MODEL DEVELOPMENT OF ESTIMATING OIL DISCHARGE FOR SUSTAINABLE GREEN PORT

NAJLAA NAZIHAH BINTI MAS'OOD

UNIVERSITI TEKNOLOGI MALAYSIA

MODEL DEVELOPMENT OF ESTIMATING OIL DISCHARGE FOR SUSTAINABLE GREEN PORT

NAJLAA NAZIHAH BINTI MAS'OOD

A project report submitted in fulfilment of the

requirements for the award of the degree of

Master of Engineering (Industrial Engineering)

Faculty of Mechanical Engineering

Universiti Teknologi Malaysia

JUNE 2015

ACKNOWLEDGEMENT

In the name of Allah the Most Gracious and the Most Merciful. First and foremost I am truly grateful for the blessings of Allah that gives me the strength to complete this thesis.

I am using this opportunity to extend my gratitude towards my supervisor Dr. Syed Ahmad Helmi Syed Hassan and my co-supervisors Dr. Erne Nazira Bazin and Prof. Dr. Ir. Saman Abd Kader for their aspiring guidance and constructive criticism throughout this project. I am very grateful with his illuminating views on number of issues encountered related to this project and without their guidance my journey in this research would went astray.

I am most thankful with people around me that always laying a helping hand in completing this study. Their knowledge, patience and guidance had given a huge impact towards success of this study. Not forgetting to thank to my best friend, Mohamed Fitri bin Johari who always help and gave me ideas in completing this thesis.

Finally, I would like to express my warm thanks to my beloved parents, Mas'ood bin Idris and Hamidah binti Buang and all of my siblings for their support and encouragement during joy and difficult times. Without them it is impossible to overcome relentless challenges and remain motivated throughout this study. May Allah bless and reward them.

ABSTRACT

Port is indeed a complex system build up from multi-subsystem, i.e. ecology, technology, economy and most importantly the community of human workforce within. As for the range of activities occurred within the port has been globally diversified, the port size also urged to expand. To that extend, maintaining port operation, has degraded the magnitude of responsibility towards the environment's concern. Fulfilling the need, this study was conducted to highlight the important of green port. This will be done by investigating the sources and impact from oil pollution that occurred at the terminal port container. Conducting the study, a set of objectives was established; to design and develop System Dynamics (SD) model of environmental sustainable green port operation, and to suggest mechanism for minimizing the oil pollution based upon the developed model. In order to do that, SD's computer simulation was designated by using Vensim^{TM} Software. The model demonstrating the oil pollution's time based design analysis which propagate the interrelation of all the causes and repercussions involved. A case study was exclusively selected on oil discharge that occurred within Port Tanjung Pelepas (PTP), Johor. From the basis of previous record provided by PTP Marine Department, equations model was derived prior to the development of the SD simulation. Calculation of Cohen's Kappa for the model construct was calculated with value of 0.671. From the simulation result, it was found that, the oil discharge is expected to be significantly increased annually. Provided that there is no preventive measure was taken, in range of 20 years' time, more than 350, 000 m^3 is expected to be observed. Treatment cost may speed up to RM30 billion annually by year 2035. On that basis, this study suggests that countermeasures need to be taken by implementing higher security level at the port and provide training about the importance of environment.

