Analysis of Spatial Characteristic of Maritime Weather in Java Sea

Rachmad Andri Atmoko[1], Aulia Siti Aisjah[1], Gunawan Nugroho[1]

Abstract - Sea transportation continuity is mainly affected by the sea weather. The sea voyage may be disturbed by the unpredictable weather pattern. The rate of shipping accident that is caused by the bad weather shows a high percentage. Accordingly, the study of java sea wave characteristic is required. The java sea waters especially in the north side of Java Island, between Surabaya, Semarang Banjarmasin and Makassar is one of the most dense shipping lanes in Indonesia. Several big harbors such as tanjung perak of Surabaya and tanjung emas of Semarang serve high frequency of stevedoring and passenger loading/unloading. In previous researches, the sea weather predictor of java sea waters is still temporal. In this research, numerical modeling of SWAN is used to models the sea wave propagation direction and significant height of the wave in java sea waters. This model uses the concept of spectral energy balance to describe physical interaction that happened in the sea. Two scenarios are applicated in this simulation. in the first scenario, the input of wind speeds are given from 4 direction (west, north, east and south), while in the second scenario, the wind speeds are given according to the character of seasonal winds of the research object area.

INTRODUCTION

The efficiency of marine transportation especially for cruise shipping is affected by maritime weather. The irregular pattern of weather holds a certain possibility to trouble the shipping efficiency. Some of the causes triggering shipping accident are human error as much as 41%, force majeure 38%, and hull structure 21% (MTI, Volume 2, 1-2-3 Langkah, 2007). Java Sea Water especially which spreads in the northern region of Java Island among Surabaya, Semarang, Banjarmasin and Makassar is a crowded shipping lane. Some of the considerable harbors such as Tanjung Perak in Surabaya and Tanjung Emas in Semarang serve high frequency of loading and unloading of passenger and goods. Based on the statistical data published by The Ministry of Transportation, the flow of shipping call in the operational area of *PT. Pelabuhan Indonesia III* covering the harbors in Central Java, East Java, and South Kalimantan since 2005 is increasing every year and in 2009 it reached out 72,480 units (Ministry of Transportation, 2009). In 2014, the Government launched a program named *Pendulum Nusantara* which aimed to extend the shipping routes making the shipping flow in Java Sea water become more hectic (Setkab-RI, 2012).

This research purposes to ascertain the characteristics of spatial waves in Java Sea using SWAN numerical methods; it is a numerical method of sea wave developed by DELFT University of Technology. This model is the developed model of the previous WAM and Wavewatch III. SWAN Model is proven reliable to model the propagation of sea waves in shallow and enclosed water (Rusu et al., 2012). Some of SWAN applications in the world of research are SWAN was used to evaluate the spatial distribution of sea wave energy in Azores Island, to estimate the energy of sea waves along the Caspian Sea, to evaluate the pattern of wave energy around Madeira Island (Rusu et al., 2008; 2012; 2013). Saket et al (2012) investigated the energy of sea waves along the northern sea of Oman Bay. Kim et al (2011) assess the wave sources between Korea Peninsulas and result in the prediction of wave monthly energy. Iglesias et al (2010) used SIMAR 44 data which is simulated with SWAN model to predict the potential wave energy along Dead Sea and Estaca de Bares in Spain. Akpinar et al (2013) proposed the assessment of wave energy characteristic in Black Sea. The purpose of this assessment is to ascertain the wave energy resources in that certain area. In Indonesia, there are several researches conducted by utilizing SWAN Model. Sujantoko (2009) analyzed the effect of wave refraction toward varied steepness of sea profile in Tegal Harbor. Rojali (2009) utilized SWAN Model to stimulate the propagation of wave in southern sea of Bali. The wave transformations observed are refraction, dissipation, and ruptured waves. The accuracy of SWAN has been tested in several researches conducted. Mai et al (1999) compared the result of SWAN computation to the result of measurement of waverider buoy and compared the computation using MIKE 21 wave model in the northern shore of Frissian, Germany. Based on the comparison mentioned, SWAN model is proven accurate. Silva et al (2002) compared the parameter of waves of SWAN to the result of measurement using ACDP sensor buoy in northern shore water in Portugal. The result shows conformity with tolerable rate of differences. The research problems are:

1. How are the characteristics of the propagation of significant wave height in Java Sea toward the wind with different velocity and different direction of generation?
2. How are the characteristics of direction of wave propagation in Java Sea toward the wind with different velocity and different direction of generation?

