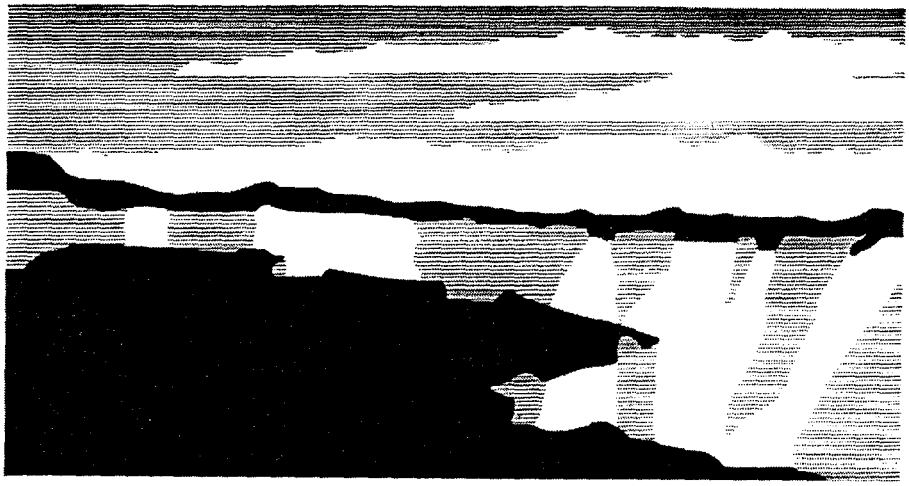
LA-UR-96- 1926

Title: **A Predictive Ocean Oil Spill Model**



Author(s): **Jim Sanderson, CIC-19**
**Daniel Barnette,**
**Sandia National Laboratories**
**Phillip Papodopoulos,**
**Oak Ridge National Laboratory**
**Kenneth Schaudt, Marathon Oil Co.**
**Dave Szabo,**
**Mobil Research and Development Corporation**

Submitted to: **DOE Office of Scientific and Technical Information (OSTI)**



**Los Alamos**
NATIONAL LABORATORY

# A Predictive Ocean Oil Spill Model

Jim Sanderson*, Daniel Barnette (Sandia National Laboratories), Phillip Papodopoulos (Oak Ridge National Laboratory), Kenneth Schaudt (Marathon Oil Co.), and Dave Szabo (Mobil Research and Development Corp.)

**Abstract**

This is the final report of a two-year, Laboratory-Directed Research and Development (LDRD) project at the Los Alamos National Laboratory (LANL). Initially, the project focused on creating an ocean oil spill model and working with the major oil companies to compare their data with the Los Alamos global ocean model. As a result of this initial effort, Los Alamos worked closely with the Eddy Joint Industry Project (EJIP), a consortium oil and gas producing companies in the United States. The central theme of our project was to use output produced from LANL's global ocean model to look in detail at ocean currents in selected geographic areas of the world of interest to consortium members. Once ocean currents are well understood this information could be used to create oil spill models, improve offshore exploration and drilling equipment, and aid in the design of semi-permanent offshore production platforms.

## 1. Background and Research Objectives

The major oil and gas companies of the United States are now exploring in deeper offshore shelf areas. Traditional methods of exploration and development such as the use of fixed platforms is excessively expensive. Instead, special deep water drilling ships are employed. Only two of these specially adapted ships are available at a cost of $100,000 per day. Less expensive anchored floating production platforms will replace fixed steel and concrete structures.

Detailed knowledge of the ocean's currents from surface to sea bottom is essential to deep water efforts. Ocean currents in selected geographic areas must be better understood. Ocean eddies can be thought of as hurricanes in the ocean and are of special importance. Often they are localized and their effects devastating, especially on anchored exploration platforms. Physical sampling of the Gulf of Mexico eddies has been carried out by the Eddy Joint

* Principal investigator, e-mail: jgsander@lanl.gov

Industry Project (EJIP, a consortium of the twelve major oil and gas producing companies in the United States) team over a number of years and EJIP would like to compare their data with computer model output. The EJIP recognizes that model output of selected geographic areas could be used to better understand ocean currents. Through the DOE Computer Hardware, Advanced Mathematics, and Model Physics (CHAMMP) Program, LANL has developed a state-of-the-art, three-dimensional, time-dependent, global ocean model that could be applied to this problem.

