Diffusion-Drift Model of Spilt Oil

Yoshiharu Nishikawa
Environment & Safety Control Dept.
TONEN CORPORATION

INTRODUCTION

The Petroleum Association of Japan (PAJ) has been conducting a project, using subsidies from the government, to reinforce large oil spill response capability since 1991. The project is consisted of two elements ; one is stockpiling of oil spill cleanup equipment and materials, and another is studies and development work concerning topics such as oil spill trajectory model, experiments on fate and behavior of spilt oils.

At an oil spill incident, it is essential to prepare and implement quickly contingency plan for rapid arrangement of cleanup equipment, based on prediction for extent of the spilt oil, properties of oil slick, and coastal or other areas at risk.

As the background of these, PAJ has been promoted investigation to develop an oil spill model, which forecasts the oil behavior expected to take place within 48 hours in the coastal waters of Japan or nearby sea areas, where oil refiners are located, and recently developed β -version and released it to the concerned. This paper outlines this forecast system. In addition, the development work is entrusted to FUJI RESEARCH INSTITUTE CORPORATION, and the author is participating in the project as research associates.

DETAILS OF INVESTIGATION

Extensively reviewing about 37 model systems (their application areas, structure, characteristics, practical use, utility, verification, etc.), we confirmed that algorithms for the processes (advection, spreading, evaporation, emulsification, etc.) have been developed for prediction of oil behavior on the surface up to 2~3 days after the spill, and that some of the spill models are already practically used.

An application of these models to Japanese waters, however, is concluded to be inappropriate due to unknown details of model structure (know-how, proprietary rights, remodeling, etc.), wide variety of Japanese waters, and possible necessity to revise environmental base data in the future.

Based on these results, PAJ decided to prepare newly an original model suitable to Japanese waters, and, in 1992, developed a prototype model and tested its function on the work station for model development, in prallel with preparation of data base relative to weather and current in Tokyo bay, as well as oils data.

In 1993, trial preparation of the model system applicable in Tokyo bay was completed and released to the concerned, after test run following a conversion to the PCs in domestic refineries, as well as improvement of manipulation and user interface. In 1994, the model system for other enclosed sea areas (Ise and Osaka bays, and Seto Inland Sea) have been released.

STRUCTURE OF THE MODEL

1) Characteristics

The major characteristics of the forecast model is as follows.

- It forecasts the behavior of marine oil spills within 48 hours after spill, with a

precision effective for oil spill response.

- The target forecast sea areas include the coastal waters of Japan where oil refiners are located.
- Oil behavior can be easily and swiftly forecasted at a practical speed (about 20 minutes) using personal computer.

2) Structure

The major components of this model are as follows.

① Input : - Oil data : volume and kind of spilt oil, physical and chemical properties, oil spill scenario, etc.
- Environmental data : wind, currents, temperature, river inflow, etc.

② Fates algorithms : advection, spreading, evaporation, emulsification, etc.

③ Output : extent of the spilt oil on surface, oil mass balance (e.g. surface, atmosphere, etc.), components as a function of time, etc.

Embeded within the system are high resolution data for coastlines and currents, statistical winds, and a library of oil types. The model system relies on an easy-to-use graphical interface, which enables the user simply to execute computation by defining minimal input data (e.g. wind, spill location and start/end times, etc.).

This system is run with personal computer under MS-Windows 3.1 environment.

3) Fates algorithms

This system (β -version) currently includes following representative algorithms as the candidates for fate processes, and allows the users to select which algorithms are to be used for the prediction.

- Advection : Empirical approach with wind factor method, etc.
- Spreading : Mackay' model (1980) etc.
- Evaporation : Payne etal. (1980), etc.
- Emulsification : Mackay etal (1980), etc.
- Vertical dispersion : Spaulding etal. (1982), etc…

FUTURE TOPICS

Current status of the model system is a kind of β -version, and it is necessary to be improved and verified. Therefore, its version-up will be carried out based on the demand derived from the trial use by the concerned. The major topics to be improved are as follows.

1) Introduction of wind mesh data

Wind data at the spill location is currently used as the representative value for whole sea area. Wind direction and velocity are different, however, by location of sea also in the closed sea areas. Therefore, PAJ is planning to introduce into the system wind mesh data (maximum horizontal resolution=2km).

2) Improvement of algorithms for spreading process

From a comparison between the results of oil release experiment (North sea) and model prediction, it is found that oil slick presents long elliptical shape toward wind direction.

