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STUDY OF SHIP ACCIDENT FACTORS AND SHIP ROUTES CORRELATION

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Abstract: The sailing safety was a very important issue that had to be solved in Indonesia. There were accidents causing victims and material losses caused by ship operator's ignorance and less awareness on safety. The ship operator was responsible for technical matters and to guide human resources. The aim was to map the correlation between ship accident causes and particular routes. The research used the Pearson Product Moment correlation trial to map correlation between accident events to particular routes. The data used was decision report of shipping court published in 2015–2016. Then, the causes were grouped and the result showed that human factor is the main factor of accident. The accident factor had the high correlation with the location where the accident happened.

Keywords: ship accidents, accident factors, Pearson Product Moment correlation.

1. INTRODUCTION

Indonesia is an archipelago country that depends on sea transportation for the inter-island connectivity. Therefore, that linkage describes the prosperity in an area. The more connected the area, the more prosperous the area (ITS & World Bank 2012), thus the government plans a sea tolls program to increase the connectivity.

Nevertheless, the sailing safety is still being an important issue that has to be solved in Indonesia. All kinds of accident still happens that causing victims and materials loss. Legislations N.17/2008 of Indonesia Republic, about sailing clause 245 stated: ship accident is an event that threatens ship safety or human lives, those are: (a) sunk; (b) run on fire; (c) collision and (d) run aground. The factors are human error, weather, and technical factor. Based on sailing court of law in 2006, 88% is caused by human error factor, whereas natural and technical factor contributed 8% and 4% each.

In terms of this issue, the Ministry of Transportation has issued recommendations relating to accident investigation result to the four main parties of shipping transportation. Those are operator, Directorate General of Land and

Sea Transportation, harbour's administrator and ship's crew. In 2010–2016, there were only 18 recommendations given to the ship's crew while there were 102 recommendations given to the operator [Kurniawan 2017]. This fact showed that there were many ship's operators who ignored the safety and had no awareness of safety. The ship's operators are responsible for technical factor and human resources development.

The problem is whether the company condition impacts the sailing safety. Generally, safety is only valued and paid by assurance that is added to freight rate not to be calculated as production price. The safety awareness is also hard to be undertaken by small operators which serve a small economical route such as people's and pioneer sailing. Therefore, this research aims to map the correlation between ship accident factors to shipping route to get new knowledge about what is needed to fix the existed problem.

Based on the explanation above, this study offers an observation regarding ship accident map based on the accident factors, the routes, and the correlation between accident factors and the ship routes.

1.1. Sailing safety

Sailing has vital role to world's economy. As 90% world trade commodity is carried on by sea transportation thus ship is the most important factor in this industry. For archipelago country such as Indonesia, ship is not only as transportation but also as infrastructure such as highway in land transportation. Sea transportation is ruled on National Legislation N.17 article 245/2008 about sailing, government rule N.7/2000 about seafarer, and Ministry of Transportation Rule N.45/2012 about ship safety management. It is also ruled in International rules such as SOLAS 1974 and the amendment, MARPOL 73/78 and the protocol, Load Line Convention 1966, COLREGS 1972, Tonnage Measurement 1966, STCW 1978 amendment 95 and also ISM Code [Ministry of Transportation Regulation 2016].

All rules and standards can be concluded into four main prerequisites, those are:

- ship requirements;
- human resources requirements;
- operation requirements;
- external factor impacts on ship operation.

Based on the hypothesis, the determinant factors of ship accident consist of accident types, accident factors, operated condition and ship characteristics [Badan Diklat Perhubungan 2000]. Generally, ship accident factors are natural condition, technical failure, route condition, factors related to ship, factors related to human and factors related to freight [Akten 2006]. Talley et al., [2005] stated that based on the 1500 claim of accident assurance worldwide between 1987 and 1996, Thomas Miller P&I Club in England found that 90% accidents were caused by human errors.

1.2. Ship accident

Ship as a float building that moved by thrust with various speed across or particular areas would face many kind or problems such as weather, sailing routes, human, ship and others that are out of human's expectation thus the accident happens. Urgent conditions that could cause ship accident as noted on basic safety training manual book are divided into: crashed, fire/explosion, aground, sink/leakage, drown persons, and pollution.

Van der Schaff [1992] explained that a danger situation causing an accident is combination of a technical failure, human error and organizational failure. By making safety enhancing system such as automatic safety system, standard safety procedure, would prevent this situation from incident. Then, the system would be back in a normal state.

The simple model of causes analysis of ship accidents can be seen in Figure 1.

