RESEARCH WITH THE GEOCOASTAL RESEARCH GROUP

This is a non-exhaustive list of possible research projects in the Geocoastal Research Group (GRG). Please note that most projects can be tailored to suit your passion, expertise and research program (i.e., Honours, Master's, Phd), and that we might be happy to supervise you on a different project. Come and talk with us if you are interested in any specific project or other broad research theme.

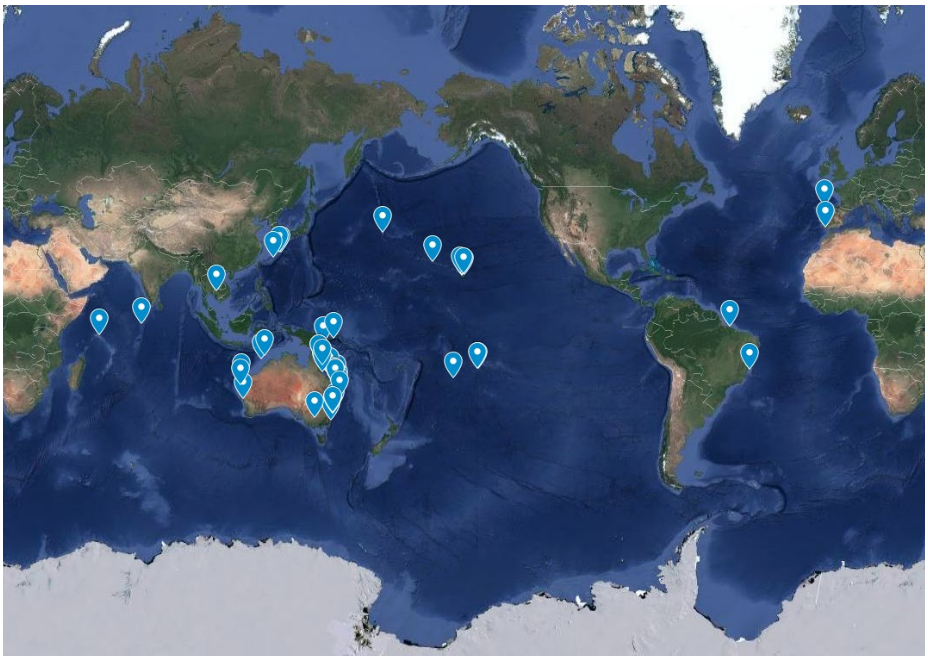
By undertaking a research project with us, you will become a member of the GRG, while also interacting with other research groups within and outside of the school as relevant to your project. Our research students participate in our numerous field campaigns each year. Therefore, even if your project does not specifically include fieldwork, you will have plenty of optional opportunities to go to the field. In the last few years, we have had students participating in fieldwork campaigns in temperate and tropical coasts around Australia and the world.

Marine Science is a multidisciplinary research area, which at The University of Sydney mostly comprises Marine Biology and Marine Geosciences. Many of our projects on marine geosciences link directly with marine biology so your bio/geo background might be a strength!

Most importantly, with our research projects you can choose to learn a set of skills to suit your future and those include fieldwork skills, numerical modelling, coding, GIS.

Come join us on our quest to undertake Marine Geoscience all around the world!

http://grgusyd.org/



GRG's fieldwork sites around the world

Contents

BLUE CARBON

Spatio-temporal patterns of coastal slatmarsh and mangrove biomass

Supervisors: Eleanor Bruce (eleanor.bruce@sydney.edu.au), Kevin Davies (Kevin.davies@sydney.edu.au)

Mangroves and saltmarshes are major sources of organic carbon that are important for global strategies to mitigate global warning. Global degradation and loss of these critical ecosystems have reduced organic carbon stocks potentially increasing release of CO_2 into the atmosphere. In addition, the ability of tidal communities, such as mangroves, to transgress inland under changing sea levels, will also impact on these environments. In urban environments, such as Sydney, coastal squeeze resulting from development pressures reduces the lateral space (accommodation space) for transgression of mangroves and other intertidal ecosystems. Assessing above ground carbon in mangrove and saltmarsh areas requires fine scale measurement of biomass. In the absence of detailed systematic field surveys, satellite and UAV borne sensors can be used to characterise patterns of aboveground biomass.

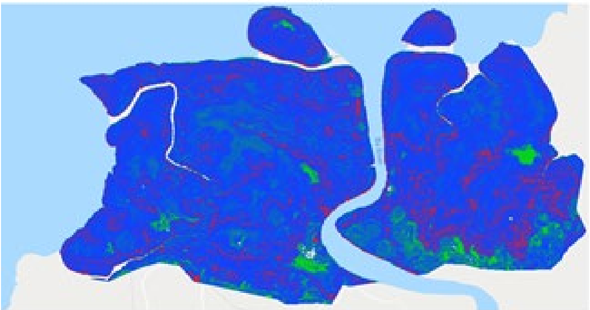
Current understanding of how saltmarsh and mangrove biomass varies across fine spatial and temporal scales and the drivers behind these trends is limited. This research project would contribute to methods for characterising spatio-temporal variability in biomass estimates in saltmarsh and mangrove communities in the Sydney Harbour and Parramatta River using ultra high-resolution UAV data, broader scale satellite imagery and field survey. This project presents an opportunity to work closely with industry partners involved in UAV and satellite data capture (Arbour Carbon) and other marine research institutes.

