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RESILIENCE TO CLUSTERED DISASTER EVENTS ON THE COAST: STORM SURGE

Project Update – 19 October 2016

Scott Nichol

Geoscience Australia

Australian Government
Department of Industry, Innovation and Science

Business Cooperative Research Centres Programme

Australian Government
Geoscience Australia

The University Of Queensland
AUSTRALIA

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PROJECT TEAM & END USERS

- Researchers
  - **Geoscience Australia**
    - Scott Nichol, Andrew McPherson, Duncan Moore, Gareth Davies, Wenping Jiang, Floyd Howard, Jane Sexton (Proj Mgr)
  - **University of Queensland**
    - 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
  - C/wealth Attorney General Dept

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

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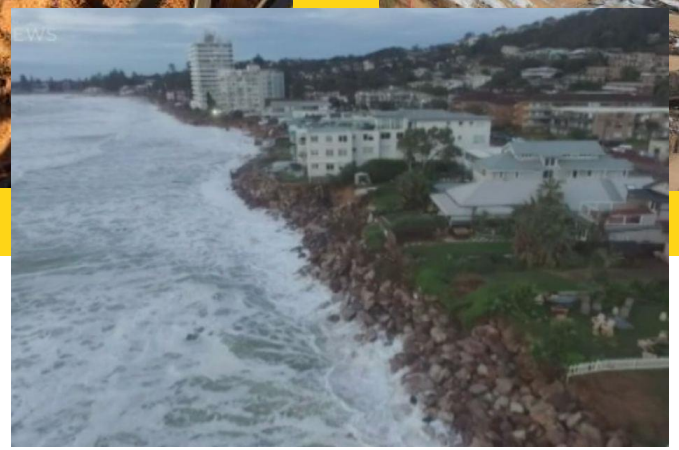
EVENTS IN 2016: EAST COAST LOW, 4-5 JUNE

Collaroy Beach, Sydney



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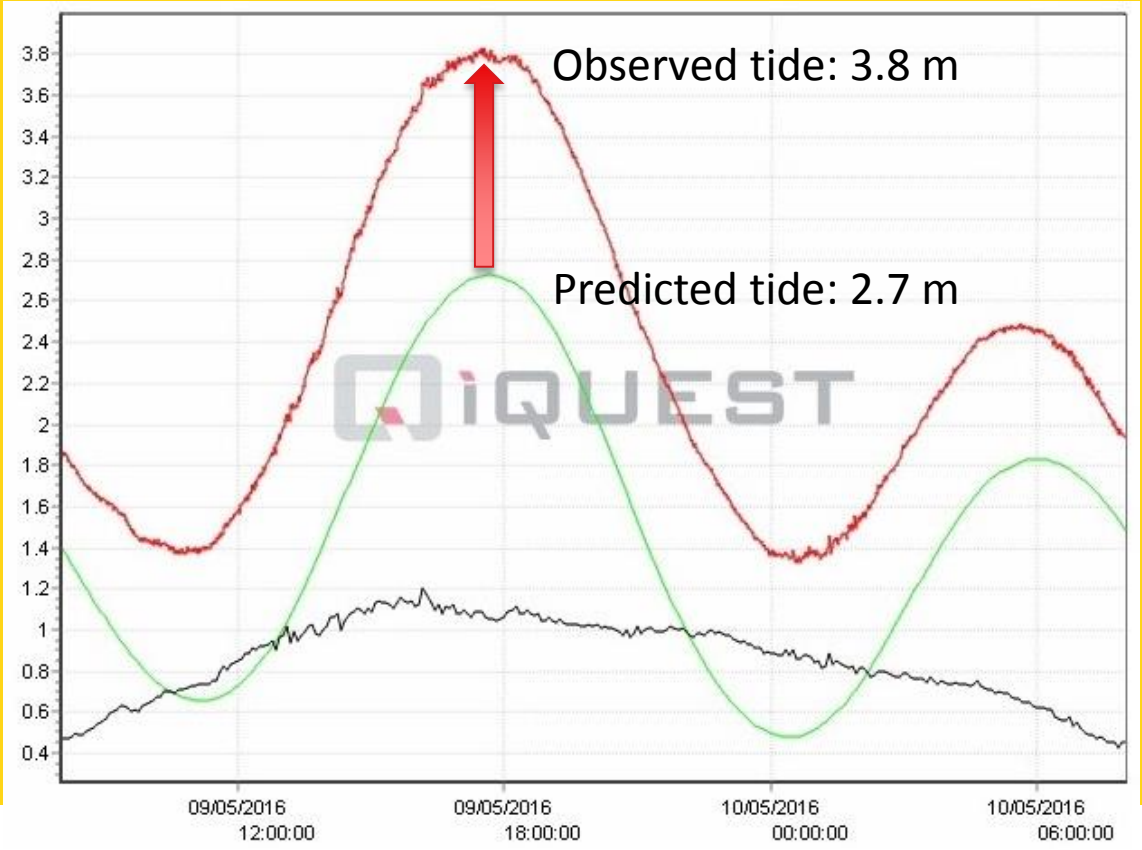
EVENTS IN 2016: ADELAIDE, 9 MAY



Highest water level ever recorded in Outer Harbour

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EVENTS IN 2016: ADELAIDE, 9 MAY

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EVENTS IN 2016: ADELAIDE, 9 MAY

" Past storms have caused much more significant damage to the coast. The ***lack of damage*** *is testament to the* ***long-term active management*** *of Adelaide's beaches by the Board and the Department of Environment, Water and Natural Resources, including the current Adelaide's Living Beaches strategy."*

SA DEWNR, Internal Report

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PROJECT OBJECTIVE & APPROACH – CASE STUDIES (NSW, SA)

Develop a **methodology** to quantify the impacts of clustered storm surge events that is **national in application**

1. Identify coastal landform systems that are **vulnerable to erosion** and inundation during storms
2. Develop **modelled storm surge events** to represent clustering at study sites
3. Model **shoreline response** to storm time series
4. Incorporate information on **coastal geology**, **geomorphology** & **sediments** in assessments of shoreline response modelling
5. Quantify the impact of clustered storm surge events on **coastal assets** (buildings and infrastructure)

PROJECT PROGRESS

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
- Study site infrastructure 'mapped' **pending modelling results**

Year 3 (16/17):

- Shoreline response modelling complete - **progressing**
- Impact modelling done **pending modelling results**
- End user presentations – **RAF early next year**

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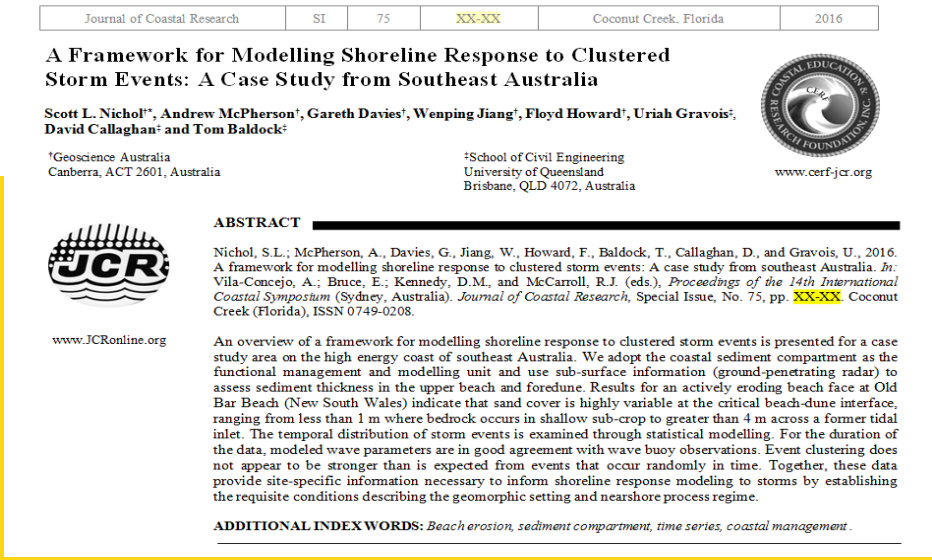
PROGRESS - OUTPUTS

Conferences

- MODSIM 2015, Gold Coast, December 2015
- International Coastal Symposium, Sydney, March 2016
- NSW Coastal Conference, Coffs Harbour, November 2016
  (2 oral papers, 1 poster)
- AFAC (poster)



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

Scott L. Nichol†*, Andrew McPherson†, Gareth Davies†, Wenping Jiang†, Floyd Howard†, Uriah Gravois‡, David Callaghan‡ and Tom Baldock‡

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www.JCRonline.org

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.*

Publications

- Journal of Coastal Research: *A framework for modelling shoreline response to clustered storm events* (Nichol et al.)
- Coastal Engineering: *Resolving confidence limits and thresholds in probabilistic modelling of storm wave climate* (Davies et al.)
- NSW Coastal Conference Proceedings:
  - *Probabilistic modelling of storm wave clustering at Old Bar, NSW, including the impacts of seasonal and ENSO cycles* (Davies et al)
  - *Physical modelling of the effect of storm sequences on beach profile evolution and beach erosion (Baldock et al)*
  - *Blue water waves: Inverse wave ray tracing of waverider measurements to deep water and comparison with global climate models (Gravois et al)*

Datasets Published (www.ga.gov.au)

- Coastal compartments
- Field survey data for study sites (ground penetrating radar, GPS, sediments)

