



EXPLORING WATER QUALITY FOR ECOTOURISM DIVERSIFICATION IN THE HUNIMUA BEACH, LIANG VILLAGE

EKSPLORASI KUALITAS AIR UNTUK DIVERSIFIKASI EKOWISATA DI PANTAI HUNIMUA, DESA LIANG

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ABSTRACT

Hunimua Beach is one of several beautiful beaches in the Maluku Province. The beach is located in Liang Village, Salahutu District, Central Maluku Regency, and covers an area of around 88,360 m² to 890,500 m². Hunimua Beach is a tourist attraction that is highly popular with the public and frequently overcrowded. Therefore, we need information on water quality to support new ecotourism activities at Hunimua Beach. The aim of this study is to identify water parameters for the diversification of banana boat, boating, and jet ski tourism activities at Hunimua Beach. Data collection in this study was conducted through direct water sampling. Sampling locations were determined using a purposive sampling method at six aquatic stations based on assessment guidelines for water quality parameters for banana boat, boating, and jet ski recreational activities. The results of the water parameter assessment indicated that pH, temperature, salinity, sigma-t, chlorophyll-a, and turbidity were classified as suitable, whereas dissolved oxygen (DO) was classified as unsuitable based on the water assessment criteria. Furthermore, the assessment of water parameters showed that water depths of 0–20 m and current velocities ranging from 0.035 m/s to 0.334 m/s indicated that the waters of Hunimua Beach were classified as suitable to highly suitable for the diversification of ecotourism activities, including banana boat tourism, boating, and jet skiing.

Keywords: ecotourism diversification, Hunimua Beach, marine tourism, water parameters

ABSTRAK

Pantai Hunimua adalah salah satu pantai indah yang terdapat di Provinsi Maluku. Pantai tersebut terletak di Desa Liang, Kecamatan Salahutu, Kabupaten Maluku Tengah, dengan luas total kawasan sekitar 88.360 m² hingga 890.500 m². Perairan Pantai Hunimua merupakan objek wisata yang sangat diminati masyarakat dan sering mengalami kepadatan berlebih. Oleh karena itu, perlu ada informasi kualitas perairan untuk mendukung kegiatan ekowisata baru di Pantai Hunimua. Tujuan penelitian ini adalah mengidentifikasi parameter perairan untuk diversifikasi ekowisata *banana boat*, berperahu, dan jet ski di Pantai Hunimua. Teknik pengumpulan data pada penelitian ini dilakukan melalui pengambilan sampel air secara langsung. Penentuan titik sampling dilakukan dengan metode *purposive sampling* pada enam stasiun perairan berdasarkan pedoman penilaian parameter perairan untuk kegiatan wisata *banana boat*, berperahu, dan jet ski. Hasil identifikasi parameter perairan, yaitu nilai pH, suhu, salinitas, *sigma-t*, klorofil-a, dan turbiditas, termasuk dalam kategori sesuai, sedangkan DO termasuk dalam kategori tidak sesuai berdasarkan standar penilaian perairan. Berdasarkan hasil penilaian parameter perairan, kedalaman 0–20 m serta kecepatan arus minimum 0,035 m/s dan maksimum 0,334 m/s menunjukkan bahwa perairan Pantai Hunimua termasuk kategori sesuai dan sangat sesuai untuk diversifikasi ekowisata *banana boat*, berperahu, dan jet ski.

Kata kunci: diversifikasi ekowisata, Pantai Hunimua, parameter perairan, wisata bahari

INTRODUCTION

Maluku is an archipelagic region where the majority of the territory consists of coastal and marine areas. Economic activities, such as tourism, rely heavily on these coastal zones. Coastal areas must preserve their tourism value and appeal through marine tourism to ensure sustainable well-being (Budiharsono 2005). Coastal regions can be transformed into sites serving various purposes, including aquaculture, tourism, education, and more (Djunaedi and Basuki 2002; Roziqin 2016). Tourism activities that leverage local resources to create attractions may encompass ecosystems, products, and other engaging experiences.

Water-based tourism is a rapidly growing sector within the global tourism industry. With their captivating natural beauty and abundance of unique ecosystems, water-based tourism destinations attract significant interest from travelers worldwide. However, the rising number of visitors also creates new management and conservation challenges (Canteiro *et al.* 2018).

While the water-based tourism sector has the potential to contribute significantly to a nation's economic growth and environmental conservation, it can also cause substantial negative impacts, including ecosystem degradation, water pollution, and coral reef destruction. These effects are particularly evident in tourism areas with high visitor intensity (Davenport and Davenport 2006).

