Accurate Low-Water Line Determination: The Influence of Malaysia's Legislation and Coastal Policies on Maritime Baseline Integrity

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Abstract

A fundamental component of any marine cadastre is the accurate positioning of the baseline since this defines the landward limit of marine parcels. Typically the maritime baseline is based on some form of Low Water Mark (LWM). However, it is notoriously difficult to determine the location of the baseline since within the highly dynamic coastal environment, the LWM is continually shifting. The primary aim of this research is to develop a methodology to efficiently determine the baseline by acquiring an integrated terrestrial Digital Terrain Model (DTM) using DGPS and a marine DTM based on near-shore bathymetry and tidal data, in order to derive the location of the baseline at a particular time. Fieldwork was carried out at Millport, Scotland using DGPS and marine radio-echo sounding to generate DTMs, which were then compared with external elevation measurements from SRTM, ASTER GDEM and NEXTMAP datasets. This method produced more robust results than those derived from existing datasets. Low-water lines (e.g. MLWS, LAT) were generated and compared to their locations shown on the current Ordnance Survey and Admiralty maps and charts. Results show highly accurate low-water lines (LAT) were produced using this method and that LAT has moved inland, likely due to a combination of sediment loss and sea level rise. A second objective was to review maritime baseline policy of other coastal countries, especially those neighbouring Malaysia. It was found that most coastal countries have a multitude of coastal management policies and initiatives to manage their coastal environment sustainably but policy design to sustain the integrity and position of the maritime baseline is almost non-existent. Such a finding also applies to Malaysia’s land and marine related legislation and coastal zone management initiatives. The principal conclusion is that the approach demonstrated here is an efficient and repeatable way to derive the low-water line along small segments of coastline for the needs of a marine cadastre but that there is an overriding need for an integrated and sustained policy to establish and regularly update the maritime baseline in Malaysia.

List of Conferences and Awards

Conferences

Oral presentation entitled: ‘Determining the maritime baseline: development of a universal methodology’, 7th ABLOS Conference 2012: UNCLOS in a Changing World, International Hydrographic Bureau (IHB) Monaco, October 2012.

Poster presentation entitled: ‘Extracting low-water lines from DTM for maritime baseline determination’, *Wavelength Conference 2013,* Glasgow (UK), March 2013.

Poster presentation entitled: ‘Extracting low-water lines from DTM for maritime baseline determination’, *Glasgow-Newcastle-Durham University Networking Conference 2013,* Durham (UK), March 2013.

Oral presentation entitled: ‘Determining the maritime baseline: development of a universal methodology’, 2013 CASLE Conference: Management of Land and Sea Resources – What's New? Glasgow (UK), July 2013.

Awards

Awarded joint 3rd place in the 2013 Technical Photography Competition organised by College of Science and Engineering, University of Glasgow.

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Most of all, to God Almighty who has blessed me with everything I've got; for the LORD is good, His mercy is everlasting, and His truth endures to all generations. Amen.

Author's Declaration

I declare that this thesis is entirely the product of my own work, except where indicated, and has not been submitted by myself or any other person for any degree at this or any other university or college.

Robin Seet Poh Aik

Definition/ Abbreviations

ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
BADC	British Atmospheric Data Centre
BODC	British Oceanographic Data Centre
CD	Chart Datum
CETC	Coastal Engineering Technical Centre
CZMP	Coastal Zone Management Program
DECC	Department of Energy and Climate Change
DEFRA	Department for Environment, Food and Rural Affairs
DGPS	Differential Global Positioning System
DID	Department of Irrigation and Drainage Malaysia
DOALOS	Division for Ocean Affairs and the Law of the Sea
DTM	Digital Terrain Model
EA	Environment Agency
EEZ	Exclusive Economic Zone
EGM96	Earth Gravitational Model 1996
FIG	International Federation of Surveyors
GPS	Global Positioning System
HAT	Highest Astronomical Tide
ICJ	The International Court of Justice
ICZM	Integrated Coastal Zone Management
IFSAR	Interferometric Synthetic Aperture Radar
IHB	International Hydrographic Bureau
IHO	International Hydrographic Organisation
IPCC	Intergovernmental Panel on Climate Change
ISMP	Integrated Shoreline Management Plans
JPDBSM	Federal Department of Town & Country Planning Peninsular Malaysia
JUPEM	Department of Survey and Mapping Malaysia
LAT	Lowest Astronomical Tide
LiDAR	Light Detection and Ranging
LTE	Low-tide Elevation
LWM	Low Water Mark
LWMOST	Low Water mark of Ordinary Spring Tide
MacGDI	Malaysian Centre for Geospatial Data Infrastructure
MACRES	Malaysian Centre for Remote Sensing
MAGIC	Marine Geodetic Infrastructures in Malaysian Waters
MGDI	Marine Geospatial Data Infrastructure
MIMA	Maritime Institute of Malaysia
MKN	National Security Council of Malaysia
MHHW	Mean Higher High Water
MHWS	Mean High Water Spring
MLLW	Mean Lower Low Water
MLW	Mean Low Water
MLWS	Mean Low Water Spring
MSL	Mean Sea Level

MSP	Marine Spatial Planning
MyGDI	Malaysia Geospatial Data Infrastructure
NCECC	National Coastal Erosion Control Council
NCES	National Coastal Erosion Study
NCZPP	National Coastal Zone Physical Plan
NKEA	National Key Economic Areas
NLC	National Land Code of Malaysia
NLLW	Nearly Lowest Low Water
NOC	National Oceanography Centre
NTSLF	National Tidal and Sea Level Facility
ODN	Ordnance Datum Newlyn
OS	Ordnance Survey
OSGM91	Ordnance Survey of Great Britain 1991
PCGIAP	Permanent Committee on GIS Infrastructure for Asia and the Pacific
PHN	National Hydrographic Centre of Malaysia
RMN	Royal Malaysian Navy
RMSE	Root Mean Square Error
RSL	Relative sea-level
SAR	Synthetic Aperture Radar
SEPA	Scottish Environment Protection Agency
SLA	Submerged Lands Act1953
SRTM	Shuttle Radar Topography Mission
TLS	Terrestrial Laser Scanning
UKCP09	United Kingdom Climate Projection 2009
UKHO	United Kingdom Hydrography Office
UNCLOS	United Nations Conventions on the Law of the Sea

1 INTRODUCTION

Marine environments are rich in resources such as fisheries, renewable energy potential and fossil energy reserves below the seabed. Marine resources generate a significant proportion of a maritime nation's wealth. Therefore it is important for coastal countries to govern and harness the marine resources within its maritime boundaries for the national good. In order to administer its marine resources, many coastal countries have implemented a marine cadastre (Figure 1-1).

> …the idea for a national marine cadastre stems from the broadly recognised need to improve administration and management of the marine environment from a spatial perspective. The marine cadastre aims to create a sustainable and equitable management system for spatially governed offshore rights, restrictions and responsibilities.
>
> (Collier & Quadros, 2006)

The prerequisite for successful administration and management of the marine environment by a coastal country is to clearly identify its maritime boundaries, in order for it to exert exclusive sovereignty over the areas of the sea and seabed it claims. Accordingly, all maritime zones and boundaries are determined from a baseline, which is usually the low-water line along the coast. However, it is notoriously difficult to determine the location of any baseline since the low-water line is ever shifting within the highly dynamic coastal environment. The dynamic nature of the coast also signals that the previously determined location of any baseline could very soon become obsolete. The conventional method of surveying the baseline such as observing the low-water line position during low-tide using Total Stations is time consuming, labour intensive and costly and struggles to keep pace with coastal changes. The location of baseline is usually depicted as chart datum in the small scale navigational charts produced mainly for the purpose of navigational safety. This is not good enough for the precise determination of the baseline location required by a marine cadastre. Therefore the primary aim of this research is to develop a methodology to efficiently determine the low-water line by acquiring and manipulating a digital terrain model (DTM), near-shore bathymetry and tidal data of a coastline, in order to derive the location of the desired baseline. Subsequently, this research investigates Malaysia's coastline management and development policies and their effect on the maritime baseline, in order to make recommendations regarding the management policies for a maritime baseline.

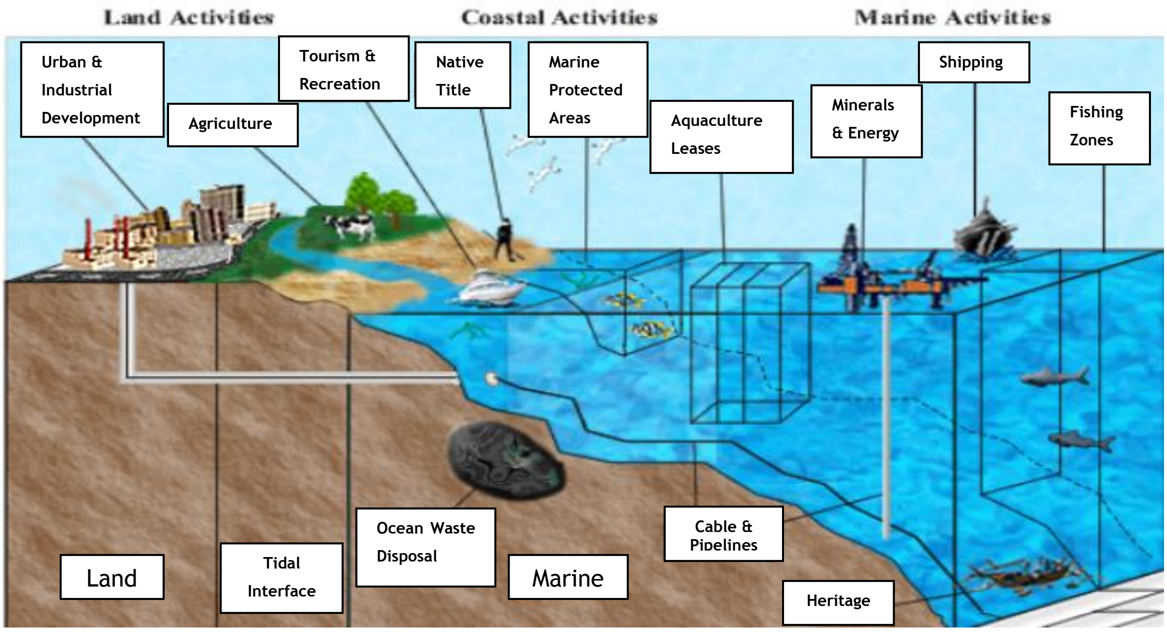

Figure 1-1 The Marine Cadastre Concept
(Binns et al., 2003)

1.1 United Nations Convention on the Law of the Sea 1982 (UNCLOS III)

The customary international law that outlines the rights and responsibility of a coastal country together with the various maritime zones that it is entitled to claim was outlined by the 1982 United Nations Convention on the Law of the Sea (UNCLOS III). Any maritime boundaries claimed and delimited have to be in accordance with the provisions stated in UNCLOS III. In order to identify and claim its maritime zones, and in the mean time promote better management of ocean resources and generate harmony and goodwill amongst States, many coastal countries have signed and ratified UNCLOS III.

UNCLOS III is the international agreement that defines the rights and responsibilities of nations in their use of the world's oceans, establishing guidelines for the management of marine natural resources. The first UNCLOS was held in 1958 and are known as the 1958 Geneva Conventions, but the conventions did not address the important issue of the maximum breadth of the territorial sea. Two years later, UNCLOS II was held but it also failed to reach consensus on the breadth for the territorial sea. The third UNCLOS was held from 1973 to 1982 (UNEP/GRID-Arendal, 2009) and was opened for signature on 10 December 1982 and entered into force on 16 November 1994, a year after the deposition of the 60th instrument of ratification. UNCLOS III comprises 320 articles and nine annexes, governing all aspects of ocean space, such as delimitation, environmental control, marine scientific research, economic and commercial activities, transfer of technology and the settlement of disputes relating to ocean matters. As of 20 September 2011, UNCLOS III has been signed by 157 countries and ratified by 162 States.

On 14 October 1996, Malaysia became the 107th country to ratify UNCLOS III and the Convention entered into force for Malaysia on 13 November 1996 (United Nation, 2011c). Prior to Malaysia's ratification, Malaysia had extended its territorial sea from 3 to 12 nautical miles (nm) in 1969 in accordance to the 1958 Geneva Convention on the Territorial Sea and Contiguous Zone, claimed its continental shelf in 1979 and 200 nm EEZ (Exclusive Economic Zone) in 1980 (Valencia, 1991). Upon ratification, Malaysia made further declarations in accordance with article 310 of UNCLOS III (DOALOS, 2012) and submitted its extended continental shelf claims with respect to the southern part of the South China Sea together with Vietnam to the Commission on the Limits of the Continental Shelf on 6 May 2009, in accordance with Article 76 of UNCLOS III (DOALOS, 2009).

1.2 Malaysia Maritime Jurisdiction

Malaysia is a coastal country with two large land masses, Peninsular Malaysia and East Malaysia, separated by approximately 640 km (400 miles) of the South China Sea. Malaysia has an estimated total land mass varying from 328,550 km^2 (JUPEM, 2009), 329,000 km^2 (Hamid-Mosaku & Mahmud, 2009) to 330,000 km^2 (CheeHai & Fauzi, 2006), and an estimated coastline varying from 4,320 km (CheeHai & Fauzi, 2006), 4,490 (Saharuddin, 2001), 4,675 km (JUPEM, 2009), 4,800 km (Li et al., 1998) to 4,809 km (Department of Irrigation and Drainage (DID) Malaysia, 2011). Malaysia has a marine jurisdiction of approximately 574,000 km^2 (CheeHai & Fauzi, 2006) and around 827 islands and 273 geographic entities and its marine jurisdiction is approximately twice that of land (1.75:1) (Hamid-Mosaku & Mahmud, 2009). Malaysia's jurisdiction over its marine environment (Figure 1-2 & 1-3) is split between the federal government and the local states' government. In international usage the term "states" refers to the local states that are separate governing entities within a federal State such as Malaysia, and every effort is made to adhere to this convention in this thesis, further strengthening it by using the term "local states" in order to distinguish them from the nation or federal State. Despite this, in the following quote from official documentation "State" refers to a local state, and so, according to Section 5 of the National Land Code 1965:

> "State Land" means all land in the State (including so much of the bed of any river, and of the foreshore and bed of the sea, as is within the territories of the State or the limits of territorial waters) other than:
>
> (a) alienated land;
>
> (b) reserved land;
>
> (c) mining land;
>
> (d) any land which, under the provisions of any law relating to forests (whether passed before or after the commencement of this Act) is for the time being reserved forest;

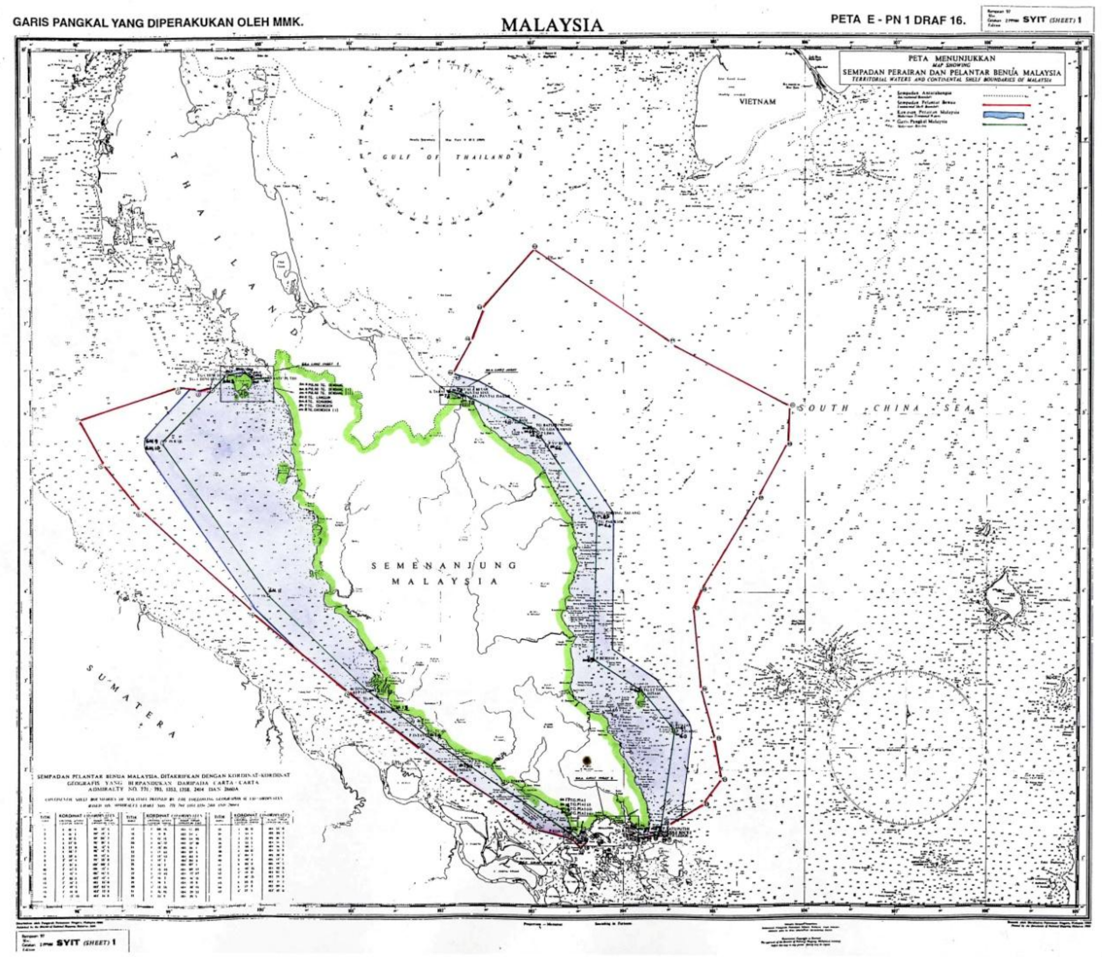

Figure 1-2 Map showing area of Peninsular Malaysia's maritime jurisdiction (JUPEM, 2007)

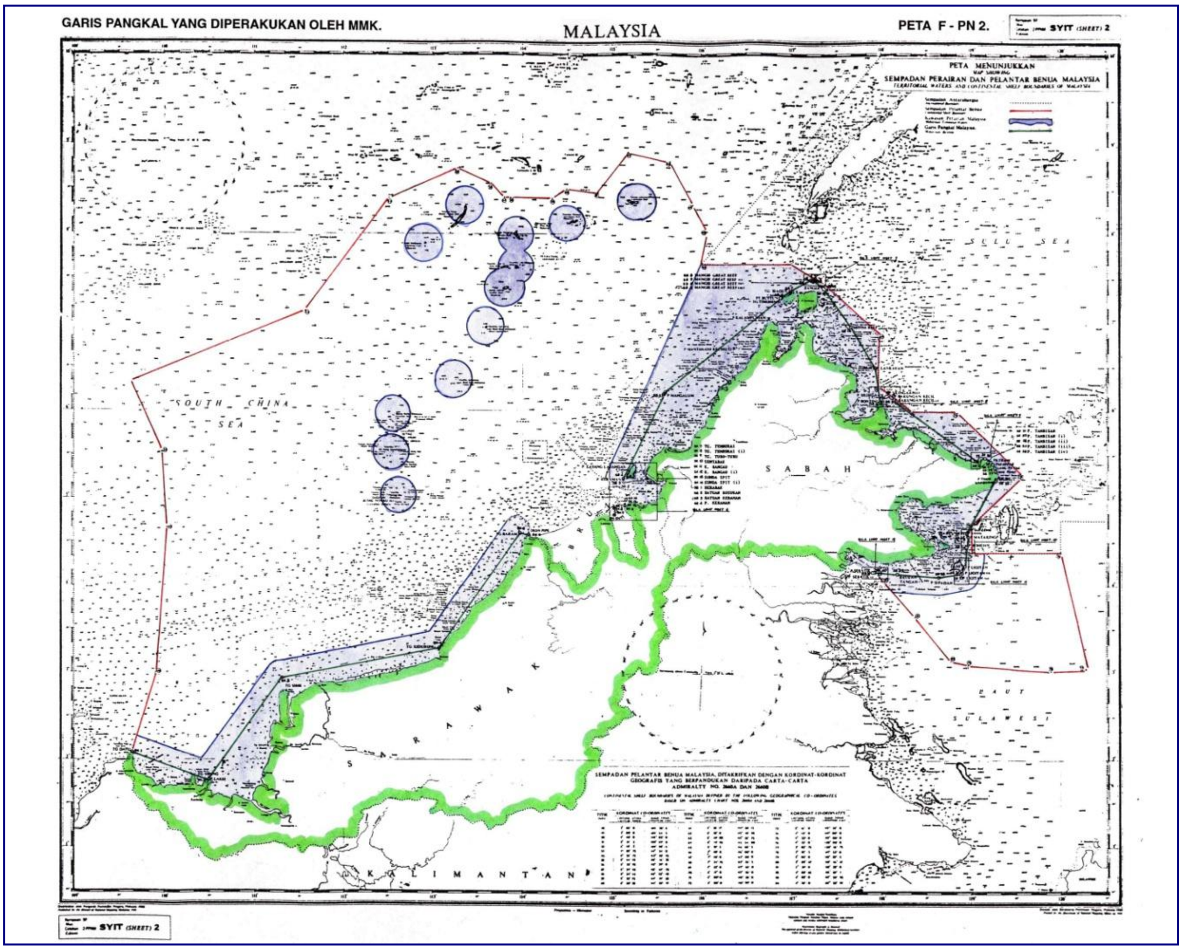

Figure 1-3 Map showing area of East Malaysia's maritime jurisdiction (JUPEM, 2007)

Meanwhile "territorial waters" has the meaning assigned thereto by sub-section (2) of section 4 of the Emergency (Essential Powers) Ordinance, No. 7/1969:

> For the purposes of the Continental Shelf Act 1966, the Petroleum Mining Act 1966, the National Land Code and any written law relating to land in force in Sabah and Sarawak, any reference to territorial waters therein shall in relation to any territory be construed as reference to such part of the sea adjacent to the coast thereof **not exceeding three nautical miles measured from the low-water mark.**

Coastal states within Malaysia have absolute jurisdiction over their coastal waters, which is the area seaward from the low-water line of ordinary spring tides for up to 3 nm, whereas seaward beyond 3 nm falls under federal government jurisdiction. According to Cheehai & Fauzi (2006) the Territorial Waters that fall under the local states' and federal government's jurisdiction are estimated as follows:

Local state jurisdiction (Coastal Waters - 3nm offshore)

- Peninsular Malaysia - 17950 km^2
- East Malaysia - 20250 km^2

Federal jurisdiction (Territorial Waters - *12nm offshore*)

- Peninsular Malaysia - 38800 km^2
- East Malaysia - 20300 km^2

(CheeHai & Fauzi, 2006)

Apart from the territorial waters of 12 nm, the estimated maritime areas encompassed by the 200 nm EEZ that fall under the federal jurisdiction are as follows:

- Peninsular East - 132,973 km^2
- Peninsular West - 68,747 km^2
- Sarawak - 155,938 km^2
- Sabah - 89,618 km^2

(Pauly, 2007)

Meanwhile, the National Security Council of Malaysia (MKN) summed up Malaysia's maritime zone extent as the following:

Table 1-1 Malaysia's maritime zone extent

Internal waters	97,306.83 km^2 37, 571 nm^2
Territorial waters/sea	63,665.3 km^2 24,581.85 nm^2
Continental Shelf	476,761.87 km^2 184,082.22 nm^2
Exclusive economic Zone	453,186.18 km^2 174,979.43 nm^2
Coastline length	4492 km - 1737 km (Sem. Malaysia) - 2755 km (Sabah/Sarawak)
Land to sea ratio	1 : 2

(MKN, 2010)

Within Malaysia's marine jurisdiction of approximately 574,000 km^2 lie substantial oil and gas reservoirs (Figure 1-4). The maritime areas encompassed by Malaysia held proven oil reserves of 4 billion barrels and proven natural gas reserves of 2.35 trillion $metres^3$ as of January 2010 (CIA, 2011). The dividends and taxes generated from all oil and gas exploration and production in Malaysia contribute almost half of the total Malaysian government's annual revenues. Malaysia's oil reserves are the third highest in the Asia-Pacific region and Malaysia was the world's tenth largest holder of natural gas reserves in 2010 and the second largest exporter of liquefied natural gas after Qatar in 2009 (EIA, 2010).

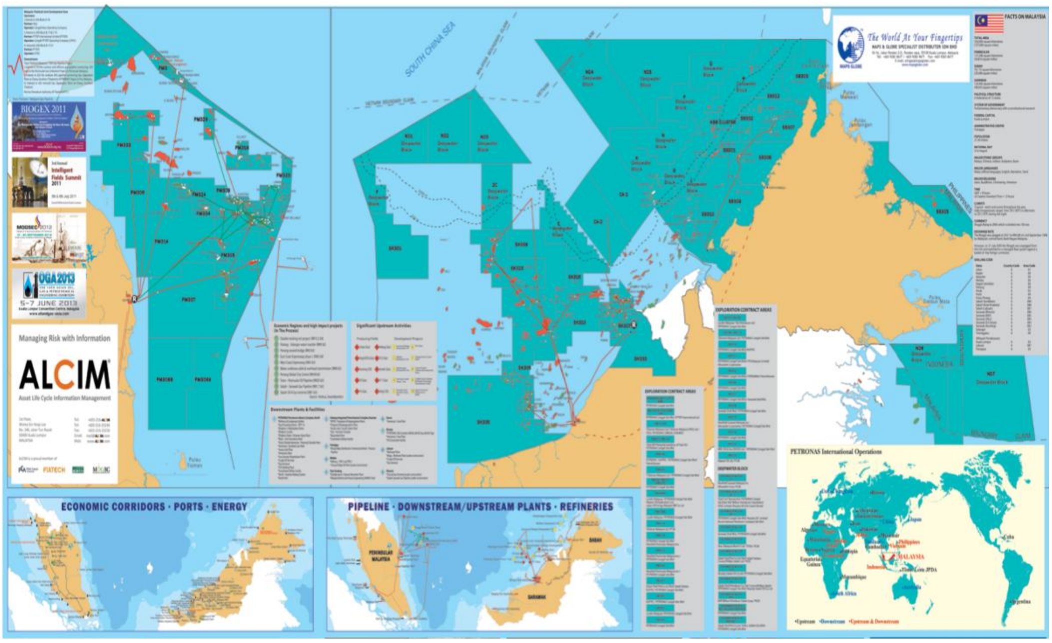

Figure 1-4 Malaysia's offshore oil and gas blocks
(Maps Globe, 2009)

While the sea off east coast of Peninsular Malaysia and East Malaysia (Sabah, Sarawak) are rich in oil and gas, the west coast of Peninsular Malaysia, the Strait of Malacca is highly valued in terms of cultural, economic, educational and historical aspects. The Strait of Melaka has been an important ancient trading route since the seventh century, and was conquered and colonised over time by the Portuguese, Dutch and British (JUPEM, 2009). Today, it remains as one of the world’s most important and longest shipping lanes used for navigational traffic (Ho, 2009), and it came in second only to the Straits of Dover in terms of density of navigational traffic (Euan, 2005), with approximately 60,000 vessels: one vessel every nine minutes (Shukla, 2012). Malaysia is also situated in a region of highly diversified coral, mangrove and seagrass environments, hosting important fishing grounds. Its coastlines are rich with mangrove vegetation and extended mudflats with rich habitats for many marine creatures (Figure 1-5). It is also gifted with a rich geological and cultural heritage (Figure 1.6), including:

1) Langkawi Island World Geoparks

2) RAMSAR sites (Kuching Wetlands National Park, Lower Kinabatangan – Segama Wetlands, Tanjung Piai, Pulau Kukup, Sungai Pulai) (RAMSAR, 2008)

3) UNESCO World Heritage Sites (Melaka & George Town)

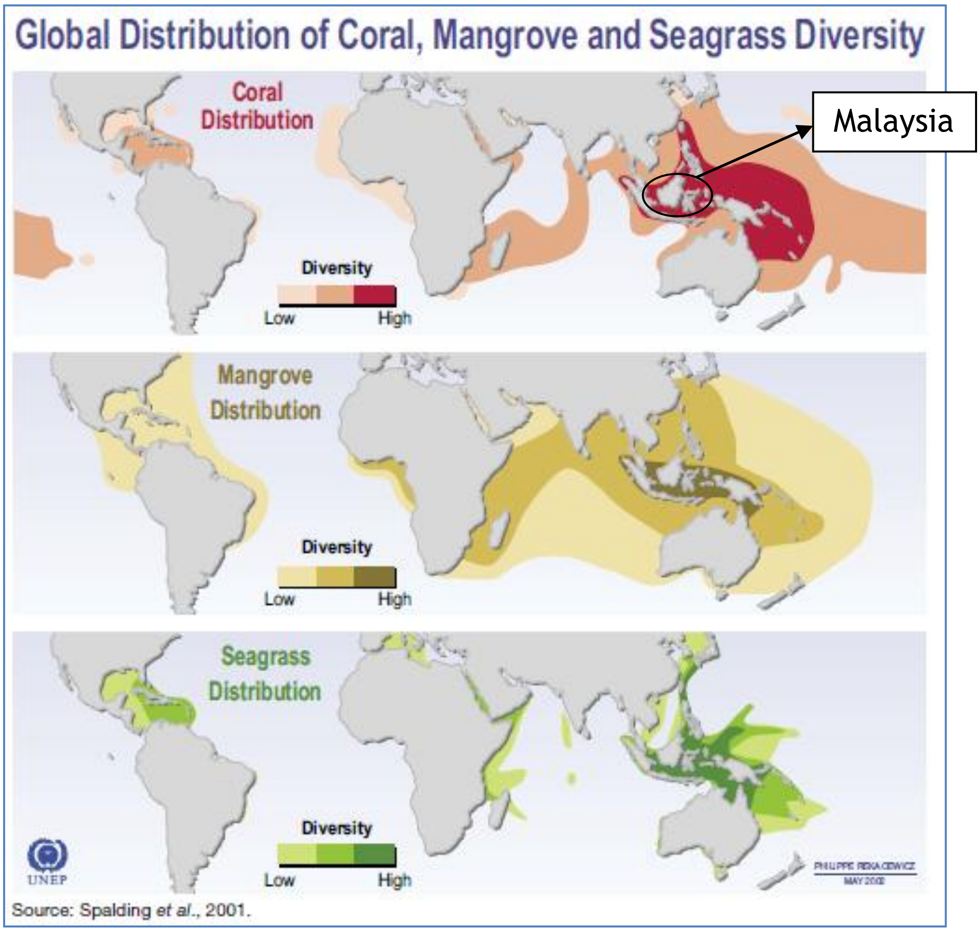

Figure 1-5 Global distribution of coral, mangrove and seagrass diversity (Rekacewicz & UNEP/GRID-Arendal, 2005)

Figure 1-6 Malaysia rich geological and cultural heritages

Malaysia's economy is highly dependent on its marine resources. The 10th Malaysia Plan (2011-2015), a comprehensive economic blueprint detailing the country's commitment and strategies to achieve various national goals has identified and focussed Malaysia's economic growth efforts on 12 National Key Economic Areas (NKEAs). An NKEA is defined as a driver of economic activity that has the potential to directly contribute a quantifiable amount of economic growth to the Malaysian economy. The 12 NKEAs are:

1. **Oil and gas**;
2. Palm oil and related products;
3. Financial services;
4. Wholesale and retail;
5. **Tourism**;
6. Information and communications technology;
7. Education;
8. Electrical and electronics;
9. Business services;
10. Private healthcare;
11. **Agriculture;** and
12. Greater Kuala Lumpur

(EPU, 2010)

Out of the 12 NKEAs, at least 25% are directly dependant or closely related to the maritime environment of Malaysia. Oil and gas alone contributed a total of RM68.3 billion or 13.1% of GDP (Gross Domestic Product) in the year 2009. Tourism in Malaysia ranked 16th in terms of global inbound tourism receipts, capturing approximately 2% of the global market share in 2008, benefiting largely from ecotourism; high value agriculture including swiftlet farming, aquaculture, seaweed, sago, ornamental fish etc contributed about 1% to GDP (EPU, 2010). It is estimated that marine and coastal tourism contribute about 20% to the GDP and that 95 per cent of Malaysia's international trade is carried through the oceans via its international seaports (MIMA, 2012).

To manage its marine resources and to fulfil Malaysia's obligations and responsibilities required by UNCLOS III in its maritime boundaries, it is essential to develop a robust marine cadastre.

1.3 Department of Survey and Mapping Malaysia (JUPEM)

The Department of Survey and Mapping Malaysia (JUPEM) is the national organisation providing survey and mapping services as well as geospatial data management in Malaysia. Its main functions are:

- to advise the government in the field of cadastral survey and mapping along with local states' and international boundaries;
- to provide complete and conclusive cadastral information for issuing land, strata and stratum titles;
- to manage efficiently the cadastral and mapping databases;
- to publish photographical, cadastral, thematic and utility maps for the purposes of planning, management of natural environment resources, preservation of environment, development, surveillance and security;
- to survey, determine, demarcate and maintain local states' and international boundaries for local states' administrative needs and the sovereignty of the country; and,
- to provide geodetic infrastructure for the purposes of cadastre survey, mapping, engineering and scientific research.

(JUPEM, 2011)

In addition, JUPEM also spearheads The National Committee on Mapping and Spatial Data, which has been mandated to formulate policies related to the use of geospatial technology, and acts as advisor to the government on mapping and spatial data issues. Under the 10th Malaysia Plan (2011-2015), JUPEM will embark on the Multi-purpose cadastre and the project is also likely to include maritime mapping and issuing titles for marine areas, with a pilot project in 2012 at Federal Territory of Putrajaya, Malaysia (Roy, 2011).

1.4 Marine Cadastre in Malaysia

A cadastre is a system registering the rights, interests and ownership of spatially determined land parcels and a marine cadastre is simply a cadastre system in the context of the marine environment. In a more elaborate sense, a marine cadastre has been defined as:

> A marine information system, encompassing both the nature and spatial extent of the interests and property rights, with respect to ownership, various rights and responsibilities in the marine jurisdiction.
>
> (Nichols et al., 2000)

During the Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP) session, Malaysia adopted the definition for the marine cadastre as defined by Robertson et al., (1999):

> A system to enable the boundaries of maritime rights and interests to be recorded, spatially managed and physically defined in relationship to the boundaries of other neighbouring or underlying rights and interests.
>
> (JUPEM, 2009)

It is clear from the above adopted definition of the marine cadastre for Malaysia that the emphasis is on the accurate spatial determination of marine parcels, within its international maritime boundaries. Realising the importance of effective and efficient management of marine resources within Malaysia's maritime territories, various studies have been carried out to identify the scope of the marine cadastre in the Malaysian context.

In parallel to this, the Malaysian government founded the Malaysian Centre for Geospatial Data Infrastructure (MacGDI) in 2002, as the nodal agency for the use of geospatial data within the country. MacGDI acts as the national centre for dissemination of geospatial data, and aims to establish a Malaysia Geospatial Data Infrastructure (MyGDI), to enhance awareness of data availability and to improve access to geospatial information, as well as developing partnerships among agencies to produce and share geospatial information to provide customer-focused, cost effective and timely delivery of geospatial data (Roy, 2011). Although the Marine Geospatial Data Infrastructure (MGDI) has been identified as one of the layers within the structure of the MyGDI, it is not yet operational. It has been suggested that a technical committee for Hydrography to oversee the implementation of MGDI needs to be established urgently (Hamid-Mosaku & Mahmud, 2009).

Thus the implementation of a marine cadastre in Malaysia is still at a rudimentary stage. Many issues which require intrinsic knowledge and a localised approach to the problems encountered remain to be addressed.

1.4.1 The Marine Cadastre's Boundary Issues

For a land cadastre, the boundary marks depicting the limit of the cadastre parcel are surveyed and demarcated on the ground. Its physical location is static, although its geographical coordinates might change due to a shift in horizontal land datum caused by natural phenomena such as earthquakes. Such events only result in the recalculation of new coordinate values for the boundaries of a land cadastre parcel without physically shifting the parcels, or altering their existing limit. Compared to land cadastre, a marine cadastre boundary is delimited, not demarcated, and generally there is no physical evidence, only mathematical evidence left behind (Carrera, 1999). Basically there are two types of spatial concerns on the sea:

- Three dimensional location of a marine parcel within a maritime zone
- Maritime rights of a designated target group within a maritime zone

The former involves the delimitation of ownership within the confines of a marine parcel, while the latter involves the confinement of activities within a zone. The dynamism of the coastline determined by, among other things, sea level, waves, currents, winds, and the added issues of coastal erosion and deposition over time, may all cause the baseline to migrate over time. However a shifting marine parcel would be unattractive to prospective developers. To avoid spatial uncertainty, very often a marine parcel will be defined in relation to a land datum, yet the determination of maritime rights within the Territorial Sea of a coastal country are measured from the maritime baseline.

Therefore the aim here is to investigate an approach to determine the baseline, so that the most up to date location of the baseline at a given location can be calculated. Depending on the availability of data, this method should also be able to pinpoint the past and future location of a shifting baseline to assist any marine cadastre users to administer and exercise their responsibilities and rights with confidence within their marine parcel. However, the maritime baseline for a marine cadastre (which is the low-water line) is different from the international maritime baseline, because the international maritime baseline is not always the low-water line. The determination of the international maritime baseline is more complex and requires an in-depth knowledge of the coastline, involving not just the low water mark, but must take into consideration low tide elevation, fringing reefs, islands, bays etc, depending on the topographic and geographical configuration of the coastline. It also depends on whether a country adopts a normal baseline, straight baseline, an archipelagic baseline or a combination of these baselines, and each has a strict criterion under UNCLOS III. Having said that, the methodology developed in this research still has relevance in determining the international maritime baseline segment which involves the low water line.

1.5 Research Aims and Objectives

Whether it is to manage a country's maritime environment via a robust marine cadastre system or to safeguard its sovereignty in international maritime boundary disputes, it is important to determine the maritime baseline precisely and keep its location up to date. The fundamental premise behind the present research is that a methodology can be identified for this purpose, and recommendations can be made as to how to best manage the baseline. These aims can be achieved overall by establishing the following objectives:

Objective 1

Determination of the baseline location:

- Identify data acquisition methods and their accuracy.
- Investigate the integration of land and sea data.
- Define the low-water line at various vertical datums.

