JOURNAL OF APPLIED GEOSPATIAL INFORMATION

Vol 4 No 2 2020

http://jurnal.polibatam.ac.id/index.php/JAGI
ISSN Online: 2579-3608

Characteristic of Ocean wave Southern Batam City waters-Northen Lingga District waters

Soedrajad Haryo Adji[1,], Risandi Dwirama Putra[2,],Mario Putra Suhana[2,], Try Febrianto[2,], Chandra Joei Koenawan[1,]

[1, 2]Raja Ali Haji Maritime University, Department of Marine Science, Tanjungpinang, Indonesia
*Corresponding author e-mail: haaryoadji@gmail.com

Received: July 25, 2019
Accepted: July 06, 2020
Published: July 17, 2020

Abstract

The southern Batam City sea and northern of Lingga District sea are often used by fishing locations and shipping traffic from Batam City to Lingga District. Southern of Batam City sea-northen Lingga District sea have uncertain sea wave conditions that can affect the stability of ship traffic. The purpose of this study is to determine characteristic of sea waves along with wind speed and directions. Characteristic analysis of ocean waves using the SPM (Shore Protection Manual) method from wind direction and speed data in 2018. The height of ocean waves in the northen Batam City sea-southern Lingga District during 2018 is 2.59 meters with periods of 8.47 s up to 0.005 m with a period of 0.39 s. The average wave height in 2018 is 0.69 m with sea wave characteristic patterns still following seasonal wind conditions. The highest sea wave height conditions are in the northern season due to the geographical location of the southern Batam City sea-southern Lingga District sea in the Northern Hemisphere.

Keywords: Wind Speed, Hidro-oseanografi, Gelombang laut, Klimatologi, Batam, Lingga

1. Introduction

The southern of Batam City waters have a cluster of small islands that are directly opposite the northern part of Lingga District and are bordered by the Pengelap Strait. The southern of Batam City waters and north of Lingga Regency are often used as fishing ground and also as an area of ship traffic. Southern of Batam City waters - northern of Lingga District have uncertain sea wave conditions that can affect the ship stability. Base on Wati et al. (2015), irregular weather and climate will affect the means of sea transportation. Weather factors, especially sea wave heights are prioritized because they affect the safety above the sea. Waves that occur every day and it's being calculated in coastal engineering are wind and tide waves. Waves can form and damage beaches and affect coastal buildings. Wave energy will produce currents and affect sediment movement in the direction of crossshore and longshore (Kurniawan et al., 2014).Wind speed raises stresses on the surface of the seawater, so the calm water surface will be disturbed and small wave ripples will appear above the water surface. When the wind speed increases, the ripple gets bigger and when the wind blows continuously it will form a sea wave. Wind data at the sea surface from generation site used for wave forecasting(Purba 2014).

Ocean wave often appear irregular and change. This can be observed from the surface of the water caused by the varying direction of the wave and irregular waveforms (Loupatty 2013).The purpose of this research was to determine the conditions of wave characteristics in the southern of Batam City waters - northern of Lingga district waters along with wind direction and speed.

2. Data and Method

Ocean wave analysis needs the wind speed data (Irawan*et al.*, 2018; Lubis and Amri 2018). Wind data Downloaded from ECMWF (the European Center for Medium-Range Weather) in range of time from 2018 December – 2019 December with 0.125 resolution data. Data obtained in the form of wind vector data then converted into direction and speed data that blows in the water surface. Conversions are made base on correction of height correction duration, stability correction, and Wind stress Factor which refers to USACE (2003a).

Ocean wave forecasting uses the SPM (Shore Protection Manual) method. Ocean wave forecasting stage consists of wind data filtering, determining effective fetch length (distance of ocean wave generation area), height calculation and period (Suhana 2016). Draw a line at every 5º angle done considering that the wind blows from all directions. The measurement of the fetch line is stretched until reach the closest land. If the fetch effective length is more than 200 km, the fetch effective length is used at 200 km due to the consistent wind speed only ≤200 km (Illona *et al.*,2018).