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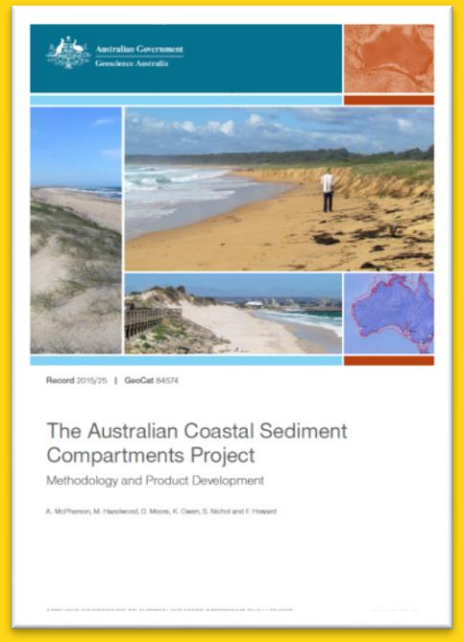
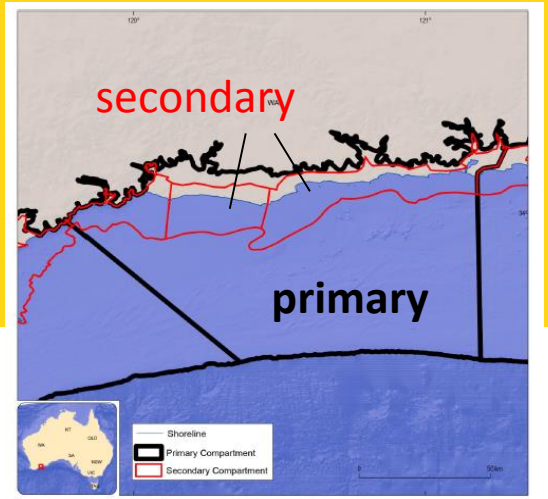
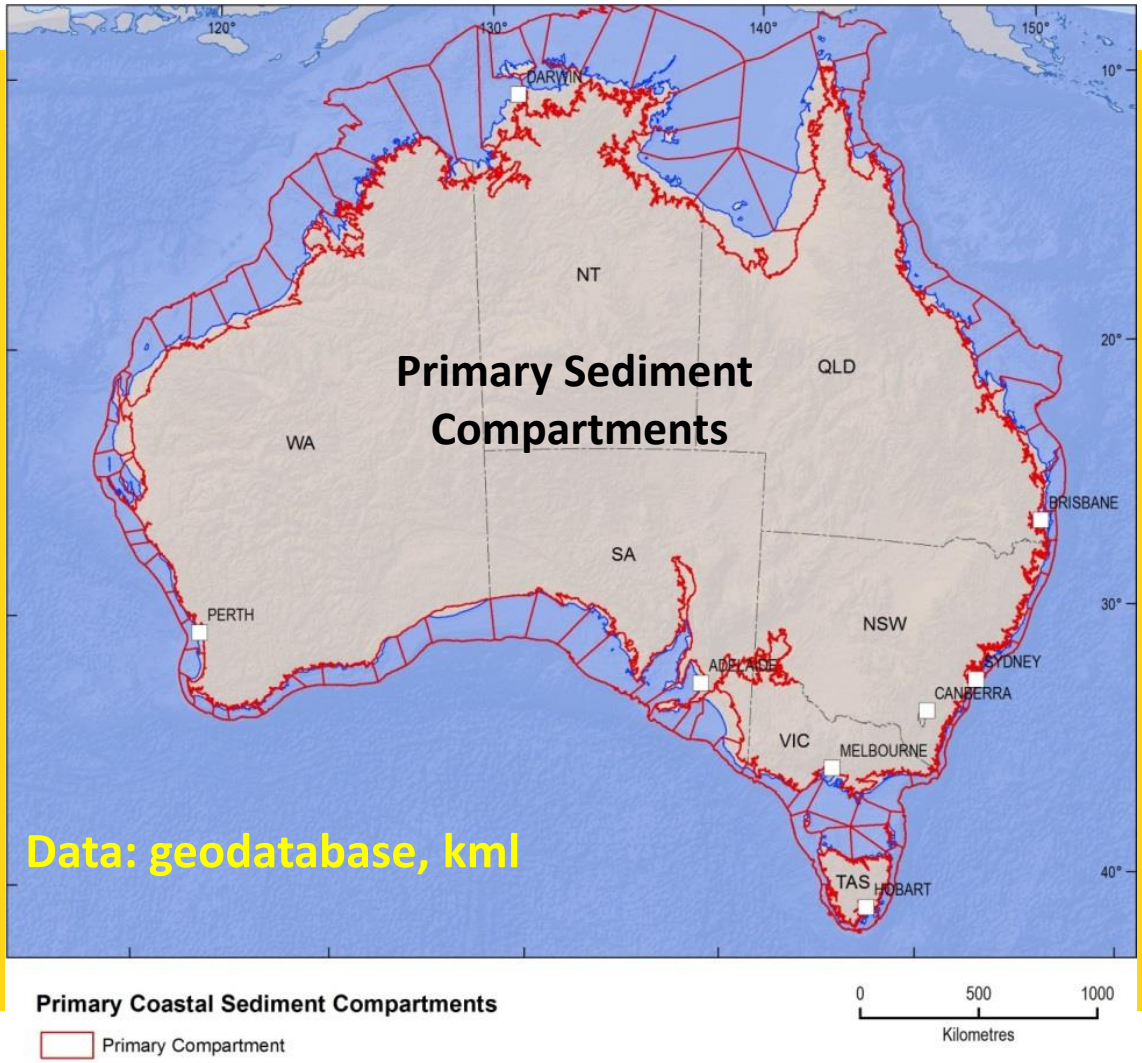
Coastal Sediment Compartments

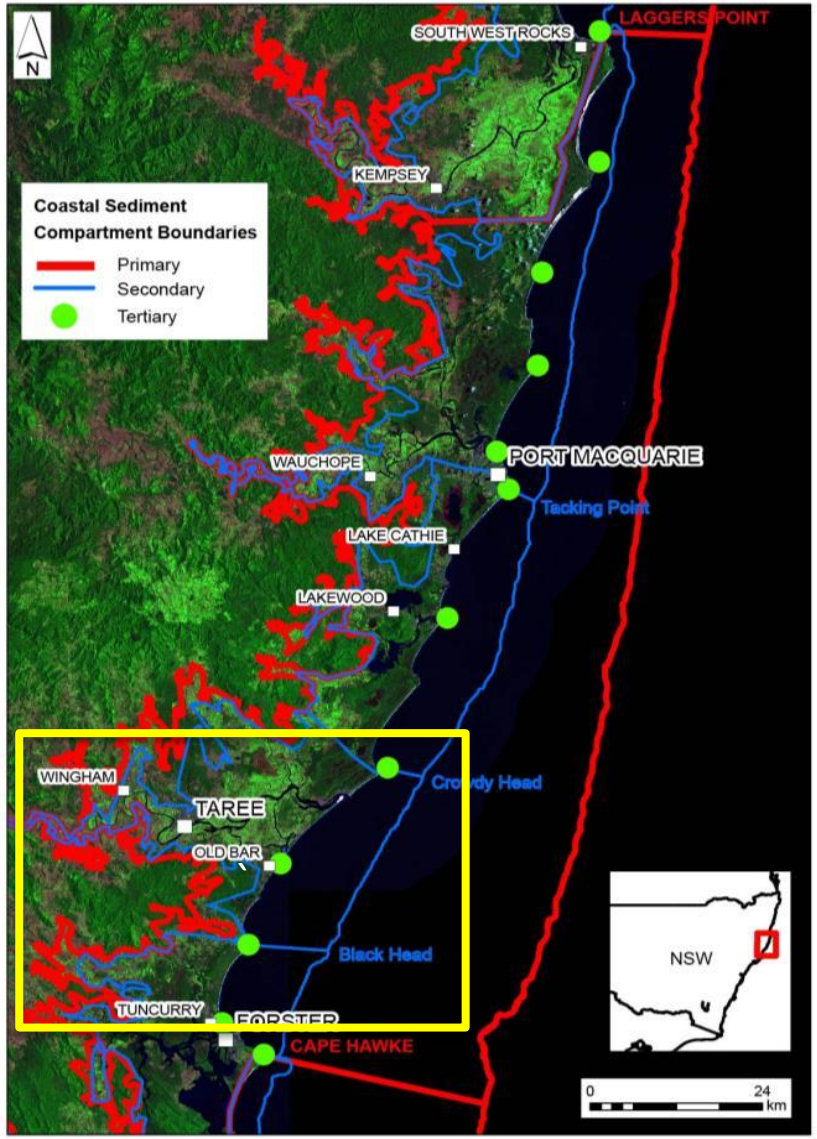


"a consistent framework for mapping vulnerable sectors of coast at multiple spatial scales"





Study Area: Old Bar Beach, NSW



- *Erosion 'hotspot'*
- *Up-drift compartment in a segmented littoral system*
- *Intermediate transverse bar & rip*
- *Swash-aligned to SE swell*
- *Infrastructure at risk*

