CHAPTER 1

IMPORTANCE OF TIDAL INFORMATION IN THE STRAITS OF MALACCA

1.0 INTRODUCTION

Malaysia is a maritime country and has over 4,000 kilometres of coastline. Every state within the country has some areas that fall within the coastal zone. The coastal zone and its associated resources create a dynamic and sensitive natural environment that supports a wide range of economic activities such as fishing, aquaculture and tourism. They also contribute significantly to the economic and social well being of the people of Malaysia. Therefore, it is recognised that proper planning of coastal resources would enhance the growth of coastal natural resources and the improvement of the coastal environment.

1.1 STUDY AREA

The area selected for this study is the Straits of Malacca. It is one of the most important international navigation routes linking Europe and the West Asian countries in the Far East. It is sandwiched between the Island of Sumatra and the Peninsula of Malaysia as shown in Figure 1.1. It merges with the Andaman Sea in the north where the width across the sea is about 300 km and tapers gradually towards the south-east. It reaches its narrowest section at 46 km wide offshore of Cape Rachado. In the southern end, it merges with the Singapore Straits. The water is deeper in the northern part with depth ranging from 50 to 200 m but many shallow spots are seen in the southern end of the Straits.

1.2 THE PROBLEM

In recent years, a rapid development of the coastal region and intensification of offshore activities occur in the Straits of Malacca that pose increasing stress on the coastal marine environment. It is imperative that coastal management will become more important with more such activities. Hence, there is an increasing need for more effective coastal management and legislative demands for improved environmental quality.

Furthermore, the narrow channel and the heavy traffic load in the Straits of Malacca create conditions favourable for collisions of vessels. About 2,000 large vessels pass through the Straits each month, of which 25% are oil tankers of varying size (Lee et al., 1979). It is thus not surprising that the Straits has experienced an increase in serious accidental spill in the past decade as listed in Table 1.1 and summarised in Figure 1.2.

In the event of an oil spill, depending on the directions of the prevailing synoptic wind and the tides, the oil slick can arrive either at the coast of Peninsula Malaysia or Island of Sumatra in a matter of a day or two. This would have detrimental effects on the coastal resources and can cause both short and long term environmental damages amounting to billions of dollars. Thus, the issue of oil spill response is of critical concern to coastal zones surrounding the Straits of Malacca.

There is clearly one important element required for addressing nearly all of the preceding environmental issues, that is, a good description of the tidal flow field in the Straits. The Straits of Malacca has very irregular boundaries and variable depth. It continues to be an extremely complex hydrodynamic environment and a great challenge to scientists attempting to model or reproduce its dynamics and to forecast the behaviours of its water. With the aid of modern computers, competency and capability of numerical modelling, effective system analyses associated with planning and policy matters could be made feasible.

1.3 THE NEED FOR TIDAL MODELS

In trying to understand the processes that are associated with tidal motion one can employ a number of techniques. The process can be observed or it can be simulated numerically. Modern instruments have enabled a systematic collection of tidal data, which shows that regular water movement is a feature along the shores of the Straits in response to the dynamics of its adjacent seas. The Hydrographic Department of the Royal Malaysian Navy is the national agency responsible for hydrographic services in Malaysia, which prior to independence was provided by the British Admiralty (Hassan, 1992). At present, the Department is maintaining data from about 21 tidal stations and harmonic constituents are constantly being updated.

However, measurement of tides or tidal current in an offshore environment over a long period of time is laborious and costly. It is totally impractical, for example, to envisage an array of oceanographic instrument that could monitor directly the circulation over the Malaysian and Indonesian shelves in the Straits. Therefore, limited real-time observations are available at isolated points which are insufficient to provide reliable information on spatial variations of tides and tidal currents. In order to fill the information gaps, a more useful approach is to recognise that the circulation is the result of forcing by tides, surface heating, wind and so on. A predictive model based on the governing physical laws to provide detailed and complete tidal current information for the entire area under study is therefore needed.

The sea dynamics in the Straits is complicated by irregular coastline and bottom topography, which means the dynamical equations must be solved numerically. Thus, given the appropriate forcing functions, numerical circulation models provide the best way of estimating the circulation patterns in the Straits.