Research partners: ARC Training Centre for Cubesats, UAVs and Their Applications (CUAVA), Arbor Carbon, UWA Oceans Institute & Australian Institute of Marine Science (AIMS)

https://www.cuava.com.au/

NDVI 3 Feb 2016 (Pre-Winston)

NDVI 24 Mar 2016 (Post-Winston)



Standardized NDVI Difference (Post - Pre)

Standardized NDVI Difference <= -1

Coastal ecosystem services, tonga

Supervisors: Eleanor Bruce (eleanor.bruce@sydney.edu.au), Kevin Davies (Kevin.davies@sydney.edu.au) and John Duncan (john.duncan@sydney.edu.au)

Susceptibility to climate variability and extremes is acutely felt by many natural resource-dependent coastal communities of the South Pacific. Livelihood and food security in these environments are inextricably linked with coastal ecosystem health. Focused on mangrove ecosystems, this project would involve the use of Earth observation data to examine the influence of biophysical interactions operating in inter-tidal environments on local livelihood and food security in Tongan coastal communities. This would potentially involve integrating remotely sensed indicators of ecosystem status and qualitative information on subsistence usage patterns, fishing activities and land use practices, to investigate key socio-ecological system interlinkages and beneficiaries of coastal ecosystem services.

Funding is available to support field travel.

https://livelihoodsandlandscapes.com/fiji-and-tonga/


Mapping coastal seagrass ecosystems using high resolution remote sensing

Supervisors: Eleanor Bruce (eleanor.bruce@sydney.edu.au), Kevin Davies (Kevin.davies@sydney.edu.au) and John Duncan (john.duncan@sydney.edu.au)

Extensive meadows of seagrass in shallow coastal waters provide important ecosystem services that directly or indirectly benefit human needs, particularly in the stabilisation of nearshore sediments and as nursery grounds for commercial fish species. Previous research has shown that the spatial patterning and species present within seagrass meadows can influence the ecosystem service flows from these environments. For example, do well established meadows vs. areas comprising smaller colonising species provide habitat characteristics that support commercially important fish or stabilise sediments? There has been no systematic review of seagrass ecosystem service provision in the South Pacific. High resolution bathymetric (LiDAR) data and satellite imagery (Digital Globe) are available that cover extensive seagrass meadows in the nearshore area of Tongatapu, Tonga. Spatial modelling and remote sensing-based research on these coastal seagrasses can provide valuable insight on species composition, benthic substrates and other variables that influence the ecosystem service contributions for local communities.

Funding is available to support field travel.

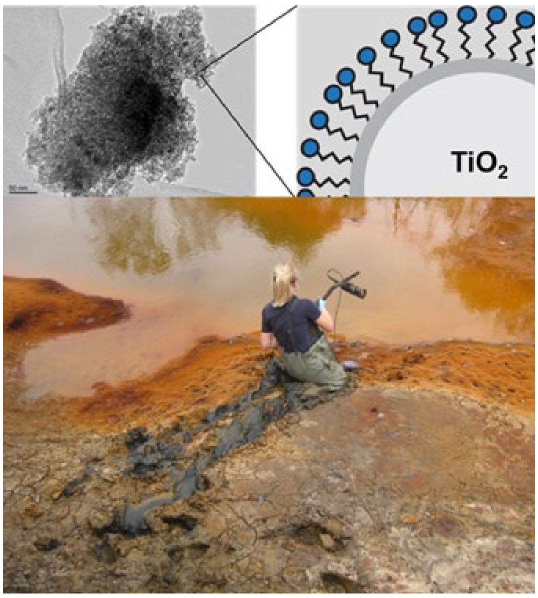

COASTAL REMEDIATION, CHEMISTRY

Mining wastewaters and remediating coastal metalliferous drainage using synthetic sorption materials

Supervisors: Bree Morgan (USYD) bree.morgan@sydney.edu.au , Jessica Veliscek-Carolan (ANSTO) jvc@ansto.gov.au

