BACHELOR THESIS & COLLOQUIUM – ME 184841

DEVELOPMENT OF DANGEROUS SCORES WITH AHP METHOD ON BALLAST WATER DISCHARGE FOR SHIP SUBJECT TO INSPECTION

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DOUBLE DEGREE PROGRAM OF
DEPARTEMENT OF MARINE ENGINEERING
FACULTY OF MARINE TECHNOLOGY
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SKRIPSI– ME 184841

Pengembangan Skor Berbahaya Dengan Metode Ahp Pada Pembuangan Air Ballast Untuk Kapal Yang Akan Diinspeksi

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APPROVAL FORM

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BACHELOR THESIS

Submitted to Comply One of the Requirements to Obtain a Bachelor Engineering Degree
on
Laboratory of Marine Operational and Maintenance (MOM)
Bachelor Program Departement of Marine Engineering
Faculty of Marine Technology
Sepuluh Nopember Institute of Technology

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DECLARATION OF HONOR

I hereby who signed below declare that:

This final project has written and developed independently without any plagiarism act. All contents and ideas drawn directly from internal and external sources are indicated such as cited sources, literatures and other professional sources.

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Final Project Title	:	Development of Dangerous Score with AHP Method on Ballast Water Discharge for Ship Subject to Inspection
Departement	:	Marine Engineering

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Surabaya, July 2019

Matthew Gervase Wimaeki

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DEVELPOMENT OF DANGEROUS SCORES WITH AHP METHOD ON BALLAST WATER DISCHARGE FOR SHIP SUBJECT TO INSPECTION

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ABSTRACT

November 5th, 2015, Indonesia became the latest country to ratify the Ballast Water Management Convention (BWMC). Indonesia had experienced ballast water problems in Teluk Lampung in 2012. Each year, ship visits continue to increase, especially ships with international routes. Consequently, the probability of discarded ballast water will increase. It means, the environmental around Tanjung Perak port may be damaged. A scoring system for ballast water discharge should be done to know the risk level of ballast water discharged from the foreign vessel which come to the port of Tanjung Perak. There are a lot of criteria for decision making in the progress of making the scoring system. Because of that, Analytical Hierarchy Process are use as the method to determine each weight of the Criteria and Sub Criteria. Because AHP are a method that rather than prescribing a "correct" decision, the AHP helps decision makers find one that best suits their goal and their understanding of the pr Using the AHP method to create the scores for each criteria and sub criteria. For the main Criteria the biggest weight factor is Origin Port, followed by Classification, Age of Ship, and flag States. For this study 4 main criteria are picked, which are Origin Port, Flag State, Classification, and Age of Ships

Keywords: Analytical Hierarchy Process, Ballast Water Discharge, Dangerous Scores

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PENGEMBANGAN SKOR BERBAHAYA DENGAN METODE AHP PADA PEMBUANGAN AIR BALLAST UNTUK KAPAL YANG AKAN DIINSPEKSI

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ABSTRAK

5 November 2015, Indonesia menjadi negara terbaru yang meratifikasi Ballast Water Management Convention (BWMC). Indonesia telah mengalami masalah air ballast di Teluk Lampung pada 2012. Setiap tahun, kunjungan kapal terus meningkat, terutama kapal dengan rute internasional. Akibatnya, kemungkinan air balas yang dibuang akan meningkat. Artinya, lingkungan di sekitar pelabuhan Tanjung Perak bisa rusak. Sistem penilaian untuk debit air ballast harus dilakukan untuk mengetahui tingkat risiko air ballast yang dikeluarkan dari kapal asing yang datang ke pelabuhan Tanjung Perak. Ada banyak kriteria untuk pengambilan keputusan dalam proses pembuatan sistem penilaian. Karena itu, Proses Hirarki Analitik digunakan sebagai metode untuk menentukan setiap bobot Kriteria dan Sub Kriteria. Karena AHP adalah metode yang alih-alih menentukan keputusan yang "benar", AHP membantu pengambil keputusan menemukan yang paling sesuai dengan tujuan dan pemahaman mereka tentang pr. Menggunakan metode AHP untuk membuat skor untuk setiap kriteria dan sub kriteria. Untuk studi ini 4 kriteria utama dipilih, yaitu Pelabuhan Asal, Bendera Kapal, Klasifikasi, dan Age of Ships. Untuk Kriteria utama, faktor bobot terbesar adalah Pelabuhan Asal, diikuti oleh Klasifikasi, Usia Kapal, dan Bendera Kapal

Kata kunci: Analytical Hierarchy Process, Pembuangan Aie Ballast, Skor Berbahaya

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PREFACE

All the gratitude towards God Almighty for all His blessings and gifts so that the author can complete bachelor thesis with title of “Development of Dangerous Score with AHP Method on Ballast Water Discharge for Ship Subject to Inspection " in order to fulfill the requirements to obtaining the bachelor degree program at Marine Engineering Department, Faculty of Marine Technology, Institut Teknologi Sepuluh Nopember Surabaya.

During the accomplishment of this final project, author want to thank every parties who helped, assisted, and supported the author so that the author is able to complete this very well. All thanks are delivered to:

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2. Dr. Eng. Muhammad Badrus Zaman, S.T., M.T. as Supervisor I of author’s thesis and Dr. Eng. Trika Pitrana, S.T., M.Sc. as Supervisor II of author’s thesis for the assitance and advices during the completion of final project.
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6. And other parties whom author can’t mention all but very meaningful for author.

Because this work is also far from a perfect work, author will really apreciated for every advice, suggestion and idea from all parties for this bachelor thesis correction and improvement in the future. By the completion of this bachelor thesis, author hopes this thesis will be helpful and beneficial for other parties who are going to conduct the similar research.

Surabaya, July 2019

Author

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CHAPTER I
INTRODUCTION

1.1. Background

Ballast water is truly needed when a vessel is not fully loaded because ballast water can provide stability during vessel is on a voyage or doing loading and unloading process. Vessels use ballast water because water is the easiest material to get and it is free to obtain. Moreover, it is also easy to adjust the volume of water that we need. However, the discharge of ballast water can lead to environmental threats.

In 2004, the Ballast Water Management Convention (BWMC) was adopted by the International Maritime Organization (IMO). It proposes to stop the spread of pathogen microorganisms from one region to another. In addition, the transfer of pathogen microorganisms through the ballast water is considered as a major ecological threat to the oceans.

November 5th, 2015, Indonesia became the latest country to ratify the Ballast Water Management Convention (BWMC). The International Convention for the control and management of ships ballast water and sediment's 2004 is authorized by Peraturan Presiden No. 132 Tahun 2015. Indonesia had experienced ballast water problems in Teluk Lampung in 2012. At that time, many sudden species of dead fish were discovered. After tracing, the cause of the problem is the invasion of pathogen organisms from outside Indonesian waters. For this reason, Indonesia ratified that regulation

Recently, ship visits continue to increase, especially ships with international routes. For instances, Tanjung Perak port has increased ship visits by 7% compared to the previous year. In 2018, Tanjung Perak port has a total visit of 14,109 units. Whereas in 2017, the port of Tanjung Perak received a total of 13,163 visits. Consequently, the probability of discarded ballast water will increase

From the information above a safety scoring should be implemented to know the risk level of ballast water discharged from each vessel that come to the port of Tanjung Perak. The Dangerous Scoring will then become a helping tool to identify any upcoming vessel that may have the potential to cause harm from its ballast water. It can be also used to analyze and help the PCSO to identify which ship that should be inspected.

The aim of this study is to make the safety scoring of ballast water at port of Tanjung Perak, Surabaya, Indonesia. From the scoring later, we will know the risk level of ballast water discharge from foreign vessel. The author chooses the port of Tanjung Perak as a location for research because the port of Tanjung Perak is an international port so that many vessels from abroad such as Malaysia, Singapore, China, etc. will be berthing there. In addition, the tools that will be developed to calculate the score of each ballast water may help the Port Safety Control Officer in their field of works.

1.2. Problem of Analysis

Based on the background that described above, author raised the following problem, there are:

1. How to identify the safety score of ballast water risk factor?
2. How to determine score for each factor that affect the ballast water risk?

3. How to develop a calculation software to identify the score of ballast water risk?

1.3. Scope of Problem

The limitations of this thesis are:

1. Analysis will be done at Port of Tanjung Perak
2. Method of determining the score will use Analytic Hierarchy Process (AHP)
3. The variable that will determined the score are: Origin port, Flag State, Classification Society, and Age of Ship.

1.4. Purpose

The objectives to be achieved from this thesis are:

1. To identify what factors that would affect dangerous scores for ballast water.
2. To determine score for each factors that affect the ballast water risk using the Analytical Hierarchy Process method.
3. To develop a web design or software for the dangerous scores calculation of the ballast water discharge risk.

1.5. Benefit

The benefits of this thesis are as follows;

1. Giving the information which is the number 1 priority factor that will affect the dangerous scores for ballast water inspection.
2. Giving Port Safety Control Officer help to identify which ship should be inspected.
3. Also give the PSCO a web interface/software that will help them work faster.

1.6. Systematics of Writing

The systematics of writing in this thesis are:

a. CHAPTER 1. INTRODUCTION

In this chapter the author explains the background of the problem as main idea to do the research, the formulation of the problem, the objectives to be achieved in the research, the benefits for the public, the limitation of the research, and systematics of writing.

b. CHAPTER 2. LITERATURE REVIEWS

In this chapter the author explains the basic theories that support the study of risk assessment of ballast water

c. CHAPTER 3. METHODOLOGY

In this chapter the author describes and explains the flow chart steps in conducting this research task that is arranged systematically.

d. CHAPTER 4. RESULT AND DISCUSSION

In this chapter the author describes the results about the risk assessment of ballast water at port of Tanjung Perak.

e. CHAPTER 5. CONCLUSION AND SUGGESTION

In this chapter the author writes the conclusions based on the goals to be achieved in this final project, as well as provide development advice for further research

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CHAPTER II
LITERATURE STUDY

2.1. Ballast Water System on Vessel

Ballast water is used to stabilize vessels and maintain their structural integrity. Typically ballast water is pumped in to special tanks while cargo is being unloaded, and discharged while cargo is being taken on board. Safety, weather conditions, the ship's load, and the route taken are the primary factors that determine how much ballast water is taken on board a vessel for a particular voyage. More ballast is necessary for ships to sit lower in the water during stormy weather to avoid bottom impact from waves. Ballast water is also adjusted so as to balance the ship as it consumes fuel during a long voyage.

Figure 2.1 shows the process of ballast water system. The working principle of this system is very simple, where pumps are used to pump seawater from sea chest box and moved into water ballast tanks into stability completed. At this time, the microorganism whether it's harmful or not will also come to the ballast tank. Then to de-ballasting, the seawater in water ballast tanks will be pumped by ballast pump through he overboard (O/B). At the
moment, the microorganism inside ballast tank will come out to the environmental. System design ballasts intimately connected with the process of loading and unloading in ports, especially the time it takes to load the unloaded, and also directly affect the change of displacement of the ship. As seen on **figure 2.2.**

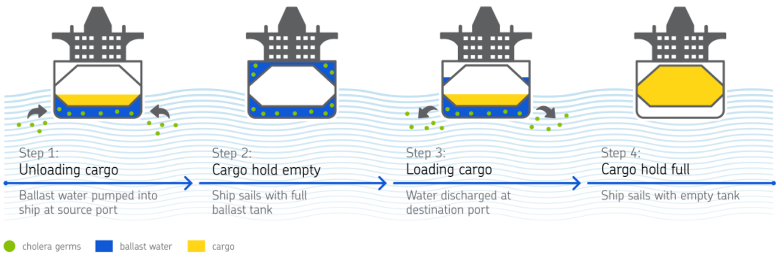

Figure 2.1 Ballast System Process
(Source: marineinaight.com)

2.2. Regulation about Ballast Water

The International Maritime Organization (IMO) has realized that ballast water carried from different waters can bring disaster or disease to the marine ecosystems because discarded ballast water may contain Invasive Aquatic Species and Harmful Aquatic Organisms. In February 13th, 2014, IMO adopted the Ballast Water Management Convention (BWMC), the purpose is to keep the marine ecosystems from harmful aquatic organisms which are come from one region to another, by implementing the standards and procedures for the management and control of ships' ballast water and sediments. However, the convention entered into force in 8th September 2017. It takes a long time because to enter the force because it was dependent on enough ratifications by states. Moreover, the suitable ballast water management systems were not available and guidelines to support the BWM convention needed to be developed (IMO, 2017). At this time, there are 60 countries including Indonesia which ratified

This convention has 5 sections which regulate ballast water management, those sections are from Annex A until Annex E. So, this is explanation about Annex A to Annex E:

a. Annex A

The concentration of this section is on general provisions includes definitions, application and exemptions. Ballast water under the regulation A-2 the general applicability is "Except where expressly provided otherwise, the discharge of Ballast Water shall only be conducted through Ballast Water Management, in accordance with the provisions of this Annex."

b. Annex B

The concentration of this section is on management and control requirements for ships. This part has 4 regulations which are B-1 to B-4. B-1 expresses that ships are required to have on board and implementation a ballast water management plant and approved by the administration. B-2 states that ships must have a ballast water record book to record the process of ballast water in a ship. B-3 contains about the specific requirement of ballast water management. And B-4 regulates about ballast water exchange.

c. Annex C

The concentration of this section is on additional measures on ballast water to prevent, reduce, or eliminate the transfer of harmful aquatic organisms and pathogen through ships' ballast water and sediment. The party should communicate their intention to establish additional measure to the organization least in 6 months, except in emergency, prior to the projected date of implementation of the measure.

d. Annex D

The concentration of this section is on standards for ballast water management. There are 2 standards on this section:

- D1

  The D-1 standard requires ships to exchange their ballast water in open seas, away from coastal areas. Ideally, this means at least 200 nautical miles from land and in water at least 200 meters deep. By doing this, fewer organisms will survive and so ships will be less likely to introduce potentially harmful species when they release the ballast water.

- D2

  The D-2 standard specifies the maximum number of viable organisms allowed to be discharged, including specified indicator microbes harmful to human health.

  This section also states that new ships built on or after 8th September 2017 must meet the D2 standard. For existing ship which is built prior to 8th

September 2017 must meet the D1 standard until their D2 compliance date. In September 8th, 2024, all ships must meet D2 standard. All ships also must have:

-ballast water management plan

-ballast water record book

-International Ballast-Water Management Certificate

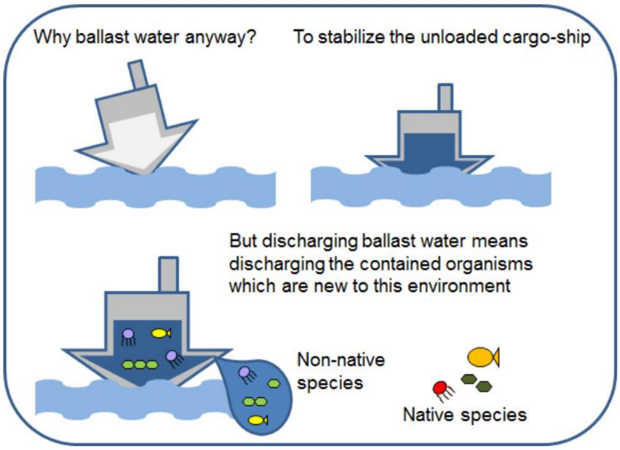

Figure 2. 2 ballast water process
(Source: marineinsight.com)

e. Annex E

The concentration of this section is on survey and certification requirements for ballast water management. This part gives requirements for initial renewal, annual, intermediate and renewal surveys and certification requirements. Appendices give form of Ballast Water Management Certificate and Form of Ballast Water Record Book.