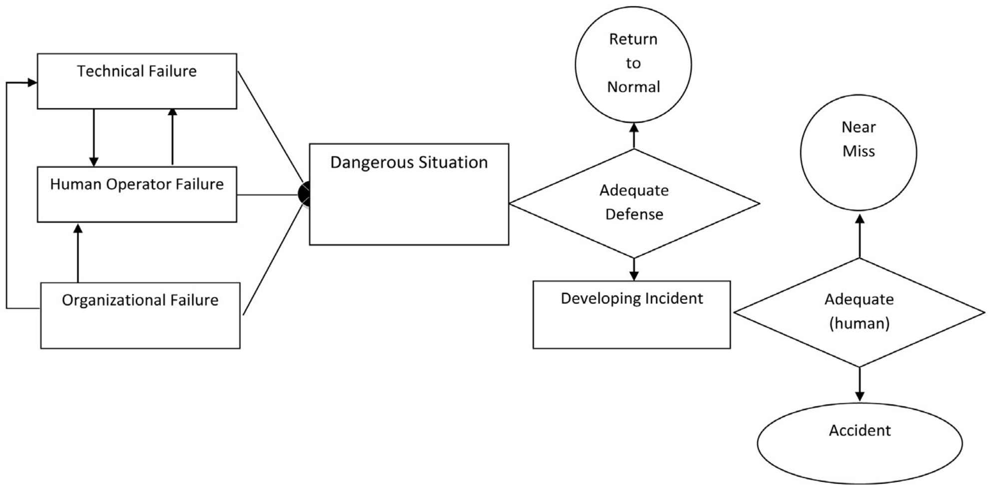

Fig. 1. *Simple model of accident cause*

Source: own study.

1.2.1. Technical failure

Technical failure is a work area of all designers and engineers. It is also as the ease and understandable explanation of accident factors. Based on the accident investigation, it is found that system fixing could decrease the probability of accident occurrence. The focus on technical system fixing could be seen from the presence of engineers in shipping organization. Design and maintenance engineer has an important role in an organization to be responsible in maintaining and repairing the reliability of technical system. They provide knowledge about technical based to an organization.

1.2.2. Human failure

The failure made by humans as their last defense have trigger the occurrence of the incident. Humans always have tendency to do mistakes. Psychologists try to find the main cause of how and why human does mistakes. From a few human custom models, the most famous model is Rasmussen; Skill, Rule and Knowledge-based behavior [1986].

Rasmussen differentiates three human custom stages related hierarchically as follow:

a. Customs based on skill: it is daily or routine tasks that need a little or no attention to run them.
b. Customs based on rule: it is known procedure to be used in decision making.
c. Customs based on knowledge: it is problem solving activity.

Other important explanations about human error are to differentiate slips and mistakes. Slip is a form of mistake done from suitable planned, while mistake is a form of mistake done from unsuitable planned. This comes from planning phase.

1.2.3. Organizational failure

The most important step to explain about organizational failure is to differentiate between active and latent failure. Active failure is a failure that is characterized by very quick effect while latent failure has a very slow effect. It could be felt after it combined with other factors that could infiltrate into all defensive system. The actions to prevent such conditions are:

1. Ship is in a qualified condition toward sea requirements.
2. Equipment and tools must be in good condition and maintained as the standards.
3. Weather forecast must be monitored well every time.
4. Ship's crew must have strong physical and mental ability.
5. Ship's crew must have high discipline and coordinating ability thus they could handle every condition quickly and precisely.

Based on Bridge Procedure Guidance, these following things have to be considered in undertaking watch keeping activity [International Chamber of Shipping 1998]:

1. Avoid leaving the bridge.
2. Weather forecast, visibility, in the afternoon and night.
3. Analyze the estimation of navigation hazard in guarding activity.
4. Ensure the usage and operational condition of navigation tool to make sure the sailing safety.
5. Ensure the automatic steering condition.
6. Ensure the radio condition well.
7. Have an alarm from the engine room.
8. Anticipate the overwhelm condition to particular handling need.

Based on STCW code in section A-VIII/1 [IMO 2010], the officers or ship crew must have enough rest time. The rest period is minimally 10 hours per 24 hours. This is useful to keep the ship crew's performance.

1.3. Sailing route

Indian Ocean sailing route has been ruled on PM 129/ 2016 Ministry of Transportation about sea sailing and construction/ installation [Ministry of Transportation Regulation 2016]. This rule impacts on determined sea routes which are crossed by ships. Therefore, there are things that need to be noticed in determining the routes. The rules are given below:

1. Route system position in assigned area.
2. Ship traffic condition and probability of traffic condition changing.
3. Fishing area positioning.
4. Existence and possible development of offshore exploration, sea bed and subsoil exploitation.
5. Sailing navigation assistance reliability, hydrographic survey and sea map.
6. Geographical condition.
7. Existence and probability of conservation area development.

Sailing routes consist of:

1. International sailing route is a continual archipelago sea route, direct and quick for foreign ships that cross Indonesian sea and confirmed by considering the safety resilience factors, sailing safety, the usual international sailing route, sea spatial, environment and natural resources and cable network or sea based pipe also authorized international organization recommendation.
2. National sailing route encircles sailing routes that connects national with international harbor, national with regional harbor, inter-regional harbor.

