KERTAS KERJA 10

Tajuk : **Determining And Sustaining The Maritime Baseline: Method And Policy**

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Determining And Sustaining The Maritime Baseline: Method And Policy

by

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Summary

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 constantly 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 coupled with marine radio-echo sounding to generate DTMs, which were then compared to DTMs using DGPS, SRTM, ASTER GDEM and NEXTMAP. This established that the method adopted produced more robust results than those derived from existing datasets. Low-water lines (eg MLWS: Mean Low Water Springs, LAT: Lowest Astronomic Tide) 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 demonstrated the movement of LAT 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 policies designed to sustain the integrity and position of the

maritime baseline are 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.

1. Introduction

Malaysia has a marine jurisdiction of approximately 574,000 kilometres^2 (CheeHai & Fauzi, 2006) and is looking to implement a marine cadastre. To do this, the low-water line needs to be determined. This research investigates an efficient method to determine the low-water line and subsequently investigates Malaysia legislation and coastal policies and their effect on the maritime baseline, and finally makes recommendations regarding the management policies for a maritime baseline.

2. Methods

The method applies in this research requires nearshore Digital Terrain Modal (DTM), bathymetric DTM and tidal information to be obtained in order to derive a low-water line (Fig. 1).

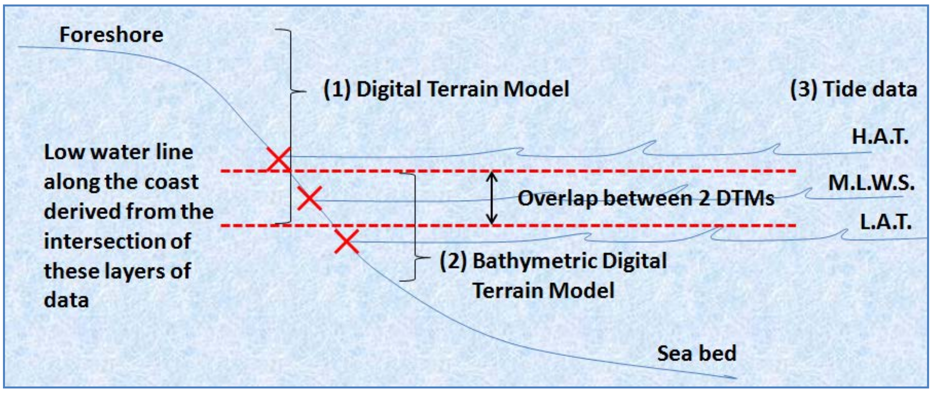

Fig. 1 Concept of research methodology used here.

2.1 Site Selection

Kames Bay, Millport, Scotland was identified as the case study area. It has both a steep rocky section at its sides and a low angled sandy section. It is also the site of a fully instrumented tide gauge allowing cross-calibration of tidal characteristics to the DTMs. This case study area is comparable with parts of the Malaysian coastline, making the tested methodology easily transferable.

2.2 Data Acquisition

The DGPS and echo sounding fieldwork was carried out to acquire a terrestrial DTM a bathymetric DTM of Kames Bay on 7 and 8 June 2012, across a spring tide at Millport. The land elevation data was collected using a Leica GPS1200 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 linked to a Leica Smartnet rover. The data produced a large overlapping area (MHWS-MLWS) of approximately 150m from the two sets of DTM (Fig. 2).

