International Journal Of Technology Science

Vol. 1, No. 1 March 2023, Hal. 17-28

DOI: https://doi.org/XX..XXXXX/ijts

PREVALENCE OF DISEASES AND HEALTH DISORDERS CORAL IN SERIBU ISLANDS

Putri *1

[1] Biology Study Program, Faculty of Science And Technology, UIN Syarif Hidayatullah Jakarta, Indonesia
*e-mail: putri@gmail.com[1]

Abstract

Seribu Islands receive a lot of pressure from the surrounding environment, both biological and anthropogenic factors. This condition can affect the life of biota in the waters and its surroundings, one of which is coral reefs. This study aims to analyzed the condition of coral reefs and the prevalence of diseases and compromised health in coral reefs in the Seribu Island. The study was conducted at 6 stations, covering Air Island (East), Semak Daun Island (South), Karang Beras Island (East), Kotok Besar Island (South), Kotok Kecil Island (North), and Karang Congkak Island (East) applied the Underwater Photo Transect (UPT). Data were collected in shallow water with a depth of 3-5 meters. Coral reef lifeform data were processed used CPCe 4.1 software. The condition of coral reef cover at the research station is in moderate to good condition. The dominated coral life forms was different at each research station include foliose, branching, submassive and massive. Coral diseases found at research stations include Black Band Disease (BBD), White Syndrome (WS), and Ulcerative White Syndrome (UWS) as well as other categories of coral compromised health, namely Bleaching (Bl), Pigmentation Response (PR), Sediment Damage (SD), Predation (Pr), and Growth Anomalies (GA). The highest overall prevalence of disease and compromised health was found at Pulau Air (17.99%) and Kotok Besar (17.46%) stations. Sediment damage was the most common coral disease and compromised health in all research stations. There was a weak relationship between live coral cover and prevalence of coral disease.

Keywords: *Seribu Island; coral reefs; disease*

INTRODUCTION

The Seribu Islands are located in the Java Sea and Jakarta Bay and consist of 110 island groups. Administratively, the Thousand Islands Administrative Regency has an area of 8.70 km2, which is divided into 2 sub-districts, namely the northern part of the Thousand Islands and the southern part. The Seribu Islands have different natural characteristics and potential from other areas of DKI Jakarta (BPS Seribu Islands Regency, 2019). The islands in the Thousand Islands receive a lot of pressure from the surrounding environment, both natural and anthropogenic factors. This condition can affect the life of biota in the waters and surrounding areas, one of which is coral reefs (Dedi & Arifin, 2017).

The poor condition of coral reefs can be influenced by human activities and climate change (Hadi et al., 2018). The designation of the Seribu Islands has changed, from initially being for settlement, fishing and mining, to being a conservation and tourism area (Estradivari, Setyawan, & Yusri, 2009). These changes increase human activity around the Thousand Islands which can cause the growth of hard coral to be disturbed or even damaged. The increase in tourism activities that do not prioritize environmental conditions and the anchoring of fishermen at snorkeling or diving locations is estimated to have a significant impact on hard corals (Hadi et al., 2018; Latuconsina, 2019). Increasing human activity in coastal areas is disrupting ocean health (Hetherington et al., 2005). Coral reefs have a very important function as a place for spawning, foraging, a place of maintenance for marine biota and as a source of germplasm. The existence of coral reefs from year to year experiences damage, namely damage occurs which causes a reduction in quantity and quality. The condition of coral reefs in the Seribu Islands in the last few decades and based on data from 2005 and 2007, the islands located in Jakarta Bay have very limited hard coral richness.

Research on hard coral cover on several islands in the Thousand Islands shows that coral reef conditions are in the moderate to poor category (Banata, 2015; Tanzil, 2018; Utami, 2018). The low percentage of hard coral can be caused by various factors, both environmental, biological

Vol. 1, No. 1 March 2023, Hal. 17-28
DOI: https://doi.org/XX..XXXXX/ijts

and anthropogenic. These three factors are related to each other. Coral disease is an impact that can result from various factors and is one of the main threats that can cause rapid and mass coral death (Estradivari et al., 2009; Giyanto et al., 2017)

Coral diseases can arise because of the relationship between pathogens, the environment and coral animals (Sabdono, 2008). Research on the prevalence of coral disease in the Seribu Islands was carried out by Johan, Kristanto, Haryadi, & Radiarta (2014) regarding the peak prevalence of Black Band Disease by surveying the condition of coral reefs on several islands based on the distance of the research location to Jakarta Bay using the belt transect method. Other research regarding the health conditions of corals was reported by Dedi & Arifin (2017) regarding the prevalence of several diseases and health problems on corals on small islands in Jakarta Bay which include Bokor Island, Lancang Kecil Island, Kongsi Island, Bird Island and Pari Island. Among them are diseases such as skeletal band erosion, brown band disease, white syndrome, and others.

Along with climate change and increasing human activity, waters are increasingly receiving waste and other anthropogenic factors which can increase damage to coral reefs and the emergence of other coral diseases. Therefore, it is necessary to carry out research on coral diseases to determine the condition of coral reef ecosystems and as monitoring and one of the monitoring efforts in taking management actions.

METHOD

The method used in this research is a survey method. The data collection method used is Underwater Photo Transect (UPT) or Underwater Photo Transect. This research was carried out in August 2019 on several islands in the Thousand Islands which are included in three different zones including Air Island (East), Semak Daun (South), Karang Beras (East), Kotok Besar (South), Kotok Kecil (North) and Congkak Reef (East). The tools used include SCUBA (Self Contained Underwater Breathing Apparatus), stationery, Global Positioning System (GPS), DO meter, pH meter, hand refractometer, thermometer, roll meter, square frame made from pipe measuring 1x1 m, and camera. underwater digital. Data collection on chemical and physical factors of waters includes temperature, pH, DO and salinity.

