PAJ Oil Spill Simulation Model for the Sea of Okhotsk

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1. Introduction

In order to assist in remedial activities in the event of a major oil spill The Petroleum Association of Japan (PAJ) has developed a model for forecasting the drift and dispersion of spilt oil. Using meteorological forecast data, the model can be applied to any sea area around the coast of Japan, and enables a simulation to be created in a short time frame.

Following the commercialization of Sakhalin's oil fields in July 1999, the necessity of building a response system to oil spills on routes other than the already established Middle East oil routes became apparent. With this in mind we have developed a forecasting model covering the Okhotsk Sea, independent of present models for Japanese waters.

We have also made the following modification on the present model to achieve more precise forecasting in open seas:

(1) Function to update ocean current data
(2) Longer term meteorological forecast data

Below we offer an overview and description of the new features of the oil spill dispersion and drift forecasting models, focusing on the Okhotsk Sea model.

2. Outline of the Dispersion and Drift Forecasting Model

The model was developed to provide information to support control operations in the event of an oil spill, using a PC-based simulation. The model combines the following features:

(1) Able to create simulations in a short time frame
(2) Simple interface
(3) Able to use the latest online meteorological data
(4) Able to forecast on any area on the Japanese coastline
(5) Supplemented with basic information about vulnerable areas

2.1 Processes Covered by the Forecasting Models

In order to forecast the behavior of spilt oil on the sea surface it is necessary to consider the drifting process of an oil slick, and the weathering and dispersion processes which predict the physical changes of the oil itself. The model is programmed with the dispersion and weathering process indicated in Fig. 2.1, and the drifting process shown in Fig. 2.2 using current standard modelling methods.

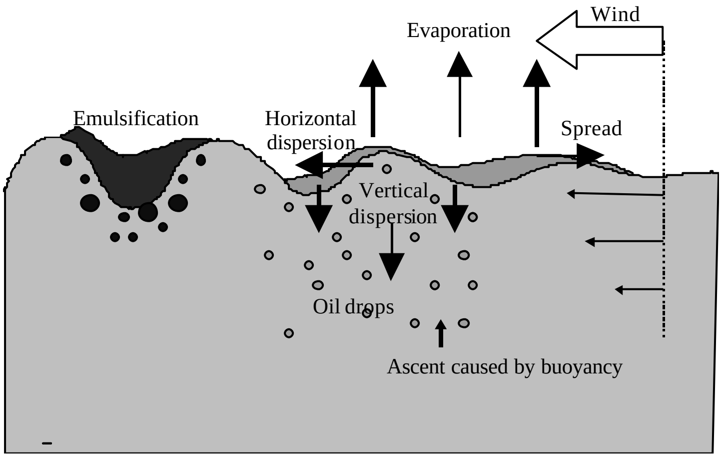

Figure 2.1 Dispersion and Weathering Process of Spilt Oil

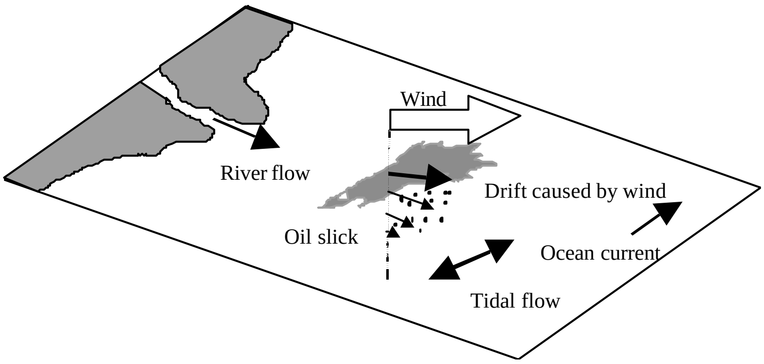

Figure 2.2 Drift Process of Spilt Oil

2.2 Forecasting Database

It is essential to prepare beforehand data about the above-mentioned processes in order to make forecasts within a short time frame. The model enables swift predictions through the use of a forecasting database that takes into consideration both seasonal and regional factors. The database includes:

(1) Topographical data (marine and terrestrial)
(2) Data on tidal, ocean and river currents
(3) Average monthly meteorological data
(4) Data on the properties of oils (physical property data on crude oils classified into 8 and four refined oils into 4, taking into account their weathering characteristics)

2.3 Use of Meteorological Data

The wind at sea is the factor exercising the greatest influence on the drift of oil. However, since the wind at sea tends to change every few hours, gaining a prior statistical grasp of this factor is somewhat difficult. To optimize the precision of the model, we have built a system enabling the downloading of up-to-date meteorological data via the Internet, updated every 12 hours for up to 51 hours in advance, which can be used in forecasting as illustrated in Fig. 2.3.

