° 27' 34.70"	E 125° 14' 23.1"	6/feb/2012	30	-	+	-
St 14	Batu Lobang	N 1° 26' 2.65"	E 125° 12' 9.719"	6/feb/2012	22	+	-	-
St 15	(South West) Sarena Kecil	N 1° 27' 19.83"	E 125° 13' 25.03"	7/feb/2012	32	+	+	-
St 16	Batu Lobang Besar	N 1° 25' 49.40"	E 125° 11' 26.80"	7/feb/2012	18	+	+	-
St 17	Tanjung Batuangus	N 1° 30' 20.59"	E 125° 14' 43.47"	8/feb/2012	28	+	+	-
St 18	Teluk Rarandam	N 1° 27' 3.20"	E 125° 14' 17.52"	8/feb/2012	25	-	+	-
St 19	Teluk Makawide	N 1° 29' 5.06"	E 125° 14' 26.12"	9/feb/2012	30	+	-	-
St 20	Kelapa Dua	N 1° 26' 19.06"	E 125° 12' 48.99"	9/feb/2012	25	+	+	-
St 21	Tanjung Kungkungan	N 1° 27' 58.39"	E 125° 14' 2.25"	10/feb/2012	28	+	-	-
St 22	Pulau Abadi	N 1° 26' 1.03"	E 125° 12' 22.28"	10/feb/2012	33	+	-	-
St 23	Tanjung Kuning	N 1° 23' 10.78"	E 125° 10' 23.23"	11/feb/2012	20	+	-	-
St 24	Tanjung Paudean	N 1° 23' 52.69"	E 125° 09' 58.93"	11/feb/2012	20	-	+	-
St 25	(North) Pulau Dua	N 1° 23' 28.64"	E 125° 12' 58.71"	13/feb/2012	25	+	-	-
St 26	(South) Pulau Dua	N 1° 23' 17.01"	E 125° 12' 43.12"	13/feb/2012	40	+	-	-
St 27	(North) Tanjung Paudean	N 1° 24' 21.70"	E 125° 10' 4.51"	14/feb/2012	25	-	+	-
St 28	Desa Pandean	N 1° 25' 16.06"	E 125° 10' 52.67"	14/feb/2012	28	-	+	-

St 29	Teluk Walemetodo	N 1° 24' 11.33"	E 125° 10' 20.31"	15/feb/2012	12	-	-	+
St 30	Tanjung Kelapasatu	N 1° 25' 38.56"	E 125° 11' 0.77"	15/feb/2012	20	-	+	-
St 31	Tanjung Kusukusu	N 1° 27' 13.75"	E 125° 14' 12.94"	16/feb/2012	18	+	-	+
St 32	(North) Sarena Kecil	N 1° 27' 26.85"	E 125° 13' 37.59"	16/feb/2012	25	+	-	-
St 33	Tanjung Nanas I	N 1° 27' 39.49"	E 125° 13' 35.79"	17/feb/2012	28	+	-	-
St 34	(West) Sarena Kecil	N 1° 27' 25.52"	E 125° 13' 31.18"	17/feb/2012	30	+	-	-
St 35	Batu Kapal	N 1° 32' 56.83"	E 125° 17' 31.84"	18/feb/2012	22	+	-	-
St 36	Pulau Putus	N 1° 31' 20.74"	E 125° 16' 37.27"	18/feb/2012	35	+	-	-

depth ranging from 0-40 m were investigated. Some common species were merely photographed in situ, while others were photographed, collected, then brought to Bitung Technical Implementation Unit for Marine Life Conservation for identification and preservation with alcohol 70%. Identification was done by reference to the keys in Clark and Rowe (1971).

The Lembeh Strait, located between the mainland of North Sulawesi and Lembeh Island, and stretching for approximately 16 km in length and about 2 km in width, offers unique and varied habitat characteristics *i.e.* walls, reefs, pinnacles and soft sediments. Its geoposition, in the Maluku Sea province, close to the geographic centre of the coral Triangle and near to the water outflow from the West Pacific Ocean, combined with the sheltered volcanic black sand environment, creates an interesting ecosystem for various animals, many with unusual colorations and behaviours. The bottom substrate is dominated by black sand, mud and rubble (Kinnaird, 2002).

