THE RELATION OF WATER CHEMICAL QUALITY TO CORAL REEF ECOCSYSTEMS IN DAMAS

Andik Isdianto[1], Oktiyas Muzaky Luthfi[2], Valessa Senshi Moira[2], Muchamad Fairuz Haykal[2], Supriyadi[3]

[1] Coastal Resilience and Climate Change Adaptation (CORECT) – Research Group, Brawijaya University, Veteran Street, Malang, Indonesia 65145
[2] Department of Marine Science, Faculty of Fisheries and Marine Science, Brawijaya University, Veteran Street, Malang, Indonesia 65145
[3] Department of Maritime Security, Faculty of National Security, Defense University, Bogor, Indonesia
Email: [1]andik.isdianto@ub.ac.id, [2]omuzakyl@ub.ac.id

ABSTRACT

Indonesia is an archipelago country that is ranked top of the world for its breadth and wealth. More than 75,000 km^2 or almost 14% of the world's coral is in Indonesia. The growth of coral reefs in a sea water is strongly influenced by the quality of waters such as chemical oceanographic factors, namely salinity, pH, DO, nitrate and phosphate. The data collection was carried out twice in September and November 2019 in Damas Waters, Trenggalek, East Java. The purpose of this study is to influence the quality of waters on the growth of coral reefs in Damas, Trenggalek, East Java. The sampling method is purposive random sampling that is the determination of the sample with certain considerations. The location points used by 20 stations are spread, namely on artificial reefs, natural coral reefs, open seas and the area around the harbor. Measurements made include in situ water quality with a multiparameter measurement tool, namely AAQ. The results showed the quality of waters in accordance with environmental quality standards with a value of (1) salinity 31.5 - 3.6 (2) pH 7.9 - 8.1 (3) DO> 5 mg / L (4) Nitrate 0.001-0.007 mg / l (5) Phosphate 0.012 - 0.345 mg / L. Correlation value of all components> 0.5 then the relationship of each parameter and coral reef affect each other.

Keywords: *Oceanographic factors, purposive random sampling, water quality, and correlation value*

1. INTRODUCTION

Indonesia occupies the top position in the world for the area and richness of coral reef species. Almost more than 75,000 km^2 or 14% of the world's coral reefs (Arini, 2013). Coral reefs are one of the ecosystems with diversity, complexity, and high productivity on earth which are a place for hatcheries, enlargements, and places to find food for another marine biota. Coral conditions in Indonesia in 2015 only had 5% in very good condition, 27,01% in good condition, 37,97% in moderate condition, and 30,02% in poor condition. Damage to coral ecosystems is caused by changes in oceanographic conditions, both natural and anthropogenic. Damaged natural coral reef ecosystems are a threat to the survival of marine life living in coral reef areas because it takes a very long time to restore coral reefs (Nugraha, 2019). Changes in water quality are caused by climate change which will affect the increasing intensity of extreme weather events in an area, changes in rain patterns, as well as increased temperatures and sea-level rise (Isdianto & Luthfi, 2019). Changes in water quality either directly or indirectly can affect the condition of coral reefs. Pollution from land will indirectly change water quality so that it can damage coral reefs (Wibawa & Luthfi, 2017). One of the efforts that can be done to reduce the impact of damage to aquatic habitats on fish resources is to provide artificial shelters for fish in the form of fish houses or often called fish apartments (Fuad *et al*., 2016).

Damas Beach is included in the administrative area of Karanggandu Village, Watulimo District, Trenggalek Regency (Prasetya, 2016). Coral reefs in the waters of Damas Beach are included in the bad category because many fishermen's nets are found related to these corals (Wibowo & Adrim, 2013).

According to Isdianto *et al*. (2014), the issue of global warming has an impact on sea level rise and causes damage to coastal areas. According to Luthfi *et al*. (2017), factors that can affect coral reef life based on chemical oceanography are salinity, pH, DO, nitrate and phosphate. Based on Luthfi *et al.* (2019) that the factors that affect coral health and growth can come from sediments, cyanobacteria, filamentous algae, and some other invading organisms. Biotic factors and abiotic factors also greatly affect the coral growth cycle such as temperature, sedimentation, predation, UV rays, and several other factors.

