Relationship between coral fish community structure and coral cover in Paiton Waters, Probolinggo-East Java, Indonesia

[1]Endang Y. Herawati, [2]Shada Maziyyah, [3]Misbakhul Munir, [3]Rizqi A. Perdanawati, [3,4]Ruly I. Khasanah

[1] Faculty of Fisheries and Marine Sciences, Brawijaya University, Malang, Indonesia; [2] Marine Science Program, Faculty of Science and Technology, Islam Negeri Sunan Ampel University, Surabaya, Indonesia; [3] Marine Science Program, Faculty of Science and Technology, Islam Negeri Sunan Ampel University, Surabaya, Indonesia; [4] Post Graduate Program of Fisheries and Marine Sciences, Faculty of Fisheries and Marine Sciences, Brawijaya University, Malang, Indonesia. Corresponding author: E. Y. Herawati, herawati_ey@ub.ac.id

Abstract. Paiton power plant's waters area in Probolinggo has a natural coral reef ecosystem and a moderate diversity. The purpose of this research was to investigate the correlation between the physical-chemical parameters of water with coral cover and community (abundance and diversity) of coral reef fish. The monitored parameters were temperature, brightness, salinity, degree of acidity (pH), dissolved oxygen (DO), nitrate and phosphate with coral sampling transects and coral reef fish, namely monitoring 3 transects. In identifying coral lifeforms, the line intercept transect (LIT) method was used, while the underwater visual census (UVC) method was used to identify reef fish. The results of measurement of temperature parameters at three stations showed 30 to 31°C, the brightness ranged between 3.5-5.7 m, salinity ranged from 30 to 31‰, the value of acidity (pH) ranged between 7–7.3, the dissolved oxygen levels were 5.7–6.4 mg L^{-1}, water nitrate level was 0–0.103 mg L^{-1}, and the phosphate level was 0.011–0.25 mg L^{-1}. The coral cover of Paiton, Probolinggo is categorized as being in good condition. The condition of coral reef fish community in Paiton, Probolinggo is middle to high diversity. The Principal Component Analysis (PCA) showed a positive correlation between most of the physico-chemical parameters of Paiton waters (brightness, salinity, pH, dissolved oxygen, nitrate) with coral cover and negative correlation was evidenced for temperature and phosphate concentration.

Key Words: coral reef, reef fish, principal component analysis, Paiton power plant.

Introduction. The power plant unit in Probolinggo regency utilizes sea water vapor as a driver and coolant for turbines, where the water source comes from the surrounding waters. The relatively high temperature turbine cooling water is channeled into the surrounding waters. These activities are considered to affect the quality of the surrounding water environment (Supriyanto 2016). The diversity of ecosystems in the waters is diverse, the coral reef ecosystem is unique and there is a large number of biota that live in this ecosystem. The water area is also one of the locations used for coral transplantation. Its potential is important to balance ecology/environment (conservation) as well because of its function as a means of scientific research and education.

Coral reef is an ecosystem of organisms that live on the bottom of shallow waters formed from massive deposits of calcium carbonate ($CaCO_3$) which are strong enough to withstand ocean wave forces. Coral is an organism that has the highest productivity and benefits, living in the bottom of shallow waters, especially in the tropics. The coral reef ecosystem is an important part of the marine ecosystem; this is because coral reefs are a source of life for more than 500 types of marine life forms. In a coral reef ecosystem, more than 300 types of coral, 200 species of fish and dozens of mollusks, crustaceans, sponges, algae and other biota can live (Dahuri 2000). Species of fish that live in coral reef ecosystems include coral reef fish, one of the organisms with the largest number of living coral associations. From juvenile to adulthood, coral reef fish live on the coral reef, if the coral reefs are damaged or destroyed, the diversity of coral reef fish will decrease due to the destruction of coral fish habitat.

Coastal areas have the highest productivity and varying benefits, because many species of fish and corals live in these areas. However, coastal waters are the most vulnerable areas and receive pressure from land and from the sea itself. It is estimated that 71% of coral reefs in Indonesia are at a high risk of being impacted by the large threat to coral reefs caused by human activities (Supriharyono 2000). Changes in environmental parameters around coral reef ecosystems can cause threats to the health of corals and the biota that live in these ecosystems.