2.3. Analytic Hierarchy Process

Analytical Hierarchy Process is a structured technique for organizing and analyzing complex decisions, based on mathematics and psychology. It was developed by Thomas L. Saaty in the 1970s and has been extensively studied and refined since then. It has particular application in group decision making.

Rather than prescribing a "correct" decision, the AHP helps decision makers find one that best suits their goal and their understanding of the problem. It provides a comprehensive and rational framework for structuring a decision problem, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions.

Users of the AHP first decompose their decision problem into a hierarchy of more easily comprehended sub-problems, each of which can be analyzed independently. Once the hierarchy is built, the decision makers systematically evaluate its various elements by comparing them to each other two at a time, with respect to their impact on an element above them in the hierarchy. In making the comparisons, the decision makers can use concrete data about the elements, but they typically use their judgments about the elements' relative meaning and importance.

The AHP converts these evaluations to numerical values that can be processed and compared over the entire range of the problem. A numerical weight or priority is derived for each element of the hierarchy, In the final step of the process, numerical priorities are calculated for each of the decision alternatives. These numbers represent the alternatives' relative ability to achieve the decision goal, so they allow a straightforward consideration of the various courses of action.

The input can be obtained from actual measurement such as price, weight etc., or from subjective opinion such as satisfaction feelings and preference. AHP allow some small inconsistency in judgment because human is not always consistent. The ratio scales are derived from the principal Eigen vectors and the consistency index is derived from the principal Eigen value.

2.3.1. Basic Steps

The basic steps in the solution of a decision problem using AHP are quite simple:

1. Define the goal of the decision – what do I want to decide, for what purpose, and what are my alternatives?
2. Structure the decision problem in a hierarchy – what are the categories and criteria that figure into my decision?
3. Pair comparison of criteria in each category – e.g. blue or green? Which do you prefer, and by how much do I prefer one or the other color?
4. Calculate the priorities and a consistency index – were my comparisons logical and consistent?
5. Evaluate alternatives according to the priorities identified – what alternative optimum solution is there to the decision problem?

The core of AHP is the comparison of pairs instead of sorting (ranking), voting (e.g. assigning points) or the free assignment of priorities. Validation of the method in practical testing shows surprisingly good agreement with actual measured values.

3.2.2. Estabilishing Priorities

There are 3 basics steps to making a priority or AHP.

1. **Decomposition**

   After finding the problems the next steps is to do the decomposition, which are breaking the problem into variables or elements. Until it gotten into each level of the problems. That’s why this analysis is called hierarchy. There are 2 types of hierarchy: complete hierarchy and non-complete hierarchy. The difference is whether its hierarchy has all the elements needed, then it is called complete hierarchy, if not then it is called non complete hierarchy.

2. **Comparative Judgement**

   This principle means that making a judgement for the sake of its relative of two elements at certain level into the next level. The judgement is the core of the AHP, because it will affect to each elements of priority. This judgement process will be presented into Pairwise Comparison matrix. In order to obtain the right scale, therefore the person who will give the judgement or score need to understand all of the elements that will be compare, in other meaning the person who give the score needed to be expert on that field of criteria that is studied.

3. **Synthesis of Priority**
   From every matrix of pairwise comparison, it will find the vector needed for getting the local priority. Every level has its own pairwise comparison matrix. So for the general it need to do the synthesis of priority to find the best priority of the hierarchy
4. **Logical Consistency**
   The consistency of the answer from the respondent for determining priorities elements is a basic principle that will determine the validity data and result f decision making. In general, respondents must have consistency in making comparisons element. Example if A > B and B > C, then logically the respondent must state that A > C, based on the numerical value that has been provided**.**

2.3.3. Model the Problem as a hierarchy

A hierarchy is a stratified system of ranking and organizing people, things, ideas, etc., where each element of the system, except for the top one, is subordinate to one or more other elements. Though the concept of hierarchy is easily grasped intuitively, it can also be described mathematically. Diagrams of hierarchies are often shaped roughly like pyramids, but other than having a single element at the top, there is nothing necessarily pyramid-shaped about a hierarchy.

In the world of ideas, we use hierarchies to help us acquire detailed knowledge of complex reality: we structure the reality into its constituent parts, and these in turn into their own constituent parts, proceeding down the hierarchy as many levels as we care to. At each step, we focus on understanding a single component of the whole, temporarily disregarding the other components at this and all other levels. As we go through this process, we increase our global understanding of whatever complex reality we are studying.

An AHP hierarchy is a structured means of modeling the decision at hand. It consists of an overall goal, a group of options or alternatives for reaching the goal, and a group of factors or criteria that relate the alternatives to the goal. The criteria can be further broken down into subcriteria, sub-subcriteria, and so on, in as many levels as the problem requires. A criterion may not apply uniformly, but may have graded differences like a little sweetness is enjoyable but too much sweetness can be harmful. In that case the criterion is divided into subcriteria indicating different intensities of the criterion, like: little, medium, high and these intensities are prioritized through comparisons under the parent criterion, sweetness. Published descriptions of AHP applications often include diagrams and descriptions of their hierarchies

To better understand AHP hierarchies, in **Figure 2.3,** consider a decision problem with a goal to be reached, three alternative ways of reaching the goal, and four criteria against which the alternatives need to be measured

Such a hierarchy can be visualized as a diagram like the one immediately below, with the goal at the top, the three alternatives at the bottom, and the four criteria in between. There are useful terms for describing the parts of such diagrams: Each box is called a node. A node that is connected to one or more nodes in a level below it is called a parent node. The nodes to which it is so connected are called its children.

Applying these definitions to the diagram below, the goal is the parent of the four criteria, and the four criteria are children of the goal. Each criterion is a parent of the three Alternatives. Note that there are only three Alternatives, but in the diagram, each of them is repeated under each of its parents.

To reduce the size of the drawing required, it is common to represent AHP hierarchies as shown in the diagram below, with only one node for each alternative, and with multiple lines connecting the alternatives and the criteria that apply to them. To avoid clutter, these lines are sometimes omitted or reduced in number. Regardless of any such simplifications in the diagram, in the actual hierarchy each criterion is individually connected to the alternatives. The lines may be thought of as being directed downward from the parent in one level to its children in the level below.

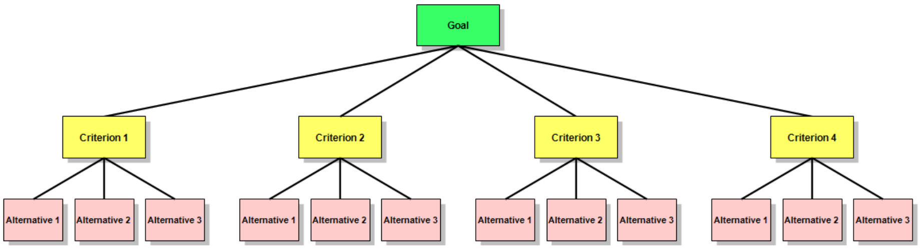

Figure 2.3 A simple AHP hierarchy
Source: *(Zaman & Santoso, 2015)*

2.3.4. Evaluate the Hierarchy

Once the hierarchy has been constructed, the participants analyze it through a series of pairwise comparisons that derive numerical scales of measurement for the nodes. The criteria are pairwise compared against the goal for importance. The alternatives are pairwise compared against each of the criteria for preference. The comparisons are processed mathematically, and priorities are derived for each node.

2.3.5 Establish Priorities.

Priorities are numbers associated with the nodes of an AHP hierarchy. They represent the relative weights of the nodes in any group.

Like probabilities, priorities are absolute numbers between zero and one, without units or dimensions. A node with priority .200 has twice the weight in reaching the goal as one with priority .100, ten times the weight of one with priority .020, and so forth. Depending on the problem at hand, "weight" can refer to importance, or preference, or likelihood, or whatever factor is being considered by the decision makers

Priorities of the Goal, the Criteria, and the Alternatives are intimately related, but need to be considered separately. By definition, the priority of the Goal is 1.000. The priorities of the alternatives always add up to 1.000. Things can become complicated with multiple levels of Criteria, but if there is only one level, their priorities also add to 1.000. All this is illustrated by the priorities in the example **figure 2.4.**

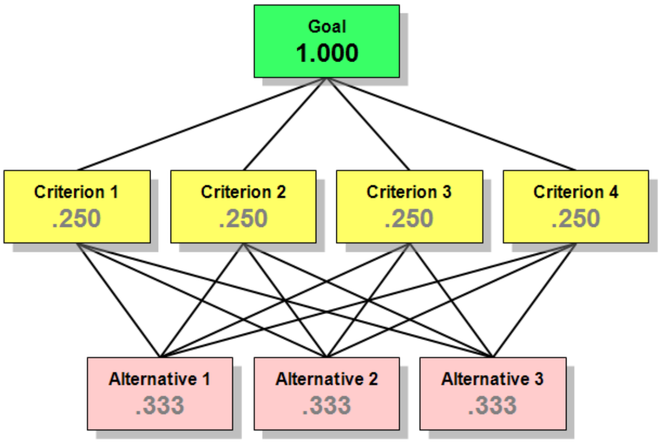

Figure 2.4 AHP with associated default priorities.
Source: *(Zaman & Santoso, 2015)*

The rule is this: Within a hierarchy, the global priorities of child nodes always add up to the global priority of their parent. Within a group of children, the local priorities add up to 1.000

Each element in the hierarchy must know their relative weights for each other. The aim is to determine the level of interests or preferences of interested parties in the problem with the criteria and structure of the hierarchy or the system as a whole. The first step needed is to compile a paired comparison of all elements for each hierarchy subsystem. The comparison is then transformed into a matrix to be used in numerical analysis as shown in **Table 2.1.**

Table 2.1 Comparison Matrix for each Criterias (Saaty, L 1993)

Goal				
Criteria	**A**	**B**	**C**	**D**
A				
B				
C				
D				

Table 2.2 shows a nine-point pair-wise comparison scale typically used in the AHP. The Ahp helps to perform a pair-wise comparison the criteria at a particular level of the hierarchy, to find out which of the criteria the decision-maker wants to assign the highest priority. While comparing those criteria qualitatively, some corresponding scale values are assigned to them

Table 2.2 Scale for pairwise comparison

Point Intensity	**Definition**	**explanation**
1	Indifferent	Dua elemen mempunyai pengaruh yang sangat besar terhadap tujuan
3	Weak preference (moderately more important)	Experience and appraisal slightly support one element compared to other elements
5	Preference (more important)	Experiences and ratings are very strong in support of one element compared to other elements
7	Strong preference (strongly more important)	One strong and dominant element is seen in practice

9	Very strong preference (extremely more important)	evidence that supports element one with another element has the highest affirmation level that strengthens
2,4,6,8	Intermediate value between the two adjacent scale values	used to represent compromise between the priorities listed aboves

The AHP approach uses the current scale starting from the weight values 1 to 9. The weight value 1 describes "equally important", this means that the attribute value is the same scale, the weight value is 1, while the weight value 9 describes the case attribute that is "absolute important" compared other.

AHP allows people to refine their definition of an issue and improve their considerations and understanding through repetition.

In AHP, policy priority setting is done by rationally capturing people's perceptions, then converting non-measurable factors into ordinary rules so that they can be compared. The stages in data analysis are as follows:

1. System identification, namely to identify problems and determine the desired solution. System identification is done by studying references and discussing with experts who understand the problem, so that the concepts that are relevant to the problem at hand are obtained
2. Compilation of hierarchical structures beginning with general objectives, followed by sub-objectives, criteria and possible alternatives at the lowest criteria level.
3. Pairwise comparisons describe the relative influence of each element on each objective or criteria above. Pairwise comparison techniques used in AHP are based on judgment or opinions of respondents who are considered as competent parties to the problems raised. They can consist of: 1) decision makers; 2) experts; 3) people involved and understand the problems faced.
4. In this step, the results of the questionnaire are calculated in a comparison matrix. The matrix was expressed by Equation 1:

$$A = \begin{matrix} 1 \\ 2 \\ 3 \\ \vdots \\ n \end{matrix} \begin{bmatrix} w_1/w_1 & w_1/w_2 & w_1/w_3 & \cdots & w_1/w_n \\ w_2/w_1 & w_2/w_2 & w_2/w_3 & \cdots & w_2/w_n \\ w_3/w_1 & w_3/w_2 & w_3/w_3 & \cdots & w_3/w_n \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ w_n/w_1 & w_n/w_2 & w_n/w_3 & \cdots & w_n/w_n \end{bmatrix}$$

5. Having a comparison matrix, we can compute the priority vector (in Equation 2), which is the normalized eigenvector of the matrix. So, in order to obtain the relative weights can be obtained from the rows in the matrix A. Below is formula for the matrix A:

   $$A * W = n * W$$

   where, W was described as (w1,w2,..,wn). Definition of T is the vector for actual relative weight and n is defined as element's numbers. For the matrix of algebra, W and n in Equation 2 were defined as eigenvector and eigenvalue of matrix A.
6. In AHP, it is not easy to know W, therefore, is not able to produce the pairwise relative weights of matrix A accurately. Calculation of W could be described as follow:

   $$A * W = \lambda max * W$$

   where, A is described as matrix of pairwise comparisons, λmax is the largest eigenvalue W is its right eigenvector
7. Consistency should be tested so that consistency can be achieved. CI values can be obtained from the following equation:

   $$CI = (\lambda max - n)/(n - 1)$$

   The above equation explains that CI is the consistency index, while λmax explain the main eigenvalues of matrix, n expressed as a sequence of matrix. Then, the Consistency Ratio (CR) is calculated as follows:

   $$CR = CI/RI \leq 0.1$$

   where, RI is average of the resulting consistency index depending on the order of the matrix. Value consistency should be less than 0.10. It shows fairness. If the value of consistency is more than 0.10, the matrix must be changed.

2.3.6. Benefit for using AHP

Some benefit for using Analytical Hierarchy Process as a method for analysis are:

1. AHP provides a single model that is easy to understand for a variety of unstructured problems.
2. AHP combines system-based design in solving complex problems.
3. AHP can handle the interdependence of elements in one system and does not impose linear thinking.
4. AHP reflects the natural tendency of the mind to sort out elements of a system at different levels and group similar elements in each level.
5. AHP gives a scale in measuring things that do not materialize to get priority.
6. AHP tracks logical consistency of considerations used in setting various priorities.
7. AHP leads to a comprehensive assessment of the goodness of each alternative.
8. AHP considers the relative priorities of various system factors and allows people to choose the best alternative based on their goals.
9. AHP does not impose consensus but synthesizes a representative result from different assessments.

