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Seagrass beds as the buffer zone for fish biodiversity in coastal water of Bontang City, East Kalimantan, Indonesia

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Abstract. *Irawan A, Supriharyono, Hutabarat J, Ambariyanto. 2018. Seagrass beds as the buffer zone for fish biodiversity in coastal water of Bontang City, East Kalimantan, Indonesia. Biodiversitas 19: 1044-1053.* The purpose of this study was to demonstrate the importance of seagrass beds as a buffer zone for fish biodiversity in a coastal ecosystem. The sampling of seagrass and fish were done in seagrass beds associated with mangrove (ST1) and coral reef (ST2). Sampling period was executed from May 2011 to May 2017. Sampling was done on the lowest tide with a six-month interval. Seagrass sampling was carried out using line transect, and fish sampling was performed using set net (belat local name) operated by local fisherman. The results showed that seagrass beds at ST1 composed of *C. rotundata* and *E. acoroides* and that at ST2 composed of *C. rotundata, E. acoroides*, *H. pinifolia, H. minor* and *T. hemprichii*. The total number of individual was 42574 divided into 112 fish species. There were 17 species (population: 15.18%) associated explicitly with ST1 and 39 species (population: 34.82%) specifically associated with ST2 while 56 fish species (population: 50.0%) were prevalently spread in both stations. This research proved the existence of seagrass beds as a buffer zone for fish biodiversity.

Keyword: Biodiversity, connectivity, fish, seagrass beds

INTRODUCTION

Seagrass is a macrophyte in coastal water (Billah et al. 2016). Structurally, the construction of seagrass beds provides nursery grounds for fish juvenile (Jones 2014), and coral fishes (Verweij et al. 2008). It also serves as feeding grounds (Coles et al. 1993; Erftemeijer and Allen 1993; Carroll and Peterson 2013) for economically high-value fishes (Hantanirina and Benbow 2013; Blandon and zu Ermgassen 2014), to provide food, food chain and biodiversity, and ecosystem service (Cucio et al. 2016) in supporting the coastal water productivity (Greening and Janicki 2006; Nadiarti et al. 2012; Bahlmann et al. 2015). Seagrass tends to be found close to mangrove forests and coral reefs (Short et al. 2011). This illustrates the importance of interaction in the coastal ecosystem (Hirst et al. 2016). Natural interactions within the coastal ecosystem protect the population's habitat (Unsworth et al. 2007). A combination of two habitats shows that mangroves specifically protects the coast and coral reef that forms a fringing reef for seagrass beds, which serve to control degradation of coral reefs in the long-term (Guannel et al. 2016).

By understanding the importance of the role of seagrass beds, we should have been able to manage its sustainability, but in reality, the fact shows that the expanse of seagrass beds have decreased in many parts of the world (Hughes et al. 2009; Jones 2014) and seagrass beds have been globally threatened by anthropogenic factors and climate change (Rasheed and Unsworth 2011; Grech et al. 2012; Unsworth et al. 2012; Duarte et al. 2013; Shafer et al. 2014; Mazarrasa et al. 2015). This same thing happened in the coastal area in Bontang where the expanse of seagrass beds had also been decreased as the result of the damage covering around 321.3 ha area or as much as 45% of total seagrass beds area of 714 ha (DPKP Kota Bontang 2011). Despite the fact that the composition of seagrass beds (consisting of 9 species of total 12 species found in Indonesia) (Tomascik et al. 1997; P3IK/P3O-LIPI 2000; DPKP Bontang 2015) had been known, it is a mangrove forest. Coral reef has become the priority in conservation management, and the critical role of seagrass beds in supporting fishery resources and the productivity in Bontang coastal water tends to be neglected.

This study aimed to demonstrate the importance of seagrass beds as the buffer zone for fish species biodiversity in coastal ecosystem especially the association between seagrass beds, mangrove, and coral reef, to initiate an integrated and continuous management system in the coastal ecosystem. This study focused on fish species composition and the distribution of fish length size and its interaction with species characteristic, the density of seagrass stand and the association between seagrass beds and mangrove and coral reef in Bontang coastal water. Mangrove forests and coral reef are creating the importance of interaction between coastal ecosystems. The natural interaction of coastal ecosystem provides protection for population habitat or combination of two habitats which shows that mangrove specifically provides protection to the coast and coral reef that forms a fringing reef for seagrass beds, and seagrass beds serve to control degradation of coral reef in a long-term.

MATERIALS AND METHODS

Study area

This research was carried out in coastal water of northern Bontang City, East Kalimantan, Indonesia. Observation station consisted of seagrass beds associated with mangrove (ST1) and seagrass beds associated with the coral reef (ST2) (Figure 1). Seagrass beds in ST1 at high tides were found in the range of 1 to 1.5 m and at the lowest tide were exposed to temporal exposure. The distance between seagrass and mangrove forest range was from 250 to 800 m. Seagrass at ST2 at highest tide was found in the depth range of 0.5-1.5 m and at lowest tide experiencing temporal exposure. The distance between seagrass and coral reefs ranged from 10-50 m. The research was executed from May 2011 to May 2017 with six months interval of observation.

Seagrass sampling

Seagrass beds were located on reef flats which were divided into two stations (ST1 and ST2). Each station consisted of 3 quadrant plot sized 0.5 m x 0.5 m. The distance between transects was 50 m, and the distance between quadrant plots was 25 m. Observation of seagrass species covered its species, shoots, frequency, and the length of leaves of each species. The identification of seagrass species was referred to den Hartog (1970), Kuo and McComb (1989), Fortes (1993), Tomascik et al. (1997) and Seagrass Wacth (2010).

Fish sampling

Fish sampling was carried out by using net set (otoshi ami, trap net, and splint: local name) operated by the local community. Set net is a passive catching device used to block fish migration by using nets that are upheld by bamboo poles to the bottom (Anand et al. 2016) with the end being a trap (Olaniyan 2015). Characteristics of the set net in the study area were pole nets from branches/tree trunks; chamber-crib: 4 m^2; chamber-wings: 70 m; main fence: 100 m; and mesh size net: crib: 1 inch; main fence and wing: 1.5 inches. The used set of seagrass beds-mangrove and seagrass beds-coral reef were migrated during high tide. Hauling was done at 24 hours interval. Fish samples were identified by its species and its total length being measured. Identification process was done by referring to Allen (1999); Fishery Research Center (2009); Verhoel (2009); Bergbauer and Kirschner (2011); Jones et al. (2011); Rudi and Mucsin (2011); Wood and Michael (2011); Sharifuddin (2012); Suyatna et al. (2016).