Aquatic environmental conditions affect coral cover in waters, especially in the Probolinggo waters and greatly affect the abundance and diversity of coral reef fish species in the ecosystem. The diversity of coral reef ecosystems in the waters of Paiton, Probolinggo can be used as a measure of the quality of water conditions. Accurate data is needed to determine the condition of the coral reef ecosystem in the Probolinggo waters. Therefore, a study of the relationship between oceanographic parameters and the condition of coral cover and coral reef fish community structure in coral reef ecosystems in the waters is needed to determine the condition of the cover and the correlation between corals and reef fish in the Probolingo waters in a sustainable manner.

This study was aimed at investigating the effect of the hydro-oceanographic factors on the condition of coral cover and coral reef fish community structure in coral reef ecosystems in the Probolingo waters.

Material and Method

Determination of sample location. The method of determining the sampling of 3 transects was carried out using purposive sampling and with the help of snorkeling at a previously determined location. The determined transects were expected to represent the Paiton Waters, Probolinggo. The sampling location was adjusted to the Global Positioning System (GPS). Brief descriptions of the three transects are as follows: Transect I-S 07°42'30.00" T 113°34'25.00" with a water depth of 10 m; Transect II-S 07°42'26.96" T 113°34'12.83" with a water depth of 5 m; Transect III-S 07°42'51.40" T 113°35'44.33" with a water depth of 8 m (Figure 1).

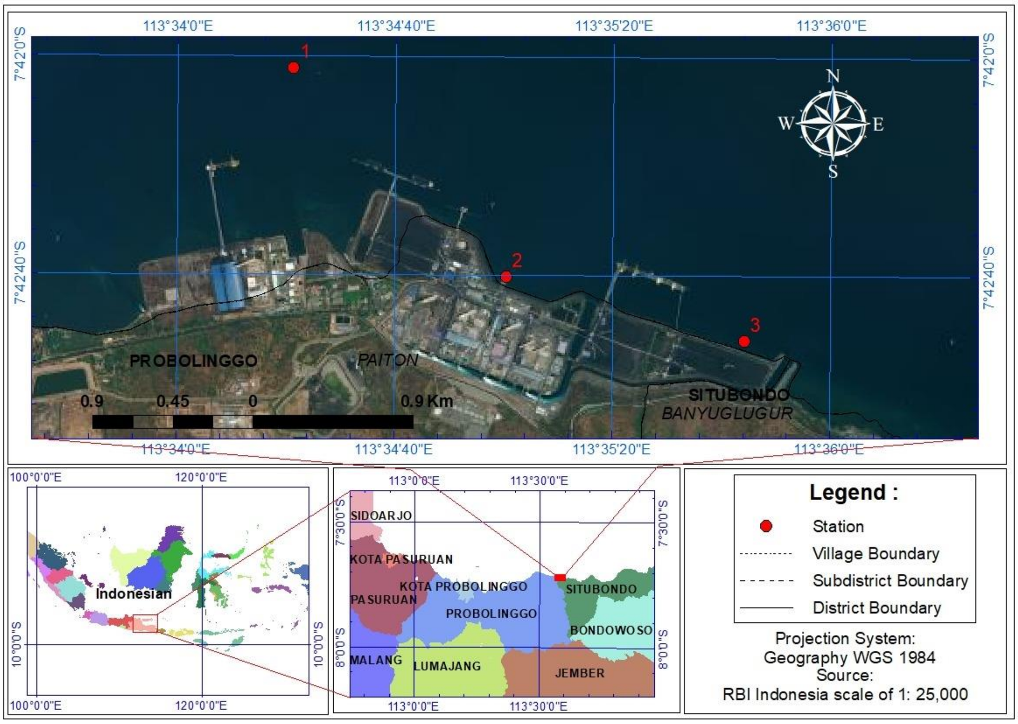

Figure 1. Map of the study area.

