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Water Quality Assessment for Mariculture in the Waters of Legundi Island, Pesawaran District, Indonesia

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Abstract. Indonesia has an extensive maritime zone, but its fisheries production achievement remains low. The potential of this marine area should be optimally utilized to boost mariculture production. This study aims to analyze the suitability level of the waters around Legundi Island for use as a mariculture site. The research method used is descriptive statistical analysis. Data collection was conducted at 12 sample points, determined using the purposive sampling method, through on-site observations and the interpretation of Google satellite images. Sample points were distributed at each location near residential areas. The results of this study show that the waters of Labuan Agung have the highest value, with an average of 96.5%, while the waters of Selesung have the lowest value at 91.6%. Overall, the waters around Legundi Island fall into the S1 (very suitable) classification with an average score of 93.8%. In conclusion, Legundi Island possesses regional characteristics that indicate significant potential for mariculture development.

Keywords: assessment; GIS; mariculture; Legundi Island.

I. INTRODUCTION

Indonesia has an extensive maritime zone, covering approximately 6.32 million square kilometers, which includes 17,504 islands, archipelagic waters, territorial waters, and the exclusive economic zone (EEZ), along with a coastline stretching over 99,093 kilometers [1]. However, Indonesia's achievements fall short of its full potential. The mariculture utilization rate is 10.95%, while pond usage is at 16%, and freshwater mariculture is approximately 30.17%. This marine potential should be utilized optimally to support the country's economy and ensure food security for the population [2, 3].

Legundi Island, situated in Punduh Pidada Subdistrict, Pesawaran Regency, Lampung Province, Indonesia, is a popular tourist destination known for its scenic beauty [4]. The potential for mariculture in Legundi Island's waters is vast, thanks to the excellent water quality and the abundance of coral reefs, which can support mariculture that heavily relies on natural conditions for its livelihood, including farmers and fishermen.

Due to the limited availability of land for aquaculture, such as ponds, and the emerging potential environmental issues, the use of floating net cages as an affordable and simple alternative medium can address these problems. [5, 6]. Assessing the water quality parameters for mariculture is essential to avoid potential environmental issues in the future [7, 8, 9].

II. METHODS

A. Research Time and Location

The research area is located on Legundi Island, which is geographically situated in Lampung Bay, in the southern region of Sumatra Island, at coordinates 5°50′24″S 105°16′40″E. Administratively, the island is part of Punduh Pidada Subdistrict, Pesarawan District, Lampung. However, only about 14.2 km is accessible to the people,

located in the northern and western parts of the island, which are near residential areas. These settlements comprise one village and three hamlets: Selesung Village and the hamlets of Kairong, Keramat, and Labuan Agung.

This study begins by selecting 12 samples around Legundi Island using purposive sampling. Water quality measurements were conducted on February 16 and 17, 2025, at each point. Past data from 2022 to 2024 is collected from satellite sources and processed on a computer. Each parameter is scored and combined to calculate a suitability score for mariculture.

The cultured species used as a reference in this study is the cantang grouper (Epinephelus fuscoguttatus x Epinephelus lanceolatus), which has high nutritional and economic value, as well as relatively fast growth compared to other grouper species. This fish has become one of the most commonly cultured species using floating net cages [7, 8, 9]. This research utilizes eight parameters for measurement, including temperature, current velocity, depth, substrate type, protection, pH, dissolved oxygen (DO), and salinity. Measurements were taken once within one month, supported by secondary data. The research location is shown in Figure 1.

