OIL SPILL TRAJECTORY & IMPACT ANALYSIS

TENGKU NOREENA TENGKU ALI

CIVIL ENGINEERING
UNIVERSITI TEKNOLOGI PETRONAS

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by

Tengku Noreena Tengku Ali

Dissertation submitted in partial fulfilment of
the requirements for the
Bachelor of Engineering (Hons)
(Civil Engineering)

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Universiti Teknologi PETRONAS
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

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Civil Engineering Programme
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Approved by,

(AP Dr Abdul Nasir Matori)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

July 2009

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

TENGKU NOREENA TENGKU ALI

ABSTRACT

The objective of the project is to assist in oil spill response plan and action that is fast and effective thus reduce the environmental impact and severity of the spill. The initial and continuous analysis during the incident needed to be timely assessed and consequently responded.

Oil spill may happen as long as the world dependency on petroleum and its product does exist. It can caused by human error or equipment failure as well as nature courses during the exploration, transportation and processing of the natural resource.

The response includes stopping the flow of the oil slick, containing the oil, and cleaning up the affected area. Various method are available, and proper planning and identification has to be made prior to the decision on the best and the most effective method is going to be implemented with minimum period and least harmful to the environment.

ACKNOWLEDGEMENTS

I would like to take this opportunity to acknowledge and thank everyone that has given me all the supports and guidance throughout the whole period of completing the final year project. Firstly, many thanks to the university and the Final Year Project coordinators that have coordinated and made the necessary arrangements, especially in terms of the logistics, for this study.

I must also acknowledge the endless help and support received from my supervisor, AP Dr Abdul Nasir Matori throughout the whole period of completing the final year project. His guidance and advices are very much appreciated.

I would also like to thank the Post Graduate Student in UTP, especially En. Basith for his endless support in terms of the tutorial on using the image processing software for this study. His continuous support and help throughout the whole period of project are very much appreciated.

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CHAPTER 1

INTRODUCTION

1.0 BACKGROUND

Oil and petroleum and its products have governed the world in various fields. The future prediction doesn't seem to change the trend yet as a major sustainer in daily life as an energy source, and many more applications on petroleum derivatives products.

While the production and consumption of oil and petroleum products is in demand, the threat of oil pollution increased accordingly. As far as the distribution is concerned, the different modes of transportation are available in order to get the end products delivered to the customer. Any accident occurred in between can result in oil spill, and it may do damage to the environment.

Prevention methods are sure the most important measure to reduce the risk of the oil spill incident. A strict legislation and implementation of stringent codes of practice has taken place in both governmental body and also the industrial sector. The frequent occurrence somehow still unavoidable thus an effective response plan should be incorporated in line with the environment protection and preservation.

Oil is a complex and variable natural substances that can be transported long distances, undergo various physical and chemical changes and affect the fragile marine ecosystem once released into the sea. Appropriate response method within the allowable time frame is crucial to minimize the impact of the oil spill incident. Thus selection strategies of analysis must be prepared as an emergency response plan.

1.1 PROBLEM STATEMENT

Oil spill response strategies is often time dependant; the faster, the lesser the complication of the methods of recovery and cleaning up the spill. Thus the initial information of the spill incident should be analysed and immediately attended before the scientific support take it course. The response includes initial trajectory modeling, oil fate information, weather forecasting and also tidal hits and currents. A structured system should be in place to assist the spiller (first line responder) even with minimal expertise and experience.

1.2 OBJECTIVES & SCOPE OF STUDY

The objective of the study includes

1. Gathering information of oil spill incident and its fate
2. To analyse the incident and recommend the best response action
3. To estimate the trajectory of the incident.

The scope of the study will cover the Malacca Street, a sensitive area as regard to the Environmental Sensitivity Index maps and also economic activities as well as the likeliness to occur. The type of oil that can be analyzed also fixed as according to the likeliness to happen such as product through the pipelines or the passing oil tanker in that region.

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 Oil Spill Response

A good response action should includes the goal that defined by the authorities (government bodies) stating the overall target of the response, objectives which specified response outcomes under the scope of response management, strategies to have the plans to carry out objectives as well as the tactics to implement it and most importantly, windows of opportunity of response actions are viable.

2.1.1 Goal

There are three main goals in oil spill response in general **[NOAA, 2007]**,

a) Maintain safety of human life;

b) Stabilize the situation to preclude it from worsening; and

c) Minimize adverse environmental and socioeconomic impacts by coordinating all containment and removal activities to carry out a timely, effective response.

2.1.2 Objectives

The objectives should be developed in such a way that addresses all three goals simultaneously and often incident-specific. It must be clearly articulated and be measureable and achievable. Effectively planning and executing a response requires a framework within which limited response resources (people, equipment, and time) can be allocated to protect multiple resources at risk. Not all of these can be protected; some will have higher priorities than others for protection.

2.1.3 Strategies

This is the conceptual plans that designed to achieve response objectives. Response methods includes

a) Natural recovery – biodegradation process

b) Mechanical treatment – contain and skimming

c) Chemical treatment – use of dispersant

d) Biological treatments – natural degrading agents

e) In-situ burning – contain the oil and lit on sea.

Effective strategy is lot depends on the initial information and condition of the whole incident. The essential yet vital information comprises of

a) Type and amount of spill

b) Spill location

c) Behavior of spilled oil

d) Spill trajectories and persistent

e) Locations and resources that may be impacted, and types of impacts, and

f) Current and weather forecasting

Response strategies will vary according to incident-specific conditions, however, strategies can often be established in spill response planning, consistent with response goals.

2.1.4 Tactics

Tactics are site-specific and individual activities taken to implement strategies, and can also be established in spill response plans, consistent with response goals. Specific tactics are usually developed for 12-to-24-hour time periods.

2.1.5 Windows Of Opportunity

Windows of opportunity (timeframes during which actions are viable) are constrained or bound by certain influences or conditions, and are available, or 'open' for limited times.

Three primary windows exist following a marine oil spill. Within each window, certain spill control measures can be taken to minimize adverse environmental effects:

Table 1: Windows of oppurtunity

Phase	Time	Condition of spill	Information
Very early	1 – 2 days	Oil is fresh and concentrated near the discharge source	Response: source control, containment near the source, removal The best opportunities to reduce adverse environmental impacts
Early	Several days – weeks	Oil has spread, is no longer concentrated	Response: minimize the spread of oil, prevent oil from contacting resource at risk, and protect resources and habitats most vulnerable to longer-term oil impacts. Sensitive resources and habitat are threatened.

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Later	Months or longer	Oil has stranded	Response: use habitat-appropriate shoreline cleanup options to minimize environmental effects and enhance natural recovery In some cases, oil may be left to degrade naturally because physical removal would cause a negative impact than leaving it in place.

The project will be narrowed down to early phase of oil spill response.

The contingency plans often developed in such a way that is 'tiered' response (NOAA, 2007), which means that response steps and plans escalate as the incident becomes more serious. As the seriousness of an incident is often not known in the initial phase, one of the first priorities is to determine the magnitude if the oil and its potential impact.

The following figure shows primary spill response options under various wind/sea conditions and oil film thickness.

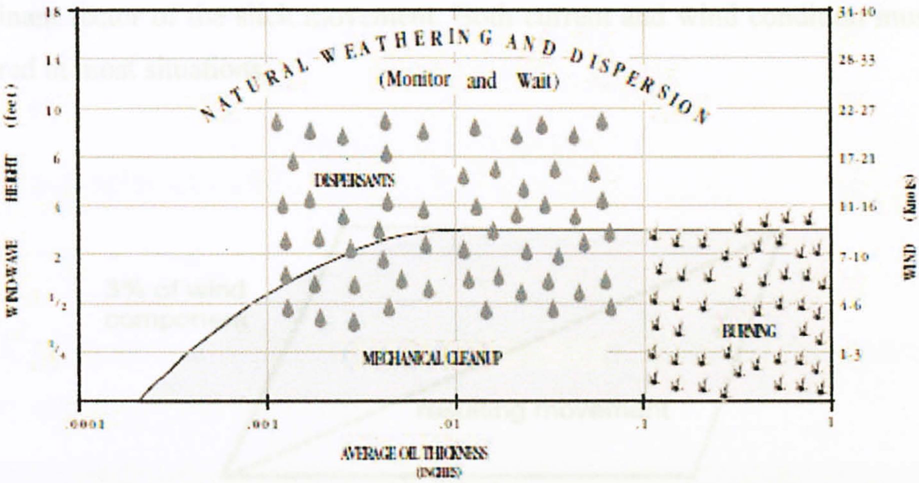


Figure 1: Primary spill response options under various wind/sea conditions and oil film thicknesses (modified from Allen, 1988).

