DEVELOPMENT OF RULES-REGULATIONS FOR SHIP INTENDED TO SAIL IN DOMESTIC INDONESIAN WATERWAYS: Effect of Storm model

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**SUMMARY**

Kurniawan et al (2016) propose the zonation system of Indonesian water from the basis of oceanographic history. This zonation system will be introduced and be proposed to replace the common service area that is used by Indonesian Administrator and their recognized organization. Prasetyo et al (2017) conducted comparison study of storm history in the two different area with the equator line basis position. The study was analyzed the storm in the sub tropical area and that of sub – tropical area. The sub-tropical area is represented from North Atlantic and North Pacific Ocean, where the tropical area is presented with Indonesian waterways and near territory waters. In this paper, effect of comparison study of storm in Indonesian water in term of proposed zonation system by Kurniawan et al, will be discussed. The possibility of strengthen of zonation system from storm study are examined.

## 1. INTRODUCTION

The safety and security shipping are mandatory aspect that should be fullfiled by all stakeholder maritim industries (shipping company, flag/port administrator, recognized organization. Indonesian Shipping act no. 17 2008 [1] mentioned that safety and security shipping consist of safety and security of shipping activities while in navigation voyage, port and include with environmental protection. Based on forementioned sentence, the ship seaworthiness becomes one aspect that suport the fullfillment of the safety and security shipping. The ship seaworthiness is dependable to the operating area, and the operating area is denoted with 'Service area" notation that is defined from Flag Administrator or recognized organization.

The Biro Klasifikasi Indonesia – BKI is Indonesian classification society that is one of Organization recognized by Indonesian goverment to conduct survey and statutoria certification on be half Indonesian goverment for Indonesian Flagged ships [2]. To support this recognization, BKI develop its own rules and regulation on basis of many aspects include with the ship operation area. Since that BKI's vessel have operating area in worldwide voyage (international trading) and/or Indonesian waterways voyage (Indonesian domestic trading).

The ship's operating area is reflected to the Service area notation from Class society that is recognized organization of FlagState Administrator. The example of service notation that it qoutes from BKI rules for classification and construction for seagoingships, Rules for Classification & Survey [3] is shown as Figure 1. The Service notation with "Unrestricted Service" means that ship will operated for all global oceans, seas and waters area. The restricted ocean service (**P**) is limited to ship having operating area only from range of 200 nautical miles from nearest port of refugess. 50 nautical miles is ranging area for coastal service (**L**) and the rest of shallow water service is area with calm seas harbours, bays and others typical areas. These service areas are based on North Atlantic ocean enviromental conditions [4, 5].

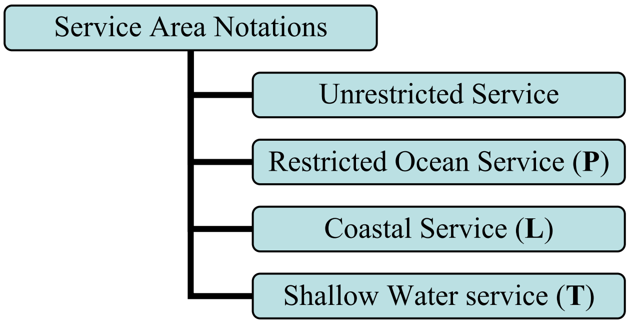



Figure 1, The Service area notation based on BKI Rules [3]

Since that the basis environmental of North Atlantic ocean might be extreme when used for the basis of Indonesia domestic trading, Kurniawan et al [6] compared three different zone in order to collect the actual condition of ocean environmental, and proposed the zonation system of service area dedicated for Indonesian waterways. Furthermore, Prasetyo et all [7] studied the applicability of storm model for the Indonesian tropical ocean. The historical wave data and storm data might be used as prime data for the development of service area that its dedicate to Indonesian water. In this paper, the effect of storm data in conjuction with wave height histories are analyzed and discussed.

The paper is organized as the following: Sect.2 presents the oceanographic data used in both study. Section 3 presents the analysis proses of oceanographic data,. Section 4 presents the obtaining results and discussion, and finally, the conclusion is given.

## 2. OCEANOGRAPHIC DATA

The development of service area definitioan is based on the actual condition of ocean. The actual condition of Ocean could be represented from the oceanograhic data collecting. The oceanograhic data has variation source, there are visual observation, instrumental observation, hind-cast data. The visual observation is performed from onboard or from coastal station inshore, while instrumental observation is provided from instrument measurement (buoy, wave radar, satellite). Thus, hind-cast data is a numerical model integration of both of observation data and instrumental data where no observation are recorded. The procedure to gather all observation data are under supervision of World Meteorological Organization (WMO) [8]. Recently, the oceanograhic data is mainly provided from the generation of the hind-cast model. Many study support the accuracy of hind-cast model, and that of collected from visual observation, instrument observation as well as buoy data or satellite data [9].