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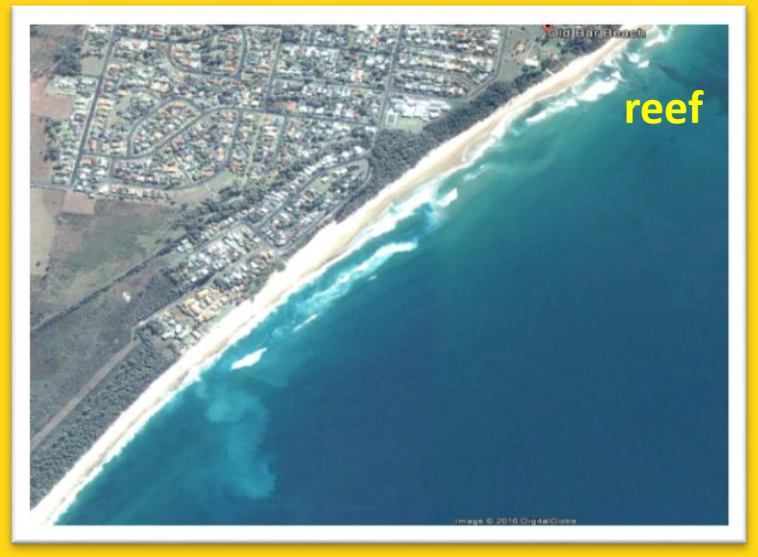
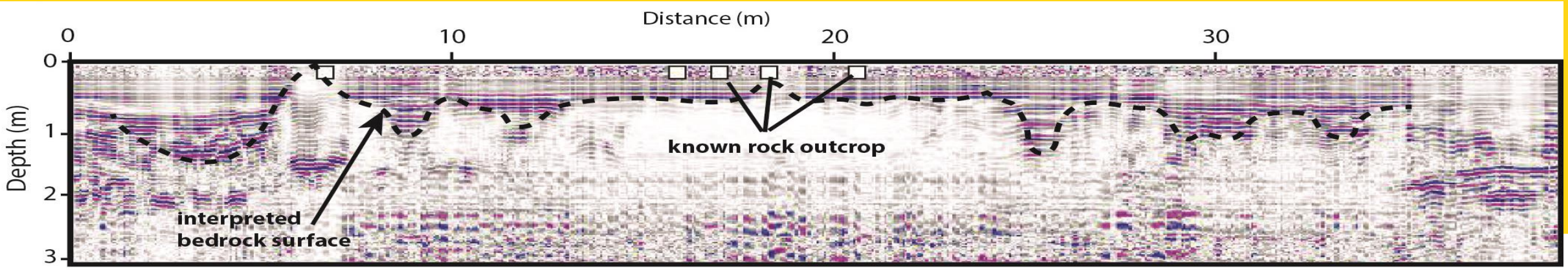
Old Bar: Variable Beach Thickness & Reefs





Ground Penetrating Radar Image of the Old Bar Sub-surface

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EVENTS IN 2016: EAST COAST LOW, 4-5 JUNE – OLD BAR STUDY SITE

Old Bar Beach, NSW

EVENTS IN 2016: EAST COAST LOW, 4-5 JUNE – OLD BAR STUDY SITE

Old Bar Beach, NSW

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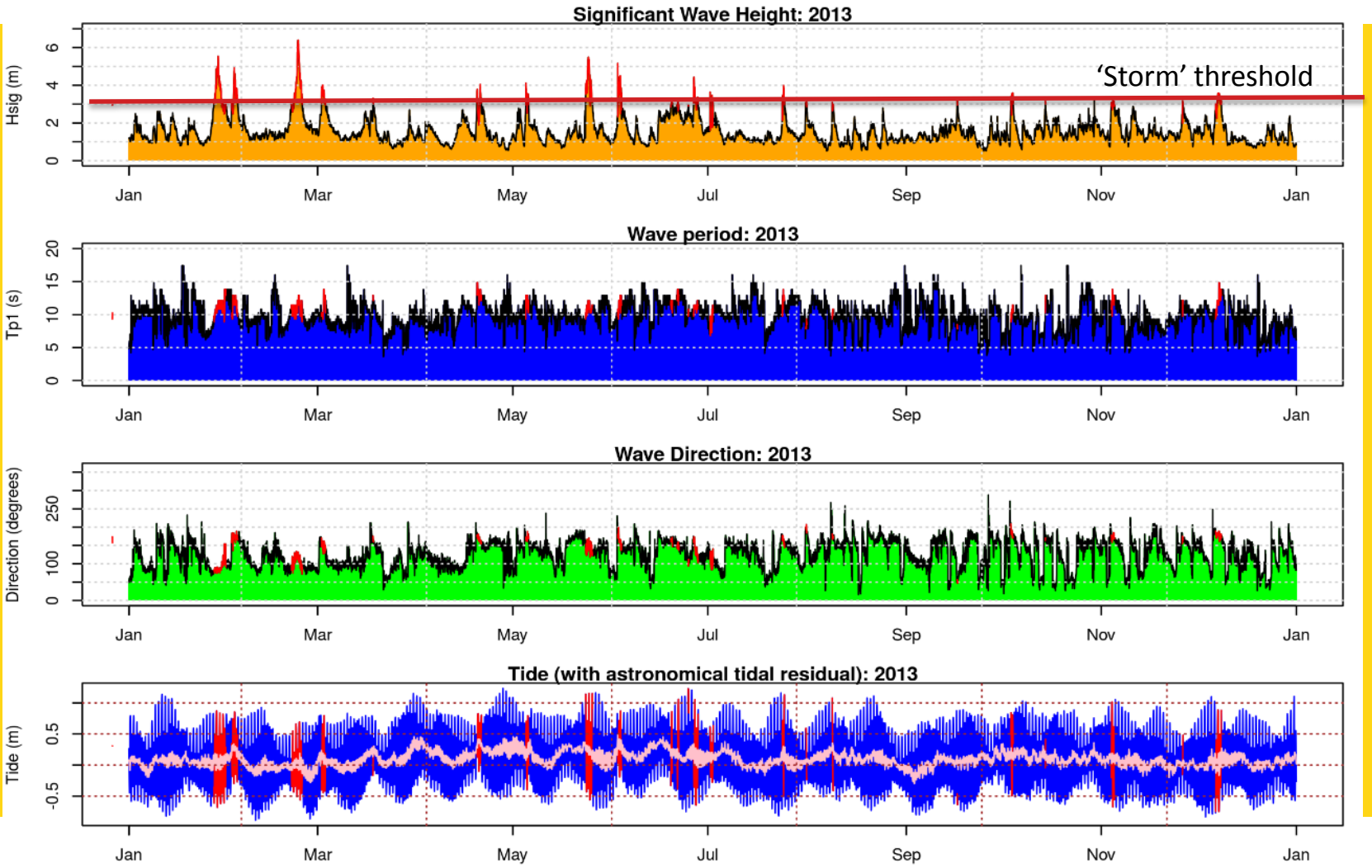
STORM 'CLUSTERING'

- **Event-based approach**
  - 'Cluster Event': 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** (including local geology/geomorphology)

- Therefore, we don't demand a universal definition of 'clustered events'
  Instead: ***we simulate storm sequences with realistic statistical properties (H_{sig}, T_{median} Dir_{median}), including the event timings***

DEFINING STORM EVENTS FOR OLD BAR



Storm = an event with Hsig > 2.9 m (upper 5% of the record)

e.g. 23 events in 2013

Crowdy Head wave-rider buoy 30 yr record: 70m w.d.; 25 km NE of Old Bar

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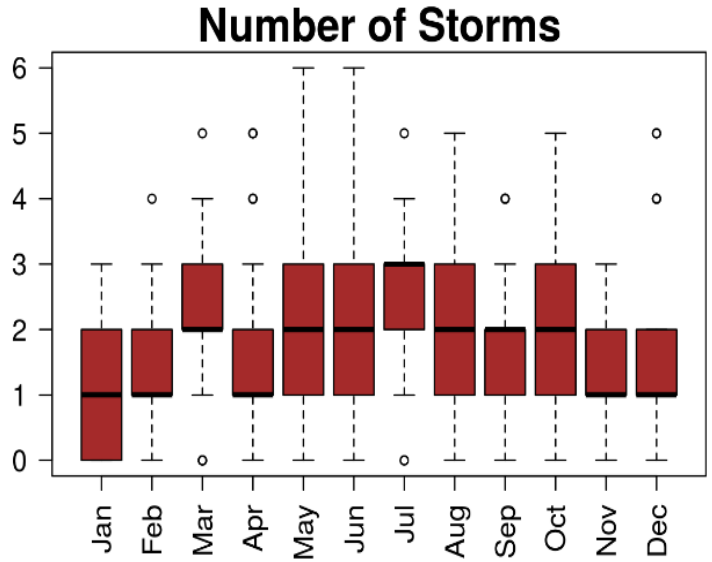
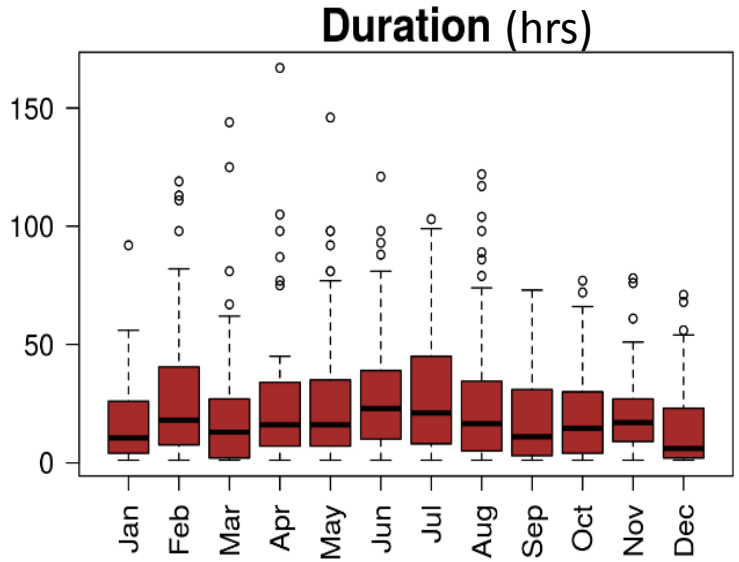
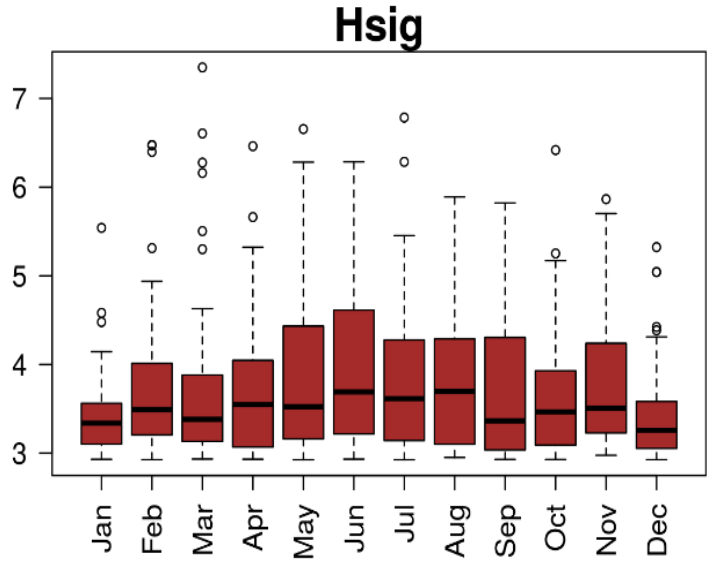
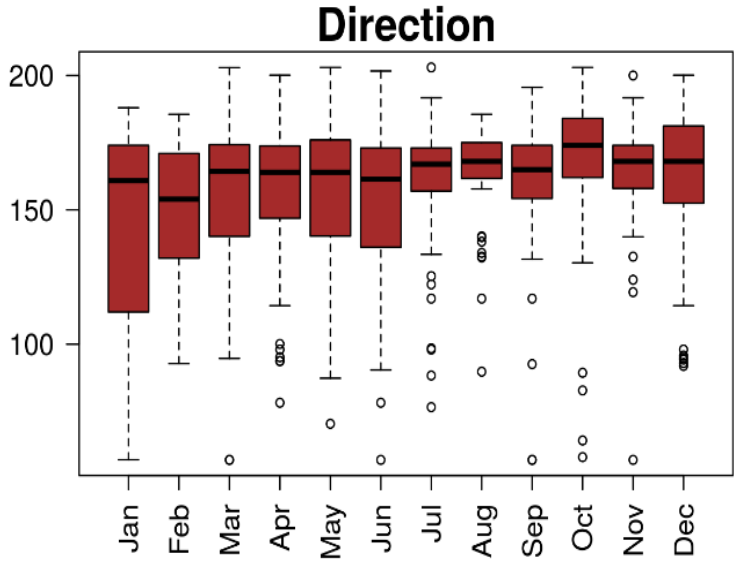
Old Bar Storm Summary Statistics – Seasonal variability