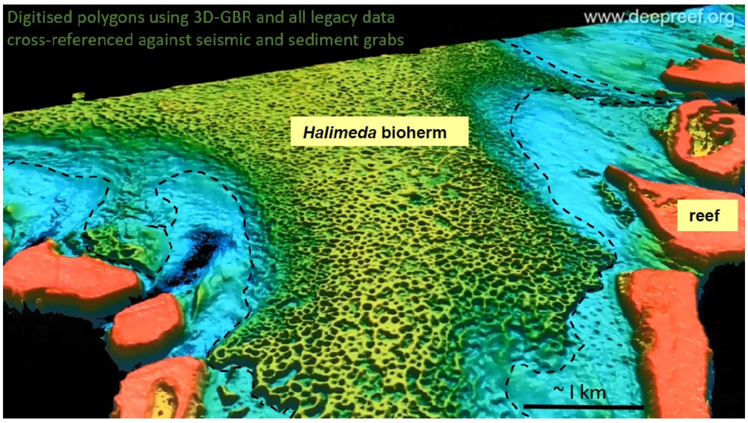
Acidic drainage from acid sulfate soils and mining activities is a considerable source of trace metal pollution to sensitive coastal ecosystems. Ideally, the treatment of metalliferous drainage would not only prevent the release of toxic metals to downstream environments but would also recover and recycle them as a valuable resource for use in other industries. While materials have been developed for removal of toxic heavy metals from environmental waters based on polymers or silica, they are often unstable in the presence of acid. On the other hand, titanium dioxide (TiO_2) is known to have a high affinity for trace metals when coated with specific ligands, and its stability over a range of pH conditions makes it a potentially ideal candidate for remediation of acidic metalliferous drainage. However, behaviour of this material in complex natural systems is poorly understood, and optimisation for metal uptake under a wide range of environmental conditions needs to be achieved. This project will combine laboratory and field experimentation to optimise functionalised titania as a stable trap for trace metals in drainage from acutely acidified coastal landscapes in Northern NSW. Research will be undertaken collaboratively between the University of Sydney and ANSTO (the Australian Nuclear Science and Technology Organisation). Interested students must be willing to travel to ANSTO, Lucas Heights, to conduct their laboratory work.

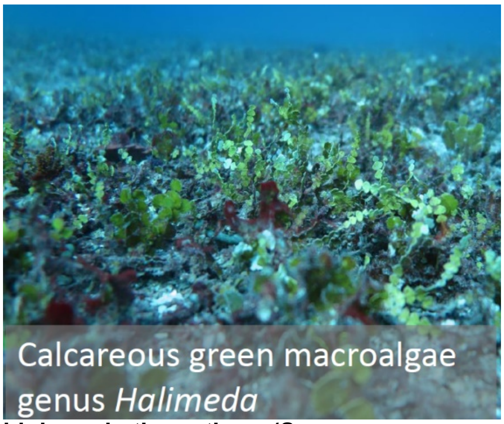
Project laboratory work will be conducted at ANSTO, Lucas Heights
Possible AINSE $5,000 stipend available through competitive application.



CORAL REEF GEOMORPHOLOGY

HALO - *Hali*meda bioherm *O*rigins, function and fate in the northern Great Barrier Reef





3D image showing the distribution and morphology of a Halimeda bioherm in the nothern (Source: www.deepreef.org GBR & sea floor image showing the alcareous green algae Halimeda (Source: Emma Kennedy).

Supervisors: Jody Webster jody.webster@sydney.edu.au; Luke Nothdurft (Queensland University of Technology); Robin Beaman (University of Queensland).

Calcareous green alga *Halimeda* is a major contributor to coral reef shelf sediments and is found along the entire Great Barrier Reef (GBR), Australia. Previous studies of extensive Halimeda deposits, or bioherms, show they represent important inter-reef habitats and potential carbon sinks in the GBR Marine Park, covering ~26% of the northern shelf, equal to the modern coral reef system. Pioneering work in 70-80s indicate the bioherms are in depths of ~20-40 m forming linear ridges and flat-topped mounds ~20 m thick.

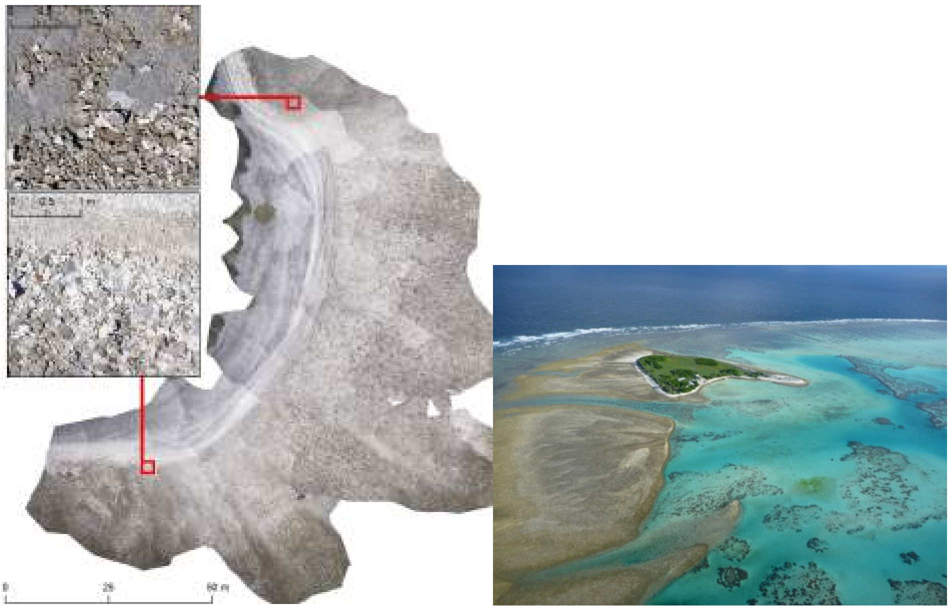
However, new bathymetry data reveals a completely different picture of their morphology, characterised by complex reticulate (honeycomb-like) shapes and covering an area >3X original estimates. These new findings confirm the Halimeda bioherms are much larger and more complex than previously thought – challenging existing paradigms as to their origin, development and significance. We will study these enigmatic features, building directly on a recently funded (**US$2.5 mill) RV Investigator cruise scheduled for May-June 2020**. We will conduct high-resolution multibeam mapping, subbottom profiling, sediment coring and innovative seabed/habitat imaging (AUVs, ASV, ROV). This will increase our understanding of the fundamental processes that control bioherm development, and have direct implications for environmental managers tasked with predicting how these poorly studied inter-reef environments might respond to future climate change.