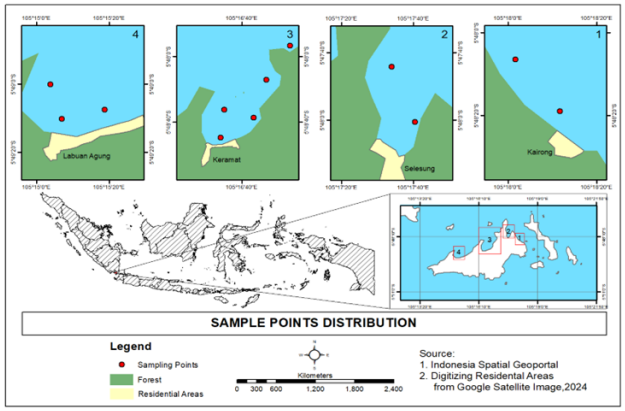

Figure1. Sample points at Legundi Island

B. Data Collection and Processing

Primary data collection was conducted by selecting sample points within the study area. The selection of these sample points employed the purposive sampling method, a non-random sampling technique based on specific criteria [10]. The criteria used to determine the sample points were community access, community activities, and shoreline substrate. As a result, 2 sample points were selected in the waters of Kairong, 2 in Selesung, 5 in Keramat, and 3 in Labuan Agung. The measurement and on-site observation of parameters were conducted on February 16, 2025. The secondary data collected included monthly data for each parameter from June 2022 to December 2024, sourced from Marine Copernicus, BATNAS, and LANSAT OLI 8 satellite imagery. Primary data is shown in tables, and secondary data is illustrated through graphs or maps. The applications used to process secondary data are Microsoft Excel, Seadas, and ArcMap 10.8.

C. Water Quality Analysis

The evaluation was carried out in two ways: classification and percentage. The percentage evaluation was calculated by determining the result in relation to the maximum value. At the same time, the classification was performed by grouping each result into three categories: S1 (very suitable), S2 (suitable), and S3 (not suitable). Weighting and scoring determine the suitability of a location. The assigned scores are 1, 3, and 5, based on the established criteria. The weights are given based on the influence of each parameter on mariculture activities, expressed with values of 5, 10, 15, and 20 [9]. Table 1 shows the suitability index used in this research. The suitability index is calculated using the following formula:

$$SI = \sum (Ps/Smax) \times 100\%$$

Details: SI is the Suitability Index; PS is Parameter Score (Weight x Score Level).

III. RESULTS AND DISCUSSION

Based on the assessment, each location yielded different results, but all remained in the S1 (very suitable) classification: Kairong (93.7%), Selesung (91.6%), Keramat (93.7%), and Labuan Agung (96.5%). Overall, the waters of Legundi Island fall under the S1 classification with an average value of 93.8%. Table 2 shows the assessment results for each sample point.

A. Physical Water Quality Parameters.

The results of the on-site measurements and observations of physical parameters, including temperature, current direction and velocity, depth, substrate, and shelter, are shown in Table 3. These parameters provide information about the physical characteristics of the water and their influence on the organisms or medium

Temperature

The results show that points 1–3 and 5–12 have optimal temperatures, falling under the S1 (very suitable) classification, with values ranging from 31 to 33°C. Point 4 is classified as S2 (suitable) with a value of 30.8°C. Fish behavior is affected by temperature; in warm water, fish tend to be more active and have a better appetite, while in cooler water, they become less active and eat less. The

ideal temperature for tropical fish is 25–32°C, and for cantang grouper, a more favorable range is 27–33°C [6, 8].

As shown in Figure 2, the temperature data for Legundi Island from June 2022 to December 2024 indicates that the waters of Legundi Island experience no drastic temperature fluctuations, with an average variation of 0.7°C per season.

