Safety Assessment of Ocean Current in Pantar Strait for Marine Tourism

Akhmad Tri Prasetyo[1], Andi Patriadi[2]*, Awaludin Ahsin[3], Nurhidayat[4], Budi Purwanto[4], Dyan P. Sobaruddin[4], Muslim[3], Muhammad Hendri[1], Septi Hermalingga[5], Eka M. Kurniasih[6]

[1]Department of Marine Science, Faculty of Mathematics and Natural Science, Universitas Sriwijaya
Palembang Boulevard - Prabumulih No.KM. 32, Ogan Ilir, 30862, Indonesia
[2]Study Program of Civil Engineering, Faculty of Engineering, Universitas 17 Agustus 1945 Surabaya
Jl.. Semolowaru 45, Surabaya 60118, Indonesia
[3]Department of Oceanography, Faculty of Fisheries and Marine Sciences, Universitas Diponegoro
Jl. Prof. Jacub Rais,Tembalang, Semarang 50275, Indonesia
[4] The Naval Hydro-Oceanography Center
Jl.. Ancol Timur. I No.1, Jakarta Utara, 14430, Indonesia
[5]Department of Chemical Engineering, Politeknik Negeri Sriwijaya
Jl.. Srijaya Negara, Palembang 30128, Indonesia
[6]Graduate School of Engineering and Science, University of the Ryukyus
Senbaru, Nishihara, Okinawa 9030213, Japan
Email: andipatriadi@untag-sby.ac.id

Abstract

The Pantar Strait with its coral reef ecosystem has encouraged many tourists to dive since the last decade. At least, ten coral reef ecosystem sites in Pantar Strait have been indicated as having potential for marine tourism, such as Munaseli Beach, Obisinga Beach, Umangdang Beach, Alor Eco Dive Resort, Ternate Island, Bakalang Beach, Pura Diving Spot, Nuhakepa Diving Spot, Pasir Putih Beach, and Savu Alor. This study illustrated the annual dynamics of ocean currents in Pantar Strait, subsequently assessing the safety rate of commercial diving at those tourism sites in each season. A three-dimensional hydrodynamic model was generated by the Delft3d flow module to illustrate the annual ocean current dynamic in the Pantar Strait. The safety assessment for marine tourism was classified into 3 levels (safe, alert, and dangerous). Ocean currents exceed maximum velocities in the west season. Various marine tourism sites close to steep slopes were not recommended for commercial diving. They are Munaseli Beach, Obisinga Beach, Pura Diving Spot, and Pasir Putih Beach. These sites experienced an increase in average currents that exceeded the safe threshold each season. Alor Eco Dive Resort was designated as the safest marine tourism, which showed a safe level for either average or maximum ocean currents in each season. Nuhakepa Diving Spot was designated as the second safest marine tourism. Several tourist sites that showed the danger of commercial diving in the west season were Umangdang Beach and Savu Alor. Many tourism sites showed an alert current for commercial diving in Springtide. Therefore, tourists are advised to avoid diving during the spring tide.

Keywords: *Pantar Strait, Marine Tourist, Commercial Diving, Ocean Current, Safety Assessment*

Introduction

Marine tourism has been a popular destination for people around the world who wish to go on vacation. Thus, it is not surprising that the promotion of marine tourism destinations is gradually becoming the main concern of various countries in this era (Koon *et al.*, 2023; Pascoe *et al.*, 2014; Shokri and Mohammadi, 2021). Surfing, diving, deep-sea fishing, and wildlife watching are some of the water activities available through marine tourism (Shokri and Mohammadi, 2021). In Indonesia, commercial diving is the most popular attraction of international tourists visiting marine tourism, about 55 % of national recording (BPS RI, 2017). Marine environments in Indonesia provide the greatest tropical coral reef, with more than 70% of all coral species worldwide. De Clippele *et al.* (2023) identified the distribution of coral reef ecosystems throughout the Indonesian Sea, especially in Pantar Strait.

The Pantar Strait, located in Alor Regency, has incredible potential as an attractive marine tourism destination (Tussadiah *et al.*, 2021). The coral reefs in the Pantar Strait offer spectacular underwater views with abundant marine biodiversity, including various fish species, corals, and other marine biota. Many diving services have been established in various sites of Pantar Strait to guide some tourists in commercial diving. Tides are another significant factor influencing the movement of water in straits and other tidal-affected water bodies (Patriadi *et al.*, 2024). Whales and dolphins are among the

*) Corresponding author

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megafauna that migrate across the Pantar Strait, increasing its tourist attraction. The appearance of dolphins in Pantar Strait has been recorded in previous research (Wirasatriya *et al.*, 2023). Pantar Strait offers a lovely marine environment for tourists, although its ocean dynamics can be hazardous at times. Physical marine hazards for commercial diving may occur in various conditions of the season, such as turbulent currents, high-velocity currents, and rip currents. Building a hydro-oceanography model is the simplest procedure to explore the seasonal circulation of ocean dynamics.

Research related to hydro-oceanography has become an important topic receiving widespread attention over the last decade, particularly in the context of maritime ecosystems and their potential for tourism activities. Carral *et al.* (2023) introduced a study on the hydrodynamics of ecosystems in the Ares-Betanzos estuary (NW Spain), where they modeled hydrodynamic simulation scenarios to recover species and marine biota habitats in locations resembling bays. Meanwhile, Madah and Gharbi (2022) explored tidal hydrodynamic simulations in the Arabian Gulf Bay, demonstrating that the hydrodynamic characteristics situated in the bay in their study did not indicate extreme flow patterns for marine tourism. Further, Purwandana *et al.* (2020) examined the crucial role of internal tides in regions of the North Pacific, including the Sulawesi Sea, Makassar Strait, and Flores Sea, as well as in the South Pacific, covering the Halmahera Sea, Maluku Sea, Banda Sea, and Seram Sea. This research found that flow patterns in Indonesia have routes from west to east, influenced by the rotating wind seasons from the east during the dry season and from the west during the rainy season. Interestingly, Indonesia, consisting of various small straits including the Pantar Strait, flanked by two islands, highlights the importance of understanding the hydrodynamics between these islands for hydro-oceanographic mitigation. Orhan and Mayerle (2017) observed hydrodynamics in the Lombok Strait, adjacent to the Pantar Strait, to analyze the potential for tidal current energy generation. Meanwhile, Bai *et al.* (2020) demonstrated different strait topographies in the Qiongzhou Strait, flanked by two islands on the north and south sides, with a dominant flow pattern moving from south to north.

