A Country Report on the Sea-level Monitoring and Measurement Activities in Malaysia

Malaysia covers an area of about 329,758 squared kilometres, consisting of 11 states in Peninsular Malaysia and 2 states in Borneo (Sabah and Sarawak) and a Federal Territory. Peninsular Malaysia, covering 131,598 sq. km. has its frontiers with Thailand and Singapore while the states in Borneo covering 198,160 sq. km, borders the territory of Indonesia's Kalimantan to the South and Brunei to the North. Malaysia lies close to the equator between latitudes of 1° and 7° N and longitudes of 100° and 119° E. It has a multi-racial population of 26 million.

Sea level monitoring and measurements are performed by three main agencies in Malaysia, namely the Malaysian Meteorological Department, the Department of Survey and Mapping Malaysia and the Royal Malaysian Navy. This paper will focus on the systems implemented by the Malaysian Meteorological Department(MMD) and the Department of Survey and Mapping Malaysia(DSMM).

2) Tide Gauge Network Operated by MMD

2.1) Introduction

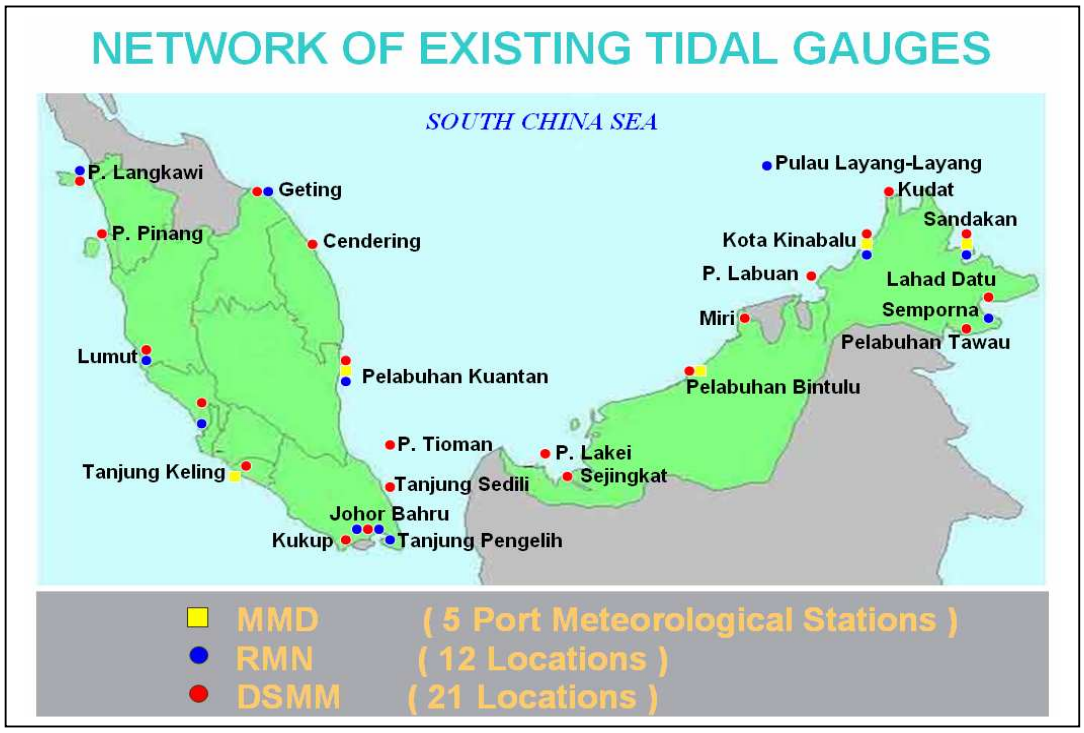
Sea-level data is an important element of the tsunami warning system. To be effective for warning purposes, sea-water level gauges need to be located near or facing the tsunami source region to get the most rapid confirmation whether a tsunami has been generated or not, and an initial estimate of its size. They should also be located between the source and threatened coastal areas to monitor the tsunami and help predict its impact. For local tsunamis, many gauges are needed along coastlines at risk to get the real-time confirmation and evaluation of tsunami waves.