ABSTRAK

Pelabuhan dikenali sebagai suatu sistem kompleks yang bertindak oleh pelbagai ekologi, teknologi, ekonomi dan masyarakat faktor. Pada masa kini, semua pelabuhan di dunia menjadi lebih besar dengan lebih banyak aktiviti yang terlibat. Tanggungjawab terhadap alam sekitar semakin berkurangan, terutamanya bagi mengekalkan operasi pelabuhan, dan meminimumkan risiko kepada alam sekitar. Oleh itu, kajian ini memberi penekanan kepada kepentingan pelabuhan hijau dan mengenalpasti punca dan kesan pencemaran yang berlaku di pelabuhan terminal kontena. Objektif kajian ini adalah untuk mereka bentuk dan membangunkan Sistem Dinamik (SD) model operasi pelabuhan hijau lestari alam sekitar dan mencadangkan peningkatan pencemaran minyak berdasarkan model maju. Oleh itu, SD adalah pendekatan simulasi komputer untuk menganalisis dan menyelesaikan masalah yang kompleks dan rumit, memberi tumpuan kepada reka bentuk dan analisis dari masa ke masa yang menunjukkan hubungan sebab dan kesan system itu. Vensim Perisian telah digunakan dalam usaha untuk membangunkan model. Di samping itu, kajian ini memberi tumpuan hanya kepada pembuangan minyak yang berlaku di Pelabuhan Tanjung Pelepas (PTP). Tambahan pula, data masa lalu dari Jabatan Laut di PTP digunakan untuk merumuskan persamaan model sebelum melakukan penyelakuan. Bahagian-bahagian penting dalam melakukan kajian ini adalah dan pengesahan model. Pendekatan “Cohen Kappa” telah digunakan untuk mengesahkan model. Selepas simulasi, didapati bahawa pelepasan minyak akan terus meningkat sehingga 20 tahun akan datang sekiranya tiada langkah pencegahan diambil. Model ini juga diunjurkan untuk 20 tahun akan datang dan pelepasan minyak mungkin lebih daripada 350, 000 m^3 setahun menjelang 2035. Tambahan pula, kos anggaran untuk rawatan pencemaran minyak adalah mungkin mencapai RM30 bilion setahun menjelang 2035. Kemudian, penambahbaikan dengan pelaksanaan keselamatan yang ketat di pelabuhan dan menyediakan latihan mengenai kepentingan alam sekitar.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter presents an overview of this study. This includes the background of the study, problem statement, objectives and scopes of the research, as well as the significance and implications of the study.

Ports can be defined as a location on a coast or shore containing one or more harbors where ships can dock and transfer people or cargo to and/or from land. Ports are also recognized to be inherently complex systems acted on by many ecological, technological, community and economical factor (Pourvakhshouri and Mansor, 2003). Suitable port locations are important to optimize access to land, navigable water for commercial demand, and for shelter from wind and waves. It is similar for container port terminals, where cargo containers are transshipped between different transport vehicles for onward transportation. Furthermore, the transshipment may be required to go between container ships and land vehicles such as trailer lorries.

Several activities are conducted at the port such as container terminal, free trade zone and marine services. Before the era of globalization, port production capacity was very limited and slow, maximising the usage of human and animal potential (Liu, Zhao, Li & Wang, 2010). Nowadays, the ports all around the world are becoming larger and more involved in activities which cater to the increasingly larger community.

The increasing complexity of port activities brought about a greater challenge in maintaining a sustainable environment. The economic systems are sustained by the consumption of renewable sources of energy such as muscle power, forests, water, land and air. Therefore, in order to sustain the environment, approaches in developing green ports are essential.

According to Environmental Protection Agency (EPA), the total volume of cargo shipped by water is expected to double by the year 2020. In addition, the change in lifestyle has made the cruise industry into one of the fastest growing segment in the travel industry. Many ports are investing billions of dollars in infrastructure improvements in order to accommodate the increases in size of cargo and cruise ships and the new security requirements. Results of those investments are deeper channels, larger cranes and other facility and property enhancements (Epa.gov, 2014). The ports which have been traditionally viewed as the environmental stewards of coastal resources are finding it challenging to balance sustainable economic, environmental and social issues. The economic, environmental and social are pillars of sustainable development.

Many ports have proactively addressed their environmental and related socio-economic responsibilities through the development of Environmental Management Systems (EMSs) to ensure sustainable growth. The main objective of EMS is to help ports in improving their efficiency, reducing costs and minimizing negative impacts on human health and the environment. Deming Cycle or PDCA method is implemented by organizations which apply the EMS approach. There are also numerous types of environmental issues that are associated with port operations such as air, water, and noise and vibration pollution. All these issues must be controlled in order to avoid negative effects to the human health and the environment.

Some developed countries have embarked into green port management. The main focus is to balance the environmental challenges based on economic demands. These pollutions are not only faced by the common industries, but are also faced by ports.

Environmental issue causes may be categorized into three (Constanza & Ruth, 1998):

(i) Human beings, fauna and flora.

(ii) Soil, water, air, climate and landscape.

