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Comparing Nearshore Wave Parameters in Amurang Bay location using MIKE-21 Spectral Wave Model

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Abstract. Wave parameters as an accurate prediction in ocean environment are important thing for good coastal development. Spectral wind wave model as a tools in MIKE 21 SW based on unstructured mesh is used in this study which the model simulates the growth, decay and transformation of wind generated waves and swell in offshore and coastal areas. The Amurang Bay as the province of North Sulawesi Indonesia was selected as the study area which the geography position around $1^0$12’16.16” N-$124^0$27’04.33” E to $1^0$15’43.80” N-$124^0$32’01.06”E. The bathymetry and tide data used in this research from Indonesian Coastline Environmental map of year 1995 with scale 1:50.000 from BIG (Badan Informasi Geospasial) with a satellite data from Google earth of year 2018 and LANTAMAL Manado, the wind and current data was obtained from BMKG Manado. Time simulations are taken from 25 November to 23 December 2016 as a wet season and 25 Mei to 23 June 2016 as a dry season.The model computed the wave parameters using the forecast wind input. The synoptic map of significant wave height (Hs), wave period, wave direction are obtained from the result of simulation. During the dry and wet season conditions the predicted wave parameters as the result of the simulation with tide and wind show to be higher than with tide and no wind simulation. The average condition of significant wave height is higher in outside of bay than inside of bay.

1.Introduction

The information about sea wave is important to be reviewed in coastal structure development. The significant wave height of direction and magnitude are the information which to be required in coastal structure design. The Amurang Bay is an interesting area for the research to be conducted. Spectral waves (SW) as the tools in MIKE 21 is a Spectral waves modul to be used for the simulation of wave propagation from generated wave location and shoreward. The fully spectral formulation which used in the simulation is based on the wave action conservation equation, as described in Komen et al (1994) and Young (1999) [6], where the directional frequency wave action spectrum is the dependent variable.

Average deep-water significant wave heights in any case generally range from 0.8 – 1.4m with mean periods of 7 – 9 seconds. Extreme events such as cyclones can produce wave heights up to 14m and wave periods up to 18 seconds, described in Strauss, D., Mirferendesk, H. and Tomlinson, R. (2007) [7]. This study aims to compare the performance of the simulation result of wave models MIKE 21 SW combined with MIKE3 Hydrodynamic in Amurang Bay location.

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2.Study Area

The area of study is in Amurang Bay as the province of The North Sulawesi Indonesia with the geography position around $1^0$12'16.16" N-$124^0$27'04.33"E to $1^0$15'43.80" N-$124^0$32'01.06"E (Figure1).

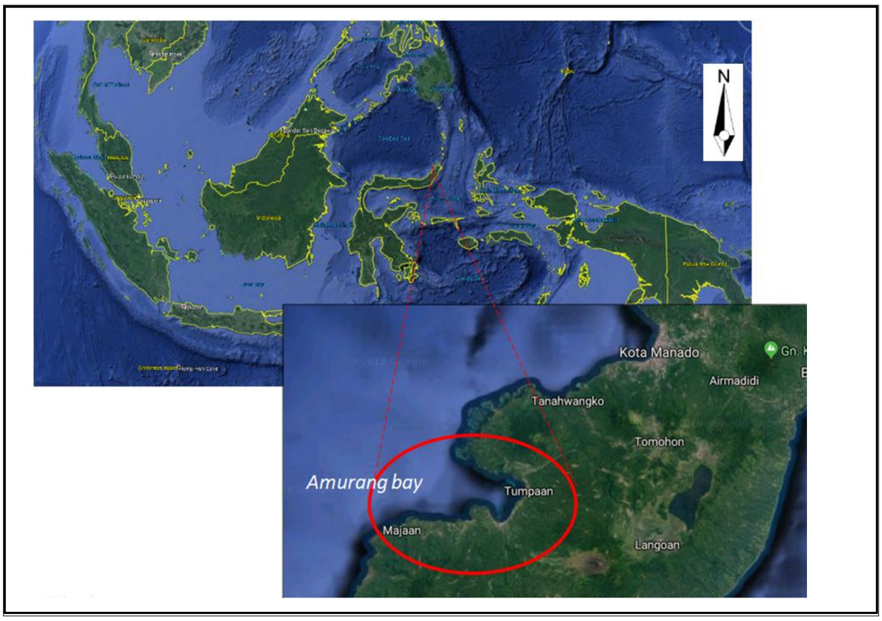

Figure 1: Location of Amurang bay (Source: Google Earth)

3.Research Method

As the computational tools the MIKE3 Flow Model Flexible mesh for Hydrodynamic mode and MIKE21 Spectral wave mode are used. In the model setting, a finite difference grid was developed as the model domain with the size of the triangular mesh option which each element maximum area is 100,000 m^2. The vertical direction z is divided into 10 layers in performance of three dimensions for hydrodynamic. The position of layer 10 is in surface of seawater and layer 1 and layer 2 are close the bottom of sea. The horizontal grid mesh contains 2140 element with 1496 nodes (Figure 2).