Data analysis

Data analysis was conducted using descriptive and quantitative approach, i.e., *t*-test (α = 5 %) and correlation (α = 5 %). Seagrass data were analyzed for density (D) (shoot m^{-2}) and relative density (RD), frequency (F) and relative frequency (RF), covered (C) and relative covered (RC) (English et al. 1994), important value index (IVI) (Brower et al., 1990). Fish data was analyzed by species composition, Bray Curtis similarity, density (D) (indiv. day^{-1}), diversity index (H'), similarity index (E) and dominance index (C). Correlation between species distribution and habitat was analyzed by Correspondence Analysis (STATISTICA v.8.0)

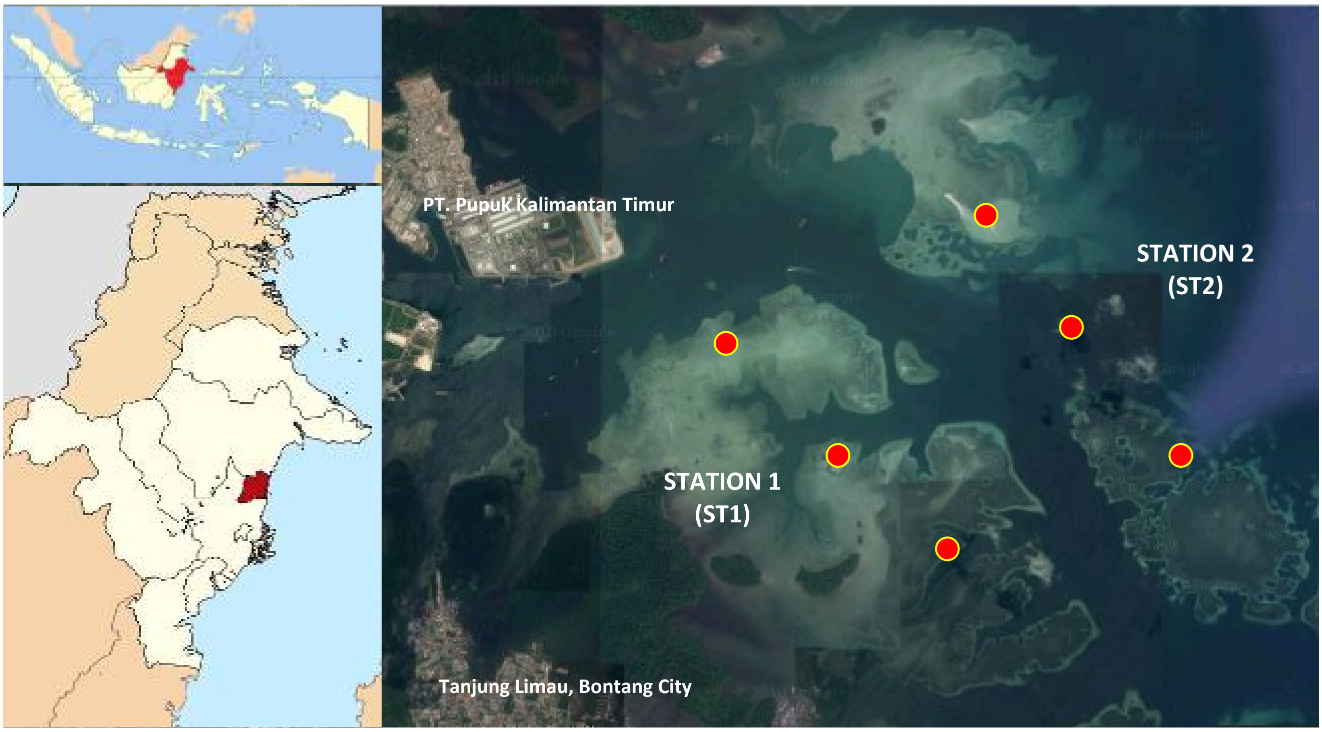


Figure 1. Research location of seagrass beds in coastal water of northern Bontang City, East Kalimantan, Indonesia. ST1: 00º09’221”N, 117º31’825”E, ST2: 00º09’226”N, 117º32’561”E

RESULTS AND DISCUSSION

Distribution of seagrasses

Seagrass beds in northern Bontang composed of *C. rotundata*, *H. pinifolia*, *E. acoroides*, *T. hemprichii*, and *H. minor*, while ST 1 composed by *E. acoroides* and *C. rotundata*, and ST 2 composed of the five species. The density of seagrass shoots on ST 1 and ST 2 was similar (P_{Value} = 0.88). Important value index shows that *C. rotundata* was more dominant in forming seagrass beds in ST1 and *E. acoroides* was dominant in ST2. Both species have a big contribution in forming seagrass beds in northern Bontang.

Species distribution and fish community structure

The Seagrass bed on both stations provided habitat for 112 fish species, with average density in ST 1 was 2087 individuals and 2180 individuals in ST2 (Table 2).

Based on the total number of fish found in ST1 and ST2, we observed the top ten rank of fish species in both stations (Table 2 and 3). The first rank in ST1 with the highest number of population was *G. flamentous* and this species were ranked as the second in ST2. *S. doliantus* was included in the higher amount of fish species found in both stations, which was ranked as the first and the second in ST2 and ST1, respectively. It was observed that Siganus, Apogon, and Gerres genera were more dominant in forming a fish community in both of the seagrass beds (Table 3). Fish density in both stations was positively correlated with diversity index values (Table 4). The distribution of species tended to be evenly distributed, and no species was dominant (Table 4).

