

STUDY TITLE: Updates to Fault Tree Approach to Oil Spill Occurrence Estimators for the Chukchi and Beaufort Sea Planning Areas

REPORT TITLE: Alternative Oil Spill Occurrence Estimators for the Beaufort and Chukchi Seas – Fault Tree Method

CONTRACT NUMBER: M05PC00037

SPONSORING OCS REGION: Alaska

APPLICABLE PLANNING AREA: Beaufort and Chukchi Seas

FISCAL YEARS OF PROJECT FUNDING: 2005, 2006, 2007

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COST: FY 2005: \$67,000, FY 2006: \$83,700; FY 2007: \$72,000 CUMULATIVE PROJECT COST: \$222,700

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KEY WORDS: Oil spill occurrence, Beaufort Sea, Chukchi Sea, Gulf of Mexico, fault tree analysis

BACKGROUND: The Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) Alaska Offshore Continental Shelf (OCS) Region uses estimates of oil spill occurrences for the development of environmental impact statements for hypothetical offshore development scenarios resulting from the sale of leases for the US Beaufort Sea OCS. Since 2000, a series of studies (summarized below under “STUDY PRODUCTS”) carried out by Bercha International Inc. (Bercha) directed at the development of a realistic method of projecting oil spill occurrences, including source, size distribution, location, and timing for hypothetical development scenarios associated with offshore OCS lease sales.

OBJECTIVES: The main objective of the work was to develop analyses, algorithms, and software to generate information that can be utilized for the optimal planning and regulation of future developments. Key objectives of the work may be summarized as follows:

- Generation of a capability to quantify oil spill occurrence indicators for a specified development scenario at any location in the Alaskan OCS under BOEMRE jurisdiction.
- Ability to generate expected and mean values of spill indicators, as well as their variability in rigorous numerical statistical format.
- Use of verifiable input data based on BOEMRE or other historical spill data and statistics.
- Ability to independently vary the impacts of different causes on the spill occurrences as well as add new causes such as those expected for the Arctic or other new environments.
- Ability to generate spill occurrence indicator characteristics such as annual variations, facility contributions, spill size distributions, and life of field (Life of Field) averages.
- Ability to generate spill occurrence indicators for comparable scenarios in more temperate regions.
- Capability to quantify uncertainties rigorously, together with their measures of variability.