Objective 2

Review the maritime baseline policy of other countries.

Objective 3

Investigate Malaysia's coastline management and development policies and deliver recommendations regarding the management policies for a maritime baseline.

1.6 Thesis Structure

Chapter one provides the background and overview of Malaysia's interest in managing its maritime space, by examining the maritime boundary claimed by Malaysia under UNCLOS III; the roles of JUPEM as advisor for the government of Malaysia; the development of marine cadastre and its issues; and detailing this research aims and objectives.

- 1 Introduction
  - 1.1 United Nation Convention on the Law of the Sea 1982 (UNCLOS III)
  - 1.2 Malaysia Maritime Jurisdiction
  - 1.3 Department of Land Survey and Mapping Malaysia (JUPEM)
  - 1.4 Marine Cadastre in Malaysia
    - 1.4.1 The Marine Cadastre's Boundary Issues
  - 1.5 Research Aims and Objectives
  - 1.6 Thesis Structure

Chapter two addresses the concept and importance of baselines at both national level (for marine cadastre) and international level (for international maritime boundary), and reviews tidal datum and State mapping practice from several major maritime countries.

- 2 Establishing Maritime Baselines
  - 2.1 Maritime Baselines
    - 2.1.1 Law of Baseline
    - 2.1.2 International Maritime Zone
    - 2.1.3 Marine Cadastre Baseline
  - 2.2 Review of Tidal Datums and State Practice

2.2.1 Tidal Datum

2.2.2 Maritime Jurisdiction between Federal and Local States' Governments

2.2.3 Publication, Revision and Recording of Baseline

2.2.3.1 Baseline Publication

2.2.3.2 Baseline Revision

2.2.3.3 Baseline Recording

Chapter three covers the methodology of this research and focuses on the data requirements.

3 Methodology for Determining the Low-Water Line

3.1 Introduction

3.1.1 What needs to be established?

3.1.2 How is it to be established?

3.2 Methods Review

3.3 Site Selection

3.3.1 Case study area – partly rocky, steep gradient and partly fine sand, low gradient, low turbidity

3.4 Data Requirements and Data Gathering

3.5 Tests Analyses and Results

3.5.1 Test Results

3.6 Summary

Chapter four reports on the fieldwork planning, execution and results obtained.

4 Determining Low-water Line at Case Study Area

4.1 Data Acquisition

4.2 Data Analysis

4.2.1 Generation of DTM

4.2.2 Test of Linearity

4.2.2.1 DGPS vs. SRTM

4.2.2.2 DGPS vs. ASTER

4.2.2.3 DGPS vs. NEXTMap

4.2.2.4 DGPS vs. Bathymetry

4.2.3 Error DTM

4.2.4 Generation of Low-Water lines

4.2.4.1 Highest Astronomical Tide (HAT)

4.2.4.2 Mean Low Water Spring (MLWS)

4.2.4.3 Lowest Astronomical Tide (LAT)

4.2.5 Different between observed and predicted tide values

4.2.6 Sea-level change rates and future estimates

4.2.7 Environmental and economy impact of a receding low-water line

4.3 Discussion

Chapter 5 aims to highlight Malaysia's current policies related to coastal management and development that may have an impact on the placing of the maritime baseline (low-water line)

5 Malaysia's Current Coastline Management and Development Policies: Implications for the Maritime Baseline

5.1 Introduction

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7 Conclusions and Future Work

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2 ESTABLISHING MARITIME BASELINES

To understand the concept of maritime baselines, this chapter will touch briefly on the history of baselines, and then consider the relevant provisions in UNCLOS III that mention the roles and types of baselines in determining various maritime zones. The maritime baseline used for the international maritime boundary and marine cadastre with reference to Malaysia will be highlighted. Finally, the adoption of various vertical datums in different coastal countries will be reviewed.

2.1 Maritime Boundaries

2.1.1 Law of Baseline

The maritime baseline is basically the low water line along the coast where the established low water datum intersects the shore. The baseline in the modern world is governed and dictated by law codified in the 1982 United Nations Convention on the Law of the Sea (UNCLOS III). However, in earlier times coastal countries used to adopt the 'cannon shot' law to determine the limit of their territorial sea. A coastal country would lay claim to the furthest seaward length of a shot from a shore based cannon. As a result there was no fixed width of this territorial sea and hence no need for a baseline; the limit of territorial sea varied among coastal countries (Caron, et al., 2008). As uncertainty in the limit of territorial water is undesirable and complicates matters when a coastal country exerts it sovereignty, the cannon shot law gradually evolved into the practice of territorial water with a fixed width. In 1793 the new United States of America (USA) was the first to claim a fixed width of territorial water in response to issues of national security and law enforcement at coastal areas (United States Office of Coast Survey, 2012). But Prescott (1987) pointed out that Sweden was the first to claim a continuous zone of territorial sea of 3 nm on 9 October 1756, and the origin of the concept of 'territorial waters were continuous' dated back as far as 1598 when Denmark had been reserving exclusive fishing grounds around Iceland within 2 leagues (4 nm) of the coast. The modest claim of three nautical miles territorial water was proposed by Galiani in 1782 and received general acceptance mostly because it had been successfully employed by Sweden since 1756 (Prescott, 1987), and this distance is believed to be based on the greatest distance that the force of gunpowder could carry a bomb or a canon ball at that time. The location of the baseline suddenly became the most pressing question in coastal countries trying to exert such a fixed width (Caron, 2008). The importance of the baseline grew as coastal countries sought to extend their seaward territory beyond 3 nm when technology advanced rapidly and interest in the sea and seabed resources increased. With the codification of the UNCLOS, the baseline became the most important feature in delineating all maritime zones and the continental shelf of a coastal country.

According to UNCLOS III, there are three types of baseline, namely normal baselines, straight baselines and archipelagic baselines. Generally speaking, the normal baseline is the default baseline for a coastal country and it is the low-water line along the coast as marked on large-scale charts officially recognized by the coastal State. When a coastline is deeply indented and cut into, fringed with islands or highly unstable areas, straight baselines may be employed in accordance with the provisions in UNCLOS III. Archipelagic baselines can only be applied by archipelagic States 'joining the outermost points of the outermost islands and drying reefs of the archipelago' (United Nations, 1982). A typical coastal country which is not an archipelagic State and does not fulfil the criteria to employ straight baselines can only employ normal baselines, whereas a coastal country that is eligible to employ straight baselines can choose to employ a mix of normal and straight baselines, while an archipelagic country may employ a mix of all three types of baseline. Archipelagic baselines undoubtedly encompass the largest areas of sea compared to the other two types of baseline, but there are only a handful of archipelagic States in the world. Most of the rest use either normal or straight baselines. For obvious reasons, the employment of straight baselines will most likely incorporate a greater area of territorial sea than would a normal baseline; therefore many coastal countries have opted to employ the straight baseline system. Although the legitimacy of straight baselines adopted by some coastal countries are disputable, the temptation to lay claim to marine resources that may be barely outside their maritime jurisdiction proved far too great to resist and many coastal countries are willing to risk protests from the international communities, indeed some will go as far as to treat the lack of protest as a sign of acquiescence. According to Roach & Smith (2000), of the more than 150 coastal

States, more than 60 have delimited straight baselines along portions of their coast while a summary tabled by the Division for Ocean Affairs and the Law of the Sea (DOALOS) as at 15 July 2011 showed that out of 163 countries, 92 countries have legislation provided for straight baseline systems, and 22 States claim archipelagic status (DOALOS, 2011).

The Department of Survey and Mapping Malaysia (JUPEM) commenced the survey of Malaysia's baselines in 1998. A total of 159 base points have been surveyed for the whole of Malaysia, with 95 base points in the Peninsular Malaysia and 64 base points in East Malaysia. The base points for the determination of baseline had been surveyed mainly using three conventional and labour intensive methods: geodetic survey using GPS (Figure 2-1), photogrammetry using aerial photography and hydrographic survey. A bill listing the base points coordinates had been submitted to and later approved by the Cabinet and The Baselines of Maritime Zones Act 2006 (Act 660) was subsequently enacted (JUPEM, 2007). Section 5(2) of Act 660 read:

> (2) Notwithstanding subsection (1), in respect of any area for which geographical co-ordinates of base points have been declared under section 4, the **method of straight baselines** interpreted as geodesics joining the consecutive geographical coordinates of base points so declared may be employed for determining the maritime zones of Malaysia.
>
> (Malaysia, 2006)

Although Malaysia has enabled legislation for straight baselines, it has not formally declared or promulgated its straight baselines to the United Nations. In 1979 Malaysia produced a new map depicting its territorial sea and maritime areas encompassed by a straight baseline system. This map was contested by neighbouring countries claiming that parts of Malaysia's inferred baselines do not conform to the specifications in the Convention. However, other than unilaterally publishing a new map in 1979 and enacting The Baselines of Maritime Zones Act in 2006 to provide legislation for Malaysia's straight baseline system, Malaysia has not formally declared its baseline to United Nations. Therefore although the international community is aware of Malaysia's intention, other than Malaysia's immediate neighbouring countries, others choose to ignore

Malaysia's claim and deemed Malaysia is adopting a normal baselines system by default. It may be that the procrastination in publishing Malaysia's baseline will render Malaysia's claim invalid in the eyes of the international community and may risk national security in instances where foreign vessels violate Malaysia's internal waters (produced by straight baselines). The validity of Malaysia's boundaries in the absence of declaration to the United Nation and the international community at large is thus at question. This was evident in 2003 when a case was brought in the High Court of Singapore when a ship sunk in the alleged 'internal waters' of Malaysia, which raised the question of the validity of Malaysia's baseline and territorial sea claims in the northern Malacca Strait (Valencia, 2003). Another similar case in 2009 involved Romania/Ukraine where the International Court also ruled that the claimed baselines may be found to be legally ineffective against other States in the absence of required publicity, as may be inferred from the reference to Article 16(1) (Symmons & Reed, 2010). A lack of publicity leading to a lack of protest cannot be interpreted as a sign of acquiescence. Nevertheless even if a maritime space is claimed and published:

> …a national claim to a maritime space which encroaches on the 'high seas' must be acquiesced in by the international community as a whole. **It is not a matter of unilateral acts, or even *res inter alios acta* between two or more coastal States.**

(Kittichaisaree, 1987)

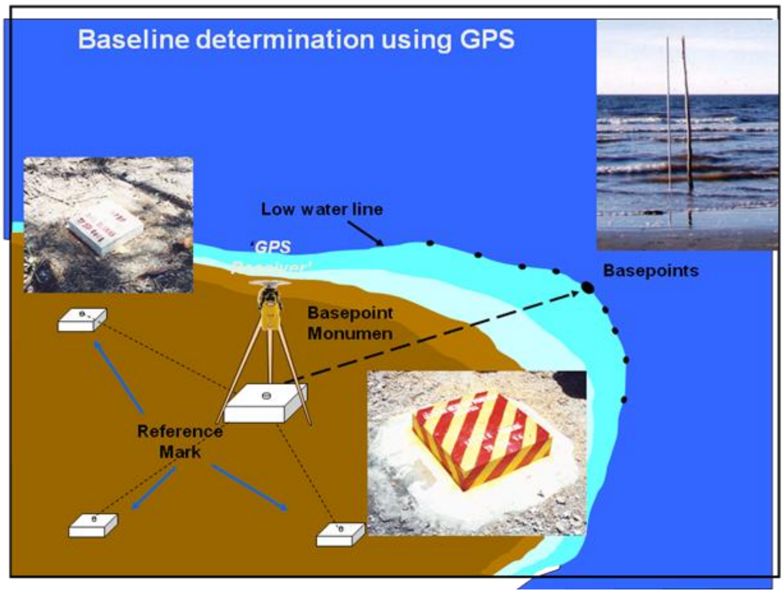

Figure 2-1 Baseline determination using GPS method
(JUPEM, 2007)

2.1.2 International Maritime Zone

As provided in UNCLOS III, all maritime limits are to be measured from the baseline (Figure 2-2). The waters on the landward side of the baseline are considered to be internal waters. Territorial Sea is a band of water measured 12 nm from the baseline over which a coastal State enjoys absolute sovereignty. The Contiguous Zone is extended from the territorial sea up to a distance of 24 nm from the baseline; within this zone a coastal country may exercise jurisdiction over matters such as customs and immigration. The rights in this zone are limited and do not extend to security interests (Prescott & Schofield, 2005). The Exclusive Economic Zone (EEZ) is a new concept introduced by the 1982 UN Convention as a compromise to satisfy coastal States' interest and demands to tap into new marine resources offshore. It is confined to 200 nm from the baseline and it enabled coastal States to explore, exploit, and conserve living and non-living resources in this area as defined by Part V of the Convention (Figure 2-3). Meanwhile a coastal country's continental shelf comprises the seabed and subsoil of the submarine areas measured up to 200 nm from the baseline. It is the only maritime zone that is permanently delimited and will not be affected by a shifting baseline once a coastal country described the outer limits of its continental shelf and deposited it with the Secretary-General of the United Nations. Every coastal country is entitled, if geographically permitted, to claim the full suite of maritime zones or any maritime zone permitted under UNCLOS III up to, but not more than, the limit stipulated.

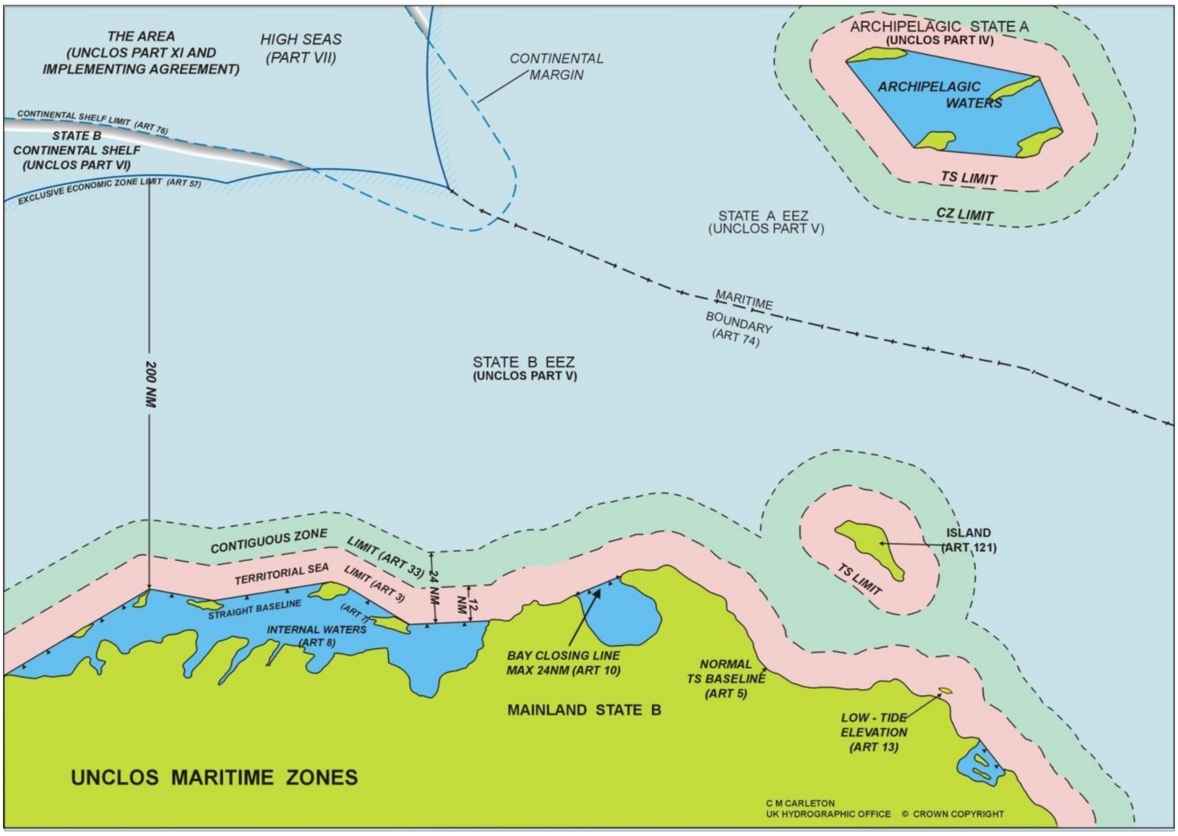

Figure 2-2 Schematic map of maritime zones, limits and boundaries (Carleton & Schofield, 2001)

Malaysia has claimed 12 nm of territorial sea, 200 nm of EEZ and 200 nm of continental shelf accordingly. The 1982 UN Convention entered into force for Malaysia on 13 November 1996. Prior to that, Malaysia had entered into several treaties with its neighbouring countries regarding its maritime territory. These treaties are between Malaysia-Indonesia (1969-1970) regarding the territorial sea and continental shelf in the Strait of Malacca, Malaysia-Indonesia-Thailand (1971) for a partial delimitation of their common maritime boundary, Malaysia-Thailand (1979) on Gulf of Thailand and part of the Straits of Malacca, and between Malaysia-Singapore (1995) on the Johor Strait following the Johor Territorial Waters Agreement of 1927 (United States Department of Defence, 2005). Malaysia and Vietnam signed a Memorandum of Understanding in 1992 to jointly explore and exploit petroleum resources in area of overlapped continental shelf claims (Anderson, 2003). Both countries also jointly submitted their claims on the continental shelf to the UN on 2009 (DOALOS, 2009).

Like many coastal countries that claim the maximum maritime area allowable under UNCLOS III, these results in overlapping jurisdictions and Malaysia has boundary disputes with almost all its neighboring countries. These include disputes over the Sipadan-Ligitan Island in the Celebes Sea between Malaysia and Indonesia, solved by The International Court of Justice (ICJ) with both islands awarded to Malaysia in 2002; the dispute of Pedra Branca, Middle Rocks and South Ledge with Singapore in 2008, ended with decisions by the ICJ to award Pedra Branca to Singapore, Middle Rocks to Malaysia and South Ledge belongs to the State in the territorial waters of which it is located (Tanaka, 2008), unresolved disputes of Louisa Reef, Rangau, Terusan, Lawas, Limbang with Brunei, Spratly Islands with Vietnam, Philippines, China/ Taiwan (Salleh et al., 2009). The loss of Pedra Branca to Singapore had rendered obsolete Malaysia's basepoint no.66 (on Pedra Branca (JUPEM, 2007) and used to define part of Malaysia's straight baseline system at the Strait of Singapore). These results are significant to the coastal countries involved because they end decades of territorial disputes in perpetuity and ultimately change the maritime landscape belonging to both coastal countries and resulting in a permanent gain or loss of maritime territory.

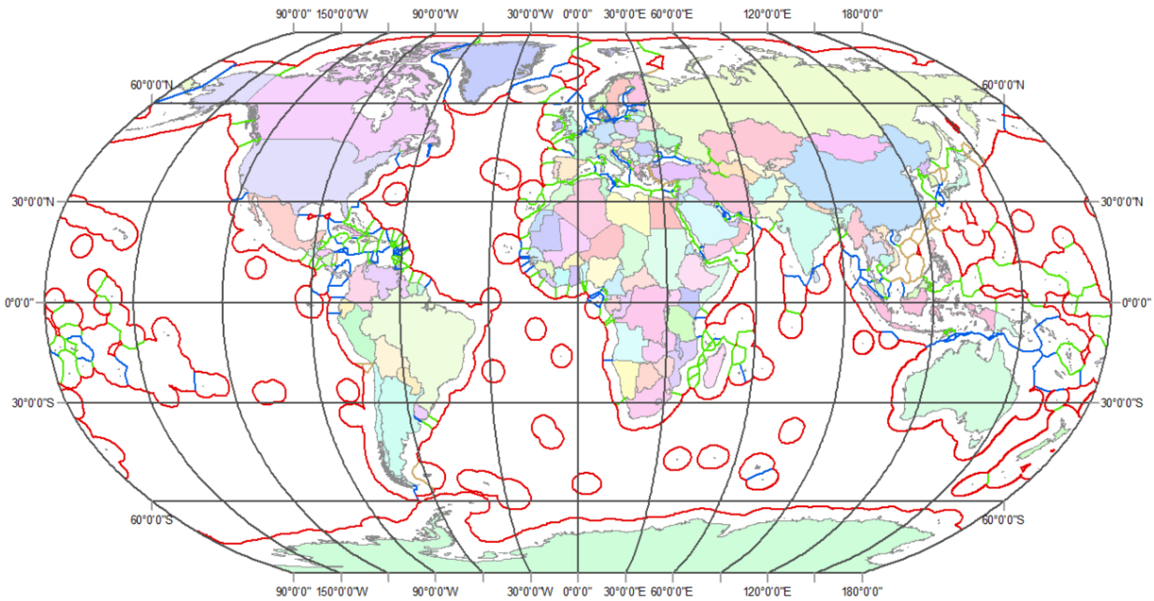

Figure 2-3 Map showing the EEZ of the world
(Flanders Marine Datacentre, 2011)

2.1.3 Marine Cadastre Baseline

A marine cadastre system should cover the whole maritime jurisdiction of a coastal country from the coastline to the end of its international maritime limits. It should include the administration and management of all ownership and rights from internal water up to the continental shelf. The baseline is arguably the most important attribute in a marine cadastre system; for it depicts where the land cadastre ends and where the marine cadastre begins and ends. Despite this importance, the issue of baseline determination in marine cadastre is seldom comprehensively addressed.

The National Land Code (Act 56 of 1965) of Malaysia (NLC) is an Act:

> '…to amend and consolidate the laws relating to land and land tenure, the registration of title to land and of dealings therewith and the collection of revenue therefrom within all the (local) states in Peninsular Malaysia'.
>
> (Malaysia, 1965)

The NLC is the overarching law governing the land cadastre in Malaysia; but it has no mention of the marine cadastre. However the NLC does define territorial waters to have the meaning assigned by sub-section (2) of section 4 of the Emergency (Essential Powers) Ordinance, No. 7/1969, and this ordinance defines the limit of local states' land as 'not exceeding three nautical miles measured from the low-water mark'. It is clear from this definition, that:

- A local state's maritime jurisdiction starts from a 'low-water mark'.
- A local state has a marine jurisdiction for a distance not exceeding three nautical miles.

Therefore this low-water mark as defined in the 1969 Ordinance can be indirectly construed as the marine cadastre baseline for Malaysia; it has also indirectly defined the limit of the marine cadastre that falls under a local state's jurisdiction.

Furthermore, Article 3(1) of the Emergency (Essential Powers) Ordinance, No. 7/1969 also mentioned territorial water shall be measured in accordance with the principles of the Geneva Convention on the Territorial Sea and Contiguous Zone (1958), therefore accordingly whatever maritime baseline applied by

Malaysia to define its international maritime boundary, the same baseline shall be used to define the local states' maritime boundary. Legally empowered by this Ordinance, if Malaysia applies a straight baseline, theoretically its State should also have its marine jurisdiction measured from a straight baseline.

2.2 Review of Tidal Datums and Nation States' Practices

2.2.1 Tidal Datum

Datum is a reference surface from where points, lines or surface are measured. A horizontal datum describes the latitude, longitude of a measurement whereas a vertical datum describes the heights. Tidal datum is one of the vertical datums to which the height of the predicted tide is referred (Antunes, 2000).There are various tidal datums in use by different countries, such as Mean Sea Level (MSL), Mean High/Low Water Springs (MH/LWS), Mean High/Low Water Neap (MH/LWN), and Highest/Lowest Astronomical Tide (H/LAT), etc. These are the common high or low water datums. Some countries adopted a more empirical tidal datum such as Mean Lowest Low Water (MLLW), Nearly Lowest Low Water (NLLW), etc (Antunes, 2000).

To seek uniformity in the tidal datum used in nautical charts of various countries, the International Hydrographic Bureau (IHB) issued Circular Letter 55/2003 seeking information regarding the implementation of LAT/HAT in the member States and the International Hydrographic Organisation (IHO) compiled a list during the 6th Tidal Committee Meeting held in Lisbon, Portugal from 11-13 October 2004 detailing the responses of the member States (Figure 2-4). Out of a possible 74 member States, 31 responses showed that 12 countries are currently using LAT/HAT, 8 countries are converting to LAT/HAT, 11 countries are not converting to LAT/HAT due to practicality considerations, and 6 countries indicated they would publish charts both showing their existing datum and LAT/HAT (IHO, 2004). According to the International Federation of Surveyors (FIG) 'most nations, if not already using LAT, are moving towards its use' (FIG, 2006).

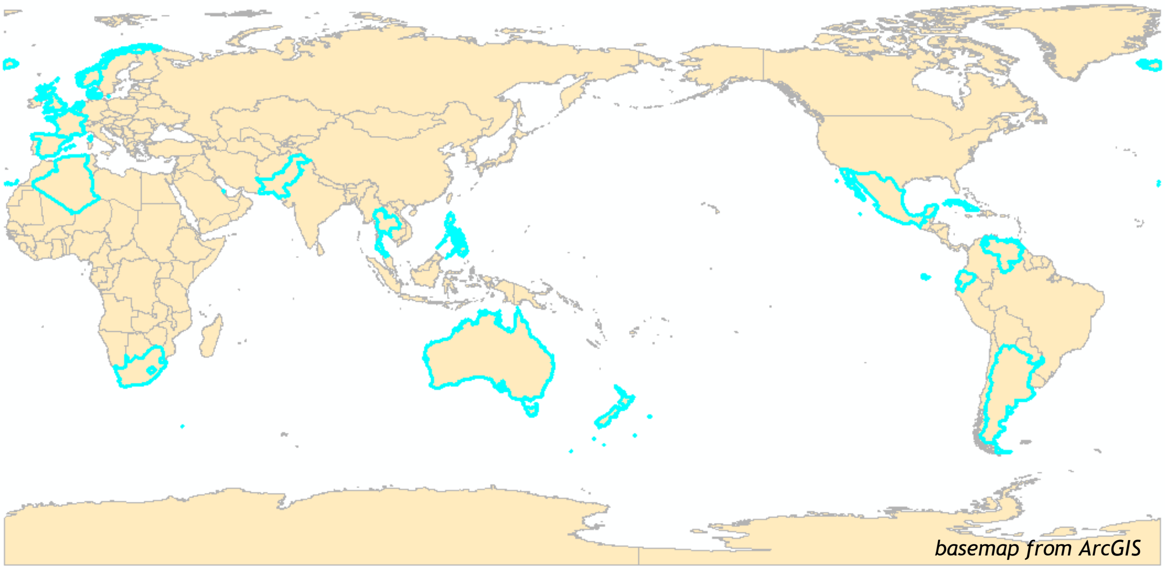

Figure 2-4 Map showing Member States of IHO implementing and converting to LAT/HAT in 2004

The selection of tidal datum used in nautical charts is important in the sense that the low-water line generated will be used to measure the breadth of the territorial sea of a coastal State. In order to maximise the claimable maritime area, a coastal State ought to carefully study the various advantages or shortcomings of using a particular tidal datum in their coastline. The selection of a tidal datum is not only vital in the determination of the international maritime boundary, it is also important in harmonising local states' baseline definitions within a country. However this is not always the case and many countries have contradicting baselines between its federal and local states' governments.

2.2.2 Maritime Jurisdiction between Federal and Local states' Governments

Coastal countries used to have only 3 nm of territorial sea under the canon shot law in the 17th century. During that period, it was likely that the territorial sea was either entirely under the jurisdiction of local states or federal government. When coastal countries begin to extend their territorial sea to 12 nm in accordance to UNCLOS III, the maritime jurisdiction is then both split and shared between the local states and federal government, or totally controlled by either local states or federal government. What transpires today is many coastal countries' federal government share their maritime jurisdiction with their local states' governments, normally with local states' government maritime jurisdiction retained at 3 nm from the cannon shot law period, and the remainder belonging to federal government.

An example of this is the United States of America, where previously all maritime areas fell under the jurisdictions of local states. In the late 1700s, the newly founded United States government asserted sovereignty over a 3 nm territorial sea from the coast with the coastal states asserting their jurisdiction out to 3 nm. In 1947 the United States Supreme Court determined that the United States, rather than coastal states, had paramount rights over the nation's coastal waters and resources. This ruling was met with displeasure by the local states, who challenged the federal government in the court. Although the federal government won the case on the grounds 'that the federal government's responsibility for the defence of the marginal seas and the conduction of foreign relations outweighed the interests of the individual states' (United States, 1953), the Congress adopted the Submerged Lands Act (SLA) in 1953, granting title to the natural resources located within three miles of their coastline to the local states, and enactment of Outer Continental Shelf Lands Act of 1953 that established federal jurisdiction beyond 3 nm (The Resources Agency of California, 1995). The low-water datum adopted by the U.S. is Mean Lower Low Water (MLLW) but the low-water datum adopted by its local states is inconsistent, from datums such as Mean Higher High Water (MHHW) (e.g. Texas) to Mean Low Water (MLW) (e.g. Delaware), mainly due to the different periods when the individual coastal state entered the Union (Fowler & Treml, 2001).

In the United Kingdom of Great Britain and Northern Ireland (U.K.), the foreshore is managed by bodies like The Crown Estate, the Duchies of Lancaster and Cornwall, etc. and leased to third parties such as local authorities, port authorities, statutory bodies and government departments. The jurisdiction of the whole maritime zone basically belongs to the reigning monarch 'in right of The Crown', but managed by others on behalf of the central government. There are different national assemblies and parliaments within the countries in U.K, which in some respects is the equivalent of a state government. These 'states governments' generally manage the whole suite of maritime zones adjacent to their shore, but their jurisdiction ultimately falls under the control of the central government (The Crown Estate, 2012). For example the U.K. Parliament devolved certain powers and responsibility to Scotland (Table 2-1) for marine activities within Scotland's maritime limits (Figure 2-5).

Table 2-1 UK Parliament devolved certain powers and responsibility to Scotland for marine activities within Scotland's seas.

Activity	Within 12 nm	12 to 200 nm
Fishing	Devolved	Devolved
Aquaculture	Devolved	Not applicable
Nature and conservation	Devolved	Reserved
Harbours & harbour orders	Devolved	Not applicable
Control of land-based discharges (WEWS Act)	Devolved	Not applicable
Planning	Devolved	Reserved
Coast Protection Act	Devolved	Not applicable
FEPA	Devolved	Executively devolved
Renewable energy	Executively devolved	Executively devolved
Telecommunications	Reserved	Reserved
Oil and gas	Reserved	Reserved
Shipping	Reserved	Reserved
Historic heritage	Devolved	Reserved

(The Scottish Government, 2008)

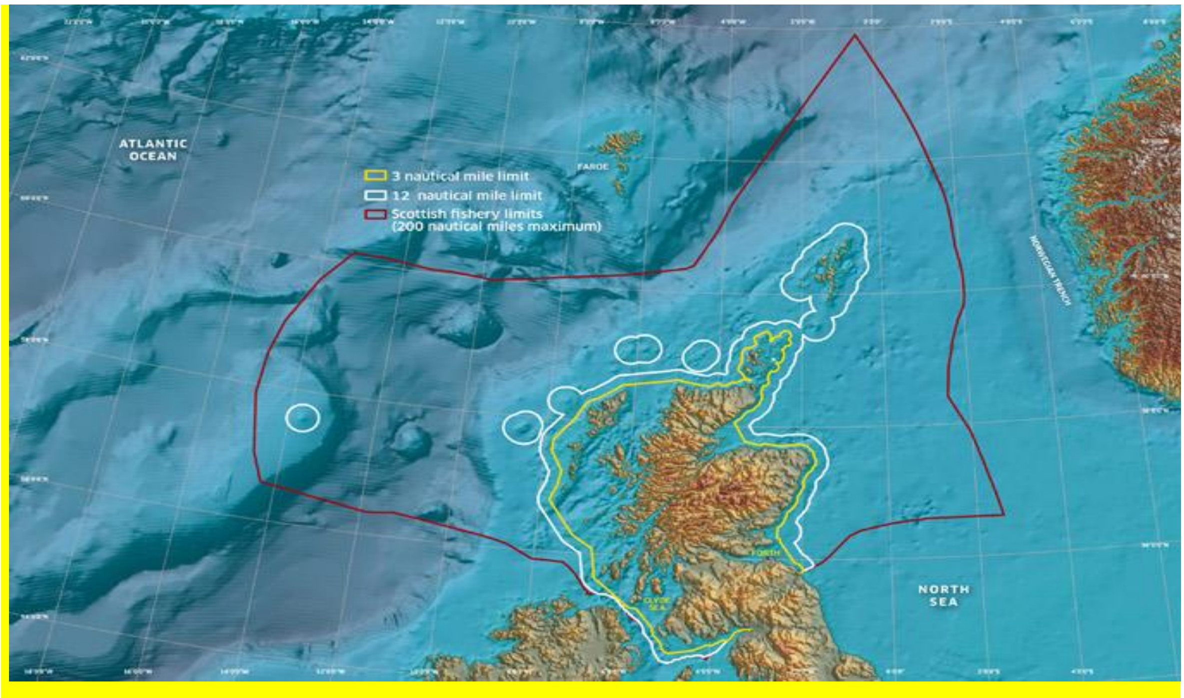

Figure 2-5 Scotland’s maritime limits
(Natural Scotland, 2012)

Australia originally claimed 3 nm of Territorial Sea under the 1958 Convention on the Territorial Sea and the Contiguous Zone but extended its claim to 12 nm in 1990 under the 1982 Convention, consequently handing over its original jurisdiction over the water column and the subjacent seabed up to 3 nm to six states and one territory government (Collier et al., 2002). Although Australia adopted LAT for its normal baseline, the terminology use to describe its states’ foreshore is inconsistent among legislation and jurisdiction, and this spatial ambiguity has hinder the implementation of marine cadastre (Collier & Quadros, 2006).

Indonesia has a decentralisation policy and devolves much of its authority to its provincial and local government. The Regional Autonomy Act No.22/1999 (revised as 32/2004) stipulates that jurisdiction 3nm from the shoreline falls under local government, 3 – 12 nm from the shoreline falls under provincial government and the rest falls under the federal government (Siry, 2006). However according to Kay & Alder (2005) the ambiguity in interpreting the law has led the central government to revise it to make it clear that the regional and local government are merely representing the central government in their respective jurisdiction and that central government has the ultimate jurisdiction to Indonesia's whole suite of maritime boundaries.

In Malaysia, maritime jurisdictions over its seas are split between the federal and the local states' government. Local states' governments retain full jurisdiction up to 3nm from the low-water line, while the rest fall under the jurisdiction of the federal government. Meanwhile the local states' governments are responsible in implementing states & federal government policies in their respective district.

A summary of the above is shown in Table 2-2 below.

Table 2-2 Review of tidal datums practises

Coastal Countries	Local states' governments* retain full control over Coastal Water** (Yes/No)	Chart Datum		Low-water datum (Baseline) adopted by	
		LAT	Others	Local states	Federal
USA	Y		MLLW	Inconsistent (MHHW, MLW, etc) (Fowler & Treml, 2001)	MLLW
UK	N	√	-	N/A	LAT
Australia	Y	√	-	inconsistent (MLW, MLWS, etc) (ICSM, 2011)	LAT
Indonesia	N	√	-	LAT	LAT
Malaysia	Y	√	-	MLWS	LAT

* In this context, the term "states" refers to the individual local states' governments that are a separate governing entity from the federal government.
**For most countries, coastal water is usually 3 nm from the baseline.

Current worldwide development does show a global trend of countries heeding the calls of IHO toward harmonising the tidal datum, either by converting to LAT or publishing charts relating existing datum to LAT. It also shows that some countries have inconsistent definitions of low-water datums between their local states and federal government.

2.2.3 Publication, Revision and Recording of Baseline

2.2.3.1 Baseline Publication

The need to publish and deposit with the United Nation the baseline used by a coastal country to determine its international maritime boundaries, or the limits of certain maritime zones whether on charts or listed in geographical coordinates, or both, are dealt with in Articles 16 (straight baselines), 47 (archipelagic baselines), 75 (exclusive economic zone), 84 (continental shelf) of UNCLOS III. It is noted that however a literal interpretation of all these articles seems to exempt States that employ normal baselines from the responsibility to publish and deposit with the United Nation (Prescott & Schofield, 2005), and this may be due to the fact that normal baselines are sufficiently published in navigational charts as required by Article 5. In the Malaysian case, the straight baselines implied in Emergency (Essential Powers) Ordinance No. 7, 1969 remained unpublished. Although Malaysia has enacted a Baseline of Maritime Zones Act 2006, reiterating the use of the straight baseline system, the fulfilment of domestic lawmaking is unlikely to be deemed as Malaysia satisfying the United Nation requirement for publication. To implement its marine cadastre, it is critical for Malaysia to publish and gain international recognition and acceptance of its maritime zones generated from its straight baseline system.

2.2.3.2 Baseline Revision

The location of the baseline is not fixed because of the dynamism of coastline processes that change its topography and position. The actual location of the baseline at a specific time in a strict sense may never be known and at best only predicted, and may only stay valid for a very short period of time and thus very soon become obsolete. Therefore for any arguments or litigation involving the location of the baseline, the newest available survey data that shows the baseline should be preferred over the last published, potentially outdated charts. Although some countries might argue that the charted baseline is the legal document that prevails over the actual baseline position, we should be aware that the frequency of updating the charts rest solely on the coastal States and is not bound by UNCLOS III. Some coastal countries might abuse this loophole and be unwilling to update its actual baseline location if it disadvantages them compared to the current mapped baseline location. Every country should endeavour to acquire up to date baseline information of its coastline, regardless of how frequently it wants to review or change its baseline. This will help policy makers to make decisions and to provide evidence for any legal disputes.

2.2.3.3 Baseline Recording

The Office for Ocean Affairs and the Law of the Sea (DOALOS) states that the range of large-scale chart requirements set forth by Article 5 may lie between 1:50 000 and 1:200 000 (DOALOS, 1989). However the location of a normal baseline derived from a chart will likely be ambiguous as the accuracy of the information on a chart is a function of the scale and there will be some degree of uncertainty to the exact location of a normal baseline (Hirst & Robertson, 2003). Therefore although there is no requirement to deposit the normal baseline in the form of charts or lists of coordinates with the United Nations, advances in today's GIS technology make it relatively easy for coastal countries to generate lists of coordinates for any normal baseline should the need arise. As navigation charts are primarily produced for safety of navigation and not for maritime boundary determination purposes, it is best to record the most up to date location of the baseline digitally in a GIS environment, and produce a specific maritime baseline chart tailored for the determination of a maritime boundary, with disclaimers stating the actual baseline prevail against the chart if the discrepancy is greater than a certain tolerance. This will eliminate any disputes that arise from the difference between the location of baseline derived from paper charts and actual baseline shown in GIS.