RESULTS AND DISCUSSION

A total of 76 species of echinoderm; 26 species of Asteroidea, 10 species of Echinoidea, 18 species of Holothuroidea and 22 species of Ophiuroidea, were recorded during the study (Table 2). The Ophidiasteridae was the most diverse family of Asteroidea, with 18 species recorded.

The distribution pattern of echinoderms in the vicinity of the Lembeh Strait, North Sulawesi is shown in Table 2. Echinoderms in and near the Lembeh Strait are diverse and some, notably three asteroid species *Linckia laevigata, Culcita novaeguineae* and *Choriaster granulatus* were abundant and present at most sites. Although some groups, for example sea stars of *Neoferdina*were not found, the species richness of the Asteroidea in particular, and the other echinoderm classes in general, appeared to be comparable to other adjacent areas in North Sulawesi. Some forms, for example *Linckia* sp. 1 (having very long purple arms) and *Linckia* sp. 2 (having long blotched arms), sometimes assigned existing species names in illustrated marine invertebrate guide books (e.g. Colin and Anderson, 1995), are probably undescribed species. The number of echinoderms in this strait region reached more than three quarters (74 species) of the 114 species recorded in North Sulawesi (Supono and Arbi, 2010; Supono and Susetiono, 2010; Supono, 2011; Yusron and Susetiono, 2005; Darsono and Aziz, 2002). The variation of habitats in the Lembeh Strait, *i.e.* sea grass, coral reefs and muddy bottom, probably offer various niches for a high diversity of echinoderms. The crown-of-thorns sea star *Acanthaster planci* which in outbreak mode can causes high coral mortality (Glynn *et al.,* 1979; Brodie *et al.,* 2005), was sighted in low numbers only at station 8 and mass aggregations were not observed in this study. The most abundant holothurians *Pearsonothuria graeffei* observed during this study feed on the mucus produced by live corals (Fjukmoen, 2006; Robert *et al.,* 2000) and removal of mucus with precipitated detritus on coral polyps by its feeding may increase the

Table 2. Echinoderm species list and distribution in Lembeh Strait and its vicinity. x: present.

Station No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Taxa																																				
ASTEROIDEA																																				
Ophidiasteridae																																				
Celerina heffernani (Livingstone 1936)																			X													X				
Fromia indica (Perrier 1869)																								X											X	
Fromia millepollera (Lamarck 1816)												X	X											X							X	X		X		
Fromia monilis Perrier 1869	X				X				X	X	X				X				X													X		X	X	
Fromia pacifica H. L. Clark 1921	X				X				X																											
Gomophia watsoni (Livingstone 1936)																							X	X												
Gomophia egyptiaca Gray 1840																																			X	X
Leiaster speciosus von Martens 1866																																			X	
Linckia laevigata (Linnaeus 1758)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				X	X	X	X	X	X
Linckia multifora (Lamarck 1816)																							X	X								X			X	
Linckia. sp. (long purple arms)						X									X																					
Linckia. sp. 2 (long mottled arms)																												X		X						
Linckia. sp. 3*																																				X
Nardoa galatheae (Lütken 1865)					X				X									X			X			X											
Nardoa novaecaledoniae (Perrier 1875)					X	X									X				X				X	X											
Nardoa. sp. 1					X																															
Nordoa. sp. 2					X																															
Nardoa tuberculata Gray 1840				X					X	X				X									X				X			X						
Echinasteridae																																				
Echinaster callosus Marenzeller 1895					X					X														X	X										
Echinaster sp.					X																															
Echinaster luzonicus (Gray 1840)	X				X	X																		X										X	

