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Fish communities associated in seagrass beds correlated to the characteristics of their habitat at the Coast of Jepara, Central Java, Indonesia

Ita Riniatsih*, Ambariyanto Ambariyanto, Ervia Yudiati and Retno Hartati

Departement of Marine Science, Faculty of Fisheries and Marine Science, Diponegoro University Jl. Prof Soedharto, SH. Tembalang, Semarang 50275, Indonesia

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ABSTRACT

Seagrass beds in the world are currently decreasing, one of which is caused by physical disturbance as a result of anthropogenic impacts. Those conditions may decline the seagrass area and potential for the habitat loss of various types of marine biota which live in association within the ecosystem, including a decrease in fish abundance and diversity in seagrass beds. Seagrass and fish sampling activities have been carried out in seagrass beds in Bandengan, Teluk Awur and Panjang Island waters situated in Jepara regency, Central Java Province of Indonesia. The sampling period was conducted in March and September 2018. Seagrass sampling was done using the quadratic line transect method, and fish sampling was carried out using visual census method on the seagrass line transect. The results of this study showed that Bandenganwaters had the highest seagrass coverage (68.5%) consisting of *Enhalus acoroides*, *Thalassia hemprichii* and *Cymodocea serrulata*, and he lowest was in i Teluk Awur (32%) comprising *E. acoroides*, *T. hemprichii*, *C. serrulata* and *Syringodium isoetifolium*. Twenty three species were found in Coastal of Jepara with average abundance of 0.511 indv.m^{-2}. The number of fish and fish species were strong to very strong relation to seagrass density, coverage and canopy. PCA analysis also showed that the abundance of fish were more affected by seagrass density. This research has proven that the conditions and species composition of seagrass can affect fish biodiversity.

Key words : *Abundance, Biodiversity, Fish, Seagrass density,*

Introduction

Seagrass grows in coastal waters and has a very substantial function to support the stability of another coastal ecosystem. Seagrass beds as a shallow marine ecosystem are linked to several highly productive ecosystems around them, such as coral reefs and mangroves (Henderson *et al.*, 2019; Moussa *et al.*, 2020; Andriyono and Suciyono, 2020). Primary and secondary productivity of seagrass beds is relatively high, including epiphytes and benthic algae, which can produce abundant organic matters so it can support the diversity of fish and benthic invertebrate organisms associated with the ecosystem (Rahmawati *et al.*, 2012; Soedarti *et al.*, 2017).

Fish inhabit and use seagrass ecosystem as spawning, nursery and foraging area (Irawan *et al.*, 2018; Purnobasuki *et al.*, 2021). Fish provide food and possess significant economic values for coastal community (Hantanirina and Benbow, 2013; Ruaeny *et al.*, 2015; Hariyoto *et al.*, 2019). The diversity of juvenile fish in seagrass beds is usually related to their surrounding ecosystem. Moussa *et al.* (2020) found that the relationship among seagrass, mangrove and coral reef ecosystems showed that seagrass ecosystem is a very important habitat for fish. Fish abundance is usually higher in high-density seagrass beds composed of either one seagrass species (monospecific) or more than one seagrass species (multispecific) than that in low-density seagrass beds and non-vegetated areas (Rina *et al.*, 2018). This is due to the fact that seagrass beds have an ecological role in the life cycle of fish. The condition of the seagrass beds with dense seagrass stands and canopy composed by seagrass leaves is favoured by fish as a shelter and foraging area for food. Several species of fish consume microorganisms and epiphytes on the seagrass leaves for their food. The existence of fish in seagrass beds in Indonesia has been widely elaborated in previous studies. Irawan *et al.* (2018) and Ambo-Rappe *et al.* (2013) stated that there are more than 14 and 24 fish families found in seagrass beds in Bontang, Kalimantan (Borneo Island) and in Spermonde waters respectivelly. Meanwhile, Rahmawati *et al*. (2012) found 73 species out of 1825 fish caught in seagrass ecosystem in Kendari waters, Southeast Sulawesi. In addition, the seagrass beds of Sibu, Tidore Kepulauan City, North Maluku Province habituated by 10 families of fish (Rina *et al.*, 2018).

