

## Hydrodynamic modeling of ocean currents case study of Popoh waters, Tulungagung

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### Abstract

Tides are the factors that affect the distribution of currents in sea waters. Current modeling is carried out in each season using software to identify the distribution of currents in the Popoh waters of Tulungagung Regency. In the Popoh waters area, it is expected to improve development using an analysis method based on a hydrodynamic current modeling. The modeling process is founded on Finite Element Method. The type of tides in the Popoh waters of Tulungagung Regency is obtained the same type in each season. For example, the type of tides in the Popoh waters is a mixed tidal type that tends to be double daily. Current modeling obtained in the transition season II and the west season obtained current velocity values which at the highest tide were 0.012-0.016 m/s and 0.00-0.004 m/s, respectively, while at the lowest ebb the values were 0.050-0.075 m/s and 0.025 m/s. The results of the two seasons showed that higher current speeds were found during the transition season II. The distribution of currents in the waters of Popoh, Tulungagung Regency was obtained based on the season, namely: in the transition season II, the currents move from the southeast to the northwest and from the west to the mainland, and during low tide the currents will predominantly move away from the mainland. Hydrodynamic modeling of currents in the waters of Popoh, Tulungagung Regency was made using tidal data for each season. Hydrodynamic modeling of currents was performed with pre-processing, processing and post-processing stages. The distribution pattern of currents in the waters of Popoh, Tulungagung Regency moves from the southeast, west and south to the north and northwest.

**Keywords:** Modeling; Tides; Hydrodynamics; Currents.

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## 1. Introduction

Indonesia is a country consisting of many islands and has a vast expanse of water. The water area that is wider than the land area of Indonesia is called a maritime country. The number of islands in Indonesia is approximately 13,466. Indonesia is a country that has the longest coastline in the world. It is geographically located between two continents and two oceans, namely the Asian continent and the Australian continent, the Pacific Ocean and the Indian Ocean. It is located on the equator and has a tropical climate, and have a lot of natural abundance and various species of plants and animals. Indonesian sea waters hold a lot of beauty and various species of marine animals and other marine organisms (Harris *et al.*, 2019).

Ocean currents are the movement of water masses that occur vertically or horizontally due to factors that affect the distribution of currents. The factors that most affect currents are tides and wind. Ocean currents play an important role in the distribution process of marine components in the form of fine and coarse components. Current distribution can affect all marine components, one of which is the distribution of fish and biological components in marine areas. Information related to currents in marine waters in all development activities to research located in marine waters. Current speed depends on the strength of the current generating factors in the form of wind and tides (Klemas, 2012).

Current modeling is an activity in providing information and descriptions at the research location without having to visit the research location. Current modeling provides information related to the direction of current movement and current speed. Current modeling is carried out using several oceanographic components in the form of coastlines, bathymetry, tides and wind. The driving factors of the current in modeling use tidal data or wind data. Current modeling can be used in various studies located in marine areas. Current modeling is useful in the development process to sea shipping lanes. Current modeling can be done using numerical modeling or physical modeling using oceanographic data (Hiwari and Subiyanto, 2020).

Popoh is one of the marine areas in Tulungagung which is included in the southern waters of Java. Popoh waters are a tourist area in Tulungagung Regency. The Popoh tourist area offers natural scenery that directly faces the open sea south of Java, the Indian Ocean. The Popoh area has its own appeal because it has many facilities in the form of recreational areas to shipping areas (Hadiputra *et al.*, 2017). In addition to tourist attractions, the Popoh waters of Tulungagung Regency also have a fishing catch that provides various fishery catches. The people around Popoh work as fishermen and sellers. The Popoh area of Tulungagung Regency provides tourism that can support the economy of coastal communities. The Popoh Tulungagung waters have water conditions that are influenced by the waters of the Indian Ocean (Suprajitno, 2021). The research was conducted with the aim of modeling the hydrodynamics of currents in the Popoh sea waters and analyzing the results of hydrodynamic modeling of currents in transitional season II and the west season, so that it can provide benefits in the form of information related to hydrodynamics of currents in the Popoh waters in transitional season II and the west season and provide

750 Hydrodynamic modeling of ocean currents case study of Popoh waters, Tulungagung information related to currents for the development and construction of the Popoh waters area.

