Rip Current

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The Utilization of Hydrodynamics Models in Validating the East Java Rip Current in the Era of Industrial Revolution 4.0

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Abstract. The earth has an ocean area larger than the land area so that there are many beaches found throughout the world, including Indonesia. Behind its beauty, there is one phenomenon that endangers tourists when doing activities on the nearshore area, namely: rip current. For example, the incident at the research location, namely Klayar Beach, East Java, on January 2, 2015, claimed lives. Therefore, this study aims to validate the existence of rip current in East Java, especially at the research location by utilizing hydrodynamic modeling in the era of the industrial revolution 4.0 based on data, internet, and technology as well as human resources during this corona pandemic. There are 3 stages of the methodology in this research, namely data collection and processing, modeling, and modeling validation. The outcomes of this research prove that the phenomenon of rip current with rip current speeds occurs in the range 0.16 - 0.18 m/s which causes 2 tourists to die. It is hoped that the results of this research can be used as input for the stakeholder concerned for the development of coastal tourism in coastal areas on the south coast of East Java in making policies.

Introduction

Geographically, the Earth has a greater ratio of sea area than land area. With such geographical conditions, it is not surprising many beaches around the world, one of which is in Indonesia. Indonesia has a total of 17,504 islands with a sea area of 5.8 million km² with a coastline of 95,161 km, the second-longest in the world [1]. The beach is the border area between the land and the ocean and this area is categorized as a natural tourist spot because it attracts tourists to visit. Behind all the beauty of beach tourism, it turns out that there have been many casualties, especially due to the rip current phenomenon. For example, in Australia, 142 cases of tourists died from being dragged down by rip current [2]. In Indonesia this also often happens, such as the incident on January 2, 2015, 2 tourists died on Klayar Beach, East Java. Rip current itself is backflow from the coast to the sea which is known to have a high speed [3], where rip itself means to tear or pull something quickly, forcibly away from something. Rip current is dangerous because it can 'eliminate' a person's swimming ability when trapped in it [4]. There are still many Indonesian people who are not aware of the rip current. The occurrence of a rip current is caused by high wind speed and duration which propagate high wave, along with of the near shore current as well as longshore current. Due to bathymetry condition, the

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longshore current meet at specific location which trigered current backflow to the sea, known as rip current.

The collection of data in this research is helped by the prevalence of industrial revolution 4.0 technology, including human resources, data, and internet connection. [5]. Other tools and software, such as sonar, 3D delft software, dashboard delft software, windrose software, and others also assisted in data retrieval and processing. The ability to collect real data, reflecting the actual situation in the field, enabled the hydrodynamic models to simulate the rip current phenomenon. This study aims to create a hydrodynamic model whose results are closest to the actual situation on the East Java coast. Researchers intend to be able to predict the occurrence of the rip current so that it can be anticipated before it takes a new toll.

Methodology

1.1. Research Location

As can be seen in Figure 1, the research location is at Klayar Beach (longitude position: East 110°56’52.24” and latitude position: South 8°13’26.27”), Pacitan Regency, East Java. This area is a famous and favorite recreational area where located about 35 km from the capital of Regency along with having carst type of topography.

Figure 1. Research Location

2.2. Data Collection

To perform this modeling required wind data. Wind data is used to be able to analyze wave height taken from March 2010 to March 2020. The wind data grouping is based on the percentage of wind speed and direction recorded by the Meteorology, Climatology, and Geophysics Agency (BMKG). The wind data used were taken from the closest station to the research location, namely the Sleman Geophysical Station with the ID World Meteorological Organization (WMO) 96855 and at latitude 07 ° 49'12 ", longitude 110 ° 18'00". For bathymetry data taken from Gebco for offshore areas and nearshore areas because it is not possible to collect primary data in this pandemic condition.

