Coral reef condition and distribution of reef fish in the coral reef of Panjang Island, Java Sea, Indonesia

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ABSTRACT

Panjang Island, a small adjacent island of Jepara Regency, is surrounded by a coral reef ecosystem. However, the reefs currently are suffered from high anthropogenic factors along with increasing tourism activity. Therefore, it is important to observe the coral reef diversity and abundance of reef fishes as the tourist's main attraction. Monitoring of coral reefs was carried out by using the line intercept transect (LIT) method while the fishes were observed by UVC (*Underwater Visual Census*) method. The result showed that the critical level in terms of percentage (%) of coral cover varied from very poor, poor, and medium level. The average critical level fell into the medium category of a percentage of coral cover was 23.21 %. Many factors cause the degradation of coral reefs, namely anthropogenic and natural. The most significant factors that affect the degradation of coral reefs are destructive fishing and coral mining, increasing the turbidity of waters and inhibiting coral growth, then leading to coral death. 1.067 fish numbers were found, which represent 7 families and 14 genera of reef fish. There were 50 (4.6 %) classified as target fish represents 3 genera, 96 (8.91 %) classified as indicator fish represents 1 genus, and 921 (85.24 %) classified as the major fish represents 5 genera. Major fish was dominated by the family of Pomacintridae with 827 fish (76.78 %). Analysis of the Ecological index showed that the diversity index (H') was moderate (1.579) means that the moderate distribution and community of reef fish moderate stability. Homogeneity Index (E) was high (0.848), meaning that the reef fish community is stable. Dominance Index (C') fell into low (0.278) and confirmed no genera dominates. Fish distribution has a lower relationship with percent hard coral cover (0.00 - 0.199). The fish abundance (R^2 =0.0328), Homogeneity Index (E) (R^2 =0.00014), Dominance Index (C') (R^2 =0.0581) suggests that the distribution of reef fish was not driven by the percentage of coral cover. Overall, the result of the study concluded that the majority of the coral reef in Panjang Island are already damaged, therefore the areal coral reef is hosted only a few fish and has a lower genera diversity of reef fish.

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Introduction

Coral reefs are complex and productive ecosystems (Bengen, 2013; Marshell and Mumby, 2015), which play an important role as the habitat of various types of fish and other marine organisms (Madiyani *et al.*, 2018; Suciyono *et al.*, 2019). There are 4000-5000 species of reef fishes that inhabit the Indo-pacific coral reefs (Lieske and Myers, 2002). The corals and the reef-inhabiting fishes have a strong mutual connection. The reefs provide an ideal place for reef fish to forage and relying on different substrata for critical resources such as shelter from predators and living space (Komyakova *et al.*, 2013; Wiguna *et al.*, 2018). While for corals, during grazing, certain reef fishes help to optimize coral reproduction (Cole *et al.*, 2008). It has been reported that the spread of Black Band Disease and other coral diseases can be mitigated by fishes (Cole *et al.*, 2009; Raymundo *et al.*, 2009; Luthfi *et al.*, 2020; Rosdianto *et al.*, 2020a; Rosdianto *et al.*, 2020b). However, nowadays, the conditions of the coral reefs are disrupted by various disturbances mainly attributed to the increasing human activities (Wisha *et al.*, 2019). The disruption of the coral reefs will have an impact on the ecosystem and various inhabitant organisms. In the worst-case scenario, conditions would bring about biodiversity changes in the ecosystem and ultimately lead to extinction (Ambariyanto, 2017).

The reef fishes group is the largest taxa of the vertebrate animals associated with coral reefs (Adrim, 2007; Rafly *et al.*, 2020). The existence and diversity of reef fish are determined by the coral reefs condition (Rondonuwu *et al.*, 2017). The main aspects of the reef condition that influence the composition of the resident fish are the live coral cover and topographic complexity (Cole *et al.*, 2008). A study conducted at the Dry Tortugas found that higher branch growth of staghorn corals increased the number of fish compare to the lower densities of corals (Huntington *et al.*, 2017). Indonesia Coral Reef Fondation/TERANGI, (2004) grouped coral fish based on their role: as target fish, indicator fish, and others. The target fish usually consist of fishes with an economic value and fish by the fishers such as Serranidae, Lutjanidae, and Kyphosidae. While indicator fish is a type of fish that mostly are feed on corals such as Chaetodontidae, the family of Lethrinidae, Acanthuridae, Mulidae, Siganidae Labridae (Chelinus, Himigymnus, Chaetodon), and Haemulidae. Major fishes are grouped of fishes generally in large quantities and widely used as ornamental seawater fishes such as Pomacentridae, Caesionidae, Scaridae, Pomacanthidae, Labridae, and Apogonidae.