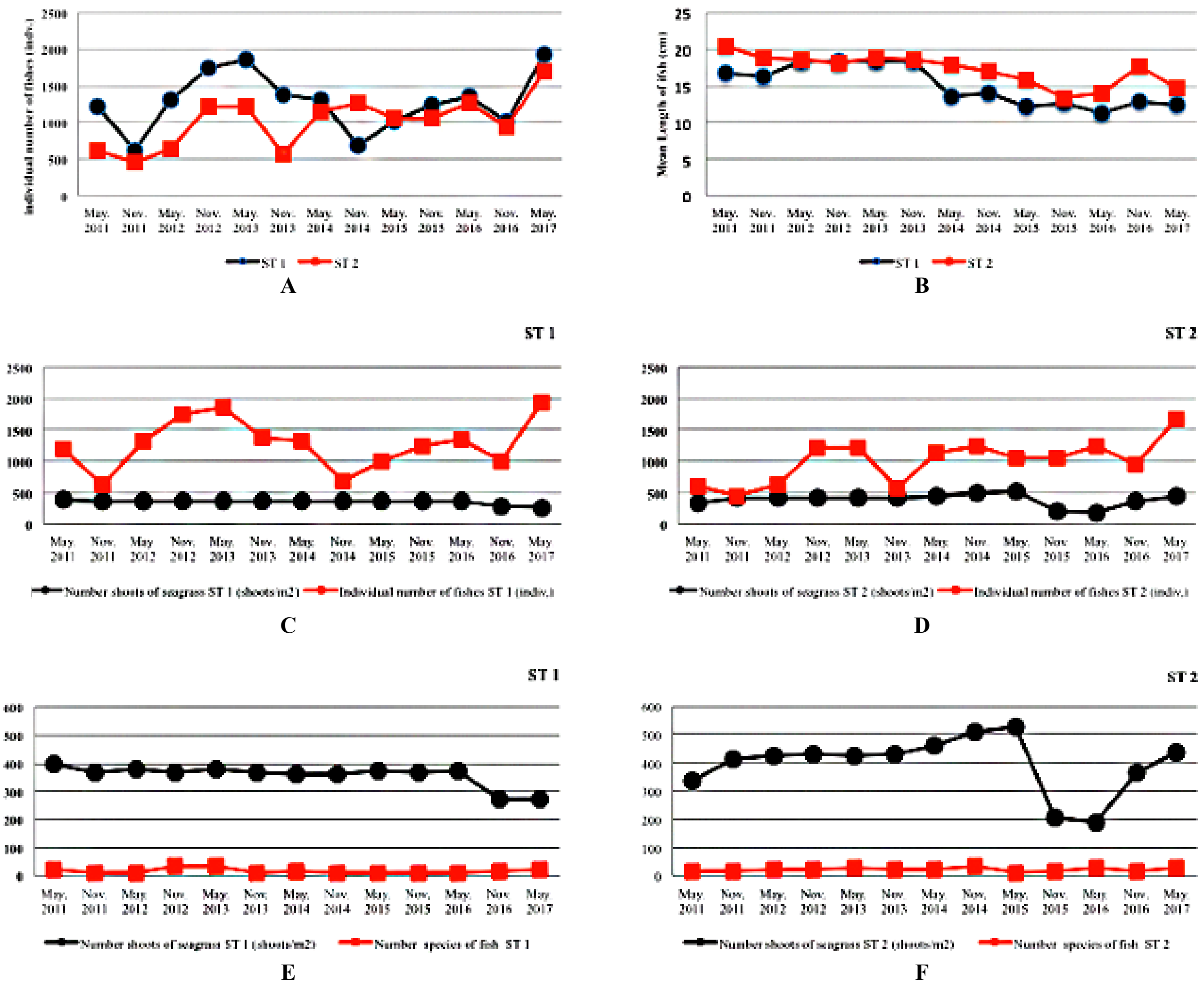


Figure 2. A. Individual number of fish. B. Mean length of fish. C. Number of shoots of seagrass and individual number of fishes at ST1. D. Number of shoots of seagrass and individual number of fishes at ST2. E. Number of shoots of seagrass and number species of fishes at ST1. F. Number shoots of seagrass and number species of fishes at ST2

Table 1. Length of leaf, density, frequency, covered (mean ± standard deviation) and important value index of seagrasses in coastal water of northern Bontang City, East Kalimantan, Indonesia

Station	Species	Length of leaf (cm) (*n*=65)		Density (shoots/m^2) (*n*=117)		Frequency (%)		Covered (%)		Important value index	
		Range	Mean	Range	Mean	Range	Mean	Range	Mean	Mean	%
ST1	*E. acoroides*	43-64.2	54.44±5.9	63-92	81±10.9	63-97	85 ±0.11	18.42-22.07	20.26±1.4	1.44	47.94
	C. ratundata	9.5-13.0	11.96±6.8	197-225	204 ± 7.3	49-60	53 ±0.04	16.12-18.94	17.42±0.9	1.56	52.06
ST2	*E. acoroides*	19.5-36.5	27.6±4.17	91-131	114 ±10.6	56-88	73 ±0.11	12.01-20.54	14.83±2.4	1.36	45.17
	C. ratundata	7.5-11.5	9.8±0.87	101-179	154 ±27.6	32-48	41 ±0.06	3.31-6.88	4.28 ±1.3	0.86	28.50
	T. hemprichii	6.5-11.5	9.6±0.97	8-34	17 ±10.1	6-36	17 ±0.10	4.13-8.28	4.89 ±2.6	0.34	11.48
	H. pinifolia	4.0-6.0	4.3±1.89	27-131	60 ±41.5	2-20	9 ±0.06	1.57-3.12	1.70 ±1.1	0.28	9.48
	H. minor	0.75-0.95	0.77±0.64	12-49	28 ±15.8	2-12	7 ±0.04	0.38-1.72	1.09 ±0.7	0.16	5.37

Table 2. Compositions of species, total length (cm) and density (mean ± standard deviation) of fishes in coastal water of northern Bontang City, East Kalimantan, Indonesia

