Oceanographic Analysis for Optimal Lobster Artificial Reef Placement in Prigi Bay, East Java

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Abstract. Oceanographic states are closely related to marine biota's distribution and breeding patterns, especially in the intertidal zone. This study analyses the water quality variability and their relationship in the water of Prigi Bay. Water quality data was collected in situ using a Water Quality Checker. The statistical analyses were performed by applying PAST software version 4.11. The suitable waters with the best tendency value for the placement of lobster artificial reefs are stations 2 (Karang Gongso) and 4 (Damas). It is not only explained by salinity and turbidity but also by the ORP role, which has the solution potential to transfer electrons from oxidants to reductants, thus affecting the chemical processes. The high potential suitability at 2 locations is due to the concentration of a supportive environment with variability in ORP concentrations, having more potential for electron transfer, which significantly affects the attached benthic life as a pioneer for the reef. Salinity stability is safer from the impact of water mixing from the estuary. Parameter concentrations are more stable according to water temperature standards for coralline algae growth and are affected by turbidity and dissolved oxygen. In addition, other research is needed, such as social factors and fishermen's activities.

1 Introduction

The total area of Indonesian marine waters is ± 1,097,000 km2, and about ± 6,782.48 km2 (0.62%) is lobster habitat [1]. The selling price of lobster from Indonesia is high in domestic and export markets. The high value of lobster and smooth market access encourage intensive lobster fishing in nature. This condition was also stated by [2] that a decrease followed the pressure on the lobster population in the lobster's sustainable capacity to grow and develop naturally. According to [3, 2], fishing activities in nature dominate the utilisation of fish resources. This condition impacts the increase in the volume of demand increase every year. This condition is very attractive for fishermen who want to make more intensive fishing efforts. It is feared that one day, the lobster population in Indonesian seas will decrease and

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may even become extinct, so efforts need to be made to preserve it. Efforts to improve lobster habitat to protect the sustainability of lobster resources is trying to improve lobster habitat in nature in several locations that are indicated to have decreased stocks by selecting locations that have similarities with natural locations as a source of seeds. Lobster growth in nature, especially in the juvenile phase, is influenced by the aquatic environment, habitat conditions and predator safety. In nature, the location of lobster growth from juvenile to adult stages is closely related to the presence of reef fish and oceanographic conditions. The relationship with reef fish is because the puerulus phase is vulnerable to predators such as grouper fish groups. This is related to the structural patterns that must be considered in creating artificial habitats, especially lobsters in the puerulus phase because some adult grouper species have a tendency to look for tiny cracks and spaces [4] and tend to move to deeper waters. Hydro-oceanographic profiles can be used as a determinant of primary products, which is a determining factor for fish resources and other aquatic biota that can be used for the prosperity of society [5].

The ocean holds many oceanographic phenomena and conditions influencing each other [6]. The ocean has many life forms, from tiny microorganisms to giant sea creatures like blue whales. Moreover, about 80 per cent of species on Earth are found in the marine environment [7]. One potential resource that is closely related to oceanographic conditions is fisheries resources. Some scientists call fisheries-related oceanography fisheries oceanography. Fisheries oceanography is a scientific discipline that studies the interaction between fisheries organisms and marine ecosystems [8]. The analyses of fisheries oceanography are fundamental because fish and other marine organisms are not only a source of food for humans but also play a role in maintaining the balance of the ocean ecosystem.

Oceanographic conditions are closely related to the distribution and breeding patterns of marine biota, especially in the intertidal zone [9]. Marine organisms, which have a reliable relationship with environmental quality changes in the intertidal zone, are the growth of biota associated with coral habitats and the coral planula attachment system on a particular medium, which is very dependent on oceanographic conditions in these waters. One of the organisms that is closely related to coral reef ecosystems with high economic value in both national and international markets is lobster resources. Lobster resources, or tropical areas, known as tropical spiny lobster, are a fishery commodity with high economic value, especially for export purposes. Lobster resources are widely distributed in Indonesian marine waters. In some areas, lobster catch production tends to decline, such as in the southern region of Java, namely Gunung Kidul waters in Yogyakarta, Pacitan in East Java, Trenggalek in East Java, and Pangandaran in West Java [10] also Wonogiri in Central Java [11].