Planning and developing sustainable tourism destinations is crucial for maintaining environmental, socio-cultural, and economic conditions for the community (Adriani *et al.* 2016). Sustainable tourism development is an approach that meets current needs without compromising the ability of future generations to meet their own needs; it achieves this through the conservation of natural, socio-cultural, and economic resources and by ensuring long-term sustainability (Weaver 2007).

Coastal ecosystems valued for their habitats and environments constitute resources categorized as ecosystem objects (Pendit 2002; Khrisnamurti *et al.* 2016). Additionally, commodity objects may consist of marine biota species or non-living elements, such as coral, fish, dolphins, sea turtles, and white sand. Conversely, activity-based objects involve local resource-based tourism in areas that appeal to visitors, such as capture fisheries and aquaculture, historical sites, and local culture (Yulianda 2019).

One of the most beautiful beaches in Maluku Province is Hunimua Beach. It is

located in Liang Village, Salahutu District, Central Maluku Regency. Hunimua Beach is a popular tourist destination thanks to its striking waters ranging from light greenish-blue to deep, intense blue, its expanse of fine white sand, lush “ketapang” (tropical almond) trees extending to the shoreline, and vast green grassy areas (Ubaiyana 2021). Hunimua Beach's current attractions include activities such as playing, relaxing, boating, swimming, fishing, and exercising, or simply taking in the scenery (Wawo *et al.* 2008). Although the Maluku Province Tourism and Creative Economy Office manages Hunimua Beach, operations are not optimal. On weekends, staff merely man the entrance, sell tickets, and clean specific areas of the beach, without addressing pollution in the seawater itself (Ubaiyana 2021). Marine pollution largely originates from land-based sources, particularly in coastal areas characterized by intense human activity (Allen *et al.* 2022).

Degradation in the quality and quantity of resources across coastal, beach, and marine areas, driven by inorganic and organic waste pollution, represents a major issue for the region. Factors influencing these conditions include consumption by biological processes, adsorption, the release and settling of suspended particles, land-based inputs (allochthonous elements), and hydrodynamic influences (Sanusi 2004). To date, there is a lack of data and information regarding water quality for ecotourism diversification at Hunimua Beach. Therefore, it is necessary to assess water depth, current velocity, chemical parameters (pH, DO, salinity), physical parameters (sigma-t, temperature, turbidity, transparency), and biological parameters (chlorophyll-a) to support water-quality-based ecotourism diversification at Hunimua Beach, Central Maluku Regency, Maluku Province.

METHODS

Six sampling stations were established in the waters off Hunimua Beach, Liang Village. Sampling locations were selected based on tidal conditions. The stations were chosen using the purposive sampling method, based on the characteristics of the location, which is one of the marine tourist attractions in Ambon City. The study was conducted over three days in August 2024 at Hunimua Beach, Ambon City, during high tide. Equipment used included a CTD (Conductivity, Temperature, and Depth) probe, GPS (Global Positioning System), DO (Dissolved Oxygen) meter, pH meter, current

meter, refractometer, and gloves; materials used included a Kemmerer water sampler, sample bottles, and labels.

The data collection procedure is as follows:

- a. Water samples were collected using a Kemmerer water sampler at two different depths: the surface (0 m) and a depth of 20 m during high tide. These samples were used to study the horizontal and vertical distribution of chemical components. Sampling was conducted at each station with three replicates (Rahmadanty *et al.* 2022).
- b. Sample analysis (chemical and biological characteristics) was performed at the Basic Biology Laboratory, Biology Education Program, Faculty of Teacher Training and Education (FKIP), Pattimura University. The parameters analyzed in this study included water depth, temperature, salinity, sigma-t, chlorophyll-a, and turbidity (measured using a CTD conductivity, temperature, and depth probe); current velocity (measured using a current meter); pH (measured using a pH meter); and dissolved oxygen (measured using a DO meter). The water parameters were analyzed based on the collected data and compared against seawater quality standards for marine tourism (Decree of the State of the Minister for the Environment Number 51 of 2004). Additionally, the suitability of the area for banana boat, boating, and jet ski activities was assessed using the criteria established by Tambunan *et al.* (2013).

This study employs quantitative and descriptive statistical analyses to interpret parameter data. The study area map is shown in Figure 1.

RESULTS AND DISCUSSION

Water conditions at Hunimua Beach

Water quality analysis results at Stations 1–6 (Table 1) show mean values at depths of 0 m and 20 m, respectively, as follows: pH (8 and 8.4), DO (1.4 and 1.18), temperature (27.76 °C and 27.74 °C), salinity (34 and 34), sigma-t (21.77 and 21.83), chlorophyll-a (1.16 and 0.76), and turbidity (1.31 and 0.51). Spatial distribution maps of pH, DO, temperature, salinity, sigma-t, chlorophyll-a, and turbidity parameters at Stations 1–6 are presented in Figures 2–8.

