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RESILIENCE TO CLUSTERED DISASTER EVENTS ON THE COAST: STORM SURGE

Research Advisory Forum

18 November 2015

Scott Nichol

An Australian Government Initiative

CRC AUSTRALIA

Australian Government
Geoscience Australia

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


Geoscience Australia


GoldCoast Bulletin

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

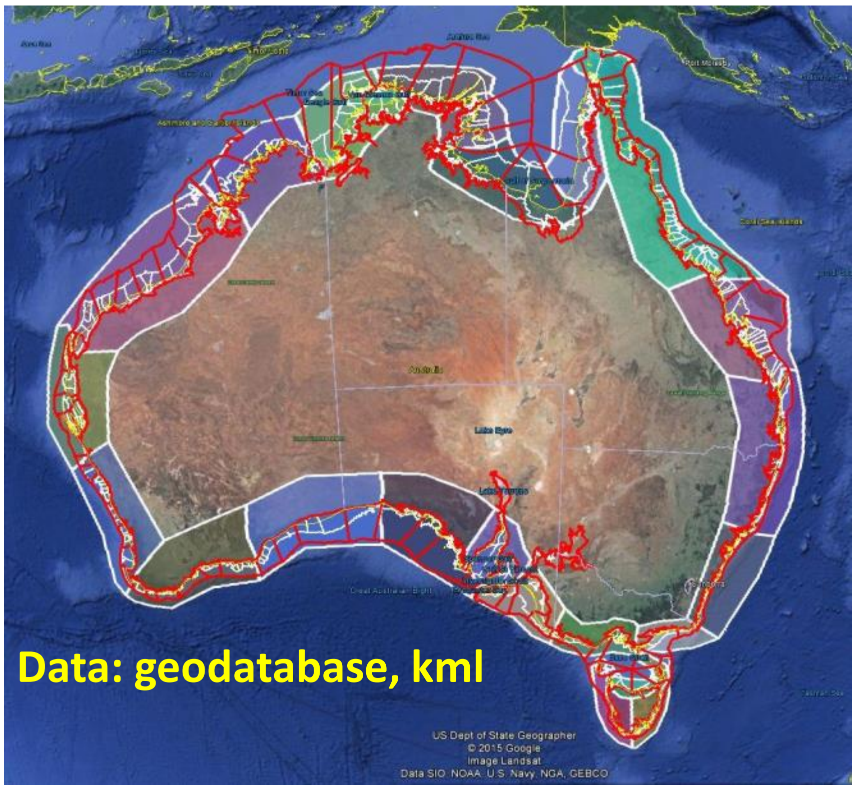
PROJECT TEAM & END USERS

- 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
  - C/wealth Attorney General Dept