The efforts to preserve and manage seagrass beds become much more substantial. However, the recent fact showed that some seagrass ecosystems in the world have immensely decreased (Jones, 2014; Irawan *et al.*, 2018). Anthropogenic impacts of upland input, rising water temperatures, changing in tidal patterns and global climate as well as natural disasters may lead to a decrease in seagrass conditions (Horinouchi *et al.*, 2016; Nugraha *et al.*, 2016). These declining of seagrass beds condition will affect the biota associated in the ecosystem. Likewise, what happened in the seagrass beds in Jepara waters recently showed a decline area and coverages (Hartati *et al.*, 2012; Riniatsih *et al.*, 2013). Community activities in the coastal areas around the seagrass beds can affect its condition, including reclamation for housing construction, fishing activities, shrimp farming, shipping traffic and marine tourism. This is assumed to bring a negative impact on decreasing the abundance and diversity of juvenile fish living in the seagrass beds. Therefore the present study was aimed to identify fish biodiversity in three different seagrass beds locations in Jepara Waters and to find out the role of the seagrass beds as a habitat for fish.

Materials and Methods

Study Area

This study was conducted in March and September 2018 in the two seagrass beds sub-stations of Station Bandengn, Teluk Awur and Panjang Island (Table 1; Figure 1). These three research stations represent different conditions, in which the Bandengan waters is a port for tourists boats and experiencing beach reclamation for residential house development; TelukAwuris close to a mangrove ecosystem and shrimp pond culture (adjacent the sampling area), as well as artisanal fishing activities done by local fishermen; while in Panjang Island, there is a coral reef ecosystem, marine tourism activities and port for tourist boats.

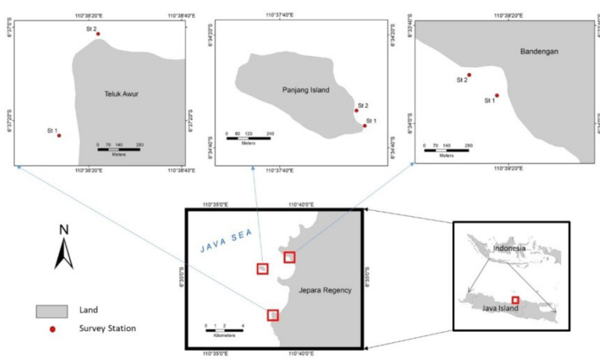

Fig. 1. Map of Research Location in Bandengan, Teluk Awur, and Panjang island waters, Jepara regency

Seagrass and Fish Sampling

The line transect referred to the LIPI method (Rahmawati *et al.*, 2017) was used to obtain the data

Table 1. Geographical position of sampling stations and substations atBandengan, TelukAwur and Panjang Island waters, Jepara, Central Java, Indonesia

No	Station	Sub-station 1		Sub-station 2	
1	Bandengan	6°33'50.1"S	110°39'11.9"E	6°33'54.3"S	110°39'17.6"E
2	Telukawur	6°37'01.4"S	110°38'22.0"E	6°37'21.2"S	110°38'21.6"E
3	Panjang Island	6°34'34.5"S	110°37'51.7"E	6°34'38.0"S	110°37'52.5"E

of seagrass coverage. The seagrass sampling was conducted along 100 m line transect which was drawn perpendicularly from the coastline towards the sea with 3 replications. The seagrass stands were counted using a quadrant frame covering an area of 0.25 m^2 placed on the right side of the transect line in every 10 m intervals. Seagrass data were included species composition, number of stands, canopy length of seagrass leaves, and seagrass coverage.

Fish composition and abundance were sampled using visual census method (Rahmawati *et al*., 2017) at the area of 20 m of 2-meters distance of left and right aside along 100 m seagrass transect line. The observations were carried out triplicate at each substation. Water quality parameters, including temperature, salinity, depth, and transparency was also measured along with seagras and fish sampling.

