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Risk Assessment Shipping Accident of Fishing Vessel

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Abstract. The fisheries industry continues to be one of the main contributors to economic growth. The Ministry of Maritime Affairs and Fisheries Republic of Indonesia reports that the total capture fisheries production rises every year. In 2016 it was recorded to produce 6.83 million tons. Comparison of safety records from the fishing industry with other industrial sectors shows that it continues to be the most dangerous occupation with a sizeable margin. The safety and efficiency of fishing vessel fleet activities is highly dependent on the quality of management decisions. The causal relationships from accidents involving fishing vessels are identified through an analysis of emergencies and fishing incidents. The purpose of this study is to improve the safety of shipping by applying the risk of accidents of fishing vessel by using Formal Safety Assessment (FSA) methodology. The result show that Mechanical failure has a highest risk followed by Vessel Foundering, Falling Overboard and Other. With the right control measure the cost can be minimized 10 – 50 %. The cause of accident is caused by human factor. Increasing the safety of the shipping is necessary with increase the competence of human and law enforcement of shipping activities especially.

1. Introduction

These Indonesian territories is an archipelago which has 17,508 islands and has a waters area of 5.8 million km² and a coastline length of 81,290 km [1]. People who live along the coastline earn a living as fishermen. Therefore, the need for transportation facilities the sea as the connection between islands is very high. The means of sea transportation are ships. The ship is a major consideration for the community because it means economical transportation. In principle, the ship was built with the aim of transporting people and cargo to carry out operations in the middle of the sea [2]. The ship is one of the transport fleets that has a vital role. Trade, export-import, and for fishermen to fish in the sea. This cannot be separated from transportation facilities such as ships [3].

The maritime industry in Indonesia is currently showing an increase in market demand. In Indonesia the activities or activities of the sea are very high considering that most of Indonesia's territory is the sea, so ships that function as working tools are very much needed [4]. In 2016 it was recorded to produce 6.83 million tons. Fishing vessels generally operate in open waters, which in certain seasons experience waves and storms that affect ship operations. These environmental conditions affect the movement of the ship which in turn can cause the condition of the crew to decline. Studies on the causes of ship accidents that occur in Indonesia show that accidents can be caused by three factors, namely: human error, natural factors and technical factors [5].



The number of fatalities, injuries and vessels lost annually remains ‘unacceptably’ high when compared to other industries. Comparisons of the safety record of the fishing industry with other industrial sectors indicate that it continues to be the most dangerous occupation by a significant margin. Fishing is a difficult and dangerous job, the fact that no one can deny it today. This is a work that burdens the body and soul. In general, the term safety implies that no accidents are acceptable but this is different from the maritime field where the reality is that a large risk of accidents always exists [6]. Fishing is an ancient activity, many times passed down from one generation to another. The majority of fishermen who operate these vessels are self-employed, hence, risk tolerant by nature. The guide is a first step towards the harmonization of current standards for training and education [7].

There are no technical problems that can be isolated from safety problems because no human effort can be free from danger or risk. It is clear that the need for safety measures will be affected by the presence of such hazards or risks. In this case, fishing vessels are no exception [6]. There is no general definition of risk that is universally accepted, but one resolution that is commonly applied and authoritative in most industrial contexts, defines risk as "a combination of probabilities, or frequencies, of the occurrence of specified hazards and the magnitude of the consequences of events" [8].

The FSA is a structured and systematic methodology, which aims to improve maritime safety, including protection of life, health, the marine environment and property, using risk analysis and cost benefit assessments. The FSA can be used as a tool to assist in the evaluation of new regulations for marine safety and protection of the marine environment or in making comparisons between existing and possibly improved regulations, with the aim of achieving a balance between various technical and operational issues, including the human element, and between maritime safety or protection of the marine environment and costs [9]. These concepts are presented as applicable to the safety analysis of each ship but also as a tool in the decision making process, in formulating new and amended regulations for shipping in general. The original Formal Safety Assessment concept, at least in part, was developed after the Piper Alpha disaster in 1988 [10] where an offshore platform exploded in the North Sea and 167 people lost their lives. In their proposal, the British delegation used the experience of the offshore industry.