The purpose of this study was to determine the relationship between the chemical quality parameters of the waters and the presence of coral reef ecosystems in Damas Beach, Trenggalek, East Java.

2. METHODS

The research location is in the Damas Beach area, Trenggalek, East Java, taking into account the presence of Natural Coral Reefs, Artificial Coral Reefs, harbor waters, and high seas in Prigi Bay. With the aim of being able to fully describe the condition of water quality in the Prigi Bay area, and especially in the area of Natural Coral Reefs and Artificial Coral Reefs in Damas Coastal Waters.

2.1 Data Retrieval

Water quality data in waters is carried out using the in-situ method or taken directly (Wibawa & Luthfi, 2017), and previously conducted observations by determining the coordinates of the location using the Google Earth application.

The sampling method was carried out by purposive random sampling, namely the determination of the sample with certain considerations (Rachman *et al.*, 2019), using this method is expected to represent the condition of the waters at the research location which includes in-situ water quality measurements with a multiparameter measurement tool, namely AAQ at a depth of 0-6 meters. According to Sidabutar *et al*. (2019), use of AAQ tools in safe conditions at a depth of 0 – 6 meters. The data taken are salinity, pH, dissolved oxygen, nitrate, and phosphate.

In-situ data collection was carried out twice, namely on September 20, 2019 and November 20, 2019, at the same time, on 06.00 – 10.00 AM and when Prigi waters were in low tide during the Transitional Season II. With the help of GPS, the coordinates of field data collection were carried out by boat to 20 sample points that could represent general water conditions, and chemical parameters using AAQ and nitrate phosphate were measured with the Prodac test kit. The following research locations can be seen in Figure 1.

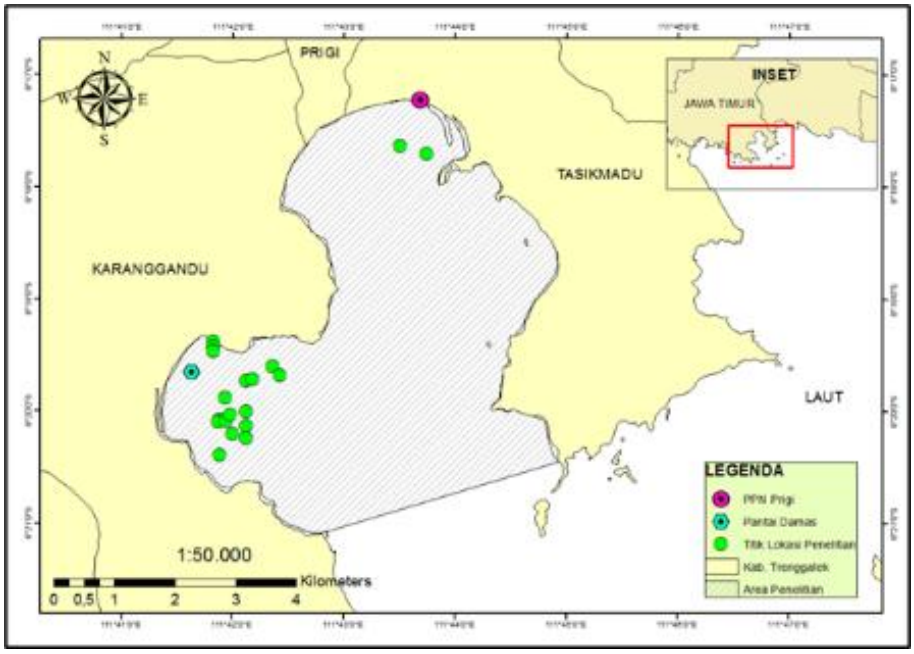

Figure 1. Research Location

2.2 Data Processing

Data processing was carried out to obtain secondary data such as data on salinity, pH, DO, nitrate, phosphate, and coral cover in the Prigi Bay area using the Google Earth application, Microsoft Excel, and ArcGIS software.

2.3 Data Analysis

The data obtained are plotted into the ArcGISapplication which will then visualize the vertical distribution of salinity, pH, DO, nitrate, and phosphate at each research station. The data is then described to provide a comprehensive picture with reference to water quality based on previous research related to water quality on coral reefs. The relationship of water chemical quality parameters with the presence of coral reef ecosystems was tested with SPSS 16 software.