## 2. Materials and methods

### 2.1. Ocean Current Modeling

Ocean currents are the movement of water masses that occur due to driving factors. Ocean currents are driven by several factors, namely wind, tides, pressure gradients and density. Analysis and research related to ocean currents are useful in the process of coastal development to oceanographic research. Currents in ocean waters can affect the movement of water components. Ocean currents can be measured directly using a tool called ADCP (Acoustic Doppler Current Profiler) and can be measured using current generating factor data by using mathematics method (Tanto *et al.*, 2017).

Ocean currents are a mass movement of water that flows due to factors that affect the current. Ocean currents are one of the dynamics that exist in sea waters. Ocean currents are influenced by wind, tides, density, pressure, upwelling and downwelling. Research related to currents generally examines current speed and current direction. Current movements can be analyzed using mathematical calculations or analyzed using software. Analysis related to ocean currents will produce forms in the form of current movement direction and current speed (Irawan *et al.*, 2018). Numerical modeling is one type of modeling. Numerical modeling is a useful method for observing ocean dynamics processes through equations and mathematical calculations. Mathematical modeling can be done in many analyzes. The analysis that can be done in numerical modeling is tidal analysis, currents, waves, sedimentation to hydrodynamics in sea waters (Diputra *et al.*, 2018).

### 2.2. Research Methods

Research related to current hydrodynamic modeling was conducted in the Popoh waters area of Tulungagung Regency. Research related to current modeling was conducted from September 2019 to February 2020. Current hydrodynamic modeling research in Popoh waters used secondary data. Current hydrodynamic research used a numerical method using Finite Element Method by software with modeling stages in the form of Pre-Processing, Processing and Post-Processing (Suharyo and Adrianto, 2018). The materials used in current modeling were tidal data, bathymetry and coastline. Modeling materials can be accessed for free through several sites, bathymetry data is provided by BATNAS (National Bathymetry) which can be accessed through the site <http://tides.big.go.id/DEMNAS/index.html>. Tide data uses data sourced from BIG (Geospatial Information Agency). Tide data from BIG can be downloaded freely on the site <http://tides.big.go.id/>. Coastline data can use Google Earth or nautical maps. The tools used in this study use computers, Microsoft Excel 2013, and Finite Element Method -based software.

The research method used in the hydrodynamic modeling of ocean currents is a quantitative research method. The results of the current model are analyzed using descriptive analysis

by describing, displaying and providing an overview of the hydrodynamic model of the current in the waters of Popoh Tulungagung. Descriptive analysis is used to analyze the results of the model in each season. The data used in the modeling uses secondary data obtained from open sources datasets. Current modeling is achieved using tidal data for two seasons, namely the transition season I and the west season or during September 2019 to February 2020.

The hydrodynamic model built in this study uses bathymetry data, coastline data, and observation data and predictions of sea tides. Modeling is carried out by collecting data in the form of tidal data, coastlines and bathymetry from several sources that provide the data. The first data processing is to process the tidal data into a time series form. Tidal data is separated each season during the research. The next processing is to create a modeling domain, the modeling domain uses coastline and bathymetry data which are used to become a grid as a modeling domain. The next modeling step is model setup, model setup is done by entering each data and modeling time. The last step is to analyze the modeling results related to the direction and speed of the current. The research method related to current modeling is stated in the diagram which can be seen in Figure 1.

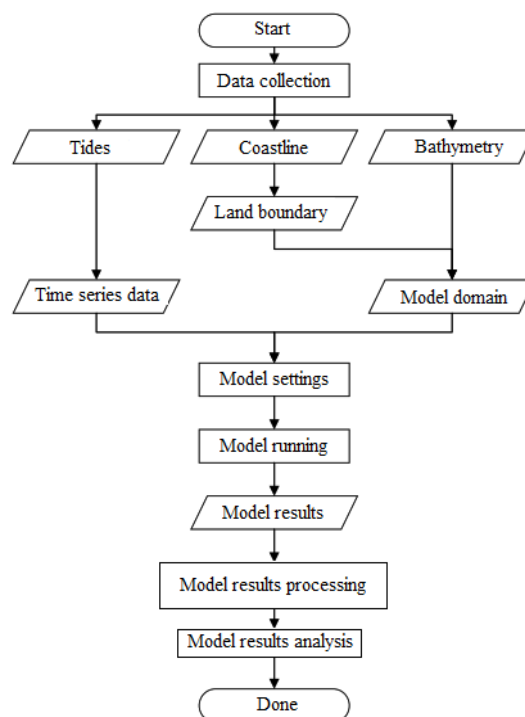


Figure 1. Modeling methods

### 3. Results and Discussion

#### 3.1. Tides (Transitional Season II)

Transitional Season II occurs in September to November 2019. The results of tidal data processing obtained the highest tidal values at locations 1, 2 and 3 have the same tides with a tidal height of 3.957 meters which occurred on October 30, 2019 at 15.00 WIB (Figure

2). The lowest tidal value was obtained at 1.342 meters which occurred on October 29, 2019 at 21.00 Western Indonesian Time (WIB).