2.4. Paper Review

a. Dangerous Score for Ship Inspection

Determining the dangerous score for ship inspection has been studied before Poor implementation of safety standard is considered as one reason of high ship accident level in Indonesia. One attempt to increase the safety standard of ship is to implement one of rules published by International Maritime Organization (IMO) regarding to inspection strategy for ships that operate in port area. The inspections are done by port state control officer (PSCO). In respect to the inspection strategy. (Gunawan, 2011)

b. AHP Method

The aim of the research is to provide a method to evaluate supply chain risks that stand in the way of the supply chain objectives. The AHP method can support managers in a broad range of decisions and complex problems – including supplier-selection decisions, facility-location decisions, forecasting, risks and opportunities modelling, choice of technology, plan and product design, and so on. (Gaudenzi, 2006)

The AHP integrates an expert’s opinion and evaluation scores and converts the complex decision-making system into a simple elementary hierarchy system. There are some key steps to making decisions in an organized way, to generate priorities and to decompose a complex multi criteria deicision-making (MCDM) problem. (Badruz, 2012)

c. Ballast Water Environmental Impact

Intercountry and intercontinental transport increasingly continues. In this regard, maritime transport has a major play role due to being cheaper and more reliable. Globalization and technological advances has been a major driving force for goods and people move at a much faster rate and to reach far more distances locations as soon as possible. Nowadays, about 90% of world trade is made by means of ships. As a result of human activities, plants, animals and other organisms are transported to new habitats with a speed and efficiency. Therefore, ship-based marine pollution reached serious levels for the marine environment. (ELÇİÇEK, 2013)

2.5. Criteria for the Scores

a. Origin Port

A port is a maritime commercial facility which may comprise one or more wharves where ships may dock to load and discharge passengers and cargo. Although usually situated on a sea coast or estuary, some ports, such as Hamburg, Manchester and Duluth, are many miles inland, with access from the sea via river or canal. Today, by far the greatest growth in port development is in Asia, the continent with some of the world's largest and busiest ports, such as Singapore and the Chinese ports of Shanghai and Ningbo-Zhoushan

Whereas early ports tended to be just simple harbours, modern ports tend to be multimodal distribution hubs, with transport links using sea, river, canal, road, rail and air routes. Successful ports are located to optimize access to an active hinterland, such as the London Gateway. Ideally, a port will grant easy navigation to ships, and will give shelter from wind and waves. Ports are often on estuaries, where the water may be shallow and may need regular dredging. Deep water ports such as Milford Haven are less common, but can handle larger ships with a greater draft, such as super tankers, Post-Panamax vessels and large container ships. Other businesses such as regional distribution centres, warehouses and freight-forwarders, canneries and other processing facilities find it advantageous to be located within a port or nearby. Modern ports will have specialised cargo-handling equipment, such as gantry cranes, reach stackers and forklift trucks.

There are several initiatives to decrease negative environmental impacts of ports. These include SIMPYC, the World Ports Climate Initiative, the African Green Port Initiative and EcoPorts

b. Flag State

The flag state has the authority and responsibility to enforce regulations over vessels registered under its flag, including those relating to inspection, certification, and issuance of safety and pollution prevention documents. As a ship operates under the laws of its flag state, these laws are applicable if the ship is involved in an admiralty case.

Ships must be registered in the ship register of the jurisdiction whose flag it is flying. Flag registers in many countries are open to ships with foreign owners. Normally, each flag state has only one ship register, but several countries have more than one register

c. Classification Society

Maritime classification societies were born out of a need to ensure the continued safety and security of the maritime domain with respect to the vessels and the various marine aiding constructions. The role of a classification society is thus quite set and of utmost importance. At present, more than 50 classification societies exist. A classification society is required to notate grades or classes for vessels, vessel structuring and its maintenance along with the structuring aspect of various constructions located in the high seas.

At the same time though, the conventions of UNCLOS and SOLAS have made special provisions to specify that in the better interests of the shipping community, vessels need to be classed. There is a specific association of classification societies known as the IACS (International Association of Classification Societies).

d. Age of Ship

The age of the ship will affect to its performance. Normally ship that is 5 years old or older will have a higher inspection, the age itself counted from the first year of that ship operated. For general a ship is designed and built for operational time of 25 years. The equipment for the ship also will aged together with the ship

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CHAPTER III
METHODOLOGY

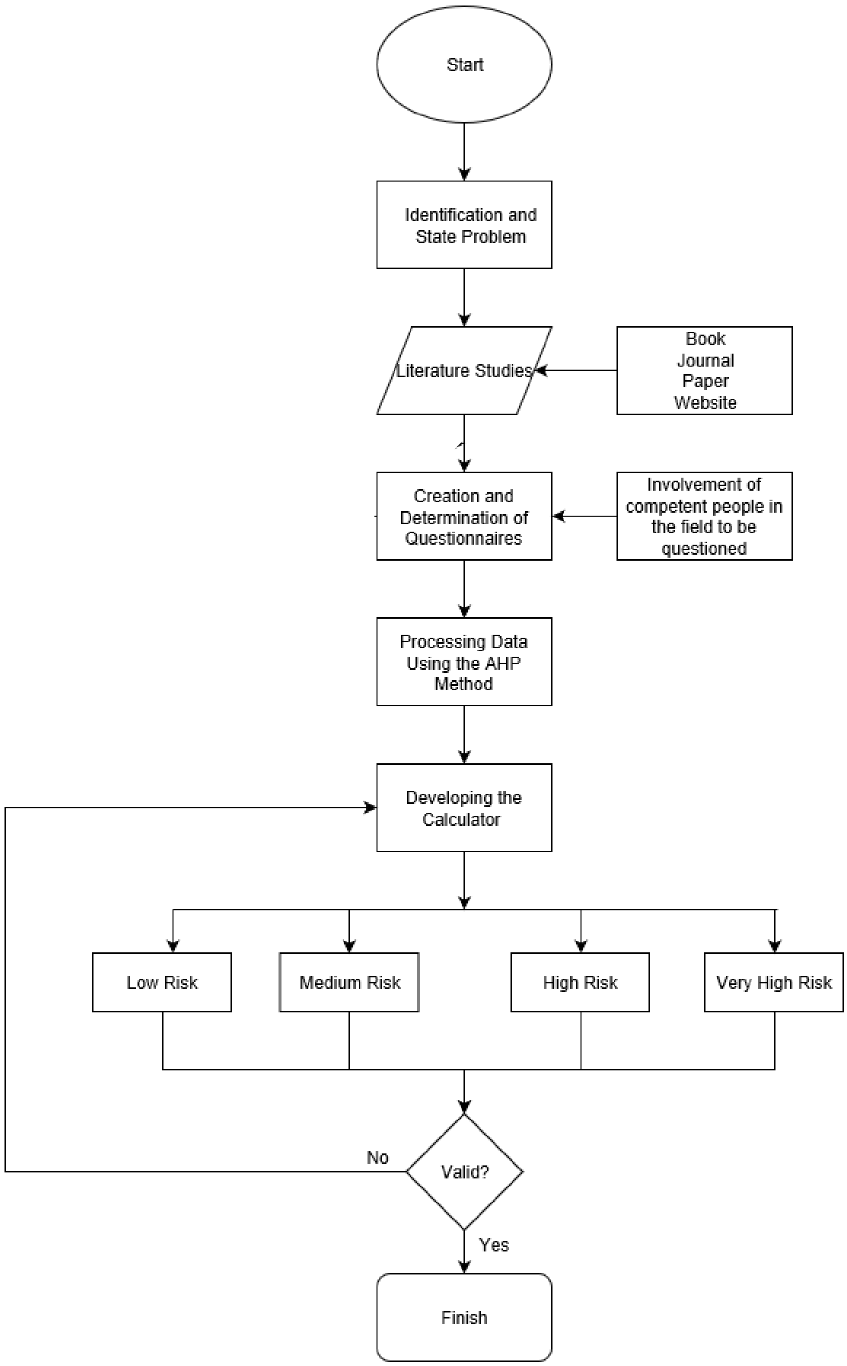

Figure 3. 1. Methodology Flow Chart Part 1

3.1. Identification and State Problem

In this step, the problem will be identified from many sources such as paper, journal, book, website etc. Those sources support the background of writing this study. The selection of problem, objective and predicted solution shall be arranged. As a result, the objective and benefit of the study could be achieved. The author suspects that with the increase of ships entering into the Surabaya port, it will may also increase the dangerous microorganism carried in the ballast water of the ship.

3.2. Literature Study

After identifying the problem, the literature study should be done. This will be the reason in solving the problem. The literature study was done by reading some sources of information. There are books, journals and other thesis which came from the trusted sources. The aim of this step is to explain the depth of review, summarize the basic theory, general and specific reference, and obtaining various other supporting information related to the study. In this study, the author involves a literature study on ballast water system, regulation about ballast water, how to create such a scoring system using AHP method, ballast water manangement system, and then develop a web based calculator for the scoring itself.

3.3. Creation and Determination of Questionnaires

Creating the Questionnaires aimed for getting the needed data for the making the software. The questionnaires will be given to a competent person who has experience in field of Marine Engineer which are Port State Control Officers

3.4. Processing Data using AHP Method

Analytic Hierarchy Process is a structured technique that will organize and analyzing complex decisions. This method will help to provide the necessary scoring system that will be the factor to determine the calculation process.

3.5. Developing the Calculator Based on the Score

At this stage, after getting the data and score from the questionnaires and scoring from AHP method, a development for calculator software will make the scoring for the upcoming ship possible. The output from this calculation will be divided into four categories: low risk, medium risk, high risk and very high risk.

3.6. Conclusion

On the final step, the author will check the validation of the score. If the calculation of the score is not valid, the author should repeat the processing and analysis step. Otherwise, if the study is valid so the author can do the next step which is conclusion. In conclusion stage, the author will summarize the study and give recommendation for the reader also PSCO (Port Safety Control Officer

CHAPTER IV
RESULT AND DISCUSSION

4.1. Creating Criteria and Sub Criteria

a. Origin Port

A port is a maritime commercial facility which may comprise one or more wharves where ships may dock to load and discharge passengers and cargo. Although usually situated on a sea coast or estuary, some ports, such as Hamburg, Manchester and Duluth, are many miles inland, with access from the sea via river or canal. Today, by far the greatest growth in port development is in Asia, the continent with some of the world's largest and busiest ports, such as Singapore and the Chinese ports of Shanghai and Ningbo-Zhoushan

Whereas early ports tended to be just simple harbours, modern ports tend to be multimodal distribution hubs, with transport links using sea, river, canal, road, rail and air routes. Successful ports are located to optimize access to an active hinterland, such as the London Gateway. Ideally, a port will grant easy navigation to ships, and will give shelter from wind and waves. Ports are often on estuaries, where the water may be shallow and may need regular dredging. Deep water ports such as Milford Haven are less common, but can handle larger ships with a greater draft, such as super tankers, Post-Panamax vessels and large container ships. Other businesses such as regional distribution centres, warehouses and freight-forwarders, canneries and other processing facilities find it advantageous to be located within a port or nearby. Modern ports will have specialised cargo-handling equipment, such as gantry cranes, reach stackers and forklift trucks.

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At the same time though, the conventions of UNCLOS and SOLAS have made special provisions to specify that in the better interests of the shipping community, vessels need to be classed. There is a specific association of classification societies known as the IACS (International Association of Classification Societies).

d. Age of Ship

The age of the ship will affect to its performance. Normally ship that is 5 years old or older will have a higher inspection, the age itself counted from the first year of that ship operated. For general a ship is designed and built for operational time of 25 years. The equipment for the ship also will aged together with the ship

4.2. Making the Questionaire

Because of its impossible to determine the Origin Port weight by using AHP method, Origin Port will use Salinity as its based to be the weight for determining the scores. While the others: Flagstate, Classification, and Age of Ship are all will be determined by using AHP.

In **table 4.1** the term 'salinity' is, for oceanographers, usually associated with one of a set of specific measurement techniques. As the dominant techniques evolve, so do different descriptions of salinity. Salinities were largely measured using titration-based techniques before the 1980s. Titration with silver nitrate could be used to determine the concentration of halide ions (mainly chlorine and bromine) to give a chlorinity. The chlorinity was then multiplied by a factor to account for all other constituents. The resulting 'Knudsen salinities' are expressed in units of parts per thousand (ppt or ‰)

The use of electrical conductivity measurements to estimate the ionic content of seawater led to the development of the scale called the *practical salinity scale 1978* (PSS-78). Salinities measured using PSS-78 do not have units. The suffix psu or PSU (denoting *practical salinity unit*) is sometimes added to PSS-78 measurement values.

Table4 1 Port Salinity Data

NO	Port Code	Source Port	Ecoregion	Country	Salinity (PSU)
1	SGSIN	SINAGPORE	Malacca Strait	SINGAPORE	38.67
2	TWKHH	KAOHSIUNG	Southern China	TAIWAN	35.25
3	MYTPP	TANJUNG PELEPAS	Malacca Strait	MALAYSIA	30.28
4	TLDIL	DILI	Banda Sea	TIMOR LESTE	34.24
5	CNSHG	SHANGHAI	East China Sea	CHINA	1.5
6	MYPKG	KLANG	Malacca Strait	MALAYSIA	32.19
7	KRPUS	BUSAN	East China Sea	KOREA	34.76
8	HKHKG	HONG KONG	Southern China	HONG KONG	25.71
9	MYWSP	WESTPORT	Malacca Strait	MALAYSIA	32.19
10	CNSHK	SHEKOU	Southern China	CHINA	29.23
12	PHDVO	DAVAO	Eastern Philippines	PHILIPPINES	38.73
11	CNNGB	NINGBO	East China Sea	CHINA	22.03
13	TWTPE	TAIPEI	East China Sea	TAIWAN	34.21
14	CNXMG	XIAMEN	Southern China	CHINA	36.51
15	JPSMZ	SHIMIZU	Suruga Bay	JAPAN	35.26
16	MYPGU	PASIR GUDANG	Malacca Strait	MALAYSIA	31.85
17	KRUSN	ULSAN	Sea of Japan	KOREA	34.35
18	THLCH	LAEM CHABANG	Gulf of Thailand	THAILAND	28.77
19	TWTXG	TAICHUNG	Southern China	TAIWAN	36.97
20	KRKAN	GWANGYANG	East China Sea	KOREA	33.4
21	MMRGN	YANGON	Nothern Bay of Bengal	MYANMAR	29.41
22	CNYAT	YANTIAN	Southern China	CHINA	36.68
23	JPNGO	NAGOYA	Ise Bay	JAPAN	29.28
24	THBKK	BANGKOK	Gulf of Thailand	THAILAND	5.37
25	CNLYG	LIANYUNGANG	Yellow Sea	CHINA	33.75
26	CNTXG	TIANJIN	Yellow Sea	CHINA	28.88
27	AUGOV	GOVE	Gulf of Carpentaria	AUSTRALIA	28.76
28	CNTAP	TAIPING	Southern China	CHINA	8.46
29	VNSGN	HO CHI MINH	Southern Vietnam	VIETNAM	1.15

30	PHMNN	MANILA NORTH	Eastern Philippines	PHILIPPINES	38.51
31	CNQGD	QINGDAO	Yellow Sea	CHINA	36.8
32	MYPEN	PENANG	Malacca Strait	MALAYSIA	36.46
33	JPTYO	TOKYO	Tokyo Bay	JAPAN	34.98
34	PHSFS	SUBIC BAY	Eastern Philippines	PHILIPPINES	34.59
35	CNDLC	DALIAN	Yellow Sea	CHINA	32.92
36	CNNSA	NANSHA	Southern China	CHINA	30.62

Salinity itself has the type that the more salt on it, the higher PSU its contained. Therefor for the purpose to make it into the calculation, we use the salinity as the local weight priority for the AHP since PSU is a percent of contained salt in the water as seen on **table 4.2**.