Data collection method. The data used in this study were primary data taken directly in the field, namely the results of measurements of oceanographic physico-chemical parameters, total length of coral lifeform, and total coral reef fish found along the coral transect. In-situ and laboratory tests were taken for physico-chemical parameters. Observation of coral lifeform used the line intercept transect (LIT) method. The LIT method was used to determine the total length of each live coral lifeform, dead coral and other biota found on the transect using a roll meter installed 50 m parallel to the coastline and then observed and data for each total length of coral lifeform found on the transect. Observation of coral reef fish used the Underwater Visual Census (UVC) method, to record coral reef fish in the transect area, namely by recording the number of individual coral reef fish found along the transect with 50 m transect length, 10 m right-left viewing width and documentation with underwater camera.

Data analysis. The percentage of coral cover for each coral lifeform category can be found using the following formula (English et al 1997):

$$Ci\ (\%) = (pi/P) \times 100$$

Where:
Ci - cover percent of a coral lifeform;
pi - total length of a lifeform category;
P - length of the transect.

The coral cover assessment criteria are presented in Table 1 (English et al 1997).

Table 1

Coral cover assessment criteria

Live coral cover (%)	*Assessment criteria*
75-100	Very good
50-74.9	Well
25-49.9	Fair
0-24.9	Low

The abundance of reef fish was calculated by the formula (Odum 1994):

$$X = xi/n$$

Where:
X - abundance of reef fish (ind m^{-3});
xi - number of fish on transect i-th observation;
n - volume of the observation transect ($50 \times 4 \times 5\ m^3$).

The abundance of coral reef fish using the criteria are presented in Table 2 (Krebs 2014).

Table 2

Criteria for abundance of coral reef fish

Abundance of coral reef fish	*Assessment criteria*
< 50	Low
50-100	High
> 100	Very high

The diversity index was used to determine the level of diversity in a community (English et al 1997):

$$H' = -\sum(Ni/N) \ln (Ni/N)$$

Where:
H' - Shannon-Wiener diversity index;

Ni - number of individual species I;
N - total number of individuals of all species.

The diversity index criteria are presented in Table 3 (English et al 1997).

Table 3

Diversity index criteria

No	*Diversity*	*Criteria*
I	H'<2.0	Low
II	2.0<H'<3.0	Average
III	H'>3.0	High

Correlation analysis between physico-chemical parameters of the waters and coral cover and coral reef fish community structure was analyzed using the principal component analysis (PCA) method using SPSS software. Data from the correlation test results were tabulated in tabular form. The results of the PCA correlation were analyzed using Table 4.

Table 4

The level of correlation between factors

Correlation result	*Category*
0.00–0.24	Low correlation
0.25–0.40	Medium correlation
0.50–0.74	Strong correlation
0.75–0.99	Very strong correlation
1.00	Perfect correlation

Results and Discussion

Water physico-chemical parameters. Analysis of the physico-chemical parameter data of the waters is presented in Table 5.

Table 5

Results of measurement of physical and chemical parameters at the research location

Parameters	*I*	*II*	*III*	*Quality standards**
Temperature	30±0.051	30±0.051	31±0.115	28-30
Brightness	5.2±0.289	3.5±0.115	5.7±0.577	>5
Salinity	31±0.00	30.7±0.577	30±0.00	30-36
pH	7.3±0.289	7.1±0.173	7.0	7.0-8.5
DO	6.4±0.017	6.26±0.053	5.7±0.058	>5
Nitrate	0.055	0.102	0.103	0.008
Phosphate	0.021	0.025	0.011	0.015

*Indonesian Minister's decree, KEPMEN LH no. 51/2004.

Temperature. The difference in transect location and the time difference when taking parameter data can cause differences in temperature ranges between transects. Temperature is one of the factors that can affect the condition of coral reefs (Giyanto et al 2017). Based on the quality standards set by the Indonesian Minister's decreee, KEPMEN LH no. 51/2004, the temperature for optimal marine biota life ranges from 28 to 30^{o}C. The temperature range obtained during the study belongs to the quality standard limit determined by the Ministry of Environment, because changes in temperature <2^{o}C can be tolerated by marine biota. This indicates that the temperature obtained from parameter measurements (Table 5) in the waters of Paiton, Probolinggo is still suitable for the life of coral reefs and another marine biota.