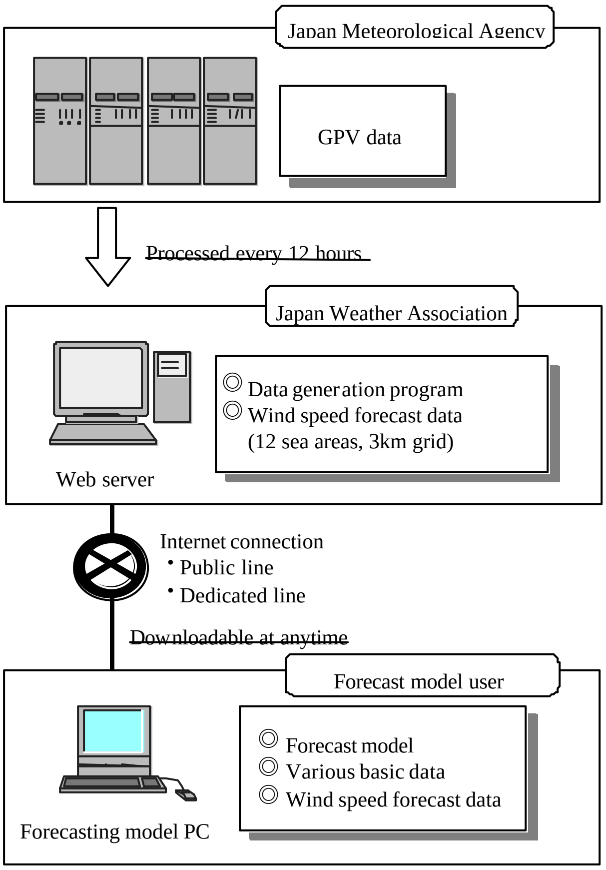

Figure 2.3 System for Use of Meteorological Data

Though the meteorological data currently available is only available for 51 hours in advance, we are working on incorporating 192 hours weekly forecasts (updated every 24 hours) in order to make long-term predictions in open seas feasible. And as this 192 hour data uses GPV's GSM data, which covers all the world's sea areas, it can be applied anywhere in the globe.

2.4 Update of Ocean Current Data

As well as the wind, another major factor in the drift of oil in the open seas is currents, typified by the Kuroshio Current (also known as the Japan Current). Since there is some degree of regularity in the movement of ocean currents, the model uses the database average values resulting from several decades of data.

However, ocean currents sometimes meander, forms vortexes, and can behave irregularly; it is conceivable that the current at the time of an accident may be different from the average. To redress this we have added to the model a function enabling the update of current-related information for forecasting, based on data from the Quick Bulletin of Ocean Conditions published by the Japan Coast Guard (Fig. 2.4), and on-the-spot reports of accident sites. This forecasting is made possible by partially inputting the vectorial data obtained from actual measurement or ocean current bulletins etc., and merging it with the average data, thereby replicating the currents at the time of an accident.