2.2 OIL FATE ON WATER

2.2.1 Movement of Oil Slicks

As presented by **Merv Fingas (2001)** oil tends to spread into slick over the water surface. Light crudes such as gasoline and diesel fuel forms thin slicks. Heavier crudes such as Bunker C spread to slicks several millimeters thick.

The spreading patterns will be horizontally even without the wind and water currents. it is due to the force of gravity and the interfacial tension between oil and water. The viscosity of the oil opposes these forces. The gravity effects will be diminished over time and the force of interfacial tension continues to spread the oil. **(P. Vethamony et al, 2007 438-444)**

If the oil slick is close to land and the wind speed is less than 10km/h, the slick generally moves at a rate that is 100% of the surface current and approximately 3% of the wind speed. Thus, the wind has no effect on the movement of the slicks.

If the wind is more than about 20 km/h, in an open sea, wind is then the predominant factor of the slick movement. Both current and wind condition must be considered in most situations.

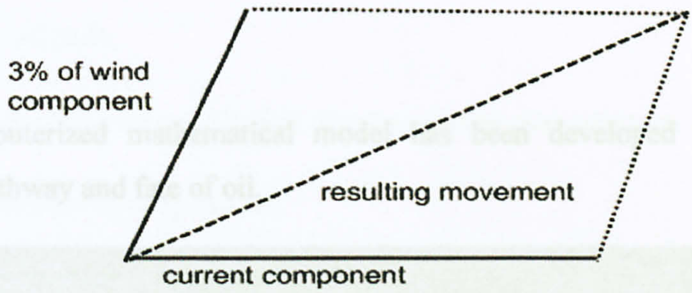


Figure 2: Effect of wind and current direction to the movement of an oil slick.

When attempting to determine the movement of an oil slick, two factors affect accuracy. The more significant factor is the inability to obtain accurate wind and current speeds at the time of a spill. The other, very minor factor is a phenomenon commonly known as the Coriolis effect, whereby the earth's rotation deflects a moving object slightly to the right in the northern hemisphere and to the left in southern hemisphere.

Windrow formation is a phenomenon when slicks, foam, seaweed and floating debris tended to collect in parallel ribbons aligned with the wind direction **(Douglas Cormack, 2001)**.

Evaporation causes a major physical change in oil spilled at sea when these have volatile component. This process is assisted by the spreading of the oil, which increases the surface to volume ratio. The rate and extent of evaporative loss from the surface of the slick is dependent on the vapour pressures of its volatile components and the concentrations to which they are present. It might be expected that wind speed and ambient temperature could substantially affect evaporative loss but high wind speed might also be expected to promote aerosol formation which in turn would increase evaporative loss from the airborne droplets.

2.3 SPILL MODELLING

A computerized mathematical model has been developed to predict the trajectory or pathway and fate of oil.

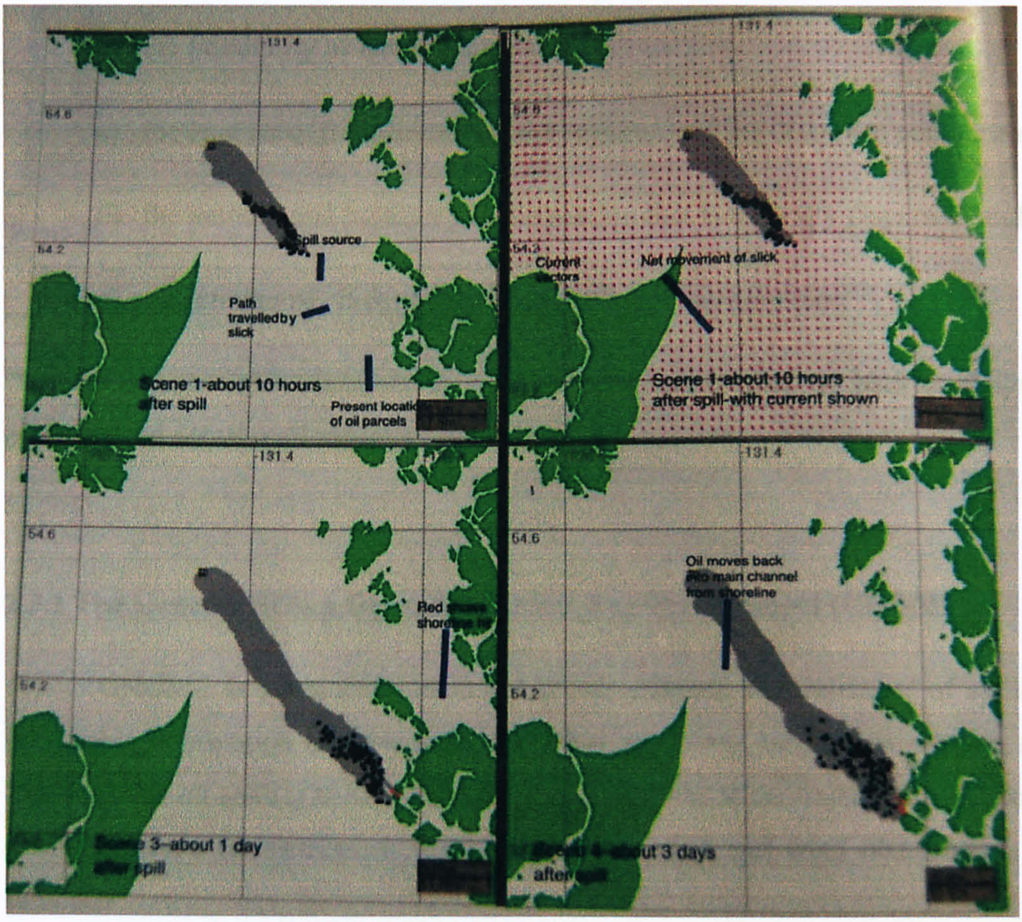


Figure 3: Outputs from a typical spill trajectory model. (*picture's courtesy of Fingas M, "Basics Of Oil Spill Cleanup, 2nd ed."*)

Today's sophisticated spill models combine the latest information on oil fate and behavior with computer technology to predict where the oil will go and what state it will be when it gets there.

However, there are limitations such as inaccuracy of predicting an oil slicks's movement due to the lack of accurate estimates of water current and wind speeds along the predicted path.

Besides the trajectory prediction, the models can also estimate

a) the amount of evaporation,

b) the possibility of emulsification,

c) the amount of dissolution and the trajectory of the dissolved component,

d) the amount and trajectory of the portion that is naturally dispersed, and

e) the amount of oil deposited and remaining on shorelines.

Accurate spill modeling is now very important part of both contingency planning and actual spill response.

2.3.1 The General NOAA Operational Modeling Environment (GNOME)

GNOME is a trajectory model that can estimate the trajectory of spills by processing information about wind and weather conditions, circulation patterns, river flow, and the oil spill(s) to be simulated. The prediction of the trajectories that can be run when there is inexactness (uncertainty) in current and wind observations and forecasts.

This software uses weathering algorithms to make simple predictions about the changes the oil will undergo while it is exposed to the environment. It can quickly be updated and re-run with new information. Besides, the trajectory output (including uncertainty estimates) can be provided in a geo-referenced format that can be used as input to GIS (geographic information system) programs.

To use GNOME, the information about an oil spill scenario must be entered. GNOME then creates and displays a spill "movie," showing how the oil spilled in the scenario is predicted to move and spread across the water.

Two Model Modes are available in GNOME:

- Standard Mode - GNOME's most automated mode, a Location File loads information into GNOME, then GNOME prompts for information it needs to run THE model. In Standard Mode, a picture can be printed or create a "movie" of the model run. The model output can also be exported in GIS-compatible format for spatial or GIS analysis.
- Diagnostic Mode – In Diagnostic Mode, the advanced mode of GNOME, a Location File is used to help set up the model, or set up a new model entirely. Diagnostic Mode is designed primarily for expert modelers.

GNOME is unique among trajectory models because it allows the uncertainty in the trajectory. For example, weather forecasts may be wrong in the wind speed, direction, or timing. GNOME takes this into account and provides two solutions to an oil spill scenario.

