



## Analysis of Loading and Unloading Productivity on Berth Utility at the Multipurpose Terminal Teluk Bayur Port

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**Abstract:** The Purpose of this study is to analyze the ability of loading and unloading productivity and the time of ship berthing in influencing the berth utility at The Multipurpose Terminal Teluk Bayur Port. This study was designed with quantitative research methods for testing hypotheses using the regression analysis method of secondary data collected by 36 samples. The results of the study found that loading and unloading productivity and berthing time significantly of affected 71.3% on berth utility. The rest is done by controlling the ratio of effective time to berthing time so that it remains above 70% by reducing idle time and not operation time, so that berth utility is achieved according to the standard BOR that has been set.

**Keywords:** Loading and Unloading Productivity, Berthing Time, Berth Utility, Effective Time

### INTRODUCTION

Port is an infrastructure which is provided as an inter-island transportation infrastructure that is open to serve ships crossing the waters of the archipelago, including the activities of foreign ships in a series of cargo distribution and international trade.

Therefore, port infrastructure must be provided with adequate capacity to accommodate every ship visiting from various regions and countries. The infrastructure is also provided for cargo handling activities, both cargo loading and unloading activities and cargo storage activities while waiting for reloading to the next transportation.

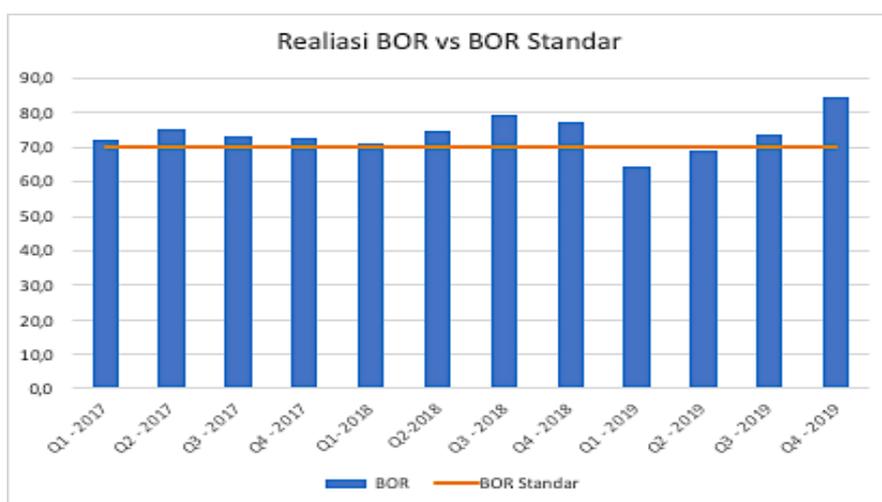
Based on data in 2010-2019 from Badan Pusat Statistik (BPS), in total the flow of domestic and foreign ships called to ports in Indonesia grew on average by 1.47%. The flow of unloaded cargo in domestic and foreign trade grew an average of 7.98% and the flow of cargo loaded through ports in Indonesia grew by an average of 7.66%.

The ships call at the port is an indicator to describe the hectic of port activities. The increase in the flow of ship visits has resulted in pressure from port management to improve

port performance by ensuring that the available berth facilities can be used for ships berthing and carry out loading and unloading activities in a series of cargo distribution at the port.

To control the use of available berth facilities, port management implements operational controls related to the performance of the utilization of berth facilities, one of which is the Berth Occupancy Ratio (BOR). Berth Occupancy Ratio (BOR) is an operational performance indicator that is used to measure the level of usage of berthing facilities at the port.