PROGRESS

Coastal mapping framework and schema developed

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




Australian Government
Geoscience Australia

Record 2015/25 | GeoCat 84574

The Australian Coastal Sediment Compartments Project

Methodology and Product Development

A. McPherson, M. Hazelwood, D. Moore, K. Owen, S. Nichol and F. Howard

APPLYING GEOSCIENCE TO AUSTRALIA'S MOST IMPORTANT CHALLENGES

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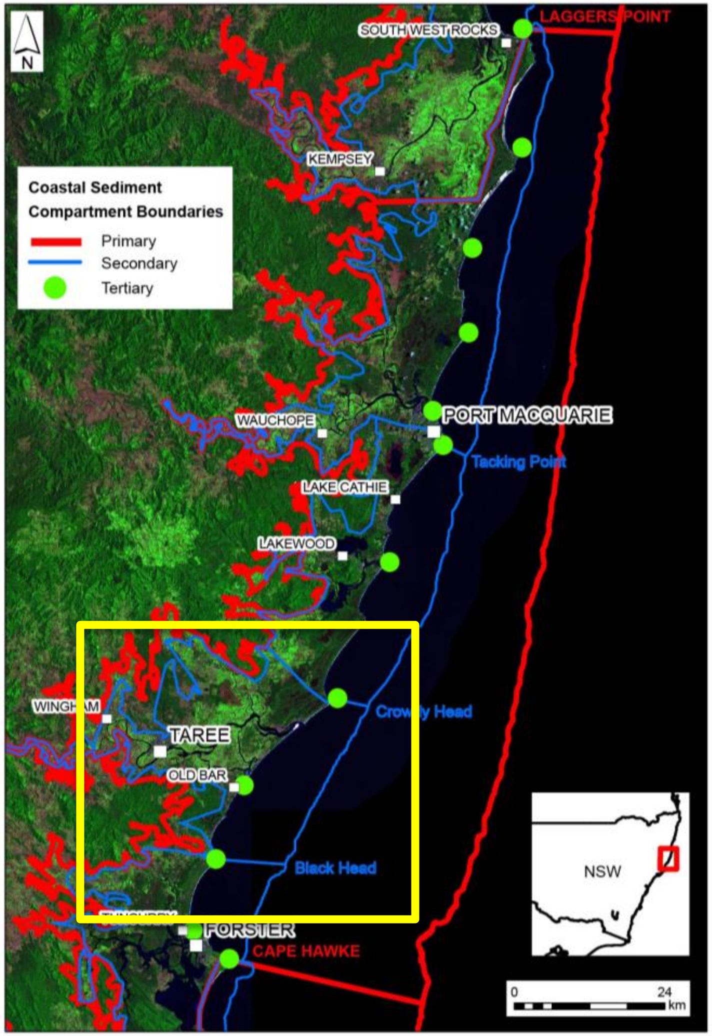
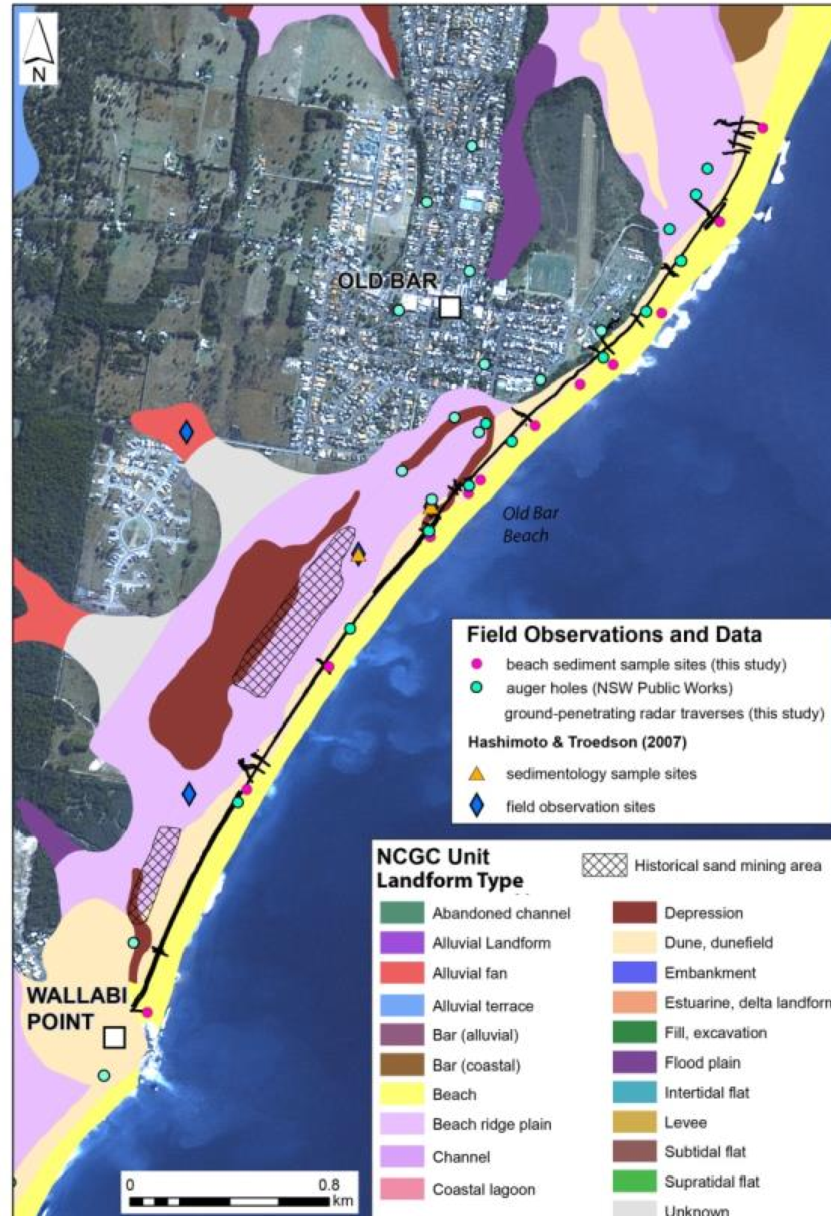
PROGRESS – DESK TOP STUDIES

Study Area 1: Old Bar Beach, NSW





PROGRESS – FIELD WORK

Purpose:

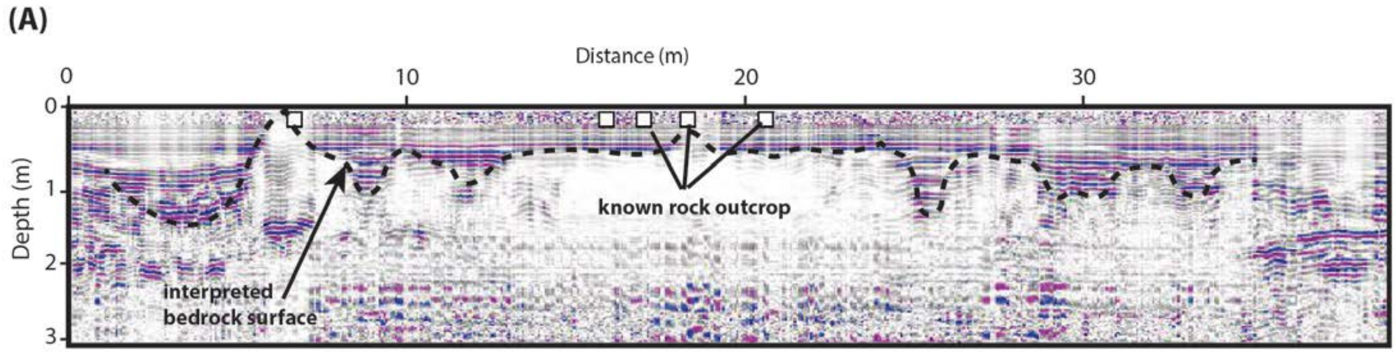
- Map rock basement to estimate potential sediment that can be mobilised in storms

