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Assessment of Community Structure of Macroinvertebrates, Coral Cover and Water Quality in Sempu Strait, Malang Regency, East Java

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ABSTRACT

Due to the sensitivity of invertebrates to environmental changes, their presence can serve as an indicator of coral reef health and water quality. This study seeks to ascertain the abundance of invertebrates, the structure of the invertebrate community, and their relationship with coral cover and water quality parameters in the waters of Sempu Strait. The belt transect method and the underwater photo transect (UPT) are used to determine the abundance of invertebrates and coral cover, respectively. Temperature, pH, DO, salinity, and water clarity are measured for water quality. According to the study's findings, seven of the nine invertebrate species were found. Between October 2021 and May 2022, seven of nine invertebrate biota categories, 733 species, and 606 species dominated by Diadema sea urchins were observed every two months. The invertebrate abundance ranged from 0.024 to 0.512. A low and imbalanced invertebrate diversity ranges from 0.078 to 0.493 (H' < 1). The range of the equality index (E < 0.4) is between 0.04 and 0.22, indicating a low community index. There are three levels of dominance index values: low, medium, and high. Due to their abundance, Diadema sea urchins dominate the Sempu Strait, particularly near the Jetty Station with its port activity. Coverage of coral reefs varies between 6% and 21.3%, indicating low and damaged corals. The correlation between coral cover and invertebrate abundance is moderate in Banyu Tawar and Rumah Apung (0.480 to 0.490), whereas it is weak in Waru-Waru, Watu Meja, and Jetty (-0.037–0.225). The abundance of invertebrates has a weak link with values ranging from -0.037 to -0.283 for water clarity, temperature, salinity, DO, and pH, but it has a strong correlation with a value of 0.610 for current velocity. The environment, including human activities and water quality, has a significant impact on macroinvertebrate communities. Environmentally tolerant macroinvertebrates will outcompete the vulnerable ones.

Keyword: belt transect, underwater photo transect, coral reef cover, abundance of invertebrates, diadema sea urchins, diversity index of invertebrate, evenness index of invertebrate, dominance index of invertebrate

INTRODUCTION

There are 1,800 species of invertebrates living on coral reefs in Indonesia (Bahri et al., 2015), making them one of the organisms associated with coral reefs. Invertebrates are non-vertebrate (Luthfi et al., 2018b) and are categorized as macroinvertebrates if they are between 0.2 and 0.5 mm or 3 and 5 mm in size (Mashar et al., 2021). Macroinvertebrates are present in all types of water, have limited mobility, and are highly sensitive to environmental changes (Mashar et al., 2021) consequently, they can serve as indicators of water contaminants for water quality (Luthfi et al., 2017a; Gani et al., 2017). The presence of benthic macroinvertebrates indicates the ecological condition of the water (Salachna & Olearczyk, 2020). Invertebrates are generally robust when the ecosystem is healthy (Bahri et al., 2015). According to Custodio et al. (2018), the quality of the anthropogenic environment will have a very positive effect on the physicochemical characteristics of the waters and the composition of the benthic macroinvertebrate community.

Sempu Strait is a busy waterway due to the presence of a national fishing port, fisheries industry, and settlements. The Sendang Biru Fishing Port (Pondokdadap), the principal port in South Java, poses a serious threat to the viability of coral reefs. Clearly, this human activity affected the water quality and coral reefs in this region, causing alterations in coral cover over time (Luthfi, 2018a; Marhaendra et al., 2021). In 1928, the Dutch East Indies government established Sempu Island as a protected nature reserve area, which includes coral reefs (Luthfi et al., 2019). Coral reefs are an integral element of the Sempu Island ecosystem, serving as a source of food and shelter for animals, plants, fish, crustaceans, and other biota in the surrounding waters (Isdianto et al., 2022b). Observations of the coral reefs in the waters surrounding Sempu Island must be conducted on a regular basis because they are directly related to the condition of the water and the organisms that inhabit it. The presence of herbivorous invertebrates can be used as a strategy to prevent algae overgrowth (Chung et al., 2019) for example controlling invasive macroalgae using the sea urchin (*Tripneustes gratilla*) (Neilson et al., 2018). The coral reef in the Sempu Island Natural Reserve is a type of edge reef (fringing reef) with more corals than the opposite side (Luthfi et al., 2017b). The coral cover in the waters of the Sempu Strait decreased from 23.3% in 2016 (Luthfi et al., 2017a) to 11.5% in 2021 (Isdianto et al., 2023). In addition, the vast majority of the 600,000 to 9 million species of biota that inhabit coral reefs are macroinvertebrates (Fabricius et al., 2014). Damage to coral reefs has a significant impact on the abundance of macroinvertebrates (Climaco et al., 2022; Licuanan et al., 2019).

