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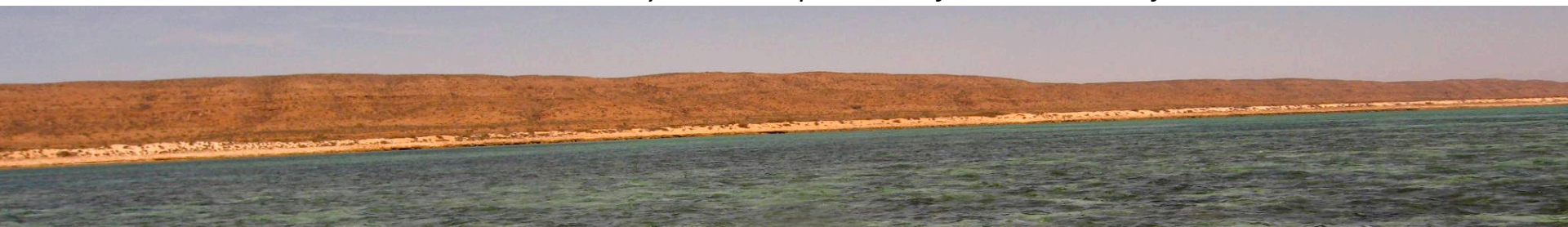
Pilbara Marine Conservation Partnership



Environmental drivers of the coastal Pilbara/Ningaloo region: the role of marine heat waves and tropical cyclones

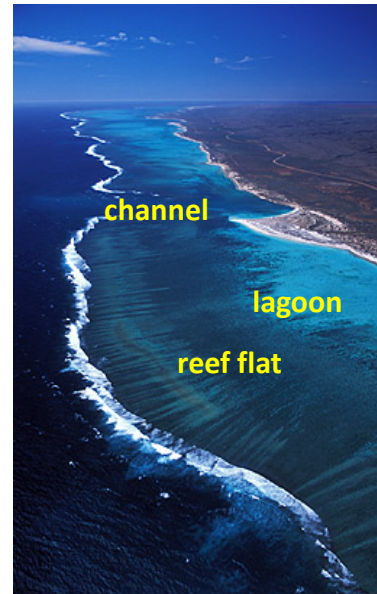
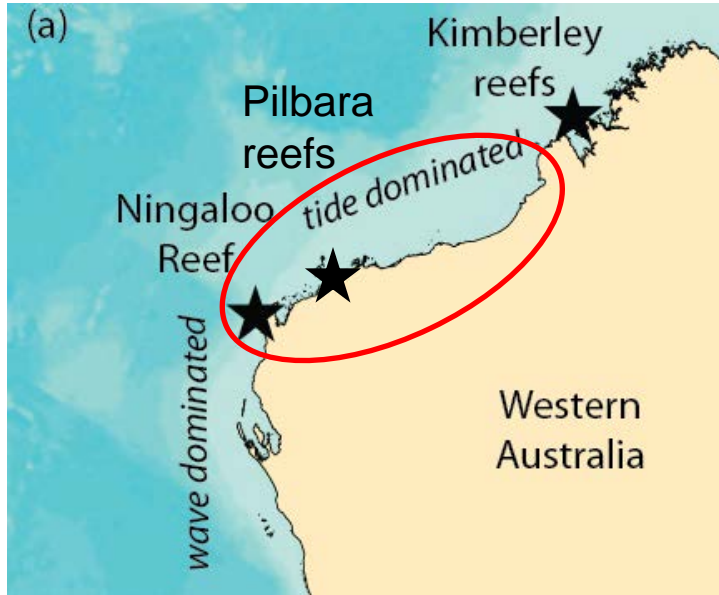
Ryan Lowe, Greg Ivey, Mike Cuttler, Edwin Drost, Jeff Hansen

*This project is funded by the Gorgon Barrow Island Net Conservation Benefits Fund,
which is administered by the WA Department of Parks and Wildlife.*





Background: wave versus tide- dominated reefs along NW Australia



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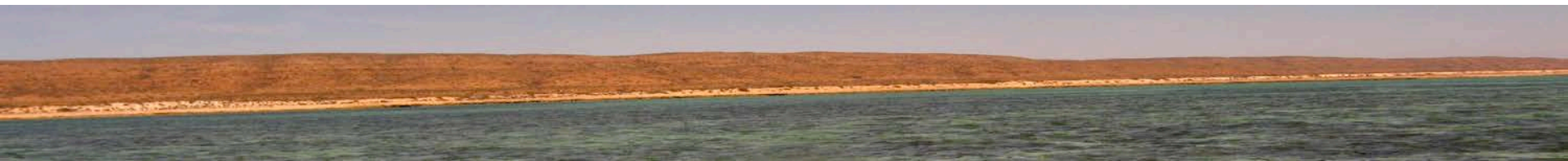
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Oceanic Forcing of Coral Reefs

Ryan J. Lowe and James L. Falter

ARC Centre of Excellence for Coral Reef Studies, School of Earth and Environment, and UWA Oceans Institute, University of Western Australia, Crawley 6009, Australia; email: ryan.lowe@uwa.edu.au, jim.falter@uwa.edu.au

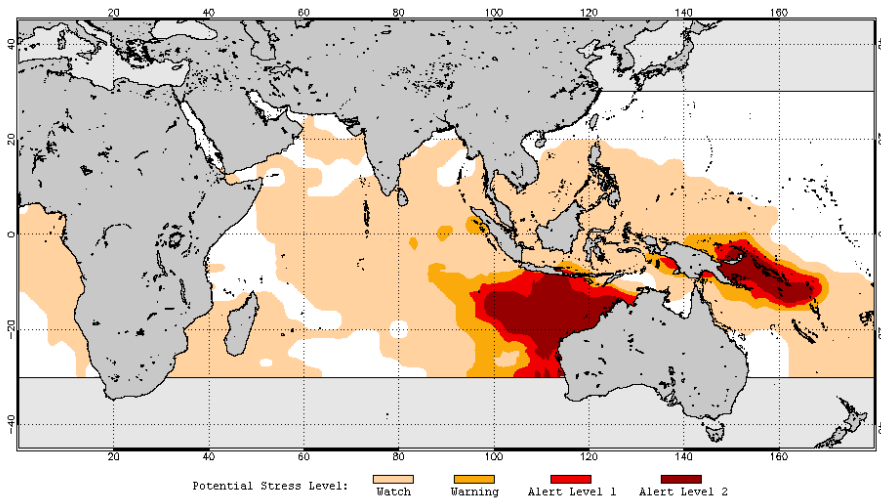
(Annual Review of Marine Science, 2015)