According to the International Maritime Organization (IMO), the risk is the “combination of the frequency and the severity of the consequence”, which thereby articulates two components of the likelihood of occurrence and the probability of severity of the (un)predictable consequences. Fisheries have been and remain one of the most dangerous human activities. The hallmark of marine fisheries and transportation services of the fishing fleet in fishing areas is that all operations are carried out under the condition of the impact of many internal and external and environmental factors “aggressive”. The safety and effectiveness of the fishing fleet is highly dependent on the quality of management decisions related to navigation and fishing safety.

It should be noted that this problem has not been adequately developed. Cause and effect relationships from accidents involving fishing vessels are identified through analysis of emergencies and fishing events. Methods for calculating predicted risk levels for various combinations of negative factors in the external and internal environment are described. This paper defines the circumstance as a condition or a set of conditions that directly or indirectly contribute to an emergency or are the direct cause of an accident.

2. Methodology

The Formal Safety Assessment (FSA) is a rational, structured and systematic methodology or process to assess risks associated with maritime activities and to evaluate the costs and benefits of multiple risk control options, with using risk analysis and cost benefit assessment (International Maritime Organization, 2002). The purpose of the FSA is to create tools that can be used by IMO or other international and national regulatory authorities and class communities to create new regulations or evaluate existing regulations based on the probability of hazards and consequences, risks and cost effectiveness, all with the aim of comparing alternatives. It aims to improve sea safety including protection of life, the environment and property. This method applies to validate existing and / or newly developed regulations by applying prescriptive or risk-based principles. This can also be applied in situations where risks need to be reduced but the decisions needed are not clearly defined and need to be analyzed [10].

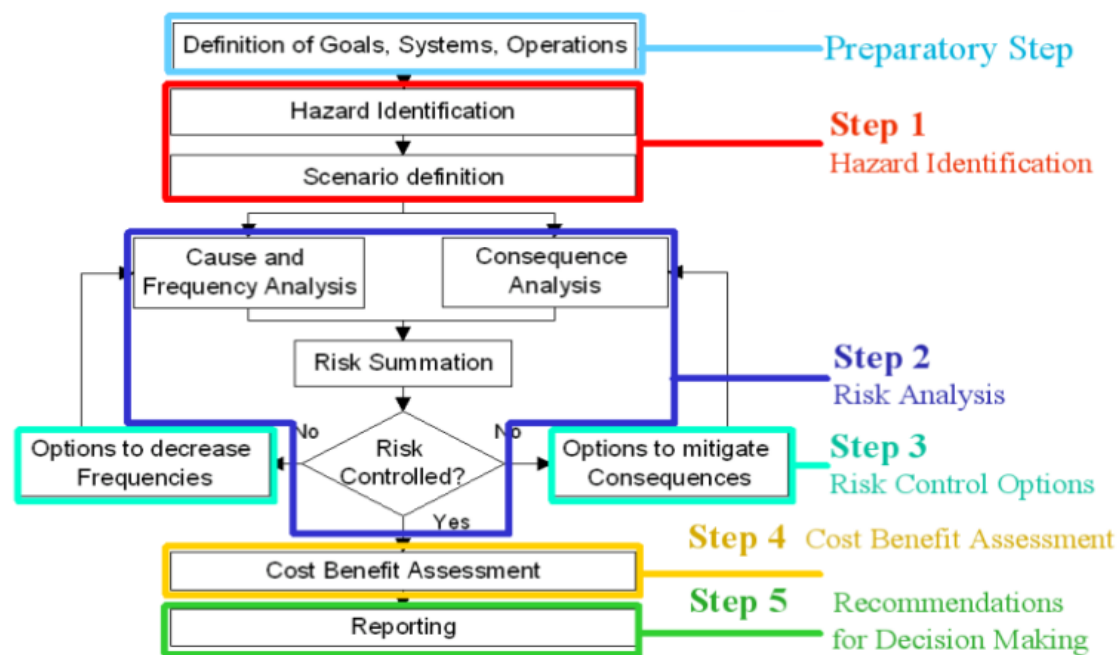


Figure 1. Formal Safety Assessment Method

In general, each FSA process must begin by defining the aims and objectives of the research. The scope of the analysis must refer to the type and size of the ship, operational specifications, hazard types, risk acceptance criteria and available historical data, so that all aspects of the problem are included and uncertainties can be considered. This type of risk information refers to individual or community risks and hazards refer to personal, marine environment and / or property. Historical data refers to the database of accidents, near misses and operational failures. In cases where appropriate historical data are not available, expert opinions, physical or numerical modeling and / or analytical models can be used to obtain the information needed [10].