3 METHODOLOGY FOR DETERMINING THE LOW-WATER LINE

This chapter will outline the approaches adopted here to determine the low water line. It will briefly review existing techniques and methods, describing site selection criteria and its possible shortcomings, identifying data requirements and data gathering, and end with a test analysis.

3.1 Introduction

3.1.1 What needs to be established

This main aim is to establish the position of the low-water line at a specific tide datum, particularly at Lowest Astronomical Tide (LAT) and Mean Low Water Spring (MLWS). These are the chosen low-water datums for the determination of the international maritime boundary and the local states' maritime boundary in Malaysia. The data requirements require overlapping DTMs of both land and sea, and local tide gauge data spanning the period of DTM acquisition. Identifying rates of sea-level change is also useful for future estimates of changes in the position of the datum over time.

3.1.2 How is it to be established

Conventionally, the low water line is determined using labour intensive ground survey methods such as geodetic survey using a Total Station or GPS to survey the coastline during low-tide, or acquiring aerial photographs to digitise the coastline, or via hydrographic survey to determine the zero contour line. All of these methods suffer from the fact that they are labour intensive and do not facilitate the re-determination of movement in the low-water line without resurvey. This research seeks to utilise the littoral zone DTM model and tide data to derive the constantly shifting low-water line in a GIS environment. This method has the ability to derive multiple low-water lines instead of just one, and predict its future location based on tidal predictions and estimates of sea level change. The concept of this research's methodology is outlined in Figure 3-1.

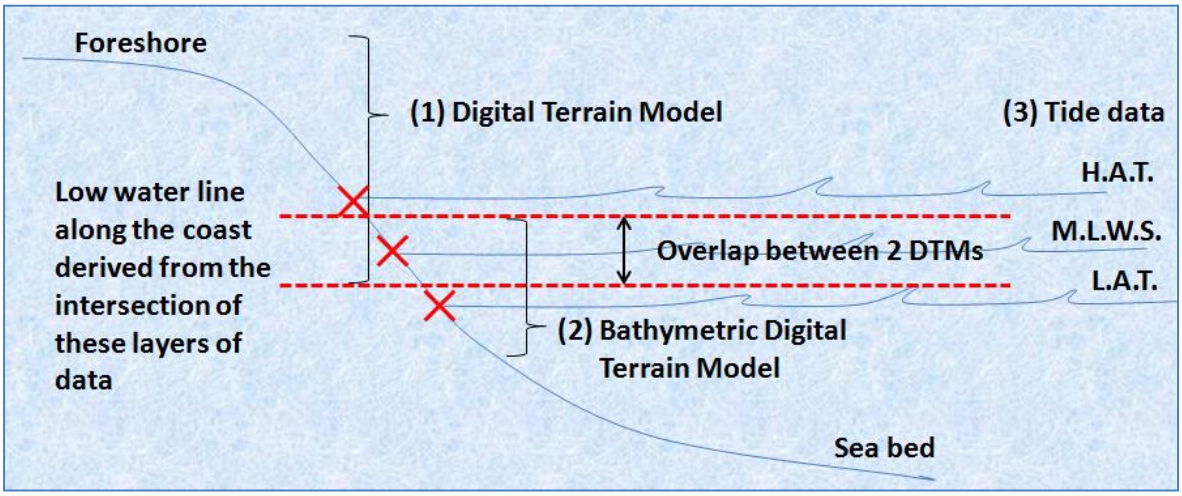

Figure 3-1 Concept of research methodology used here

3.2 Methods Review

There are various methods and technologies in acquiring terrain data, and it can be categorised into two major categories: terrestrial-borne and airborne/space-borne. Common terrestrial-borne methods and technologies used to acquire terrain data are via Total Stations, and Differential Global Positioning System (DGPS), while less common methods include Terrestrial Laser Scanning (TLS). Whereas some widely used airborne/space-borne methods are aerial photogrammetry, Airborne Laser Scanning such as LiDAR and satellite imagery. Terrestrial-borne techniques have proven to be the most accurate and precise techniques for acquiring terrain data, with Total Stations generally producing height accuracy within +/- 0.03 m, GPS +/- 0.05 m (Jonas & Byrne, 1999) and TLS generally +/- 0.05–0.25 m (Coveney et al., 2010). The terrain data from highly accurate terrestrial-borne methods are often used to validate airborne/space-borne terrain data.

However terrestrial methods are extremely labour intensive, time consuming and only suitable for acquiring terrain data over small areas. Most terrestrial methods, with the exception of TLS, suffer from the fact that its data are usually not sufficiently dense to accurately represent complicated terrain surfaces. Meanwhile, airborne/space-borne methods are mainly used in acquiring terrain data of large areas because of their efficiency, acceptable accuracy for most applications and their ability to produce realistic models of rugged terrain.

Generally, commercially available aerial photogrammetry can produce DTMs with a vertical accuracy ranges of 5 to 50 cm and image resolution ranges from 5 to 50cm, LiDAR with image resolution ranges of 15 to 40 cm can produce DTMs with vertical accuracy ranges of 10 to 50 cm, while high resolution (less than 1m) satellite imagery are able to produce DTMs with +/- 2 m vertical accuracy (AAM, 2010). Most users agree that LiDAR is the most promising technology in acquiring terrain data whether in dense forest areas (Jonas, 2007) or in the coastal zone (Quadros & Collier, 2008a). Jonas summed up the merit of using various methods in a typical scenario like densely forested area:

> …the fact remains though that, in densely vegetated areas, LiDAR remains the most efficient survey technology available. Photogrammetry won't work in such timber. Field GPS would not receive the signals through the canopy. High precision IFSAR does not penetrate vegetation; the penetrating P-band radar cannot obtain the accuracy of LiDAR.
>
> (Jonas, 2007)

However airborne/space-borne methods are not cost effective for the survey of small areas. The pros and cons of various methods have been widely discussed and are well understood although technological advances over the years have made significant improvements in data quality, wider coverage, shorter acquisition times etc, but the fundamental limitation surrounding each method's nature remains unchanged.

Depth measurement or bathymetric survey is conventionally performed via echo sounding. Single beam echo sounding is usually used in the survey of small areas whereas multi-beam echo sounder is used in the survey of larger areas. The advances in technologies have made it possible to acquire bathymetry of nearshore areas using airborne methods such as Synthetic Aperture Radar (SAR) (Marghany & Hashim, 2011) and dual-frequency LiDAR (Danson, 2006). However the acquisitions of depth measurements using airborne methods are usually limited to the shallow waters of the coast, and its efficiency and accuracy (vertical accuracy +/- 50cm, horizontal accuracy +/- 5m) (Quadros et al., 2008) is affected by various factors such as water turbidity, surface water velocity, sediment thickness, surf wash, and nature of the sea floor.

The inter-tidal zone is an important area that serves various public interests and it also defines the maritime boundaries of national and local authorities. The increasing demand for inter-tidal zone DTMs require the nearshore topography and bathymetry to be mapped efficiently and regularly. However most technologies are not able to acquire both topography and bathymetry simultaneously to a satisfactory level of accuracy, and the separate acquisition of nearshore topography and bathymetry has resulted in terrain data integration difficulties caused by gaps, limited overlapping areas, data noise, different data resolution and use of different height datums, etc (Quadros & Collier, 2008b).

In Malaysia, most of the DTMs produced by JUPEM are taken from photogrammetric analysis. DTMs derived from LiDAR are uncommon and confined to certain special project areas. It is in the interest of this research to look at the feasibility of deriving low-water lines for small coastal areas using timesaving and cost effective methods, and to investigate the possibility of utilising land-based satellite elevation data such as SRTM, ASTER GDEM, and NEXTMAP to derive satisfactory low-water lines.

Meanwhile tide data is usually collected using a range of tide gauge instruments consisting of different measuring systems. Tide gauges set up along the coast observe and record sea level heights over extensive time periods. The harmonic constants derived from analysis of tide data enable tides to be accurately predicted (+/- 0.3m) (Baily, 2009).

3.3 Site Selection

Malaysian coastlines consist mainly of three sediment types: mud, sand and rock (Figure 3-2). The majority of coastal sediments along the west coast of West Malaysia consist mainly of muds which include sections of mangrove and swampy areas. While the east coast of West Malaysia consists mainly of low gradient sandy beaches. East Malaysia coastlines have an equal distribution of muddy and sandy coastlines.

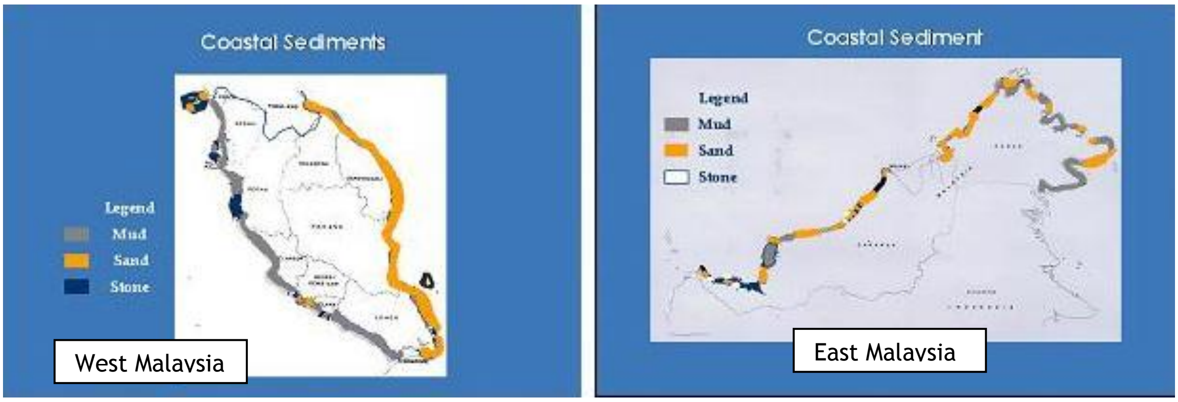

Figure 3-2 Coastal sediments along Malaysian coastlines
(Department of Irrigation and Drainage (DID) Malaysia, 2011)

In order to investigate the effectiveness of the chosen DTM acquisition technique in coastal contexts similar to Malaysia and accessing how accurate the generated low-water line might be, a study area has been selected from a similar site in Scotland where a range of data exist, the method was then tested on these data and should be applicable to the Malaysian context.

3.3.1 Case study area – partly rocky, steep gradient and partly fine sand, low gradient, low turbidity

A case study area was identified in Kames Bay, Millport on Great Cumbrae Island, Scotland (Figure 3-3). This area was selected as it has several of the required characteristics. It has both a steep rocky section and a low angled sandy section. Crucially it is also the site of a fully instrumented and calibrated National Oceanography Centre (NOC)/ UK Hydrography Office (UKHO) tide gauge so that cross-calibration of tidal characteristics is convenient.

Based on the information inferred from the Ordnance Survey map and Google Earth, the shoreline of Great Cumbrae island consists mostly of a stable rock platform, with the exception of Ballochmartin Bay at the eastern side of the island made up of a narrow strip of sand and gravel over ~1.6 km, and Newton and Kames Bays located at the southern end of the island are mainly composed of sand spanning a distance of ~360 m and ~280 m respectively. Kames Bay has the widest sandy littoral zone (~160 m from MHWS to MLWS).

A coastal zone assessment survey for Firth of Clyde carried out between October and December 2002 by Sneddon (2003) classified the rock foreshore in Great Cumbrae Island as currently stable with low rates of change, and Kames Bay sandy beach as stable.

Figure 3-3 Case study area: Kames Bay, Millport, Scotland

Any Scottish study area has limitations in that there are no mangroves or swampy areas that are commonly found along parts of the Malaysian coastline. However, the rocky and sandy study sites do have extensive counterparts on the Malaysian coastline and so the method should be transferable into that context.

3.4 Data Requirements and Data Gathering

There are four datasets that needed to be acquired and manipulated to satisfy the requirements of this research (Figure 3-4):

i. Tide data prediction of the heights of LAT, MLWS and Highest Astronomical Tide (HAT) at the field site. Tidal data for Kames Bay is obtained from the National Oceanography Centre (NOC)/ UK Hydrography Office (UKHO).
ii. Foreshore DTMs derived from DGPS surveys are needed: simple yet highly accurate method for small area terrain mapping. Satellite imageries,

where available, and of high enough quality, will allow direct comparisons to be made of the error and accuracy of the DTMs.

iii. Bathymetric DTM derived from echo sounding are needed: DGPS or LiDAR. DGPS linked echo-sounding is the favoured route in the absence of dual-frequency LiDAR.

iv. Past sea level trends and estimates of future changes in sea level are needed: past trends are available in the literature and future estimates from the UKCP09 UK Government website.

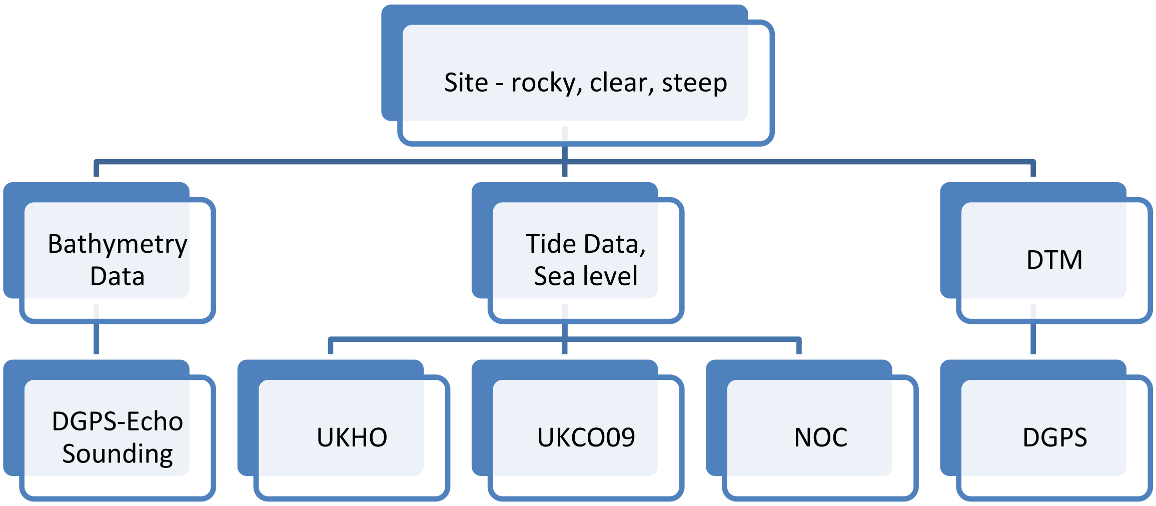

Figure 3-4 Overall Research Sources

3.5 Test Analyses and Results

Test analyses were carried out for the site using DTMs derived from Edina Digimap using the method outlined above, in order to investigate whether DTMs acquired primarily for land applications and deep sea bathymetric DTMs can produce satisfactory low-water lines (Figure 3-5). For this purpose, the following data were used:

i. Ordnance Survey 10m resolution profile DTM (5km by 5km)(version November 2009) from Edina Digimap (Digimap, 2009b).

ii. 6 arc second grids (~180m cell size) bathymetric DTM from Edina Marine Digimap (released 16 January 2008) (Digimap, 2009b).

iii. 1:10 000 scale raster backdrop map (version June 2011) from Edina Digimap - Ordnance Survey raster dataset (Digimap, 2009b) and Admiralty Chart (Leisure chart folio SC 5610 3rd edition)(Hydrographic Office, 2008).

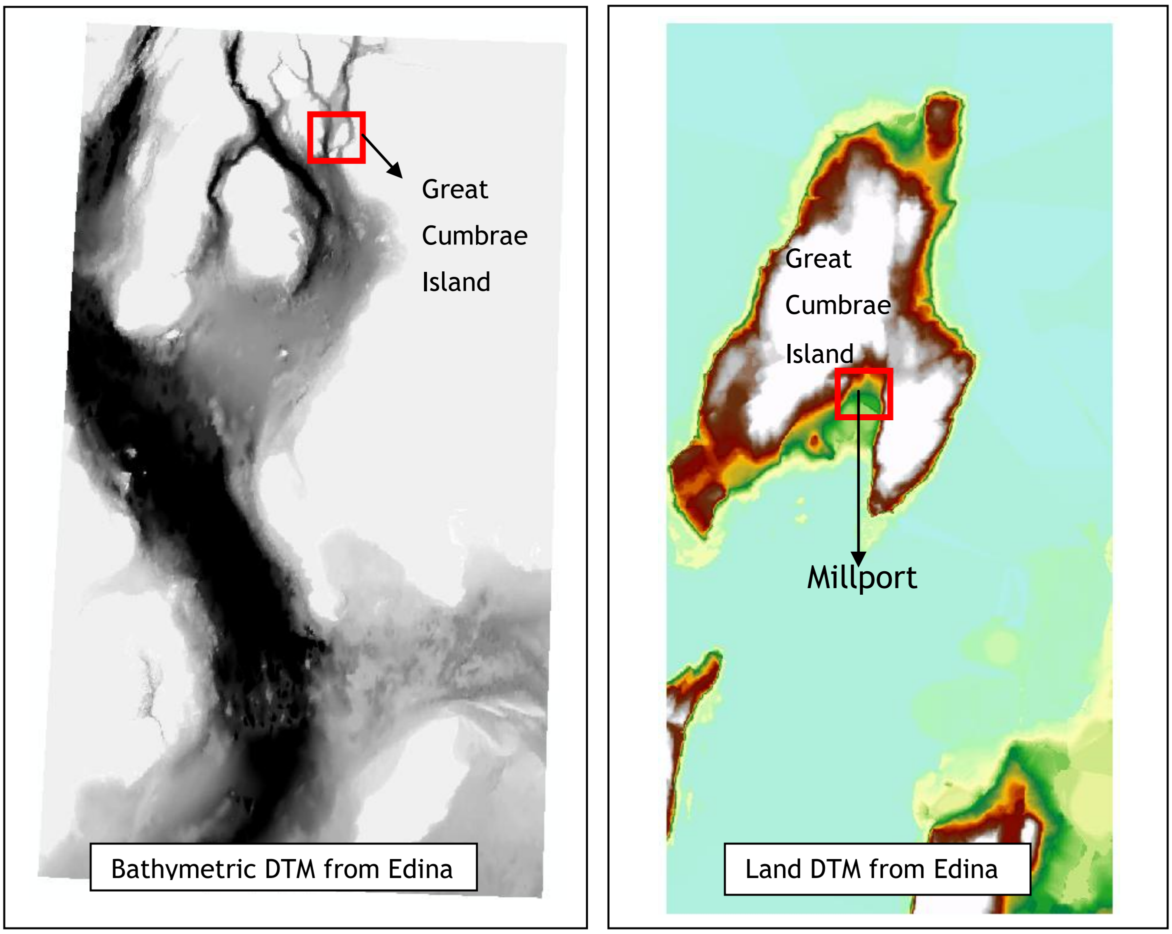

Figure 3-5 DTMs used for test analyses

All the above data were brought into ArcMap 10.0 (Build 2800) and projected onto the British National Grid. The Ordnance Survey raster dataset and Admiralty Chart were subsequently added as basemaps to enable comparison of the existing low-water line to the generated low-water lines. The reference level of the depth data in the bathymetry layer approximates to LAT chart datum (CD) (Seazone, 2012), however the height information of Edina DTMs are relative to Ordnance Survey datum (OD). Therefore the HAT, MLWS and LAT values obtained from NOC which are relative to chart datum (CD) have to be converted accordingly (Table 3-1).

Table 3-1 Heights of low-water lines in Chart Datum transferred to Ordnance Datum

Millport's low-water datum heights prediction (2008-2026):	In Chart Datum (metres)	In ODN (metres)
HAT	3.860	2.240
MLWS	0.440	-1.180
LAT	-0.040	-1.660

(National Oceanography Centre, 2012a)

3.5.1 Test Results

The Edina land DTM covered the height range of -2.2 – 137.6 m; meanwhile bathymetric DTM from Edina marine covered the height range of -310 – 7 m. At a glimpse, the bathymetric DTM resolution is simply too coarse for determining any meaningful low-water lines. Any height value above 0m in a bathymetric DTM is also doubtful and unreliable as in most cases bathymetric DTMs are designed to give depth information and not land elevation. This is evident since both HAT and MLWS line cannot be generated for Kames Bay, Millport. Meanwhile the LAT generated from the bathymetric DTM showed a grossly generalised and different location of LAT compared to the LAT line shown in Admiralty Chart (Figure 3-6).

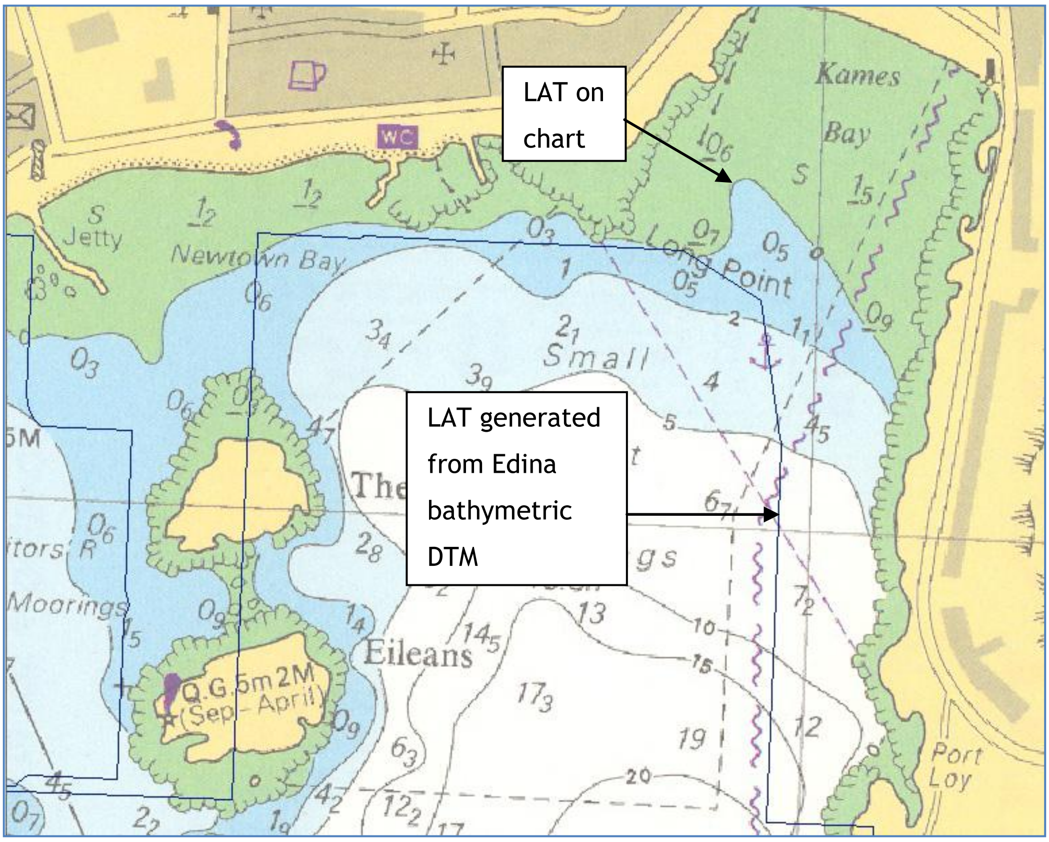

Figure 3-6 Comparison of LAT generated from Edina bathymetric DTM with LAT shown in Admiralty Chart

The Edina land DTM has a significantly higher resolution than the bathymetric DTM, but they are primarily intended to portray accurate land topography rather than marine topography. Results show a HAT that is correctly located landward of Mean High Water Spring (MHWS) indicated in Ordnance Survey raster map, but closer examination casts doubt on the reliability of the HAT, when the rather odd shape of HAT cuts across houses that should lie on the same height contour, and shows the front but not the rear part of houses inundated by sea water during HAT, particularly evident in the east of Kames Bay (Figure 3-7). A cross-check with the Indicative Flood Mapping of the Scottish Environment Protection Agency (SEPA) for Kames Bay confirmed the inundated area showed by the HAT line generated from the Edina land DTM to be unreliable; hence the accuracy of the HAT itself is questionable (Figure 3-8). Meanwhile it is clear that the Edina land DTM has insufficient or unreliable depth data to generate both MLWS and LAT around Kames Bay and can only generate scattered and discontinued low-water lines.

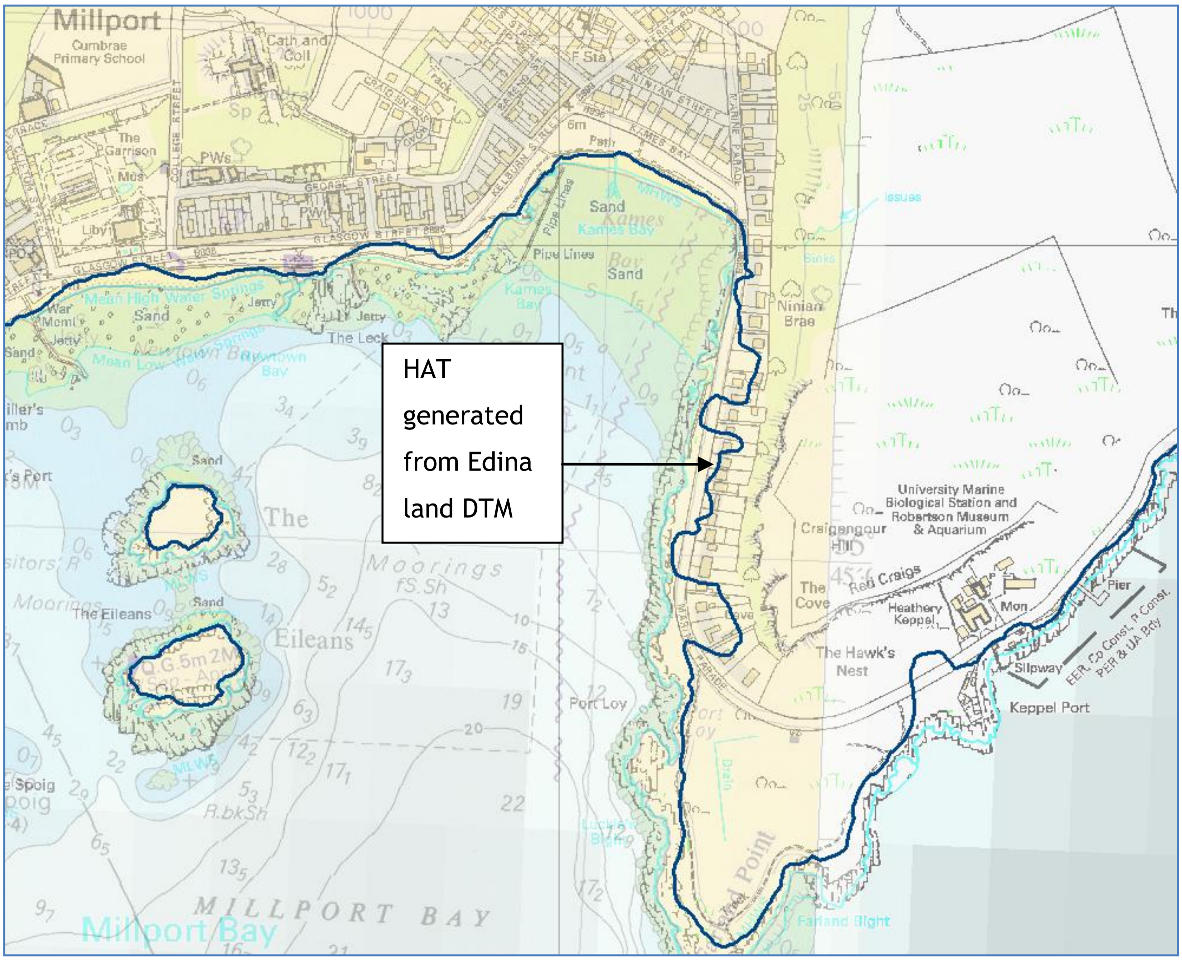

Figure 3-7 Inaccurate HAT line generated from Edina land DTM

Figure 3-8 SEPA flood warning target area
(SEPA, 2012)

3.6 Summary

These tests nonetheless indicate that it is possible to generate low-water lines from DTMs with the method outline above. It is a more efficient method compared to conventional methods such as manually digitising low-water lines from aerial photography. Once the height of a low water datum relative to the height datum of the DTM is known, it is possible to derive the specific low-water line. However these tests also highlight some major obstacles in deriving low-water lines using land based DTMs and low resolution bathymetric DTMs. Firstly most land-based DTMs do not have heights below 0 m, and of those which do are probably interpolated and thus unreliable. Even for low-water lines above 0 m, such as HAT, that are generated from land-based DTMs can be unreliable, as showed in Figure 3-7. Secondly, the vertical accuracy of most land-based DTMs drops when it approaches the coastline, as is the case with Edina DTM, and the resolution of most bathymetric DTMs resolution are simply not high enough to represent the coastline accurately, as showed in the bathymetric DTM used in the test. These tests demonstrated that a dedicated coastline survey has to be carried out, covering the foreshore and nearshore bathymetry, if an accurate and reliable low-water line is to be determined using this method.

The next chapter will detail the execution of the method outlined in this chapter with fieldwork carried out at Kames Bays. DTMs generated from the DGPS and bathymetric surveys will be compared to a range of third party DTMs such as SRTM, ASTER GDEM, and NEXTMAP, with results statistically analysed.

4 DETERMINING LOW-WATER LINE AT CASE STUDY AREA

Kames bay of Millport on the Great Cumbrae Island of Scotland was selected as the case study area because it has both a steep rocky section and a low angled sandy section which resemble parts of the Malaysian coastline. Fieldwork was carried out in order to investigate the effectiveness of the technique introduced in Chapter 3. This chapter will detail the processes of data acquisition, data analyses, interpretation of the result for the fieldwork carried out at the case study area.

4.1 Data Acquisition

The DGPS and echo sounding fieldwork was carried out to acquire a terrestrial DTM and a bathymetric DTM of Kames Bay on 7 and 8 June 2012, across a spring tide at Millport. The case study area has a coastline length of ~920 m (~280 m flat sandy beach, ~640 m rocky steep shoreline) and a total area of ~150,000 m^2 (Figure 4.1). The land elevation data was collected using a Leica GPS1200 (accuracy 20 mm + 1 ppm, kinematic) (Leica Geosystems, 2006) and a Leica Smartnet with a GS08 Antenna. The bathymetric data was collected using a 5.5m rigid-inflatable boat (RIB) vessel with a 0.4m draught carrying a SONARLITE echosounder (accuracy 0.025m RMS) (Euronet, n.d.) linked to a Leica Smartnet rover. The Smartnet base station was set up on shore within 2 kilometres of the furthest bathymetric data point. The bathymetric survey was carried out within 2 hours of high water on the 7th June 2012. Soundings were taken as far inshore as possible without running aground and extended well seaward beyond any historically plotted position of LAT. The acquisition of the land DTM was carried out within 2 hours of low water on the 8th June 2012 in order to maximise the overlap area. The ellipsoidal heights of the DGPS and bathymetric surveys were subsequently converted relative to Newlyn (UK Ordnance Survey datum, ODN). The data produced a large overlapping area (MHWS-MLWS) of approximately 150m from the two sets of DTM (Figure 4-2).

Figure 4-1 Millport during low tide and high tide

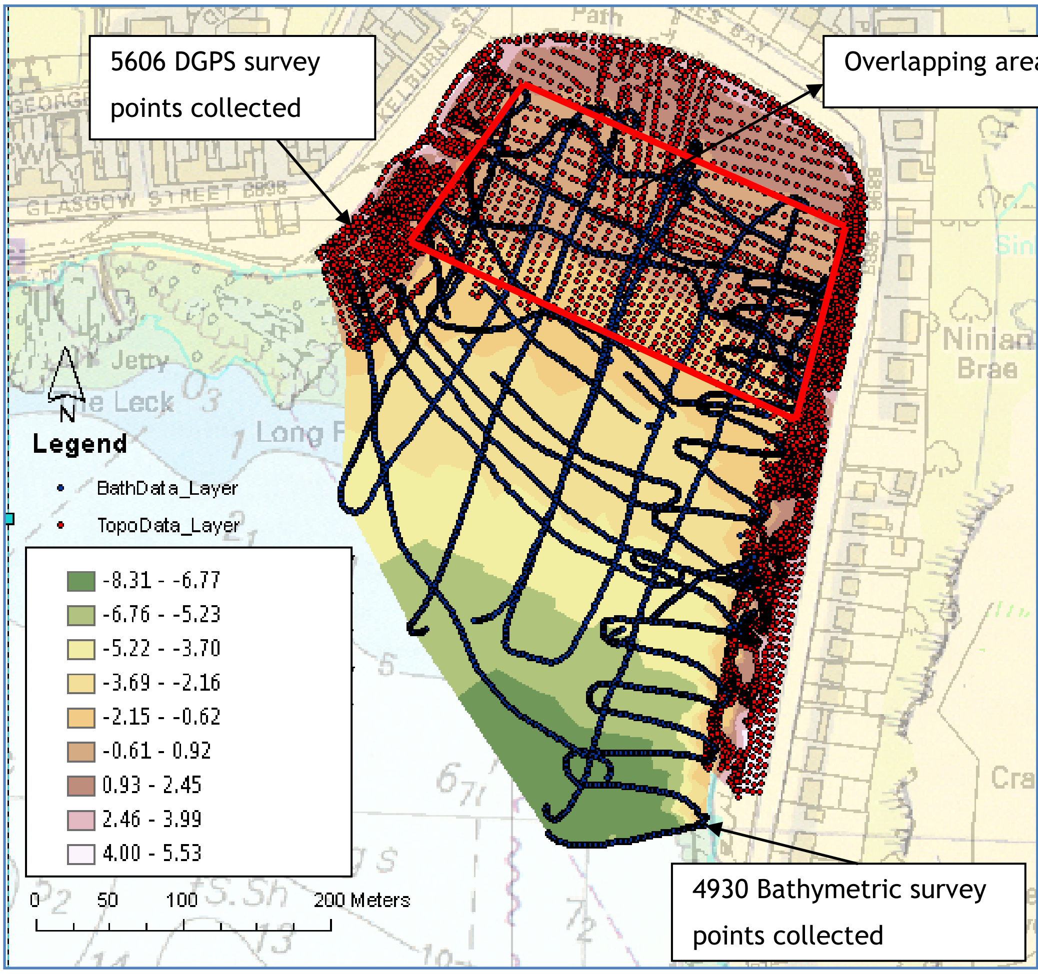

Figure 4-2 DGPS and bathymetric surveys carried out at Kames Bay where the dark blue lines represents the bathymetric survey vessel's course and the red points are the terrestrial DGPS points

4.2 Data Analysis

Spatial and statistical analyses were carried out by extracting the cell values of the land topography and bathymetry data to compare with the following third-party DTMs:

i. 90m resolution (version 4.1) DTM (5 ° by 5°) from NASA Shuttle Radar Topographic Mission (SRTM) (CGIAR-CSI, 2008).
ii. 30m resolution DTM (version 2) (1 ° by 1°/ 60km x 60km) from Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model (GDEM) (ERSDAC, 2009).
iii. 5m resolution NEXTMap DTM (10km x 10km) from Intermap Technologies (INTERMAP, 2004)

Table 4-1 Datum of various DTMs and their quoted accuracies, data value range, and % of No Data value compared to DGPS DTM

DTMs	Resolution (metres)	Vertical DATUM	Quoted Vertical Accuracies	Elevation Range (H: High, L: Low)	No Data Value	% of No Data Value in Kames Bay
DGPS	0.5	ODN (OSGM91)	20 mm + 1 ppm, kinematic (Leica Geosystems, 2006)	H: 5.45, L: -1.98	N/A	N/A
SRTM v4.1	90	EGM96 (USGS, 2008)	~16 m (Hayakawa et al., 2008, Rodríguez et al., 2005)	H:1309, L: -61	NoData	22%
ASTER v2	30	EGM96	~17 m (Meyer, 2011)	H: 844, L: 0	0	30%
NEXTMap	5	ODN (OSGM91)	~1 m (Hall & Tragheim, 2010, INTERMAP, 2004)	H: 149.4, L: -10	0	63%
Bathymetric	0.5	ODN (OSGM91)	0.025 m (Euronet, n.d.)	H: 1.13, L: -8.31	N/A	64%

SRTM elevation data was acquired from the Space Shuttle Endeavour in 2000 covering 80% of the globe from 60° N to 56° S, providing 30m resolution DTM for

United States and 90m DTM resolution for the test site (Jet Propulsion Laboratory, 2009b). The SRTM data used here is the version 4.1 void-filled data released in 2008 by CGIAR-CSI. ASTER GDEM was acquired by NASA's Terra spacecraft in 2009 covering 99% of the globe from 83° N to 83° S, providing 30m DTM resolution for the whole coverage (Jet Propulsion Laboratory, 2009a). The ASTER data used here is version 2 released by NASA in 2011. The NEXTMap DTM is made available commercially by Intermap Technologies and was acquired using the airborne interferometric synthetic aperture radar (IFSAR). The NEXTMap data used in this research was obtained via British Atmospheric Data Centre (BADC) through the NERC's GAS project in the University of Glasgow.

There are a lot of 'no data' values in the third-party DTMs compared with the DTM generated from our fieldwork. This suggests some of the third party DTMs have no-data in the lowest elevation regions. All the 'no data' values in the corresponding DTMs have been discarded prior to the analyses to give a more accurate account of comparison.

The following analyses were made with the assumption that the DGPS DTM produced here is of a higher level of accuracy (standard deviation of DGPS points heights collected ~ 8 mm) than other DTMs and will be used as a reference dataset against which comparisons will be made.

4.2.1 Generation of DTM

DTMs were generated in ArcMap 10.0 (Build 2800) from both the DGPS and bathymetric data using Inverse Distance Weighted Squared (IDW2) interpolation technique, with a 0.5 m output cell size (to correspond with the average point interval), with 12 points in the Search Radius Settings, using a predefined mask to confine the extent of DTM generated within the actual extent of the survey parameters (Figure 4-3 & 4-4). Contours were subsequently generated to show the overall relief of Kames Bay (Figure 4-5).