Potential lobster resources in Prigi Bay, Trenggalek Regency, was very promising, ranging from 0.16-0.96 ind./m^3 with dominated juvenile size between 30-50% to > 50% [12] in addition to several waters in Indonesia such as Simeulue, Pangandaran, Pacitan, Gunung Kidul Yogyakarta, Jember and Kebumen [13]. Trenggalek Regency is one of the lobster-producing centres in WPP-NRI 573. [12] revealed that the potential diversity of crayfish in this region identified five species out of seven in Indonesian waters [14]. Lobster fishing areas are spread along coastal waters from Prigi Bay, Damas Bay, Munjungan Bay, and Sumbreng Bay to Panggul Coast. Lobster production fluctuates in the range of 2.6-3.43 tonnes/year and tends to show a decline [15] [16]. Stock enhancement is an effort to increase or preserve the recruitment of one or more aquatic organisms and increase the total production or selected production elements of a fishery that is still below the sustainable level of its natural processes (FAO (Food and Agriculture Organization), 1999).

This research aims to analyse oceanographic parameters and the relationship between oceanographic water parameters in Perigi Bay. The correlation results among oceanographic parameters are the basis for determining the site location, material type in the making, and the the Lobster Artificial Reef or “Lobster AR” model. Referring to [19], one of the

requirements in selecting site for the Lobster AR location is the result of the analysis of the suitability of aquatic environmental conditions based on oceanographic parameters. The study also explained that Lobster Artificial Reef is one of the media for enriching lobster resources in the East Java Perigi Bay area. Efforts to enrich lobster resources by using artificial media in the form of artificial habitat models (cement material) have been carried out in other countries, such as Japan, Canada, Australia, Mexico and Cuba, through habitat rehabilitation programmes for lobster life have been carried out by [19].

2 Methodology

The research was fieldwork conducted on 10 November 2016 and 29 April 2019, with observations in 5 locations spread across Prigi Bay (see in Fig. 1). The research station was determined based on a preliminary survey using Participatory Rural Appraisal (PRA) and the FGD (Focus Group Discussion) result with local communities and fishermen. The PRA method is an evolving approach and process to enable local communities to share, improve and analyse their knowledge about their lives and conditions, plan and act [20]. Using the PRA method provides more information that is shared with the local community that belongs to the local community.

Water quality measurements were collected using a WQC (Water Quality Checker)-HORIBA U52. Data measured included water temperature, pH, ORP (Oxidation-reduction potential), turbidity, DO (Dissolve Oxygen) and salinity. Data collection was carried out in one-time repetition. Water temperature is an external factor affecting aquatic organisms' metabolic activity and distribution [21]. It is closely related to solar penetration of benthic life. The size (in mV) of the tendency or strength, indicating whether a solution is an oxidising or reducing agent, is known as Oxidation Reduction Potential (ORP). A Positive (+) ORP represents an increasingly oxidative solution, while a negative (-) ORP value would indicate a reductive solution (Setiawan et al., 2019). pH concentration is the negative logarithm of hydrogen ions released in a liquid and indicates water quality. The nature of water is harmful, but it can cause concern because of the chemical content, which has toxic effects on humans and biota. One such concern is turbidity, which refers to the degree of turbidity or opacity of a fluid generally due to large numbers of individual particles that are generally not visible to the naked eye. High turbidity can indicate poor water quality and can be harmful to aquatic life [22]. Dissolved oxygen concentration is the total amount of oxygen present (dissolved) in the waters; usually, dissolved oxygen is needed by all living things for respiration, metabolic processes or substance exchange, which can then produce energy for growth and reproduction [23]. The salinity concentrations of all salt solutions obtained in seawater affect the osmotic pressure of water. This parameter is an oceanographic parameter that is closely related to the growth of biota in waters such as benthic communities and coral growth.