This research aims to ascertain the spatial characteristics of wave in Java Sea Water (significant propagating height of wave and wave direction). The significance of this study is to be the consideration in

[1]Rachmad Andri Atmoko, Aulia Siti Aisjah, and Gunawan Nugroho are with Department of Engineering Physics, Faculty of Industrial Technology, Institut Teknologi Sepuluh Nopember, Surabaya. Email: ra.atmoko@ppns.ac.id; auliasa@ep.its.ac.id; gunawan@ep.its.ac.id

managing shipping lanes to increase the safety rate during the shipping..

METHOD

A. SWAN (Simulating Wave Near shore)

SWAN Model is numerical model of wave which is used to estimate the realistic parameter of waves in the sea lines, lakes, and estuary based on the wind force, basic conditions of the water and stream. SWAN is the third generation of the model which is based completely on the spectrum. The explanation of the theory of this model, specifically for its numerical segment, is provided in the writing of Holthuijesen et al (1993) and Ris et al (1994).

SWAN is based on the action energy balance. The rate of action density changes can be explained by the equation of conservation of action spectrum Whitham, 1974; Philips, 1977; Mei, 1983; Hasselman et al., 1973):

$$\frac{\partial}{\partial t}N(\sigma,\theta)+\frac{\partial}{\partial X}c_xN(\sigma,\theta)+\frac{\partial}{\partial y}c_y N(\sigma,\theta)+\frac{\partial}{\partial\sigma}c_\sigma N(\sigma,\theta)+\frac{\partial}{\partial\sigma}c_\theta N(\sigma,\theta)=\frac{S(\sigma,\theta)}{\sigma} \quad (1)$$

$$\frac{S(\sigma,\theta)}{\sigma}=S_{in}(\sigma,\theta)+S_{nl}(\sigma,\theta)+S_{ds}(\sigma,\theta) \quad (2)$$

CONCLUSION

1. Some archipelagos located in Sea Java Water – they are Karimunjawa, Bawean, Masalembu, and Sembilan – trigger the occurrence of wave deflection and cause dissipation of energy spreading along Java Sea Water.
2. Based on the result of the validation between the output of SWAN model and measurement data of wave buoy in four measurement points simulated since one year, the RMSE in point 1, point 2, and point 3, and point 4 is as much as 0.35664, 0.3553, 0.31794, 0.15189.

ACKNOWLEDGEMENTS

The Authors would like to thank all parties helping to succeed this study; Fresh-graduate Scholarship - DIKTI The Ministry of Education , research funding by Beasiswa Pendidikan Indonesia (BPI) - Indonesia Endowment Fund for Education (LPDP). Supporting research funding provided by BMKG Maritim II Perak Surabaya, ECMWF, GEBCO and accommodated software of SWAN version 41.01 by DELFT University of Technology.

REFERENCES

[1] BMKG (2010) .*Studi Karakteristik Gelombang laut di Perairan Selat Sunda*. Jurnal Maritim, Volume 7, 24-27

[2] Rusu E, Onea F. (2013), *Evaluation of the wind and wave energy along the Caspian Sea*, Energy, Vol. 50.

[3] Rusu E, Pilar P, Soares G. (2008), *Evaluation of the wave conditions in Madeira Archipelago with spectral models*, Ocean Eng., Vol. 35.

[4] Rusu L, Soares CG. (2012), *Wave energy fassessments in the Azores Islands*, Renew Energy, Vol. 45.

[5] Rusu E, Soares CG (2012), *Wave energy pattern around the Madeira Islands*. Renew Energy, Vol. 45(1).

[6] Saket A, Etemad-Shahidi (2012), *A. Wave energy potential along the northern coasts of the gulf of Oman, Iran*, Renew Energy, Vol. 40(1).

[7] Kim G, Jeong WM, Lee KS, Jun K, Lee ME (2011), *Offshore and nearshore wave energy assessment around the Korean Peninsula*, Energy Vol. 36(3).