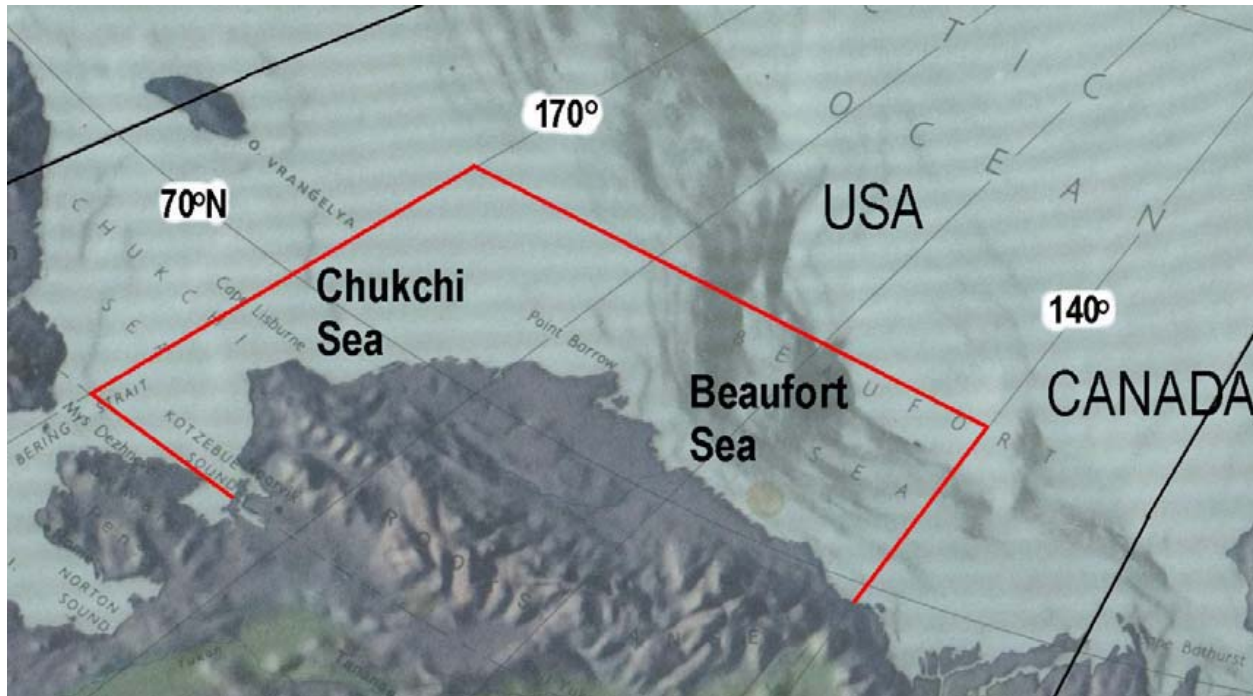


Figure1: Beaufort And Chukchi Sea Study Area

DESCRIPTION: An analytical tool for the estimation of oil spill occurrence indicators for systems without history, such as hypothetical offshore oil exploration and production developments in the Beaufort and Chukchi seas, has been developed based on the utilization of fault tree methodology. Although the results generated are voluminous, they are essentially transparent, simple, and easy to understand. The analytical tool developed is also quite transparent, very efficient in terms of computer time and input-output capability. In addition, the predictive model is setup so that any input variables can be entered as distributions.

SIGNIFICANT CONCLUSIONS: General conclusions from the work may be summarized as follows:

- The following three spill indicators for each scenario considered were quantified, as a function of scenario, location, schedule, and other development scenario variables:
 - o Spill frequency
 - o Spill frequency per barrel produced
 - o Spill index, the product of spill size and spill frequency
- These indicators were also quantified for the following spill size categories:
 - o Small (S): 50 to 99 bbl
 - o Medium (M): 100 to 999 bbl
 - o Large (L): $\geq 10,000$ bbl
 - o Huge (H): $\geq 10,000$ bbl
- The objectives set out above were achieved for all scenarios and spill indicator categories.
- Spill indicators as a function of spill size, scenario location, and development characteristics and schedule were quantified.
- Analysis and incorporation of the Arctic effects, including as relevant: gouging, scour, upheaval buckling, and thaw settlement, as well as other effects such as low temperatures and ice forces on structures, were included.
- The spill indicator results for the Chukchi and Beaufort locations were similar but not identical in value and variable dependence.

- The spill indicators for non-Arctic comparable developments were found to be roughly 35% higher than those for the Arctic developments.
- Several recommendations for further work were generated and are listed below.

The following recommendations based on the work may be made:

- Continue to utilize the Monte Carlo spill occurrence indicator model for new scenarios to support BOEMRE needs, as it is currently the best model available for estimation of spill occurrence.
- Utilize this oil spill occurrence indicator model to generate additional model validation information, including direct application to specific non-Arctic scenarios, such as GOM projects, which have an oil spill statistical history.
- Utilize the oil spill occurrence indicator model in a sensitivity mode to identify the importance of different Arctic effect variables introduced to provide a prioritized list of those items having the highest potential impact on Arctic oil spills.
- Generalize the model so that it can be run both in an adjusted expected value and a distributed value (Monte Carlo) form with the intent that expected value form can be utilized without the Monte Carlo add-in for preliminary estimates and sensitivity analyses, while for more comprehensive rigorous studies, the Monte Carlo version can be used.