Note: multiple opportunities exist to join the voyage on the RV Investigator next year and then undertake post cruise research on the data and samples as part of your hons, Mphil or PhD project(s). The HALO project is also funded by an $150,000 grant from the Ian Potter Foundation to support pre- and post cruise activities and science.

Morphologic evolution of the rubble cays at One Tree Reef

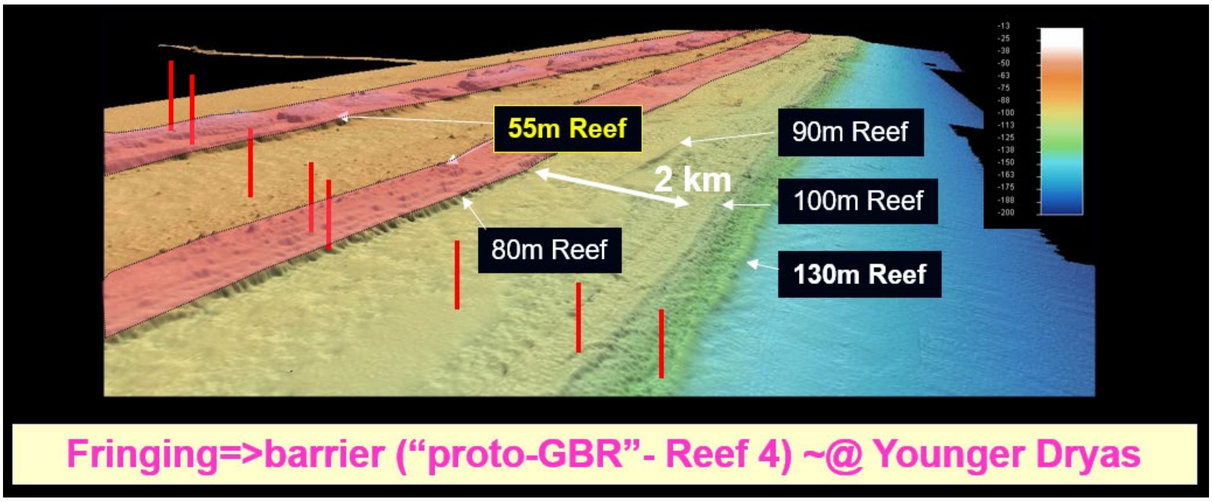
Supervisor: Ana Vila-Concejo ana.vilaconcejo@sydney.edu.au & Tristan Salles tristan.salles@sydney.edu.au

One Tree Reef in the Southern Great Barrier Reef has two rubble cays: One Tree Island is located on its SE corner, and Two Tree Island is located on its NE flank. They are both composed of unconsolidated sediment that is deposited under high energy conditions. We have a collection of remotely sensed images that can be used to determine the decadal evolution of the islands; we also have some annual measurements taken over the last few years using state-of-art techniques such as real time kinematic positioning systems and structure from movement remote sensing using kites. This project encompasses analysing the decadal and annual evolution of One Tree Island in relation with the wave climate and cylonic events.



[Photo credit: Mosaic obtained using kite imagery S Duce (left) D. Kauffman(right)]

Death by a thousand cuts: understanding the role of paleowater quality (high sediment & nutrient flux) in the growth and demise of the Great Barrier Reef over the past 30,000 years

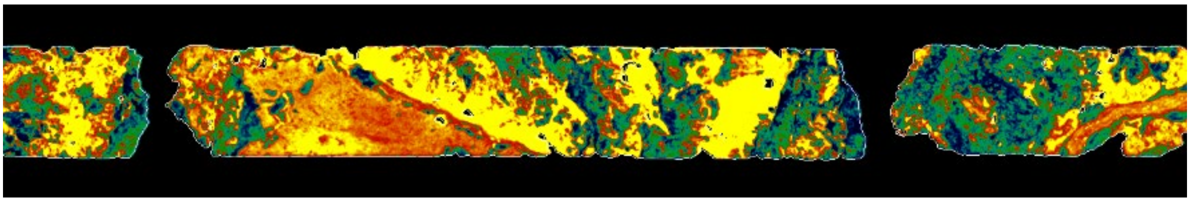


Supervisors: Jody Webster jody.webster@sydney.edu.au; Dirk Erler (Southern Cross University); Gregg Webb (University of Queensland).

