Introduction to Coastal Zone Management

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28th August 2017
Structure of Presentation

1) Coast line Definition
2) Coastal Lining and demarcation
3) Coastal Zoning, Hydrographic surveying and terrestrial surveying
4) Issues in Coast line length and precision
5) ICZM criticality and comprehensiveness
6) Coastal vertical zoning and types
7) Coastal Land forms: Erosional and Depositional Processes & challenges
8) CRZ Notification of 2011 of MENFF & CC
9) Coastal Instrumentation
10) Case study example of RS and GIS for CZM activity
What is a Coastal Zone?

- Coastal Zone also called a littoral zone
- It is part of a sea, lake, or river that is close to the shore
- Extends from the high water mark (HWL) to shoreline areas that are permanently submerged
The Coastal Zone
Coast lining

The Hydrographic surveying, the coast line is defined as the “high water line” (HWL); on a cliff coast where the tide reaches foot of the cliff, or on a steep beach, the demarcation of HWL is clear; on a gently shelving beach, it is more difficult to judge but generally speaking the line of drift wood, flotsam and jetsam farther up the beach gives the best idea of the position.

Inland surveying , the coast line is generally defined as the “ line of high Water Ordinary spring tides “ (HWOST). Which is the same as high Water line . However, in many land surveys, the coast line delineated from air Photos and it is not always easy to identify the High Water Line with any certainty from air Photos. The coast line also changes its shape and position by accretion, erosion, land reclamation and development . For these reasons coastline is never transferred to hydrographic maps .
Coast and shore defined

Coast: Area of contact between land and sea—Extend inland until meets a different geographical setting
Shoreline: Precise boundary where water meets adjacent dry land

Waves and tides

Waves: transport energy by motion—ultimate source of wave energy is the sun
Long shore current: Current that parallels shoreline developed by waves coming in at an angle to shore
Depth of closure (DoC) is an important concept used in coastal engineering. The DOC is a theoretical depth along a beach profile where sediment transport is very small or non-existent, dependent on wave height and period, and occasionally, sediment grain size.
The actual length of coast line is a Critical parameter
As most areas are indented

Indented line

Actual line when stretched is measured using fractal geometry
Passive remote sensing: VISIBLE

Landsat 7

Bahamas

Bora Bora
coastline & paradox

Unit = 200 km, length = 2400 km (approx.)

Unit = 50 km, length = 3400 km

British
<table>
<thead>
<tr>
<th>Country</th>
<th>The World Factbook(^3)</th>
<th>World Resources Institute(^2)</th>
<th>Land area km(^2) (TWF)(^4)</th>
<th>Coast/area ratio (m/km(^2)) (TWF)</th>
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"coast/area ratio" for both TWF and WRI coastline measurement measures how many meters of coastline correspond to every square kilometer of land area. The ratio illustrates the ease of accessibility to the country's coast from every point in its interior. Therefore, an island country like Maldives, or a country carved by the sea like Greece, is more likely to have a high ratio, while a landlocked country will have a ratio of zero.
The accurate delineation of the coastline (shoreline) and coastal features is an essential feature of a Hydrographical Survey, since the mariner is often required to fix his position by bearings and angles or ranges to promontories and similar features on the coastline.

Generally, in hydrographical surveying, the coastline is defined with respect to a HW datum.

The coastline, must always be walked over in the field. Many small river mouths and streams have been will missed of taking a boat.

In some instances, modern air photography or satellite imagery will provide data in plotting the coastline. Occasionally air photography. This however does not obviate the need to walk the coastline in the field.
Integrated Coastal Zone Management

In both developed and developing countries the coastal zone is likely to undergo the most profound change in the near future.

Already more than 60% of the world's population lives within 60 km of the coast.

By the turn of the century two-thirds of the population (3.7 billion) in developing countries is expected to occupy the coast.
Integrated Coastal Zone Management

High population density in coastal areas warrant, careful environmental management and planning are needed else severe conflicts over coastal space and resource utilization are likely, and the degradation of natural resources truncate development options.