(iii) Material assets and the cultural heritage.

1.1.1 Oil Pollution in Malaysia Sea Water

Malaysia has a relatively long sea frontage, approximately 4830km with unique ecosystems and marine resources (Zakaria et al., 2000). One of the unique characteristic of the Malaysian coastline is the abundance of mangrove forests. These forests count as one of the most productive ecosystem due to its significant contribution to the national fishing industry. The mangrove ecosystem has various type of ecological niches which provides nurseries and spawning area as well as habitats for many important species of fishes and prawns.

Due to the important economic role played by the coastal fisheries and its contribution to the national protein demands, national interests in the marine environmental pollution is essential in the context of the overall national environmental policy. According to Mohd Hilmi (2001), the coastal pollution in Malaysia has already been known for quite some time, but the implications are only starting to be felt in the recent years. This is due to the rapid development of the country's establishment of industrial and residential estates, land clearance for agriculture and resettlement, and the navigational activities, particularly in the Straits of Malacca. The impacts of marine pollutions are mostly felt in the estuarine and inshore coastal areas of the Malacca Strait.

The increase of maritime activities has also been a major contributor to the marine pollution. According to Zakaria et al. (2000), the Straits of Malacca has become one of the busiest waterways in the world. The emergence of new industrializing economies such as Singapore, Hong Kong and South Korea creates a high demand for oil in those regions. As the Straits of Malacca is known to be the

shortest and most economic shipping route linking between the oil-rich Middle-East and Pacific nations, higher shipping traffic is seen.

In addition, with the ever increasing size and variety of cargo ships and oil-tankers, the Straits of Malacca is constantly exposed to the danger of grounding and collisions at sea. This consequently may cause catastrophic oil spills. The grounding of Japanese Showa Maru off Buffalo Rock in Singapore Straits in 1975 and the collisions of the Philippine tanker Diego Silang, for example, has underlined this concern (Md. Yassin, 1988). The oil pollution is also a result from normal operations of the tanker such as loading and unloading of oil, cleaning of the tanks, the release of bilge and deballasting (Mohd Hilmi, 2000).

There are several of types of pollutants intoxicating the Malaysian marine environment, the Straits of Malacca in particular. The most widespread pollutant known which has threatened the marine environment are coming from domestic and industrial wastes. Examples of domestic wastes are detergents, pesticides, sewage and garbage, while the industrial wastage are paint, dye, oil dispersants, emulsifier, oil and other petroleum derivatives, organic and inorganic solvents, as well as woods and sawdust. Moreover, oil and petroleum hydrocarbon are of major concern due to their hazardous characteristics and adverse impacts that they have on the marine flora and fauna.

1.1.2 Sources of oil pollution

Mohd Hilmi (2000) estimated that 75% of all marine transport comes from routine shipping operations. Various operation activities ranging from shipping and transportation contributes to the oil pollution of the marine environment. Deballasting is one of the most significant discharge of oil, either during transit through or shortly after the vessels enter the Straits of Malacca (Mohd Hilmi, 2000). Deballasting activities are also carried out by ships and vessels from the South China Sea (Harper, Godon & Allen, 1995). It is estimated that about two tonnes of oil are

discharged into the marine environment per day through deballasting. The oil then ends up in the Malacca Straits.

The largest source of oil pollution in transportation activities is identified to be the tanker operations. It is usually associated with the cleaning of cargo residues during deballasting of ships or the cleaning process of storage tanks. The pertaining activities occur when the ships harbour in the ports and discharge after/while on a voyage (Mohd Hilmi, 2000). The oil is usually associated with fuel oil sludge and machinery-space bilges. Illegal desludging activity has been frequently observed in Malaysia waters due to the lack of proper reception facilities and high cost of deslopping. Apart from the operational oil discharge by large ships and oil tankers, discharge from small fishing boats also contributed significantly to the oil pollution in the sea. According to Zakaria et al. (2000), roughly two tonnes of oil are discharged from 10, 000 fishing boats into the Straits of Malacca.

