Coastline Dynamic in Belitung Timur: A Hydrodynamic and Sediment Transport Model Approach

Hariyadi[1], Pratomo Danar Guruh[2], Handoko Eko Yuli[2], Froditus Nicolody Ofirla Eflal[2], Wirasatrya Anindya[1], Yusuf Muh[1] and Hutabarat Johanes[1]

[1]*Department of Ocean Engineering, Faculty of Fisheries and Marine Sciences, University of Diponegoro, 50275, Semarang, Indonesia*

[2]*Geomatics Engineering, Institut Teknologi Sepuluh Nopember, 60111, Surabaya, Indonesia*

Keywords: The Coastline Dynamic, Belitung Timur, Hydrodynamic, Sediment Transport.

Abstract: This research developed a three-dimensional hydrodynamic model to simulate the flow and sediment transport pattern in Belitung Timur coastal area. The hydrodynamic model was formed by sea level variations and river discharges to generate the simulation of the flow pattern in the research area. Based on this simulation, a sediment distribution pattern was modelled to understand the accretion and erosion processes in the research area. The sediment transport model implemented non-cohesive and cohesive sediment classes. The advection-diffusion algorithm was utilized to get the picture of suspended-sediment transport pattern in water column. Flux formulations were implemented to understand the erosion and deposition of the sediment. The maximum current magnitude is 0.3 ms-1 which occurs during spring tide period. The sediment transport rate is 18 x 10-4 m2s-1 with alteration of the depth is approximately 0.2m up to 0.6m. The sedimentation processes in the area could modify the coastline morphology and ultimately will affect the boundary definition in this area.

1 INTRODUCTION

The coastline is an area with unique ecosystems which is interconnected with the beach. A coastal area is a very dynamic area as well as its coastline (Mukhtar, et.al, 2018). The coastal area in Belitung Timur regency is active as many activities located in this area. The regency contributes great revenue to the state from the mining sector especially minerals. Belitung Timur has a potential of a unique natural resources especially sand, kaolin, quartz, and lead mining activities (Natasia, et.al, 2016). These mining activities, apparently, cause various effects on the environment such as changes in the coastline.

In addition to mining activities, changes of coastline also caused by the abrasion in the coastal area because of the dynamics of the ocean. Here, the hydrodynamics modelling was used to monitor the alteration of the coastline in Belitung Timur. In this research, a hydrodynamic model was utilized to analyze changes in coastline due to the dynamics of the ocean. The research attempted to investigate the variations of the shoreline dynamic in Belitung Timur due to mining activity based on the sediment distribution pattern.

2 IMPLEMENTATION OF RESEARCH

2.1 Research Area and Data

The location of this research is on the eastern coastal area of Belitung Timur, Bangka Belitung province. The geographical location of the area is 2˚20’00” S and 108˚00’00” E to 3˚20’00” S and 108˚40’00” E, which is shown in Fig 1.

The main spatial data used in this research was derived from Belitung Timur Chart with 1:200,000 in scale provided by Pushidrosal (2001). The hydro-oceanographic data used in the research are bathymetry data, tidal, river discharge, and wind of Belitung Timur. In addition to these data, cohesive and non-cohesive sediment samples are also used to generate the model which sand is the dominant sediment type in the area.

Hariyadi, ., Guruh, P., Yuli, H., Eflal, F., Anindya, W., Muh, Y. and Johanes, H.
Coastline Dynamic in Belitung Timur: A Hydrodynamic and Sediment Transport Model Approach.
DOI: 10.5220/0008848601950199
In *Proceedings of the 6th International Seminar on Ocean and Coastal Engineering, Environmental and Natural Disaster Management (ISOCEEN 2018)*, pages 195-199
ISBN: 978-989-758-455-8

The research utilized Delft3D as a hydrodynamic modelling software, ArcGIS 10.3 to perform the on-screen digitation process, Matlab R2014a to support the data processing, and file format conversion software.

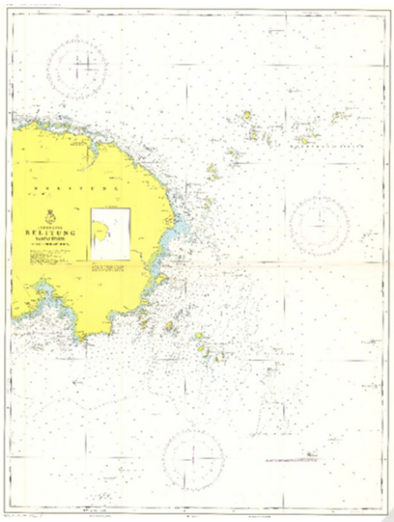


Figure 1: Belitung Timur Chart (Pushidrosal).