Coral reef data taken includes coral growth form (lifeform), genus and disease and coral health disorders. The Underwater Photo Transect (UPT) method is carried out in shallow waters with depths ranging from 3-4 meters with 5 data collection points at each station. The coral reef data that has been obtained is identified and processed using CPCe 4.1 software for the growth form (lifeform) of coral reefs, while the genus and disease are identified visually based on the book Coral of the world (Veron, 2002), the Underwater Cards for Assessing Coral guidebook Health on Indo-Pacific Reefs (Beeden et al., 2008) and Coral Disease Handbook (Raymundo et al., 2008).

RESULTS AND DISCUSSION

Table 1. General conditions of research locations (City Planning Department, 2014; Putri & Kristiyanto, 2018)

Station	Manager	Zoning	Sub Zone	Activity
Water Island	Personal	Area outside TNKpS	Trade and service zone	-Air tourism -Lodging -Camping ground
Bushleaf Island	Personal	Residential	Open green cultivation zone	- Air tourism - Camping ground - *Sea farming*

Vol. 1, No. 1 March 2023, Hal. 17-28
DOI: https://doi.org/XX..XXXXX/ijts

Karang Beras Island	Personal	Kawasan luarTNKpS	Trade and service zone	-Air tourism -Gazebo-like building
Kotok Besar Island	Personal	Tourism use	Trade and service zone	-Air tourism -Conservation of the Bondol Eagle -Lodging
Kotok Kecil Island	Personal	Tourism use	Green open zone cultivation	- Restaurant - Air tourism - Lodging
Karang Congkak Island	Provincial governme nt	Residential	Green open zone cultivation	- Air tourism -Camping ground

The Seribu Islands are designated for settlement, fisheries, mining, conservation areas and tourism. In 2002, the Thousand Islands were designated the Thousand Islands National Park (TNKpS). The TNLKpS area is divided into 4 zones, namely the Core Zone, Protection Zone, Tourism Use Zone and Residential Zone. Air Island, which is outside the TNKpS area, is used as a buffer area. Buffer areas function to protect the existence of national parks and their ecosystems against disturbances from outside the area which could endanger the potential for sustainability within the TNKpS area (Yulianda et al., 2017). Only Karang Congkak Island is managed by the DKI Jakarta Provincial Government, while the other islands are managed privately by individuals or companies. With the facilities that support activities on these islands, there are several shortcomings such as limited fresh water on Air Island, Karang Beras and Karang Congkak. Fresh water is usually found on inhabited nearby islands.

Table 2. Chemical and Physical Conditions of Water

No.	Island	Temperature (°C)	DO(mg/l)	Salinity(‰)	pH
1.	Water	30,8	7,8	43	6,3
2.	Shrub Leaves	30,2	7,5	35	7,1
3.	Rice Coral	31,5	10,3	35	7,2
4.	Kotok Besar	30,7	11,6	35	6,3
5.	Kotok Kecil	33,4	7,7	40	7,1
6.	Congkak Coral	29,8	12,5	35	6,5

Temperature is one of the physical parameters of waters which is a limiting factor for coral reefs. Varying temperature changes can affect the life of coral reefs. Sudden temperature changes of 4-6oC below or above the threshold can reduce coral growth and can even cause death (Tambunan, Anggoro, & Purnaweni, 2013). The temperature at the research station ranges from 29.8 to 33.4 °C. Only the water temperature on Karang Congkak Island is the ideal temperature for coral reef growth, while temperatures in other locations have quite high values for coral reefs. This was found in the marine water quality standards based on Minister of Environment Decree Number 51 of 2004 that the water temperature for coral reefs ranges between 28-30°C. An increase in sea water temperature above its normal temperature will cause coral bleaching so that the color of the coral becomes white. If this continues continuously over a period of several weeks,

Vol. 1, No. 1 March 2023, Hal. 17-28
DOI: https://doi.org/XX..XXXXX/ijts

it will cause coral death (Giyanto et al., 2017). However, coral reefs can still survive at high water temperatures. Coral animals can survive in a temperature range between 18 - 36°C with the optimal temperature for growth being 26 - 28°C and most corals will lose their ability to capture food at temperatures <16 oC and >33.5oC (Supriharyono, 2000). Temperature patterns in waters are influenced by various factors such as sunlight intensity, heat exchange, geographic height and cover by surrounding tree vegetation (Reid, Marshall, Logan, & Kleine, 2011).

Condition of Coral Reef Cover

Live coral cover at each research station has different percentages (Figure 1). The percentage of live coral cover is the average percentage for several transects. The highest percentage of coral cover is on Kotok Kecil Island at 73.24%. Then Karang Sawah Island with a percentage of 71.91%, Air Island 57.01%, Kotok Besar Island 54.96%, Karang Congkak Island 43.19%, and Semak Daun Island with the lowest percentage, namely 36.19%.