In this study, the oceanographic data that collected from hindcast data of European centre for medium-range weather forecasts (ECMWF)[10], is significant wave heigh, $H_W$; mean period, $T_W$ and wave direction, θ. The data was collected for more than 30 years (1979 – 2015) within 4 times per days (06.00am, 12.00am, 18.00pm, 24.00pm). The data of Indonesian waterways is utilized from ranging area between 90°E to 140°E and 10°N to 10°S (see Figure 2).


Figure 2 The map of area of Indonesian waters that is used for data collecting. [Source: Google Earth].

## 3. ANALYSIS OF OCEANOGRAPHIC DATA

3.1 (a) TIME HISTORY OF WAVE HEIGHT

Kurniawan et al [11] conducted study in order to develop the wave scatter map for Indonesian waterways (see Figure 3). Based on this map, the service area **P**, **L**(50) and **L**(20) are plotted. The $H_W$ history of selected data points for each selected service area are analyzed based on 0.75degree and 1.0 degree lattice in order to simplify the numerical analysis. The total selected data location is ± 13800 points.

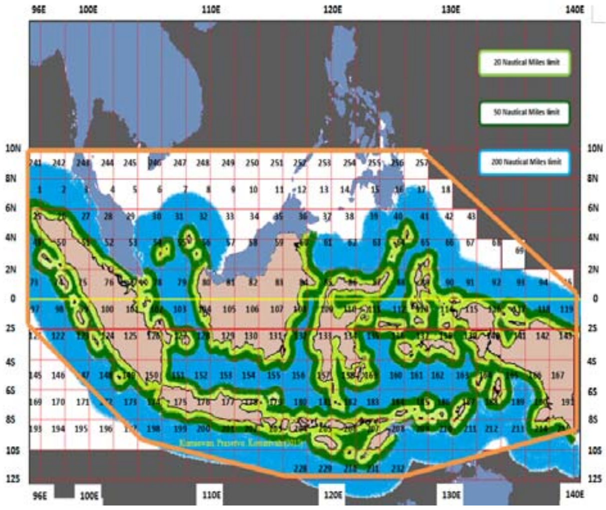
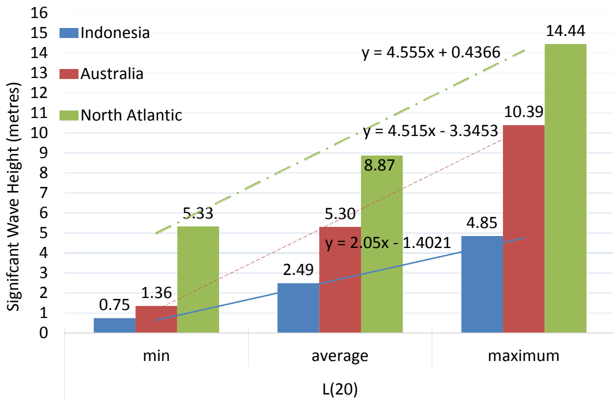
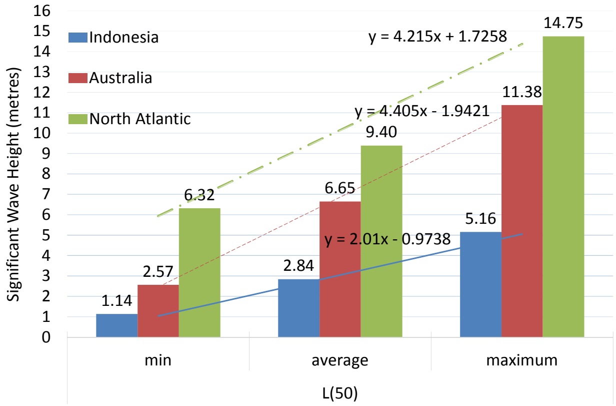



Figure 3 Wave scatter map of Indonesian waterways. The plotting of Service area based on Classification Society Rules[3].




(a) Comparative result for **L**(20)




(b) Comparative result for **L**(50)

Figure 4 Comparison Three water area, North Atlantic Ocean, Australian waters, Indonesian waters. (a) is the result for service area **L** with 20 nautical miles from coastal, and (b) is that of 50 nautical miles.