The profile graphs of Kames Bay showed some rugged terrain at the left and right cross-section (line 1 & 3) which coincide with hard bedrock whereas the middle cross-section (line 2) is composed mainly of sand. The shortcomings of

DGPS and bathymetric survey in acquiring the DTM of these rugged terrains are shown in the Error DTM analyses.

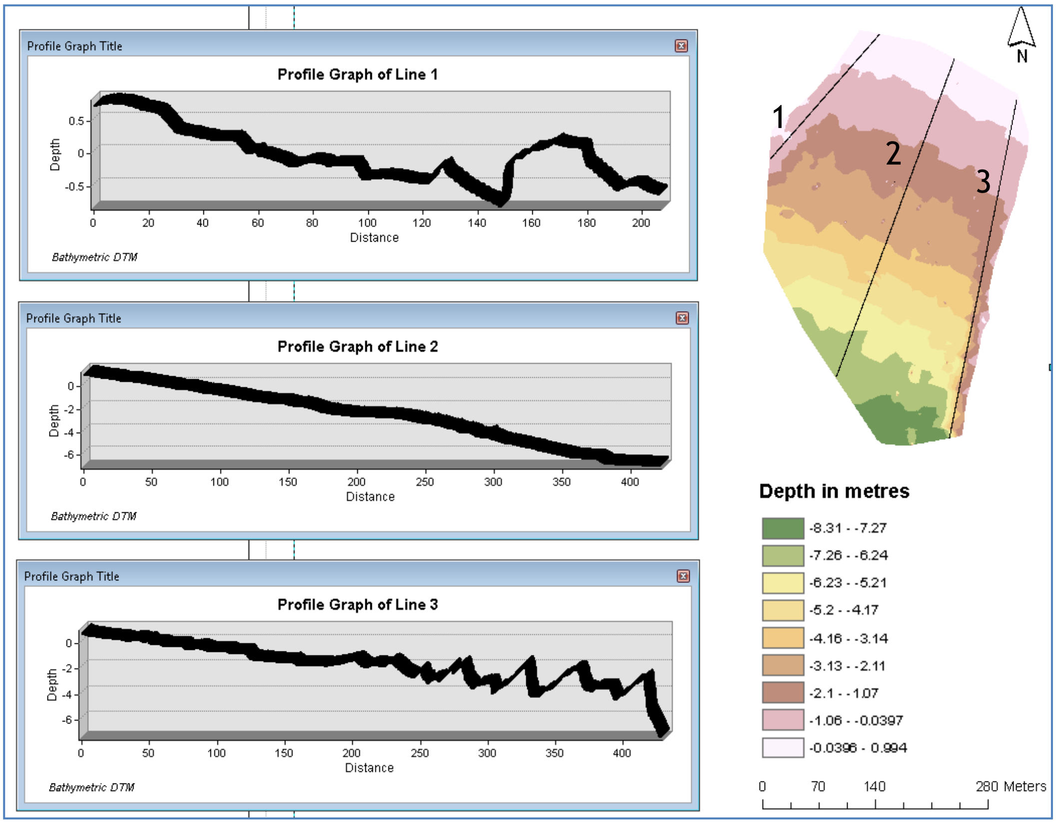

Figure 4-3 Profile graphs of bathymetric DTM

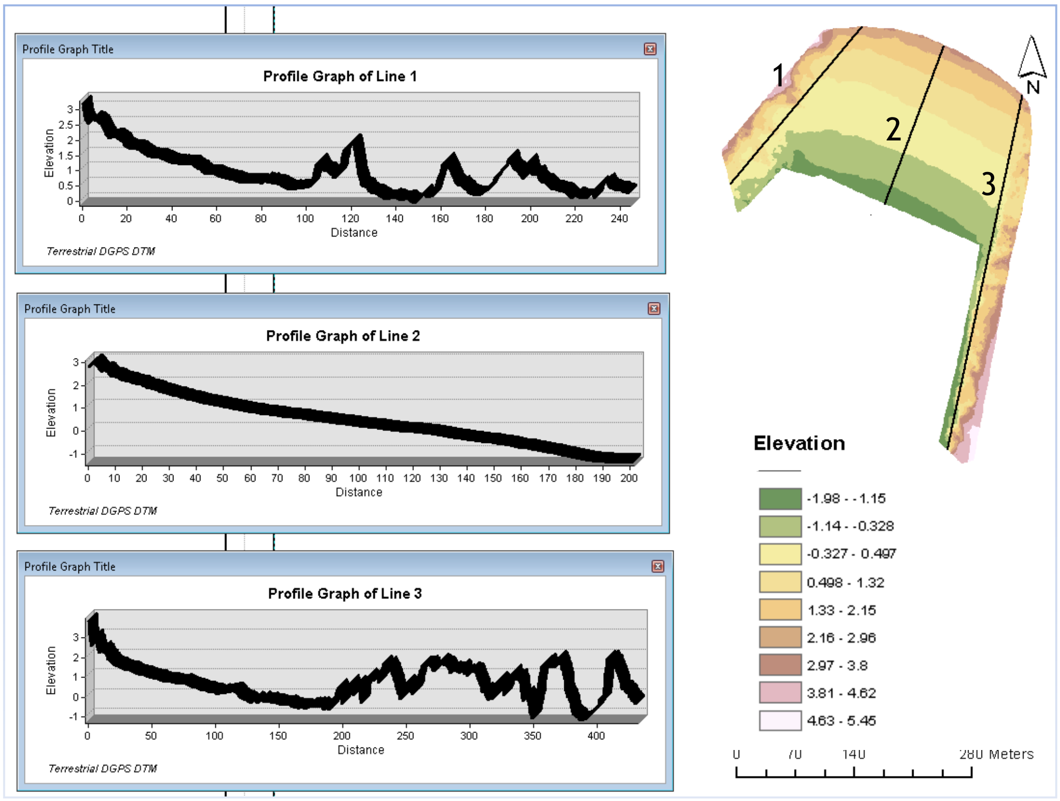

Figure 4-4 Profile graphs of terrestrial DGPS DTM

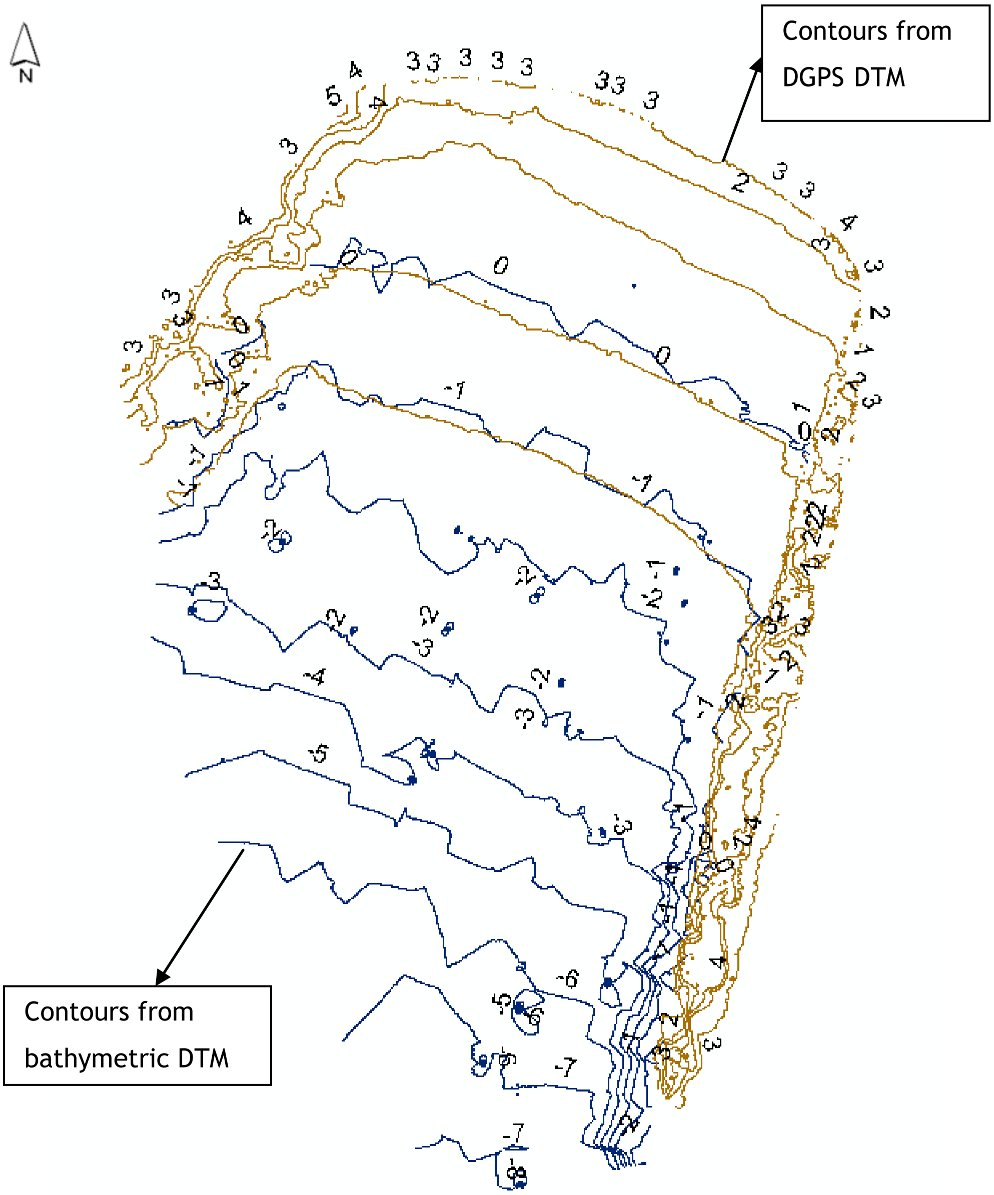

Figure 4-5 Contours generated from Kames Bay's DGPS and bathymetry survey (metres)

4.2.2 Test of Linearity

4.2.2.1 DGPS vs. SRTM

A total of 3719 corresponding points in both DTMs were compared (Figure 4-6). A scatter plot of linearity between the elevation values acquired by DGPS and the SRTM DTM showed a very weak correlation between both sets (R^2 = 0.0519/ R= 0.2278) with the regression line showing a bias of 8.5635 m. The differences between the two sets of height values range from 0 to 21 m, which is not surprising given the stated accuracy of SRTM to be 16 m. The horizontal lines in

Figure 4-7 are a consequence of tens/hundreds of DGPS points being confined to one cell of the SRTM DTM. Given that the range of DGPS heights being investigated is only about 7 m, the correlation statistic is almost meaningless. This same argument can be applied with the comparison between GPS and ASTER data, as discussed below.

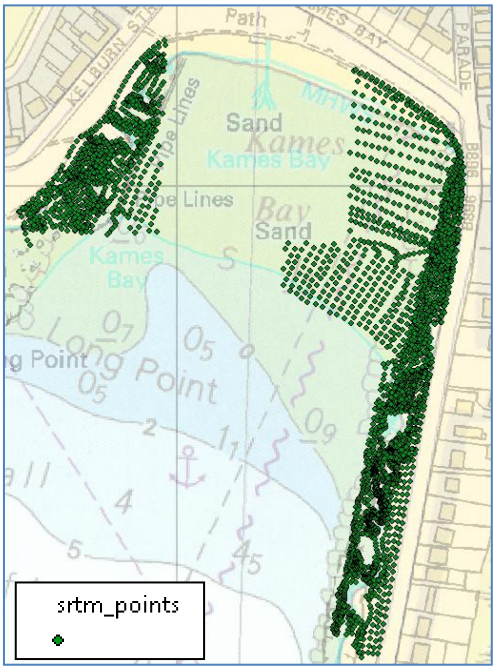

Figure 4-6 Extracted cell values of SRTM with ‘no data’ values excluded

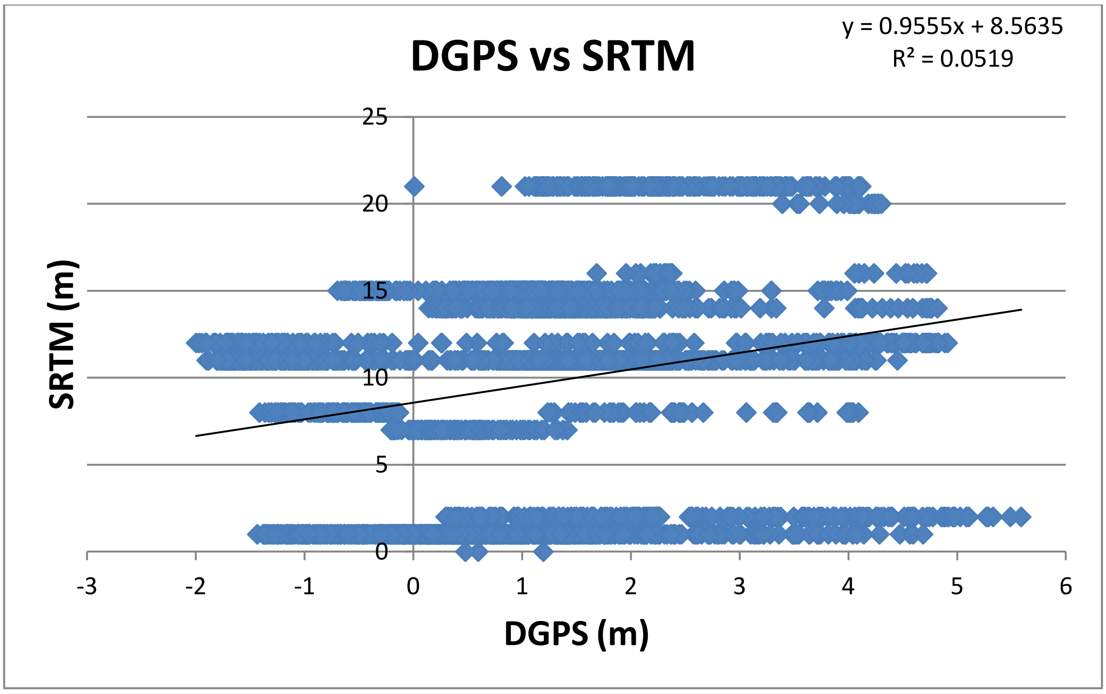

Figure 4-7 Linearity of DTM elevation values between DGPS and SRTM (3719 points)

4.2.2.2 DGPS vs. ASTER

A total of 3338 corresponding points in both DTMs were compared (Figure 4-8). A second scatter plot of linearity between the elevation values acquired by DGPS and the ASTER DTM showed another very weak correlation between both sets of DTM (R^2 = 0.0294/ R= 0.1715) and the regression line shows a slightly greater bias than SRTM at 9.3596 m. The differences in the height values range from 2 to 23 m (Figure 4-9), remembering that the specified accuracy of ASTER is 17 m. For the same reasons as explained above (i.e. quoted vertical accuracy vs. overall height range), the lack of correlation is unsurprising.

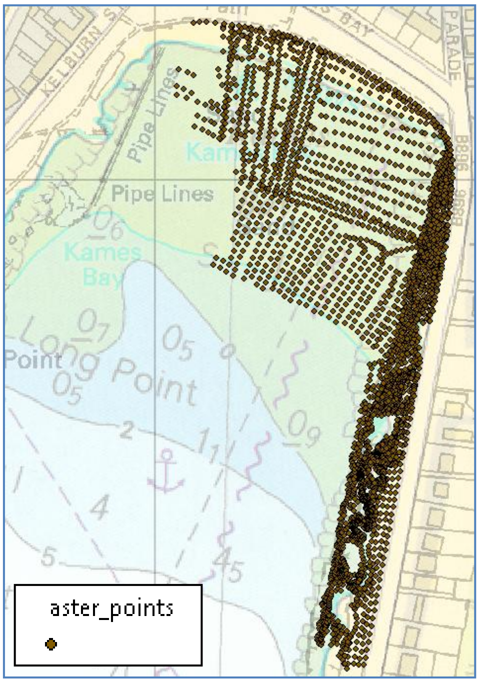

Figure 4-8 Extracted cell values of ASTER with 'no data' values excluded

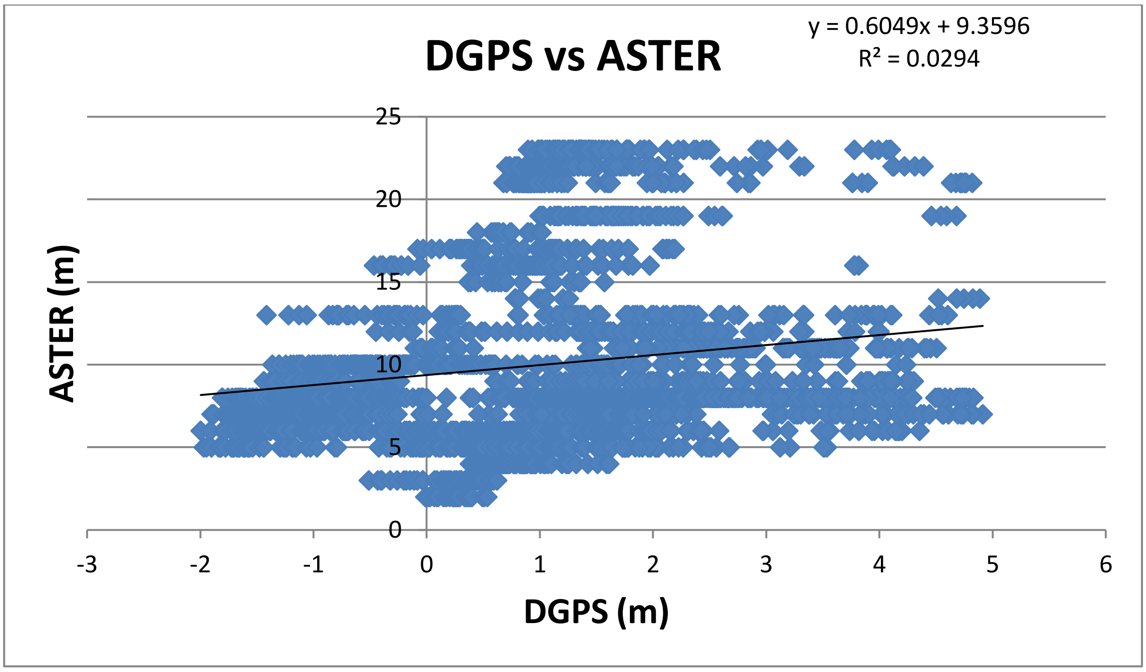

Figure 4-9 Linearity of DTM elevation values between DGPS and ASTER (3338 points)

4.2.2.3 DGPS vs. NEXTMap

A total of 1764 corresponding points in both DTMs were compared (Figure 4-10). A third scatter plot showing the linearity between the elevation values acquired by DGPS and the NEXTMAP DTM showed a stronger correlation between both sets of DTMs (R^2 = 0.3204/ R=0.5660) and the regression line shows a bias of only 0.2318 m. This higher correlation can be considered to be an indication of the higher quality of the NEXTMap DTM (Figure 4-11). The comparison with NEXTMap dataset shows it is more accurate than SRTM and ASTER, given the quoted vertical accuracy is a significantly smaller proportion of the height range over the test site.

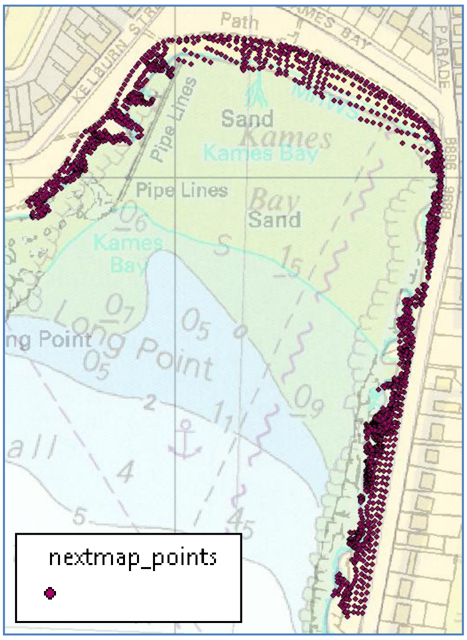

Figure 4-10 Extracted cell values of NEXTMap with ‘no data’ values excluded

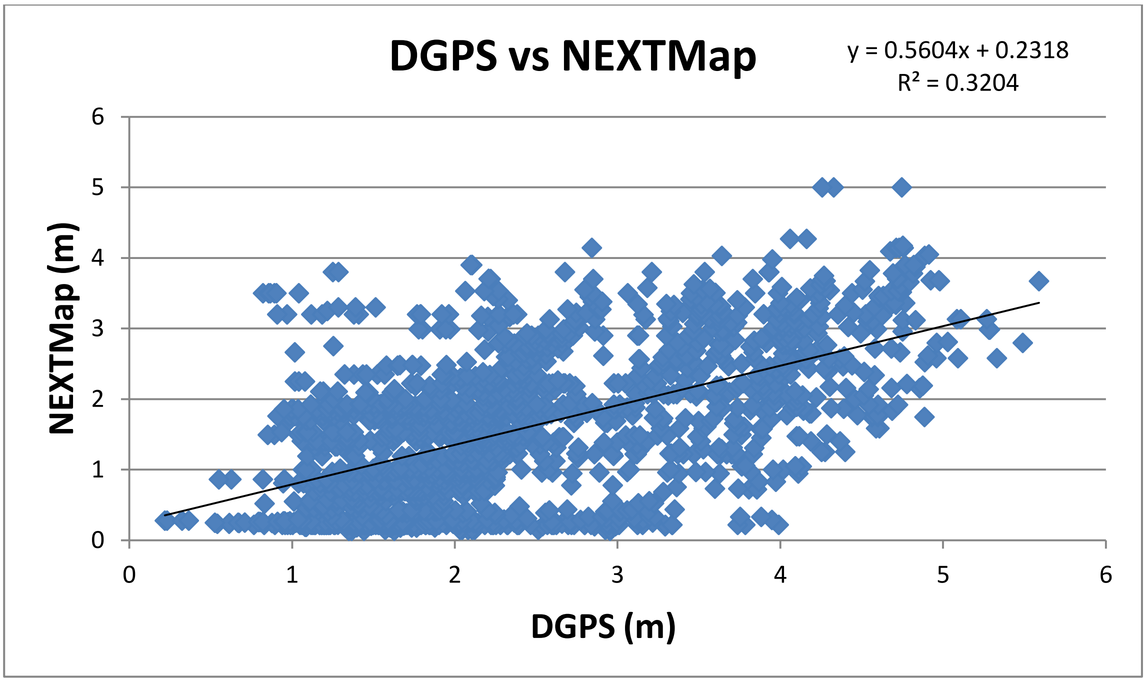

Figure 4-11 Linearity of DTM elevation values between DGPS and NEXTMap (1764 points)

4.2.2.4 DGPS vs. Bathymetry

Finally, comparisons were made between the topography DTM acquired by DGPS and fieldwork bathymetry acquired by echo sounding. A total of 1704 corresponding points in both DTMs were compared (Figure 4-12). The scatter plot (Figure 4-13) showed that there is a very strong correlation between the two sets of points (R^2 = 0.7625/ R=0.8732) and the regression line shows a bias of -0.2221m. Height differences fall within the range of -2.5m to 1m. The high correlation between the DGPS values and echo sounding elevations in the area of overlap provides a high confidence in the echo sounding results further offshore where the measurements using other data sources could not be validated.

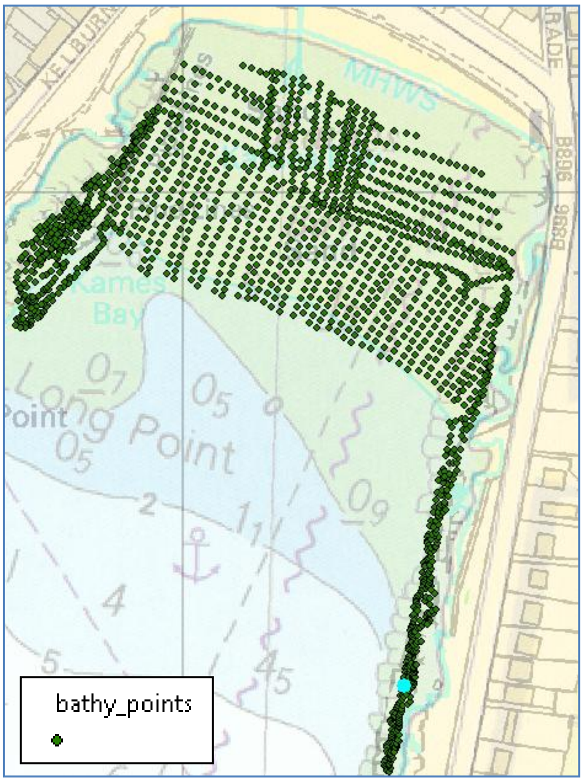

Figure 4-12 Extracted cell values of bathymetry with ‘no data’ values excluded

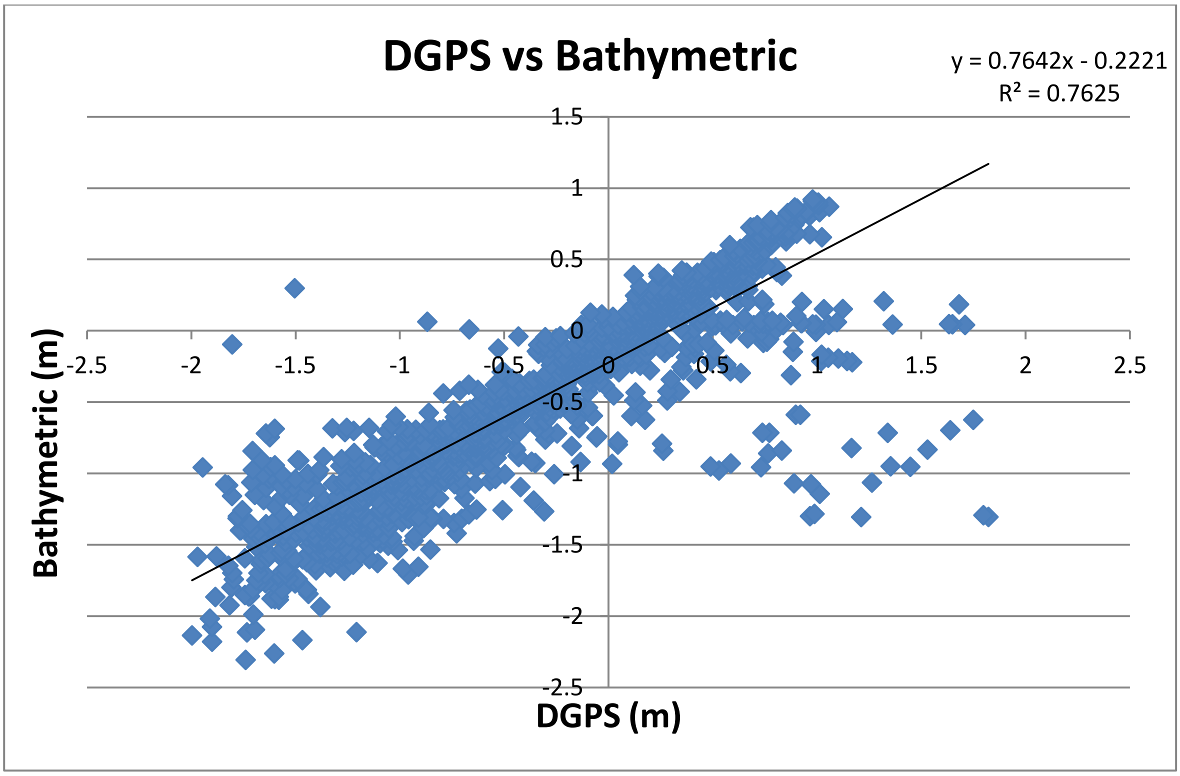

Figure 4-13 Linearity of DTM elevation values between DGPS and bathymetry in the overlapping area (1704 points) (Note: the apparent 'outliers' away from the regression line of the graph are related to rocky areas)

The point by point differences between the extracted cell values of the third party DTM and bathymetric DTMs points and the corresponding DGPS points were calculated and an accurate account of their accuracies and relationship in the overlapping area were given by the root mean square error (RMSE) and correlation shown in Table 4.2.

Table 4-2 Statistics of comparisons showing the differences between DGPS DTM and various DTM (DGPS points subtracting other DTM's points)

Statistics of comparisons between DGPS DTM and various DTM (metres)

DTM	Δ Min	Δ Max	Mean	RMSE	Correlation*
ASTER	-22.1048	-1.4641	-8.8831	10.2105	0.1715
SRTM	-20.9902	3.6871	-8.5072	10.4047	0.2279
NEXTMap	-2.6784	3.7714	0.8319	1.2910	0.5660
Bathymetric	-1.8032	3.1258	0.1461	0.3918	0.8732

Note: the correlation is between the original data values rather than the 'difference'.

The result showed that the DGPS and bathymetric data have a strong relationship with a relatively high correlation and low RMSE. Meanwhile among the third party DTMs, NEXTMap which has the highest resolution is significantly more precise and accurate than ASTER and SRTM. However, despite the reasonably good correlation with NEXTMap, its data does not extend beyond the low-water line region, implying that the time of data collection was not the most appropriate for this purpose, thus limiting its usability (Figure 4-14). Although both SRTM and ASTER provide a greater number of points for comparison (SRTM: 3719, ASTER: 3338), both the 30m resolution ASTER and 90m resolution SRTM resulted in similarly low accuracy and correlation against the DGPS data, which proved to be statistically insignificant in Kames Bay. Despite their global availability, analysis shows that neither the ASTER nor SRTM datasets are suitable for use in determining the marine baseline. Although not analysed here, marine LiDAR shows much more promise at covering extensive areas of coastline with the required accuracy, but with significant costs involved.

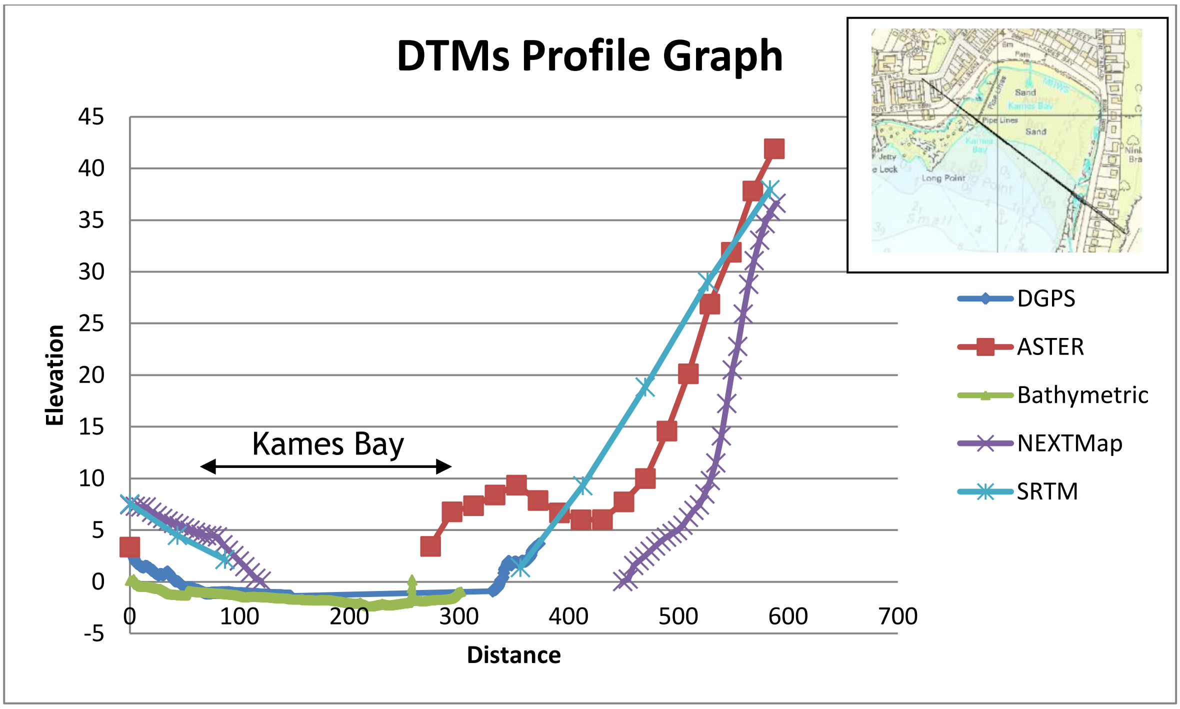

Figure 4-14 Profile graphs of various DTMs from a northwest to southeast cross section of Kames Bay, highlighting their differences in elevation and lack of data across Kames Bay

4.2.3 Error DTM

In order to detect the distribution of error (i.e. the difference between DGPS and bathymetric values), an error DTM was generated by subtracting the land DGPS DTM from the bathymetric DTM. The generated error DTM showed that majority of the heights of both DTMs agree well with each other, with the mean vertical difference in the overlapping area being about 0.1358 m. Figure 4-15 shows that the outliers lie mainly on the rocky shorelines of Kames Bay where loss of survey overlap occurred due to dangerous terrestrial surfaces or limited safe boat access to the rocky shoreline and changing boat headings at these locations. The high values on the sandy shore are concentrated mainly in the shallows, albeit with one gap where the boat was in danger of grounding. Figure 4-16 shows the error between DGPS and the bathymetry DTMs to be normally distributed.

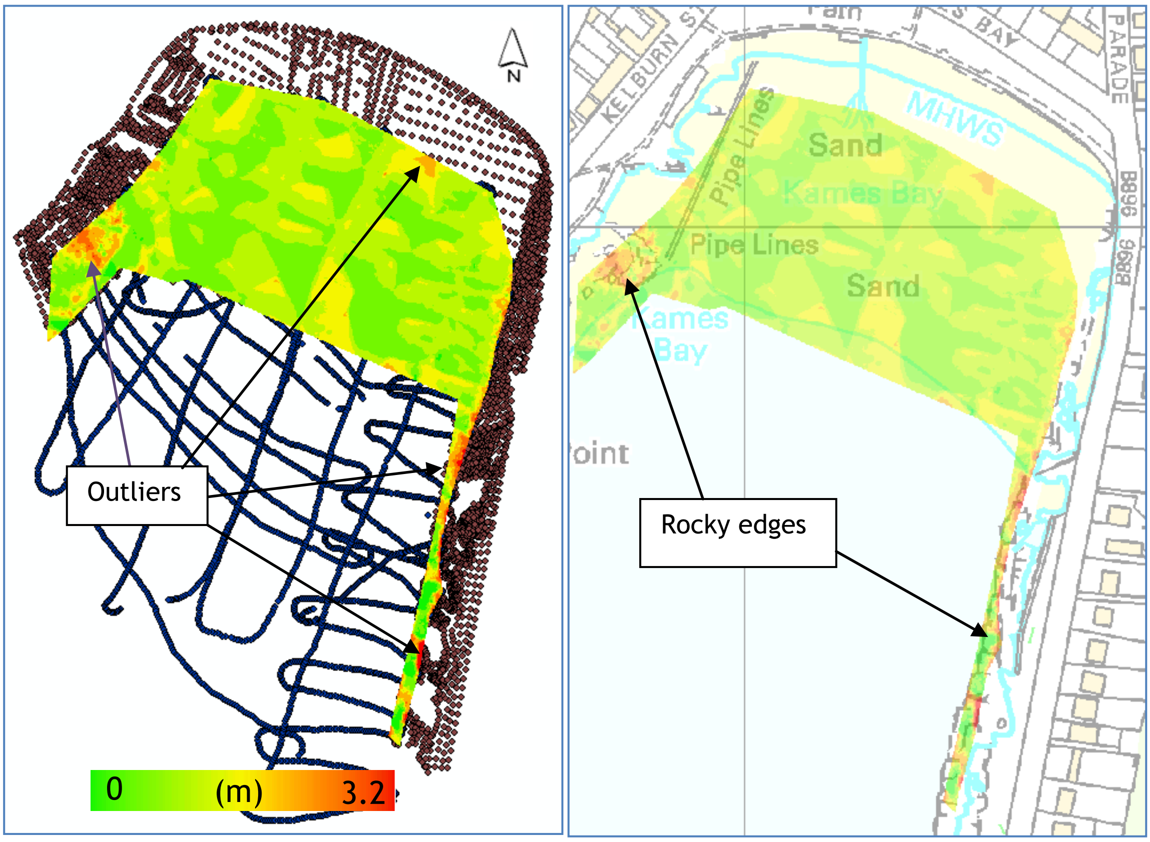

Figure 4-15 Absolute error distribution as shown in the Error DTM

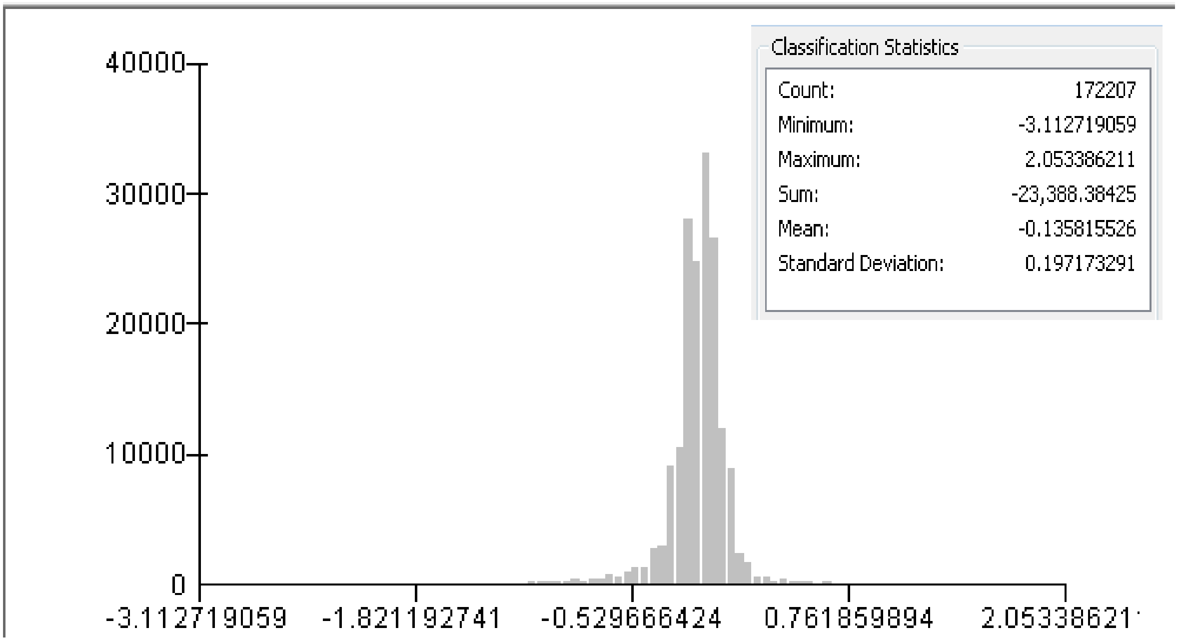

Figure 4-16 Histogram of error DTM showing normally distributed data (metres)

4.2.4 Generation of Low-water Lines

Low-water lines were subsequently generated from the three highest resolution DTMs (NEXTMap, DGPS, Bathymetric) using the tidal height information obtained from UK National Oceanography Centre (NOC). NOC is responsible for managing the National Tidal and Sea Level Facility (NTSLF) which has tide gauges at 44 sites around the UK. NTSLF provide both unprocessed and quality-controlled tide gauge data, including tidal predictions derived from the database of tidal constants maintained by NOC's Applications Group (McGarrigle et al., 2010). The tidal predictions used here were the highest and lowest predicted tides at Millport from 2008 to 2026 provided by NTSLF.

