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Current patterns and distribution of suspended solids on the sea coast

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ABSTRACT

The ocean faces a variety of environmental challenges, including pollution, overfishing, habitat destruction, and climate change. These threats can have significant impacts on marine ecosystems and the livelihoods of coastal communities. The sea is also affected by currents, which are the continuous and directional movement of seawater. A number of variables, including wind, temperature, salinity, and the earth's rotation, influence ocean currents. Ocean current patterns are complex and can vary greatly depending on the region and time of year. Ocean current patterns can significantly impact the distribution and movement of suspended solids in the ocean. High levels of suspended solids can reduce water clarity, making water appear cloudy. The value of the concentration of suspended solids in a body of water greatly affects how high its turbidity is. Hydrodynamic models are used to study the movement of water and sediment in estuaries and coastal areas, including tidal, wave, and current effects. Understanding the movement of suspended solids in the ocean is important because it can help predict the spread of pollutants, determine sediment transport patterns, and understand the impact of suspended solids on marine ecosystems.

Introduction

The sea is full of diverse and complex ecosystems that support a variety of marine life. These ecosystems include coral reefs, kelp forests, seagrass beds, and deep-sea habitats. The sea is home to an incredible variety of organisms, including fish, mammals, invertebrates, and various species of plants and algae. The ocean is confronted with numerous environmental concerns such as pollution, overfishing, habitat destruction, and climate change. Numerous elements, including terrestrial inputs, offshore oil exploitation, coastal industrial and agricultural operations, maritime transportation, seawater-atmosphere interchange, and atmospheric deposition, affect the quality of marine water. These factors introduce organic matter, toxic substances, nutrients, and petroleum pollutants into the marine environment, leading to a decrease in seawater quality (G. Wu *et al.*, 2023). This threat can have a significant impact on marine ecosystems and the livelihoods of coastal communities. According to (Hindaryani *et al.*, 2020), Coastal areas are land areas on the edge of the sea that are still influenced by the sea. The sea has several different physical properties. It is influenced by tides, which are the periodic rise and fall of sea level caused by the gravitational forces of the moon and sun. The sea is also influenced by currents, which are continuous and directed movements of seawater. Ocean currents are driven by a combination of factors such as wind, temperature, salinity, and the Earth's rotation. Ocean current patterns are very complex and can vary greatly depending on the region and time of year. Ocean currents consist of surface currents and deep currents. Surface currents refer to the movement of currents over the ocean surface. Deep currents refer to the movement of currents below the surface of the sea (Hendra *et al.*, 2022). The climate, aquatic life, and even the distribution of contaminants and nutrients in the ocean can all be significantly impacted by ocean currents.

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According to (Kasharjanto *et al*., 2017), Ocean currents are the movement of bodies of seawater vertically (upward movement) and horizontally (lateral movement) from one place to another. There is a flow in seawater that has a certain direction, Current refers to the flowing movement of a body of water induced by wind action, differences in density, or the movement of long waves (Daruwedho *et al*., 2016).

Ocean current patterns can significantly impact the distribution and movement of suspended solids in the ocean. Suspended solids refer to small particles, including sediment, organic matter, and pollutants, suspended in the water column that settle on the seabed. The wind largely determines the direction and strength of currents in the open sea's surface layers. The winds that blow in Indonesian waters are mainly seasonal winds (monsoons) which experience two reversals of direction in a year, specifically the Western Season and the Eastern Season. This results in the formation of seasonal currents in several Indonesian waters (Rahmawitri *et al*., 2016).

Suspended solids originate from diverse sources, including natural phenomena like erosion, weathering, and biological activity, as well as anthropogenic activities such as industrial processes, agriculture, and urban runoff. Suspended sediment is sedimentary material floating in water that moves without touching the bottom of the water and then settles (Pasaribu *et al*., 2014). It can enter water bodies through runoff, wastewater discharge, or natural processes such as wind and wave action. Waves that propagate towards the beach at a certain angle to the coastline, after breaking can cause currents along the coast (longshore current). These currents can cause sediment transport along the coast (longshore transport). Meanwhile, the currents generated by the tides cause an asymmetrical transport process due to the existence of two opposite current directions, namely currents towards land when seawater moves at high tide (flood tide) and currents towards the sea when sea water recedes (ebb tide) (Soerjawo & Maryanto, 2018). Suspended solid materials are all solid substances or particles with a size greater than 1 μm that are suspended in water. Suspended solid material in waters can be sand, mud, and clay originating from land which is transported via rivers, air and originating from the sea (Taohid *et al*., 2017).

Understanding the movement of suspended solids in the ocean is important for many reasons. It helps in predicting the distribution of pollutants, determining sediment transport patterns, and understanding the impact of suspended solids on marine ecosystems. Hydrodynamic models are often used to simulate and study the movement of suspended solids in the ocean, taking into account the complex interactions of currents, winds, and other factors that influence their distribution. Hydrodynamic models represent water motions, including currents, tides, and various hydrodynamic phenomena. The model's results indicate a disparity in speed and direction between the westerly and easterly monsoons (Hidayat *et al*., 2023).

Hydrodynamic models analyze the flow of water and sediment in estuaries and the coasts, including the effects of tides, waves, and currents. Hydrodynamics is a scientific discipline that investigates fluid motion, especially incompressible liquids which are influenced by internal and external forces (Surinati & Marfatah, 2019). This modelling can help in understanding the impacts of coastal erosion, sediment transport, and coastal infrastructure design. Hydrodynamic models exhibit a high degree of reliability, attributed to their comprehensive coverage of geographical and temporal data (Jahanmard *et al*., 2023). Hydrodynamic models can be integrated with water quality models to simulate the transport and dispersion of contaminants or nutrients in aquatic environments. It helps in understanding the impact of pollution sources, designing wastewater treatment systems, and assessing the effectiveness of water quality management strategies.

Although ocean current conditions in a body of water are very difficult to study directly, hydrodynamic modelling can help in analyzing water conditions by simulating the movement of current patterns. One of the advantages of hydrodynamic modelling is that it can predict flow patterns according to the area and time required, so there is no need to collect flow data all the time, and determining the placement of many observation points will save time, energy, tools, and costs (Anisa *et al*., 2017).

Materials and Methods

Location and time of research

This research was conducted at the outfall location of liquid waste disposal for the plastic industry in Cilegon City with coordinates 05°58'04,70"S and 105°59'49,23"E. This location borders directly on the Sunda Strait to the west and the area is shallow water <100 m. The morphology of the coastline from North to South of Cilegon City is an industrial reclamation area with a water depth of ±5 m (Figure 1).