Panjang Island, a small island about 2.8 km from the Jepara coast, is known as a tourist destination area surrounded by coral reefs (Munasik *et al.*, 2020). Increasing tourist activities, combine with natural disturbance and various anthropogenic activities at the adjacent Jepara coast, made the reefs experienced stressful conditions (Sabdono *et al.*, 2014). Those stresses cause a detrimental effect to the reefs, which are home to various organisms, including reef fishes (Suryono *et al.*, 2017). Therefore, it is important to observe the coral cover of Panjang Island, which provides crucial habitat for reef fishes. The corals and the fishes are the main tourist attraction of the island. This study results can be used for further management of the island.

Materials and Methods

The study was conducted at Panjang Island, Jepara Regency at the north coast of Central Java Province (Suraji *et al.*, 2015). Fourteen (14) sampling stations at Panjang Island were selected in this study (Figure 1.). Monitoring of coral reefs in the island was carried out using the line intercept transect (LIT) method (English *et al.*, 1997). Reef fish assessment was carried out using UVC (*Underwater Visual Census*) (English *et al.*, 1997; Sweatman *et al.*, 2003). Reef fish as the component of the coral reef ecosystem was censused visually and simultaneously with coral reef surveys. The transect was combined with a long swim method providing a more precise estimation of the abundance and biomass of large, high mobile species, patchy or clumped in distribution (Choat and Pears, 2003). Reef fish data were identified after the dive with reference according to Allen *et al.* (1998); Allen (1999) and Kuiter and Tonozuka (2001). The fish that were censused then classified into three large groups, namely: target fish, indicator fish, and major fish, according to their function and role. Those were target fish (economic and edible value fish as the target catch of fishermen), major fish that generally lives in coral reef ecosystem to protecting the balance of the ecosystem), and indicator fish (indicating the coral health) (Indonesian Coral Reef Foundation/TERANGI, 2004). The benthic live form was analyzed by manual live form 5.1. (Rahmat *et al.*, 2001).

The percentage of coral reef cover was calculated with the following formula by English *et al.*, (1997). The fish density was calculated with the following formula According to (Odum and Barrett (1971). Diversity Index was calculated by formula Wilhm (1975). Homogeneity index was calculated by the formula Krebs (2009). The dominance index is calculated by the formula Odum and Barrett (1971).

The correlation of the percentage of coral reef cover with the total number of reef fish and reef fish abundance, Diversity Index (H'); Homogeneity Index (E); Dominance Index (C') of herbivorous coral reef fish was calculated using the Linear Regression method (Cleophas and Zwinderman, 2016).

Fig. 1. Location of research in Panjang Island, Jepara. Java Sea

Results and Discussion

Condition of Coral reef

This study found 9 families of 13 genera of living coral in Panjang Island (Table 1). The results showed a decrease in the number of live coral families found compared to those reported by Indarjo *et al.* (2004), which reported that there were 54 species of corals included in 24 genera hermatypic corals that were found in the waters of Panjang Island. This is presumably due to the damage and death of coral reefs during the 6-14 year difference in the study time. The four most dominant genera of live coral present in almost all stations were Acropora, Porites, Goniastrea, and Favia. The observed results of coral reef condition showed that Coral cover percentage range from very poor category (5 %) in Station 11, to in the poor category (10 %-20%) in Stations 1, 2, 3, 4, 9, 10, 13 and medium category (30 %-40 %) in stations 5, 6, 7, 8,12, and 14, (Table 2). In average percentage (%) of a coral cover of living coral in Panjang Island fell in the medium category

in number 23.21%). High dead coral cover in most stations was due to a high level of degradation, directly affecting the loss of coral life. The results of the study were higher than what was reported by Indarjo *et al.* (2004) but lower than what was reported by (Suraji *et al.*, 2015). The medium category of coral cover coral reef of Panjang Island is due to the high cover percentage (%) of dead coral, stone, and sand compared to coral cover life (Table 2).