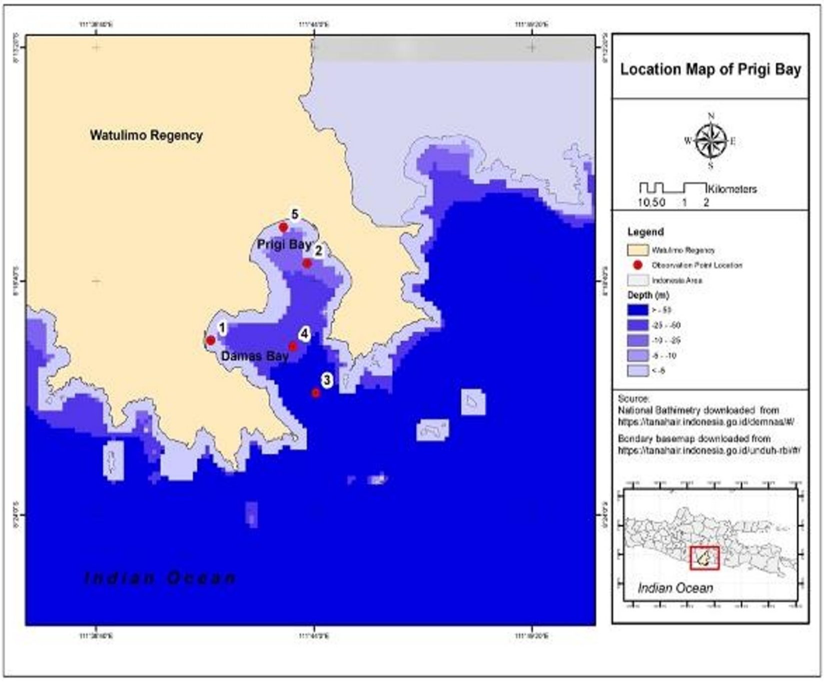


Fig. 1. Map of sampling station in Prigi Bay, East Java

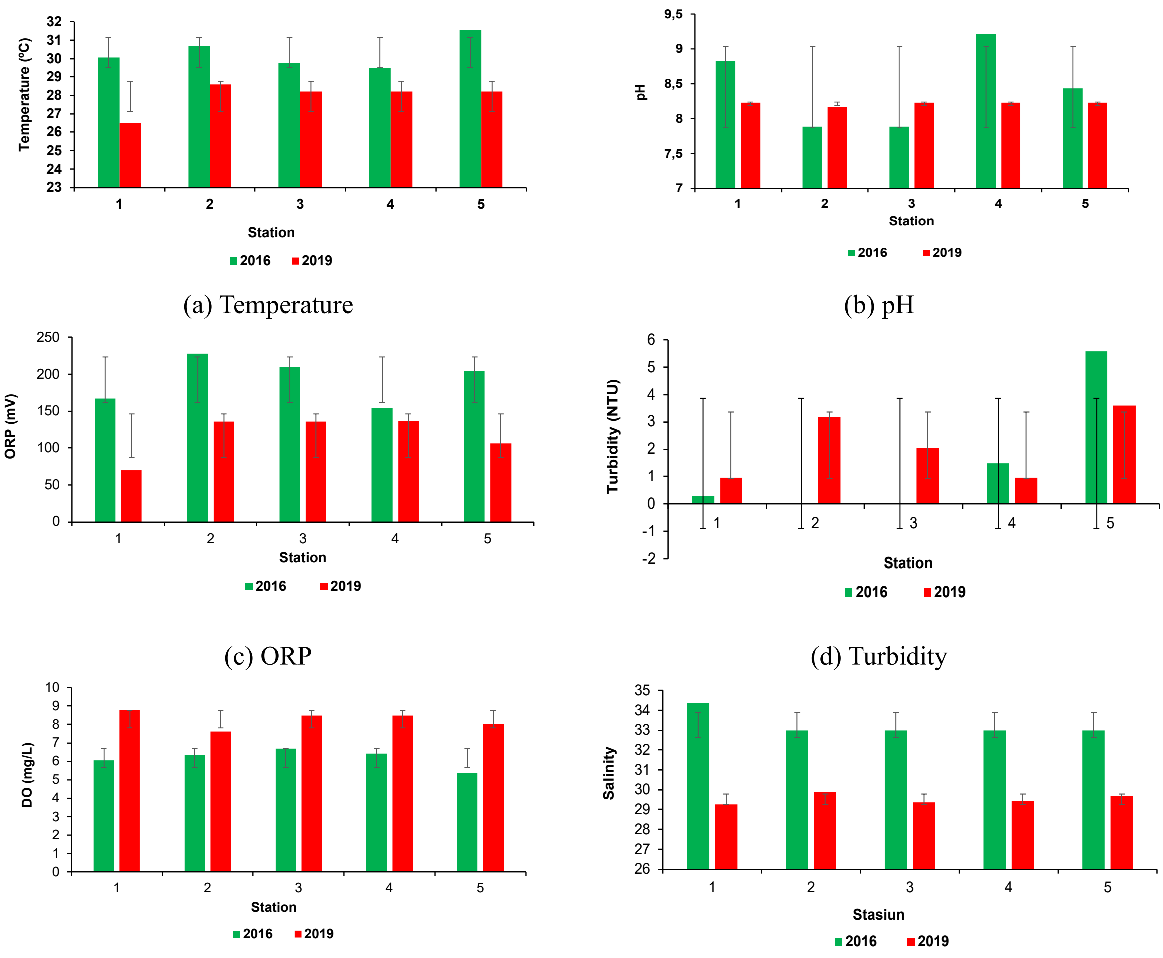
Water quality data processing consists of bar charts processed using Excel Office 2011 software, Principal Component Analysis (PCA), Pearson Correlation and Hierarchical clustering analysis (CA) processed using PAST software version 4.11[24]. Analysis of the relationship between water quality parameters and the use of PCA was also carried out in [25], which explained that principal component analysis was used to analyse multidimensional variations in physio-chemical parameters at measurement points. The principal component method (PCA) can be applied in multiple factor extraction processes [26]. Each water parameter as a variable is analysed because it has different units that are standardised beforehand by the tool [27]. Data standardisation is generally known as the process of normalising variables or parameters, and the condition is based on the method of zero union, where the character between parameters refers to the nature of each water quality parameter before normalisation [28]. Then the results of data processing were compared with the Government Regulation of the Republic of Indonesia on Environmental protection and management implementation to determine the parameters which are suitable for biota life [29].

