OIL SPILL TRAJECTORY AND FATE FORECASTING, RESPONSE AND CLEANUP OPTIONS FOR A COASTAL ENVIRONMENT: A GREEN FIELD MODEL OFFSHORE INDONESIA

B.O. Bassey, T.O. Ajare, D. C. Ozurumba, A.S. Baroni
Coventry University, Coventry, United Kingdom

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ABSTRACT

- Indonesian government and operators seek means of shielding highly sensitive and vulnerable environment from spill hazards.
- GNOME and ADIOS were used to forecast likely trajectory and fate of oil spilled from an FSO.
- Estimated trajectory of oil released as depicted by GNOME results for nine days after the spill and the contact probabilities show 5,200 barrels of the oil would beach on the ninth day.
- Response efforts must thus be effected before this occurs.
- ADIOS used to capture both winter and summer conditions; indicating that more spilled oil would remain after a 5-day period if it occurs during winter, than would be obtained for a spill during summer.
- Dispersants not a good response option due to toxicity to the ecologically sensitive area.
- Recommended to contain imminent spills using dykes and booms within a few hours of occurrence, before further dispersion and beaching, for subsequent in-situ burning.

INTRODUCTION

- Spill conditions, nature of area, quantity and type of oil released, meteorological and climatological factors and response technique affect its environmental impacts and the attendant response applied for ecological restoration.
- Global attention for oil spill risks has greatly increased in the last few decades, resulting from its effects on the quality of life and the environment in general.
- Moreover, some oil spill accidents are usually considered inevitable but the number of spill accidents has reduced in the past few years as a result of new operating and maintenance legislation procedures implemented by the industry.
- Furthermore, developed training programs have been applied to reduce human errors, which is considered the main cause of oil spill incidents (Fingas 2011).
- The Indonesian government and oil industry operators due to began considering means to protect the environment and their reputation from similar hazards (Valencia 2002).
- Java Sea is surrounded by Sumatra on the West, Sulawesi on the East, Borneo on the North and Java on the South. About 433,000 sq. km surface area and 46 metres shallow water depth (figure 1). Average temperatures 22 – 29°C; average humidity 75% (Java Indonesia 2011).

RESEARCH METHODS

Oil Spill Transport Forecasting

- GNOME is a particle tracking model that simulates oil spill transport by returning displacement and velocity components of the movement of oil and water using the forward Euler method (Zelenke et al. 2012).
- The spill was simulated from 24 hours after it occurred, taking 0000hrs on 21 February 2016 as start time of release of oil.
- A forecast was then run for every subsequent day up to the ninth day after the spill commenced in order to adequately predict its transport pattern.

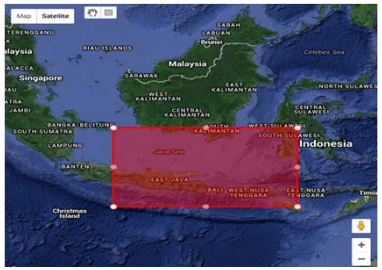

Figure 1: Java Sea Location Map (NOAA 2016)

Figure 2: Map showing location of the Cepu Oil Block, Java Sea (Sorkhabi 2009)

Minimum Regret Option

- Uncertainties often present in current directions when oil spill models are used for estimation due to challenges that arise from prediction of future climate and oceanographic parameters in the statistics (Sebastiao and Soares 2007).
- The minimum regret option thus introduced to bring modelling results as close to reality as possible; red splots indicate worst case scenario.
- 50% along current and 25% cross current uncertainty and to develop the accuracy of lag spill trajectory 0.25 hours was effective in the density (NOAA 2009; Korsah and Anifowose 2014).

Oil Spill Fate Forecasting

- ADIOS contains the properties and environmental data of all commercial crude blends around the world.
- It simulates oil weathering processes: evaporation, spreading, dispersion and emulsification, as well as other properties such as density, viscosity and water content, with a view to informing spill response decisions.
- Bunyu medium light oil and gas option for Indonesia selected for this study; same spill start time as that used for GNOME.
- Model was run for both winter and summer conditions to mirror how spilled oil would behave in each situation, for a more robust analysis.
- Salinity selected as 32 PSU for winter and 37 PSU for summer; typically assumed to increase during summer owing to lower dilution factor in the sea, compared to winter periods.