Two factors that cause the degradation of coral reefs were namely anthropogenic and natural. The field observations found that the most significant influence on the degradation of coral reefs at Panjang island is destructive fishing (Departemen Kelautan and Perikanan, 2006); and tourist activities (Badan Pusat Statistik, 2017). The fishes are fished by stepping on the reefs and collect the fishes or gleaning (Suryono *et al.*, 2017). Fishing using explosives, toxic materials, electricity, and using fishing gear that is destructive to the ecosystem in coastal areas and small islands are not allowed in the fishing zone. (Pemerintah Provinsi Jawa Tengah, 2018). Apart from that, coral mining by local and from another regency fisherman for building accelerates the process of coral reef degradation (Dinas Lingkungan Hidup Pertambangan dan Energi Kabupaten Jepara, 2007). Coral mining activities as a building material carried out by residents who live close to the island for building accelerates the process of coral reef degradation, speed up the abrasion process of the Island (Badan Perencanaan Pembangunan Daerah Jepara, 2003). Uncontrolled coral mining was a destructive activity for the coral reef of Panjang Island and had been happening for more than 20 years (Suara Merdeka, 2008; Personal Observation). Coral mining can increase the turbidity of waters and inhibits coral growth, even kills coral reefs (Ariani, 2006).

Distribution of Reef Fish

Several fish rely on coral reefs, therefore habitat degradation and coral loss will have significant consequences for biodiversity and productivity of reef fish assemblages (Coker *et al.,* 2014). A total of fish was found in the number of 1.067, representing 7 of a family of 14 genera of reef fish (Table 3). The figure of distribution of reef fish in each station can be seen in Figure 2. Figure 3 explained the percentage of reef fish distribution on coral reefs in Panjang Island. There were some 50 fish (4.6 %) target fish represents 3 genera; a sum of 96 fish (8.91 %) indi-

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Table 1. Family and Genera of Living coral in coral reefs of Panjang Island, Java Sea

No.	Family Genera	Station													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
I	Acroporidae														
1.2.	*Acropora*	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Montipora	x	x	x	x	x	x	x	x	x	x	x	x	x	x
II	Oculinidae														
3.	*Galaxea*	x	-	x	x	-	-	-	-	x	-	x	-	-	-
III	Agariciidae														
4.	*Pavona*	x	-	x	x	-	-	-	x	x	-	x	-	-	x
IV	Pectiniidae														
5	*Pectinia*	x	x	-	x	x	x	x	x	x	x	x	x	x	x
V	Poritidae														
6	*Porites*	x	x	x	x	x	x	x	x	x	x	x	x	x	x
7	*Goniopora*	x	x	x	x	x	x	x	x	-	x	x	x	x	x
VI	Pocilloporidae														
8.	*Stylophora*	-	x	-	-	-	x	x	-	-	x	-	x	x	-
VII	Mussidae														
9.	*Symphyllia*	-	x	-	-	x	x	x	x	x	x	-	x	x	x
VIII	Merulinidae														
10.	*Merulina*	-	-	-	-	x	-	-	x	-	-	-	-	-	x
11.	*Hydnophora*	x	x	x	x	x	x	x	-	x	x	x	x	x	-
IX	Faviidae														
12	*Goniastrea*	x	x	x	-	x	x	x	x	x	x	x	x	x	x
13	*Favia*	x	x	x	x	x	x	x	x	x	x	x	x	x	x

Note :

- = none

X = exsist

cator fish represents 1 genus and sum of 921 fish (85.24 %) major fish represents 5 genera. Family of Pomacentridae contribute a sum of 827 (76.78 %) Major fish.

Target fish found in Panjang island, Jepara only a two (2) families e.i Nemipteridae and Serranidae. Low target fish at Panjang island, Jepara coral reefs because of intensive fishing activities, and low coral cover. Campbell and Pardede (2006) and Yuliana *et al.* (2017) reported that fishing activity affects fish abundance, especially the use of fishing gear that is not environmentally friendly. The small number of genera of target fish was found in the coral reefs of Panjang Island, suspected that fishing activities have been relatively intensive for a long time. This island is one of the tree fishing grounds for the fisherman in the Jepara Area (Kunarso *et al.*, 2016). Therefore, target fish were under pressure. Moreover, Imron *et al.* (2020) reported that during the last five years (from 2015 - 2019), production of catch per unit effort (CPUE) tends to experience a significant decline in Jepara fish Landing. The abundance of target fishes, a group of small fish predators such