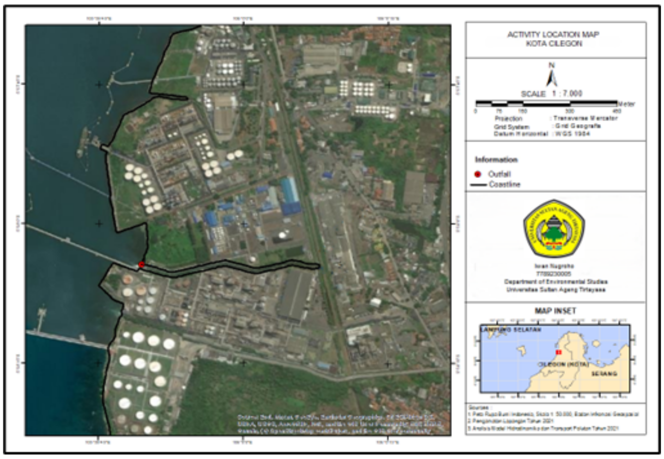

Figure 1. Activity Location Map

Data analysis

The numerical model employed in this research is a user interface software known as DHI MIKE, produced by the Danish Hydro-Environmental Institute (DHI). This study makes use of one of the model packages that make up the DHI MIKE model; specifically, the DHI MIKE 21 Flow Model FM.

The DHI MIKE 21 Flow model FM is a modeling package utilized for two-dimensional modeling (depth-averaged) employing a finite element methodology. This model package consists of several modules to solve several problems that occur in the aquatic environment. The Hydrodynamics (HD) module is used to solve the hydrodynamics of a water body, The Mud Transport (MT) module is utilized to analyze the dynamics of sediment entering a water body, and the transport module is used to solve the dynamics of sediment entering a water body, and the transport module is used to resolve the dynamics of sediment entering a water body (DHI, 2012). Sediment that enters a water body is used to overcome the distribution of pollutants. In this research, these three modules are used for modelling.

In this study, we set the hydrodynamic model domain to be as large as possible or as far away from the region under study as possible. The goal is to maintain correct open tidal flow and good model stability in the region of interest. The location-targeted in this research is near a wastewater treatment plant. In addition, because this research uses the finite element method for the numerical approach, the model surface is divided into small triangles and applied in the form of discretization. The elements used in this research vary in size to reduce computer calculation time. Detailed sizes of elements are created in the desired area, and elements far from the study area are enlarged. Figure 2 shows the scope and geometry of the model elements in general.

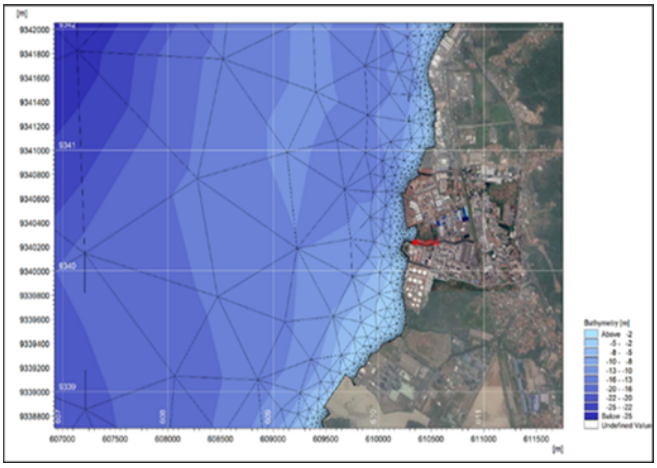

Figure 2. Model Discretization in Triangular Mesh Form

Model Input and Generation

a) Hydrodynamics

Initial condition

The initial circumstances employed in hydrodynamic modeling are the parameters of surface water elevation and velocity. The quality and reliability of simulations in hydrodynamics modelling at coastal areas heavily depend on the initial conditions. These circumstances generally encompass factors that include temperature at the surface of the sea, salinity, levels of water, and meteorological data. The study conducted on the Vengurla coastal in Maharashtra utilised the most recent prototype data to calibrate the MIKE 21 flexible mesh software. This calibration process ensured precise predictions of hydrodynamic behaviour and sediment movement (Sinha *et al.*, 2022). This study used the value zero as the initial state value for the water level and flow velocity. Alternatively, the sea surface may be flat and the water mass does not move.

Boundary condition

The boundary conditions utilized in hydrodynamic modeling consist of closed boundaries, open sea boundaries, free surface boundaries, and discharge. Boundary conditions play a critical role in hydrodynamic modelling of coastal regions as they are essential for accurately replicating a range of physical phenomena. These conditions may involve setting water levels, velocity, or a mix of both and are crucial for models such as Delft3D or Mike 21 (Carmo & Simão, 2021).

Closed boundary

The closed boundaries used are land areas or islands within the model calculation area. Because of this limitation, calculations are not performed automatically. Venkatesan's research focuses on the

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mesoscale characteristics of coastal atmospheric boundary layers. It emphasizes the significance of land-sea interactions, which are affected by the existence of land boundaries (Campuzano *et al.*, 2020).

Open Sea Boundary Condition

The open boundaries used in this research are tidal data. The propagation speed of tidal waves is influenced by the geometry and bathymetry of the area, as well as the spatial grid size and timestep in numerical models. These factors also have an impact on the accuracy of tidal wave predictions (Abubakar *et al.*, 2019). Data are predictions from AG95 developed by Ole Baltazar Andersen (updated to Andersen 2006). This model serves as a global tidal prediction tool featuring a resolution of 0.125°. and the model location in this study utilises open tidal boundaries, which are semicircular on the west side of the research location. Tidal prediction data used as open boundaries vary in space and time. The tidal prediction data utilized comprises data for January (indicative of the western season) and data for August (indicative of the eastern season). Figure 3 depicts a single tidal data point utilized as an open border.

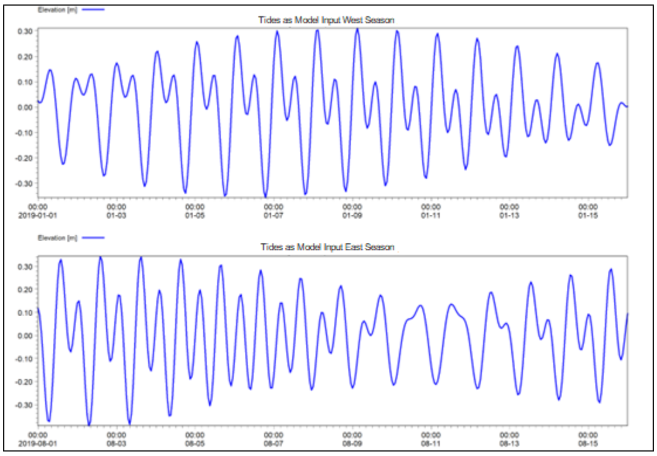

Figure 3. Tides as Model Input

Free Surface Boundary Condition

The surface boundary used in this research is wind. This is because the movement of wind above the water surface changes the flow speed below the water surface due to the influence of shear stress. Sea surface temperature fluctuations significantly impact coastal areas, making them more vulnerable to changes in vertical wind speed and shear (Ryu *et al.*, 2018). The European Center for Medium-Range Weather Forecasts provided the wind data used in this model. The wind data used includes west monsoon wind data (January 2019) and east monsoon wind data (August 2019). An overview of the model input wind data is presented in Figure 4, while the windrose diagram is presented in Figure 5. From this figure, the prevailing winds during the West Monsoon originate from the West, exhibiting a maximum velocity of 8 m/s, during the East Season, it originates from the South at a maximal speed of 5 m/s.