3 Result and Discussion

3.1 Water quality parameters variability in Prigi Bay

Water surface temperature conditions at station 5 ranged from 31.55 °C in 2016, higher than at other stations, while for 2019, it occurred at station 2 at 28.6 °C (see in Fig. 2a). Water sampling in 2016 was conducted during the day while in 2019 it was conducted in the morning. The temperature difference is influenced by several factors such as the intensity of

daylight entering the water, circulation currents, sea depth, wind and season. The intensity of light correlates to the depth topography. In shallow waters, light will more easily enter the aquatic bottom compared to deeper waters [30].



(a) Temperature (b) pH

(c) ORP (d) Turbidity

(e) DO (f) Salinity

Fig 2. Water quality in Prigi Bay in 2016 and 2019 based on oceanography parameters (note: The black line colour as standard deviation)

Shown in Fig. 2a, the temperature in 2016 around Prigi Bay at station 5 was around 31.55°C as well as in 2019 at station 2 was 28.6°C. Station 5 and station 2 are located around the pier of the fishing harbour with depth contours ranging from -5 to -10 m (see in Fig. 1), thus causing high temperatures. The water mass movement can cause heat, due to friction between water molecules, so that the seawater temperature in nearshore waters is warmer than the water mass in offshore waters [31]. Stations 3 and 4 in 2016 had similar temperature values ranging from 29.5°C to 29.76°C (Fig. 2a) at depths of -25 to -50 m (see in Fig. 1). The optimal water temperature for the tropics ranges from 25-32 °C [32], in accordance with the study location. Temperature conditions for marine biota are generally suitable for coral reefs

ranging from 28-30 °C. In accordance with Appendix VIII of The Indonesian Government Regulation No 22/2021.

Marine waters generally have a pH value above 7 (categorised as alkaline), but under certain conditions, the value can go below seven and be acidic. Most marine organisms are resistant to changes within the pH value; the recommended score for survival is around 7 to 8.5 (see in Fig. 2b). The aquatic pH's consentration was above 7, which means it is alkaline, but it can also be below 7, making it acidic. The ideal value for aquatic biota life is 7-8.5 [33].

The parameter value of acidity (pH) in 2016 at station 4 is very alkaline, 9.22, at a distance of 5.38 metres from the shoreline of Prigi Bay. Stations 2 and 3 have the same value of 7.89. In 2019, the pH value had similar values ranging from 8.17-8.23 at almost each station (see in Fig. 2b). The pH value is 8.17 at station 2 and 8.23 at stations 1, 3, 4 and 5. The ideal acidity value for marine biota ranges from 6-8.5 [29,34,35].

Redox potential (reduction and oxidation) describes the electron activity in the water [36]. ORP is the solution's potential to transfer electrons from oxidants to reductants, thus affecting the chemical processes in the water. Electron activity has the potential to transfer oxidants to reductants, thus affecting the chemical processes of the aquatic environment. However, the higher the amount of pollutants in the water, the lower the dissolved oxygen content. When the ORP value is higher, the water's ability to destroy unknown pollutants, such as microbes, will be better [37]. The highest 2016 data at station 2 was 228 mV around Prigi Bay, and the lowest at station 4 was 154 mV, a distance of 4.13 metres from Damas Bay. In 2019, stations 2, 3 and 4 have the same range of values, 136.2-136.6 mV. Station 4 has the highest ORP value, at 136.6 mV. The lowest at station 1 is 69.6 mV in Damas Bay (see in Fig. 2c). ORP conditions in Prigi Bay waters were relatively good because the ORP value is above 0 mV, which indicates good water conditions [38].

ORP to marine life caused by bacterial infection raises the importance of ORP monitoring in waters [39]. Reactions under aerobic conditions have ORP values > 200 mV, while reactions under anaerobic conditions have ORP values < 50 mV. Waters with saturated oxygen levels of pH seven and temperature conditions of 25 °C have an ORP value of 0.80 mV. Natural waters usually have ORP values ranging from 0.45-0.52 mV. ORP values are little affected by temperature but are significantly affected by oxygen levels. In the hypolimnion layer, ORP values can reach zero. In bottom mud waters with anaerobic conditions, ORP values can get 0.1 volts.