as Nemipteridae and Serranidae became low due to intensive fishing activities (Choat and Bellwood, 1991). The abundance of target fishes, a group of small fish predators such as Nemipteridae and Serranidae became low due to intensive fishing activities (Choat *et al.,* 2002). High anthropogenic pres-
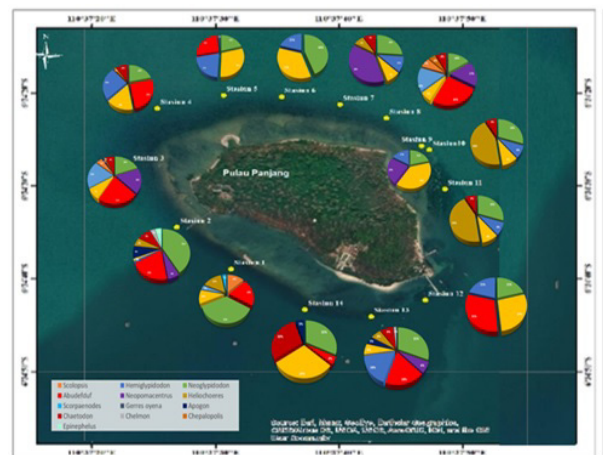

Fig. 2. Distribution of reef fish of the coral reef in Panjang Island Jepara, Java Sea

sure on all coral reefs areas in Panjang Island has a positive impact on fish abundance. The pressure is causing the food shortage and lead to lower fish abundance. Based on the Shannon-Wiener category, the diversity index in 14 stations classified in the moderate category. This indicates that the coral reef ecosystem at Panjang Island experienced pressure or in a decreased state. The target fish group is dominated by Nemipteridae, which is classified as herbivorous fish (Choat and Clements, 1998). The indicator fish is dominated by Chaetodon, a genus of obligate corallivorous fish (Cole *et al.,* 2008; Munasik *et al.,* 2012).

The Chaetodontidae family is the type of indicator fish for reefs coral because the fish from the family Chaetodontidae is a type most strongly associated with corals or depends on its coral reef (Suharyanto and Utojo, 2007). The Chaetodontidae family, known as a butterflyfish, is a reef fish family that plays a reef health indicator. The fish showed a strong obligate symbiosis with the coral since the fish feed on corals (Rondonuwu *et al.,* 2014). Butterflyfish is recognizable with the characteristics of many colors variation. In a healthy coral reef, many types of fish indicators will be observed. Only a small number of indicator fish was found in the coral reef of Panjang Island, Jepara. The results revealed that the coral reefs condition in Panjang Island was not ideal for Chaetodon fish.

The group major fish dominated by Pomacentridae include types of reef fish that exhibit

territorial behavior and narrow mobility around the reef coral, and the fish do not go away from food sources and places protection (Adrim, 2007). Masuda *et al*. (1984) said that most of the fish family of order Perciformes live in sedentary reefs coral. Food availability is still good for reef fish cause fish communities are not extinct and moved to other places to find food and places new shelter. The condition of a coral reef significantly affects the homogeneity Index of each fish community that inhabits these locations. This condition also applies to the fish community in the coral reefs of Panjang Island. Base on the ecological index, this study found that the reef fish community in the coral reefs of Panjang Island is in a very depressed condition caused by anthropogenic activities. The abundance of fish species major group (major family) because of habitat variations such as rocky, sand, coral reef, and sand for a place to live certain types of fish (Table 2.) The reef fish will not migrate to the place which is fur-
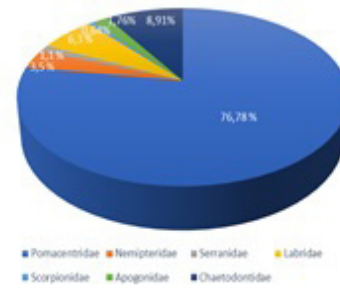

Fig. 3. Percentage (%) of family distribution of reef fish of the coral reef in Panjang Island Jepara, Java Sea