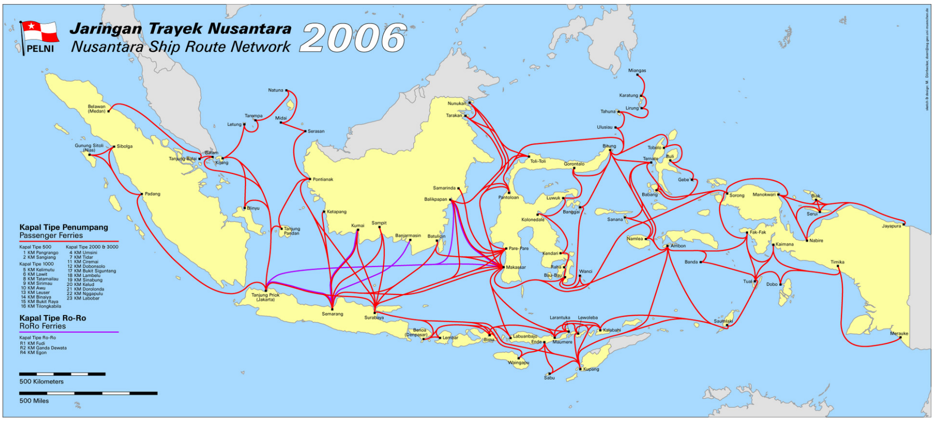

Fig. 2. *Inter-nation ship routes*

Source: www.wikiwand.com/id/Pelayaran_Nasional_Indonesia.

1.4. Shipping cost

Shipping cost consists of capital cost and operating cost, which are counted as time charter hire and voyage cost. Generally, operating cost can be divided into four cost components. Those are: capital cost, operation cost, travel cost and load handling cost, presented in Figure 3 [Stopford 2009].

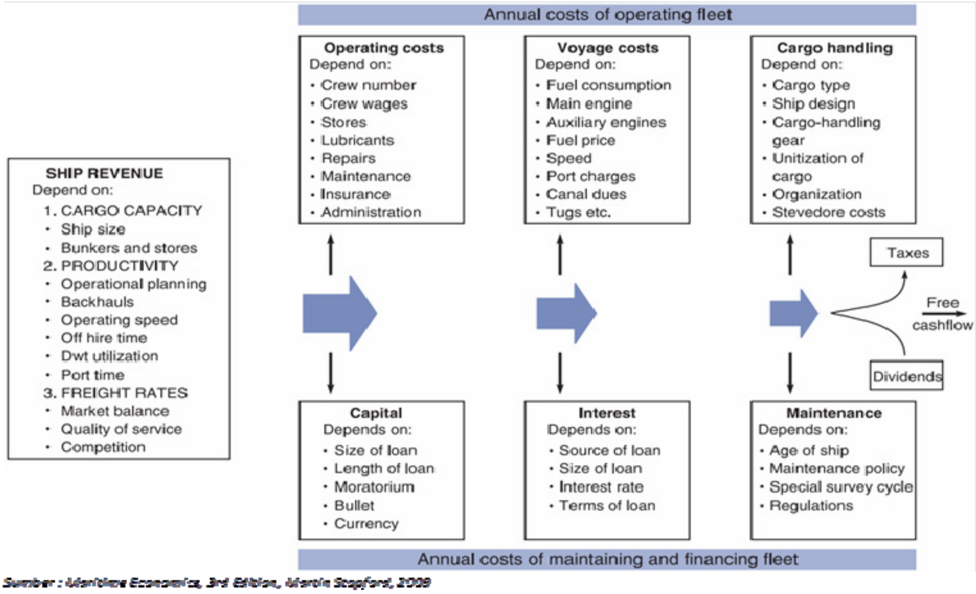

Fig. 3. *Ship operation cost component*

Source: [Stopford 2009].

The three ship operational cost elements (capital cost, operating voyage cost) has more than 95% portion of total cost and impacts on confirmed freight rate. Safety increasing must be burdened to maintenance and crew cost. Maintenance cost is to increase the technical ship performance while crew cost is to increase the ship's crew ability in terms of facing safety problem.

1.5. Pearson Product Moment Correlation (PPM)

Correlation is statistic term for linear relationship between two variables or more. It is found by Karl Pearson in 1900. Therefore, it is known as Pearson Product Moment Correlation (PPM). Correlation is one of statistical analysis techniques that is widely used by researchers to analyze a statistical relationship between happened events, indicating predictive association and predictive events [Walpole 1995].

The numerical measure that informs about the degree of the linear relationship between two variables is called as correlation coefficient (r). The connection between two variables is not reciprocal, but only one way connection. Hence, it is known as the cause and effect in correlation. Predictor variable is called independent variable and response variable is called dependent variable. Independent variable is symbolized by X or X1, X2, X3… Xn (depend on the numerous independent variables) while dependent variable is symbolized by Y.