- 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

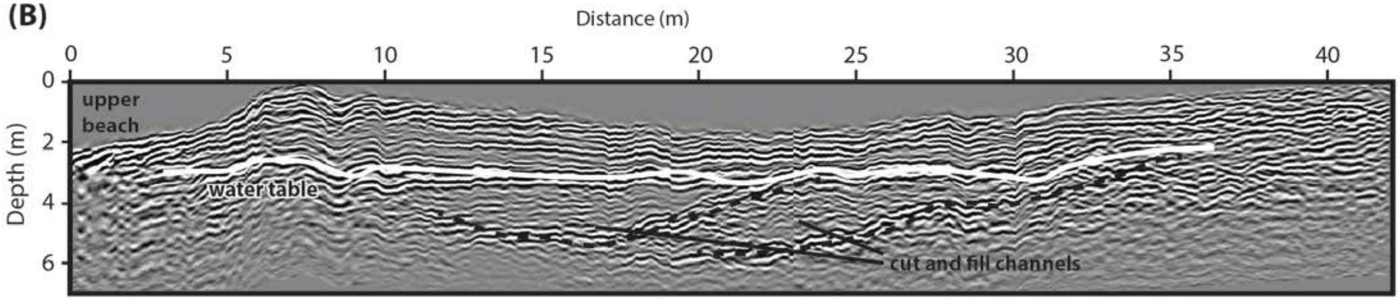
PROGRESS – RESULTS

Old Bar Ground Penetrating Radar Profiles

Thin sand cover

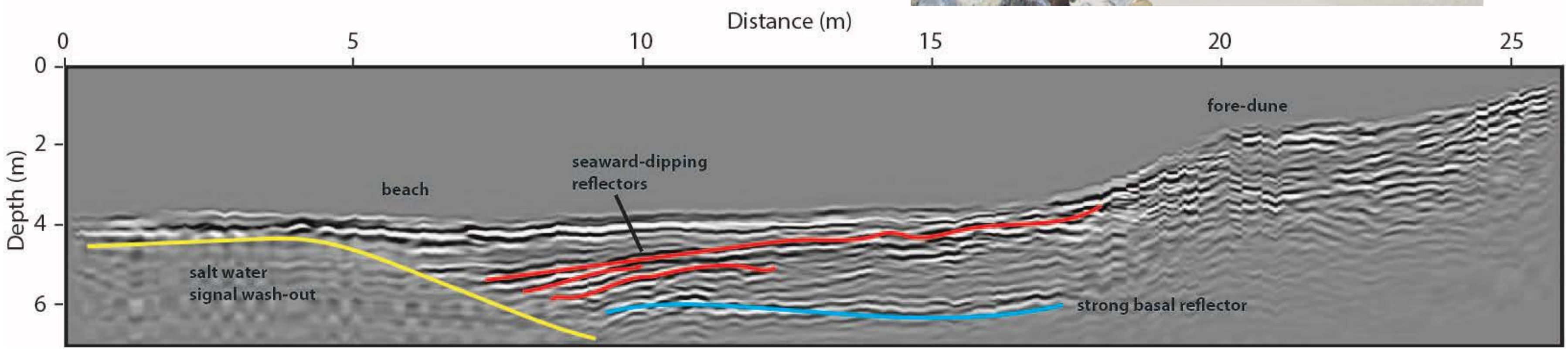


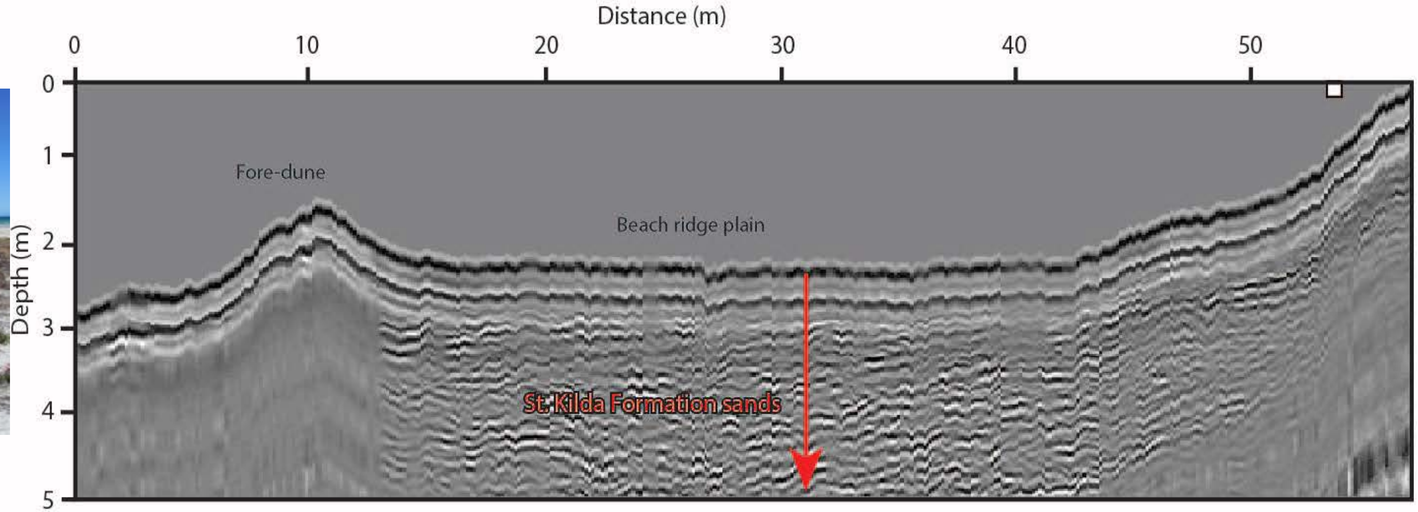
Thick sand cover



PROGRESS – RESULTS

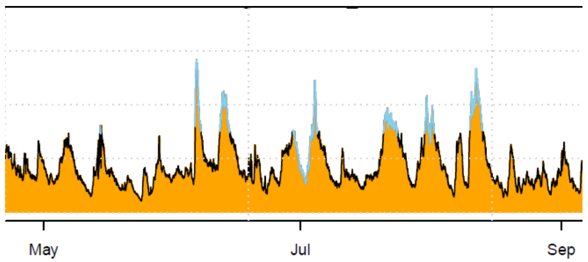
Adelaide Ground Penetrating Radar Profiles