The selected locations on each service area of Indonesian water also compared by [6] with North Atlantic Ocean and Australian waters. Generally, it is reported that ratio between North Atlantic Ocean and Indonesian waters is 4. Thus, the ratio between Australian waters and Indonesian waters is 2.

In deeply discussion, as seen on Figure 4, the comparative of three different water area at two range of service area **L** are given. Two different coatal range of L are plotted, these are 20 nautical miles and 50 nautical miles. These figures show the comparative of trendline of minimum to maximum $H_W$ include average of $H_W$ for each water area. It is found that both of North Atlantic and Australian waters have the same gradients, that is about 4.2 to 4.5. The gradient of Indonesian waters is about a half of either of North Atlantic Ocean and Australian waters.

The above paragraph indicates that the application of service area by using the basis of North Atlantic ocean may not be suitable if they are applied at Indonesian waters.

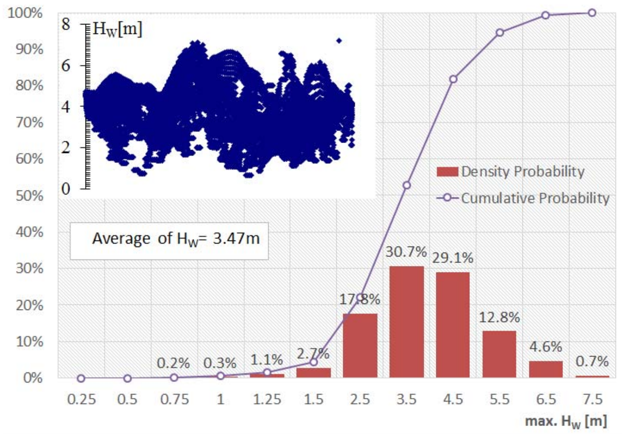



Figure 5 The histogram of $H_W$ distribution on Indonesian waters [Figure 3]. The $H_W$ distribution is also detailed.

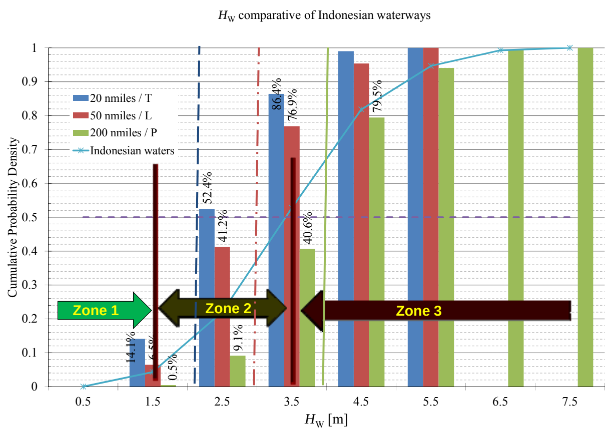



Figure 6 The comparative of $H_W$ on service area (**P, L, T)** of Indonesian waters. The proposed zone condition also be drawn.

3.1(b) PROPOSED ZONATION AREA

Kurniawan et al [6] analyzed the time history of $H_W$ at data locations with 43680 points. Figure 5 shows histogram of $H_W$ distribution on Indonesian water, in which the range of $H_W$ distribution also be plotted. The distribution of $H_W$ is ranged from 0.68 meter to 7.23 meter, with average value is 3.47 meter. The distribution 's coeficient of variance is 0.34. The histogram shows 1meter discrete of $H_W$, exclude $H_W$ which is lower than 1.5 meter, the 0.25meter discrete is applied. This figure shows that $H_W$ ranges from 3.5 meter to 7.5 meter have population, 47.25%. The $H_W$ ranges from 1.5 meter to 3.5 meter have populuation, 52.75%.

Furthermore, Figure 6 shows the comparative of $H_W$ on Indonesian waters. The discrete 1meter $H_W$ is also applied. The service area (**P, L, T**) on Indonesian waters are displayed. Based on the last report of Kurniawan [6], the average of $H_W$ on the service area **P, L, T** are 3.74 meter, 2.84 meter and 2.49 meter. If it is compared with all Indonesian waters, 60% $H_W$ in **P**, 23% $H_W$ in **L** and 14 % $H_W$ in **T** are located on cluster with $H_W$ larger than 3.5meter. The ranged '1.5 meter $\leq H_W \leq$ 3.5 meter' consists of 35% $H_W$ of **P**, 70.5% $H_W$ of **L** and 71.9% of **T**. Thus, The ranged "$H_W$ < 1.5 meter" consists of 0.5% of **P**, 6.5% of **L** and 14.1% of **T**.

It is concluded that the $H_W$ could be clustered in three categories. The clustered system is defined on Table 1.