- More storms in winter
- Longer storms in winter
- Larger waves in winter
- More storms from the **east/SE** in late summer
- Clustering not strong
  - ➢ Statistically random









MODELLED STORM WAVE PARAMETERS – OLD BAR

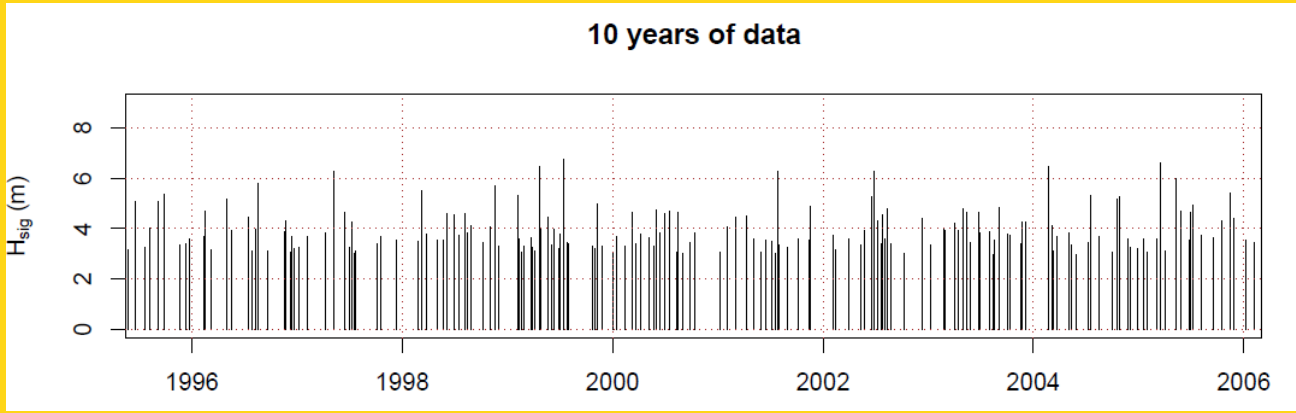
Simulating storm event timing & magnitude with realistic statistical properties

