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Patterns and Tidal Characteristics of East Coast of Bintan Island, Riau Archipelago Province

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Abstract

This research was conducted considering the important roles of tides data against all oceanographic phenomenon that gives the effects on activities around the area of coastal waters. This research was conducted around the area of the east coast of Bintan Island Riau Archipelago Province in December 2017. Tidal data is retrieved from the global tidal modelling uses MIKE 21. The results of the analysis show the range of tidal height on the east coast of Bintan Island during 2007-2017 is 0.70-3.50 m of height range with the average of mean sea level (MSL) is 2.20-2.60 m.

Generally, tidal fluctuations on the east coast of Bintan Island form an asymmetric pattern which is a common pattern occurring in any waters. The tidal type of the east coast of Bintan Island is mixed predominantly semi-diurnal with the value of formzahl number in each station respectively is 1.19-1.44. The interesting phenomenon obtained from this research is during 2007-2017 the maximum of sea level height in each station tends to decrease, this is considered attractive because over the past 20 years earth surface temperature has tended to increase so that melting of ice in polar has implications for increasing of sea water volume.

Keywords: Tide, harmonics component, oceanography, east coast of Bintan Island

1. Introduction

Tidal is a process of sea level change that is characterized by the movement up and down of the sea surface periodically caused by the influence of tensile forces of celestial bodies, especially the sun and moon, where the influence of tensile forces resulted in the movement of water masses on the surface of the earth (Carter, 1988; Adibrata, 2007).

Sea tidal process on a regular basis is one of the important factors that affect oceanographic processes around the waters widely as sea currents. Tides also have a significant influence on the dynamics of the geomorphology of waters, especially coastal waters, this is caused by tidal phenomenon causing changes that occur regularly at sea surface level along the coast (Suhana, et al., 2016).

Tidal is one parameter of oceanography that has an important role in almost all oceanographic phenomena that occur in the waters (Adibrata, 2007). Some examples of the importance of tidal data are as reference data for correction of field measurement data such as water depth (bathymetry) and water level visibility. In addition, can be a reference for the phenomena of other oceanographic parameters which becomes a parameter in carrying out activities of utilization and management of marine and fishery resources in the coastal area.

Seeing the importance of the role of tidal data on all oceanographic phenomena and giving effect to the activities around the coastal areas as well as the fact that tidal in each waters area have different patterns and characteristics, so it is necessary to do research about tidal patterns and characteristics of the waters which are specifically the waters of the east coast of Bintan Island.

East coast of Bintan Island are densely populated waters, population settlements, tourism areas, conservation areas and fishing grounds are the types of existing utilization in this area. This is also one of the reasons why this research is very necessary to do.

2. Methods

This research was conducted around the area of the east coast of Bintan Island Riau Archipelago

Province in December 2017. Tidal data is retrieved from the global tidal modelling using MIKE 21.

Tidal predictions made at four different locations so that the variability of data obtained more diverse so that it can represent the condition of the tidal of the east coast of Bintan Island as a whole (**Figure 1**). Tidal predictions made during a month (1-31 December) at different time periods during 2007, 2012 and 2017.

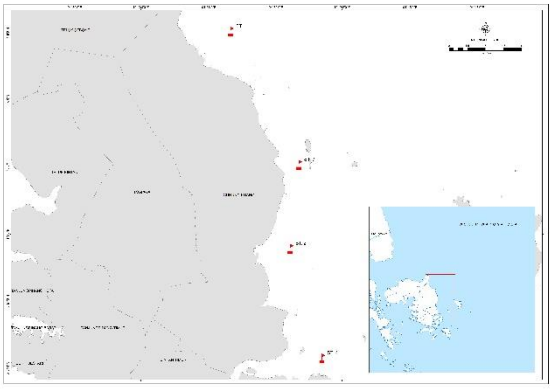

Figure. 1. Research location

Tidal data analysis using IOS method refers to DHI (2012) to acquire tidal harmonic components and tidal residual value. Some equations that are used to answer the research purposes refers to Surbakti (2012), as follows:

Z_0 = S0-(M2+S2+K1+O1)
TR = (MHHWS+MLHWN)/2-(MLLWS+MLLWN)/2
MHHWS = LAT+M2+S2+2(K1+O1)
MHHWN = LAT+M2+S2+2K1
MLLWN = LAT+M2+S2+2O1
MLLWS = LAT+M2+S2
LAT = S0-K1-O1-S2-M2
HAT = LAT+2(K1+O1+S2+M2)

Where:
Z0 = Chart Datum
TR = Tidal Range
MHHWS = Mean Highest High Water Spring
MHHWN = Mean Highest High Water Neap
MLLWN = Mean Lowest Low Water Neap
MLLWS = Mean Lowest Low Water Spring
LAT = Low Astronomical Tide
HAT = High Astronomical Tide

3. Results and Discussion

There are four points of tidal measurement round the east coast of Bintan Island with different depth conditions, namely in the waters of Trikora 4, Trikora 3, Trikora 1 and in the northern part of Poto Island (**Figure 1**).

The results of the analysis showed that the tidal range of east coast of Bintan Island during 2007-2017 is 0.70-3.50 with mean sea level height range is 2.20-2.60 m.

Table 1. Results analysis of tidal fluctuation and characteristics on station 1

Data	Year		
	2007	2012	2017
Max. (m)	3.57	3.48	3.46
Min. (m)	0.96	0.95	0.98
MSL (m)	2.61	2.53	2.48

Table 2. Results analysis of tidal fluctuation and characteristics on station 2

Data	Year		
	2007	2012	2017
Max. (m)	3.43	3.27	3.14
Min. (m)	0.89	0.87	0.83
MSL (m)	2.54	2.40	2.31

Table 3. Results analysis of tidal fluctuation and characteristics on station 3

Data	Year		
	2007	2012	2017
Max. (m)	3.39	3.28	3.04
Min. (m)	0.87	0.86	0.78
MSL (m)	2.52	2.41	2.26

Table 4. Results analysis of tidal fluctuation and characteristics on station 4

Data	Year		
	2007	2012	2017
Max. (m)	3.51	3.32	3.04
Min. (m)	0.92	0.88	0.78
MSL (m)	2.58	2.43	2.26

Tidal fluctuations of east coast of Bintan Island as general making an asymmetric pattern where this is a common pattern in any waters. This is because when the tide in high level conditions, water volume has given much more toward the land, while the tide in low level conditions the water volume has given much more toward the sea in different time periods (Surbakti, 2012). Tidal fluctuations of east coast of Bintan Island during 2007-2017 in each station measurement can be seen in the following figure.

