# Study of The Physical Condition of The Waters of The Kabil-Batam Port, Indonesia Based on Hydro-Oceanography

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**Abstract.** The Kabil-Batam Liquid Bulk Port is a special port that serves the distribution of processed Crude Palm Oil (CPO) products or palm oil located in Kabil Village, Nongsa District, Batam City, Riau Islands, Indonesia. The research by looking at the hydro-oceanographic conditions in these waters aims to determine the physical condition of Kabil Port. The purpose of this study is to determine the condition of the Kabil port in terms of depth, tidal type, distribution of sea surface currents, and wind direction and speed. The data used in this study are bathymetry, tidal, and wind data in 2020. The results of the processing show that the waters of Kabil Harbor have a depth ranging from -1.0 m to -17.0 m LWS with mixed tidal types tending to double daily. In this type, in one day there are two high tides and two low tides. Based on the modeling of ocean currents, it is found that the direction of the surface ocean currents is irregular and divided into two directions, namely one towards the south and one towards the north. The movement of currents in Kabil waters tends to be weak due to the movement of the velocity from 0 - 1 m/s. The distribution of wind speed and direction for 15 days shows that in the waters of the Kabil-Batam CPO port, Indonesia is more dominated to the north with the highest speed or dominant value of 3.50 – 5.50 m/s at 44.0%. Based on the description, it can be concluded that the physical condition of the Kabil port using hydro-oceanography is still stated in terms of depth, tides, currents, and winds because the depth of the Kabil port can still be anchored. In addition, the current and wind speed at the port of Kabil do not have extreme values.

**Keywords:** Bathymetry, Tides, Currents, Wind, Kabil Port-Batam.

## 1 Introduction

The Batam is an island located in the border area between Singapore and Malaysia makes Batam Island the gateway to Indonesian territory which has a strategic location on international shipping lanes. This makes Batam a free trade area and port. One of the important parts in

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supporting this is the physical condition of each port which will become a gateway for exports and imports for other regions in Indonesia. In addition, ports have an important role in supporting transportation and the country's economy.

Kabil Bulk Liquid General Port is one of the special ports that serve the distribution of Crude Palm Oil (CPO) processed products or palm oil which is located in Kabil Village, Nongsa District, Batam City, Riau Islands. As a port that has been built since 1987 with an old pier length of 420 meters with a pool depth of 12 mLWS which can accommodate ships with a capacity of 35,000 DWT, it has undergone port development with the construction of a pier in 2019. As well as the maturation of an area of 10 hectares in order to maximize ship traffic and loading and unloading capacity of liquid bulk. The Kabil Bulk Public Port also has a pipeline network that is directly connected to the CPO refining industry in Batam (Port Batam, 2020).

In the construction of ports or docks as a stopover for ships with large loads and in order to ensure the smooth flow of ship traffic at these locations, many aspects need to be studied (Fanjul et al., 2018). One of them is from a technical point of view, it is necessary to know the condition of the port or dock based on the hydro-oceanographic aspect to determine the depth that the ship can anchor and ensure the safety of the ship's shipping (Herzfeld et al., 2004). With an understanding of the dynamics of hydro-oceanographic conditions in these waters, it is possible to choose and determine the appropriate control measures for port conditions (Brodie et al., 2015).

According to the Head of the Indonesian Navy's Hydrographic and Oceanographic Center who has carried out a field survey. The results of the review revealed that the last time a survey was carried out in the waters of Kabil Port-Batam, Indonesia by PUSHIDROSAL-Indonesia was in 2012. Therefore, it is necessary to carry out a full coverage hydro-oceanographic survey and mapping to update the Indonesian marine map No. 49 and nautical publications to ensure the safety of shipping in these waters (Pushidrosal, 2020).

In conducting surveys and mapping of hydro-oceanography, it is necessary to know the parameters of hydro-oceanography. According to (Denafiar et al., 2017; Riter & Pratikto, 2018) in his research on the characteristics of oceanographic parameters in the North and South waters of Bangka Island, it shows that an understanding of the characteristics of oceanographic parameters in the waters is very necessary in order to know the conditions of tides, currents, and waves in these waters. According to (Lubis et al., 2020), physical and chemical parameters are closely related to the dynamics of waters in Indonesia. Characteristics of waters can be known both through the physical and chemical properties of the water mass such as temperature, salinity, conductivity, dissolved oxygen, and others. Among these variables, temperature and salinity have an important role in reflecting the condition of seawater masses, this is very important to do in the waters of Batam, Indonesia (Lubis et al., 2019). These things are strongly influenced by the activities of coastal areas or estuaries, one of which is due to waste or mud disposal activities, ship shipping lanes, and aquaculture activities (Alvarez-Berastegui et al., 2016).