The standard pH range for nitrification is 8–9 (Decree of the State of the Minister for

the Environment Number 51 of 2004). A pH value below 6 causes the nitrification process to cease. pH levels also influence the presence of phosphates in the water. The pH values measured at the study site were generally above 7. Phytoplankton distribution is significantly influenced by water pH, as phytoplankton presence relies on nutrient availability in the marine environment. This pH range remains suitable for aquatic biota (Effendi 2003). pH values deviating from the normal range may indicate disturbances in water conditions. An increase in organic compounds in the water is associated with a decrease in pH. The pH values at the six stations fell within the Ministry of Environment's Threshold Limit Value (NAB) range of 7–8.5 (Decree of the State of the Minister for the Environment Number 51 of 2004), making the waters suitable for tourism activities.

In general, dissolved oxygen (DO) levels at the surface (0 m) were relatively higher than at a depth of 20 m. Higher DO values in the surface layer are attributed to photosynthesis and oxygen diffusion from the atmosphere, a natural phenomenon in tropical marine waters (Ross 1982). Aquatic organisms utilize dissolved oxygen for respiration, while microorganisms use it to decompose organic matter. Oxygen sources in seawater include diffusion and phytoplankton photosynthesis. Marine life relies heavily on dissolved oxygen, which serves as an indicator of water quality. Higher levels of organic waste in a given body of water result in lower dissolved oxygen concentrations, as bacteria require oxygen to degrade organic matter into inorganic substances (Simanjuntak 2012). The Ministry of Environment's standard threshold (NAB) for dissolved oxygen (DO) content in waters is above 5 mg/L; however, the DO levels at the six stations ranged from 0.6 to 2.3 mg/L (Decree of the State of the Minister for the Environment Number 51 of 2004), indicating that the waters are unproductive.

Temperature is a crucial factor in tourism development. Optimal temperatures for coral reef growth range from 28 to 30 °C (Decree of the State of the Minister for the Environment Number 51 of 2004). Unsuitable water temperatures and nutrient levels can lead to coral reef mortality. Rising global surface temperatures over the years have resulted in high rates of coral bleaching (Salim 2012). Furthermore, a 2 °C rise in global temperature, often a response to the Pacific El Niño, can trigger coral bleaching (DeCarlo *et al.* 2017). The ideal temperature for growth is between 36 and 40 °C, with a tolerance limit of up to 40 °C. At the six research stations, the average

temperature was around 28 °C, a range that remains suitable for tourism development.

Salinity levels play a crucial role in supporting aquatic life. Healthy coral reefs serve as a major attraction for snorkeling and diving activities in marine tourism areas. The salinity recorded at the six research stations was 34‰, which falls within the standard range for coral reef health (33–34‰). Furthermore, coral reefs thrive in salinity levels between 30‰ and 35‰ (Dahuri 2003). Physical factors, such as temperature, influence water salinity; higher temperatures increase salinity, as does the gradual process of evaporation (Putra 2008). This salinity range is conducive to coral reef life.

Sigma-t (density) values increase with rising salinity and decrease with rising temperature. The distribution of sigma-t values across the six stations was approximately 22. According to Ramdhan (2015), seawater density is around 1,025 kg/m³, whereas freshwater density is approximately 1,000 kg/m³. Water fertility is linked to chlorophyll-a content. Waters with chlorophyll-a levels below 2 µg/L are classified as oligotrophic (Hakanson and Bryhn 2008). The chlorophyll-a levels at the six stations ranged from 0.55 to 2 µg/L, indicating oligotrophic waters. Oligotrophic waters are typically clear and lack abundant aquatic vegetation or algae, signifying low nutrient levels (Zulfia and Aisyah 2013).