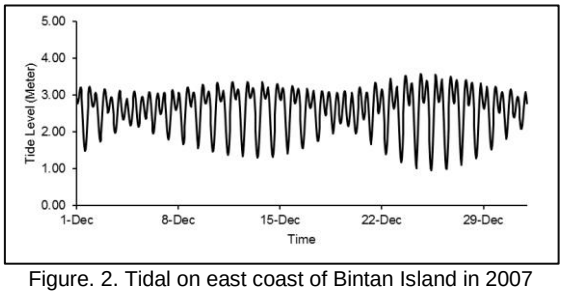

Figure. 2. Tidal on east coast of Bintan Island in 2007

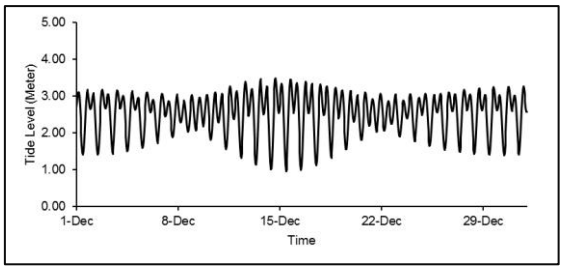

Figure. 3. Tidal on east coast of Bintan Island in 2012

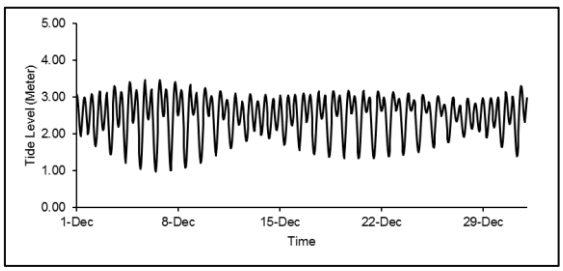

Figure. 4. Tidal on east coast of Bintan Island in 2017

From the pictures above it can be seen the different of tidal time in every year, but overall tidal patterns of the east coast of Bintan Island which is shown in the pictures above are semi-diurnal tide where there is a process of two pairs and two times subsided in a day. It can be seen from the results of analysis of tidal harmonic components in each station measurement in every year.

The results of analysis of tidal harmonics component showed that M_2 component is the component with highest amplitude value in three stations, the anomaly was found in station 4 in the northern part of Poto Island where the highest amplitude value is K_1 component.

Apart from tidal harmonics component, tidal type of east coast of Bintan Island waters can be seen from the value of formzahl number. Based on formzahl number, tidal type of waters can be classified into four types (Wyrtki, 1961).

The value of formzahl number in each station respectively are 1.19, 1.44, 1.36 and 1.60. from these values it found that the tidal type of east coast of Bintan Island waters is mixed predominantly semi-diurnal tide, this is the same with Suhana et al (2016) research results, where in the study mentioned that the type of tidal waters east coast of Bintan Island is mixed predominantly semi diurnal tide with the value of formzahl number is 0.77.

The results obtained are reinforced by the statement of Triatmodjo (1999) that the tidal with mixed predominantly semi-diurnal type in Indonesia waters generally occurring around the waters of the Malacca Strait and the Andaman Sea. This statement is also in accordance with the results of research conducted by Daya, et al., (2017) in the waters of Nongsa Island, Batam which explains that the waters of Nongsa Island located around the Malacca Strait have the type of semi-diurnal tide.

Table 5. Harmonic components of tidal on station 1

Harmonic Components	Station 1	
	Amplitude (m)	Phase (°)
O_1	0.3496	273.47
K_1	0.424	329.95
N_2	0.1297	45.35
M_2	0.525	84.23
S_2	0.1248	119.71
M_4	0.0001	11.29
MS_4	0.0001	336.9

Table 6. Harmonic components of tidal on station 2

Harmonic Components	Station 2	
	Amplitude (m)	Phase (°)
O_1	0.3735	279.18
K_1	0.4587	341.77
N_2	0.1192	48
M_2	0.4721	89.25
S_2	0.107	122.06
M_4	0.0001	27.1
MS_4	0.0001	357.57

Table 7. Harmonic components of tidal on station 3

Harmonic Components	Station 3	
	Amplitude (m)	Phase (°)
O_1	0.3657	276.66
K_1	0.4448	336.65
N_2	0.1226	45.83
M_2	0.4854	86.1
S_2	0.1113	119.63
M_4	0.0001	22.83
MS_4	0.0001	19.81

Table 8. Harmonic components of tidal on station 4

Harmonic Components	Station 4	
	Amplitude (m)	Phase (°)
O_1	0.3879	281.58
K_1	0.4868	346.03
N_2	0.1149	49.45
M_2	0.4494	91.58
S_2	0.0988	123.06
M_4	0.0001	36.36
MS_4	0.0001	19.81

Table 9. Formzahl number value and tidal type on each station

Station	Formzahl Number	Tidal Type
I	1.19	Semi diurnal mixed predominantly tide
II	1.44	Semi diurnal mixed predominantly tide
III	1.36	Semi diurnal mixed predominantly tide
IV	1.60	Semi diurnal mixed predominantly tide

Meanwhile, the results of the analysis using the Indian Spring Low Water method obtained tidal characteristics of the east coast of Bintan Island have the highest mean sea level ranges between 3.14-3.25 m on spring tide and 2.36-2.55 m on neap tide with the tidal ranges between 0.85-0.97 m.