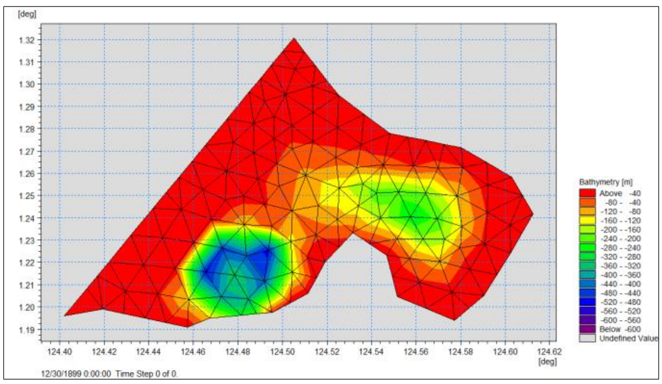

Figure 2. Unstructure Mesh and Bathymetry

4.Calculation Method

The method by finite approximation for hydrodynamic equations used FEM/FVM and MIKE21 Spectral Wave module which use fully spectral formulation. The discretisation of the governing equation in geographical and spectral space is performed using cell-centre finite volume method. In the geographical domain, an unstructured mesh technique is used.

In horizontal Cartesian coordinates, the conservation equation for wave action can be written as,

$$\frac{\partial N}{\partial t} + \nabla.(\bar{v}N) = \frac{S}{\sigma} \tag{1}$$

where : $N(\bar{x}, \sigma, \theta, t)$ is the action density, t is the time, $\bar{x} = (x, y)$is the Cartesian coordinate. $\bar{v} = (c_x, c_y, c_\sigma, c_\theta)$is the propagation velocity of a wave group in the fourdimensional phase space $\bar{x}, \sigma, \theta$. S is the source term for the energy balance equation. ∇ is the four-dimensional differential operator in the $\bar{x}$,σ, θ-space. The left hand side of this equation describes the wave spectral energy propagation in space and time and the term in the right hand side represents source terms including wave generation, energy dissipation due to white-capping, non-linear wave interaction, bottom dissipation due to friction, and depth-induced wave breaking. The characteristic propagation speeds are given by the linear kinematic relationship,

$$(c_x, c_y) = \frac{d_{\bar{x}}}{d_t} = \bar{c}_g + \bar{U} \tag{2}$$

$$c_\sigma = \frac{d_\sigma}{d_t} = \frac{\partial_\sigma}{\partial_d}\left[\frac{\partial_d}{\partial_t} + \bar{U}.\nabla_{\bar{x}} d\right] - c_g \bar{k}.\frac{\partial \bar{U}}{\partial s} \tag{3}$$

$$c_\theta = \frac{d_\theta}{d_t} = -\frac{1}{k}\left[\frac{\partial_\sigma}{\partial_d}\frac{\partial_d}{\partial_m} + \bar{k}.\frac{\partial_{\bar{U}}}{\partial_m}\right] \tag{4}$$

The two wave phase parameters can be the wave number vector $\bar{k}$ with magnitude k and direction θ.Relative angular frequency is σ, and the current velocity vector is $\bar{U}$. The magnitude of the group velocity is c_g, s is the space coordinate, *m* is a coordinate perpendicular to s. $\nabla_{\bar{x}}$ is the two dimensional differential operator in the $\bar{x}$ space [1].

There are some points of interesting for study from A to H spread within Amurang Bay. The geography position respectively, point A 1.24^0 N- 124.45^0 E ; point B 1.24^{0}N-124.53^{0}E ;point C 1.225^{0}N-124.49^{0}E ; point D 1.205^{0}N-124.475^{0}E ; point E 1.24^{0}N-124.6^{0}E ; point F 1.22^{0}N-124.45^{0}E ; point G1.21^{0}N-124.42^{0}E ; point H1.3^{0}N-124.5^{0}E (Figure 3).