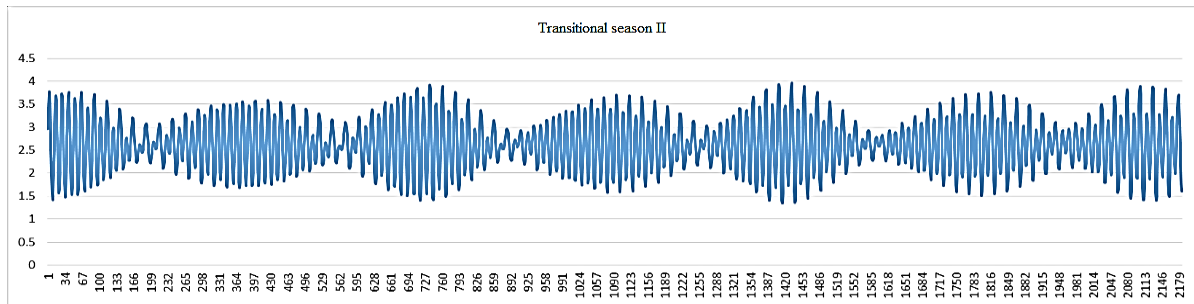


Figure 2. Tides in transitional season II

### 3.2. West season

The West Season occurs from December 2019 to February 2020. The results of tidal data processing obtained the highest tidal values at locations 1, 2 and 3 have the same tides with a tidal height of 3.937 meters which occurred on February 11, 2020 at 15.00 WIB. The lowest tidal value was obtained at 1.483 meters which occurred on December 13, 2019 at 21.00 WIB (Figure 3).

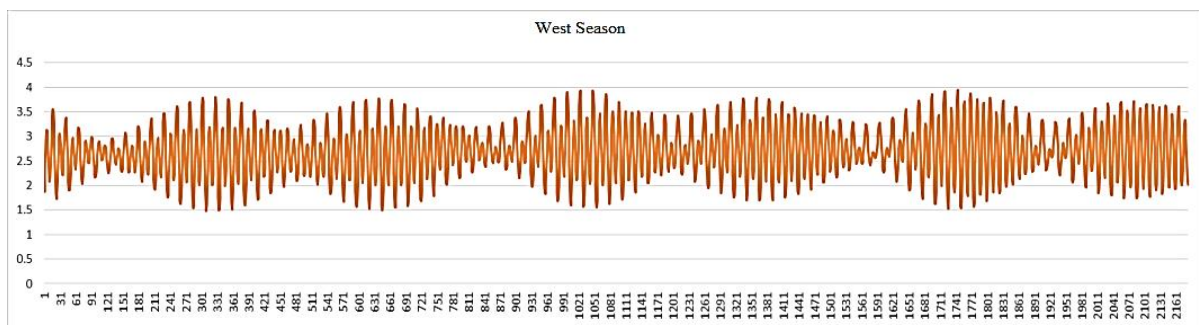


Figure 3. Tides in west season

The tides in Popoh waters show a mixed tidal type that is more dominant daily double. The mixed tidal type that is more dominant daily double occurs 2 times in 1 day with each different tidal height.

### 3.3. Current Results

#### 3.3.1 Transition Season II

Transition season II is the transition season from the west season to the east season. Transition season I generally occurs in September, October, and November. Current modeling was carried out from September 2019 to November 2019 with a time step of 2184. As seen in Figure 4 and Figure 5, the current in the west season at the highest tidal conditions has a dominant current speed of 0.00-0.004 m/s and 0.012-0.016 m/s in the open sea area while in the near-shore area it is dominated by a current speed of 0.016-0.020 m/s. The current in transition season II at the lowest tidal conditions has a dominant current speed of 0.050-0.075 m/s and the area near the Popoh coast has a current speed of 0.075-

0.100 m/s. The current speed in the waters near the Popoh coast has a relatively high current compared to the open sea area. The direction of the current comes from the southeast to the northwest and from the west to the north. The current in the Popoh waters is influenced by the height of the tide, when the sea level rises the dominant current is towards the northwest or towards the mainland and when the tide recedes the current is dominant away from the mainland.