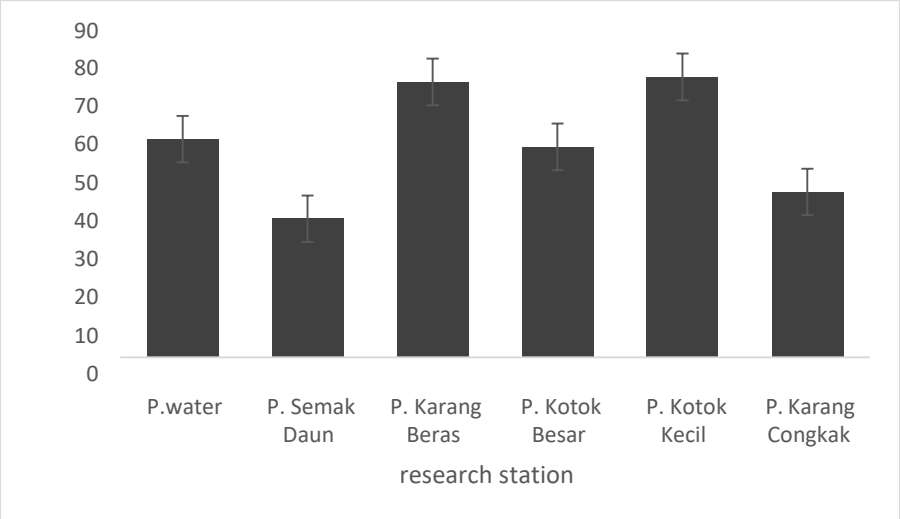

Figure 1. Percentage of live coral cover at the research station

The condition of coral reefs in a body of water can be determined by the percentage of live coral cover. Based on Minister of Environment Decree No. 4 of 2001, live coral cover on Kotok Kecil Island and Karang Rice Island is in the good category, even almost reaching the very good category. There are various factors that influence the high percentage of coral cover, such as environmental factors and human activities. Based on physical chemistry data, both islands have several environmental factors that are quite good, except for temperature. The temperature on both islands has quite high values. This will have negative impacts if it happens continuously. Rising temperatures on coral reefs can cause coral bleaching and will cause coral death (Giyanto et al., 2017).

Vol. 1, No. 1 March 2023, Hal. 17-28
DOI: https://doi.org/XX..XXXXX/ijts

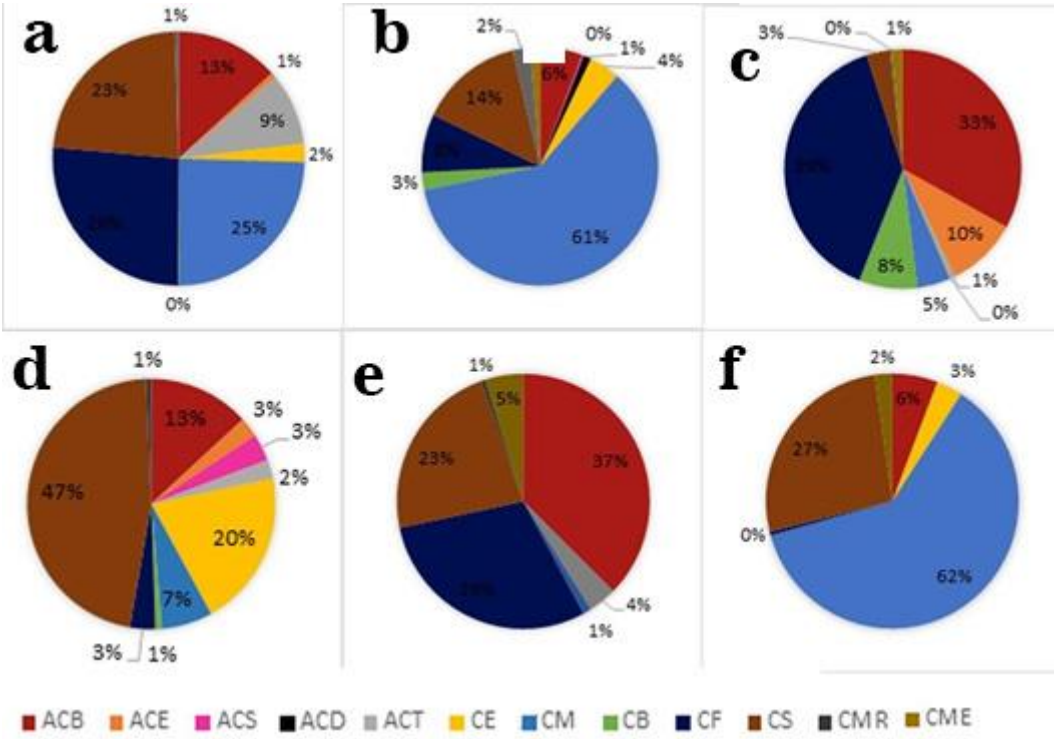

Figure 2. Growth form of live coral at the research station. pair; b) P. Leaf Shrubs; c) P. Karang Beras; d) P. Kotok Besar; e) P. Kotok Kecil; f) P. Karang Congkak. Information; ACB: Acropora branching; ACE: Acropora encrusting, ACS: Acropora submassive, ACT: Acropora tabulate, ACD: Acropora digitate, CE: Coral encrusting, CM: Coral massive, CB: Coral branching, CF: Coral foliose, CS: Coral submassive, CMR: Coral Mushroom, and CME: Millepora coral

Air Island has a percentage of coral reef cover which is included in the good coral reef category with a percentage of 57.01%. The shallow water area to the edge of Air Island is quite far and the type of coral growth which is fringing reef, allows Air Island to be quite protected (Iqbal, 2013). Apart from that, Air Island is a buffer area close to Pramuka Island as an island in the southern part of the Seribu Islands National Park (Banata, 2015). According to Soemarwoto (1985), a buffer area is an area around a protected area which functions to limit human activities in the protected area so as not to damage the ecosystem within the protected area. The good condition of coral reefs is supported by good chemical and physical factors for coral growth, however the salinity at the research station has a fairly high value, namely 43‰. This condition is still within the tolerance range of coral reefs because corals have a level of protection against high salinity (Thamrin, 2006). The ideal salinity for coral reefs is between 30-36‰. However, even though coral reefs are able to survive at salinities outside this range, their growth is poor compared to normal salinity (Dahuri, 2003).