Species	ST 1 (*n*=13) Total length (cm)		ST 1 Density (ind day^{-1})	ST 2 (*n*=13) Total length (cm)		ST 2 Density (ind day^{-1})	T-test (ST1 vs. ST2) TL	T-test Density	Max. TL (cm)	L_m (cm)
	Range	Mean	Mean	Range	Mean	Mean	p-values	p-values		
Acanthurus albipectoralis	26.5-28.3	27.3±0.77	1±0.55	20-21	20.3±0.45	1±1.22	0.000	0.335	33*[#a]	
Acreichthys tomentosus	7.5-7.8	7.7±0.13	1±0.50	5.9-9.1	7.8±1.03	6±0.58	0.841	0.100	12*[#a]	
Apogon fuscus	5.7-8.1	7.1±0.87	7±0.96	-	-	-	-	-	10*11.2[#a]	
A. kallopterus	5.9-8.8	7.8±0.70	51±1.29	5.1-9.9	7.2±0.64	18±3.51	0.437	0.126	15*16[#a]	
A. kiensis	4.5-10.6	7.7±0.41	104±3.37	6.0-11.2	8.3±0.72	12±1.15	0.129	0.000	9*8[#a]	
A. poecilopterus	8.0-9.9	9.3±0.35	3±1.15	10.1-11.0	10.4±0.43	1±1.1	0.013	0.216	12*14[#a]	
Arothron hispidus	10.2-28.9	19.6±6.09	9±1.01	10.2-25.8	21.1±4.60	5±0.82	0.636	0.080	51*50[#a]	
A. mappa	-	-	-	21.0-22.0	21.5±0.41	1±0.50	-	-	60*65[#a]	
A. manillensis	-	-	-	16.0-16.9	16.4±0.45	1±0.58	-	-	31*[#eg]	
A. nigropunctatus	12.8-24.7	21.3±4.85	2±0.89	15.7-19.5	18.6±1.46	1±0.49	0.178	0.109	30*33[#a]	
A. stellatus	17.2-40.7	26.3±3.03	1±0.58	-	-	-	-	-	90*120[#deg]	
Caesio cuning	19.3-21.6	20.6±0.76	3±0.87	15.2-16.9	15.7±0.69	2±0.71	0.000	0.053	43*60[#a]	
C. lunaris	-	-	-	7.8-8.5	8.2±0.29	2±1.26	-	-	38*40[#a]	
C. teres	12.0-13.2	12.7±0.44	1±0.55	12.3-13.2	12.9±0.39	3±1.41	0.610	0.434	40[#a]	
Carangoides dinema	-	-	-	10.0-16.5	14.2±3.63	8±1.19	-	-	85[#d]	
C. ferdau	8.7-14.5	11.6±2.45	1±0.45	-	-	-	-	-	70*[#d]	
C. ignobilis	-	-	-	12.0-19.0	15.0±2.94	7±3.30	-	-	170*[#f]	
Centriscus scutatus	-	-	-	10.0-12.5	10.7±1.24	1±1.73	-	-	15*[# d]	
Cephalopholis sonnerati	9.0-10.1	9.5±0.42	1±0.65	10.8-13	11.9±0.91	1±1.41	0.000	0.006	58*57[#a]	
Chanos chanos	27.3-36.8	32.1±3.09	1±0.82	-	-	-	-	-	120*[d]	98.1[#]
Cheilio inermis	-	-	-	16.5-29.5	23.0±4.65	1±1.22	-	-	50*[#c]	
Cheilodipterus quinquelineatus	9.8-11.2	10.8±0.65	2±1.19	10.2-11.6	10.9±0.57	1±0.82	0.905	0.002	12*13[#a]	
Chelmon rostratus	8.0-8.7	8.4±0.24	1±0.79	-	-	-	-	-	20*[#a]	
Colurodontis paxmani	5.0-14.5	9.9±2.27	16±0.84	-	-	-	-	-	15*12[#c]	
Cymbacephalus beauforti	28.9-34.5	31.7±1.66	1±0.90	18.5-25.5	23.5±2.87	2±0.84	0.000	0.247	50[#g]	
Dexillichthys muelleri	-	-	-	29.0-33.5	30.5±1.75	1±0.55	-	-	20 *[g]	
Diodon liturosus	25.1-26.3	25.5±0.48	1±0.76	21.0-32.0	25.7±4.60	2±0.50	0.911	0.247	40*65[#a]	
Dipterygonatus balteatus	11.6-12.7	12.1±0.33	1±1.07	-	-	-	-	-	14*[a]	
Epinephelus coioides	8.5-13.4	10.9±1.27	3±0.71	23.5-29	26.3±3.89	1±1.41	0.001	0.003	95*120[#ae]	48.3[#]
E. quoyanus	15.0-27.0	22.2±4.67	2±1.14	10.5-24.5	19.8±5.46	2±1.30	0.469	0.589	35*40[#f]	
E. tukula	-	-	-	11.0-12.5	11.5±0.68	1±1.41	-	-	140*200[#a]	99[#]
Escualosa thoracata	-	-	-	7.2-11.5	9.2±1.77	3±0.82	-	-	10[#d]	
Fistularia commersonii	30.0-50.2	39.8±11.31	2±0.96	29.0-32.0	30.5±1.41	1±1.41	0.335	0.194	163*[#ad]	
F. petimba	62.5-64.8	63.4±0.70	1±0.76	48.0-53.7	52.7±1.16	1±0.82	0.000	0.672	185*200[#a]	
Gerres abbreviatus	8.8-15.5	10.4±2.26	4±1.52	10.4-16.5	13.0±0.84	9±0.96	0.207	0.265	30[#de]	
G. flamentous	4.2-17.4	12.0±2.29	370±4.19	8.8-17.2	13.4±4.75	101±4.75	0.061	0.000	25*35[#d]	19[#]
Gnathanodon speciosus	7.1-8.4	7.7±0.38	1±0.32	8.6-9,7	9.0±0.40	1±0.41	0.000	0.337	111*120[#f]	32.5[#]
Gymnothorax undulatus	-	-	-	49.4-63.0	56.2±6.80	1±1.15	-	-	150 *[#a]	
Halichoeres biocellatus	-	-	-	8.2-10.0	8.9±0.65	1±0.45	-	-	15*12[#a]	
Hemirhampus far	-	-	-	29.0-37.3	32.7±2.73	6±0.71	-	-	35*45#[d]	[range]18[#]
Himantura toshi	8.7-17.5	13.1±3.30	5±1.35	38.5-42.5	40.5±1.63	1±0.82	0.000	0.005	180*[beg]	
Hippocampus hystrix	20.7-21.7	21.3±0.39	1±0.55	10.8-20.0	14.7±4.77	3±1.15	0.017	0.864	15*17[#d]	7.9[#]
Nematalosa come	-	-	-	13.5-15.0	14.0±0.67	1±0.50	-	-	23*21[#d]	
Lactoria cornuta	-	-	-	24.6-26	25.3±0.70	1±0.71	-	-	46*[#cg]	
Lagocephalus inermis	7.5-11.3	8.8±1.38	4±0.82	-	-	-	-	-	90[#f]	30[#]