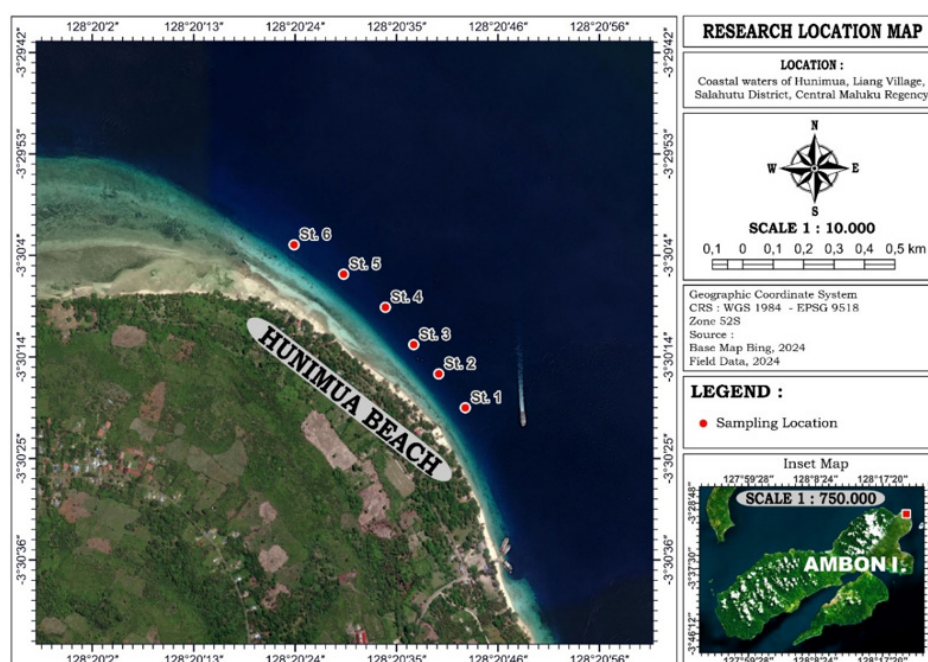


Figure 1. Map of research locations for Hunimua Beach waters, Liang Village, Central Maluku Regency.

Table 1. Measurement results of water quality parameters at six stations in the waters of Hunimua Beach, at depths of 0 and 20 m.

Station	pH		DO (mg/L)		Temperature (°C)		Salinity (ppt)		Sigma-t		Chlorophyll-a (µg/l)		Turbidity (NTUs)	
	0	20	0	20	0	20	0	20	0	20	0	20	0	20
1	8.4	8.5	2.3	0.7	28	28	34	34	22	22	2	0.62	2	0.399
2	8.5	8.4	1.6	1.9	28	28	34	34	22	22	0.55	0.655	0.246	0.36
3	8.5	8.5	0.6	0.7	27.76	28	34	34	22	22	0.668	0.908	1	0.753
4	7.6	8.4	0.9	1.9	28	28	34	34	22	22	0.974	0.584	1	0.21
5	7.0	8.2	2.6	1.3	28	28	34	34	22	22	1	1	1	1.25
6	8.4	8.6	0.6	0.6	28	28	34	34	22	22	1	0.593	2	0.147

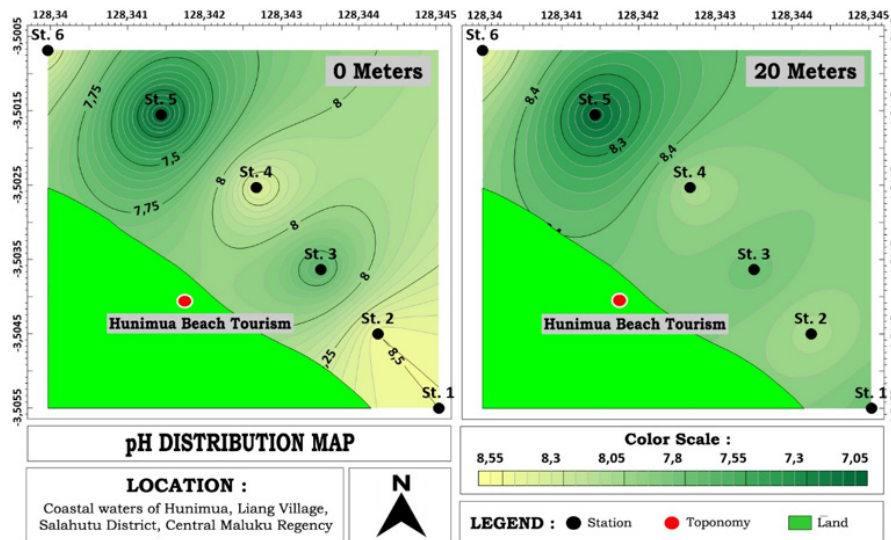


Figure 2. Map of the spatial distribution of pH in the waters of Hunimua Beach at depths of 0 and 20 m.