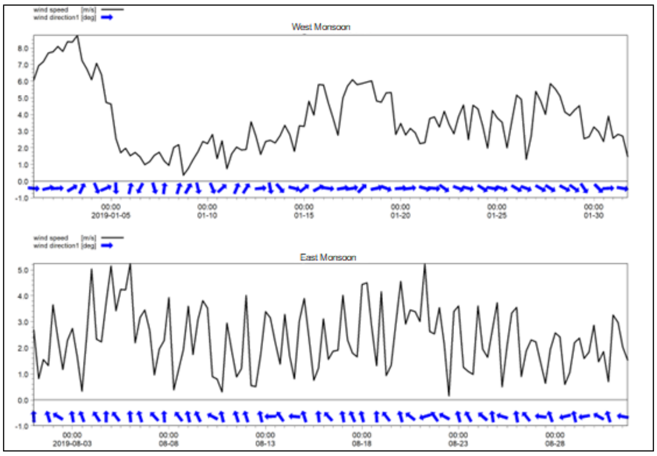

Figure 4. Wind generator model

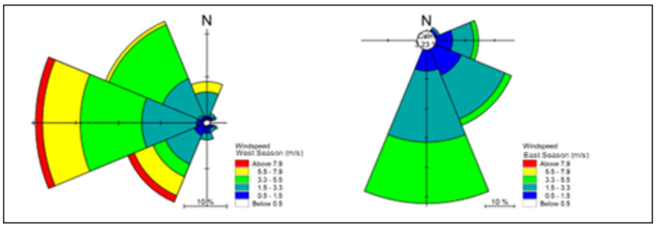

Figure 5. Windrose diagram

b) Model Simulation Scenario

This study involved a 15-day simulation of the hydrodynamic model to achieve neap tide and full moon tide conditions. Apart from that, the simulation time was carried out in two different seasonal conditions, that is:

- Scenario 1: the simulation is carried out in January to determine the influence of the West Monsoon.
- Scenario 2: the simulation is carried out in August to obtain the influence of the East Monsoon.

c) Model Input Parameter for Total Suspended Solids (TSS)

The initial TSS input value used in the modeling is 200 mg/L, which is the maximum TSS concentration according to the standards of wastewater quality in Annex VIII for Port Area Waters (Government Regulation of the Republic of Indonesia Number 22 of 2021 concerning the Implementation of Environmental Protection and Management). This value is chosen using a conservative approach to describe the worst-case scenario related to the potential implications of TSS concentrations in the modeling.

Based on prior research on the thermal characteristics of coastal regions, sea surface temperatures are adjusted between 28 and 30°C. According to data from the Copernicus Marine Environment Monitoring Service, salinity is managed between 30 and 33 PSUs. In the Western Season, the real salt concentration was 32 PSU, whereas in the Eastern Season, it was 33 PSU.

Results

Simulation Model Result

1. Model Verification

Model verification aims to find out how good the quality of the model results that have been run are. Model verification involves the comparison of model data with field measurement data in the form of series graphs and the calculation of correlation coefficients. In this model the variable to be verified is tides. The tides used for verification are the tides measured by the Geospatial Information Agency. The Geospatial Information Agency (BIG) oversees the operation of tidal stations throughout Indonesia to monitor sea tides, which are essential for establishing vertical references and mapping systems (Fitriana *et al*., 2019). Figure 6 shows the model verification findings. From this figure, it can be seen that the tides measured by the Geospatial Information Agency have a pattern similar to the model output and have a correlation coefficient of r = 0.99 for the West Monsoon tides and the East Monsoon tides, thus the hydrodynamic model has been made for tidal parameters which can be said to be good and close to actual conditions.

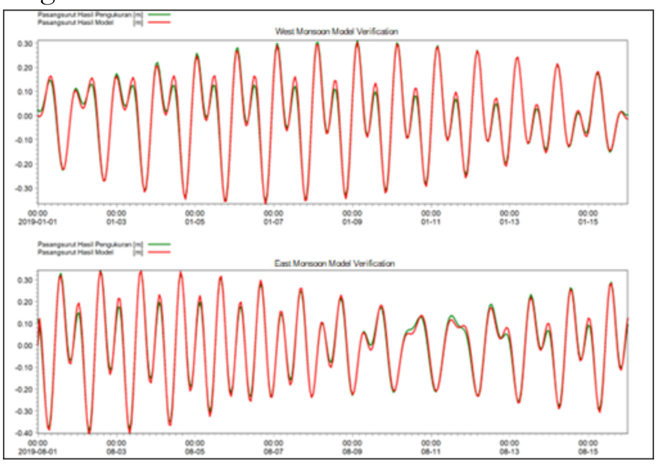

Figure 6. Comparison between tides from BIG measurement results and model results

2. Hydrodynamics Model Result

The hydrodynamic model does not fully exhibit the current pattern at each modeling time step; it is only presented under specific conditions: prior to high tide, during high tide, before low tide, and during low tide. The arrangement of contemporary patterns for tidal conditions is comprised of three image panels: panel A illustrates the surface current pattern of the study area, panel B depicts the tides, and panel C conveys the speed and direction of currents in the vicinity of the study area. The results of the current model for four tidal conditions for both the West and East Monsoon conditions are presented respectively in Figure 7 to Figure 14.

Based on the results of the hydrodynamic model, the current pattern in the study area is the same as the strait current pattern in general, where the role of tides and winds in generating currents is very strong. In four samples of currents at the time of high tide, high tide, low tide, and low tide, where the flow patterns between the West Monsoon and the East Monsoon of these four conditions appear different. This is because the influence of the West Monsoon winds is greater than the East Monsoon winds so the sea surface currents of the West Monsoon have a greater speed than the East Monsoon. Wind movement influences the characteristics of water masses in the ocean, including causing changes in the direction of surface currents (Sari *et al*., 2020).

When the waters are experiencing high tide (just before high tide), both the West Season, Figure 7, and the East Season, Figure 8, Current patterns often progress from north to south. In the West Season, the peak current velocity within the designated model area is recorded at 0.12 m/s, while the current speed in proximity to the waste disposal zone is notably lower, measuring at 0.02 m/s. In the East Season, the model area exhibits a maximum current speed of 0.31 m/s, while the current speed near the waste disposal area is notably lower, recorded at 0.007 m/s.