Table 4.2 Water Salinity

Water salinity			
Fresh water	**Brackish water**	**Saline water**	**Brine**
< 0.05%	**0.05 – 3%**	**3 – 5%**	**> 5%**
< 0.5 ‰	**0.5 – 30 ‰**	**30 – 50 ‰**	**> 50 ‰**

4.2.1. Making the Hierarchy

An AHP hierarchy is a structured means of modeling the decision at hand. It consists of an overall goal, a group of options or alternatives for reaching the goal, and a group of factors or criteria that relate the alternatives to the goal. The criteria can be further broken down into subcriteria, sub-subcriteria, and so on, in as many levels as the problem requires. A criterion may not apply uniformly, but may have graded differences like a little sweetness is enjoyable but too much sweetness can be harmful. In that case the criterion is divided into subcriteria indicating different intensities of the criterion, like: little, medium, high and these intensities are prioritized through comparisons under the parent criterion, sweetness. Published descriptions of AHP applications often include diagrams and descriptions of their hierarchies. For this dangerous scores the critera and sub criteria are listed in **Figure 4.1.**

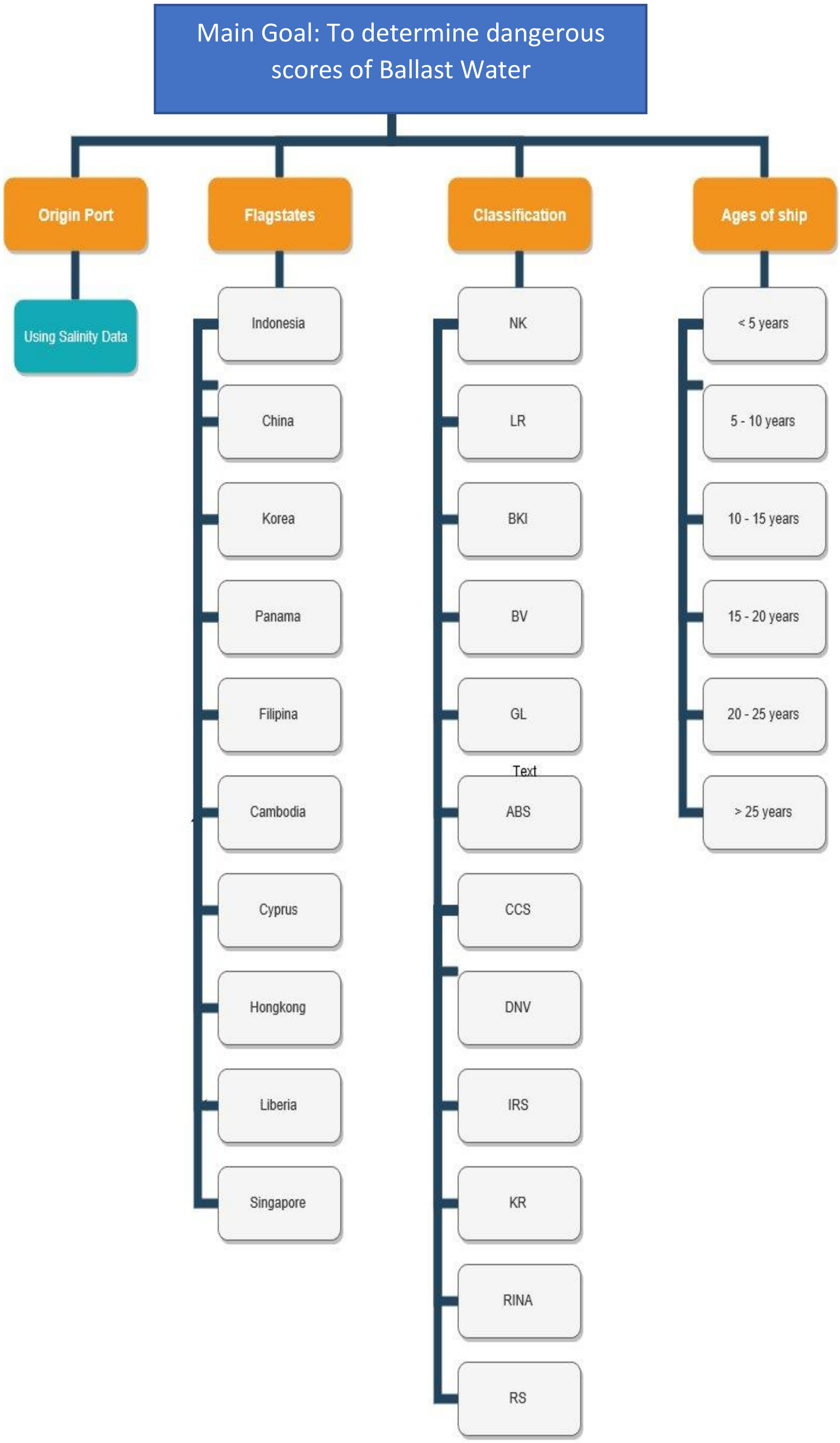
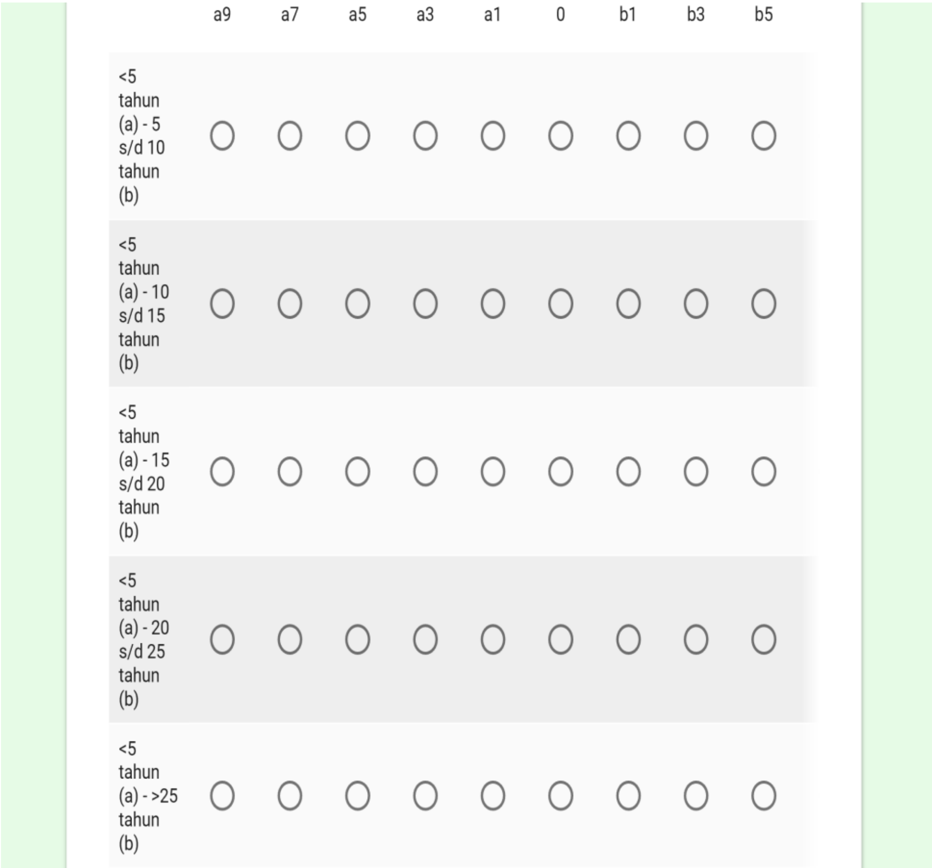


Figure 4.1 Hierarchy of the safety scores

4.2.2. Creating form

then the results of these criteria are made an expert judgment questionnaire where the questionnaire is distributed and will produce values ranging from 1 to 9 based on personal experience by a port state control officer on duty. by using google form as an online questionnaire. then sent directly online to the person concerned.



	a9	a7	a5	a3	a1	0	b1	b3	b5
<5 tahun (a) - 5 s/d 10 tahun (b)									
<5 tahun (a) - 10 s/d 15 tahun (b)									
<5 tahun (a) - 15 s/d 20 tahun (b)									
<5 tahun (a) - 20 s/d 25 tahun (b)									
<5 tahun (a) - >25 tahun (b)									

Figure 4.1 Example of Questionare

4.3. Data Collections

In the calculation process of Inspection Score the first step is to calculate the Relative Weight for each sub-criteria Inspection Score. In this thesis the method used is Analytic Hierarchy Process (AHP).

Then from the data obtained from the questionnaire, numerical values between elements will be processed in a comparison matrix. Table 4.3, and Table 4.4, are pairwise comparison matrices for each criterion, where the comparison of the matrices is obtained after calculating the geometric average, because the respondents in filling in the questionnaire are not only one but many respondents so it is necessary to calculate geometric averages.

Table 4. 3 Matrix of Sub Criteria from Flagstates.

	Indonesia	China	Korea	Panama	Filipina	Cambodia	Cyprus	Hongkong	Liberia	Singapore
Indonesia	1.00	1.32	0.90	0.83	1.13	1.94	0.90	0.82	1.94	0.90
China	0.76	1.00	0.80	0.82	2.45	3.65	0.77	0.82	1.13	0.38
Korea	1.12	1.24	1.00	1.81	1.81	4.11	0.79	1.23	1.66	0.55
Panama	1.20	1.21	0.55	1.00	1.66	3.92	0.82	0.55	0.65	0.35
Filipina	0.89	0.41	0.55	0.60	1.00	2.36	0.31	0.39	0.34	0.50
Cambodia	0.51	0.27	0.24	0.26	0.42	1.00	0.26	0.33	0.31	0.27
Cyprus	1.12	1.30	1.26	1.21	3.19	3.51	1.00	1.60	1.47	0.53
Hongkong	1.21	1.21	0.81	1.81	2.54	3.00	0.62	1.00	1.21	0.55
Liberia	0.51	0.89	0.60	1.54	2.97	3.27	0.68	0.82	1.00	0.65
Singapore	1.12	2.66	1.81	2.89	2.02	3.65	1.87	1.81	1.54	1.00
	9.44	11.51	8.52	12.77	19.19	30.41	8.02	9.37	11.25	5.68

Table 4.3 is a comparison matrix for the Flagstates criterion describing a comparison matrix where there are two different conditions and gives an importance value between the two conditions,

Then the data are compiled to the table in the matrix like above. For instance in row 3 column 1 Korea has higher score to Indonesia for 1.12. so tu filled the scores of Indonesia to Korea which are row 1 column 3, it will be calculate that 1/1.12 which equals 0.8928… but we round it to 2 decimal which are 0.9. and so on.

Table 4.4 Matrix of Subcriteria of Year of Ship

	<5 th	5 - 10 th	10 - 15 th	15 - 20 th	20 - 25 th	> 25 th
<5 th	1.00	3.60	4.87	6.75	6.91	7.16
5 - 10 th	0.28	1.00	4.63	5.77	6.43	6.58
10 - 15 th	0.21	0.22	1.00	3.64	4.26	6.50
15 - 20 th	0.15	0.17	0.27	1.00	3.23	4.37
20 - 25 th	0.14	0.16	0.23	0.31	1.00	3.39
> 25 th	0.14	0.15	0.15	0.23	0.30	1.00
	1.92	5.30	11.15	17.70	22.13	29.00

The description of the matrix table for comparison of safety scores and classification can be seen in Attachment A of this thesis.

4.4. Consistency Ratio

To find the consistency ratio or C.R. first, consistency index should be calculated. To find the C.I. to know the CI we have to find the λmax.

	origin port	flagstate	classificatic	year	weighted sum value	criteria weight	ratio
origin port	0.313376	0.17783	0.64302	0.309725	1.443950457	0.313375634	4.60773
flagstate	0.325911	0.185239	0.169961	0.146138	0.82724915	0.185239293	4.465841
classificatic	0.137885	0.307497	0.283269	0.268283	0.996934371	0.283268586	3.519396
year	0.219363	0.276007	0.229448	0.218116	0.942933532	0.218116487	4.323073
						[illegible]	4.22901

Each of the data are calculated by multiplying the pairwise comparison data with each of their weight criterion vertically. The weighted sum value is the total of all the data that has been multiplied before. To get the ratio the weight sum value must be divided by the crtieria weight. And λmax is the average of the ratio.

$$ratio = \frac{weighted\ sum\ value}{criteria\ weight}$$

$$C.\ I. = \frac{\lambda max - n}{n - 1}$$

Consistency Index are calculated by dividing λmax with n, n is the number of criterion on the subject, so n = 4.

$$C.\ I. = \frac{4.22901 - 4}{4 - 1}$$

Therefor the consistency index is 0.076337. after that consistency ratio is calculated by Consistency index divided by Saaty's Random Index. Because the n =4, then the random index is 0.90.

$$CR = CI/Ri$$

So 0.076337 / 0.90 which the consistency rartio is 0.084819. since CR < 0.10 the matrix is reasonably consistence.

4.5. Data Process

Calculating the process first took place in the table 4.3 before, By multiplying each value in the comparison matrix with the number above of rows, then summing the results in each column divided by the number of elements, then the value of relative weight is obtained as shown. sum up for each column. Like in the first column the sum value is 9.44. then each of the cell on first column are going to be divided by 9.44. so for example column 1 row 1 will be undergo as 1/9.44 or equals to 0.1059. round up to 2 decimals so it will be 0.11 and so on.

Table 4.5 Weight pf the Flag States

	Indonesia	China	Korea	Panama	Filipina	Cambodia	Cyprus	Hongkong	Liberia	Singapore	bobot
Indonesia	0.11	0.11	0.11	0.06	0.06	0.06	0.11	0.09	0.17	0.16	0.10
China	0.08	0.09	0.09	0.06	0.13	0.12	0.10	0.09	0.10	0.07	0.09
Korea	0.12	0.11	0.12	0.14	0.09	0.14	0.10	0.13	0.15	0.10	0.12
Panama	0.13	0.11	0.06	0.08	0.09	0.13	0.10	0.06	0.06	0.06	0.09
Filipina	0.09	0.04	0.06	0.05	0.05	0.08	0.04	0.04	0.03	0.09	0.06
Cambodia	0.05	0.02	0.03	0.02	0.02	0.03	0.03	0.04	0.03	0.05	0.03
Cyprus	0.12	0.11	0.15	0.09	0.17	0.12	0.12	0.17	0.13	0.09	0.13
Hongkong	0.13	0.11	0.10	0.14	0.13	0.10	0.08	0.11	0.11	0.10	0.11
Liberia	0.05	0.08	0.07	0.12	0.15	0.11	0.08	0.09	0.09	0.11	0.10
Singapore	0.12	0.23	0.21	0.23	0.11	0.12	0.23	0.19	0.14	0.18	0.18
											1

After that each row will be sum up and take the average value, as in row 1 if we sum all of each cells in row 1 and divided with 10, it will goes on 0.1044.. round up into 0.10. and that is the weight for the Indonesia flag state in this calculation. The sum of all averaged weight of each sub criteria should be 1. If it below or even exceed 1, then there must be a miscalculation on the steps before that and it should be redone.

Table 4.6 Weight from subcriteria of Age of Ships

0	<5 years	5 - 10 years	10 - 15 years	15 - 20 years	20 - 25 years	> 25 years	weight
<5 years	0.52	0.68	0.44	0.38	0.31	0.25	0.43
5 - 10 years	0.15	0.19	0.42	0.33	0.29	0.23	0.27
10 - 15 years	0.11	0.04	0.09	0.21	0.19	0.22	0.14
15 - 20 years	0.08	0.03	0.02	0.06	0.15	0.15	0.08
20 - 25 years	0.07	0.03	0.02	0.02	0.05	0.12	0.05
> 25 years	0.07	0.03	0.01	0.01	0.01	0.03	0.03
							1.00

Same goes for all of the sub criteria table, with will be seen on the attachment of this thesis. All of the weight of each sub criteria should not exceed 1 when all of it are being sum up. If the total of all the weight exceed 1, then there must be a problem in the determining the weight of the data itself.