TABLE 1
SUITABILITY INDEX

No	Parameters	Weight	Suitability Level			Source
			S1 (5)	S2 (3)	S3 (1)	
1	Temperature (^{0}C)	10	27 - 33	25 – 27 or 33 - 34	<25 or >34	Sodiq *et al.*, (2022); Rochmad & Mukti (2020)
2	Current Speed (m/s)	10	0.2 - 0.3	0.05 - 0.2 or 0.3 - 0.5	<0.05 or >0.5	Wibowo *et al.*, (2022); Wilmansyah *et al.*, (2019)
3	Depth (m)	10	7 - 20	5 – 7 or 20 - 40	<5 or >40	Hidayah *et al.* (2020); Lesmana *et al.*, (2022)
4	Substrate	15	Coral sand	Muddy sand	Mud	Sahril *et al.*, (2019)
5	Protection	20	Bay or Strait	Shallow coral	Open waters	Adamimawar *et al.*, (2022)
6	pH	5	7 - 8.5	5 – 7 or 8.5 - 9	<5 or >9	Yuspita *et al.*, (2022)
7	DO (ppm)	20	6 - 8	4 - 6	<4 or >8	Anita dan Dewi, (2020); Bangun *et al.*, (2024)
8	Salinity (ppt)	5	30 - 32.9	25 - 34	<25 or >34	Wilmansyah *et al.*, (2019); Hasan *et al.*, (2021)

TABLE 2
WATER QUALITY ASSESSMENT RESULTS AT EACH SAMPLING POINT

Sample point	Location	Suitability	Value
1	Kairong	S1	93.7%
2	Kairong	S1	93.7%
3	Selesung	S1	93.7%
4	Selesung	S1	89.5%
5	Keramat	S1	93.7%
6	Keramat	S1	93.7%
7	Keramat	S1	93.7%
8	Keramat	S1	93.7%
9	Keramat	S1	93.7%
10	Labuan Agung	S1	93.7%
11	Labuan Agung	S1	97.9%
12	Labuan Agung	S1	97.9%

TABLE 3
PHYSICAL PARAMETER MEASUREMENT RESULTS

Sample point	Parameter/Parameter			Substrate	
	Temperature (^{0}C)	Current Velocity (m/s)	Depth (m)		Protective
1	32.8	0.11	<20	Sand Coral	Shallow Coral
2	32.3	0.11	<20	Sand Coral	Shallow Coral
3	32.9	0.09	<20	Sand Coral	Bay
4	30.8	0.06	<20	Sand Coral	Bay
5	31	0.12	<20	Sand Coral	Bay
6	31.8	0.11	<20	Sand Coral	Bay
7	31.8	0.07	<20	Sand Coral	Bay
8	32.4	0.05	<20	Sand Coral	Bay
9	32.9	0.09	<20	Sand Coral	Bay
10	31.4	0.06	<20	Sand Coral	Bay
11	32.2	0.2	<20	Sand Coral	Bay
12	33	0.2	<20	Sand Coral	Bay

Current

Currents play a crucial role in the distribution of nutrients and the ocean's fertility. Open waters tend to have strong and variable current patterns, which allow for a wider distribution of nutrients. However, currents that are too strong can cause stress to the organism and damage the medium; therefore, the optimal current speed is between 0.2 and 0.5 m/s [11, 12].

On-site measurements indicate that sampling points 1 to 10 are categorized as S2 (suitable), with current speeds ranging from 0.06 to 0.12 m/s. In contrast, points 11 and 12 fall into the S1 (very suitable) category, with a speed of 0.2 m/s. Figure 3 shows that the average seasonal fluctuation of current speed around Legundi Island is 0.16 m/s. Figure 4 illustrates the direction and speed of currents in the waters of Legundi Island for each season.

Depth

The required depth for using floating net cages ranges from 6 to 40 meters. If the depth is less than 6 meters, waste from the seabed can affect water quality, while depths greater than 40 meters make it difficult to anchor the floating net cages. Therefore, the most suitable depth is between 7 and 20 meters [13, 14, 15]. Based on the bathymetry map shown in Figure 5, the depth at each point around Legundi Island does not exceed 20 meters; thus, it is categorized as S1 (very suitable). The nearest distance from the sampling points to the contour line is approximately 800–1,100 meters at points 10–12 located in Labuan Agung.