The decline in the number of macroinvertebrates in Indonesia is attributable to an alarming reduction in the complexity of the structure and coral coverage (De'ath & Fabricius, 2010; Fabricius et al., 2014). So that reduced coral cover in the waters of the Sempu Strait can serve as a solid basis for monitoring the abundance and community structure of invertebrate, and for determining the relationship between reduced coral cover and water parameters and the abundance of invertebrates in the waters of the Sempu Strait.

MATERIALS AND METHODS

Study area

In October 2021, December 2021, February 2022, and May 2022. Monitoring is carried out approximately once every 2 months, with the aim of knowing differences in macroinvertebrate availability and coral cover in the three types of seasons, namely Transition Season II (October), West Monsoon (December and February), Transition Season I (May). This study was conducted in the Sempu Strait Waters, Malang Regency, East Java. Take five observation stations with coral reefs that, according to their respective criteria, are representative of the waters of the Sempu Strait in general. Watu Meja Station (WM) is located in the most western portion of the strait, rendering Watu Meja a remote location. Waru-waru (WW) Station is one of the most renowned and frequently visited tourist destinations. Banyu Tawar Station (BT) receives river water because it is located near the estuary of the river on Sempu Island. The Jetty Station (JT) is closest to the activities at Pondokdadap Beach Fishing Port. Rumah Apung Station (RA) is located near residential areas and has a precipitous coastal topography. Figure 1 depicts five stations within the Sempu Strait.

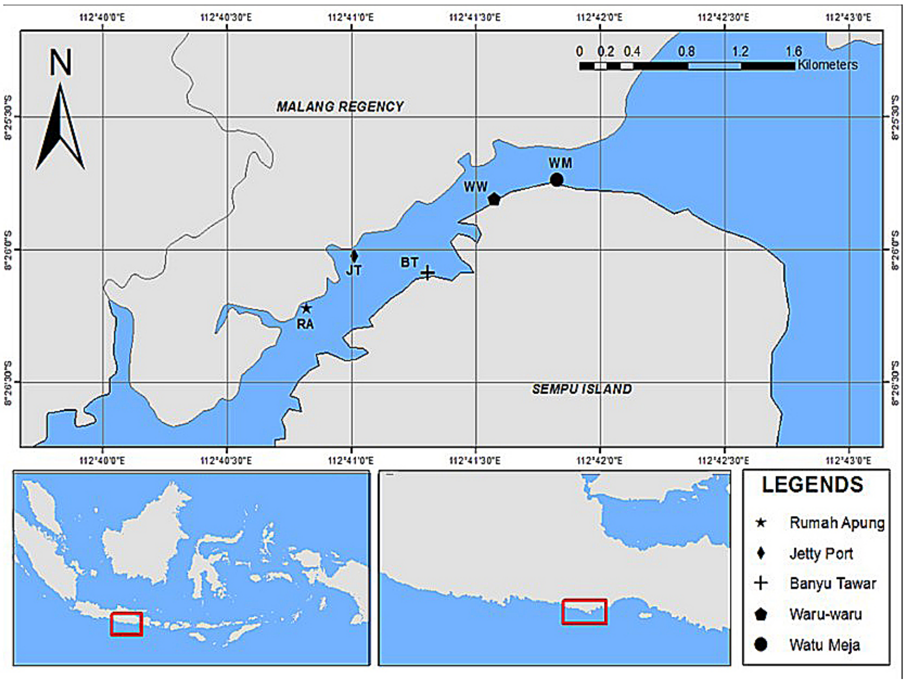


Figure 1. Research site map

Data collection

Data on coral were collected at five observation stations. Each station had a total of five quadrant transect sites, each measuring 1×1 m. The diver swims in a zig-zag shaped pattern and records all the targeted appearances inside belt transect. Divers also equipped with pointers to see biota in coral crevices, therefore good bouyancy is needed for observers. These transect points were located at depths ranging from 2 to 6 metres above sea level, as shown in Figure 2. The positioning of the transect quadrants is achieved by maintaining a consistent 10-meter spacing between each quadrant, following a serpentine pattern. Specifically, the first quadrant is situated on the left side at a distance of 10 metres, the second quadrant on the right side at a distance of 20 metres, and so forth, until reaching a maximum distance of 50 metres (Figure 3). According to the guidelines provided by Giyanto et al. (2014), the Coremap-CTI LIPI Coral Reef Health Monitoring Guidelines 2014, the UPT (Underwater Photo Transect) method was employed to collect data pertaining to coral reefs inside the designated transect quadrant.

Data analysis

Calculations of invertebrate abundance (Ki), diversity index (H'), evennes index (E), dominance index (D), percentage of coral reef cover, and statistical analysis of the relationship between coral reefs and invertebrates in the Sempu Strait were performed as part of the data analysis.