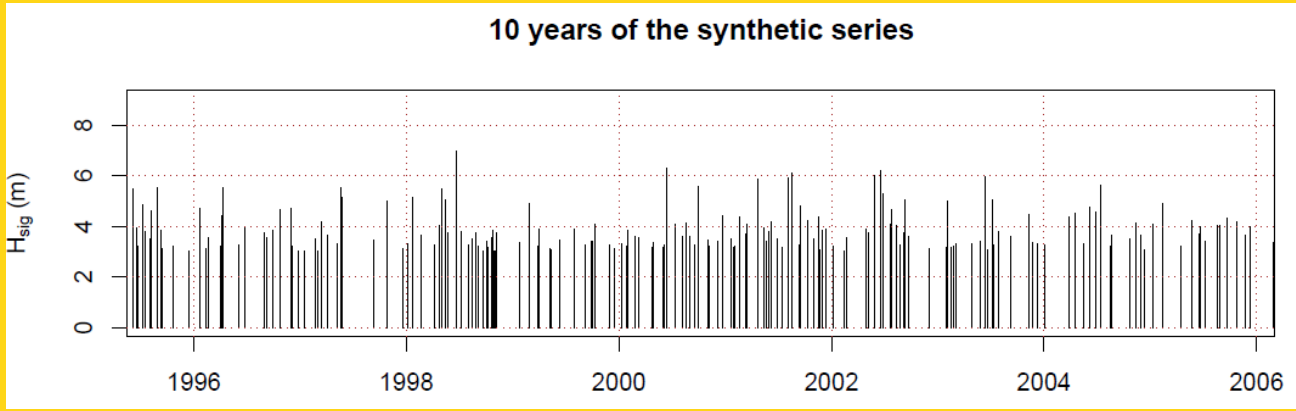
Old Bar synthetic wave record

Storm events > 5 m Hsig and < 6 wks apart

- 0.03 clusters per year (1 in 33 yrs)
  - 95% confidence interval

Provides input data for shoreline response modelling

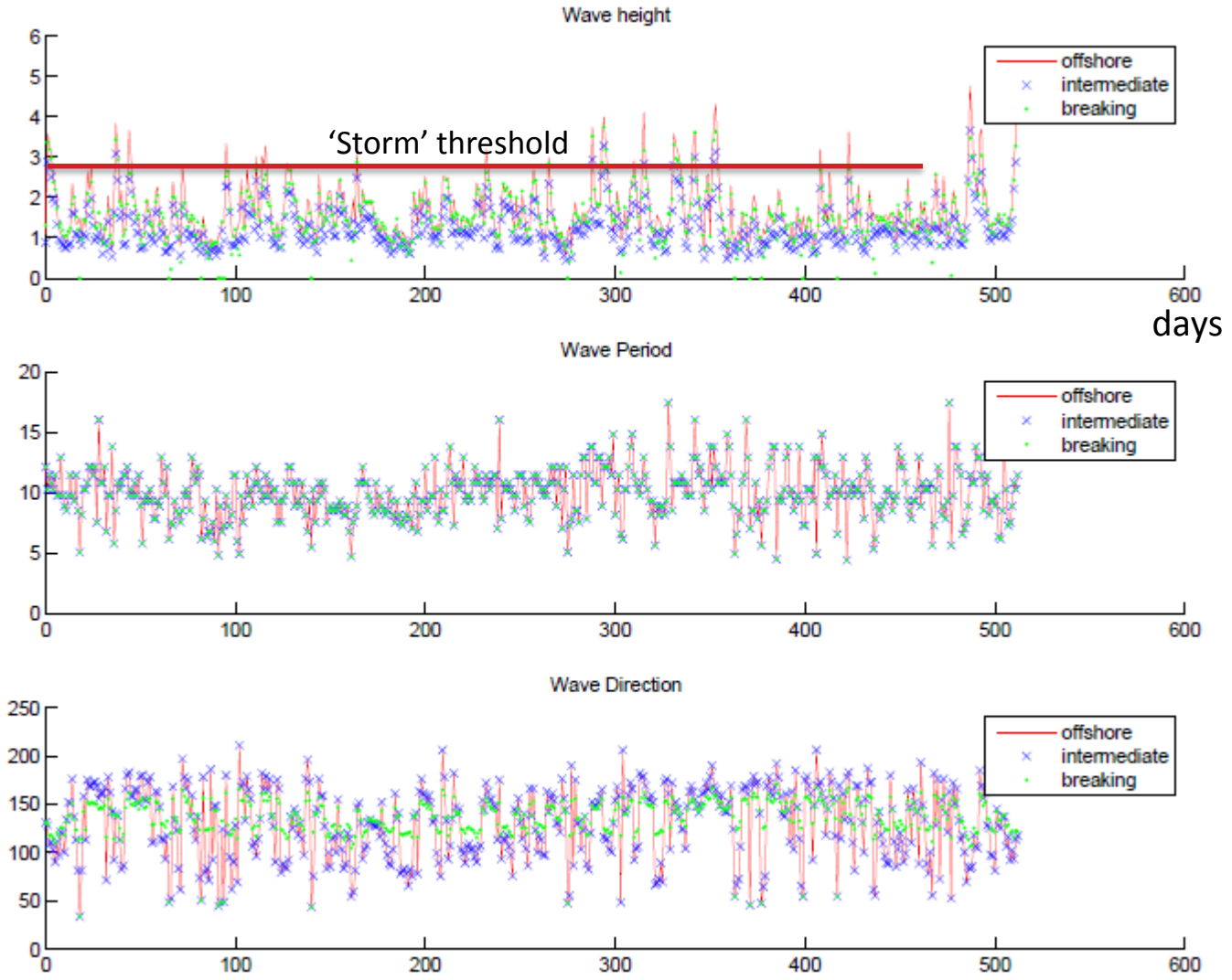




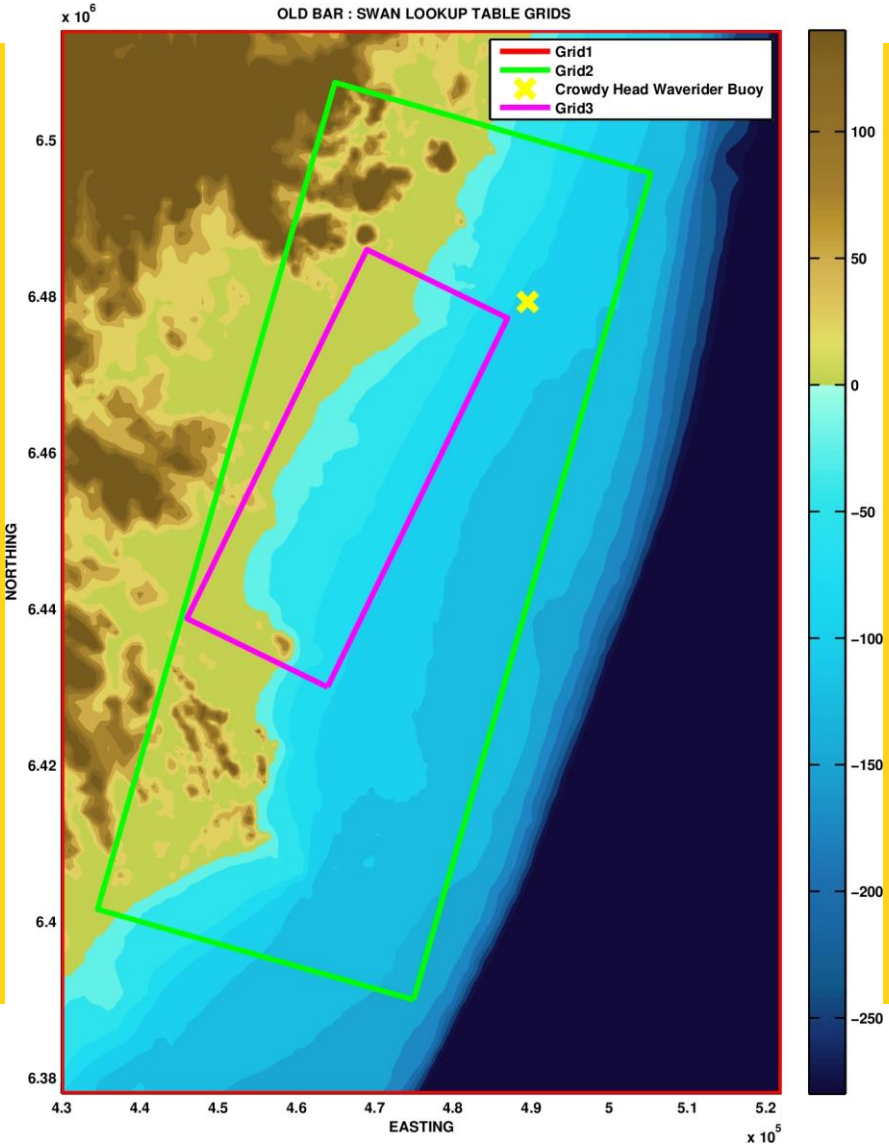
SHORELINE RESPONSE MODELLING

Preliminary Modelling Runs

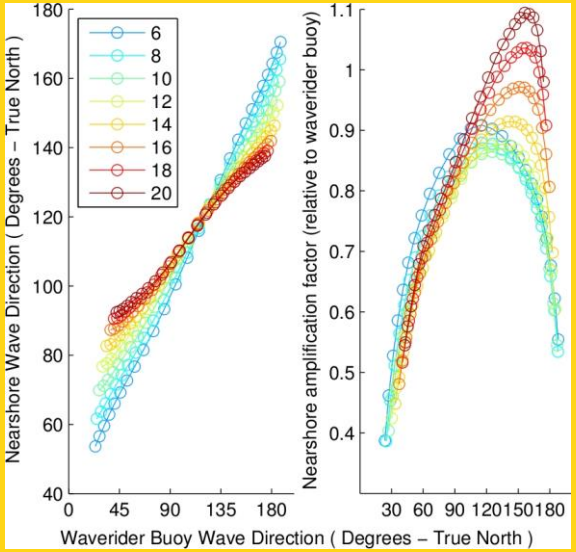
- **Input data from offshore waverider buoy**
  - **Wave height**
  - **Wave period**
  - **Wave direction**
- **Initially forced by 10 yr time series**
  - **1.5 yr subset shown here**



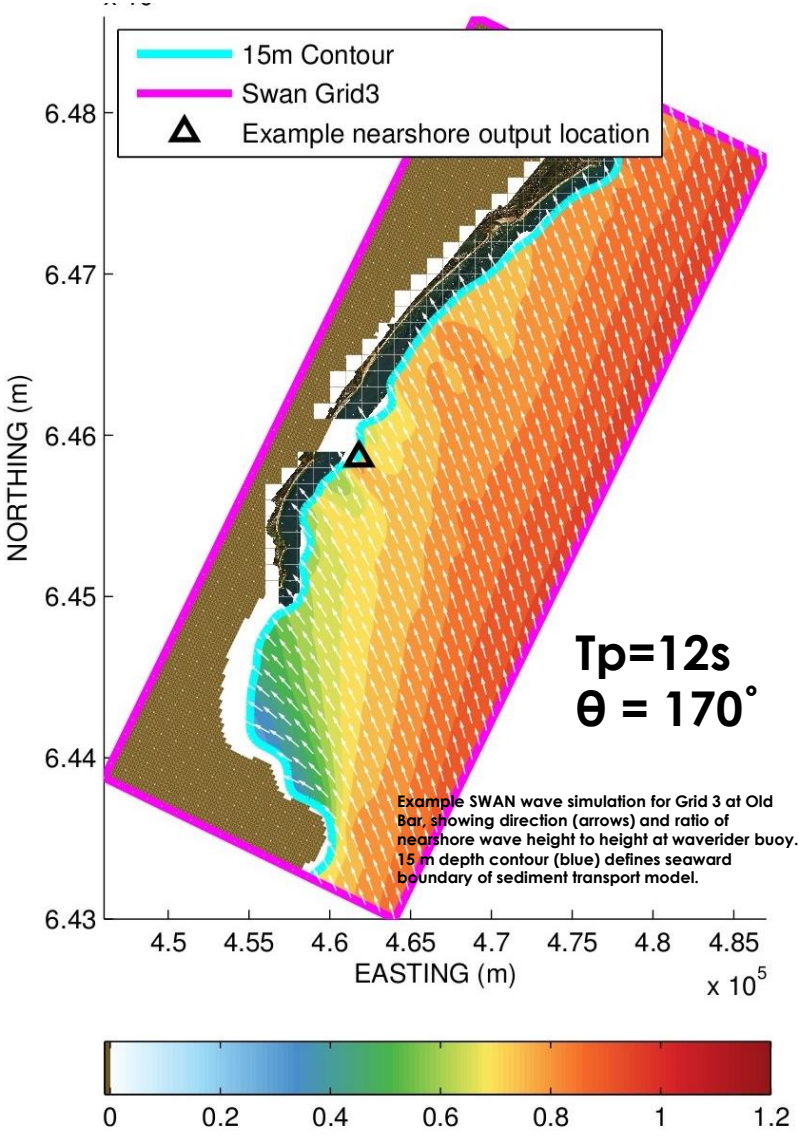
SHORELINE RESPONSE MODELLING



Getting the wave direction right



Wave Transformation Modelling (SWAN)