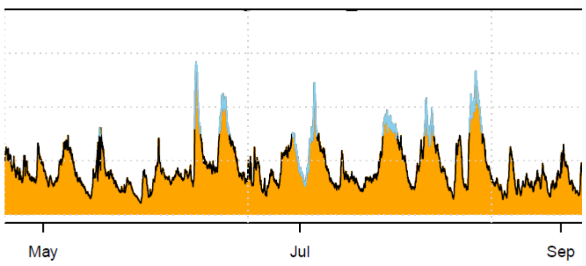
PROGRESS - STORM CLUSTERING

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 <u>strongly</u> 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.

PROGRESS - STORM CLUSTERING



- Statistical approach:

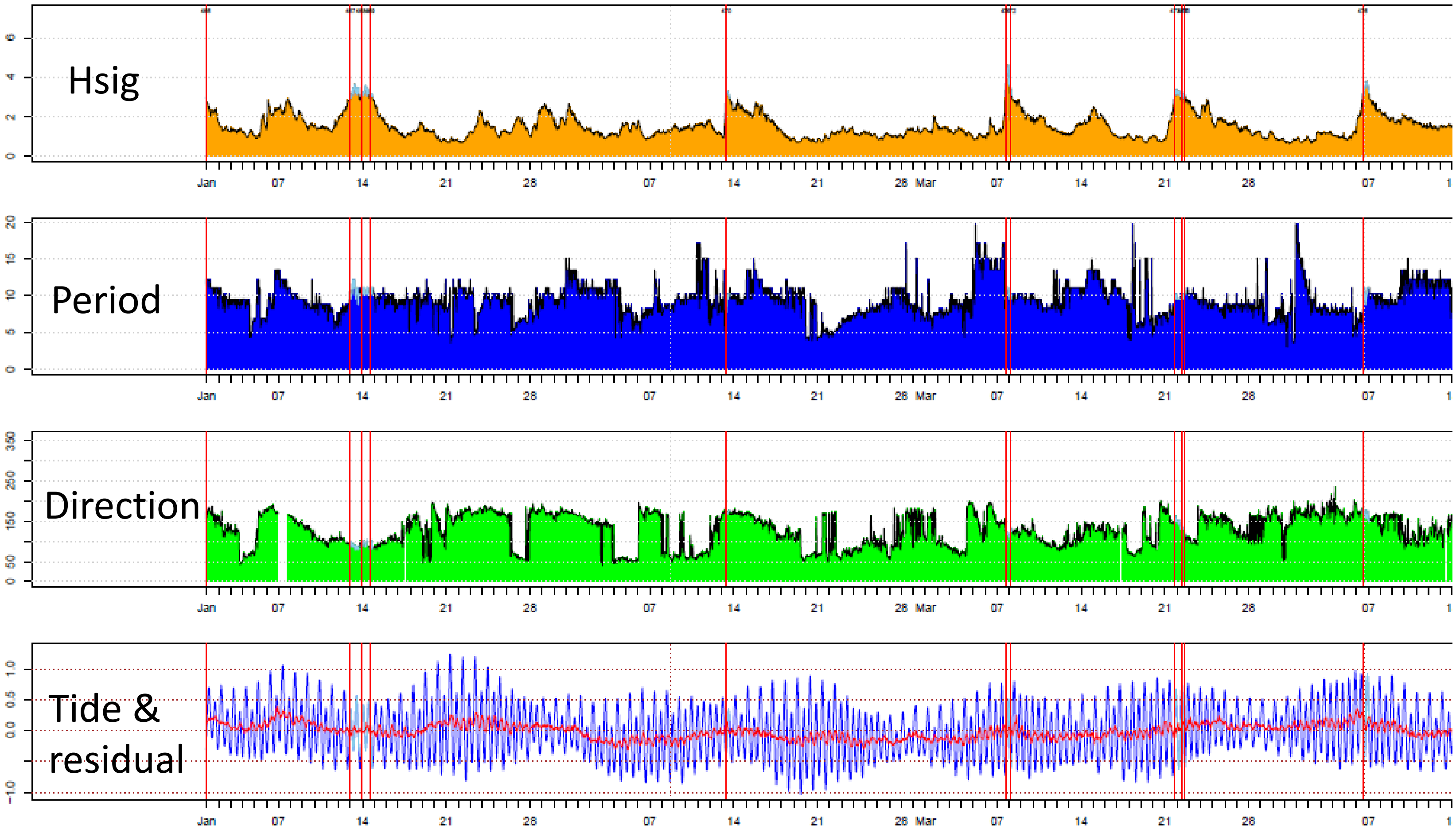
  a) Storm wave events have some statistical properties
    - e.g. Seasonally dependent storm frequencies / magnitudes
    - Possibly storms are more/less likely to occur following another storm?