Sea-level gauges that are located at strategic locations, shall play key roles in tsunami warning, particularly in:

- Confirming the existence or non-existence of tsunami waves following an earthquake
- Monitoring tsunami's progress
- Estimating the severity of the hazard along the coast
- Providing a basis for declaring the hazard to be over

2.2) Existing Tide Gauges Network

Malaysian Meteorological Department, Royal Malaysian Navy and the department of Survey and Mapping operate the tide gauges along the coastal waters of Malaysia. A list of all tide gauge stations is shown in diagram below. Most of the tidal gauges are not equipped for real time data transmission. Malaysian Meteorological Department installed 5 near real time tide gauges spanning across the country. These stations are located in Tanjung Keling, Pelabuhan Kuantan, Pelabuhan Bintulu, Kota Kinabalu and Sandakan. The recording of the data is on 10 minutes interval and the data is transmitted on hourly basis. GSM modem is used for the real time data transmission. The coverage for GSM is not very satisfactory at some stations which affect the performance of the network.



2.3) A Summary of the Existing Tide Gauges Stations Operated by MMD is Shown Below :

No.	Tide Gauge Station	Latitude	Longitude	Equipment
1	Kuantan	3.0°N	101.4°E	AANDERAA (RDCP 600)
2	Tanjung Beruas (Melaka)	2.21°N	102.16°E	AANDERAA (RDCP 600)
3	Bintulu	3.16°N	113.03°E	AANDERAA (RDCP 600)
4	Kota Kinabalu	5.98°N	116.06°E	AANDERAA (RDCP 600)
5	Sandakan	5.9°N	118.06°E	AANDERAA (RDCP 600)

2.4) Future Plan to Upgrade the Tide Gauges Network

A total of 6 water level and tide monitoring stations is planned to be installed in 6 selected outpost islands. These monitoring stations serve as the first line monitoring system as they will detect the rise of water level. Each of the 6 new stations will have a water level meter coupled with a tide gauge to measure the rise and fall of water.

Each station will have the following components

- Measurement of water level
- Data logger that captures the water level and tide at regular time intervals
- Transmitting sea level and tide data on an hourly basis during non tsunami time
- Able to be triggered remotely to operate on a real time basis when tsunami alert is on until they are commanded to stand-down

2.5) Communication System

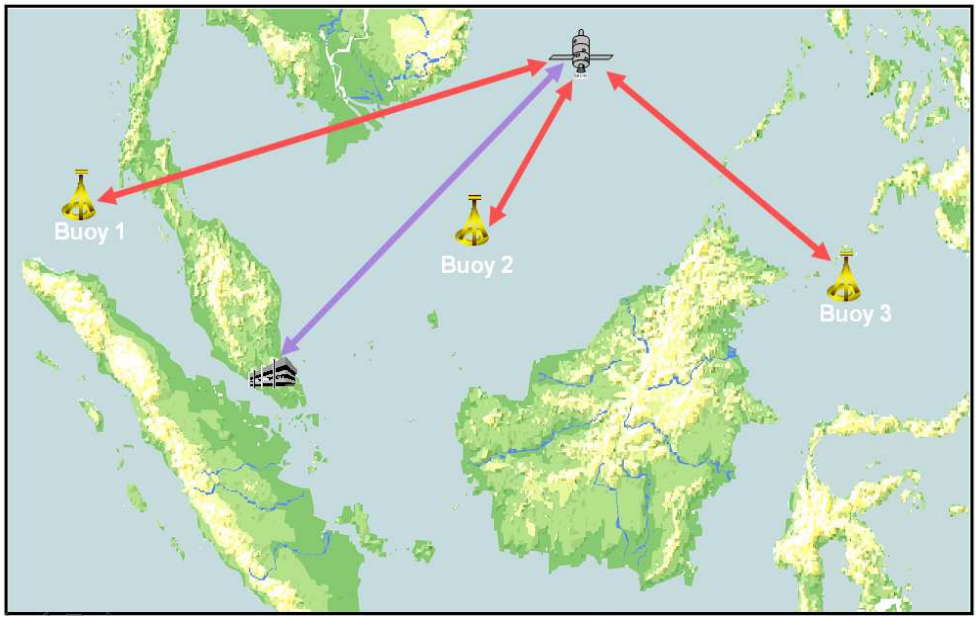
The VSAT satellite communication is used for real time data transmission of the tide gauges data to the central processing centre in Kuala Lumpur for analysis.