The abiotic percentage at the research station ranges from 3.90% - 29.14%. Abiotic components consist of rocks, sand, and coral fragments (debris). Debris is an abiotic component that dominates almost all research stations (Appendix 2-7). The high percentage of coral fractures is thought to be caused by anthropogenic factors in the form of human activities such as ship traffic (Utami, 2018). The presence of cargo from land carried by coastal currents can also be a factor in the presence of coral faults.

BBD was found on Karang Rice and Kotok Besar Islands with a low prevalence value, namely 0.28-0.3%. BBD disease is known by the presence of black or brownish red circular bands between living coral tissue and exposed coral skeletons (Beeden et al., 2008). Previous research on BBD disease in the Thousand Islands has a prevalence ranging from 0.31% to 31.64% (Delpopi , Zamani, Soedharma, & Johan, 2015; Johan, 2013). Optical observations show

Vol. 1, No. 1 March 2023, Hal. 17-28
DOI: https://doi.org/XX..XXXXX/ijts

that there are various types of bacteria that colonize the coral tissue. However, the main agent that causes BBD is the Cyanobacterium class of bacteria. A high number of BBD diseases can be used as an indicator of climate change in a body of water (Edmunds, 1991). Harvell's research (2007) also states that there is a correlation with the increasing incidence of Black Band Disease coral disease with increasing water temperatures and pollution. At both stations, BBD disease infects the Acropora genus with a branching growth form. The rate of BBD infection in branching corals is quite fast, namely around 4-8 mm/day, while in tabular corals it is around 1-4 mm/day (Beeden et al., 2008).

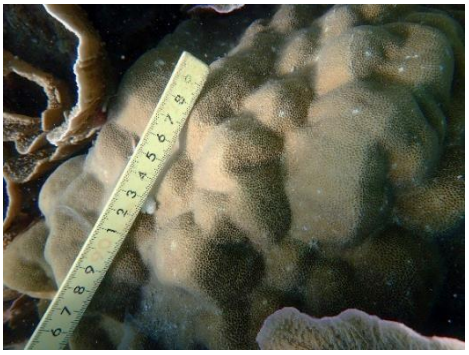

Figure 3. White Spot Ulcerative Disease on Porites coral

Coral diseases arise due to a combination and interaction between coral as the host, transmission medium, and environmental pressure. Infections by viruses, bacteria, fungi and protists are diseases caused by biotic factors. Apart from disease, there are also categories of coral health problems. Abiotic health problems are caused by environmental stress such as temperature, sediment, toxins and ultraviolet radiation (Raymundo et al., 2008). Bleaching is bleaching of coral reefs which is characterized by the loss of Zooxanthellae algae from coral tissue. In contrast to WS, in bleaching conditions coral still has living tissue. However, if this condition continues, it will cause stress and death of the coral. Bleaching occurred at all research stations with a prevalence of 2.06% -4.21%. Porites (Benzoni, Galli, & Pichon, 2010).

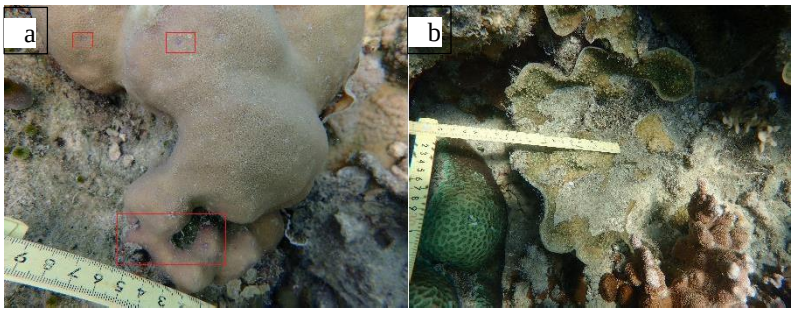

Figure 4. Coral disease disturbance at the research station; a) pigmentation response and b) sediment damage at the research station

Apart from bleaching and pigmentation responses, sediment damage was also found at all research stations and had the highest prevalence value compared to other coral diseases and health disorders. SD was found with prevalence values ranging from 3.13%-11.31%. Pulau Air, Kotok Besar and Karang Congkak stations were the research with the highest SD prevalence values. The third island is included in the National Park Management Section (SPTN) III area. SPTN III is the area closest to the main land so it is visited by many tourists, especially local tourists (Yulianda et al., 2017). SD is characterized by the presence of sediment that accumulates so that it covers the surface and coral polyps. SD can occur due to the high influence of anthropogenic activities. The existence of marine tourism activities at all research stations is one of the factors

Vol. 1, No. 1 March 2023, Hal. 17-28
DOI: https://doi.org/XX..XXXXX/ijts

for the high sedimentation on the island (Table 1). According to Zikrillah (2016) also stated that the damage to coral reefs in the Seribu Islands was caused by sedimentation. Accumulation of sediment on corals over a certain period of time can cause coral death. Sediments rich in organ material cause a constant increase in hydrogen sulfide which can increase the degradation of coral mucosa and cause coral tissue death (Weber et al., 2012). Increased sedimentation will also cover the corallites and reduce the penetration of light needed by Zooxanthellae for photosynthesis. In general, sediment accumulation occurs in water areas where currents and air circulation are not too strong so that sediment particles cannot be cleaned from coral bodies (Rogers, 1990).