Substrate

Seabed substrate plays a crucial role in determining an ideal site. While it may not directly affect fish growth, unsuitable substrates can hurt cultured organisms. Suitable substrates for placing floating net cages are coral rubble, coral, and sand, as they do not cause turbidity in the water and also serve as primary habitats for grouper fish [16-18]. Based on on-site observations, each point has a sandy coral substrate, which falls under the S1 (very suitable) classification. The substrate map in Figure 10 was created through image analysis and adjustments. The area of sandy coral substrate accessible to the community varies by location: Kairong (181 m²), Selesung (174 m²), Keramat (502 m²), and Labuan Agung (444.6 m²).

Protection

Protection is an important parameter that determines the boundaries of the mariculture area that can be utilized. The defined limits serve to protect the floating net cages from strong currents and winds. Bay or strait areas can help reduce the impact of currents or winds, and shallow coral areas also minimize the effects of strong currents [19]. Observations show that points 3–12 are situated in bay areas and are categorized as S1 (very suitable). Meanwhile, points 1 and 2 in Kairong are classified as S2 (suitable), as this area does not feature bays or straits. Nevertheless, its shallow, coral-dominated waters remain suitable for mariculture.

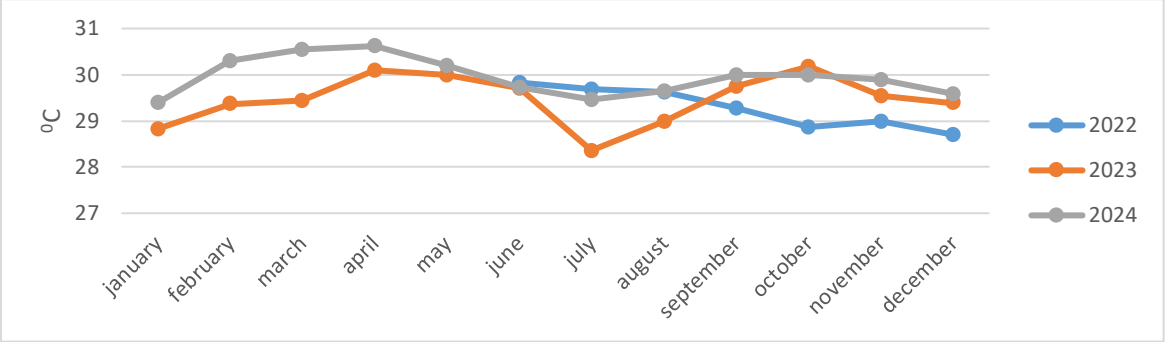

Figure 2. Change of temperature in the waters of Legundi Island (June 2022 - December 2024)

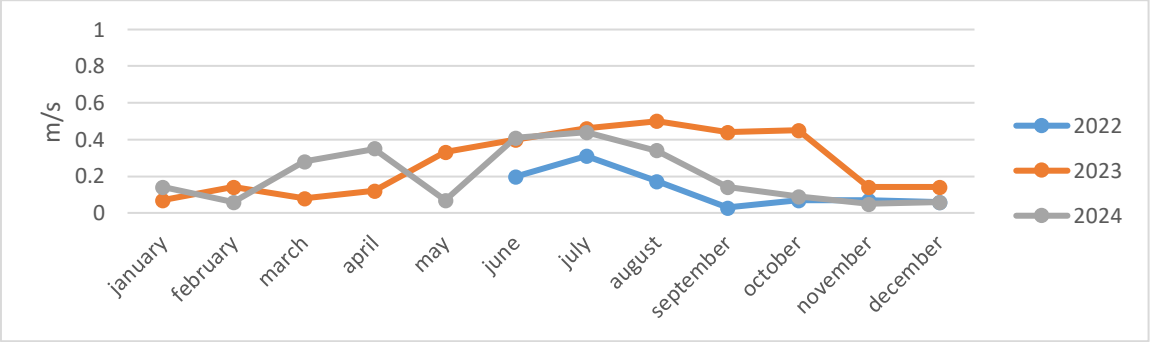

Figure 3. Change of current speed in the waters of Legundi Island (June 2022 - December 2024)