The "best estimate" solution shows the model result with all of the input data assumed to be correct. However models, observations, and forecasts are not always perfect. Consequently, we have incorporated in GNOME our understanding of the uncertainties (such as variations in the wind or currents) that can occur.

The second solution allows the model to predict other possible trajectories that are less likely to occur, but which may have higher associated risks. It's called the trajectory that incorporates these uncertainties the "minimum regret" solution because it gives you information about areas that could be impacted if, for example, the wind blows from a somewhat different direction than you have specified, or if the currents in the area flow somewhat faster or slower than expected. In some cases, some of these areas might be especially valuable or especially sensitive to oiling.

Both trajectories are represented by "splots," which are statistically independent pieces of the modeled pollutant. They appear as small "pollutant particles" on a map when the simulation is running. The "best estimate" trajectory is represented by black "splots"; the "minimum regret" trajectory is represented by red "splots".

2.3.2 Automated Data Inquiry for Oil Spills (ADIOS2)

Automated Data Inquiry for Oil Spills (ADIOS2) is an initial oil spill response tool for emergency spill responders and contingency planners to use on either a Macintosh or Windows-compatible computer. The program looks the same on either type of computer. ADIOS2 integrates a library of approximately one thousand oils with a short-term oil fate and cleanup model to help to estimate the amount of time that spilled oil will remain in the marine environment, and to develop cleanup strategies.

ADIOS2 calculations combine real-time environmental data that entered, such as wind speed, with carefully researched chemical and physical property information in its oil library. The program provides a best-guess answer and also calculates possible ranges in the values of estimated spill properties.

It is also important to note that many oil weathering processes depend on the extent of the oil's emulsification. Data for emulsification are very scarce. If ADIOS2 results contradict observed oil property changes, try modifying the emulsification constant.

ADIOS2 assumes that oil spreads unhindered in open ocean conditions due to winds, currents and gravity effects. Once the spread of the oil is dominated by land boundaries or confined by booms, ADIOS2's answers may not be accurate.

ADIOS2 assumes that the temperature of the oil remains unchanged at the user-entered sea water temperature. If the temperature of the oil changes due to solar radiation, sea-air interactions, or any other process, ADIOS2 results may not be accurate.

Many oil weathering processes are sensitive to wind speed. Be careful when using observations and forecasts for locations other than the spill site.

ADIOS2 will make predictions for a maximum of five days. For periods longer than this, other processes, such as biodegradation and photo-oxidation are important. The program does not model these processes.

2.4 REMOTE SENSING

Remote sensing of oil involves the technology of sensors rather than human vision for oil spills detection and mapping. However, oil often cannot be detected in some conditions. Remote sensing provides a timely means to map out the locations and approximate concentrations of very large oil spills in many conditions.

Remote sensing is usually carried out with instruments onboard aircraft or by satellite. While many sensors have been developed for a variety of environmental applications, only a few are useful for oil spill work. Remote sensing of oil on land, for instance is particularly limited and only one or two are useful.

2.4.1 Radar

Many satellites provides images in the visible spectrum thus normally oil cannot be seen in these images unless the spill is very large or rare sea conditions are prevalent that provide a contrast to the oil.

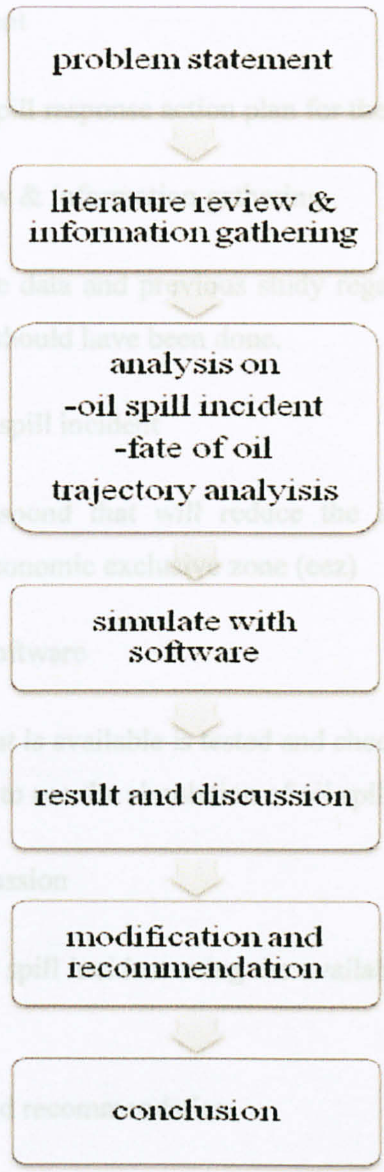
Oil has no spectral characteristics that allow it to be enhanced from the background.

Several radar satellites are now available that operate in the same manner as airborne radar and share their many limitations.

Despite these limitations, radar imagery from satellite is particularly useful for mapping large oil spills. Arrangements to provide the data within a few hours are possible, making this a really useful and fast option.

CHAPTER 3

METHODOLOGY



3.1 DESCRIPTION

- Problem statement

  To develop oil spill response action plan for the use of the spiller.

- Literature review & information gathering

  To gather all the data and previous study regarding oil spill incident and review of what should have been done.

- Analysis on the spill incident

  To plan the respond that will reduce the impact to the environment especially the economic exclusive zone (eez)

- Simulate with software

  The software that is available is tested and check the compatibility with the chosen location to run the simulation of oil spill modelling

- Result and discussion

  Model a known spill incident using the available software and analyze the output.

- Modification and recommendation

  The software used might be suitable with slight adjustment and alteration to suit the local area.

- Conclusion

  To have a complete oil spill trajectory and impact analysis system.

The data for the analysis will be obtained from available information in the software (oil type and properties)

The wind and current information will be gathered from Malaysia's meteorological department. The pattern is to be observed throughout the year.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 INCIDENT INFORMATION

In October 26th 1997, a material fatigue spill incident has spotted in The Straits of Malacca. The amount of spill is reported to be 237 tons of fuel oil.

Table 2: The details of the incident

Date	26th October 1997
Name of the ship	AN TAI
Location	The Straits of Malacca
Cause of accident	Material Fatigue
Type and quantity of spill	Fuel oil 237 tons

4.2 REMOTE SENSING

The figure below shows the RADARSAT image on the day. However, it low contrast image and the oil slick cannot be identified. Thus an image processing must be executed.

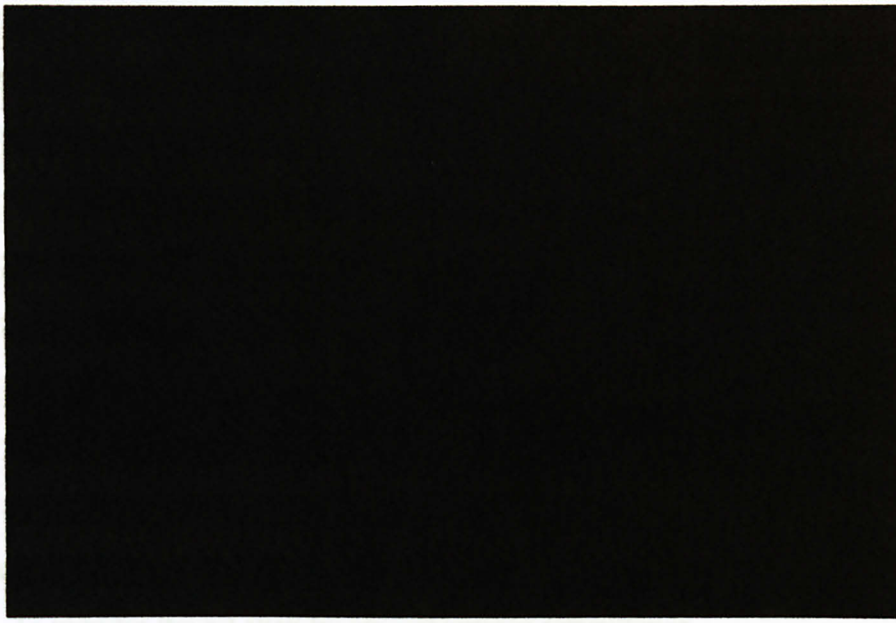


Figure 4: RADARSAT image

A 3-D view is generated by Envi Image Processing Software.