Relationship between disease prevalence and coral health problems and live coral cover

Regression analysis of the percentage of live coral cover on the prevalence of disease and coral health disorders obtained y = -0.1503x + 22.224 with an R2 value = 33.79% which shows that there is a negative influence between the two. The correlation coefficient (r) has a value of -0.581 which indicates a very weak relationship. Raymundo, Rosell, Reboton, & Kaczmarsky (2005) also stated that there is a weak correlation between live coral cover and the prevalence of coral disease. The linear regression graph shows that the higher the prevalence percentage, the lower the percentage of live coral cover. This is different from Dedi & Arifin (2017) who stated that a high prevalence percentage value was followed by a high percentage of live coral cover. It is thought that this difference could occur due to several factors. One of them is the dominance of a certain genus at the research station. Porites is one of the dominant genera at several research stations (Appendix 3C-8C). Several diseases found at the research station also dominate in infecting the Porites genus, such as white ulcerative symptoms, pigmentation response, and predation. According to Raymundo et al., (2005), Porites is susceptible to diseases and coral health disorders such as white ulcerative syndrome, tumors, pigmentation response, and necrotic syndrome. A strong positive correlation was also demonstrated between the prevalence and distribution of the Porites genus. This condition also occurred in the research of Fahlevy et al. (2019) which shows that certain coral diseases have a high prevalence in low-lying live corals.

CONCLUSION

The condition of coral reef cover on several islands in the Seribu Islands is in moderate to good condition. Two research stations have a coral cover percentage of <50%, namely Karang Congkak Island and Semak Daun. Meanwhile, other research stations, namely Air Island, Karang Rice, Kotok Besar, and Kotok Kecil, have a percentage of >50%. Coral diseases found at other research stations include Black Band Disease (BBD), White Syndrome (WS), and Ulcerative White Syndrome (UWS) as well as other categories of coral health disorders, namely Bleaching (Bl), Pigmentation Response (PR), Sediment Damage (SD), Predation (Pr), and Growth Anomalies (GA). The overall prevalence of disease and coral health problems was highest at Pulau Air and Kotok Besar stations. Sediment damage was the most frequently found at all research stations.

BIBLIOGRAPHY

Ahmad, J., Hasan, A. ul, Naqvi, T., & Mubeen, T. (2019). A Review on Software Testing and Its Methodology. *Manager's Journal on Software Engineering*, *13*(1), 32–38. https://doi.org/10.26634/jse.13.3.15515

Aljawarneh, S., Aldwairi, M., & Yassein, M. B. (2018). Anomaly-based intrusion detection system through feature selection analysis and building hybrid efficient model. *Journal of Computational Science*, *25*(1), 152–160. https://doi.org/10.1016/j.jocs.2017.03.006

Guo, Y., Han, S., Li, Y., Zhang, C., & Bai, Y. (2018). K-Nearest Neighbor combined with guided filter for hyperspectral image classification. *International COnference On Identification, Information and Knowledge in the Internet of Things*, 159–165.

Handoko, D. (2016). Sistem Pendukung Keputusan Seleksi Penentuan Penerima Beasiswa Dengan Metode Simple Additive Weighting (SAW). In *Program Studi Teknik Informatika* (Vol. 5, Issue

Vol. 1, No. 1 March 2023, Hal. 17-28
DOI: https://doi.org/XX..XXXXX/ijts

2). Universitas Muhammadiyah Surakarta.

Kurniawan, Y. I., Rahmawati, A., Chasanah, N., & Hanifa, A. (2019). Application for determining the modality preference of student learning. *Journal of Physics: Conference Series*, *1367*(1), 1–11. https://doi.org/10.1088/1742-6596/1367/1/012011

Kurniawan, Y. I., Soviana, E., & Yuliana, I. (2018). Merging Pearson Correlation and TAN-ELR algorithm in recommender system. *AIP Conference Proceedings*, *1977*. https://doi.org/10.1063/1.5042998

Low, C. (2015). *NSL-KDD Dataset*. https://github.com/defcom17/NSL_KDD

Shams, E. A., & Rizaner, A. (2018). A novel support vector machine based intrusion detection system for mobile ad hoc networks. *Wireless Networks*, *24*(5), 1821–1829. https://doi.org/10.1007/s11276-016-1439-0

Sridevi, M., Aishwarya, S., Nidheesha, A., & Bokadia, D. (n.d.). *Anomaly Detection by Using CFS Subset and Neural Network with WEKA Tools*. Springer Singapore. https://doi.org/10.1007/978-981-13-1747-7

Aeby, G. S., Williams, G. J., Franklin, E. C., Kenyon, J., Cox, E. F., Coles, S., & Work, T. M. (2011). Patterns of coral disease across the Hawaiian Archipelago : relating disease to environment. PloS ONE, 6(5). https://doi.org/10.1371/journal.pone.0020370

Afni, N. (2017). Kondisi terumbu karang di Pulau Samatellu Pedda Kecamatan Liukang Tupabbiring Kabupaten Pangkep Sulawesi Selatan (Skripsi). UIN Alauddin Makassar.