3) Tuning of process model parameter.

This system uses parameters introduced in the documents for each of process model. Regarding these parameters, we are investigating pertinent value based on comparison between example of oil spill incident and model prediction, or experiment on a drift in actual sea areas.

FUTURE PLAN

Together with version-up of this model system, PAJ is planning to develop other models applicable to the coastal open ocean areas of Japan in the near future.

PAJ Diffusion-Drift Model of Spilt Oil

To Support effective control of the spill

Simulation Time

Get Result within 20 minutes computation

Oil behaviors within 48 hours after spill.

Users

Oil Spill Responders in Refineries

Easy operation system on PC for setting the simulation conditions and displaying the forecast results.

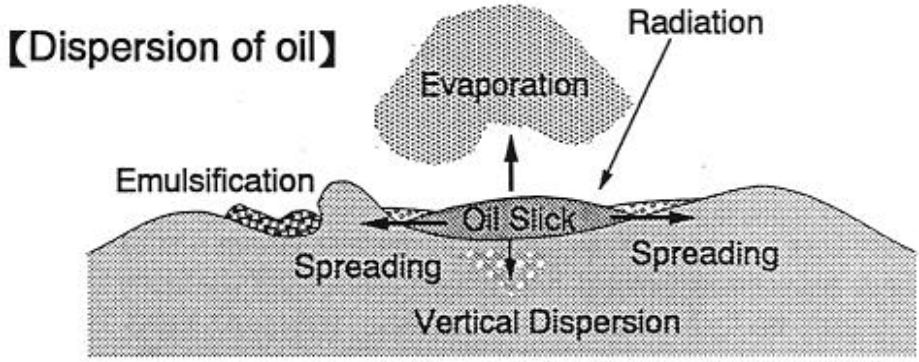
Sea Areas

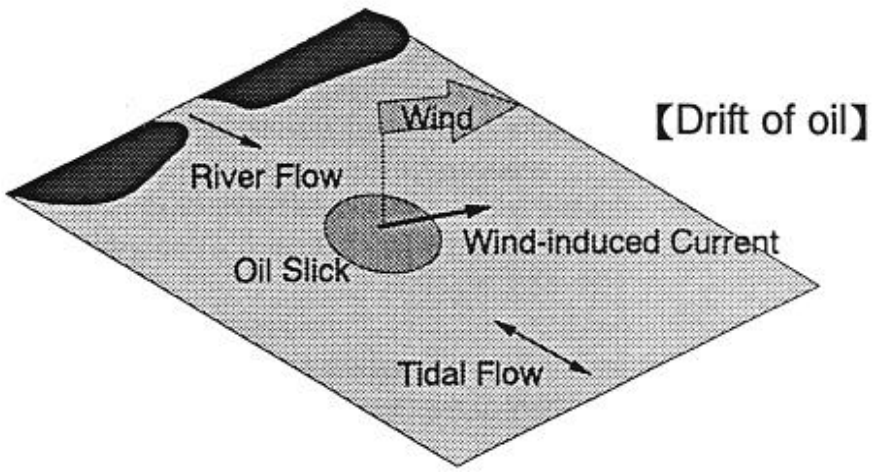
Tokyo Bay, Ise Bay, Osaka Bay,
Seto Inland Sea

The current data for each sea area, the characteristic data for crude oils, etc. are provided in the system.