The highest turbidity parameter in 2016 at station 5 was 5.6 nm at the Perikanan Nusantara Port dock. The lowest turbidity was 0 at station 2 around Prigi Bay and station 3 around the mouth of Damas and Prigi bays. In 2019, the lowest turbidity at stations 1 and 4 located around Damas Bay was 0.97 NTU; clear waters with no turbidity, there was no activity around stations 1 and 4 because they were far from the port and were at depths between 5-50 m from sea level. Turbidity is highest at station 5 of the Perikanan Nusantara Harbour dock area at 3.6 NTU (see in Fig. 2d).

At the station 5 is located in Prigi Bay, a high-activity fishing ground by the community around Prigi Bay and Tenggalek people. At this locations, the turbidity value remained high in 2016 and 2019 compared to other locations. Based on The Indonesian Government Regulation Number 22 of year 2021 turbidity value in marine tourism and marine biota is 5 NTU. Turbid water conditions in the location cause the water to be unproductive because it blocks the entry of sunlight for photosynthesis [40].

The DO concentration measurement results in 2016 have similar values ranging from 6.05 mg/L to 6.68 mg/L at stations 1 to 4. Among the five research stations, the most high was at station 3, 6.68 mg/L. The lowest at station 5 was at the Perikanan Nusantara Harbour dock at 5.35 mg/L. In 2019, the lowest at station 2 in Prigi Bay was 7.63 mg/L. The highest value was at station 1 at 8.79 mg/L in Damas Bay (see in Fig. 2e). The 2016 DO data was taken

during the day, while for 2019, it was taken in the morning. It shows that in Prigi Bay's waters, the freshness level in 2019 was better than in 2016. DO levels in Prigi Bay are suitable for marine biota > 5 mg/L [29,41].

The distribution of salinity concentration can be affected by several factors, such as circulation, evapotranspiration, rainfall, and river runoff. Waters with high levels of rainfall and affected by river inlets have low salinity, while waters that have high evaporation have high salinity levels [40].

The highest salinity in 2016 was at station 1, 34.4 ‰, in Damas Bay. The concentration value of salinity at each research station, on average, has the same value of 33 ‰. 2019 has a range that is worth 29.44 ‰ to 29.89 ‰ at stations 1 to 5. The highest value of salinity, 29.89 ‰, is at station 2. There is a difference between 2016 and 2019; in 2016, the salinity value was higher than in 2019. The tabulated results of the bar chart of temperature, pH, ORP, Turbidity, DO and salinity parameters are shown in Table 1. Overall, the water quality parameters are suitable for the placement of the lobster artificial reef.

Table 1. Water quality parameters in Prigi Bay

Parameters	2016			2019			Quality Standards	
	Min	Max	Mean	Min	Max	Mean	PP RI No 22 (2021)*	www.fondriest.com
Temperature (°C)	29.5	31.55	30.312	26.5	28.6	27.94	Coral: 28-30	
pH	7.9	9.22	8.454	8.17	8.23	8.218	7-8.5	
ORP (mV)	154	228	192.6	69.6	136.6	117.02		0,45 - 0,52
Turbidity (NTU)	0	5.6	1.48	0.97	3.6	2.152	5	
DO (mg/L)	5.34	6.68	6.168	7.63	8.79	8.28	> 5	
Salinity (‰)	33	34.4	33.28	29.27	29.89	29.53	Coral: 33-34	

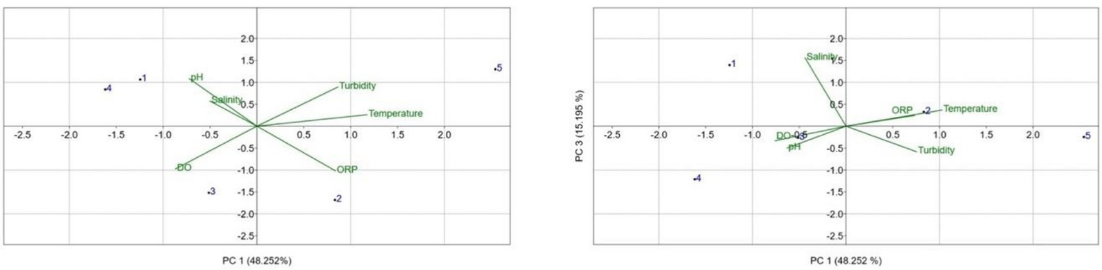
*Note: *) Regulation of Indonesian Government Number 22, 2021*

3.2 Multivariate analysis results

Analysis was used to determine the specific correlation between water quality parameters at each research station in 2016 using PCA. In quadrant 1, a positive correlation exists between PC 1 (48.252%) and PC 2 (36.067%), namely the turbidity and temperature parameters described at station 5 (see in Fig 3a). Among the two parameters, temperature is more dominant than turbidity. Quadrant 4 is the last quadrant of the correlation relationship between PC 1 negative and PC 2 positive parameters in the area pH and salinity are the characterisation of station 1 and station 4, where the pH concentration is more dominant than salinity.