2.6) Location and Completion of 6 New Tide Gauge Stations

Tide Gauge Network will comprise 6 new tide gauges to be located at Porto Malai (Langkawi), Pulau Perak and Teluk Bahang over the Northwestern part of Peninsular Malaysia, at Pulau Perhentian in the northeast region of Peninsular Malaysia and at Kudat and Lahad Datu in Sabah. The installation of this tide gauge network is in progress and expected to be completed by May 2006.

The Deep Ocean Buoy Network comprises of three buoys to be located at strategic locations in the seas surrounding Malaysia. The first buoy was installed near Pulau Rondo, Sumatra on 30 Dec 2005. The second buoy was installed at Layang-Layang Island waters in the South China Sea by 7 March 2006 and the third buoy in the Sulu/Sulawasi Sea before the end of May 2006.

PROPOSED NEW BUOY LOCATIONS



3) THE MALAYSIAN GEODETIC NETWORK OPERATED BY DSMM

The Department of Survey and Mapping, Malaysia (DSMM) traces its origin way back in 1886. At present, its functions amongst others include geodetic and topographic surveys, topographic and thematic mapping, demarcation and survey of international boundaries and cadastral surveys.
In the recent years, there have been numerous geodetic projects implemented by DSMM on a nation wide scale. Collectively, these projects were and are executed with the final aim of providing horizontal and vertical controls for the development of various infrastructures across the country.

3.1) Introduction

The Department of Survey and Mapping Malaysia (DSMM) is the main government agency in Malaysia responsible for the acquisition, processing, archiving, and dissemination of sea-level data. To date, there are 12 tidal stations along the coast of Peninsular Malaysia (West Malaysia) and 9 tidal stations along the coast of Sabah and Sarawak (East Malaysia).
Before DSMM took over the responsibility for the tide stations from the State Land and Survey of Sabah in 1984 and from the State Land and Survey of Sarawak in 1990, all the tide stations in the states were held under the responsibility of each State Land and Survey respectively.
This section will describe briefly the history of the tidal observations prior to the establishment of the present sea level network in Malaysia; stipulate the objectives of the network; the description of the model of the tide gauges and their date of establishment; the types of tides available in Malaysia and also the policy of the Department regarding the dissemination of tidal data.

3.2) Background

Since colonial times, way back from the nation's independence in 1957, there were quite a number of sites selected for tide measurements by various government agencies such as in Kuantan (1908), Port Dickson (1930), Pulau Pinang (1955 and 1958), Pulau Lakei (1950-1951 & 1955-1956) and Tawau (1918). The observation periods ranged from a month to a year. However, the records and the methods of observation were not available in the Department. There was no long term planning for sea level measurements and monitoring of sea level changes at that time. The

In 1963-1964, there were attempts to establish a tide station network along the coast of Peninsular Malaysia. The attempts did not materialize due to the lack of expertise and experience. The urge to set up a tidal observation network finally came to light again after the tidal observation project was initiated in 1981. The technical aids were provided by the Hydrographic Department, Maritime Safety Agency, Japan and funded by the Japan International Cooperation Agency {JICA) under the Colombo Plan. In a span of 6 years {1981-1986), 12 tide stations were established.
When DSMM took over the maintenance and custody of Sabah tide gauges at Kota Kinabalu, Tawau and Sandakan in 1984, the stations were not in good condition and eventually the stations were not functioning due to either break-down or other reasons {Takanori Imanishi, October 1991). The stations were later revived in 1987 for Kota Kinabalu and Tawau stations while the Sandakan station was only revived in 1993.
Similar problems were encountered in Sarawak when DSMM took over the responsibility of maintaining the tide gauges from the State Land and Survey, Sarawak in 1990. Two stations, namely Bintulu and Miri, were restored in 1991.