Table 2. Coral Reef Condition in Panjang Island, Java Sea

Station	(%) Hard Coral Live (HCL)	(%) Dead Hard Coral (DHC)	(%) Soft Coral (SC) (%)	Ruble (RB)	(%) Rock (RO)	(%) Sand (SD)	(%)Macro Algae (MA)	(%) Sponge/ Others (SP)
1	10	40	0	9.95	20	10	10	0.050
2	20	20	0	9.90	20	20	10	0.100
3	20	20	25	9.27	10	10	5	0.730
4	20	10	20	19.47	20	10	0	0.530
5	40	30	5	4.80	0	10	10	0.200
6	40	40	0	0	9.27	10	0	0.730
7	30	20	10	10	20	5	5	0.360
8	30	30	20	0	19.55	0	0	0.450
9	20	20	10	9.75	20	10	10	0.250
10	20	30	10	4.70	25	0	10	0.300
11	5	10	0	0	0	84.78	0	0.220
12	30	40	0	4.34	5	10	10	0.660
13	20	30	9.59	0	30	0	10	0.410
14	30	20	10	0	20	10	9.41	0.590
Average	23.928	25.714	8.542	5.155	13.840	13.555	6.386	0.398

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ther due to its habitat is suitable for development and growth (Honda *et al.*, 2013; Tamario *et al.*, 2019).

Family Pomacentridae represents one of the most common inhabitants of a coral reef and is the key species on coral reef ecosystems (Hixon and Brostoff, 1996; Coker *et al.*, 2014). Pomacentridae is one of the reef fish groups most abundant on tropical coral reefs, both in terms of the number of species and individuals. Fish solitary is a type of fish that lives in pairs or aggregates to become common and depending on the species. These fish inhabit coral reefs and rocky reefs and common in aquatic habitats shallow and piles of coral fragments, murky waters, harbor areas, and seagrass beds. Pomacentridae are a family that is most often found in a coral reef ecosystem. The high abundance of the Pomacentridae family is due to the characteristics of certain types of fish in this family, which has a character like clustering so that every time it is found, it is usually in numbers very much. The research results reported that at each observation station, a fish family of Pomacentridae is found in groups and large numbers. The results confirmed with a statement of Allen *et al.* (1998) that the Pomacentridae family of reef fish is a family of fish that is quite abundant in tropical waters. Family Pomacentridae fish has reported at least 187 known species in the Indian Islands East (Allen *et al.*, 2013). Pomacentridae is one of the damselfishes as one of a few reef fish families that are brood benthic eggs and tend to have an extended period of relatively short pelagic larvae (Wellington and Victor, 1989). Family Pomacentridae was generally herbivorous fish that play an important role in maintaining coral reef systems because it affects growth and diversity of algae and changing the structure of coral communities (Gobler *et al.*, 2006; Edwards *et al.*, 2014; Putra *et al.*, 2015). Herbivorous fish consume algae that dominate and fertilize their feeding area with fecal material (Choat *et al.*, 2002; Tolentino-Pablico *et al.*, 2008). Herbivores have long been recognized as having effect mitigation of algae on coral reefs (Carpenter, 1986). Also, herbivores influence benthic changes, diversity of herbivores, and coral reef restoration (Eynaud *et al.,* 2016) erefore, fish existence of Pomacentridae is indicator health of coral reef ecosystems in Panjang Island. The height of the Pomacentridae fish as a herbivore fish shows that the condition of the reef ecosystem the coral at that location is still in stable condition.
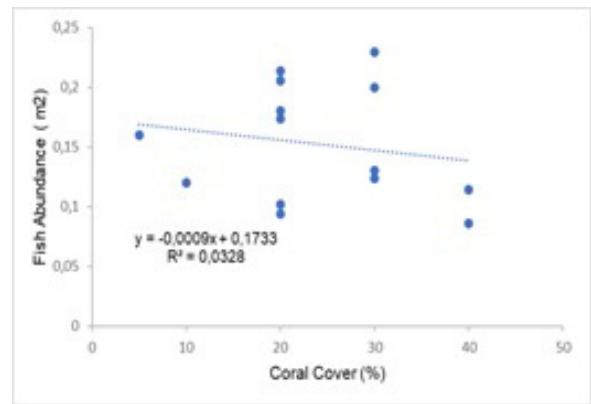