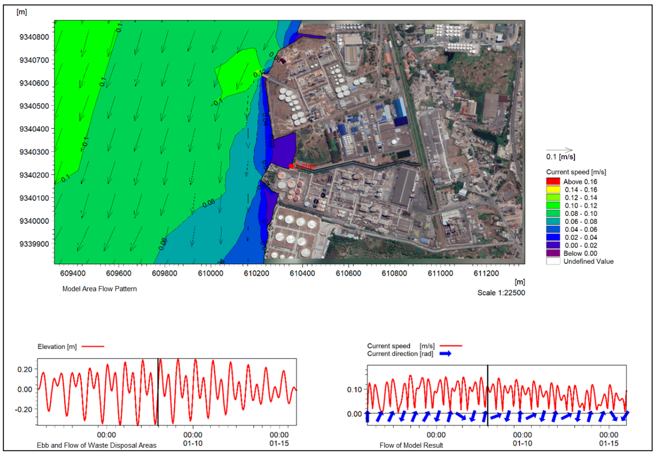

Figure 7. Current Pattern Before the Highest Tide West Monsoon Conditions

The current pattern in Figure 9 during the West Season is comparable to the conditions prior to high tide, but the current speed is reduced. This is due to the water level conditions at the highest tide. During

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the Western Season, the waste disposal area has a current speed of 0.02 m/s and the model area has a maximum current speed of 0.08 m/s. Meanwhile, in the East Season, Figure 10, the current conditions appear calm, where the maximum current speed in the model area is 0.015 m/s, with the current speed around the waste disposal area relatively greater than the West Season, namely 0.007 m/s. In Bayur Bay, the velocity of the sea current during the east season varies between 3.48 and 24.9 cm/s, whereas during the west season, it ranges from 1.4 to 57.7 cm/s. This suggests that there is a greater fluctuation and possibility for higher speeds during the east season (Wisha *et al.*, 2017).

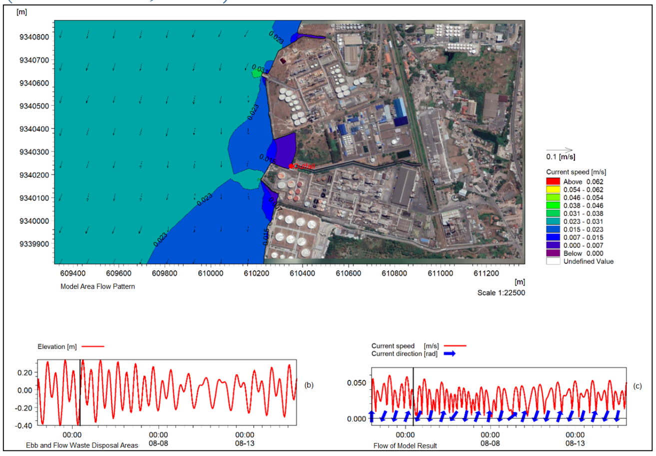

Figure 8. Current Pattern Before the Highest Tide East Monsoon Conditions

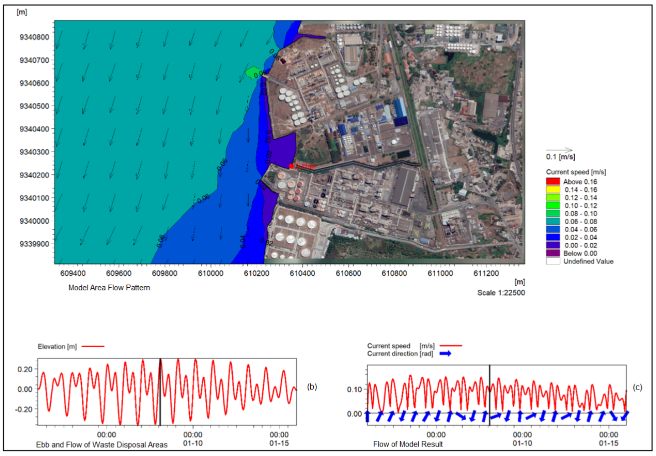

Figure 9. Highest Tidal Flow Pattern for West Monsoon Conditions

The current pattern when the water level experiences its lowest ebb (near low tide) is shown in Figure 11 (West Monsoon conditions) and Figure 12 (East Monsoon conditions) which shows the dominant current moving from South to North. During the Western Season, the greatest current velocity in the model region is 0.12 m/s, whereas the current speed near the waste disposal site is very low at 0.02 m/s. In the East Season, the model area exhibits a maximum current speed of 0.046 m/s, while the current speed near the waste disposal area is notably lower at 0.007 m/s.

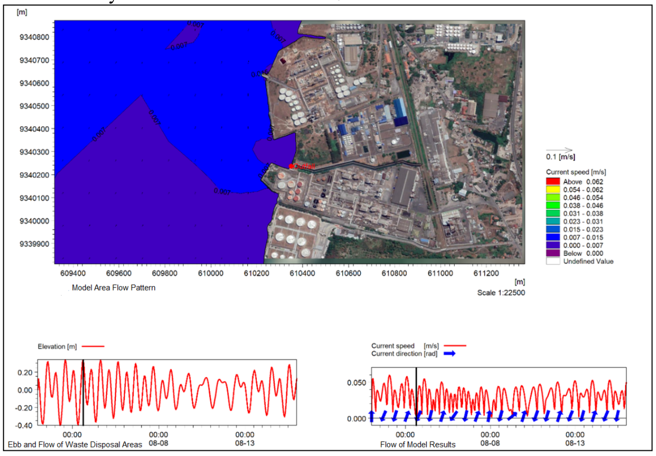

Figure 10. Highest Tidal Flow Pattern for East Monsoon Conditions

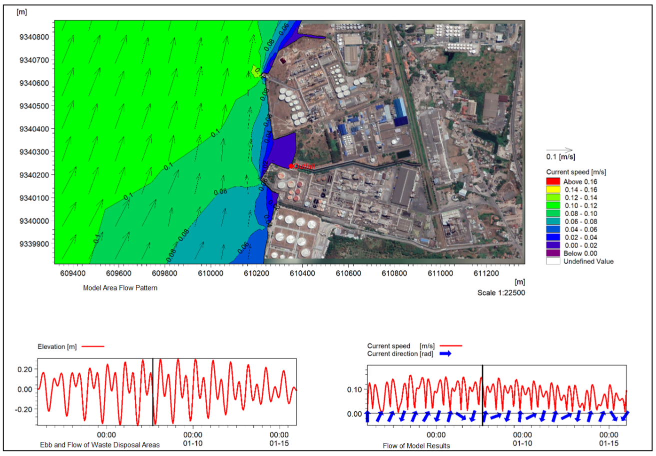

Figure 11. Current pattern towards the lowest low tide in the West Monsoon Conditions