Data Analysis

Seagrass data were calculated for their density (D, shoot.m^{-2}) and seagrass coverage (%). Fish data were analyzed concerning their species composition, density, and thir community structure such as diversity (H'), similarity (E) and dominance (C) index. Correlation between species fish distribution and habitat was analyzed by linear regression and Principal Component Analysis (PCA) and Correspondence Analysis (CA) using SPSS Ver.17 were done to understand the effect of seagrass condition on fish abundance.

Results and Discussion

There were six seagrass species found in the three stations, i.e. *Enhalusa coroides, Thalassia hemprichii, Cymodocea serrulate* and *Cymodocea rotundata* which were recorded from all stations, while *Halophila ovalis* and *Syringodium isoetifolium* were only found in Bandengan and Panjang Island. The highest and the lowest seagrass coverage was found in Bandengan and Teluk Awur Station respectively. The data on seagrass density, seagrass coverage, and length of seagrass leaves (canopy) were presented in Table 2. The highest leaf length measurement showed by *E. acoroides*. This species serves as a protection for the surrounding small seagrass species and to calm the waves (Hartati *et al*., 2012; Irawan *et al*., 2018).

The seagrass ecosystem in sampling station of Jepara waters were inhabited by 221indv. of fish (0.511 indv.m^{-2}) composed of 23 species (Table 3). The lowest number of species and fish abundance were found in TelukAwur Waters. The highest abundance of fish was 0.783 indv.m^{-2} (in Bandengan waters) and the highest fish composition was 22 species (in Panjang Island). The highest abundance species in Bandengan, TelukAwur and Panjang Island seagrass ecosystems were *Siganus javus* (0.106±0.055 indv.m^{-2}), *Mugil chepalus* (0.050 ± 0.035 indv.m^{-2}), and *Ephinephelusacoioides* (0.038 ± 0.002 indv.m^{-2}) respectively.

Seagrass beds provide habitat for many species

Table 2. The species, length of the leaf, density and coverage (±SD) of the seagrasses in Jepara Waters of Central Java, Indonesia

Station	Species	Length of leaf (cm)		Density (shoot.m^{-2})		Coverage (%)	
		Range	Mean±SD	Range	Mean+SD	Range	Mean+D
Bandengan	*E. acoroides*	60-94	76.63±13.10	4 - 16	11.9±3.53	9.34-14.8	12.13±3.08
	T. hemprichii	13-21.4	16.05±2.87	40-176	139.53±50.56	17.61-20.31	19.15±1.21
	C. serrulata	6-12.5	8.64±2.16	48-150	155.46±37.23	21.21-28.21	24.49±3.31
	H. ovalis	2.3-2.5	2.27±0.15	4-12	2.67±1.39	1.32-1.51	1.415±1.32
TelukAwur	*E. acoroides*	55-157	123.25±32.3	4-24	10.33±3.75	5.47-7.23	05.90±0.98
	T. hemprichii	4.5-6.4	5.96±0.64	40-120	84.66±31.03	5.68-10.04	8.03±1.8
	C. serrulata	3.2-5.7	5.16±1.04	80-167	141.5±17.88	15.34-20.68	17.29±2.06
	C. rotundata	8.5-10.3	9.78±0.67	40-120	90.33±29.57	1.7-2.65	2.31±0.45
	S. isoetifolium	7.8-12.4	11.28±1.73	36-80	58.14±11.82	2.46-2.84	2.65±0.27
Panjang Island	*E. acoroides*	60-83	77.2±7.98	4-16	17.65±6.74	3.51-4.69	4.29±0.55
	T. hemprichii	6.7-8.3	7.65±0.64	40-120	98.33±22.05	7.78-15.61	10.49±3.65
	C. serrulate	4.6-7.2	6.575±0.88	4-8	173.8±34.42	20.38-26.7	35.15±3.06
	C. rotundata	6.8-9.5	8.46v1.02	40-60	85.16±23.4	6.31-10.56	8.54±2.36
	S. isoetifolium	6.5-7.7	7.09±0.37	80-120	31.75 ± 15.4	1.32-2.46	1.85±0.61

of fish (Ambo-Rappe *et al.*, 2013) and other marine invertebrates (Avila *et al.*, 2015), especially *E. acoroides* and *C. rotundata*, the vegetation preferably chosen by many species of fish as shelter and association (Irawan *et al.*, 2018). However, fish and seagrass association in Bandengan waters showed that the highest fish abundance was found in seagrass habitats with *E. acoroides* and *C. serrulata*. The same finding byHorinouchi *et al.* (2016) showed that the presence of *E. acoroides* and *C. rotundata* species supports a relatively high abundance of fish. Panjang Island Station has a highest number of species. The existence of coral reef ecosystems around the seagrass beds is thought to provide an abundance of several reef fish species found at that station (Latuconsina *et al.*, 2012).