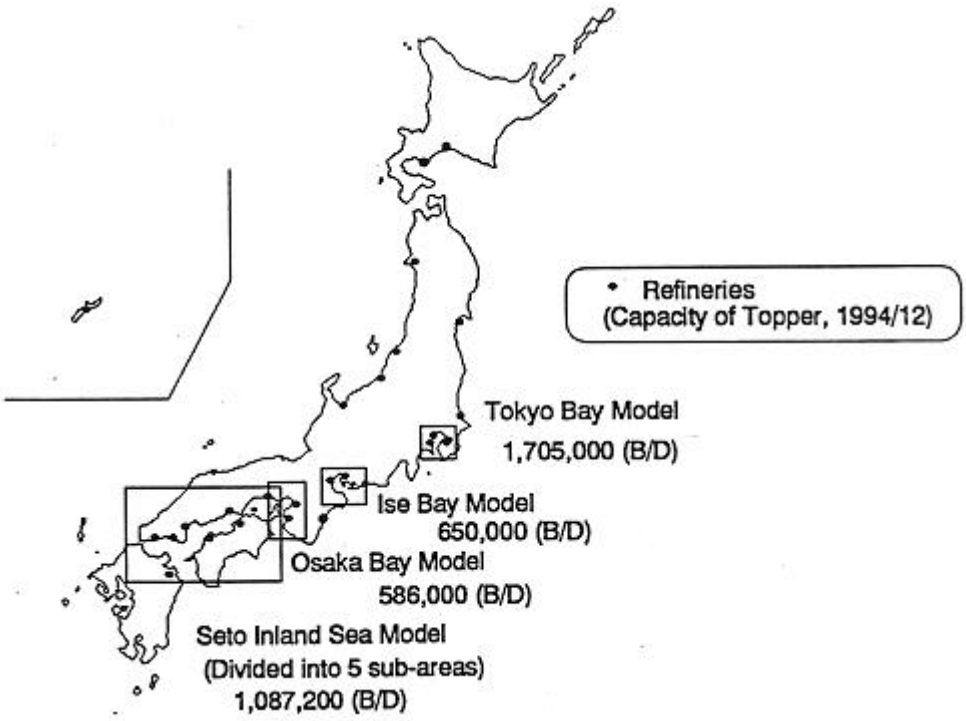
Available for previous assessment of oil spill incidents