Table 1 The definition of zone clustering systems [6]

| Zone | Definition |
|---|---|
| I | $H_W$ < 1.5 meter |
| II | 1.5 meter $\leq H_W \leq$ 3.5 meter |
| III | 3.5 meter < $H_W$ |

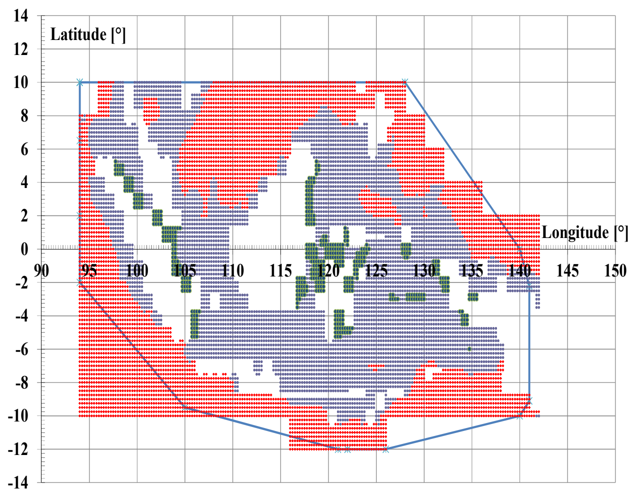



Figure 7 The mapping of point locations of Indonesian waters based on zone clustering as define in Table 1.

The combination of data locations of the source that is used in measurement of $H_W$ and that of zonation area based on clustering system of Table 1 is plotted in Figure 7. This figure shows the graphical border and separation of zone clustering system in point view of maximum $H_W$ around Indonesian waters. This figure describes zones separation with different colour. Zone I is by green colour, Zone II is by blue colour and Zone III is by red colour.

## 3.2 STORM MODEL ANALYSIS

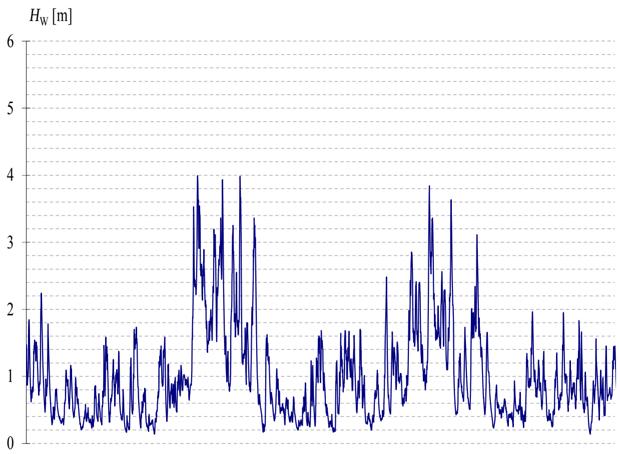



Figure 8 Typical time histories of $H_W$, which is used to generated storm model.

In the study of the extreme condition of ocean in tropical/ equator region, Prasetyo et al [7] developed the analyses system based on storm model. The Indonesian waters is choosed as representation of the tropical/equator region. The storm profil is generated from time history of $H_W$ in the selected locations as described in previous paragraph. The example of typical time history of $H_W$ is shown as Figure 8.

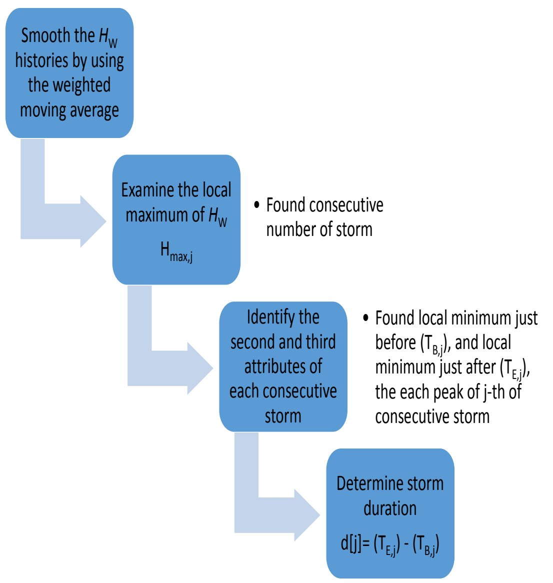



Figure 9 Storm profile analzing procedure

The storm profile is examined from the changing nature of $H_W$ time histories by using specific procedure [12]. The procedure could be drawn as Figure 9. The storm profile will be identified based on storm class. Storm class is maximum local $H_W$ ($H_{max,j}$), that is identified during storm generation as described in Figure 9. The storm class is considered with integer number and discrete it every 1 meter.