The coastal area with different density and canopy of seagrass have varied number of fish. The number of fish were connected in a liner equation with seagrass density and canopy (lenth of seagrass leaf). Both has strong and very strong positive relationship with correlation coefficient (ρ) range of

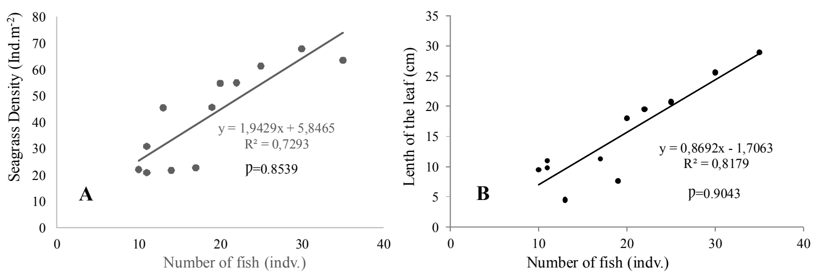

Fig. 2. Relation between seagrass density (A) and number of fish and between length of the leaf (canopy) with number of fish (B) in seagrass ecosystem of Jepara Waters.

Table 3. Species composition, abundance (indv.m^{-2}) and relative abundance (%) of the fish in the seagrass ecosystems in Jepara Waters of Central Java, Indonesia

Fish Code	Fish Species	Bandengan		TelukAwur		Panjang Island	
		Fish abundance ± SD	Relative abundance (%)	Fish abundance ± SD	Relative abundance (%)	Fish abundance ± SD	Relative abundance (%)
F1	*Arius thalassinus*	0.075±0.035	9.57	-	-	0.039±0.038	4.41
F2	*Apogon fragilis*	0.033±0.014	4.26	-	-	0.016±0.013	1.47
F3	*Apogonhoevenii*	0.050±0.025	6.39	0.016±0.013	1.92	0.018±0.014	2.94
F4	*Amblygobiusphalaena*	0.031±0.024	3.99	0.016±0.014	3.85	0.038±0.014	8.82
F5	*Yongeichthys nebulosus*	0.013±0.014	1.60	-	-	0.029±0.024	4.41
F6	*Istigobiusdecoratus*	0.029±0.024	2.39	-	-	0.0183±0.014	2.94
F7	*Lutjanus fulviflamma*	-	-	0.017±0.014	3.85	0.029±0.024	4.41
F8	*Ephinephelusfuscoguttatus*	-	-	0.033±0.025	3.85	0.031±0.031	7.35
F9	*Syngnathoidesbiacaleatus*	0.016±0.013	0.80	-	-	-	-
F10	*Gymnothoraxnudivomer*	0.031±0.031	3.99	0.016±0.013	1.92	0.013±0.005	2.94
F11	*Chaetodon klenii*	0.035±0.029	3.19	0.033±0.025	3.85	0.031±0.008	7.35
F12	*Ephinepheluscoioides*	-	-	0.044±0.031	13.46	0.038±0.002	8.82
F13	*Aethalopercarogaa*	0.025±0.020	3.19	0.006±0.013	1.92	0.019±0.004	4.41
F14	*Halichoeresleucurus*	0.006±0.,013	0.80	0.016±0.013	1.92	0.025±0.020	5.88
F15	*Chelmonmuelleri*	0.033±0.025	1.60	0.019±0.024	5.77	0.013±0.014	2.94
F16	*Abudefduf bengalensis*	0.025±0.020	3.19	0.018±0.014	3.85	0.031±0.024	7.35
F17	*Amphiprionacellaris*	0.049±0.038	2.39	0.029±0.024	5.77	0.013±0.014	2.94
F18	*Mugil dusumeira*	0.058±0.048	4.79	0.038±0.032	11.54	0.006±0.013	1.47
F19	*Mugil chepalus*	0.075±0.061	9.58	0.050±0.035	15.38	0.013±0.025	2.94
F20	*Sphyraena genie*	0.081±0.024	10.38	0.035±0.029	7.69	0.013±0.025	2.94
F21	*Siganusjavus*	0.106±0.055	13.57	0.031±0.024	9.62	0.013±0.025	2.94
F22	*Siganusvermiculatus*	0.069±0.043	8.78	0.016±0.013	1.92	0.025±0.020	5.88
F23	*Paramonacantusfilicauda*	0.075±0.035	5.59	0.016±0.013	1.92	0.019±0.024	0.20