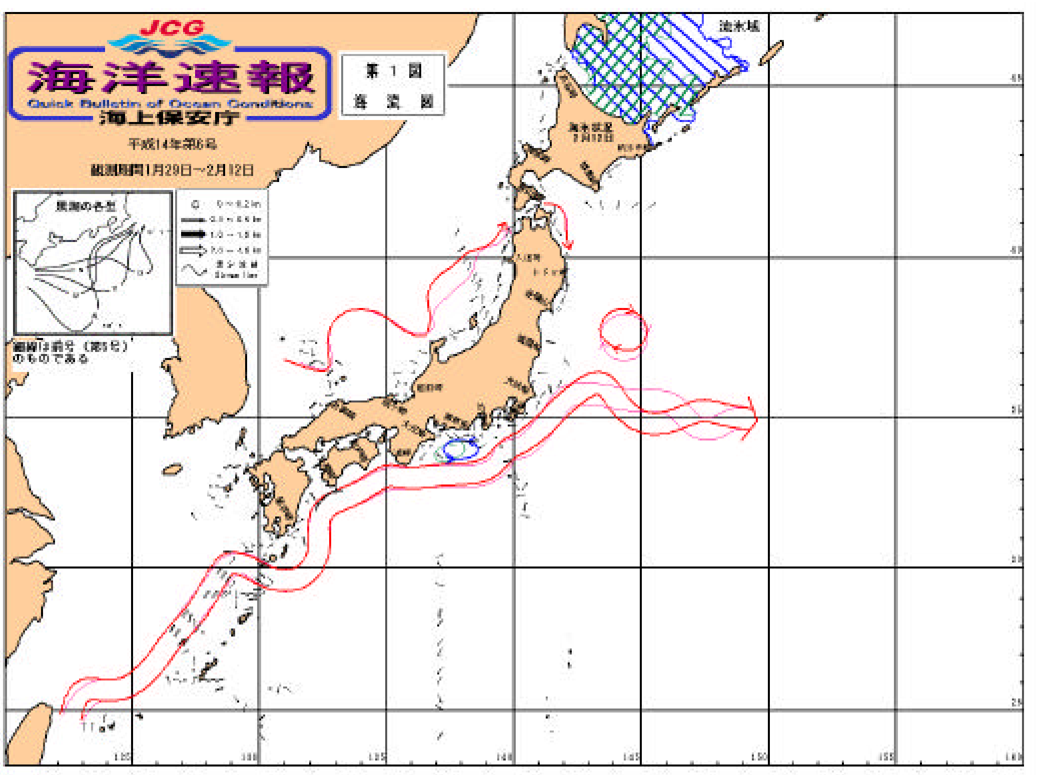

Figure 2.4 Quick Bulletin of Maritime Conditions, No. 6., 2002

Source: Japan Coast Guard（http://www1.kaiho.mlit.go.jp/）

The ocean currents are updated by adding the average current data shown in Fig. 2.5 to the latest current data illustrated in Fig. 2.6, making a combined picture as in Fig. 2.7.

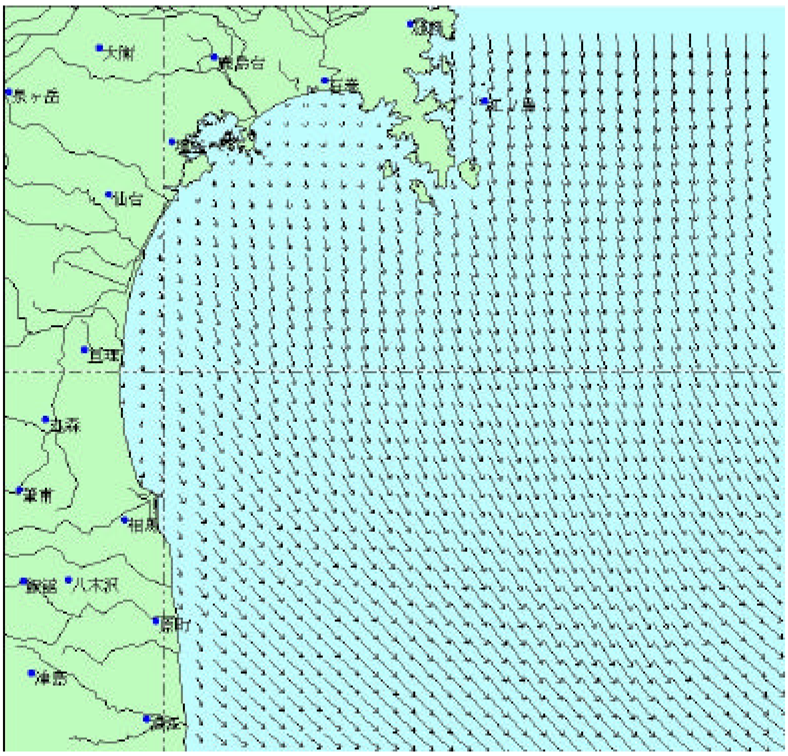

Figure 2.5 Average Ocean Current Data (original data)