Exp. 325 revealed that the Great Barrier Reef (GBR) had a complex and dynamic history of reef growth and demise over the past 30 kyr, characterized by five distinct reef sequences. Reef death occurred in two ways: subaerial exposure caused by sea-level fall or due to rapid sealevel rise and associated environmental changes. Previous work highlighted the importance of high sediment flux and poor water quality, rather than abrupt sea-level rise alone, in ultimately determining reef demise. The objective of this project is to investigate the role of paleowater quality (sediment and nutrient flux) had in controlling the evolution of the GBR over the past 30 ky. We will investigate fossil coral reef material for IODP Expedition 325 (Great Barrier Reef Environmental Changes) to: (1) reconstruct a unique, high-resolution record of sediment and nutrient flux to the reef using a suite of geochemical proxies (major trace and rare earth elements, nitrogen isotopes); and (2) relate the changes in paleowater quality to changes in reef communities, accretion and bioerosion, that ultimately led to reef demise. This project will greatly improve our understanding of the critical environmental thresholds that led to reef demise in the past and how reefs recovered after disturbances on different spatio-temporal scales.

Note: this project is funded by new ANZIC IODP Legacy grant to support analyses on the fossil core reefs cores.

The origin of the Great Barrier Reef – when, where and why?

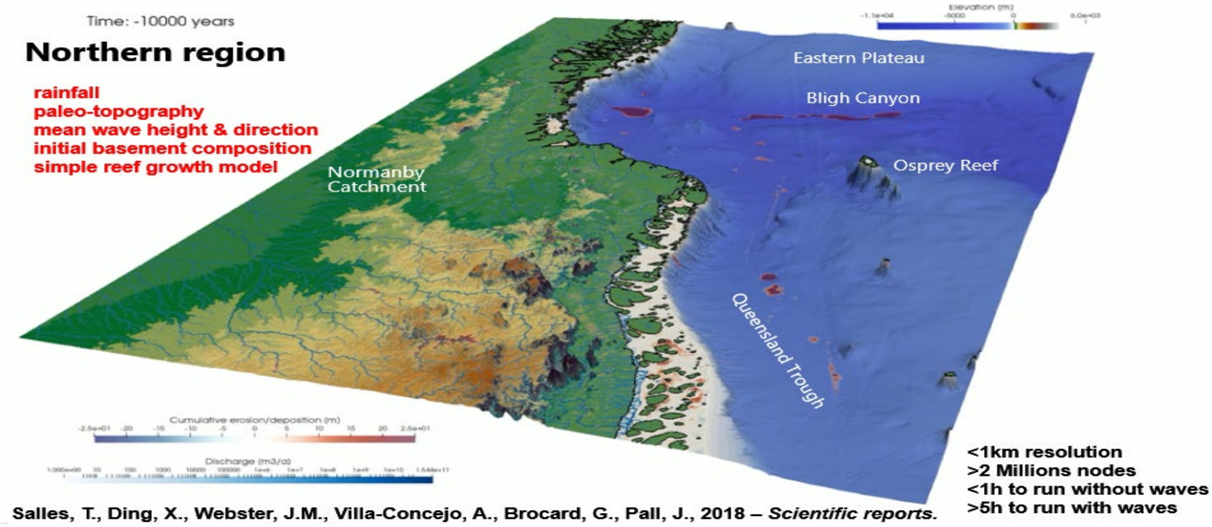


Ribbon Reef 5 reef hyperspectral imaging data showing the downhole distribution of carbonate minerals.

Supervisor: Jody Webster jody.webster@sydney.edu.au; Gregg Webb (University of Queensland).

The origin of the Great Barrier Reef is still shrouded in mystery. The when, where and why of how this iconic reef system turned-on is still very poorly understood. You will integrate new and existing sedimentologic, biologic, geochemical, and chronological data sets from a unique suite of fossil reef cores from the GBR (Ribbon Reef 5, Boulder Reef) to explore the past evolution of the GBR in response to major global climate and environmental changes. Using a suite cutting edge analytical techniques, combined with a quantitative paleoecologic approach, will test a range of hypotheses put forward to explain the turn-on of the GBR (sea level, SST, sediment influx, upwelling etc). This will provide new insights into how the GBR ecosystem evolved over past 700 ka.

The lives and deaths of the Great Barrier Reef – combining data & models to understand the evolution of Australia's iconic reef.