3. RESULT AND DISCUSSION

3.1. Coral Reef Condition

The percentage of coral cover is done to see how well the condition of the corals in a location. According to Alifia (2017), natural coral cover at Damas Beach was 39.52 %. However, at Damas Beach itself, it is estimated that the healthy coral cover or live coral is estimated to be no more than 20%.

Based on research conducted by Alifia (2017), there are 17 genera of corals found on the coast of the Prigi Bay area. As many as 3,15% of the coral reefs in Damas Beach were found to be affected by different diseases. Coral reefs were found in poor condition because from direct observations at the time of data collection, coral reef ecosystems had the low cover, cloudy waters, and were too shallow. Around the coral reefs, rubble caused by fishing nets caught in the reef was also found. The nets get stuck when they are fishing in natural coral reef areas.

Based on the information of fishermen in the waters of Damas Beach that the damage to coral reefs is influenced by natural factors and the behavior of the surrounding community who looks for fish with tools that can damage coral reef ecosystems such as potassium and bombs. According to Giyanto *et al.* (2017), that human disturbance greatly determines the condition of the coral reef itself, if carried out continuously it can damage the coral reef ecosystem in the future.

According to Luthfi *et al*. (2019), there is a lot of coral debris and high turbidity of seawater in Prigi Waters including Damas Beach. This is also reinforced by data from research Giyanto *et al*. (2017), that the status of Indonesia's coral reefs in 2017 at the location of Prigi Bay including Damas Beach

found coral reefs that were all classified as bad or bad. It is estimated that coral reefs have died because they have been under pressure due to high tourism activities, fishing port activities in the archipelago, sedimentation from rivers flowing in Prigi Bay, an increase or decrease in global seawater temperature, and other oceanographic conditions. According to Supriyadi *et al*. (2017), currents can carry sediments that are on the surface or at the bottom of the water.

3.2 Water Chemical Parameter Quality Condition

Almost all types of coral are very sensitive to changes in physical and chemical waters (Luthfi *et al*., 2017).

The results of the chemical conditions of the waters can be seen in Table 1.

Table 1. Measurement of Chemical Oceanographic Water Conditions

Data Collection time	Parameter									
	Sal. (ppt)		pH -		DO (mg/l)		NO_3 (mg/l)		PO_4 (mg/l)	
	Sept.	Nov.	Sept.	Nov.	Sept.	Nov.	Sept.	Nov.	Sept.	Nov.
St. 1	34,5	33,6	8,0	8,1	6,7	11,7	0,02	0,03	0,023	0,023
St. 2	34,6	33,9	8,1	8,1	6,9	11,0	0,03	0,05	0,345	0,042
St. 3	34,5	34,0	8,1	7,8	6,8	11,2	0,01	0,02	0,067	0,023
St. 4	34,5	34,0	8,2	8,1	7,1	11,3	0,02	0,04	0,213	0,025
St. 5	34,6	33,9	8,2	8,1	7,1	12,2	0,1	0,01	0,071	0,036
St. 6	34,6	33,7	8,3	8,1	7,1	12,2	0,04	0,03	0,148	0,063
St. 7	34,6	33,7	8,3	8,1	6,9	11,8	0,08	0,05	0,012	0,057
St. 8	34,5	33,8	8,3	8,1	7,1	11,8	0,01	0,07	0,275	0,035
St. 9	34,4	34,0	6,9	8,1	6,9	11,5	0,09	0,02	0,018	0,063
St. 10	34,5	34,0	8,4	8,1	6,9	11,3	0,02	0,01	0,123	0,053
St. 11	34,5	33,9	8,3	8,2	7	10	0,08	0,04	0,045	0,033
St. 12	34,6	33,6	8,4	8,2	7	12	0,04	0,06	0,093	0,085
St. 13	34,5	33,3	8,3	8,2	7	13	0,05	0,04	0,146	0,035
St. 14	34,6	34,0	8,3	8,3	6,9	11,6	0,05	0,02	0,231	0,211
St. 15	34,6	32,3	8,4	8,2	7	14	0,01	0,05	0,241	0,201
St. 16	34,6	33,3	8,4	8,3	7	13	0,1	0,07	0,075	0,242
St. 17	34,4	32,9	8,3	8,3	7	14	0,09	0,08	0,202	0,031
St. 18	34,3	32,8	8,4	8,3	6,9	13,5	0,08	0,07	0,249	0,052
St. 19	34,6	32,6	8,3	8,4	7	13	0,07	0,06	0,189	0,063
St. 20	33,5	32	8,2	8,3	7	11	0,05	0,07	0,176	0,057