These correlations are beneficial as followed:

1. To show whether there is significant correlation among variables.
2. To know each variable contribution presented in percentage. Thus, r^2 is called determined coefficient because r^2 x 100% happens in Y that is determined by X.

The correlation happens between two variables as follows:

1. Positive Linear Correlation (+1)
   One variable changing is followed by regular other variable changing with the same direction. If independent variable is up, then dependent variable is up. If independent variable is down, then dependent variable is down. If correlation coefficient score approaches +1, it means that independent variable and dependent variable pair has strong/perfect/tied positive linear correlation.
2. Negative Linear Correlation (–1)
   One variable changing is followed by regular other variable changing with the opposite direction. If independent variable is up, then dependent variable is down. If independent variable is down, then dependent variable is up. If correlation coefficient score approaches –1, then it shows both independent and dependent variable has strong/tied/perfect negative linear correlation.
3. Uncorrelated (0)
   One variable uprising can be followed by other variable decreasing or sometimes followed by other uprising variable. The direction is not regular whether one way or another. If variable coefficient score approaches 0 (zero) then independent and dependent variable pair has low correlation or is uncorrelated.

The form and pattern of Pearson Product Moment Correlation is shown in Figure 4.

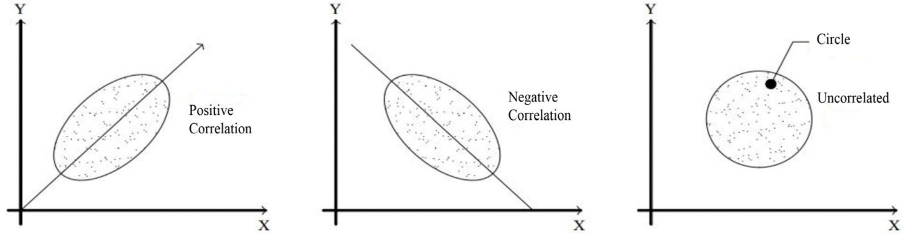

Fig. 4. *Pearson Product Moment Correlation illustration*

Source: own study.

Counting the correlation between independent variable with dependent variable using this pattern can be seen in the formula below:

$$r_{XY} = \frac{N\sum XY - (\sum X)(\sum Y)}{\sqrt{\left[N\sum X^2 - (\sum X)^2\right]\left[N\sum Y^2 - (\sum Y)^2\right]}} \quad (1)$$

where:

r_{XY} = coefficient correlation Y and X
X = independent variable
Y = dependent variable
N = total number of data

r score is always on –1 and 1, hence *r* score can be written as $-1 \leq r \leq +1$.

For r = +1, it means there are perfect positive correlation between X variable and Y variable. Otherwise r = –1, it means there are perfect negative correlation between X variable and Y variable, whereas r = 0, it means there are no correlation between X and Y. If one increasing variable is followed by the uprising other variable, those variables have positive correlation. Otherwise, if one variable uprising is followed by other variable decreasing, then it has negative correlation. Then, if there is no variable changing, it can be concluded that both variables do not have any connection. *r* score interpretation is shown in Table 1.

Table 1. *Correlation coefficient interpretation (r)*

R	Interpretation
0	Uncorrelated
0.01 – 0.20	Very low
0.21 – 0.40	Low
0.41 – 0.60	Rather Low
0.61 – 0.80	Medium
0.81 – 0.99	High
1	Very High

2. RESEARCH METHOD

2.1. Method

Generally, research design can be described by scheme given in Figure 5.

This research was undertaken through general methods such as:

1. The recent condition identification of general description related to ship accident and route characteristics as the secondary data. Data was collected from shipping court 2016.
2. Correlation model production with collected used data, then analysis was undertaken to know the relationship between accident and route ship.
3. Decision making and recommendation based on correlation analysis result.

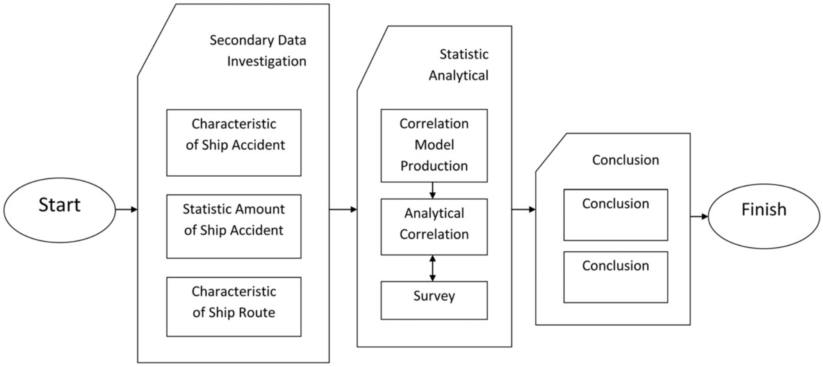

Fig. 5. Research route diagram

Source: own study.