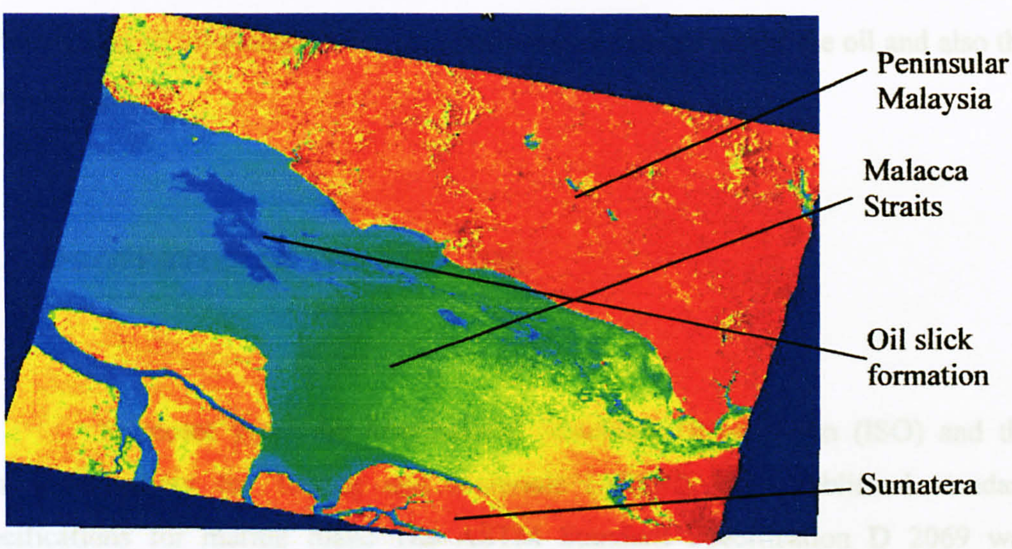


Figure 5: Processed RADARSAT image on 26th October 1997

The dark blue spots along the Malacca Straits were identified as oil slick. The formation and shape of the oil slick is threatening the shorelines nearby.

As the oil slick moved from the collision site northwards into the Straits of Malacca the whole west coast of Peninsular Malaysia from Johor to Selangor was exposed to the threat of the oil pollution. Beside the environment in general the followings were under major threat from the pollution: -

- The mangrove swamps and jungles
- Fish and prawn farm in the coastal areas
- The beach resorts along the coast
- Power plants cooling water intake at Port Dickson and Selangor
- Fishing grounds and activities

The following strategies were adopted by Malaysia throughout the incidents:

- To monitor the oil slick by air and surface surveillance
- To protect high sensitive areas that were likely hit by the oil
- To mobilize oil spill equipment and resources to areas under threat
- To combat the oil only if its threatening to land onshore/beach

Different type of oil reacts differently due to the characteristics of the oil and also the surrounding.

4.3 PROPERTIES OF THE FUEL OIL

In recent years the International Standards Organization (ISO) and the American Society for Testing and Materials (ASTM) have published standard specifications for marine fuels. The ASTM Standard Specification D 2069 was adopted in 1991 and is intended to be technically equivalent to the ISO Specification 8217 adopted in 1987.

In summary, these documents set out specifications for 19 grades of marine fuels: four distillate fuels and 15 residual fuels. Despite the existence of such specifications, marine fuels continue to be referred to using broad categories such as Marine Diesel Oil (MDO), Intermediate Fuel Oil (IFO), and Bunker C.

MDOs are generally formulated from middle distillates, typically containing less than 10% residuum.

Table 3 is a summary of MDO physical properties. As can been seen from Table 3, fuel oil viscosities are generally specified at elevated temperatures. In the case of MDOs, the already low viscosities are not likely to increase significantly at the lower temperatures more typically encountered in the environment.

Table 3: Physical Properties of Marine Diesel Oils

Property	Range	Median
API Gravity	-	33.7
Density at 15 °C (g/mL)	0.839 to 0.903	0.863
Viscosity at 40 °C (cSt)	2.9 to 11	5.2
Flash point (°C)	71 to 116	104
Pour point (°C)	-23 to -5	-1

4.4 INCIDENT SIMULATION

Using the data obtained the software ADIOS2 is used to model the spill scenario. The fate of oil can be predicted therefore the necessary efficient response action can be taken.

a) Open the application.

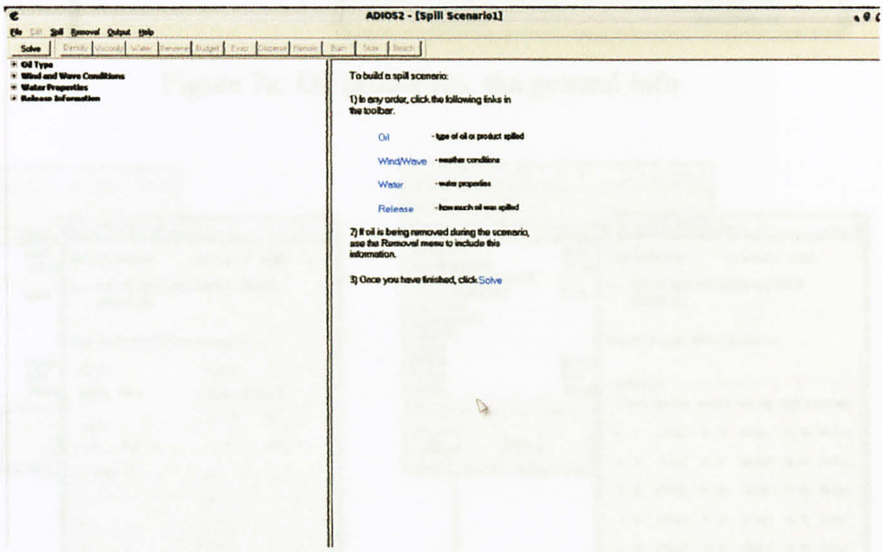


Figure 6: ADIOS2 with no data input

b) Insert the data input

i) Oil type - Specify the type of oil that has spilled. The standard oil in the library already has the Fuel Oil No 2 (High Aromatic Content Heating Oil). This is the diesel fuel oil and also known as Furnace Oil or Heating Oil.

The pictures shown are the basic information and properties of this oil.