Fig. 4. The correlation of Reef Fish abundance (Fish/m²) with a coral cover of coral reef in Panjang Island Jepara, Java Sea
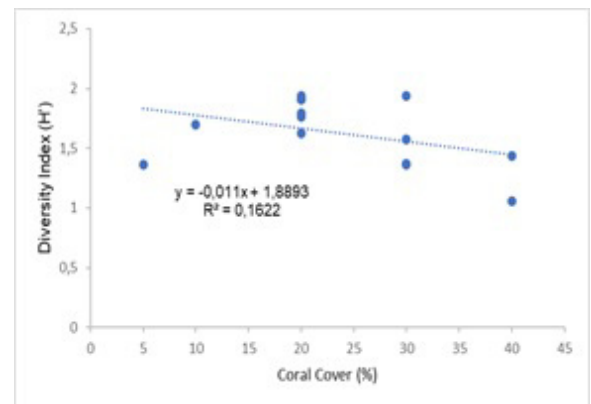

Fig. 5. The correlation of reef fish diversity Index (H2) with a coral cover of Coral Reef in Panjang Island, Jepara, Java Sea
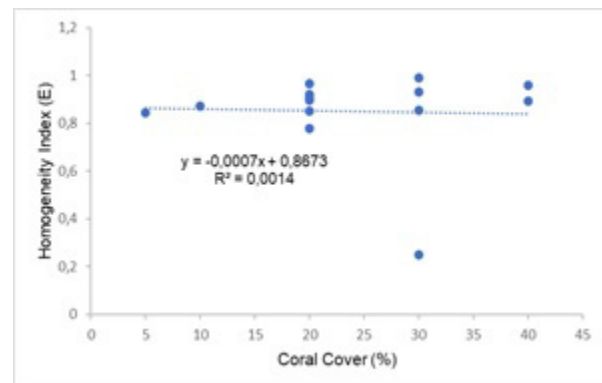

Fig. 6. The correlation of reef fish homogeneity index (E) with a coral cover of Coral Reef in Panjang Island, Jepara, Java Sea

Index Ecology of Reef Fish in Coral Reef of Panjang Island

Table 2. Showed the distribution of reef fish in the

coral reef of Panjang Island. The number of diversity Index (H') in a moderate category e.i 1.579 (Wilhm, 1975); Homogeneity Index (E) at high category e.i 0.848 (Krebs, 2009) and Dominance Index (C') at Low category e.i., 0.278 (Odum and Barrett, 1971). When the results of fish Abundance, Diversity Index (H'), homogeneity index (E), Dominance Index (C') were plotted with percentage (%) of coral cover, there was a low relationship with an (R^2) 0.0328; 0.1622; 0.0014 and 0.0581 respectively (Fig. 4. to Fig. 7). The live coral cover has a weak correlation to fish abundance, diversity index, homogeneity index, and dominance index of reef fish. The results mean that there was no significant influence between the percentage of live coral cover with the existence of reef fish. The reef fish distribution was not correlated with the percentage of coral reef cover. The results of this research are not compromising with other studies which found that the percent cover of coral reef correlates with fish distribu-

tion as reported by Bell and Galzin, 1984; Syms and Jones, 2000; Pratchett *et al*., 2006; Holbrook *et al*., 2008; Pratchett *et al*., 2011. However, similar results
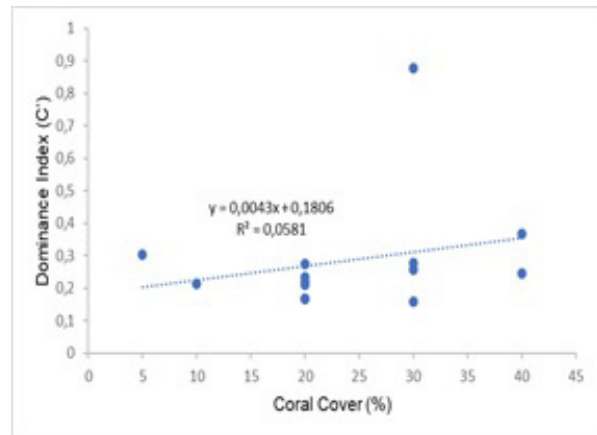

Fig. 7. The correlation of reef fish dominance index (C2) with a coral cover of Coral Reef in Panjang Island, Jepara, Java Sea

Table 3. Distribution of Reef Fish, Abundance, Diversity Index, Homogeinity Index, and Domination Index in Coral Reef of Panjang Island, Java Sea