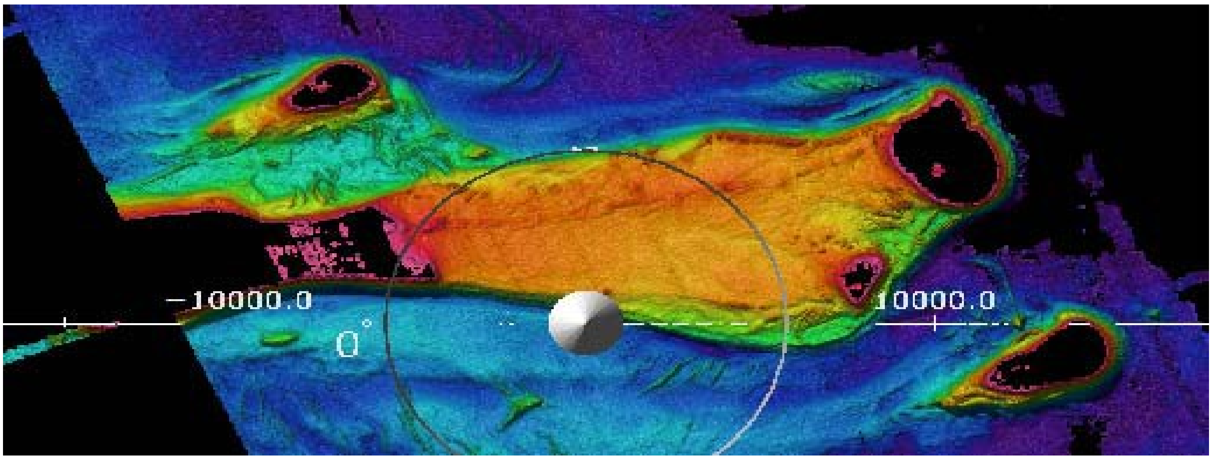


Salles, T., Ding, X., Webster, J.M., Villa-Concejo, A., Brocard, G., Pall, J., 2018 – *Scientific reports.*

Supervisor: Jody Webster jody.webster@sydney.edu.au & Tristan Salles tristan.salles@sydney.edu.au

Predicting how the Great Barrier Reef (GBR) will respond in the face of future global climate changes is both poorly constrained and controversial. This relates to our incomplete understanding of how reef systems respond to environmental changes but also the lack of baseline data — particularly on centennial to millennial time scales. The study of the evolution of the GBR over past 500-600 ka can provide unique insights about how this iconic reef system responded to abrupt and major environmental changes over a range of spatio-temporal scales. In this project, you will integrate existing sedimentologic, biologic, geochemical, and chronological data sets from a unique suite of fossil reef cores from the GBR. Then you will use sophisticated modelling software (pyReef-Core) that predicts core stratigraphy, facies, and reef communities, in combination with innovative data sciences tools (BayesReef - bayesian inference computational algorithm) to optimize model inputs/parameters, to explore the past evolution of the GBR in response to major global climate and environmental changes. **Note: this project is part of the new DARE ARC ITTC and fully funded PhD scholarships are available to suitable candidates.**

The last coral reef frontier - quantitative geomorphology of the modern Coral Sea reefs

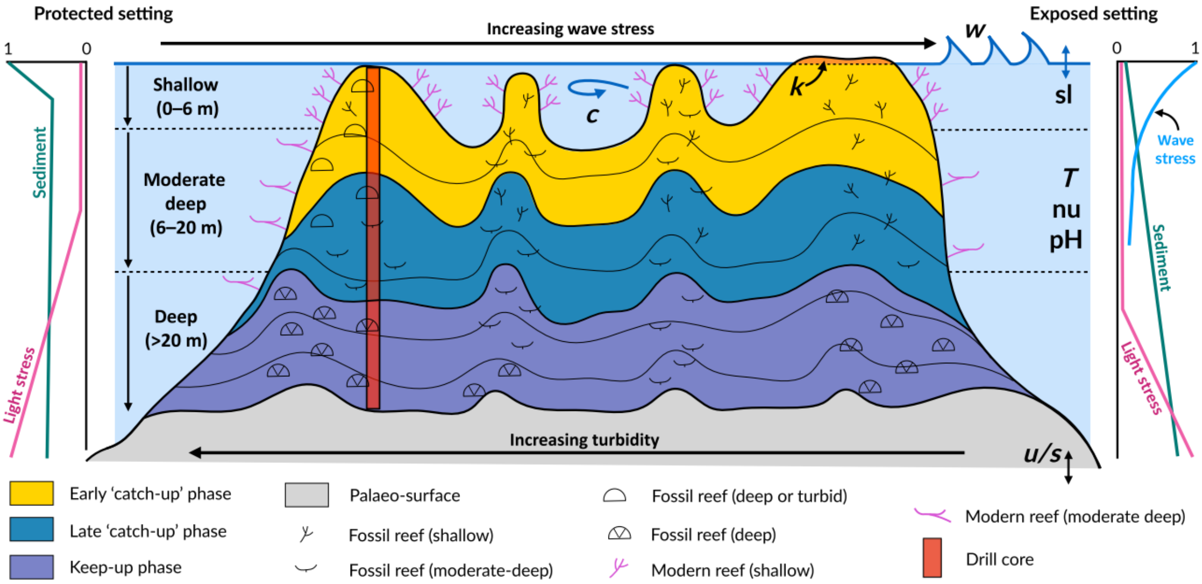


High-resolution LADS bathymetry data from southern Great Barrier Reef showing reef and inter-reef areas (data source http://www.hydro.gov.au/aboutus/lads/lads.htm).