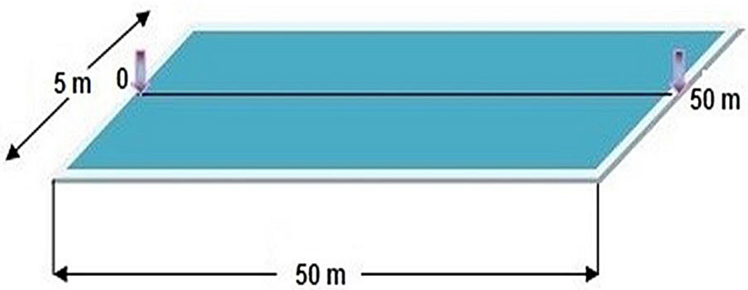


Figure 2. Belt transect

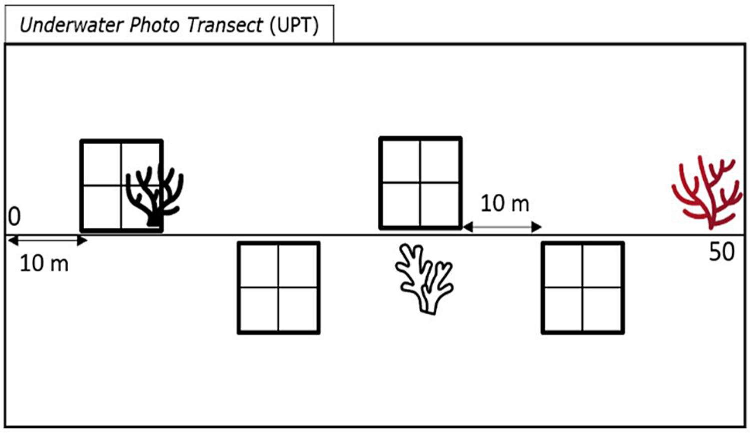


Figure 3. UPT methods ilustration

Abundance aquatic invertebrates

Invertebrate Abundance is calculated by followed formula (Odum, 1993):

$$Ki = \frac{Ni}{A} \quad (1)$$

where: Ki – abundance of types (individual/m^2),
Ni – number of individuals of Type I,
A – large area of observation.

Diversity index (Shannon-Wiener index)

Diversity index is calculated by Shannon-Wiener formula (Puspita & Istikomah, 2013):

$$H' = -(\sum \frac{ni}{N} \ln \frac{ni}{N}) \quad (2)$$

where (Nuntakwang et al., 2021):
H' – Shannon-Wiener Diversity Index,
ni – number of individuals of Type I,
N – number of total individu.

Evenness index

Evenness index is calculated by followed formula (Odum, 1993):

$$E = \frac{H'}{H'maks} \quad (3)$$

where (Nuntakwang et al., 2021):
E – Evenness index,
$H'max$ – Shannon-Wiener diversity index maximal (Ln S),
S – the number of biota species.

Dominance index

Dominance index is calculated by followed formula (Odum, 1993):

$$D = \frac{ni^2}{N^2}\, x\, 100\% \quad (4)$$

where: D – dominance index,
Ni – number of individuals of Type I,
N – total number of individuals.

Percentage of coral cover

Coral cover is calculated by followed formula (Giyanto et al., 2014):

$$Percent\ cover = \frac{Total\ point\ of\ category}{Total\ of\ point}\, x\, 100\% \quad (5)$$

RESULTS AND DISCUSSION

The abundance of invertebrate

Seven types of invertebrates, including banded coral shrimp (BCS), diadema urchin, collector urchin, triton, sea cucumber, lobster, and giant clam, were represented by 733 individuals in the waters of the Sempu Strait, as determined by data collected periodically at five observation stations over four distinct periods (October 2021, December 2021, February 2022, and May 2022) (Figure 4). The observed invertebrates are shown in Figure 5.

In comparison to the other biota, Diadema has the highest number of individuals, clocking

Table 1. Diversity criteria (Krebs, 2014)

Diversity Index	Criteria
H' < 1	Low
1 < H' < 3	Medium
H' > 3	High

Table 2. Evenness criteria

Evenness Index	Criteria
E < 0,4	Depressed community
0,4 < E < 0,6	Labil community
E > 0,6	Stable community

Source: Odum, 1993.