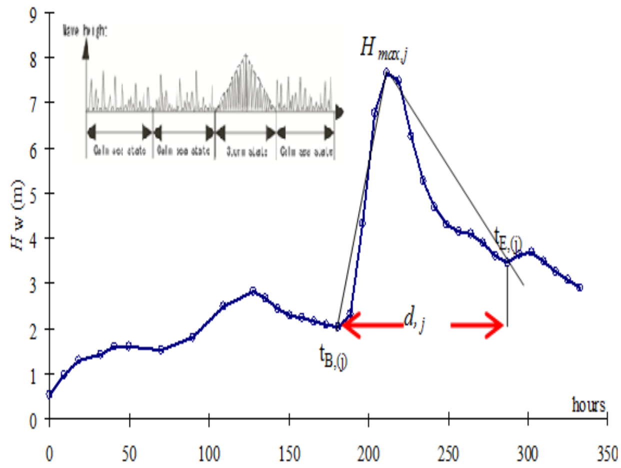



Figure 10 The storm definition based on Equivalent triangular storm [12].

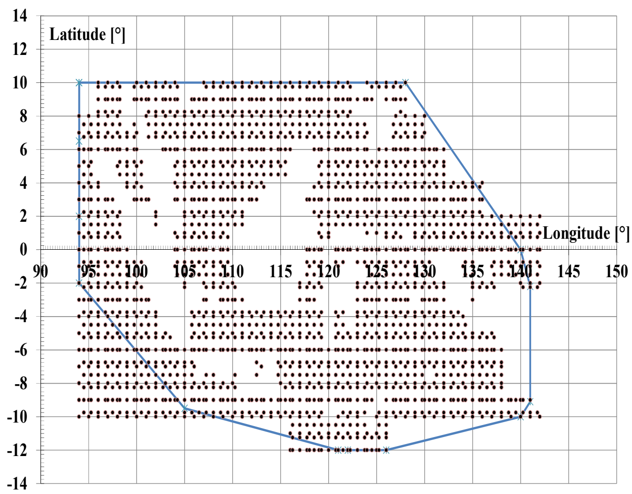



Figure 11 Point location that the storm is identified at the chosen location of Indonesian waters.

The results, Prasetyo [7] reported that the storm is not identified at all point locations (see Figure 11). The number of storm class occurs in 1936 points from 43680 points. The identified storm/ extreme wave condition on Indonesian waters is ilustrated in Figure 12. The average duration of storm in Indonesian waterways ranges from 2.0days to 2.857days, with the maximum duration is ranging from 3days to 8.75days and minimum duration is about 1.25days. The storm duration fluctuation could be regressed by using the linear interpolation of lognormal of exceedance probability, as present in Figure 13.