2.2. Data collection

Data collection was undertaken by literature review or documentation study. The used source data on this research was secondary data from shipping court. Relevant qualitative data with ship accident in 2015–2016 was also used. Then qualitative data was made to quantitative by codification.

The data used was random sample from shipping court data in 2015–2016. This research consisted of 33 ship accidents involving 40 ships. The graphic of ship accidents based on ships' route can be seen in Figure 6.

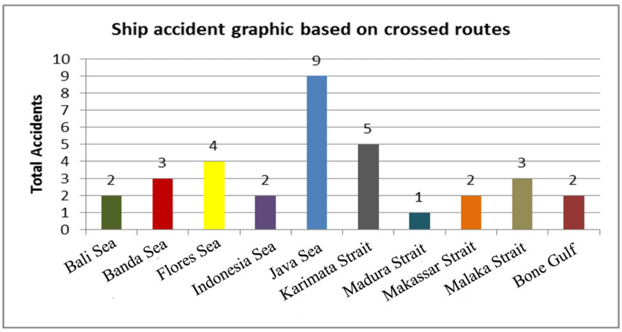

Fig. 6. Total accidents based on the crossed route

Source: own study.

Figure 6 shows ship accidents in 2015–2016 on three main routes. There were 9 accidents in Java Sea, 5 accidents in Karimata Strait, and 4 accidents in Flores Sea. The accident data were grouped based on GT ships' division, those were GT 0–500 ton as group one, then GT 501–1500 ton as group two, GT from 1501–5000 ton as group three, then GT 5001–10 000 ton as group four and GT more than 10 000 ton as group five. The grouping based on GT ship can be seen in Figure 7.

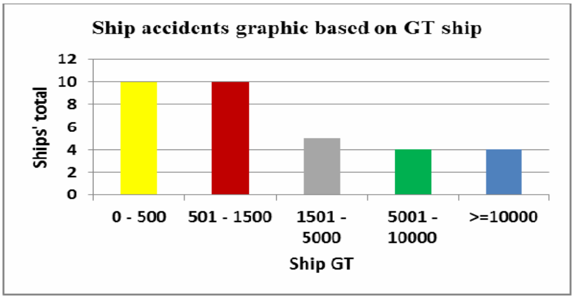

Fig. 7. Accident distribution based on GT ship

Source: own study.

Figure 7 shows that the highest accident happened on GT 0–1500 ship in various ships' routes, that is 10 times higher than others. Accident data grouping was adjusted by ship accident factors, that is sunk, crashed, fired, and aground. These factors caused the ship cannot be operated well. The clearer explanations are below based on ship accident reports sailing court in 2015–2016.

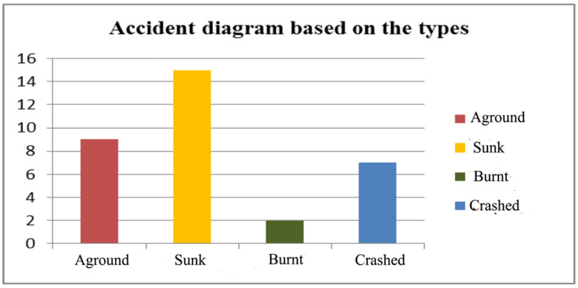

Fig. 8. Ship accidents based on the types

Source: own study.

From Figure 8, it could be known that the most often accident was sunk ships, there were 15 such accidents. Then the second position was 9 accidents of ships aground. Whereas, the least factor was fired ship. There were two types of accident factors, main and supporting factor. The main factors are leakage, watch keeping, construction, navigation, sailor, ballast, load and float resources. Then, supporting factors are human, weather and technical factor.

Figure 9 shows ship accidents diagram based on the factor.

Figure 9 and 10 above show the accident events in various routes which occurred because of human error factor. There was 52% human error dominated by the sailor for 30% and watch keeping for 19%.

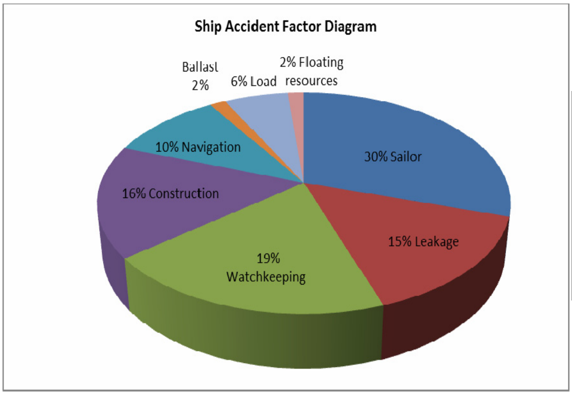

***Fig. 9**. Ship accident factor*

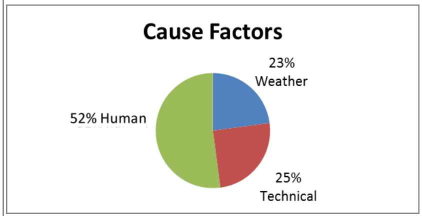

***Fig. 10**. Ship accident cause factor*

Source: own study.