Generally in the beach area the DGPS survey was able to cover the foreshore from HAT to a little beyond the MLWS; meanwhile the bathymetric survey was able to cover the foreshore from above MLWS to well seaward of LAT, but less so in the rocky area.

4.2.4.1 Highest Astronomical Tide (HAT)

HAT was generated from NEXTMap and DGPS DTM (Figure 4-17) with the predicted height of HAT in Chart Datum converted relative to ODN. The high resolution NEXTMap DTM generated an accurate but less detailed HAT line within Kames Bay. Meanwhile the DGPS DTM generated a very detailed line within the coastline at Kames Bay and plots beyond the Mean High Water Spring (MHWS) line indicated in the Ordnance Survey (OS) raster map, providing confidence in the DGPS DTM accuracy.

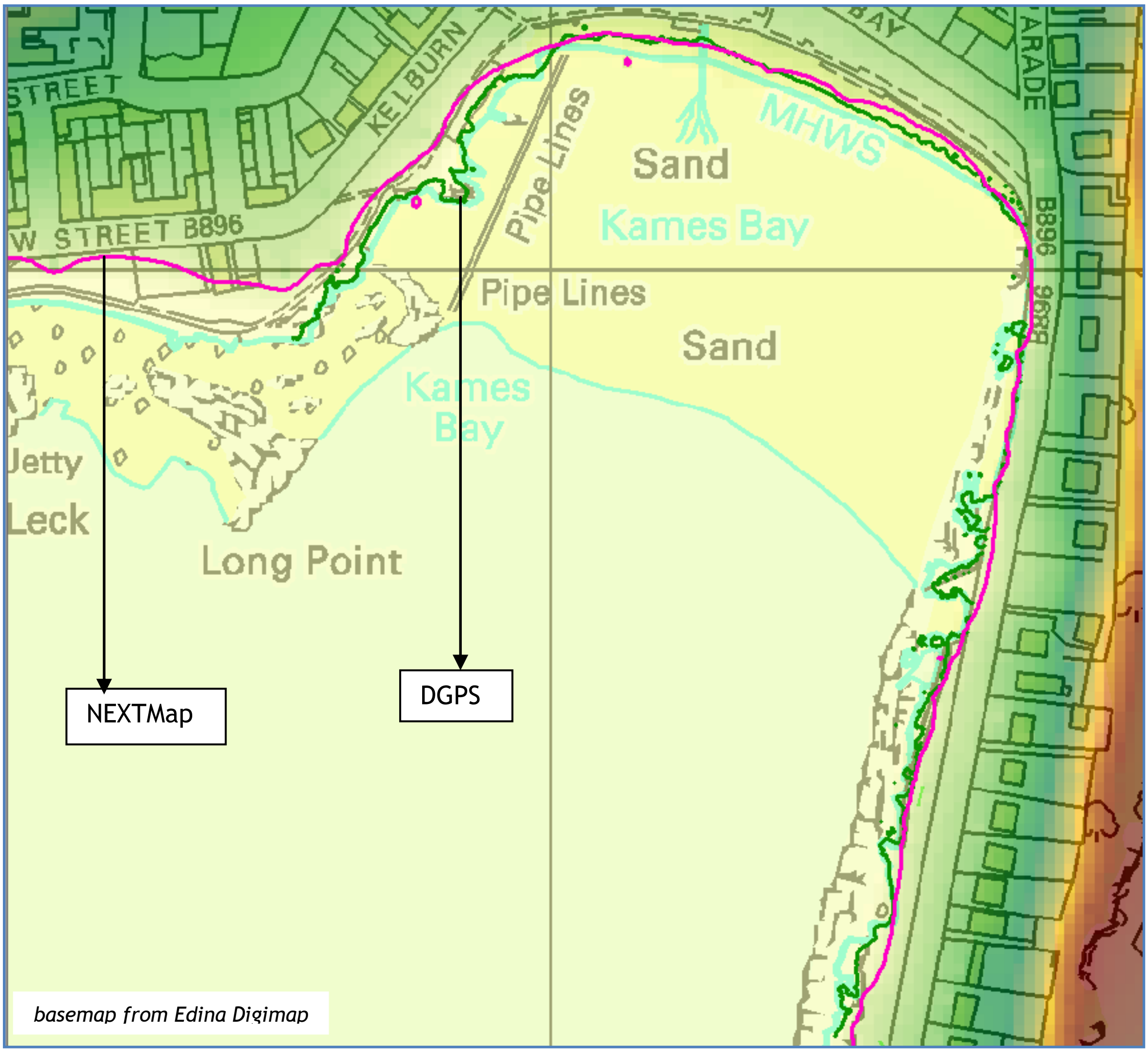

Figure 4-17 HAT generated from both DTMs
(Digimap, 2009a)

4.2.4.2 Mean Low Water Spring (MLWS)

The NEXTMap DTM has no elevation data at this location; hence MLWS was generated solely from the fieldwork data of DGPS and bathymetry. Both MLWS show good agreements with each other with the line matching well particularly in the steeper parts of the coastline, while slight variation was noted in the flatter beach area (Figure 4-18). Given the boat movements during the bathymetric survey, a more undulating MLWS was produced, while a straighter MLWS was produced from DGPS carried out on foot. The assumption here is that the MLWS generated by the DGPS is more reliable. In order to investigate whether an integrated DTM from both DGPS and bathymetry data yields a better result the raw survey data of DGPS and bathymetry was brought into ArcMap 10.0 (Build 2800) to create an integrated DTM using IDW2. A third MLWS was generated subsequently from this integrated DTM and comparison made with the previous two MLWS. It was found that the third MLWS from the integrated DTM has a higher similarity to the MLWS generated from the DGPS rather than the bathymetric MLWS (Figure 4-19). It is suggested that the MLWS can be derived from the DGPS DTM alone.

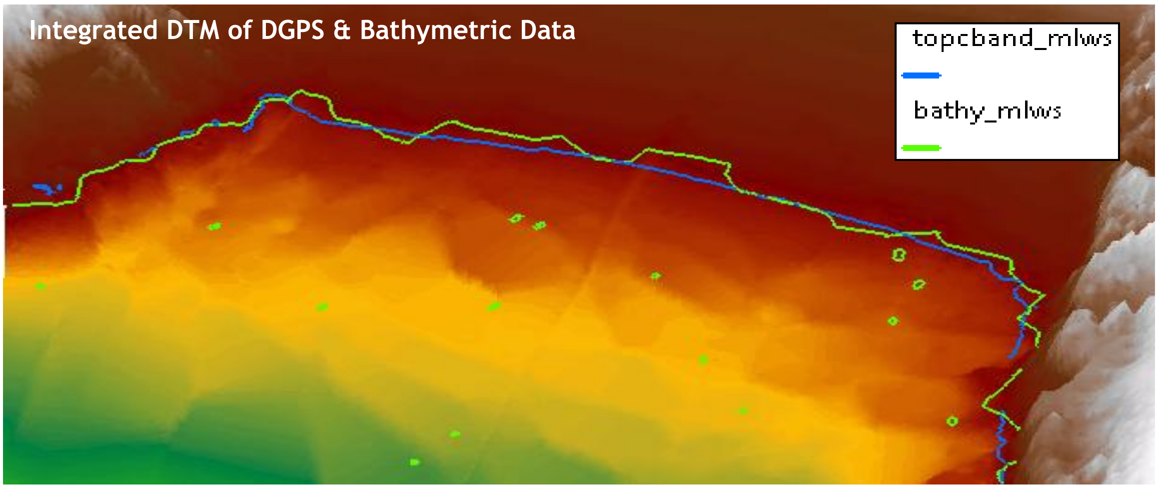

Figure 4-18 MLWS generated from DGPS (topcband) and bathymetry (bathy) shown in ArcScene 10.0 (Build 2800) against an integrated DTM of DPGS & Bathymetric Data

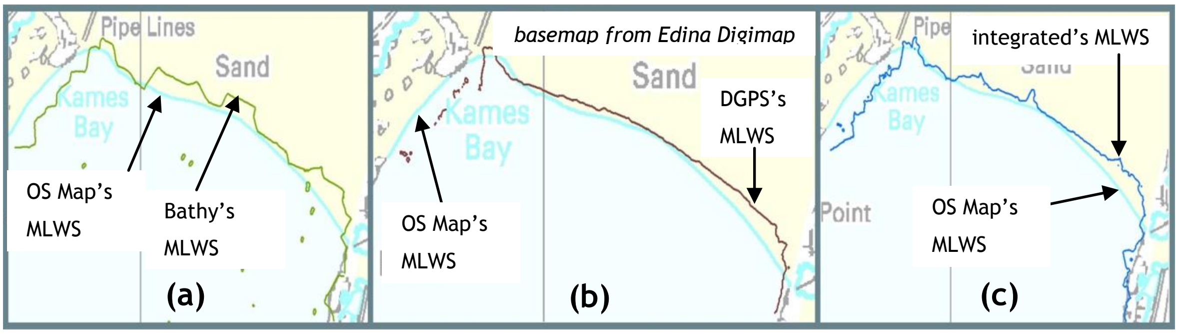

Figure 4-19 Comparison of generated MLWS with OS Map's MLWS. (a) MLWS from the bathymetric DTM. (b) MLWS from the DGPS DTM. (c) MLWS from the integrated DTM
(Digimap, 2009a)

The generated MLWS location was then compared to the MLWS location shown on Ordnance Survey (OS) raster map. An investigation into the changes of MLWS location over the years at Kames Bay showed that MLWS was previously shown as 'low-water mark of ordinary spring tide (LWMOST)' prior to 1890s – 1960s. The term MLWS has been adopted instead of LWMOST since 1962 and its location has shifted seaward ~35m from its previously defined location (Figure 4-20). When the generated MLWS was compared to the current MLWS shown on the OS map, it showed an almost identical line with slight shift landward ~12m at the southeast of Kames Bay (Figure 4-21), indicating MLWS remain largely unchanged from 1962 – 2012. However the subtle changes of seabed at the southeast area at this level portend a greater change further south at lower depths.

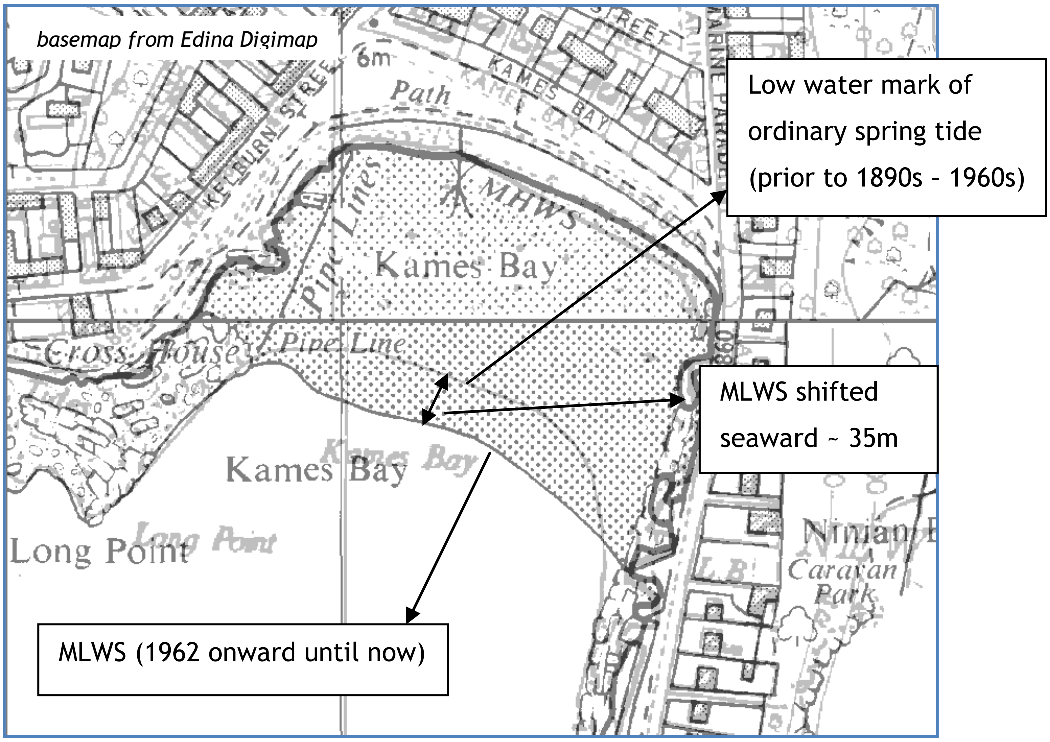

Figure 4-20 Historical positions of LWMOST and MLWS at Kames Bay (Digimap, 2009a)

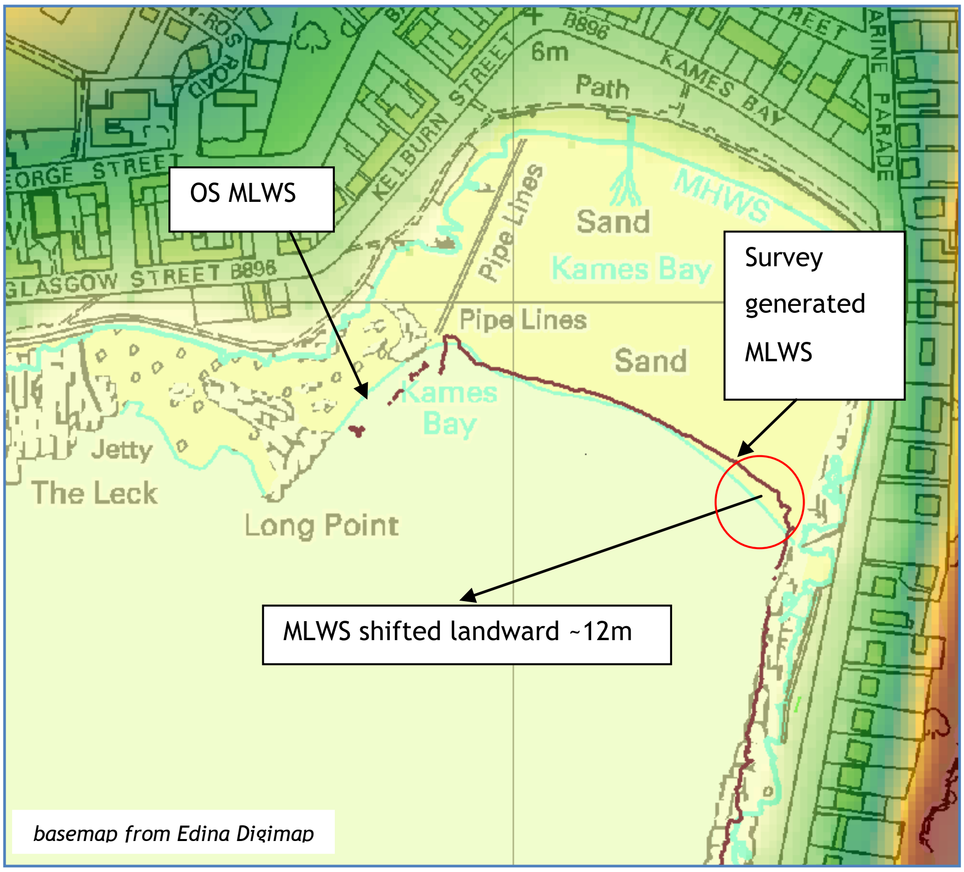

Figure 4-21 Comparison of the generated MLWS with the current MLWS shown on OS map
(Digimap, 2009a)

4.2.4.3 Lowest Astronomical Tide (LAT)

The LAT generated from the bathymetric DTM was then compared to the 1:12500 Leisure Chart SC 5610.1 (3rd Edition, published in 2008) based on Admiralty Chart 1867 (published in 1975). The LAT line generated indicated that the seabed which was once shallower (depth value 07 and 09, circled red in Figure 4-22) in the northwest and southeast of Kames Bay has retreated landward by approximately ~72 m and ~94 m respectively (Figure 4-22). This suggests that changes have occurred in the mobile nearshore. The UK Hydrographic Office (UKHO) confirmed that the LAT line represented on the admiralty chart was surveyed by HMS Gulnare in May 1940 and that information has not been superseded (Hannaford, pers comm, 2012). Admiralty charts adopted LAT as chart datum from 1968 (Burningham & French, 2008) yet the current LAT line shown in Chart 5610.1 has not been revised since the 1940 survey. This suggests that particular sections of Kames Bay have been eroding at an average rate of more than 1 m per year over the last 72 years (1940-2012). This is not an unusual rate of movement within the lower intertidal on the Scottish coast, mostly driven by sea level change and dwindling sediment supply (Hansom, 2010). A typical large scale chart at 1:50 000 would usually have a plotting accuracy of 0.2 mm on paper that translates to 10 m on the ground (Forrest, pers comm, 2012), and so the magnitude of changes in LAT detected in Kames Bay should warrant a replotting of the charts in this area. Figure 4-23 shows comparison of all the generated low-water lines with Ordnance Survey raster dataset and the Admiralty chart.

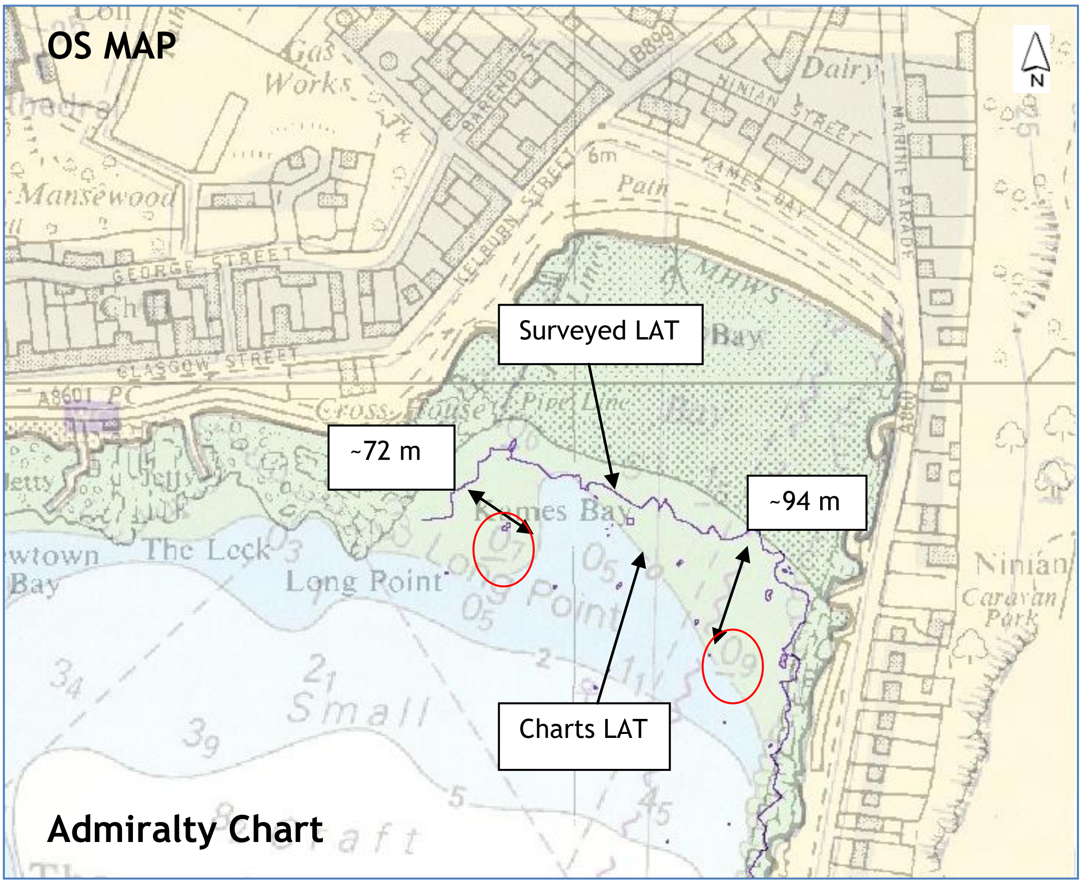

Figure 4-22 Shift noticed in LAT location when compared to Admiralty Chart (Digimap, 2009a)(Hydrographic Office, 2008)

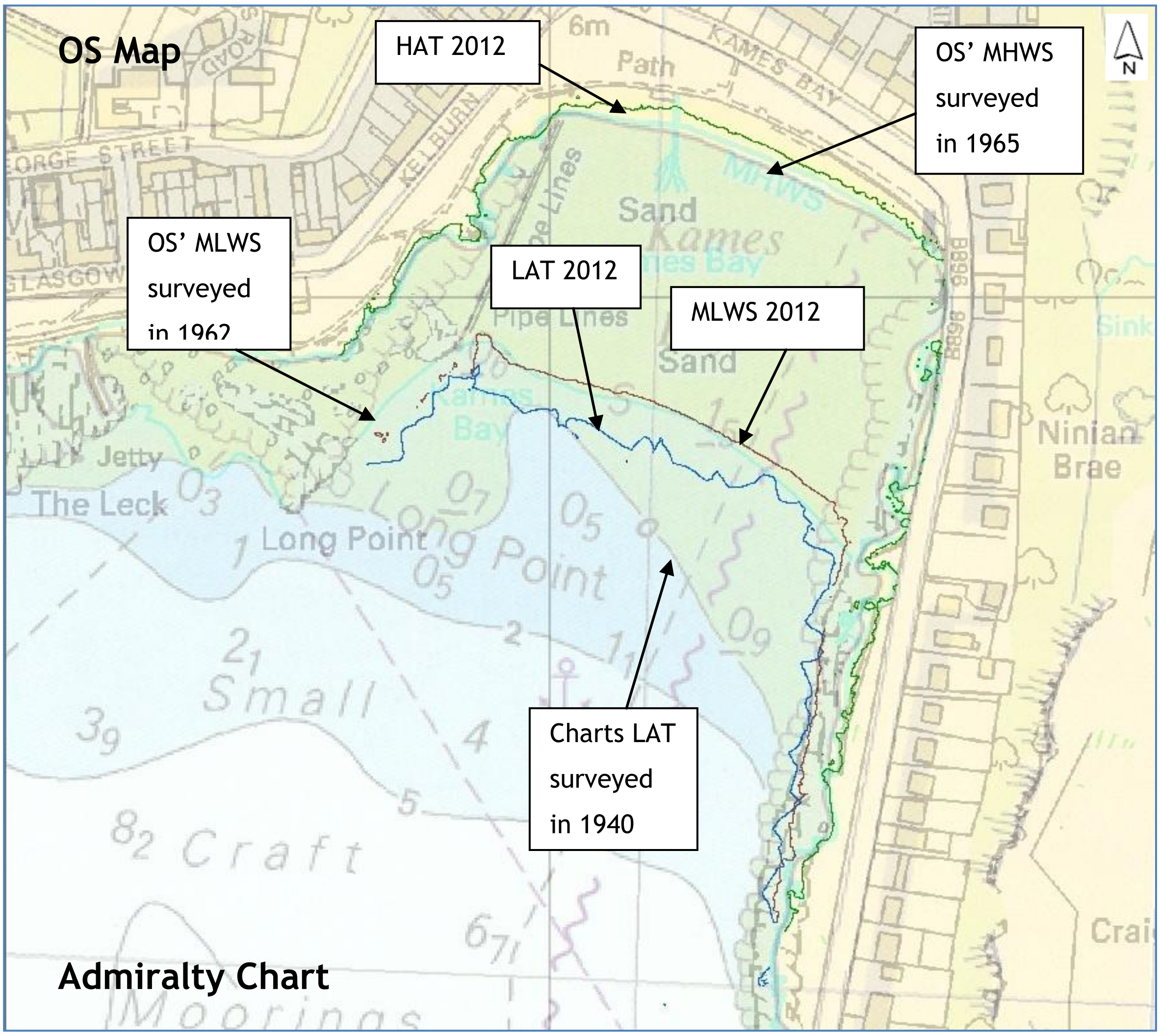

Figure 4-23 Comparison of low-water lines generated with Ordnance Survey raster dataset and the Admiralty chart
(Digimap, 2009a)(Hydrographic Office, 2008)

4.2.5 Difference between observed and predicted tide values

According to Baily (2009), a contemporary reference in the 1940s stated that more than 85% of high and low water predicted from the tide table published by the Hydrographic Department of the Admiralty were accurate within ten minutes and within one foot (~0.3 m). The low-water lines above were generated using the highest and lowest predicted tides values for Millport from 2008 to 2026 obtained from National Oceanography Centre. These predictions were generated using the four largest Harmonic Constants (M_2, S_2, O_1 & K_1) by tidal analysis using tide gauge data spanning from 1987 to 2007 (National Oceanography Centre, 2012b). As the values are predicted based on the past 20 years observation using four major harmonic constants, there is a possibility that the actual tide height on the day itself will be different from the prediction. In order to investigate the accuracy of the predicted values for the highest and lowest tides, the historical recorded tide data can be compared against the predicted values.

Table 4-3 Highest and lowest predicted tides values for Millport from 2008 to 2026

10 HIGHEST TIDES	
3.86 m	2/Feb/2010
3.86 m	3/Feb/2010
3.82 m	21/Feb/2011
3.81 m	4/Jan/2010
3.81 m	3/Feb/2014
3.81 m	24/Jan/2019
3.81 m	5/Jan/2018
3.81 m	23/Jan/2011
3.81 m	25/Jan/2019
3.81 m	22/Feb/2019
10 LOWEST TIDES	
-0.04m	21/Mar/2015
-0.04m	8/Apr/2016
-0.04m	11/Mar/2024
-0.02m	7/Apr/2016
-0.02m	20/Mar/2015
-0.02m	8/Apr/2024
-0.02m	13/Aug/2014
-0.02m	9/Apr/2024
-0.01m	12/Aug/2014
-0.01m	8/Apr/2020

(National Oceanography Centre, 2012c)

As no LAT has been established since 2008 at Millport, the only comparison made was against the actual HAT vs. predicted HAT in February 2010. Past tide gauge quality checked data is available from British Oceanographic Data Centre (BODC) (British Oceanographic Data Centre, 2012).

Table 4-4 Quality checked tide gauge data from BODC for Millport

Date	Time	Observed Sea Level	Predicted Sea Level	Residual
02/02/2010	02:30:00	3.401	3.371	0.03
02/02/2010	14:30:00	3.849	3.871	-0.022
03/02/2010	03:15:00	3.186	3.363	-0.177
03/02/2010	15:00:00	3.87	3.86	0.01

Table 4.4 show the difference between the observed sea level and the predicted of two highest tides within a day. The residual is calculated from the observed sea level values minus the predicted sea level values. Table 4.5 shows the average residual for a whole day of observation (96 records) on 2 February 2010 is 0.0076 with a RMSE of 0.0643 m, whereas on 3 February 2010 the average residual is -0.0127 with a RMSE of 0.1026 m. Meanwhile the month of February 2010 has an average residual of -0.3910 with a RMSE of 0.1603 m. These statistics show that daily prediction is comparatively precise and the relatively low RMSE values indicate that the difference between the observed tide and prediction is rather small, and so the prediction is very accurate.

Table 4-5 Statistics of comparisons showing the differences between observed high tide and the predicted tide (Observed subtracting prediction)

Day	**Δ Min**	**Δ Max**	**Mean**	**RMSE**
2/2/10	-0.102	0.13	0.0076	0.0643
3/2/10	-0.177	0.251	-0.0127	0.1026
Month	**Δ Min**	**Δ Max**	**Mean**	**RMSE**
February	-0.0009	0.369	-0.391	0.1603

4.2.6 Sea-level change rates and future estimates

One of the concerns brought about by global warming is sea-level rise. Sea-level rise is threatening to inundate low lands along the coastal area around the world and this has potentially huge impacts on the environment, habitat and human settlement, etc., along the coast. As sea-level rises, not only do land areas decrease, but as the low-water lines retreat landward, the maritime jurisdiction of a country will also shrink accordingly.

Main stream scientific opinion currently advocates that sea-level rise is real and rising fast (Intergovernmental Panel on Climate Change, 2007)(Dasgupta et al., 2007)(Brahic, 2009). This means that changes to low-water lines need to be adjusted according to sea-level rise trends. The main agencies that deal with climate change in United Kingdom are The Department of Energy and Climate Change (DECC), Department for Environment, Food and Rural Affairs (DEFRA) and the Environment Agency (EA). EA is the UK government's delivery body for climate change adaptation in England, providing advice and support to help organisations adapt to climate change. DECC is the government lead department on climate change mitigation, while DEFRA leads on domestic adaptation policy and is responsible for developing a National Adaptation Programme (DEFRA, 2012a). According to a climate projection report produced by DEFRA in 2006, net sea-level rise from 1990-2025 in Scotland will be 2.5 mm/yr and vertical land upward movement is 0.8 mm/yr (DEFRA, 2006). So in year 2025, LAT at Millport since 2008 will be:

$$
\begin{aligned}
\text{LAT in 2025} &= \text{Projected LAT in 2025} + \text{Total sea level rise} + \text{Total land movement} \\
&= -1.66\ \text{m} + (2.5\ \text{mm}*18\text{yrs}) + (-0.8\ \text{mm}*18\text{yrs}) \\
&= -1.66\ \text{m} + 45\ \text{mm} - 14.4\ \text{mm} \\
&= -1.6294\ \text{m}
\end{aligned}
$$

However this is a grossly generalised scenario that portrays the average sea-level rise and vertical land movement trend across the whole of Scotland. A more realistic regional scenario for various parts of the Scottish coast differs considerably from the DEFRA estimates as shown by Rennie & Hansom (2011). DEFRA have since produced the fifth generation of climate change information for the UK, which is the United Kingdom Climate Projection (UKCP09), released in June 2009 which reflects regional nuances (DEFRA, 2012b) (Figure 4-24).

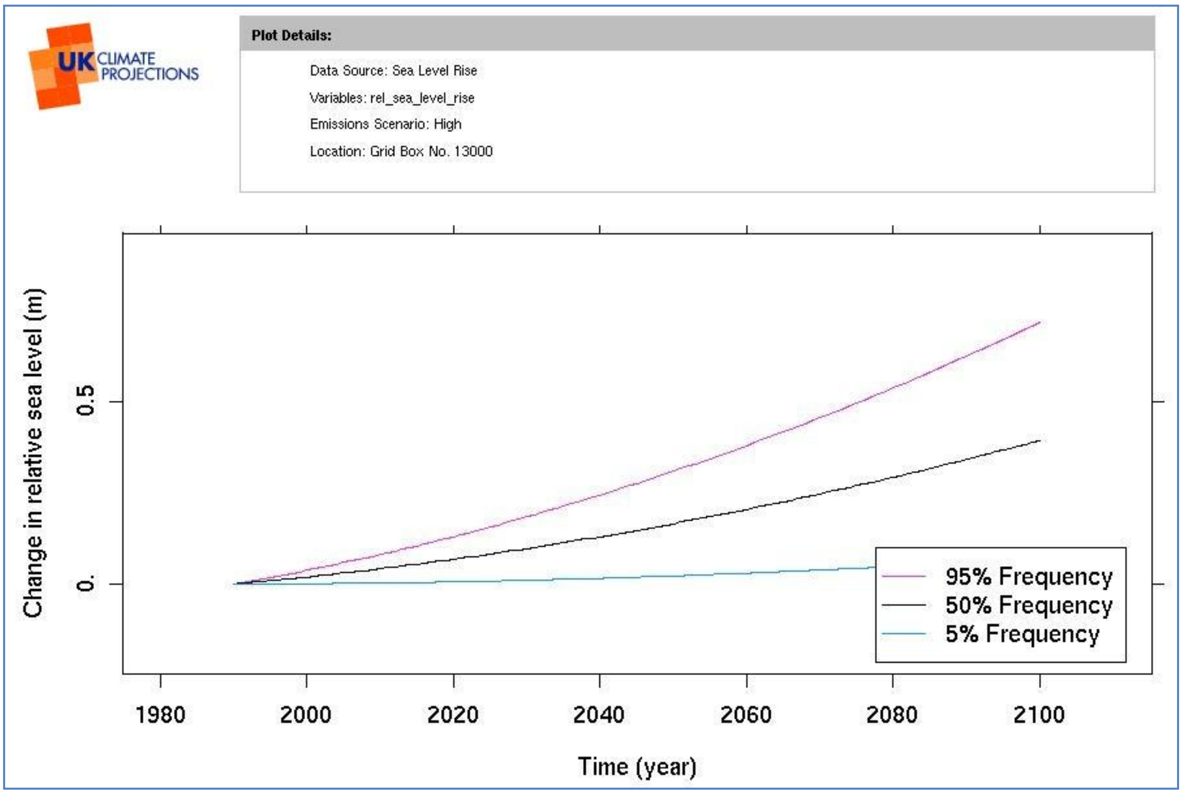

Figure 4-24 Plot showing relative sea-level (RSL) rise projection at high emissions scenario (of substances such as greenhouse gases) at Millport

According to the UKCP09 projection for a high emissions scenario for Millport, in 2025 the change in relative sea level (RSL) is ~0.152 m at 95% high estimate, ~0.082 m at 50% estimate and ~0.007 m at 5%. Therefore adopting a high emissions scenario, the LAT at Millport in 2025 taking into consideration the RSL will be (Figure 4-25):

i. 95% frequency

LAT in 2025 = Projected LAT in 2025 + RSL
= -1.66 + 0.152
= -1.508 m

ii. 50% frequency

LAT in 2025 = Projected LAT in 2025 + RSL
= -1.66 + 0.082
= -1.578 m

iii. 5% frequency

LAT in 2025 = Projected LAT in 2025 + RSL
= -1.66 + 0.007
= -1.653 m

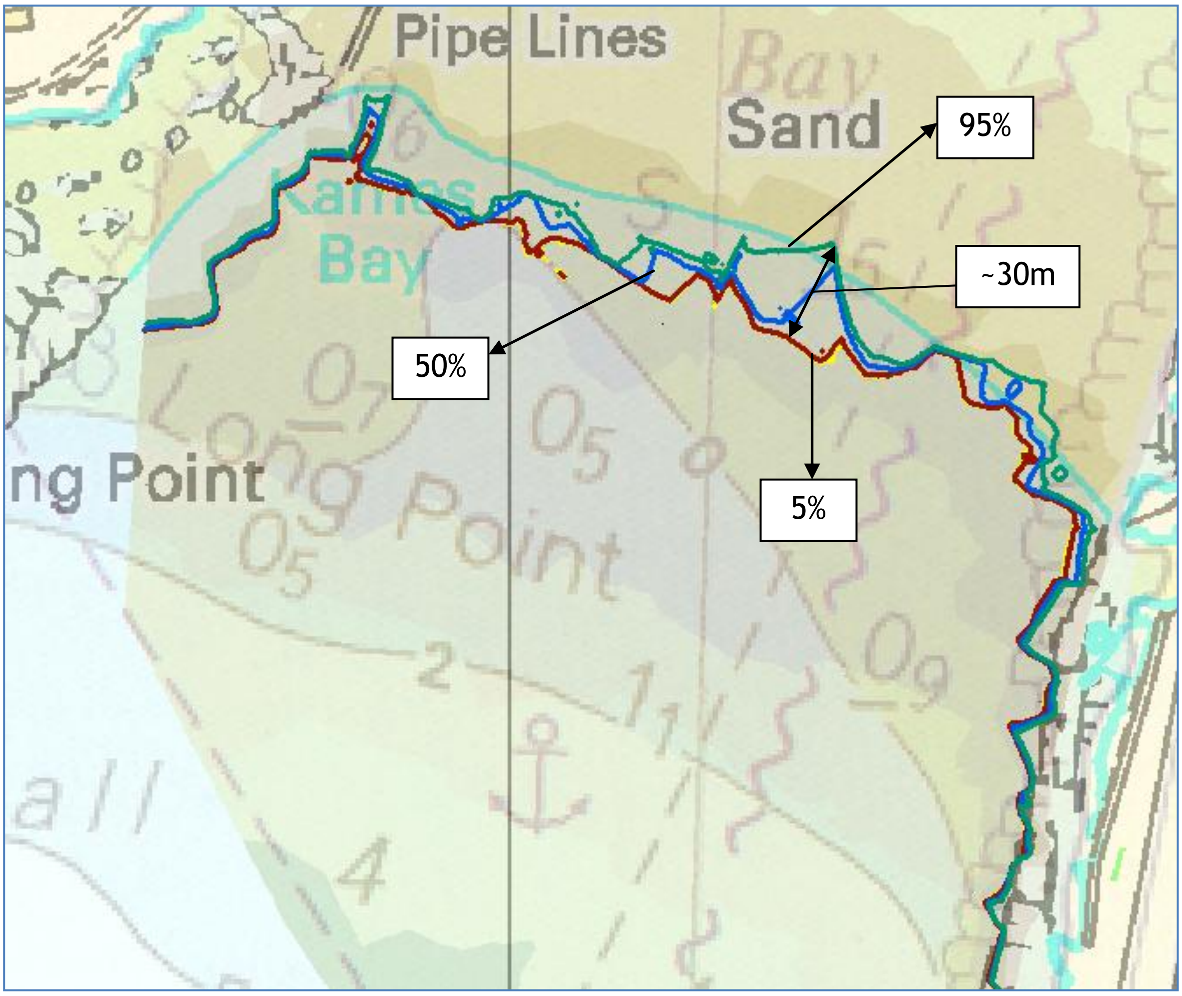

Figure 4-25 Projected LAT position in 2025 based on 5%, 50% & 95% estimates in the high emissions scenario projected by UKCP09

Provided nothing has changed in the mobile nearshore, 13 years from now, a 5% value high emissions scenario will result in a barely shifted location of LAT from its 2012 position. However a 95% value high emissions scenario will shift the location of LAT landward mainly in the low gradient sandy beach ~30 m, whereas the LAT location at the steep, rocky part of the coastline will remain about the same.