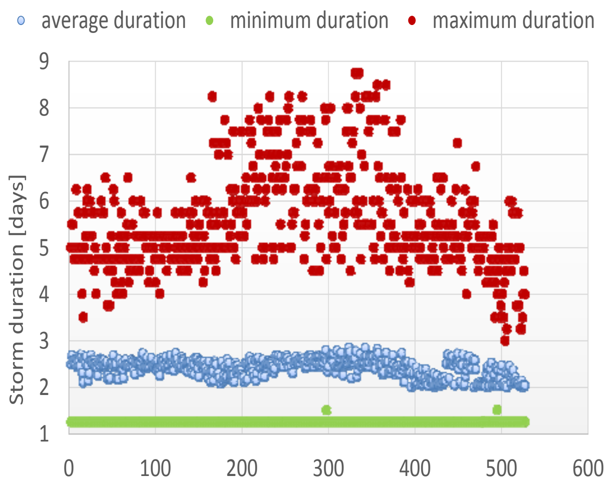



Figure 12 Identified storm duration on Indonesian waters

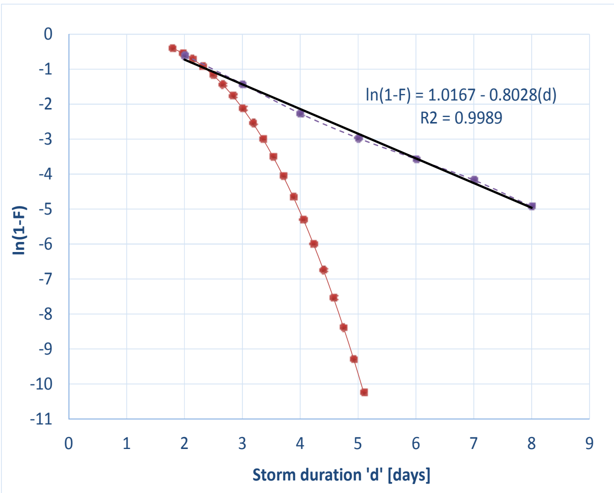



Figure 13 The regressed storm duration on Indonesian waters

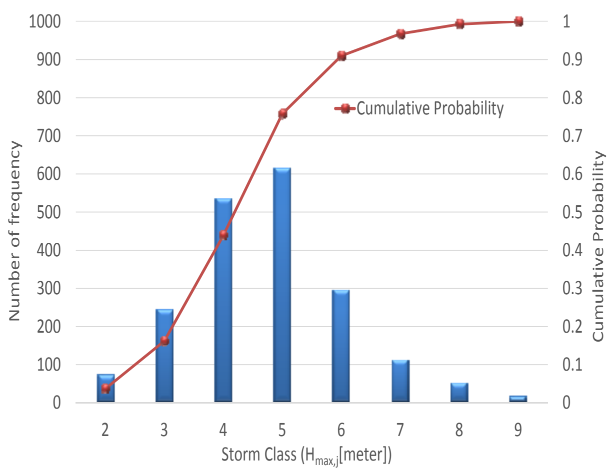



Figure 14 Histogram of maximum storm class from identified points locations along Indonesian waters. The cumulative probability distribution is plotted.

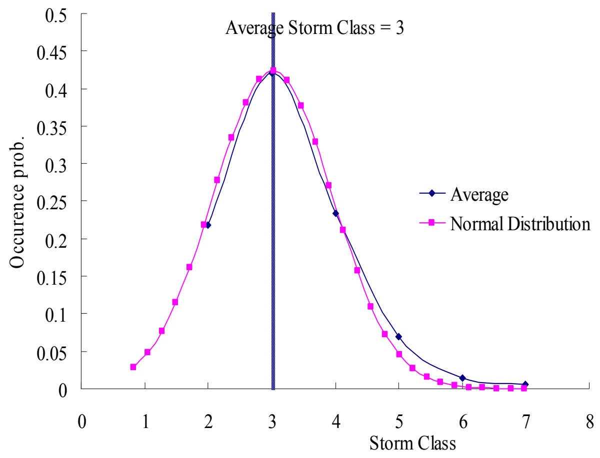



Figure 15 The regressed storm classes on Indonesian waters

It also be reported that the storm is profiling from cresecendo de crescendo of storm class, while the histogram of storm class are figured in Figure 14. The minimum of storm class is 2 meter and maximum of storm class is 9 meter. Furthermore, the statistic characteristic or value of storm class that identified on Indonesian water could be distributed by using Normal Distribution. Figure 15 shows the regressed Normal distribution and that of occurence probability for all storm classes, and it is fitted in good agreement.

## 4. DISCUSSION

From above paragraph, the maximum $H_W$ and storm class for each data locations could be generated. The wave height histories are clustering based on Table 1. Since that the storm profile is consist of crescendo de crescendo of wave height (see Figure 16), it is also noted that storm class could also be clustered as well as the wave height histories.

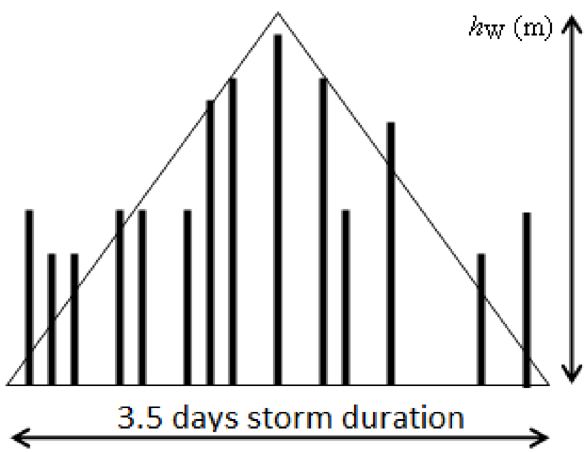



Figure 16 Typical storm profile

Figure 14 indicates that the majority distribution of storm class occurs while it is larger and equal than 4 meter storm class. It is denoted with Class A. The other storm class group is distributed when storm class is ranging from 2 meter to 4 meter. This is denoted with Class B. The all groups of storm class location are shown in Table 2.