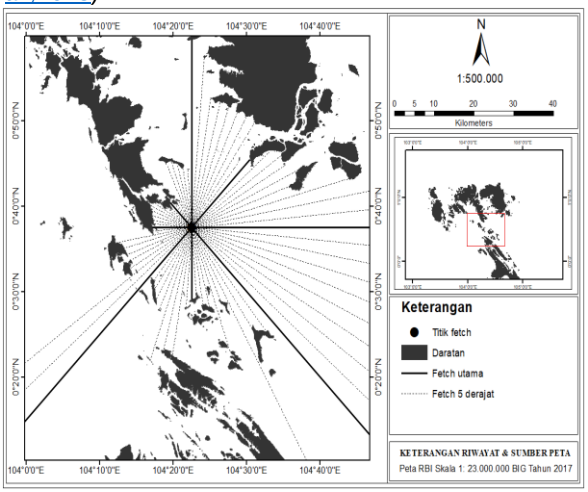

Fig 1. Map of Fetch Point Location

The main principle in the calculation of ocean waves is to consider 3 factors, wind speed (UA), the duration of windblown (t) and the length of fetch effective (Feff). the analysis comparative uses the following formula.

$$\frac{gt_d}{U_A} = 68.8\left(\frac{gF_{eff}}{U_{A^2}}\right)^{2/3} \leq 7.15 \times 10^4 \qquad (1)$$

Dimana :

t_d = Duration wind Blown (s)
U_A = Wind stress factor (m/s)
F_{eff} = Lenght of fetch effective (m)
g = Earth's gravitational acceleration = 9.81 m/s^2

If the results obtained do not meet the equation, the waves that occur are the result of perfect wave formation. So the calculation of height and period uses the following equation:

$$H_{m0} = 0.2433 \times \frac{U_{A^2}}{g} \qquad (2)$$

$$T_P = 8.134 \times \frac{U_A}{g} \qquad (3)$$

Dimana

Hmo = Sea waves height (m)
Tp = Wave peak period
U_A^2 = Wind stress factor (m/s)
g = Earth's gravitational acceleration = 9.81 m/s^2

But if the results of the analysis in this equation, so the wave that occurs is the result of the formation of an imperfect wave. This imperfect wave formation is formed because of two things, limited wave formation by fetch (fetch limited) and limited duration (duration limited). To find out the difference, it is necessary to calculate the critical duration (tc) first as follows:

$$t_c = \frac{68.8 \times U_A}{g}\left(\frac{g \times F_{eff}}{U_{A^2}}\right)^{2/3} \qquad (4)$$

Dimana

tc = critical duration
F_{eff} = Length of Fetch effective (m)
U_A^2 = Wind stress factor (m/s)
g = Earth's gravitational acceleration = 9.81 m/s^2

Next check the specified duration (td), then compare it to the critical duration (tc). If td>tc then the wave that occurs is a wave resulting from a limited formation by fetch (fetch limited). Calculation of height and wave period uses the following equation:

$$H_{m0} = 0.0016 \times \frac{U_{A^2}}{g}\left(\frac{gF}{U_{A^2}}\right)^{1/2} \qquad (5)$$

$$T_P = 0.2857 \times \frac{U_A}{g}\left(\frac{gF}{U_{A^2}}\right)^{1/3} \qquad (6)$$

If the value of td <tc then the wave that occurs is a wave of limited by duration. In this kind, the duration of the blowing wind is not long enough. The calculation of wave height and period using the above equation, but Feff is changed to Fmin, calculated by the following equation:

$$F_{min} = \frac{U_A^2}{g}\left(\frac{gt_d}{68.6\, U_A^2}\right)^{3/2} \qquad (15)$$

3. Result and Discussion

Based on Table 1, the characteristics of ocean waves along with wind speed, where the conditions of the northern season (December, January, February), the wind direction entering the southern waters of Batam City-northern of Lingga District, are dominant from north and northwest (**Fig 2**). The maximum speed is 9 m/s and its around the middle of January at the second peak with the wave height are formed by a wave height of 2.59 m with a period of 8.48 s. The minimum speed is 1 m/s and produces a wave height is 0.02 with a period is 0.65 s. The average wind speed in the north season is 4.91 m/s. The relation between wind speed and wave height can be seen in Figure 2. Which at the maximum peak wind speed is in line with the maximum wave height and also followed by the maximum sea wave period in the season north. The highest peak is at the second peak in each season (**Fig 2**).

In north season, wind speed conditions are faster than other seasons, this is caused by the West Munson is form from the Northern Hemisphere which is dominated by the vast waters of the Pacific Ocean and the South China Sea with many atmospheric conditions containing moisture to the southern hemisphere. With this condition, the southern of Batam City waters-north of Lingga District waters, are directly affected by the western Munson wind due to its geographical location in the northern part of the earth.

