Understanding macro-tidal estuaries: data driven versus modelling approaches

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Introduction

Coastal zones and estuaries provide ecosystem services at local, national, and international levels. The sustainable provisioning of ecosystem services requires broadly impacting and costly regulatory actions, using available scientific resources. Developing countries face additional challenges:
• Rapid urbanisation (pressure on coastal resources)
• Limited resources for scientific study
• Significant opportunity cost in choosing one research activity over another, or over other development priorities

Scientific challenges are faced in the investigation of, and transfer of knowledge for, such systems. These arise from:
• The complex cascading nature of hydro-geomorphologic processes
• Transfer of knowledge from well studied estuarine systems to very different and understudied systems in the "global south"

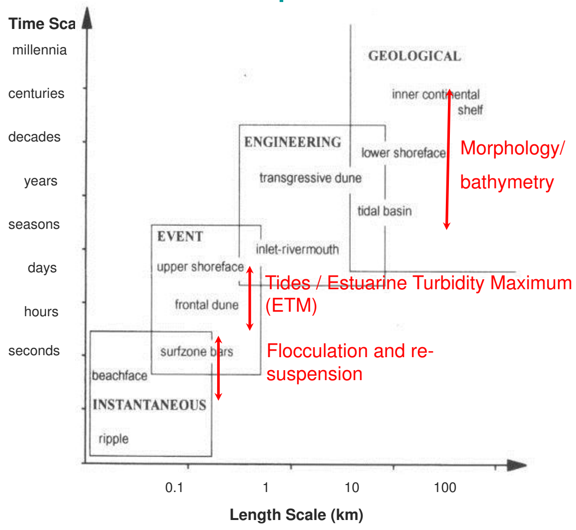
A "top down" or "rule-based" conceptual modelling approach[3] is proposed to:
• To provide a framework to guide the initial scientific investigation
• then, to guide further higher resolution "bottom up" studies, taking full advantage of the recent improvements in data collection and investigation methodologies.

However, the additional management value obtained by using alternative approaches needs to be adequately quantified.

Management priorities for African marine and coastal institutes[1]:

- Environmental Impact Assessments
- Water quality
- Impacts of Climate Change, storm surge, flooding and erosion
- Sediment transport, channel dredging
- Oil spill simulation
- Design of infrastructure - jetties, ports
- Marine outfall and, thermal plume
- Ballast water management, larval transport
- Max load/carrying capacity assessments

Cascading spatial and temporal scales of coastal processes[2]

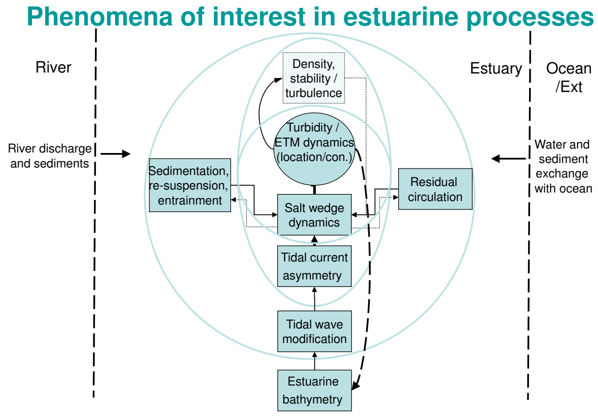


This project focuses on a poorly studied macro-tidal estuary of central Mozambique and has the following aims:
Aim 1: Develop existing rule-based hydro-morphological characterisations of estuarine functioning and use them for the prediction of key estuarine characteristics

Aim 2. Quantify the uncertainty associated with the rule-based analysis/classification schemes, by comparing outputs with the best practice numerical modelling outputs, and with data collected empirically

Aim 3. Develop a framework for the application of rule-based analysis/classification schemes, and for the prioritisation of data collection for both the rule-based and hydrodynamic modelling methodologies