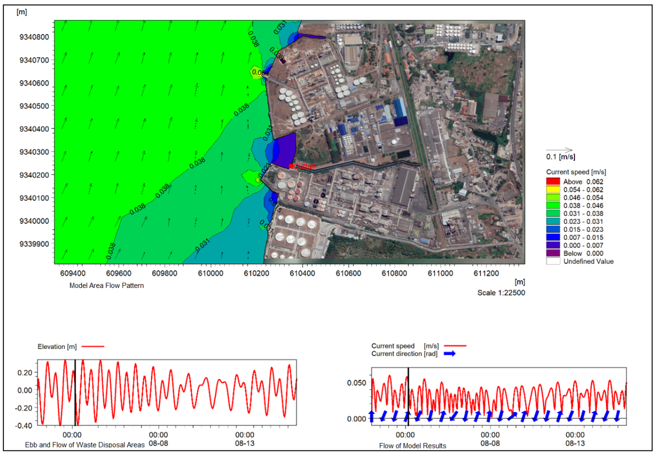

Figure 12. Current pattern towards the lowest low tide. East Monsoon Conditions

Figure 13 depicts the West Season, which occurs when the water level is at its lowest, while Figure 14 depicts the East Season. The prevailing current at low tide during the West Monsoon predominantly flows from South to North, whereas in the East Monsoon, the dominant current flows from North to South. While the trash disposal region experiences a current speed of 0.02 m/s during the West Season, the greatest current speed in the model area is 0.04 m/s. In the East Season, the maximum current speed in the model area is lower than in the West Season, measuring 0.038 m/s, while the current speed near the trash disposal area is 0.007 m/s.

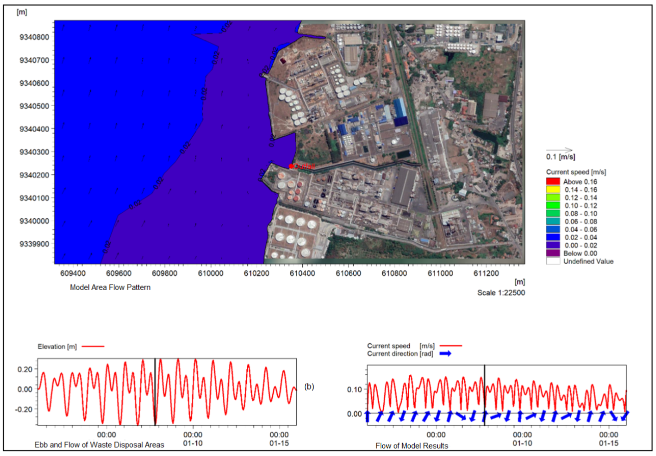

Figure 13. Lowest Ebb Flow Pattern for West Monsoon Conditions

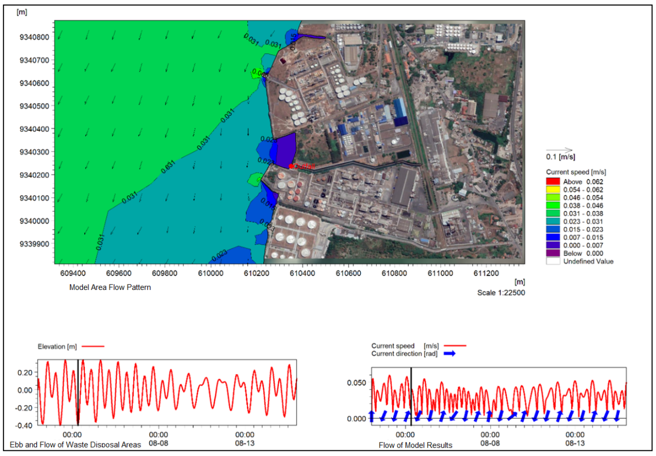

Figure 14. Lowest Ebb Current Pattern in East Monsoon Conditions

3. Pollutant Distribution Model Results

The results of the pollutant or waste distribution model are not presented in their entirety during the model simulation, but only the maximum conditions (worst case) from the 15-day simulation are presented. It's important to note that in this modeling, the starting point or initial conditions of the parameters being modeled in the water are taken to be zero. This is because the initial data that was available was only momentary and didn't show how the water was in different situations. As a result, the model output is the value of the increase or increase in concentration. Pollutants released by industry. Meanwhile, the temperature and pH parameters have initial conditions of 30°C and 8.5.

Total Suspended Solids (TSS)

The outcomes of the TSS distribution model for the West and East Seasons are illustrated in Figure 15 and Figure 16. It is known that the pattern of tidal currents, West and East Season winds influence the extent of distribution and dilution of the concentration of TSS waste from industry. Currents at high tide cause TSS waste to concentrate around the outfall, while currents at low tide cause TSS waste to spread away from the outfall. During the West Monsoon, the wind generates higher current speeds than during the East Monsoon so TSS waste is diluted more quickly than during the East Monsoon.

During the Western season, TSS waste released into the sea originates from nearby industrial wastewater treatment facilities, exhibiting a concentration of 200 mg/l and a discharge rate of 50 m^3/day. After entering the sea, the outfall has a maximum TSS concentration of 0.48 mg/l. The water is diluted with saltwater and extends to the coastal basin and 140 m north of the outfall, with a minimum TSS content of <0.05 mg/l.

In the East Season, the total suspended solids waste released into the ocean originates from the nearby industrial wastewater treatment facility, exhibiting a concentration of 200 mg/l and a discharge rate of 50 m^3/day. The maximum TSS concentration in the outfall after entering the sea is 0.75 mg/l. After that, it is diluted with saltwater until it reaches 160 meters north of the outfall and the coastal basin, with a minimum TSS concentration of less than 0.05 mg/l.

Based on Indonesian Government Regulation No. 22 of 2021, seawater quality standards for port use, the TSS concentration permitted in seawater is 80 mg/l. If the waters plus TSS waste discharge from industry around the West and East Seasons do not exceed the quality standards in the area around the outfall.

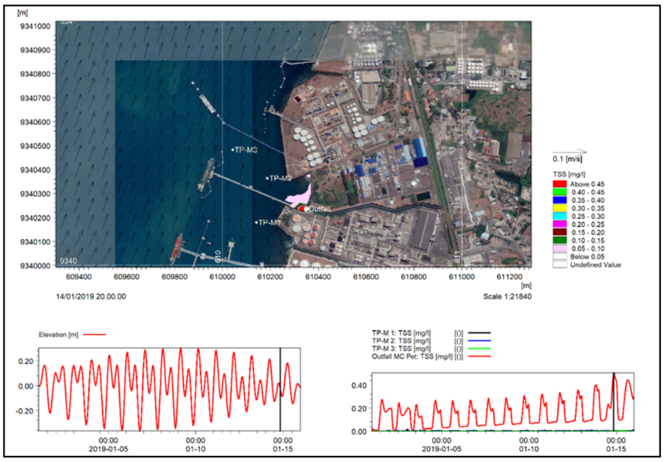

Figure 15. Simulation Results of Maximum TSS Distribution During the West Season

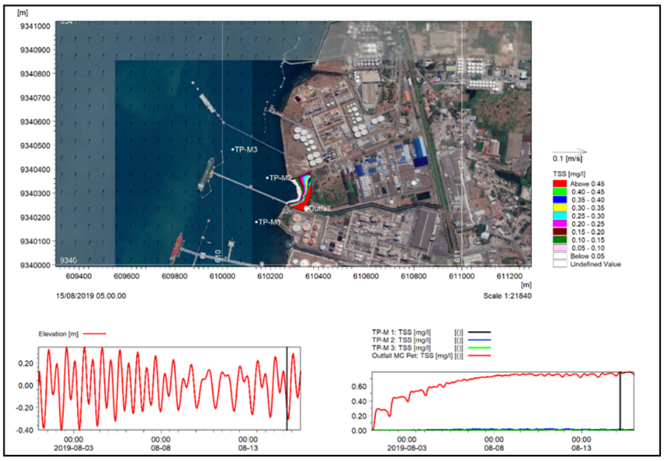

Figure 16. Simulation Results of Maximum TSS Distribution During the East Monsoon

Discussion

- **Model Verification**

The comparison of field measurement data with model data for tidal predictions demonstrates substantial insights into their correctness and reliability. Field measurements, albeit offering direct observations, frequently encounter constraints such as limited data duration and localized variability. Conversely, model data, especially when augmented with sophisticated approaches, can provide more extensive and uniform forecasts. The subsequent sections elucidate these elements.