The analysis results of 2016 data, PC 1 (48.252%) vs PC 3 (15.195%) (see in Fig. 3b). In quadrant 1, there is a positive correlation between PC 1 and PC 2, namely temperature and ORP as characteristics of station 2. Of the two parameters, temperature is more dominant than ORP. Quadrant 2 correlation relationship PC 1 positive and PC 3 negative, there is a turbidity parameter, which does not indicate from the character of any station. Station 5 is in quadrant 2, but there is no correlation with the turbidity parameter. Next, quadrant 3, PC 1 negative, and PC 3 negative parameters that play a role are DO and pH as a characteristic of station 4. In the next quadrant, four correlation relationships between PC 1's negative and PC 3's positive salinity parameters characterise station 1. From the review of PC1 (48.252%) vs PC3 (15.195%), the dominant to weak parameters are temperature, ORP, turbidity, salinity, DO and pH. The role of temperature is very influential on the life of biota. The ORP loading and temperature range is in the quadrant one (0.3-1).

The results of both PC 1 (48.252%) vs PC 2 (36.067%) and PC 1 (48.252%) vs PC 3 (15.195%) are similar where temperature is the dominant factor, ORP, turbidity and salinity as supporting parameters DO and pH do not play a role (see in Fig. 3a). DO and pH parameters from the correlation relationship result in PC 1 (48.252%) vs PC 2 (36.067%) and PC1 (48.252%) vs PC3 (15.195%) are weak because they have negative values (see in Fig. 3b). Based on the analysis results between quadrant of PC 1 vs PC 2 and quadrant of PC 1 vs PC 3, some parameters remain in quadrant 1, namely temperature, but some are in different quadrants, namely turbidity. Turbidity is in PC 1 vs PC 2 in the positive quadrant but in PC 1 vs PC 3 in the negative two quadrants. This shows that the turbidity parameter does not affect water quality in Prigi Bay.

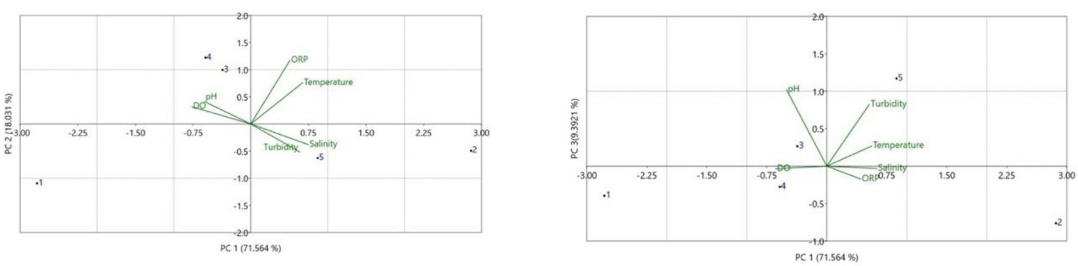


(a) PC 1 (48.252 %) vs PC 2 (36.097%) in 2016 (b) PC 1 (48.252 %) vs PC 3 (15.195%) in 2016

Fig 3. Loadings and variance of water quality data surveyed in 2016, PC1 vs. PC2 (a) and PC1 vs. PC3 (b)

3.2.1 PCA 1 vs PC 2 (2019)

The analysis results of PCA 1 (71.564%) vs PC 2 (18.031%) can be seen in Fig. 4a. In quadrant 1, a positive correlation exists between PC 1 and PC 2, namely ORP and temperature parameters. The ORP parameter plays a more significant role than the temperature parameter. There is no nature of the station characteristics. In quadrant 2, where PC 1 is positive, and PC 2 is negative, there is a correlation between salinity and turbidity. The salinity parameter plays more of a role than turbidity, a characteristic of station 5. On the other hand, station 2 is an outlier or isolated station. No parameters are in quadrant three, negative (-) PC 1 and negative (-) PC 2. In the quadrant 4, negative (-) PC 1 and positive (+) PC 2, there are DO and pH parameters, where the DO parameter is more dominant than pH.