Supervisor: Jody Webster jody.webster@sydney.edu.au; Robin Beaman (JCU), Tristan Salles tristan.salles@sydney.edu.au

The project will investigate new and existing high-resolution remote sensing data (LIDAR & multibeam bathymetry data, aerial photographic imagery) to understand the main processes controlling the geomorphic variation of reef and associated environments in the largely unexplored reefs of the Coral Sea. Using advanced GIS and 3D visualization tools, we will develop a new quantitative morphologic characterisation of the reef and inter-reef areas (ie. terraces, banks, sediment wedges, channels, shoals, sand wave/dunes). We will also explore the relationships between the benthic habitats/sedimentary facies, the quantitative geomorphic data and physical processes operating in the Coral Sea. This project could also incorporate sophisticated new numerical reef model tools (pyBadlands, pyReef) under development by the GRG. The project will have implications for improving our understanding modern reef environments and processes as well enhancing our knowledge of ancient carbonate platforms.

Controls on the Holocene evolution of the Great Barrier Reef: linking 4D numerical modeling and observational data.

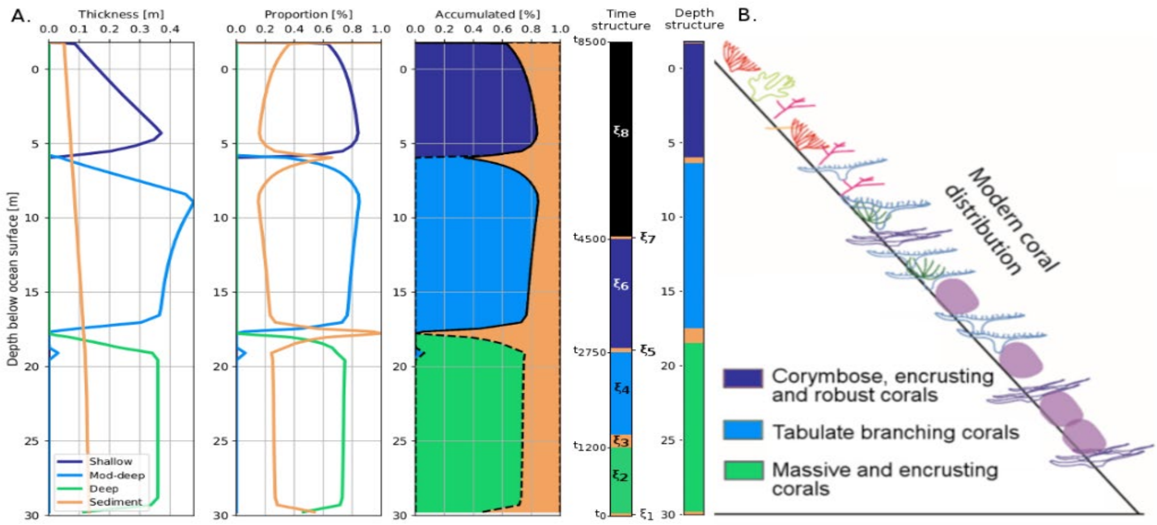


Modelling of One Tree Reef using pyReef and pyReef core (Salles et al., 2018).

Supervisor: Jody Webster jody.webster@sydney.edu.au & Tristan Salles tristan.salles@sydney.edu.au

This project will investigate the relationship between biological and geological processes controlling the evolution (stratigraphic ages, residence times and geometries ('architecture') of coral reef systems. We will construct new 4D numerical models using state of the art software (eg.,pyBadlands, pyReef) and compare them against observational reef data sets from the Great Barrier Reef that grew during the Holocene (9,000 years to now). We aim to assess the sensitivity of coral reef systems to various environmental stresses (eg. sea-level rise, subsidence and sediment flux) acting on different timescales, magnitudes and rates. The project may also involve field work to One Tree Reef in the southern GBR to calibrate model parameters and processes against real world sedimentary and biological examples. **Note: this project is part of the new DARE ARC ITTC and fully funded PhD scholarships are available to suitable candidates.**

Multi-core parallel tempering for extending BayesReef for modelling reef growth on geological timescales.



Supervisor: Rohitash Chandra rohitash.chandra@sydney.edu.au Tristan Salles tristan.salles@sydney.edu.au; Jody Webster jody.webster@sydney.edu.au;

Estimating the impact of environmental processes on vertical reef development in geological timescales is a very challenging task. This is due to complex models and data with missing information. py-Reef Core is a vertical reef growth simulation model for geological timescales. BayesReef has been proposed to estimate and provide uncertainty quantification for py-Reef Core which features environmental condition parameters. BayesReef features limitations when the size of the problem increases due to computational requirements in sampling and hence only a few parameters were estimated. Parallel tempering (PT) is an advanced MCMC method suited for irregular and multi-modal distributions. Moreover, PT is more suitable for multi-core implementations that can speed up computationally expensive geophysical models. The Honours research project extends Bayeslands using parallel tempering to estimate dozens of parameters on a synthetic reef core dataset. **Note: this project is part of the new DARE ARC ITTC and fully funded PhD scholarships are available to suitable candidates.**

MORPHODYNAMICS OF TEMPERATE COASTS

What is special about beaches in estuaries and bays?