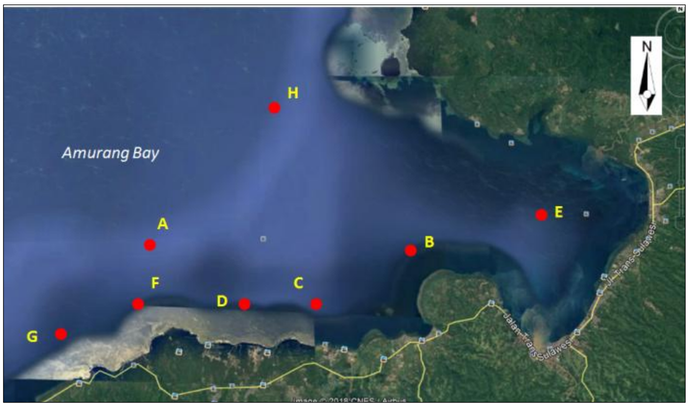

Figure 3: Amurang bay with spread points as the stations of study (Source: Google Earth)

5.Result and discussion

The input data for the numerical model as the hydrodynamic mode are divided by the tide data and wind data and combination by tide and wind data, and bathymetry data. The simulations consist by tide and tide-wind, then comparing the both combination. Comparing the simulation result between tide-wind effect and water level data can be depicted in Figure 4.

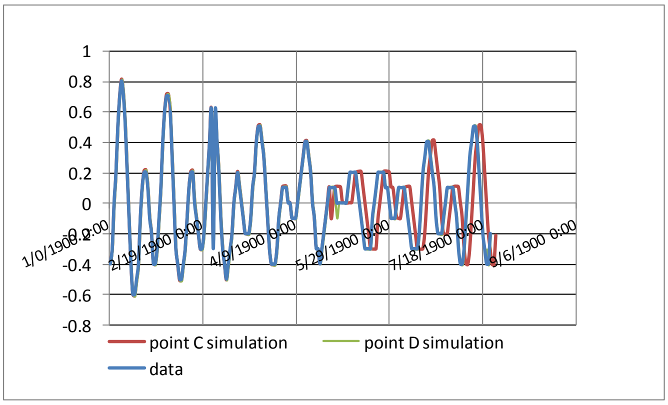

Figure 4: Comparing water level between data and simulation at point C and point D

Comparing simulation result between tide-wind effect and current data in form of current –rose can be depicted in Figure 5 to Figure 8.

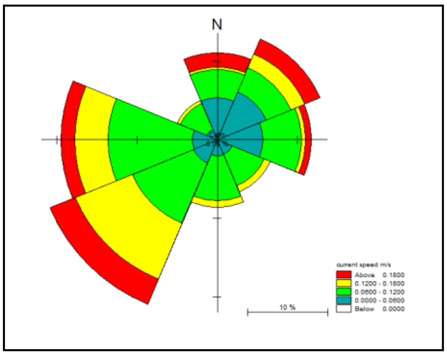

Figure 5: Current rose simulation 25 Nov-14Dec 2016

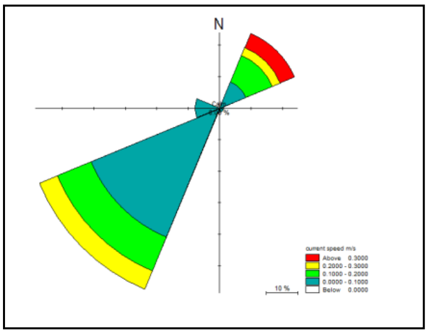

Figure 6: Current rose data 25 Nov-14Dec 2016

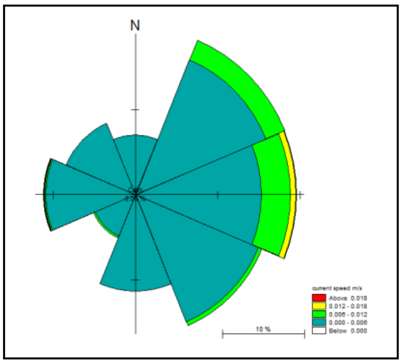

Figure 7: Current rose simulation 25May-23June 2016

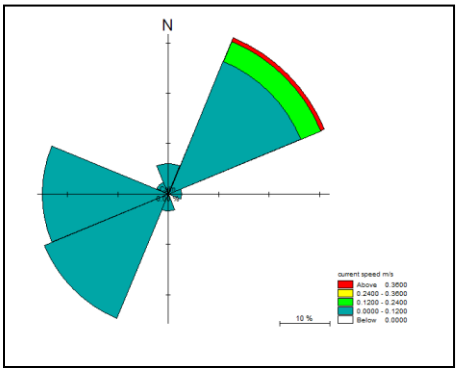

Figure 8: Current rose data 25May-23June 2016

The hydrodynamic computer model has been compared with the data at dry season in range 25Nov-14Dec 2016 and wet season in range 25May-23June2016 of water level and current rose, it can be seen