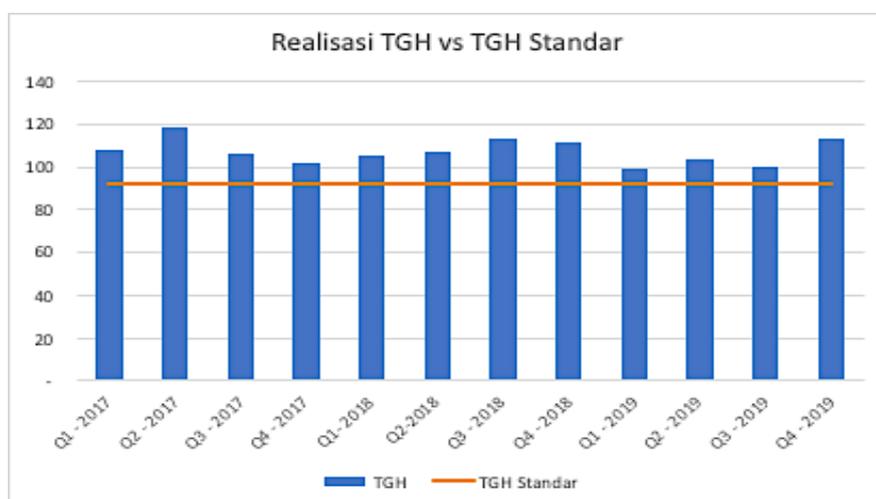
Based on the operational performance data of the Multipurpose Terminal at Teluk Bayur port for the period 2017-2019, the average berth utility (BOR) reached 74% or above the BOR performance standard of the Director General of Sea Transportation of the Republic of Indonesia (called DGST) which was 70%, as shown in Figure 1.



Source: Teluk Bayur Port Operational Performance Report

**Picture 1. BOR realization graph with DGST performance standard BOR**

The BOR achievement indicates that The Multipurpose Terminal Teluk Bayur Port is experiencing congestion at the berth facilities from ship berthing activities and cargo loading and unloading activities at the berth. This condition will affect the queue of ships waiting for their turn to berthing at the berth.



Source: Teluk Bayur Port Operational Performance Report

**Picture 2. TGH realization graph with DGST performance standard TGH**

On the other hand, loading and unloading productivity (TGH) was recorded at an average of 107.4 TGH for all commodities unloaded and loaded from and to ships. This achievement exceeds the average TGH standard set by DGST of 92 TGH as shown in Figure 1.2. This achievement indicates that the Multipurpose Terminal shows good performance.

The Condition shows that the increase in loading and unloading productivity (TGH) does not have an impact on decreasing ratio of berth utility, and it shows differences from the previous studies which told that an alternative to reduce the level of dock use or dock utility by improving the loading and unloading performance by focusing on TGH (Simanjuntak *et al.*, 2019).

From this description, the author finds that there is a gap phenomenon between the results disclosed in previous research and the realization of the operational performance of the Multipurpose Terminal Teluk Bayur Port, especially on the recommendations that need to be made as an effort to fulfill the conventional berth utility standards (level of use of the berth) set by the Director General of Sea Transportation of the Republic of Indonesia.

### **Research Problem Formulation**

1. How does loading and unloading productivity affect the length of time the ship stays at the berth?
2. How does the length of time the ship stay at the berth affect the utility of the berth?
3. How is the effect of loading and unloading productivity at the berth on the utility of the berth?
4. How does the ship berthing time and productivity of loading and unloading at the berth affect the utility of the berth?

### **Research Purpose**

1. Analyzing the effect of loading and unloading productivity on the length of time the ship is in berth;
2. Analyze the effect of the length of time the ship stays at the berth on the utility of the berth;
3. Analyzing the effect of loading and unloading productivity at the berth on the utility of the berth; and
4. Analyzing the effect of berthing time and loading and unloading productivity at the berth on the utility of the berth.

## **LITERATURE REVIEW**

### **Berth Utility**

Berth utility is a port operational performance to measure the extent the berth facilities which are used intensively. The berth utility is shown by the Berth Occupancy Ratio (BOR) indicator. It is a comparison between the amount of time used for available berth with the available time for one period and expresses in percentages (Triatmodjo, 2010). Berth Occupancy Ratio (BOR) as a measurement of the level of port infrastructure utilization depends on the number of moorings (Layaa dan Dullaert, 2014), so the Berth Occupancy Ratio (BOR) can be calculated with different approaches according to the type of mooring in a port.

#### **a) Single Mooring**

It is a port facility which only has one mooring. The use of this type of berth is not affected by the length of the ship (LOA) or the length of the available berth, so the Berth Occupancy Ratio (BOR) is calculated using the following formulation:

$$BOR = \frac{\sum \text{Berthing time}}{\sum \text{Available time}} \times 100\%$$

Where,  $\sum$  berthing time is obtained from the calculation of the total berthing time of all number of ships mooring at the pier in certain period.