Hypothetically the LAT at Millport in 2100 taking into consideration the RSL will be (Figure 4-26):

i. 95% frequency

LAT in 2100 = Projected LAT in 2025 + RSL
= -1.66 + 0.714
= -0.946 m

ii. 50% frequency

LAT in 2100 = Projected LAT in 2025 + RSL

= -1.66 + 0.393

= -1.267 m

iii. 5% frequency

LAT in 2100 = Projected LAT in 2025 + RSL

= -1.66 + 0.071

= -1.589 m

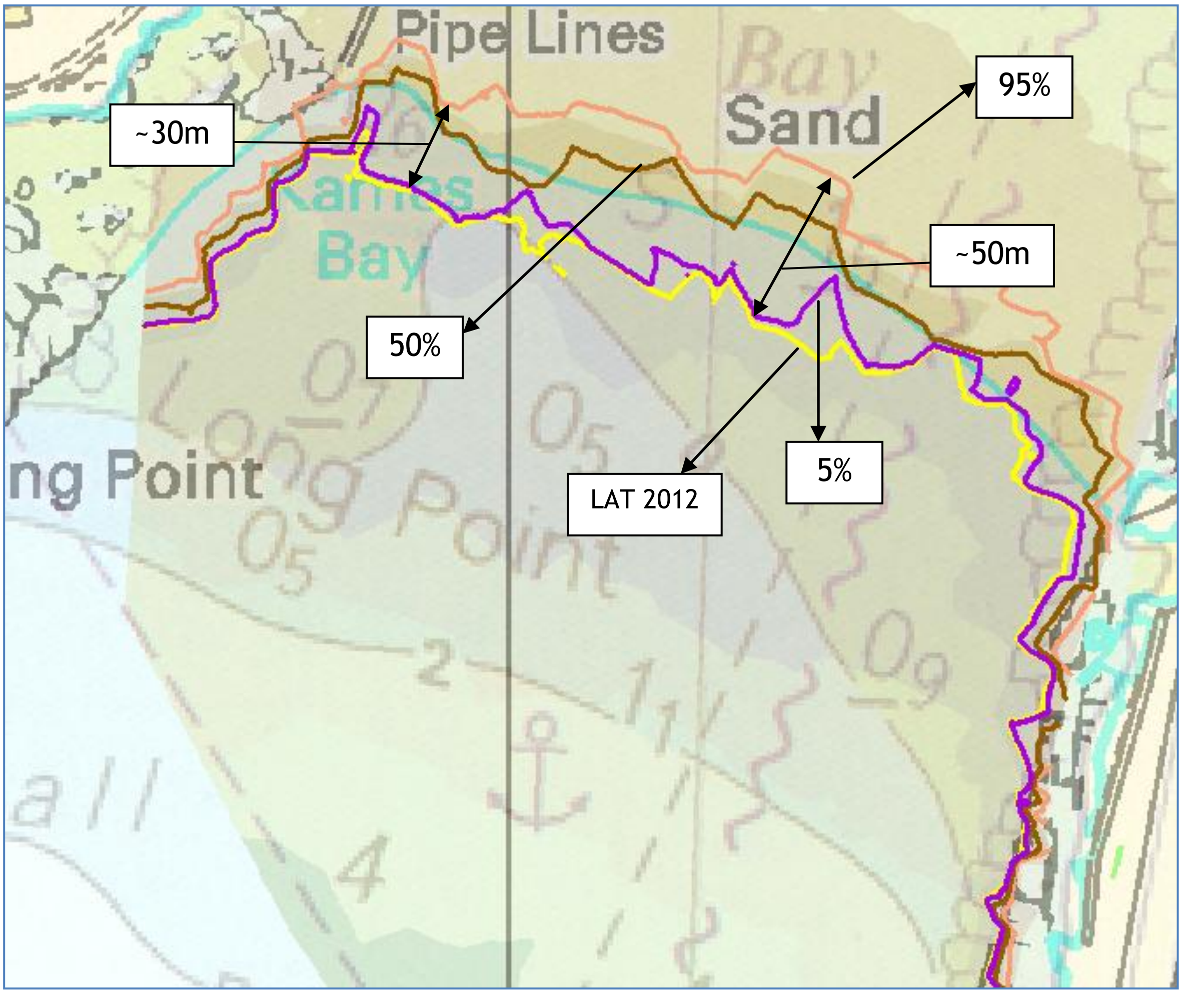

Figure 4-26 Projected LAT position in 2100 based on 5%, 50% & 95% estimates in the high emissions scenario projected by UKCP09

Again, provided nothing has changed in the mobile nearshore, 88 years from now, a 5% value high emissions scenario will shift the location of LAT identical to a 50% value in 2025. A 50% value high emissions scenario in 2100 will exceed the 95% value high emissions scenario in 2025 and shift the LAT even more landward than the current MLWS. A 95% value high emissions scenario in 2100 will shift the location of LAT landward 30~50m (Figure 4-27).

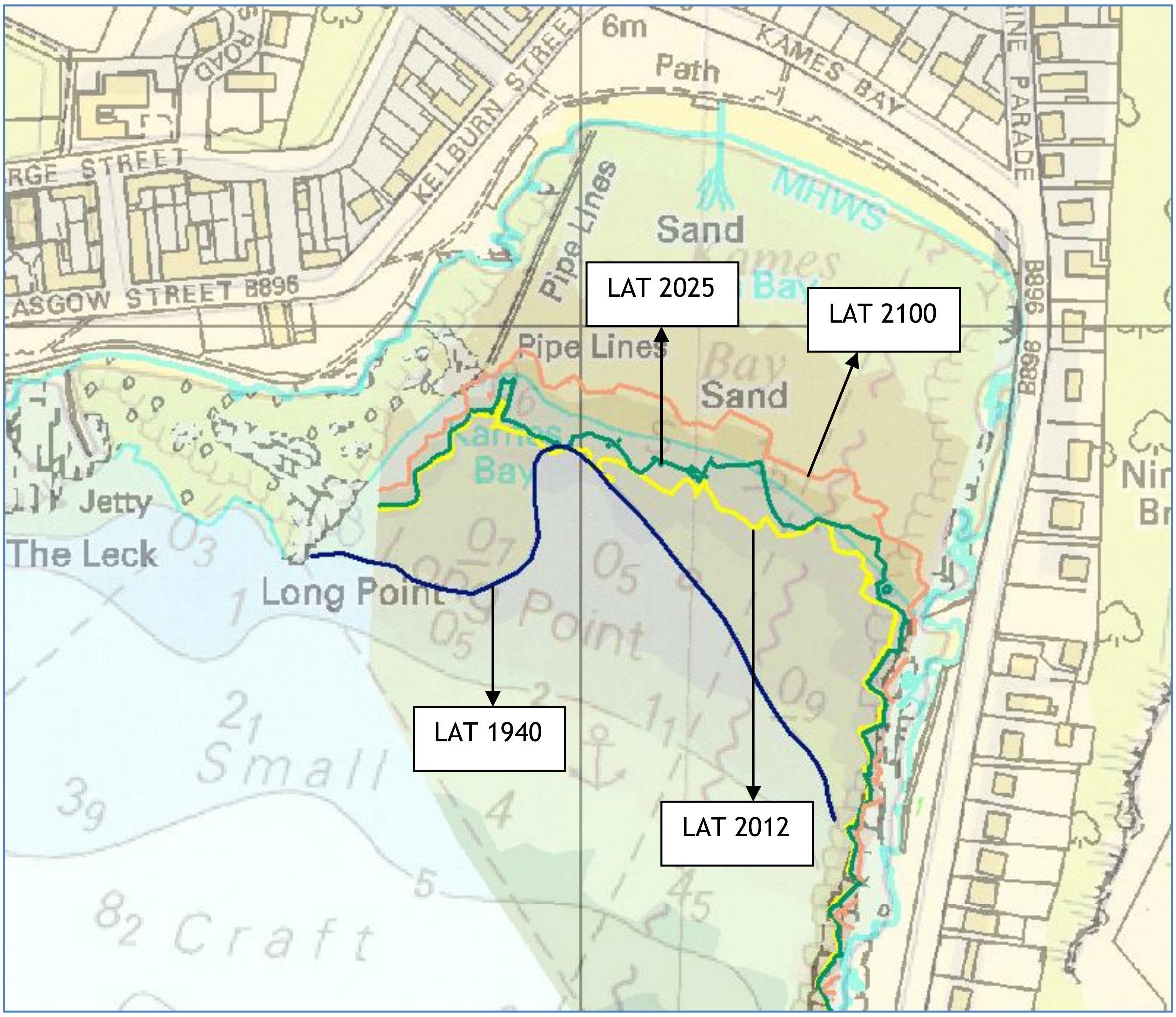

Figure 4-27 The shift of LAT position from 1940 to 2100 based on historical data, current survey data and 95% estimates in the high emissions scenario projected by UKCP09

4.2.7 Environmental and economic impact of a receding low-water line

In addition to the implications to the marine cadastre of a shifting baseline over time, the movement of LAT has important environmental consequences. It is well known that the landward movement of MHWS (Mean High Water Springs), otherwise known as coastal erosion, is ongoing as a result of sea level rise and sediment deficiencies on coasts worldwide. What is less obvious is the often unseen and unrecorded landward movement of LAT that results in loss of coastal intertidal habitat as well as loss of intertidal sediments and thus a steepening of the intertidal zone (Hansom, 2010). Changes to the gradient and sediment composition of the intertidal may ensue since deeper water will promote enhanced wave activity, the result of which may be an elevated erosion and flooding risk and calls for artificial coast protection structures as well as accelerated loss of intertidal habitat.

4.3 DISCUSSION

Several accurately-derived low-water lines of a foreshore have been generated from terrestrial and bathymetric DTMs combined with the predicted tidal levels of the low-water lines in question.

Conventionally the surveys of low-water lines are time-bound, since they are usually carried out during the time that the specific tide was predicted to occur, either by terrestrial methods such as DGPS to physically survey the wet line trace left behind by tides, or airborne methods such as aerial photography that capture and then digitise the line's location. The time constraints of these methods are the major disadvantage, apart from other shortcomings such as the need to resurvey the same site at different periods in order to determine different low-water lines. The method demonstrated here provides flexibility in terms of survey timing and is able to provide the location of multiple low-water lines. The ease of execution is especially attractive for determining low-water lines for small areas and thus provides a cost-effective, time saving, accurate alternative to conventional methods. The most important piece of information for this method to work is the availability of accurate tidal levels. The tidal prediction data derived from the nearby tide gauge at Millport is sufficient to generate accurate low-water lines for a homogenous coastline characterised by clear water. The information that can be derived from this method has great potential for other applications such as coastal management and monitoring of migration of tide lines associated with sea-level. Historical locations of low-water lines can be used in cases of dispute or to project future locations for planning purposes.

DGPS and echo sounding was used here to acquire terrain and bathymetric DTMs for a small coastal area as an effective and easy to execute technique. The local tide gauge data has also been shown to generate satisfactory low-water lines. It is clear that while most DTMs are acquired primarily for land terrain purposes and so may include parts of the littoral zone, they do not have sufficient data at low coastal elevations to derive an accurate maritime baseline. Many researchers have advocated that the most promising technique for acquiring land DTMs is terrestrial LiDAR, and now marine LiDAR is also effective at gathering height data in shallow water contexts. However the acquisition of foreshore terrain and bathymetry using LiDAR faces some challenges in the sense that acquisition is best carried out separately in order to achieve high accuracy. Traditionally, these LiDAR systems use different height datums, complicating the integration of DTMs. There also exists a limited penetration ability of bathymetric LiDAR systems in highly turbid waters (Quadros et al., 2008). Recent advancements in technology have shown some promising LiDAR instruments with higher resolution and net measurement rates that are able to acquire seamless topography and bathymetry in a single overflight. This gathers useful data from shallow depths and less than perfect water transparency: conditions where traditional LiDAR has suffered (Pfennigbauer & Rieger, 2012). Nonetheless although these LiDAR instruments might be an ideal solution for providing seamless land-water interface for large areas, it might not be cost effective for solving the needs of the small areas typical of cadastre systems.

From the fieldwork reported here the overlap of DTMs is only realistic in the region of approximately MHWS-MLWS and unlikely in the location of HAT and LAT. However the bathymetric DTM can be validated from the land DTM if they are highly correlated and this provides confidence in the location of the derived LAT. The results clearly demonstrate the effectiveness and efficiency of this method in generating low-water lines. This method also does not face the integration problem encountered by traditional land and bathymetric LiDAR systems. In the implementation of a marine cadastre, the method outlined above may provide easy and rapid determination of low-water lines for various small priority areas scattered around the coastline.

However the method presented here does have several constraints. Firstly the use of DGPS survey to acquire the DTM of the foreshore is not suitable for large areas, simply because it will be too time-consuming. DGPS is not ideal for acquiring land DTM of rocky shorelines because of the overwhelming amount of DGPS points that have to be collected to represent the complex rocky surface with accuracy, aside from the danger of acquiring data in inaccessible places.

Secondly, the accuracy of the low-water line derived depends on the availability of tide gauge data close to the location in question. In coastal areas where reliable tide gauge data cannot be obtained, it is advisable to establish a secondary tide gauge station to obtain the necessary tide data prior to applying this method to derive the low-water lines. Thirdly, the land and bathymetric DTM of an area might only stay valid for a limited period due to the dynamism of a foreshore; therefore frequent acquisition at a suitable interval might be necessary. What's more, the realisation of a baseline from the intersection of the foreshore and tide make sense only when both DTM and tide data are roughly from the same period. An obsolete land DTM from the past does not reflect the current topography of the shoreline it represents, so it is meaningless to intersect it with current tidal data, likewise using an obsolete tidal data with up to date land DTMs has little meaning.

In conclusion, aside from its constraints, the low-water line derivation method investigated in this research shows feasibility and great promises of a faster and cheaper alternative to traditional methods or LiDAR for smaller coastal areas with good tide data.

5 MALAYSIA'S CURRENT COASTLINE MANAGEMENT AND DEVELOPMENT POLICIES: IMPLICATIONS FOR THE MARITIME BASELINE

This chapter aims to identify Malaysia's current policies related to coastal management and development that may have an impact on the placing of the maritime baseline (low-water line).

5.1 Introduction

The littoral zone refers to the coastal area between the low and high water mark and is a delicate and highly dynamic zone. The low-water line is the intersection of the sea with the shore at a specific time. Its position is therefore also dynamic and subject to change due to natural coastal processes (erosion, accretion, sea-level rise, land uplift/subsidence etc) or human induced activities (recreational activities or development) carried out near the shoreline. The questions are: to what extent is movement of the boundaries of the littoral zone tolerable in the context of defining a marine boundary? How will it affect infrastructure and development plans at the coast? What should be done in policy terms to mitigate the impact of any movement? The main concern in terms of its effect on the maritime baseline should be: to determine the acceptable magnitude or tolerance for changes that may take place; whether action is needed to mitigate or reverse the changes, and to assess the consequences of these actions to the maritime jurisdiction limit. To answer these questions, the subtle interaction of the maritime related legislation that influences the coastline need to be considered, together with the parties involved, the current impact on stakeholders and, what initiatives have been undertaken to address any problems.

5.2 The Treaties and Legislation Concerning Coasts and Seas in Malaysia

According to the Maritime Institute of Malaysia (MIMA), in 1997 there were at least 74 national laws and 35–40 subsidiary legislative items and by-laws pertaining to maritime management in Malaysia (Anon, 1997). Meanwhile, the following treaties and national laws of relevance are related to the maritime boundary in Malaysia (Table 5.1).

Table 5-1 Chronological list of treaties/ agreements, national laws that are related to maritime boundaries in Malaysia

Year	Declaration, Treaties/ Agreements entered & enactment of maritime related national laws
1928	Straits Settlements & Johore territorial waters agreement 1927
1930	Convention Delimiting the Boundary the Philippine Archipelago and the State of North Borneo, 2 January 1930.
1936	Penal Code 1936 – (Revised 1997)
1952	Merchant Shipping Ordinance 1952 Dangerous Drugs Act 1952 (Act 234)
1958	The North Borneo (Definition of Boundaries) Order in Council, 1958 The Sarawak (Definition of Boundaries) Order in Council, 1958 (*Malaysia participated in Geneva Convention (UNCLOS 1); several principles embodied in it were duly adopted into Malaysian legislation through the law that followed)
1959	Immigration Act 1959/1963 (Act 155) - (Revised 1997)
1965	National Land Code 1965 (Act 56)
1966	Continental Shelf Act 1966 (Act 83) Petroleum Mining Act 1966 (Act 95) - (Revised 1972)
1967	Customs Act 1967 (Act 235) - (Revised 1980) Police Act 1967 (Act 344) - (Revised 1988)
1969	Agreement between the Government of Malaysia and the Government of Indonesia on the Delimitation of the Continental Shelves between the two countries, 27 October 1969. Emergency (Essential Powers) Ordinance No. 7/1969 (*extending Malaysian Territorial Sea to 12nm and enabling legislation for straight baselines)
1970	Treaty between the Republic of Indonesia and Malaysia on Determination of Boundary Lines of Territorial Waters of the Two Nations at the Strait of Malacca, 17 March 1970.
1971	Treaty between the Republic of Indonesia, Thailand and Malaysia on Delimitation of Continental Shelves Boundaries in the Northern Part of the Strait of Malacca, 21 December 1971.
1974	Environment Quality Act 1974 (Act 127) Petroleum Development Act 1974 (Act 144)
1975	Establishment of a Joint Council with Indonesia and Singapore on navigation safety and pollution in Straits of Malacca.

1976	Extra-Territorial Offences Act 1976 (Act 163) Antiquities Act 1976 (Act 168) - Repealed by National Heritage Act 2005 [Act 645]) Town and Country Planning Act, 1976 (Act 172)
1979	Treaty between the Kingdom of Thailand and Malaysian Relating to the Delimitation of the Continental Shelves Boundaries in the Gulf of Thailand, 24 October 1979. Unilateral publication of 1979 New Map depicting Malaysian maritime zone limit.
1982	United Nations Convention on the Law of the Sea (UNCLOS III) 1982. Treaty between Malaysia and the Republic of Indonesia relating to the legal regime of Archipelagic State and the rights of Malaysia in the territorial sea and archipelagic water as well as in the airspace above the territory of the Republic of Indonesia lying between East & West Malaysia, 25 February 1982.
1984	Petroleum (Safety Measures) Act 1984 (Act 302) Atomic Energy Licensing Act 1984 (Act 304) Exclusive Economic Zone Act 1984 (Act311) *(*declared Malaysian EEZ up to 200nm)*
1985	Fisheries Act 1985 (Act 317) *(* declared Malaysian Fisheries Waters (MFW) of 200 nm)*
1988	Dangerous Drugs (Forfeiture of Property) Act 1988 (Act 340)
1990	Malaysian-Thailand Joint Development Authority Act 1990 (Act 440)
1992	Tourism Industry Act, 1992 (Act 482)
1994	Merchant Shipping (Oil Pollution) Act 1994 (Act 515) Mineral Development Act 1994 (Act 525)
1995	Agreement between the Government of Malaysia and the Republic of Singapore to delimit precisely the territorial waters boundary in accordance with the Straits Settlements & Johore territorial waters agreement 1927, 7 August 1995.
1996	**Malaysia's declaration upon ratification of UNCLOS III.*
2004	Malaysian Maritime Enforcement Agency Act (Act 633)
2006	Baselines Of Maritime Zones Act 2006 (Act 660)
2010-Current	Drafting of National Geospatial Act

Source: modified from United States Department of Defence, 2005 and MKN, 2010. *This list is not exhaustive.

Clearly this is a complex area with many items of legislation many of which may overlap in terms of areal footprint and jurisdiction. The development of these items has taken place over a lengthy time period, the timing of which spans the pre-independence period early in the 20th century up to present (Figure 5-1).

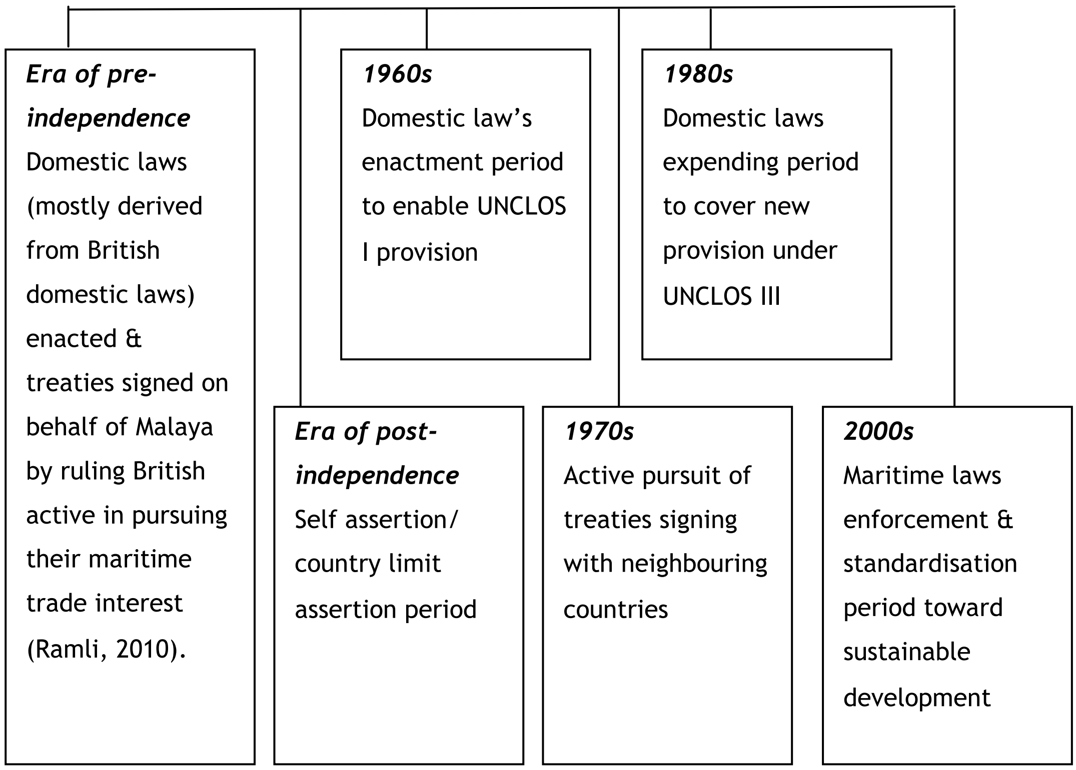

Figure 5-1 General trend of maritime legislation development since the early 20th century to the present in Malaysia

Some of the Acts mentioned above depend on knowledge of the location of the maritime boundary for effective interpretation or enforcement, while some of the Acts make provision for, or regulate, activities that may indirectly impact on the maritime baseline. Table 5.2 summarises this interaction or dependence on the maritime baseline/boundary.

Table 5-2 Maritime related national laws' interaction with the maritime boundary in Malaysia

Act	How is it related to/rely on maritime baseline/ boundary?	Are there any provisions inside these Acts that might possibly alter/affect the maritime baseline/ boundary position?
Penal Code 1936	This Act relies on knowledge of maritime boundary to determine whether a crime is committed within Malaysia's boundary (Sec.3, Sec.4), etc.	No provision that will affect the maritime boundary.
Merchant Shipping Ordinance 1952	This Act relies on knowledge of maritime baseline to determine territory limits, prescribed for ships, limits of Federations waters, etc.	No provision that will affect the maritime boundary.
Dangerous Drugs Act 1952 (Act 234)	This Act relies on knowledge of maritime boundary to determine whether possession of dangerous drug is in or abroad of the waters of Malaysia; to inspect and seize by boarding any ship or aircraft remains in Malaysia (Sec.27); to demand reporting of concealing dangerous drug at the earliest opportunity while entering Malaysia territorial waters (Sec. 38(3)); etc.	No provision that will affect the maritime boundary.
Immigration Act 1959/1963 (Act 155)	This Act relies on knowledge of maritime boundary to determine the instance of entering or departing from Malaysia; power to seize, detain & forfeit vessels, vehicles or aircraft in the territorial waters of Malaysia (Sec.49A); etc.	No provision that will affect the maritime boundary.
National Land Code 1965 (Act 56)	This Act does not rely on knowledge of maritime boundary; instead it defines the limit of land cadastre, foreshore, shoreline, local states' land etc., which are crucial to the definition of maritime boundary.	Sec.5 definition of foreshore, shoreline determines local states' maritime limit.
Continental Shelf Act 1966 (Act 83)	This Act relies on knowledge of maritime baseline to determine continental shelf limit from the baseline.	No provision that will affect the maritime boundary.
Petroleum Mining Act 1966 (Act 95)	This Act relies on knowledge of maritime boundary to regulate mining happens within Malaysian waters; to determine limit of on-shore & off-shore land.	No provision that will affect the maritime boundary.
Customs Act 1967 (Act 235)	This Act relies on knowledge of maritime boundary to enable enforcement within territorial waters of Malaysia such as detaining vessel within territorial waters violating the Act, etc.	No provision that will affect the maritime boundary.
Police Act 1967 (Act 344)	This Act relies on knowledge of maritime boundary for the preservation of peace and security of Malaysia including the territorial waters thereof (Sec.3).	No provision that will affect the maritime boundary.
Emergency (Essential Powers) Ordinance No. 7/1969	This Act does not rely on knowledge of maritime boundary.	Article 3 & Article 4(2) defining the breadth of territorial waters & limit of territorial waters to be measured from the low-water mark.

Environment Quality Act 1974 (Act 127)	This Act relies on knowledge of maritime boundary to regulate pollution, environment protection etc in inland waters (above the low –water line along the coast) & Malaysian waters (Sec.29).	No provision that will affect the maritime boundary.
Petroleum Development Act 1974 (Act 144)	This Act relies on knowledge of maritime boundary to enable exploration and exploitation of petroleum whether onshore or offshore by a Corporation (Petronas), within Malaysian waters.	No provision that will affect the maritime boundary.
Extra Territorial Offences Act 1976 (Act 163)	This Act relies on knowledge of maritime boundary to enable dealing of offences committed without and beyond the limits of Malaysia and on the high seas on board any ship or on any aircraft registered in Malaysia or otherwise as if they were committed in Malaysia.	No provision that will affect the maritime boundary.
Town and Country Planning Act, 1976 (Act 172)	No indication of enforcement of this Act relies on knowledge of maritime boundary.	No provision that will affect the maritime boundary. Possible affects to the low-water line resulting from developments approved for construction such as seaports, dams etc near the shoreline Currently there is no regard to maritime baseline in consideration of approval (Impacts of decisions).
Petroleum (Safety Measures) Act 1984 (Act 302)	Knowledge of maritime boundary is probably needed to regulate vessels entering Malaysian waters which carry petroleum; to regulate the loading, unloading and discharging of petroleum (Sec.6); to regulate pipeline works executed in or on land, on the surface of or underwater, onshore or offshore, etc (Sec.16).	No provision that will affect the maritime boundary.
Atomic Energy Licensing Act 1984 (Act 304)	No indication of enforcement of this Act relies on knowledge of maritime boundary. Knowledge of maritime boundary is probably needed to regulate nuclear material in transit through Malaysia (Sec.44); to claim compensation for nuclear damage to environment that is damaged within jurisdiction of the Government of Malaysia (Sec.48), etc.	No provision that will affect the maritime boundary.
Exclusive Economic Zone Act 1984 (Act311)	This Act relies on knowledge of maritime baseline to determine EEZ limit from the baseline (Sec.3 (1)).	Sec.3 (2) where there is an agreement between Malaysia and another nation, the delimitation of EEZ shall be determined in accordance with the provisions of that agreement.
Fisheries Act 1985 (Act 317)	This Act relies on knowledge of maritime baseline to regulate fishing activity in Malaysian fisheries waters.	Possible consequences from Sec.19 (4) (p) construction of shore-based facilities related to fisheries.
Dangerous Drugs (Forfeiture of Property) Act 1988 (Act 340)	This Act is remotely connected to maritime boundary in the sense that it needed make sure person persecuted by this Act does not leave Malaysia, removed property from Malaysia; to	No provision that will affect the maritime boundary.

	forfeit property of any persons violating this Act in Malaysia; to give assistance to foreign authority in Malaysia etc.	
Tourism Industry Act, 1992 (Act 482)	No indication of enforcement of this Act relies on knowledge of maritime boundary. Knowledge of maritime boundary is probably needed to determine limit of inbound marine tour.	No provision that will affect the maritime boundary.
Merchant Shipping (Oil Pollution) Act 1994 (Act 515)	This Act relies on knowledge of maritime baseline to determine pollution happened in Malaysian waters; etc.	No provision that will affect the maritime boundary.
Mineral Development Act 1994 (Act 525)	No indication of enforcement of this Act relies on knowledge of maritime boundary. Knowledge of maritime boundary is probably needed to regulate mining in or under the sea or sea-bed within Malaysian waters.	No provision that will affect the maritime boundary. Possible affects to the low-water line come from mining activities changing the bathymetry of the sea bed , altering beach dynamics causing erosion, etc.
Malaysian Maritime Enforcement Agency Act (Act 633)	This Act relies on knowledge of maritime boundary for ensuring the safety and security of the Malaysian Maritime Zone with a view to the protection of maritime and other national interests in such zone and for matters necessary thereto or connected therewith.	No provision that will affect the maritime boundary.
National Heritage Act 2005 [Act 645])	This Act relies on knowledge of maritime boundary to determine whether an underwater cultural heritage is situated in Malaysian waters.	No provision that will affect the maritime boundary.
Baselines Of Maritime Zones Act 2006 (Act 660)	This Act does not rely on knowledge of maritime boundary. It is an Act that defines the characteristic of Malaysian maritime baseline and all maritime zones shall be measure from it.	The Yang di-Pertuan Agong (the Head of State of Malaysia), on the recommendation of the Minister may declare the geographical coordinates of base points; declare the outer limit lines or the lines of delimitation of the whole or any part of any of the maritime zones of Malaysia; cause to be prepared and issued any map or large-scale chart showing the above. In addition, the Minister may make regulations as may be necessary or expedient for giving full effect to the provisions of this Act.

There are currently five Acts defining the limits of the maritime baseline and Malaysian Maritime Zone, namely the National Land Code 1965 (Act 56), Continental Shelf Act 1966 (Act 83), Emergency (Essential Powers) Ordinance No. 7/1969, Exclusive Economic Zone Act 1984 (Act311) and the Baselines Of Maritime Zones Act 2006 (Act 660). Apart from these five Acts, most of the listed Acts do not have any provision to create any direct impact on the maritime baseline, but some Acts do have the potential to affect the maritime baseline consequent on actions taken while implementing their provision, most noticeably from the Town and Country Planning Act, 1976 (Act 172), Environment Quality Act 1974 (Act 127) and Fisheries Act 1985 (Act 317). Furthermore these Acts also empower the relevant Minister to make regulations from time to time for the implementation of their provisions. Thus, without a proper policy in place there exists the potential for collateral damage to the placement of the maritime baseline from enforcement of the legislation for other purposes. Currently none of these Acts have any measures to specifically safeguard the maritime baseline or its position. This deficiency is probably due to a sectoral approach to maritime management, a situation that is not unique to Malaysia.

5.3 Parties Involved and Activities That Affect the Low-Water Line Position

Many activities occur in the coastal area and these activities are administered and regulated by a variety of agencies or departments under various ministries or local states' authorities. Frequently there are activities that are subject to more than one authority, signalling an overlapping of authority (and potential confusion) among agencies. Indeed, there is no single agency that has overall authority over all maritime matters. Again, Malaysia is not unique in this respect. Currently, there are at least 14 ministries and more than 26 departments/units/authorities responsible for the management of the maritime sector in Malaysia (Saharuddin, 2001). Table 5.3 lists those activities that take place predominantly in the coastal area and their possible impacts on the maritime baseline, the relevant authority governing these activities and the relevant legislation.

Table 5-3 Activities and authorities involved in coastal area and their potential impacts on maritime baseline

Activities	Administration and enforcement	Legislation/ Policies/ Guidelines	Activities' impacts on the maritime baseline
Port	MOT, MD, Federal & local states' PA, etc.	Merchant Shipping Act 1952; Fisheries Act 1985 (Act 317); Port Authorities Act 1963; Port Privatisation Act 1990; Penang Port Commission Act 1955; Bintulu Port Authority Act 1981; Sabah Port	Likely from construction work, etc.

		Authority Enactment 1967; etc.	
Shipping	MOT, Marine Dept., NSC, MNSC, SRB, etc.	Merchant Shipping Act 1952; Merchant Shipping (Oil Pollution) Act 1994; etc.	Unlikely
Fisheries & living resources	DOF, etc.	Fisheries Act 1985; Fisheries (Maritime) (Licensing of Local Fishing Vessel) Regulations, 1985; Fisheries Comprehensive Licensing Policy; Fisheries (Marine Culture System) Regulations, 1990; Fisheries (Cockles Conservation and Culture) Regulations, 2002; Exclusive Economic Zone Act 1984 (Act311); etc.	Likely from construction of fisheries port, etc.
Offshore oil and gas	PM's Dept., EPU, etc.	Petroleum Mining Act 1966 (Act 95); Petroleum Development Act 1974 (Act 144); Petroleum (Safety Measures) Act 1984 (Act 302); etc.	Unlikely
Other marine industries/ non-living resources	DDGLM, etc.	Mineral Development Act 1994 (Act 525); Continental Shelf Act 1966 (Act 83); etc.	Likely from near coastal mining activities
Marine tourism	MOCAT, DOF	Tourism Industry Act, 1992 (Act 482), EIA Guidelines for Development of Tourist Recreational Facilities on Islands in Marine Parks; etc	Unlikely
Coastal zone management	DID, DOF	Environment Quality Act 1974 (Act 127); Environmental Impact Assessment Order 1987; General Circular 5/1987, etc.	Likely from coastal rehabilitation action
Marine environment management	DOE, MD, DOF, RMN, MP, PERHILITAN, MMEA	Environment Quality Act 1974 (Act 127); Environmental Impact Assessment Order 1987; Merchant Shipping (Oil Pollution) Act 1994 (Act 515); Exclusive Economic Zone Act 1984 (Act311); Environmentally Sensitive Areas Guide Book etc.	Unlikely
Maritime surveillance	MD, RMN, RMP, MMEA,	Panel Code 1936; Merchant Shipping Ordinance 1952; Immigration Act 1959/1963 (Act 155); Continental Shelf Act 1966 (Act 83); Exclusive Economic Zone Act 1984 (Act311); Malaysian Maritime Enforcement Agency Act (Act 633); Customs Act 1967 (Act 235);	Unlikely
Maritime safety	MD, RMN, RMP, MMEA, etc.	Panel Code 1936; Extra Territorial Offences Act 1976 (Act 163); Police Act 1967 (Act 344); Customs Act 1967 (Act 235); Maritime Enforcement Agency Act (Act 633); etc.	Unlikely
Reclamation & dredging	MOT, DOE, DID, MD, Federal & local states' PA, etc.	Environment Quality Act 1974 (Act 127); Environmental Impact Assessment Order 1987; General Circular 5/1987; etc.	Likely from accretion, erosion etc.
Development/ Construction	JPBDSM, etc.	Town and Country Planning Act, 1976 (Act 172); EIA Guidelines for Coastal Resort and Development Projects; etc.	Likely from coastal development projects.

MOT – Ministry of Transport; **EPU** – Economic Planning Unit; **PA** – Port Authority; **SRB** – Sarawak River Board; **NSC** – National Shipping Council; **MNSC** – Malaysia National Shippers Council; **DOF** – Department of Fisheries; **DDGLM** – Department of Director General of Land and Mines; **MOCAT** – Ministry of Culture, Arts and Tourism; **DID** – Department of Irrigation and Drainage; **DOE** – Department of Environment; **MD** – Marine Department; **RMN** – Royal Malaysian Navy; **PERHILITAN** – Wildlife Protection and National Park Department; **MMEA** – Malaysian Maritime Enforcement Agency, **RMP** – Royal Malaysia Police Force (Marine unit); **JPBDSM** – Federal Department of Town & Country Planning Peninsular Malaysia. Source: excerpted and modified from Saharuddin (2001).

As seen from Table 5.3, there are at least eight authorities/ agencies (MOT, MD, Federal & local states' PA, DOF, DDGLM, DID, DOE, JPBDSM) regulating six main activities that have the potential to impact on the maritime baseline, and at least 18 maritime related Acts depend on knowledge of a precise maritime boundary for effective implementation. However, none of these authorities/ agencies has the expertise to determine the location of the maritime baseline or maritime zone boundary, and most each probably is unaware or unconcerned about how their administrative decisions will impact on the maritime baseline or other actors. The mapping and charting authorities, JUPEM and PHN, whose maps and charts are admissible in evidence as *prima facie* proof of location according to the Baselines of Maritime Zones Act 2006 (Act 660), are missing from the forefront and currently play a passive catch-up role in the mapping of the maritime environment. Arguably, they should be actively participating in coastal planning and ensuring the coastal line used for maritime baseline determination is safeguarded. The spatial component, arguably the most important piece of information and the most fundamental basis for any claims of sovereignty or rights to any part of the maritime environment, has not been given the appropriate attention. As the maritime baseline has shifted, the federal – local states' maritime boundaries will also be shifted, and this serves to complicate the regulation of activities near the maritime federal – local states' border. Yet this will determine which level of government has primary jurisdiction over different spaces and at different times. If the maritime resources are to be governed in a holistic and sustainable fashion, the maritime baseline cannot be allowed to be affected in an unsupervised manner and proper policies are needed in order to address the uncertainties that emerge with shifting maritime baselines. Clearly, the guardians of the maritime baseline, that is the mapping and charting authorities, are central to this.