No prior studies were found that seasonally examined ocean dynamics in the Pantar Strait. Previous studies have proven the existence of phenomena affected by the ocean dynamic of Pantar Strait, such as coral bleaching (De Clippele *et al.*, 2023) and extreme upwelling events (Wirasatriya *et al.*, 2023). The motivations for this study were to illustrate the seasonal changes in the ocean current of Pantar Strait and to mitigate ocean current conditions at various tourism sites in the Pantar Strait during each season. This study is expected to provide important information for tourists regarding safe times for commercial diving at Pantar's Marine Tourism sites, thereby preventing dangerous conditions. The result of this study may also support the scientific reason for many phenomena in the Pantar Strait derived from previous studies.

Materials and Methods

Model design

This research assessed the safety rate often marine tourism sites, as shown in Figure 1. These marine tourism sites feature diverse coral reef ecosystems and are utilized for commercial diving in Pantar Strait. The three-dimensional hydrodynamic model was generated by the Delft3d flow module during entire tropical seasons with various spatial resolutions. To derive more detailed data in shallow waters, these areas were designed with higher spatial resolution rather than deep water (Madah and Gharbi, 2022). The model results provided the ocean current pattern to assess the safety rate of tourism. Marine tourism was decided safe to dive if the average ocean velocity did not exceed 0.5 $m.s^{-1}$ (Budhiawan *et al.*, 2013; Hendyanto *et al.*, 2014; Sari *et al.*, 2020). This research classified the safety assessment into 3 conditions based on the reference as illustrated in Table 1.

Data source

This study applied time-series tidal force in either Flores or Sawu Sea as 2 boundary conditions (Figure 1.). This study derived predictive tide data from the tide model driver (TMD) as it provided global data on tide. The surface wind stress was also considered to vary by season influencing the ocean dynamics in Pantar Strait. This parameter was obtained from ERA 5 Land by the European Centre for Medium-Range Weather Forecasts (ECMWF). ERA 5 Land has provided re-analysis data by combining forecast, data assimilation system, and observation. The coastline used in this research was established from Indonesian geospatial data which was produced by Badan Informasi Geospasial (https://tanahair.indonesia.go.id/portal-web). This agency provided all coastline data of Indonesia throughout mean sea level (MSL) conditions with annual updates.

This study was fully supported by the 3rd Jala Citra Expedition which was conducted by Naval Hydro-Oceanography Canter (Center or Canter). This expedition collected various ocean topographies of Flores Sea through KRI SPICA 934 equipped with 302 Echosounder Multibeam. This instrument produced accurate bathymetry data for this study in Pantar

Table 1. Classification of Safety Assessment in Marine Tourism of Pantar Strait

Condition	Average Velocity (m.s^{-1})	Maximum Velocity (m.s^{-1})
Safe	< 0.5	< 0.5
Alert	< 0.5	> 0.5
Dangerous	> 0.5	> 0.5

Source: (Budhiawan *et al.*, 2013; Hendyanto *et al.*, 2014; Sari *et al.*, 2020)

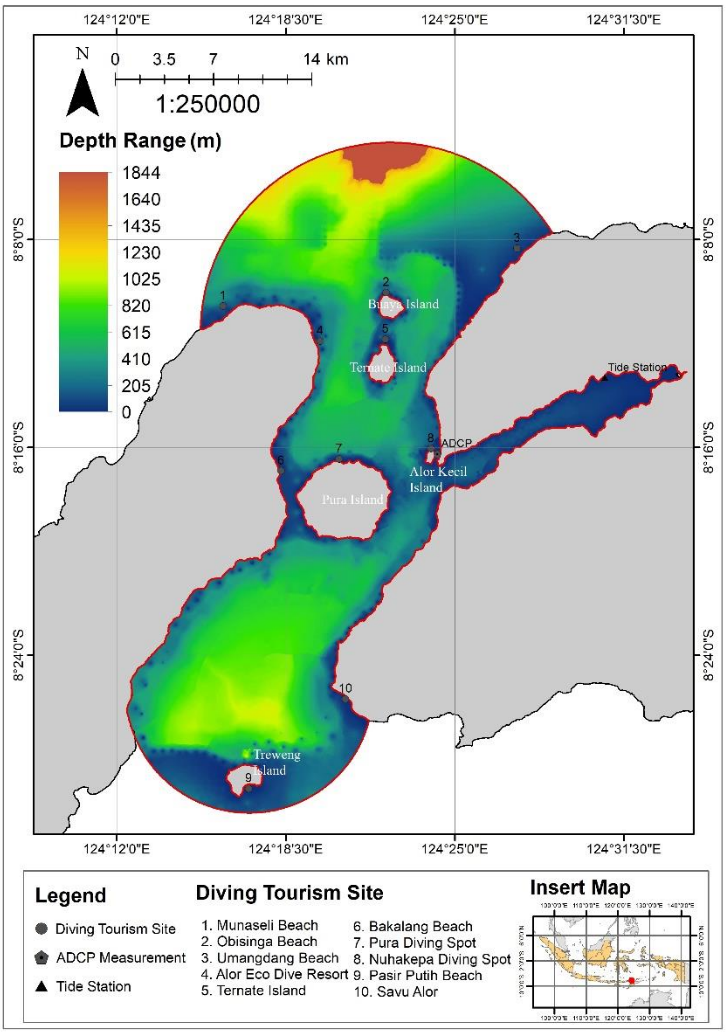


Figure 1. Research Location and Bathymetry Map

Strait. Nevertheless, KRI SPICA 934 did not collect all data in the model boundary (Figure 1.) due to limited duration and extreme sites, then it made the leakage data in several sites. This study filled some gaps in bathymetry data by incorporating National Bathymetry data and nautical charts obtained from the National Geospatial Information Agency and Naval Hydro-Oceanography Canter, respectively.