Table 1.Table of Comparison between wind speed and wave height ,wave height and wave period in the north season

	Wind Speed (m/s)	Wave Height (m)	Wave Period (s)
Max	8.99	2.59	8.48
Min	1.00	0.02	0.65
Avg	4.91	0.79	4.29

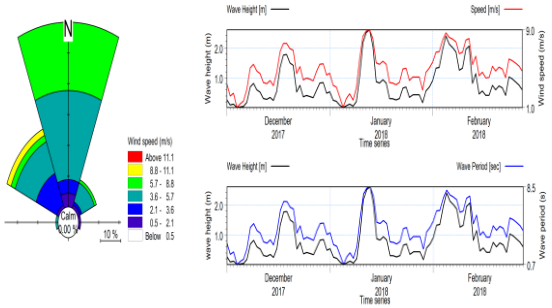

Fig 2. Relationship of wind direction and speed with the height of ocean waves and periods in the north season

According to **Table 2**, East Season (March, April, May) is a transition season from the northern season to the southern season so that it has a low wind speed compared to the wind speed in the northern season. The direction of the wind can come from all directions and randomly. The direction of the wind is more dominant from the east and northeast. The highest wind speed of 6.29 m/s produces waves with a height of 1.15 m with a period of 5.64 s. The peak height in the east season is in March with an average wind speed of 2.67 m/s and an average wave height of 0.21 m. March is the beginning of the western season and still has an influence from the northern season so that it has a higher wind speed and wave height compared to the other winds which are in the east season (**Fig 3**).

In the East Season, the sun is above the equator so that solar energy received in the northern hemisphere and in the southern hemisphere is the same as a result of wind circulation in the northern hemisphere in general is irregular (Martono 2009)

Table 2.Table of Comparison between wind speed and wave height ,wave height and wave period in the east season

	Wind Speed (m/s)	Wave Height (m)	Wave Period (s)
Max	6.29	1.15	5.64
Min	0.30	0.005	0.39
Avg	2.67	0.21	2.18

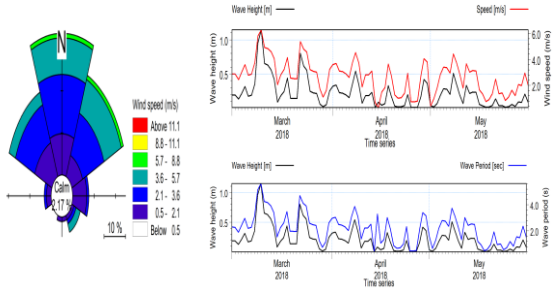

Fig 3. Relationship of wind direction and speed with the height of ocean waves and periods in the east season

Based on **Table 3**, the condition of the South season (June, July, Agustus) has wind direction and speed influenced by winds originating from the south and southeast with a top speed of 6.25 m / s resulting in wave height of 1.13 m with a period of 5.60 s. Minimum wind speed is 1.13 m/s and produces waves of 0.02 m with a period of 0.75 s. The average wind speed is 4.33 m/s. The highest wave height is in the middle of June and July, this is followed by the maximum wind speed and period (**Fig 4**).

The south wind season is influenced by the Munson east wind originating from the southern hemisphere that is dominated by the vast continent of the Australian continent. The impact of the southern season in the southern waters of Batam City, north of Lingga Regency is not as big as the northern season. The geographical location of the southern of Batam City waters-northern of Lingga District is in the northern hemisphere that affects this. Wind from the Australian continent to the northern hemisphere is blocked by the mainland of Java.

Table 3.Table of Comparison between wind speed and wave height ,wave height and wave period in the south season

	Wind Speed (m/s)	Wave Height (m)	Wave Period (s)
Max	6.25	1.13	5.60
Min	1.13	0.02	0.75
Avg	4.33	0.52	3.68

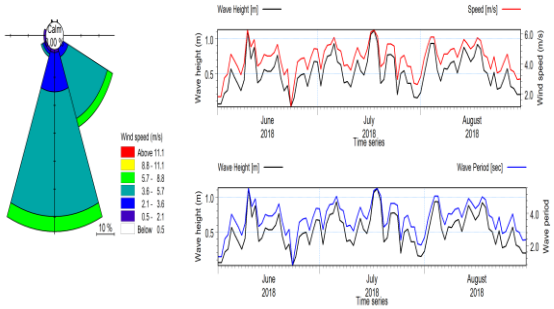

Fig4. Relationship of wind direction and speed with the height of ocean waves and periods in the south season

.