(a) PCA 1 (71.564 %) vs PC 2 (18. 031%) in 2019 (b) PCA 1 (71.564 %) vs PC 3 (9. 3921%) in 2019

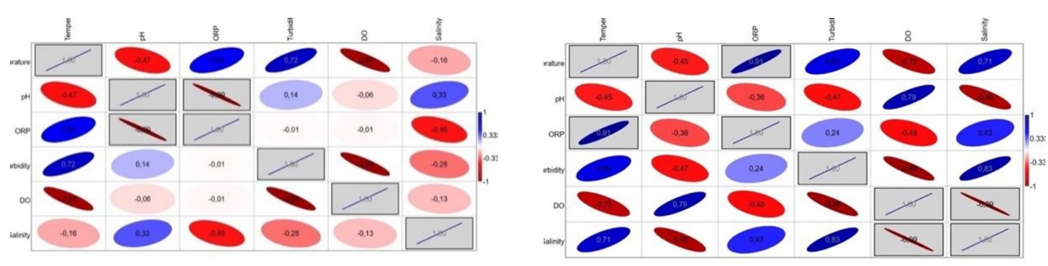
Fig 4. Loadings and variance of water quality data surveyed in 2019. PC1 vs. PC2 (a) and PC1 vs. PC3 (b)

In From the review of PC 1 (71.564%) vs PC 2 (18.031%) (see in Fig. 4a), the dominant to weak parameters are temperature, ORP, salinity, turbidity, DO and pH. The range of ORP and temperature parameter loading values in quadrant 1 is (0.75-1.2). Fig. 4b, in quadrant one, there is a positive correlation between PC 1 and PC 3, namely temperature and turbidity parameters. In quadrant 2, where PC 1 is positive and PC 2 is negative, there is a correlation between ORP and salinity. The parameter salinity plays a more significant role than ORP and does not characterise the station. In quadrant 3, where PC 1 is negative and PC 2 is negative, the parameter that plays a role is DO, characterising station 4. Station 1 is an outlier station. Quadrant 4 PC 1 is negative, and PC 2 is positive for the parameter pH, characterising station 3. From the review of PC 1 (71.564%) vs PC 3 (9.3921%) (see in Fig. 4b), the dominant to weak parameters are temperature, turbidity, salinity, ORP, DO and pH. The range of loading values for turbidity and temperature parameters in quadrant 1 is (0.7-0.8).

From the results of both quadrant "PC 1 (71.564 %)" vs "PC 2 (18.031 %)" and "PC 1 (71.564 %)" vs "PC 3 (9.3921 %)", the dominant factor in each study is different in PC 1 (71.564 %) vs PC 2 (18.031 %) is ORP, while in PC 1 (71.564 %) vs PC 3 (9.3921 %) is turbidity. The weakly different parameter in PC 1 (71.564%) vs PC 2 (18.031%) is pH, while PC 1 (71.564%) vs PC 3 (9.3921%) is DO. Based on the analysis results between quadrants in PC 1 with PC 2 and between quadrants in PC 1 with PC 3, some parameters remain in quadrant 1, namely temperature. However, some parameters are in different quadrants, namely ORP. ORP in PC 1 vs PC 2 in the positive quadrant but in PC 1 vs PC 3 in the negative quadrant 2. This illustrates that ORP concentrations do not significantly impact changes in the quality of the water environment in Prigi Bay.

3.2.2 Correlation between parameters

Pearson Correlation displayed in Fig. 5a dan Fig. 5b shows a correlation relationship whose value is more than 0.5, which identifies a strong correlation relationship, and a positive direction indicates a perfect correlation relationship [42]. The parameter with a person coefficient correlation value of more than 0.5 is 0.72, namely temperature with turbidity, marked in dark blue (see Fig. 5a). This indicates that 72 per cent of the variable bound by temperature explains turbidity. Turbidity is strongly influenced by temperature. In addition to a perfect relationship with a correlation value of more than 0.5, there is also a negative value of more than -0.5, which indicates that it is not interdependent and has a negative direction [42]. The Pearson correlation value is -0.88, shown in dark red. The parameters that are not mutually dependent on each other are turbidity and DO, where 88 per cent between turbidity and DO are not mutually dependent, which is characteristic of a perfect negative correlation relationship.



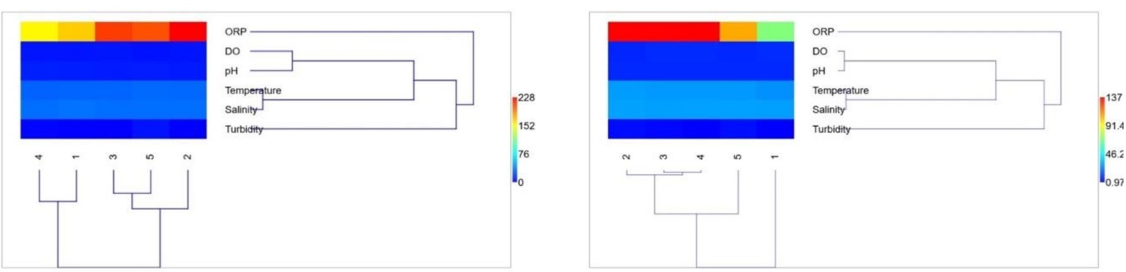
(a) 2016 (b) 2019

Fig 5. Pearson Correlation analysis results for surveyed data in 2016 (a) and 2019 (b)