b) Continuous Mooring

Is a berth facility that has more than one mooring. the use of the pier in this mooring is strongly influenced by the length of the pier and the length of the ship (Length Over All = LOA) ,plus 5 meters as a security distance between ships (front and back of the ship). In addition, the use of the pier is also influenced by the length of the pier, so that the BOR can be calculated using the following formulations:

$$BOR = \frac{\sum (LOA+5) \times \text{Berthing time}}{\text{Length of Berth} \times \sum \text{Available time}} \times 100\%$$

c) Betel Stacking

Betel Stacking is a Berth facility that is used for ships that are moored in betel position. The ship that is moored is not in the position of the hull attached to the pier wall but only as a small part of the ship attached to the pier wall, namely the bow of the ship. The calculated pier length does not follow the length of the ship, but the actual length of the mooring used, so the BOR calculation uses the formulation

$$BOR = \frac{\sum (\text{length of usage of berth} \times \text{Berthing time})}{\text{Length of berth} \times \sum \text{Available time}} \times 100\%$$

According to Triatmodjo (2010) Berth Occupancy Ratio (BOR) is strongly influenced by several parameters, they are: the type of cargo handled at the berth, ship size, loading and unloading productivity, working gang number (working team), length of berth, effective working days and spare working time while the ship is in berth.

Based on the Decree of the Director General of Sea Transportation of the Republic of Indonesia Number: UM.002/38/18/DJPL-11 of 2011 concerning Port Operational Service Performance Standards, that the standard BOR value for operated berth is 70% as the maximum allowable BOR value.

If the BOR value is more than the standard BOR value set (>70%) ,it indicates congestion and a decrease in service, and if the berth usage rate is low (<50%), it indicates a lack of utilization for the available facilities (Mwasenga, 2012). Triatmodjo (2010) stated that when a berth facility has Utilities with a BOR > 70, it indicates that the condition of the berth is congested and it is possible for the ships to moor waiting until the pier available. This will certainly have an impact on the cargo distribution at the port.

**Loading and Unloading Productivity**

Productivity of loading and unloading is the level of ability and speed of carrying out handling of cargo unloading activities from the ship to the warehouse or stacking yard and for cargo loading activities from the warehouse / stacking field to the ship (Gurning dan Budiyanto, 2007).

The level of capability and speed of carrying out the handling of cargo loading and unloading activities is indicated by the following indicators:

- a) Ship Output, is an indicator to measure the total tonnage of cargo handled on one ship during service time. Ship output is measured by several approaches, including:

- 1) Tonnes per ship working hour, is the average tonnage of cargo handled during the ship working hours.
  - 2) Tonnes per ship hour at berth, is the average tonnage of cargo handled during the ship berthing time.
  - 3) Tonnes per ship hour in port, which is the average tonnage of cargo handled during the time the ship is in port.
- b) Gang Output (Tonnes per gang hour) or TGH, is the average tonnage of cargo handled by a team/workgroup/crane in a certain time interval for each ship, usually in one effective working hour (effective time). This indicator is commonly used to measure loading unloading productivity associated with loading and unloading human resource productivity. Productivity of loading and unloading is calculated by the formulation:

$$\text{TGH} = \frac{\text{total tonnage handled}}{\text{total geng x effective time}}$$

- c) Crane Output (Boxes per crane hour) or BCH, namely the average number of loading and unloading of container achieved per effective working hour and carried out by container loading unloading equipment. This indicator is generally used to measure the productivity of loading and unloading of cargo by type of container packaging.
- d) Berth Throughput (BTP), which is an indicator to measure the total tonnage of cargo handled at a berth in a certain period.

### **Berthing Time**

According to Gurning and Budiyo (2007), berthing time is the time used for the ship to moor at the berth to carry out loading and unloading activities which is calculated from the first rope is tied up to the berth until the last mooring rope is released from.

Berthing time is an indicator of ship service performance, specifically used to measure the time of using the berth while the ship is in port. There are some indicators in the service of the ship while mooring, they are :

- a) Effective Time (ET) is the time actually or effectively used to carry out loading and unloading activities while the ship is moored. This indicator is expressed in units of Hours.
- b) Not Operation Time (NOT) is the time used by the ship while mooring and it is out of the time for handling loading and unloading activities, for example, lunch break for all the workers and also equipment operators, ships waiting time to depart and/or time provided for physical inspection (calculation of cargo volume) results of loading and unloading activities by surveyors. Generally, the amount of time specified as Not Operation Time (NOT) has been calculated in the ship service planning process before the ship arrives.
- c) Idle Time (IT) or wasting time is the time wasted in handling loading and unloading activities caused by several things that are categorized as operational obstacles such as :truck waiting time to receive cargo from ships, waiting for cargo to be loaded onto ships, equipment damage in loading unloading process, bad weather ( rain ), and delays in the document completion process.