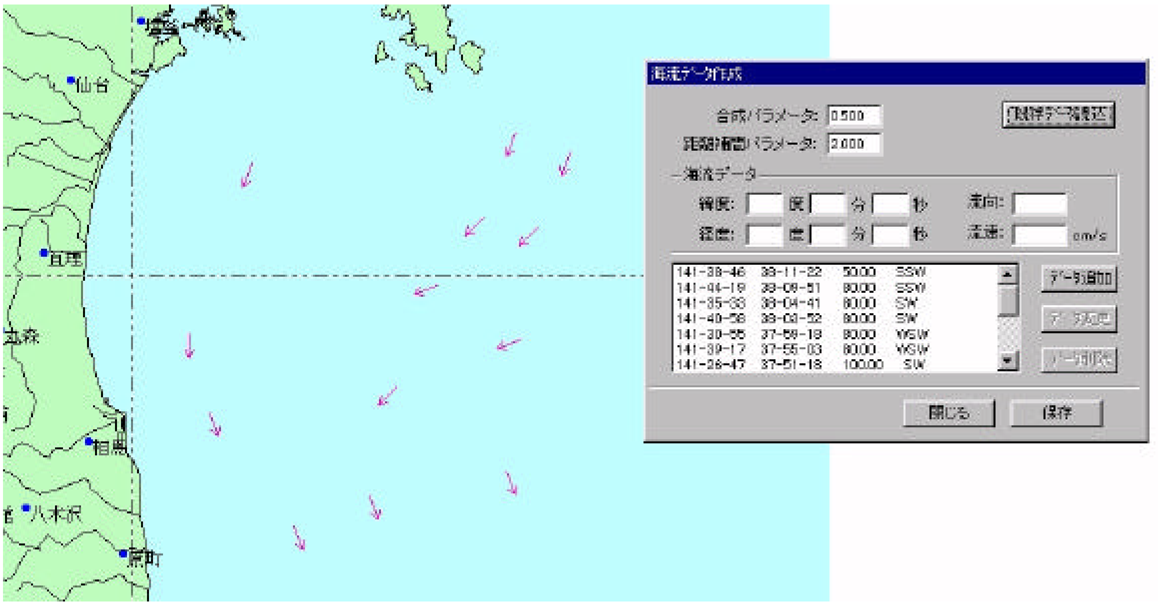

Figure 2.6 After Input of Current Data (may be input as a vector in the desired location)

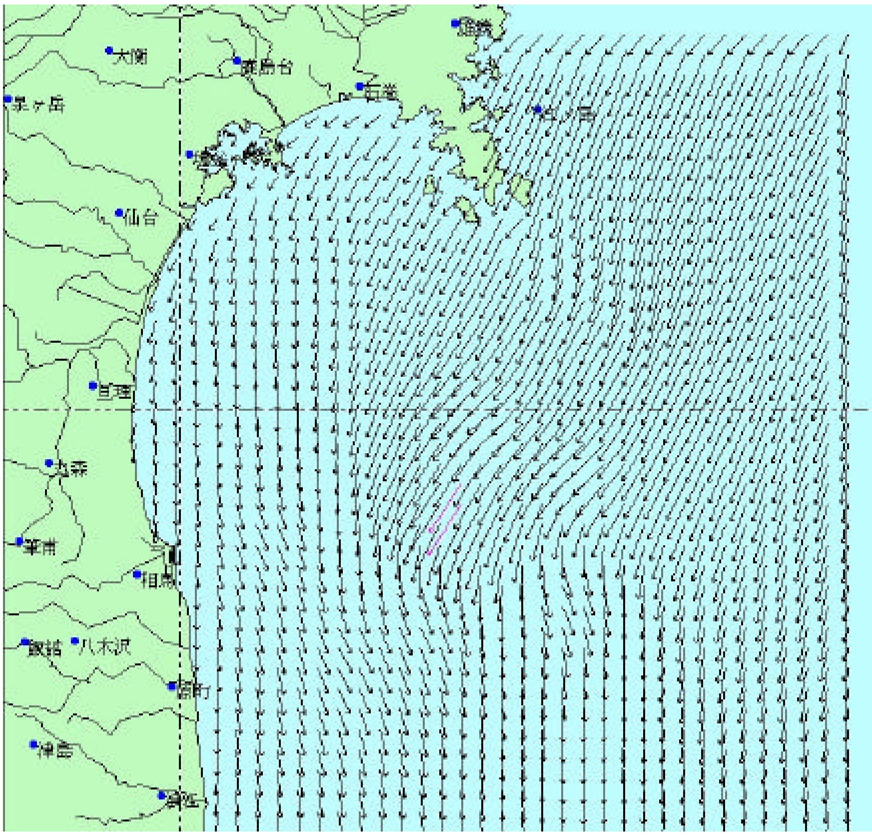

Figure 2.7 Updated Combined Current Vectors

2.5 Information about Vulnerable Areas

Whilst it is not directly related to forecasting itself, it is of great assistance in planning response operations to have geographical data on surrounding land areas relevant to the results of the forecast. Information about the vulnerability of beaches to oil pollution is particularly important. Bearing this in mind, the forecasting model has prepared data in vulnerable areas such as shorelines, fisheries, harbors and industrial districts), in order that they may be identified as the necessity arises. The data display pattern follows NOAA's symbols as its norm, but can be altered. The name display can also be changed, and the details of information are to be displayed upon clicking.