Leiognathus equulus	8.8-11.2	9.9±1.23	2±0.58	9.2-10.1	9.5±0.35	1±0.55	0.5717	0.281	24*28[#ae]	10.7[#]
L. elongatus	6.0-10.5	8.1±1.03	3±1.29	6.0-12.5	9.1±1.96	37±0.89	0.4068	0.001	12*[#a]	
L. fasciatus	4.9-5.8	5.5±0.39	2±0.82	9.7-14.1	12.9±0.11	5±1.53	0.000	0.353	21[#de]	
Lethrinus lentjan	6.5-21.5	14.0±2.05	130±4.73	8.5-23.0	15.6±2.30	9±12.65	0.132	0.000	50*52[#ag]	27.7[#]
L. ornatus	-	-	-	11.2-18.3	12.7±1.56	1±0.71	-	-	40*45[#a]	20[#]
L. variegatus	6.8-9.0	9.2±1.96	3±1.26	7.6-18.2	12.9±1.88	29±1.05	0.016	0.006	20*[#acg]	
Liza vaigiensis	43.1-47.0	45.0±1.95	1±0.58	-	-	-	-	-	55*63[#ade]	
Lutianus lutjanus	14.1-14.9	14.3±0.31	1±0.82	11.8-12.0	11.9±0.10	1±1.15	0.485	1.000	30*[#a]	
L. bitaeniatus	9.8-13.4	11.6±1.30	9±2.17	14.2-15.5	14.8±0.56	1±0.82	0.002	0.010	30*[#af]	
L. decussatus	10.7-13.2	12.0±1.13	5±1.29	11.1-13.7	12.6±1.10	4±1.41	0.009	0.731	30*[#af]	
L. fulviflamma	10.6-17.2	13.8±3.31	1±1.15	20.1-21	20.6±0.46	1±0.96	0.533	0.550	35*[#a]	17.1[#]
L. fulvus	13.5-21.0	15.5±2.22	65±3.08	10.6-19.8	16.2±1.39	5±0.89	0.000	0.000	40*[#a]	22.5[#]
L. johnii	12.4-15.5	14.3±1.48	2±5.52	-	-	-	-	-	70*97[#be]	39[#]
L. lunulatus	-	-	-	22.0-24.2	23.1±0.90	1±0.82	-	-	35*40[#a]	
L. quinquelinetus	10.7-12.3	11.1±0.67	1±0.55	16.5-17.7	17.0±0.43	1±0.55	0.000	1.000	38*[#a]	
Megalops cyprinoides	30.1-31.0	30.5±0.35	1±0.52	25.2-29.5	27.5±1.54	1±0.45	0.001	0.318	150*[#be]	25[#]
Monodactylus argenteus	15.3-16.7	16.0±0.41	1±0.53	-	-	-	-	-	27*[#be]	13[#]
Mulloidichthys vanicolensis	-	-	-	17.1-19.3	18.0±0.80	1±0.71	-	-	33*38[#ag]	24[#]
Mugil cephalus	17.5-18.3	18.0±0.24	1±0.79	-	-	-	-	-	100[#d]	35.4[#]
Pomacentrus milleri	-	-	-	9.8-11.6	10.7±0.65	1±1.22	-	-	13 *[a]	
Paramonacanthus choirochephalu	9.0-19.5	11.8±2.19	6±1.73	13.4-18.0	16.0±1.78	3±1.50	0.037	0.320	14 *[g]	
P. filicauda	-	-	-	7.0-13.5	10.0±2.57	2±0.58	-	-	22*[#g]	
Parapercis tetracanata	11.7-12.9	12.4±0.50	1±0.82	6.0-13.4	7.9±3.20	2±1.34	0.029	0.152	29[#d]	
Paraplotosus albilabris	-	-	-	8.7-16.5	13.5±1.93	63±1.40	-	-	134*[#a]	
Pardachirus pavoninus	13.0-20.4	17.4±3.84	2±3.79	12.0-17.3	14.7±1.88	1±1.41	0.219	0.383	25*[#g]	
Parupeneus margaritatus	11.0-13.7	12.2±1.11	1±2.45	10.6-22.7	17.3±5.40	1±0.71	0.117	0.723	23[#a]	
P. indicus	-	-	-	12.5-15.0	13.8±0.80	1±1.03	-	-	40*45[#ag]	
Pelates quadrilineatus	-	-	-	9.0-13.0	11.1±1.62	10±1.72	-	-	20*30[#de]	
Pentapodus caninus	11.5-16.0	13.1±1.47	3±2.52	11.0-14.8	13.0±1.07	9±1.64	0.221	0.556	20*35[#a]	
P. bifasciatus	6.5-16.0	13.0±1.93	21±5.50	6.5-16.0	14.1±1.10	25±1.72	0.900	0.013	18*20[#a]	
Pentaprion longimanus	-	-	-	16.3-18.1	14.8±1.43	1±0.71	-	-	15*[#dg]	
Platax sp.	9.0-17.0	14.7±3.35	5±2.06	18.0-20.5	17.2±4.61	6±1.33	0.382	0.566	50*[a]	
Platybelone argalus platyura	-	-	-	39.0-42.3	39.7±1.36	1±0.82	-	-	40*45[#f]	
Pseudomonacanthus macrrurus	-	-	-	15.9-17.1	16.7±0.54	1±1.64	-	-	24 *[c]	
Rastrelliger brachysoma	-	-	-	7.5-8.7	8.8±1.54	1±0.58	-	-	34.5[#eh]	17[#]
R. kanagurata	17.7-21.3	19.6±1.80	1±1.53	17.5-30.0	23.8±6.25	1±1.41	0.326	0.147	35*[^ad]	23[^]
R. faughni	19.1-20.1	19.7±0.39	1±0.82	-	-	-	-	-	20[#h]	
Sardinella gibbosa	-	-	-	6.5-10.8	8.9±0.48	13±1.29	-	-	19*17[#d]	12.8[#]
Scarus chameleon	13.1-13.8	13.5±0.29	1±0.50	14.9-31.6	18.7±6.01	1±1.15	0.134	0.438	28*[a]	
S. dimidiatus	-	-	-	14.5-17	15.9±0.10	1±0.71			34*40[#a]	
S. globiceps	9.5-9.9	9.7±0.17	1±0.45	10.4-29.4	16.7±6.94	2±0.63	0.050	0.040	30*45[#a]	
S. gobban	-	-	-	36.7-49.0	43.0±6.15	1±0.58	-	-	100 *[ac]	[range]49[#]
Scolopsis auratus	-	-	-	15.0-21.0	18.2±0.75	1±1.53	-	-	22*24[#a]	
S. ciliatus	9.0-14.3	13.8±1.01	11±8.02	10.1-21.0	14.8±2.46	50±1.13	0.834	0.000	16*25[#g]	
S. margaritifer	8.5-18.1	13.1±0.60	7±1.15	11.6-20.0	15.2±2.52	5±1.26	0.226	0.531	20*28[#f]	
S. taeniopterus	14.2-15.2	14.6±0.36	1±0.89	12.0-20.0	16.0±3.61	2±0.58	0.385	0.256	23*30[#f]	
Scomberoides tala	13.8-14.4	14.1±0.22	1±0.55	30.7-31.9	31.5±0.54	1±0.50	0.000	0.603	75*70[#c]	
Selar boops	11.0-15.7	14.8±2.10	7±0.58	11.0-17.5	13.7±2.29	32±1.33	0.415	0.003	25*[#c]	
S. crumenthalmops	-	-	-	8.0-18.0	13.7±5.13	1±0.58	-	-	30*70[#c]	17[#]
Scatophagus argus	12.1-12.9	12.5±0.30	1±0.55	-	-	-	-	-	33*38[#be]	[range]14[#]
Siganus canaliculatus	6.5-24.5	16.3±4.30	149±2.80	11.1-29.0	16.6±3.84	77±1.38	0.886	0.049	20*30[#cg]	11.6[#]
S. corallinus	8.1-8.3	8.2±0.08	1±0.82	-	-	-	-	-	28*35[#ac]	
S. doliantus	6.5-21.0	14.4±3.63	187±2.96	9.1-24.3	13.4±1.41	297±7.14	0.263	0.182	30*25[#a]	
S. fuscescens	-	-	-	11.7-14.5	13.6±1.62	3±1.15	-	-	41*[c]	
S. guttatus	14.5-25.5	19.6±3.40	29±1.75	12.5-25.0	19.1±2.87	72±5.61	0.777	0.000	53*[#ad]	
S. vermiculatus	-	-	-	24.6-27.3	26.2±1.31	1±0.96	-	-	45*[#a]	
S. virgatus	-	-	-	9.7-12.3	11.2±0.26	4±1.41	-	-	30 *[a]	
Sphyraena jello	-	-	-	27.5-70.0	46.9±1.13	1±0.82	-	-	150*[#def]	
S. qenie	15.5-25.5	23.5±0.47	4±1.71	18.5-30.0	24.0±4.61	2±0.96	0.284	0.238	90*170[#d]	
Sphaeramia orbicularis	-	-	-	5.5-11.0	8.7±2.37	5±4.36	-	-	11.5*10[#bd]	
Stolephorus indicus	8.3-10.2	9.2±0.85	10±1.41	6.5-13.0	9.9±2.07	15±1.11	0.517	0.444	16*15.5[#de]	9[#]
Synanceia verrucosa	14.5-15.8	15.0±0.64	1±0.45	-	-	-	-	-	35*40[#a]	[range]24[#]
Taeniura lymma	-	-	-	43.0-51.0	47.0±3.74	1±1.41	-	-	70*[ag]	20.3[#]
Thryssa hamiltonii	20.0-20.9	20.5±0.34	1±0.89	-	-	-	-	-	25*27[#beg]	
Tylosurus gavialoi	-	-	-	30.5-33.7	32.1±1.60	1±0.58	-	-	130 *[d]	
Upeneus tragula	13.5-18.2	14.7±0.23	4±2.63	13.0-18.1	16.3±1.90	5±1.81	0.262	0.613	30*25[#cg]	
U. vittatus	11.5-13.4	13.0±0.98	7±1.00	9.0-15.0	11.0±2.83	4±2.52	0.170	0.398	28*[#cg]	
Mean			1280			1013				