5.4 Other Coastal Management Initiatives

A National Coastal Erosion Study carried out from 1984-1985 concluded that about 29% or 1400km of Malaysia coastline was facing erosion (Department of Irrigation and Drainage (DID) Malaysia, 2011). Since then, Malaysia has embarked on a series of coastal resources and zone management initiatives as shown in Table 5.4. A major milestone in these initiatives was the creation of a National Coastal Resource Management Policy (NCRM) which served as a basis for pilot Integrated Coastal Zone Management (ICZM) projects in Sabah, Sarawak and Penang; and provided directions for DID's 'Guideline on Erosion Control for Development Projects in the Coastal Zone'. A national ICZM (NICZM) was prepared in 2004, but has not yet been presented to the Cabinet for approval (Gopinath, 2010). The NICZM boundary limits are 5 km landward and 3 nm seaward (Gopinath, 2010). In 2001, DID embarked on a programme of Integrated Shoreline Management Plans (ISMP) tailored along the principles of ICZM covering 1 km landward and 3 km seaward from the shoreline. The ISMP concentrate on formulating management strategies and specific guidelines for development activities along local states' coastline. To date it has completed ISMP for 5 local states and 1 Federal Territory (Department of Irrigation and Drainage (DID) Malaysia, 2011). In 2012 the Federal Department of Town & Country Planning Peninsular Malaysia (JPBDSM) prepared the National Coastal Zone Physical Plan (NCZPP) to provide the strategies to be adopted for the sustainable development, management and rehabilitation of coastal zones from 2008-2030. However the NCZPP does not present a detailed output for those local states which have implemented ISMP in the meantime, because JPDBSM understood ISMP to have prepared a comprehensive management policy for these states which is in line with NCZPP objectives. They will instead combine the framework of NCZPP within the implementation of ISMP (JPBDSM, 2012). There are clear examples of duplication in effort and initiatives by different agencies that cover similar subjects or have similar objectives, but so far none have taken into account the marine spatial planning of marine resources or the allocation of marine parcels (the alienation of three-dimensional lots on and below sea surface to third parties, similar to land cadastre) to specific uses (Gopinath, 2010). This gap is due to be addressed when JUPEM embark on a 3D marine cadastre during the 11th Malaysia Plan (2016-2019). A further confusion is that internationally SMPs are linear and deal with the shoreline (usually based on engineering assessments of coastal erosion) whereas Coastal Zone Management Program (CZMP) is, in effect, a process that provides the relevant authorities with tools to deal with a zone of variable width and cover a range of activities affecting the coastal zone.

Table 5-4 Coastal resources and zone management in Malaysia

Date	Initiatives
1984-1985	National Coastal Erosion Study
1986-1992	South Johore coastal resource management project with United States Agency for International Development (USAID)
1987	• Government circular on coastal development • Environment Impact Assessment Order 1987
1991-1996	National Coastal Resource Management Policy (NCRM)
1993	National Conservation Strategies prepared by WWF
1995	Study towards developing a National Integrated Ocean Policy by Maritime Institute of Malaysia (MIMA)
1996	National Aquaculture Guidelines
1997	• Town & Country Planning Department Guidelines on Coastal Development • Department of Irrigation and Drainage Guideline on Coastal Zone Management • Integrated management Plan for sustainable use of Johore Mangrove Forests • Environment Profile of the Malacca Straits under the GEF/UNDP/IMO Regional Programme
1997-2000	Pilot Integrated Coastal Zone management (ICZM) projects in Sabah, Sarawak and Penang
1998-present	Drafting of the National Wetlands Policy
1999	Department of Environment Guideline for environmental impact assessment in coastal zone development projects
1999-2004	National coastal zone policy initiative (NICZM)
2001-present	Preparation for an Integrated Shoreline Management Plan (ISMP) for beach conservation and restoration
2001-2004	Integrated Coastal Management pilot study in Klang, Selangor under the GEF/UNDP/IMO/PEMSEA Regional Programme
2010	Malaysia Ocean Policy 2011-2020 by the National Oceanography Directorate
2012	National Coastal Zone Physical Plan (NCZPP) by Federal Department of Town & Country Planning Peninsular Malaysia

Source: excerpted and updated from Mokhtar & Ghani Aziz (2003).

5.5 Problems facing the delimitation of a Maritime Baseline

5.5.1 Legal Issues

Currently there is a legislative gap on the issues concerning the maritime baseline. Five Acts define the maritime limit of Malaysian waters but no single policy or guideline is in place that addresses or even acknowledges the shifting nature of the maritime baseline. The closest legislation to safeguarding of maritime baseline currently is the ‘Guidelines on Erosion Control for Development Projects in the Coastal Zone (DID Guidelines 1/97)’ established under the General Administrative Circular No.5/1987 by the National Coastal Erosion Control Council (NCECC) via the Prime Minister’s Department. It requires development proposals in the coastal zone to receive comment and approval from the Coastal Engineering Technical Centre (CETC) of the Department of Irrigation and Drainage (DID) before proceeding (Siry, 2006). This guideline aims to ensure sustainable development along the coast, according to the erosion control management plan of the National Coastal Resources Management Policy. It provides recommendations such as setback limits, advice on suitable erosion control structure etc for shore front development, back shore development, land reclamation, sand mining and river mouth dredging projects (Department of Irrigation and Drainage (DID) Malaysia, 1997).

Although this guideline is supposed to be read together with mandatory data required for the processing of all development applications under the Town and Country Planning Act, 1995 (Act A933), Siry (2006) and Ramli (2010) suggest that the lack of integration, coordination and ambiguity is coupled with the fact that the guideline is not legally binding and that this has led to a minimal and ineffective implementation regime. Furthermore, the primary aim is the prevention of erosion along the coastline and does not address the complications associated with a shifting maritime baseline or the actions needed to deal with it. Most coastal management initiatives focus on the sustainable management of the marine resources from the perspectives of ecology, biology and geomorphology, but rarely from a geographical or spatial perspective. The Department of Survey and Mapping Malaysia (JUPEM) and the National Hydrographic Centre (PHN) of the Royal Malaysian Navy (RMN) are responsible for the survey of the maritime baseline and produce navigational charts which show the location of low-water lines. Both need to be involved in providing an expert view on how erosion controls affect the federal – local states’ maritime jurisdiction and so act to safeguard the Malaysian maritime baseline.

5.5.2 Institutional Issues

At the moment, the Department of Irrigation and Drainage (DID) is the only department responsible for the rehabilitation of the coastline. Although JUPEM and PHN are the mappers of the nation, they currently do not have any role to play in any coastal rehabilitation action taken by DID that might inadvertently alter the maritime baseline. PHN primarily produces navigational charts for safety of navigation purposes and so PHN is probably unaware or unconcerned by movement of low-water lines along the coast unless it presents a danger to navigation. However, the navigation chart does have a significant secondary application because, according to UNCLOS III, it also serves as 'large-scale charts officially recognized by the coastal State, showing the normal baseline for measuring the breadth of the territorial sea'. Meanwhile JUPEM is the department charged with the responsibility to survey and produce maps showing the nation's boundary limits. The coastline is changing rapidly, but JUPEM has yet to produce maps showing the federal – local states' maritime limit, and has not been involved in any coastal management policy or kept abreast with any changes in the position of the coastline. As establishing a marine cadastre is gaining momentum worldwide, the issue of shifting maritime baselines needs urgent action together with policies to pave the way for inter-agency cooperation and overcome institutional issues encountered along the way.

5.5.3 Technical issues

Several technical issues face the determination of a maritime baseline ranging from its determination and visualisation to implementation. Foremost, the low-water line is not stationary and might not stay in one position for long and so its determination is hardly straightforward. Depending on which low water datum is chosen to define the low-water line, this line is not always actually identifiable or visible on the foreshore. Due to the dynamism of the coastline, constant determination may be thus required. In effect it remains as an imaginary line that is prone to shift. Because this line is the intersection between the sea and the land, it is also subject to influences from sea-level rise, land movement, etc. Secondly, the low-water datum used to define local states and federal maritime boundaries is not harmonised. The Malaysia federal-local states' maritime boundary has not been defined and even the maritime boundary between local states has yet to be agreed upon. In addition, no maritime baseline has been officially declared for the country, and this has an effect on the level of jurisdiction exercisable between different maritime zones. The technical issues related to a shifting baseline and how it impact marine parcel or maritime rights within a maritime zone have thus not been addressed.

5.6 Maritime Baseline Policies in Neighbouring Countries

In this section the issue of whether neighbouring countries to Malaysia have policies in place to safeguard their maritime baseline is examined.

Indonesia is the closest neighbouring country to Malaysia with both countries sharing vast stretches of land and maritime boundaries in Borneo, the Strait of Malacca, South China Sea and Sulawesi Sea. Indonesia is an archipelagic country with approximately 81,000 km coastline and 17,500 islands. Out of these, 92 of the outermost small islands were used as the location of the basepoints to construct Indonesia's archipelagic baselines. Realising the importance of upholding their maritime claim to more than three million km^2 of archipelagic waters, Indonesia established a policy to manage these outermost islands and protect them from hazards and areal reduction through the Presidential Decree (PD) no. 78/2005 (Tri et al., 2008). PD 78/2005 acknowledges the strategic value of these islands as basepoints, dictates that these islands should be managed collaboratively by a Coordination Team made up by representatives from various ministries with the objectives of:

a. maintaining the territorial integrity, national security and defence of the Republic of Indonesia and create stability in the region.
b. utilising natural resources in the context of sustainable development;
c. empowering communities in order to improve welfare.

The establishment of PD 78/2005 helps to combine the efforts of coastal zone management initiatives in Indonesia. For example, the Coordination Team is helped by two Work Teams coordinated by the Minister of Marine Affairs and Fisheries, with Work Team 1 in charge of natural resources, the environment, infrastructure and transport, economic, social, and cultural rights; and Work Team 2 in charge of territory, defence and security (Indonesia, 2005). In May 2011 it was further reported that Indonesia plans to build giant dykes around 12 of the 92 islands which are likely to be threatened or engulfed by sea level rise in the archipelago (Courrier International, 2011). In comparison, coastal management initiatives in Malaysia lack awareness of the need to maintain the coastline for maritime territorial integrity. Hence, Malaysia can learn from Indonesia to establish a similar policy.

Singapore has an active coastal reclamation policy and has been performing coastal reclamation for more than four decades with large areas of the north eastern coast and almost the entire southern coast of the mainland modified. This has resulted in an increase of land area of almost 20 percent (Wong et al., 2008). It is unclear whether Singapore has a policy in place to protect its maritime baseline integrity, but given their active pursuit of reclamation their maritime baseline is more likely to advance instead of retreat, thus pushing their maritime boundary further seaward especially in areas facing the open sea and unrestricted (and uncontested) by claims of neighbouring countries.

5.7 Summary

In summary, to date Malaysia does not have a clear policy on the management of its maritime baseline. Malaysia does have regulations and Acts related to maritime management, yet none specify exactly how to deal with maritime baseline changes, what actions to take and which authority is responsible, etc. It is not an exaggeration to say that other than JUPEM and a few other related agencies, most authorities, agencies and organisations have little interest in what and where the country maritime baseline is nor any grasp of how important it may be to the nation. They may well be involved in regulating matters related to the littoral zone on a regular basis and making policies that affect the locality of the maritime baseline, yet they appear to be unaware of the consequences of their actions on the position of the nation's maritime jurisdiction. This is an undesirable situation, especially when the low-water line is the main foundation of the nation's international maritime boundaries. In the age of the marine cadastre, where nations are seeking to regulate maritime activities in a systematic and holistic approach in the littoral zone and beyond to the EEZ zone, there is a clear need for a policy on how the maritime baseline is to be managed and sustained. The next chapter will deliver recommendations and a draft proposal for such a maritime baseline policy.

6 RECOMMENDATIONS FOR MALAYSIA

In the light of the imminent advent of a marine cadastre, the following recommendations are made for consideration by the relevant Government agencies for swift implementation in order that the needs and interests of all stakeholders of Malaysia's marine environment are safeguarded. The chapter ends with a draft policy proposal to safeguard the maritime baseline.

6.1 Recommendations in order to apply the maritime baseline determination method shown in this research

6.1.1 A government funded marine LiDAR campaign to survey the whole coastline

Results from the fieldwork in Chapter 4 have shown that low-water line of a foreshore can be accurately derived for a small coastal area in just a matter of days by using a combination of accurate tide data and DTMs, themselves produced by highly accurate DGPS survey and echo sounding. However to develop a national foreshore land and bathymetry DTM database covering the whole coastline, marine LiDAR is a more efficient method. Not only is it be more cost effective for larger areas, it is also be faster and have the ability to acquire data in foreshore areas that are inaccessible or too dangerous to access, such as rocky or, in the Malaysian context, muddy coastlines, coastal swamps and mangrove forests. Meanwhile Malaysia is planning to embark on a 'Marine Geodetic Infrastructures in Malaysian Waters (MAGIC)' project and one of its objectives is to develop a marine topography database for the seabed up to 12 nm from the coastline using ship-borne seabed topography survey, for a marine cadastre and other purposes. Therefore a government funded marine LiDAR campaign would complement the MAGIC project and produce a seamless topography from the foreshore out to 12 nm offshore. Once the whole foreshore DTM is acquired, routine low-water line position validation using the method outlined above as part of this research can be utilised for smaller areas of high priority, or for solving disputes in small areas.

6.1.2 Enhancing tide gauge station density

Malaysia has 21 tide stations, with 12 tide stations situated on Peninsular Malaysia and 9 stations on East Malaysia (Figure 6-1) (JUPEM, 2001). Peninsular

Malaysia has a coastline length of ~2031 km while East Malaysia has a coastline length of ~2778 km (Department of Irrigation and Drainage (DID) Malaysia, 2011). On average, tide stations on Peninsular Malaysia are ~170 km apart while on East Malaysia they are ~308 km apart. In comparison, Singapore has 12 tide gauge stations with 8 along the coasts of the main island of Singapore (Singapore, 2001). On its main island (coastline length of ~131.5 km) (Chia, 1992) the tide stations are ~16 km apart on average. Meanwhile Thailand with a coastline length of ~2778 km has 27 tide stations with an average of ~102 km apart (Thailand, 2001). Indonesia has a total coastline length of 54,716 km (CIA, 2013) and 113 tide stations and the number of new stations is being increased by about 2 per year (Khafid, 2011). Malaysia last established a tide station almost 18 years ago in 1995, and the tide station in Miri has been damaged since 1998. With the increasing need for a reference to vertical datum for surveying and mapping activities and the impeding implementation of marine cadastre, there is an urgent need for Malaysia to enhance its existing Tidal Observation Network. A sensible target would be to increase the number of tide stations gradually in highly populated or sparsely covered coastal area, therefore decreasing the average distances between tide stations (for example to an average of ~100 km apart or less), depending on need and priority dictated by economic growth.

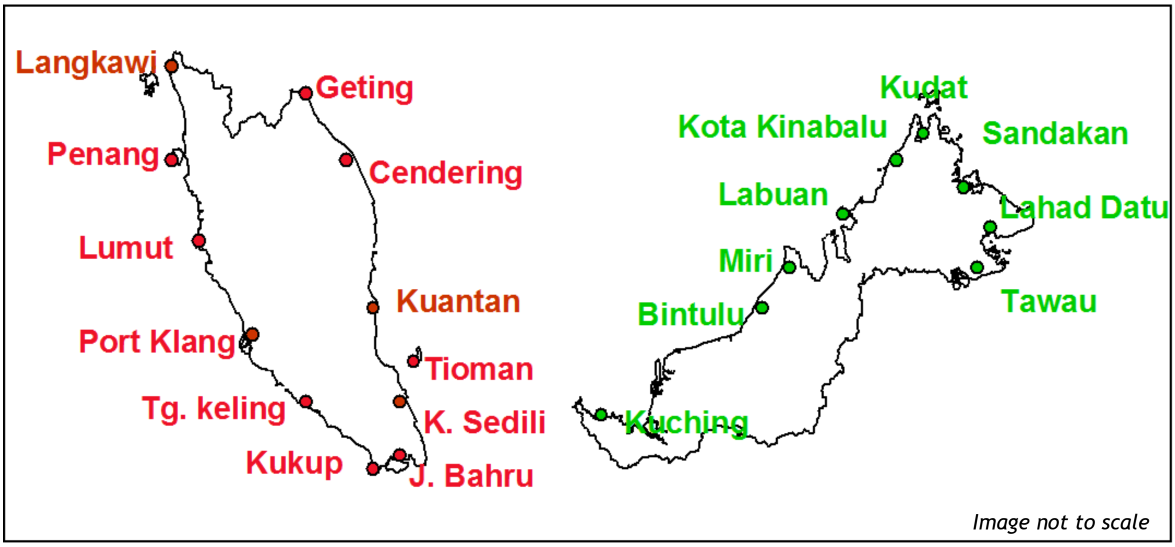

Figure 6-1 The location of Tidal Stations in Malaysia
(JUPEM, 2001)

6.2 Recommendations regarding the maritime baseline for Marine Cadastre implementation

6.2.1 Harmonising Local States' and Federal Low-Water Datums

Malaysia was party to the first United Nation Conference on the Law of the Sea (UNCLOS I) held from 1956 – 1958 in Geneva, Switzerland. UNCLOS I established the principles to determine the normal baseline, straight baseline, etc., and these principles were retained during UNCLOS III in 1982. However UNCLOS III does not address the choice of low-water datum for the low-water line used to define the baseline. This was likely due to historical use of different datums, the effort involved in resurvey if a change of datum was forced on countries, and:

> '…the fact that the tidal phenomenon varies in different localities of the world, with the result that no single formula will satisfy all tidal regimes.'
>
> (Kapoor & Kerr, 1986)

Malaysia enacted its National Land Code (NLC) in 1965 and explicitly mentions in Section 5 that the limit of 'foreshore' is measured from the 'land lying between the shore line and the low-water mark of ordinary spring tides' (Malaysia, 1965). In another words, Malaysia has chosen to use Mean Low Water Spring (MLWS), which is the average of the heights of two successive low waters during those periods of 24 hours when the range of the tide is the greatest (UKHO, 2007), as its low-water datum to determine its local states' territorial waters. Whereas according to Part II, Territorial Sea and Contiguous Zone, Article 5 of UNLOS III:

> 'Except where otherwise provided in this Convention, the normal baseline for measuring the breadth of the territorial sea is the low-water line along the coast **as marked on large-scale charts officially recognized by the coastal State**.'

Officially recognized large-scale nautical charts of Malaysia use the lowest astronomical tide (LAT) as the chart datum (Figure 6-2). LAT is the lowest level which can be predicted to occur under average meteorological conditions and under any combination of astronomical conditions yet this level will not be reached every year (UKHO, 2007). The usage of LAT as chart datum corresponds with Technical Resolution A2.5 of the International Hydrographic Organisation (IHO) that LAT shall be adopted as Chart Datum ‘where tides have an appreciable effect on the water level’. Most nations are either already using LAT or moving towards its use (FIG, 2006). Most neighbouring countries of Malaysia, including Indonesia and Singapore, use LAT. By having the same vertical datum it will also facilitate negotiation with neighbouring countries in any boundary disputes. An example of problems caused by different vertical datums is best illustrated by the dispute between Belgium and France about Banc Breedt, a sandbank that appears as a low-tide elevation (LTE) on French charts but not Belgian charts because of the different vertical datum adopted by the two countries. The dispute was resolved by splitting the difference between two delimitation lines constructed, one using Banc Breedt as a basepoint and one ignoring it (Carleton & Schofield, 2001) (Figure 6-3).

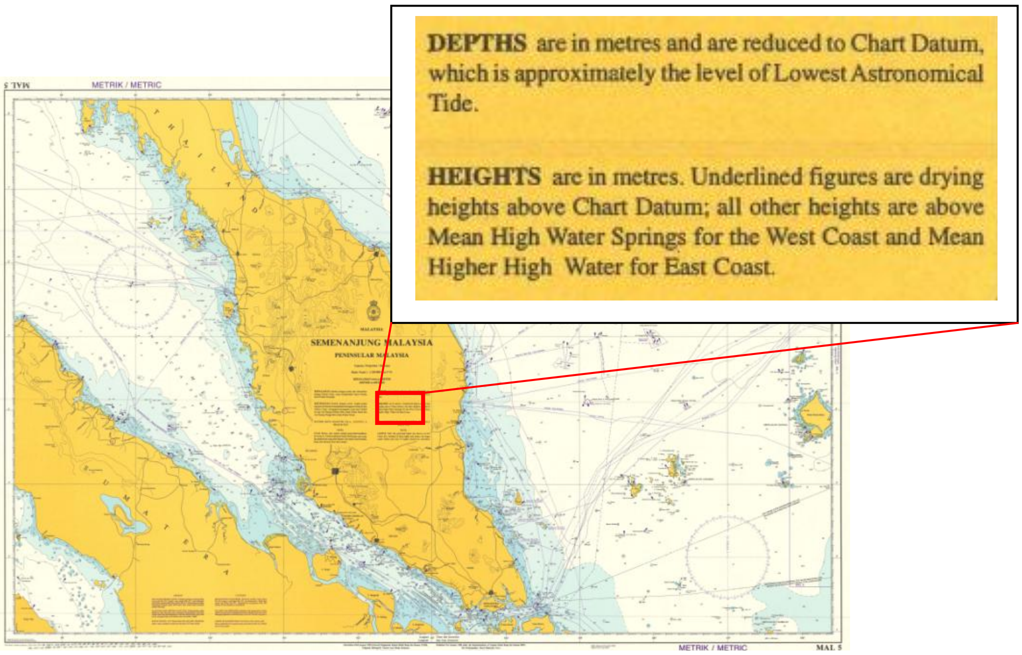

Figure 6-2 Malaysia's nautical chart using approximate LAT as Chart Datum (Royal Malaysian Navy, 1989)

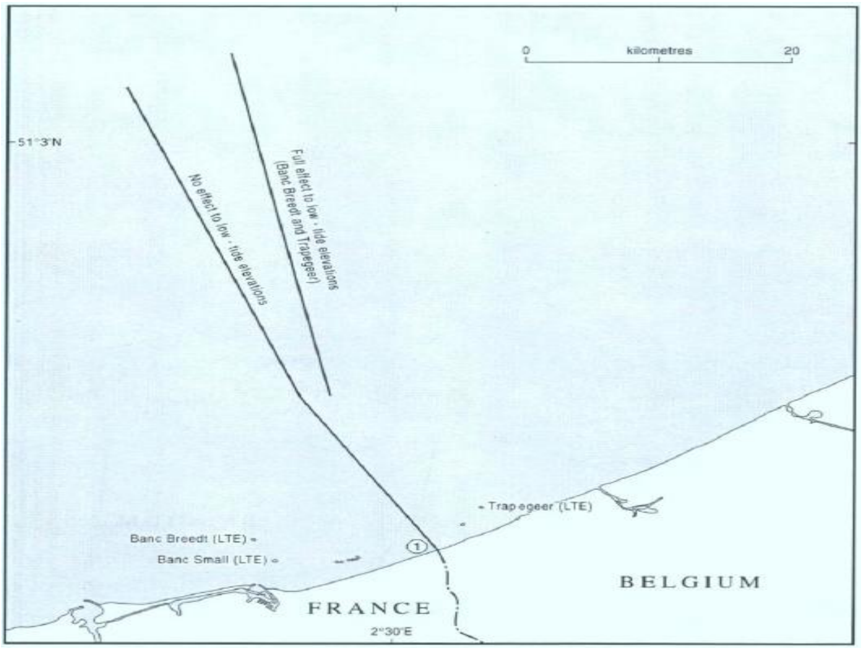

Figure 6-3 Maritime boundary dispute between France and Belgium caused by Banc Breedt
(Carleton & Schofield, 2001)

Similarly, the current Malaysian states' and federal low-water datums are not harmonised. This has the potential to create considerable confusion among various coastal zone users, as well for local states' and federal government agencies in management, data sharing, law enforcement, etc. Furthermore, the littoral zone is a highly dynamic environment; accretion and erosion can change the gradient of a coastline locally, resulting in a variable horizontal distance displacement between MLWS and LAT along the coastline (Figure 6-4).

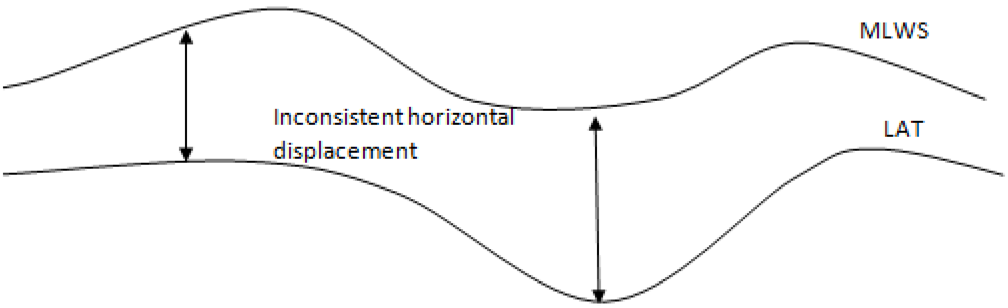

Figure 6-4 Horizontal displacement between MLWS and LAT is inconsistent

Harmonising local states' and federal maritime baselines in turn would streamline data sharing, promote interoperability and integration, eliminate confusion between user and enforcer, and encourage seamless collaboration between the local states and Federal government for the planning and management of coastal resources, thus facilitating better decision-making involving marine and coastal spatial information. It is also vital for the impending implementation of the marine cadastre that seeks to realise a system that can cope with spatially managed and physically defined maritime rights and interests both within the local states' maritime jurisdiction of 3 nm, as well as up to 200 nm for federal maritime jurisdiction.

It is proposed here that the National Land Code abandon MLWS and use LAT as the low-water datum used to define local states' maritime territory. The advantages of using LAT is that it is the lowest possible predicted low-water datum to occur under normal meteorological conditions (lower levels are possible during abnormal meteorological conditions), hence using LAT moves the maritime boundary seaward and increases the extent of foreshore. Adopting LAT for delimiting local states' maritime jurisdiction is also beneficial to the states, mainly because the majority of Malaysian shoreline is low gradient. Depending on location and tidal range, the difference in distance between the position of MLWS and LAT can vary greatly. For a coastline with steep terrain and a small tidal range, MLWS and LAT will practically coincide, whereas for a flat coastline with a large tidal range, the difference between the two can be considerable. In Scotland for example, the predicted difference in height between MLWS and LAT at Lerwick, Scotland is merely 0.44 m (National Oceanography Centre, 2012). Given Lerwick's steep coastline, the location of both low-water lines can practically coincide. Whereas a predicted tide difference between MLWS and LAT of 1.26 m of a flat coastline like Avonmouth (National Oceanography Centre, 2012c), England can result in a considerable planimetric difference between the two low-water lines (assuming the Avonmouth foreshore has a gradient of 2 degrees, the planimetric difference between MLWS and LAT will be a planimetric length of 36.082 m) (Figure 6-5). The west coast of Peninsular Malaysia facing the Straits of Malacca has a tidal range average from 1.6 m to 3.7 m but the inshore range can be up to 5 m vertically (UNEP East Asian Regional Coordinating Unit, 2003), while the east coast of Peninsular Malaysia facing the South China Sea usually experiences tidal ranges of 1.5 m to 2 m (TiongSa & HuiBoon, 2010).

These ranges produce significant linear displacement of the low water line on a low gradient beach.

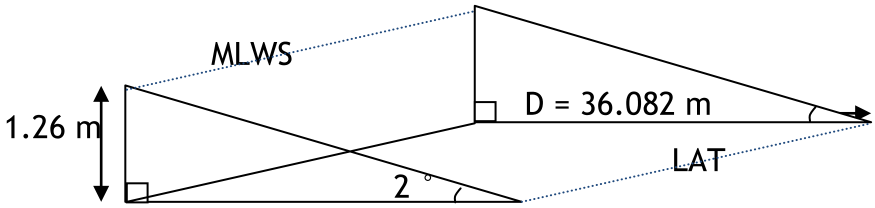

Figure 6-5 Planimetric difference hypothesis between MLWS and LAT at Avonmouth

Also, if a local state adopts a higher low-water datum than the federal one, they are actually forfeiting some territorial waters to the federal government. By adopting the same low-water datum as the federal government, local states may avoid some states' land falling into the jurisdiction of the federal government, as shown in Figure 6-6 below.

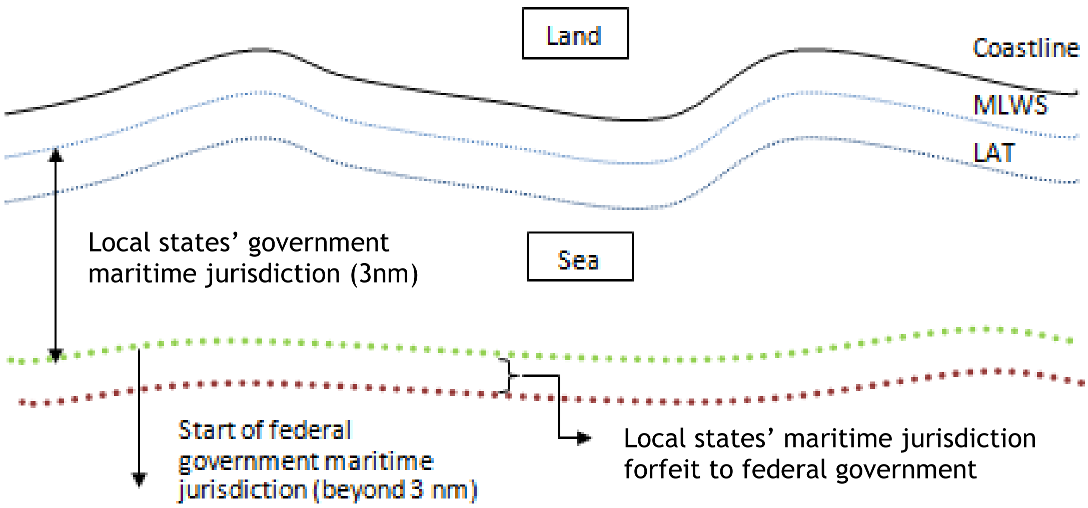

Figure 6-6 Loss of local states' land occurs from adoption of a different low-water datum from that used by the federal government

Another major benefit for adopting LAT for local states is that the existing nautical charts which already show the LAT location for the majority of the Malaysian coastline can also be used to help determine the maritime baseline for the individual states. This eliminates the cost involved in determining the baseline for another new vertical datum.

In conclusion, there is a need to unify the definition of territorial waters for the purposes of domestic land law and written law relating to land. Therefore advice to government would be to amend the National Land Code to change the low-water datum used to define local states' territorial water from ordinary spring tides to lowest astronomical tide (LAT), in order to achieve homogeneity in terms of management and ease of execution, to use a standardised legislative procedure for giving effect to the baselines, and to implement a nationwide marine cadastre.

6.2.2 Determining where a marine cadastre commences

The location from where a marine cadastre should commence will affect the rights of marine parcels or marine activities granted in the different maritime zones. Bear in mind that the absolute jurisdiction of the land cadastre does not apply to the marine cadastre, because the jurisdiction of the individual local states along the sea is restricted by the rights defined by UNCLOS III in UNCLOS zones (Cockburn et al., 2003). A marine parcel that falls within internal waters can prohibit trespassing of other parties, except in cases mentioned in Article 8 of UNCLOS III:

> 'where the establishment of a straight baseline in accordance with the method set forth in article 7 has the effect of enclosing as internal waters areas which had not previously been considered as such, a right of innocent passage as provided in this Convention shall exist in those waters.' (United Nations, 1982)

Meanwhile marine parcels that fall in the Territorial Sea Zone (12 nm from baseline) enjoy sovereignty except in the prohibition of innocent passage (albeit temporary suspension on innocent passage is permissible under Article 25). Marine parcels beyond the Territorial Sea Zone will have even less private privileges, where other nation States enjoy freedom of navigation and overflight for vessels as well as rights to lay submarine pipelines and cables (Prescott & Schofield, 2005).

According to Section 13(1) of Malaysia's National Land Code (NLC), the alienation of land by a state's Director, etc., generally ends 50 m from any bank of any river, lake or spring, shoreline (high-water mark of ordinary spring tides); and only the local state authorities have the power to dispose of states' land within fifty metres of those features. Meanwhile Section 76 goes on to state that the foreshore (all that land lying between the shoreline and the low-water mark of ordinary spring tides) and sea-bed can be temporarily disposed of for a period not exceeding ninety-nine years. In other words, the land cadastre generally ends 50 m away from the Mean High Water Spring (MHWS), except for the temporary disposal of foreshore which extends to the low-water mark. This means that the marine cadastre only begins seaward from the low-water mark of ordinary spring tides (MLWS) (Figure 6-7). If the federal and local states' low-water datum is harmonised, then marine cadastre would commence from LAT.

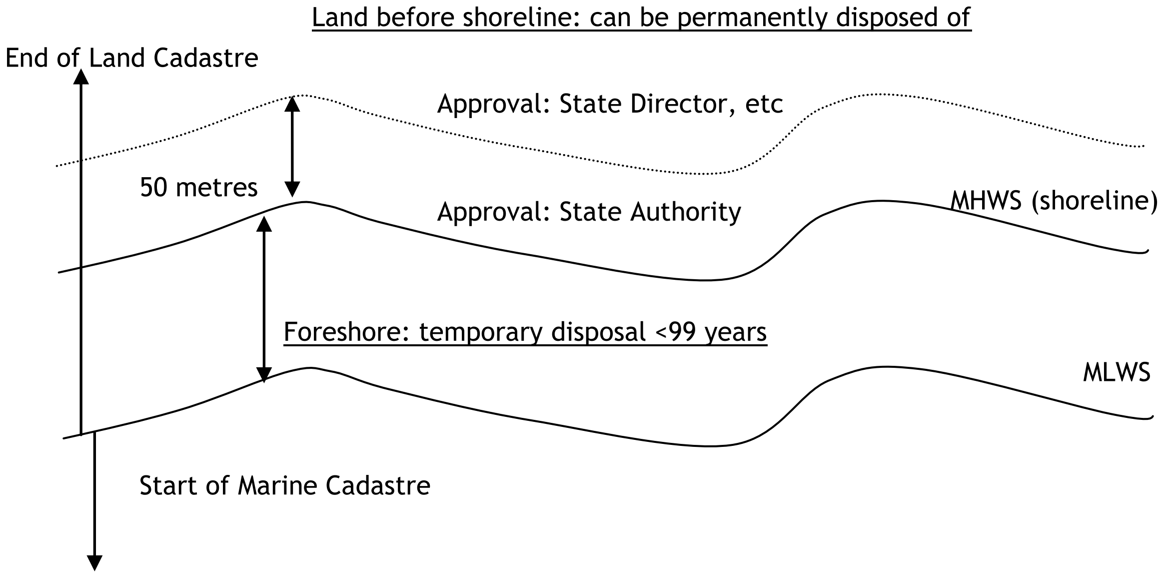

Figure 6-7 Limit of the land cadastre according to the National Land Code (as at 15th April 2011)

6.2.3 Consider fixing jurisdictions

6.2.3.1 Marine parcels near federal – local states' maritime boundaries;

Another complication apart from the low-water datum issue comes from the baseline itself. The maritime baseline is not stationary, so the federal – local states' maritime jurisdiction limit will also move accordingly, and this will give rise to administration difficulties and legal complications to any marine parcels that are located close to the 3 nm limit. As the local states' maritime jurisdiction is limited to on-shore land, which only includes the foreshores and submarine areas beneath the territorial waters of the local states (3 nm from the low-water mark), any marine parcels that cease to fall within this limit because of a shifting baseline will fall under federal government jurisdiction. Such a constantly shifting baseline in a marine cadastre system is problematic to say the least (Fowler & Treml, 2001), and the constant shift of federal – local states' maritime boundary will complicate the administration of nearby marine parcels affected by this movement. For pragmatic reasons the marine cadastre should consider fixing the jurisdiction of marine parcels alienated near the federal – local states' maritime boundary. For example, if a marine parcel falls under the jurisdiction of a local state when it was alienated, it shall remain that way regardless of any future movement of the baseline.

6.2.3.2 Federal – local states' maritime jurisdiction limit

Alternatively, consideration could be given to fixing the maritime jurisdiction limit between the federal and the local states permanently after survey, regardless of any movement of the maritime baseline in the future. In this case, both owner of marine parcels and the authorities will have peace of mind and confidence over their rights.

6.2.4 Declaring a Contiguous Zone

A Contiguous Zone allows a coastal country to exercise control to prevent infringement of its customs, fiscal, immigration or sanitary laws within its territory or territorial sea (United Nations, 1982). Among the South East Asia countries, Thailand, Myanmar and Vietnam have all declared a Contiguous Zone, meanwhile Malaysia and its immediate neighbours like Indonesia, Singapore, Brunei, Philippines have not (DOALOS, 2011). Although a Contiguous Zone may overlap with an Exclusive Economic Zone, the declaration of a Contiguous Zone gives a coastal country more control over features absent from the Exclusive Economic Zone.

The alienation of 3D marine parcels beyond 12 nm in a marine cadastre might spur the need for tighter control over pollution, illegal immigration, and drug trafficking; and so declaring a Contiguous Zone will advance the enforcement of such law beyond the Territorial Sea. Therefore declaring a Contiguous Zone is certainly beneficial and offers more control over maritime space, particularly in the east coast of Peninsular Malaysia facing the open South China Sea.

6.2.5 Establishing multi-disciplinary coastal working groups to address spatial concerns

A review of Malaysia's coastline policies in the previous chapter has shown the coastline to be governed by a myriad of agencies that sometimes have conflicts of interest and overlapping jurisdictions. Often there is a lack of communication among these stakeholders and duplicated management efforts whilst other aspects have been completely neglected. Most agencies are primarily concerned with coastal management issues at a very local scale, focused solely upon the impacts on affected communities. The importance of safeguarding the low-water line for maritime boundary determination is therefore neglected or completely ignored, since this may only have more regional and national implications. An integrated network of all stakeholders involved at all scales of coastal management is therefore required, in order to work together to safeguard the position of the low-water line and ensure an integrated management strategy.