Table 3. Dominance criteria **(**Magurran, 1988)

Dominance Index	Criteria
D < 0,5	Low
0,5 < D < 0,75	Medium
0,75 < D < 1	High

Table 4. Criteria of coral cover

Coral Cover (%)	Criteria
75 – 100	Very good
50 – 74.9	Good
25 – 49,9	Moderate
0 – 24.9	Damaged

Note: Decree of the Minister of Environment (MoE) No. 4, 2001.

in at 606 altogether. Despite the diversity of invertebrate species, invertebrates are in an unstable state. In the presence of biota in very large quantities and very little. Similar to prior study that discovered five indicators of biota in the waters of the Sempu Strait, but in small quantities, it is possible to draw the conclusion that the level of damage to coral reefs and water is fairly serious (Luthfi et al., 2018d). According to Pakpahan et al. (2020), abundance is affected by both biotic and abiotic causes, both biotic and abiotic factors influence abundance. Mikroinvertebrata have different levels of contamination tolerance, from sensitive to very tolerant. On bad land, more tolerant species will dominate, while more sensitive species will be few (López-López & Sedeño-Díaz, 2015).

Based on the data shown in Table 5, the Diadema has the highest abundance value. According to Miala et al. (2015), this particular species of Diadema urchin lives in unusually big groups. The Diadema urchin biota had the highest abundance, with an average value of 0.61 ind/m^2, while the lobster had the lowest abundance, with a value of 0.01 ind/m^2. These findings are based on the abundance results that were acquired. The number of individuals that can be found in a given area is used as a measurement for the abundance of a species. The abundance of Diadema is supported by a variety of food factors, including the large number of microorganisms adhered to coral, which sea urchins consume (Al-Risqia et al., 2021). Since sea urchins are herbivores, their presence can be linked to algae and they serve as a natural