## 2. Importance to LANL's Science and Technology Base and National R&D Needs

This project supports Los Alamos core competencies in theory, modeling, and high-performance computing as well as earth and environmental systems. The LANL has developed a global ocean model whose output interests EJIP consortium members. A graphics program allows one to display and manipulate the topography of any geographical area around the world and to view model output in time-dependent fashion so that a fully three-dimensional current profile can be animated in real time. This project enhances LANL's visibility in modeling global ocean phenomena and enhances the Laboratory's ability to respond to initiatives in that area.

## 3. Scientific Approach and Results to Date

The goal of this project was to use output form the Laboratory's global ocean model to look in detail at ocean currents in selected geographic areas of the world. Once ocean currents were well understood, this information could be used to create oil spill models, improve the design of offshore exploration and drilling equipment, and aid in the design of semi-permanent offshore production platforms. Our efforts have included a detailed analysis of the ocean currents in selected geographic areas of interest to consortium members. Also, this analysis would tell us whether we had sufficient resolution of currents to be able to model oil spills with the necessary accuracy.

Los Alamos already had a fully three-dimensional, time-dependent ocean model working and conversations with oil industry representatives suggested that this was something in which industry would be very interested. Subsequent to receiving LDRD funding technical staff members from Los Alamos, Sandia National Laboratories and Oak Ridge National Laboratory met with the EJIP consortium. Each laboratory presented its efforts in global climate modeling and gave a brief overview of projects that might to relevant to EJIP team

members. The EJIP team was not especially interested in modeling ocean oil spills for several technical reasons. First, oil spills are extremely rare events. Industry is progressing to the use of double-hulled transport vessels, and increased security on transport ships has led to fewer minor accidents. Furthermore, oil spill modeling required a much finer grid scale that presently used in the global ocean model. Surface winds were also a critical element in spill management and clean-up, and wave action and tides were essential to any ocean oil spill model. These are not currently features of our global ocean model.

However, EJIP teams members were enthusiastic with respect to three-dimensional current modeling. Indeed, laboratory team members were told by industry to investigate the possibility of providing three-dimensional model output in selected geographic areas of the world of interest to industry. The Gulf of Mexico was of particular interest as were the Guinea coast of Africa, the South China Sea, areas around Indonesia and the North Sea. The reason for their enthusiasm was that industry is moving offshore in most areas around the world. Exploration and drilling are taking place in areas on the continental shelves never before explored and in depths of water that "turned 8-inch steel pipe into spaghetti." Most existing off shore oil platforms are in one-half mile of water or less. Exploration is now taking place in waters three times that depth. Also, as industry moves further offshore, currents become increasingly important and are less well understood. For example, in the Gulf of Mexico Amoco had a platform that was stable and calm, while twelve surface miles away Exxon had two tug boats running twenty-four hours a day holding a producing platform in place against severe ocean currents. Ocean eddies are "ocean storms" that can and do remove platforms. Also, because industry is moving into deeper water conventional steel platforms are no longer be applicable. Indeed, if steel platforms were to be used, they would be five times as large as the largest steel buildings. Floating platforms are the only viable option and thus a knowledge of ocean currents is essential.

Based on six meetings with the EJIP consortium over a period of eight months we redirected our efforts to make available three-dimensional, time-dependent ocean current data. Industry made available their large collection of data from the Gulf of Mexico. Industry provided a list of geographic areas of special interest and we began investigation with them on currents in these regions. In addition, LANL sponsored a workshop in April, 1995 at Los Alamos to show industry how to use state-of-the-art graphics tools used to analyze model output of selected geographic areas around the world. As a result of the high quality of model output and the ease of use of the graphics tools, industry remains enthusiastic. Furthermore, industry-provided data proved to be a valuable verification tool for the model.

The three DOE laboratories delivered several products and sponsored a number of joint meetings and workshops. We delivered a graphical program to allow EJIP members to extract

any geographical area around the world and display the full topography and manipulate it. This was most useful in viewing complex ocean bottom topography. We also delivered graphical user interfaces to view model output in a time-dependent fashion so that a fully three-dimensional current profile could be animated in real time. This interface allows animations to be made in minutes and viewed repeatedly.

The DOE Advanced Computation Technology Initiative (ACTI) offered a way to provide support to the laboratory consortium of Sandia, Oak Ridge, and Los Alamos. Together with EJIP's members, we submitted a strong joint proposal to the ACTI committee. Our joint proposal was not approved by the ACTI committee.