2.1 Hazard Identification

Hazard Identification is a list of all accident scenarios relevant to potential causes and their consequences, in response to the question "what error might occur"

2.2 Risk Assessment

These objectives can be achieved by using techniques that match the model of risk being made and attention focused on high-rated risk. The value in question is the level of risk, which can be differentiated into:

- Risk that cannot be justified or accepted or intolerable.
- Risks that do not need further precautions or negligible.
- The risk that the level is between intolerable and negligible level.

2.3 Risk Control Selection

The purpose of step 3 is to propose effective and practical Risk Control Options (RCO), through the following four principle steps:

- Focusing on risks that require control.
- Identify actions to control potential risks (risk control measures = RCMs)
- Evaluate the effectiveness of RCMs in reducing risk.
- Group RCMs into practical options.

2.4 Cost and Benefit Assessment

The purpose of step 4 is to identify and compare the benefits and costs of implementing each RCOs identified in step 3. Costs must be expressed in life cycle costs, including initial, training, workshop, decommission, and others. Benefits may include reductions in fatalities, injuries, casualties,

environmental harm and clean-up, and others. The equation used to solve this problem is with the Cost of Averting a Risk Index (ICAR) as given in the following equation:

$$\frac{\Delta C - \Delta B}{\text{Risk Reduction}} \quad (1)$$

Where:

ICAR = Implied cost of averting a risk

ΔC = Cost of risk control

ΔB = Economic benefits of the application of risk control

Risk Reduction = Decrease in risk after control

2.5 Recommendations for Decision Making

The aim of step 5 is to emphasize recommendations to be made to decision-makers, in a way that can be audited and traceable.

3. Result and Discussions

There is no natural environment that is harsher than the sea, there are very few workplaces where people are required to work on machines on platforms that are often wet and keep moving. These factors making it one of the most physically and physically demanding jobs. In hazard identification the first objective can be accomplished by creative combinations and analysis aimed at identifying all relevant hazards. In this process, the main goal is to find the causes and effects of accidents and hazards. The next goal is to group these elements into concreteness. In addition, the level of consciousness affects each factor. The set of data related to marine accidents to quantitative values and the amount of output obtained as a list of hazards and scenarios related to the level and description of cause and effect.

In this case, 10 hazards identified over the 10-year period from 2000 to 2010. Evaluation of risk assessment is an important factor of the FSA's methodology. For the development of an integrated security system, the total number of risks should be known. The FSA Methodology will figure out the information and accident detail and provides quantitative risk estimates. IMO has introduced a 7 x 4 Risk Matrix, which reflects potential variations in frequency greater than the consequences. To facilitate ranking and ranking validation, the index of consequences and frequency is defined on a logarithmic scale. The so-called "risk index" is defined by adding a frequency and consequence index.

Table 1. Severity Index

SI	Severity	Human	Ship
1	Minor	Minor Injuries	Local Equipment Damage
2	Significant	Severe Injuries	Non-Severe Ship Damage
3	Severe	Multiple Severe Injuries	Severe Damage
4	Catastrophic	Multiple Fatalities	Total

From the standpoint of risk assessment, the system-dangerous (or event) circumstances must be identified and indicated in the risk model. For this subject, total risk must be determined quantitatively. Therefore, the total risk is the number of probabilities of occurrences in which the danger occurs. Risk can be characterized by SI function (Severity) and possibly (F). Table 1 shows the level of severity index for human and ship. Meanwhile Table 2 shows the frequency index of ship accidents that can occur. If the frequency is small, then a particular place or area is rarely hit by an accident, but if the frequency is high this place has many accidents.

Table 2. Frequency Index

Fi	Severity	Definition
7	Frequent	Likely to occur once per month on one ship
5	Reasonably Probable	Likely to occur once per year in a fleet of 10 ships
3	Remote	Likely to occur once per year in a fleet of 1000 ships
1	Extreme Remote	Likely to occur once in the lifetime (20 years) of a world fleet of 5000 ships

Table 3 shows the risk index, which is a mix of severity and frequency index. The table explains how much danger should be addressed. If the green area the accident can be ignored, if the yellow area should be responded and if in the red area it must immediately provide action.