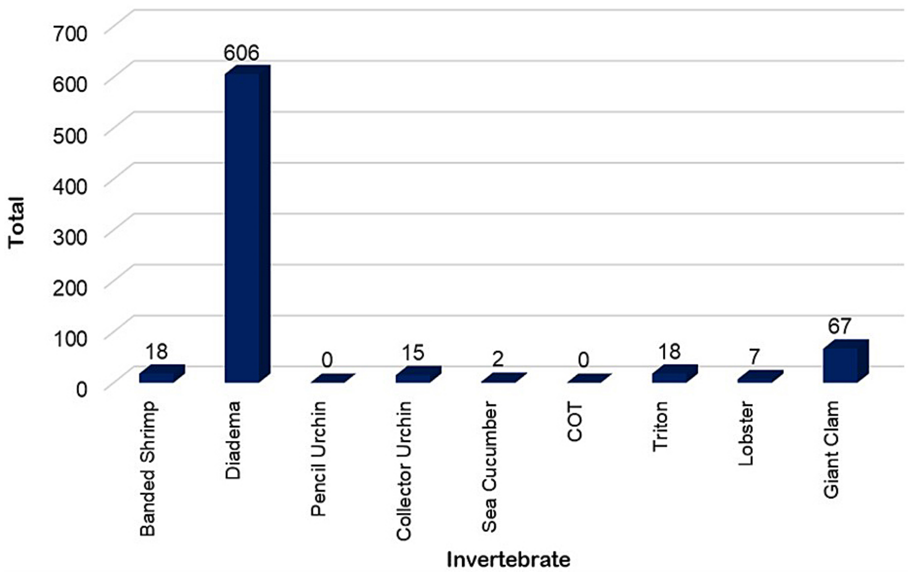


Figure 4. Total individu of invertebrate

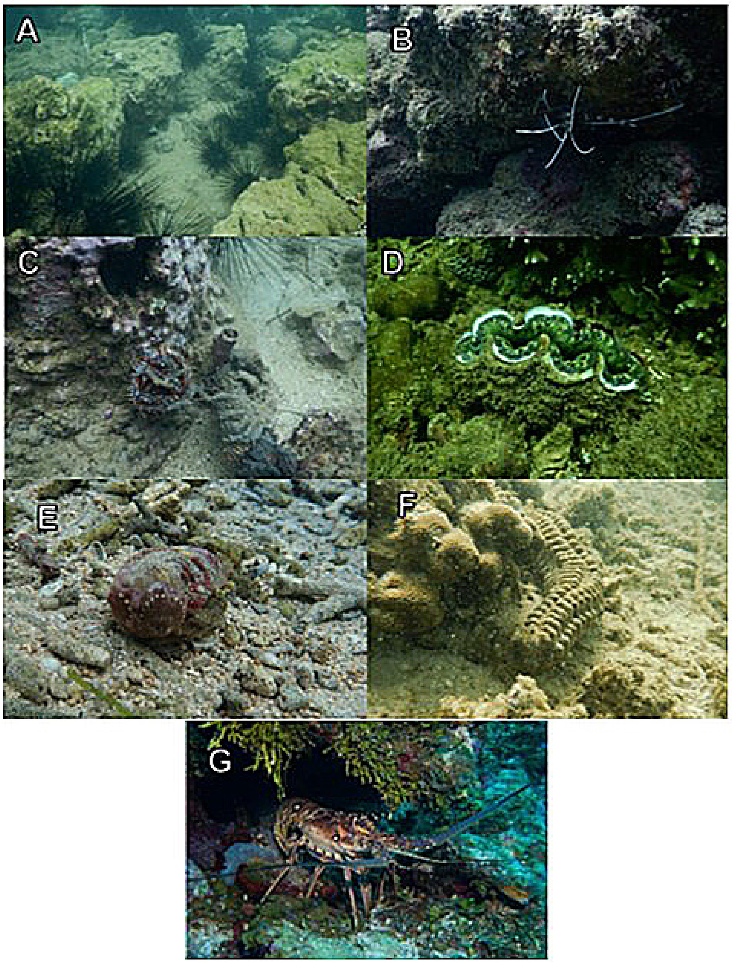


Figure 5. The observed invertebrates: (A) Diadema; (B) Banded Coral Shrimp; (C) Collector urchin; (D) Giant Clam; (E) Triton; (F) Sea cucumber; (G) Lobster

Table 5. Abundance index

Invertebrate	Abundance Index (Ki)			
	Oct.	Dec.	Feb.	May
Banded shrimp	0.02	0.01	0.02	0.02
Diadema	0.65	0.61	0.65	0.52
Pencil urchin	0.00	0.00	0.00	0.00
Collector urchin	0.00	0.00	0.02	0.04
Sea cucumber	0.00	0.00	0.00	0.00
COT	0.00	0.00	0.00	0.00
Triton	0.02	0.02	0.00	0.03
Lobster	0.01	0.01	0.01	0.00
Giant clam	0.02	0.08	0.09	0.07

Note: Oct. (October, 2021); Dec. (December, 2021); Feb. (February, 2022); and May (May, 2022).

control for algae populations (Mangawi, 2020). According to research conducted by Isdianto et al. (2023), 0.83–32.5% algae cover was discovered in the Sempu Strait, which supports the abundance of Diadema.

Diadema is a genus of sea urchins that is ecologically important and widespread in tropical regions. It facilitates coral recruitment at medium densities by reducing space competition between corals-algae, and it is regarded as essential for maintaining and restoring coral populations. However, a larger density will have an opposite impact (Muthiga & McClanahan, 2020). There is a positive correlation between the abundance of sea urchins-algae (Samuel et al., 2017); however, there is a negative correlation between algae and coral, so the presence of sea urchins can affect the growth and health of coral reefs (Alfi & Malik, 2016), as well as the ecological balance in coral reef ecosystems in a body of water (Al-Risqia et al., 2021).

The diversity index of invertebrate

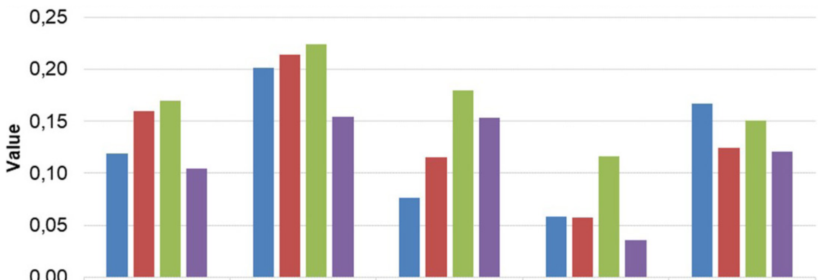
Number of species and distribution of individuals within each species affect diversity index. The Diversity index would rise with more individuals within a species and an even distribution across species (Bai'un et al., 2021). Waru Waru has always had the highest diversity index value, which ranges between 0.34 and 0.49, according to the findings of the diversity index (Figure 6), which were calculated for all five stations and four different time periods. Between 0.08 and 0.26, the Jetty has consistently held the position of having the lowest diversity index value among the stations. The diversity index can be used to determine whether or not the water's state is considered to be balanced. According to Gani et al. (2017), an ecosystem is considered to be out of balance when one type of biota is more prevalent than others. It was established that the invertebrate delinquency levels can range anywhere from 0.13 to 0.49, based on the observations that were made. A value that is less than one should be assigned to the category of inadequate and imbalanced diversity. According to Rustiasih et al. (2018), pollutants that enter the water as a result of human activities can have an effect on the index of macroinvertebrate diversity.