Modeling of Oil Spill

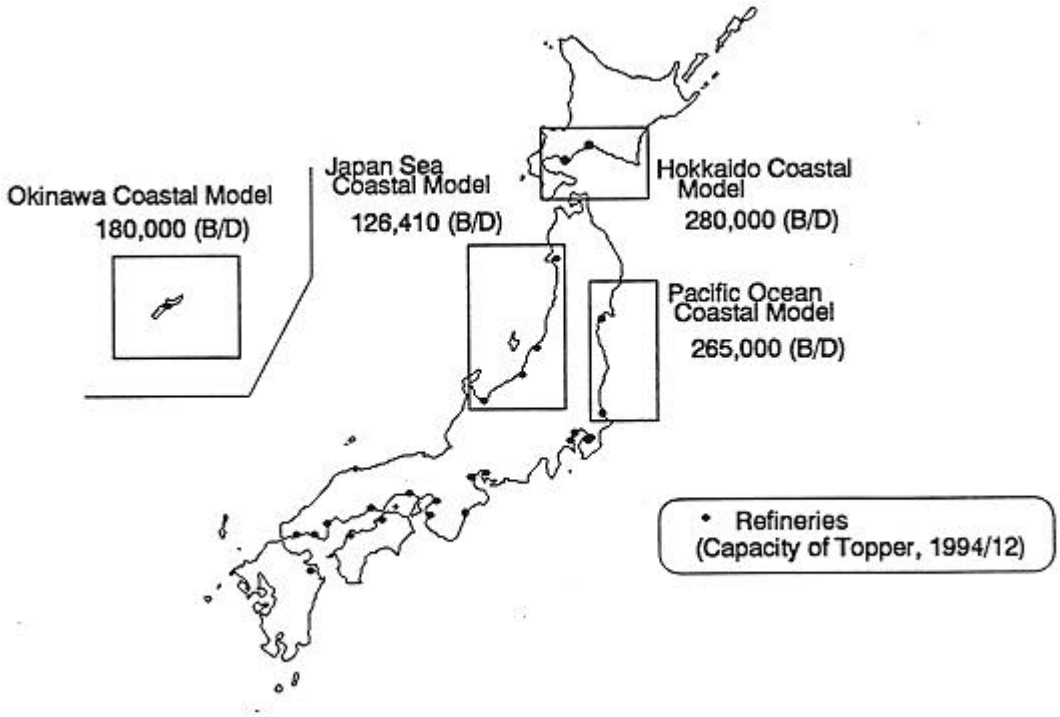




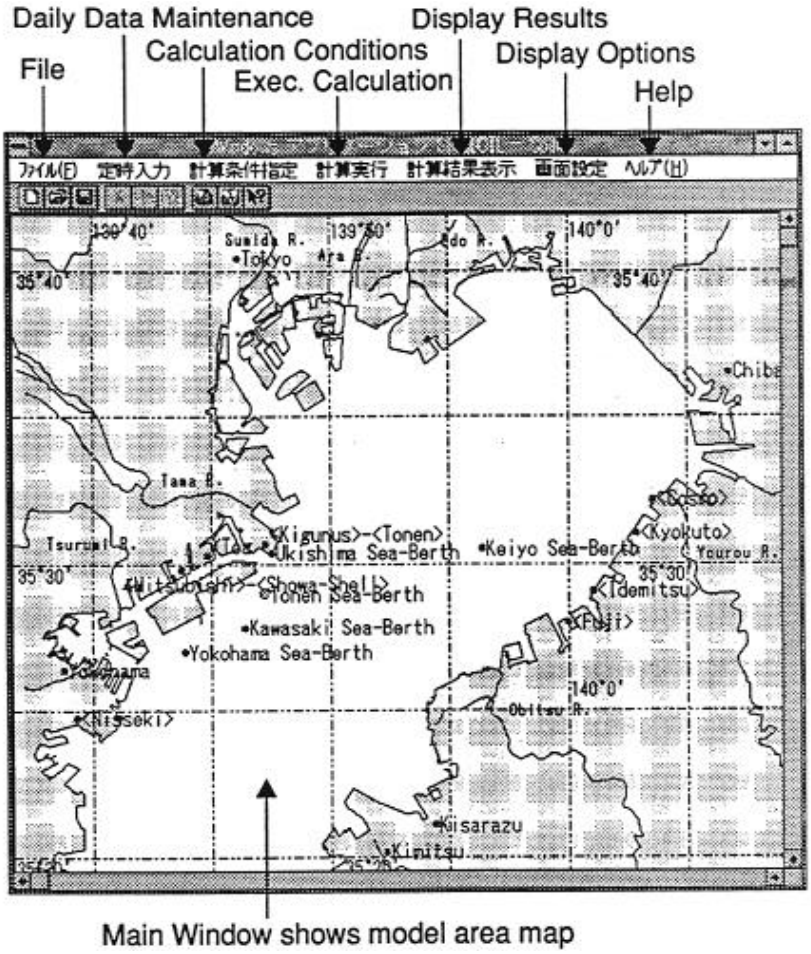
Enclosed Sea Areas of Oil Spill Model