Name of Fish	Station														Total	%
	1	2	3	4	5	6	7	8	9	10	11	12	13	14		
Target Fish																
Nemipteridae															**38**	**3.5**
Scolopsis	8	0	5	0	0	0	0	7	0	18	0	0	0	0		
Serranidae															**12**	**1.1**
Chepalopolis	0	0	0	1	0	0	0	0	0	0	0	0	0	0		
Epinephelus	0	4	2	0	0	0	0	0	0	0	0	0	0	0		
Indicator Fish																
Chaetodontidae															96	8.91
Chaetodon	0	8	7	5	0	0	6	8	0	7	7	0	9	34		
Chelmon	0	3	0	0	0	0	0	0	0	0	0	0	2	0		
Major Fish																
Pomacentridae															**827**	**76.78**
Hemiglypidodon	2	1	21	13	12	9	7	16	8	24	7	13	19	0		
Neglypidodon	21	36	21	11	12	19	17	16	10	24	24	13	34	37		
Abudefduf	16	17	23	13	15	0	0	25	0	11	0	19	0	5		
Pomacentrus	6	1	8	8	17	15	5	6	18	8	7	17	7	33		
Neopomacentrus	0	5	19	0	0	0	25	17	11	0	0	0	7	0		
Labridae															**68**	**6.3**
Heliocheores	9	5	0	0	0	0	5	0	0	7	35	0	7	0		
Scorpionidae															**7**	**0.4**
Scorpaenodes	2	0	0	0	0	0	0	0	0	4	0	0	0	0		
Gerres oyena	0	0	0	0	1	0	0	0	0	0	0	0	0	0		
Apogenidae															**19**	**1.76**
Apogon	0	7	1	0	0	0	0	0	0	0	0	0	5	6		
Total	60	87	107	51	57	43	65	100	47	103	80	62	90	115		
															Total	Average
Abundance (Number of Fish/m²)	0.120	0.174	0.214	0.102	0.114	0.086	0.130	0.200	0.094	0.206	0.160	0.124	0.180	0.230	2.134	0.152
Diversity Index (H')	1.7	1.79	1.91	1.62	1.43	1.05	1.57	1.94	1.33	1.91	1.36	1.37	1.76	1.37	22.11	1.579
Homogeneity Index (E)	0.87	0.78	0.89	0.90	0.894	0.96	0.24	0.93	0.96	0.92	0.84	0.99	0.85	0.85	11.874	0.848
Dominance Index (C')	0.21	0.23	0.16	0.21	0.24	0.36	0.87	0.16	0.27	0.16	0.30	0.25	0.21	0.27	3.9	0.2

were reported by Fatimah *et al*., (2018) and Nugraha *et al*., (2020). Suharti (2006) stated that reef fish distribution depends on the ranges of coral cover and topography of different coral reefs and the complexities of coral reefs on the study location. Diversity and the abundance of reef fish are very dependent on the condition of the coral reefs and the complexity of the habitat that exists in the ecosystem and does not depend on the percentage of coral cover (Allen *et al*., 1998).

Conclusion

It was concluded that coral reef conditions in Panjang island, Jepara have a critical level in terms of percentage (%) of coral cover varied from very poor, poor, and medium level (5% to 40%). Two factors suspected cause degradation of coral reef, namely anthropogenic, natural. Factors that have the most significant influence on the degradation of coral reefs are destructive fishing, mass tourism, and coral mining. The number of fish found was found 1.067 representing 7 of the family and 14 Genera of coral fish. There were 50 (4.6 %) target fish represents 3 genera, 96 (8.91 %) indicator fish represents 1 genus, and 5 genera of the major fish of 921 (85.24 %), respectively. Major fish are dominated by a family of Pomacintridae with 827 fish (76.78%). Distribution of coral fish in Panjang Island, Jepara have ecology Index i.e. diversity Index (H') moderate, Homogeneity Index (E) hight and Dominance Index (C') low confirmed that the was no species dominates. fish distribution had a lower relationship with percent hard coral cover (0.00 - 0.199). A total number of reef fish and reef fish abundance (R^2 =0.0328), Homogeneity Index (E) (R^2 =0.00014), Dominance Index (C') (R^2 =0.0581), This suggests that the abundances of reef fish were not driven by the percentage of coral cover.

Acknowledgment

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