The evenness index of invertebrate

Based on the results of the evenness index (Figure 7), Waru Waru has always had the highest evenness value, with a value greater than 0.15, while Jetty has always had the lowest, with a value between 0.04 and 0.12. According to Nurafni et al. (2019), the value of the evenness index may be interpreted as the balance of biota and composition of each variety of individual in an area or community. A body of water is said to be in a balanced community if each species appears in equal proportions (Daly et al., 2018). A community that is unequal is more vulnerable to invasion and less resistant to stress and disturbance (Mashar et al., 2021). The value of the evenness index ranges

	WM	WW	BT	JT	RA
Oct.	0,26	0,44	0,17	0,13	0,37
Dec.	0,35	0,47	0,25	0,13	0,27
Feb.	0,37	0,49	0,40	0,26	0,33
May	0,23	0,34	0,34	0,08	0,26

Figure 6. Diversity index: WM (Watu Meja); WW (Waru-waru); BT (Banyu Tawar); JT (Jetty); and RA (Rumah Apung/Floating House).



	WM	WW	BT	JT	RA
Oct.	0,12	0,20	0,08	0,06	0,17
Dec.	0,16	0,21	0,11	0,06	0,12
Feb.	0,17	0,22	0,18	0,12	0,15
May	0,10	0,15	0,15	0,04	0,12

Figure 7. Evenness index: WM (Watu Meja); WW (Waru-waru); BT (Banyu Tawar); JT (Jetty); and RA (Rumah Apung/Floating House)

from 0 to 1, and as the value approaches 0, it indicates that the unequal distribution is probably caused by environmental factors (Pakpahan et al., 2020). The study obtained an invertebrate evenness index value ranging from 0.04 to 0.22. Because it has a value less than 0.4 and a biota that dominates, this explains why the study area has depressed community conditions and an irregular composition in the region.

The dominance index of invertebrate

Based on the analysis of the dominance index (Figure 8), The Jetty has the highest dominance index value, with a value that is always greater than 0.80, whereas Watu Meja has the lowest, with a value that is always less than 0.41. The dominance index is used to determine whether a particular variety of biota dominates a particular area. If the dominance of large species results in a despondent community state (Gani et al., 2017). The greater the proportion of dominant species in an area, the closer the value is to 1 (Nurafni et al., 2019). The invertebrate dominance index ranged from 0.39 to 0.95 based on the results of the observations, indicating that its condition is quite diverse. With low, medium, and high dominance criteria. During observation, the Jetty Station has a high dominance index value and is a maritime community with numerous activities. The accumulation of waste will degrade water quality as a consequence of the port's capacity to load ships of varying sizes (Stonkus et al., 2010). Environmental and population factors can influence the dominance of a species (Pakpahan et al., 2020).

Water quality

In accordance with the 2004 Decree No. 51 of the Minister of the Environment (MoE), Table 6 demonstrates that the temperature, dissolved oxygen, and pH parameters at all stations were within the permissible range. Season, altitude, cloud cover, sunlight intensity, weather, and depth all have an effect on temperature (Azwar et al., 2016). Parameters for salinity and water clarity are not optimal at all stations. Several factors, such as evaporation, water circulation patterns, river flow, and precipitation, impact ocean salinity values (I Patty & Akbar, 2018). Although coral reefs can develop in waters with salinities outside the optimal range, it is less advantageous than when salinities are optimal (Thovyan et al., 2017). Weather, measurement time, suspended particles, compounds, and turbidity influence the clarity of water (Effendi, 2003). For zooxanthellae to perform photosynthesis, water clarity is also essential (Muqsit et al., 2016). According

Table 6. Water quality parameter

Site / parameters	Temp. (°C)	Salinity (‰)	pH	Water clarity (m)	DO (mg/L)
WM	29.51	32.70	7.98	2.12	6.95
WW	31.44	31.53	7.78	2.51	6.98
BT	30.49	32.25	7.82	2.14	6.73
JT	29.97	30.30	8.20	2.46	6.69
RA	30.54	29.49	7.72	3.02	6.90
Threshold	28 – 30	33 – 34	7 – 8,5	>5	>5

Note: Decree of the Minister of Environment (MoE) No. 51, 2004. (a standard for seawater quality).
WM (Watu Meja); WW (Waru-Waru); BT (Banyu Tawar); JT (Jetty); RA (Rumah Apung/Floating House).

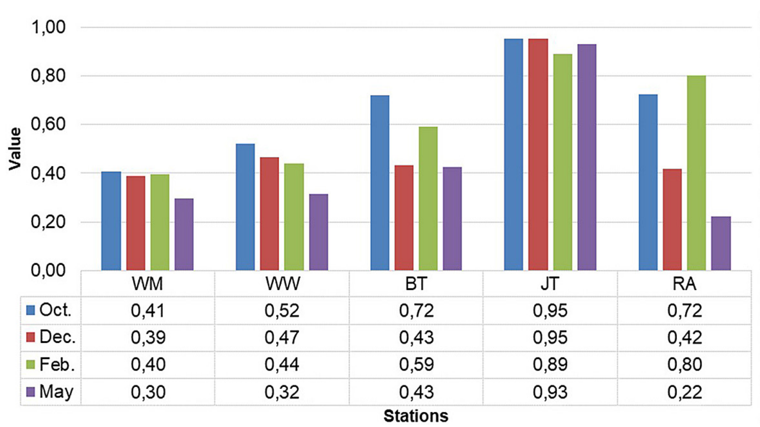


Figure 8. Dominance index: WM (Watu Meja); WW (Waru-waru); BT (Banyu Tawar); JT (Jetty); and RA (Rumah Apung/Floating House).