Another type of spill is accidental oil discharge. This is happenes during the event of ship accidents. The Straits of Malacca is regarded as a major international shipping lane. As such, the strait continues to be an important sea route for local and international trade. Its narrow characteristic along with shallow water at certain stretches, combined with heavy traffic caused several major accidents. These in turn, may cause catastrophic oil spills. Major shipping accidents results from numerous factors such as human error, bad weather, navigational hazard and the likes.

There was once a big catastrophe in California which was remembered as the Exxon Valdez oil spill in the year 1989. It spilled about 42 000 m^3 to 144 000 m^3 of crude oil and it was considered to be one of the most devastating human-caused environmental disasters (Kim, 2002). Many cases had been reported regarding this incident. The incident was very costly, especially in terms of the recovery and clean-up process. This disaster was reported in the media and costs a huge amount of money from the company for the recovery and oil clean-up process.

1.2 System Dynamics

System Dynamics (SD) can be defined as a modeling and simulation approach to study the behavior of complex systems over time (Forrester, 1987). This approach was developed in 1961 by MIT professor, Prof. Jay Forrester. SD is focused on the internal feedback loops and the time delays that affect the dynamics of the entire system. Forrester treated a complex system as a system of stocks and flows where the flows are rates of change determined via feedback loops. The changes in stocks occur only through associated rates of change and not through the correlation with other variables (Forrester, 1994). In other words, SD model focuses on those key rates that increase or reduce the stock over time.

There are many advantages when using the SD modeling. The causal loop diagram or close loop diagram is very powerful. STELLA, Vensim and Powersim software are examples of the types of computer simulation which can be utilized in order to develop the models. The models are used to investigate deeper into the dynamic issues that are of concern to the management. The advantages include the following (Maani & Cavana, 2007):

(i) More information can be obtained in a computer simulation model than in a conceptual model.
(ii) Causal relationships and assumptions can be formulated clearly and unambiguously.
(iii) Once the model has been validated, it can be used reliably to simulate alternative model experiments without manual errors.
(iv) Assumptions can be altered easily for different experiments.
(v) Experiments can be performed readily with different structures and policies.
(vi) Uncertainties and errors can be incorporated into the model explicitly.
(vii) Graphical and tabular output can be communicated easily to management or model users.

Moreover, SD modeling technique can be used as a tool in order to show the simulations of environmental behavior. In addition, the SD modeling can also be implemented in project management. Project management is one of the most important and most poorly understood areas of management. Delays and cost overruns are the rule rather than the exception in construction, defense, power generation, port development and other areas. Normally, a large project involves significant accumulations, time delays, feedback processes and nonlinearities (Leal Neto, Legey, González-Araya & Jablonski, 2006). The features of SD shows the difficulty for people to understand and manage.

One of the best examples is coming from Flour Corporation. This corporation implements SD modeling which has transformed their management of projects and changes. Through this approach, the corporation managed to identify and obtain over USD$800 million worth of savings for their company (Sterman, 2000). Below are the major benefits of the (company and its clients) gained when applying SD modeling.

(i) Advanced quantification enables project teams and clients to determine if change is an economically correct decision.
(ii) Advanced diagnosis allows managers to formulate and consult with clients on what actions can be taken to reduce impacts.
(iii) Transform the industry to a positive and proactive mindset.

1.2.1 Topics in System Dynamics

The important elements of system dynamics diagram are feedbacks, accumulation of flows into stocks and time delays.

(i) Causal loop diagrams

In the system dynamics methodology, a problem or a system such as ecosystem, political system or mechanical system is represented in causal loop diagram. A causal loop diagram is a simple map of a system which includes all its constituent components and their interactions. By capturing interactions and consequently, the feedback loops, a causal loop diagram reveals the structure of a system and it becomes possible to ascertain a system's behavior over a certain time period (Sterman, 2000).

A causal loop diagram (CLD) aids in visualizing relationship of different variables in a system. The diagram consists of a set of nodes and edges. Nodes represent the variables and edges are the links that represent a connection or a relation between the two variables. A link marked positive indicates a positive relation and a link marked negative indicates a negative relation. A positive causal link means the two nodes change in the same direction. For example, if the node in which the link starts decreases, the other node also decreases. Similarly, if the node in which the link at start increases, the other nodes increases as well. Accordingly, a negative causal link means the two nodes change in opposite directions. If the node increases, the other node decreases and vice versa.