When it comes to tidal predictions, both field measurement data and model data have advantages and disadvantages. Field measurements enable direct observations, which are critical for validating and improving model predictions. Nonetheless, spatial and temporal coverage may impose limitations. In contrast, model data, particularly when reinforced with modern approaches such as deep learning, provide complete spatial coverage and can forecast future circumstances, but their accuracy is strongly dependent on input data quality and model calibration. The comparison of these two systems illustrates the significance of integrating them to generate credible tidal predictions.

Accuracy of Field Measurements

Field measurements, such as those conducted in the Zhoushan region, provide critical validation data for models. They are essential for evaluating the effectiveness of numerical simulations and deep learning models, which can considerably enhance prediction accuracy when calibrated with field data (R. Zhang *et al.*, 2022).

The accuracy of tidal level estimates improves with larger datasets. For example, 400-day datasets reduced the discrepancy in Highest Astronomical Tide (HAT) estimates to 0.06 m, whereas shorter datasets resulted in larger disparities (Metters, 2022).

Reliability of Model Data

When evaluated using high-resolution field data, numerical models like the General Shoreline Beach (GSb) model have demonstrated great dependability in predicting shoreline evolution (Francone & Simmonds, 2023). Advanced models such as the UBoF, which integrate observed overtides, exhibit enhanced accuracy in forecasting mean dynamic topography in tidally influenced areas, underscoring the significance of precise bathymetry and model parameters (Renkl & Thompson, 2022).

The revised tidal models for Texas and Western Louisiana demonstrate enhanced performance compared to earlier models, with spatially varying uncertainty fields contributing to the reliability of tidal datum predictions (W. Wu *et al.*, 2019). Models give the capacity to forecast and simulate conditions outside the purview of direct observations, whereas field measurements supply the ground truth required for model validation. Combining the two methods can result in more accurate and consistent tidal predictions, especially with improvements in modeling techniques.

- **Hydrodynamics Model Result**

Modeling hydrodynamics in coastal zones or marginal seas is more complex than in global oceans due to the necessity of greater efforts to precisely include the effects of bottom topography and lateral boundaries. These boundaries impose shear stress on water flow and function as impermeable barriers (Umgiesser *et al.*, 2022). The hydrodynamic model is a generic numerical model system that models water surfaces and currents. A hydrodynamic model was developed to simulate 2D flow in a fluid layer that is considered vertically homogeneous (Milasari *et al.*, 2021).

Several significant elements determine the amplitude of wind-driven variations in ocean currents, including vertical eddy viscosity, changes in air circulation, sea ice dynamics, wind wave-induced velocities, and Earth's rotation. These components interact in intricate ways to influence the behavior and strength of ocean currents, which has important consequences for climate and weather patterns. The following are the primary variables influencing these changes:

Vertical Eddy Viscosity

Vertical eddy viscosity is essential in the dynamics of surface ocean currents. It impacts the frictional forces in the water, which subsequently affect the

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intensity and direction of wind-driven currents (Constantin, 2021).

Atmospheric Circulation Changes

Changes in air circulation can accelerate the rate of global surface warming by influencing wind-driven ocean circulation. This amplification was predicted to be roughly 17% between 1979 and 2014, underlining the need of properly anticipating atmospheric changes for climate forecasts (McMonigal *et al.*, 2023).

Sea Ice Dynamics

Sea ice affects the transmission of momentum from wind to oceanic currents. The presence of sea ice reduces the intensity of mixed layer inertial oscillations, whereas the net Ekman transport is not influenced. Seasonal variations in sea ice extent and internal stress significantly influence the inertial response of ocean currents (Brenner *et al.*, 2023).

Wind Wave-Induced Velocities

Wind wave-induced artifact surface velocity (WASV) affects the accuracy of ocean current measurements. Elements including wind velocity, swell height, and radar settings affect WASV, which is essential for enhancing synthetic aperture radar (SAR) current velocity assessments (K. Zhang *et al.*, 2023).

Earth's Rotation

The Coriolis effect, induced by the Earth's rotation, affects ocean current dynamics. The latitude at which wind stress changes sign is very important since it controls whether water columns converge or diverge, altering the stability and oscillatory motion of currents (Paldor & Friedland, 2023).

While these aspects are crucial in understanding wind-driven changes in ocean currents, it is also necessary to evaluate the potential feedback mechanisms between ocean currents and climate systems. Changes in ocean circulation, for example, can influence global warming rates, which in turn affect atmospheric and oceanic conditions, resulting in a complex interplay that necessitates additional research to fully comprehend its global ramifications.

- **Pollutant Distribution Model Results**

The concentration of suspended solids depends on the degree of sedimentation that occurs in the estuary (Qualifa *et al.*, 2016). Suspended solids are sediments that float in water and move without touching the base (Paramitha *et al.*, 2016). The dynamics of water mass flow in coastal seas are affected by numerous physical elements. These factors include wind, currents (tides), and river volumes (Kamat *et al.*, 2014). According to (*Putra et al.*, 2017), several factors influence sea surface currents, comprising the topographical configuration of the seabed and adjacent islands, Coriolis forces and Ekman currents, variations in water pressure, seasonal currents, upwelling and downwelling, and discrepancies in density.

The spatial distribution of Total Suspended Solids (TSS) resulting from industrial activities is significantly influenced by seasonal winds, which vary between the West and East. The influence of these winds on the dispersion patterns of TSS has significant implications for marine ecosystems and local fisheries.

- **Impact of Seasonal Winds on TSS Distribution**

West Season Winds: Generally linked to more robust and regular wind patterns, these winds can facilitate the dispersion of TSS from industrial sources, resulting in a wider distribution across aquatic environments. In Jakarta Bay, reclamation efforts have elevated total suspended solids (TSS) levels, which are then disseminated by prevailing winds, impacting local fisheries (Mukhtar, 2023).