Recognizing these threats, in 1992 UNCED in Rio de Janeiro recommended that guidelines on Integrated Coastal Zone Management (ICZM) be drafted to minimize conflicts and to provide for optimal sustainable resource use.
Integrated Coastal Zone Management

In response to this request the "Noordwijk Guidelines" on ICZM were presented at the 1993 World Coast Conference in Noordwijk, The Netherlands.

World bank provided guidelines are of conceptual as to how ICZM may be applied to contribute to the evolving practice of environmentally sustainable development
In fact, terms such as coastal zone management, coastal resource management and coastal area management have been used interchangeably to such efforts. Many of these, dealt with a single sector—say, coastal erosion or shore land use. Most did not attempt to deal comprehensively with the entire coastal zone and its full range of resources.

As the difficulties inherent in using a single sector, the concept of Integrated Coastal Zone Management came into being. ICZM differs from the earlier form of CZM in that it attempts a more comprehensive Approach
ICZM taking account of all of the sectoral activities that affect the coastal zone and its re-sources and deal with economic and social issues as well as environmental/ecological concerns. The goal, of-course, is to harmonize these activities in such a way that all of them are consistent with and support a broader set of overarching national goals for the coastal zone.
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<th>Development concerns</th>
<th>Environment concerns</th>
<th>Environment/development interactions</th>
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<td>140 Coastal resources</td>
<td>118 Erosion/sedimentation</td>
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<td>Petroleum industry</td>
<td>65 Wetlands</td>
<td>103 Environmental impact</td>
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<td>43 Marine biology</td>
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<td>Industry/commerce</td>
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<tr>
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<td>22 Aesthetics</td>
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<td>Shipping</td>
<td>18 Resource protection</td>
<td>22</td>
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<td>21</td>
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<td>14 Cultural/historical resources</td>
<td>12</td>
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<td>Navigation</td>
<td>14 Groundwater</td>
<td>10</td>
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<td>Oil and gas</td>
<td>14 Barrier islands</td>
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<tr>
<td>Marine mining</td>
<td>9 Open space</td>
<td>7</td>
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<tr>
<td>Coal transportation/storage</td>
<td>9 Preservation</td>
<td>5</td>
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<td>Forestry/logging</td>
<td>7 Air resources</td>
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<tr>
<td>Aquaculture</td>
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</table>

Total: 778 | Total: 844 | 278
Coastal Land forms
Erosional and Depositional Process

Coast lines: Dynamic; Interactive changes with time
Product of its environment

Inputs: Depositional debri
Out puts: Erosional material
Forcing functions:

Sea Level changes: Global, Long term Driver
Eustatic Sea level changes:
  Amount water in basins
  Basin volume
  Temperature variations

Local or relative sea level changes
  Tectonic or isostatic adjustments
  winds, storm surges, hurricanes etc..
Types of tides

• Neap Tide
  – a less than average tide occurring at the first and third quarters of the moon

• Spring Tide
  – tides with the greatest range between highs and lows, usually occurring during the full or new moons
A horizontal movement of water often accompanies the rising and falling of the tide. This is called the **tidal current**.

The incoming tide along the coast and into the bays and estuaries is called a **flood current**; the outgoing tide is called an **ebb current**.

The strongest flood and ebb currents usually occur before or near the time of the high and low tides. The weakest currents occur between the flood and ebb currents and are called slack tides. In the open ocean tidal currents are relatively weak.

Near estuary entrances, narrow straits and inlets, the speed of tidal currents can reach up to several kilometers per hour (Ross, D.A., 1995).
Waves and tides

Tides: Daily fluctuations in the height of the ocean—Caused by gravitational attraction of water to sun and moon

Tidal range: varies depending on latitude and the shape of the coasts

[Images of high and low tide]
Hydrographic survey is conducted with sonar device - measurement of bathymetry etc. Gyroscope, GPS receiver are used in survey.

Other advanced investigations and analyses over ocean current, salinity, nutrients, and even aquatic species at fixed points for a long period of time.

The data obtained from the hydrographic survey can be used for sailing, dredging of sea-route, coastal protection, port engineering, sea territory claim, anti-smuggling crimes, protection of fishery, and development of fishing ground. Disaster protection planning and so on of CZM, including maritime entertainment activities.