2.2 Methods

The early stages of the data processing in this research is rectification and on-screen digitation of the Belitung Timur chart using ArcGIS. This is performed to produce coastlines in a shapefile (*.shp) format. The next stage is building a mesh. The process was accomplished by using RGFGRID module. The grid used in the research is a structured grid type, with rectangular shape model.

The mesh is created by merging the grid and depths data using QUICKIN module. The interpolation used a triangular irregular network method. The main parameter of flow generators is from the water level variation. The open boundaries condition in this research is generated by water level. The simulation model was run for 29 days from November 26 to December 26, 2017 with time frame that is divided into 4.5 days (warming up), 0.5 days (spin up), and 24 days (simulation). In this research used time step 0.5 seconds which considered terms of stability (CFL - Courant Fredrich Lewy).

3 RESULTS AND DISCUSSION

3.1 Domain Model (Mesh)

The research used 500m × 500m grid for representing the modelling area. Fig 2 shows the grid used in the research.

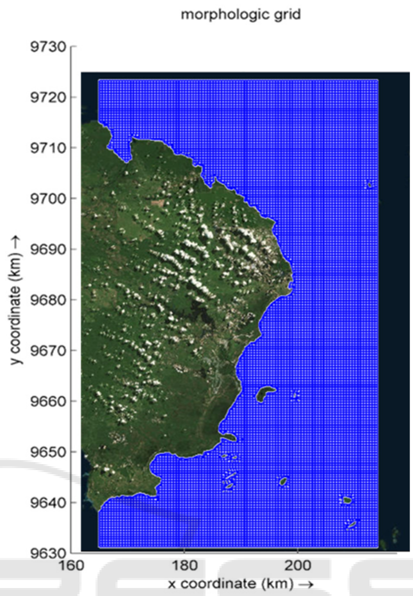


Figure 2: Grids model of the research area.

The result of a depth interpolation process with a triangular interpolation grid method on entire grid models can be seen in Fig 3.

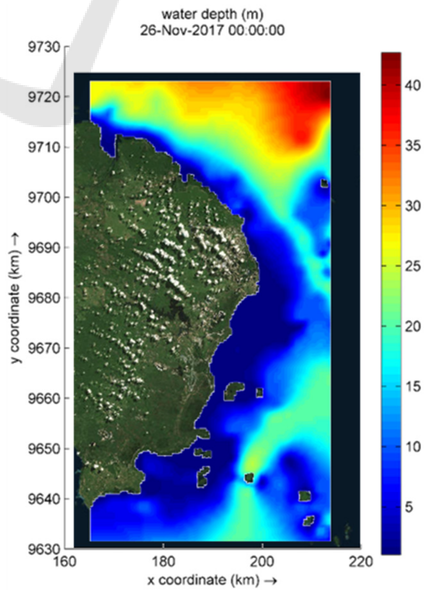


Figure 3: Model Domain.

3.2 Tide

Tide observation is used as an input parameter of the model. The tidal power generator and the flow are the main force for simulating the hydrodynamics condition in the vicinity area. Based on the tidal analysis, Belitung Timur water has mixed semidiurnal dominant tide type.

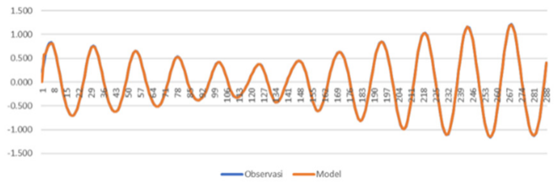


Figure 4: The Comparison Between Tide Observation and Model Data.

Fig 4 shows the comparison diagram of the observation tide and the model data. Data modeling in the time window has a Mean Absolute Error (MAE) of 0.004m This indicates that MAE value obtained is relative small, with error rate belongs to small classification (Wilmott and Matsuura, 2005).