3. RESULT AND DISCUSSION

3.1. Normal data analysis of total ship accidents in routes

Normality test was used to know whether the data distribution is normal or not. Normality test used in this study was Lilie fors test. If the variable was $\alpha = 0.05$ score $L_0 < L_{tabel}$, then the data distribution was normal, otherwise if $L_0 \geq L_{tabel}$ data was not distributed normally.

The data of normality test result crossed by ships can be seen in Table 2.

***Table 2.** Ship accidents' data normality test*

n	10					
α	0.05					
L_{table}	0.258					
N	**Route**	**Total accidents**	**Z**	**f(z)**	**s(z)**	**s(z)-f(z)**
1	Madura Strait	1	-0.697	0.243	0.100	0.143
2	Bali Sea	2	-0.394	0.347	0.500	0.153
3	Indian Ocean	2	-0.394	0.347	0.500	0.153
4	Makassar Strait	2	-0.394	0.347	0.500	0.153
5	Bone Gulf	2	-0.394	0.347	0.500	0.153
6	Banda Sea	3	-0.091	0.464	0.700	0.236
7	Malaka Strait	3	-0.091	0.464	0.700	0.236
8	Flores Sea	4	0.212	0.584	0.800	0.216
9	Karimata Strait	5	0.515	0.697	0.900	0.203
10	Java Sea	9	1.727	0.958	1.000	0.042
	Total	**33**				
	Average	**3.3**		**L_0**		**0.236**
	Standard deviation	**3.3**				

That table describes data route statistic test result that crossed by ship with one-tailed Liliefors test. Based on the table, it could be known that mean was 3.3, standard deviation was 3.3 and reliable stage significant level 0.05 was 0.258 (**L_{table}**). By Liliefors test, it was obtained score L_0 = 0.236 which means mistake potential counting is 5%, and shows the average score is smaller than the significant score 0.236 < 0.258. Hence, ship accident data was normally distributed.

3.2. Correlation analysis of ship accident cause in terms of crossing routes

The data normality test was used to know the relation between accident cause variable and crosses ship routes data. Those were tested by Pearson Product Moment correlation by using Microsoft Excel 2007.

Table 3. *The correlation between total accident and causes*

Route	Total Accident	Total cause
Madura Strait	1	2
Bali Sea	2	4
Bone Gulf	2	2
Indian Ocean	2	2
Makassar Strait	2	1
Malaka Strait	3	2
Banda Sea	3	3
Flores Sea	4	3
Karimata Strait	5	5
Java Sea	9	13
Grand Total	**33**	37
Correlation	**0.93**	

The table above shows that the correlation between accidents and routes had correlation coefficient of 0.93 with 5% significance level. That means there are positive correlation between accident and crossed routes.

The effective variable contribution to routes and ships' accident was 86% which was derived from r^2 x 100. Whereas, the 14% rest was other variable's contribution. Specifically, ships' accidents were caused by leakage, watch keeping, construction, navigation, sailor, ballast, load and float resources.

Table 4 explains each variable percentage.

Based on the table above, it could be seen the number of ship accident cause. The maximum factors that caused the accident were sailor for 30%, watch keeping for 19%, also construction 16%.Continued by leakage for 10%, navigation 10%, and load 6% as other factors in ship accidents. While the minimum factors were ballast and float resource cause, with one percentage for each.

Table 4. *Accident cause variation*

Cause	Total accident	Percentage
Sailor	20	30%
Leakage	10	10%
Watchkeeping	13	19%
Construction	11	16%
Navigation	7	10%
Ballast	1	1%
Load	4	6%
Float Resources	1	1%

3.3. Leakage cause analysis and accident location route

Table 4 shows the leakage contributes 10% of ship accident cause. Indirectly, leakage has correlation with the ship crossing routes. Table 5 explains the correlation between the leakage and accident location routes.

Table 5. *Correlation between leakage and total accident events in routes*

Routes	Leakage	Total accident events
Bali Sea	0	2
Banda Sea	3	3
Flores Sea	2	4
Indian Ocean	1	2
Java Sea	1	9
Karimata Strait	1	5
Madura Strait	0	1
Makassar Strait	0	2
Malaka Strait	2	3
Bone Gulf	0	2
Grand Total	**10**	**33**
Correlation	**0.27**	

The table above showed that there was correlation between the number of accidents due to leakage and crossed routes. There were correlation coefficient (r) as 0.27 with 5% significance level, which means there was positive correlation between ship leakage and crossed routes with low connection level.

3.3.1. Watchkeeping cause analysis and accident location routes

Table 4 shows that there were 13 accidents caused by watch keeping. Indirectly, watch keeping had correlation with crossed routes.