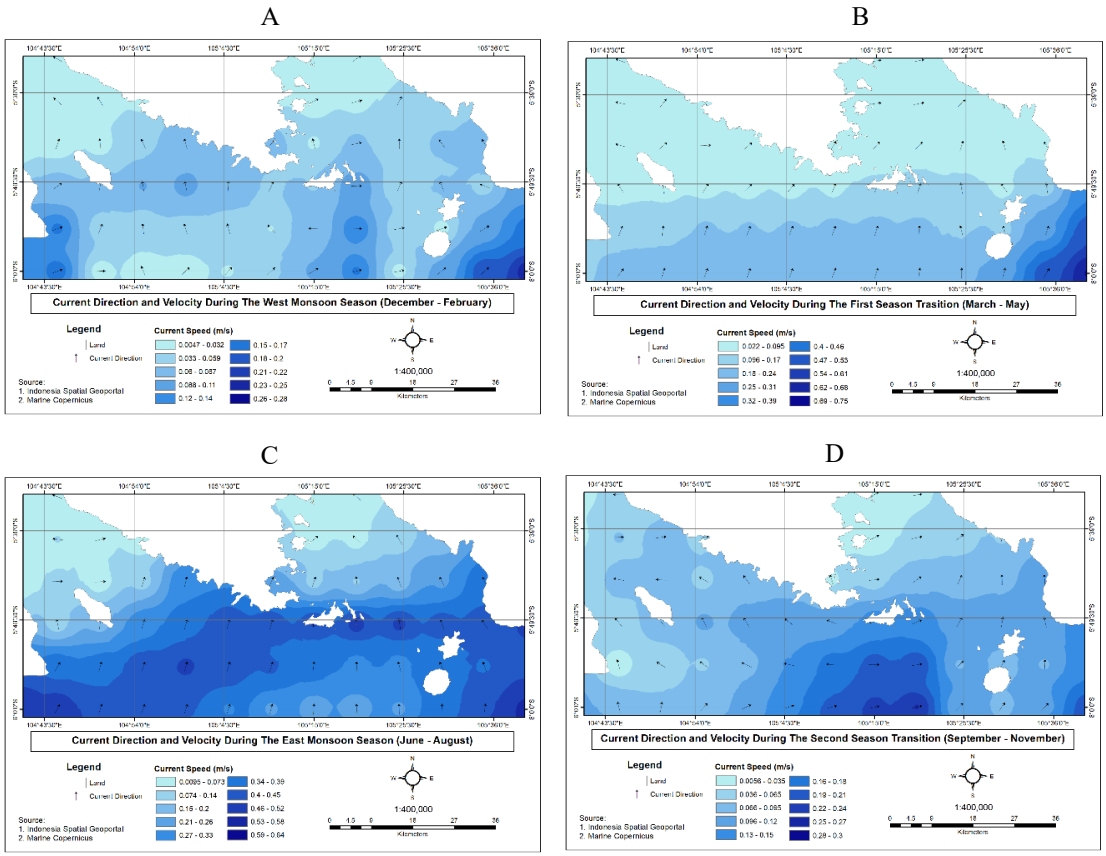

Figure 4. Current Direction and Speed in: (A) West Monsoon Season, (B) Transition Season I, (C) East Monsoon Season, (D) and Transition Season II