  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 DEFINITION

Old Bar

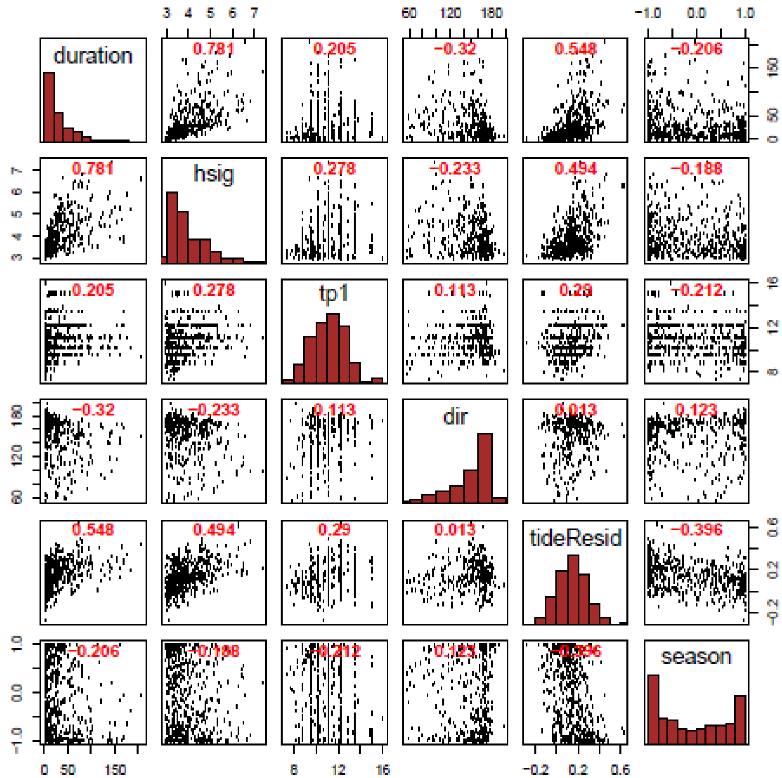


STORM EVENT SUMMARY STATISTICS

1) For each event, extract:

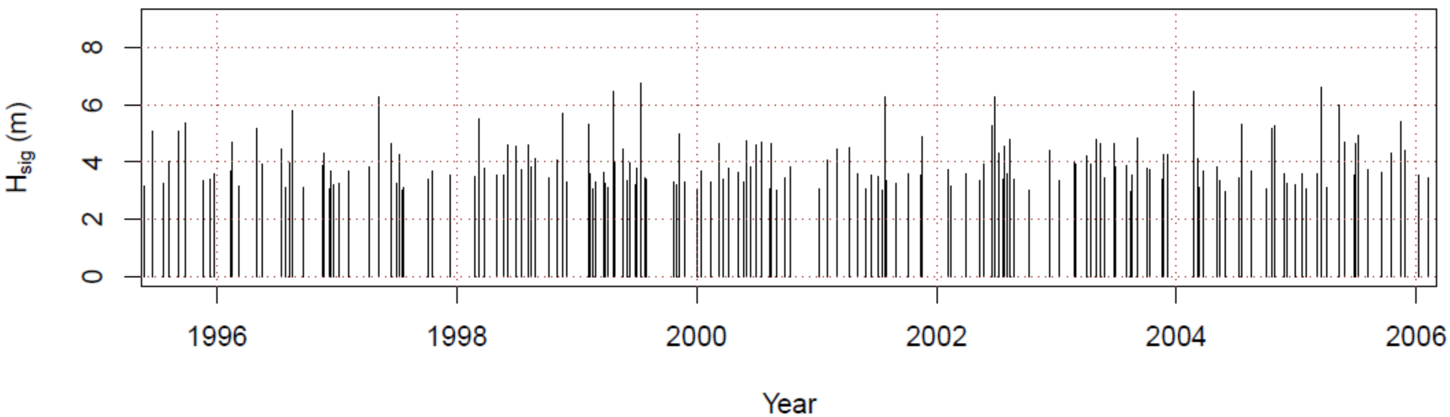
   a) Peak Hsig and Tidal Residual; Median Wave Period and Direction; Duration and Start-time