Based on the problems obtained from the literature review and also the current conditions, it is necessary to conduct a study related to the physical condition of the port based on a hydro-oceanographic review at the current Kabil-Batam Port to review the conditions of depth, tides, currents, and winds around the port and see the changes that occur. With the hydro-oceanographic research on the waters of the Kabil-Batam port, the results of the study of physical conditions or the latest updates related to each parameter in the port waters can provide information in the form of water depth, tidal type, direction and speed, currents and winds.

## 2 Material and Methods

### 2.1 Research location and time

The location of the research was carried out at the Kabil Liquid Bulk Public Port in Kabil Village, Nongsa District, Batam City, Riau Islands. The research area includes the wharf pond and the surrounding waters (Latitude: 1°4'22.36" N, Longitude: 104°8'19.45" E). The following map of the Kabil study location can be seen in Figure 1.

The main data used in this study are tidal and depth data obtained from the results of field measurements for 30 days from September 10 to October 9, 2020, for tidal data collection while bathymetry information is obtained from September 10 to 24 2020. Wind data downloaded via website https://cds.climate.copernicus.eu/ for 15 days from September 09 – September 25, 2020. The software used in the processing of this research is ArcMap 10.3, Arcscene, Surfer, WR. The plot, and Mike 21 Software.

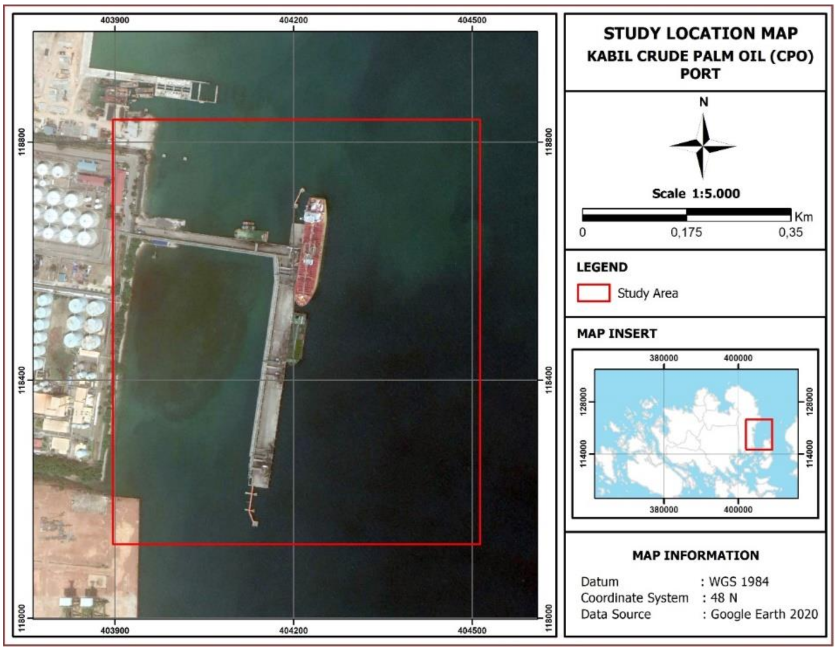


**Fig. 1.** Research location map (Kabil Port-Batam, Indonesia)

### 2.2 Tides with the Least Square method

Tidal data in this study is used to determine the type or characteristics of the tides. Tidal data used is predictive tidal data at the Kabil-Batam port obtained from the results of field measurements by related parties in 2020 which was carried out for 30 days on September 10 - October 09, 2020. Tidal data that has been obtained directly will be processed by using the least square method to obtain the MSL (Mean Sea Level) value which will later be used as the actual bathymetric correction value. The chart datum used in this measurement is MSL, where the zero-depth point refers to the average sea level. This serves to determine the depth value obtained from the sounding results referring to the average sea level. The definition of MSL is the average sea level value obtained from the results of tidal observations throughout the observation period.