0.8539-0.9043 respectively (Figure 2). While relation between seagrass cover (A) and number of fish species as well between length of the leaf (canopy) with number of fish species in seagrass ecosystem of Jepara also showed strong positive relationship with correlation coefficient (ρ) range of 0.8186-0.859 (Figure 3).

The relationship between coastal ecosystems including seagrass beds, mangroves and coral reefs has a complementary relationship in population abundance and fish species associated within it (Bunuel *et al.*, 2021). Similarly with a research carried out in the Adriatic Sea, it showed a comparative relationship between the high diversity, abundance and distribution of fish associated with seagrass habitat more than those from habitats without vegetation. Differences in fish populations are mainly caused by differences in temporal size and fish size of several species, and this indicates different habitat preferences (Park and Kwak, 2018; Alam *et al.,* 2020). In addition, the composition of fish in seagrass beds varies widely based on time and area so that it cannot be simply generalized (Rahmawati *et al.*, 2012). Some fish species permanently inhabit seagrass beds while other fish species are only temporary, for example at the juvenile stage (Jones, 2014; McCloskey *et al.*, 2015), or are seasonal inhabitants, or fish that move from adjacent habitats such as coral reef ecosystems or mangrove ecosystems to seagrass beds for foraging (McCloskey *et al.*, 2015). Fish abundance and diversity in seagrass depends on the species composition of seagrass (Rahmawati *et al.*, 2012), fish in juvenile stage prefer inhabitate in *E. acoroides* seagrass species with high leaf crowns, not only providing a quiet place from the current but also giving space for shelter from predators (Irawan *et al.*, 2018). The coastal area with different density and canopy of seagrass have varied number of fish.

Based on the observation, of several commercially important fish species found during the study, the sizes of fish ranged between 3-5 cm or categorized as in the juvenile stage. This result supports the premise stating that seagrass beds possess a high ecosystem service value as nursery habitats. Important commercial fish species found as juvenile included *Siganusjavus, Siganusvermiculatus, Ephinephelus coioides, Mugil dusumeira, Mugil chepalus,* and *Lutjanus sp* which are commonly found in seagrass beds (Bertelli and Unsworth, 2014; Lilley and Unsworth, 2014; Mc Closkey and Unsworth, 2015; Pinandita *et al.*, 2017).

Ecological index showed the community structure of fish in Coastal of Jepara in which the diversity and eveness index in all stations was in moderate condition, while the dominance index was in low to moderate conditions (Table 4). This condition illustrates that the fish diversity in the three locations has moderate diversity, high similarity and no dominance, which indicates that the habitat is in a stable condition.

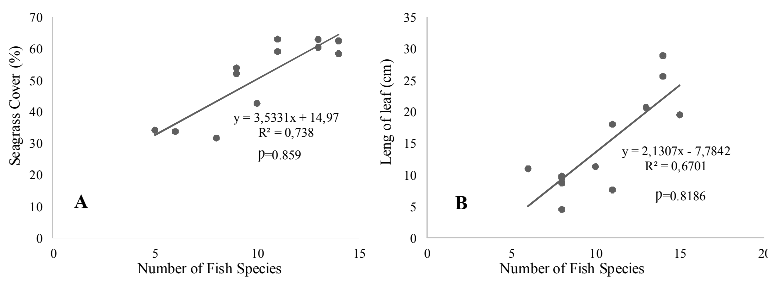

Fig. 3. Relation between seagrass cover (A) and number of fish species and between length of the leaf (canopy) with number of fish species (B) in seagrass ecosystem of Jepara Waters.