2) Analysis based on these summary statistics

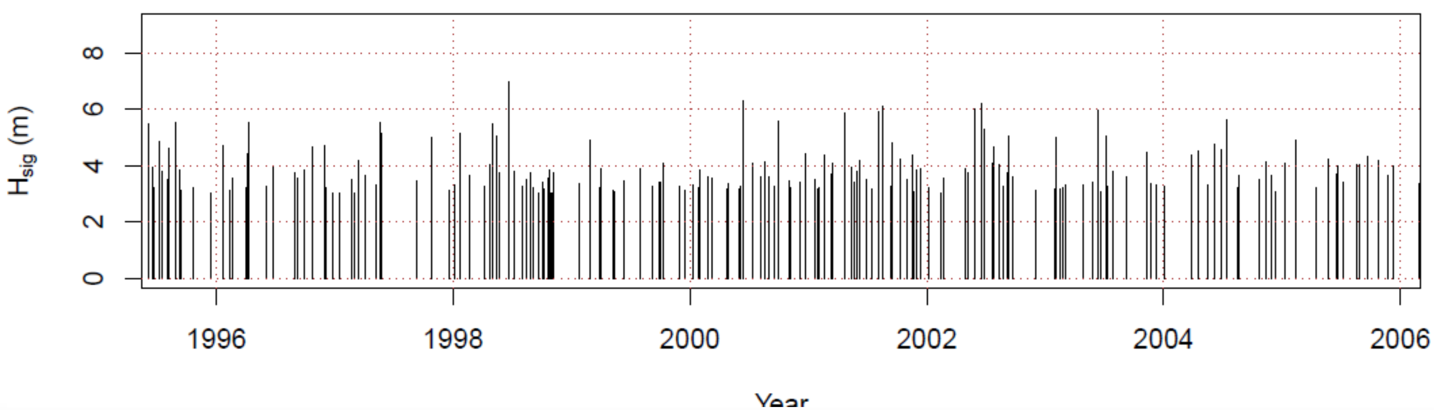


RESULTS: MODEL VS DATA
EXAMPLE SYNTHETIC SERIES – OLD BAR

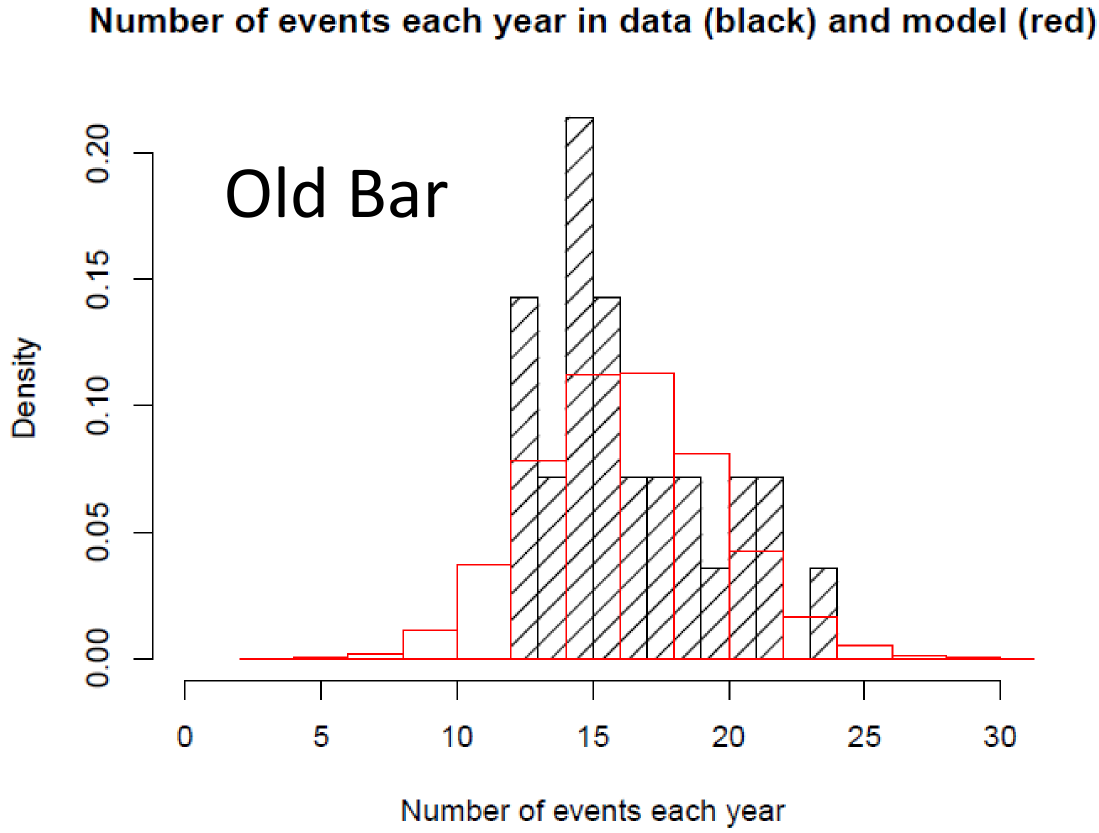
10 years of data



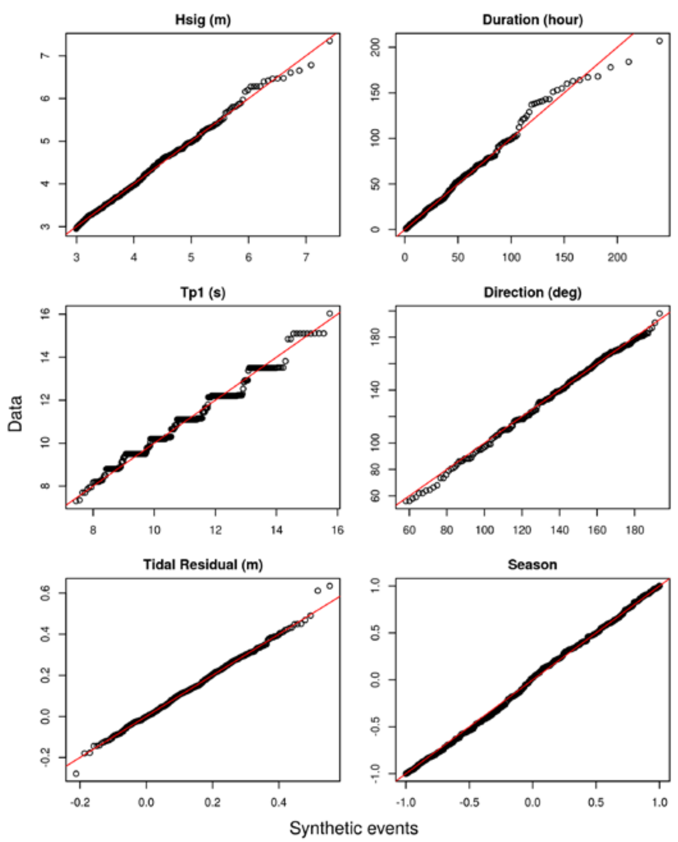