Based on the results of tidal data processing with the least-squares calculation method through the Ms. Excel Least Square with tidal data intervals every one hour starting at 00:00-23:00 will later get nine tidal harmonic components, namely M2, S2, N2, K2, K1, O1, P1, M4, and MS4 so that it can calculate formzhal value to determine the type of tide using the following formula (Lubis et al., 2020):

$$F = \frac{K_1 + O_2}{M_1 + S_2} \quad (1)$$

Information:

F = Number Formzahl

O1 = Amplitude of the main single tidal component caused by the moon's gravitational pull

K1 = Amplitude of the main single tidal component caused by the moon's gravitational pull and the sun

M2 = Amplitude of the main double tidal component caused by the moon's gravitational pull.

S2 = Amplitude of the main double tidal component caused by the sun's attraction

To find out the classification of tidal types can be seen in table 1.

**Table 1.** Type Classification

| F Value | Tidal Type |
|---|---|
| ≤ 0,25 | Double Daily |
| 0,25 – 1,50 | Mixed Leaning to Double Daily |
| 1,50 – 3,00 | Mixes Lean to Single Daily |
| ≥ 3,00 | Single Daily |

## 2.3 Bathymetry Data Processing

The depth data obtained will be corrected for sea level elevation in order to obtain accurate depth data (Lubis, et al., 2020). The formula to get the corrected depth is as follows:

$$E = D + d + (MSL – B) \quad (2)$$

Information:

E = Corrected depth

D = Depth / H.

d = Draft ship.

MSL = Average of sea level

B = Tidal Interpolation

The depth data is corrected with the x, y, and z coordinate values against the DATUM Mean Sea Level (MSL) chart which will be visualized in the form of 2D and 3D contour maps. Bathymetry data were processed using ArcGIS 10.3 software with the Topo to Raster interpolation method so that the depth contours were obtained. While making 3D maps can be processed using Arcscene and Surfer software. In addition, bathymetry data will also be modeled using Mike 21 software, which is a parameter in the input of current modeling in hydro-oceanography studies in the waters of the port of Kabil-Batam, Indonesia.

### 2.4 Sea Surface Current Modeling

The data used in modeling sea surface currents are tidal data, shoreline, and depth modeling. Making a meshing area using shoreline and bathymetry data input. The meshing area is a triangle-shaped point which is the result of interpolation from the sea depth input. The point made will determine the result of the current vector distribution. The more points, the more accurate the resulting model will be. Figure 2 is a bathymetric mesh resulting from the interpolation of bathymetric data.

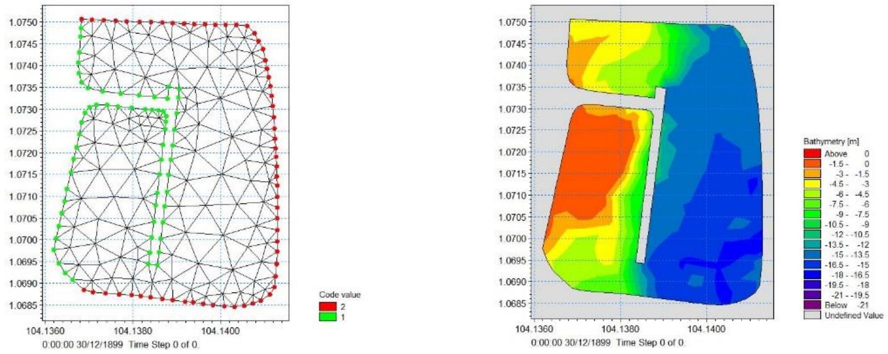


**Fig. 2**. Mesh of Bathymetry (Kabil Port-Batam, Indonesia).

Figure 2 shows a mesh formed from bathymetric data found in the waters of Kabil-Batam, Indonesia, where current modeling requires tidal prediction data (tidal time series) as the main input for current generation forces. After that, create a flow model in the Mike software by entering a bathymetric mesh and a time series for tidal predictions which will produce current modeling with the output direction and speed of the current.