Extreme events: marine heat waves and tropical cyclones

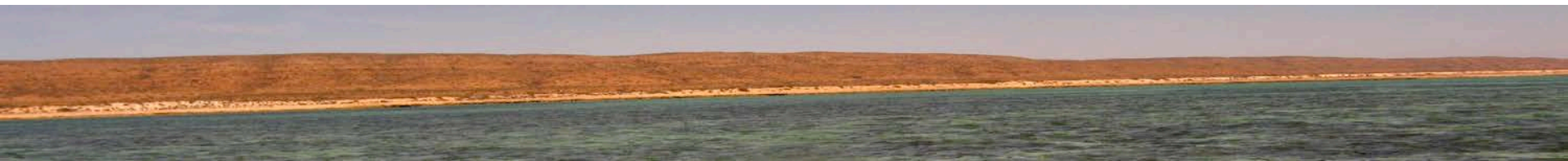
- Waves and tides provide the background forcing to coastal ecosystems
- Extreme impacts associated with marine heat waves and tropical cyclones



Marine heat waves



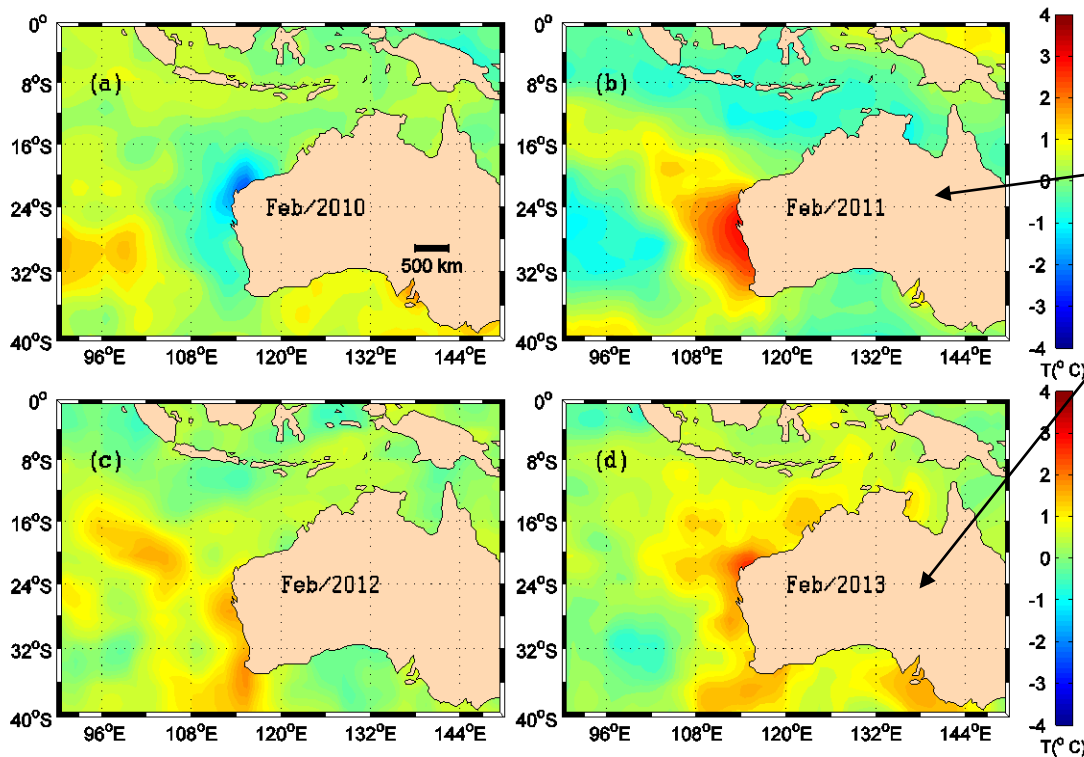
TC Olwyn 2015





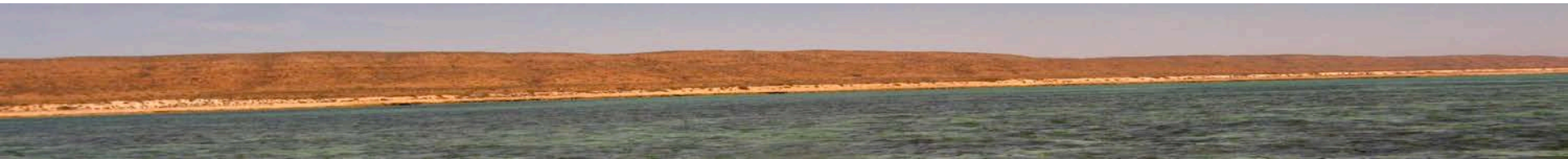
Marine heat waves impacting the coastal Pilbara

Summer temperature anomalies (2010-2013)

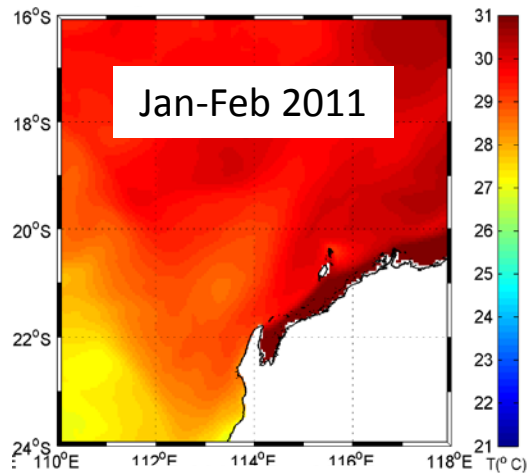


La Niña associated
marine heat waves

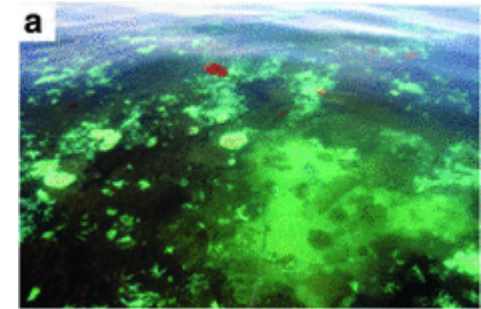
Also, the recent 2015/16
El Niño event...