3.3) Objectives Of The Tidal Observation Network

The objectives of the network are:
a) To carry out continuous tide observations at these locations for at least 19 years to complete a cycle of the regression of the moon's nodes.
b) To process the observed tidal data and to obtain the mean sea level values at the selected tide stations.
c) To analyze the observed tidal data and obtain the Harmonic Constants for tidal prediction.
d) To publish records of Tidal Observation and Tide Prediction Tables annually. e) To study the tidal characteristics along the coast of West and East Malaysia.

3.4) Tidal Network Operated by DSMM

There are 21 tidal stations in Malaysia. 12 are in West Malaysia and 9 are in East Malaysia. Table 1 below shows the location, date of establishment and type of tide gauge used at all the tidal stations.

Table 1

Station	Established	Type	Type / Date Replaced
Peninsular Malaysia			
1. Pulau Langkawi	Nov. 1985	LTT-3AD	DFT-1 / April 1998
2. Pulau Pinang	Nov. 1984	LTT-3AD	DFT-1 / April 1998
3. Lumut	Nov. 1984	LTT-3AD	DFT-1 / April 1998
4. P. Klang	Dec. 1983	LTT-3AD	DFT-1 / Oct 1993
5. Tanjung Keling	Nov. 1984	LTT-3AD	DFT-1 / May 1998
6. Kukup	Nov. 1985	LTT-3AD	DFT-1 / May 1998
7. Johor Bahru	Dec. 1983	LTT-3AD	DFT-1 / May 1998
8. Tanjung Sedili	Oct. 1986	LTT-3AD	DFT-1 / May 1998
9. Pulau Tioman	Nov. 1985	LTT-3AD	DFT-1 / May 1998
10. Tg. Gelang	Dec. 1983	LTT-3AD	DFT-1 / April 1998
11. Cendering	Oct. 1984	LTT-3AD	DFT-1 / April 1998
12. Geting	Oct. 1986	LTT-3AD	DFT-1 / April 1998
Sarawak/Sabah			
13. Kuching	Feb 1996	LTT-3AD	DFT-1 / June 1998
14. Bintulu	Aug 1992	LTT-3AD	DFT-1 / Sept. 1993
15. Miri	Jan 1993	LTT-3AD	damaged since Dec. 1998
16. Labuan	Dec 1995	DFT-1	
17. Kota Kinabalu	June 1987	LTT-3AD	DFT-1 / June 1998
18. Kudat	Oct 1995	DFT-1	
19. Sandakan	Aug. 1993	DFT-1	
20. Lahad Datu	Oct 1995	DFT-1	
21. Tawau	June 1987	LTT-3AD	DFT-1 / Aug. 1993

Example of a Tide Station

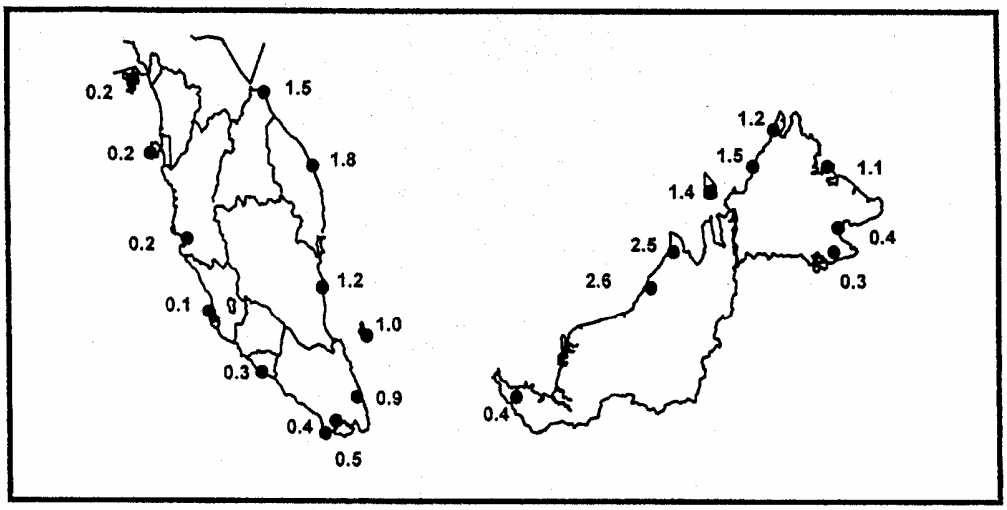
DSMM was also involved in the ASEAN-Australia Tides and Tidal Phenomena Project (AATTP) which was implemented in 1985 for the purpose of improving regional cooperation in marine science. The project aimed to obtain simultaneous observations of sea level time series in the ASEAN region and to centralize all modern sea level data into a certified database. Furthermore, the tidal stations at Lumut and Cendering were included in the network of Global Sea Level Observing System (GLOSS) coordinated by the Intergovernmental Oceanographic Commission (IOC). Data were also sent to the TOGA Sea Level Centre at the University of Hawaii, USA on a regular basis. In addition, data from all the 21 stations were also sent to the Permanent Service for Mean Sea Level (PSMSL) in the United Kingdom and the Joint Archive for Sea Level based at the University of Hawaii, USA.