All of the required data was processed by the Grid module in Delft3D software (Delft Hydraulics, 2014). Table 2 illustrates each data along with its format and description, which this study needed to generate the model.

Model validation

The three-dimensional hydrodynamic model produced ocean current and water elevation data which must be validated with observational data. The model's ocean current, including x and y components, was compared with observed data using an ADCP instrument moored of Alor Kecil Water for 4 days starting from 14th to 17th, June 2022 (Figure 1.).

Table 2. Data Input Model

No	Data	Format	Description
1	Land Boundary	<name.ldb>	Coastline and model boundary
2	Grid model	<name.grd>	Parts of model data
3	Dry Point	<name.dry>	To define land among model boundary
4	Depth	<name.dep>	Interpolated bathymetry
5	Boundary	<name.bnd>	Open boundary area
6	Water level Time-Series	<name.bct>	Tidal force as a condition in the open boundary
7	Wind	<name.wnd>	Surface wind stress influence
8	Monitoring	<name.obs>	Observation site to validate model data

Source : (WL | Delft Hydraulics, 1999)

Meanwhile, the model's tide data were validated using a real-time tide station constructed by *Badan Informasi Geospasial* in Kalabahi City, the capital of Alor District. This study applied root mean square error (RMSE) to validate the model (Prasetyo *et al.*, 2021).

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(O_i - M_i)^2}{n}}$$

O_i is observed data, M_i is model data, and n is the amount of both data. The model could be assumed to increasingly illustrate the real condition if *RMSE* approached zero.

Result and Discussion

The Pantar Strait showed a mixed semidiurnal with a formzahl number of 0.47. This means that Pantar Strait experienced twice either high or low tides with different phases and amplitude. The tidal elevation of the model had about 7.7% for RMSE value. This study compared 2 layers of ocean velocity components, which were the surface and bottom layers. The biased value of the RMSE (Root Mean Square Error) at the surface layer was 9.6% for the x component and 26.3% for the y component (Figure 2.), while at the bottom layer was 5.7% for the x component and 36.5 % for the y component. The RMSE value can be eligible if it is not larger than 40% for ocean velocity (Wisha *et al.*, 2018) and 10% for tidal elevation (Muslim *et al.*, 2016).

The current pattern did not show significant dynamics between the spring tide and neap tide periods. The maximum current velocities in Pantar Strait were 2.8–3.2 m.s^{-1} during the spring tide period, while during the neap tide period were 2–2.4 m.s^{-1}. Figures 3 and 4 illustrate ocean currents between each season at high tide and low tide respectively. Sea water flowed homogeneously towards the Savu Sea during low tide conditions. On the other hand, tidal conditions indicated irregular movements of ocean currents, however, most of the ocean currents were directed towards the Flores Sea. The irregular movement of water masses increased the opportunity for turbulent current. The largest turbulent currents were detected present in the waters between the Pura Diving Spot and Ternate Island. Its intensity increased during high tides.

The highest ocean velocity occurred in the east water of Pura island in the entire season. This narrow waterway provided access to Kalabahi Port. The velocity value in that water reached 3.2 m.s^{-1}, while other waters only reached 2.4 m.s^{-1}. The multibeam echosounder detected the quite steep slope in this special site which contrasts with the narrow water of Pura Island. The west narrow water of Pura Island had a gentle and shallow bathymetry.

In general, the current velocities reached the maximum condition in the west season. The slowest condition of current velocity generally occurred in the second transition season. Nevertheless, various marine tourism sites specifically showed some differences in ocean current dynamics from the general seasonal conditions in the Pantar Strait. The next section explains safety mitigation for diving activities at 10 tourist locations for each season.

Tourist safety mitigation

Figure 5 illustrates the monthly average Velocity in each tourism according to the Hydrodynamic Model. Several tourist sites that maintained the average velocities at a safe level in entire seasons are Alor Echo Dive Resort, Nuhakepa Diving Spot, Ternate Island, and Bengkalang Beach. These sites have the highest average velocities of 0.2 m.s^{-1}, 0.25 m.s^{-1},0.37 m.s^{-1}, and 0.46 m.s^{-1} respectively. On the other hand, tourist sites with an average velocity exceeding the safety threshold in entire seasons are Munaseli Beach, Obisinga Beach, Pura Diving Spot, and Pasir Putih Beach. Those tourism sites show the highest average velocity of 1.34 m.s^{-1}, 1.1 m.s^{-1}, 1.27 m.s^{-1}, and 1.62 m.s^{-1}, respectively. Figure 5 illustrates monthly maximum velocities in each tourist site according to the Hydrodynamic Model. Nuhakepa Diving Spot, Ternate Island, and Bengkalang Beach achieved the maximum