Brightness. If the brightness of the sunlight obtained by coral reefs is low, the rate of photosynthesis will decrease and the coral-forming calcium carbonate will decrease (Giyanto et al 2017). Based on the results of the parameter data obtained, the level of brightness in the Paiton waters, waters that have low brightness values even in normal climatic conditions can indicate the number of particles suspended in the waters, especially in Transect II, turbidity can be caused due to the large supply of sediment and dissolved particles so that will affect the value of suspended solids (TSS) (Khasanah et al 2020). Generally the level of turbidity or brightness of waters is strongly influenced by the content of suspended solids. High suspended solids content reduces the penetration of sunlight into the sea, but the turbidity and TSS contained in Transect II were in high conditions, the higher the TSS, the lower the brightness and light intensity in water will decrease (Partini 2009). The shallow area is also a factor in the high TSS level and low brightness (Shodiqin 2016). Based on the results obtained, the level of brightness in the waters of Paiton, Probolinggo can be said to be optimal for coral reef life in Transects I and III in accordance with the opinion of Indonesian Minister's decree, KEPMEN LH no. 51/2004 concerning sufficient brightness for coral reefs.

Salinity. According to Haruddin et al (2011), the optimal salinity level for coral reefs is 25-30‰, the salinity of seawater in the tropics is 35‰, and the coral biota is fertile at a salinity level of 34-36‰. In accordance with Indonesian Minister's decree, KEPMEN LH no. 51/2004, the quality standard regarding salinity levels is 30-36‰, the salinity levels of the waters of Paiton, Probolinggo in Transect I, Transect II and Transect III can be categorized as optimal and suitable for marine biota (Table 5).

Acidity (pH). Based on the Indonesian Minister's decree, KEPMEN LH no. 51/2004 concerning the quality standard of coral reef ecosystems, the optimal pH level is in the range of 7.0-8.5. Marine biotas, especially coral reefs, are sensitive to changes in pH. The optimal acidity degree for the development and growth of marine life is 7-8.5 (Effendi 2003). The results of the pH obtained on Transect I, Transect II and Transect III from the Paiton waters, Probolinggo can be considered to be in optimal conditions (Table 5).

Dissolved oxygen (DO). Oxygen has an important role in the aquatic environment, as a chemical element used by biota for metabolic processes (Herawari 2020). According to Faturohman et al (2016), if a water has a dissolved oxygen (DO) value of less than 3 mg L^{-1}, this will cause the death of aquatic organisms. Based on the measurement results on each observation transect, it can be concluded that the coral reef ecosystem in the waters of Paiton, Probolinggo is in optimal conditions in supporting the life of coral reefs and other marine biota with DO levels of more than 5 mg L^{-1} (Table 5).

Nitrate. Effendi (2003) stated that nitrate levels in natural waters are not more than 0.1 mg L^{-1}. However, if the nitrate level exceeds the value of 0.2 mg L^{-1}, it will result in a eutrophication event in these waters. Nitrates are used by zooxanthellae as nutrients in the photosynthesis process. Based on the results of the parameter data obtained, nitrate levels in the waters of Paiton, Probolinggo are suitable for coral reefs in the waters of in accordance with the Indonesian Minister's decree, KEPMEN LH no. 51/2004.

Phosphate. Based on the Indonesian Minister's decree, KEPMEN LH no. 51/2004 the optimal condition of nutrient phosphate for aquatic biota is at a value of 0.015 mg L^{-1}. Based on this value, it can be said that the phosphate nutrient conditions in each observation transect are under normal conditions. According to the EPA (2002), phosphate levels in waters are high if the phosphate levels are >0.096 mg L^{-1}, the presence of excessive phosphate levels can cause algae blooms which have a negative impact on coral reef ecosystems. The limit of uncontaminated waters is <0.087 mg L^{-1} phosphate level (Ketchum 1969). The high levels of phosphate in Transect II can be caused by its shallow location and proximity to the mainland, naturally the phosphate is distributed from the surface to the bottom, so in the shallower waters, the concentration is higher due to high nutrients on the seabed (Patty 2015).