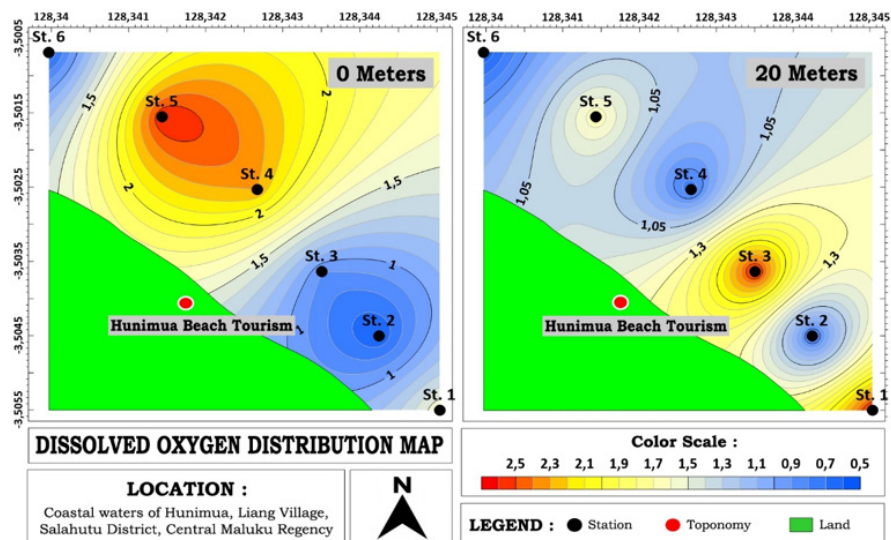


Figure 3. Map of the spatial distribution of DO in the waters off Hunimua Beach at depths of 0 and 20 m.

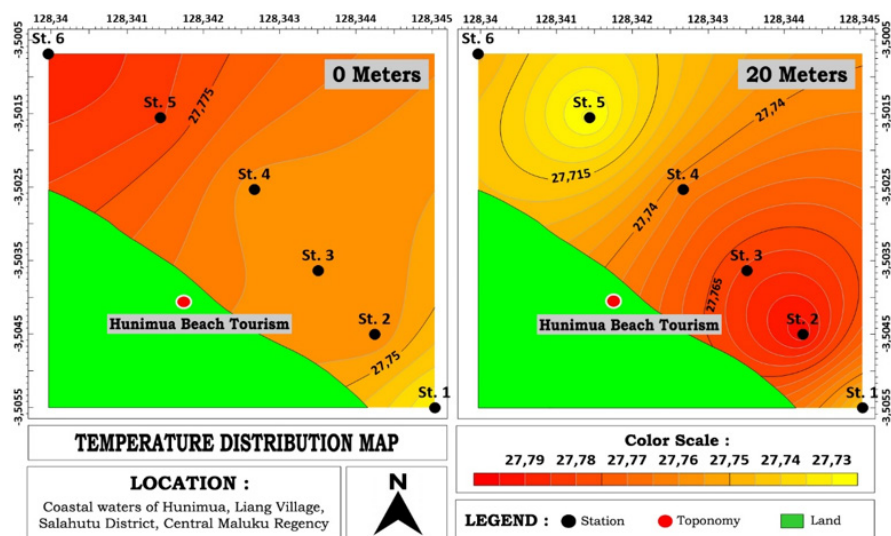


Figure 4. Map of the spatial distribution of temperature in the waters off Hunimua Beach at depths of 0 and 20 m.

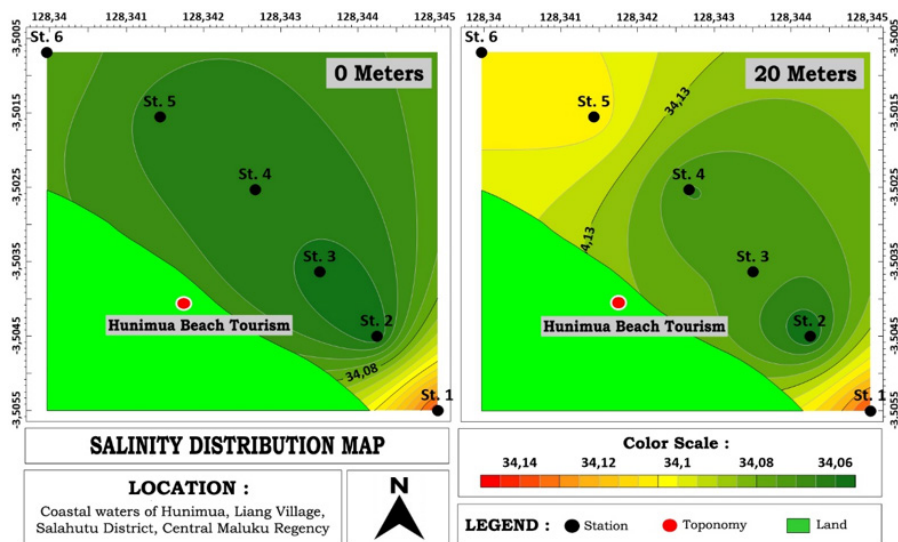


Figure 5. Map of the spatial distribution of salinity in the waters off Hunimua Beach at depths of 0 and 20 m.