## **RESEARCH METHODS**

### **Research Design**

This study used quantitative research method. This is done by considering the objectives of this study, in determining the effect of the variables. There are two variables. First, loading unloading productivity and berthing time as independent variables and second, berth utility or berth usage rate as dependent variable.

### **Population and Research Sample**

The population in this study is a number of events from all operational activities in Teluk Bayur Port since the port was operated until present. These activities include ship docking activities and handling loading and unloading of cargo from and/or to ships at conventional berth.

The number of samples is decided by considering the terms that in multivariate research (including regression analysis) the sample size must be ten times larger than the number of variables to be analyzed. Therefore, for the convenience and smoothness of this research, the writer decided to take 36 samples, in order to consider the number of independent and dependent variables.

### **Data Collection**

This study used The form of secondary Data. The data was taken from master data on the operational report of Loading and Unloading services of Multipurpose Terminal in Teluk Bayur. Data Collection is done by having documentation method, by recording data related to the problem from the data sources and sites that provide research information. The data process that is done by the writer is by recording or duplicating the loading and unloading operational service data in Multipurpose Terminal. It is documented by Teluk Bayur Port Management.

### **Data Analysis Method**

For Data analysis , this study used the inferential statistical analysis method to find out the established hypotheses related to the influence between the variables studied with a causal approach. Data analysis was carried out with the following stages:

- a) Variable Description
- b) Classical Assumption Test
- c) Linear Regression Analysis

## **FINDINGS AND DISCUSSION**

### **Research object**

The research was conducted on port services related to the provision and business of berth facilities for ship berthing activities and handling of loading and unloading of cargo at the Multipurpose Terminal Teluk Bayur Port.

### **Descriptive Variable Analysis**

Based on the results of data processing, it is explained that the average (mean) Pier Utility or Pier usage rate (BOR) at the Teluk Bayur Multipurpose Terminal in 2017 – 2019 was recorded at 74.08% with the highest BOR (max) reaching 89% and the lowest BOR (min) recorded 53%.

In terms of berth utilization, the descriptive statistical table records that berthing time (BT) or the number of times ships mooring at the berth average (mean) reaches 6,431 hours per month with the longest time (max) reaching 8,547 hours and the shortest berthing time 4,792 hours.

Regarding to the Handling Cargo Performance, the average B/M Productivity (mean) is 107.39 TGH with the highest productivity (max) reaching 129.4 TGH and the lowest (min) being recorded at 94.2 TGH.

### **Classical Assumption Test Result**

To fulfill the requirements before conducting regression analysis, a classical assumption test was carried out to provide certainty that the regression equation obtained had

estimation accuracy and gave unbiased results. The results of the classical assumption test in this study are explained as follows:

- a) The normality test was carried out using the One Sample Kolmogorov-Smirnov method, and created a significance value (Asymp. Sig. 2-tailed) of 0.128. This value is bigger than the significance level (0.05), so it is stated that the residuals are normally distributed.
- b) The multicollinearity test that was carried out resulted in a VIF of 1.353 and a Tolerance of 0.739 for both variables, berthing time (BT) and B/M Productivity (TGH) variables. The Tolerance and VIF values of the two variables have Tolerance > 0.1 and VIF < 10, which means that the multiple linear regression equation model is stated no collinearity between the two variables of Productivity B/M (TGH) with berthing time (BT) as the variable. independent.
- c) Heteroscedasticity test was carried out using the Glejser test by regressing independent variables with absolute residuals (ABS\_RES). From the results of testing the berthing time (BT) variable has a significance value of > 0.05, which is 0.766 and the B/M Productivity variable (TGH) has a significance value of > 0.05, which is 0.968, which means that there is no inequality of variation from the residuals of all observations or heteroscedasticity.
- d) The autocorrelation test was carried out using the Durbin-Watson approach. Taking into account the significance level of 0.05 for data of n = 36 samples and the number of independent variables k = 3, look for the value of du in the Durbin-Watson table and the result is du = 1.654 which means < Durbin-Watson value (d) from the results of data processing SPSS. Then by using the formula 4 – du, obtained the value (4 – du) = 2,346. From these calculations, it shows that the Durbin-Watson (d) value of 2,122 has a value greater than the value du and less than the value (4 – du), which means that the regression model does not have autocorrelation.