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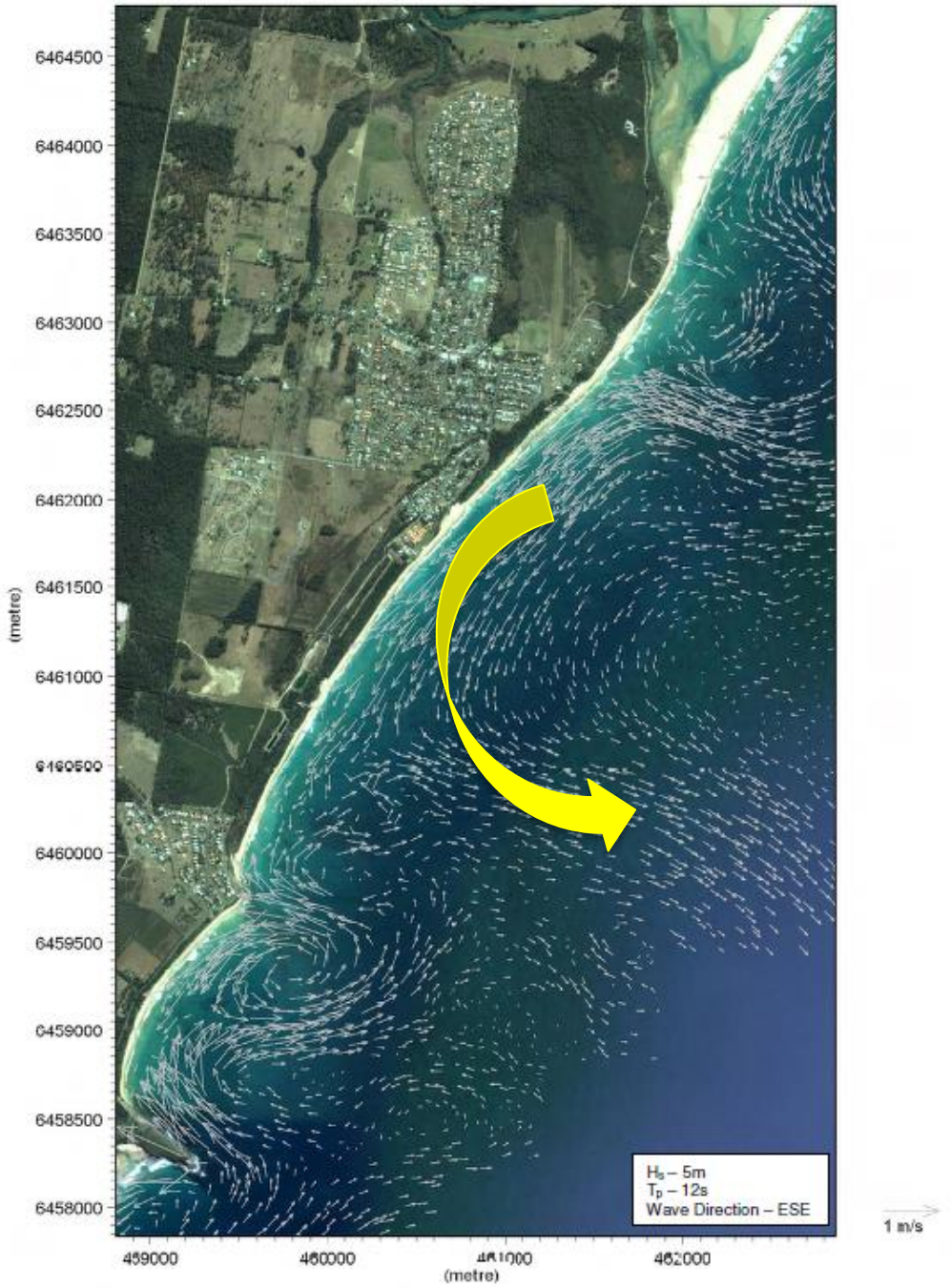
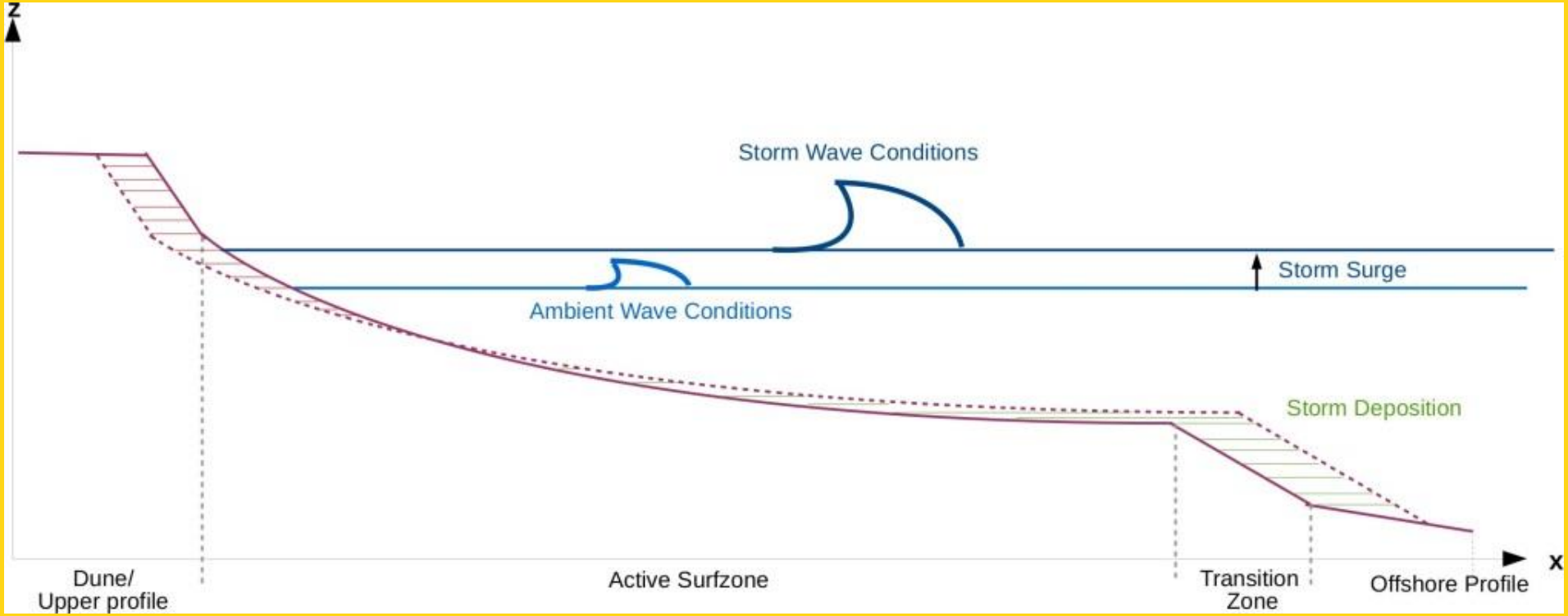
WAVE DIRECTION IS IMPORTANT

- Independent modelling of nearshore currents (Worley-Parsons, 2010)
- Strong rip cell set up under ESE storm wave direction when significant wave height > 5m
- Sets up sediment transport north to south, then offshore (lost to the coastal cell?)



SHORELINE RESPONSE MODELLING

- Using Shoreline EVOlution model (EVO) developed by BMT WBM engineering consultants

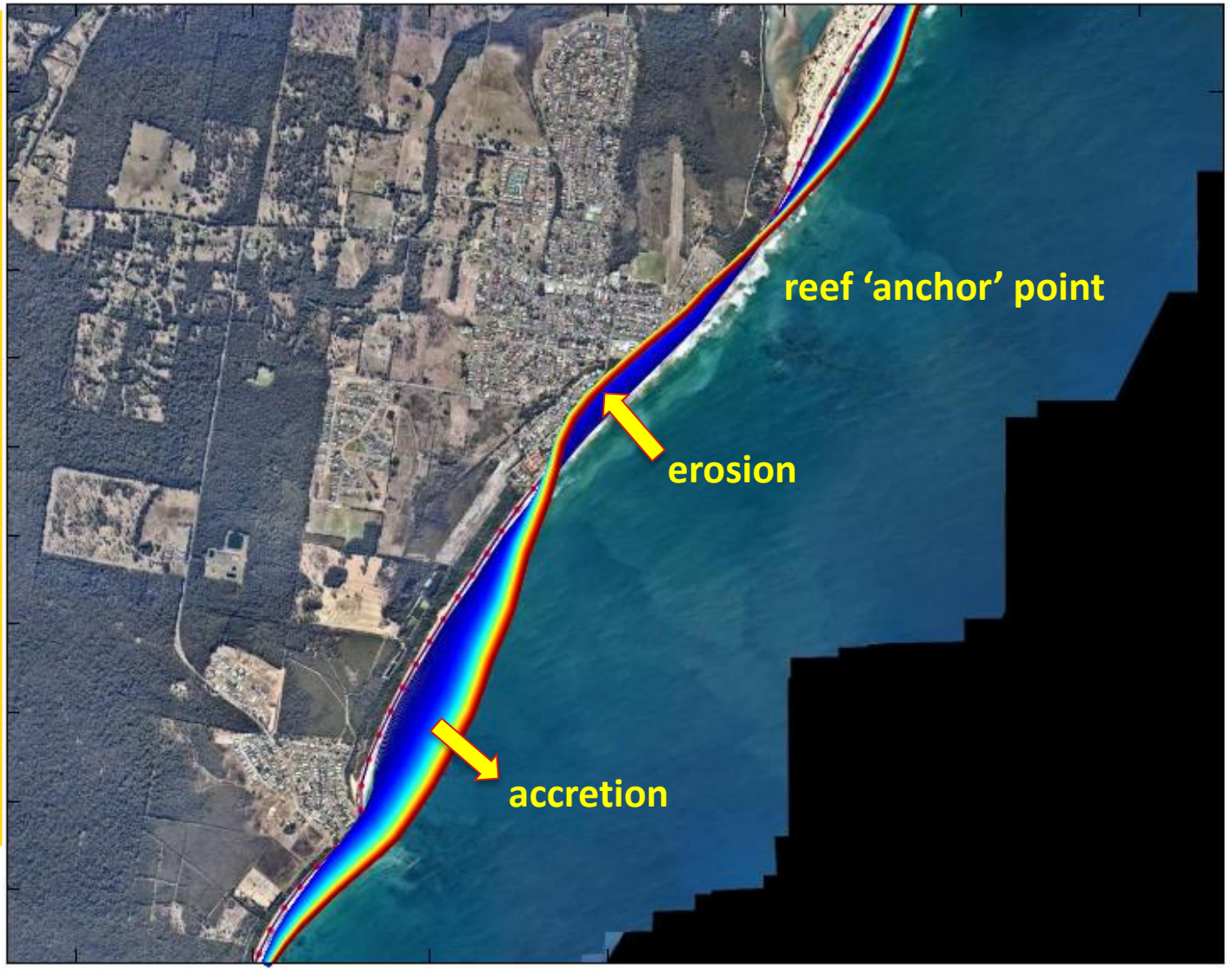


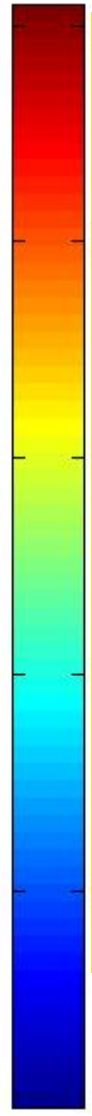
SHORELINE RESPONSE MODELLING

Old Bar Preliminary model run

Response from 1.5 yr simulation

- **Shoreline realignment <u>trend</u>**
- **Anchored on reef & shallow bedrock**
- **Consistent with rip cell modelling**
- **Fine tuning required (e.g. scale of change)**