to Isdianto et al. (2023), coral reefs continue to flourish in the Sempu Strait due to the environmental characteristics of the study site. Although some parameters provide optimum living conditions for biota, others do not, and conditions for invertebrates and coral reefs are not optimal.

Coral cover

Figure 9 depicts the coral coverage at five stations over four times the observation period. According to this study's findings, coral cover falls into the "damaged" category, which is consistent with previous research findings. Due to the fact that the value of coral cover is less than 24.9 percent, it is possible to conclude that coral reef cover is damaged. The severity of coral reef damage in the waters of the Sempu Strait is extreme. The devastation of coral reefs in the Sempu Strait is caused primarily by the use of environmentally unfriendly fishing gear, garbage that covers corals, and ship anchors (Luthfi & Januarsa, 2018c). The existence of coral reefs has decreased due to natural and anthropogenic hazards (Bahri et al., 2015). According to Wibawa & Luthfi (2017), overexploitation by the surrounding community and the establishment of Sempu Island as a tourist destination harmed the waters of the Sempu Strait.

Relationship of invertebrate abundance with coral reef

At the five observation stations, statistical analysis revealed no correlation between coral cover and invertebrate abundance. Table 7 indicates that all p-values are greater than 0.05. Banyu Tawar and Rumah Apung have correlation values within the moderate range (0.40–0.599), whereas Waru-Waru and Watu Meja have correlation values within the weak range (0.20–0.399). At these four stations, the orientation of the coral-invertebrate abundance relationship is positive, indicating that the invertebrate abundance will increase as the percentage of coral coverage increases. At the Jetty station, correlation values entered a range of extremely low strength (0.00–0.199) with a negative direction. This suggests that the station's invertebrate diversity and coral reef coverage percentage are influenced by additional variables. Numerous community activities at the jetty station, which is a port area, have a significant impact on the water quality.

The jetty is a protected port area with weaker average current velocity and wave than other stations such as Watu Meja, Waru-waru, Banyu Tawar, and Rumah Apung. This is due to the large number of anchored ships, which reduces the impact of surface winds, thereby weakening the

Table 7. Relationship between abundance of invertebrate and coral reefs

Stations	p-value	Correlation	Category
WM	0.775	0.225	Weak
WW	0.786	0.214	Weak
BT	0.520	0.480	Moderate
JT	0.963	-0.037	Very Weak
RA	0.510	0.490	Moderate

Note: WM (Watu Meja); WW (Waru-Waru); BT (Banyu Tawar); JT (Jetty); and RA (Rumah Apung/ Floating House).

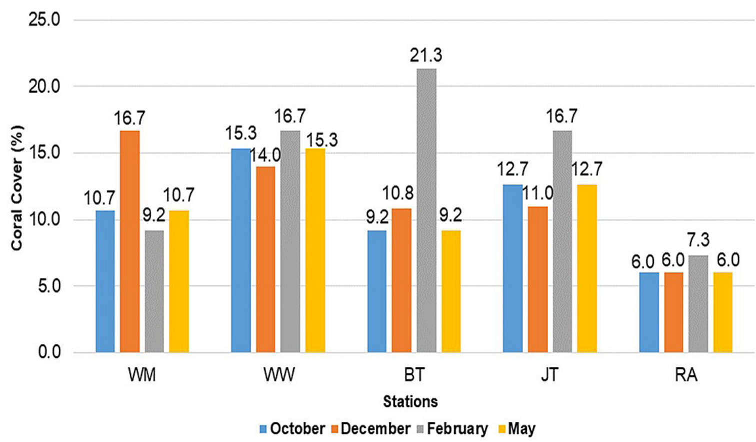


Figure 9. Coral cover percentage: WM (Watu Meja); WW (Waru-waru); BT (Banyu Tawar); JT (Jetty); and RA (Rumah Apung/Floating House)

current (Isdianto, 2022a). Strong currents velocity will make habitat conditions unfavourable for benthic macroinvertebrates (Salachna & Olearczyk, 2020). There will be a significant overlap in faunal preferences if the current velocity is in the range of 60–80 cm/s or 0.6–0.8 m/s (Degani et al., 1993), thus directly affecting the survival patterns and growth rates of invertebrates (Yang et al., 2023). According to research conducted by Al-Risqia et al. (2021), sea urchins prefer clear, calm waters and relatively slow current velocity because their feeding behaviour is affected by water waves, which in turn affects their movements to locate food. This could explain why there are so many sea urchins at the Jetty station.