Closed cycles in the diagram are very important features of the CLDs. A closed cycle is either defined as a reinforcing or balancing loop. A reinforcing loop is a cycle in which the effects of a variation in any variables propagates through the loop and returns to the variable reinforcing the initial deviation. For example, if variables increase in a reinforcing loop the effect through the cycle will return and increase to the same variable and vice versa. A balancing loop is the cycle in which

the effect of a variation in any variables propagates through the loop and returns to the variable a deviation opposite to the initial one.

(ii) Stock and flow diagram

Causal loop diagrams aid us in visualizing a system's structure behaviour, and analysing the system qualitatively. In order to perform a more detailed quantitative analysis, a causal loop diagram is transformed to a stock and flow diagram. A stock and flow diagram helps in studying and analysing systems in a quantitative way at which models are usually built and simulated using computer software.

A stock is the term for entity that accumulates or depletes over time while a flow is the rate of change in a stock. Based on Figure 1.1, it shows the stock and flow diagram. For example, a situation where someone pours water from a jug into a cup. Therefore, the water flow can be represented as the flow while the quantity of water in the cup and jug as stock.

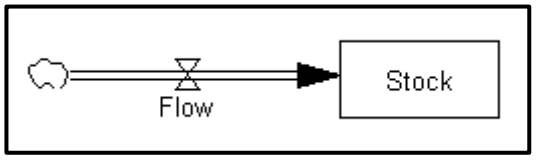

Figure 1.1: A flow is the rate accumulation of the stock

1.3 Problem Statement

Assilzadeh and Gao (2010), have defined the oil spill or discharge hazard as an incident which can occurred in a sudden manner and complex in nature. It causes loss of animal lives, damage to property or natural environment and has a serious effect on local activities. Such incidents require responsive management that involves extensive resources, equipment, skills and man power from many agencies

through an efficient coordination. This coordination demands complex action and would take a long period of time. They have also pointed out that many parts of coastal areas are exposed to such hazards in which may cause significant distraction to socio-economies and life of communities in coastal areas. Furthermore, it may lead to the loss of properties and environmental damage.

In previous researches, there have been many studies discussing about oil spill management. An example of this is the designation of an integrated system based geo-database, where internet and communication system are implemented for real-time interactive oil spill management. This design is able to cover all aspects of oil spill management including before, during and after disaster events. This includes early warning, assessments, mitigation, communication, documentation and data repository. Nevertheless, this study is different in that the main objective of this study is to estimate the number of oil spill by using System Dynamics in terms of a sustainable green port. It is vital to know the amount of oil spill per year. By knowing that amount, management can take necessary preventive measures to avoid oil pollution from occuring at the port.

Sustainable green port is a part of global movement towards sustainable development. It is driven by the realization that society cannot continue current modes of operation and consumption without seriously considering the ecological damage. Most of the ports do not realize the importance of sustainability. Therefore, this study emphasizes the importance of green port management and finds out the causes and effects of the pollution that occurs at container terminal ports. It is known that many types of pollution happen at container terminal ports that are very hazardous to the workers and the environment. Accordingly, this study aims to build up the level of awareness on sustainable green port management among the population, and especially the top management brass of container terminal ports.

Malaysia coastal area is vulnerable to petroleum hydrocarbon pollution. This arises mainly from the marine transportation activities, oil exploration and production, and the discharges of hydrocarbon-contaminated wastewater from land-

based activities. Pollution from shipping activities, accompanied by illegal oil dumping in the Straits Malacca has become a serious concern. As such, oil pollution inputs from shipping activities have received great attention and captured more publicity than land-based sources, although the latter have been known to present a more significant contribution on a global basis.