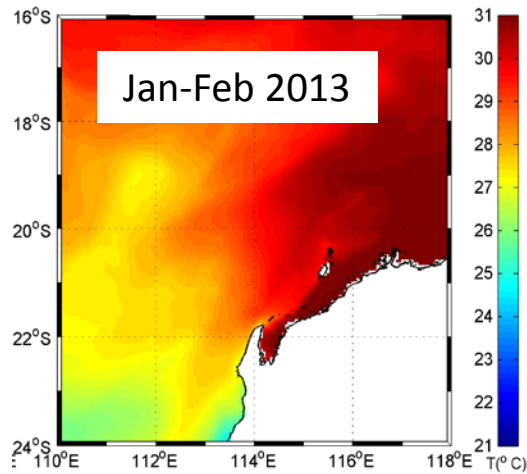
Assessing differences in Pilbara warming mechanisms during two La Niña events



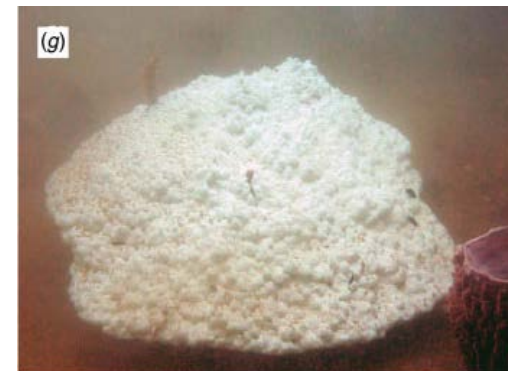
- Severe bleaching from Ningaloo to the south
- Negligible bleaching in the Pilbara region
- Oceanography well-studied (Ningaloo Niño)



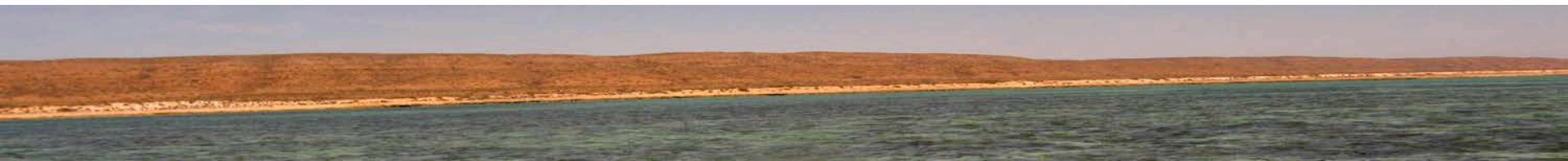
Northern Ningaloo
(Depczynski et al. 2013)



- Limited bleaching south of Ningaloo
- Severe bleaching in the central Pilbara (e.g. up to 60% off Onslow)

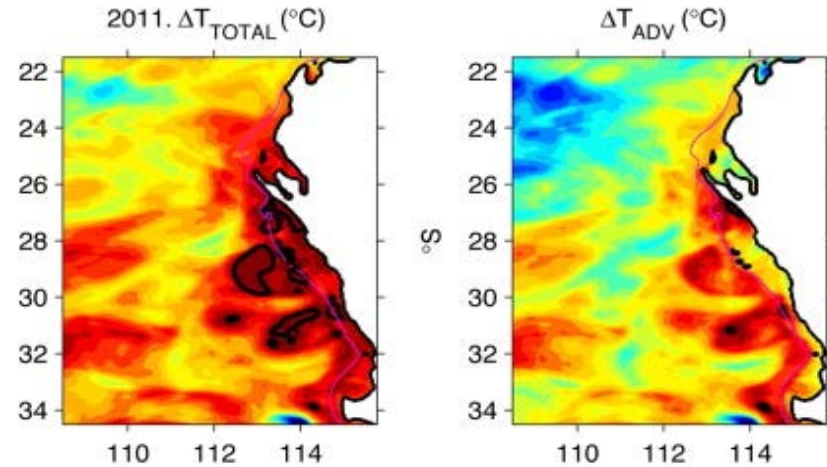
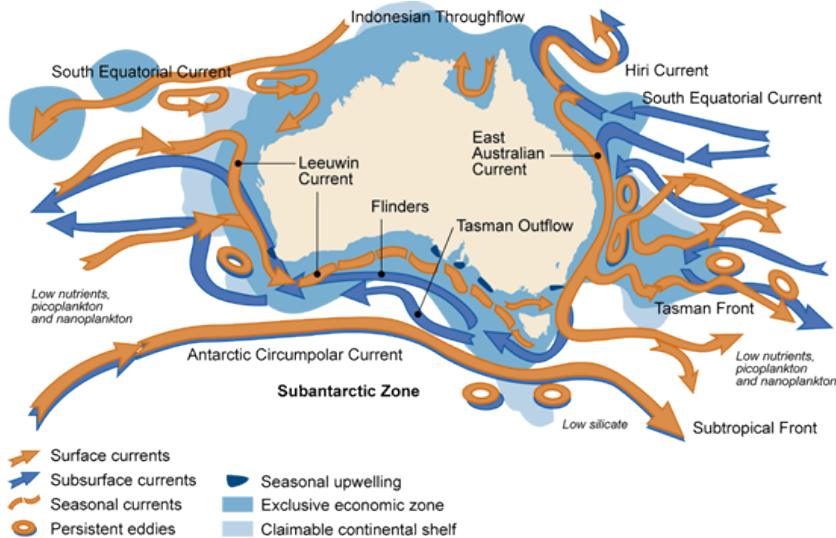


Onslow (Lafratta et al. 2016)

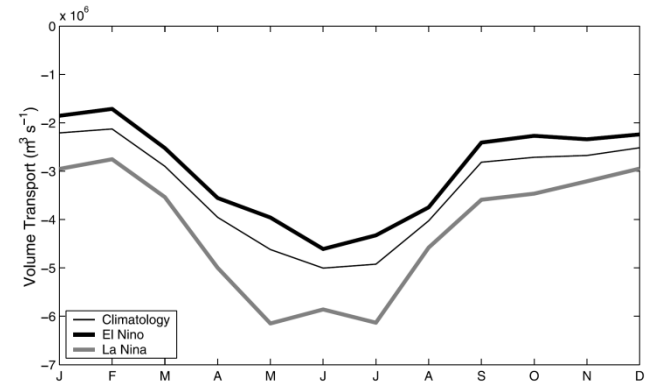


Role of the Leeuwin Current on ENSO driven marine heat waves

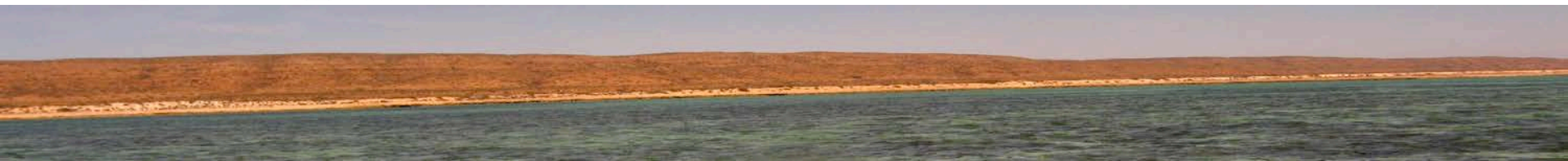
- The LC consolidates south of the NW Cape (~22° S)
- LC transport enhanced during La Niña -> enhanced heat transport (Ningaloo Niño)
- 2010/11 heat wave along WA largely driven by anomalous advection