Table 2 Storm class group point location

| Notes | Points | Longitude | Latitude |
|---|---|---|---|
| Class A | 9216 | 94°E | 10°S |
| | 10240 | 96°E | 4°N |
| | 10974 | 97.5°E | 6°N |
| . . . | | | |
| Class B | 10239 | 96°E | 3.75°N |
| | 10240 | 96°E | 4°N |
| | 10953 | 97.5°E | 0.75°N |
| . . . | | | |

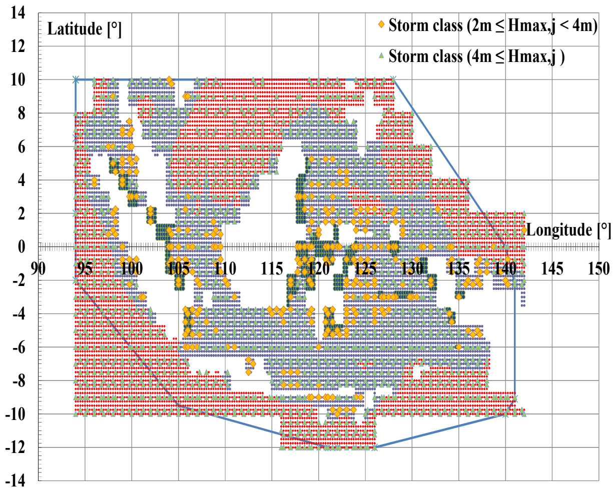



Figure 17 Plotting of storm classes for each longitude and lattidue locations.

Table 3 Correlation between $H_W$ histories and storm class cluster.

| Cluster | $H_W$ histories | Storm Class ($H_{max,j}$) |
|---|---|---|
| I-C | $H_W < 1.5$[m] | --------- |
| II-B | 1.5[m] $\leq H_W \leq$ 3.5[m] | 2[m] $\leq H_{max,j} <$ 4[m] |
| III-A | 3.5[m] $< H_W$[m] | 4[m] $\leq H_{max,j}$ |

Based on storm class grouping and its locations, all storm class locations are plotted in Figure 17. Two group of storm classes are plotted, that is group A and group B, as described in previous paragraph. The maximum wave height for each point locations also be plotted in this figures. It is shown that storm classes with group B (2m $\leq H_{max,j} <$ 4m) is identified in the same locations with points of zone I and II of Table 1. On the other group, group A of storm Classes, its identify with that of points of zone III of Table 1. It is concluded that the cluster of storm classes be identified in Indonesian waters may be clustered as the same as wave height histories [Table 1]. The clustering system of both of wave height histories and storm class is described on Table 3. The illustration of joint cluster between wave height history and storm class is shown as Figure 18. This figure shows that the joint cluster is in line from the cluster II – B and III – A. This means that two clusters are medium and high severe area. The calm area become the cluster I- C.

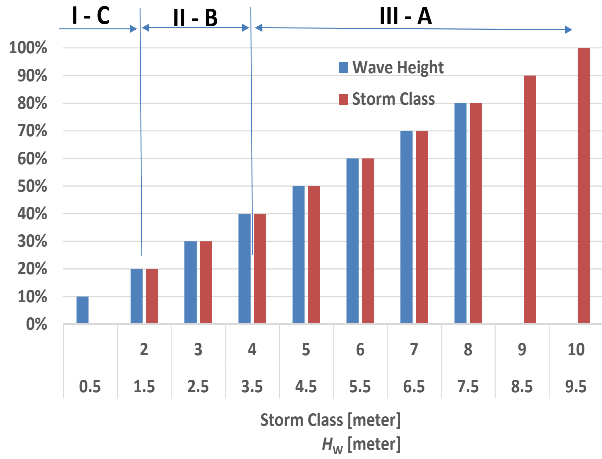



Figure 18 Ilustration of the correlation between $H_W$ and Storm class cluster.

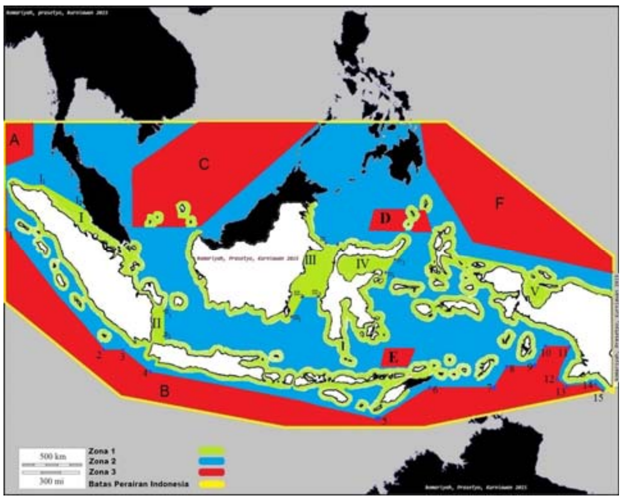



Figure 19 The proposed service area of Indonesian waterways, based on zonation system [6].