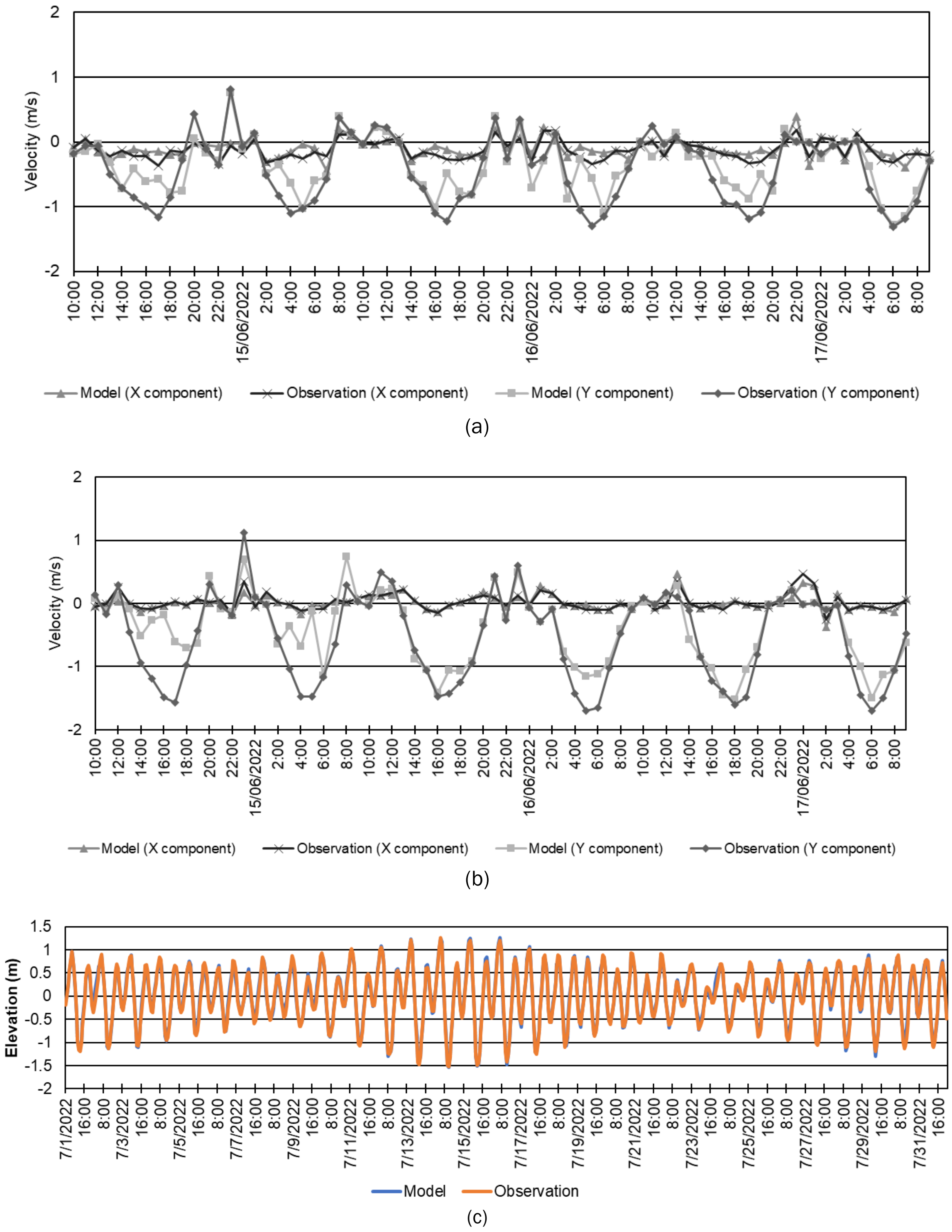


Figure 2. Validation Graph, a) and b) illustrated as x component and y component validation of surface current and bottom sea current, and c) illustrated as tide validation.

velocities that exceeded the safe threshold during the west monsoon months. However, while a marine tourism site was indicated safe in terms of average velocity during the season section, its velocities still had the potential to surpass the safety limit. Safe current conditions for diving activities in each season are only demonstrated at Alor Echo Dive Resort.

Based on the graph above, this study does not recommend commercial diving at Munaseli Beach, Obisinga Beach, Pura Diving Spot, and Pasir Putih Beach. These sites often exhibit high velocities. This study identified some safe diving tourist sites, such as Umangdang Beach, Alor Eco Dive Resort, Ternate Island, Bengkalang Beach, Nuhakepa Diving Spot, and Savu Alor. Nevertheless, during some seasons, these areas occasionally experienced dangerous velocities. The safe and unsafe months for all recommended diving spots during each tidal period and annual season are illustrated in Tables 3-6.

Some marine tourism sites were still identified as safe for commercial diving during the wet season, although the ocean currents of Pantar Strait generally increased during this season. According to the research findings, Alor Eco Dive Resort is the most

Table 3. Safety Rating at Various Diving Sites in Wet Season

Diving Spot	December				January				February			
	HN	LN	HS	LS	HN	LN	HS	LS	HN	LN	HS	LS
Umangdang Beach	√	!	√	x	!	x	√	!	√	!	!	x
Alor Eco Dive Resort	√	√	√	√	√	√	√	√	√	√	√	√
Ternate Island	√	√	√	!	√	!	√	!	√	!	√	!
Bakalang Beach	√	√	!	!	√	!	√	!	√	√	√	!
Nuhakepa Diving Spot	√	√	√	√	√	√	!	√	√	√	√	√
Savu Alor	x	x	√	√	x	x	x	!	!	!	!	!

Table 4. Safety Rating at Various Diving Sites in Transition I Season

Diving Spot	March				April				May			
	HN	LN	HS	LS	HN	LN	HS	LS	HN	LN	HS	LS
Umangdang Beach	√	!	!	!	√	!	!	!	√	!	√	!
Alor Eco Dive Resort	√	√	√	√	√	√	√	√	√	√	√	√
Ternate Island	√	√	√	√	√	√	√	!	√	!	√	!
Bakalang Beach	√	!	√	√	√	!	!	!	!	√	√	√
Nuhakepa Diving Spot	√	√	√	√	√	√	√	√	√	√	!	√
Savu Alor	√	√	!	!	√	√	√	√	√	√	√	√

Table 5. Safety Rating at Various Diving Sites in East Season

Diving Spot	June				July				August			
	HN	LN	HS	LS	HN	LN	HS	LS	HN	LN	HS	LS
Umangdang Beach	√	!	!	!	√	√	!	!	!	!	!	!
Alor Eco Dive Resort	√	√	√	√	√	√	√	√	√	√	√	√
Ternate Island	√	√	!	√	√	√	√	!	√	!	√	!
Bakalang Beach	!	!	!	!	√	!	!	!	!	!	!	!
Nuhakepa Diving Spot	√	√	!	!	√	√	!	!	√	√	√	!
Savu Alor	√	!	√	√	√	√	√	√	√	√	√	√

Table 6. Safety Rating at Various Diving Sites in Transition II Season

Diving Spot	September				October				November			
	HN	LN	HS	LS	HN	LN	HS	LS	HN	LN	HS	LS
Umangdang Beach	√	!	√	!	√	!	!	!	√	√	!	!
Alor Eco Dive Resort	√	√	√	√	√	√	√	√	√	√	√	√
Ternate Island	√	√	√	!	√	!	√	!	√	√	√	!
Bakalang Beach	!	√	√	√	!	!	√	√	!	√	!	!
Nuhakepa Diving Spot	√	√	√	√	√	√	√	√	!	√	!	!
Savu Alor	√	√	√	√	√	√	√	√	!	!	√	√