Supervisors: Ana Vila-Concejo ana.vilaconcejo@sydney.edu.au with Shari Gallop (U Waikato, NZ)

Despite the ubiquitous distribution of beaches in estuaries and bays, little is known of the short to long term morphodynamics of these systems when compared to open coast environments. The fact is that they are often taken as small-scale versions of their oceanic counterparts. However, recent research shows that they behave in different ways and that the key to their behaviour seems to reside on the ratios of the different types of energy (swell waves; wind waves; infragravity energy; tidal currents) that they receive. In this project, the student will survey the hydrodynamics and topography of estuarine beaches in the Sydney region, including Sydney Harbour, Botany Bay and/or the Pittwater estuaries, and will determine the processes inciting geomorphic change and evolution of these systems.

Fieldwork on estuarine beaches – Botany Bay June/July 2018

What will happen to Sydney's beaches with climate change? How can we prepare?

Supervisors: Ana Vila-Concejo ana.vilaconcejo@sydney.edu.au with Shari Gallop (U Waikato, NZ)

This project involves monitoring of beaches on selected Sydney Eastern suburbs including Bondi Beach. The student will measure the topography of selected beaches monthly and after storms. One question relevant to 2019 is why do the beaches have so much sand? The students will analyse topographic and video data from 2015 until present to quantify the processes that control sediment deposition. Analyses of longer data series of wave climate will allow to compare those years with past erosive states like, for example 2011. Where is the sand coming from? Where will it go? And what are the conditions that will trigger erosion again?

Most importantly, this research aims to quantify sand management approaches to adapt to climate change.

2011

2013

2016

2017

2018

2019

Estuarine beaches of Sydney Harbour: what's going on in rose bay?

Supervisor: Ana Vila-Concejo ana.vilaconcejo@sydney.edu.au & Tristan Salles tristan.salles@sydney.edu.au

In a new collaboration with Woollarah Council (2019), we are initiating a study of the estuarine beaches in Sydney Habour. We will survey the Woollarah beaches on the harbour, deploying wave sensors to understand the hydrodynamic controls of those beaches. We are also analysing the case of Rose Bay where there is an abnormal sediment accumulation around a storm water drain that is encroaching on properties that front the beach.

There are at least two honours projects that can be developed from this new research. The students will get fieldwork and laboratory skills as well as data analysis skills such as coding and GIS.

Rose Bay in a photo from Google Earth

Biomorphodynamics of oyster reefs

Supervisors: Ana Vila-Concejo ana.vilaconcejo@sydney.edu.au; Bree Morgan bree.morgan@sydney.edu.au

Natural oyster reefs were extinct from NSW estuaries in the late 20th century. But some of them survived and are still going. While scientists still don't understand why some reefs have survived, we suspect that the physical and sedimentary processes exert some control in whether they survive or not. Oysters are being used all over the world to remediate contaminated estuaries. With our research we want to understand the following:

1. What ranges of physical and sedimentary processes, allow oyster reefs to thrive
2. What are the effects that oyster reefs have on the sediments
3. What are the effects that oyster reefs have on physical processes such as wave and current attenuation

This research is part of collaborative research with Marine Biology. This is a new, interdisciplinary, line of research that started in 2018.

SEDIMENT GEOCHEMISTRY, CARBON CAPTURE

Unravelling the trace element signatures of rare CO_2 traps

Supervisors: Bree Morgan (USYD) bree.morgan@sydney.edu.au; Jody Webster (USYD) jody.webster@sydney.edu.au ; Siobhan Wilson (University of Alberta) sawilson@ualberta.ca

Highly-stable Mg-carbonate minerals, such as magnesite ($MgCO_3$) and dolomite ($CaMg(CO_3)_2$), are ideal safe and permanent sinks for CO_2, but their formation is kinetically restrained under Earth's surface conditions. Despite this, they are found as rare modern precipitates in ephemeral playa lake sediments in Australia and Canada. Their occurrence in both environments despite the extreme contrasts between geochemical, lithological, topographic and climatic conditions, provides the ideal natural settings to unravel the underlying mechanisms driving their formation.

Accumulation and fractionation of trace elements (including rare earth elements) can provide powerful insights into biogeochemical processes and conditions impacting coastal sediments. In this Honors project, trace element signatures will be mapped in modern sediments containing both dolomite and magnesite, along with fringing microbialites, collected from the Coorong Lakes in South Australia, and the Cariboo in British Columbia. The aim will be to build on our fundamental understanding of biogeochemical conditions that drive the safe and permanent capture of CO_2 in environmentally friendly minerals. This will be critical for innovating efficient and affordable carbon capture and storage strategies to mitigate the impacts of CO_2 pollution and global warming. Additionally, this fundamental knowledge will substantially build our scientific understanding of carbonate sediments as a CO_2 sink over geologic timescales.