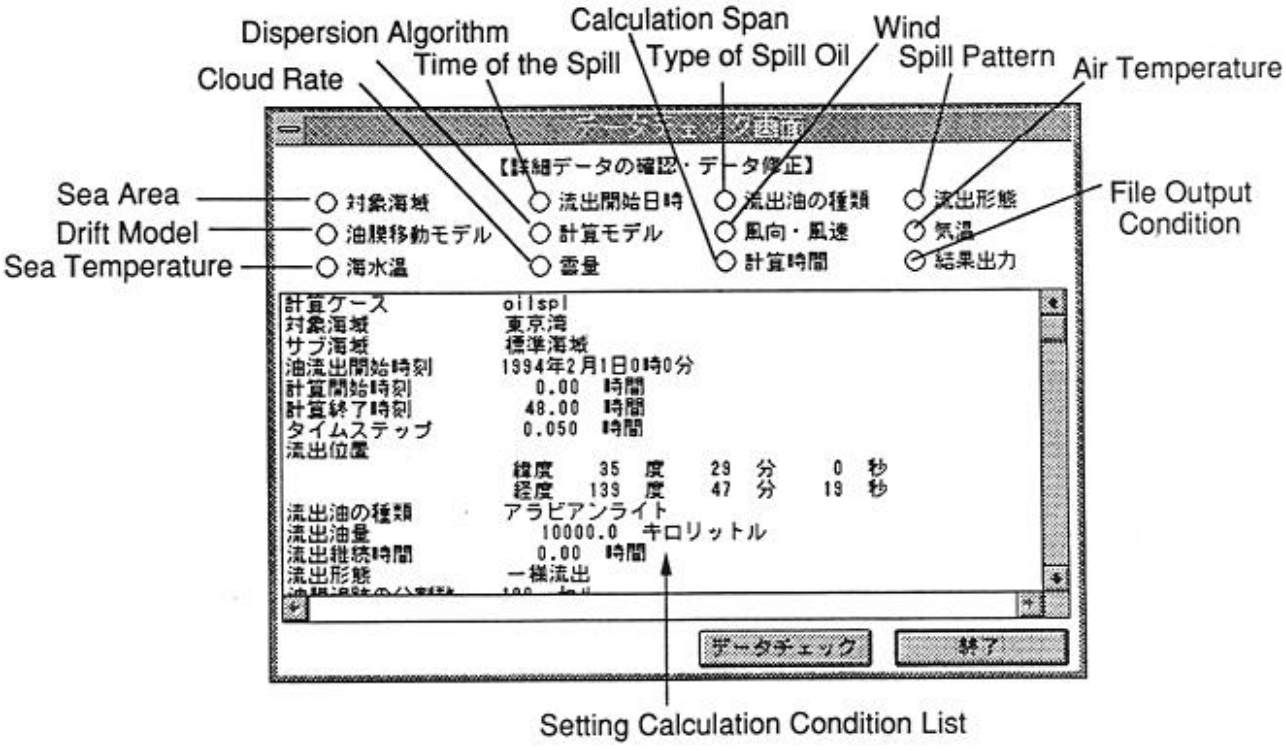
Coastal Areas of Oil Spill Model



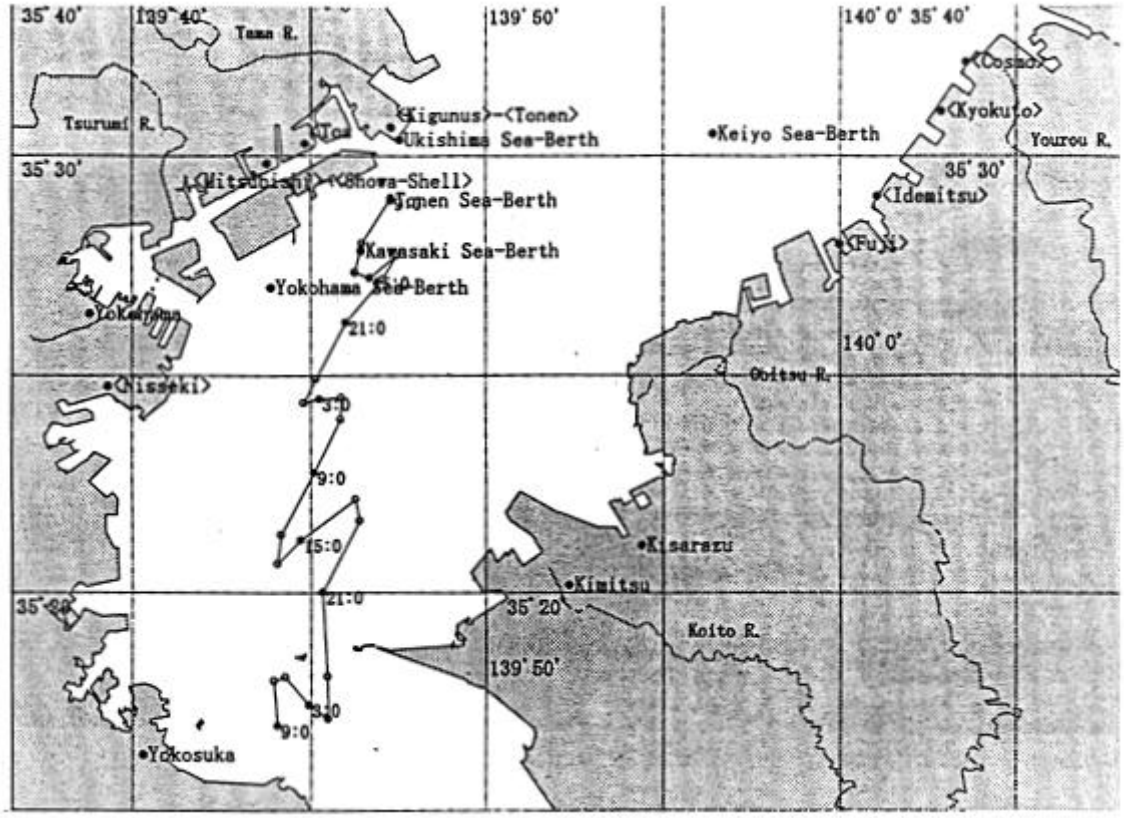
Window of Diffusion-Drift Model of Spilt Oil (Tokyo Bay)