3.2.1. Salinity

The results showed that the salinity in November is lower when compared to September. In September the range of salinity values is between 33.5 – 34.6 ppt, while in November the range of salinity obtained is between 31.5 – 34 ppt. Salinity levels obtained in the high seas are almost the same and the changes are not too significant, changes in salinity in offshore are relatively smaller than in coastal waters.

According to Naiu *et al*. (2014), corals are reef-forming as true marine organisms, cannot survive in salinity that clearly deviates from normal seawater salinity, which is 32-35 ppt. Low salinity values can kill corals. This is reinforced by Ompi *et al*. (2019), that in his research that good salinity for coral reefs found in the sea with water salinity that remains above 30 ppt but below 35 ppt.

3.2.2 pH

The main factors that affect the acidity of seawater in coastal areas are the activity of phytoplankton and aquatic plants, flows from land, tides, and weather that affect the chemical fluctuations of the waters. Damas Beach, there is no large river flow that enters the waters and the runoff from the surrounding land is also not large, so it does not affect the distribution of the pH value relatively (Tito, 2015). The pH value affects the resistance of organisms where at a low pH will interfere with the absorption of dissolved oxygen by these organisms. Based on the results of measurements on the Damas beach, it was found that the pH value was in the range of 6.9 – 8.4 which according to Barus *et al*. (2018), in general, the results of pH measurements in the range of about 7 - 8.5 are common conditions in Indonesian (tropical) waters. This is in accordance with the statement Corvianawatie & Abrar (2018), that the pH value of the waters in all observation stations is still appropriate in levels between 7.0 - 8.5 is classified as good. The ideal pH range for marine life is between 6.5 - 8.5. According to Juliani & Rahmatsyah (2011), that the pH value of seawater quality standards for marine tourism is around 7 - 8.5 then for fisheries the pH is around 6 - 8.5 and pH levels in normal waters are between 6 - 9. Based on these explanations, it can be assumed that the pH obtained at the research station still supports the life of coral reefs.

3.2.3 Dissolved Oxygen

The average DO level in September 2019, which is between 6.7 – 7.1 mg/L where the value is lower than November 2019, which is in the range of 10 – 14 mg/L. Dissolved oxygen levels obtained at the time of data collection if associated with the statement Prasetyo *et al*. (2018) included in good condition, because the oxygen level in the water quality standard is more than 5 mg/L. So the DO value in the waters of the Damas Beach area is classified as good or meets the quality standards of sea water and for coral life. This is confirmed by the statement Sumarno & Mryanto (2014), that corals can grow in DO conditions with levels above 3.5 mg/L.

3.2.4 Nitrate (NO_3)

Based on observations at all stations for 2 months (September and November), the nitrate levels contained in these waters are in accordance with the statement Patty *et al*. (2015), that normal nitrate levels in marine waters generally range from 0.001 to 0.007 mg/l. Coral reefs can live in an environment that is low in nutrients (nitrate, phosphate, water) because of the ability of corals to produce their nutrients, so it can be assumed that the largest contribution to aquatic productivity is coral organisms themselves.

3.2.5 Phosphate ($P0_4$)

The high and low levels of phosphate in water are one of the indicators to determine the fertility of a waters. According to Isnaeni *et al*. (2015), rivers as carriers of drifting garbage and other land phosphate sources will result in concentrations in the estuary being greater than its surroundings. Phosphate content generally decreases the further towards the sea (*off shore*).

According to Makatita *et al*. (2014), the main source of phosphate naturally comes from the waters themselves through the process of decomposition, weathering, plant decomposition, the remains of dead organisms, land waste disposal (domestic, industrial, agricultural, livestock, and feed residues) which will be decomposed by bacteria into

nutrients. Phosphate levels for marine biota are 0.015 mg/l. According to Ilyas *et al*. (2017), stated that phosphate levels for the chemical parameters of coral reef waters ranged from 0.27 to 5.51 mg/L.