1.4 UNCERTAINTIES IN THE MODEL SOLUTIONS

A major problem confronting a numerical modeller of tides in the Straits of Malacca lies in the need to reconcile the model results with observed data. Before a numerical model can be used as an instrument to predict tidal flow, it has to be ascertained that the model is capable of giving accurate prediction. In most of the modelling approaches, the prediction is performed by adjusting the model parameters such that the model output matches the observation as closely as possible. The outcome, in essence, represents the best combination of parameter values and may be specific to the model and the discretization scheme taken in total. Hence, there is a need for continuous effort in devicing better models and exploring the effects of model parameters so that good prediction can be achieved.

Although two-dimensional hydrodynamic models have been used to study tides in the Straits of Malacca, little has been done to investigate systematically the arbitrary nature of the parameters or the sensitivity of the tidal model towards the specifications of the parameters. In a few modelling attempts by Hadi, 1992, Mihardja and Radjawane, 1992 and Lee,1994, the parameters were fine-tuned so that the yielded results were close to the observed data. The major uncertain parameters in a tidal model are usually the bottom friction coefficient, open boundary conditions and bathymetry depth. Beside bathymetry depth, both open boundary condition and bottom friction coefficient are in general depth and position dependent as well and have inadequately known values. Taking the bottom friction coefficient as a constant value results in substantial simplifications. Therefore, it is desirable to examine the prescription of drag coefficients so as to minimise the discrepancies between predicted result and observed data. In addition, the proper specifications of the elevations at open boundaries, bathymetric depth interpolation scheme and grid size dependency are important issues.

Given the diversity of uncertain factors involved in a tidal model, data assimilation is desirable in bringing the observed tidal data to bear upon the model results. The overall goal of data assimilation is to combine data and dynamics to get optimal estimates of the quantities of interest. In the present context this may be thought of as using all available oceanographic data, together with a tidal model, to fill in the flow field over the entire Straits. That is, we wish to map out flow fields using the model to interpolate and extrapolate available measurements both spatially and temporally.

1.5 OBJECTIVES AND SCOPE OF STUDY

In view of the importance of the Straits of Malacca and the paucity of tidal data available, it is an urgent task to obtain a reliable model capable of predicting the tidal behaviour of the Straits so that effective coastal management and oil spill containment could be carried out.

The scope of this thesis includes:

(i) To formulate a transient hydrodynamic numerical model suitable for the Straits of Malacca.

(ii). To study the behaviour of the numerical model during the spin-up phase. Of interest will be the time step restrictions and duration to reach the quasi-steady phase.

(iii) To conduct a sensitivity study on the influence of bottom friction coefficient and open boundary conditions on the predicted tidal elevations and currents. Comparison of predicted and published data will be made at selected tidal stations.

1.6 OUTLINE OF THE THESIS

This thesis consists of five chapters. In the following Chapter, an overview of tides and tidal modelling in general is presented together with a review on tidal modelling efforts in the Straits of Malacca. Chapter 3 contains the mathematical formulations of the governing equations, the descriptions of the physics of the model and the methods of discretization and solutions. Chapter 4 describes the results of investigation on the numerical model. The sensitivity of the model output i.e. elevations and currents towards the two parameters of bottom friction and open boundary conditions is discussed. An objective method based on minimisation of the sum of root mean square errors between the published and model results is used to determine the appropriate values of these parameters. Modelling results for four tidal constituents M2, S2, K1 and O1 after parameters modifications are also presented in Chapter 4. Chapter 5 concludes on the findings of the thesis investigation and some recommendations for future work are proposed at the end of the chapter. A list of references is appended after Chapter 5.

Figure 1.1 The location map of the Straits of Malacca.

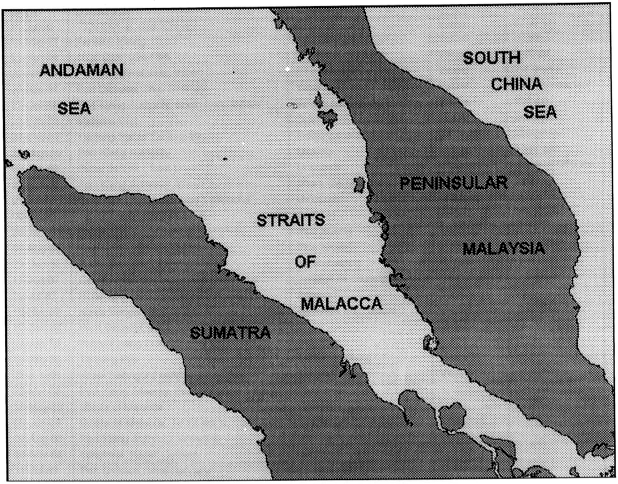

Table 1.1 Major oil spill incidents in the Straits of Malacca (from Department of Environment, Malaysia)