Relationship of invertebrate diversity with water quality parameters

According to Ngodhe et al., (2014), water quality factors such as nitrate and phosphate content, temperature, pH, DO and BOD are known to have a significant effect on macroinvertebrate diversity, therefore macrozoobenthos can be used as an assessment of water conditions, because it has the ability to integrate and predict the impact of environmental change (Chazanah et al., 2020). Correlation analyses were performed using SPSS statistical software to detect relationships between water quality parameters and the diversity of macroinvertebrates (Table 8). There is a positive correlation and a strong category between current velocity-macroinvertebrates diversity. This indicates that the reduction of current velocity will directly reduce macroinvertebrate biodiversity because species with preferences for higher flow will be lost, and vice versa (Degani et al., 1993; Hille et al., 2014). The diversity index is influenced by the number of individuals of a species distributed evenly among species, and the distribution of macroinvertebrates is influenced by the current velocity (Kärnä et al., 2018). Temperature (0.146) and salinity (0.122) have a positive correlation and a weak category. his indicates that the higher the temperature and salinity, the more diverse the macroinvertebrates in the water. In general, macroinvertebrates are ectothermic animals whose metabolism is directly influenced by temperature (Croijmans et al., 2021). Higher temperatures increase metabolism and photosynthesis, which affect macroinvertebrate community development, but each species has a specific temperature range for optimal growth (Bonacina

Table 8. Relationship between invertebrates diversity and water quality parameters

Parameters	p-value	Correlation	Category
Temperature	0.540	0.146	Weak
Salinity	0.609	0.122	Weak
pH	0.226	-0.283	Weak
Water clarity	0.877	-0.037	Very Weak
DO	0.432	-0.186	Weak

et al., 2023). Likewise, the diversity and number of macroinvertebrates decreased with salinity (Hou et al., 2020).

There exists a weak to weak negative relationship between the pH (-0.283), water clarity (-0.037), and dissolved oxygen (DO) (-0.186) and the diversity of invertebrates. According to Bai'un et al. (2021), there is a correlation between the pH value of water and its diversity, whereby higher pH values are associated with both greater or smaller levels of diversity. The Jetty station has the highest pH value (Table 6) and the lowest level of diversity (Figure 6) in comparison to the other stations. The observed negative correlation between water clarity, dissolved oxygen (DO) levels, and macroinvertebrate diversity may be attributed to water pollution and the addition of organic matter due to ongoing human activities in the surrounding area. The previously mentioned variables can potentially have a negative impact on the penetration of sunlight into the water, consequently delaying the process of photosynthesis and leading to a decline in dissolved oxygen levels. As a result, the number and diversity of macroinvertebrates inhabiting these waters may be adversely affected (Croijmans et al., 2021; Hellen & Rahardjo, 2020). All three parameters tend to have a weak relationship, so the diversity of macroinvertebrates in these waters can also be influenced by other variables. According to previous studies, catch activities, community refuse, ship anchors, and exploitation by the surrounding community are the primary causes of damage to the water area of the Sempu Strait (Luthfi et al., 2018d).

CONCLUSIONS

Based on observations made every two months between October 2021 and May 2022, there are seven out of nine invertebrate biota types, 733 species of invertebrates, and 606 of them are dominated by Diadema sea urchins.

Between 0.024 and 0.512, the abundance of invertebrates indicates a relatively high abundance. The diversity of invertebrates ranges from 0.078 to 0.493 (H' < 1), indicating that it is relatively low and unbalanced. The range of 0.04 to 0.22 for the equality index (E < 0.4) indicates that the community index is in a depressed state. The dominance index yields values between 0.22 and 0.95 that are classified as low, medium, and high. Due to their high abundance, Diadema sea urchins dominate the waters of the Sempu Strait, particularly at the Jetty Station with all the extant port activities. The percentage of coral reef cover ranges from 6% to 21.3%, indicating that the proportion of living corals is low and damaged. There is a moderate relationship between coral cover and abundance of invertebrates in Banyu Tawar and Rumah Apung (0.480 to 0.490), while others have a weak relationship. The correlation between invertebrate abundance and water clarity, temperature, salinity, pH, and DO is weak, ranging from -0.037 to -0.283, whereas the correlation between invertebrate abundance and current velocity is comparatively strong, with a value of 0.610.. Environmental conditions have a substantial impact on the existence of macroinvertebrate communities. Contaminant-tolerant macroinvertebrates are going to dominate sensitive ones.

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