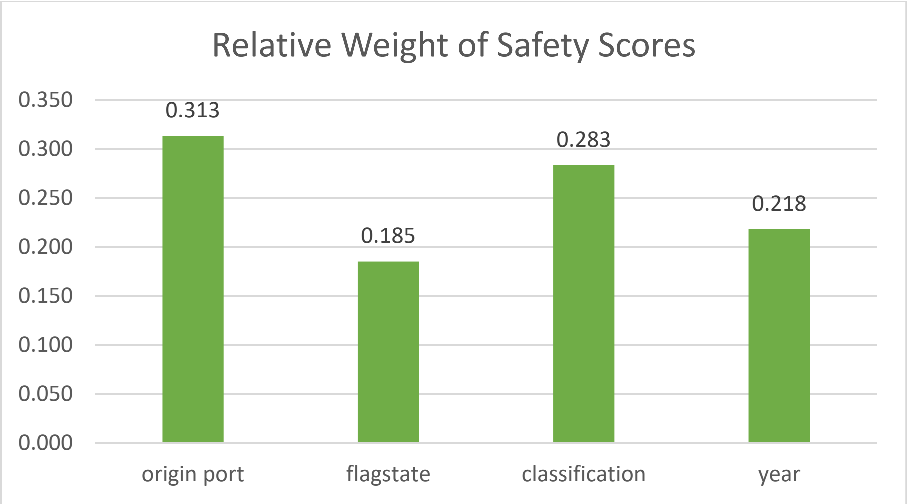


Figure 4.5 Relative Weight for Safety Scores

as seen in figure 4.5 the highest weight is located on the origin port with a value of 0.313. Followed by classification with a weight of 0.283 then with the age of the ship with a weight of 0.218 and flag state with the smallest value of 0.185.

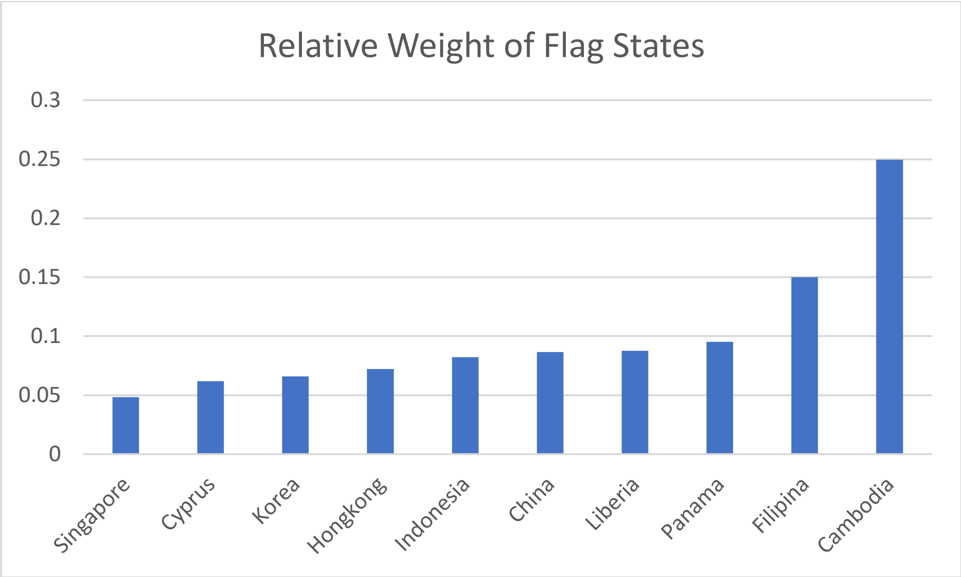


Figure 4.6 Relative Weight of flag states

for flag state weights with the highest dangerous score achieved by Cambodia with a difference that is quite high compared to other flag states. followed by Philippines, Panama Liberia, China and Indonesia with adjacent positions. and the country with the smallest weight is owned by Singapore with a score 0.048.

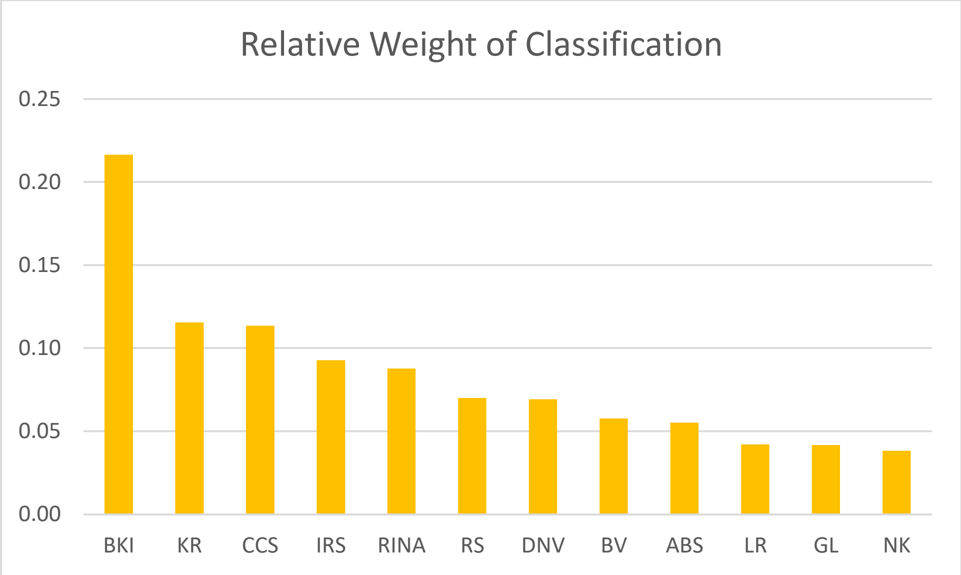


Figure 4.7 Relative Weight for Classification

Figure 4.7 is for classification, weights with the lowest dangerous score achieved by NK or *Nippon Kaiji Kyokai (* / Japanese Classification Society) followed by GL (*Germanischer Lloyd)*, then LR (Lloyd's Register) and then ABS (American Bureau of Shipping). for weights with the highest scores found by BKI (Biro Klasifikasi Indonesia) and then CCS (/China Classification Society) .

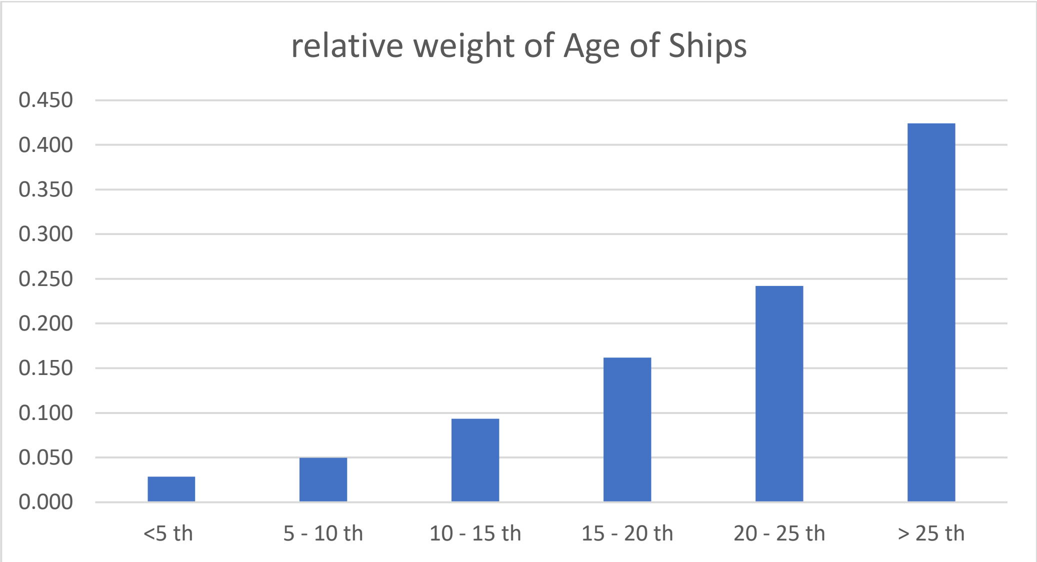


Figure 4.8 Relative Weight of Age of Ships

For **Figure 4.8,** naturally for the scoring for the age of the ship, the younger vessels certainly have a lower level of dangerousness than the older vessels. this certainly reflected in the charts above. where the value of the safety of younger ships is always higher than that of older vessels.

4.6. Data Processing for Safety Scores

Processing the criteria weight data from inspection score will be processed to determine the value of the safety score. Weight data that have been determined from the results of the distributed questionnaire will be displayed in the form of an offline website interface as a tool for determine inspection targets for each ship that will dock at the port of Tanjung Perak. The following is a way to determine the value of the safety score based on the calculation of the function value;

$$SC = (WO * wO) + (WF * wF) + (WC * wC) + (WY * wY)$$

Where *SC* is the total dangerous scores for the calculation. W is the relative weight of the inspection scores that has been multiplied by 2 digits. And *w* is the relative weight of each sub criteria for each criteria. Where O, F, C, and Y continuously is for Origin Port, Flag states, Classification, and Age of the Ships.

The priority weights of the factors represent the importance of these factors. Priority weights have two types: local priority weights and global priority weights. The local priority weights represent the relative weights of the nodes within a group of factors with respect to their categories. The local priority weights are derived from each set of pairwise comparisons in each level. The global priority weights are obtained by multiplying the local priorities of the factors by the global priority of their corresponding categories.

Table 4.7 weight and function of each criteria

Criteria	Global weight	Weight * 100
origin port	0.304	30.39
Flag states	0.200	19.97
classification	0.285	28.48
year	0.211	21.15

As the **table 4.7** above, after getting the weight of each criterion, the next step is to round up the weight so that the value is obtained which if all in total it will be 100. The functions that have been obtained will be multiplied by the weight of each sub-criteria of each criterion so that each has a weight and function correspondingly.

Table4. 8 origin port scores

1	Port Code	local weight	global priority	global weight
1	SGSIN	0.3867	30.395	11.754
2	TWKHH	0.3525	30.395	10.714
3	MYTPP	0.3028	30.395	9.203
4	TLDIL	0.3424	30.395	10.407
5	CNSHG	0.015	30.395	0.456
6	MYPKG	0.3219	30.395	9.784
7	KRPUS	0.3476	30.395	10.565
8	HKHKG	0.2571	30.395	7.814
9	MYWSP	0.3219	30.395	9.784
10	CNSHK	0.2923	30.395	8.884
12	PHDVO	0.3873	30.395	11.772
11	CNNGB	0.2203	30.395	6.696
13	TWTPE	0.3421	30.395	10.398
14	CNXMG	0.3651	30.395	11.097
15	JPSMZ	0.3526	30.395	10.717
16	MYPGU	0.3185	30.395	9.681
17	KRUSN	0.3435	30.395	10.441
18	THLCH	0.2877	30.395	8.745
19	TWTXG	0.3697	30.395	11.237
20	KRKAN	0.334	30.395	10.152
21	MMRGN	0.2941	30.395	8.939
22	CNYAT	0.3668	30.395	11.149
23	JPNGO	0.2928	30.395	8.900
24	THBKK	0.0537	30.395	1.632
25	CNLYG	0.3375	30.395	10.258
26	CNTXG	0.2888	30.395	8.778
27	AUGOV	0.2876	30.395	8.741
28	CNTAP	0.0846	30.395	2.571
29	VNSGN	0.0115	30.395	0.350
30	PHMNN	0.3851	30.395	11.705
31	CNQGD	0.368	30.395	11.185
32	MYPEN	0.3646	30.395	11.082
33	JPTYO	0.3498	30.395	10.632
34	PHSFS	0.3459	30.395	10.513
35	CNDLC	0.3292	30.395	10.006
36	CNNSA	0.3062	30.395	9.307

Table 4.8 presents the values of the origin port criteria and sub criteria. Local weight is the weight of the sub criteria of origin port, global priority is the value of origin port and the global weight is the calculation between local weight and global priority where the highest weight is owned by the port with PHOVO code originating from the Philippines at 0.3873 with a global prioity of 30,395 and having a safety score of 11.772. Whereas the lowest is owned by the port with VNSGN code from Ho chin mhin, Vietnam at 0.0115 with an inspection score of 0.350.

Table4. 9 scores of flagstates

flag states	local weight	global priority	global weight
Cambodia	0.250	19.974	4.987
Filipina	0.150	19.974	2.999
Panama	0.095	19.974	1.903
Liberia	0.088	19.974	1.749
China	0.087	19.974	1.732
Indonesia	0.082	19.974	1.644
Hongkong	0.072	19.974	1.444
Korea	0.066	19.974	1.318
Cyprus	0.062	19.974	1.236
Singapore	0.048	19.974	0.962

Table 4.10 classification scores

class	local weight	global priority	global weight
BKI	0.216	28.483	6.163
KR	0.115	28.483	3.287
CCS	0.113	28.483	3.232
IRS	0.093	28.483	2.641
RINA	0.088	28.483	2.497
RS	0.070	28.483	1.997
DNV	0.069	28.483	1.970
BV	0.058	28.483	1.646
ABS	0.055	28.483	1.572
LR	0.042	28.483	1.201
GL	0.042	28.483	1.187
NK	0.038	28.483	1.089

Table 4.9 presents the function values of the criteria and sub criteria of the ship flag where the lowest weight is owned by the Singapore flag of 0.05 with a priority value of 19,974 and has a global weight of 0.962. Whereas the highest is owned by the Cambodian flag of 0.25 with a global weight of 4.987.

From **table 4.10** shows the lowest weight value is owned by NK of 0.038 with a global priority of 28,483 and has a global weight of 1.089. while the highest is owned by BKI at 0.216 with an inspection score of 6.613.

Table 4 11 age of ship scores

Year	local weight	global priority	global weight
<5 th	0.029	21.148	0.605
5 - 10 th	0.050	21.148	1.052
10 - 15 th	0.093	21.148	1.977
15 - 20 th	0.162	21.148	3.424
20 - 25 th	0.242	21.148	5.120
> 25 th	0.424	21.148	8.969

Table 4.11 shows the global priority and global weight for the criteria and subcriteria of ship age, where the lowest value is obtained for ship age less than 5 years at 0.029 with a global priority of 21,148 and global weight of 0.605, while for the highest the ship age is above 25 amounting to 0.424 with inspection score 8.969.

4.7. Making Script for Website

All scripting languages are programming languages. The scripting language is basically a language where instructions are written for a run time environment. They do not require the compilation step and are rather interpreted. It brings new functions to applications and glue complex system together. A scripting language is a programming language designed for integrating and communicating with other programming languages.

The author tries to make a simple script to run the safety score test which will be displayed on an offline based website. The script used is a PHP-based script, and the type used is the form script. The script will be displayed in the attachment in this thesis.

after creating the script, it's time to display the results of the script on an offline website. use localhost as the placeholder for the script to give the desired appearance and also perform the function score as expected.