(Benthuisen et al. 2014)



(Feng et al. 2013)

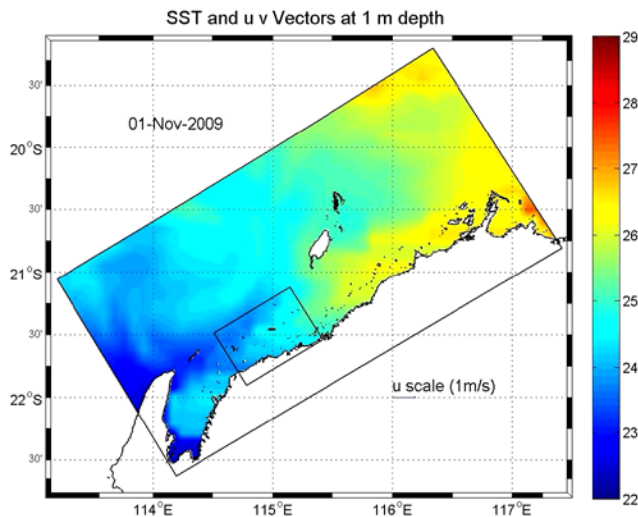




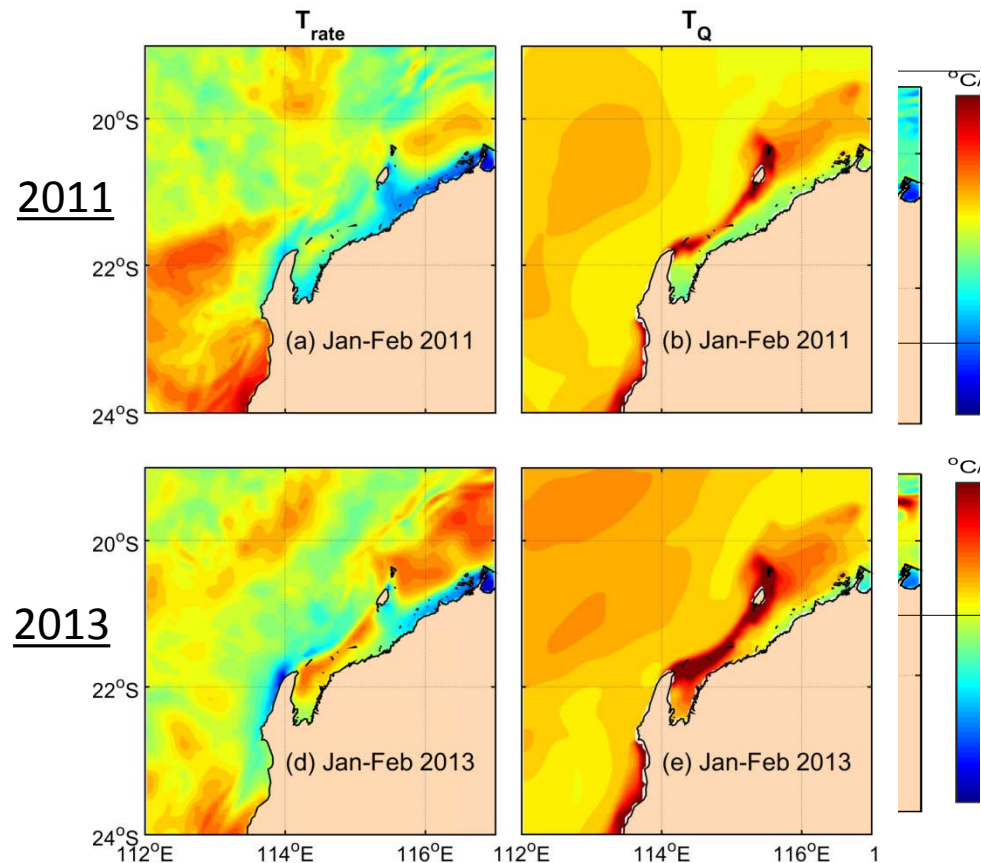
Role of advection versus local heating (heat budget analysis)



- Nested hydrodynamic-thermodynamic modelling (large-scale -> regional -> coastal). Down to 250 m resolution
- Hindcast modelling (~5 years, 2009-14)
- Enhanced warming in 2013 due to anomalous atmospheric heat exchange (importance of local weather)