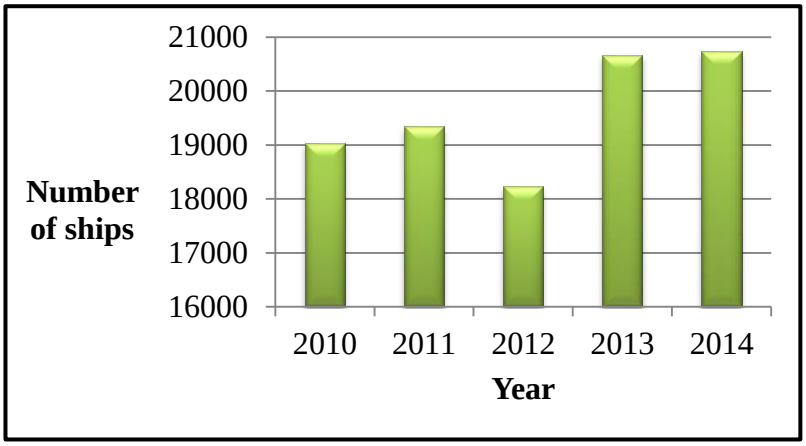

Figure 1.2: Total vessels traffic (Courtesy of: Marine Department, Tg. Pelepas, 2015)

Figure 1.2 shows the average number of vessels that passed through the port from 2010-2015. It can be concluded that the number of ships increases steadily by the years. This statistic considered any type of ship that passed through and anchored at the port. There are several types of ships docked at Malaysia's port such as bulk carrier, containers and Very Large Crude Carrier (VLCC). All of these ships are using oil as its fuel in order to move their ships. Hence, the port management must ensure that the ships arriving at the port are following the regulations. The port management must be more effective in managing their customers. When there is a high number of ships passing through to the port, the possibility of oil pollution at the port increases.

1.4 Research Questions

Research questions are essential in order to start thinking about the objectives of the study. The question sets about how to learn regarding the topic at hand. Research questions will also guide and structure the choice of data which needs to be collected and analyzed. Accordingly, the research questions of this study are:

(i) How are the interrelationships between causes of oil discharge and the effects of human activities at the container terminal port?
(ii) How much oil has been discharged by ships and how much is the cost to recover from the spills?
(iii) How to improve the environmental issues at the port container terminal using the developed model?

1.5 Objectives of the Study

There are several objectives in relation to this study. The main objectives are:

(i) To design and develop the model of oil discharge using System Dynamics.
(ii) To estimate oil discharge rate and cost of pollution treatment at port on ship volumes.
(iii) To suggest the improvement of oil pollution, based upon the developed model.

1.6 Scope of the Study

When doing a research, the scope of the study is very important. This is so that the research is within the scope topic. It also helps the researcher to focus on the objectives. The scopes for this study are as follows:

(i) Study was carried out at Port Tanjung Pelepas (PTP), port container terminal.
(ii) Study was under the Marine Department of Tanjung Pelepas.
(iii) Environmental issue focused on only oil pollution.
(iv) Vensim System Dynamics software is used for modelling purposes.
(v) Historical data based on 2010 until 2014.
(vi) Experts from the department were involved in order to validate the model.

1.7 Significance and Implications of the Study

Port handles a large number of ocean-going ships and other smaller vessels. Aside of that, there are other facilities such as refineries and power generators that deal with oil. A major pollution threat is the transportation of oil and petroleum products (B.Ohawa, 2008). Port activities such as the handling of petroleum tankers, in addition to the frequent tanker operations, especially when there are frequent tanker operation, present risks of oil spill (Md. Yassin, 1988). However, activities at the PTP does not involve oil tankers which contain petroleum products. Regardless, it can still pose a significant risk of oil pollution. It is such because all kinds of vessels that passes through the PTP have uses oil or diesel to operate. Thus, the ships pose a threat to the marine ecosystem.

Most of the activities at the PTP involve the transshipment of cargo. Many big containers have been shipped by using different types of vessels such as Very Large Crude Carrier (VLCC), Maersk Triple E (EEE) ships and others of the kind. VLCC is the largest ship that disembarks at the PTP. The deadweight (DWT) of VLCC is about 250, 000 to 350, 000 DWT. Since the Straits of Malacca is one of the busiest waterways, port management has to control the number of ships that disembark or pass through the port in order to minimize security risk such as invasion, burglar and illegal activities that could affect the environment. Hence, this study considers the effects upon the environment, caused by human activities such as deballasting and oil discharged.