Phosphate levels ($P0_4$) in September 2019 were 0.012 - 0.345 mg/L, and in November 2019 in the range of 0.023 – 0.242 mg/L. This value is generally still considered good for coral reef growth, where the highest phosphate content ($P0_4$) was found at station 2 which is an area that is still close to the beach, rivers, and floating houses. Meanwhile, the lowest phosphate content was found at station 7, which is located close to the high seas, which is suspected to have no coral reefs in the area. If referring to the fertility category stated by the two opinions above, then Damas Beach waters are included in the category of quite fertile and still good for the growth and development of coral reefs.

3.3 Analysis of the Relationship between Chemical Conditions of Waters and Coral Reefs

The analysis used is PCA or principal component analysis which is a descriptive statistical model to display the calculation results in a maximum of information from the data matrix. The data matrix consists of observation stations as factors (rows) and variables as quantitative (columns). PCA test results obtained salinity (0.929), pH (0.625), DO (0.744), Nitrate (0.847) and Phosphate (0.690). These results indicate whether the value of the variable under study can explain the relationship with coral reefs or not, where the variable is considered capable of explaining the factor if the extraction value is greater than 0.50. Based on these results, it is known that the extraction value for all variables is greater than 0.50. Thus, it can be concluded that all these variables can be used as factors that affect coral reefs. The results of statistical tests to determine the relationship between the chemical quality of the waters and coral reefs can be seen in Table 2.

Table 2. Statistical Test for Correlation Water Quality Chemistry on Coral Reefs

Comp. PCA	**Parameter**				
	Sal.	**pH**	**DO**	**NO_3**	**PO_4**
Coral Cover	0,929	0,625	0,744	0,847	0,690

To ensure that a variable can be included in the factor group, it can be determined by looking at the largest correlation value between the variables and the formed factors. Based on Table 3, the correlation value for component 1 is 0.998 > 0.5, in component 2 the correlation value is 0.975 > 0.5, and component 3 the correlation value is 0.976 > 0.5. Because the correlation value of all components > 0.5, the three factors formed can be concluded that it is feasible to summarize the chemical quality of the analyzed waters as a parameter that has an influence on the life of coral reefs in general.

Table 3. Matrix Transform Components

Component	1	2	3
1	**0,998**	-0,057	0,028
2	0,050	**0,975**	0,216
3	-0,039	-0,214	**0,976**

4. CONCLUSION AND RECOMMENDATION

Overall at all station locations during observations in September and November 2019, the condition of the chemical quality of

the waters in the Damas Beach to Prigi Bay area is classified as good for coral life. Based on the analysis calculation, component 1 has a correlation value of 0.998, component 2 has a correlation value of 0.975, and component 3 has a correlation value of 0.976. Because the correlation value of all components > 0.5, it can be concluded that the three factors formed can be concluded that it is feasible to summarize the chemical quality of the analyzed waters as a parameter that has an influence on the life of coral reefs in general. Even though in reality, in the field it does not describe that coral reefs can grow well. This is because there are other influences, namely physical oceanography, sedimentation, and the inappropriate placement of artificial coral reefs in the sea. According to Luthfi *et al*. (2019), the increasing threat to coral reef ecosystems is also influenced by the number of human activities in coastal areas which can cause heavy metals to enter marine waters.

For further research, it is better to measure water quality in more detail. It is also advisable to conduct further research or time series in all seasons in Indonesia (rainy, dry, and transitional seasons) to be able to monitor further the quality of the waters. For local communities, there is a need for socialization about coral reef ecosystems so that tourists or fishermen who come to Damas Beach to Prigi Bay are more careful and protect the life of coral reef ecosystems.

5. ACKNOWLEDGEMENTS

The researcher would like to thank colleagues from the Research Group CORECT (Coastal Resilience and Climate Change Adaptation - Research Group) Faculty of Fisheries and Marine Sciences Universitas Brawijaya, and students who participated to support this research so that it can run well.