### 2.5 Wind Data Processing

Wind data was obtained from the Climate Data Store website, implementation of the ECMWF (The European Center for Medium-Range Weather Forecasts) website. The parameters contained in this wind data are wind speed data every hour for 15 days around the waters of the CPO Kabil port, Batam. Wind data in .nc format will be processed first in ODV then converted u and v into r, theta (θ). The conversion equation for u and v can be seen as follows:

**Table 2.** Equation formula u and v

| Quadrant | θ ( ° ) | Speed |
|---|---|---|
| Quadrant I | 90 - arcTAN \| v/u \| | $V = \sqrt{(u^2) + (v^2)}$ |
| Quadrant II | 90 + arcTAN \| v/u \| | |

| | |
|---|---|
| Quadrant III | 270 - arcTAN \| v/u \| |
| Quadrant IV | 270 + arcTAN \| v/u \| |

Wind data processing that has been converted is done using WR Software. Plot View through this processing will present wind data in windrose which serves to determine the distribution of wind direction and speed so that the largest speed frequency and dominant wind direction can be obtained. The data inputted into the WR plot is in Ms. format. Excel will be identified by year, month, day, hour, wind direction, and wind speed data. The data that has been identified will be inputted in .SAM format. The data is used to analyze the windrose which can be set to determine wind direction, wind classes, units of wind speed and orientation, number of hours, average wind speed, and so on. The information generated is the number/frequency of each class of wind in a certain direction which will be analyzed together with the results of the windrose which contains information on the speed and direction of the dominant wind.

## 3 Result and Discussion

### 3.1 Tides

Tidal data from the results of the study by observing for 30 days with a measurement interval of 1 hour and analyzed using the least square method to get the tidal component values M2, S2, N2, K2, K1, O1, P1, M4, and MS4 can seen in Table 3.

**Table 3** Tidal Components

| No | Constituent | Amplitude (meters) | Phase (deg/hour) |
|---|---|---|---|
| 1 | M2 | 0,6077 | 52,1479 |
| 2 | S2 | 0,1638 | 195,0188 |
| 3 | N2 | 0,1177 | 195,7477 |
| 4 | K2 | 0,0555 | 130,9953 |
| 5 | K1 | 0,3492 | 274,5561 |
| 6 | O1 | 0,372 | 349,6976 |
| 7 | P1 | 0,1319 | 156,8699 |
| 8 | M4 | 0,0005 | 209,2774 |
| 9 | MS4 | 0,0008 | 152,0210 |

In table 3, the results of tidal data processing show the Formzhal number (F) of 0.95. Based on the Formzhal value, it is concluded that the tidal type in the study area is mixed tide prevailing semi-diurnal because the range of Formzhal values is $0.25 < F < 1.50$. In this type, in one day there are two high tides and two low tides. The results of the analysis using the tidal component through the least square calculation, it is known that several water level elevation values can be seen in Table 4. The results of the analysis of the tidal component at the data collection location are also influenced by factors such as being in the southern equator, where the position of the moon is at a small declination angle up to the height achieved by the semi-diurnal tide appears to be greater while the diurnal tidal variation does not exist (Tonbol & Shaltout, 2013).

**Table 4.** Elevation of research area

| Parameter | Value | Unit |
|---|---|---|
| HWS | 3,4160 | m |
| MHHWS | 2,6447 | m |
| MSL | 1,9233 | m |
| MLWS | 0,4306 | m |
| MLLWS | 1,2021 | m |
| LWS | 0,1243 | m |

Based on Table 4, the HWS (high water spring) value or the highest water level is 3.41 meters, the MHHWS (mean highest high-water spring) value is 2.64 meters, the MLLWS (mean lowest low water spring) value is 1.20 and the LWS (low water spring) value or the lowest water level is 0.12 meters. tidal height graph obtained from the results of tidal data processing using the least square method (Figure 3). The results obtained are based on the processing of tidal riding derived from data collection at the port of Kabil-Batam, Indonesia, namely the daily Mean Sea Level (MSL) obtained from tidal measurements of 30 plantains in the waters of the Kabil port-Batam, Indonesia is 1.92 meters, the results This is also not too far from the results of calculations carried out by (Lubis et al., 2019b; Geurhaneu & Susanto, 2017).