In Pearson correlation conditions in 2019, in Fig. 5b, there is a correlation relationship whose value is more than 0.5, namely a Pearson correlation value of 0.91 between the temperature parameter and ORP, characterised by dark blue. This indicates that 91 per cent of ORP is strongly tied to temperature, and the direction of the Pearson correlation is positive, which is a perfect correlation relationship. In addition to the ideal positive correlation relationship, there is a perfect negative correlation relationship with a person correlation value of -0.86, identified in dark red (see Fig. 5b). There is no correlation between DO and turbidity, where 86 per cent of the parameters DO and turbidity do not affect each other.

3.2.3 Hierarchical Clustering results

Fig. 6a dan Fig. 6b show that temperature and salinity parameters have similar variations or ranges of values that occur at almost every station. Likewise, the parameters DO and pH have a similar range of variations that occur at each station. The turbidity parameter has the same range of values as the previous parameters, namely temperature with salinity and DO with pH. This condition occurs at almost every station. The last parameter variable, ORP, has a frequency value comparable to the clustering of all parameters (temperature with salinity and DO with pH and turbidity). The highest ORP frequency is 228 at station 2 (see Fig. 6a).



(a) 2016 (b) 2019

Fig 6. Two-way hierarchical clustering analysis of water quality in Prigi Bay surveyed in 2016 (a) and 2019 (b).

Based on the results of hierarchical clustering in 2019 (see Fig. 6b), it shows that temperature and salinity parameters have similar variations or ranges of values that occur at almost every station. The same applies to DO and pH parameters that have a similar range of variations that occur at each station. The following parameter, turbidity, has the same range of values as the previous parameters: temperature with salinity and DO with pH. This condition occurs at almost every station. The last parameter is the ORP variable, which has a frequency value comparable to the clustering of all parameters (temperature with salinity and DO with pH and turbidity). The highest ORP frequencies are at stations 2, 3, and 4 (see Fig. 6b).

The processed results of Hierarchical Clustering between 2016 and 2019 found that the ORP parameter has a high frequency. The ORP value in a body of water can indicate the health of a body of water; if the ORP value is high, the waters are said to be healthy because they can rid themselves of contaminants such as organic matter through the decomposition process with a high DO value. Vice versa, a low ORP value is said to be unhealthy waters with a low DO value and can reduce the pH value of the seas [43,44] where the range of pH range values by the quality standards of seawater [45] the value of a suitable pH range for marine tourism and marine biota or cultivation is 7-8.5 [46].

Oceanographic conditions are closely related to marine biota distribution and breeding patterns, especially in the intertidal zone [9]. Biota has a significant dependence on changing the environmental quality of marine aquatic life in the intertidal zone, such as the presence of coral reefs, which play an extremely crucial role in the fish diversity in the ecosystem [47]. The growth of biota associated with coral habitats and the coral planula attachment system is highly dependent on oceanographic conditions in these waters. One of the biota that is closely related to coral reef ecosystems and holds high economic value in both national and international markets is lobster resources.

4 Conclusion

Aquatic environment quality between 2016 and 2019 based on the characteristics of oceanographic parameters shows the suitability for coral growth on artificial reefs, such as Lobster Artificial Reefs made of cement or other materials that are easily formed according to the characteristics of both juvenile and adult lobsters. This condition is reinforced by the value of temperature, which is very influential on other parameter components in the Perigi Bay and is an essential indicator of the success of reef planula life on a substrate. For other parameters that have a strong relationship, such as temperature with turbidity (0.72), 72 per cent of related variables explain turbidity and temperature. With ORP (0.91), 91% of ORP was strongly associated with temperature. Station 2 (Karang Gongso) and Station 4 (Damas) are suitable waters with the best trend values for placing artificial reefs for lobster. It is not only due to the presence of salinity and turbidity but also due to the role of ORP, which has the potential for solutions to transfer electrons from oxidants to reductants, thus affecting chemical processes in the waters. The highest ORP frequency value was 228 (Station 2) and the highest ORP Frequency was 137 (Station 2, 3, and Station 4). Potential adoption in other locations is expected to have similar locations based on oceanographic parameters that are suitable for the growth of pioneer biota. However, the location must avoid direct disturbance factors such as fishing activities, which can disrupt the ecosystem and negatively impact the success of the artificial reefs. Further analysis to determine the suitability of the carrying capacity of the waters for the placement of lobster artificial reef units requires location-related data such as aesthetics, social factors such as the number of fishermen, tourists and other facilities that are closely related to the carrying capacity of prospective lobster artificial reef placement locations.

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