In connection with, wave height histoy, storm class and service area on the zonation basis, it could be concluded as following:

a. Time histories of $H_W$ at Indonesia waterways are examined, and its compare with that of North Atlantic Ocean and Australian waters.

b. The cluster of $H_W$ at Indonesian waterways is proposed and it consists 3 cluster based on $H_W$:
  i. $H_W < 1.5$m
  ii. $1.5\text{m} \leq H_W \leq 3.5$m
  iii. $3.5\text{m} < H_W$

c. The storm/extreme wave occurs in Indonesian waters is identified by using storm model. The storm model has each storm profil that identify by using storm class. The cluster of storm is divided based on two conditions, that is:
  i. $H_{max,j} < 4$m
  ii. $4\text{m} \leq H_{max,j}$

d. The characteristics of Indonesian waters on the wave height histories, storm duration and storm class have widely range of scatter.

In combination with ship service, distance from coastal/ range of refuge, the Indonesian water enviromental and its analysis, it is concluded that service area based on zonation system could be applied on Indonesian waters as be shown in Figure 19.

## 5. CONCLUSIONS

The study on rules regulation development intended to ship sailed on Indonesian waters has been established. The continuity of work is started from wave scatter map analysis, comparative study on the three different waters; North Atlantic Ocean, Australian water and Indonesian waters. Thus, it is continued by work on extreme wave condition in Indonesia water as a part of equator/ tropical area.

The current work gives the joint cluster group for both of wave height histories and storm class, as representation of analysis on Indonesian waters as well as the extreme wave condition, as following :

| | | |
|---|---|---|
| I-C | $H_W < 1.5$[m] | |
| II-B | $1.5[\text{m}] \leq H_W \leq 3.5[\text{m}]$ | $2[\text{m}] \leq H_{max,j} < 4[\text{m}]$ |
| III-A | $3.5[\text{m}] < H_W[\text{m}]$ | $4[\text{m}] \leq H_{max,j}$ |

Finally, the service area based on zonation system is proposed to be implemented for Indonesian domestic voyage.

## 8. ACKNOWLEDGEMENTS

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## 9. REFERENCES

1. Undang-Undang Republik Indonesia, Nomor 17 Tahun 2008, tentang Pelayaran, 2008.

2. Direktorat Jenderal Perhubungan Laut, DJPL, Surat Keputusan Direktur Jenderal Perhubungan Laut Nomor PK.204/1/3/DJPL-16 tentang Penunjukan Biro Klasifikasi Indonesia (Persero) sebagai Recognized Organization untuk melaksanakan survey dan sertifikasi Statutoria atas nama Pemerintah pada kapal Berbendera Indonesia, 2016.

3. BKI, “Rules for Classification and Surveys, Volume I”, Rules for the classification and construction of seagoing steels ships part 1, BKI, 2016.

4. IACS, “IACS Reccomendation No. 34 Standard Wave Data”, IACS, 2001.

5. IMO MSC resolusi MSC.287(87), “Adoption of the International Goal-Based Ship Construction Standards for Bulk Carriers and oil Tankers”, IMO, 2010.

6. Kurniawan M A, Prasetyo F A, Komariyah S, “A comparison of three different water areas and its influence for development of rules regulations”, proceeding of Asian-Pacific Technical Exchange and Advisory Meeting (TEAM) 2016.

7. Prasetyo FA, Kurniawan MA, Komariyah S, Rudiyanto, Herawan T: Storm application at Indonesian Tropical Ocean, ICCSA 2017, part IV, LNCS 10407, pp.732-745, Springer International Publishing AG, 2017

8. World Meteorological Organization: ‘Guide to wave analysis and forecasting’, World Meteorological Organization (WMO) , 1998.

9. Mao W, Prasetyo FA, Ringsberg JW, Osawa N: ‘ A comparison of two wave models and their influence on fatigue damage in ship structure, proceeding of 32nd the International Conference on Ocean, Offshore and Arctic Engineering (OMAE), ASME, 2013.

10. European Centre for Medium-Range Weather Forecasts (ECMWF), www.ecmwf.int.

11. Kurniawan M A, Prasetyo F A, Komariyah S, “Study on wave scatter mapping of Indonesia waterways based on hind-cast data”, proceeding

of Asian-Pacific Technical Exchange and Advisory Meeting (TEAM) 2014, ITU published.

12. Prasetyo F A, Study on advanced storm model for fatigue assessment of ship structural member, Doctoral dissertation, Osaka University Suita Japan, 2013

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