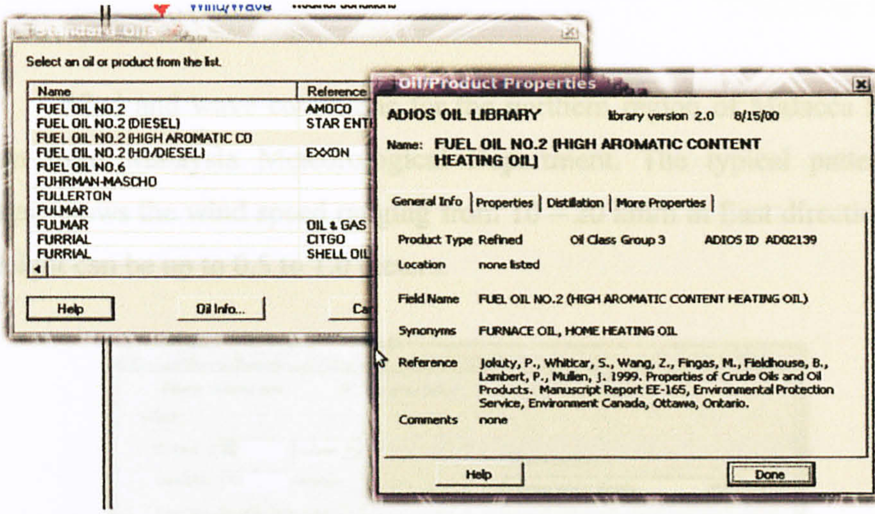


Figure 7a: Oil properties; the general info

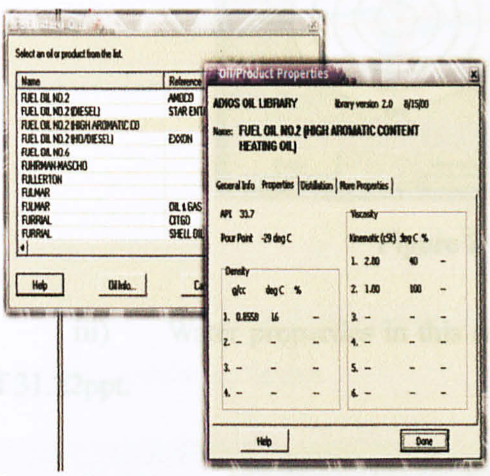


Figure 7b: Oil properties

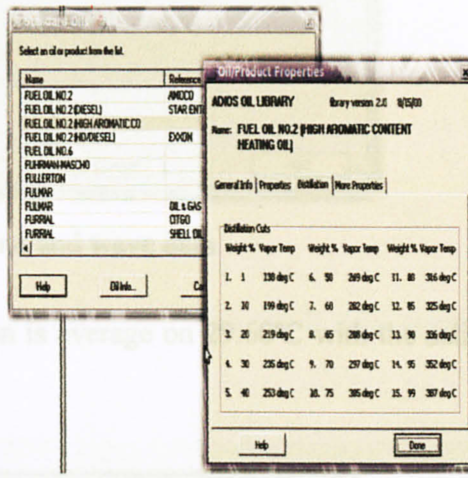


Figure 7c: Distillation

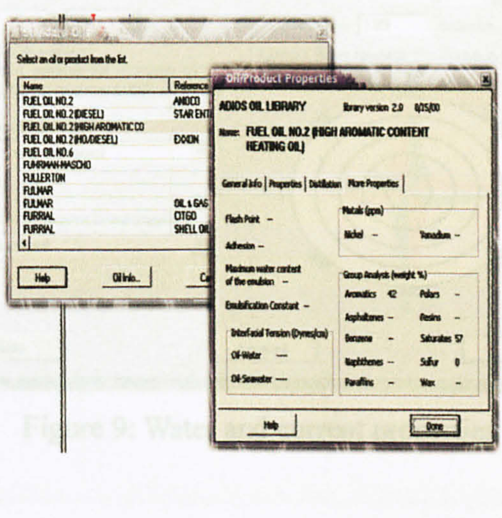


Figure 7d: The extra properties information

ii) Wind and wave conditions for the northern region of Malacca Straits were obtain from Malaysia Meteorological Department. The typical pattern on October days, shows the wind speed ranging from 10 – 20 km/h in East direction and the wave height can be up to 0.5 to 1.0 meters.

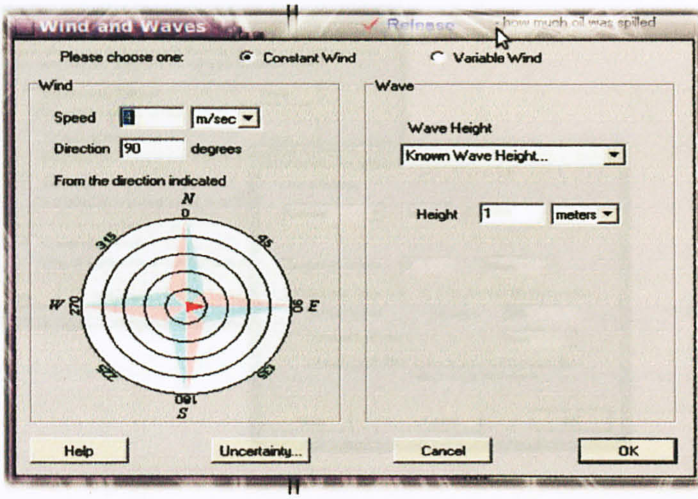


Figure 8: Wind and wave data

iii) Water properties in this region is average on 29.60°C with the salinity of 31.22ppt.

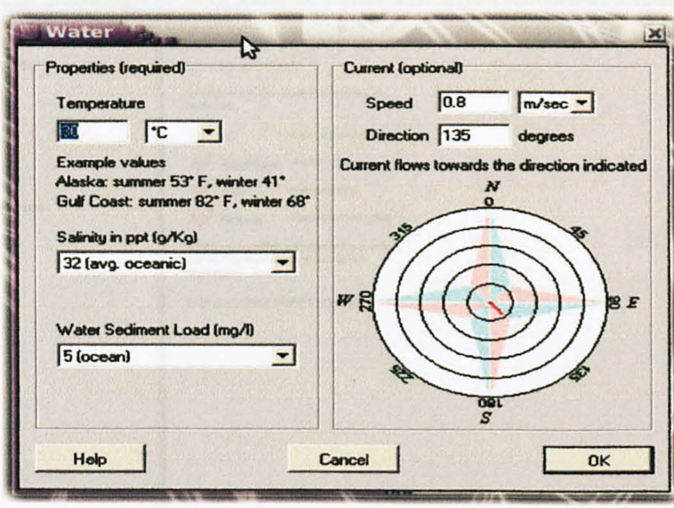


Figure 9: Water and current properties

iv) Release information – the only information available was the amount of release. Thus, an assumption is made that is the duration is 3 hours. This is because the fuel tanker system is multiple tank thus the it will not be flowing out for too long before it dries up.

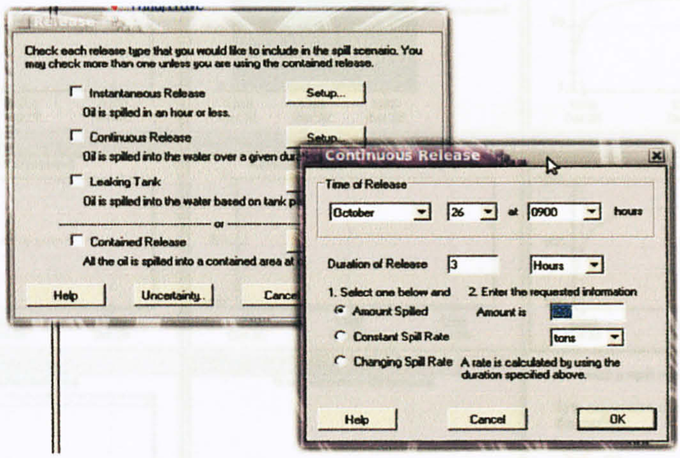


Figure 10: Release information

c) the overall data input – the picture shows the overall data input just before the simulation is run.

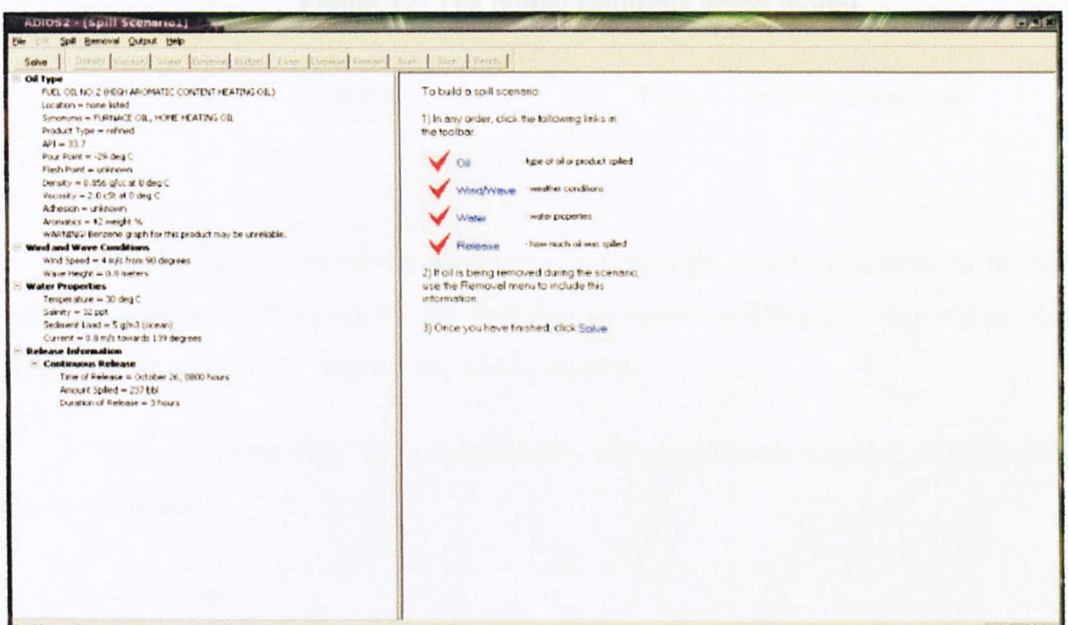


Figure 11: The ADIOS2 when all the data has been keyed-in

d) Run the simulation by click on solve button. It will take some times to calculate the output and generate the graph.