Table 1 continued

Station No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Oreasteridae																																				
Choriaster granulatus Lütken 1869				X		X				X	X	X		X		X		X	X				X		X	X	X	X	X	X				X	X	
Culcita novaeguineae M & T 1842	X	X	X	X		X	X		X	X	X		X	X		X		X		X	X			X	X	X	X					X	X		X	X
Protoreaster nodosus (Linnaeus 1758)			X								X	X	X			X		X		X										X	X					
Acanthasteridae																																				
Acanthaster planci (Linnaeus 1758)								X																												
Asterinidae																																				
Aquilonastra. sp.**																												X								
ECHINOIDEA																																				
Cidaridae																																				
Eucidaris metularia(Lamarck 1816)																							X													
Plococidaris verticillata (Lamarck 1816)																											X									
Diadematidae																																				
Astropyga radiata (Leske 1778)			X																																	
Diadema setosum (Leske 1778)			X				X		X											X																
Diadema savignyi Michelin 1845			X		X																															X
Echinothrix calamaris (Pallas 1774)			X		X		X		X																X											
Temnopleuridae																																				
Mespilia globulus (Linnaeus 1758)																								X							X					
Toxopneustidae																																				
Tripneustes gratilla (Linnaeus 1758)																X									X											
Echinometridae																																				
Echinometra mathaei (Blainville 1825)															X																					
Echinostrephus aciculatus A. Agassiz 1863																																				X

Table 1 continued

Station No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
HOLOTHUROIDEA																																				
Holothuriidae																																				
Actinopyga palauensis Panning 1944																													X							
Bohadschia argus Jaeger 1833			X			X	X			X									X																	
Bohadschia marmorata Jaeger 1833			X																																	
Holothuria atra Jaeger 1833								X																			X		X							
Holothuria edulis Lesson 1830																										X			X							X
Holothuria hilla Lesson 1830																											X									
Holothuria fuscopuntata Jaeger 1833								X																												
Holothuria impatiens (Forskal 1775)																											X									
Holothuria leucospilota (Brandt 1835)																											X									
Holothuria sp. (pink)																										X										X
Pearsonothuria graeffei (Semper 1868)	X		X	X				X		X						X	X		X						X						X	X	X			X
Stichopodidae																																				
Stichopus herrmanni Semper 1868						X	X	X																												
Stichopus. sp.							X	X																												
Thelenota anax H. L. Clark 1921			X	X			X								X					X				X			X			X					
Synaptidae																																				
Polyplectana sp.																														X						
Euapta godeffroyi (Semper 1868)																										X										
Synapta. sp.																	X																			
Synaptula lamperti Heading 1928											X																			X							
OPHIUROIDEA																																				
Ophiocomidae																																				
Ophiarthrum elegans Peters 1851													X																							
Ophiarthrum pictum M & T 1842													X														X									
Ophiocoma erinaceus M & T 1842										X							X			X		X	X													

Table 1 continued

Station No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Ophiomastix caryophyllata Lütken 1869		X		X		X						X											X	X											
Ophiomastix cf venosa Peters 1851				X		X											X		X																
Ophiomastix janualis Lyman 1871				X	X			X					X			X				X							X			X					
Ophiomastix variabilis Koehler 1905		X		X	X		X	X						X						X			X	X	X										
Ophiotrichidae																																				
Macrophiothrix longipeda (Lamarck 1816)													X																							
Macrophiothrix rhabdota H. L. Clark 1915													X																							
Ophiomaza cacaotica Lyman 1871		X																															X			
Ophiothela danae Verrill 1869																	X																			
Ophiothrix foveolata M-T 1887																X																			
Macrophiothrix nereidina (Lamarck 1816)						X		X																X												
Ophiothrix purpurea von Martens 1867		X		X	X			X		X						X	X				X	X		X			X									
Ophiolepididae																																				
Ophioplocus imbricata (M & T 1842)																			X																	
Ophiodermatidae																																				
Ophiarachna delicata (H. L. Clark 1932)																											X									
Ophiarachna incrassata (Lamarck 1816)			X										X																							
Ophiarachnella gorgonia (M & T 1842)					X								X																	X						
Ophiarachnella infernalis (M & T 1842)															X																					
Ophiarachnella septemspinosa (M & T 1842)				X		X							X				X																	X		
Ophiuridae																																				
Ophiolepis superba H. L. Clark 1915															X																					
Ophiactidae																																				
Ophiactis savignyi (M & T 1842)																												X								
Total Number of Taxa	**6**	**6**	**12**	**12**	**16**	**12**	**9**	**11**	**8**	**10**	**6**	**5**	**12**	**5**	**8**	**9**	**8**	**5**	**9**	**8**	**4**	**3**	**10**	**16**	**8**	**6**	**14**	**4**	**4**	**8**	**6**	**7**	**4**	**4**	**10**	**9**