International attentions have paid to focus on the topic of continental shelf,
Navigation Chart and Base Chart of Marine Area

Charts
Chart, different from land map, is traditionally used for sailing with the lowest tide height as the beginning of water depth for safety consideration. Generally, the contents in chart include water depth, seabed, current velocity and blocks (wrecked ships, reefs), with sea-route pole (flags) lantern, compass, coastal type, dyke, island, submarine cables (pipes), fishery zone marks (anchor, hazard or warnings) and others.
2】 Base Charts of Marine Areas
The base charts cover the marine areas of the territorial sea and the contiguous zone. They mainly contain the basic information of administrative boundaries, seabed terrain, properties, ocean currents, seabed texture and so on.

The final goal of base charts production is to offer overall platform for the purpose of verification of national maritime territory, exploring marine resources, everlastingly planning and managing under a integrated coordinate system among the information both on land and marine areas.

Depending on the adequacy base charts are planned with two scales to produce. Generally, those areas with the water depth of 30 meter or shallower or 6 nautical miles seaward are produced with 1:5,000, and others are with 1:50,000 to meet the various needs or as per the development need of CZM activity.
3】Littoral Zone Mapping

National land consists of sea territory, land, and littoral zone. During flood tide, shipboard bathymetric instruments is in a quandary at the shallow water, while during the ebb tide, mud and soft sand sentiment hinder the surveying work from land. Constantly, scattered sites have been surveyed according to specific purposes with small area. As a result that there is a gap with no information to connect the land and sea territory. Airborne LiDAR (Light Detecting and Ranging) technology equipped with IMU (Inertial Measurement Unit) and GPS (Globe Positioning System) can obtain 3D terrain relief information quickly and make the establishment of littoral zone possible.
Based on benthic environment

**Intertidal zone** – Includes areas that are exposed to tides

**Littoral zone** – Extends from the high tide line down to about 200m at the edge of the continental shelf. Often the shallowest part of the littoral zone is sub-divided on the degree of exposure by tides – A supralittoral zone; eulittoral zone. And sublittoral zone.

**Deep sea:**

- **Archibenthic zone** – Extends down to about 1000m.
- **Bathys benthic zone** – Extends from 1000-4000m depth
- **Abyssobenthic zone** – Extends from 4000-6000m depth
- **Hadobenthic zone** –
Based on depth

**Epipelagic zone** – Extends from the shoreline down to 200m. Productivity is quite high in the presence of nutrients due to availability of sunlight. Water is warm.

**Mesopelagic zone** – Extends from 200-1000m. Little light is available. Water temperature is cold and oxygen poor.

**Bathypelagic zone** – Extends from 1000-4000m. There is no light excluding that from bioluminescent creatures and occasional lava flows. Biological productivity is low and water is cold.

**Abyssopelagic zone** – Extends from 4000-6000m depth. No light available and cold water.

**Hadopelagic zone** – Extends from 6000, to the deepest depths in the ocean. No light available and cold water. This area is covered with deep, narrow trenches.
Based on the shape of the ocean floor
Continental shelf – It is the shallow platform extending from the shore line down to about 200 m depth. Continental slope – Marks the end of underlying oceanic crust. Continental rise – It is the area sloping gently seaward beyond the continental slope. Abyssal plain – It is the deep area of the sea floor beyond the continental rise. Deep sea trench – The trenches are narrow and abnormally deep parts of the ocean floor marking zones of subduction.

Based on light availability
Euphotic zone – In this zone there is enough sunlight penetration for photosynthesis to take place. Thickness of this zone depends on the turbidity of the water column. It can extend down to 200m in clear water areas. Disphotic zone – There is light penetration but not enough for photosynthesis. Aphotic zone – No sunlight penetration.
What is the legal U.S. shoreline?

There is no legal reference that designates one specific shoreline as the legal shoreline. Furthermore, there is no simple answer to this question as there are many legal, technical, and general uses of the terms related to shoreline (shoreline, coastline, baseline, mean high-water line, mean-low water line, etc.).