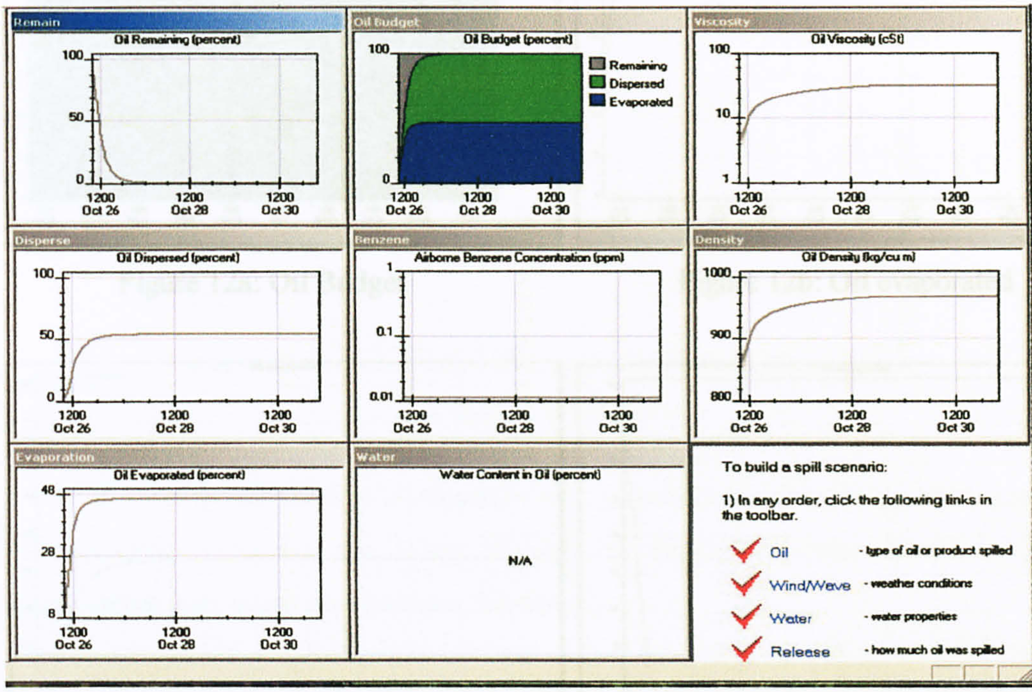


Figure 12: The output (multiple graph mode)

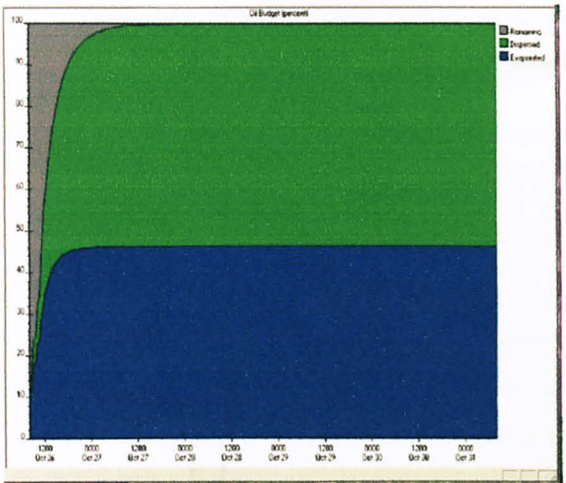


Figure 12a: Oil Budget

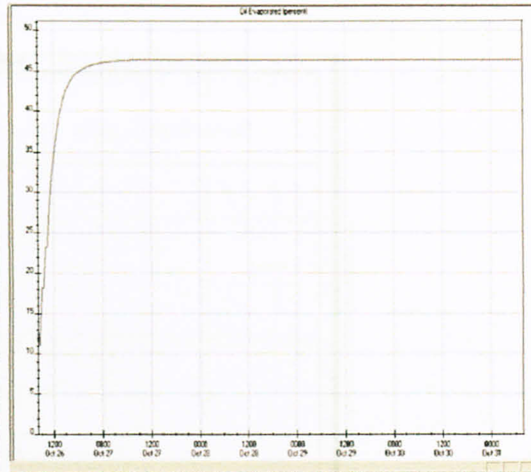


Figure 12b: Oil evaporated

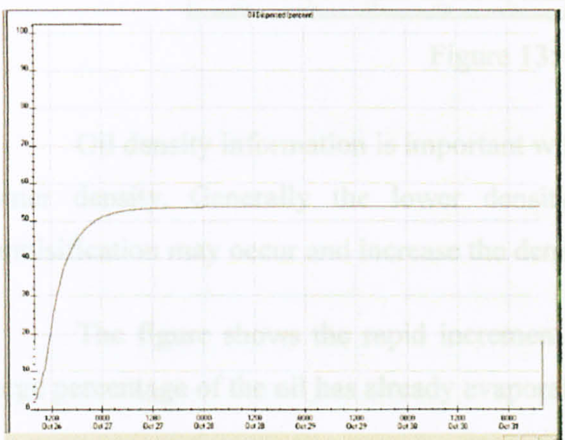


Figure 12c: Oil dispersed

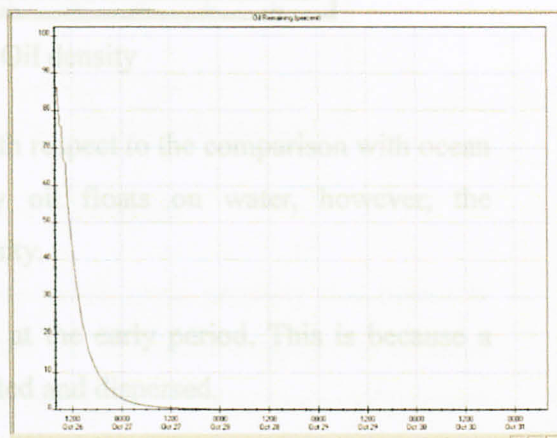


Figure 12d: Oil remaining

The Figure 12a shows the oil budget information. The evaporation, as further detailed in Figure 12b occur on the first day as much as 45%. The dispersion also rapidly occur up until the second day of the incident

Thus, the remaining oil is theoretically not significance because of those two physical reactions.

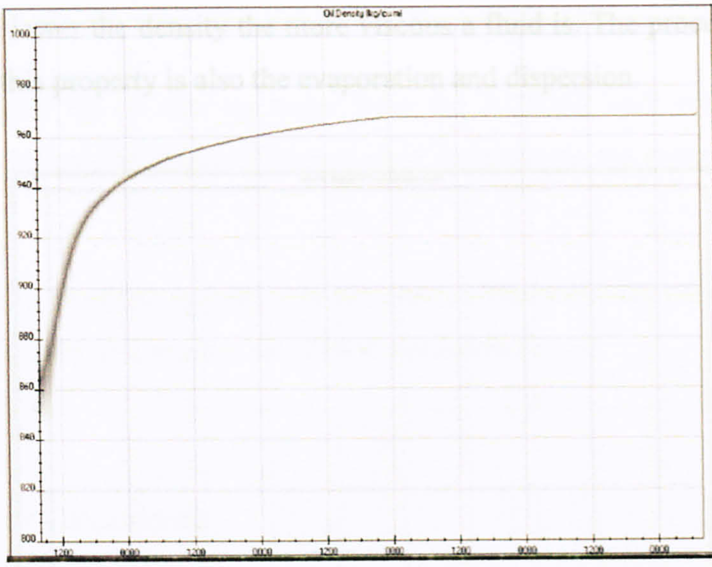


Figure 13: Oil density

Oil density information is important with respect to the comparison with ocean water density. Generally the lower density oil floats on water, however, the emulsification may occur and increase the density.

The figure shows the rapid increment at the early period. This is because a large percentage of the oil has already evaporated and dispersed.

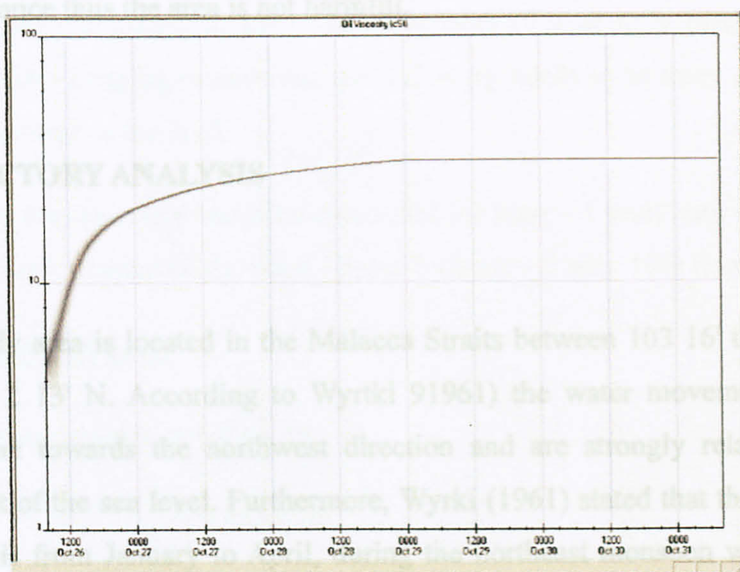


Figure 14: Oil viscosity

The viscosity also shows the same pattern as the density. This follows the general rule; the lower the density the more viscous a fluid is. The process that takes place and affect this property is also the evaporation and dispersion.

