COASTLINE CHANGE MEASUREMENT AND
GENERATING RISK MAP FOR THE COAST USING
GEOGRAPHIC INFORMATION SYSTEM

Presentation by:
Durairaju Kumaran Raju, Research Fellow
Kanakappan Santosh, Research Engineer
Chandrasekar Jayaraj, Research Engineer
T EH Tiong Sa, Visiting Professor

Tropical Marine Science Institute,
National University of Singapore,
Singapore – 119223.
E-Mail : tmsks@nus.edu.sg
www.porl.nus.edu.sg
OBJECTIVE

- To measure coastline changes so that the results derived can be properly applied for planning purposes of coastal community and avoid any sort of loss in property and infrastructure.
Coastline Definition

• Coastline Changes are measured with respect to a particular datum which separates the land from the sea.
• For Singapore, coastline is defined 2.515 m Chart datum (CD) and this line theoretically separates land from sea.
• This chart datum (CD) for the study area is 0.863m RL with respect to the mean sea level (Singapore Tide Tables, 2009).
A short section of the ECP, from HL 2 (Headland 2) to HL 4 (Headland 4), is selected as the study area.
Method to Measure Coastline change

- **Short-medium term measurements**
- The usual technique is to conduct repeat surveys along fixed profile lines from a temporary bench mark (TBM) down to low water with Digital level survey instrument.
- Profiles are set at fixed intervals along the coast.
- Monitoring over several years will provide useful data on Short-medium term coastline change.
The profiles monitored in the study area consists of 10 profiles,

These profiles were grouped under compartment 1, consisting of P5 to P6iic and compartment 2, consisting of P6iiib to P6v. The profiles are analyzed for rate of coastline change individually.

Trimble Dini digital level was used for profile measurements.
# Profiles for Short term coastline change

<table>
<thead>
<tr>
<th>Profile</th>
<th>Location</th>
<th>Start-end monitoring</th>
<th>No. month</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P5</td>
<td>HL2-3</td>
<td>18/7/03-9/4/09</td>
<td>69</td>
<td>East of headland 2</td>
</tr>
<tr>
<td>P6i</td>
<td>HL2-3</td>
<td>19/7/01-9/4/09</td>
<td>93</td>
<td>Across dry headland, scarped</td>
</tr>
<tr>
<td>P6ii</td>
<td>HL2-3</td>
<td>24/12/01-9/4/09</td>
<td>88</td>
<td>Badly eroding sector, erosion mitigated, scarped</td>
</tr>
<tr>
<td>P6iib</td>
<td>HL2-3</td>
<td>13/8/04-9/4/09</td>
<td>56</td>
<td>West HL3, erosion mitigated, scarped</td>
</tr>
<tr>
<td>P6iic</td>
<td>HL2-3</td>
<td>10/9/04-9/4/09</td>
<td>55</td>
<td>West HL3, erosion mitigated, scarped</td>
</tr>
<tr>
<td>P6iiiib</td>
<td>HL3-4</td>
<td>10/9/04-9/4/09</td>
<td>55</td>
<td>East HL3, nourished, scarped</td>
</tr>
<tr>
<td>P6iv</td>
<td>HL3-4</td>
<td>24/12/01-9/4/09</td>
<td>88</td>
<td>East HL3, nourished, scarped</td>
</tr>
<tr>
<td>P6ivb</td>
<td>HL3-4</td>
<td>13/8/04-9/4/09</td>
<td>56</td>
<td>East HL3, nourished, scarped</td>
</tr>
<tr>
<td>P6ivc</td>
<td>HL3-4</td>
<td>13/8/04-9/4/09</td>
<td>56</td>
<td>West HL4, nourished, bermmed</td>
</tr>
<tr>
<td>P6v</td>
<td>HL3-4</td>
<td>24/12/01-9/4/09</td>
<td>88</td>
<td>West HL4, nourished, bermmed</td>
</tr>
</tbody>
</table>

Table 1. Profiles monitored from HL2 to HL4
Method to Measure Coastline change

- The collected data was processed in the Profile information system developed using GIS software.

- The system allows the user to choose the different time period and calculate rate of recession of coast for that particular period.

- The coastline change measured graphically and the rate of change expressed in meter per month and meter per year.
Results Of Profile Survey

- Figure 2 displays the graphs for selected profiles (P5 and P6i) generated by the system.