The table above describes the correlation between the number of accidents due to watch keeping and crossed routes. There was correlation coefficient (r) of 0.92 with 5% significance level, which means the positive correlation between watch keeping and crosses routes with high correlation level.

Table 6. *Correlation between watchkeeping and accident location routes*

Routes	Watchkeeping	Total accident events
Madura Strait	1	1
Bali Sea	0	2
Bone Gulf	0	2
Indian Ocean	1	2
Makassar Strait	1	2
Malaka Strait	1	3
Banda Sea	1	3
Flores Sea	1	4
Karimata Strait	2	5
Java Sea	5	9
Grand Total	**13**	**33**
Correlation	**0.92**	

3.3.2. Construction cause analysis and accident location routes

Table 4 shows that there were eleven accidents caused by ship construction.

Table 7 explains the relationship between ship construction and crossed ship routes.

Table 7. *Correlation between ship construction and total accident in routes*

Routes	Constrcution	Total accident events
Madura Strait	0	1
Bali Sea	2	2
Bone Gulf	1	2
Indian Ocean	1	2
Makassar Strait	0	2
Malaka Strait	1	3
Banda Sea	0	3
Flores Sea	1	4
Karimata Strait	1	5
Java Sea	4	9
Grand Total	**11**	**33**
Correlation	**0.79**	

The correlation between the number of accidents caused by ship construction and crossed ships had correlation coefficient of 0.79 with 5% significance level. This means, there was positive correlation between ship construction and crosses ships with high correlation level.

3.3.3. Navigation cause analysis and accident location route

Table 4 shows that there were seven accidents caused by navigation.

Table 8 explains correlation between ship navigation variable and crossed ships' routes.

Table 8. *Correlation between navigation and total accident in the route*

Rute	Navigation	Total accident events
Madura Strait	0	1
Bali Sea	0	2
Bone Gulf	1	2
Indian Ocean	0	2
Makassar Strait	0	2
Malaka Strait	0	3
Banda Sea	1	3
Flores Sea	1	4
Karimata Strait	1	5
Java Sea	3	9
Grand Total	**7**	**33**
Correlation	**0.91**	

The table above shows that from 33 total accidents, there were 7 accidents caused by ship navigation. The connection between the accidents caused by ship navigation and crossed routes had correlation coefficient (r) of 0.91 with 5% significance level. This means there was positive correlation between navigation variable and crossed routes with high correlation level.

3.3.4. Sailor cause analysis and accident location routes

Table 4 shows, there were 20 accidents caused by sailor.

Table 9 explains the high correlation between the number of accidents due to ship sailor and crossed routes. There were 20 accidents from 33 accidents caused by sailor.

Table 9. *Correlation between sailor and total accident in routes*

Routes	Sailor	Total accident events
Madura Strait	1	1
Bali Sea	0	2
Bone Gulf	1	2
Indian Ocean	2	2
Makassar Strait	1	2
Malaka Strait	2	3
Banda Sea	2	3
Flores Sea	0	4
Karimata Strait	4	5
Java Sea	7	9
Grand Total	**20**	**33**
Correlation	**0.87**	

The table above, describes the correlation between the number of accidents caused by sailor and crossed ship routes. There was correlation coefficient (r) of 0.87 with 5% significance level. This means, there was positive correlation between sailor variable and crossed ship routes with high correlation level.

3.3.5. Ballast cause analysis and accident location routes

The table below describes the correlation between ship ballast accident cause and crossed ships routes. The correlation coefficient (r) as 0.26 with 5% significance level. This means, there were positive correlation between ballast and crossed ship routes with low correlation level.

Table 10. *Correlation between ballast and total accident events in routes*

Routes	Ballast	Total Accident Events
Madura Strait	0	1
Bali Sea	0	2
Bone Gulf	0	2
Indian Ocean	0	2
Makassar Strait	0	2
Malaka Strait	0	3
Banda Sea	0	3
Flores Sea	0	4
Karimata Strait	1	5
Java Sea	0	9
Grand Total	**1**	**33**
Correlation	**0.26**	

3.3.6. Load cause analysis and accident location routes

Table 4 shows, there were four accidents caused by load. The correlation between ship load and crossed ship is explained in Table 11.

Table 11. *Correlation between load and total accident in the route*

Routes	Load	Total accident events
Madura Strait	1	1
Bali Sea	1	2
Bone Gulf	0	2
Indian Ocean	0	2
Makassar Strait	0	2
Malaka Strait	0	3
Banda Sea	1	3
Flores Sea	0	4
Karimata Strait	0	5
Java Sea	1	9
Grand Total	**4**	**33**
Correlation	**0.17**	

The table above describes the correlation between ship load variable and crossed ship routes. There was correlation coefficient as 0.17 with 5% significance level. This means, there was positive correlation between load and crossed ship routes with low correlation level.