Table 4. The diversity, similarity and dominance index of fish community from three research locations in Coastal of Jepara, Indonesia

Station	Diversity Index	Eveness Index	Dominance Index
Bandengan	1.61-1.87	0.86-1	0.16-0.44
TelukAwur	1.75-2.25	0.97-0.98	0.12-0.180
Panjang Island	1.04-2.23	0.95-0.97	0.11-0.38

The influence of environmental conditions (temperature, salinity, pH, water transparency, water depth, dissolved oxygen, seagrass density) on fish abundance in different station in Coastal of Jepara were analyzed using PCA (Principle Component Analysis). The horizontal axes represent the first PCA axis, the vertical axes represent the second PCA axis. It is revealed that at all sampling station (Bandengan, TelukAwur, and Panjang island) the fish abundance were more affected by seagrass density and other factor, such as temperature in TelukAwur Waters, salinity in Panjang Island (Figure 4).

The PCA (Principal Component Analysis) analysis illustrates that there were several parameters water quality in the three research locations which affected fish abundance. Fish abundance in TelukAwur Station was seen to be highly influenced by salinity and density of seagrass. Salinity in TelukAwur waters is still classified as optimal for fish life ($30-31.5^{o}/_{oo}$), and the seagrass density ranges from 77-150 ind. m^{-2}. Meanwhile, it can be seen in Bandengan Station that there were parameters affecting fish abundance was seagrass density, water depth, salinity and dissolved oxygen. Seagrass density ranged from 178-240 ind. m^{-2}, water depth was 80-158 cm, salinity fluctuated from $30-31.5^{o}/_{oo}$ and while dissolved oxygen varied from 5-5.5 $mg.l^{-1}$. These parameters were still categorized as optimal conditions according to Minister of Environment Decree No. 51 Year 2004 (Local Term: Kepmen LH No.51/2004) which states that the quality standard for dissolved oxygen is >5 $mg.l^{-1}$.

PCA analyses showed that the abundance of fish at Panjang Island was influenced by seagrass density, temperature and dissolved oxygen parameters. Seagrass density at these locations ranged from 92-197 $ind.m^{-2}$, dissolved oxygen ranged from 4.5-5.5$mg.l^{-1}$ and the temperature ranged from 28.5-30.5°C. This temperature slightly exceeds the quality standard for marine life (optimal temperature for seagrass life ranges from 28-30 °C based on Kepmen LH No. 51 of 2004). An increase in water temperature at the optimal range may affect the metabolic process of seagrass and also increase seagrass biomass which will influence the increasing fish abundance (Tebaiy *et al.*, 2014). The results of the analysis on the condition of seagrass and fish at the three locations of observation station showed that the density of the seagrass substantially affect the abundance of fish found. Several studies have shown that in low seagrass density conditions, there are usually fewer fish associated within than that in habitats with high seagrass density. The locations in the seagrass beds with the characteristics of certain seagrass species chosen by fish communities to be their habitat is likely high related to the habitat they prefer for nursery ground, especially for juvenile