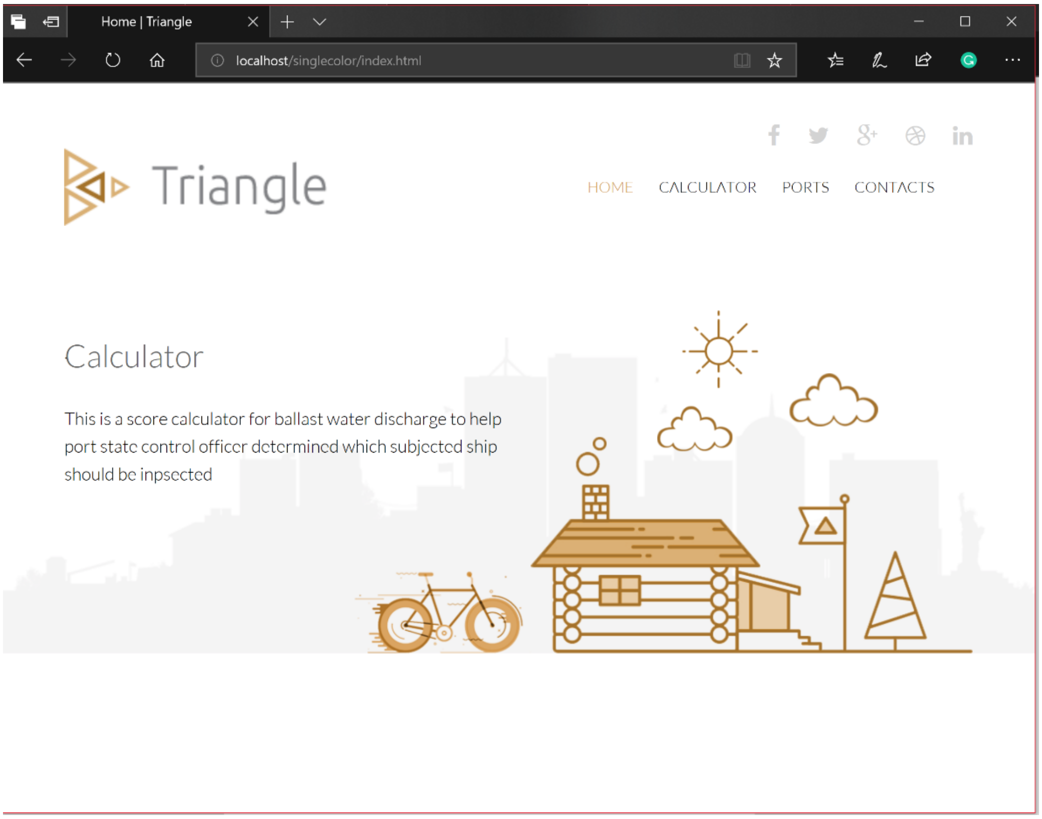


Figure 4 9 main website appearance

in the main homepage of the website there are some tabs that can help the user to surf trough the website, there are calculator, list of port that are available and the contact for information.

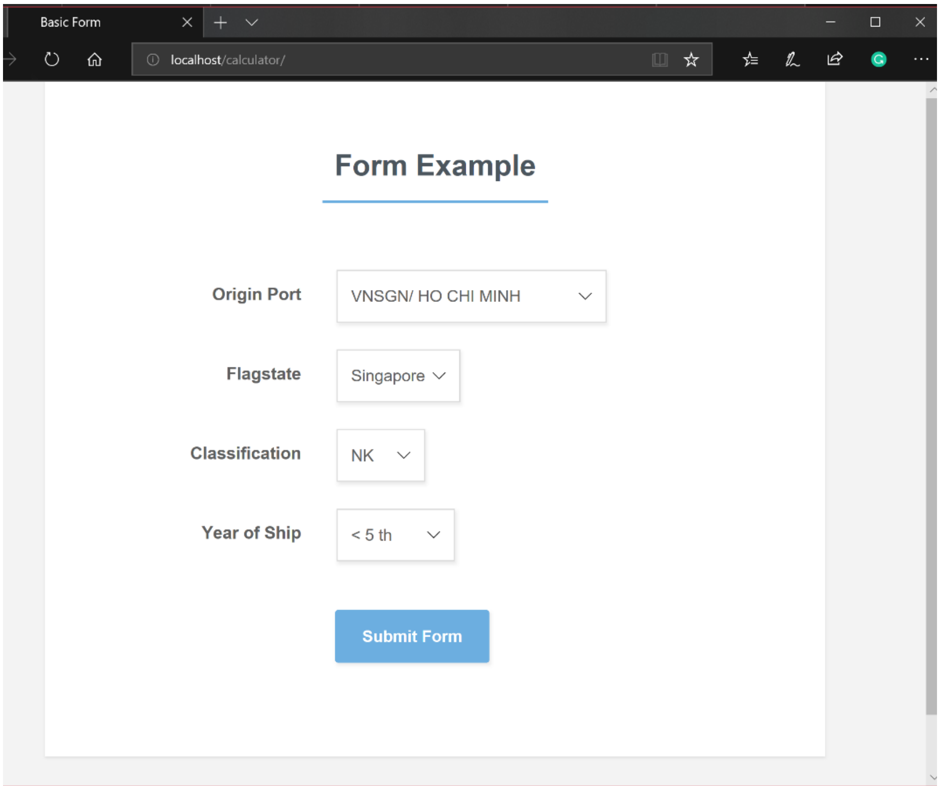


Figure 4.10 dangerous score calculator pageview

In the **figure 4.10** The calculator page will be shown as above. there is a column for each criterion of safety scores. each criterion has a column whose data can later be selected according to the docking ship data. later after the data entered is correct, then after submission, scores and risks will be seen which will determine whether the ship must be inspected for ballast water or not inspected.

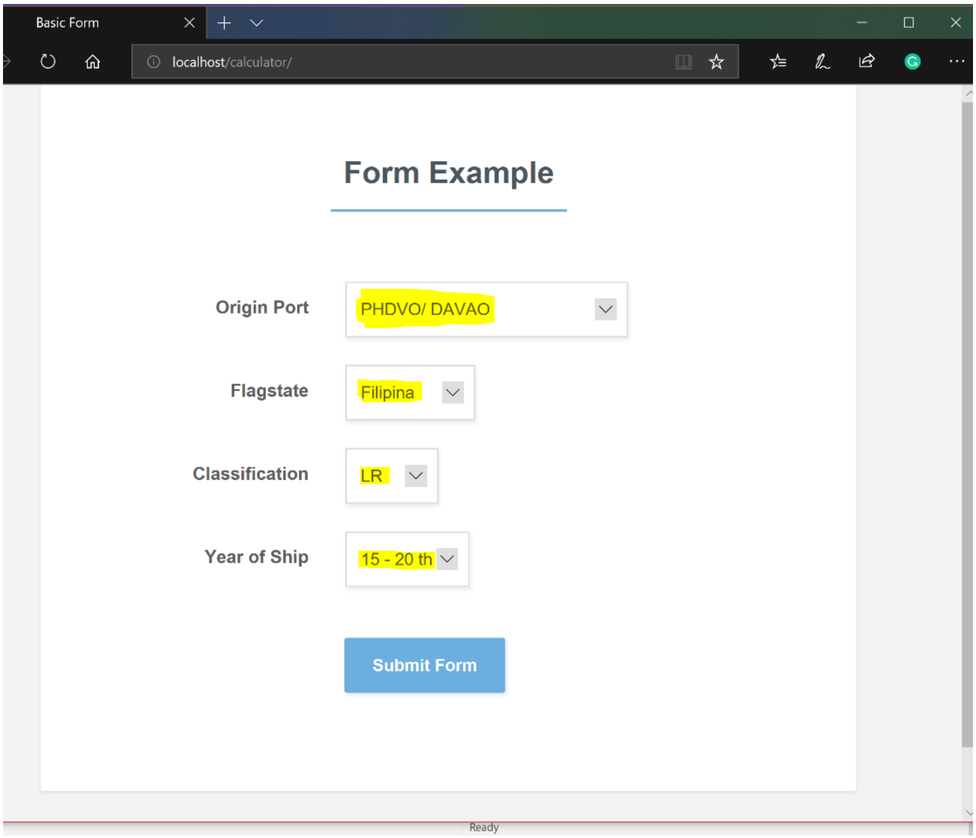


Figure 4 11 ship from davao input

Let's make an example, a ship with a flag of Philippines just arrives from the port of Davao, Philippines. The ship has a LR classification and she is 19 years old. The Port State Control Officer then have to make sure whether this ballast water ship safe or not to be disposed in the Tanjung Perak seawater. PSCO then input the data as seen in **figure 4.11** above.

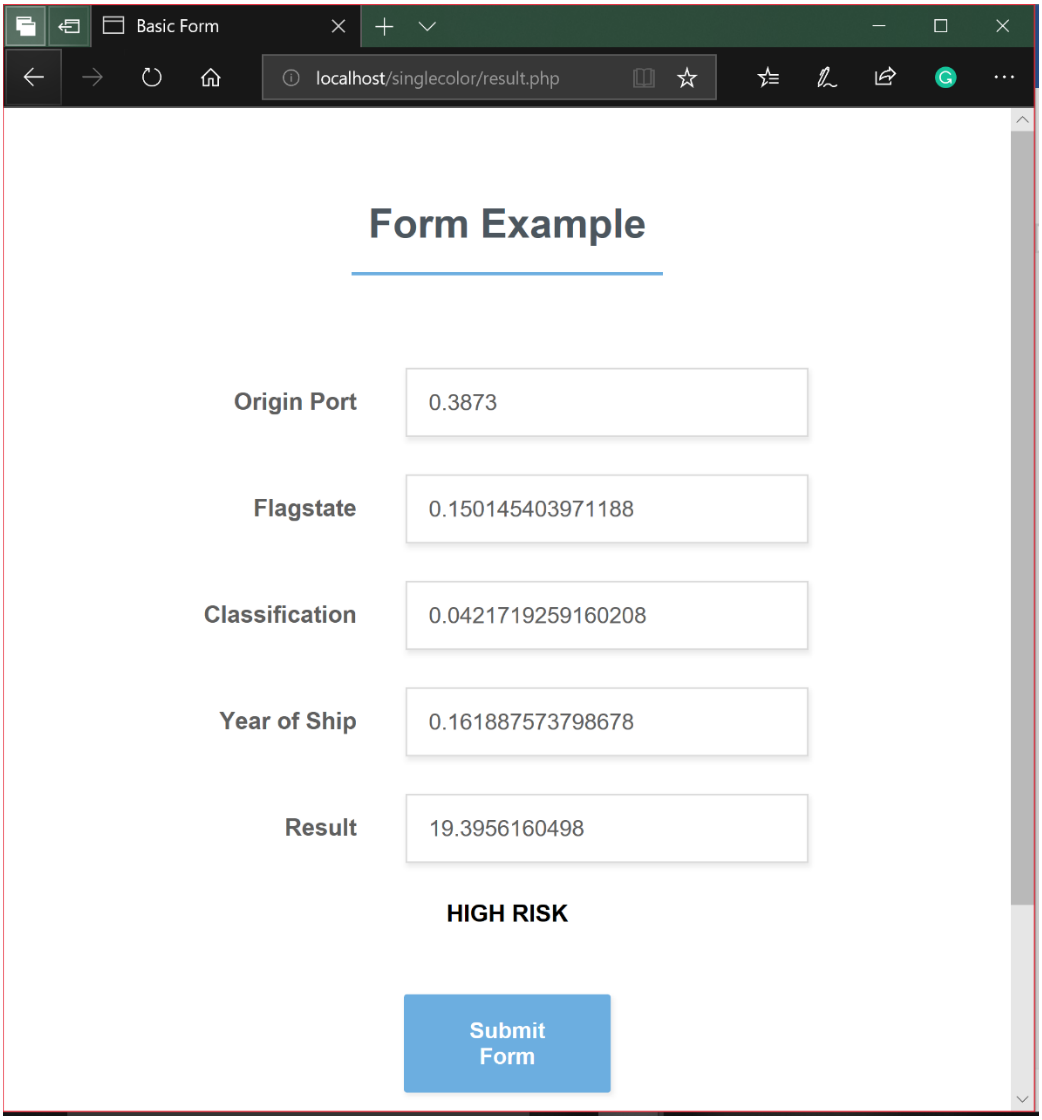


Figure 4 12 Davao output

After the data is submitted, the script will automatically calculate the scores for each criteria seen on **Figurw 4.12.** After that the result is 19.39 which are high risk which may harm the environment if the ballast water will be discharge without inspection first. So Port state control officer have to check whether the ship will unload is cargo or not. If they did not do the unloading the then it is okay for the ship to dock. And if they are unloading it that is mean the ship has to discharge the ballast water. It means that officer has to check the equipment for the ballast water discharge to ensure that the water that will be discharged is unharmed to the environment of port

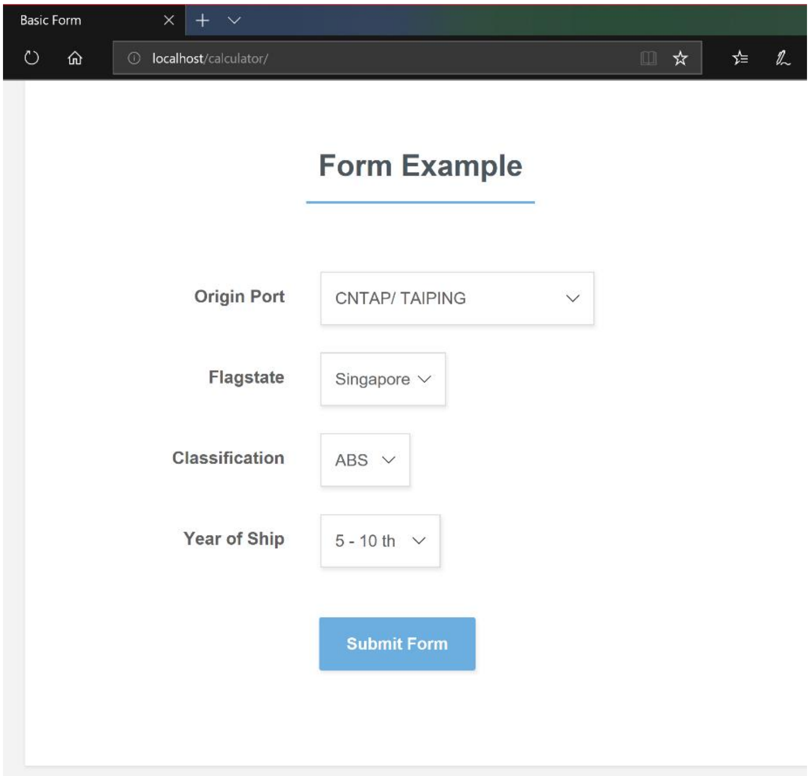


Figure 4.13 ship from taiping input

Another example:

If a ship comes from port of Taiping, China, with a flag of Singapore has just arrive and want to dock and unload her cargo. The ship has an ABS for its classification society and the vessel is 7 year's old which are pretty new. Then the PSCO input the necesary data to the website as seen on **Figure 4.13.**

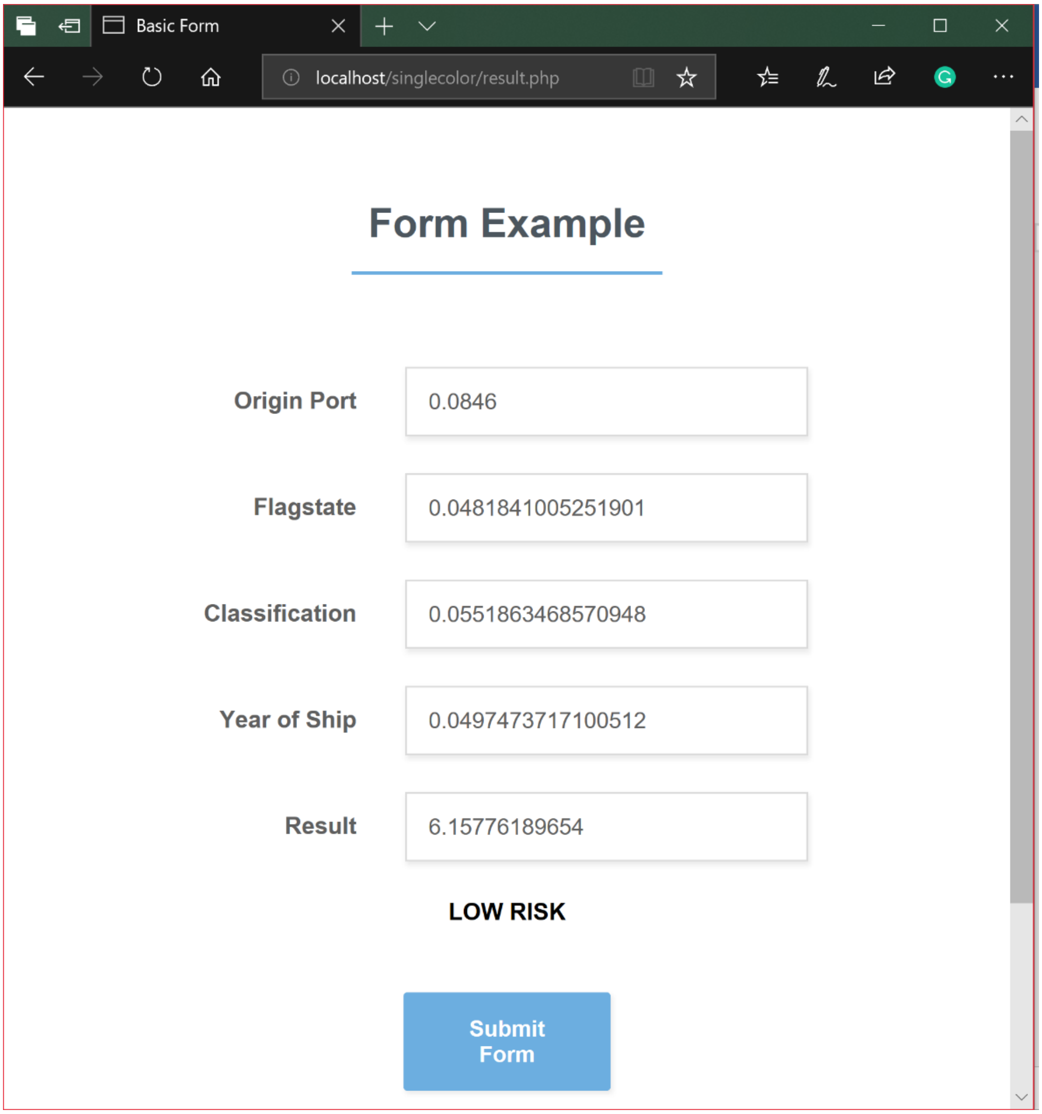


Figure 4.14 ship from Taiping output

In **Figure 4.14** the ship has scored of 6.1577 and it/s got low risk for the inspection of ballast water. So the PSCO may or may not to inspect the ballast water of this ship.