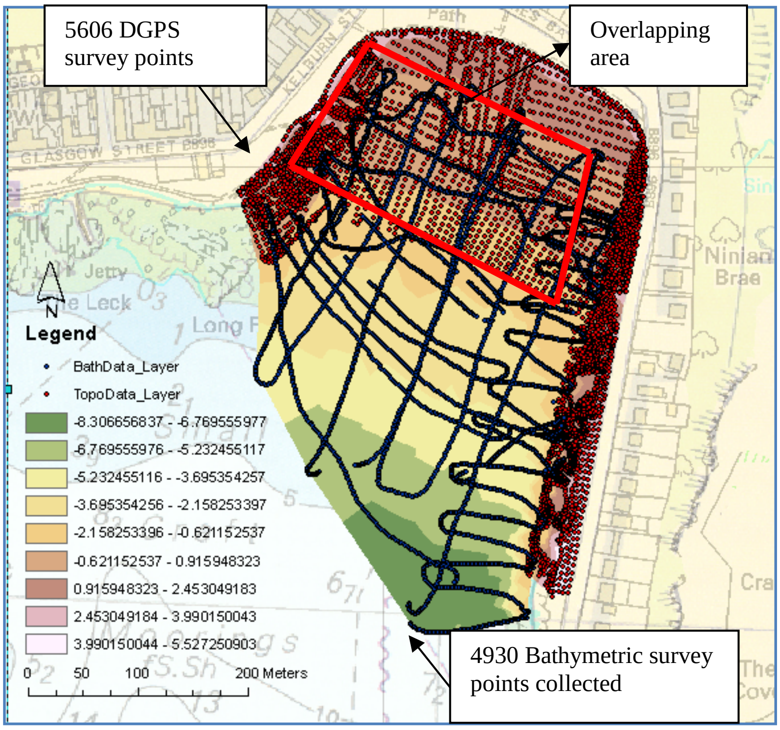

Fig. 2 DGPS and bathymetric surveys carried out at Kames Bay

3. Determining The Low-Water Lines

3.1 Data Analyses

Spatial and statistical analyses were carried out to validate the DTMs generated from the fieldwork by extracting the cell values of the land topography and bathymetry data at each DGPS point to compare with DTMs from ASTER, SRTM and NEXTMap. The following analyses were made with the assumption that the DGPS DTM produced here is of a higher level of accuracy (standard deviation of each DGPS height point collected averaged ~ 8mm) than other DTMs and will be used as a reference dataset against which comparisons will be made.

Table 1 show that the DGPS and bathymetric data have a strong relationship with a relatively high correlation and low RMSE. 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. 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.

Table 1 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’.

Despite their global availability, analysis shows that neither the ASTER nor SRTM datasets are suitable use for 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.

3.1.1 Generation of Low-water Lines

Mean Low Water Spring (MLWS) & Lowest Astronomical Tide (LAT) were subsequently generated from the DGPS and bathymetric DTMs using the tidal height information obtained from UK National Oceanography Centre. Generally in the beach area the DGPS survey was able to cover the foreshore from HAT to a little beyond MLWS; meanwhile the bathymetric survey was able to cover the foreshore from MLWS to well seaward of LAT, but less so in the rocky area.

Table 2 Heights of low-water lines in CD and ODN

Millport’s low-water datum heights prediction (2008-2026):	In Chart Datum (metres)	In Ordnance Datum Newlyn (metres)
MLWS	0.440	-1.180
LAT	-0.040	-1.660

(National Oceanography Centre, 2012**)**

The generated MLWS location was then compared to the MLWS location shown on Ordnance Survey (OS) raster map and it showed an almost identical line with slight shift landward ~12m at the southeast of Kames Bay (Fig. 3).

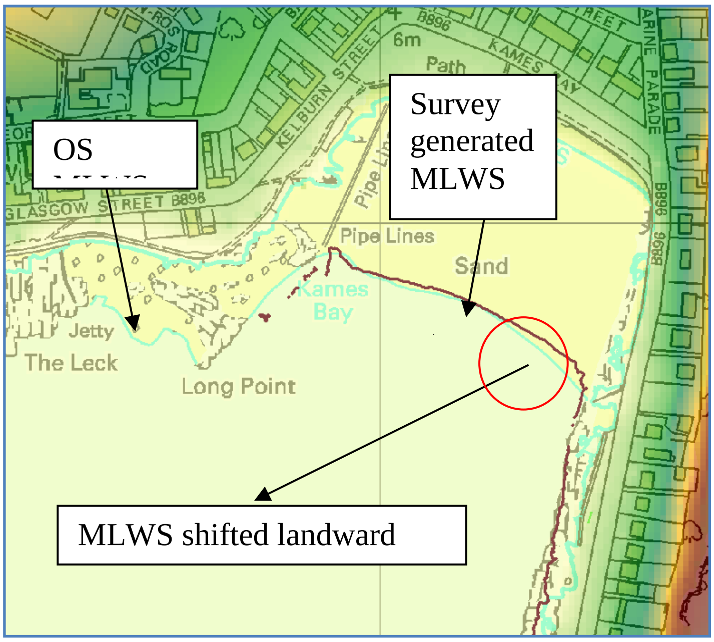

Fig. 3: Comparison of the generated MLWS with the current MLWS shown on OS map.

The LAT generated from the bathymetric DTM was then compared to the 1:12500 Leisure Chart 5610.1 (published in 2005). The LAT line generated indicated that the seabed which was once shallower (depth value 07 and 09) in the northwest and southeast of Kames Bay has retreat landward by approximately ~72m and ~94m respectively (Fig. 4). 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 1m 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).