viability of corals, particularly when sea waters become turbid. The abundances of commercial species of aspidochirote sea cucumbers were very low and high-commercial value species, e.g. *Thelenota ananas* and *Holothuria fuscogilva* were not found.

Investigations on echinoderms have been done in several regions in Indonesia, for example, Aceh with 21 species recorded (Yusron, 2003), Jepara with 23 species (Aziz & Darsono, 1999), Sekotong Bay West Nusa Tenggara with 29 species (Triana *et al.,* 1999), Bali with 37 species recorded (Triana *et al.,* 1999), Ternate with 36 species (Supono & Susetiono, 2010), Thousand Island with 86 species (Hutomo & Moosa, 2005), South and Southeast Sulawesi with 82 species and Maluku with 145 species recorded (Hutomo &Moosa, 2005). For comparison, a comprehensive review of Thai echinodermata reported about 381 species (39 crinoids, 69 asteroids, 112 ophiuroids, 67 echinoids and 94 holothurians) (Putchakam & Sonchaeng, 2004). Dao (2002) listed occurrences of asteroids and echinoids in several regions of the South China Sea. In total about 40 asteroids and 89 echinoids were found in Vietnam, 49 asteroids and 82 echinoids in Malaysia and open waters of Sunda shelf, 17 asteroids and 48 echinoids in Borneo waters (Dao, 2002). Philippine waters have the highest number of species of asteroids and echinoids among the regions with 73 and 107 respectively (Dao, 2002). A separate work on holothurians in the Philippines, by Kerr *et al.* (2006), recorded about 49 species of holothurians, most of them being widely dispersed in the Indo-West Pacific species. Finally, Lane *et al.* (2000) compiled an inventory of echinoderms from the South China Sea and noted about 982 species (113 crinoids, 227 asteroids, 272 ophiuroids, 167 echinoids and 203 holothurians).

The survey coverage of the Lembeh area is thus far only partial as is knowledge for the Indonesian Archipelago as a whole. Other areas of North Sulawesi (except for the Bunaken National Marine Park) are little-known. Despite the three centuries of echinoderm diversity studies in Indonesia much sampling for both shallow and deep waters-remains to be done in order to have a comprehensive impression of the current biodiversity status of the phylum in this equatorial Archipelagic country.

ACKNOWLEDGMENT

We wish to thank Dr. Bert W. Hoeksema and the NCB Naturalis teams for providing the opportunity and the logistic support that made Lembeh Marine Biodiversity Survey all possible. Acknowledgement is also due to the JSPS-ACORE COMSEA program for the chance to present an earlier version of this paper at LIPI-JSPS International Seminar on Coastal Ecosystem in Southeast Asia.

REFERENCES

Aziz, A. and P. Darsono. 1999. Fauna ekhinodermata dari pulau-pulau Karimunjawa, Jepara. Majalah Ilmu Kelautan, 14(IV): 83–92.

Bakus, G.J., 1973. The biology and ecology of tropical holothurians. In: Endean, R. 6 O.A. Jones (eds.), Biology and ecology of corai reefs. Academic Press, New York, p. 325–367

Brodie, J., K. Fabricus, G. De'ath and K. Okaji. 2005. Are increased nutrient inputs responsible for more outbreaks of crown-of-thorns starfish? An appraisal of the evidence. Marine Pollution Bulletin, 51: 266–278.

Clark, A.M. and F.W.E. Rowe. 1971. *Monograph of Shallow-Water Indo West Pasific Echinoderms*. Trustees of the British Museum (Nat. Hist. Mus), London. 238 pp.