Coral cover percentage. Analysis of the cover percentage data used to determine the condition of coral reefs in the waters of Paiton, Probolinggo is presented in Table 6.

Table 6

Results of live coral cover on Transect I, Transect II, and Transect III

Transect	*Live coral cover (%)*	*Assessment criteria*
I	73.32	Good
II	28.44	Moderate
III	51.80	Good

The results of the calculation of data processing Transect I with a depth of 10 m obtained a percentage of live coral cover of 73.32% which is categorized as good (Table 6, this is evidenced by the results of optimal measurement parameters and results of high nitrate levels. Khasanah et al (2013) stated that nitrate is one of the main nutrients used by marine biota and coral reefs for their growth. The results of calculations on Transect II at a depth of 5 m showed that the percentage of live coral cover was 28.44% which was categorized as sufficient (Table 6). An aspect that can affect the low coral cover is low levels of nitrate. The waters in Transect II obtained 0 mg L^{-1} nitrate, while all parameters in Transect II were optimal. The results of calculations on Transect III obtained a percentage of live coral cover of 51.80% which is categorized as good (Table 6), this is due to the results of parameter measurements in Transect II which are optimal and good for coral reef ecosystems.

The structure of the reef fish community. The structure of the reef fish community is shown by abundance which is presented in Table 7.

Table 7

Abundance categories of reef fish (individuals $transect^{-1}$)

Transect	*Coral reef fish abundance*	*Assessment criteria*
I	996	Very high
II	70	High
III	255	Very high

Overall, the number of fish observed on Transect I was 996 individuals/transect consisting of 24 species. The abundance of reef fish in Transect II was 70 individuals/transect. The abundance results in Transect III showed 255 individuals/transect, the abundance in Transects I and III was categorized as very high because the abundance was >100, while the abundance in Transect II was in the high category because the abundance was <100 (Table 7). Transect I has the highest coral fish abundance. This is evidenced by the good coral cover in Transect I compared to the coral cover in Transect II and Transect III. While the lowest fish abundance was in Transect II, this was also evidenced by the lowest coral cover results compared to Transect I and Transect III. Diversity index data analysis used to determine the level of coral fish diversity in the waters of Paiton, Probolinggo is presented in Table 8.

Table 8

Categories of coral reef fish diversity

Transect	*Coral reef fish diversity*	*Assessment criteria*
I	2.199	Moderate
II	1.848	Low
III	2.354	Moderate

The diversity index value (H') obtained on Transect I was 2.199 which can be categorized as moderate (Table 8), this is due to the high coral cover on Transect I which is the habitat for reef fish. Transect II, namely 1,848, the diversity of reef fish is categorized as low, this is because the habitat of reef fish had low coral cover compared to Transect I. It met the criteria for the level of diversity grouping, namely >2.00 and the condition of live coral cover in Transect III was good (Table 6) (English et al 1997).

Correlation of oceanographic parameters with coral cover and coral reef fish community structure. Correlation analysis between the physico-chemical parameters of the waters with coral cover and the structure of the reef fish community was analyzed using the principal component analysis (PCA) method using SPSS software and Microsoft Excel 2013 and is presented in Table 9.

Table 9

Matrix of correlation of physico-chemical parameters of waters with coral cover

Correlation	*Coral reef cover*
Temperature	-0.21
Brightness	0.75
Salinity	0.27
pH	0.63
DO	0.16
Nitrate	0.50
Phosphate	-0.85

The results of the PCA analysis concerning the relationship between the physical and chemical parameters of water and coral cover showed a positive relationship with brightness, salinity, pH, DO, and nitrate, where the relationship was unidirectional, namely the higher the variable X, the higher the Y variable. Results obtained concerning temperature and phosphate parameters, the relationship between these variables was opposite, which means that if variable X has increased then variable Y has decreased or vice versa. The results of the relationship matrix of water chemistry physics parameters with coral fish abundance are presented in Table 10.