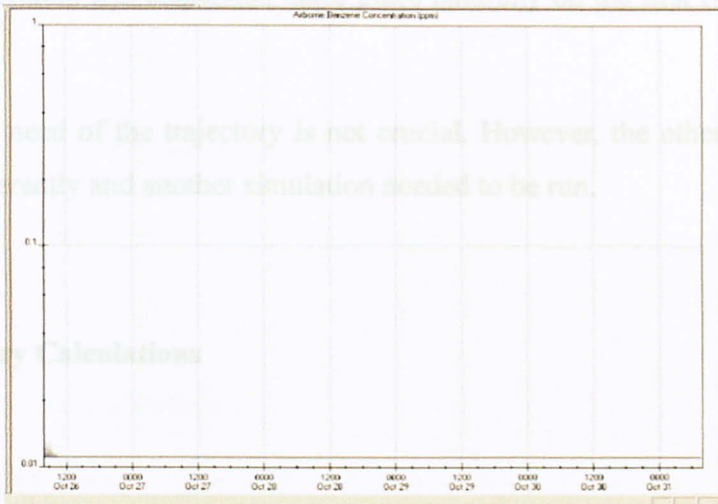


Figure 15: Airborne Benzene

The airborne benzene is significant due to the toxic property that normally released by hydrocarbon, either crude oil or fuel oil. Excessive exposure to benzene can affect the health. As evaporation is rapidly takes place, the presence of benzene also not significance thus the area is not harmful.

4.5 TRAJECTORY ANALYSIS

The study area is located in the Malacca Straits between 103 16' to 103 48'E and 1 16'N to 2 13' N. According to Wyrtki 91961) the water movements are in general direction towards the northwest direction and are strongly related to the surface gradient of the sea level. Furthermore, Wyrki (1961) stated that the period of strongest flow is from January to April, during the northeast monsoon with current velocity of 0.95 m/s.

The two software, GNOME and ADIOS2 were developed By National Oceanic and Atmospheric Administration Of US Department Of Commerce (NOAA).

The analysis on oil fate on water from the ADIOS2 spill scenario shows significant evaporation and dispersion takes place naturally on the first two days and quite rapidly.

Thus the need of the trajectory is not crucial. However, the other type of oil may behave differently and another simulation needed to be run.

Trajectory Calculations

From the literature review, the formula for the calculation has been given whereby the resultant must be a 3% from the wind component and 100% from the current component.

Therefore the calculation made as according to the state of the spill; the oil remaining.

The oil gone completely on the second day, after 27 hour, to be precise. Beside from doing satellites imaging monitoring, the trajectory needs to be carry out to keep trank of the movement of the spill.

Therefore the trajectory has been calculated for hour – 1 until hour – 9. This is because the 50% oil remains on the hour – 3 and by hour – 9 only 10% remains.

<u>Wind component = 15 km/h</u>

3% from current component $= 0.03 \times 15$

$= 0.45$ km/h

trajectory hour – 1 = 1h x 0.45km/h

= 0.45km

hour – 2 = 2h x 0.45km/h

= 0.9km

hour – 3 = 3h x 0.45km/h

= 1.35km

hour – 9 = 9hr x 0.45km/h

= 4.05km

<u>Current component = 2.88km/h</u>

100% current component = 1 x 2.88

= 2.88km/h

trajectory at hour – 1 = 1h x 2.88km/h

= 2.88km

hour – 2 = 2h x 2.88km/h

= 5.67km

hour – 3 = 3h x 2.88km/h

= 8.64km

hour – 9 = 9h x 2.88km/h

= 25.9km

<u>Resultant distance</u>

hour – 1 = $\sqrt{0.45^2+2.88^2}$

= 2.9km

hour – 2 $= \sqrt{0.90^2+5.67^2}$

$= 5.74\text{km}$

hour – 3 $= \sqrt{1.35^2+8.64^2}$

$= 8.74\text{km}$

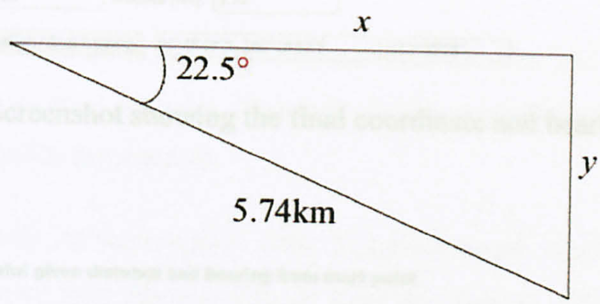
hour – 9 $= \sqrt{4.05^2+25.9^2}$

$= 26.2\text{km}$

Direction $= \dfrac{135° - 90°}{2} + 90°$

$= 112.5°$

New coordinates



$\cos 22.5° = \dfrac{x}{5.74}$

$x = 5.74 \cos 22.5°$

$x = 5.3\text{km}$

$$\sin 22.5° = \frac{y}{5.74}$$

$$y = 5.74 \sin 22.5°$$

$$y = 2.19\text{km}$$

Next, the new coordinates obtained for the web calculator.

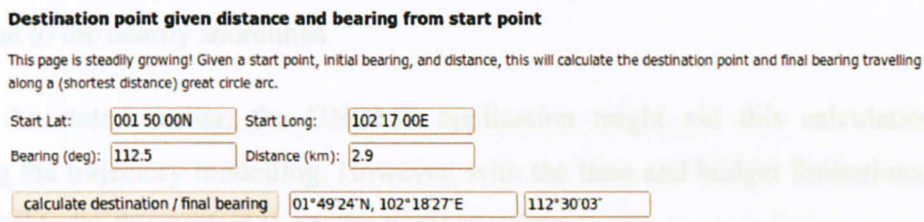


Figure 16: Screenshot showing the final coordinate and bearing (Hour – 1)

Figure 17: Screenshot showing the final coordinate and bearing (Hour – 2)

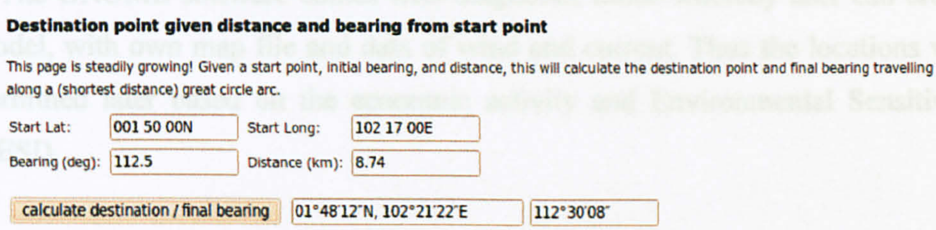


Figure 18: Screenshot showing the final coordinate and bearing (Hour – 3)

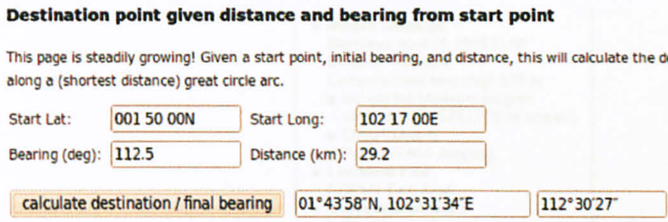


Figure 19: Screenshot showing the final coordinate and bearing (Hour – 9)

Looking up the coordinate from the map, none of it fall on the shoreline thus no threat to the nearby shorelines.

As stated earlier, the GNOME application might aid this calculation by running the trajectory modelling. However, with the time and budget limitations, it is not possible for this project to get the necessary data.

Therefore, the software is needed to be further tested to check the compatibility with another location. The maps that are provided include American region and few locations on Middle East (e.g. Gulf Sea).