This study emphasizes on the importance of sustainable green port. It is hoped that through this study, improvements in the level of awareness among humans, and especially the management of the port about the sustainable environment that can be implemented at terminal port. Many cases have been recorded in accordance to pollution at container terminal ports. Improvement of environmental issues with respect to sustainable green port management will be suggested. This study gives positive impacts due to the following reasons:

(i) Raise awareness of the environmental issues to the management at the container terminal port.
(ii) Protect the community from harmful environmental impacts of port operations.
(iii) Promote sustainability.
(iv) Employ the suggestions of the improvement of environmental issues in order to avoid or reduce environmental impacts.
(v) Engage and educate the community about green port sustainability.

There are an abundant number of relevant studies conducted by researchers relating to environmental issues, of which a large quantity comprising of discussions about determining the polycyclic aromatic hydrocarbon (PAH) pollution in the sedimentary environment, water analysis due to oil spilt and the likes. The researchers also mainly interested on profit gain on the port. However, there is a lack

of study being done on estimating the oil discharge rate to the environment and the prevention of oil pollution. Therefore, this study attempts to emphasize the particular issue. Figure 1.3 shows the implication to the environment, especially for the marine life due to oil spills, which is regarded as oil pollution.

Figure 1.3: Impact to the marine life
(Source: Wikipedia, 2015)

1.8 Conclusion

The described chapter is dedicated to the thesis introduction and background. It introduces the thesis objectives, the problems and questions to be solved, the scope to which the thesis is limited to, the expected significant results, and finally, the structure in which the thesis is conducted.

REFERENCES

Ahmed R. (2005) "*A Rapid Simulation Modeling Process For Novice Software Process Simulation Modelers*". Phd thesis, Dept of Computer Science, From University of Hertfordshire, UK.

Assilzadeh, H., & Gao, Y. (2010). Designation of an interactive oil spill management system. *Disaster Prevention And Management*, *19*(2), 233-242.

Bames, P.,Olruntoba, R. (2005). Assurance of security in maritime supply chains: Conceptual issues of vulnerability and crisis management. *Journal of International Management*, 11, 519-540

Bernard, H. (2000). *Social research methods*. Thousand Oaks, Calif.: Sage Publications

Chao, S., & Lin, P. (2009). Critical factors affecting the adoption of container security service: The shippers' perspective. *International Journal of Production Economics*, *122*(1), 67-77.

Costanza. R., & Pruth. M., (1998). Using Dynamic Modelling to Scope Environmental Problems and Build Consensus. Environmental Management, 22(2), 183-195

Epa.gov,. (2014). *Response Techniques |US Environmental Protection Agency*. Retrieved 12 November 2014, from http://www.epa.gov

Epa.gov,. (2015). *Environmental Management Systems (EMS) | Pollution Prevention | US EPA*. Retrieved 24 April 2015, from http://www.epa.gov/ems/

Forrester, J. (1961). *Industrial dynamics*. [Cambridge, Mass.]: M.I.T. Press.

Forrester, J. (1987). Lessons from system dynamics modeling. *System Dynamics Review*, *3*(2), 136-149.

Forrester, J. (1994). System dynamics, systems thinking, and soft OR. *System Dynamics Review*, *10*(2-3), 245-256.

Greenberg, M. (2009). Risk analysis and port security: some contextual observations and considerations. *Ann Operation Res*, *187*(1), 121-136.

Güneralp, B., & Barlas, Y. (2003). Dynamic modeling of a shallow freshwater lake for ecological and economic sustainability. *Ecological Modelling*, *167*(1-2), 115-138.

Harper, J., Godon, A., & Allen, A. (1995). COSTS ASSOCIATED WITH THE CLEANUP OF MARINE OIL SPILLS. *International Oil Spill Conference Proceedings*, *1995*(1), 27-30.

Ishii, M., Lee, P., Tezuka, K., & Chang, Y. (2013). A game theoretical analysis of port competition. *Transportation Research Part E: Logistics And Transportation Review*, *49*(1), 92-106.

Kim, I. (2002). Ten years after the enactment of the Oil Pollution Act of 1990: a success or a failure. *Marine Policy*, *26*(3), 197-207.