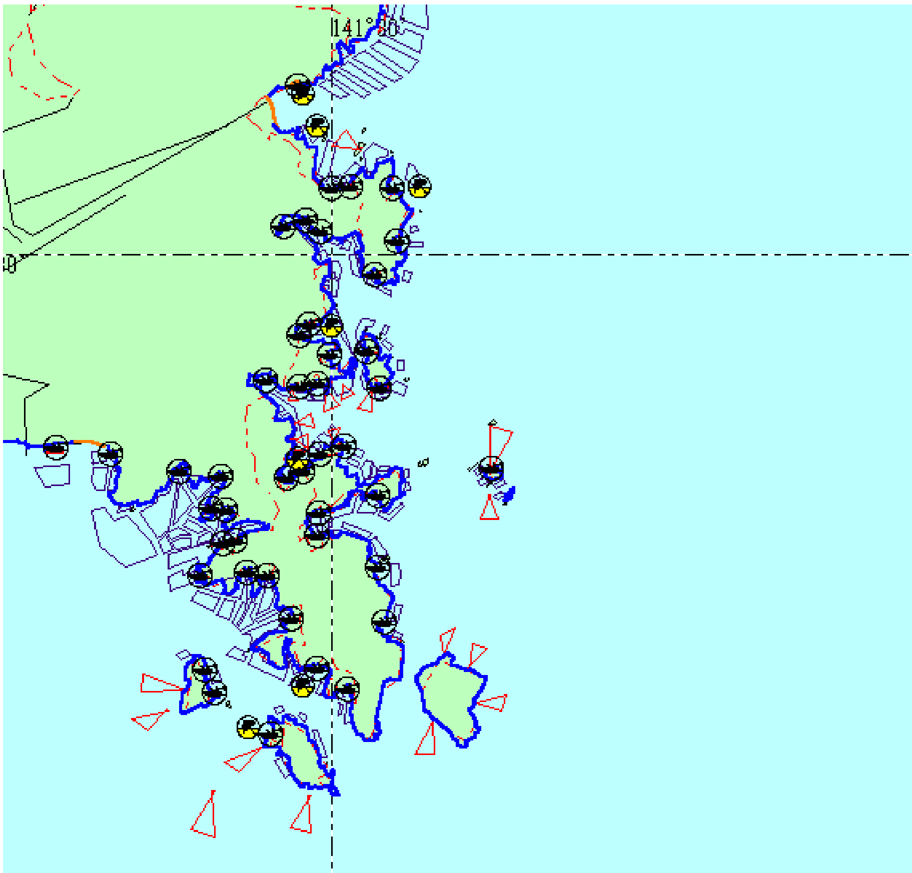

Figure 2.8 Example of vulnerable areas display

2.6 Forecast Coverage Area

Fig. 2.9 shows the original nationwide model covering the Japanese coast, and the forecast area of the Okhotsk Sea covered by the newly developed model. As the original program of the model had multi-purpose capabilities, providing data for the region in question enabled it to be applied to any sea area, and the Okhotsk Sea model too was basically developed through this data building process. There are more details of the Okhotsk Sea model in the next section of this paper .

- Japanese Nationwide Edition
  - ? Area Covered: 20°N120°E – 50°N150°E
  - ? Topographical Resolution: 3km grid cells
- Okhotsk Sea Edition
  - ? Area Covered: 39.2°N135°E – 60.8°N160.5°E
  - ? Topographical Resolution: 3km grid cells