Thus the map of Malacca Straits is yet to be obtained to run the real simulation.

Thus the simulation is run first neglecting the location just to see the pattern or model of the real location later on. However, the interpretation of the results can be done with the available information.

The GNOME software comes with diagnostic mode whereby user can create own model, with own map file and data of wind and current. Thus the locations will be determined later based on the economic activity and Environmental Sensitivity Index (ESI).

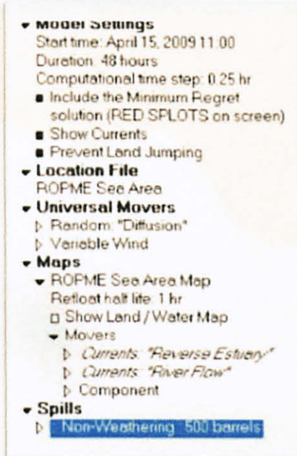


Figure 20: The model setting in GNOME

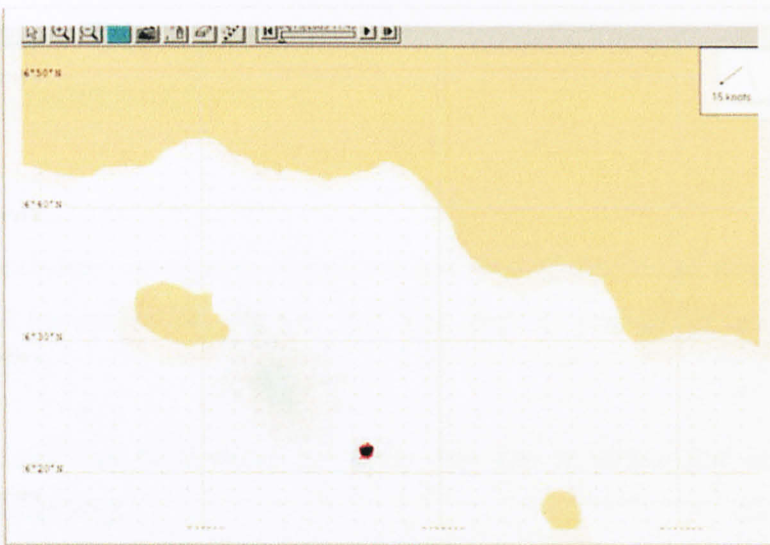


Figure 21: Trajectory of spil (DAY 1, the first hour)

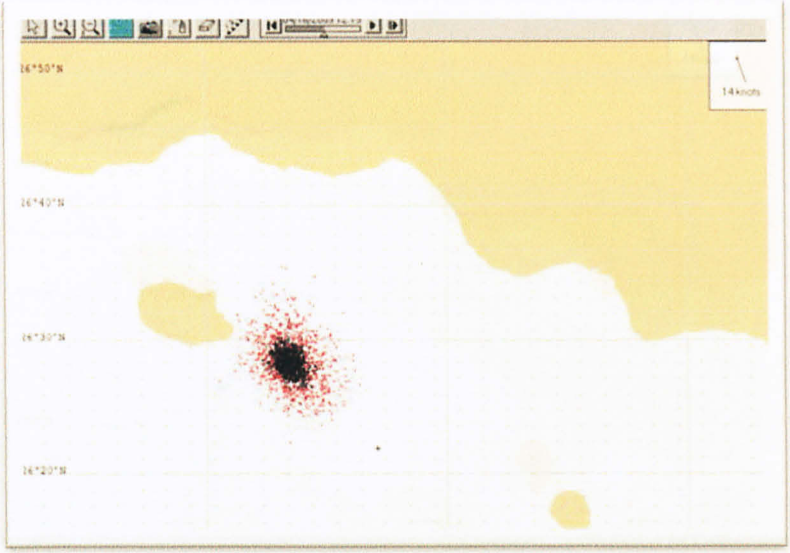


Figure 22: Trajectory of spil (DAY 2, after 24 hour)

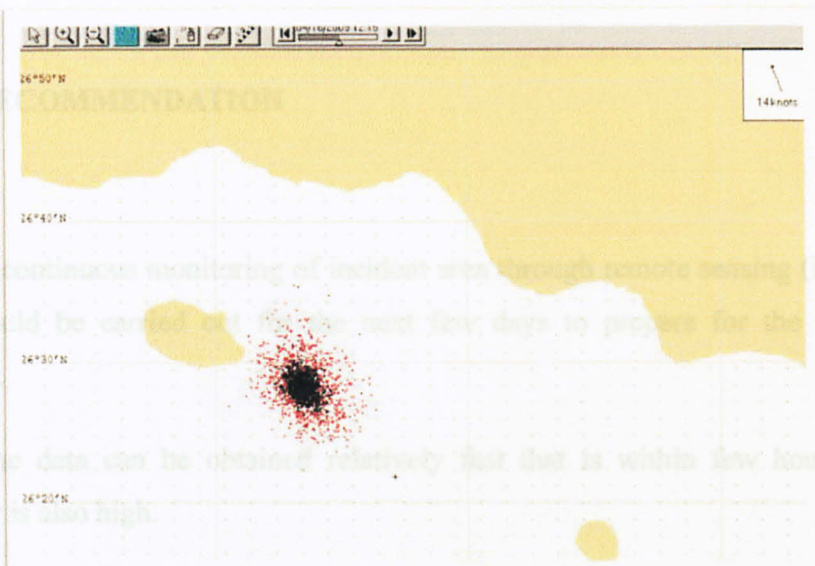


Figure 23: Trajectory of spil (DAY 3, after 55 hours)

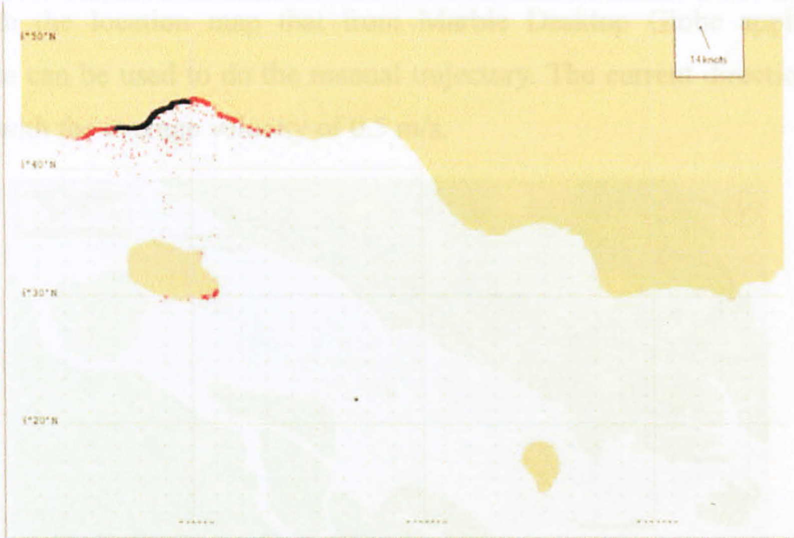


Figure 24: Trajectory of spill (DAY 3, after 72 hour)

4.6 RECOMMENDATION

A continuous monitoring of incident area through remote sensing (i.e. satellite data) should be carried out for the next few days to prepare for the worst case scenarios.

The data can be obtained relatively fast that is within few hours and the reliability is also high.

Using these two software, the prediction of the oil spill incident will be used to develop another application that will suggest the best response action. Using the information from previous chapter user will need to enter the prompted information based on the analysis.

For example, the boom usage will be suitable for non-weathering type of oil, near the shore with allowable wind and current condition. Using the boom can contain the oil and the usage of skimmer will be recommended for collecting the oil. Besides, the boom can also deflect the oil for faster action to avoid the oil reaching the shore or any sensitive spots (e.g. coral breed center).

With the location map that from Marble Desktop Globe application, the location file can be used to do the manual trajectory. The current direction is toward northwest with the average velocity of 0.5 m/s.

Figure 25: Malacca Straits Map that matches with the RADARSAT image.

CHAPTER 5

CONCLUSION

The data gathering on general oil spill has cover various types of oil indifferent condition. This has includes its all the response action that is currently adapted to global practice.

The incident of specific case has been selected to be the An Tai Ship accident whereby has caused an oil spill in Malacca Straits in 1997. the satellite imaging data is obtained and all the necessary information are gathered.

The oil impact analysis is carried out using the recommended softwares together with the manual trajectory as suitable with the oil budget calculated.

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