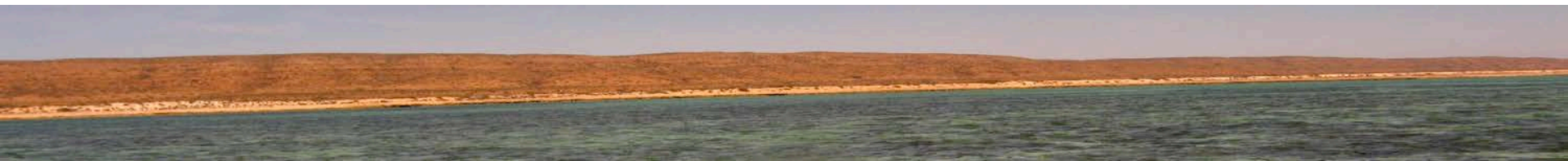
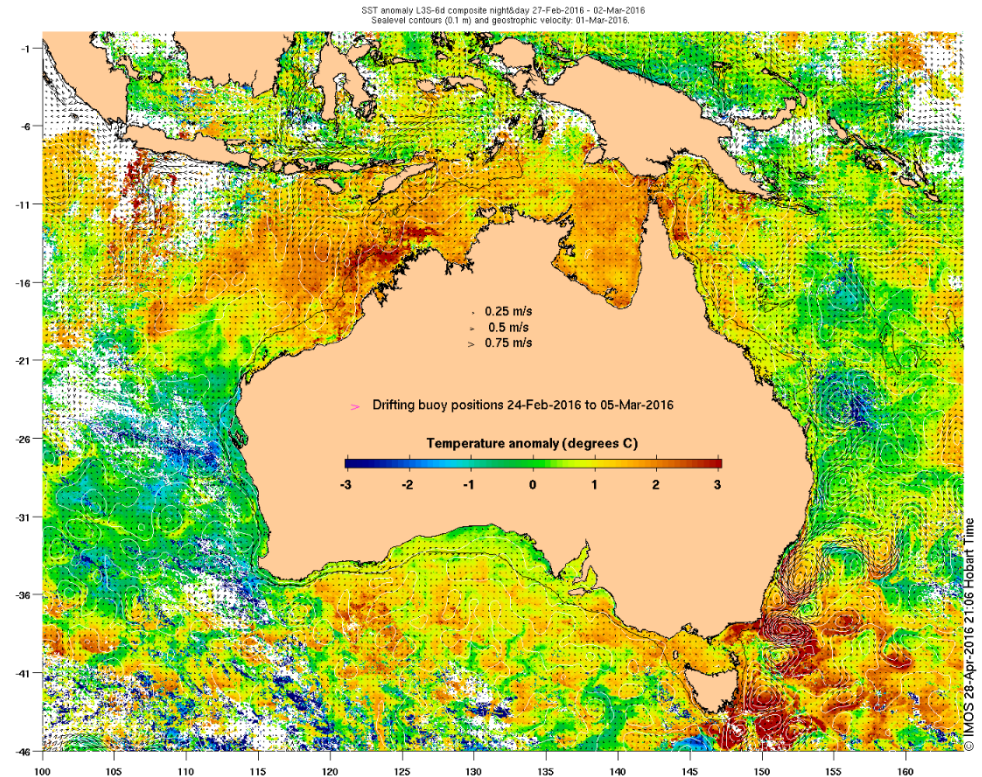
Rate of warming Air-sea heat exchange



Marine heat waves in the Pilbara during El Niño years

SST anomalies – March 2016

- Generally the opposite pattern during El Niño -> northern Australia anomalously warm
- Weaker Leeuwin Current -> cooler along WA south of 22° S)
- The Pilbara as a transition zone -> can experience heat waves during either ENSO phase

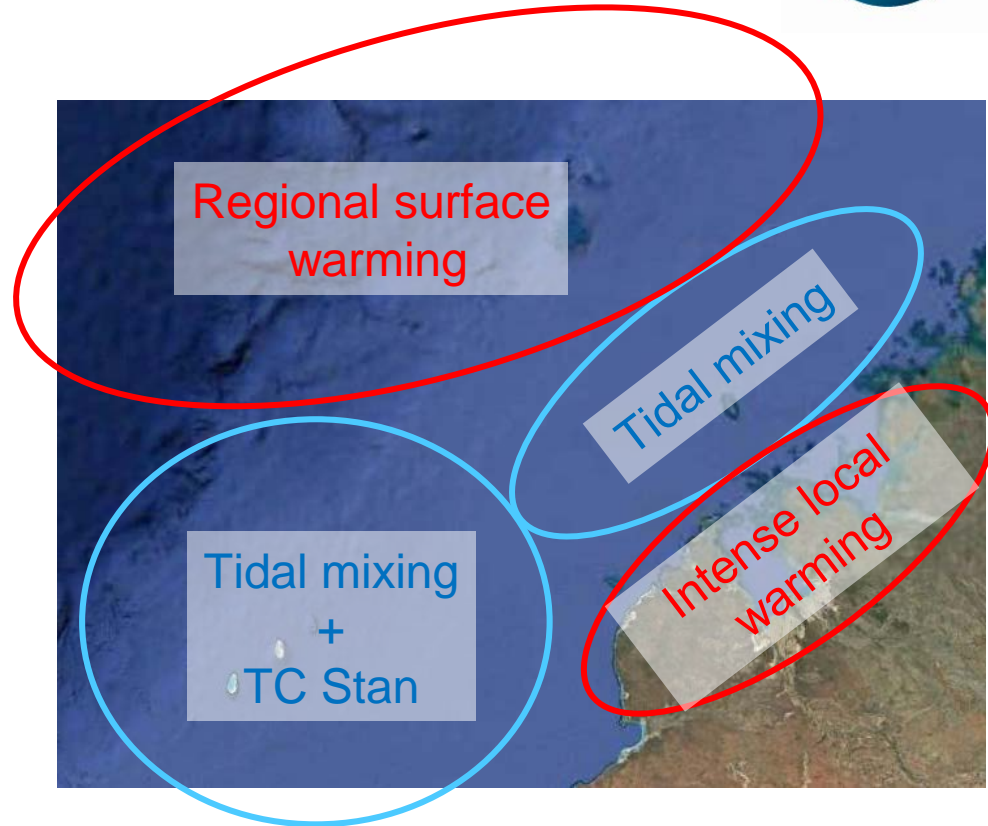
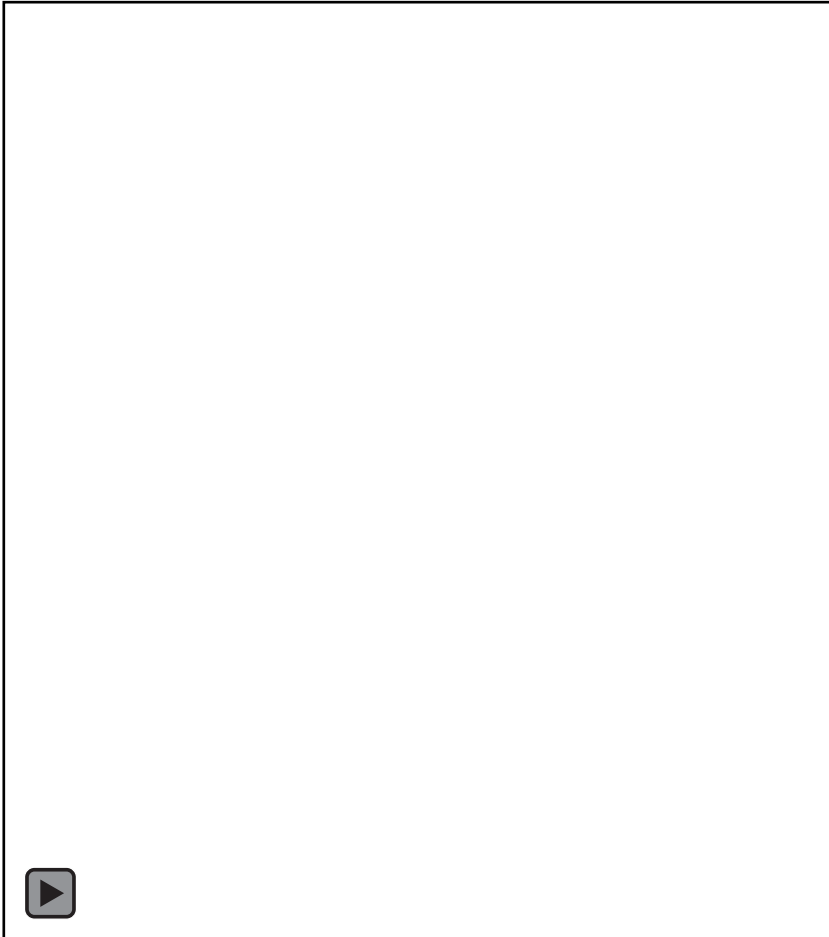