Aldyza, N., & Afkar. (2015). Analisis genus dan penyakit karang di perairan Pulau Tuan Kecamatan Peukan Bada Kabupaten Aceh Besar. Jurnal Biotik, 3(2), 107–115.

Amin. (2009). Terumbu karang; aset yang terancam (akar masalah dan alternatif solusi penyelamatannya). Region, 1(2).

Anggara, S. P., Afrizal, T., & Elizal. (2017). The condition of coral reefs in the waters around the Banyan Tree Bintan Bintan Regency Riau Islands Province (Skripsi). Universitas Riau.

Assuyuti, Y. M., Zikrillah, R. B., Tanzil, M. A., Banata, A., & Utami, P. (2018). Distribusi dan jenis sampah laut serta hubungannya terhadap ekosistem terumbu karang Pulau Pramuka, Panggang, Air, dan Kotok Besar di Kepulauan Seribu Jakarta. Majalah Ilmiah Biologi Biosfera : A Scientific Journal, 35(2), 91–102. https://doi.org/10.20884/1.mib.2018.35.2.707

Bahri, A. D., Hamdani, A., & Wibowo, A. (2017). Di Balik Krisis Agraria dan Ekosistem Kepulauan Seribu : Apakah Wisata Bahari adalah Jawabannya? Jakarta.

Banata, A. (2015). Kepadatan Acanthaster planci L. dan hubungannya dengan persentase tutupan karang hidup di Pulau Air (daerah penyangga Taman Nasional Kepulauan Seribu) (Skripsi). UIN Syarif Hidayatullah Jakarta.

Barus, B. S., Prartono, T., & Soedarma, D. (2018). Environmental effect on coral reefs life form in the Lampung Bay. Jurnal Ilmu Dan Teknologi Kelautan Tropis, 10(3), 699–710.

Beeden, R., Willis, B. L., Raymundo, L. J., Page, C. A., Weil, E., & Disease, C. (2008). Underwater cards for assessing coral health on indo-pacific reefs underwater cards for assessing coral health on Indo-Pacific reefs how to use these cards. St.Lucia: CRTR.

Benzoni, F., Galli, P., & Pichon, M. (2010). Pink spots on Porites: not always a coral disease. Coral Reef, 29, 4810. https://doi.org/10.1007/s00338-009-0571- z

BPS Kabupaten Kepulauan Seribu. (2019). Kabupaten Kepulauan Seribu dalam angka 2019. Jakarta: BPS Kabupaten Kepulauan Seribu.

Melendy, A. M. (2007). Thermal stress and coral cover as drivers of coral disease outbreaks. PLoS Biology, 5(6), 1220–1227. https://doi.org/10.1371/journal.pbio.0050124

Vol. 1, No. 1 March 2023, Hal. 17-28
DOI: https://doi.org/XX..XXXXX/ijts

Castro, P., & Huber, M. E. (2005). Marine Biology (5th ed.). New York: Mc Graw- Hill Companies Inc.

Cervino, J. M., Hayes, R., Goreau, T. J., & Smith, G. W. (2004). Zooxanthellae regulation in yellow blotch/band and other coral diseases contrasted with temperature related bleaching: In situ destruction vs expulsion. Symbiosis, 37(1–3), 63–85.

Dahuri, R. (2003). Keanekragaman hayati laut. Jakarta: Gramedia Pustaka Utama. Dedi, & Arifin, T. (2017). Kondisi kesehatan karang di pulau – pulau kecil Teluk

Jakarta. Jurnal Kelautan Nasional, 11(3), 175–187.

Delpopi, M., Zamani, N. P., Soedharma, D., & Johan, O. (2015). Prevalensi, insidensi dan perkembangan black-band disease pada karang Scleractinia (Montipora spp) di Perairan Dangkal Gugusan Pulau Pari. Ilmu Kelautan, 20(1), 52–60. https://doi.org/10.14710/ik.ijms.20.1.52-60

Dinas Penataan Kota. (2014). Buku Saku Perda Nomor 1 Tahun 2014 Kepulauan Seribu. Jakarta: Suku Dinas Penataan Kota Kabupaten Administrasi Kepulauan Seribu.

Dubinsky, Z., & Stambler, N. (2011). Coral reefs: An ecosystem in transition.

Springer Science, 1–552. https://doi.org/10.1007/978-94-007-0114-4

Edinger, E. N., Kolasa, J., & Risk, M. J. (2000). Biogeographic variation in coral species diversity on coral reefs in three regions of Indonesia. Diversity and Distributions, 6(3), 113–127. https://doi.org/10.1046/j.1472- 4642.2000.00076.x

Edmunds, P. J. (1991). Extent and effect of Black Band Disease on a Caribbean reef. Coral Reefs, 10(3), 161–165. https://doi.org/10.1007/BF00572175

Estradivari, Setyawan, E., & Yusri, S. (2009). Terumbu Karang Jakarta. Jakarta: Yayasan TERANGI.

Fahlevy, K., Khodijah, S., Prasetia, M. F., Idham, A., Yudha, F. K., Subhan, B., & Madduppa, H. (2019). Live hard coral coverage and coral diseases distribution in the Ujung Kulon National Park, Banten, Indonesia. AACL Bioflux, 12(4).

Fauziah, S., Komala, R., & Hadi, T. A. (2018). Struktur komunitas karang keras (bangsa Scleractinia) di pulau yang berada di dalam dan di luar kawasan Taman Nasional, Kepulauan Seribu. BIOMA, 14(1), 10–18. https://doi.org/10.21009/Bioma14(1).6

Giyanto. (2013). Metode transek foto bawah air untuk Penilaian kondisi terumbu karang. Oseana, XXXVIII(1), 47–61.