East Season Winds: These winds may result in localized accumulation of TSS, especially in protected regions. The fluctuations in wind speed and direction can generate areas of increased concentration, affecting marine ecosystems and fishing operations (Xiong et al., 2023).

Case Studies and Observations

The presence of suspended solids in water can have several effects. First, high levels of suspended solids can reduce water clarity, making the water appear cloudy. The concentration value of suspended solids in a body of water greatly influences how high the turbidity is. The greater the quantity of suspended particles in the water, the turbidity will also increase automatically (Panjaitan *et al.*, 2014). This can impact aquatic ecosystems by reducing light penetration, affecting photosynthesis and the growth of aquatic plants. It can also hinder the organism's ability to find food or detect predators. Total Suspended Solids (TSS) is a metric used to quantify solid particles suspended in water. It is utilized to quantify the level of contamination in wastewater (Aniyikaiye *et al.*, 2019).

The research indicated that total suspended solids (TSS) levels remained moderate following reclamation; however, wind patterns significantly influenced the distribution of TSS, requiring fishermen to travel further into the sea (Mukhtar, 2023). Chengdu, China: Research indicates that wind speed significantly influences pollutant dispersion, suggesting that similar mechanisms may apply to total suspended solids (TSS), with higher wind speeds facilitating increased diffusion (Xiong *et al.*, 2023).

The influence of seasonal winds on TSS distribution is significant; however, other factors, including topography and industrial practices, must also be considered, as they can complicate dispersion dynamics and affect environmental assessments.

Conclusion

Tidal current patterns, West Monsoon, and East Monsoon winds influence how far the concentration of Suspended Solids from Industry is distributed and diluted. When the tide is high, the current causes the Total Suspended Solids to concentrate around the outfall, while the current at low tide causes the Total Suspended Solids waste to spread away from the outfall. During the West Monsoon, the wind generates higher current speeds than during the East Monsoon so TSS waste is diluted more quickly than during the East Monsoon. In conclusion, tidal current patterns, West Monsoon, and East Monsoon winds influence the distribution and dilution of TSS waste from industry. High tides cause TSS waste to concentrate around the outfall, while low tides cause it to spread away.

References

Abubakar, A. G., M. R. Mahmud, K. K. W. Tang, A. Hussaini, N. H. Md Yusuf. 2019. A review of modelling approaches on tidal analysis and prediction. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences – ISPRS Archives*, 42(4/W16): 23–34. https://doi.org/10.5194/isprs-archives-XLII-4-W16-23-2019

Anisa, M. N., Purwanto, I. B. Prasetyawan. 2017. Studi pola arus laut di perairan Tapaktuan, Aceh Selatan. *Jurnal Oseanografi*, 6(1): 183–192.

Aniyikaiye, T. E., T. Oluseyi, J. O. Odiyo, J. N. Edokpayi. 2019. Physico-chemical analysis of wastewater discharge from selected paint industries in Lagos, Nigeria. *International Journal of Environmental Research and Public Health*, 16(7). https://doi.org/10.3390/ijerph16071235

Brenner, S., J. Thomson, L. Rainville, L. Crews, C. M. Lee. 2023. Wind-driven motions of the ocean surface mixed layer in the western Arctic. *Journal of Physical Oceanography*, 53(7): 1787–1804. https://doi.org/10.1175/JPO-D-22-0112.1

Campuzano, F., F. Santos, A. I. R. de Oliveira, L. Simionesei, R. Fernandes, D. Brito, E. Olmedo, A. Turiel, M. Alba, A. Novellino, M. Tonani, H. Lewis, M. G. Sotillo, A. A. Baladrón, T. Dabrowski, B. Jacob, J. Staneva, R. Neves. 2020. Framework for improving land boundary conditions in regional ocean products. *EGU General Assembly*, 17977. https://doi.org/10.5194/EGUSPHERE-EGU2020-17977

Carmo, A. do, J. Simão. 2021. Remarks on the boundary conditions for a Serre-type model extended to intermediate-waters. *Ocean and Coastal Modelling*, 2(4): 626–640. https://doi.org/10.3390/MODELLING2040033

Constantin, A. 2021. Frictional effects in wind-driven ocean currents. *Geophysical and Astrophysical Fluid Dynamics*, 115(1): 1–14. https://doi.org/10.1080/03091929.2020.1748614

Daruwedho, H., B. Sasmito, F. J. A. 2016. Analisis pola arus laut permukaan perairan Indonesia dengan menggunakan satelit altimetri Jason-2 tahun 2010–2014. *Jurnal Geodesi Undip*, 5(2): 147–158.

DHI. 2012. *MIKE 21 & MIKE 3 Flow Model FM ECO Lab Module. Hydrodynamic and Transport Module Scientific Documentation*. https://www.dhigroup.com/upload/dhisoftwarearchive/shortdescriptions/marine/MIKE213_FM_EL_Short_Description.pdf

Fitriana, D., N. Oktaviani, I. U. Khasanah. 2019. Analisa harmonik pasang surut dengan metode Admiralty pada stasiun berjarak kurang dari 50 km. *Jurnal Meteorologi Klimatologi dan Geofisika*, 6(1): 38–48. https://doi.org/10.36754/jmkg.v6i1.113

Francone, A., D. J. Simmonds. 2023. Assessing the reliability of a new one-line model for predicting shoreline evolution with impoundment field experiment data. *Journal of Marine Science and Engineering*, 11(5). https://doi.org/10.3390/jmse11051037

Hendra, S. Widodo, P. Mukhlis, Triaji, Agustinus. 2022. Karakteristik arus musiman di Selat Sunda. *Jurnal Chart Datum*, 8: 117–124.

Hidayat, R. R., I. Harun, E. Eddiyanto, I. Prihatiningsih, A. Farabi. 2023. Characteristics and dispersion model of wastewater PT Kayu Lapis Indonesia, Kendal, Central Java. *Journal of Applied Geospatial Information*, 7(2): 875–882. https://doi.org/10.30871/jagi.v7i2.5841

Hindaryani, I. P., M. Zainuri, B. Rochaddi, S. Y. Wulandari, L. Maslukah, P. Purwanto, A. Rifai. 2020. Pola arus terhadap sebaran konsentrasi nitrat dan fosfat di perairan pantai Mangunharjo, Semarang. *Indonesian Journal of Oceanography*, 2(4): 313–323. https://doi.org/10.14710/ijoce.v2i4.8528

Jahanmard, V., R. Hordoir, N. Delpeche-Ellmann, A. Ellmann. 2023. Quantification of hydrodynamic model sea level bias utilizing deep learning and synergistic integration of data sources. *Ocean Modelling*, 186: 102286. https://doi.org/10.1016/j.ocemod.2023.102286

Kamat, Y. N., P. N. I. Kalangi, M. S. Sompie. 2014. Pola arus permukaan saat surut di sekitar muara Sungai Malalayang, Teluk Manado. *Jurnal Ilmu dan Teknologi Perikanan Tangkap*, 1: 99–104. https://doi.org/10.35800/jitpt.1.0.2014.6177

Kasharjanto, A., D. Rahuna, D. Rina. 2017. Kajian pemanfaatan energi arus laut di Indonesia. *Jurnal Wave*, 11: 75–84.