2A. P5 beach profile and coastline change 2003-09

2B. P6i beach profile and coastline change 2001-09

Figure 2. Selected Profiles of Compartment 1
Results Of Profile Survey

- Table 2 displays the report generated by the system for the individual profile.
- Table 3 displays the report generated by the system for the complete set of profiles.
Interpreting the Profile Data Report:

- The rate of retreat since 2001/2003 for the coast from HL2 to the Dry HL (P5 and P6i) was greater than coast from Dry HL to HL3.

- For the coast from Dry HL to HL3(P6ii), recorded a retreat rate.

- The coastline has propagated between HL3 and HL4.
COASTLINE RETREAT AND IMPACTS – P6ii

- 2002
- May 04
- Jan 07
- Jan 2009
COASTLINE RETREAT AND IMPACTS  DRY HL

- June 01
- May 04
- June 07
- Jan 09
Method to Measure Coastline change

**Longer -term measurements**

- Longer term coastline change is measured by overlaying a series of topographic maps of the same scale from different years.

- The displaced coastline is then measured and the rate of change calculated.
Long Term Coastline Change

- The longer term coastline change of the study area is established by comparing the 1972, 2.515 m CD coastline shown on cadastral map with that of the 2007, 2.515 m CD coastline.
- Source of 1972 cadastral map: Singapore Land Authority.
Long Term Coastline Change

- 2007, 2.515 m CD coastline (0.863 m RL) was generated in ArcGIS from a dense network of elevation points.
- Triangulated Irregular Network (TIN) was generated in ArcGIS.
- Digital Elevation Model (DEM) of resolution 0.25m generated from the TIN in ArcGIS.
Long Term Coastline Change

- Spot heights supplied from government survey agency were imported as thematic layer in ArcGIS for validating the resultant DEM.

- The vertical accuracy of the DEM was below 0.1m.

- 0.863 m, elevation line was generated from the DEM by executing a spatial query in ArcGIS spatial analyst.
Long Term Coastline Change

- Figure 4a displays 2007, 2.515 m CD coastline (0.863 m RL w.r.t MSL) generated in ArcGIS from a dense network of elevation points collected on the beach from low water mark to 5m using total station. (Trimble total station was used in our study)

- World View -1 Image (Source: Digital Globe) was georeferenced and the two lines of different years were overlaid to create a map.

Figure 4a Coastline 2007
Long Term Coastline Change

Retreating coastline of ECP 1972-2007 (35 years)
Result of Long-term Analysis

- The 300 m coast between HL2 and the Dry HL recorded the least retreat, with an average of 6.55 m (-0.187 m/yr) and a maximum of 12.37 m (-0.354 m/yr).

- The coast from the Dry HL to HL3 shows an increasing landward displacement of the coastline eastwards. The average retreat was 29.82 m (-0.852 m/yr) and the maximum retreat 46.52 m (-1.33 m/yr).

- The greatest retreat took place between HL3 and HL4. Average retreat was 45.35 m (-1.29 m/yr) and the maximum retreat was 49.52 m (-1.41 m/yr).
Coastal Erosion Hazard and Risk Map of ECP

- Erosion is widespread along the whole ECP, especially within the study area.

- Erosion hazards are tentatively grouped under 4 classes. These are <0.5 m/yr (very low), 0.5-1.0 m/yr (low), 1.0-1.5 m/yr (moderate), and >1.5 m/yr (high).

- With this an initial attempt is made here to prepare a coastal erosion hazard and risk map for the ECP study area.
Coastal Erosion Hazard and Risk Map of ECP

- Three classes of erosion hazard are identified for the study area based on the long term rate of coastline change.
- The coast from HL2 to Dry HL is classed as very low, the coast from Dry HL to HL3 as low and the coast from HL2 to HL as moderate.
- Assuming the rate of recession as linear a projection of future coastline was visualised for 15, 30, 50 and 100 years.
Coastal Erosion Hazard and Risk Map of ECP

A coastal erosion hazard and risk map of study area
Conclusion

- The erosion hazard and risk map produced here represents a first approximation and will be refined as more data becomes available from the field monitoring.
- Reliable information on short and long term trends in shoreline dynamics form the basis for identifying coastal sectors of varying sensitivities to development and aid in proper land use planning of the coastal zone.
- The information provided by an erosion hazard and risk map helps coastal managers to assess degrees of risk when a particular coastal site is developed.
Thank You

Share your Views @

tmsdkr@nus.edu.sg

tmsks@nus.edu.sg