Note: *: Allen (1999). Max.TL: Maximum total length. Habitat: a. Coral reefs, b. Mangrove, c. Seagrass beds-weedy area, d. Coastal water. # : www.fishbase.org L_m: Length maturity, e. Estuaries, f. Inshore/offshore reefs, g. Mud/sand bottom. ^: FAO 2013 (www.fao.org/fishery), h. pelagic-neritic

Table 3. Top ten ranks of fish species based on the amount of fish found in ST1 and ST2 of the coastal water of northern Bontang City, East Kalimantan, Indonesia

ST1				ST2			
		Percentage (%)				Percentage (%)	
Rank	Species□	Mean Number of ind.	Contributions	Rank	Species□	Mean number of ind.	Contribution
1	*Gerres flamentous*	32.29	19.25	1	*Siganus doliantus*	36.51	18.76
2	*Siganus doliantus*	20.85	12.43	2	*Gerres flamentous*	13.87	7.13
3	*Apogon kiensis*	15.45	9.21	3	*Siganus guttatus*	13.74	7.06
4	*Lethrinus lentjan*	15.07	8.98	4	*Siganus canaliculatus* □	12.22	6.28
5	*Siganus canaliculatus* □	14.03	8.37	5	*Paraplotosus albilabris*	9.93	5.10
6	*Apogon kallopterus*	12.38	7.38	6	*Scolopsis ciliatus*	9.10	4.68
7	*Lutjanus fulvus*	6.88	4.10	7	*Pelates quadrilineatus*	7.06	3.63
8	*Siganus guttatus*	5.27	3.14	8	*Leiognathus elongatus*	6.76	3.47
9	*Pentapodus bifasciatus*	4.10	2.44	9	*Selar boops*	5.68	2.92
10	*Stolephorus indicus*	2.89	1.72	10	*Apogon kallopterus*	5.65	2.90

Table 4. Density, diversity, similarity, dominance (mean ± standard deviation) and correlation of fish found in ST1 and ST2 of the coastal water of northern Bontang City, East Kalimantan, Indonesia

Station	Density (indv. day^{-1})			Index								
				Diversity			Similarity			Dominance		
	Range	Mean	r	Range	Mean	r	Range	Mean	r	Range	Mean	r
ST1	623-1928	1280±401.2	+)0.47	0.58-2.84	1.74±0.66	(+)0.61	0.41-0.81	0.62±0.18	+)0.11	0.10-0.79	0.33±0.20	(+) 0.42
ST2	457-1686	1013±358.4		1.39-2.98	2.36±0.43		0.49-0.87	0.76±0.11		0.07-0.42	0.16±0.09	