Giyanto, Abrar, M., Hadi, T. A., Budiyanto, A., Hafizt, M., Salatalohy, A., & Iswari, M. yulia. (2017). Status terumbu karang di Indonesia 2017 (Suharsono, Ed.). Jakarta: COREMAP-CTI Pusat Penelitian Oseanografi – LIPI.

K., Anita, D. Z. (2014). Panduan monitoring kesehatan terumbu karang. Jakarta: PT. Sarana Komunikasi Utama.

Haapkylä, J., Seymour, A. S., Trebilco, J., & Smith, D. (2007). Coral disease prevalence and coral health in the Wakatobi Marine Park, south-east Sulawesi, Indonesia. Marine Biological Association, 87(April), 403–414. https://doi.org/10.1017/S0025315407055828

Hadi, T. A., Giyanto, Prayudha, B., Hafizt, M., Budiyanto, A., & Suharsono. (2018). Status terumbu karang Indonesia 2018. Jakarta: Pusat Penelitian Oseanografi – LIPI.

Hamdani, B. (2014). Laju Infeksi, Prevalensi, dan Insiden Penyakit Karang Black Band Disease Pada Karang Keras (Scleractinia) Di Perairan Pulau Barranglompo (Skripsi). Universitas Hasanuddin.

Harvell, C. D. (2007). Coral Disease Environmental Drivers, and The Balance Between Coral and Microbial Associates. Oceanography, 20(1), 36–59.

Vol. 1, No. 1 March 2023, Hal. 17-28
DOI: https://doi.org/XX..XXXXX/ijts

Hetherington, J., Leous, J., Anziano, J., Brockett, D., Cherson, A., Dean, E., … Reilly, K. (2005). The marine debris research, prevention and reduction act: a policy analysis. The Marine Debris Team, …, (January 2005), 40. https://doi.org/10.13140/RG.2.2.26619.54562

Iqbal, M. (2013). Aplikasi SIG Untuk Kesesuaian Wilayah Wisata Snorkeling dan Scuba Diving di Pulau Air dan Pulau Karang Beras, Kepulauan Seribu (Skripsi). Institut Pertanian Bogor.

Johan, O. (2010). Penyebab, dampak, dan manajemen penyakit karang di ekosistem terumbu karang. Media Akuakultur, 5(2), 144–152.

Johan, O. (2013). Epidemiologi penyakit karang sabuk hitam (black band disease) di Kepulauan Seribu, Jakarta. Institut Pertanian Bogor.

Johan, O., Kristanto, A. H., Haryadi, J., & Radiarta, I. N. (2014). Puncak prevalensi penyakit karang jenis sabuk hitam (black band disease) di Kepulauan Seribu, Jakarta. Jurnal Riset Akuakultur, 9(November 2011), 307–317.

Jompa, J., & Mccook, L. J. (2002). The effects of nutrients and herbivory on competition between a hard coral (Porites cylindrica) and a brown alga (Lobophora variegata). American Society of Limnology and Oceanography, 47(2), 527–534.

Kabupaten Administrasi Kepulauan Seribu. (2005). Sebaiknya Anda tahu: Data Kabupaten administrasi Kepulauan Seribu. Jakarta: Bagian Humas dan Protokol, Kabupaten Administrasi Kepulauan Seribu.

LAPI-ITB. (2001). Laporan Akhir Pengelolaan Laut Lestari: Pendataan dan Pemetaan Potensi Sumberdaya Alam Kepulauan Seribu dan Pesisir Teluk Jakarta. Jakarta: LAPI-ITB.

Lardizabal, S. (2007). Beyond the refugiu: a makroalgal primer. Reefkeeping Magazine, 5(12).

Latuconsina, H. (2019). Ekologi perairan tropis: prinsip dasar pengelolaan sumber daya hayati perairan. Yogyakarta: Gadjah Mada University Press.

Le Tissier, M. D. A. A., & Brown, B. E. (1996). Dynamics of solar bleaching in the intertidal reef coral Goniastrea aspera at Ko Phuket, Thailand. Marine Ecology Progress Series, 136(1–3), 235–244. https://doi.org/10.3354/meps136235

Mansur, W., Kamal, M. M., & Krisanti, M. (2013). Estimation of organic waste and waters carrying capacity in relation to coral reefs management on Semak Daun Island Thousand Islands. Depik, 2(3), 141–153.

Menteri Lingkungan Hidup. (2001). Keputusan Menteri Negara Lingkungan Hidup tentang : kriteria baku kerusakan terumbu karang. (4), Nomor 51.

Paramitha, A., Utomo, B., & Desrita. (2013). Study of chlorophyll-a around sea of Belawan, North Sumatera. Program Studi Manajemen Sumberdaya Perairan, Fakultas Pertanian Universitas Sumatera Utara, 106–119.

Purnomo, T., Hariyadi, S., & Yonvitner. (2013). Study the potential of shallow water for increasing marine tourism and utilization imfact to local people (case study semak daun island as support area tourism activity pramuka island of Kepulauan Seribu Administration Regency) Triyadi. Depik, 2(3), 172–183.