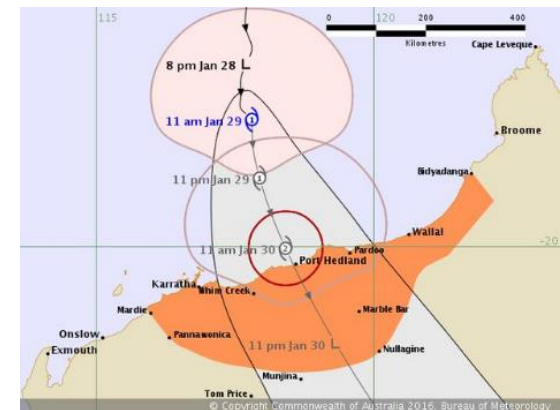
The 2015/16 El Niño event



- Northern Pilbara unaffected largely due to TC Stan



TC Stan
(30 Jan 16)

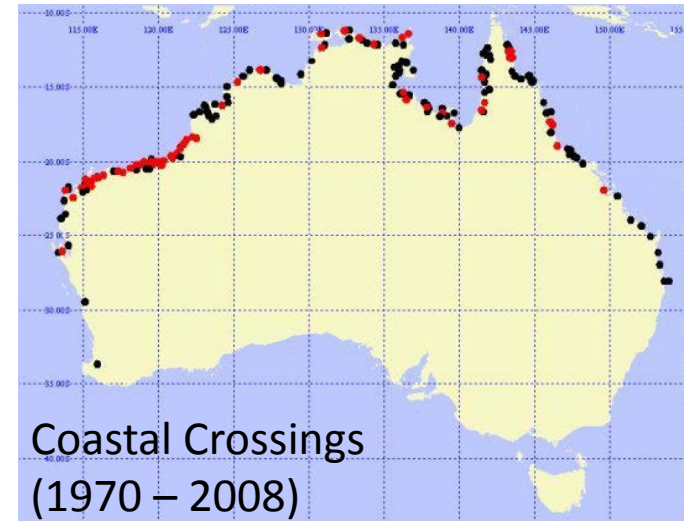
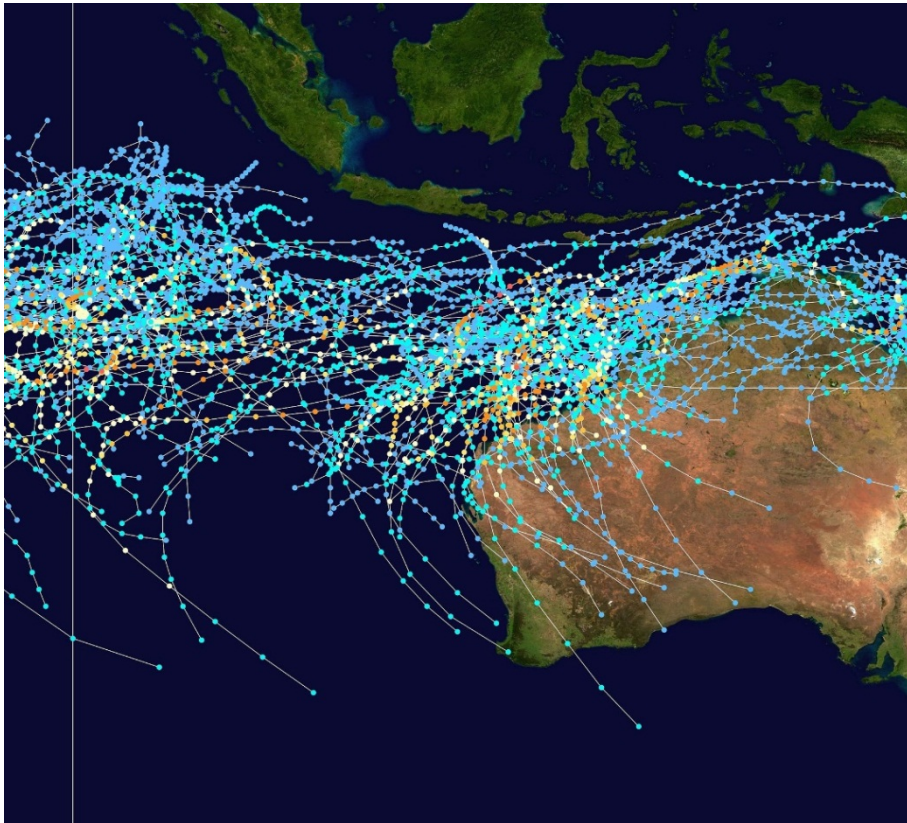




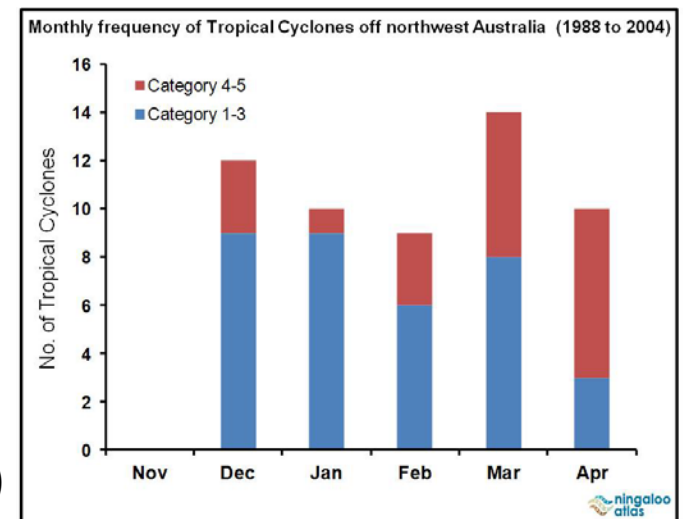
Impact of tropical cyclones along the Pilbara coast