**Hypothesis Test**

The basis for making decisions on the testing of the hypotheses presented in this study is carried out by considering the results of the t-test and F-test based on the results of simple regression analysis and multiple linear regression analysis conducted to assess the effect of the independent variable on the dependent variable. The results of the hypothesis tests are presented in a summary of test results as described in Table 1.

**Table 1. Hypohotesis Test Result**

Hypothesis	Hypothesis Staement	Criteria	Counting Result	Testing Result
H1	Productivity of loading and unloading (TGH) affects the time the ship is berthing at the berth or berthing time (BT).	t hitung > 2,034	t = 3,467	Hyphotesis accepted
H2	Berthing time (BT) has an effect on berth utility or dock usage rate (BOR	t hitung > 2,036	t = 6,101	Hyphotesis accepted
H3	Productivity of loading and unloading (TGH) affects berth utility or dock usage rate (BOR	t hitung > 2,036	t = 2,640	Hyphotesis accepted
H4	H4 Productivity of loading and unloading (TGH) and berthing time (BT) have an effect on berth utility or dock usage rate (BOR).	F hitung > 3,28	F = 41,052	Hyphotesis accepted

### **Result of Simple Analysis Linear Regression Discussion**

From the results of hypothesis testing of loading and unloading productivity length of time for ships berthing, the results of the t-test are obtained which states that t-count is 3.467 > t-table is 2.034 as in Table 4.13 above, so loading and unloading productivity has influenced on berthing time. The form of influence is described from the regression equation model:  $BT = 706.328 + 53.304 \text{ TGH} + e$ . This equation explains that if loading and unloading productivity increases by 1 unit, then berthing time will increase by 53,304 units. So it can be concluded that loading and unloading productivity significantly has a positive effect on berthing time.

These results are connected to previous research related to the effect of loading and unloading productivity and ship berthing time at Tanjung Emas Port. Previous research explained that there was a significant effect between loading and unloading productivity variables and ship berthing time variables (Najoan, Putri dan Nurhayati, 2017).

However, the ability of loading and unloading productivity in giving effect to berthing time is relatively low, which is only 26.1% as the result of the coefficient of determination ( $R^2$ ) test shown in the R Square column in Table 4.14 above. While the remaining 73.9% is influenced by other factors such as effective working hours (effective time), idle time and not operation time also other factors related to the use of loading and unloading equipment and the number of work teams.

### **Multiple Linear Regression Analysis Results Discussion**

From the results of hypothesis testing on the results of multiple linear regression analysis to assess the effect of berthing time and loading and unloading productivity on berth utility, there are results related to the effect of each independent variable through the t-test, as follows:

- a) That berthing time has an influence on the berth utility
- b) That the productivity of loading and unloading has an influence on the berth utility.

Furthermore, by using the F-test, the result is that F-count is 41.052 > F-table is 3.28 as described in Table 4.13 above. Thus, it is stated that berthing time (BT) and loading and unloading productivity (TGH) have a significant effect on berth utility (BOR).

The shape of the influence of three variables is described by regression equation model:  $BOR = 8.17 + 0.006 \text{ BT} + 0.264 \text{ TGH} + e$ . The equation model explains that if the berthing time increases by 1 unit and the loading and unloading productivity remains or not change, the dock utility will increase by 0.006 units. If the berthing time remains constant or not change and the loading and unloading productivity increases by 1 unit, the dock utility will increase by 0.264 units. This can be interpreted that the increasing in loading and unloading productivity will increase the dock usage ratio.

However, with the ability of berthing time and loading and unloading productivity in giving effect to the berth utility of 71.3%, there are still other factors that affect the berth utility of 28.7%. Referring to theoretical studies related to these variables, these factors can be from effective time (ET), idle time (IT) and not operation time (NOT).

From This result, it can be said that previous studies confirmed that in addition to the rate of ship visits, another factor that most influenced the BOR value was berth time. To meet the BOR value according to port utility standards, which is 70%, it can be done by speeding up the berthing time (Widyarti, Rinaldi dan Fatnanta, 2017). Although not specifically confirming the effect, previous research also revealed that to meet the conventional jetty utility standard of 70%, it can be done by shortening the berthing time or berthing time of the ship by paying attention to TGH (Simanjuntak et al., 2019).