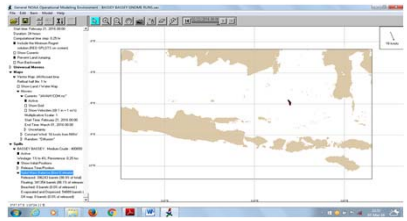

Figure 3: GNOME Model for Spill Trajectory a day after the release of Oil

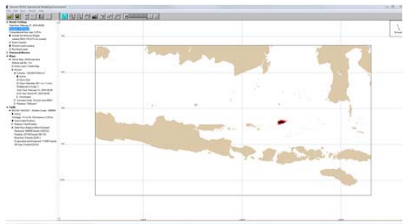

Figure 4: GNOME Model for Spill Trajectory 5 days after the release of Oil

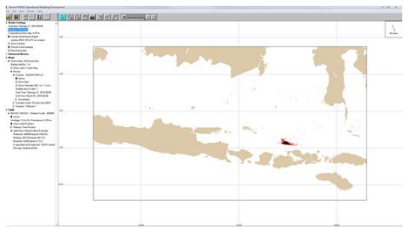

Figure 5: GNOME Model for Spill Trajectory 9 days after the release of Oil

RESULTS

Spill Trajectory

- The likely trajectory of oil released from the FSO in Banyu Urip field is depicted by figures 3 to 5 for the first day after the spill, fifth day and ninth day.
- Results show 5,200 barrels of the oil would beach on the ninth day after the spill.
- Under different wind directions run by the GNOME model to see the effect of the wind on the spill, the most significant change was observed for the amount of oil that beached.
- Response efforts must thus be effected before this occurs.

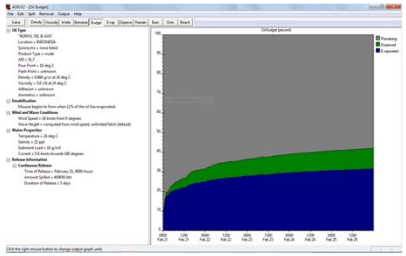

Figure 6: ADIOS Results showing Oil Budget after a Spill during the Winter

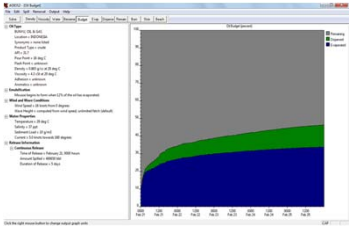

Figure 7: ADIOS Results showing Oil Budget after a Spill during the Summer

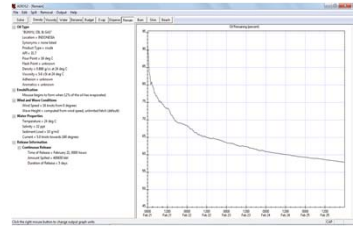

Figure 8: ADIOS Results for Remaining Oil after a Spill during the Winter

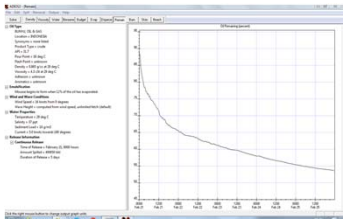

Figure 9: ADIOS Results for Remaining Oil after a Spill during the Summer

Spill Fate

- ADIOS results captured in figures 6 to 11 for both winter and summer.
- Figures 6 and 7 indicate more of discharged oil would remain after a 5-day spill period if it occurs during the winter than as predicted for the summer period.
- Hence, clean-up would be easier during summer than during winter.
- However, since the oil is medium light, lighter fractions would readily evaporate out, leaving behind heavier oily residues that may form tar balls with the marine sediments and sink to the sea bottom or arrive at the beach.
- Therefore, it is recommended to contain imminent spills using dykes and booms within a few hours of occurrence, before advection forces disperse the oil further and/or transport it to shore.

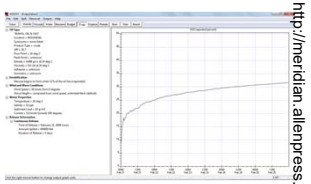

Figure 10: ADIOS Model for Evaporated Oil after a Spill during the Winter

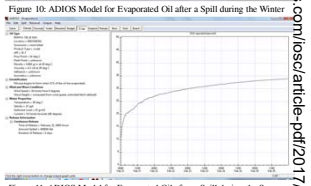

Figure 11: ADIOS Model for Evaporated Oil after a Spill during the Summer

Clean-up Options/Best Response Techniques?

- OSCP is required of operators of offshore oil storage, production and/or transport facilities; must be approved by the regulator (Cheremisinoff and Davletshin 2010).
- Several clean-up methods used to prevent the oil from spreading in specific areas or move it elsewhere for treatment and/or recovery (Fingas 2013).
- Booms, Skimmers, In-Situ Burning, Manual Recovery, Bioremediation - suggested response options in this case.

CONCLUSION

- Bunyu oil spillage can be handled during first 4 days before it travels to shore. From day 5, the minimum regret uncertainties showed some possibility of spill to spreading to coastline.
- Oil trajectory analysis requires proper evaluation for uncertainties related to environmental and spill data used in the simulation, as it represents a high risk trajectory prediction less likely to happen.
- Identifying worst case scenarios (Precautionary Principle) for spills can play a significant role in response planning.

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