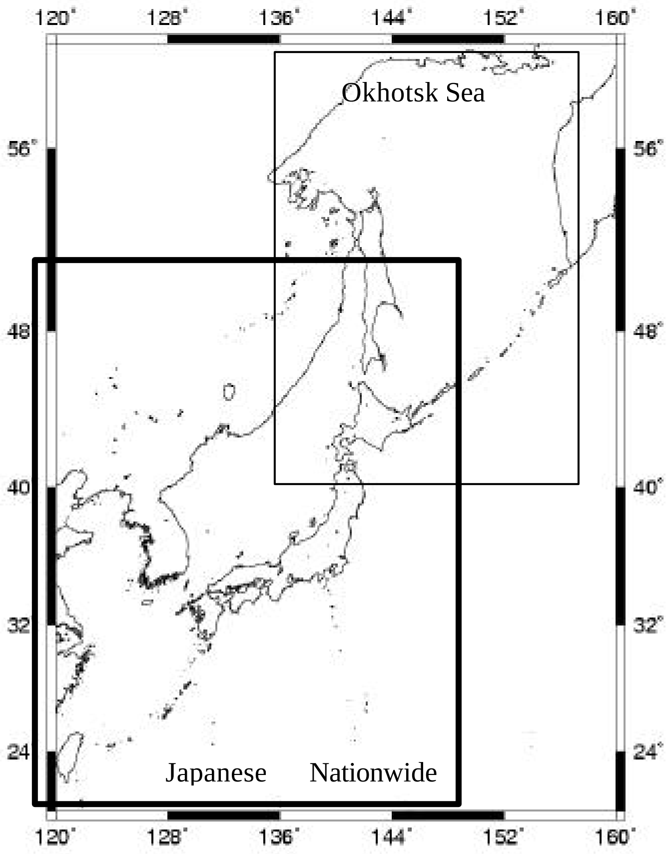

Figure 2.9 Forecast Coverage Area

3. The Okhotsk Sea Area Model

3.1 Outline of the Model

The Okhotsk Sea model basically has the same functions as the Japanese nationwide model. The forecast coverage area is indicated in Fig. 3.1 (39.2°N135°E - 60.8°N160.5°E), which enables to locate freely the area (within the limits of the overall area covered) to make calculation of the drifts.

We also intend to enable the model to use 192 hour meteorological forecast data, though, as the model is the same as the Japanese version, it will not be able to forecast during the winter periods in which icebergs form.

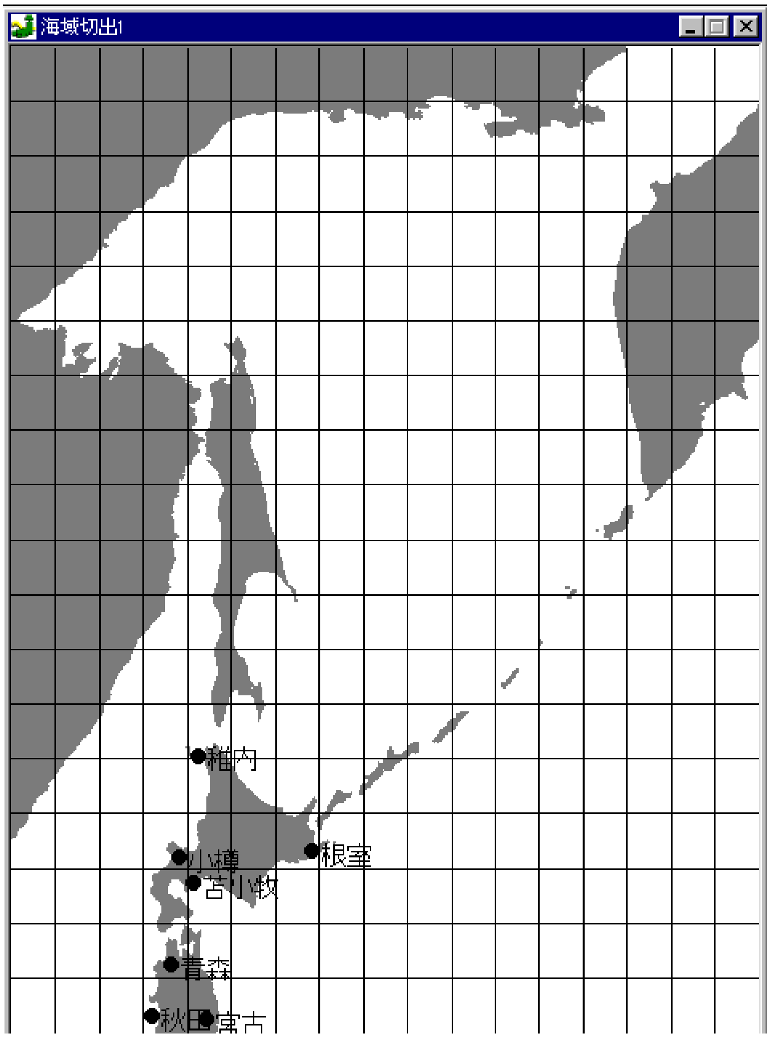

Figure 3.1 Area Covered by the Okhotsk Sea Model

3.2 Ocean Current Data

Unfortunately there is hardly any data available in Japan about currents in the Okhotsk Sea. The main currents are described in the Japan Coast Guard’s *East Coast Of Siberia Pilot,* regarded as the standard work on this subject, and the model has made use of this data to create the database shown in Fig. 3.2. However, as we have already mentioned, it is likely that the data will be different from the real current at the time specified. It is recommended that, should an accident occur, the most recent data is collated, updated and used to make a forecast.