TCs (1980 – 2005)



TC frequency (1988 – 2004)





TC wave modelling of the Pilbara region



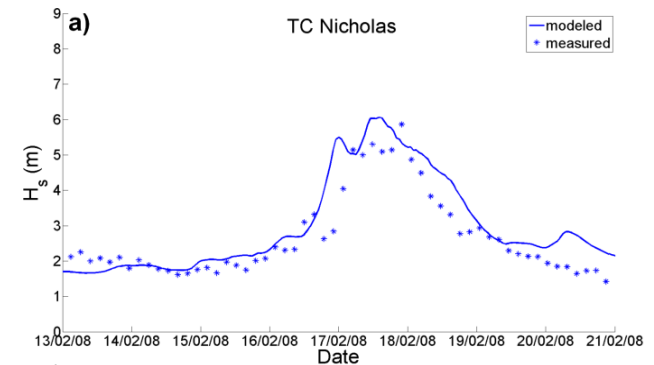
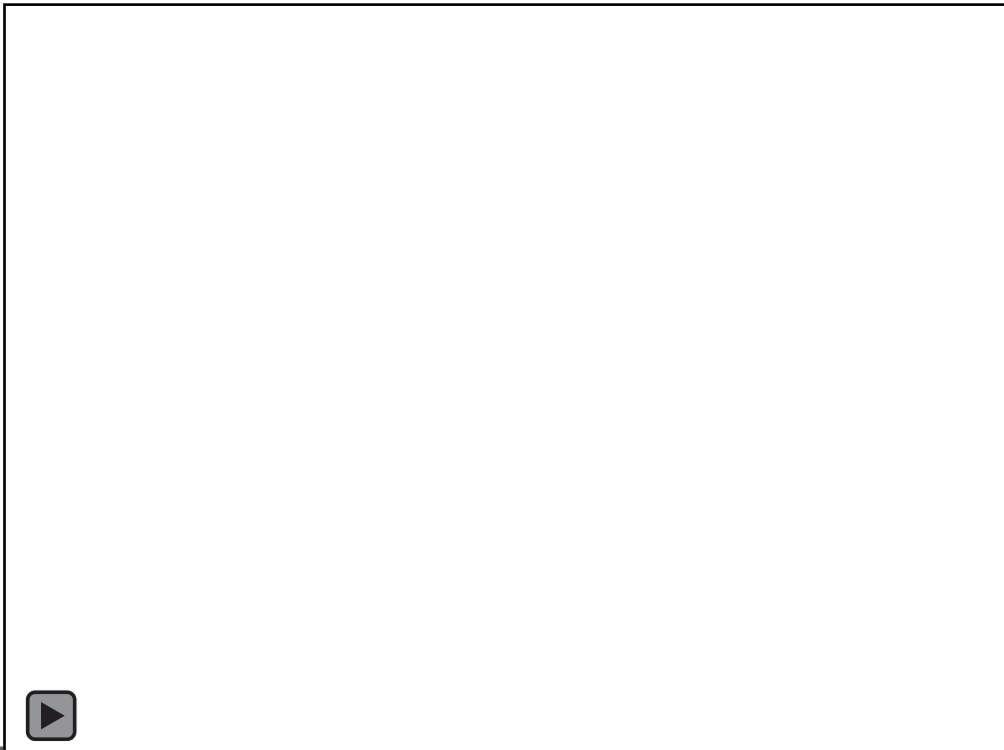
Wind model

- Fine-scale (cyclone resolving) double vortex wind model with blended background winds (CFSv2)
- Optimized with data from wind stations

Wave model

- Numerical wave model SWAN
- Validation with historical wave buoy and wind data for several events

TC Olwyn (March 2015)

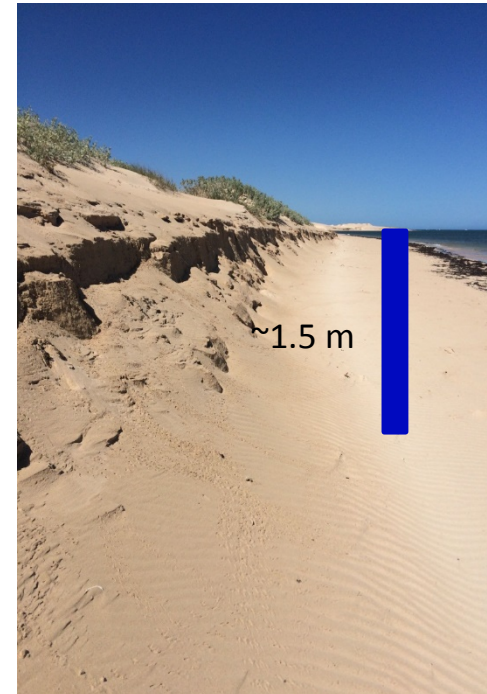
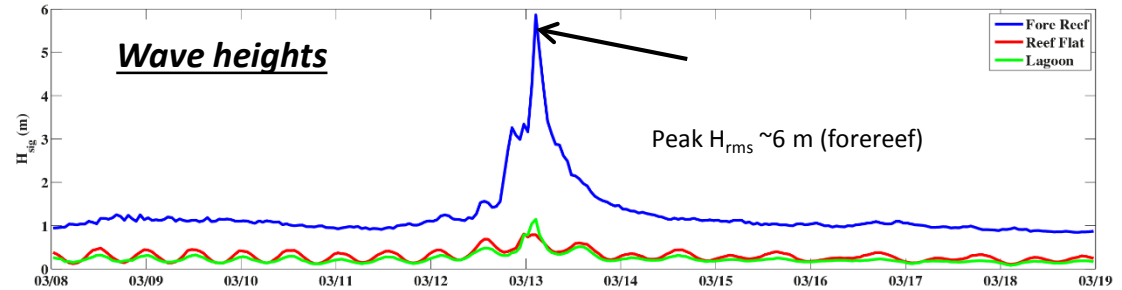
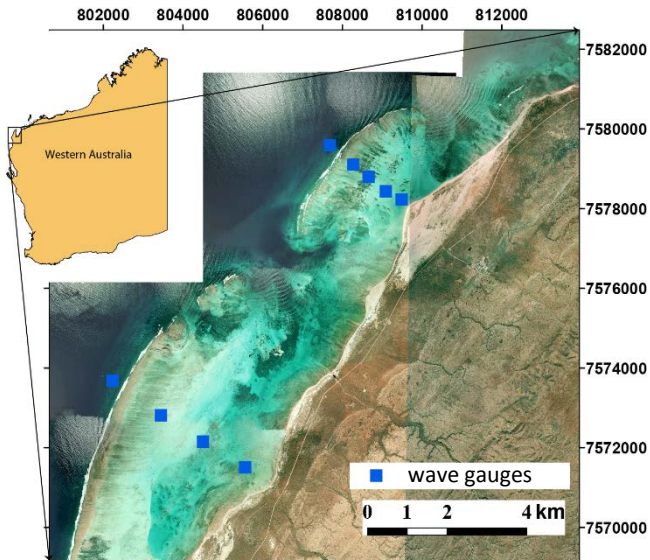