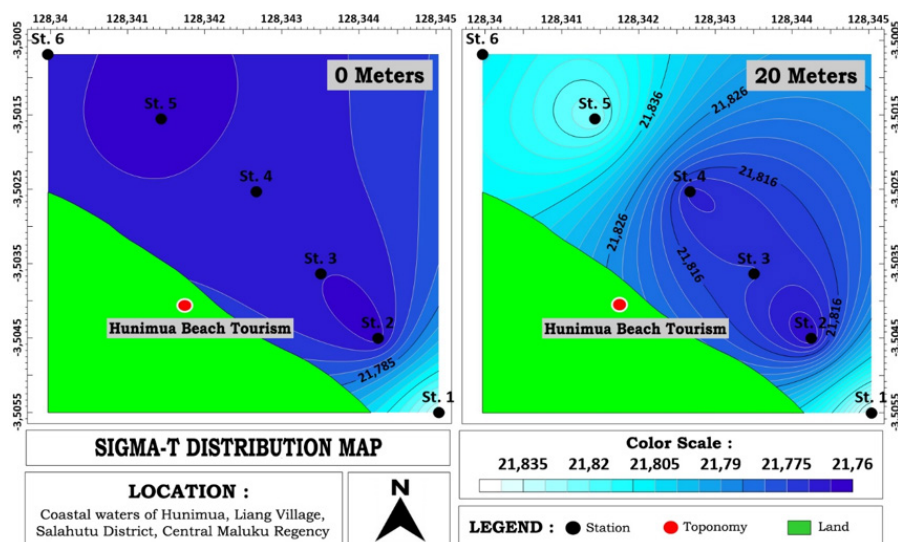


Figure 6. Map of the spatial distribution of sigma-t in the waters of Hunimua Beach at depths of 0 and 20 m.

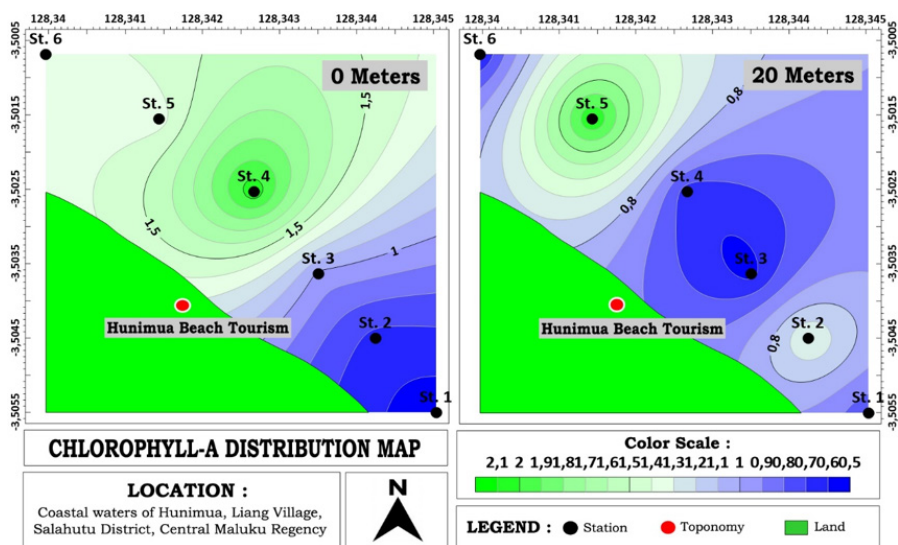


Figure 7. Map of the spatial distribution of chlorophyll-a in the waters off Hunimua Beach at depths of 0 and 20 m.

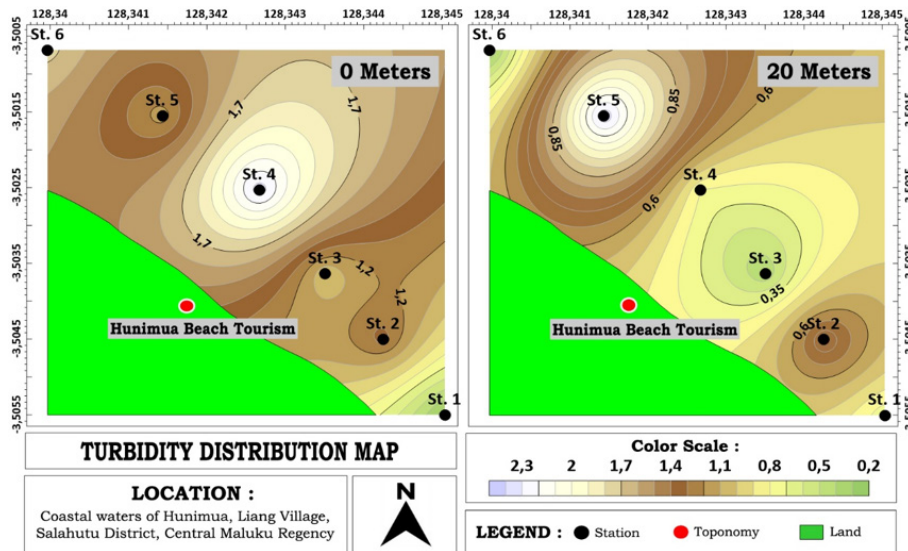


Figure 8. Map of the spatial distribution of turbidity in the waters off Hunimua Beach at depths of 0 and 20 m.