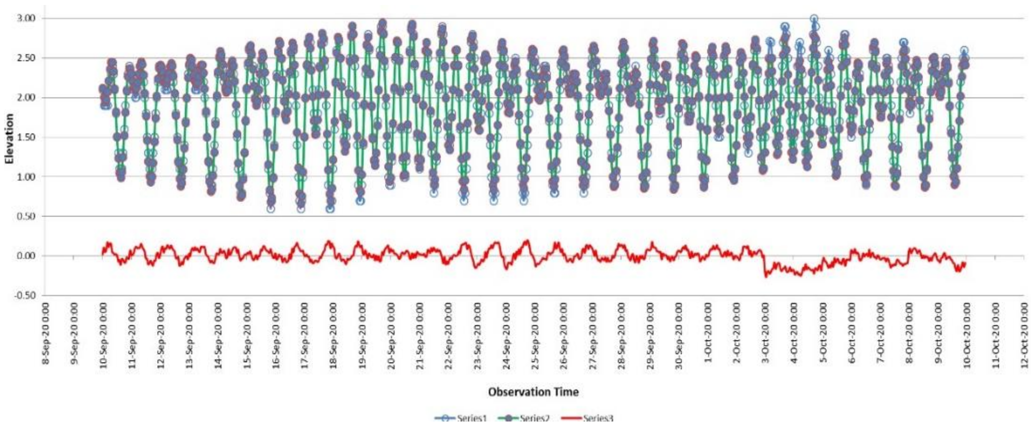


**Fig. 3.** Tidal Height Chart in Kabil -Batam Port, Indonesia

### 3.2 Bathymetry

Based on the results of bathymetry data processing in the waters of the Port of Kabil-Batam, Indonesia, it can be seen that the waters of the Port of Kabil have a depth ranging from -1.0 m to -17.0 m MSL. The condition of the port can be seen in detail in 3D which shows the depth of the water area of the Kabil port. The morphology of the seabed surface in the form of waves is mostly found in the river estuary area to the shore, which is indicated by a gradation of light blue to dark blue with a depth ranging from -1 to -17 meters. Bathymetric contour maps can be seen in Figure 4 and 3D visualization maps can be seen in Figures 5 and 6. Changes in depth (bathymetry) in waters that change from time to time follow changes in sea-level changes (Geurhaneu & Susanto, 2017), there are also a study conducted in the waters of the port of Kabil-Batam, Indonesia.