(Drost et al., submitted)
ARC Linkage

Coastal impacts of TC Olwyn (example from northern Ningaloo)

- A direct hit -> the first hydrodynamic observations of a reef coastline during a large TC
- Downscaled regional -> reef-scale modelling

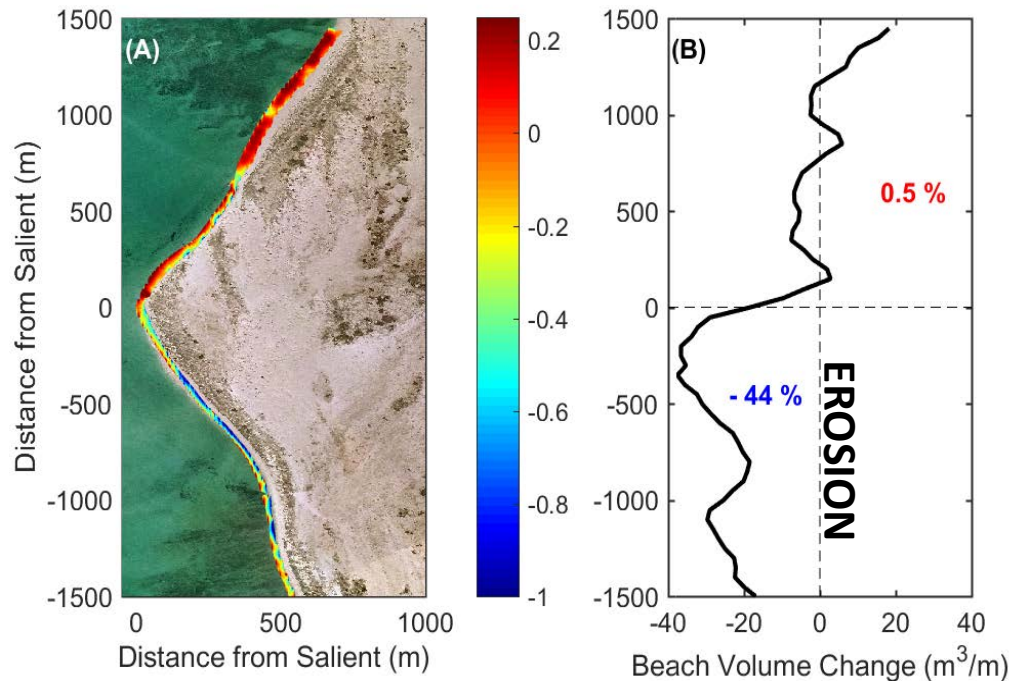
Field observations



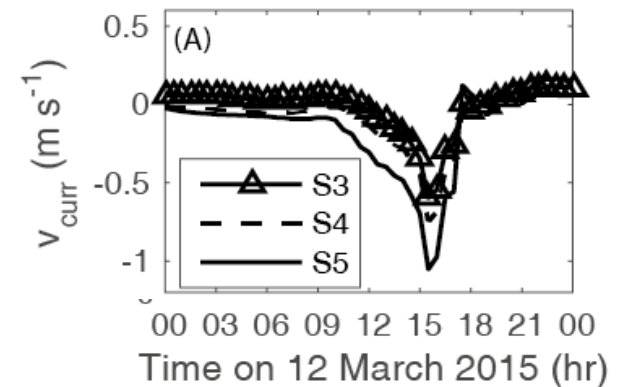
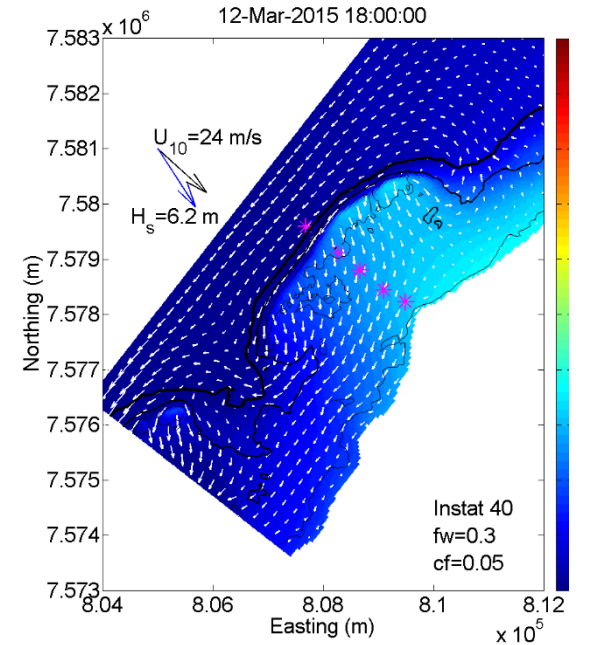
Substantial alongshore variability in beach erosion patterns

- Shows the vulnerability of particular sections of coastline -> shoreline habitats

Pre- and post-TC beach surveys



Coupled wave-circulation model





Summary



- Ocean climate drivers establish conditions favourable to marine heat waves along WA -> La Niña = SW (including Ningaloo), El Niño = northern Australia
- Pilbara as a transition zone -> response depends on local weather anomalies
- TC impacts to reefs and coastlines can be predicted using downscaled hydrodynamic (wave and circulation models)
- Coastal responses and vulnerability depends on coastline and reef morphology -> ongoing work

Acknowledgements

- Gorgon Barrow Island Net Conservation Benefits Fund
- ARC Centre of Excellence for Coral Reef Studies
- ARC Linkage and ARC Future Fellowship
- Rich Evans, Andrew Pomeroy, Gundula Winter, Carlin Bowyer, Anton Kuret, Harry Clarke