Shoreline data that is generated by the NOAA National Geodetic Survey (NGS) for the purpose of nautical charting is what constitutes the National Shoreline. This data set includes both MHW and MLLW. Since it is regularly updated, the National Shoreline cannot be accessed as a single discrete data set, but the individual vectors are available (see NOAA National Shoreline).

https://shoreline.noaa.gov/faqs.html?faq=2
Territorial Sea Baseline

The term Territorial Sea Baseline (TSB) refers to the line from which the seaward limits of Australia's Maritime Zones are measured. These include the breadth of the territorial sea; the seaward limits of the contiguous zone, the exclusive economic zone and, in some cases, the continental shelf.

The territorial sea baseline may be of various types depending upon the shape of the coastline in any given locality:

The Normal baseline corresponds with the low water line along the coast, including the coasts of islands.

Straight baselines are a system of straight lines joining specified or discrete points on the low-water line, usually known as straight baseline end points. These may be used in localities where the coastline is deeply indented and cut into, or where there is a fringe of islands along the coast in its immediate vicinity.

Bay or river closing lines are straight lines drawn between the respective low-water marks of the natural entrance points of bays or rivers. Waters on the landward side of the baseline are internal waters for the purposes of international law.
Coastal Land forms
By Waves and tides

Waves: Swash: The white foamy water that rushes up the coast is called SWASH. The SWASH carries the materials up the coast. The friction and the pull of gravity then cause the water to flow back towards the sea.

Back wash (return wave carries material perpendicular to coast line)

under tow (gravity pull) sub surfave water flow through gravity pull is more vulnerable for material loss)
This movement of sediment along the coastline is called **longshore drift**.
Processes

1) Erosional: washes away the material from the land

2) Depositional: debris accumulation or deposition

3) Transportational: Movement of material
Erosional Processes
1) Corrosion (solution) : dissolution of material
2) Corrasion (abrasion) : due to rubbing and weathering
3) Attrition : break down of bigger particles to smaller
4) Hydrolic Action : disintegration

Transportation Process
1) Solution - minerals are dissolved in the water and carried along .
2) Suspension - fine light material is carried along in the water.
3) Saltation - small pebbles and stones are bounced along the sea bed.
4) Traction - large boulders and rocks are rolled along the sea bed.
Depositional Process

- Leads to Progradation of coast or Beach
- River water enters to sea and expands Delta
- Beach area increases in width and decreases in wave action and velocity

When the sea loses energy, it drops the sand, rock particles and pebbles it has been carrying. This is called deposition. Deposition happens when the swash is stronger than the backwash and is associated with constructive waves. (destructives Waves have more fetch)
Coast lines: 2 types

Concordant Coast line: here soft, Hard rock and soft rock formations are parallel to the coastline. Hence erosion is a slow process.

Discordant coast line: here the hard, soft and Hard rock formations are perpendicular to coast line.
Coastal Cliffs are shaped through a combination of erosion and weathering

Soft rock, eg sand and clay, erodes easily to create gently sloping cliffs. Hard rock, eg chalk, is more resistant and erodes slowly to create steep cliffs.

Forming a wave cut platform:

Weather weakens the top of the cliff. The sea attacks the base of the cliff forming a wave-cut notch. The notch increases in size causing the cliff to collapse. The backwash carries the rubble towards the sea forming a wave-cut platform. The process repeats and the cliff continues to retreat.
Caves, Arches, Stacks and Stumps

4 nos

Figure 5.18 Formation of caves, arches and stacks
1) Inlets
2) Geo or Blow holes
3) Tidal pool
4) Marine terraces
5) Hanging Valleys
6) Rock Reef
7) Beach Scrap
8) Rill markers
9) Back wash pattern
10) Indented coast line
DEPOSITIONAL LANDFORMS

Beaches: regions formed between HWL - LWL

1) Shingle beach
2) Beach ridge
3) Beach cusp
4) Bar – Bay moth bar, Bay head sand Bar, Off shore bar

5) Barrier Island
6) Tombolo –tidal cluster
7) Spit
8) Hook
9) Look
10) Wave cut Plat form
11) Ridge and runnel
12) Lagoons
13) Mudflats
14) Berms
15) Berm Crest
Coastal Regulation Zone Notification 2011

(i) the land area from High Tide Line (hereinafter referred to as the HTL) to 500mts on the landward side along the sea front.