Turbidity levels in the waters of Hunimua Beach ranged from 0.24 to 2 NTU. Water turbidity indicates clarity, and these levels are highly favorable for coastal tourism activities. According to the Decree of the State of the Minister for the Environment Number 51 of 2004, the turbidity standard for marine tourism areas is 5 NTU. Seawater turbidity is influenced by currents, waves, and tides (Indrayana *et al.* 2014).

Water quality plays a crucial role in determining the ecotourism potential of a region, particularly in coastal and marine areas. Clean, healthy waters support the sustainability of marine ecosystems, including coral reefs, seagrass beds, and mangrove forests, which serve as primary attractions for nature-based ecotourism. If water quality deteriorates due to pollution or eutrophication, ecotourism appeal diminishes as ecosystems suffer damage and biodiversity declines. Conversely, effective water quality management, such as waste control and ecosystem conservation, can enhance tourism appeal, attract more visitors, and support the local economy (Leiwakabessy

et al. 2025). The accumulation of various types of waste presents a specific challenge for local governments and other stakeholders regarding waste management; key measures include providing trash receptacles and waste banks, managing inorganic waste with economic value, handling existing waste, and implementing zero-waste management strategies (Kubangun *et al.* 2024). Therefore, water quality monitoring is essential for the planning and management of sustainable ecotourism areas (Leiwakabessy *et al.* 2025).

Ecotourism diversification

Water depth and current velocity parameters compared against tourism suitability indicators for banana boat, boating, and jet ski activities based on Tambunan *et al.* (2013) are presented in Table 2. Stations 1–6, located at depths of 0–20 m in the waters off Hunimua Beach, are shown in Figure 9. Additionally, the current velocity at Hunimua Beach, illustrated via stick plots, is shown in Figure 10.

Table 2. Water suitability matrix for banana boat, boating, and jet ski activities at Hunimua Beach.

Criteria	Weight	Suitability Class (Score)		
		3	2	1
Water depth (m)	5	> 8	4–8	< 4
Current velocity (m/s)	3	0–0.15	0.15–0.40	> 0.40

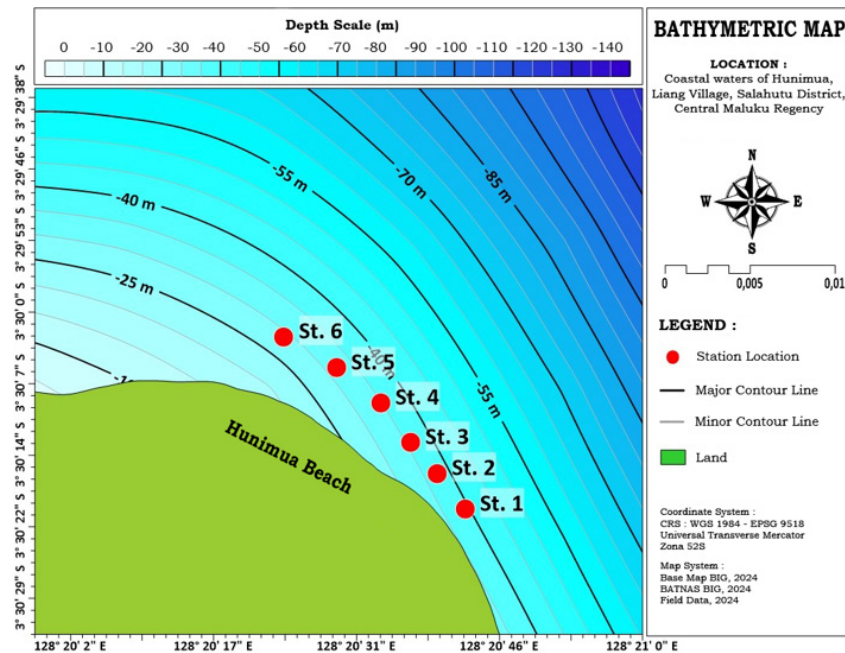


Figure 9. Bathymetric map and observation station locations in the waters off Hunimua Beach.