Based on **Table 4**, in west Season (September, October, November) is also referred to as the

transition season II. The direction and highest wind speed at 5.28 m/s produce a wave height of 0.77 m with a period of 4.61 s while at a minimum wind speed of 0.04 m/s produces a wave height of 0.01 m with a period of 0.42 s. The average speed of 2.55 m / s. Fluctuations in wind speed along with the height of ocean waves and shaped wave periods are random where conditions can change every day. The highest condition is in September (**Fig 5**).

During this season, duration limited wave conditions happen where the wave conditions are limited by the duration of the wind blowing. According to Mulyadi.,*et al* (2015), significant sea wave height at Karimata Strait waters in the western season ranged from 0.51-1.05 m.

Based on the research of Kurniawan et al. (2011),In the transition season I and II the wind speed tends to be low so the ocean waves are lower than the west and east seasons because during this transition period the position of the sun is in the area around of equator, so the temperature gradient between the Asian Continent and the Australian Continent is not too large and wind speed across Indonesia is low.

Table 4.Table of Comparison between wind speed and wave height,wave height and wave period in the west season.

	Wind Speed (m/s)	Wave Height (m)	Wave Period (s)
Max	5.28	0.77	4.61
Min	0.04	0.01	0.53
Avg	2.55	0.19	2.13

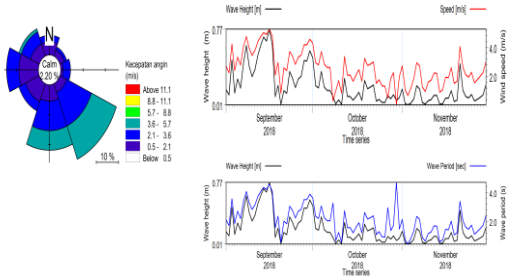

Fig5. Relationship of wind direction and speed with the height of ocean waves and periods in the west season

Based on **Table 5**, During 2018 the highest wind speed of 8.99 m/s produced 2.59 m waves which occurred in the northern season, precisely in January and the lowest was in October in the western season with wind speeds of 0.04 m / s with a wave height of 0.01 m and a period of 0.53 s. The average wind speed is 3.49 m / s and the average wave height is 0.69 m. Based on **Fig 6**. During 2018 peak wave conditions occur every 6 months. Based on the research of Suhana (2016),the maximum sea wave height formed in the east coast waters of Bintan Island generally occurs at the peak of the western season (December-February) and east season (June-August) this is due to the speed of wind blowing in the east coast waters. Bintan Island during the west and east seasons is higher than the other seasons.

Characteristics of ocean waves from the northern season to the west season in the southern of BatamCity waters-northern of Lingga District waters, direction and conditions of wave propagation are still influenced by the wind season characteristics.

Based on the research of Saputro and Mulsandi (2016), the characteristics of the waves in the Riau islands relate to seasonal wind patterns.

The higher the wind speed blows, the bigger waves will be created (Khoirunnisa and Karima, 2019)

Table 5.Table of Comparison between wind speed and wave height ,wave height and wave period along 2018.

	Wind Speed (m/s)	Wave Height (m)	Wave Period (s)
Max	8.99	2.59	8.48
Min	0.04	0.01	0.53
Avg	3.49	0.69	3.96

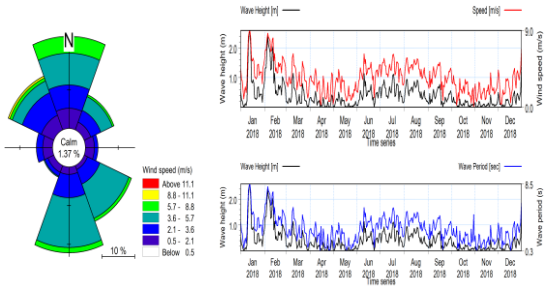

Fig6. Relationship of wind direction and speed with the height of ocean waves and periods along 2018

The characteristics of ocean waves are more predominantly affected by the winds from Karimata Strait in the eastern part of the southern of Batam City waters-northern of Lingga District, which is a high sea and there are no obstacles. Whereas sea waves in the western part of the southern of Batam City waters-northern of Lingga District waters are influenced by winds that pass through the Malacca Strait and do not have a significant impact.

Wave conditions during 2018 are more dominant in the condition of fully development waves where formed waves have sufficient energy both from fetch length and wave duration until energy will run out on land and form a breaking wave. According to Ningsih (2000), in this fully developed condition, the height and wave period will reach the maximum value. Based on Trenggono (2009),Fully developed waves are conditions where the wave height reaches the maximum condition (occurs if the fetch is long enough).