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in Figure 4 to Figure 8. Comparing the result of water level between simulation in point C and point D with the water level data, it can be seen in Figure 4. The results are comparable with in good results between data and simulation results. A fully spectral approach was used for the computation of the wave parameters. The model computed the wave parameters using the forecast wind input. Synoptic maps of Significant Wave Height (Hs), wave period, wave direction were generated.

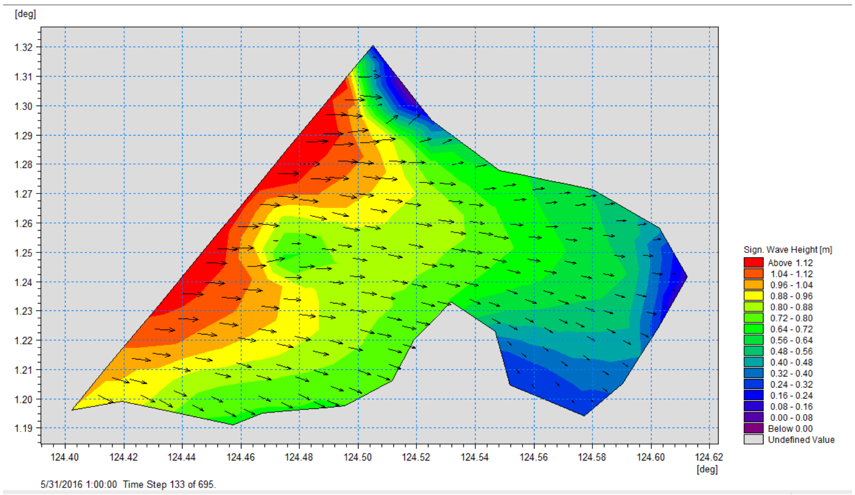

Figure 9. Significant Wave Height distribution(Hs) at May-June period simulated using MIKE21 SW model

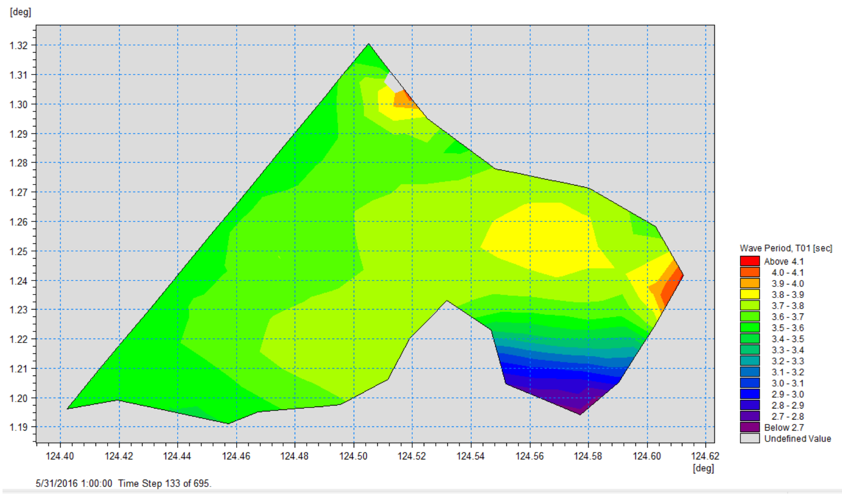

Figure 10. Wave Period distribution (T) at May-June period simulated using MIKE21 SW model

The performance of significant wave height (Hs) and wave period (T) at May-June can be shown in Figure 9 and Figure 10.The magnitude of significant wave height average 0.96 to 1.12m at outside of bay and 0.24 to 0.96m at inside of bay. The wave period average 3.3 to 3.8 sec at outside of bay and about 2.7 to 3.0 sec at inside of bay.

