RESILIENCE TO CLUSTERED DISASTER EVENTS ON THE COAST: STORM SURGE

Research Advisory Forum
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Scott Nichol
THE PROBLEM

• Coastal communities and infrastructure are at risk from the impacts of storm surge
• Clustered surge events reduces time for recovery of the coastline
• Not accounting for the impact of clustered events underestimates the risk to coastal assets
PROJECT OBJECTIVE

• Develop a **methodology** to quantify the coastal impacts of clustered storm surge events

→ As a basis for risk management: to inform decisions around resource investment in disaster mitigation, planning and recovery

→ At a range of scales suited for use by National, State and Local Government agencies
METHODOLOGY - CASE STUDIES

• Identify coastal landform systems that are **vulnerable to erosion** during storm surge events

• Develop **modelled storm surge** events to represent clustering at study sites

• Reconstruct **shoreline response** to clustered storms

• **Assess numerical models** quantifying coastal response to storm surge based on coastal system characteristics

• Collect **field data** to validate findings

• **Quantify the impact** of clustered storm surge events on coastal assets (buildings and infrastructure).
OUTPUTS

National Datasets
• Coastal compartments maps (primary and secondary scale)
• Schema for mapping coastal landforms

Study Site Datasets
• Integrated geodatabases showing landforms & infrastructure
• Sediment thickness (volume) information (ground penetrating radar)
• Modelled shoreline response to storm surge (maps, charts, profiles)

Synthetic Storm Event time series
• Modelling Code – (PENDING REVIEW etc)

Conceptual Model(s) – Representing shoreline response(s) to storm clusters

Publications / Reports
PROJECT TEAM & END USERS

• Researchers
  ➢ Geoscience Australia
    o Scott Nichol, Andrew McPherson, Duncan Moore, Gareth Davies, Wenping Jiang, Floyd Howard, Jane Sexton (PM)
  ➢ University of Queensland
    o Tom Baldock, David Callaghan, Uriah Gravois (postdoc)

• End Users
  • NSW, Office of Environment & Heritage
  • SA, Dept of Environment, Water & Natural Resources
  • QLD, Dept of Science, Information Tech, Innovation & Arts
  • NSW, State Emergency Services
  • Commonwealth Attorney General Dept
Coastal mapping framework and schema developed

- Project Report for Q4 milestone: Application of the National Coastal Geomorphology Classification in a Coastal Sediment Compartment Framework

Data: geodatabase, kml
PROGRESS - DESKTOP STUDIES

Study Area 1: Old Bar Beach, NSW
Purpose:

- Map rock basement to estimate potential sediment that can be mobilised in storms
- Collect baseline information to inform shoreline modelling
  - When: Feb-March 2015 Old Bar & Adelaide
  - Outputs: Geophysical site characterisation
  - Observations:
    - Old Bar – highly variable sediment thickness, related to rock substrate (connected to offshore reefs)
    - Adelaide – beach width and thickness increases northward, consistent with longshore drift pattern
**PROGRESS - RESULTS**

Old Bar Ground Penetrating Radar Profiles

**Thin sand cover**

**Thick sand cover**
PROGRESS – RESULTS

Adelaide Ground Penetrating Radar Profiles
What is a Cluster?

- **Event-based approach:**
  - Idea: Sequence of storms “close enough in time” to force a physical response to the shoreline (i.e. net erosion)
  - No widely applicable definition of ‘close enough in time’
    - Site specific and strongly dependent on antecedent conditions
  - Therefore, we don’t demand a universal definition of ‘clustered events’
    - Instead: provide a method to simulate storm sequences with realistic statistical properties, including the event timings
  - Can combine with any particular ‘storm cluster’ definition to compute clustered event frequencies, drive hazard models, etc.
Statistical approach:

a) Storm wave events have some statistical properties
   - e.g. Seasonally dependent storm frequencies / magnitudes
   - Possibly storms are more/less likely to occur following another storm?

b) Goal: **Simulate storm event timings / magnitudes with realistic statistical properties**
   - Don’t have to define ‘a cluster’ at the event level if we correctly model timings/magnitudes

c) Statistical Clustering:
   - Are there significantly more/less closely spaced storm events than expected if storms occurred randomly in time?
STORM EVENT SUMMARY STATISTICS

1) For each event, extract:
   a) Peak $H_{sig}$ and Tidal Residual; Median Wave Period and Direction; Duration and Start-time

2) Analysis based on these summary statistics
RESULTS: MODEL VS DATA
EXAMPLE SYNTHETIC SERIES - OLD BAR

10 years of data

10 years of the synthetic series
MODEL VS DATA: NUMBER OF EVENTS EACH YEAR

Number of events each year in data (black) and model (red)

Old Bar
WHAT IS THE EXCEEDANCE RATE OF A STORM SEQUENCE “LIKE 1974” AT OLD BAR?

Hindcast wave height 1974: Jan-June
(courtesy of Dave Hanslow)
WHAT IS THE EXCEEDANCE RATE OF A STORM SEQUENCE “LIKE 1974” AT OLD BAR?

- Event definition
  - three events with $H_{sig} > 5m$,
  - occur within 6 weeks

- Answer: 0.03 clusters/yr (1 in 33 yrs)
  - 95% confidence interval [0.014, 0.058]

- Can compute average exceedance rate of any clustered event with a clear definition
  - Site-specific, problem-specific definition of clustered event sequence.
PROGRESS - PUBLICATIONS

- International Coastal Symposium, Sydney 2016 – accepted oral paper (Nichol et al)
- Special Issue Journal of Coastal Research – overview paper (Nichol et al., in review)
- MODSIM 2015 – extended abstract on time series modelling (Davies et al., accepted)
- International Conference on Coastal Engineering, 2016. Investigating Site Specific Directional Wave Measurement Bias Using Inverse Ray Tracing (Gravois et al., submitted)
PROJECT TIMELINE

Year 1 (14/15):
- Workshop with end users – study sites selected ✓
- Field work & reporting ✓
- Coastal mapping schema developed ✓
- Shoreline model evaluation ✓

Year 2 (15/16):
- Storm event time series established ✓
- Coastal mapping schema published ✓
- Shoreline response modelling underway (soon)
- Study site infrastructure ‘mapped’ (under discussion)

Year 3 (16/17):
- Shoreline response modelling complete
- Impact modelling done
- End user presentations
- Project review
NEXT STEPS - EXPOSURE ANALYSIS
Year 2 (15/16):
- Q3 milestone: Shoreline Response Modelling Underway
SUMMARY

• Project is on track with all milestones delivered
• Datasets in place with analysis well underway
• Regular interactions among the project team
• Face to face meetings with stakeholders
• Ongoing review of project direction and outputs