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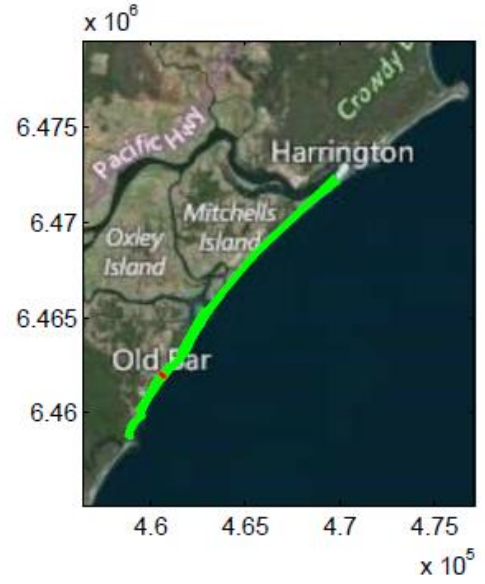
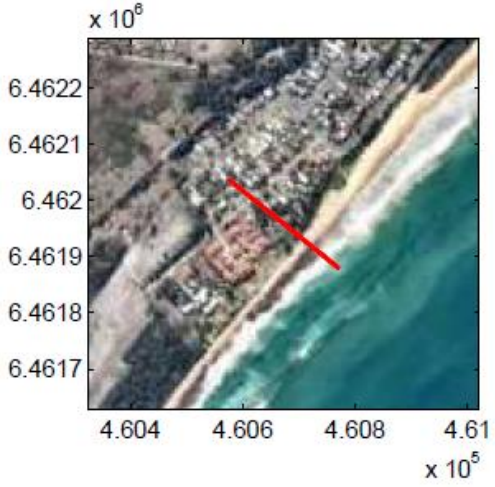
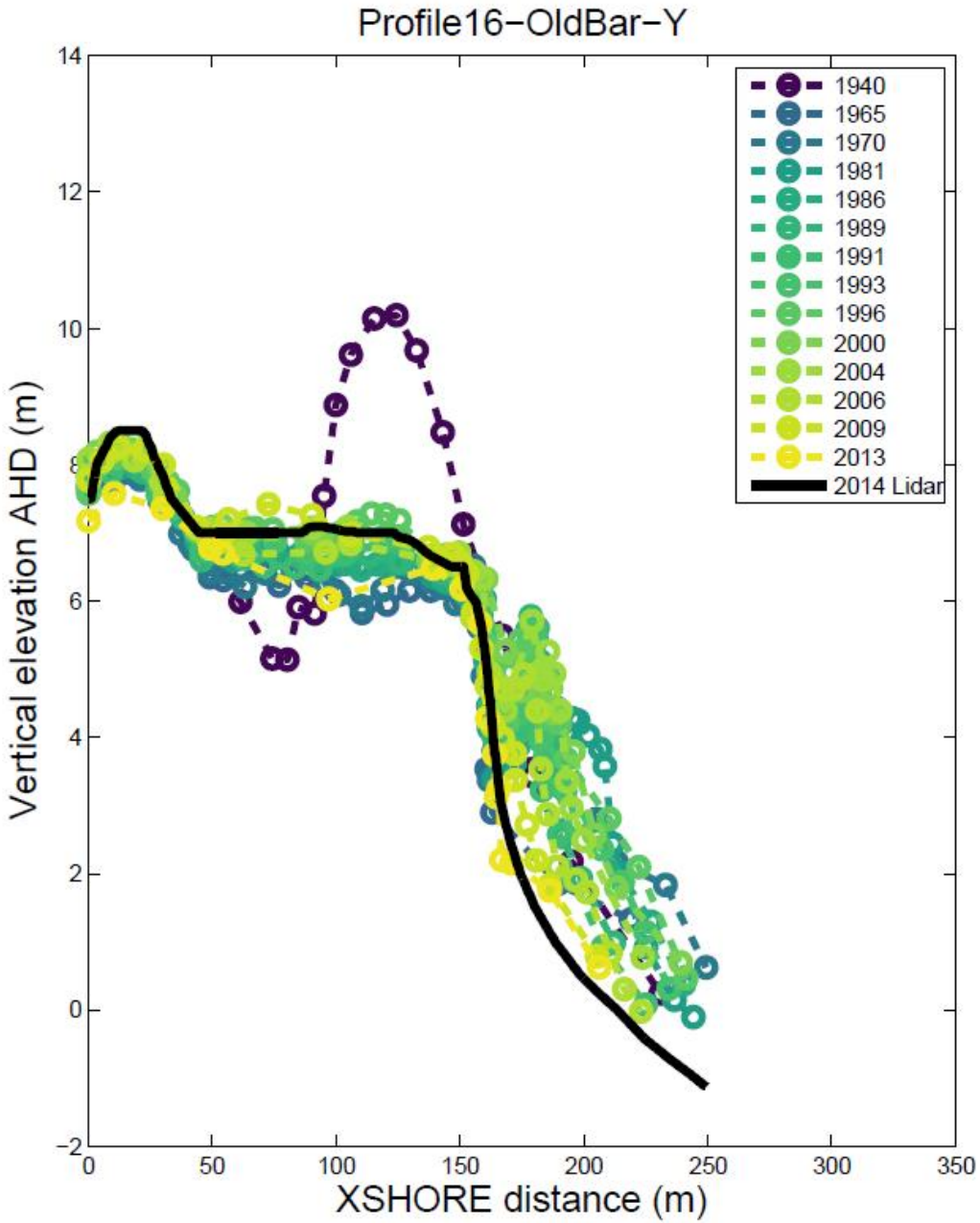
Model Validation Check

- Historical shoreline position
- Mapped for the entire sediment cell
- 1940 - 2014
- 164 profiles







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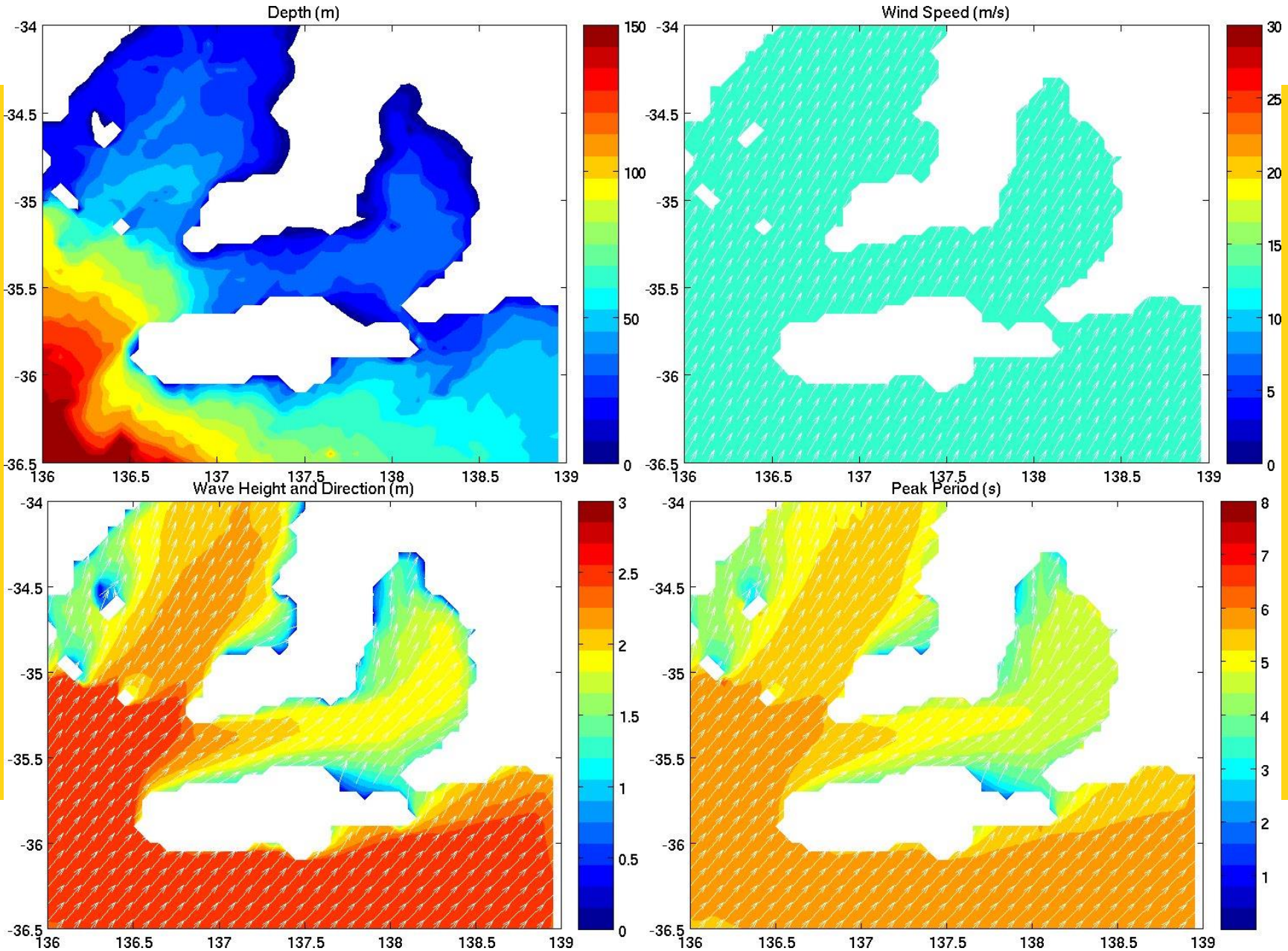
NEXT STEPS: ADELAIDE