Colin, P.L. and C. Arneson, 1995. *Tropical Pacific Invertebrates: A Field Guide to the Marine Invertebrates Occurring on Tropical Pacific Coral Reefs, Seagrass Beds and Mangroves*. Coral Reef Press, Beverly Hills, California, U.S.A. 295 pp.

Dao, T.H. 2002. The echinoderm fauna of the coastal waters of Khahn Hoa province (Central Vietnam). Journal of Marine Science and Technology, 1:1–11.

Darsono, P. and A. Aziz. 2002. Komunitas echinodermata dari beberapa pulau di daerah Sulawesi Utara. Majalah Ilmu Kelautan, 26(7): 77–88.

Edinger, E.N., J. Jompa, J.V. Limmon, W. Widjatmoko and M.J. Risk. 1998. Reef degradation and coral biodiversity in Indonesia: effects of land based pollution, destructive fishing practices and changes over time. Mar. Pollut. Bull., 36:617–630.

Fujita T., L.M. Marsh 2004. Results of the Rumphius-Biohistorical Expedition to

Ambon (1990).Part 12.The Asteroidea (Echinodermata) collected from Ambon. Zool.Med.Leiden, 78: 161–179.

Fjukmoen, Ø. 2006. The shallow-water macro echinoderm fauna of Nha Trang Bay (Vietnam): Status at the onset of protection of habitat. Master Thesis, University of Bergen, Bergen, Norway. 77 pp.

Glynn, P.W., G.M. Wellington and C. Birkeland. 1979. Coral reef growth in the Galapagos: Limitation by sea urchins. Science,203: 47–49.

Guille, A. and W.J. Wolf. 1984. Résultats Biologiques de I'Expédition Snellius. Echinodermata. Ophiuroidea 1. Zool. Verh. Leiden,213: 1-39.

Heding, S.G. 1928. Papers from Dr. Th. Mortensen's Pacific Expedition 1914-16. 46. Synaptidae. Vidensk. Meddr. dansk naturh. Foren, 85:105–323

Hutomo, M and M.K. Moosa. 2005. Indonesian marine and coastal biodiversity: present status. Indian J. Mar. Sci., 34: 88–97.

James, D.B. 1976. The history of echinodermology of the Indian Ocean.J. Mar. Biol. Ass.India, 18: 298–309.

Kerr, A.M., K. Netchy and A.M. Gawel. 2006. *Survey of the shallow-water sea cucumber of the central Philippines*. Technical Report No. 119. University of Guam Marine Laboratory. 56 pp.

Kinnaird, M.F. 2002. Sulawesi Utara: Sebuah Panduan Sejarah Alam. In:Arbi, U.Y. (ed), Moluska di Pesisir Barat Selat Lembeh, Kota Bitung, Sulawesi Utara. Jurnal Bumi Lestari,10(1): 60–68.

Koehler, R. 1895. Echinodermes de la baie d'Amboine. Rev. suisse Zool., 3(2): 275–293.

Lane, D.J.W. 1999. Distribution and abundance of *Thelenota rubralineata* in the Western Pacific: Some conservation issues. SPC-Beche-de-mer Information Bull., 11: 19-21.

Lane, D.J.W., L.M. Marsh, D. VandenSpiegel and F.W.E. Rowe. 2000. Echinoderm fauna of the South China Sea: An inventory and analysis of distribution patterns. The Raffles Bull. Zool.,8: 459–493.

Ludwig, H. 1882. List of the holothurians in the collection of the Leyden Museum. Notes Leyden Mus., IV (10): 127–137.

Ludwig, H. 1888. Die von Dr. J. Brock in Indischen Archipel gesammelten Holothurien.Zool. Jb. Abt. Syst., 3(6): 805-820.

Massin, C. 1996. Results of the Rumphius Biohistorical Expedition to Ambon (1990). Part 4. The Holothuroidea (Echinodermata) collected at Ambon during the Rumphius Biohistorical Expedition. Zool. Verh. Leiden,307: 1–153.