3.3.7. Ship buoyancy cause analysis and accident location route

Table 4 shows, there was one accident event that caused by ship buoyancy.

Table 12 explains there was correlation connection between ship buoyancy and crossed ship routes.

Table 12. *Correlation between ship buoyancy and total accident in routes*

Routes	Float resources	Total accident events
Madura Strait	0	2
Bali Sea	1	4
Bone Gulf	0	2
Indian Ocean	0	2
Makassar Strait	0	1
Malaka Strait	0	2
Banda Sea	0	3
Flores Sea	0	3
Karimata Strait	0	5
Java Sea	0	13
Grand Total	**1**	37
Correlation	**-0.20**	

The table above, describes the correlation between the number of accidents due to ship buoyance and crossed ship routes. There was correlation coefficient (r) of -0.20 with 5% significance level. This means, there were negative correlation between buoyancy and crossed ships routes with low correlation level.

4. DISCUSSION

This research aimed to reveal the positive correlation between accident causes and ship routes crossed. Based on the data, there was positive correlation between the cause and routes. Correlation analysis result showed r of 0.93 with 0.05 significant level. This positive correlation showed that the opportunity of ships accident was influenced by variety of ship accidents cause. The occurrance of ships' accident was equal to the amount of its effective contribution.

Based on the correlation analysis, the ship accidents were on high category, that is 86% from the total of ship accidents. This showed the significant relation between routes and causes.

Table 13. *Ship accident cause correlation and crossed routes*

Causes	Sailor	Leakage	Watch-keeping	Construction	Navigation	Ballast	Load	Float resources
Correlation	0.87	0.27	0.92	0.79	0.91	0.26	0.17	-0.20

The table above showed the correlation between accident cause and ship routes. Watch keeping was the biggest cause in the correlation with ship routes for 0.92, then navigation for 0.91, also sailor for 0.87. Hence, it showed that the most dominant factor is human error. Whereas, the most accident routes were presented in Figure 11.

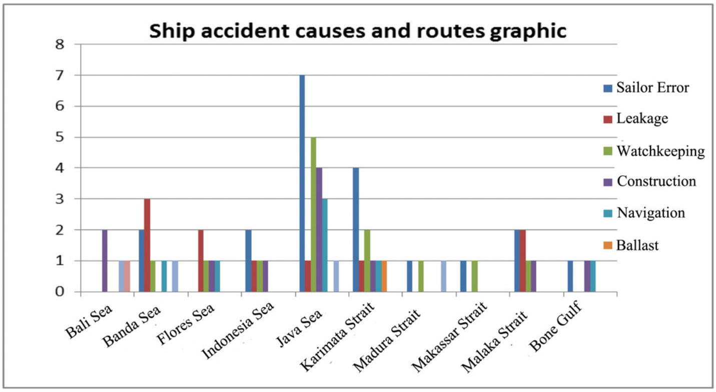

***Fig. 11.** Ship accident causes and routes*

Source: own study.

Based on the graphic, the ship accidents happened mostly in Java Sea caused by sailor error. The same as Java Sea, Karimata strait placed on the 2nd rank. The main cause is sailor error.

Java sea has the highest sailing density level, whether leads to Java or out of from Java because Java is still being the central industrial spot in Indonesia, whether national or international trade. Java Island has two biggest ports. Those are Tanjung Priok in Jakarta and Tanjung Perak in Surabaya which serves domestic and international sea load and also several other ports in Java. Technically, Java Sea has high risk level from the sailing density. The high density sailing can cause human exhaustion and ignorance. It can be concluded, that human factor is the most dominant factor of accident cause, particularly to high sailing density and intensity.

5. SUMMARY & CONCLUSION

Based on the data, from shipping court in 2015–2016, the ship accidents happened in Bali Sea (2 cases), Banda Sea (3 cases), Flores Sea (4 cases), Java Sea (9 cases), Karimata Strait (5 cases), Madura Strait (1 cases), Makassar Strait (2 cases), Malaka Strait (3 cases) and Bone Gulf (2 cases). Whereas, the accident cause consists of crews/sailor unknowingness/ error, mal-procedure watchkeeping, construction, navigation, ballast, load and buoyancy. There were 9 ship accidents because of aground. The least was fired accident that was 2 cases. Specifically, the ship routes accident consists of leakage, watch keeping, construction, navigation, sailor, ballast, load and float resources while other factors are human error, weather and technical error.

Based on the correlation analysis, sailing route has significant impact on ship accident cause. Human error becomes the highest dominant factor and is correlated with ship accident routes. The correlation between ship accident and ship route was mostly caused by watch keeping for 0.92 and navigation for 0.91, also sailor for 0.87. This shows the most dominant factor is human error. The highest accidents in Java Sea were caused by sailor unknowingness. Karimata Strait placed the second position and mostly caused by sailor unknowingness.

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