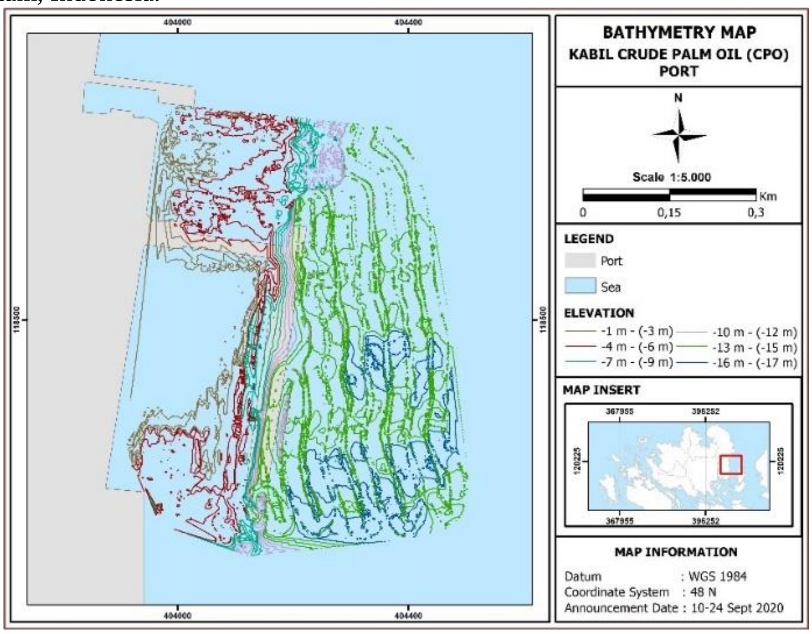


**Fig. 4.** Layout of Bathymetry Contour Map

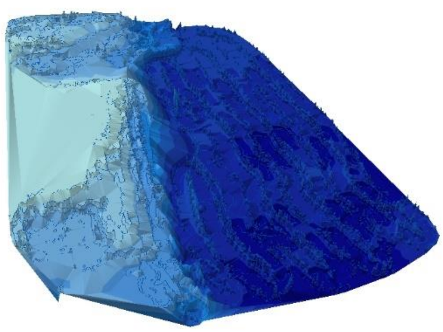

**Fig. 5.** Bathymetric Contour Map

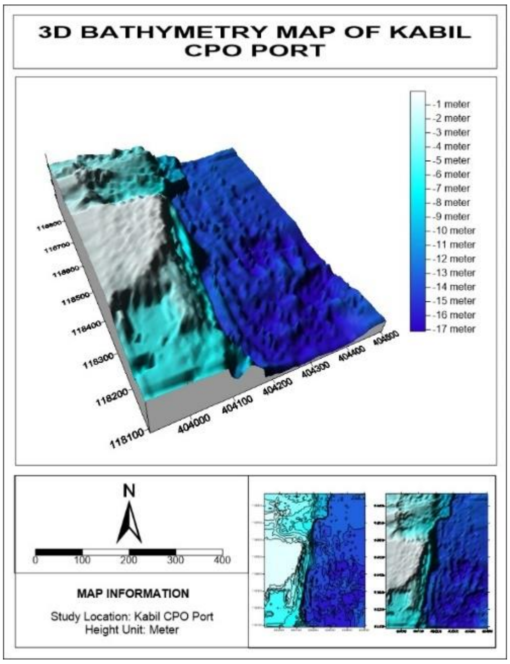


**Fig. 6.** 3D Bathymetry Map

The results from Figures 5 and above show that the condition of the kabil port is still categorized as good because the depth at the front of the pond or the waters of the kabil port-Batam is still deep enough for more than 12 meters so that it is safe for ships measuring 35,000 DWT to dock. In addition, based on KM 63 of 2021, it is explained that the depth of the ship's berth in the port area that can be docked is 5.6 mLWS to 46 m LWS. The function of direct sounding in obtaining bathymetric data in waters by using an echosounder can produce a continuous depth profile along the track lane with fairly good accuracy. The measurement results will be recorded and displayed digitally (Ramadhan et al., 2016).

### 3.3 Sea surface current

Based on the results of current modeling, it is known that the waters of the Kabil port have a current velocity that tends to be small. At high tide the current moves into the port pool and vice versa at low tide the current moves out of the port pool. Image modeling results can be seen in Figures 7 and 8.

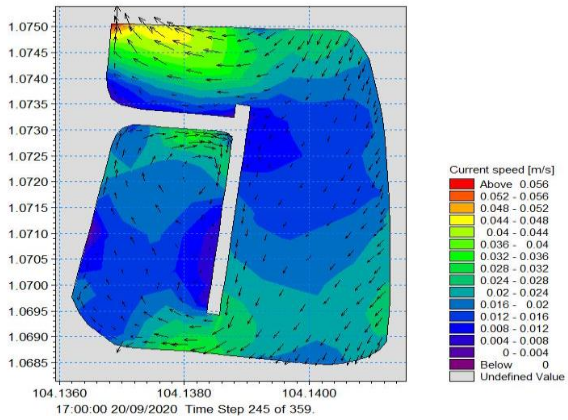


**Fig. 7.** Sea surface current model at highest tidal condition

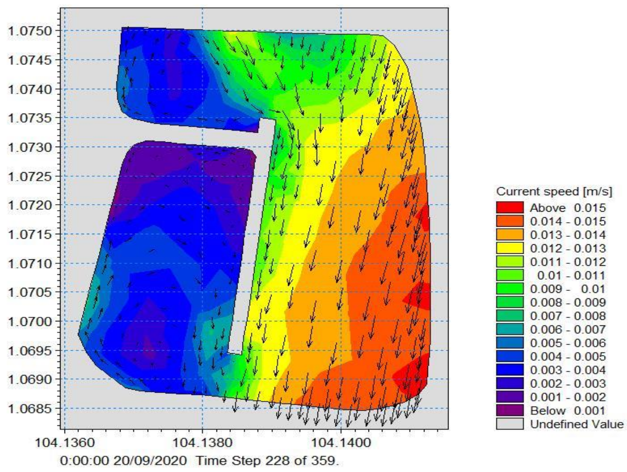


**Fig. 8** Sea surface current model at lowest tidal

In Figure 7, it is known that the condition of the current model when the highest tide will go to the port pool with the highest speed of 0.052 and the lowest speed of 0.004. While in Figure 8, it is known that the condition of the current model when the lowest tide will leave the port pool with the highest speed of 0.015 and the lowest of 0.001. Figures 7 and 8 show the pattern of water currents at high tide, and at low tide, this is done because at high tide and full ebb, the current has a high speed due to high tidal elevation (Austin et al., 2009; Vidal et al., 2011; Sharma et al., 2021).