(ii) CRZ shall apply to the land area between HTL to 100 mts or width of the creek whichever is less on the landward side along the tidal influenced water bodies that are connected to the sea and the distance upto which development along such tidal influenced water bodies is to be regulated accordingly in the Coastal Zone Management Plans (hereinafter referred to as the CZMPs).

(i) CRZ-I:
The areas that are ecologically sensitive and the geomorphological features which play a role in the maintaining the integrity of the coast,
(ii) CRZ-II

The areas that have been developed upto or close to the shoreline.

Explanation.- For the purposes of the expression “developed area” is referred to as that area within the existing municipal limits or in other existing legally designated urban areas which are substantially built-up and has been provided with drainage and approach roads and other infrastructural facilities, such as water supply and sewerage mains;
(iii) CRZ-III,-
Areas that are relatively undisturbed and those do not belong to either CRZ-I or II which include coastal zone in the rural areas (developed and undeveloped) and also areas within municipal limits or in other legally designated urban areas, which are not substantially built up.

Area upto 200mts from HTL on the landward side in case of seafront and 100mts along tidal influenced water bodies or width of the creek whichever is less is to be earmarked as “No Development Zone (NDZ)”,-
(iv.) CRZ-IV:

A. the water area from the Low Tide Line to twelve nautical miles on the seaward side;

B. shall include the water area of the tidal influenced water body from the mouth of the water body at the sea upto the influence of tide which is measured as five parts per thousand during the driest season of the year.
(v) Areas requiring special consideration for the purpose of protecting the critical coastal environment and difficulties faced by local communities,-

A.

1) CRZ area falling within municipal limits of Greater Mumbai;
2) the CRZ areas of Kerala including the backwaters and backwater islands;
3) CRZ areas of Goa.

B.

- Critically Vulnerable Coastal Areas (CVCA) such as Sunderbans region of West Bengal and other ecologically sensitive areas identified as under Environment (Protection) Act, 1986 and managed with the involvement of coastal communities including fisher folk.
Tides and Water Levels

- Semidiurnal tides
- Diurnal tides
- Mixed semidiurnal tides

Diurnal

- High Tide
- Low Tide

Semidiurnal

- High Tides
- Low Tides

Mixed Semidiurnal

- High Tides
- Low Tides
Most coastal areas, with some exceptions, experience two high tides and two low tides every lunar day (Ross, D.A., 1995).

Unlike a solar day, however, a lunar day is 24 hours and 50 minutes. The lunar day is 50 minutes longer than a solar day because the moon revolves around the Earth in the same direction that the Earth rotates around its axis. So, it takes the Earth an extra 50 minutes to “catch up” to the moon (Sumich, J.L., 1996; Thurman, H.V., 1994).

Because the Earth rotates through two tidal “bulges” every lunar day, coastal areas experience two high and two low tides every 24 hours and 50 minutes. High tides occur 12 hours and 25 minutes apart. It takes six hours and 12.5 minutes for the water at the shore to go from high to low, or from low to high.
Tidal Gauge

Old System

New System
Drift wood

SIDE SCAN SONAR

Groynes

DUTT ITCO ocean workshop INCOIS
Advanced tools in Coastal surveys

Terrestrial Lase Scanner

Tripod and Leveling shaft
Advanced tools in Coastal surveys

Heaxacopter UAV

GPS and DGPS surveys
Ground Triangulation

Polygons with central points

Base line

Check base

Control station
NALCO CPP ASH DYKE BREACH MONITORING

EXTENT OF ASH DEPOSITION ACROSS THE RIVER NANDIRA
NALCO CPP ASH DYKE BREACH MONITORING

EXTENT OF ASH DEPOSITION ALONG THE RIVER NANDIRA
CYCLONE HAZARD MITIGATION

COASTAL SHELTER BELT DEVELOPMENT

RS and GIS COASTAL VEGETATION MAP
PRAKASAM DISTRICT

<table>
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<tr>
<th>SI No.</th>
<th>Category</th>
<th>0.5Km Buffer</th>
<th>%</th>
<th>5Km Buffer</th>
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<td>Area (sq.km)</td>
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<td><strong>3894.04</strong></td>
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Thank you

I. Navigational admiralty Manual of India
II. WMO guidelines on Coasts
III. NASA coast and US coastal lining
IV. Etc....