Table 10

Matrix of correlation of physico-chemical parameters of waters with abundance of coral reef fish

Parameters	*Correlation*
Temperature	-0.54
Brightness	0.47
Salinity	0.58
pH	0.86
DO	0.50
Nitrate	0.17
Phosphate	-0.62

The result of the relationship between water temperature and coral fish abundance is a strong negative relationship, this happens if two or more variables go opposite, which means that if variable X increases, variable Y decreases or vice versa. This is because the higher the temperature in the waters, the level of coral life will decrease, the sudden and continuous increase in sea water temperature will cause the death of coral polyps and subsequently become a trigger for coral bleaching, where the condition of corals as habitat decreases native reef fish will reduce the abundance of fish in a waters (As-Syakur & Wiyanto 2016). The relationship between reef fish abundance and temperature results from a strong negative relationship analysis, because the value of the relationship obtained is 0.5-0.74, the relationship is categorized as a strong relationship (Pandiangan 2009).

The results of the relationship matrix of water chemistry physics parameters with coral fish abundance are presented in Table 11.

Table 11
Matrix of correlation of physico-chemical parameters of waters with diversity of coral reef fish

Parameters	*Correlation*
Temperature	-0.55
Brightness	0.99
Salinity	0.50
pH	0.11
DO	0.59
Nitrate	0.97
Phosphate	-0.96

The result of the relationship between phosphate and reef fish diversity is a very strong negative relationship, which means that if variable X increases then variable Y experiences a decrease or vice versa, meaning that the higher the phosphate, the condition of coral fish diversity will get worse because of too much nutrients that are in the waters, and can cause eutrophication in these waters (Effendi 2003).

Conclusions. Based on the results of the physico-chemical parameters measurements of water obtained from the Paiton waters, Probolinggo, it was found that the water conditions were in accordance with the quality standards of the Indonesian Minister's decree, KEPMEN LH no. 51/2004 and were supportive of the coral reef ecosystem. The basic cover and condition of live corals found in the waters of Paiton, Probolinggo are categorized as moderate to good. The structure of the reef fish community in the waters of Paiton, Probolinggo is categorized as high to abundant, with low to moderate diversity. Data on water physical and chemical parameters need to be added to the sediment collection and currents on each transect to determine the total suspended solids that affect the coral reef ecosystem.

Conflict of interest. The authors declare no conflict of interest.

References

As-Syakur A. R., Wiyanto D. B., 2016 [Study of hydrological conditions as locations for placement of artificial reefs in the waters of Tanjung Benoa Bali]. Jurnal Kelautan 9(1):86-92. [In Indonesian].

Dahuri R., 2000 [Utilization of marine resources for community welfare]. Lembaga Ilmu Pengetahuan Indonesia, Jakarta, Indonesia, 163 p. [In Indonesian].

Effendi H., 2003 [Study of water quality for management of aquatic resources and environment]. 5th edition. Kanisius, Yogyakarta, Indonesia, 76 p. [In Indonesian].

English S., Wilkinson C., Baker V., 1997 Survey manual for tropical marine resources. Australian Institute of Marine Science, Towns Ville, 101 p.

Faturohman I., Sunarto, Nurruhwati I., 2016 [Relationship between plankton abundance and sea water temperature around PLTU Cirebon]. Jurnal Perikanan Kelautan 7(1):115-122. [In Indonesian].

Giyanto A. M., Tri A. H., Agus B., 2017 [Status of coral reefs in Indonesia 2017]. COREMAP-CTI Research Center for Oceanography, Indonesian Institute of Sciences, 24 p. [In Indonesian].

Haruddin A., Edi P., Sri B., 2011 [Impact of damage to coral reef ecosystems on traditional fishermen catching on Siompu Island, Buton Regency, Province]. Jurnal Eko Sains 3(3):82-84. [In Indonesian].