Putri, L. S. E., Hidayat, A. F., & Sukandar, P. (2012). Diversity of coral reefs in Badul Island Waters, Ujung Kulon, Indonesia. Journal of Biological Sciences, 1(3), 59. Retrieved from www.isca.in

Putri, Lily Surayya E, & Kristiyanto. (2018). Role of government and private sector in marine ecotourism related to conservation of biodiversity in Seribu Islands. International Journal of GEOMATE, 14(43), 140–147. https://doi.org/10.21660/2018.43.3698

Rachmawati, R. (2001). Terumbu Buatan (Artificial Reef). Pusat Riset Teknologi Kelautan Badan Riset Kelautan dan Perikanan Departemen Kelautan dan Perikanan Republik Indonesia.

Raymundo, L. J., Couch, C. S., Bruckner, A. W., & Harvell, C. D. (2008). Coral disease handbook. Melbourne: Coral Reef Targeted Research and Capacity Building for Management Program.

Vol. 1, No. 1 March 2023, Hal. 17-28
DOI: https://doi.org/XX..XXXXX/ijts

Raymundo, L. J., Rosell, K. B., Reboton, C. T., & Kaczmarsky, L. (2005). Coral diseases on Philippine reefs: genus Porites is a dominant host. Disease of Aquatic Organisms, 64, 181–191.

Reid, C., Marshall, J., Logan, D., & Kleine, D. (2011). Terumbu karang dan perubahan iklim: Panduan pendidikan dan pembangunan kesadartahuan. Brisbane: Coral Watch The University of Queensland.

Riska, Tasak, A. R., Lalang, Kamur, S., Wahab, I., & Maharani. (2019). Identification of coral reef diseases and health disruption in the waters of Langgapulu Village, Konawe Selatan, Southeast Sulawesi. Ilmu Kelautan, 1(2), 63–74.

Riznawati, A. E. (2015). Prevalensi white syndrome padakarang masif di perairan pembangkit listrik tenaga uap (PLTU) Paiton, Probolinggo (Tesis). Institut Teknologi Sepuluh Nopember.

Santoso, A. D. (2010). Kondisi terumbu karang di pulau karang congkak kepulauan seribu. Jurnal Hidrosfir Indonesia, 5(2), 73–78.

Santoso, A. D., & Kardono. (2008). Teknologi konservasi dan rehabilitasi terumbu karang. Teknologi Lingkungan, 9(3), 121–226. Retrieved from http://ejurnal.bppt.go.id/index.php/JTL/article/view/465/366

Soemarwoto, O. (1985). Ekologi, lingkungan hidup dan pembangunan. Jakarta: Djambatan.

Stimson, J., & Kinzie, R. A. (1991). The temporal pattern and rate of release of zooxanthellae from the reef coral Pocillopora damicornis (Linnaeus) under nitrogen-enrichment and control conditions. Journal of Experimental Marine Biology and Ecology, 153(1), 63–74. https://doi.org/10.1016/S0022-0981(05)80006-1

Supriharyono. (2000). Pelestarian dan pengelolaan sumber daya alam di wilayah pesisir tropis. Jakarta: Djambatan.

Supriharyono. (2007). Pengelolaan ekosistem terumbu karang. Jakarta: Djambatan.

Suryanti, Supriharyono, & Roslinawati, Y. (2011). The depth influence to the morphology and abundance of corals at Cemara Kecil Island, Karimunjawa National Park. Jurnal Saintek Perikanan, 7(1), 63–69.

Sutherland, K. P., Porter, J. W., & Torres, C. (2004). Disease and immunity in Caribbean and Indo-Pacific zooxanthellate corals. Marine Ecology Progress Series, 266(Table 1), 273–302. https://doi.org/10.3354/meps266273

Syam, A. R., & Mujiyanto. (2011). Populasi ikan karang dan biota penempel di sekitar terumbu buatan perairan Pulau Kotok kecil dan Pulau Harapan, Kepulauan Seribu. Prosiding Forum Nasional Pemacuan Sumber Daya Ikan III, 1–14.

Tambunan, J. M., Anggoro, S., & Purnaweni, H. (2013). Kajian kualitas lingkungan dan kesesuaian wisata Pantai Tanjung Pesona Kabupaten Bangka. Prosiding Seminar Nasional Pengelolaan Sumberdaya Alam Dan Lingkungan, 356–362.

Tanzil, M. A. (2018). Tutupan karang di Pulau Pramuka Kepulauan Seribu dan kaitannya dengan kepadatan Acanthaster planci (Skripsi). UIN Syarif Hidayatullah Jakarta.

Weber, M., Beer, D. De, Lott, C., Polerecky, L., Kohls, K., Abed, R. M. M., … Fabricius, K. E. (2012). Mechanisms of damage to corals exposed to sedimentation. Proceedings of the National Academy of Sciences, (May), 1– 10. https://doi.org/10.1073/pnas.1100715109

Yamashiro, H. (2004). Coral disease. Ministry of the Environment of Japan: The Japanese Coral Reef Society.

Yee, R. W. Y., Yeung, A. C. L., & Cheng, T. C. E. (2008). The impact of employee satisfaction on quality and profitability in high-contact service industries. Journal of Operations Management, 26(5), 651–668. https://doi.org/10.1016/j.jom.2008.01.001

Yulianda, F., Samosir, A., Fachrudin, A., Adimu, H. E., Febryane, A., & Muhidin. (2017). Daya dukung lingkungan di Taman Nasional Kepulauan Seribu. Bogor: Direktorat PJLHK.

Vol. 1, No. 1 March 2023, Hal. 17-28
DOI: https://doi.org/XX..XXXXX/ijts

Zikrillah, R. B. (2016). Kondisi Ekosistem Terumbu Karang pada Zona yang Berbeda di Kepulauan Seribu (Skripsi). UIN Syarif Hidayatullah Jakarta.