McMonigal, K., S. Larson, S. Hu, R. Kramer. 2023. Historical changes in wind-driven ocean circulation can accelerate global warming. *Geophysical Research Letters*, 50(2). https://doi.org/10.1029/2023GL102846

Metters, D. R. 2022. Variance in the accuracy of tidal levels with increasing data length. *The International Hydrographic Review*, 27(May): 23–34. https://doi.org/10.58440/ihr-27-a02

Milasari, A., D. H. Ismunarti, E. Indrayanti, F. Muldiyatno, A. Ismanto, A. Rifai. 2021. Model arus permukaan Teluk Lampung pada musim peralihan II dengan pendekatan hidrodinamika. *Buletin Oseanografi Marina*, 10(3): 259–268. https://doi.org/10.14710/buloma.v10i3.38293

Mukhtar, M. K. 2023. Analyzing the impact of Jakarta's reclamation on the distribution of TSS using remote sensing technology. *Jurnal Pendidikan Geografi*, 28(2): 134–144. https://doi.org/10.17977/um017v28i22023p134-144

Paldor, N., L. Friedland. 2023. Wind-driven transport on the rotating spherical Earth. *Physics of Fluids*, 35(5). https://doi.org/10.1063/5.0151488

Panjaitan, R., M. Yusuf, M. Zainuri. 2014. Kajian pola sebaran padatan tersuspensi dan unsur logam berat di Teluk Ujung Batu, Jepara. *Jurnal Oseanografi*, 3: 357–365.

Paramitha, V. K., M. Yusuf, L. Maslukah. 2016. Sebaran muatan padatan tersuspensi di perairan Karangsong, Kabupaten Indramayu. *Jurnal Oseanografi*, 5(2): 293–300.

Pasaribu, F. H., B. Rochaddi, D. N. Sugianto. 2014. Studi pola arus dan sebaran muatan padatan tersuspensi di muara Sungai Lasem, Kabupaten Rembang. *Jurnal Oseanografi*, 3(4): 476–485.

Putra, I. I., A. Sukmono, A. P. Wijaya. 2017. Analisis pola sebaran area upwelling menggunakan parameter suhu permukaan laut, klorofil-a, angin dan arus secara temporal tahun 2003–2016. *Jurnal Geodesi Undip*, 6(4): 157–168.

Qualifa, F., W. Atmodjo, J. Marwoto. 2016. Sebaran material padatan tersuspensi di perairan muara sungai. *Jurnal Oseanografi*, 1(12): 13.

Rahmawitri, H., A. S. Atmadipoera, S. S. Sukoraharjo. 2016. Pola sirkulasi dan variabilitas arus di perairan Selat Sunda. *Jurnal Kelautan*

Nasional, 11(3): 141–150. https://doi.org/10.15578/jkn.v11i3.6115

Renkl, C., K. R. Thompson. 2022. Validation of ocean model predictions of mean dynamic topography in shallow, tidally dominated regions using observations of overtides. *Journal of Geophysical Research: Oceans*, 127(3). https://doi.org/10.1029/2021JC018095

Ryu, G. H., J. S. Ko, M. G. Baek, J. K. Jang. 2018. Analysis for vertical wind shear change at coastal area according to the sea surface temperature. *Journal of the Korean Society of Hazard Mitigation*, 18(2): 505–514. https://doi.org/10.9798/kosham.2018.18.2.505

Sari, Y. N., A. Wirasatriya, K. Kunarso, B. Rochaddi, G. Handoyo. 2020. Variabilitas arus permukaan di perairan Samudra Hindia Selatan Jawa. *Indonesian Journal of Oceanography*, 2(1): 1–7. https://doi.org/10.14710/ijoce.v2i1.6785

Sinha, S., V. K. Shukla, A. Singh. 2022. Hydrodynamics and sediment modelling for a fishery harbour in Konkan Region of Maharashtra, India. *Journal of Water Engineering and Management*, 3(1). https://doi.org/10.47884/jweam.v3i1pp38-53

Soerjawo, P. A., T. I. Maryanto. 2018. Kajian pola arus laut dan distribusi sedimen di perairan pantai Muara Kamal, Jakarta Utara. *Jurnal Rekayasa Hijau*, 1(1): 34–42. https://doi.org/10.26760/jrh.v1i1.1335

Surinati, D., M. R. Marfatah. 2019. Pengaruh faktor hidrodinamika terhadap sebaran limbah air panas di laut. *Oseana*, 44: 26–37.

Taohid, R. A., A. Satriadi, S. Saputro. 2017. Studi pola arus dan sebaran material padatan tersuspensi. *Jurnal Oseanografi*, 6(1): 116–123.

Umgiesser, G., C. Ferrarin, M. Bajo, D. Bellafiore, A. Cucco, F. De Pascalis, M. Ghezzo, W. McKiver, L. Arpaia. 2022. Hydrodynamic modelling in marginal and coastal seas: the case of the Adriatic Sea as a permanent laboratory for numerical approach. *Ocean Modelling*, 179: 102123. https://doi.org/10.1016/j.ocemod.2022.102123

Wisha, U. J., T. Al Tanto, I. Ilham. 2017. Physical and chemical conditions of Bayur Bay waters on the east and west season. *Ilmu Kelautan: Indonesian Journal of Marine Sciences*, 22(1): 15–24. https://doi.org/10.14710/ik.ijms.22.1.15-24

Wu, G., J. Li, W. Luo. 2023. Spatial distribution, source apportionment, and assessment of marine water quality parameters in the Bohai Sea, China. *Marine Pollution Bulletin*, 195: 115526. https://doi.org/10.1016/j.marpolbul.2023.115526

Wu, W., E. Myers, L. Shi, K. Hess, M. Michalski, S. White. 2019. Modeling tidal datums and spatially varying uncertainty in the Texas and western Louisiana coastal waters. *Journal of Marine Science and Engineering*, 7(2): 1–24. https://doi.org/10.3390/jmse7020044

Xiong, J., J. Li, F. Gao, Y. Zhang. 2023. City wind impact on air pollution control for urban planning with different time-scale considerations: a case study in Chengdu, China. *Atmosphere*, 14(7). https://doi.org/10.3390/atmos14071068

Zhang, K., X. Wang, H. Wu, X. Zhang, Y. Fang, L. Zhang, H. Wang. 2023. Study of the performance of deep learning methods used to predict tidal current movement. *Journal of Marine Science and Engineering*, 11(1). https://doi.org/10.3390/jmse11010026

Zhang, R., J. Zhang, X. Zhang, C. Cao, X. Wang, G. Gao, G. Liu, M. Bao. 2022. Influence of radar parameters and sea state on wind wave-induced velocity in C-band ATI SAR ocean surface currents. *Remote Sensing*, 14(17). https://doi.org/10.3390/rs14174135

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