6. DAFTAR PUSTAKA

ALIFIA, R. (2017). Relationship between Prevalence of Hard Coral Disease (Scleractinia) and Water Quality in Transitional Season I in Prigi Bay Waters, Trenggalek, East Java. http://repository.ub.ac.id/id/eprint/8176

ARINI, D. I. D. (2013). Indonesia's Coral Reef Potential; Challenges and Conservation Efforts. *Forestry Research Institute Info*, *3*(2), 147–172.

BARUS, B. S., PRARTONO, T., & SOEDARMA, D. (2018). The Effect of the Environment on the Growth Form of Coral Reefs in Lampung Bay Waters. *Journal of Tropical Marine Science And Technology*, *10*(3), 699–709. https://doi.org/10.29244/jitkt.v10i3.21516

CORVIANAWATIE, C., & ABRAR, M. (2018). The suitability of oceanographic conditions in supporting coral reef ecosystems in the waters of Pari Island. *National Marine Journal*, *13*(3), 155–162. https://doi.org/10.15578/jkn.v13i3.6322

FUAD, M. A. Z., SAMBAH, A. B., ISDIANTO, A., & ANDIRA, A. (2016). Bathymetry mapping as basic information for fish apartment placement in Bangsring waters , Banyuwangi , East Java. *5*(3), 143–150. https://doi.org/10.13170/depik.5.3.5655

GIYANTO, ABRAR, M., HADI, T. A., BUDIYANTO, A., HAFIZT, M., SALATALOHY, A., & ISWARI, M. YULIA. (2017). Status of Coral Reefs in Indonesia 2017 (Suharsono (ed.)). CoreMap - CTI. http://www.oseanografi.lipi.go.id

ILYAS, I. S., ASTUTY, S., HARAHAP, S. A., & PURBA, N. P. (2017). The Diversity of Targeted Reef Fish in Relation to Coral Growth Forms in the Core Zone in the Anambas Archipelago Aquatic Tourism Park. *Journal of Fisheries and Marine*, *8*(2), 103–111.

ISDIANTO, A., CITROSISWOYO, W., & SAMBODHO, K. (2014). Coastal Zone Zoning Due to Sea Level Rise. *Residential Journal*, *9*(3), 148–157.

ISDIANTO, A., & LUTHFI, O. M. (2019). Popoh Bay Community's Perception and Adaptation Pattern to Climate Change. 5, 77–82.

ISNAENI, N., SURYANTI, & PURNOMO, P. W. (2015). Water Fertility Based on Nitrate, Phosphate, and Chlorophyll-a in Coral Reef Ecosystem Waters on Karimun Island, Java. *Diponegoro Journal of Maquares*, *4*, 75–81.

JULIANI, R., & RAHMATSYAH. (2011). Pattern of Determination of Coral Reef Damage Parameters in Sibolga Area.

Saintika Research Journal, *11*(1), 53–66.

LUTHFI, O. M., AGUNG, R. M., SONTODIPOERO, M. R., ISDIANTO, A., SETYOHADI, D., JAUHARI, A., & JANUARSA, I. N. (2017). Skeleton microstructure of Porites lutea in Skeleton Microstructure of Porites lutea in Kondang Merak ,. *030009*(November). https://doi.org/https://doi.org/10.1063/1.5012709

LUTHFI, O. M., RIJATMOKO, S., ISDIANTO, A., ASADI, M. A., SETYOHADI, D., JAUHARI, A., LUBIS, A. A., & SOEGIANTO, A. (2019). Study Of Concentrations Of Heavy Metals Cadmium Trapped In Study Of Concentrations Of Heavy Metals Cadmium Trapped In Porites Lutea Skeleton In Kondang Merak ,. *38*.

LUTHFI, O. M., RIJATMOKO, S., ISDIANTO, A., SETYOHADI, D., JAUHARI, A., & LUBIS, A. A. (2017). Copper (Cu) content in Porites lutea at South Java Sea : Case study at Pantai Kondang Merak , Malang , Indonesia Copper (Cu) Content in Porites lutea at South Java Sea : Case Study at Pantai Kondang Merak, Malang, Indonesia. *030010*(November). https://doi.org/; https://doi.org/10.1063/1.5012710

LUTHFI, O. M., ROSYID, A., ISDIANTO, A., JAUHARI, A., SETYOHADI, D., ROSDIANTO, & SOEGIANTO, A. (2019). Water quality impact to coral compromised health prevalence of prigi bay, east java, indonesia. *Ecology, Environment and Conservation*, *25*(July), S211–S219.