2.3. Hydrodynamic Model Determination

In this study, the hydrodynamic calculations were carried out at the research location manually along with the hydrodynamic model developments [6,7]. The first modeling is done to calculate numerical manually the wave height using empirical methods Sverdrup Munk and Breitsneider or SMB [8] and Darby Shire method using graphical method. While the calculation of wave height using the hydrodynamic model method using Delft Dashboard software is expected to show several simulation results such as water level, wave height, and current [9–12]

The making of this hydrodynamic model is trial and error to find the closest result to the actual conditions. From several trials and errors that were tested, finally found a model that was close to the situation in the field. By using a 2,200-meter square grid, manning roughness 0.05, time step 60 minutes, wind data, 2 observation points at Klayar, and Benoa Beach. Depth data comes from GEBCO at the position of Universal Transverse Mercator (UTM) 49L which will be simulated from 1-31 March 2020 as can be seen in Figure 2.

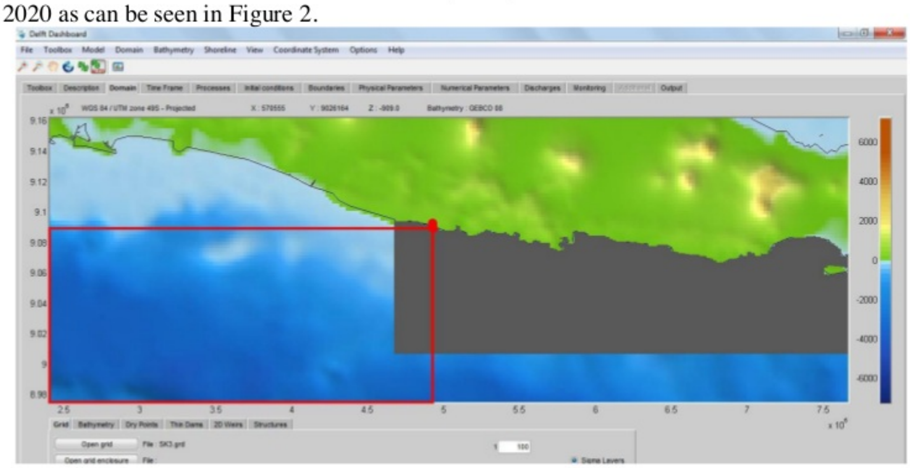

Figure 2. Hydrodynamic Numerical Modeling with Delft Dashboard

RESULTS AND DISCUSSION

3.1. High of Water Level

From Figure 3a, it is found that regarding hydrodynamics model outcomes, the average high water level at the research location (Mean Sea Level) at maximum tide is 1.02 meters and the maximum low tide is -0.9 meters at the Klayar observation point.

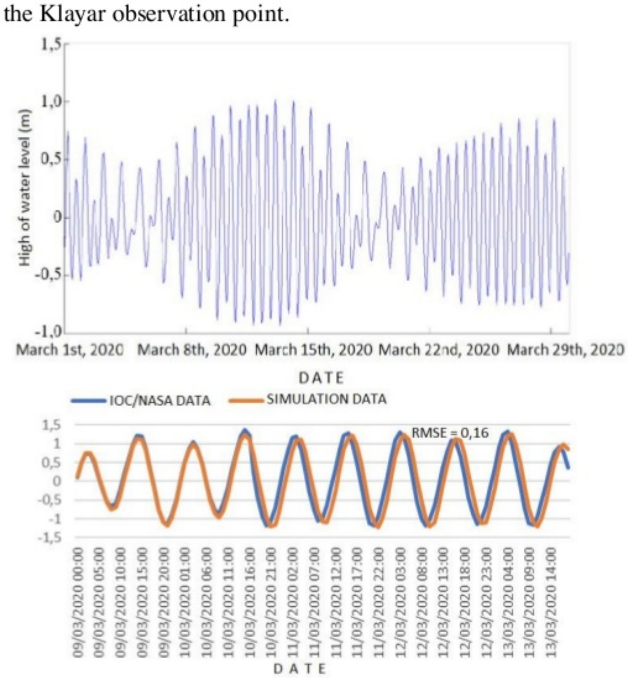

Figure 3. Results of Mean Sea Level and Validation at the Klayar Beach Observation Points

Furthermore, in Figure 3b it can be seen that the simulation results must be tested with validation. Validation for MSL was carried out at the nearest Klayar observation point by finding the smallest root mean square error (RMSE) simulation results with readings from IOC-sea level monitoring in Klayar. The comparison results get an RMSE value of 0.16 meters, which means that the modeling can be said to be close to the actual situation so that the MSL at Klayar Beach can also be said to be close to the actual situation.