Below is the detailed Standard Operating Procedure for the PSCO that should be done through the process of using the dangerous score calculator.

Further plan can be seen on **figure 4,15** for more complete standard operation procedure for a ship when she wants to visit the port, how the PSCO should take action for each ship that has been scored.

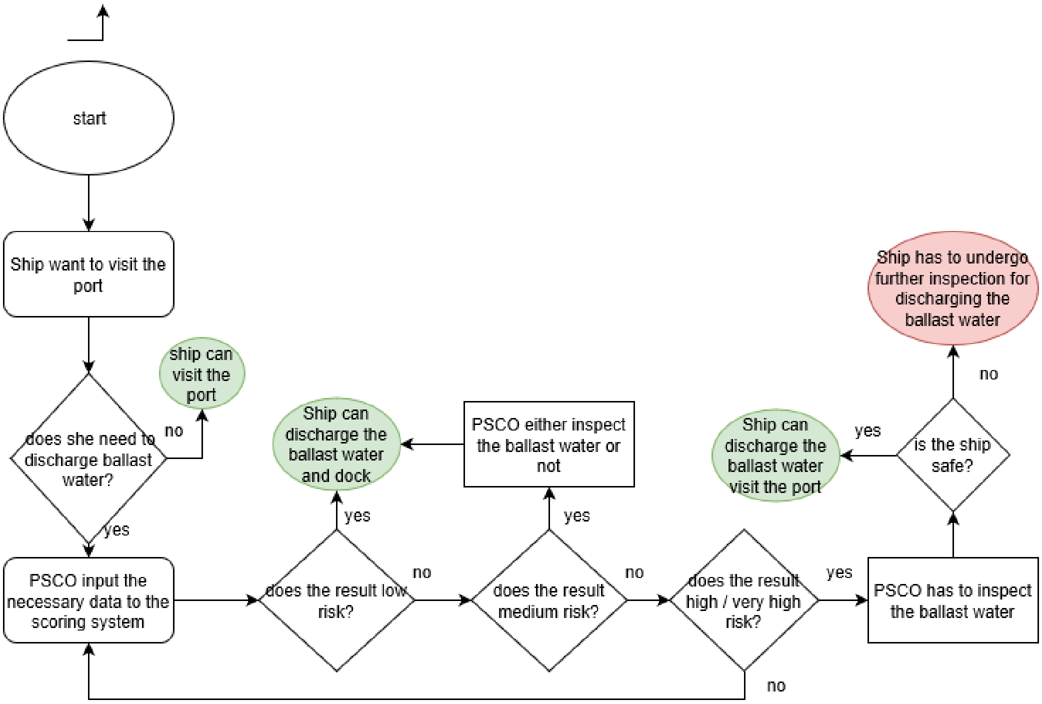


Figure 4 15 Standard Operation Procedure of ship visit to port flowchar

CHAPTER V
Conclusion and Suggestion

5.1. Conclusion

After carrying out the entire process of this thesis, and from the results of processing the data obtained, some conclusions can be drawn as follows:

1. Factors that can be identified to affect the scores are: Origin Port, Flag States, Classification, and Age of the ship.
2. Using the AHP method to create the scores for each criteria and sub criteria. For the main Criteria the biggest weight factor is Origin Port, followed by Classification, Age of Ship, and flag States.
   a. For Origin Port using the salinity data of the port it can be determined that VNSGN/ Ho Chi Minh has the lowest score and the highest score is DAVAO/ Philippines.
   b. Flag states has the sub criteria with lowest scores is Singapore, the higest score was gained by Cambodia with a high margin.
   c. Class has the sub criterion with the lowest dangerous scores is NK, followed by GL, LR, ABS, BV, RS, DNV. RINA, IRS, CCS, KR, BKI
   d. Age of ship has the sub criterion with the lowest score continuously from less than 5 years old to more than 25 years old.
3. Making a web design using PHP script which has a form base that has included and can be seen in localhost. Scripting language is basically a language where instructions are written for a run time environment. They do not require the compilation step and are rather interpreted.

5.2. Suggestion

Suggestions that can be taken after doing the thesis on the method of measuring the value or weight of safety scores are:

1. This project is still a prototype to inspect the condition of ship's ballast water that can be applied by PSCO of Tanjung Perak. but this prototype is still not tested in the field, so it's a good idea to test it in the future.
2. the questionnaire distributed was an online questionnaire where it was possible for an incompetent person to fill in the questionnaire. so it's always a good idea to check whether the questionnaire is valid or not
3. The website offline based is used a data from the year of making this thesis, namely 2018/2019. so that it is likely that it cannot be used for a long time because the data must always be updated according to real-world conditions.

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APPENDIX I

Survey Ballast Water Inspection

* Required

Nama

Pekerjaan

Pengalaman pada bidang yang digeluti (diisi dalam tahun)

Perbandingan Per- Kriteria

Berikut adalah kriteria yang memberikan penilaian terhadap inspeksi suatu kapal dilihat dari ballast yang dikeluarkan saat docking, untuk kelayakan berlayar di perairan Indonesia. Manakah perbandingan berikut yang lebih bahaya? *

Mohon dipilih dalam menentukan jawaban sesuai skala yang tersedia dari 1-9. Dimana a dan b merujuk pada subkriteria pada baris tersebut, a= sub kriteria pertama dan b= sub kriteria kedua.

Mark only one oval per row.

	a9	a7	a5	a3	1	b3	b5	b7	b9
Origin Port(a) - Bendera Kapal(b)	○	○	○	○	○	○	○	○	○
Origin Port(a) - Klasifikasi(b)	○	○	○	○	○	○	○	○	○
Origin Port(a) - Umur Kapal(b)	○	○	○	○	○	○	○	○	○
Bendera Kapal(a) - Klasifikasi(b)	○	○	○	○	○	○	○	○	○
Bendera Kapal(a) - Umur Kapal(b)	○	○	○	○	○	○	○	○	○
Klasifikasi(a) - Umur Kapal(b)	○	○	○	○	○	○	○	○	○

Bendera Kapal(Flag States)

Pada kriteria Bendera Kapal (Flag State), ada beberapa sub kriteria yang mempengaruhi tingkat penilaian inspeksi syahbandar berdasarkan negara asal untuk kelayakan pembuangan ballast selama docking pada pelabuhan Tanjung Perak. Manakah perbandingan berikut yang lebih mempengaruhi bahaya dalam ketentuan untuk menginspeksi ballast suatu Kapal yang berkunjung.

Bagian 1 *
Mohon dipilih dalam menentukan jawaban sesuai skala yang tersedia dari 1-9. Dimana a dan b merujuk pada subkriteria pada baris tersebut, a= sub kriteria pertama dan b= sub kriteria kedua.
Mark only one oval per row.

	a9	a7	a5	a3	1	b3	b5	b7	b9
Indonesia(a) - China(b)	○	○	○	○	○	○	○	○	○
Indonesia(a) - Korea(b)	○	○	○	○	○	○	○	○	○
Indonesia(a) - Panama(b)	○	○	○	○	○	○	○	○	○
Indonesia(a) - FIlipina(b)	○	○	○	○	○	○	○	○	○
Indonesia(a) - Kambodia(b)	○	○	○	○	○	○	○	○	○
Indonesia(a) - Cyprus(b)	○	○	○	○	○	○	○	○	○
Indonesia(a) - Hong Kong(b)	○	○	○	○	○	○	○	○	○
Indonesia(a) - Liberia(b)	○	○	○	○	○	○	○	○	○
Indonesia(a) - Singapura(b)	○	○	○	○	○	○	○	○	○

Bagian 2 *
Mohon dipilih dalam menentukan jawaban sesuai skala yang tersedia dari 1-9. Dimana a dan b merujuk pada subkriteria pada baris tersebut, a= sub kriteria pertama dan b= sub kriteria kedua.
Mark only one oval per row.

	a9	a7	a5	a3	1	b3	b5	b7	b9
China(a) - Korea(b)	○	○	○	○	○	○	○	○	○
China(a) - Panama(b)	○	○	○	○	○	○	○	○	○
China(a) - Filipina(b)	○	○	○	○	○	○	○	○	○

	a9	a7	a5	a3	1	b3	b5	b7	b9
China(a) - Kambodia(b)	○	○	○	○	○	○	○	○	○
China(a) - Cyprus(b)	○	○	○	○	○	○	○	○	○
China(a) - Hong Kong(b)	○	○	○	○	○	○	○	○	○
China(a) - Liberia(b)	○	○	○	○	○	○	○	○	○
China(a) - Singapura(b)	○	○	○	○	○	○	○	○	○

Bagian 3 *
Mohon dipilih dalam menentukan jawaban sesuai skala yang tersedia dari 1-9. Dimana a dan b merujuk pada subkriteria pada baris tersebut, a= sub kriteria pertama dan b= sub kriteria kedua.
Mark only one oval per row.

	a9	a7	a5	a3	1	b3	b5	b7	b9
Korea(a) - Panama(b)	○	○	○	○	○	○	○	○	○
Korea(a) - Filipina(b)	○	○	○	○	○	○	○	○	○
Korea(a) - Kambodia(b)	○	○	○	○	○	○	○	○	○
Korea(a) - Cyprus(b)	○	○	○	○	○	○	○	○	○
Korea(a) - Hong Kong(b)	○	○	○	○	○	○	○	○	○
Korea(a) - Liberia(b)	○	○	○	○	○	○	○	○	○
Korea(a) - SIngapura(b)	○	○	○	○	○	○	○	○	○

Bagian 4 *
Mohon dipilih dalam menentukan jawaban sesuai skala yang tersedia dari 1-9. Dimana a dan b merujuk pada subkriteria pada baris tersebut, a= sub kriteria pertama dan b= sub kriteria kedua.
Mark only one oval per row.

	a9	a7	a5	a3	1	b3	b5	b7	b9
Panama(a) - Filipina(b)	○	○	○	○	○	○	○	○	○
Panama(a) - Kambodia(b)	○	○	○	○	○	○	○	○	○
Panama(a) - Cyprus(b)	○	○	○	○	○	○	○	○	○

	a9	a7	a5	a3	1	b3	b5	b7	b9
Panama(a) - Hong Kong(b)	◯	◯	◯	◯	◯	◯	◯	◯	◯
Panama(a) - Liberia(b)	◯	◯	◯	◯	◯	◯	◯	◯	◯
Panama(a) - Singaputa(b)	◯	◯	◯	◯	◯	◯	◯	◯	◯
FIlipina(a) - Kambodia(b)	◯	◯	◯	◯	◯	◯	◯	◯	◯
FIlipina(a) - Cyprus(b)	◯	◯	◯	◯	◯	◯	◯	◯	◯
FIlipina(a) - Hong Kong(b)	◯	◯	◯	◯	◯	◯	◯	◯	◯
FIlipina(a) - Liberia(b)	◯	◯	◯	◯	◯	◯	◯	◯	◯
FIlipina(a) - Singapura(b)	◯	◯	◯	◯	◯	◯	◯	◯	◯

Bagian 5 *
Mohon dipilih dalam menentukan jawaban sesuai skala yang tersedia dari 1-9. Dimana a dan b merujuk pada subkriteria pada baris tersebut, a= sub kriteria pertama dan b= sub kriteria kedua.
Mark only one oval per row.

	a9	a7	a5	a3	1	b3	b5	b7	b9
Kambodia(a) - Cyprus(b)	◯	◯	◯	◯	◯	◯	◯	◯	◯
Kambodia(a) - Hong Kong(b)	◯	◯	◯	◯	◯	◯	◯	◯	◯
Kambodia(a) - Liberia(b)	◯	◯	◯	◯	◯	◯	◯	◯	◯
Kambodia(a) - Singapura(b)	◯	◯	◯	◯	◯	◯	◯	◯	◯
Cyprus(a) - Hong Kong((b)	◯	◯	◯	◯	◯	◯	◯	◯	◯
Cyprus(a) - Liberia(b)	◯	◯	◯	◯	◯	◯	◯	◯	◯
Cyprus(a) - SIingapura(b)	◯	◯	◯	◯	◯	◯	◯	◯	◯
Hong Kong(a) - Liberia(b)	◯	◯	◯	◯	◯	◯	◯	◯	◯

	a9	a7	a5	a3	1	b3	b5	b7	b9
Hong Kong(a) - Singapura(b)	◯	◯	◯	◯	◯	◯	◯	◯	◯
Liberia(a) - Singapura(b)	◯	◯	◯	◯	◯	◯	◯	◯	◯

Klasifikasi

Pada kriteria kelas (Classification), ada beberapa sub kriteria yang mempengaruhi tingkat penilaian inspeksi syahbandar berdasarkan klasfiikasi kapal untuk kelayakan pembuangan ballast selama docking pada pelabuhan Tanjung Perak. Manakah perbandingan berikut yang lebih mempengaruhi bahaya inspeksi ballast saat Kapal tersebut sedang berkunjung?

Daftar Kelas Kapal

• NK (Nippon Kaiji Kyiokai) • LR (Lloyd's Register) • BKI (Biro Klasifikasi Indonesia) • BV (Bureau Veritas) • GL (Germanischer Lloyd) • ABS (American Bureau Shipping) • CCS (China Classification Society) • DNV (Det Norske Veritas). • IRS (Indian Register Society) • KR (Korean Register) • RINA (Royal Institution of Naval Architects) x RS (Russian Society)

Bagian 1 *

Mohon dipilih dalam menentukan jawaban sesuai skala yang tersedia dari 1-9. Dimana a dan b merujuk pada subkriteria pada baris tersebut, a= sub kriteria pertama dan b= sub kriteria kedua.