Note :

HN = High Neaptide
LN = Low Neaptide
HS = High Springtide
LS = Low Springtide

√ = Safe (mean velocity and maximum velocity under 0.5 $m.s^{-1}$)
! = Alert (However mean velocity is safe, Maximum velocity above 0.5 $m.s^{-1}$)
X = Dangerous (Mean velocity is above 0.5 $m.s^{-1}$)

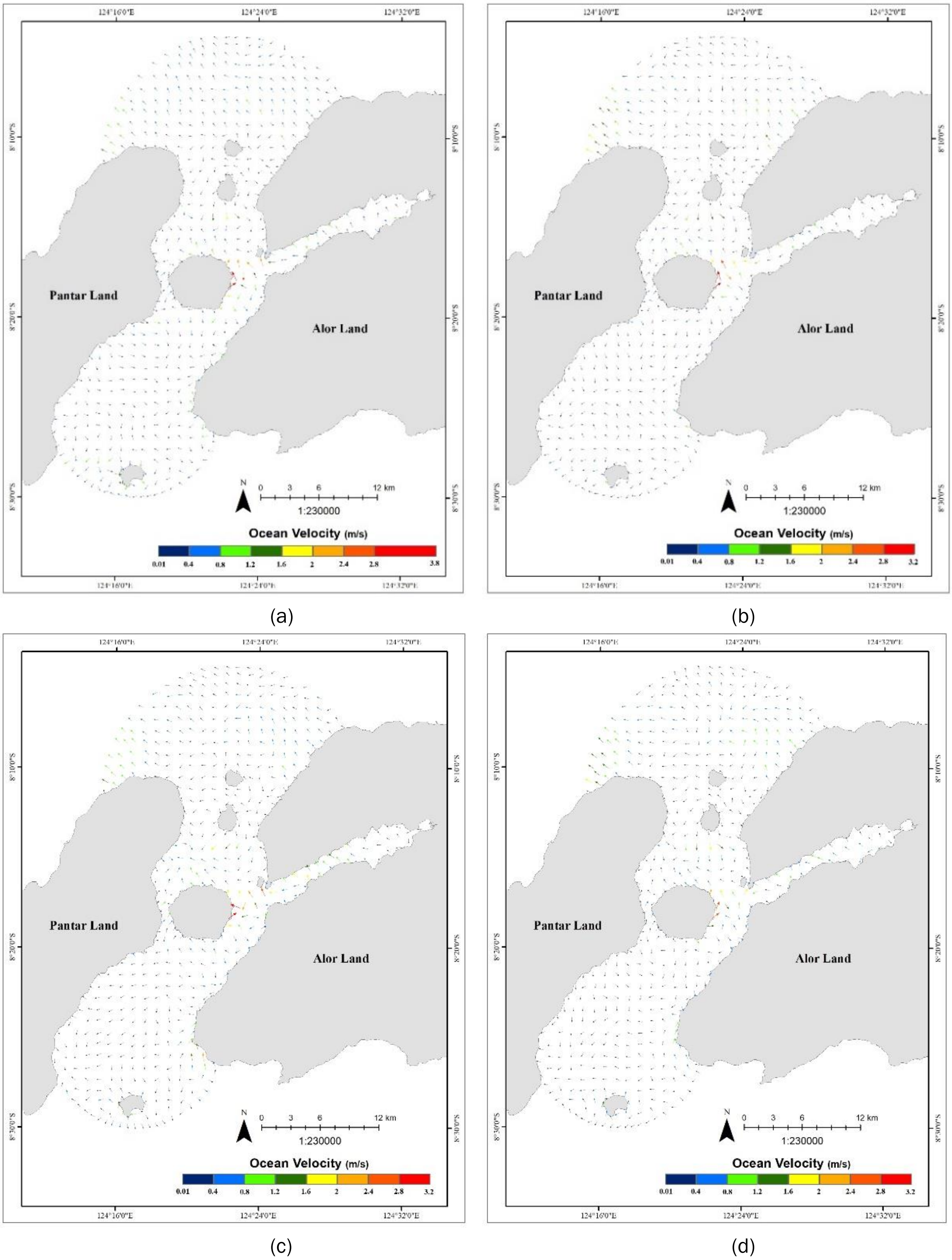


Figure 3. Ocean current during high springtide in each season; a) west season, b) transition I, c) east season; d) transition II

secure marine tourist site for diving activities in all seasons. Nuhakepa Diving Spot was identified as the second safest tourist attraction site, with tourists advised to avoid the spring tide period. The tourists who decide to visit Bakalang Beach should note that, the intensity of alert level increases in months of the east season. Umangdang Beach and Savu Alor indicated some dangerous levels of current velocities in west season. This study strongly advised tourists to avoid diving activity at both sites during the west season. In other seasons, tourists could explore Savu Alor while maintaining a cautious level of alertness. Meanwhile, Umangdang Beach still derived many alert levels in other seasons. Tourists visiting Umangdang Beach should watch the daily weather predictions before deciding on diving activity.