Correspondence analysis showed three groups of species-associated, i.e., (i) 29 species were closely associated with ST1 (*A. kallopterus*, *A. poecilopterus*, *A. nigropunctatus*, *C. lunaris Cymbacephalus beauforti*, *F. petimba, G. undulatus*, *H. hystrix*, *N. come*, *L. equulus*, *L. elongatus*, *L. lentjan*, *L. bitaeniatus*, *L. quinquelinetus*, *M. cyprinoides*, *M. argenteus*, *P. caninus*, *R. kanagurata*, *R. faughni*, *S. ciliatus*, *S. margaritifer*, *S. margaritifer*, *S. doliantus*, *S. guttatus*, *T. gavialoi*, *U. tragula*, *U. vittatus*), (ii) 32 species were closely associated with ST2 (*A. stellatus*, *C. teres, C. dinema*, *C. inermis*, *E. coioides*, *E. tukula*, *E. thoracata*, *G. speciosus*, *H. biocellatus*, *H. far, H. toshi*, *L. fasciatus*, *L. fulviflamma*, *L. fulvus*, *L. lunulatus*, *M. vanicolensis*, *P. milleri*, *P. filicauda*, *P. albilabris*, *P. margaritatus*, *P. quadrilineatus*, *Platax* sp., *P. platyura*, *P. macrrurus*, *S. chameleon*, *S. globiceps*, *S. gobban*, *S. auratus*, *Selar boops*, *S. vermiculatus*, *S. indicus*, *T. lymma*), (iii) and 51 species were spread in both stations (Figure 3.A and 3.B).

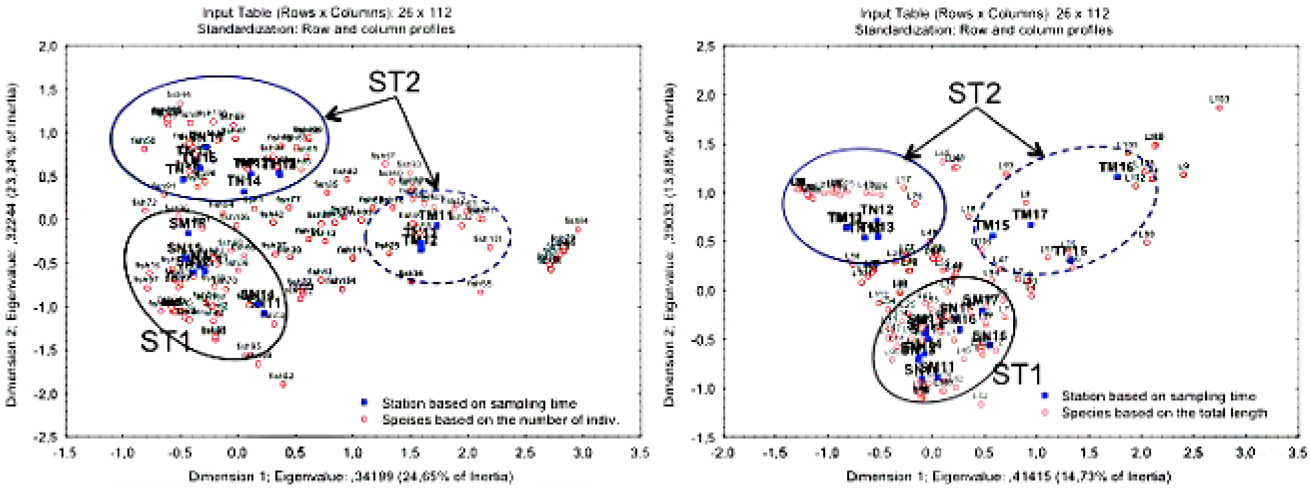
Discussion

Seagrass beds

Seagrass beds ST1 were constituted by two species which was dominated by the density of *C. rotundata* and ST2 was constituted by five species dominated by *E. acoroides* (Table 1). Based on the morphometric analysis, *E. acoroides* had the biggest size than the rest of the species (Table 1). Thus, its existence could protect other smaller seagrass species against stream and waves (Fonseca and Cahalan 1992; John et al. 2015). Seagrass beds provide habitat for a fish community (Phinrub et al. 2014), the existence of seagrass stand especially *E. acoroides* (Lotuconsina et al. 2012; Ambo-Rappe et al., 2013) and *C. rotundata* is a vegetative option chosen by the fish species to associate. The association can be seen especially in ST2 where the density of the seagrass was experiencing a decline, especially *H. pinifolia*, *T. hemprichii*, and *H. minor* but the number of fish species available in ST2 was consistent, and so was the fish species in ST1 which was likely stable (Figure 2.E and 2.F).

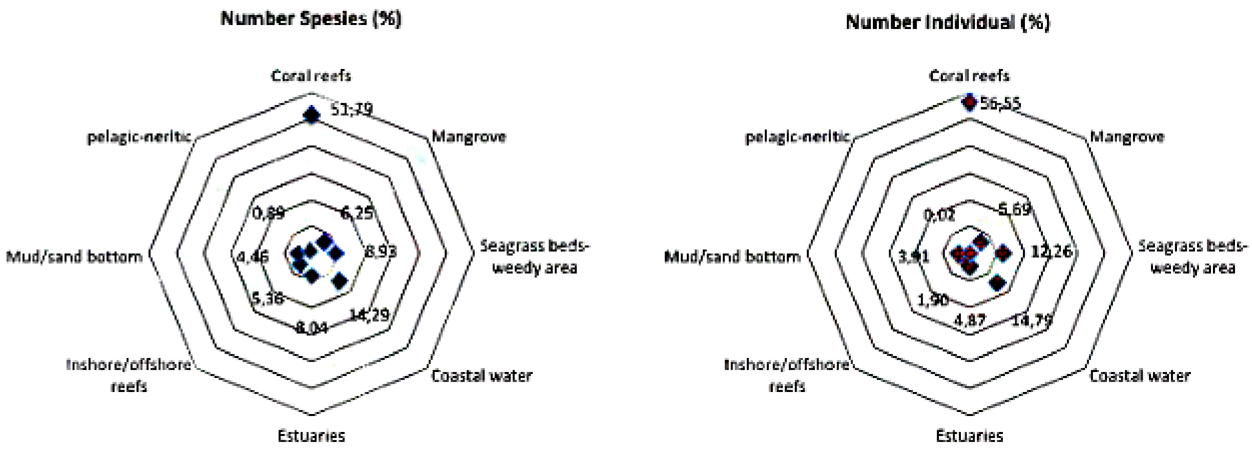
Distribution and fish community structure