SWAN wave modelling complete

Shoreline modelling ready to commence



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NEXT STEPS: EXPOSURE MAPPING & ANALYSIS

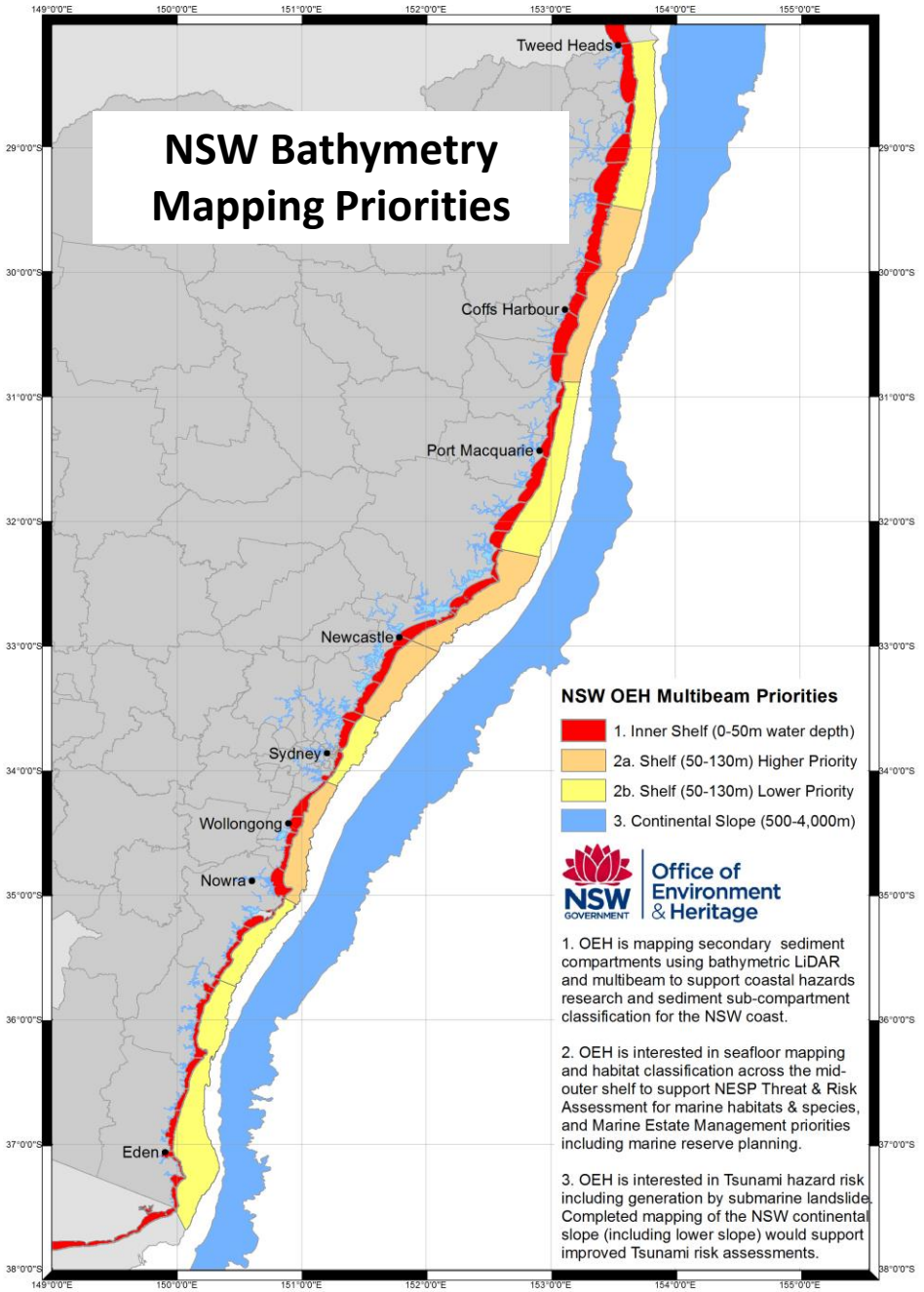
End-user Uptake

NSW Office of Environment & Heritage

- Coastal Reform Program 2016
- Coastal & nearshore mapping program
- Prioritised around **coastal compartments**

Victoria Dept Environment, Land, Water & Planning

- Scoping **coastal compartments** for coastal change monitoring



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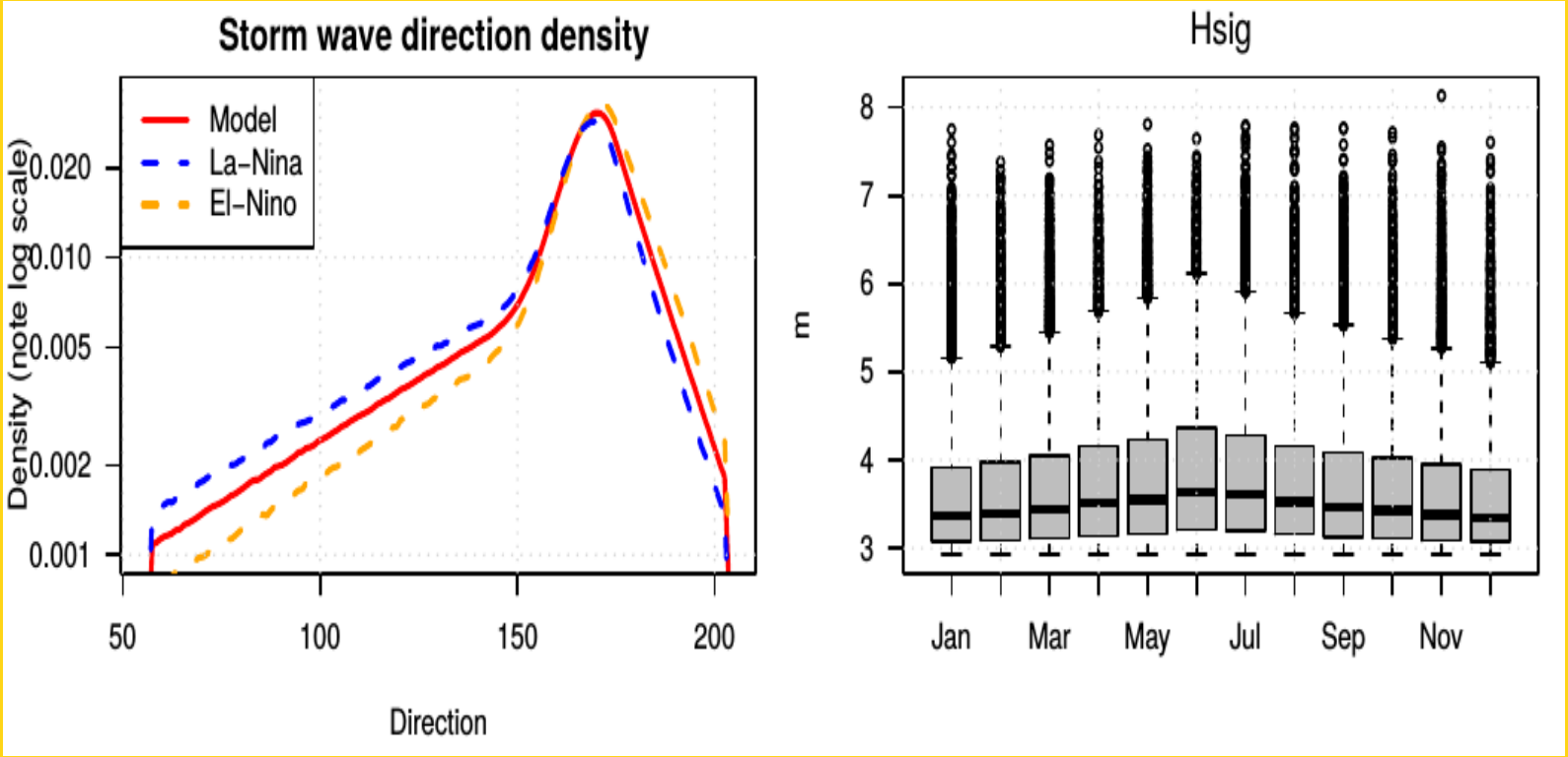
SUMMARY

- Project on track with all milestones delivered
- Field site & wave datasets feeding into shoreline modelling
- Clustering less of a focus → spatial & temporal variability the key
- Regular interactions between project team & end users (NSW, SA)
- Utilisation plan drafted – to focus on transfer of modelling skill

Storm event model predicts an average of 2.05 storms in the easterly sector (north of 120 degrees) during ‘El Nino years’, compared with an average of 3.90 events during ‘La Nina years’.

Good agreement with observed data, average of 1.7 and 4.0 such events in ‘El Nino type years’ and ‘La Nina type years’ respectively .



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Old Bar Storms – Synthetic Time Series

- Observed vs modelled events
- Good model fit to observed data
- Seasonality replicated in model
- Event frequency replicated also
- ENSO also represented
- Will allow for probability of exceedance to be calculated