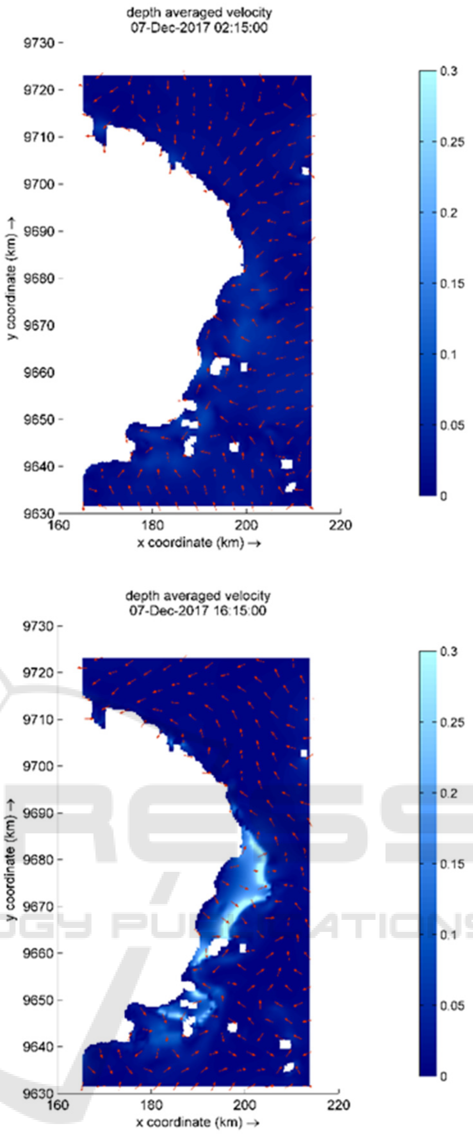
The Formula 1 shows the calculation of MAE:

$$MAE = \frac{1}{N} \sum_{i=1}^{n} \left| x_{mod,i} - x_{obs,i} \right| = 0.004\ meters \quad (1)$$

Based on the statistic tests, the results comply the requirement. The next process is building sediment transport model according to the flow model (Khotimah, 2012).

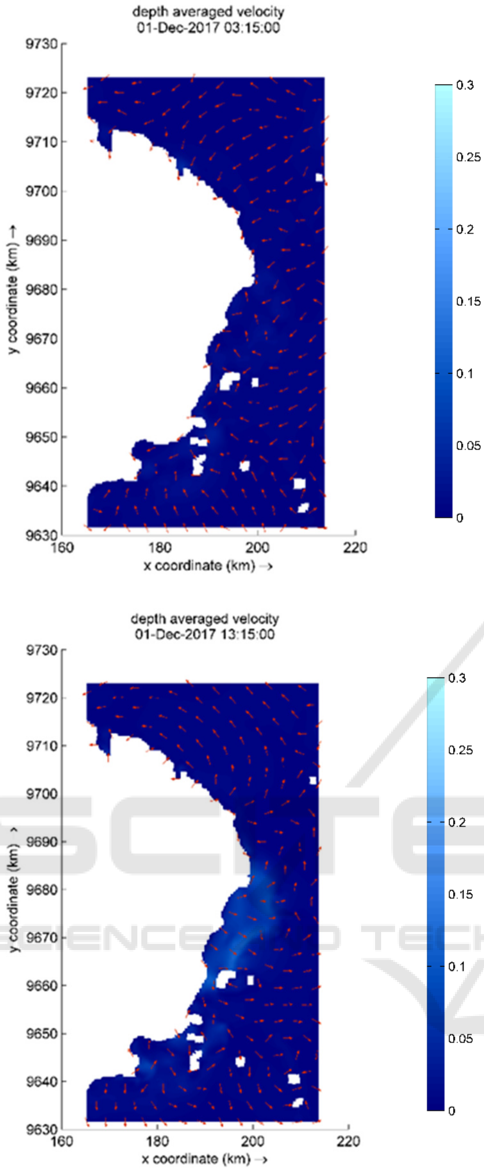
3.3 Hydrodynamic Modelling

Process modelling of hydrodynamics generate the conditions of flow and sediment transport modelling approach of motion dynamics of the sea in Belitung Timur. In this research generated simulation of the flow indicated by Fig 5, as follows:



(a) Spring Tide

Figure 5: Patterns of Flow at (a) Spring Tide Period and (b) Neap Tide Period.



(b) Neap Tide

Figure 5: Patterns of Flow at (a) Spring Tide Period and (b) Neap Tide Period (cont.).

The flow pattern was analyzed in two periods (spring and neap tide periods). During the spring tide (Fig 5a), the depth average velocity is between $0.05ms^{-1}$ to $0.3ms^{-1}$. The largest flow velocity occurs on Selandu Island. The largest velocity of flow also occurs on Selandu Island in the neap tide period. Overall flow during this period between from 0.05ms-1 to 0.2ms-1. The dominant flow direction on both a period is moving from deep sea towards the land on flood conditions. In contrast to the dominant ebb tide conditions leads to Northeast and Southeast. Analysis of sediment distribution pattern in this research based on the condition from magnitude of the mean total transport, shown in Fig 6.