### Discussion on Evaluation of Simulation of Linear Equation Models.

Related to the factors that can affect the berth utility as described above, to get an overview, an evaluation is carried out using multiple linear regression equation models and formulations related to berthing time and loading and unloading productivity on the following data:

- Cargo Handled = 385.288 (average permonth in 2017 – 2019)
- Produktivitas B/M = 107,4 (according to descriptive variable)
- Berthing Time = 6.431 (according to descriptive variable)
- ET/BT Standart = 70% (according to DGST regulation)

As the following results:

1. Assuming the number of gangs = 1 in data processing using the formulation:

$$\text{Effective Time} = \frac{\text{Tonase Handled}}{\text{Jumlah Geng} \times \text{Produktivitas B/M}}$$

$$\text{Effective Time} = 3.588 \text{ Jam} \Rightarrow \text{ET/BT} = 56\% < \text{ET/BT Standar}$$

2. By using the formula:  $\text{BT} = \text{ET} + \text{IT} + \text{NOT}$ , then taking into account the results of ET/BT, then  $\text{IT} + \text{NOT} = 6.431 - 3.588 = 2.844$  Hours is equivalent to 44% East. These results explain that the high berthing time is caused by the high idle time (IT) and not operation time (NOT) which are grouped as ineffective time.
3. In order to obtain dock utility in accordance with the provisions of DGST performance standards, it is necessary to reduce idle time and not operation time to 1,538 Hours so that berthing time is reduced to 5,125 Hours and the ratio of effective time to berthing time (ET/BT) is 70% in accordance with ET/BT DGST performance standard.
4. So by using a multiple linear regression equation model such as the formulation:  $\text{BOR} = 8.17 + 0.006 \text{ BT} + 0.264 \text{ TGH} + e$ , where  $\text{BT} = 5.125$  and  $\text{TGH} = 107.4$  then the Berth Occupancy Ratio (BOR) is 67% or below the Standard BOR DGST performance.

Thus, in order to achieve berth utility in accordance with the BOR DGST performance standards, increasing in loading and unloading productivity must be achieved by reducing the ineffective time while the ship is berthing, such as: idle time and not operation time, so that the ratio of effective time and berthing time can be maximized above 70%.

## CONCLUSION AND RECOMMENDATION

### Conclusion

Based on the results of simple and multiple linear regression analysis to assess the effect of the variables in this study, after a series of hypothesis testing, this study concludes the following:

- a) That loading and unloading productivity (TGH) significantly affects the berthing time (BT). If there is an increase in loading and unloading productivity (TGH) by 1 unit, then berthing time (BT) will increase by 53.304.
- b) Whereas berthing time (BT) has a significant effect on the berth utility or berth occupancy ratio (BOR). If there is an increase in berthing time (BT) by 1 unit, the berth occupancy ratio (BOR) will increase by 0.006 provided that the loading and unloading productivity (TGH) has no value.
- c) That loading and unloading productivity (TGH) has a significant effect on berth utility (BOR). If there is an increase in loading and unloading productivity (TGH) by 1 unit, the berth utility (BOR) will increase by 0.264 provided that berthing time (BT) has no value.
- d) Whereas berthing time (BT) and loading and unloading productivity (TGH) have a significant effect of 71.3% on the berth utility or berth occupancy ratio (BOR). The achievement of high loading and unloading productivity (TGH) will have an impact on the berth utility in accordance with the DGST performance standard BOR, if the ratio of effective time (ET) to berthing time (BT) is  $> 70\%$ .

## Suggestion

Referring to the results of the analysis and discussion of the operational performance data of Multipurpose Terminal Teluk Bayur Port, it is suggested to the port management the following matters:

- a) In carrying out loading and unloading activities while the ship is berthing at the berth, in addition to carrying out operational control related to loading and unloading productivity, monitoring of the utilization of service time while the ship is berthing at the berth is carried out. This is because the achievement of high loading and unloading productivity will not have an impact on optimizing the level of dock usage, if the ET/BT composition is achieved below 70%.
- b) To optimize berth utilities in accordance with the performance standard BOR set by the DGST, management should try to minimize unproductive time in loading and unloading activities while the ship is moored at the dock, such as resting time which tends to exceed the normal rest time specified.

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