3.5) Types of Tides

The classifications of tides are based on the value of the ratio (F) of the sum of the amplitudes of the two main diurnal components (Kl and 01) to the sum of the amplitudes of the two main semi-diurnal components (M2 and S2).

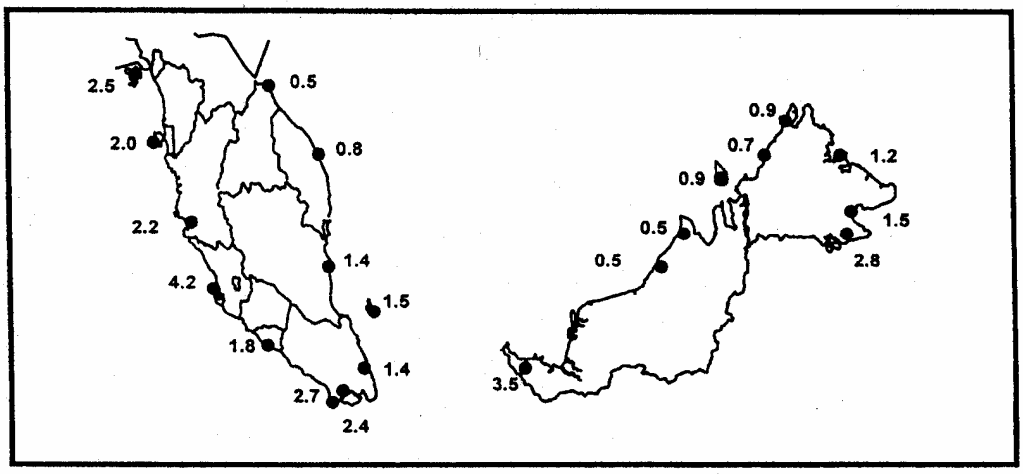
a) Semi-diurna1 type Ratio(F) < 0.25
b) Mixed (Dominant semi-diurnal) 0.25 < Ratio (F) < 1.5
c) Mixed (Dominant diurnal) 1.5 < Ratio (F) < 3.00
d) Diurnal type Ratio (F) > 3.00

In Peninsular Malaysia, it is dominated by semi-diurnal and mixed (Dominant semi-diurnal) tide except Cendering station which has a mixed (Dominant Diurnal) tide. On .the other hand, the tide in East Malaysia is either dominated by mixed (Dominant semi diurnal) tide or mixed (Dominant diurnal) tide, There is no diurnal tide available in Malaysia.



(H' + Ho) / (Hm + Hs)