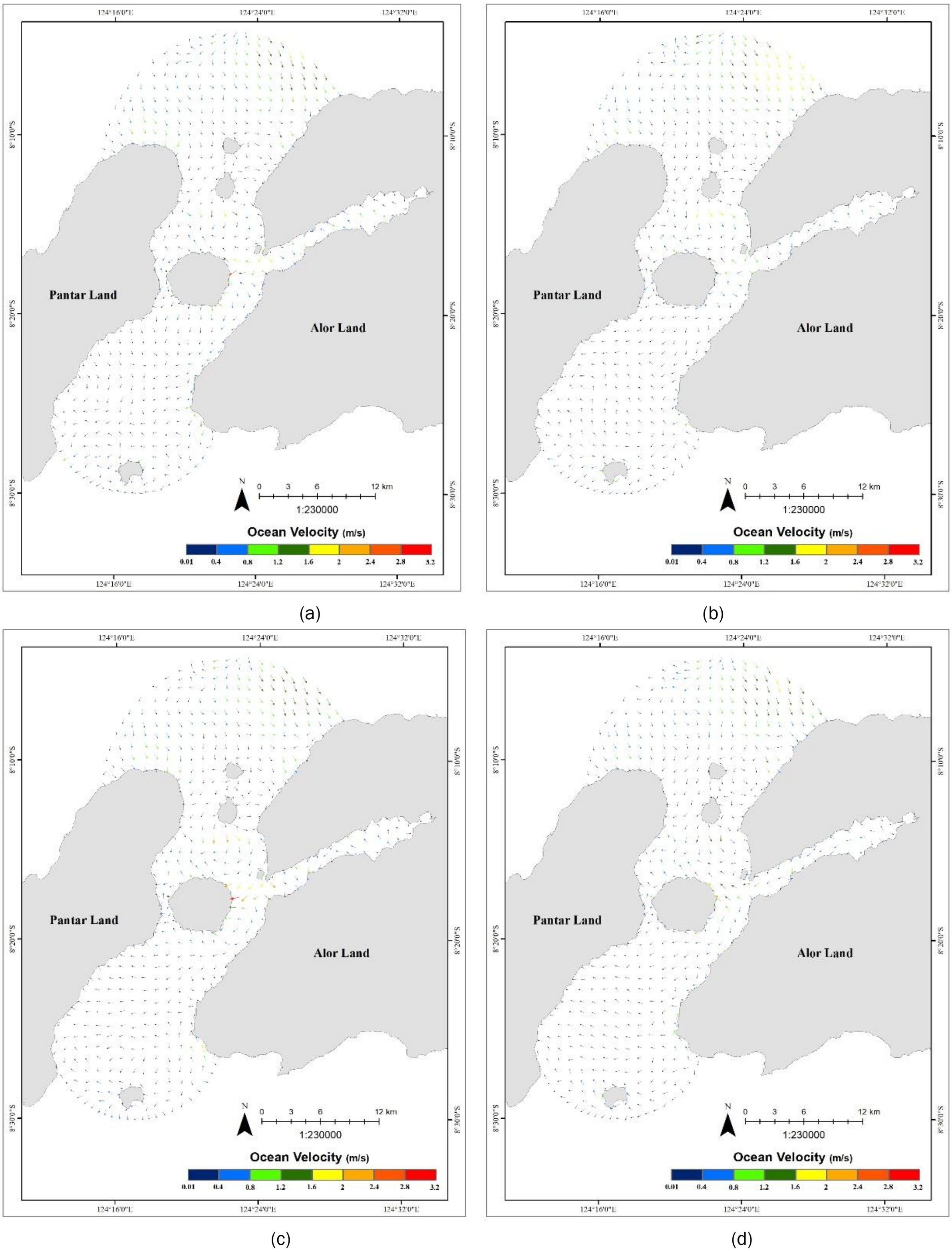
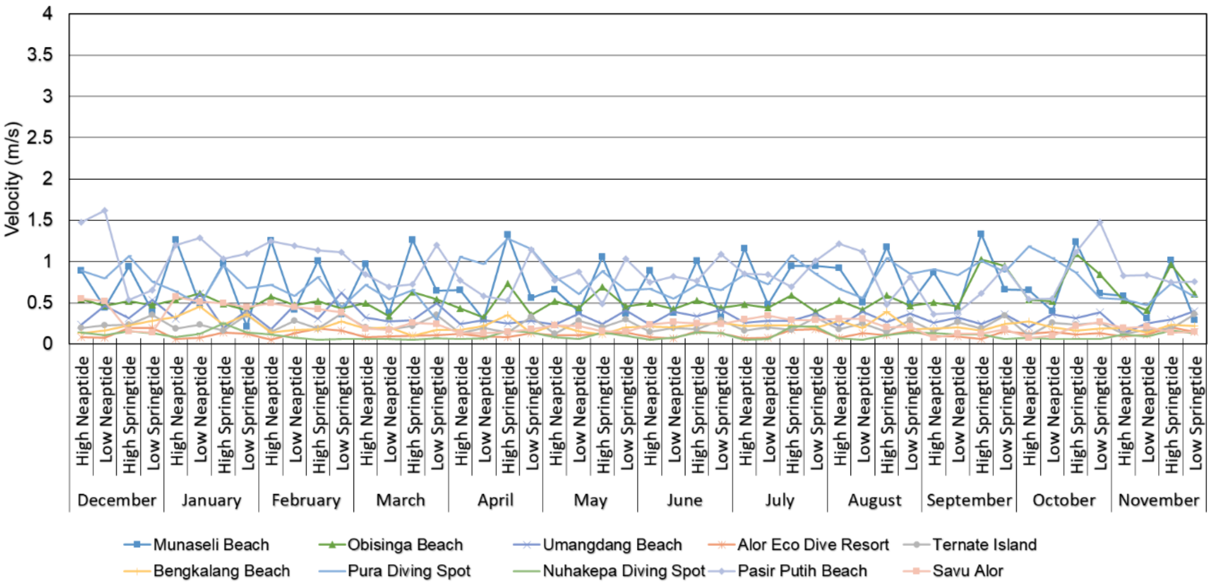
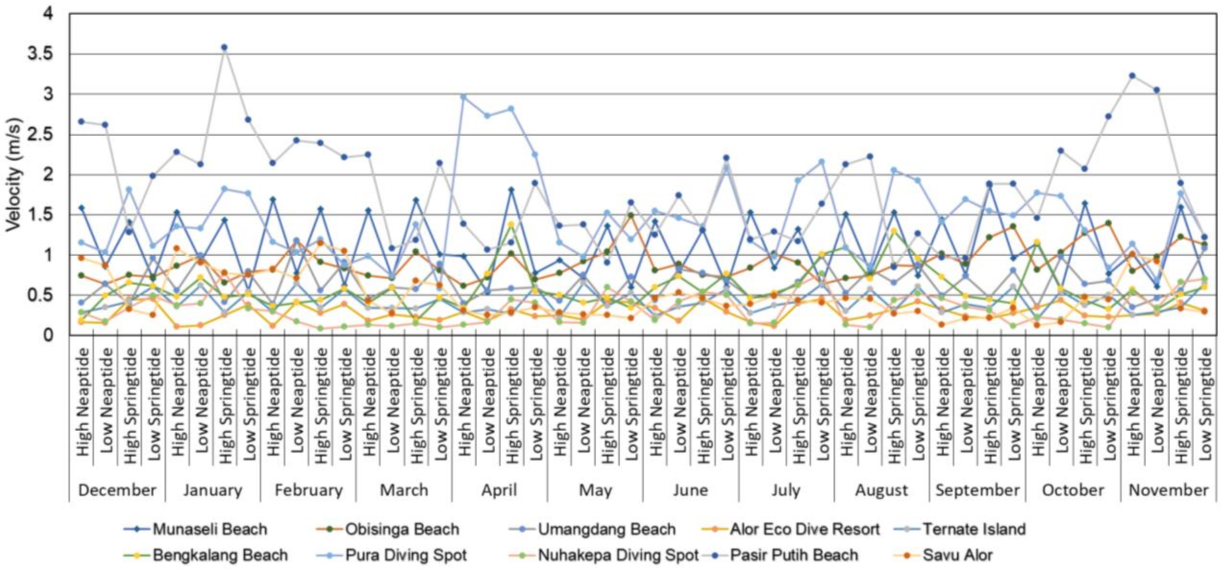


