Australian coastal modelling and information systems: assisting management decision making.

Introduction

• Historical Perspective
  • From Port Philip Bay to INFORMD
• The components of a coastal information system
  • Observing System
  • Modelling Framework
• Current Projects
  • eReefs
• Where and what observations do we need
  • Process Understanding
    – Physics
    – Sediments
    – BGC
  • Data Assimilation / Parameter Estimation
• Future Vision
Integrated Coastal Modelling Studies in Australia

- North West Shelf 2007
- Ord-Bonaparte Study 2003
- SRFME 2006
- Spencer Gulf 2008
- Port Phillip Bay Study 1992/96
- Gippsland Lakes Study 2001
- Derwent Estuary 2008/01
- Huon Estuary Study 2001
- Huon D'Entrecasteaux Channel 2008
- Fitzroy Estuary 2005
- South East Queensland 2009-2011
- South East Tasmania near real time model 2009-2012 (SETas)
- GBR 2012-2015
Coastal Information Systems

Observations
- Moorings
- CTD’s
- Gliders
- Remote Sensing

Modelling System (EMS)
- Biogeochemistry (Ecology)
- Sediments (MecoSED)
- Waves (SWAN)
- Hydrodynamics (SHOC)

Data Assimilation & Parameter Estimation
Calibration & Validation
Observing System (Simulation) Experiments

Managers/Policy Makers
- Australian Government
- Great Barrier Reef Marine Park Authority
- Healthy Waterways
- Southern Water

Coastal Information System

Periodically re-examine overall management program
Determine management objectives
Implement strategies and actions to achieve objectives
Evaluate management effectiveness
Review findings and recommendations of investigations
Develop management strategies and actions
Activities in Southeastern Tasmanian Coastal Waters

E. Butler, 2000

Australian Coastal Modelling and Information Systems | Coastal Environmental Modelling Team
Modelling Platform: Environmental Modelling Suite (EMS)

Hydrodynamics uses ‘sparse’ internal coordinates allowing dry cell removal.

Useful for domains with < 10% wet cells.

- Jones et al., (2012) Ocean Modelling

Observational Requirements

Near Real Time Moorings & Sensor Networks

Monthly Sampling

Glider Transects

- TAFI station
- TAFI station
- CMAR glider

longitude (°E)

latitude (°S)
Recent Activities

Routine NRT results can be viewed at:
http://www.emg.cmar.csiro.au

e.g. for

• Storm Bay, D’Entrecasteaux, Huon, Derwent

• South East Queensland

• GBR
Current Projects

• Combined approach using observations and models to give managers a tool to make decisions across a large range of spatio-temporal scales. From the paddock to the shelf edge.
eReefs: Downscaling

Global products:
- OceanMAPS
- ACCESS

Local models

Hi-res regional (1km)

Regional models (4km)

Observational Requirements: Process Understanding

**Physics** - parameterize processes that occur at spatial scales unresolved by the model grid.
Observational Requirements: Physics Cal/Val

- Some parameterisations in the model require tuning
- Data are required to calibrate these variables:
  - Temperature and salinity (model integrated variables)
  - Sea level
  - Velocity
- Independent data are required to validate the calibrated model
- Calibration reduces the misfit between observations and model output by:
  - Perturbing model parameters
  - Using alternate schemes to better represent processes
  - Inserting additional schemes to represent unresolved processes
**Observational Requirements: Hindcast Mode**

**GBR NEAR REAL-TIME HYDRODYNAMIC MODELLING**

**OceanMAPS**

**GBR4**

**Moorings**

**TEMPERATURE**

**Tide gauge**

**Satellite**

Enhanced true colour

Burdekin and Herbert Rivers, 19 February 2009.
Observational Requirements: NRT mode

- NRT calibration requires a different mindset
- Daily perturbation of parameters
- Further experience is required
TasMAN Project: Low-Cost Nodes

- Low-cost Observing Platform
- Cellular comm’s covered coastal areas < ~30m
- Self describing pre-assembled sensor arrays
- Primarily Temp, EC (DO and Fluorometer tests)
- Materials and Labor assembled platform costs:
  - 10m including buoy and mooring equipment: $5000ea
  - For fixed infrastructure $2500ea
Sediment Modelling: Derwent and SE Queensland

• Sediments
eReefs Pilot BGC Modelling

- BGC
Near Real Time Nutrients

Near Real Time Mooring

Live nutrient data (nitrate, ammonia, silica, phosphate)

Chlorophyll

Light
Glider Data for Model Validation
High Resolution Data Streams

Continuous Nitrate & Chlorophyll Observations

- Surface Nitrate Derwent Estuary

NOx ~1400 samples in 3 days
DIP ~1800 samples in 3 days

Compact reverse FIA nutrient system, Ian McKelvie, Monash University

NOx ~1400 samples in 3 days
DIP ~1800 samples in 3 days

Remote sensing

3D Glider Data
Use of models to support observing systems

- A hydrodynamic model can be used as ‘training’ data to build a Gaussian process (GP) regression model of a variable at a mooring site.
- Here the GP model is used to interpolate between observations recorded by temperature sensors on the Myrmidon mooring.
Use of models to support observing systems

- The Gaussian process method learns the covariance structure of the process under study.
- The resulting variance model can be used to quantify the uncertainty from observations and inform sensor placement on a mooring.
- In this example the uncertainty is greatest at around 140m depth, in between the instruments placed at 92m and 188m.
Data Assimilation: EnOI - Glider Data

Glider and model comparison: temperature profiles

Observations: Glider

Model: Control (no assimilation)

Model: Assimilating

Temperature (°C)
Data Assimilating Coastal Model: Ensemble Methods?
Data Assimilating Coastal Model: Augmented EnKF for joint state and parameter estimation
Future Vision

- National Coastal Information System
  - Ribbon Model for the Australian Shelf.
  - Foundation to investigate marine carbon budgets and fluxes (Blue Carbon)
- Autonomous 2-way nesting with ‘plug & play’ capability for local domains.
- Seamless model deployment, forcing and data collation then execution using the TRIKE framework.
Thank you

CSIRO Marine and Atmospheric Research
Coastal Environmental Modelling Team and the ICT Centre

http://www.emg.cmar.csiro.au/

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Observational Requirements: Process Understanding

Numerical Experiments

Horizontal velocity, magnitude (m/s) at 1m depth
20-Jan-2012 00:00
Grid "4km"

4km

Horizontal velocity, magnitude (m/s) at 1m depth
20-Jan-2012 00:00
Grid "High resolution"

1km