Table 10. Tidal characteristics of east coast of Bintan Island on each station

Character	Station			
	I	II	III	IV
Z_0	1.06	0.90	0.95	0.84
LAT	1.06	0.90	0.95	0.84
HAT	3.90	3.72	3.76	3.69
MHHWS	3.25	3.14	3.17	3.14
MLHWN	2.55	2.39	2.44	2.36
MLLWN	2.40	2.22	2.28	2.16
MLLWS	1.71	1.48	1.55	1.39
TR	0.85	0.92	0.89	0.97

Interesting phenomenon obtained from the results of this study is from 2007-2017 maximum sea level in each station tend to decrease, this is considered attractive because during the last 20 years the surface temperature tends to increase, resulting in the melting of polar ice that implies the increase in sea water volume.

It must, of course, have linear implications between the melting of polar ice and sea level rise due to the increased volume of water caused by polar ice melting.

The anomalies obtained from this study are interesting phenomena to be carried out a follow-up study on sea level rise, considering that this phenomenon is in contrast to the current condition of sea level changes with sea level at the research sites that are increasingly decreasing years and not vice versa.

However, based on research conducted by Surya, et al., (2017) and Lubis, et al., (2017) on the characteristics of sea surface temperature in the

waters of Batam Island showed that sea surface temperature around Batam Island waters tend to be low in period December to January, this may have implications for the east coast of Bintan Island that is quite close to the waters of Batam Island.

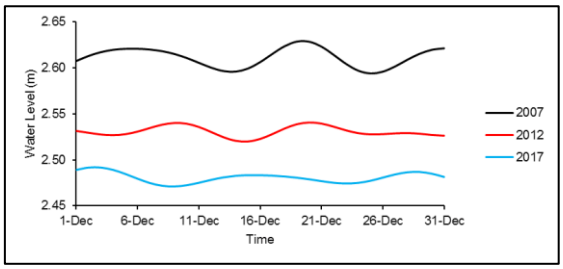

Figure. 5. Comparison of sea surface height on station 1 in every year

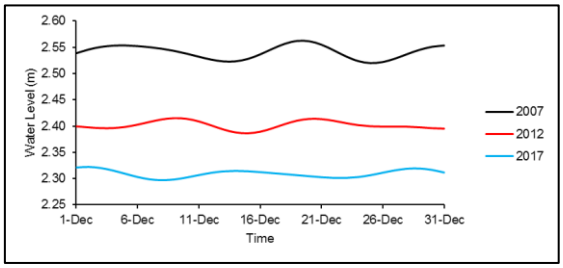

Figure. 6. Comparison of sea surface height on station 2 in every year

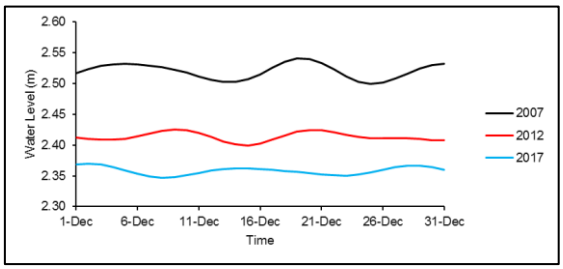

Figure. 7. Comparison of sea surface height on station 3 in every year

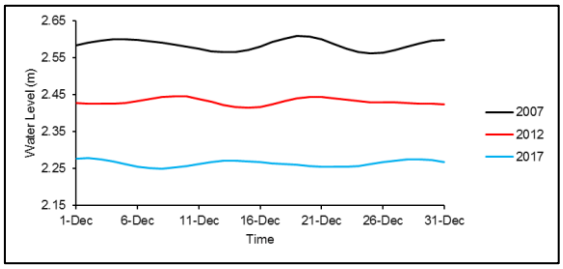

Figure. 8. Comparison of sea surface height on station 4 in every year

4. Conclusion

From the analysis results obtained that the tidal type of east coast of Bintan Island is mixed predominantly semi diurnal tide. The interesting things found from the results of this research is in every year sea surface height level of east coast of Bintan Island tends to decrease, this becomes an anomaly of its own, with the increase of earth's temperature makes ice at the poles was melt and will increase the volume of sea water on the earth, so it should have a linear impact with east coast of Bintan Island waters level.

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