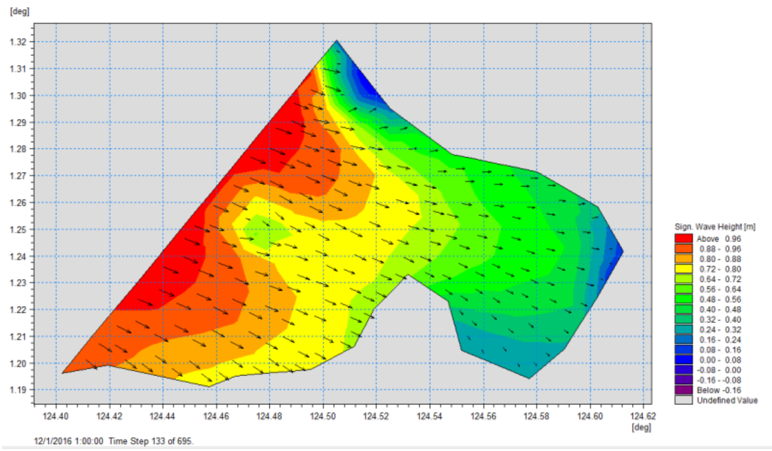

Figure 11. Significant Wave Height distribution(Hs) at Nov-Dec period simulated using MIKE21 SW model

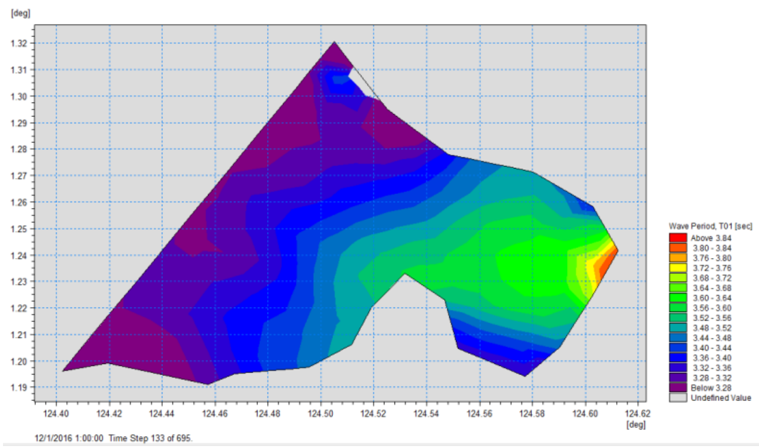

Figure 12. Wave Period distribution(T) at Nov-Dec period simulated using MIKE21 SW model

The performance of significant wave height (Hs) and wave period (T) at Nov-Dec period can be shown in Figure 11 and Figure 12.The magnitude of significant wave height average 0.80 to 0.96m at outside of bay and 0.16 to 0.80m at inside of bay. The wave period average 3.28 to 3.48sec at outside of bay and below 3.28sec at inside of bay. This condition shows that along the shore of bay the wave is lower than seaward.

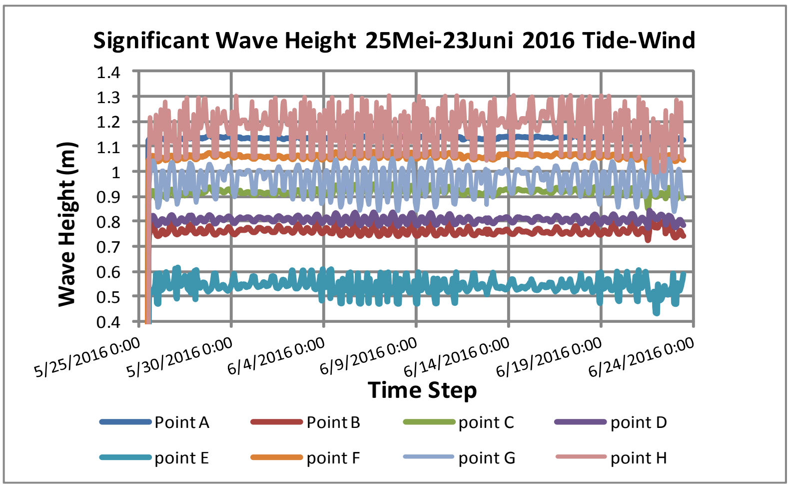

Figure 13. Significant Wave Height comparison at May-June period of point A to H using MIKE21 SW model