Massin, C., 1999. Reef-dwelling Holothuroidea (Echinodermata) of the Spermonde Archipelago (South-West Sulawesi, Indonesia).Zool. Verhandel., 329: 1–144.

Muller, K. 1997. Diving Indonesia. Periplus Action Guides.332pp.

Purwati, P and D.J.W. Lane. 2004. Asteroidea of the Anambas Expedition 2002. The Raffles Bull. Zool.,2: 89–102.

Putchakam, S and P. Soancheng. 2004. Echinoderm fauna of Thailand: History and inventory reviews. Science Asia,30: 417–428.

Roberts, D., A. Gebruk, V. Levin and B.A.D. Manship, 2000. Feeding and digestive strategies in deposit feeding holothurians. Oceanogr. Mar. Biol. Annu. Rev., 38: 241-310.

Rowe, F.W.E. 1983. A collection of holothurians in the Leiden Museum from the East Indies and New Guinea, with the description of a new species of Protankyra (Holothurioidea: Synaptidae) from Java. Zool. Meded., Leiden, 57: 149–154.

Rumphius, G.E. 1705. D'Amboinsche Rariteitkamer, etc. Amsterdam. 41pp.

Selenka, E. 1867. Beiträge zur Anatomie und Systematik der Holothurien. Z. wiss. Zool, 17(2): 291-374.

Semper, C. 1868. Reisen im Archipel der Philippinen. Holothurien.2. Wissenschaftliche Resultate. Leipzigix: 1–288.

Sheppard, C. and S.M. Wells. 1988. Coral reefs of the world. Indian ocean, Red Sea. Nairobi, Kenya. UNEP and Cambridge, UK. IUCN (2). 389pp.

Sluiter, C. Ph. 1890. Nachträgliches über die Echinodermen Fauna des JavaMeeres. Natuurk. Tijdschr. Ned.Indië. 49, 8 ser., 10: 105–110.

Sluiter, C. Ph. 1894. Holothurien. Zool. Forsch. Aust. malay Archipel., V (1): 101–106.

Sluiter, C. Ph. 1895. Die Holothuren Sammlung des Museums zu Amsterdam.Bijdr. Dierk., 17: 75-82.

Sluiter, C. Ph. 1901. Die Holothurien der Siboga Expedition. Siboga Exped., 44:1–142.

Supono, 2011. Struktur komunitas ekhinodermata di perairan padang lamun Likupang Timur. Bunga rampai Perairan Maluku dan Sekitarnya, LIPI Press: 13–20.

Supono and Susetiono. 2010. Struktur komunitas ekhinodermata dibeberapa lokasi perairan Wori, Minahasa Utara. Prosiding Seminar Nasional Kelautan IV, Universitas Hangtuah, 3: 85–91.

Supono and U.Y. Arbi. 2010. Struktur komunitas ekhinodermata di padang lamun perairan Kema, Sulawesi Utara. Oseanol. Limnol. Indonesia, 36(3): 329–342.

Théel, Hj., 1886. Holothurioidea. Part 2. Rep. scient. Res. Voy. Challenger (Zool.), 39: 1–290.

Tomascik, T., A.J. Mah, A. Nontji and M.K. Moosa. 1997. The ecology of Indonesian seas.Vol I and II Periplus edition.1388 pp.

Triana, C., A. Basukriadi and A. Aziz. 1999. Beberapa aspek ekologi fauna echinodermata di rataan terumbu karang Pulau Menjangan, Bali. Jurnal Pusat Studi Lingkungan,19(2): 90–99.

Yusron, E. 2003. Beberapa catatan fauna ekhinodermata dari perairan Tapak Tuan, Aceh Selatan, Nangroe Aceh Darussalam. Makara Sains,7(3): 97-103.

Yusron, E. 2009. Biodiversitas fauna ekhinodermata di perairan Selat Lembeh, Bitung-Sulawesi Utara. Oseanol. Limnol., 35(2): 225–-237.

Yusron, E and Susetiono. 2005. Fauna ekhinodemata dari perairan Tanjung Merah, Selat Lembeh-Sulawesi Utara. Makara Sains,9 (2): 60–65.