DATE	LOCATION	CAUSAL	SOURCES	QUANTITY
24-Jul-76	102d 56m E, 01d 32m N	Accident	Vessel	5,500 ton
16-May-77	Tanjung Keling	Pine line rupture	Vessel	60 ton
13-Oct-78	102d 09m, 02d 13m	Oily water discharge	Vessel	5-10 gal
20-Jan-80	Port Klang Authority, Wharf 2	Pine leaking	Vessel	2-3 drums
20-Sep-81	Port Dickson, Shell Refinery	Valve leaking	Vessel	1,037 metric ton
21-Oct-81	Port Klang Authority, South Port, Wharf 1	Wrong open valve	Vessel	200 gal
22-Feb-82	Malacca Port	Operational discharge	Vessel	Unknown
20-Dec-82	Tanjung Piai to Tanjung Bin	Indiscriminated dumping	Unknown	Unknown
29-May-84	Port Klang Authority	Leaking	Vessel	1,350 gal
02-Jun-86	Pulau Jerejak (East)	Unknown	Unknown	A few oil patches
23-Jun-86	Port Klang Authority, Wharf 2	Shore line host break	Vessel	1 ton
01-Jul-86	Terendak (3-4 miles away), Malacca	Unknown	Unknown	
09-Jul-86	1d 42.3 m N, 102d 45.5m E	Collision	Vessel	Unknown
26-Jul-86	Penang, Esso Depot	Pipe leaking	Depot	< 2 barrels
08-Aug-86	Telok Intan, Shell Installation	Pipe leaking	Installation	
29-Dec-86	Pulau Sembilan, Selangor	Tank cleaning	Vessel	
11-Jun-87	Gelang Patah	Spillage on cleaning	Vessel	2,000 ton
22-Jul-87	Helen Mar Reef (Indonesian waters)	Agraund	Vessel	
18-Nov-87	Kuala Sungai Baru beach, Melaka (10 mile	Oil mixed from vessel	Vessel	200 litres
17-Dec-87	Porrt Dickson, Esso Jetty	-	Vessel	
14-Jan-88	Pulau Pinang Port Authority	Unknown		
18-Jan-88	Tanjung Piai	Tanker cleaning	Vessel	
25-Jan-88	Kuala Selangor (nearby)	Unknown	Vessel	
23-Mar-88	Port Klang Aithority, Esso chemical plant	Unknown		180 gal
16-May-88	Straits of Malacca	Unknown		
06-Jun-88	Straits of Malacca, 1d 17.4m N, 104d 8.3m	Unknown	Unknown	
03-Aug-88	Port Klang Authority, Wharft 8	Unknown		
10-Nov-88	Langkawi, Kedah Cement	Leaking		
11-Jul-89	Port Dickson, Shell Refinery	Unknown	Unknown	
15-Oct-89	Port Dickson, Esso Refinery	Overflow during transfer	Vessel	80 litres
18-Oct-89	Port Dickson	Pipe leaking		18 gal
04-Dec-89	Port Dickson, Shell Refinery	Overflow	Refinery	200 ton
06-Dec-89	Langkawi, Kuah	Ballast tank	Vessel	
16-Aug-90	Johor (South West)	Tanker cleaning	Vessel	4,000 metric ton
25-Sep-90	Pulau Pinang, near LLN station		Maybe	
14-Jan-91	Port Klang Authority, Near Kapar Power	Unknown	Unknown	
05-Sep-91	Lat: 4d 7.5m N; Long: 100d 22.4m E	Spillage	Vessel	
25-Feb-92	12 nm from Tanjung Tohor, 01T0T, 102T0T	Unknown	Suspected	Unknown
20-Jun-92	Tiram Kimia Depot, Port Klang	Vessel exploded	Vessel	Unknown
20-Aug-92	Pulau Undan, 02 T 06' N, 102T 10'40" E	Unknown	Unknown	
23-Aug-92	Nearby Port Dickson	Collision	Vessel	Unknown
20-Sep-92	31 nm east of Ujong Temiang	Collision	Vessel	13,000 ton

Figure 1.2 Accidental Oil Spills in the Straits of Malacca for the Period from 1976 to1992 (Data from Department of Environment, Malaysia)