3.2. Wave height

The results of the second hydrodynamic modeling produce wave height which can be seen in Figure 4. The wave height at Klayar Beach shows a range of 3.4 meters. To validate wave height, it can be done in 2 ways, namely the empirical method (Sverdrup Munk and Breitsneider or SMB) and graph reading (Darby Shire). Calculation of wave height using hydrodynamic modeling, empirical methods, or graphic methods or the Darby Shire all show a range of 3.4 meters. From the graphical results of the nomogram or Darby Shire, it shows a wave height of 3.4 meters. Thus, it is proven that the hydrodynamic model simulation using Delft dashboard, graphical and empirical models provides appropriate results.

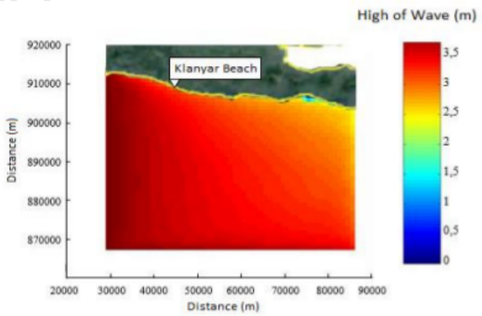

Figure 4. Simulation Results of Wave Height at Klayar Beach (UTM 49L)

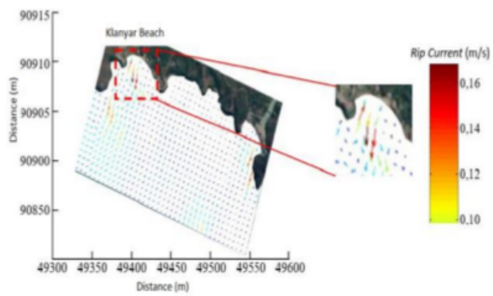

Figure 5. Simulation Results of Wave Height at Klayar Beach (UTM 49L)

3.3. Rip Current

Then, the last outcome due to the hydrodynamic model is to read the rip current speed, it can be done by paying attention to the direction of the arrow returning to the sea and its color. As shown in Figure 5, it can be seen that there is a rip current phenomenon on January 2, 2015, at 3:00 p.m. on Klayar Beach, East Java, which caused 2 tourists to die. From the results of this modeling, it is found that the rip current speed ranges from 0.16 to 0.18 m/s. It is known that the rip current speed can already harm someone if it is in the range of 0.15-0.3 m/s [13]. Thus, this model proves that Hydrodynamics Models can validate the rip current related to this research.

4. Conclusion

According to the results of this study, it can be concluded that hydrodynamic modeling with Delft Dashboard can be used to determine the occurrence of the rip current. This can be proven by the results of the validation which are relatively the same starting from high of water level results with RMSE of 0.16 meters and wave heights ranging from 3.4 meters. From the results of this modeling, it is found that the rip current speed ranges from 0.16 to 0.18 m/s, where it is known that the rip current speed can already harm someone if it is in the range of 0.15-0.3 m/s. These results also prove that natural occurrences in the form of rip current occurring on Klayar Beach can be proven scientifically. It is hoped that by socialization in focus group discussion these outcomes can be used by parties involved in making policies for the development of coastal tourism in the southern region of the sea of East Java. Due to the outcomes of the research still use a coarse resolution grid, thus producing better results of the hydrodynamic model in future research, it is needs a powerful computer/server due to computing and analyzing data.

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