Table 3: Risk Index

Severity	4	5	6	7	8	9	10	11
	3	4	5	6	7	8	9	10
	2	3	4	5	6	7	8	9
	1	2	3	4	5	6	7	8
Frequency		1	2	3	4	5	6	7

 Negligible
  ALARP
  Intolerable

Table 4. Total Ship Accident

Type	Total
Vessel Foundering	42
Falling Overboard	8
Mechanical Failure	113
Operating The Winch	1
Grounding	16
Flooding	13
Collision	11
Fire	4
Capsize	2
Other	4

This data is needed to analyze the patterns and types of accidents occurring, then be included in the form of frequency criteria. The types of accidents seen in the table above, such as Vessel Foundering, Falling Overboard, Mechanical Failure, Grounding, Flooding, Collision, Fire, Capsize and other events that can be life-threatening and property. Four important factors when an accident occurs are ship, cause of accident, accident time and place of accident. The FSA approach on this existing ship are Fishing vessels. The causes of accidents are caused by the human factor itself, technical factors, and natural factors. This analysis makes a large amount of data being shared, the most important thing in the data collection of sea accidents. In the process of determining the accident scenario, all accidents

must be recorded or collected and each accident is a different accident scenario. The use of the FSA approach method is to improve the safety of maritime depending on accurate statistical data. After considering the accident factor, each accident is defined in several scenarios. In the data there are 214 total accidents in the period. The most frequent accidents are ship collisions followed by ship fire and others. Table 5 shows the risk type of accident.

Table 5. Risk Type of Accident

Event	Most Likely Consequence				Worst Credible Consequence			
	Human	Property	Environment	Stake Holder	Human	Property	Environment	Stake Holder
Vessel Foundering	9	9	0	9	10	10	5	10
Falling Overboard	6	6	0	2	7	7	3	4
Mechanical Failure	10	10	0	6	11	11	7	7
Operating The Winch	2	2	0	2	3	5	2	4
Grounding	3	3	0	3	5	5	3	5
Flooding	3	3	0	2	4	5	2	4
Collision	3	6	0	3	5	7	3	5
Fire	2	3	0	2	4	4	3	4
Capsize	2	6	0	3	5	7	3	6
Other	2	3	0	3	3	5	3	5

To rank the highest risk, need to give scoring to the value that occurs in humans, the environment, etc. so each type of accident can be in a proportional order. This process is envisioned as being objective and transparent with all assumptions and uncertainties clearly identified and pre-determined for their validation and acceptance or rejection [10]. Giving a value of 0.6 is quite rational if we place human safety as a top priority. It would be irrational if the weighted value for humans is given as high as 0.7 and above because it means very little material value, which in reality should be considered [11]. Table 6 shows safety weighted value.

Table 6. Safety Weighted Value

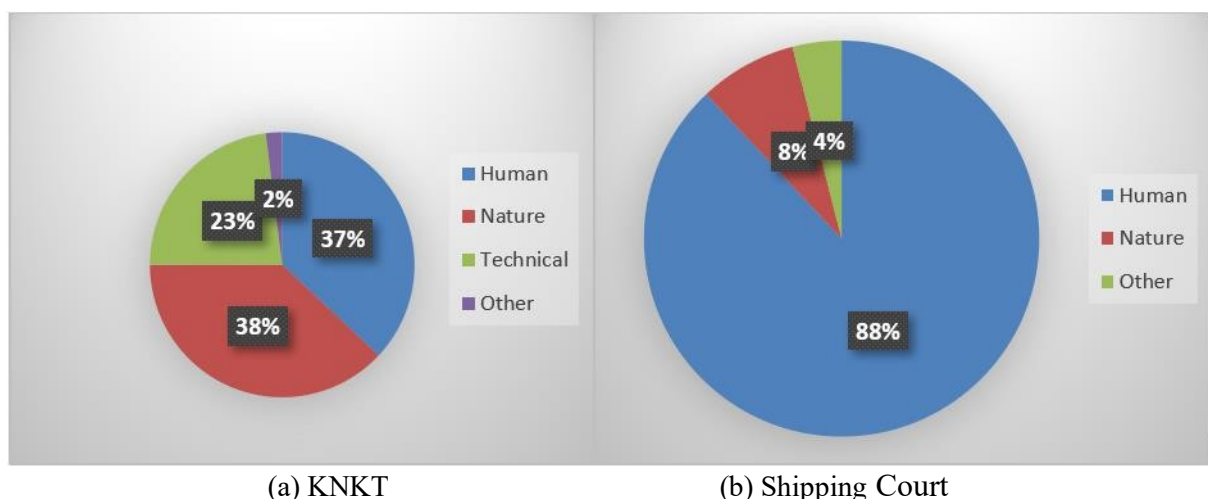
Scoring	
Human	0,6
Property	0,15
Environment	0,15
Stake Holder	0,1