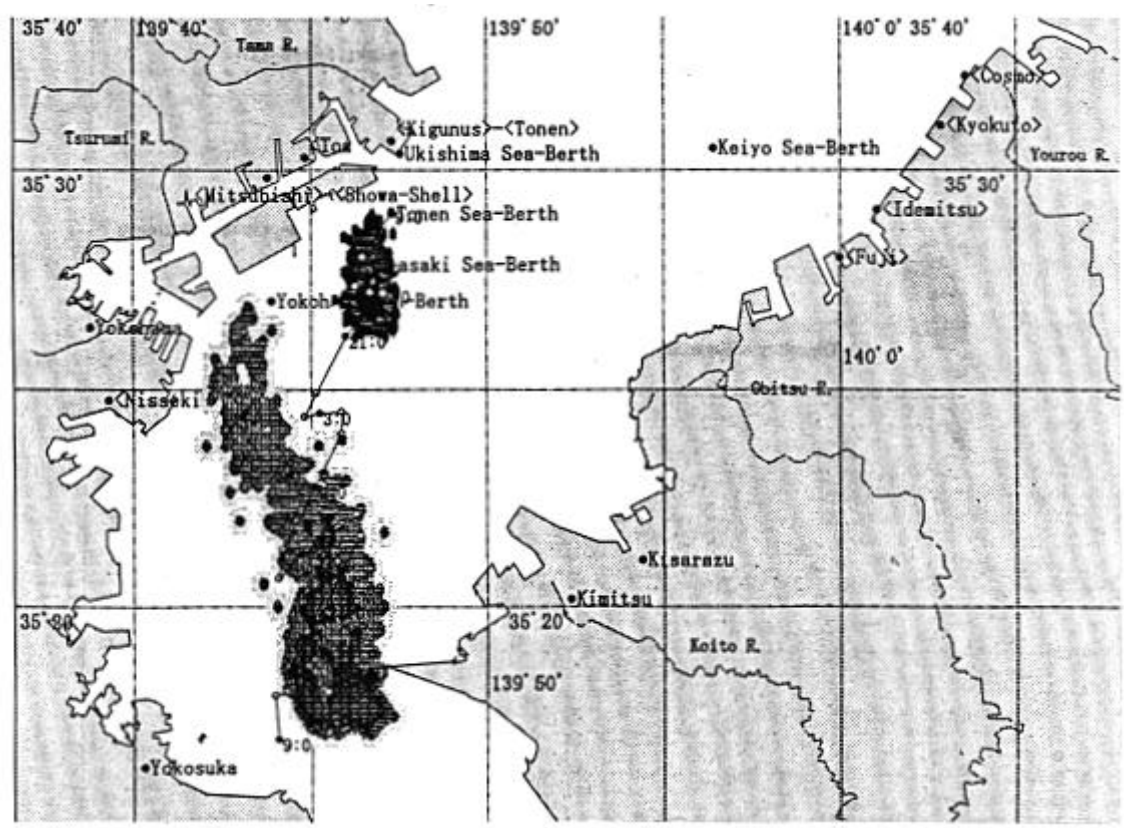
Set Calculation Conditions



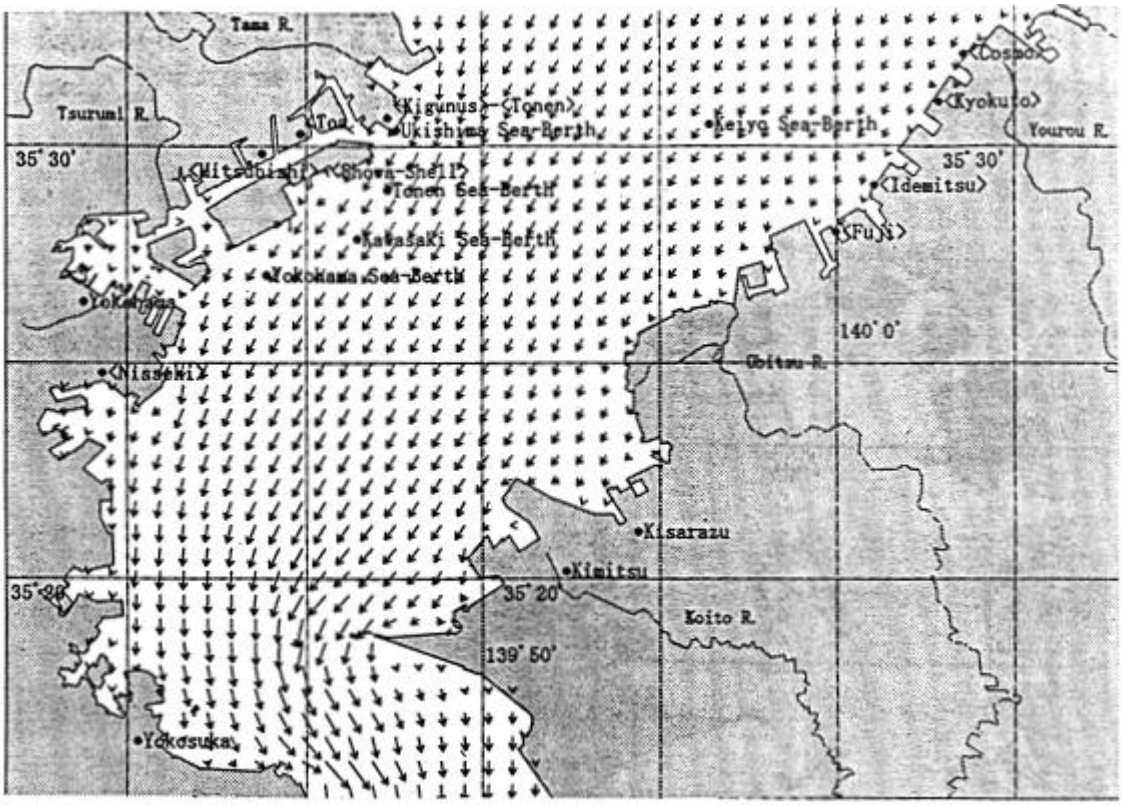
Trajectory of Oil Slick (Tokyo Bay)

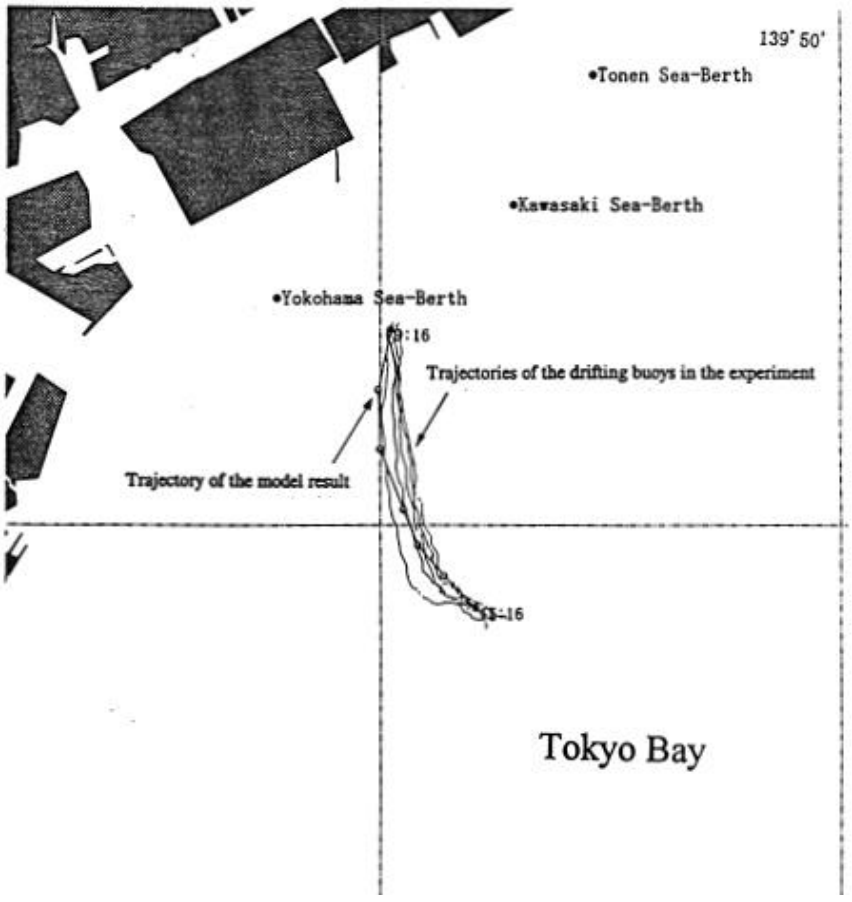


Predicted Distribution of Oil Slick (Tokyo Bay)



Vectoral Sum of Wind, Tidal Current, etc. (Tokyo Bay)





Comparison of the Trajectories between the Model Result and the Experiment