10 years of the synthetic series



MODEL VS DATA: NUMBER OF EVENTS EACH YEAR

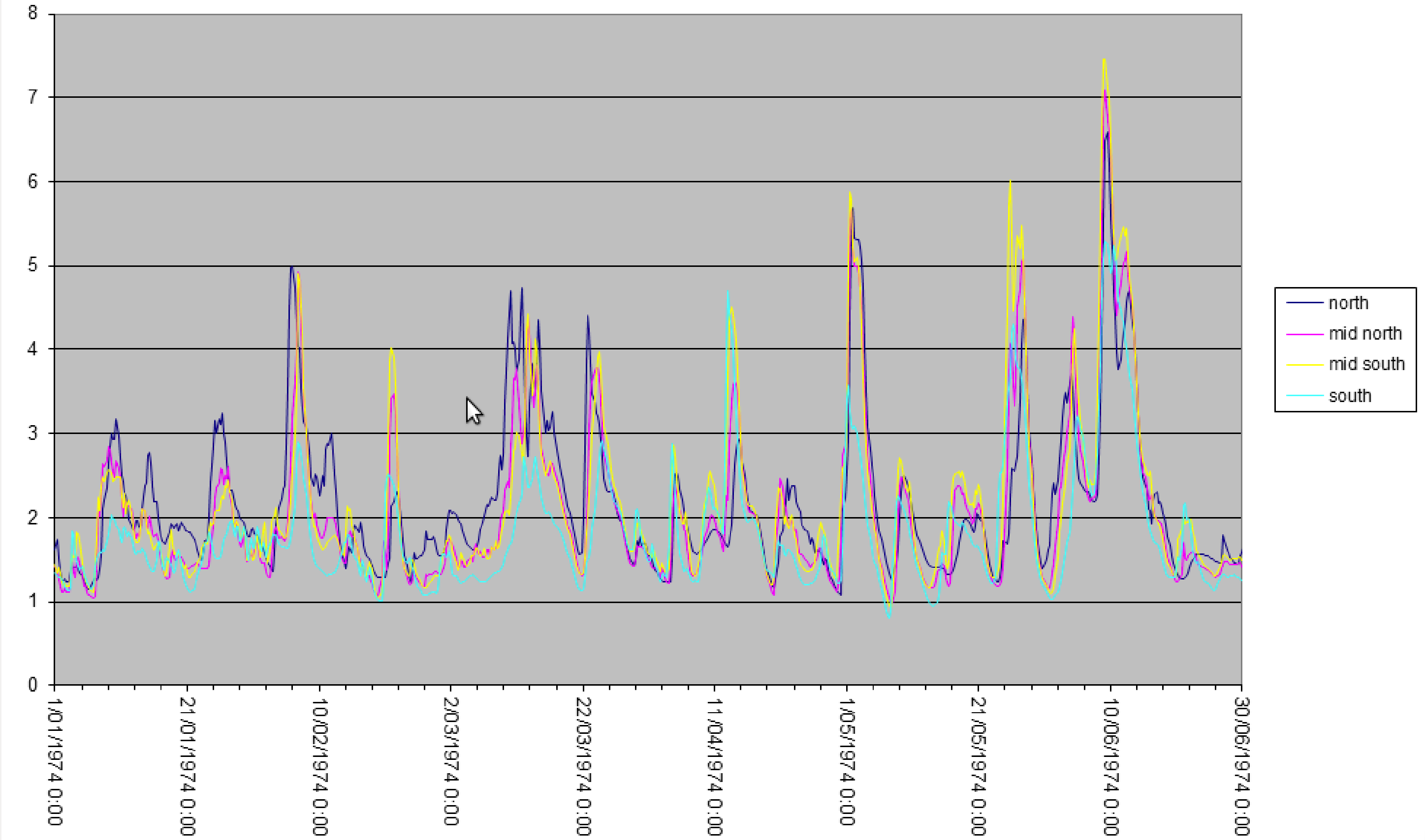


Model vs Data Quantiles

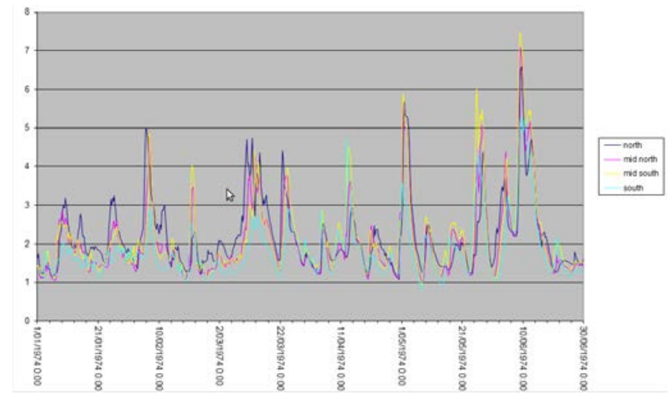


WHAT IS THE EXCEEDANCE RATE OF A STORM SEQUENCE “LIKE 1974” AT OLD BAR?