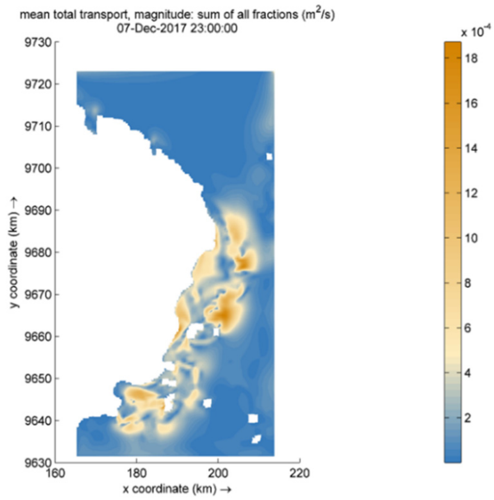


Figure 6: The Mean Total Transport at Belitung Timur.

Fig 6 shows the largest sediment transport conditions occur around at Selandu Island (designated by red box), yet the magnitude of sediment transport is relative still small conditions, between 4x10-4 m2s-1 to 8x10-4 m2s-1.

3.4 The Coastline Changes

In order to show the coastline changes in Belitung Timur, the analysis process was performed by creating the cross-sections of the seabed at the coastal area. The comparison is completed by taking pieces of the transverse cross-section from the beach to the deep sea areas in 3 conditions: initial, middle, and finish from simulation condition. Fig 7 and 8 show the comparison chart of the bed level from some samples of the transverse cross-section in the Belitung Timur.

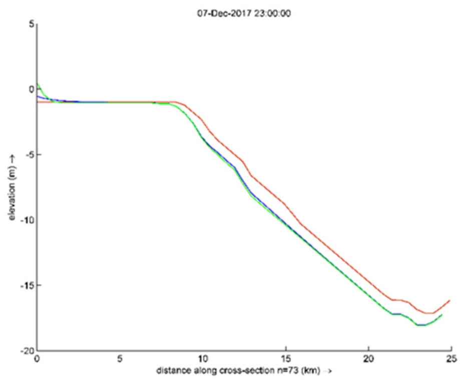


Figure 7: The Cross-Section of North Coastal Area from Linggang's River.

In Fig 7, the erosion occurs in 10.0m to 25.0m of the depth from the coastal area. The depth variation arises in approximately 0.2m to 0.6m deeper than initial conditions. The coastal area was altered; however, the alteration is not significant.

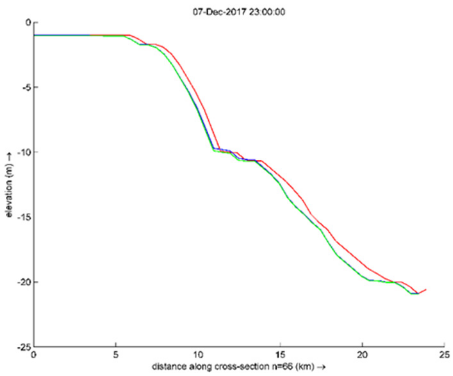


Figure 8: The Cross-Section of South Coastal Area from Linggang's River.

The sample of the transverse cross-section at South of Linggang's River, shown by Fig 8. Notice that the erosion occurred at a distance 5.0m to 10.0m from coastal area. The change of the depth ranges from 0.2m to 0.4m. It is clearly shown that at the distance of 10.0m to 15.0m from the coastal area, the activity of erosion and sedimentation is quite significantly altered from initial condition.

4 CONCLUSION

Based on the results of processing and data analysis, the coastline changes which occurred in the coastal area of Belitung Timur because of abrasion. The magnitude of the changes in the coastline due to abrasion is maximum 0.6m from the initial condition, with simulation period is 1 month. The main factors cause the magnitude of the changes coastline is a small value of grain size sediment on Belitung Timur, thus the mainland easily eroded by ocean waves or current that comes. The mining activities at Belitung Timur also accelerate the change of shoreline.

REFERENCES

C.J. Willmott, K. Matsuura, 205. Adv MAE and RMSE, Clim. Res., 30.

M. K. Mukhtar, T. Hariyanto, C. B. Pribadi, 2018. Evaluasi Perubahan Garis Pantai, POMITS.

M. K. Khotimah, 2012. Validasi Tinggi Gel. Sig., UI.

N. Natasia, M. N Barkah, D. H. Saputra, M. K. Alfadli, 2016. Studi Awal Potensi Bahan Galian Pada Daerah Kabupaten Belitung Timur, BSC 14.