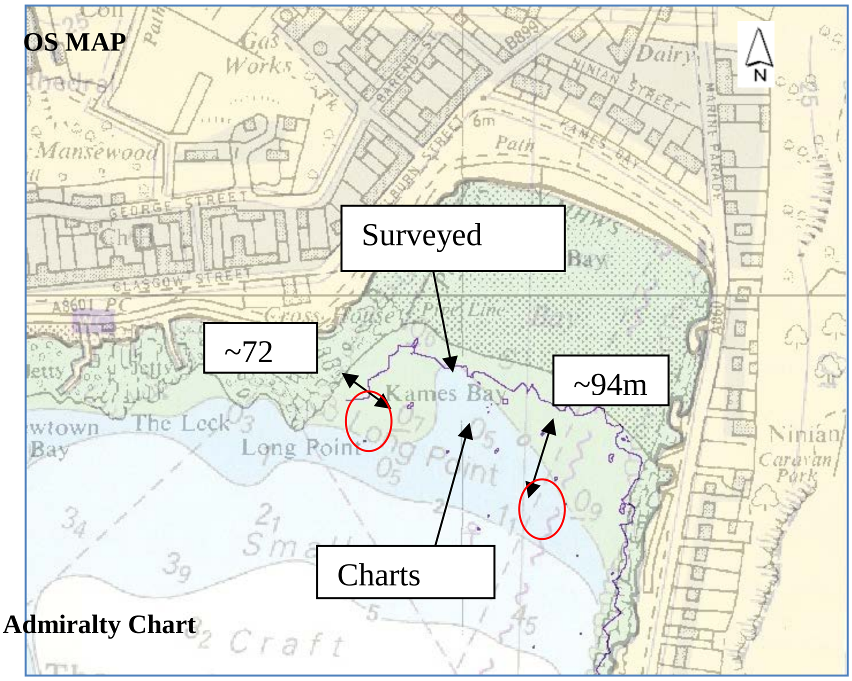

Fig. 4 Shift noticed in LAT location when compared to Admiralty Chart

3.1.2 Sea-level change rates and future estimates

One of the concerns brought about by global warming is sea-level rise. According to the United Kingdom Climate Projection (UKCP09) produced by Department for Environment, Food and Rural Affairs (DEFRA) for a 95% high estimate emissions scenario for Millport, in 2025 the change in relative sea level (RSL) is ~0.152m; and in 2100 the RSL will be ~0.714m (DEFRA, 2012). Provided nothing has changed in the mobile nearshore, the shift of LAT position from 1940 to 2100 is show in Fig. 5.

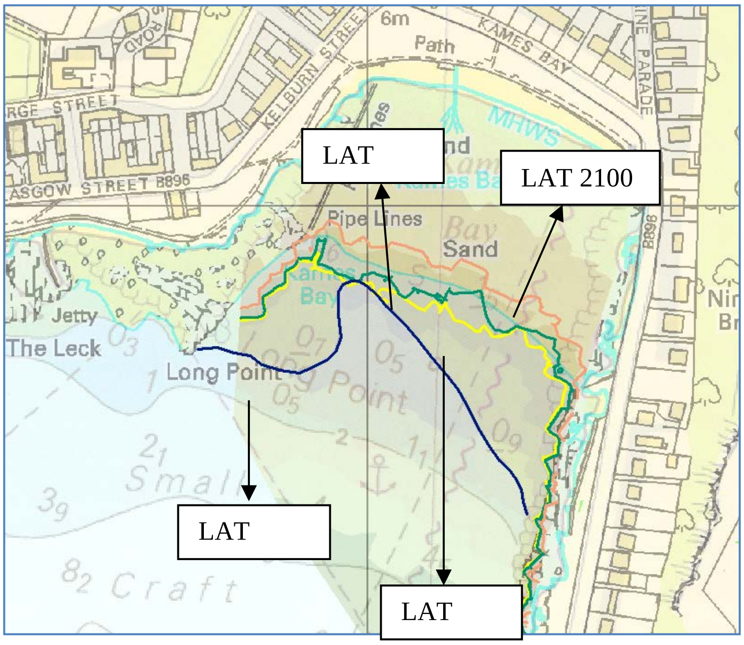

Fig. 5 The shift of LAT position from 1940 to 2100 based on historical data, current survey data and 95% estimates in the high emissions scenario projected by UKCP09

3.1.3 Environmental and economy 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. Marine Cadastre In Malaysia

Marine cadastre in Malaysia emphasis on the accurate spatial determination of marine parcels within its international maritime boundaries. However its implementation is still at a rudimentary stage. One of the prerequisite of marine cadastre is to clearly identify its spatial extent within Malaysia's marine jurisdiction, therefore the effective determination of maritime baseline which define the outer limits of individual state (*negeri*) maritime jurisdiction is of paramount importance.

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) from the low-water line and generally there is no physical evidence, only mathematical evidence left behind (Carrera, 1999). However 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. To avoid spatial uncertainty, constant determination may thus be required.

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. The Dilemma Of Malaysia's Marine Cadastre Baseline

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)' but its primary aim is prevention of erosion along the coastline and does not address the complications associated with a shifting maritime baseline or the actions needed deal with it. Institutionally, many activities occur in the coastal areas are administered and enforced by a variety of agencies or departments under various ministries or state authorities. No single agency has overall authority over all maritime matters. Likewise, the technical difficulties facing the determination and visualisation of a maritime baseline coupled with coastal dynamism that threatens baseline stability has made it impossible to efficiently govern the low-water line without putting in place a proper mechanism involving all stakeholders.

The absence of an articulate policy on maritime baseline conservation has also caused ambiguity in the limits of federal – state maritime zones and thus subjects it to unwarranted disturbance. Therefore, at the end of this research, a draft proposal for a national maritime baseline policy is presented that might guide how the maritime baseline is to be managed and sustained. In addition, a series of recommendations for Malaysia has been made in order to apply the maritime baseline determination method shown in this research, and how to overcome various issues regarding the maritime baseline for Marine Cadastre implementation.

6. ACKNOWLEDGEMENTS

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