6.2.6 Determining maritime boundaries amongst local states, and between local states' and federal territories

JUPEM has conducted research since 2007 on determining the maritime boundary amongst the local states in Peninsular Malaysia and has prepared a map suggesting the possible maritime boundaries (Figure 6-8). These maritime boundaries were based on treaties, awards, government gazette, memorandums of understanding, etc. However the final land boundary points between the local states, which will serve as the starting points for their maritime boundaries, have yet to be finalised. To date no survey has yet commenced to survey the coastline in order to determine the latest low-water line position needed for equidistance determination of the maritime boundaries (JUPEM, 2010). As such, the delimitation of the 3 nm maritime territory is also pending. It is paramount for a local state to know the maritime boundary with its neighbouring local states and also its coastal limit against the federal limit for it to administer (or alienate) marine parcels within its maritime jurisdiction. Determination of the maritime boundary either between local states, or between local states and federal territories is a Herculean and time-consuming task that will require significant political will, cost and effort to achieve.

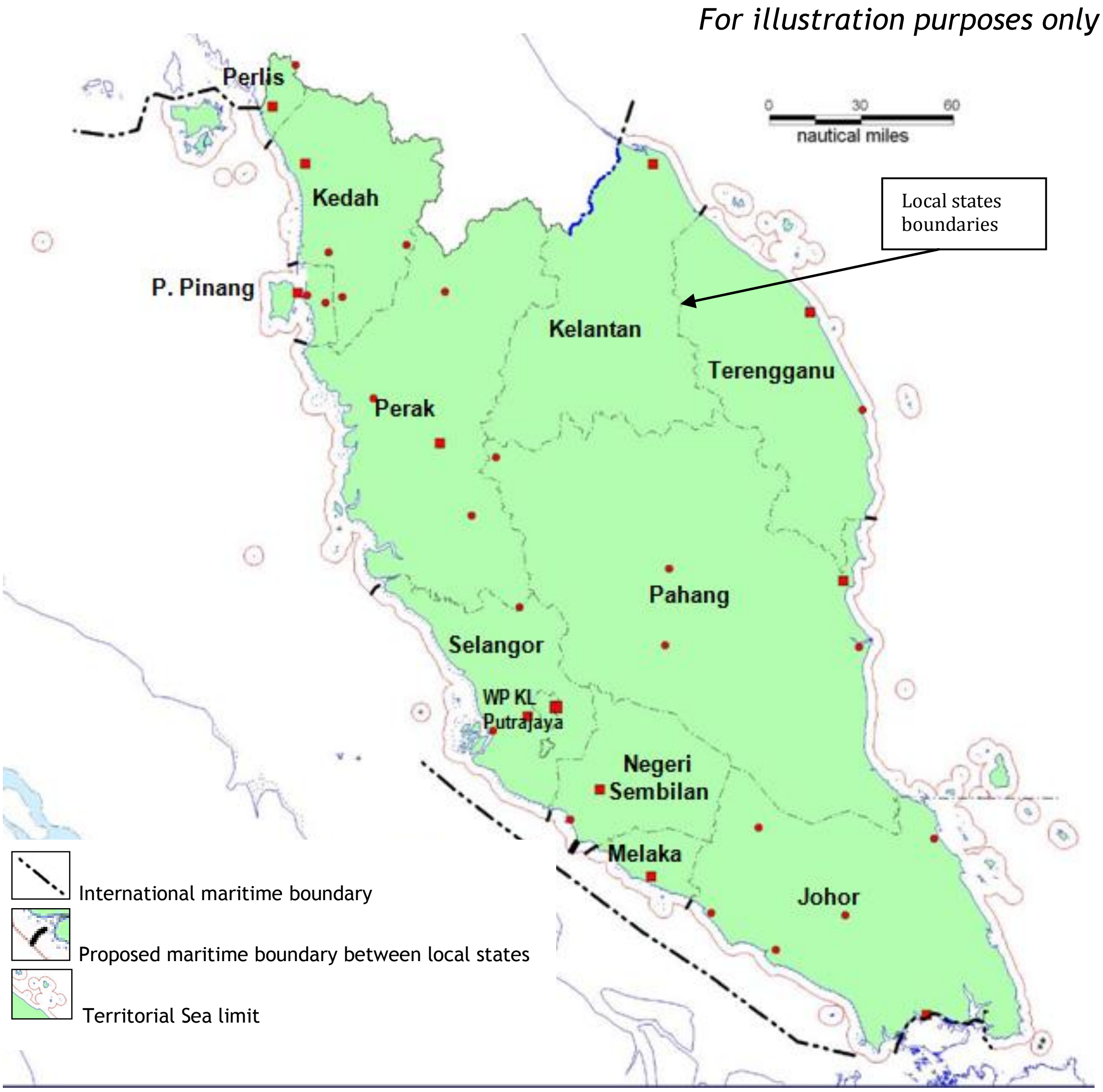

Figure 6-8 Result of research showing a possible maritime boundary between the local states of Peninsular Malaysia
(JUPEM, 2010)

6.2.7 Defining maritime baseline information

To implement the marine cadastre within the three nm zone, the low-water line needs to be surveyed and defined, and if implementation of the marine cadastre is to be achieved then the international maritime baseline needs to be defined in order to gain recognition of sovereignty from the international community and particularly from Malaysia's immediate neighbouring countries. It is acknowledged that the inferred straight baseline of many countries is controversial and does not conform to provisions of the Convention, but there are instances where countries have also interpreted the Convention liberally and have not been challenged (Valencia, 1991). Regardless of any controversy that might arise, a country needs first to define its baseline before it rectifies or defends it. From an academic point of view, it is appropriate for Malaysia to define and promote its maritime baseline and justify each segment of its inferred baselines. Not only will this justify and strengthen Malaysia's claim of sovereignty in its maritime jurisdiction, it will also help to settle continental shelf and EEZ boundary disputes with neighbouring countries. Promulgating the maritime baseline is also a sensible decision in view of the threat of sea-level rise. When a coastal country has defined its maritime baseline and gained consensus from the international community, its boundary is then deemed as 'fixed'. Therefore unless radical changes occur to the territorial sea a 'fixed' definition and mapping provides sovereignty of its territorial seas to the coastal country and preserves existing maritime claims.

6.2.8 Safeguarding the maritime baseline

The littoral zone is a highly dynamic environment and impacts from natural causes and human activities can alter its width dramatically in a very short period of time. Coastal dynamics are determined by waves, currents, winds, sea level rise, severe meteorological conditions and extreme geologic events such as tsunamis (Di Leva & Morita, 2008). Human activities such as dredging, reclamation, mining of sand, construction of harbours, jetties, clearing of mangrove forest, recreational activities, etc., are the chief contributors that directly impact on the coastline. While human activities can be governed and restricted by implementing strict rules and regulation to prevent or minimise the damage inflicted on the littoral zone, threats such as sea level rise and movement of the land are problematic.

According to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) 2007, sea levels are rising globally at around 2 mm/year and projected to rise by as much as 0.18 – 0.59 m by 2099 (Intergovernmental Panel on Climate Change, 2007), whereas researchers and experts from the World Bank estimate a sea level rise of as much as 1 – 5 m by 2099 (Dasgupta et al., 2007). More recent data in 2009 shows that waters have been rising by 3 mm/year since 1993, and if this trend continues, sea level is likely to rise 1 m or more by 2100 (Brahic, 2009). Meanwhile at a local scale, satellite altimetry data has suggested that the mean sea level in the Malaysian Sea has been rising at a rate of between 1.42 – 4.08 mm/year from year 1993 – 2008, while the observations from tide gauge stations around Malaysia's coastline for the same period showed the average of sea level rise to be about 2.2 mm/year (Md. Din & Mohd Omar, 2009), echoing the global trend projected by IPCC.

According to a National Coastal Erosion Study (NCES) carried out for the Department of Irrigation and Drainage Malaysia (DID) from November 1984 to January 1986, 90% of Malaysia's 4800 km coastline is erodible alluvium, and approximately 1300 km of the coastline is eroding at the rate of 1 to 100 m annually, threatening 400 km of facilities along the coastline (Ooi et al., 1997). The vertical threat from global sea level rise is relatively small (2 to 3 mm/year), compared to the horizontal threat of erosion of the coastline which can happen rapidly. Nevertheless, the threat posed by global sea level rise can be significant because a 1 cm rise in sea level is predicted to produce approximately 1 m of horizontal beach erosion (Hamzah & Omar, 2010).

Fixing the position of the coastline is essential for any boundary used to determine the limit of various maritime zones. However given the transgressive nature of the coastline, the baseline can be migratory and the outer limits of various maritime zones will also move in sympathy. Various solutions to resolve this problem caused by migratory boundaries have been proposed with some urging the use of straight baseline segments along unstable coastlines to replace normal baselines (Khadem, 1998). Others urge changing international law to adapt to climate change (Wei et al., 2011), and some urge permanent fixing of ocean boundaries (Caron, 2008). Despite all the potential solutions outlined, amending UNCLOS III would require ratification by at least half the States party to the Convention and an agreement by consensus (Lorenzon CROCE, 2013). It would require tremendous political will from all States involved and therefore is unlikely to take place anytime soon. Until it does, the best precautionary action for a coastal State is to preserve its existing baseline to the best of its ability. Nevertheless, it is a painstakingly difficult and expensive task, with financial pressure and lack of technological readiness placing less developed countries at a disadvantage.

A well-known costly example of preservation of its maritime boundary is Japan. The southernmost island of Japan – Okinotori-shima is situated around 1740 km south of Tokyo (Figure 6-9). In 1925 it was an atoll originally comprised of five above-water rocks, but erosion took its toll and eventually only two of the rocks still stand today. Japan claimed an Exclusive Economy Zone (EEZ) over 400,000 km around Okinotori-shima but this was disputed by China, reasoning Okinotori-shima was not an island under the definition of UNCLOS III and hence not entitled to any EEZ around it. To counter the Chinese protest, Japan proceeded to strengthen and prevent the island from submersion caused by erosion by launching an embankment project from 1987 – 1993, spending over $600 million fortifying the two remaining rocks, Higashikojima and Kitakojima with a concrete and titanium net, a marine investigation facility and a light beacon on the island (Figure 6-9) (Diaz et al., 2007). Japan has even gone so far as breeding *foraminifera* microorganisms to increase the size of the reef 'naturally' (De Meyer, 2011).

This illustrates the importance of safeguarding the basepoints used for a maritime baseline and it is suggested that Malaysia might similarly wish to safeguard its coastline.

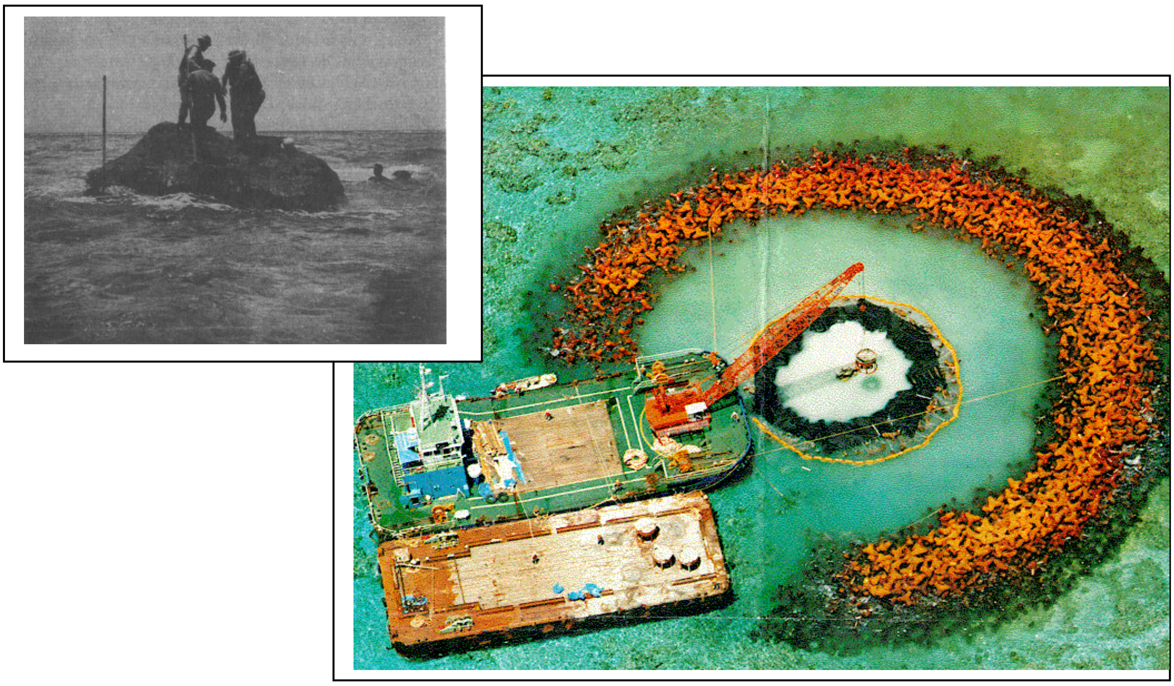

Figure 6-9 Okinotori-shima, Japan
(Schofield, 2009)

In the past, Malaysia had identified and surveyed 159 basepoints along its coastline that were then used to determine Malaysia's straight baseline along the coast and to claim 200 nm of EEZ. According to Valencia (1991), Malaysia has gained approximately 138,700 km^2 of extra territorial water with the extension of maritime jurisdiction using the inferred straight baselines in accordance to UNCLOS III provision (Valencia, 1991), whereas according to Saharuddin (2001) Malaysia has gained control over a continental shelf of 373,500 km^2 and an EEZ of 475,600 km^2. However the location of the low-water line determined from 159 basepoints surveyed more than 10 years ago is almost certainly obsolete and any subsequent development or changes along the coastline by the local states' governments would have shifted the surveyed location of the low-water line and changed the outer limit of the country's maritime jurisdiction. It is prudent for coastal states to preserve their maritime boundaries, in turn it promotes stability in boundaries, maintains local states' and federal government authority over the oceans and their resources, as well as preserving the 'historic use' of the waters. It avoids the costs of adjustment and prevents reduced confidence among marine users in locating the maritime limits (Di Leva & Morita, 2008).

6.3 Key questions to effectively preserve the maritime baseline

6.3.1 Which is the best baseline to establish

LAT is preferred over MLWS. Although MLWS and LAT might not differ by much vertically, a difference of even a few centimetres influences which topographical features will be defined as 'rock' or 'low-tide elevation' (LTE). According to Article 121(3) of UNCLOS III:

> '3. Rocks which cannot sustain human habitation or economic life of their own shall have no exclusive economic zone or continental shelf.'

And Part II, Territorial Sea and Contiguous Zone, Article 13 stated that:

> 1. A LTE is a naturally formed area of land which is surrounded by and above water at low tide but submerged at high tide. Where a low-tide elevation is situated wholly or partly at a distance not exceeding the breadth of the territorial sea from the mainland or an island, the low-water

line on that elevation may be used as the baseline for measuring the breadth of the territorial sea.

2. Where a LTE is wholly situated at a distance exceeding the breadth of the territorial sea from the mainland or an island, it has no territorial sea of its own.

In other words, a rock can generate its own internal water, territorial sea and contiguous zone, but not an EEZ and continental shelf. A LTE which is situated not more than 12 nm from the mainland or an island can be used as part of a normal baseline, or straight baseline, only if it has permanent structures built on it or 'in instances where the drawing of baselines to and from such elevation has received general international recognition' (United Nations, 1982). So legally speaking, a rock is more useful to a coastal country in extending its maritime boundary than a LTE. By choosing LAT over MLWS, there is a possibility some existing LTE will be 'promoted' to rock status. It is recommended that the low-water line as defined by LAT is safeguarded.

6.3.2 How to safeguard the baseline

The Department of Irrigation and Drainage (DID) carried out the National Coastal Erosion Study from November 1984 to January 1986 and set up the Coastal Engineering Technical Centre (CETC) within DID in 1987 to implement a coastal erosion control program for the whole country. Among the measures taken to mitigate coastal erosion are beach nourishment and mangrove replanting. These methods are a feasible way to safeguard the baseline by rendering it static or restore it back to its former position. Hence, agencies like the National Hydrography Centre (PHN) & JUPEM can provide CETC with technical input and advisory services on the location of low-water lines to be sustained in specific areas of the coastline.

6.3.3 How often to review the location of a baseline

The frequency of reviewing will depend on the rate and magnitude of erosion or deposition that has taken place in a coastal area, and the accuracy of baseline required to satisfy the criteria set forth by UNCLOS III. Although there is a widely held view that scales smaller than 1: 100000 should not be relied upon for baseline determination (Carleton et al., 2002), the Office for Ocean Affairs and the Law of the Sea (DOALOS) states that where circumstances permit, the range may lie between 1:50000 and 1:200000 to satisfy the large-scale chart requirement set by Article 5, UNCLOS III (DOALOS, 1989). Therefore, it is sufficient to say that for the purpose of measuring the breadth of the territorial sea for international maritime boundary, the largest scale required by UNCLOS III is 1:50000. In practice the frequency of reviewing a chart must be in proportion to the scale required. However, the thinnest line possible on a chart is typically 0.1 mm, but 0.2 mm is more realistic for the representation of the low-water line, and the high-water line is usually slightly bolder. Therefore a low-water line of 0.2 mm thickness on a 1:50000 charts represent 10 m in reality, and 50 m of changes on the ground is merely a 1 mm shift on the chart and rarely worth revising. Therefore the changes that are worth plotting on the largest scale (1:50 000) of chart required by UNCLOS III for international maritime boundary purposes is probably at least a 2 mm shift (equivalent of 100 m on the ground).

For marine cadastre purposes, the magnitude of changes that should trigger a review would be much smaller, given the typical scale of a plan required to show the location of marine parcels is much larger. For example if a typical marine cadastre plan scale is 1:5000, a 0.2 mm thick line will represent 1 m on the ground; a hardly noticeable 50 m shift on a 1:50 000 chart (equivalent to 1 mm shift) would be an obvious 1 cm shift on the marine cadastre plan. If a 2 mm shift on a plan is deemed significant, then we are talking about reviewing a marine cadastre plan for every 10 m shift of the baseline on the ground.

Another factor that might influence the frequency of baseline review for marine cadastre purposes is the buffer between the marine parcels located close to the seaward limit of maritime zones. For example, if the baseline movement is greater than the buffer, it might actually cause a particular marine parcel that initially locates within internal waters to become dislocated onto the territorial waters. (The owner of a marine parcel within the internal waters enjoys rights similar to land parcel owners, where the owner can prevent others from trespassing its parcel, which is not the case in the territorial waters). If this change of zones happened, the rights of the parcel owner will be affected considerably from absolutely ‘no trespassing’ to a requirement allowing innocent or transit passage (according to UNCLOS III provision) to a foreign vessels navigating in the territorial sea.

Alternatively, if constant reviewing of plans caused by baseline movement is impractical, then a policy to sustain the maritime baseline location is needed to avoid triggering a review and dislocation of a marine parcel onto a different maritime zone. For example, DID is recharging a beach at a typical interval of 5 years (Department of Irrigation and Drainage (DID) Malaysia, 2011). However the frequency of recharging a beach should also take into account how quickly and how far its low-water line has moved from the original position to warrant a compulsory review and whether the movement has caused a loss of maritime jurisdiction, etc. It is necessary for agencies like JUPEM and DID to cooperate in this matter to identify priority areas, magnitude of changes that warrant a review and interval of recharging in a manner consistent with safeguarding the nation's best interest, whether for international maritime boundary or marine cadastre applications.

6.3.4 Where is the historical location of a baseline

Investigation is required to locate the outermost limit of a coastline recorded in plans, maps, aerial photographs, or other recorded medium and this identified section of coastline could be used in maritime baseline determination. Decisions are then needed to account for the tolerance of change allowed before a review is triggered, whether to maintain the current low-water line location or to revert it back to the previous recorded outermost location. The costs involved and the consequences of doing so need to be assessed thoroughly. Leading government agencies in mapping resources such as JUPEM, Malaysian Centre for Remote Sensing (MACRES) and National Hydrographic Centre (PHN) which have archives of aerial photographs, topographic plans, satellite imagery and nautical charts need to collaborate for the best interests of the nation.

6.4 Proposal for a national maritime baseline policy

The absence of an articulate policy on maritime baseline conservation has caused ambiguity in the limits of federal – local states' maritime zones and thus subjects it to unwarranted disturbance, as a consequence of the lack of action concerning a shifting low-water line. Simply put, current practise does not make the maritime baseline sustainable. The current efforts to curb erosion and replenish parts of the coast suggest measures are taken in ignorance of their impact on the maritime baseline. Current coastal planning and development approval also does not take into account the consequences of their actions toward federal – local states' maritime sovereignty. A concerted effort guided by governing principles among all marine stakeholders is necessary to ensure that the spatial basis of all maritime rights, arguably the most important element in marine cadastre, is accommodated fully.

As there is currently no maritime boundary policy in Malaysia it is clear that a draft policy should bring together all coastal stakeholders and provide input to reduce disturbance to the maritime baseline, and also to sustain it for the national good. Furthermore, federal agencies with mapping responsibility for the coastline (e.g. Department of Survey and Mapping Malaysia (JUPEM)) can provide spatial information and technical advice on matters pertaining to the maritime baseline to other agencies and help to instil an awareness of the impact of actions on the maritime baseline. Therefore the formulation of an articulate policy is imperative for the development and implementation of a marine cadastre for Malaysia.

A draft proposal for a national maritime baseline policy is presented in **Appendix A** that might guide how the maritime baseline is to be managed and sustained.

7 CONCLUSIONS AND FUTURE WORK

7.1 Conclusion

The impending implementation of a marine cadastre in Malaysia demonstrates the need to highlight a fundamental issue affecting marine cadastre execution - the uncertainty of the maritime baseline in the littoral zone. The research reported here was divided into two major parts – the method and the policy. This thesis reports on previous research, followed by the study of various topics including cadastre (land, marine and multipurpose cadastre), land legislation and maritime laws (Malaysian legislation and United Nations Convention on Law of the Sea), and reviews of various technical methods to determine the low-water line. This involved acquiring GIS skills using ArcMap and ArcScene to perform analyses of data acquired from the fieldwork. To understand coastal dynamism and its effect on the low-water line, this research also required an appreciation of the drivers of coastal dynamism such as sea-level rise. Finally, existing coastal zone management initiatives and policies were analysed in order to understand how human interactions impact on the coastline and the baseline.

Objective 1 (Determination of the location of the baseline) was addressed by using DGPS and bathymetric surveys to acquire nearshore terrestrial and bathymetric DTMs for a case study area. The method used in this research successfully defines the low-water line at several datums (MLWS, LAT). Both terrestrial and bathymetric data were referred to the same ellipsoidal heights during acquisition and this resulted in the integration of land and sea data into a single DTM. The DTMs generated derived highly accurate low-water lines, due to the relatively small area and proximity of the tide gauge. However the accuracy of such lines will likely decrease as the distance increases away from the location where the tide prediction was made.

Objective 2 (Reviewing the maritime baseline policy of other countries) was addressed, particularly with respect to the maritime baseline policies of Indonesia and Singapore. It was found that a dedicated maritime baseline policy to safeguard the low-water line is almost non-existent. This may be due to: the sensitivity of any issues regarding the location of maritime boundaries, many documents may be classified and restricted, therefore are unavailable; the fact that this remains a work in progress in most parts of the world; or it may be obscured within the coastal management policy of some coastal countries. Regardless, the gap in Malaysia's coastal management initiatives has lead to the conclusion here that there is a need for Malaysia to establish a dedicated maritime baseline policy to safeguard its low-water line.

Objective 3 (Investigate Malaysia's coastline management and development policies and deliver recommendations regarding the management policies for a maritime baseline) was addressed in the context of related laws and regulations, roles of stakeholder and various coastal management initiatives in Malaysia. There is legislation that defines the limit of Malaysia's maritime boundary, but no policy is in place to deal with the shifting nature of the maritime baseline. It was also found that there are duplicated efforts in managing the coastal areas, but the importance of the integrity of the low-water line to the nation maritime boundary is largely overlooked. A list of recommendations has been made to determine the low-water line for Malaysia's marine cadastre and a draft proposal for a national maritime baseline policy has been prepared as part of this research.

7.2 Future Work

Future research should focus on a number of areas to improve results obtained in this research.

This research was conducted with a case study area selected from Scotland that has similar characteristics to parts of the Malaysian coastline. Further investigation could be conducted on case study areas in Malaysia with different topography. To allow more comprehensive comparison, multiple case study areas could be selected involving different coastal contexts such as bare rocky coastline to heavily forested mangrove, muddy, swampy coastline to better understand constrains of the DTM acquisition techniques used by the adopted method in different coastal contexts. It would also be useful to select case study areas which already have LiDAR or satellite imagery to allow comparisons of DTMs generated from different sources, and also to access the degree of ground detail (number of points) needed to represent different coastlines sufficiently well for derivation of low-water lines according to the scale needed for presentation on a plan or map.

To improve on the method, a clear route would be to produce DTMs using a marine LiDAR. This would efficiently integrate nearshore land and sea DTMs for larger lengths of coastline including complicated coastal features (such as mangrove forest and creeks) and inaccessible areas. A larger area will also facilitate examination of the extent of tidal influence between several tide gauge stations and how it affects the accuracy of the low-water line derived.

To improve on the accuracy of the low-water line derivation for coastlines with complex tidal characteristics, an improved tide gauge network is needed to refine tidal predictions from hydrodynamic models. Further research is also recommended to derive and compare algorithms to derive low-water lines within GIS software.

Apart from the maritime boundary application, the method used here has great potential for coastal environmental monitoring, planning aspects and economic aspects such as flood prediction, etc., in specific areas.

The policy drafted in this research focuses solely on the maritime baseline perspective. In order to draft a more comprehensive policy, input and opinion from other relevant stakeholders is needed. The draft policy proposed in this research can either be further expanded to cover additional aspects such as data exchange policies, data format, coastal surveillance, data safety, management, etc, or it can be treated as part of a more holistic maritime policy.

Over the course of investigation, it has become clear that there are alternative routes to establishing a cadastre that are intriguing and worth sharing here. Some countries, like the United Kingdom, which do not have a land cadastre system, instead have a land estate system that emphasizes rights over land (proprietary) rather than ownership. Estates consist of four dimensions and can physically overlay each other, cease to exist after a certain period and give way to other estates; and all this can happen in the same physical entity (Grover, 2008). The estates concept is akin to what might actually happen in a marine cadastre environment. The term cadastre is used because geomaticians are relating rights and interests defined within boundaries, which is similar to land cadastre. In truth however a marine cadastre is envisaged as a marine information system that functions beyond the scope of cadastre. The term 'cadastre' in marine cadastre can be misleading and somewhat restricting in term of what it might encapsulate. The estate concept is rather appealing and maybe a more appropriate description of the relationship of rights and interests of three dimensional parcels which can overlay each other on or below the sea surface.

Other concepts of managing space in the marine environment are advocated by some on the theme of 'marine spatial planning (MSP)'. Accordingly, MSP is the allocation of three-dimensional marine spaces to achieve ecological, economic and social objectives that usually results in a comprehensive plan for a marine region (Maes, 2008). It would appear that the main objective of MSP is for effective management, conservation and protection of the marine environment through spatial planning and zone designation, providing a guide to multi-sector management that increases compatibilities and reduce conflicts across sectors. Meanwhile the marine cadastre focuses on providing spatial information and legal certainty to rights of marine stakeholders within their boundaries. For example, in Scotland, the Marine (Scotland) Act 2010 established Marine Scotland, a Directorate responsible for the integrated management of Scotland's seas (The Scottish Government, 2013). This Act also provides for a National Marine Plan aimed not just at conservation, but also at boosting economic investment in Scotland's marine environment, and delegating marine planning functions to the regional level (UNESCO, 2012).

With the ever evolving needs of the marine and maritime environment, and regardless of whatever management system or initiatives are undertaken by coastal countries, it is vital to get the baseline boundary accurately identified, plotted and updated and to have the appropriate policies in place to allow this to happen.

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APPENDIX A

DEPARTMENT OF SURVEY AND MAPPING MALAYSIA (JUPEM)

National Policy on Sustaining the Integrity of a Maritime Baseline

A Policy Proposal for the Malaysian Government

Robin Seet

2013

Kementerian Sumber Asli dan Alam Sekitar Malaysia
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Contents

Introduction

This is a draft policy proposal relating to the conservation, management and safeguarding of the Malaysian outermost low-water line position along the coast, commonly used in delimiting the maritime baseline. It explains the importance of the low-water line position to all stakeholders and promotes efforts to safeguard it against retreat in order to promote stability to the maritime baseline. This policy will provide guidance to all federal and local states' agencies involved in any undertaking or activity that may alter the configuration of the coastline and result in a shift of the low-water line position. This policy intends to consolidate effort in sustaining the low-water line in a prudent manner, to help asserting local states' sovereignty within the territorial water limit stipulated by sub-section (2) of section 4 of the Emergency (Essential Powers) Ordinance, No. 7/1969.

Background

Malaysia has a marine jurisdiction of approximately 574,000 km^2 and a coastal length of approximately 4,800 km. A National Coastal Erosion Study carried out from 1984-1985 concluded about 29% or 1400 km of Malaysia's coastline was facing erosion. Since then Malaysia has established 'Guidelines on Erosion Control for Development Projects in the Coastal Zone', and embarked on a series of initiatives to manage its coastal resources in a sustainable manner with the introduction of management plans such as the Integrated Coastal Zone Management (ICZM), Integrated Shoreline Management Plan (ISMP) and the latest being National Coastal Zone Physical Plan (NCZPP). However all of these guidelines and management plans overlook the consequences of management decisions impacting on the low-water line function in asserting the limit of the federal – local states' maritime boundary and the limits to the sovereignty of the country. The foreshore has also been altered frequently by actions such as human activities and development and in places it has been protected using hard techniques, such as seawalls as well as soft techniques such as beach nourishment, to create a static coastline without considering how the new coastline configuration changes the federal – local states' maritime boundary or affects the international maritime boundary. At the moment the limit of the federal – local states' maritime boundary, which is 3 nautical miles (nm) seaward from the low-water line, has not been delimited. Any actions to sustain the coastline that alter the 3 nm limit will complicate administration of marine resources near the vague federal – local states' maritime boundary for both federal and states governments.

Malaysia is a member of the United Nations supported Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP) and currently provides the vice chairman of its Working Group 3 which is working toward 'spatially enabled government and society' with a work plan and strategy to discuss the marine administration and marine cadastre. Through PCGIAP, Malaysia adopted the definition of a marine cadastre as 'A system to enable the boundaries of maritime rights and interests to be recorded, spatially managed and physically defined in relationship to the boundaries of other neighbouring or underlying rights and interests'. As Malaysia is moving towards establishing the ownership of marine parcels in the 11th Malaysia Plan (2016-2019), a policy to manage the low-water line in a prudent manner is needed.

Low-water line on a shore

Policy Statement

Sustaining the integrity of the maritime baseline by ensuring low-water line stability for effective management of the federal – local states' maritime boundaries.

Policy Rationale

The local states' government has a maritime jurisdiction up to 3 nm measured from the low-water line. This seaward limit is subject to change because the coastline is not static, and currently there is no policy and no coordination among government agencies to regulate the low-water line spatially. In order to alienate marine parcels within any local states' maritime jurisdiction, its low-water line first has to be delimited. Although it is impossible to demarcate the low-water line with physical marks on the ground, it is possible to delimit it by clearly defining its location on a map or chart of an appropriate scale.

However, any attempt to delimit the low-water line is futile if related agencies and stakeholders continue to make management decision that will alter the coastline in an uncoordinated fashion. A policy is needed to bring about collaborative participation of all stakeholders to agree to update the position of the low-water line in an organized manner, set the strategic direction and action for federal and local states' government to govern their respective maritime jurisdiction with confidence, and ensure the rights of marine parcel owners is guaranteed and not affected by a shifting low-water line. As such, this policy seeks to address the uncertainty of the low-water line that will shift the maritime baseline and causes conflict of overlapping maritime jurisdiction and hinder the implementation of a marine cadastre.

Policy Principles

P1: Up to date low-water line information for integrated decision making

The low-water line is to be delimited to enable the local states' maritime jurisdiction limit to be asserted. Due to the dynamic nature of the coastline, sectors of the coastline should be prioritised according to their economic importance, erosion rate and other relevant factors. The changing position of the low-water line needs to be recorded and the impact of changes in its position on maritime jurisdiction can thus be assessed. Subsequently all stakeholders can be kept informed of changes in order to make integrated decisions.

P2: Low-water line sustainability

The low-water line should not be allowed to retreat. The low-water line serves as the foundation to assert the maritime jurisdiction limit between the federal and local states' governments. However, the coastline may retreat, be rendered static which may negatively affect the best interest of the local states' governments from the maritime jurisdiction perspective. Policies need to be put in place to sustain it to prevent retreat and maintain its strategic location wherever and whenever necessary. This will provide confidence to the enforcement of law and regulation within a state maritime territory and to protect interest of marine parcel owners. It seems unlikely that retreat of the baseline will be politically acceptable even though repeat surveys along an eroding shore, or where sea level rise allows the shore to move inland, may suggest this.

P3: collaborative governance

All relevant stakeholders shall be informed and made aware of their actions toward their impact on the low-water line. Their collaboration and inclusiveness is vital for addressing maritime baseline governance concerns.

Policy Objectives

- To give a common interpretation of the provisions of particular laws regarding the low-water line and to prevent maritime jurisdiction conflicts in the marine environment.

- To prevent legal insecurity produced by unsystematic modification of maritime borders.

- To instil awareness in all stakeholders of the importance of the low-water line for maritime governance and jurisdiction stability.

- To streamline responsibilities and obligations of various parties in ensuring an effective management of the coastline and to put in place a revision mechanism to sustain the location of low-water lines according to priority, urgency and level of threats.

- To provide a platform to set out strategies, complement existing coastal management policy, strengthen maritime jurisdiction governance through uniform approaches and pave way for alienation of marine parcel in marine environment.

Strategic Action Plan

This policy will facilitate the integration of maritime baseline considerations into planning and implementation of development programmes and decision-making processes in coastal area.

SP1: Determining the federal – local states' maritime boundary

Delimitation of the low-water line position on a nationwide scale and determination of the administrative limit of states' three nautical miles maritime jurisdiction.

SP1: Develop a comprehensive maritime baseline information system

Establish a marine cadastre that can record the boundaries of maritime rights and interests and their relationship to the boundaries of other neighbouring or underlying rights and interests in the maritime territory.

SP2: Establish a comprehensive maritime baseline revision mechanism

Devise a comprehensive and regular assessment of the state of the maritime baseline. Monitoring the changes of the low-water line's position caused by natural coastal dynamism and human activities and investigates methods to sustain the low-water line.

SP2: Preventing loss of maritime jurisdiction

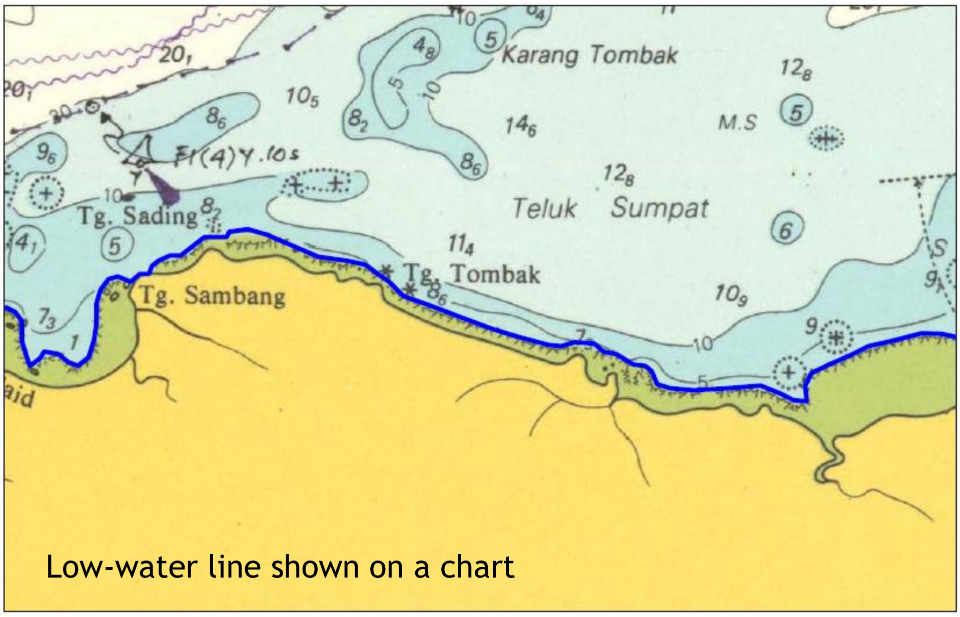
Devise a long-term national plan for low-water line protection and rehabilitation to minimise the loss of maritime jurisdiction and subsequently loss of rights to marine resources.

SP3: Integrated administrative and institutional mechanism

Establish an inter-ministerial body to coordinate interagency initiatives and provide guidelines and technical advice to clarify local authority decisions that impact on the low-water line. A new National Maritime Boundary Safeguarding Board (NMBSB) will drive the implementation of the policy, assisted by an Advisory Group as a key consultative mechanism.

SP3: Facilitate the harmonisation of existing policies to address maritime boundary concern

Incorporate considerations for the low-water line position in existing coastal management initiatives, plans and policies, consolidate coastal management practises to maintain the integrity of the maritime boundary.



Low-water line shown on a chart

Glossary

Low-water line

Generally refers to the line where a certain low tide intersects with the shore. More specifically, it is the line where the established low-water datum intersects the shore. The current low-water datum adopted in the National Land Code (Act 56 of 1965) is low-water mark of ordinary spring tides. For international boundary determination, the preferred low-water line is Lowest Astronomical Tide.

Marine Cadastre

A system to enable the boundaries of maritime rights and interests to be recorded, spatially managed and physically defined in relationship to the boundaries of other neighbouring or underlying rights and interests.

Maritime baseline

The low-water line along the coast for measuring the breadth of the territorial sea.

Maritime jurisdiction

This refers to maritime territory belonging to a local state or a nation. According to section 4 of the Emergency (Essential Powers) Ordinance, No. 7/1969, a local state's territorial waters are construed as reference to such part of the sea adjacent to the coast thereof not exceeding three nautical miles measured from the low-water mark.