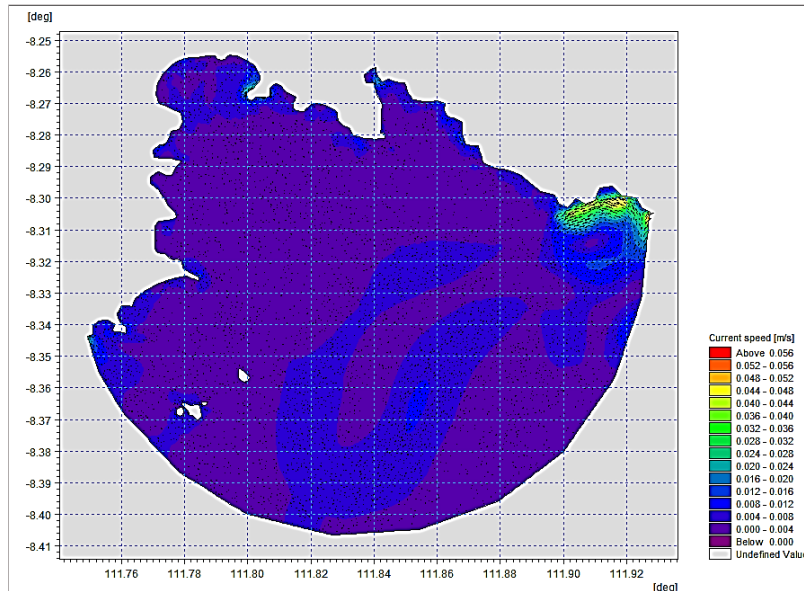


Figure 4. Highest tide flow transition season II

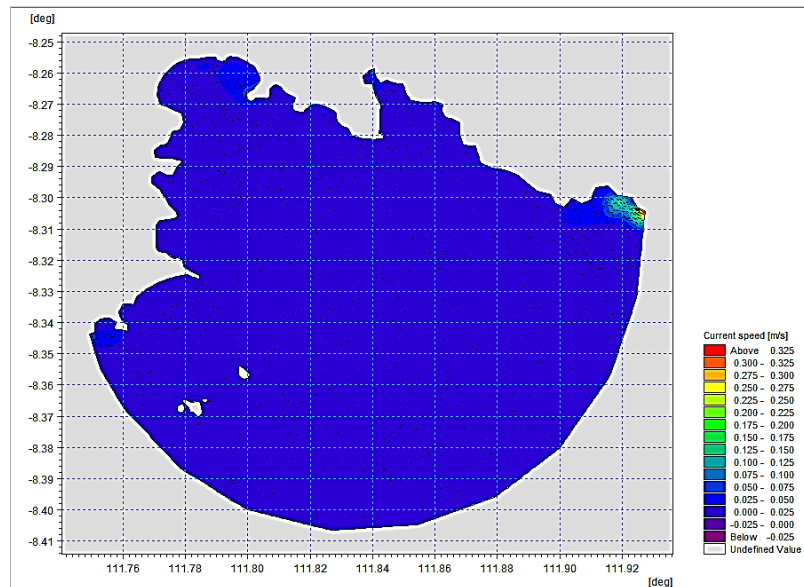


Figure 5. Lowest ebb flow transition season II

### 3.3.2 West Season

The west season generally occurs in December, January, and February. Current modeling was carried out from December 2019 to February 2020 with a time step of 2183. The Figure 6 and Figure 7 show that current in the west season at the highest tidal conditions has a dominant current speed of 0.00-0.004 m/s in the open sea area while in the near-shore area

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it is dominated by a current speed of 0.016-0.020 m/s. The current in the west season at the lowest tidal conditions has a dominant current speed of  $>0.025$  m/s. The current speed in the waters near the Popoh coast has a relatively high current compared to the open sea area. The direction of the current comes from the south to the north. The current in the Popoh waters is influenced by the height of the tide, when the sea level rises the dominant current is towards the north or towards the mainland and when the current recedes it will be dominant away from the mainland or towards the south.