L., & Andersen, D. (2003). Collecting and analyzing qualitative data for system dynamics: methods and models. *System Dynamics Review*, *19*(4), 271-296.

Landis, J., & Koch, G. (1977). The Measurement of Observer Agreement for Categorical Data. *Biometrics*, *33*(1), 159

Leal Neto, A., Legey, L., González-Araya, M., & Jablonski, S. (2006). A System Dynamics Model for the Environmental Management of the Sepetiba Bay Watershed, Brazil. *Environmental Management*, *38*(5), 879-888

Liu, X., Zhao, B., Li, B., & Wang, N. (2010). A System Dynamics Model of the Interaction between Port and City Based on the Green Concept. *Logistics For Sustained Economic Development : ICLEM*, 684-691.

Liu, Y., Li, R., & Li, C. (2010). A System Dynamic Model of the Interaction Between Port and City Based on Green Concept. *Chin. Geograph.Sc.*, *15*(3), 219-226.

Luna-Reyes, L., & Andersen, D. (2003). Collecting and analyzing qualitative data for system dynamics: methods and models. *System Dynamics Review*, *19*(4), 271-296

Maani, K., & Cavana, R. (2007). *Systems thinking, system dynamics*. North Shore, N.Z.: Pearson Education New Zealand.

Martis, M. S. (2006). Validation of simulation based models: a theoretical outlook. *The Electronic Journal of Business Research Methods*, *4*(1), 39-46

Md. Yassin, D. (1988). Legislation On Oil Pollution Prevention And Control During Petroleum Production. *Jurnal Teknologi*, *11*(1)

Mikel D. Petty (2008). *Principles of modeling and simulation*. Hoboken, N.J.: John Wiley.

Mohd Hilmi, J. (2001). *Distribution of Petrogenic Hydrocarbons in Water, Sediment and Cockles From Kuala Sungai Sepetang and Kuala Sungai Selangor* . Master of Technology (Environmental Management). Universiti Malaya.

Pourvakhshouri, S., & Mansor, S. (2003). Decision support system in oil spill cases (literature review). *Disaster Prevention And Management*, *12*(3), 217-221

Seguí, M., Cabrero-García, J., Crespo, A., Verdú, J., & Ronda, E. (2015). A reliable and valid questionnaire was developed to measure computer vision syndrome at the workplace.*Journal Of Clinical Epidemiology*, *68*(6), 662-673

Sterman, J. (2000). *Business dynamics*. Boston: Irwin/McGraw-Hill.

Tako, A., & Robinson, S. (2008). Comparing discrete-event simulation and system dynamics: users' perceptions. *Journal Of The Operational Research Society*, *60*(3), 296-312.

Torabizadeh, M., Khatami Rad, M., & Noshadi, A. (2012). Effect of Information System, Strategies on Supply Chain Strategies and Supply Chain Performance. *World Academy Of Science, Enginering And Technology*, *6*(1), 792-797.

Warrens, M. (2010). Weighted kappa is higher than Cohen's kappa for tridiagonal agreement tables. *Statistical Methodology*, *8*(2), 268-272

Warrens, M. (2011). Cohen's kappa is a weighted average. *Statistical Methodology*,*8*(6), 473-484.

Wikipedia,. (2015). *Exxon Valdez oil spill*. Retrieved 20 Mac 2015, from http://en.wikipedia.org/wiki/exxon_valdez_oil_spill

Williams, D., (2000). Dynamic Synthesis: A Theoretical Framework for Research in Requirements Engineering Process Management. *Operational Research Society*

Winz, I., Brierley, G., & Trowsdale, S. (2008). The Use of System Dynamics Simulation in Water Resources Management. *Water Resources Management*, *23*(7), 1301-1323.

Yeo, G., Pak, J., & Yang, Z. (2013). Analysis of dynamic effects on seaports adopting port security policy. *Transportation Research Part A: Policy And Practice*, *49*, 285-301.

Zakaria, M., Horinouchi, A., Tsutsumi, S., Takada, H., Tanabe, S., & Ismail, A. (2000). Oil Pollution in the Straits of Malacca, Malaysia: Application of Molecular Markers for Source Identification. *Environmental Science & Technology*, *34*(7), 1189-1196.