STUDY RESULTS: The study results included three principal areas as follows:

1. GOM oil spill data analysis and statistical update
2. Beaufort Sea oil spill indicators
3. Chukchi Sea oil spill indicators

Historical data and their statistical analyses are used as a starting point for fault tree application to oil spill indicator quantification for the Alaskan OCS. In the initial fault tree analysis, data from the GOM OCS were analyzed for the period from 1972 to 1999. Subsequently, a more refined publication of the data characteristics by BOEMRE made it possible to conduct a more thorough statistical analysis, as well as an update of the data and its analysis to 2006. Additionally, the work generated data summaries and typical statistical results for the re-analysis of the data, including an update of the GOM OCS data for platform and pipeline spills. In addition, a summary of worldwide blowout statistical data was compiled.

Oil spill occurrence indicators were quantified for hypothetical offshore development scenarios in the Beaufort Sea in the area of BOEMRE jurisdiction. The quantification included the consideration of the variability of historical and hypothetical scenario data, as well as that of Arctic effects in estimating oil spill occurrence indicators. Consideration of the variability of all input data yields both higher variability and a higher expected value of the spill occurrence indicators. The three types of spill occurrence indicators were: annual oil spill frequency, annual oil spill frequency per billion barrels produced, and annual spill index – and, additionally, the life of field averages for each of these three oil spill indicators were assessed. Finally, spill indicators assessed for the Arctic scenarios were compared to those for a development of similar characteristics in a non-Arctic location, such as the GOM. This comparison was effected by utilizing the GOM data without the introduction of any variations for Arctic effects for a development consisting of identical quantities of wells, facilities, and pipeline miles.

Both the Beaufort and Chukchi Seas quantitative results included the following:

- Oil spill occurrence indicators by spill size
- Oil spill occurrence indicators by spill source
- Variability of oil spill occurrence indicators due to uncertainties
- Comparison of Arctic and non-Arctic spill indicators

The above results were presented in tabular and graphical form with commentary on perceived trends and significance of these.

STUDY PRODUCTS:

Bercha International Inc., *Alternative Oil Spill Occurrence Estimators for the Beaufort and Chukchi Seas – Fault Tree Method*, (OCS Study BOEMRE 2011-030), Summary Final Report to U.S. Department of the Interior, Bureau of Ocean Energy Management, Regulation and Enforcement, Alaska Outer Continental Shelf Region, March 2011.

Bercha International Inc., *Alternative Oil Spill Occurrence Estimators and their Variability for the Alaskan OCS – Fault Tree Method – Update of GOM OCS Statistics to 2006*, (OCS Study MMS 2008-025), Final Task 3.1 Report to U.S. Department of the Interior, Minerals Management Service, Alaska Outer Continental Shelf Region, March 2008.

Bercha International Inc., *Alternative Oil Spill Occurrence Estimators and their Variability for the Beaufort Sea – Fault Tree Method*, (OCS Study MMS 2008-035), Final Task 4A.1 Report to U.S. Department of the Interior, Minerals Management Service, Alaska Outer Continental Shelf Region, Vols. 1 and 2, March 2008.

Bercha International Inc., *Alternative Oil Spill Occurrence Estimators and their Variability for the Chukchi Sea – Fault Tree Method*, (OCS Study MMS 2008-036), Final Task 4A.2 Report to U.S. Department of the Interior, Minerals Management Service, Alaska Outer Continental Shelf Region, Vols. 1 and 2, March 2008.

Bercha, F.G., Prentki, R.T., and C. Smith. 2008. *Prediction of Oil Spill Occurrence Probabilities in the Alaskan Beaufort and Chukchi Seas OCS*. Proceedings International Conference and Exhibition on Performance of Ships and Structures in Ice (ICETECH 2008), held July 20-23, 2008, Banff, Canada. Banff Canada: Paper No. ICETECH08-118-RF.

Bercha, F. G. 2009. *Updates to the Fault Tree Approach to Oil Spill Occurrence Estimators for the Beaufort and Chukchi Sea*. Proceedings Alaska OCS Region 11th Information Transfer Meeting, held October 28-30, 2008, Anchorage AK, Anchorage AK: Prepared by BGES, Inc for MMS Alaska OCS Region, OCS Study MMS 2009-005.

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