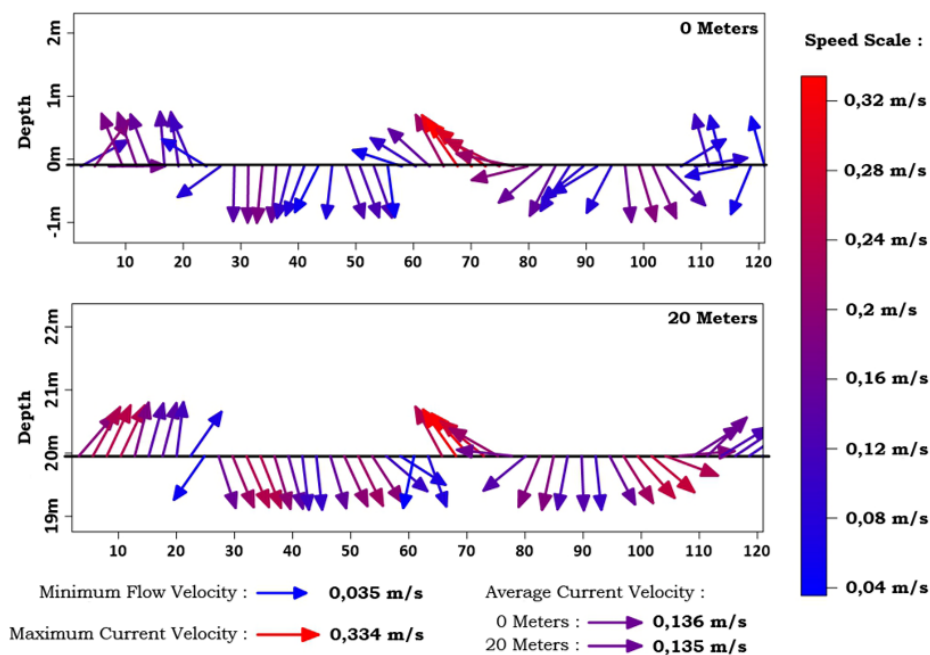


Figure 10. Stick plots of current direction and speed at depths of 0 m and 20 m in the waters off Hunimua Beach.

Stick plots indicate that surface currents (0 m) predominantly flow southward and southwestward, though they occasionally shift toward the northwest. These currents range from a minimum speed of 0.21 m/s to a maximum of 0.34 m/s, with an average speed of 0.136 m/s. At a depth of 20 m, the currents predominantly flow southward and southeastward, occasionally shifting toward the northeast; speeds range from a minimum of 0.019 m/s to a maximum of 0.296 m/s, with

an average of 0.145 m/s. Current speeds of 0–0.15 m/s are classified as slow, 0.15–0.40 m/s as moderate, and speeds exceeding 0.40 m/s as fast. Based on biophysical parameter measurements, activities such as banana boating, boating, and jet-skiing occurring within a current speed range of 0.035 m/s (minimum) to 0.334 m/s (maximum) fall into the "highly suitable" and "suitable" categories. Suitable conditions for these marine tourism activities involve moderate to slow current

speeds and water depths exceeding 5 m (Tambunan *et al.* 2013). The carrying capacity of an area for marine tourism is inseparable from the biophysical conditions of the waters. According to Dodds (2007), marine tourism activities are closely linked to available natural resource potential, often characterized by the "3S" concept: Sea (referring to coral reef ecosystems, mangroves, and other marine life), Sun (associated with sunbathing), and Sand (related to beach recreation). Marine tourism areas must preserve the characteristics of the ecosystems within them. In addition, according to Gautama (2011), marine tourism is a special market for people who are environmentally aware and interested in observing nature and an economic process with the aim of marketing interesting and rare ecosystems.

Based on the views above, the management of marine tourism in the waters of Hunimua Beach must continue to utilize existing natural resources optimally while ensuring the long-term sustainability of the area so that it can be enjoyed by future generations. Spatial planning, the enhancement of facilities and infrastructure, human resource development, and the regulatory framework established for managing the marine tourism area in the waters off Hunimua Beach must optimize existing natural resources while prioritizing the area's preservation and sustainability, thereby maintaining activities such as banana boating, boating, and jet skiing.

CONCLUSION

Based on parameters such as pH, temperature, salinity, sigma-t, chlorophyll-a, and turbidity, the waters of Hunimua Beach (Liang Village) fall within the "suitable" category; however, dissolved oxygen (DO) levels fall into the "unsuitable" category according to water quality standards. Based on the assessment of these parameters, along with a depth range of 0–20 m and current speeds ranging from a minimum of 0.035 m/s to a maximum of 0.334 m/s, the waters of Hunimua Beach are classified as suitable to highly suitable for ecotourism activities such as banana boat rides, boating, and jet skiing.

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