Figure 4. Ocean current during low springtide in each season; a) west season, b) transition I, c) east season; d) transition II



(a)



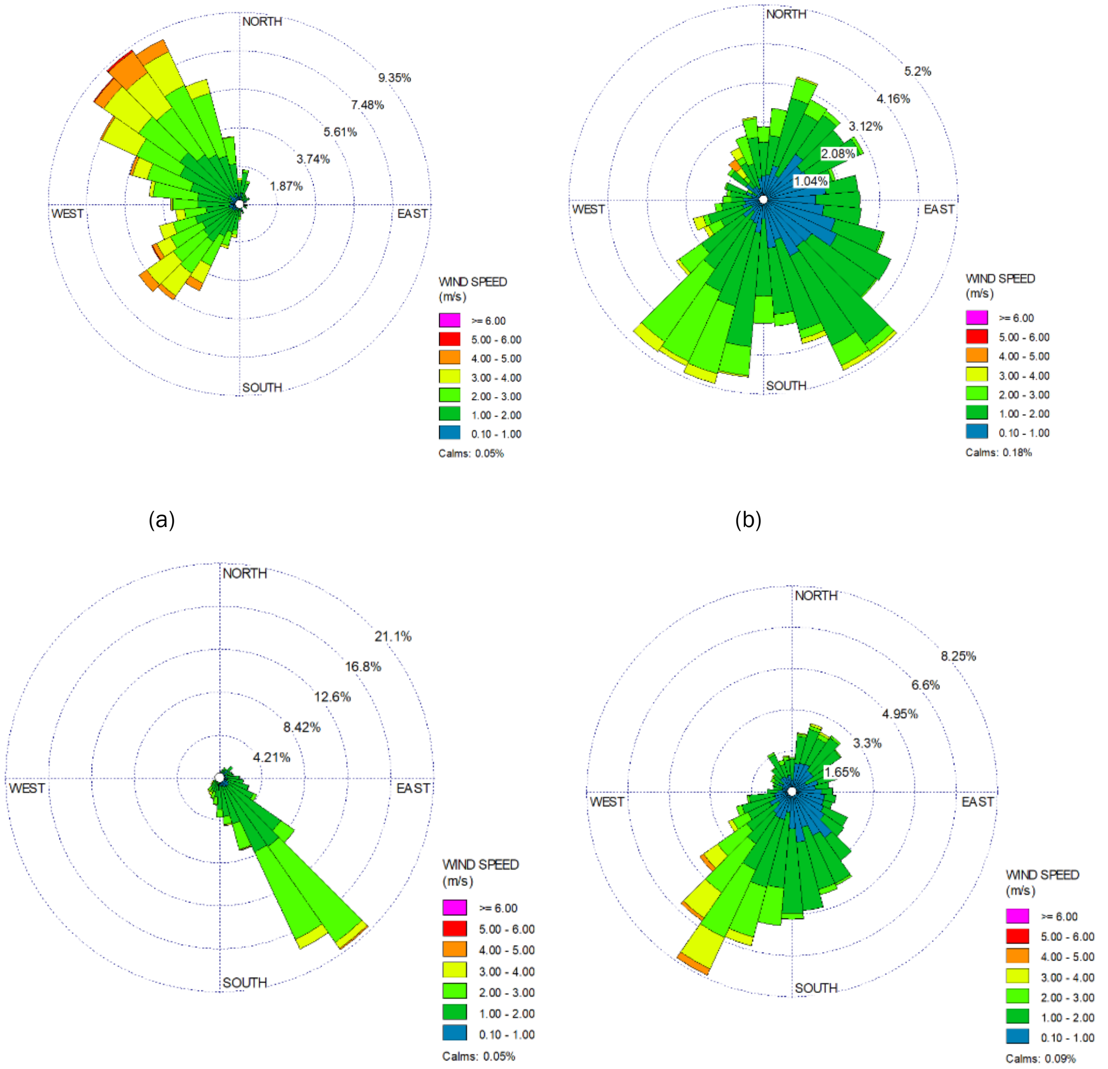
(b)

Figure 5. Monthly Velocity in each tourist site, (a) Monthly Average Velocity (b) Monthly Maximum Velocity

It was not quite different to Umangdang Beach, Ternate Island also indicated many alert levels for commercial diving in various periods. The study decided that the safest period for commercial diving in Ternate Island was in the east season.