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 Hsig > 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)**

Journal of Coastal Research	SI	75	XX-XX	Coconut Creek, Florida	2016

A Framework for Modelling Shoreline Response to Clustered Storm Events: A Case Study from Southeast Australia

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ABSTRACT

Nichol, S.L.; McPherson, A., Davies, G., Jiang, W., Howard, F., Baldock, T., Callaghan, D., and Gravois, U., 2016. A framework for modelling shoreline response to clustered storm events: A case study from southeast Australia. *In:* Vila-Concejo, A.; Bruce, E.; Kennedy, D.M., and McCarroll, R.J. (eds.), *Proceedings of the 14th International Coastal Symposium* (Sydney, Australia). *Journal of Coastal Research*, Special Issue, No. 75, pp. XX-XX. Coconut Creek (Florida), ISSN 0749-0208.

An overview of a framework for modelling shoreline response to clustered storm events is presented for a case study area on the high energy coast of southeast Australia. We adopt the coastal sediment compartment as the functional management and modelling unit and use sub-surface information (ground-penetrating radar) to assess sediment thickness in the upper beach and foredune. Results for an actively eroding beach face at Old Bar Beach (New South Wales) indicate that sand cover is highly variable at the critical beach-dune interface, ranging from less than 1 m where bedrock occurs in shallow sub-crop to greater than 4 m across a former tidal inlet. The temporal distribution of storm events is examined through statistical modelling. For the duration of the data, modeled wave parameters are in good agreement with wave buoy observations. Event clustering does not appear to be stronger than is expected from events that occur randomly in time. Together, these data provide site-specific information necessary to inform shoreline response modeling to storms by establishing the requisite conditions describing the geomorphic setting and nearshore process regime.

ADDITIONAL INDEX WORDS: *Beach erosion, sediment compartment, time series, coastal management.*

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

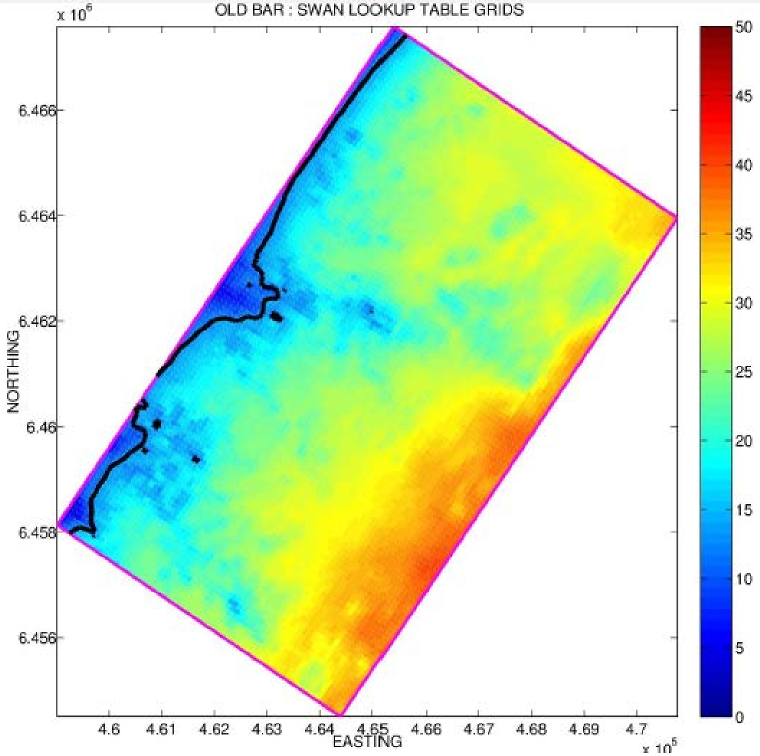
NEXT STEPS - EXPOSURE ANALYSIS

NEXT STEPS

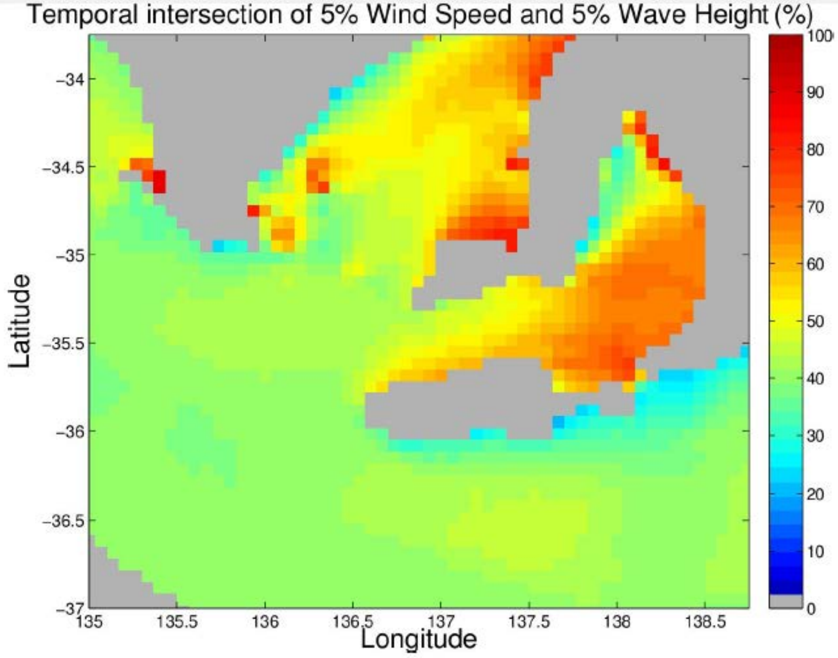
Year 2 (15/16):

- Q3 milestone: Shoreline Response Modelling Underway

Old Bar
Swan Modeling with Buoy Data (3)



Adelaide - CAWCR Wave Hindcast



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