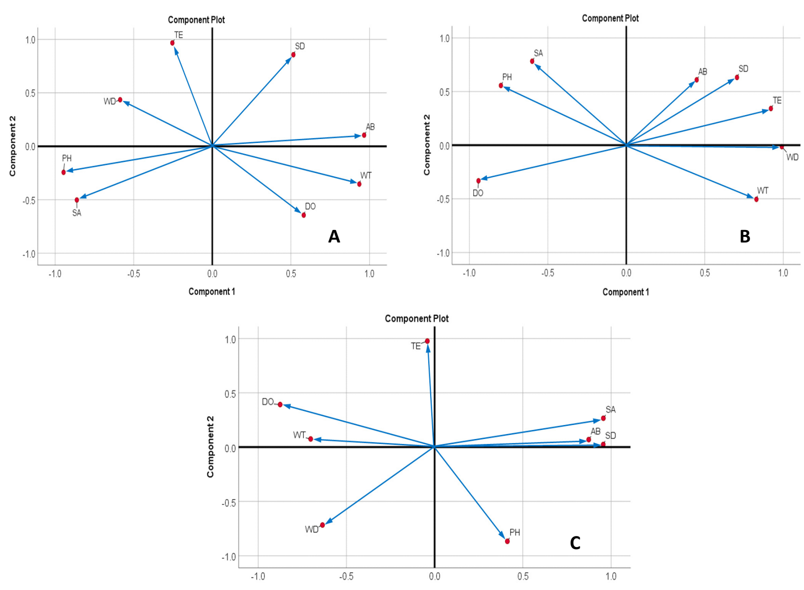

Fig. 4. Principal component analysis (PCA) of fish abundance (AB) for the three seagrass ecosystem i.e. Bandengan (A), TelukAwur (B) and Panjang Island (C) of Coastal of Jepara, Indonesia. Eigenvalues of the first, second and third PCA axis are (A) 0.55 and 0.33; (B) 0.63 and 0.27, and (C) 0.55 and 0,31 respectively.

stage fish (Jone, 2014; McCloskey *et al.*, 2015), and dietary changes into adult (Lepoint *et al.*, 2016; Dromard *et al.*, 2017) or migratory phase regarding to age (phase)(Honda *et al.*, 2013; Phinrub *et al.*, 2014; Oliveira *et al.*, 2016).

Based on the results of Correspondence Analysis (CA) (Fig. 5), there were 3 groups of fish habitats depended on the location. In Bandengan station which has high seagrass density, many estuary fish species *A. thalassinus* were found. It might have come from Sekembu River which flew away to this coast. *Siganusjavus* and *S. vermiculatus* were also most abundant in these locations. This might be due to relatively long leaf canopy seagrasses condition (Table 2) as has been stated by Jone (2014) and McCloskey and Unsworth (2015). In addition, this sampling station was close to coral reef edge which becomes fish habitat for *Siganus sp*. (Polte and Asmus, 2006). Meanwhile, it was recorded in this present work that fish inhabited in Teluk Awur station were *Ephinephelu scoioides, Chelmon muelleri, Mugil dusumeira* and *Mugil chepalus* species. Those are categorized as important economic values fish (Pinandita *et al.*, 2017). Meanwhile, *Apogon fragilis, Amblygobiu sphalaena, Istigobius decorates, Lutjanus fulviflamma, Syngnathoides biacaleatus, Gymnothora xnudivomer, Halichoeresleucurus* and *Abudefduf bengalensis* were found in Panjang Island. This confirms that the seagrass beds bordered by coral reefs and presence of coral fragments substrate and massive corals among the seagrass vegetation is the most preferable habitat for these fish species (Park and Kwak, 2018).

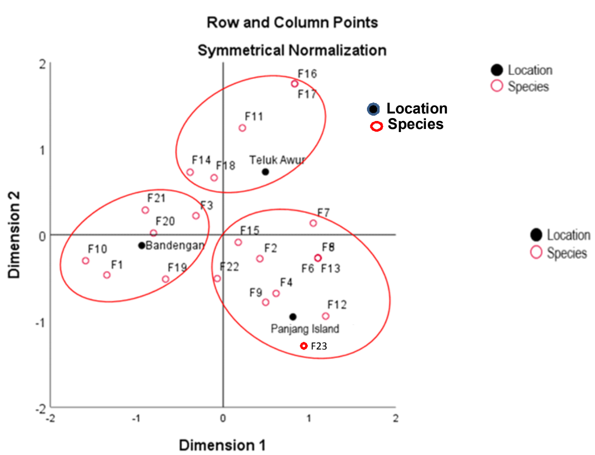

Fig. 5. Correspondence Analysis of fish species in the seagrass ecosystem in coastal of Jepara, Indnesia

Conclusion

It can be concluded that the diversity and abundance of fish in seagrass beds habitat is significantly influenced by the density and type of seagrass as the vegetation constituent in the seagrass bed.

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