Pantar Strait is the seawater that connects 2 large seas, the Flores Sea in the north and the Savu Sea in the south. These seas may involve fluctuating ocean dynamics in the Pantar Sea during each season. Various current velocities in Pantar Strait exceeded 3.2-3.8 m.s^{-1}, this range was not far away compared to Larantuka Strait (the contiguous strait with Pantar) which showed 3–4 m.s^{-1} (Orhan and Mayerle, 2017). The maximum velocity occurred in the eastern water of Pura Island. On the other side, the western water of Pura Island performed much gentler current velocities (0.4–0.8 m.s^{-1}), however its width is smaller. Both strait gaps had been designed with different slope characteristics, the eastern gap with a gentle slope and the western gap with a steep slope (Figure 1.). (Chen *et al.*, 2014) delineated that ocean current in the Malacca Strait would be quite slower than real conditions if it is designed to be a flat slope. A steep slope encourages bottom shock upstream and gravitational support downstream. The bottom shock causes the upwelling event and turbulent circulation in the upstream, meanwhile, gravitational support can increase the current velocity and shape the homogenous circulation towards the downstream (Berntsen *et al.*, 2023). These conditions were experienced in either Gibraltar Strait (González *et al.*, 2019) or Tatar Strait (Ponomarev *et al.*, 2018), but a slight exclusion was conducted in the Pantar Strait. In certain of the Pantar Strait's steeply sloping points, the downstream velocity was enhanced without the uniform streams; instead, some circulations displayed irregular flow. This event indicated that the surface wind stress dominantly influenced the ocean current in Pantar Strait.

These turbulent currents occur in the northern and southern regions of Pura Island throughout the season. Its intensity was increased during the west season accompanied by an increase in surface wind speed. The hourly surface wind of ECMWF inferred that the distribution of wind speeds achieved the maximum in the west season (Figure 6). The magnitude of the surface ocean wind influence depends on the intensity of the surr.ounding island clusters, which is usually called wind fetch. In the west monsoon, The surface wind flowed to Pantar Strait from the Flores Sea with longer wind fetch rather than the east monsoon which entered Pantar Strait from the Savu Sea. The Flores Sea is not larger than the Savu Sea. There is Timor Island, which sufficiently obstructs the east season toward Pantar Strait. The



(c) (d)

Figure 6. Windrose in each season,
(a) west season, (b) first transition, (c) east season, (d) second transition

same mechanism also occurred on the South Coast of Java, which experienced decreased wind speeds in the west season and an increase in the east season (Satiadi *et al.*, 2023). This geographical condition caused an increase in surface wind intensity which influenced ocean dynamics during the west monsoon.

The Pantar Strait has become one of many diving tourism in East Nusa Tenggara Province (Tussadiah *et al.*, 2021). Previously, this article had explained various oceanographic dynamics in Pantar Strait, therefore the safety assessment for commercial diving should be presented in each of Pantar's marine tourism sites. The cluster of islands within Pantar Strait is a mountainous area (Elburg *et al.*, 2002). Subsequently, volcanic activity over the last centuries has created the fluctuating topography in both land and marine areas of Pantar Strait. The steep slope of bathymetry can inhibit the propagation of internal tides, leading to their flow dissipating suddenly (Purwandana *et al.*, 2021). This process also caused turbulent currents with relatively high velocity in Pantar Strait, besides the influence of monsoon wind which had been explained in the previous paragraph. Consequently, this study did not recommend some marine tourism sites that are contiguous to the steep slope for commercial diving, such as Munaseli Beach, Pasir Putih, Obisinga Beach, and Pura Diving Spot.

The hydrodynamic model illustrated that Alor Eco Dive relatively showed safe ocean current variations in each situation of the entire season. This Marine Tourist site is located in the north of Alor Kecil Island surrounded by shallow water. Apart from that result, the unique event is presented in the south of Alor Eco Dive (ADCP site in Figure 1.). (Wirasatriya *et al.*, 2023) detected the extreme upwelling in Alor Kecil Water during high tide conditions in Alor Kecil Water. This unique event attracted the emergence of dolphins that preyed on small fishes that had died due to extreme drops in water temperatures. Of course, the emergence of dolphins provides more attraction for marine tourism. The multibeam of KRI Spica 934 found extreme shallowing in the east water of Pura Island (400 m) towards narrow waters between Alor Kecil and Alor Island (30 m). This shallowing formed a bottom ditch which was indicated as the pathway for bottom water mass from south deep water to flow vertically towards narrow water in Alor Kecil Water during high tide. This bottom ditch was detected thousands of years ago (Kealy *et al.*, 2020). Therefore, the narrow water in Alor Kecil sometimes experiences an extreme temperature drop during high tide. The presence of this event depends on how much tidal force is in the hightide delivering bottom water mass to Alor Kecil Water.

The safety assessment for marine tourism in this study remained focused on general events from each season. However, this analysis did not include any abnormal wind occurrences that could alter the Pantar Strait's unique dynamics during a certain period, such as ENSO or tropical cyclones. La Nina caused an increase in precipitation in several Indonesian regions, particularly the eastern region (Rodysill *et al.*, 2019). The Savu Sea also experienced Tropical Cyclone Seroja in 2021 (Setiawan *et al.*, 2021) which triggered extreme ocean currents (Ningsih *et al.*, 2023). As a result, it is still required to check the daily visitor forecast before choosing commercial diving. Furthermore, ocean currents will often increase during the spring tide period, after large tidal amplitudes. Tourists should avoid commercial diving during the spring tide season.

Conclusion

The Pantar Strait has experienced various complex dynamics of ocean currents, as an effect of its steep topography and the dominant influence of monsoon. The hydrodynamic model illustrated that various current velocities in the Pantar Strait increased in the west season, this should be noted by tourists. This research inferred that not all considered marine tourism sites were safe for commercial diving. Some marine tourism sites such as Munaseli Beach, Obisinga Beach, Pura Diving Spot, and Pasir Putih Beach are not recommended due to their proximity to steep slopes. Inversely, this study identified other considered marine tourism sites as a safe site for commercial diving. Alor Eco Dive Resort was determined to be the safest site for commercial diving. Tourists can dive safely in this marine tourism site in any season. This research advised tourists to avoid diving activities at Umangdang Beach and Savu Alor during the west season. The average current velocities in both marine tourism sites exceeded the safe threshold for commercial diving. The tourists should also be aware that at any period, there is potential for increased current velocities exceeding the safe threshold in each recommended marine tourism site. The current velocity can increase dramatically during specific intervals, but on average, it stays safe. This condition is referred to as alert in this study.

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