### 3.4 Wind Condition

In the results of the study, the data obtained were based on direction and speed which were grouped in the form of windrose. Windrose is a radial line that shows the direction of the wind and each circle shows the percentage of wind occurrences in the measurement time period. The wind direction above shows that the wind tends to move north and then it is followed to the northwest, while the direction that rarely blows is from east to south. In addition, the units of direction and velocity stated in the legend are % and m/s (Figure 9).

The graph of the frequency distribution of the wind class for 15 days at the port of Kabil-Batam Indonesia shows that the wind moves with the highest speed or the domain value of 3.50 – 5.50 m/s of 44.0%. While the wind that moves at low speed is 7.50 – 10.00 m/s with a percentage rate of 0.5% (Figure 10). The results of wind analysis at the study site can also be influenced by the movement of the sun from the tropic of Cancer to the tropic of Capricorn, causing a change in wind direction from the east monsoon to the west monsoon (Afriady et al., 2019; Gierycz et al., 2016). This is due to the circulation of monsoon winds originating from high-pressure areas in subtropical northern latitudes to low-pressure areas in southern subtropical latitudes (Chang et al., 2005; Zhou et al., 2008). Based on this,the wind at the port of Kabil-Batam, Indonesia has a relatively safe wind speed so that wind conditions do not have a major effect on the occurrence of waves, including when the ship will lean or enter and leave the port because the location of the Kabil does not have extreme wind movements.

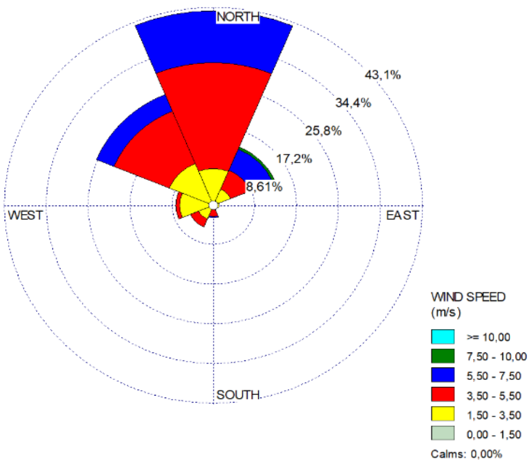


**Fig. 9** Windrose in the waters of the port of Kabil-Batam, Indonesia

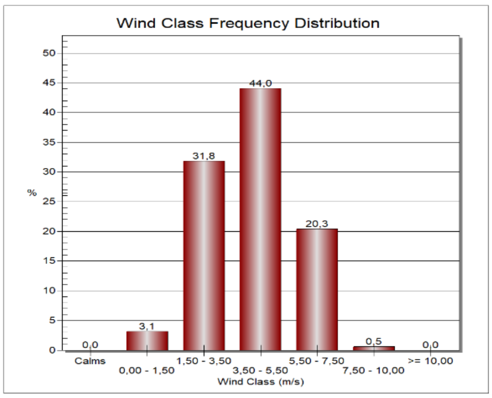


**Fig. 10** Wind Class Distribution Graph in the waters of the port of Kabil-Batam, Indonesia

## 4 CONCLUSION

Based on the modeling of the sea currents of the Kabil-Batam port, Indonesia has found that the direction of the surface sea currents is irregular and divided into two directions, namely towards the south and towards the north. The movement of currents in Kabil waters tends to be weak due to the movement of the velocity from 0 - 1 m/s. The distribution of wind speed and direction for 15 days shows that in the waters of the Kabil-Batam port, Indonesia is more dominated to the north with the highest speed or dominant value of 3.50 – 5.50 m/s at 44.0%. While the wind that moves at a low speed is 7.50 – 10.00 m/s with a percentage rate of 0.5%. Based on this description, it can be concluded that the physical condition of the Kabil port from a hydro-oceanographic review is still stated in terms of depth, tides, currents, and winds because it has a depth of about 12 meters more so than large ships with a capacity of 35,000 DWT can still dock at sea. high tide conditions but at the lowest low tide, large ships are not recommended to dock.

## 5 ACKNOWLEDGEMENT

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