The maximum wave height in the southern of Batam City waters-northern of Lingga District waters has no significant difference compared to the maximum altitude conditions in the eastern part of Bintan Island according to Illona.,*et al* (2018), the maximum wave height is at 2.67 m. The maximum height occurs during the northern season so it is important to be aware of shipping and fishing activities. According to Dewi*et al* (2012), at wave heights ranging from 2,00-3,00 m are dangerous for

fishing boats and barges. According to Wirjohamidjojo and Sugarin (2008), generally large vessels have been designed to withstand the wind and wave conditions. There is no possibility of extreme conditions that exceed the tolerance limits and resistance limits used. Ships used for international shipping or shipping in the deep sea have been designed to withstand waves that are less than 2 meters high.

5. Conclucion

Wind speed conditions in the northern of Batam City waters-northern of Lingga District waters tend to be high in the north and south seasons with the highest in the northern season. The characteristics of ocean waves in the southern waters of Batam City - north of Lingga Regency are influenced by the conditions of the wind season whose changes still follow patterns of changing seasonal wind conditions. The highest sea wave height is in the northern season in January. So we need to watch out for activity safety at sea.

6. References

CERC. 1984. Coastal Engineering Research Center. Shore Protection Manual, Volume I (Cetakan ke 4). US Army Coastal Engineering Research Center. Washington DC.

Dewi, R., Pratomo, A., Jaya, Y,V. 2012. Pendugaan Tinggi Gelombang Berdasarkan Kecepatan Angin Pada Zona Alur Penangkapan Ikan Diperairan Tanjungpinang. 1-7.

Illona, D.J., Jaya, Y.V., Koenawan, C.J., Suhana, M.P. 2018. Global Warming dan PengaruhnyaTerhadapKarakteristikGelombang Laut di PantaiTimurPulauBintan yang Ditinjau Dari PerspektifKlimatologi. DinamikaMaritim. 7(1): 20-26.

Irawan, S., Fahmi, R., Lubis, Z,S., Aji ,S,B., Roziqin, A.,Khoirunnisa, H. 2018. Hydro-oceanographic Condition (Tide, Sea Current, and Waves) of Nongsa Batam sea. Journal of Applied Geospatial Information 2(2): 135-144.

Khoirunnisa, H., Karima, S. 2019. The Condition of Significant Wave Height and Wind Velocity in Makassar Strait during 2017. Journal of Applied Geospatial Information 3(1): 179-189.

Kurniawan, L.P., Sarwito, S., Kusuma, I.R. 2014. Studi Perancangan Prototype Pembangkit Listrik Tenaga Gelombang Laut Tipe Salter Duck. Jurnal Teknik POMITS 3(1): 76-79.

Lubis, M. Z., & Amri, U. (2018, October). Beach Profile (Oceanography Factors) of Labuhan Bilik Island, Aruah Island, Rokan Hilir District, Indonesia. In *2018 International Conference on Applied Engineering (ICAE)* (pp. 1-6). IEEE.

Lupatty,G. 2013. Karakteristik Energi Gelombang dan Arus Perairan Provinsi Maluku. Jurnal Barekeng 7(1): 19-22.

Martono. 2009. Karakterisitik dan Variabilitas Bulanan Angin Permukaan di Perairan Samudra Hindia. Jurnal MAKARA Sains 13(2): 157-162.

Mulyadi.,Jumarang, M, I., Apriansyah. 2015. Studi Variabilitas dan Periode Gelombang Laut Signifikan di Selat Karimata. POSITRON. 5(1): 19-25.

Purba, N.P. 2014. Variabilitas Angin dan Gelombang Laut Sebagai Energi Angin Sebagai Energi Terbaharukan Di Pantai Selatan Jawa Barat. Jurnal Akuatika 1(1): 8-15.

Saputro, H., Mulsandi, A. 2016. Karakteristik Gelombang Laut Diperairan Kepulauan Riau. Jurnal Meteorologi dan Geofisika. 3(2):25-31.

Suhana, M.P. 2016. Analisis Perubahan Garis Pantai di Pantai Timur Pulau Bintan Provinsi Kepulauan Riau. (Thesis).

Trenggono, M. 2009. TransformasiGelombang dan PengaruhnyaTerhadapDinamikaPantaiMuaraAjkwatahun 1993-2007. (Tesis).

Wati, L., Nikentari, n., Ritha, N. 2015. Prediksi Ketinggian Gelombang Laut Perairan Pulau Bintan Menggunakan Grammatical Evolution.

Wirjohamidjojo, S., Sugarin. 2008. Praktek Meteorologi Kelautan. Badan Meteorologi dan Geofisika. Jakarta.