Mark only one oval per row.

	a9	a7	a5	a3	1	b3	b5	b7	b9
NK - LR	◯	◯	◯	◯	◯	◯	◯	◯	◯
NK - BKi	◯	◯	◯	◯	◯	◯	◯	◯	◯
NK - BV	◯	◯	◯	◯	◯	◯	◯	◯	◯
NK - GL	◯	◯	◯	◯	◯	◯	◯	◯	◯
NK - ABS	◯	◯	◯	◯	◯	◯	◯	◯	◯
NK - CCS	◯	◯	◯	◯	◯	◯	◯	◯	◯
NK - DNV	◯	◯	◯	◯	◯	◯	◯	◯	◯
NK - IRS	◯	◯	◯	◯	◯	◯	◯	◯	◯
NK - KR	◯	◯	◯	◯	◯	◯	◯	◯	◯
NK - RINA	◯	◯	◯	◯	◯	◯	◯	◯	◯

Bagian 2 *
Mohon dipilih dalam menentukan jawaban sesuai skala yang tersedia dari 1-9. Dimana a dan b merujuk pada subkriteria pada baris tersebut, a= sub kriteria pertama dan b= sub kriteria kedua.
Mark only one oval per row.

	a9	a7	a5	a3	1	b3	b5	b7	b9
LR - BKI	◯	◯	◯	◯	◯	◯	◯	◯	◯
LR - BV	◯	◯	◯	◯	◯	◯	◯	◯	◯
LR - GL	◯	◯	◯	◯	◯	◯	◯	◯	◯
LR - ABS	◯	◯	◯	◯	◯	◯	◯	◯	◯
LR - CCS	◯	◯	◯	◯	◯	◯	◯	◯	◯
LR - DNV	◯	◯	◯	◯	◯	◯	◯	◯	◯
LR - IRS	◯	◯	◯	◯	◯	◯	◯	◯	◯
LR - KR	◯	◯	◯	◯	◯	◯	◯	◯	◯
LR - RINA	◯	◯	◯	◯	◯	◯	◯	◯	◯

Bagian 3 *
Mohon dipilih dalam menentukan jawaban sesuai skala yang tersedia dari 1-9. Dimana a dan b merujuk pada subkriteria pada baris tersebut, a= sub kriteria pertama dan b= sub kriteria kedua.
Mark only one oval per row.

	a9	a7	a5	a3	1	b3	b5	b7	b9
BKI - BV	◯	◯	◯	◯	◯	◯	◯	◯	◯
BKI - GL	◯	◯	◯	◯	◯	◯	◯	◯	◯
BKI - ABS	◯	◯	◯	◯	◯	◯	◯	◯	◯
BKI - CCS	◯	◯	◯	◯	◯	◯	◯	◯	◯
BKI - DNV	◯	◯	◯	◯	◯	◯	◯	◯	◯
BKI - IRS	◯	◯	◯	◯	◯	◯	◯	◯	◯
BKI - KR	◯	◯	◯	◯	◯	◯	◯	◯	◯
BKI - RINA	◯	◯	◯	◯	◯	◯	◯	◯	◯
BV - GL	◯	◯	◯	◯	◯	◯	◯	◯	◯
BV - ABS	◯	◯	◯	◯	◯	◯	◯	◯	◯

	a9	a7	a5	a3	1	b3	b5	b7	b9
BV - CCS	◯	◯	◯	◯	◯	◯	◯	◯	◯
BV - DNV	◯	◯	◯	◯	◯	◯	◯	◯	◯
BV - IRS	◯	◯	◯	◯	◯	◯	◯	◯	◯
BV - KR	◯	◯	◯	◯	◯	◯	◯	◯	◯
BV - RINA	◯	◯	◯	◯	◯	◯	◯	◯	◯

Bagian 4 *
Mohon dipilih dalam menentukan jawaban sesuai skala yang tersedia dari 1-9. Dimana a dan b merujuk pada subkriteria pada baris tersebut, a= sub kriteria pertama dan b= sub kriteria kedua.
Mark only one oval per row.

	a9	a7	a5	a3	1	b3	b5	b7	b9
GL - ABS	◯	◯	◯	◯	◯	◯	◯	◯	◯
GL - CCS	◯	◯	◯	◯	◯	◯	◯	◯	◯
GL - DNV	◯	◯	◯	◯	◯	◯	◯	◯	◯
GL - IRS	◯	◯	◯	◯	◯	◯	◯	◯	◯
GL - KR	◯	◯	◯	◯	◯	◯	◯	◯	◯
GL - RINA	◯	◯	◯	◯	◯	◯	◯	◯	◯
ABS - CCS	◯	◯	◯	◯	◯	◯	◯	◯	◯
ABS - DNV	◯	◯	◯	◯	◯	◯	◯	◯	◯
ABS - IRS	◯	◯	◯	◯	◯	◯	◯	◯	◯
ABS - KR	◯	◯	◯	◯	◯	◯	◯	◯	◯
ABS - RINA	◯	◯	◯	◯	◯	◯	◯	◯	◯

Bagian 5 *
Mohon dipilih dalam menentukan jawaban sesuai skala yang tersedia dari 1-9. Dimana a dan b merujuk pada subkriteria pada baris tersebut, a= sub kriteria pertama dan b= sub kriteria kedua.
Mark only one oval per row.

	a9	a7	a5	a3	1	b3	b5	b7	b9
CCS - DNV	◯	◯	◯	◯	◯	◯	◯	◯	◯

	a9	a7	a5	a3	1	b3	b5	b7	b9
CCS - IRS									
CCS - KR									
CCS - RINA									
DNV - IRS									
DNV - KR									
DNV - RINA									
IRS - KR									
IRS - RINA									
KR - RINA									

Umur Kapal

Pada kriteria usia kapal ada beberapa sub kriteria yang mempengaruhi tingkat penilaian inspeks keamanani syahbandar berdasarkan usia untuk inspeksi kelayakan pembuangan ballast selama docking pada pelabuhan Tanjung Perak. Manakah yang lebih berbahaya?

Bagian 1 *

Mohon dipilih dalam menentukan jawaban sesuai skala yang tersedia dari 1-9. Dimana a dan b merujuk pada subkriteria pada baris tersebut, a= sub kriteria pertama dan b= sub kriteria kedua.

Mark only one oval per row.

	a9	a7	a5	a3	1	b3	b5	b7	b9
<5 tahun(a) - 5 s/d 10 tahun(b)									
<5 tahun(a) - 10 s/d 15 tahun(b)									
<5 tahun(a) - 15 s/d 20 tahun(b)									

	a9	a7	a5	a3	1	b3	b5	b7	b9
<5 tahun(a) - 20 s/d 25 tahun(b)									
<5 tahun(a) - >25 tahun(b)									
5 s/d 10 tahun(a) - 10 s/d 15 tahun(b)									
5 s'd 10 tahun(a) - 15 s/d 20 tahun(b)									
5 s/d 10 tahun(a) - 20 s/d 25 tahun(b)									
5 s'd 10 tahun(a) - >25 tahun(b)									

Bagian 2 *

Mohon dipilih dalam menentukan jawaban sesuai skala yang tersedia dari 1-9. Dimana a dan b merujuk pada subkriteria pada baris tersebut, a= sub kriteria pertama dan b= sub kriteria kedua.

Mark only one oval per row.

	a9	a7	a5	a3	1	b3	b5	b7	b9
10 s'd 15 tahun(a) - 15 s/d 20 tahun(b)									
10 s'd 15 tahun(a) - 20 s/d 25 tahun(b)									

	a9	a7	a5	a3	1	b3	b5	b7	b9
10 s'd 15 tahun(a) - >25 tahun(b)	○	○	○	○	○	○	○	○	○
15 s'd 20 tahun(a) - 20 s/d 25 tahun(b)	○	○	○	○	○	○	○	○	○
15 s/d 20 tahun(a) - >25 tahun(b)	○	○	○	○	○	○	○	○	○
20 s/d 25 tahun(a) - >25 tahun(b)	○	○	○	○	○	○	○	○	○

[null,null,"0"]¶

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APPENDIX II

FLAG STATE	Indonesia	China	Korea	Panama	Filipina	Cambodia	Cyprus	Hongkong	Liberia	Singapore	weight
Indonesia	0.085616	0.060413	0.073107	0.100756	0.121088	0.131783	0.069179	0.086676	0.039443	0.054983	0.082304
China	0.113014	0.079491	0.08094	0.101595	0.055782	0.069767	0.080296	0.086676	0.068832	0.130584	0.086698
Korea	0.077055	0.063593	0.065274	0.04618	0.07483	0.062016	0.077826	0.058023	0.046404	0.088856	0.066006
Panama	0.071062	0.065183	0.118146	0.083963	0.081633	0.067183	0.074737	0.129656	0.119103	0.141875	0.095254
Filipina	0.096747	0.194754	0.118146	0.139379	0.136054	0.108527	0.197035	0.181948	0.229698	0.099165	0.150145
Cambodia	0.166096	0.290143	0.268277	0.329135	0.321088	0.258398	0.2168	0.2149	0.2529	0.179185	0.249692
Cyprus	0.077055	0.061208	0.051567	0.06885	0.042177	0.067183	0.061767	0.044413	0.052591	0.091802	0.061861
Hongkong	0.070205	0.065183	0.080287	0.04618	0.053061	0.085271	0.098826	0.071633	0.063418	0.088856	0.072292
Liberia	0.166096	0.089825	0.108355	0.054576	0.046259	0.080103	0.090797	0.086676	0.07734	0.075601	0.087563
Singapore	0.077055	0.030207	0.035901	0.029387	0.068027	0.069767	0.032736	0.039398	0.050271	0.049092	0.048184
											1

	NK	LR	BKI	BV	GL	ABS	CCS	DNV	IRS	KR	RINA	RS
NK	1	1	0.25	0.73	1.09	0.39	0.34	0.54	0.32	0.37	0.43	0.55
LR	1	1	0.27	0.62	1.37	0.85	0.38	0.58	0.44	0.38	0.41	0.48
BKI	3.96	3.64	1	3.39	3.64	3.27	2.89	3.39	3.23	3.08	2.86	2.56
BV	1.37	1.6	0.3	1	1.6	1.58	0.5	0.73	0.62	0.41	0.54	0.74
GL	0.92	0.73	0.27	0.62	1	0.62	0.34	0.62	0.73	0.39	0.51	0.55
ABS	2.54	1.17	0.31	0.63	1.6	1	0.41	0.85	0.58	0.41	0.5	0.73
CCS	2.97	2.66	0.35	2.02	2.93	2.42	1	1.56	1.21	0.84	2.19	1.54
DNV	1.85	1.72	0.3	1.37	1.6	1.17	0.64	1	0.79	0.43	0.62	1.58
IRS	3.08	2.27	0.31	1.6	1.37	1.72	0.82	1.27	1	0.83	1.44	1.81
KR	2.69	2.66	0.32	2.45	2.57	2.45	1.18	2.33	1.2	1	1.85	1.13
RINA	2.33	2.45	0.35	1.85	1.94	2.02	0.46	1.6	0.7	0.54	1	1.85
RS	1.81	2.09	0.39	1.35	1.81	1.37	0.65	0.63	0.55	0.89	0.54	1
	25.52	22.99	4.42	17.63	22.52	18.86	9.61	15.1	11.37	9.57	12.89	14.52

	NK	LR	BKI	BV	GL	ABS	CCS	DNV	IRS	KR	RINA	RS	
NK	0.039185	0.043497	0.056561	0.041407	0.048401	0.020679	0.03538	0.035762	0.028144	0.038662	0.033359	0.037879	0.038243
LR	0.039185	0.043497	0.061086	0.035167	0.060835	0.045069	0.039542	0.038411	0.038698	0.039707	0.031808	0.033058	0.042172
BKI	0.155172	0.15833	0.226244	0.192286	0.161634	0.173383	0.300728	0.224503	0.284081	0.321839	0.221877	0.176309	0.216366
BV	0.053683	0.069595	0.067873	0.056721	0.071048	0.083775	0.052029	0.048344	0.054529	0.042842	0.041893	0.050964	0.057775
GL	0.03605	0.031753	0.061086	0.035167	0.044405	0.032874	0.03538	0.04106	0.064204	0.040752	0.039566	0.037879	0.041681
ABS	0.09953	0.050892	0.070136	0.035735	0.071048	0.053022	0.042664	0.056291	0.051011	0.042842	0.03879	0.050275	0.055186
CCS	0.116379	0.115702	0.079186	0.114577	0.130107	0.128314	0.104058	0.103311	0.10642	0.087774	0.169899	0.106061	0.113482
DNV	0.072492	0.074815	0.067873	0.077708	0.071048	0.062036	0.066597	0.066225	0.069481	0.044932	0.048099	0.108815	0.069177
IRS	0.12069	0.098739	0.070136	0.090754	0.060835	0.091198	0.085328	0.084106	0.087951	0.086729	0.111715	0.124656	0.092736
KR	0.105408	0.115702	0.072398	0.138968	0.114121	0.129905	0.122789	0.154305	0.105541	0.104493	0.143522	0.077824	0.115415
RINA	0.091301	0.106568	0.079186	0.104935	0.086146	0.107105	0.047867	0.10596	0.061566	0.056426	0.07758	0.12741	0.087671
RS	0.070925	0.090909	0.088235	0.076574	0.080373	0.072641	0.067638	0.041722	0.048373	0.092999	0.041893	0.068871	0.070096
													1

	<5 years	5 - 10 years	10 - 15 years	15 - 20 years	20 - 25 years	> 25 years	local weight
<5 years	0.033014196	0.011340624	0.013265951	0.016322089	0.026768642	0.07106599	0.028629582
5 - 10 years	0.118851106	0.040502228	0.013897663	0.018498368	0.030592734	0.076142132	0.049747372
10 - 15 years	0.160779135	0.187525314	0.063171194	0.029379761	0.043977055	0.076142132	0.093495765
15 - 20 years	0.222845824	0.233697853	0.229943146	0.108813928	0.059273423	0.116751269	0.161887574
20 - 25 years	0.228128095	0.260429324	0.269109286	0.351468988	0.191204589	0.152284264	0.242104091
> 25 years	0.236381644	0.266504658	0.410612761	0.475516866	0.648183556	0.507614213	0.424135616
							1

AUTHOR BIOGRAPHY

The author's name is Matthew Gervase Wimaeki, born on 1st April 1997 in Jakarta, Indonesia Author is the eldest child from 2 siblings. Author is derived from a family with father named Michael Wijaya Utama and mother named Setiawaty Lukman. the author was raised in Jakarta. The author had formal studies at SDK 11 BPK Penabur Jakarta (2003-2009), SMPK 7 BPK Penabur Jakarta (2009-2012), and SMAK 4 BPK Penabur Jakarta (2012-2015). In 2015, the author went to Surabaya in order to continue the study at Department of Marine Engineering (Double Degree Program with Hochschule Wismar), Faculty of Marine Engineering, Institut Teknologi Sepuluh Nopember Surabaya specialized in Marine Operation and Maintenance. During the study period, the author did activities in campus organizations, e.g., Staff of Persekutuan Mahasiswa Kristen ITS (2016-2017), MOM Laboratory member (2018-2019). The Author also joined in several event organizers, e.g., Committee Marine Icon 2016, Member of Funding Division of Christmas Celebration ITS (2016), Vice-chief of Funding Division of Easter Celebration ITS (2017). The author also has work experiences in two companies as engineering student intern e.g., PT. Daya Radar Utama (2017) and PT. PELINDO III Tanjung Benoa (2018). For further discussion and suggestion regarding to this research, the author can be reached through email stated as below.

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Motto: "The circumstances of one's birth are irrelevant. It is what you do with the gift of life that determines who you are."