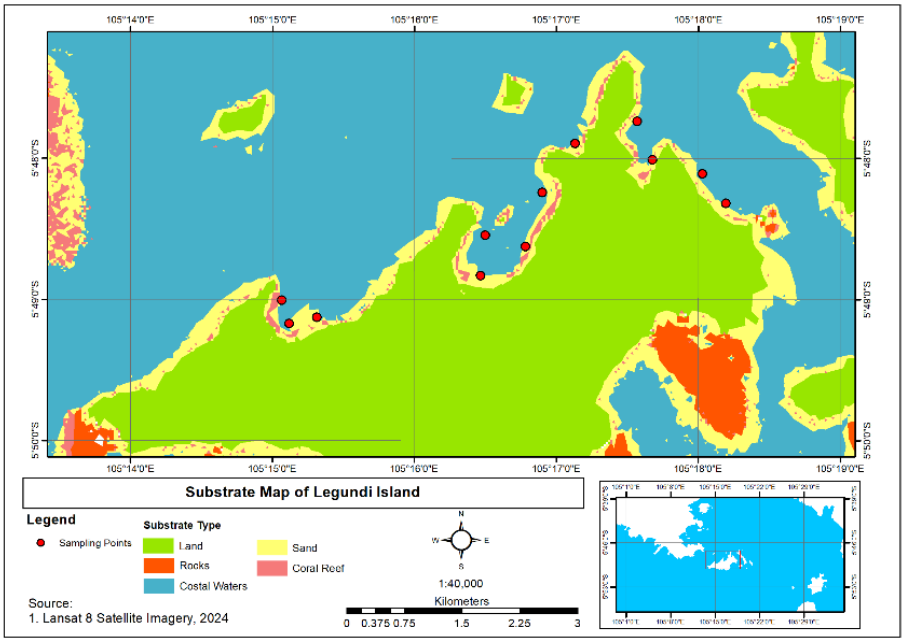

Figure 6. Map of the bottom substrate

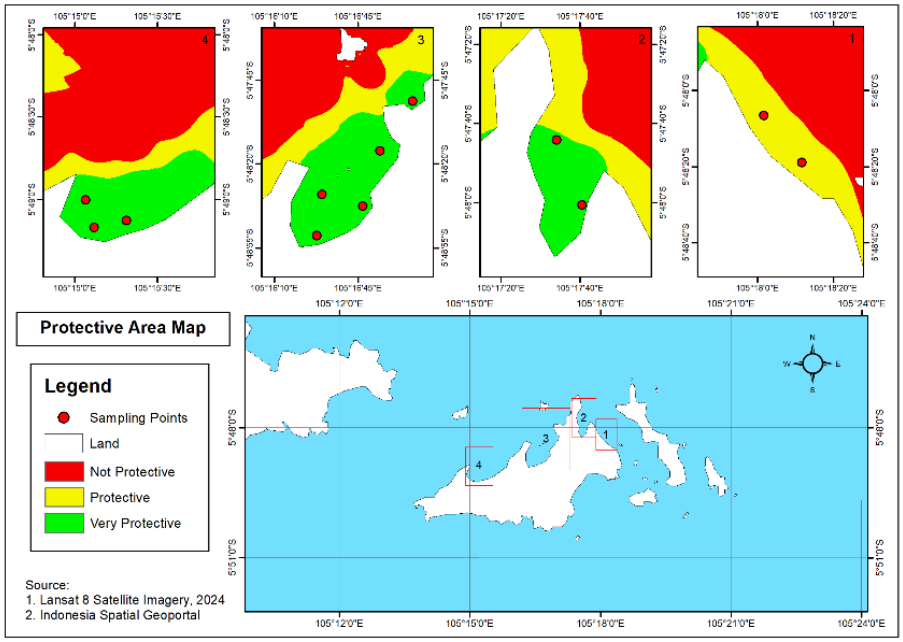

Figure 8. Protected area map on Legundi Island

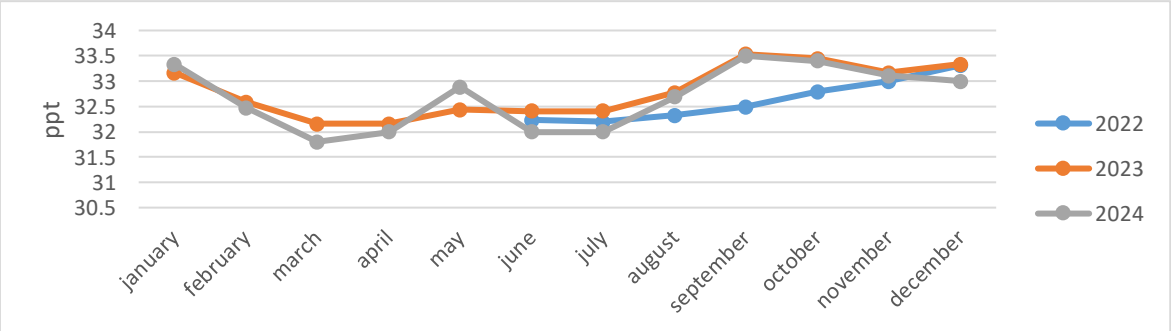

Figure 8. Change of salinity level in the waters of Legundi Island (June 2022 – December 2024).

B. Chemical Water Quality Parameters

The chemical parameters of the water consist of various chemical components; those measured in this study include pH, dissolved oxygen (DO), and salinity. These parameters provide information about the chemical characteristics of the water and can influence biological and chemical processes within the aquatic environment, as shown in Table 4.

TABLE 4
CHEMICAL PARAMETER MEASUREMENT RESULTS

Sample point	Parameter		
	pH	DO (ppm)	Salinity (ppt)
1	8.2	6.4	27
2	8.2	6.4	28
3	8.2	6.3	28
4	8.2	6.3	29
5	8.1	6.4	28
6	8.2	6.4	27
7	8.2	6.3	27
8	8.2	6.2	27
9	8.2	6.4	28
10	8.1	6.4	26
11	8.1	6.4	26
12	8.2	6.4	27

pH

Marine organisms are generally sensitive to pH levels, as they influence the physiological conditions of fish. Typically, seawater has a pH above 7, and any decrease suggests contamination by accumulated chemical waste. The suitable pH range for mariculture is 7-8.5 [20]. Each sampling point meets the S1 (very suitable) classification, with pH levels ranging from 8.1 to 8.2. From June 2022 to December 2024, the pH values remained stable at 8, showing no variation.

Dissolve Oxygen