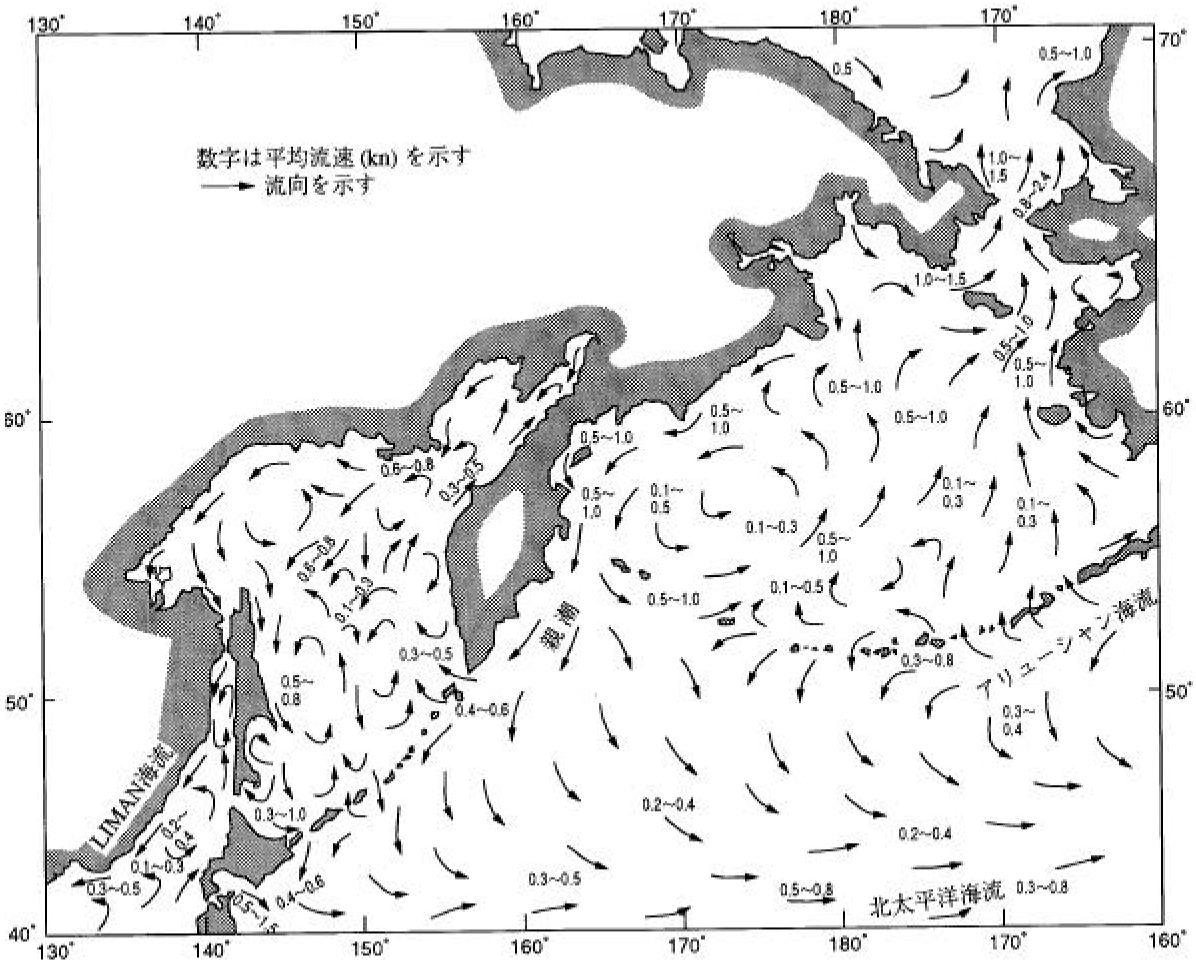

Figure 3.2 Summertime Current Patterns in the Okhotsk Sea Area

Source: Japan Coast Guard’s *East Coast Of Siberia Pilot*

3.3 Sample Calculation

Fig. 3.3 shows a forecast calculation example featuring a section of the area near the oil fields of northern Sakhalin. It is possible to display a grid with a resolution of 3km, and compute a two to three day forecast within a couple of minutes like the nationwide version. Fig. 3.4 shows a sample forecast result.