The risk type accident results gained after weighting as shown in Table 7. The giving of the rank is subjective because so far there is no count or standard value to explain how important human life compared with property, ownership or the other things, nevertheless there are some considerations of why to take that value. The results show that the mechanical failure is the highest-risk event followed by vessel foundering, Falling Overboard and other. However more important is how lowered the high risk that happens to be an acceptable risk value. Capsize has a low value, but has a high enough risk.

Table 7. Safety Weighted Value

Event	Most Likely Consequence				Worst Credible Consequence				Total	Position
	Human	Property	Environment	Stake Holder	Human	Property	Environment	Stake Holder		
Vessel Foundering	5,4	1,35	0	0,9	6	1,5	0,75	1	16,9	2
Falling Overboard	3,6	0,9	0	0,2	4,2	1,05	0,45	0,4	10,8	3
Mechanical Failure	6	1,5	0	0,6	6,6	1,65	1,05	0,7	18,1	1
Operating The Winch	1,2	0,3	0	0,2	1,8	0,75	0,3	0,4	4,95	10
Grounding	1,8	0,45	0	0,3	3	0,75	0,45	0,5	7,25	6
Flooding	1,8	0,45	0	0,2	2,4	0,75	0,3	0,4	6,3	7
Collision	1,8	0,9	0	0,3	3	1,05	0,45	0,5	8	4
Fire	1,2	0,45	0	0,2	2,4	0,6	0,45	0,4	5,7	8
Capsize	1,2	0,9	0	0,3	3	1,05	0,45	0,6	7,5	5
Other	1,2	0,45	0	0,3	1,8	0,75	0,45	0,5	5,45	9

From the accidents, there are several factors that affect the occurrence of the type accident. Among the human, technical and natural factor, the human factors are the highest in the occurrence of accidents According to the shipping court. Figure 2 shows the accident causes, more than 80% are caused by humans and the remaining 8% and 4% are caused by natural factor and other factors. According to the National Transportation Safety Committee, cause of accident is 38% by Natural factor, 37% by Human, 23% by technical Factor and 2% by another factor. This show that human is a factor causing the accident.



(a) KNKT

(b) Shipping Court

Figure 2. Accident Causes

The technical factor consists of navigation, management and the ship itself, from the three factors the navigation factors are caused by technical constraints on the navigational system, while the ship's factors are caused by the age of the vessel and its linkage and factor management due to the owner and management of the vessel from maintenance management and operation management. Natural factors are caused by bad weather factors. The weather that generates wind, currents, big waves that lead to unexpected events. Related to determining the selection of risk control, all are crucial accident factors

that have been analyzed and the level of risk established to prevent hazard. Therefore the risk reduction is very important associated with the level of accidents if sorted in the highest such as collision, ship fires, sink, grounding and others.

There are several ways to reduce the risk of such accidents, such as seafarer training and certification, routine patrol and installation of channel sign, human rescue training, tight port area, tightening of sailing permit and law enforcement. Selection of risk Control, such as ship collision can be minimized by tightening the port area. Ship fires can be minimized by training and certifying seafarers. Others that can be life-threatening and property can be minimized by routine patrols around the harbor or cruise line. The sinking vessels can be minimized by procuring a sailing permit so that it will still sail on a specified channel or area. Falling Overboard can be minimized by All persons should wear a suitable personal flotation device (PFD) of 150N or more when working on deck. Accident by winch can be minimized by Make sure that the winch is adequately guarded such that a person falling against the rotating winch would be safe. A simple handrail in front of the winch could be sufficient to prevent someone being seriously injured or killed. Mechanical Failure can be minimized by Maintain the engine and associated equipment in a clean condition to enable you to see leaks of water, fuel and oil before they become a bigger problem.

Cost and benefit assessment are the process of evaluating the costs and benefits of risk reduction measures. In this step, if the benefits of risk reduction have a higher value than the cost, it may be selectable and applicable. If ships are monitored more cautiously, the cause of crews can be prevented and the risk of accidents can be reduced.