The availability of dissolved oxygen (DO) is a major limiting factor in mariculture, as it is essential for the physiological systems of fish, including respiration and metabolism. For cantang grouper, the optimal DO range is between 6 and 8 ppm [9]. On-site measurements show that all sample points fall into the S1 (very suitable) classification, with values ranging from 6.2 to 6.4 ppm. Based on data obtained from June 2022 to December 2024, the DO levels remained stable at 6.4 ppm, showing no significant changes.

Salinity

Salinity affects fish growth because part of the energy from feed is used for the process of osmoregulation. The suitable salinity range for cantang grouper is 25–34 ppt; however, at 30–32 ppt, the fish's digestive enzymes function optimally, leading to better feed digestion as less energy is required for osmoregulation [21, 22]. The measurements show that all sample points fall into the S2 (suitable) classification, with salinity values ranging from 26 to 29 ppt. The salinity fluctuation in the waters around Pulau Legundi is relatively low, at 0.81 ppt per season, as shown in Figure 8

IV. CONCLUSIONS

Based on the results and discussion, the average abundance of microplastics in corals in the coastal waters of Penimbangan Beach was recorded at 1.95 ± 0.60 particles per gram. The highest abundance of microplastics was found at Station 1, which is likely due to its proximity to tourist areas and the higher intensity of tourism activities. The characteristics of microplastics found in corals in the Penimbangan waters showed that the most dominant shape was fiber, followed by fragments and granules. The most commonly found microplastic size was in the 0.001–1 mm range, followed by the 1–5 mm size range. Meanwhile, black was the most dominant color of microplastics, followed by blue, red, transparent, and brown.

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