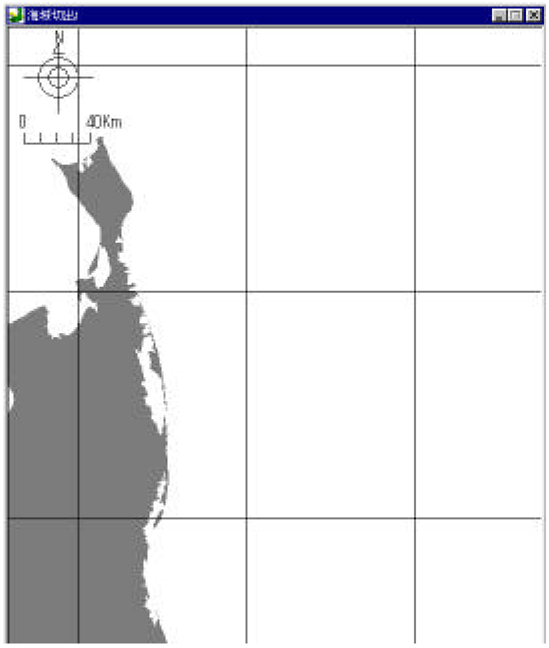

Figure 3.3 Area Selected for Calculation by the Okhotsk Sea Model

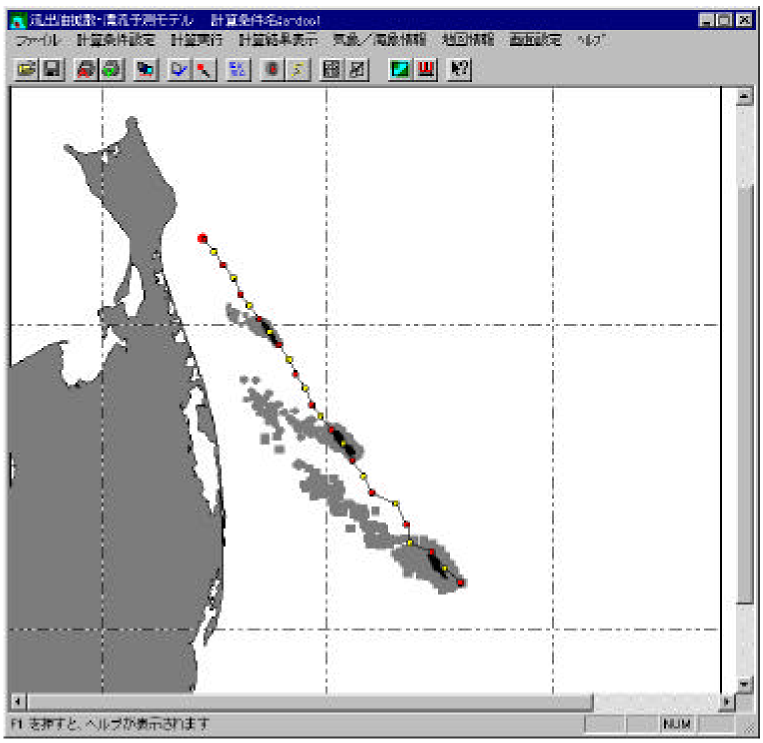

Figure 3.4 Okhotsk Sea Model Forecast Sample (drift trajectory and distribution of slick at three stages)

4. Conclusions

By providing both the nationwide and Okhotsk Sea versions of the PAJ's oil spill dispersion and drift forecasting model, we have achieved coverage of the sea around Japan in the event of an oil spill accident a possibility. Furthermore, through the extension of forecast data and the addition of functions enabling the update of ocean current data, we have optimized the precision of forecasts for the Okhotsk Sea and Japanese waters, and made long-term forecasting a reality.

As for the creation of the database on the factors exerting the greatest influence on the drift of oil – the wind at sea and ocean currents, PAJ's simulation model can be applied to any sea area in the world if the Okhotsk Sea model incorporating GSM (Global Spectral Model) meteorological data via the Internet and the ocean current creation function are used.

In preparation for an actual accident we intend to carry on upgrading the model and make it even more useful through the addition of new features including: an accumulation of forecasting data; improved support for response actions through the provision of comprehensive data on vulnerable areas; and compilation of a reference manual to reduce operator mistakes in an emergency.