Spatial patterns. Seagrass beds ST1 that was formed by two seagrass species contributed in providing habitat for 73 fish species or 51.09% of total amount of fish species (Table 2). The seagrass beds ST2 formed by five species of seagrass contributed in providing habitat for 95 fish species or 48.91% of total amount of caught fishes (Table 2). Specifically, in ST1, only 17 species were found. These species share a relatively similar total length (Table 2). The total length of a species was relatively shorter than that appeared in South-East Asia (Allen 1999) and tended to be in the juvenile phase or immature, such as *A. fuscus*, *L. vaigiensis* and *T. hamltonii*, *A. stellatus*, *C. ferdau*, *Chanos chanos*, *C. rostratus*, *C. paxmani*, *Lagocephalus* sp., *L. johnii*, *M. argenteus*, *M. cephalus*, *R. tayenus*, *S. argus*, *S. corallinus*, and *S. verrucosa* (Table 2). There were 39 fish species found in ST2 which had relatively similar total length. Some of the fish species tended to be in the juvenile phase or immature, such as *A. mappa*, *A. manillensis*, *C. dinema*, *C. ignobilis*, *E. tukula*, *L. cornuta*, *L. ornatus*, *P. albilabris*, *P. indicus*, *P. quadrilineatus*, *S. gibbosa*, *S. dimidiatus*, *S. gobban*, *S. auratus*, *S. crumenthalmops*, *S. virgatus*, *S. jello*, *T. Gavialoi* (Table 2). Meanwhile, the same species found in both stations showed that (Table 2), there was a tendency of differences in the total length and a significant difference in the number of species. The same species found in both stations were insignificantly different in their total length but significantly differed in their density (*A. hispidus*, *Caesio* sp., *C quinquelineatus*, *L. equulus*, *L. fulviflamma*, *P. bifasciatus*, *S. ciliatus, S. canaliculatus*, *S. indicus*). It also noted that in ST1 the species density was higher and total length shorter than that in ST2 (Figure 3.B). This included the total length of fishes ranked in top 10 in which the total length of *G. filamentosus* in ST1 was shorter than in ST2 (Table 2 and 3). This shows that the characteristic of the land compiler seagrass species in both stations serves not only as a space for biology phase from each species but also as a biomass distribution (Figure 3.A and 3.B) (ter Braak 1987; Ludwig and Reynolds 1988; ter Braak and Verdonschot 1995).



A B

Figure 3. Correspondence analysis with 90% of inertia: A. Distributions of species based on the number of individual vs. station based on sampling time; B. distributions of species based on the total length vs. station based on sampling time. Fish1-fish112 represents number of individual of species and L1-L112 represents total length of species



A B

Figure 4. The estimated contribution for a number of species (A) and a number of fish (B) on the mature phase from seagrass beds to coastal water of northern Bontang City, East Kalimantan, Indonesia

Table 3 shows that the contributions of *S. doliantus* (31.19%), *G. filamentosus* (26.38%), *S. canaliculatus* (14.65%), *A. kallopterus* (10.28%), *S. guttatus* (10.20%) were larger than other species stated on both stations in forming a fish community of seagrass beds. *A. kiensis*, *L. lentjan*, *L. fulvus*, *P. bifasciatus* and *S. indicus* tended to be critical species on ST1 while *P. albilabris*, *S. ciliatus*, *P. quadrilineatus*, *L. elongatus*, and *S. boops* tended to be key species on ST2.

The density of fishes tended to be higher in ST1 compared to ST2, showing that the abundance relationship between the two stations is positively correlated (Table 4). This fact indicated that when the population of fish species in ST1 is higher, the number of fish species population in ST2 will also increase and vice versa (Figure 2.A). Study based on the total length size of the fishes showed that the average total length of fishes in ST1 tended to be shorter than that in ST2 (Table 2). It shows that fishes with smaller sizes tended to be found in ST1 and fishes with larger sizes from the same species tended to be found in ST2 (Figure 2.B). The selection of habitat characteristics by the fish communities in the seagrass is related to seagrass beds (McCloskey et al. 2015) as nursery ground especially in the juvenile phase (Jones 2014) and dietary changes (Lepoint et al. 2016) in the adult (Dromard et al. 2017) or migratory phase with regard to age (phase) (Ambo-Rappe et al. 2013; Honda et al. 2013; Phinrub et al. 2014; Oliveira et al. 2016).

Temporal patterns. Species of predator fishes found in ST1 (Genera: *Acreichthys, Arothron, Carangoides, Cephalopholis, Dexillichthys, Diodon, Epinephelus, Gymnothorax, Hemirhampus, Himantura, Leiognathus, Lethrinus, Lutjanus, Mulloidichthys, Paramonacanthus, Paraplotosus, Parupeneus, Pelates, Pentapodus, Pentaprion, Platax, Platybelone, Pseudomonacanthus, Rastrellinger, Scarus, Scolopsis, Scomberoides, Taeniura,* and *Upeneus*) were longer in size than that found in the ST2. This condition shows that the existence of seagrass beds in ST1 was more likely to become the place for smaller fishes to find shelter and food (Cucio et al. 2016); their existence attracts predator fishes originated from coral reef ecosystem (Verweij et al. 2008). This shows the tendency of the ST1 role as a nursery ground and ST2 as a feeding ground. This fact confirmed the role of seagrass beds as a nursery grounds (Verweij et al. 2008; Campbell et al. 2011) and a feeding ground (Hantanirina and Benbow 2013; Blandon and zu Ermgassen 2014) and on that mature phase in part of the big fish species will be going to other ecosystem which is specific to a coral reef as their habitat (Allen 1999).

The above phenomenon shows a distribution or migration of the same fish species which made ST1 and ST2 as their habitat at different times. This condition can be seen from diversity index value, similarity, and dominance values which showed a positive correlation between two stations (Table 4). The high level of diversity index value and similarity as well as the lower level of dominance index value in both stations shows that seagrass beds had played an important role in preserving fish biodiversity in coastal water (Nadiarti et al. 2012) which was confirmed from the fish connectivity (Unsworth et al. 2007; Waycott et al. 2009) in both stations.

The estimated contribution for a number of species and a number of fish on the mature phase from seagrass beds to coastal water, shows that seagrass bed contributed significantly not only to the coral reefs but also to coastal water, mangrove, estuaries, inshore/offshore reefs, mud/sand bottom, and pelagic-neritic), while species staying permanently in seagrass beds was over 8.9% (Figure 4). Physical interaction among fishes in the two stations had made seagrass beds as a buffer zone for physical distribution of fish species found in the coastal ecosystem. The fact shows the existence of seagrass beds as an ecosystem can connect fish species between mangrove and coral reef ecosystem as well as in other ecosystems. This condition gives us the ability to forecast the impact of losing seagrass beds to fish species biodiversity in the coastal ecosystem.

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