Phenomena of interest in estuarine processes



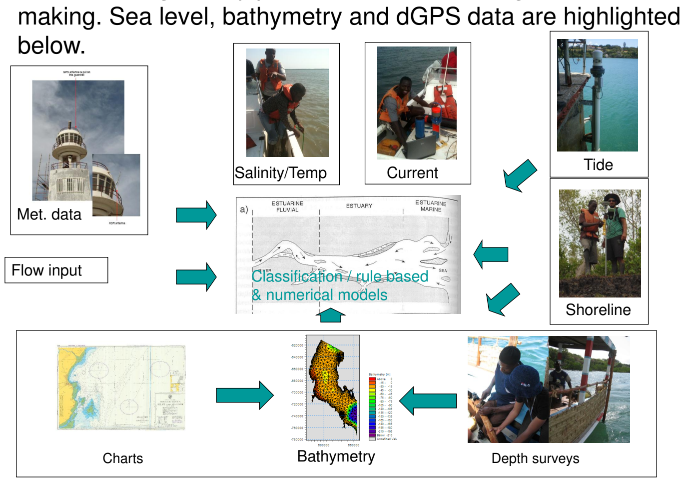
Site and classification

Managers at Bons Sinais estuary face similar problems to others in the region[1], a few of which are highlighted in the map below. The location of sampling sites is also shown for current meters (green), sea level (purple) and tributary flow data (blue) data collection. Towards the first project aim, a review is underway of existing rule-based analysis and classification schemes that quantify hydro-morphological characteristics of estuaries, applicable to management decision making. Preliminary classification of the system is included in the table below.

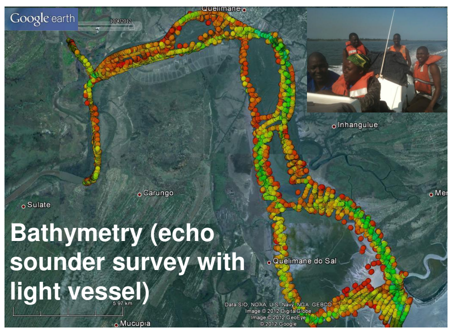
Classification type examples	**Preliminary classification of Bons Sinais** (Additional analysis of recent wet season data required to confirm classifications)
Morphological classification	Genetic: Primary estuary, tide / river dominated Shoreline type: delta front shoreline type
Process based classification (dominant forcing function)	Tide dominated estuary throughout the year (large tidal range of 4.65m), river dominated during flood periods*. Comparatively low wave energy, sheltered elongated estuarine shape, salinity brackish to marine).
Salinity dynamics (mixing type)	Partially mixed to well mixed throughout the year with a salt wedge high in the tributaries, moving to estuary during peak flow of wet season
Sediment dynamics	High sediment loads during intense flood peak
Higher scale classification of sub components	Further spatial data required for such classification. Any wave domination at the mouth (1) would be dramatically reduced due to the sheltered channel, and would therefore be classified as a more river dominated central (2) and upper zone (3) that changes relative magnitude with freshwater input.
Homogenous units for management in EU WFD and USA CWA typologies	Classification zones throughout estuary changes from "seawater" (>25 ppm) to "mixing" (0.5-25 ppm) to "tidal fresh" (0-0.5 ppm) during peak flows*

Data collected

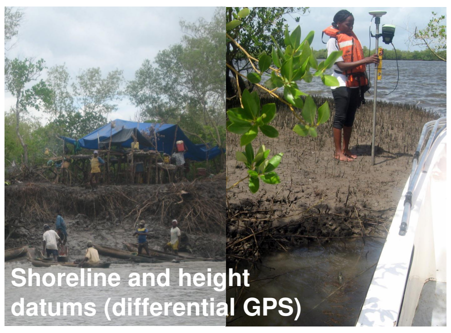
Baseline data collection of physical data sets supporting understanding of key phenomena, and management decision making. Sea level, bathymetry and dGPS data are highlighted below.



• Low cost sea level gauges
• Short (1mth or 1yr) implementation
• Accuracy acceptable for broad range of applications
• Tide predictions have long term validity



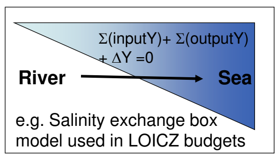
• Low cost equipment enables repeat, economic bathymetric surveys
• Rapid survey (1wk)
• Greater temporal resolution through repeat surveys
• Coarse level data acceptable for multiple applications



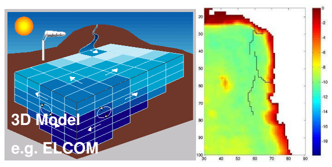
• dGPS gives highly accurate data and benchmarks for future studies, e.g. morphological change / sea level change
• Rapid (1m) and cost effective with in-country surveyors
• Important for macro-tidal deltaic systems

Future work

Rule based models



State of the art hydrodynamic model



Comparative analysis at various temporal and seasonal scales:
- System characterisation
- Management scenarios
- Output uncertainty

Framework development

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References

1. Drawn from Capacity Development activities from 2006 to 2010 involving member states of UNESCO Intergovernmental Oceanographic Commission (IOC). These included the input on capacity development needs by 50+ national marine institute and government directors from all countries of the Western Indian Ocean region (East Africa) with the exception of Somali.
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3. Spencer, T. and Reed, D.J., 2010. Estuaries. In Burt, T. and Allison, R.(eds.) *Sediment Cascades: an Integrated Approach.* Chichester, United Kingdom, Wiley-Blackwell, pp. 403-432.