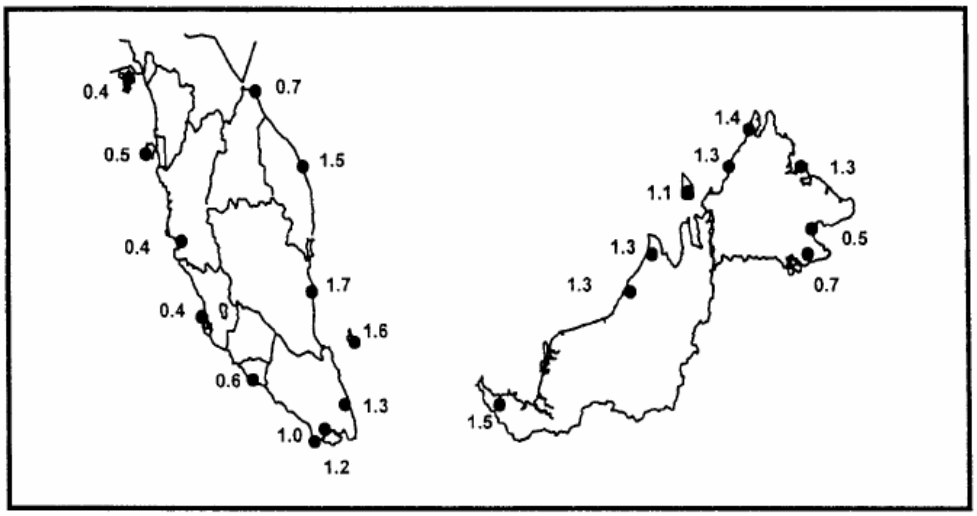
Tidal (Spring Range)



2 (Hm + Hs)

Spring range – large at Port Kelang and Kuching

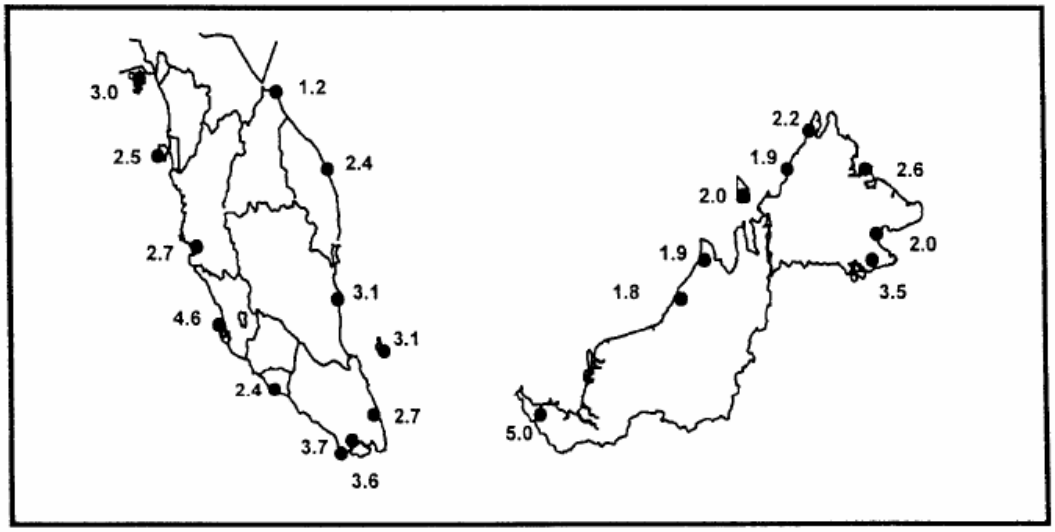
Tidal (Diurnal Range)



2 (H' + Ho)

Large Diurnal Range at stations facing Suoth China Sea

Tidal (Spring and Diurnal Range)



2 (Hm + Hs + H' + Ho)

The maximum tidal range

3.6) Dissemination of Tidal Information

The Department of Survey and Mapping Malaysia produces two publications annually. They are:
(a) Record of Tidal Observation; and
(b) Tide Prediction Tables.

The tidal predictions of all the stations are based on a set of 60 harmonic constituents, analysed from the yearly observation. The final predicted tide values that would be adopted for Tide Prediction Tables are the mean of the past 5 years of good observations.

Conclusion

With the upgrading of the tidal network and the strengthening of existing cooperation, it is hoped that the rapid exchange of data could be facilitated among agencies both locally and internationally.
In this respect, the Malaysian Meteorological Department and Department of Survey and Mapping Malaysia will continue to give their support to GLOSS and other institutions in the form of data contribution from all its stations for the purpose of sea level study.

6th May 2006

Prepared by:

Muhammad Helmi bin Abdullah
Malaysian Meteorological Department
46667 PETALING JAYA
SELANGOR, MALAYSIA
Tel: 603-79678119
Fax: 603-79578052
email: helmi@kjc.gov.my

Note:

Sections 3 – 3.6 of the report is taken from the 2004 Country Report for Malaysia prepared by the Department of Survey and Mapping Malaysia.