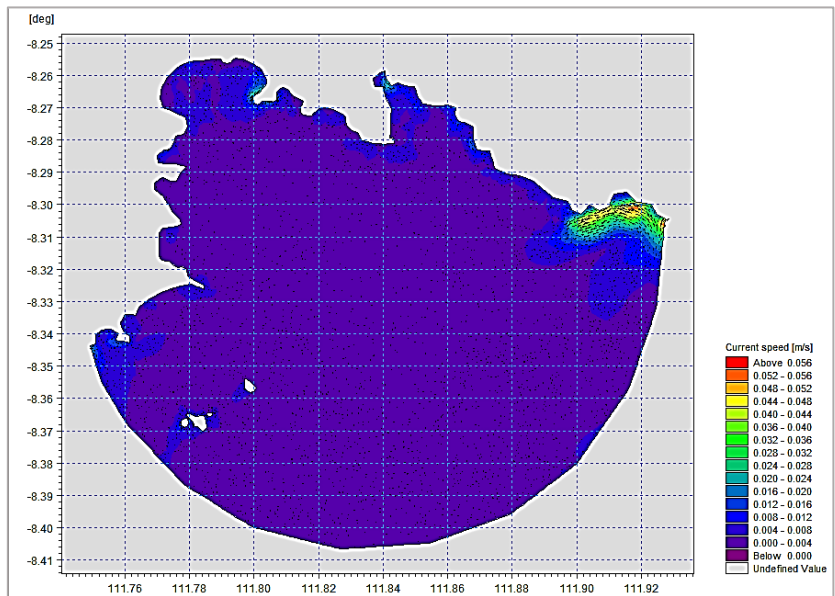


Figure 6. Highest tide flow in west season

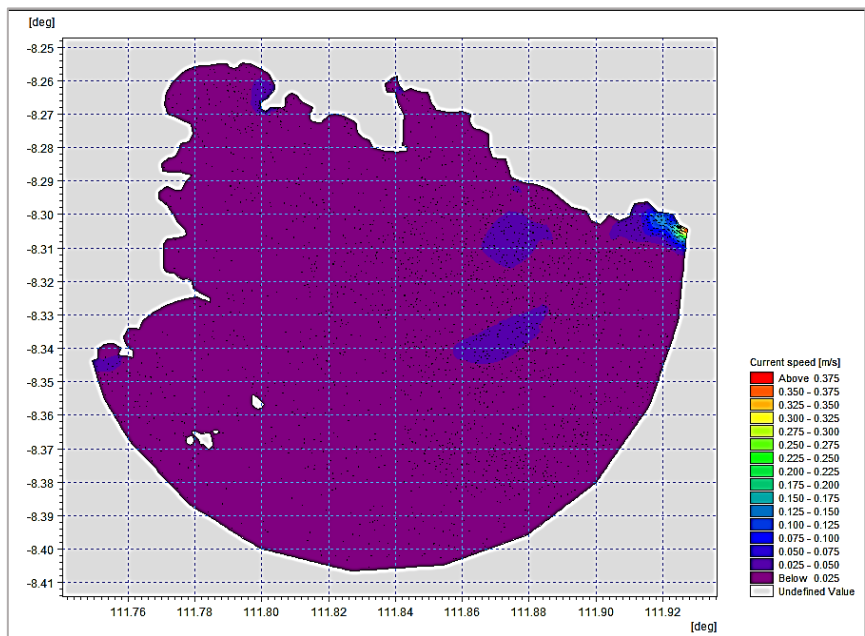


Figure 7. Lowest ebb current of west season

The current in the waters of Popoh Tulungagung has a current direction that at high tide tends to move towards land and at low tide tends to move towards the open sea or away from land. These results are in accordance with research according to Pratomo and

Widiastuti (2017), where the current at high tide will move towards the coast and at low tide will tend to move away from the coast. The current in the waters of Popoh comes from the south, southeast and west which moves towards the north and northwest.

## Conclusion

Hydrodynamic modeling of currents in the waters of Popoh, Tulungagung Regency was carried out using FEM-based software using tidal data for each season. Hydrodynamic modeling of currents was carried out with the stages of Pre-Processing, Processing and PostProcessing. The current modeling obtained in the transition season II and the west season obtained current velocity values which at the highest tide were 0.012-0.016 m/s and 0.000-0.004 m/s, respectively, while at the lowest ebb the values were 0.050-0.075 m/s and >0.025 m/s. The results of the two seasons showed that higher current velocities were found during the transition season II. The distribution pattern of currents in the waters of Popoh, Tulungagung Regency moved from the southeast, west and south towards the north and northwest.

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