With the correct handling the risk accident can be reduce or in this case, any risk from the cause of accidents can be reduced by 10-40%. Because the risk is reduced, the cost of countermeasures can be reduced. And the benefits of accident risk reduction can save expenses by 10 - 50%. The value 10 – 50 % get by formula (1) which has been calculated. Based on the formula that the risk accident has been reduction because of the RCO. ΔC is the cost incurred to deal with the risks that occur. ΔB is the benefits that can be saved due to risk control. Risk Reduction is a reduction in risk points due to risk management. Cost control is derived from calculating the needs of each type of risk control. Based on the formula 1 ICAR can be obtained. The ICAR value of each incident is compared with ΔC of each incident so that it can get what percentage of the cost benefits from risk management. The cost to be incurred for each type of accident is reduced due to RCO. Each type of control has the required different cost depending on the need Benefit cost is obtained by calculating the benefits of the existence of the cost of risk control. Recommendations for decision making with implementation of FSA can reduce the risk of accidents. However, the risks cannot be completely eliminated, at least minimally. In this risk assessment, the highest risk reaches 11 and it can be defined as a very high risk and includes intolerable. Risk control techniques should be applied continuously and should be continuously improved to ensure safety while Catching the Fish. The following is a list of recommendations:

- Monitoring marine traffic is more cautious. This recommendation is useful to reduce the occurrence of the risk of collision.
- Limitation of marine traffic in bad weather conditions. Especially in times of bad weather, this option helps reduce accident risk factors caused by natural factors such as weather.
- Monitoring of places at risk of accidents.
- The emergency teams must be in the most dangerous position of the area and the team must have a fire-fighter.
- The ship registry for travel: vessel with the high risk should be recorded. Based on this information, ships that have a high level at an inaccessible level should be monitored more carefully.
- In order to maintain the level of risk, it is necessary to have the relevant monitoring, procedures, and rules applied port users by the safety committee.
- The fire fighting equipment required by regulation is generally fairly minimal on small vessels. Consider the possible fire situations, the structure and layout of your vessel and decide if additional equipment would be desirable.

- If do not have a life raft by regulation, consider buying or hiring one and consider also an Emergency Position Indicating Radio Beacon (EPIRB).
- Stability is not easy to assess and must be assessed by a qualified expert. Ideally, when the vessel was first commissioned, full stability calculations will have been made and a stability book produced, giving information on the limitations of the vessel in different loading conditions. For small vessels, however, this is unlikely but the designer will have calculated the level of stability of the hull to ensure that it would achieve the desired requirements.
- It should be possible to move easily around the working areas of the vessel without the risk of slips, trips and falls. For safe working, everything needs to be stowed to leave walkways and working areas clear.
- Ensure that the vessel is controlled safely for all on board, and for the safety of other vessels
- Proper planning, preparation and checks before the fishing trip will ensure that you can go fishing with confidence in vessel.
- Ensure that the correct safety equipment is available with the tools and is used.
- Ensure that the landing equipment is in good order and is suitable for the load being lifted. In some countries legislation is in place requiring that the lifting equipment is tested and certified.

4. Conclusion

The overall objective of risk assessment is to help identify the main safety trends and hazards that may exist in fisheries. As mentioned earlier, identification of known safety hazards is the first step in developing recommendations and solutions to reduce risk and improve safety, such as targeted safety training programs, accident prevention programs, or changes in management approaches. If a fishery has experienced a major change in management regimes, the analyst may be able to deduce whether the change helps improve positive or negative safety outcomes. It may not be possible to encode all safety accidents for a particular fishery or to calculate accident rates for all fisheries due to data limitations. Lack of reliable failure data and lack of confidence in safety assessment have been the two main problems in the safety analysis of various technical activities. However, when information is available, we believe it will be useful to better understand security issues. In marine safety assessments, it is often difficult to measure the likelihood of unintended events and their associated consequences. Based on the result show :

1. Human factor are the caused of the accident.
2. Mechanical failure has a highest risk arround 20% followed by Vessel Foundering arround 19%, Falling Overboard arround 12 % and Followed by Other.
3. The risk can be reduced by 10-40% and the benefits of accident risk reduction can save expenses by 10 - 50%.
4. With the right Control Measure, the accident can be minimized. Caused the minimized accident, the Cost for accident can be minimized too.

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