Herawati E. Y., Khasanah R. I., Ambarwati M., Sofarini D., 2020 The effect of hydro-oceanographic factors on the community structure of plankton in natural and artificial coral reefs in Paiton waters. AACL Bioflux 13(1):71- 85.
Ketchum D. H., 1969 Eutrophication of estuaries. In: Eutrophication causes, consequences, corrective. Rohlich G. A. (ed), pp. 197-209, National Academy of Sciences, Washington D.C.
Khasanah R. I., Herawati E. Y., Hariati A. M., Mahmudi M., 2020 Growth rate and survivorship of *Acropora* sp. fragments that transplanted on the artificial substrate made from fly ash and bottom ash. IOP Conference Series: Earth and Environmental Science 441:012126.
Khasanah R. I., Sartimbul A., Herawati E. Y., 2013 [Plankton abundance and diversity in Bali Strait waters]. Ilmu Kelautan 18(4):193-202. [In Indonesian].
Krebs, 2014 Ecological methodology. 4th edition. Ecology at the University of Canberra and the Biodiversity Center at the University of British Columbia, Camberra, 213 p.
Odum E. P., 1994 [Ecology basics]. Gajah Mada University Press, Yogyakarta, Indonesia, 143 p. [In Indonesian].
Pandiangan S. L., 2009 [Study of coral fish diversity in the western waters of Rubiah Island, Nanggroe Aceh Darussalam]. BSc Thesis, Faculty of Mathematic and Sains, Universitas Sumatera Utara, Indonesia, 68 p. [In Indonesian].
Partini, 2009 [Effects of sedimentation on coral reefs on the east coast of Bintan Regency]. MSc Thesis, Coastal and Ocean Resources Management Study Program, IPB Postgraduate School, Bogor, Indonesia, 88 p. [In Indonesian].
Patty S. I., 2015 [Characteristics of phosphate, nitrate, and dissolved oxygen in Lembeh Strait Waters, North Sulawesi]. Jurnal Pesisir dan Laut Tropis, pp. 1221-1228. [In Indonesian].
Shodiqin M. A., 2016 [Study of total suspended solid and water transparency using citrasatelit worldview-2 as a limiting factor for coral reef growth]. MSc Thesis, Faculty of Civil Engineering and Planning, Sepuluh Nopember Institute of Technology, 51 p. [In Indonesian].
Supriharyono, 2000 [Management of coral reef ecosystems]. Djambatan, Jakarta, Indonesia, 134 p. [In Indonesian].
Suprianto, 2016 [Management of hazardous and toxic waste management innovation PLTU Paiton Unit 5 & 6]. Jawa Power, Fillapress, Probolinggo, Indonesia, 32 p. [In Indonesian].
*** Environmental Protection Agency, EPA, 2002 Water quality criteria. Mid-Atlantic integrated assessment (MAIA) estuaries. Ecological Research Series, Washington DC, USA, 595 p.
*** Indonesian Minister's Decree, [KEPMEN LH no. 51/2004]. [In Indonesian].

Received: 11 November 2020. Accepted: 24 April 2021. Published online: 07 May 2021.
Authors:
Endang Yuli Herawati, Brawijaya University, Faculty of Fisheries and Marine Sciences, Jl. Veteran, 65145 Malang, Indonesia, e-mail: eyulih@yahoo.co.id
Shada Maziyyah, Islam Negeri Sunan Ampel University, Program Study of Marine Science, Faculty of Science and Technology, Jl. Ahmad Yani No. 117, 60237 Surabaya, Indonesia, e-mail: shadamaziyyah@gmail.com
Misbakhul Munir, Islam Negeri Sunan Ampel University, Program Study of Marine Science, Faculty of Science and Technology, Jl. Ahmad Yani No. 117, 60237 Surabaya, Indonesia, e-mail: misbakhul_munir@uinsby.ac.id
Rizqi Abdi Perdanawati, Islam Negeri Sunan Ampel University, Program Study of Marine Science, Faculty of Science and Technology, Jl. Ahmad Yani No. 117, 60237 Surabaya, Indonesia, e-mail: abdirizqi@yahoo.com
Ruly Isfatul Khasanah, Islam Negeri Sunan Ampel University, Program Study of Marine Science, Faculty of Science and Technology, Jl. Ahmad Yani No. 117, 60237 Surabaya, Indonesia, e-mail: ulick.isfatul@gmail.com

How to cite this article:
Herawati E. Y., Maziyyah S., Munir M., Perdanawati R. A., Khasanah R. I., 2021 Relationship between coral fish community structure and coral cover in Paiton Waters, Probolinggo-East Java, Indonesia. AACL Bioflux 14(3):1213-1221.