MAKATITA, J. R., SUSANTO, A. B., & MANGIMBULUDE, J. C. (2014). Study of Nutrients Phosphate and Nitrate in Water and Sediment Seagrass Padang Tujuh Seram Island North West Central Maluku. *National Seminar FMIPA-UT 2014*, *4*, 3–5. https://doi.org/https://doi.org/10.1186/s12986

NAIU, C. A., SAHAMI, F. M., & HAMZAH, S. N. (2014). Condition of Coral Reefs in the Waters of Bintalahe Village, Kabila Bone District, Bone Bolango Regency, Gorontalo Province. *Nike Journal*, *II*. http://ejurnal.ung.ac.id/index.php/nike/article/view/1248

NUGRAHA, D. R. W. (2019). The effect of hydro-oceanographic factors on the growth and survival rate of transplanted coral reefs of Acropora sp. in the waters of Paiton, Probolinggo.

OMPI, B. N., REMBET, U. N. W. J., & RONDONUWU, A. B. (2019). Condition of Coral Reefs on Hogow and Dakokayu Islands, Southeast Minahasa Regency. *Platax Scientific Journal*, *7*(1), 25–32.

PATTY, S. I. (2013). Distribution of Temperature, Salinity and Dissolved Oxygen in Kema Waters, North Sulawesi. *Platax Scientific Journal*, *1*(3), 148–157.

PRASETYO, A. B. T., YULIADI, L. P. S., ASTUTY, S., & PRIHADI, D. J. (2018). The Relationship between Substrate Type and Sedimentation Rate with Coral Reef Cover Conditions in Panggang Island Waters, Thousand Islands National Park. *Fisheries and Marine Journal*, *IX*(2), 1–7.

RACHMAN, D., KUSHARTONO, E. W., & SANTOSA, G. W. (2019). Suitability of Eretmochelys imbricate Hawksbill Turtles, Linnaeus, 1766 (Reptilia: Cheloniidae) at the Marine National Park Hall, Seribu Islands Jakarta. *Journal of Marine Research*, *8*(2), 168–176.

RITONGA, I. R. (2012). Distribution of Nutrients and pH in Coral Reef and Seagrass Ecosystems in Wet Rice Waters of Bontang City. *Proceedings of the National Seminar on Natural Resources and Environment Management*. https://www.academia.edu/5861499/I.R._Ritonga_2012._distribusi_nutrien_dan_ph_pada_ekosistem_terumbu_karang_dan_lamun_di_perairan_beras_basah_kota_bontang_kaltim

SUMARNO, D., & MRYANTO, T. (2014). Levels of Salinity, Dissolved Oxygen, and Water Temperature in the Artificial Coral Reef Unit of Little Kotok Island and Harapan Island. *Btl*, *12*(2), 121–126.

SUPRIYADI, HIDAYATI, N., & ISDIANTO, A. (2017). Analysis of Surface Ocean Current Circulation and Sediment Distribution. *Proceedings of the National Marine and Fisheries Seminar III*, *September*, 175–181.

TITO, C. K. (2015). pH and Temperature Conditions in Coral Reef Ecosystems in the Waters of Nusa Penida and Pemuteran Bali. *October*.

WIBAWA, I. G. N. A., & LUTHFI, O. M. (2017). Water Quality Of Coral Reef Ecosystem At Sempu Strait, Sendang Biru Malang. *Jurnal Segara*, *13*(1), 25–35.

WIBOWO, K., & ADRIM, M. (2013). Fish Community - Coral Fish in Prigi Bay Trenggalek, East Java. *Zoo Indonesia*, *22*(2), 29–38.

YUSUF, M., HANDOYO, G., & WULANDARI, S. Y. (2012). Characteristics of Current Patterns in Relation to Water Quality Conditions and Phytoplankton Abundance in the Waters of the Karimunjawa Marine National Park. *Marina Oceanography Bulletin*, *1*(5), 63–74. https://doi.org/10.14710/buloma.v1i5.6918.g5673