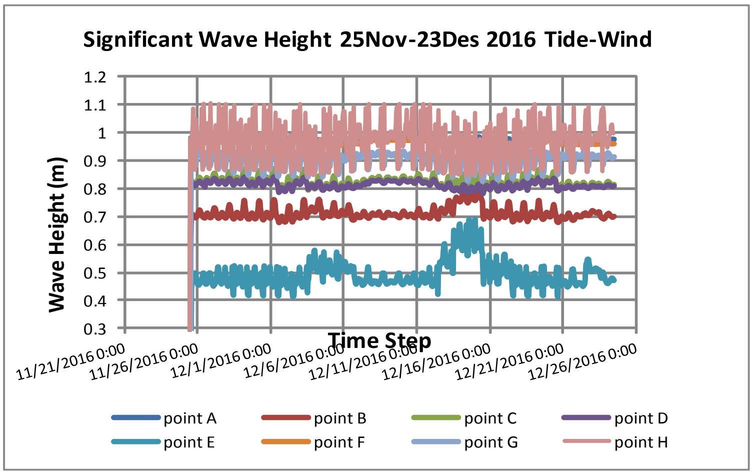

Figure 14. Significant Wave Height comparison at Nov-Dec period of point A to H using MIKE21 SW model

The results of model simulations for significant wave height Hs, peak wave period Tp and direction with corresponding tide-wind and wave parameter input are presented in the Figures 9 to 14.

Wave Period and Significant Wave Height follow the tide pattern which significant wave height at point interest F is more than other point in Amurang Bay location. Peak Wave Period at May-June at point interest D is more than other point, at Nov-Dec period point E is more than other point in location of bay.

As general the significant wave height average 0.8 to 1.12m in close of outside of bay and 0.16 to 0.96m in inside of bay, the wave period average 3.0 to 4.0 sec in close of outside of bay and 2.0 to 3.48 sec in inside of bay.

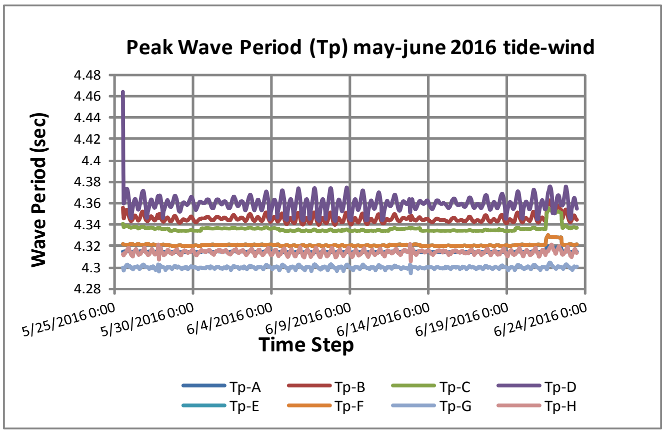

Figure 15. Peak Wave Period at May-June period of point A to H using MIKE21 SW model

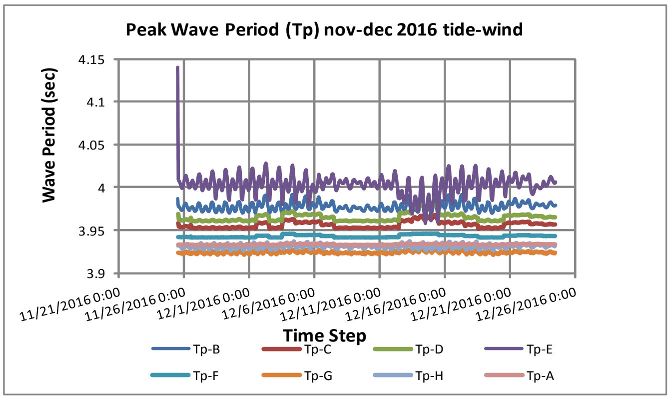

Figure 16. Peak Wave Period at Nov-Dec period of point A to H using MIKE21 SW model

Figure 15 and Figure 16 show the comparison of wave period in point A to H at Nov-Dec and May-June period in year. It shows that point onshore D and E have wave period which is higher than other point in bay. The magnitude of peak wave period is about 3.925 to 4.38 sec in interest point A to H in location of bay.

6.Conclusion

In this study the investigation of wave height potential around Amurang Bay coastal area by using MIKE21 Spectral Wave Modeling. The study was based on data collected covering the period from May-June and November-December 2016. These investigation shows that significant wave height in the near-shore along Amurang Bay is significantly smaller than significant wave height in the offshore area.

Therefore, the findings of this study could be useful for the shoreline protection and coastal zone management activities.

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