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

Supervisor: Jody Webster (USYD) jody.webster@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., CARBONATE 3D) and compare them against observational reef data sets from the Great Barrier Reef. 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. This project is part of the Geocoastal Research Group’s new ARC Discovery funded project to recover fossil reef cores from One Tree and Heron Reef.

![Fig. 5. 3D visualization looking east through the best estimate model output.](image)

Modelling of One Tree Reef using CARBONATE 3D (Barrett and Webster, 2012).
As global climates change the modern Southern Great Barrier Reef (Capricorn Bunker Group) will likely record the first and most marked biologic and geologic changes. Therefore it is crucial, now more than ever, to develop a comprehensive geological framework with which to interpret these possible changes. The project will focus on a major event in the evolution of this sensitive region of the GBR – the Holocene “turn-on” between 8-9 ka and the growth of the reef during the Last Interglacial Period (~125 ka). We will investigate a suite of new and existing fossil coral cores from the region to: (1) establish the precise timing of reef initiation and early growth using new C14-AMS and U/Th ages; (2) assess the sedimentologic and biologic composition (ie. corals, coralline algae) of the reefs; and (3) reconstruct the paleoceanographic conditions during these important periods in Earth History. The project may involve field work to One Tree Reef in the southern GBR in order compare modern sedimentary and biological environments to those observed in the fossil reef cores. This project is part of the Geocoastal Research Group’s new ARC Discovery funded project to recover fossil reef cores from One Tree and Heron Reef.
Reconstructing paleoclimate variability using fossils corals in the western tropical Pacific Ocean

Supervisor: Jody Webster (USYD) jody.webster@sydney.edu.au

The climate of the tropical Pacific has a far reaching influence on global climate, delivering large amounts of heat to the atmosphere, playing a leading role in driving global atmospheric circulation, and influencing climate far from the Pacific through the El Niño-Southern Oscillation (ENSO). This project will involve reconstructing short, seasonally resolved paleoclimate “windows” (eg., sea surface temperature and salinity) from fossil corals during the last deglaciation (20-10 ka). The project will be conducted jointly with Dr. Mike Gagan at the Australia National University and the student will learn advanced techniques in geochemistry (eg. paleo-climate proxies - stable isotopes and trace elements) and paleoclimate data analysis. This project is part of the Geocoastal Research Group’s large ARC Discovery funded project to support work on IODP Exp. 325 http://publications.iodp.org/preliminary_report/325/index.html.

Modern sea surface temperate in the Indo Pacific (Mean annual SSS/SST: Levitus, 1994).
Quantitative geomorphology of the modern Great Barrier Reef

Supervisor: Jody Webster (USYD) jody.webster@sydney.edu.au

The project will investigate new and existing high-resolution remote sensing data (LADS & LADS & multibeam bathymetry data, aerial photographic imagery) to understand the main processes controlling the geomorphic variation of reef and associated environments in Great Barrier Reef. Using advanced GIS and 3D visualization tools, we will develop a new quantitative morphologic characterisation of the reef and inter-reef areas (ie. sediment wedges, banks, 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 GBR. The project will have implications for improving our understanding modern reef environments and processes as well enhancing ancient carbonate petroleum reservoir models. This project is part of the Geocoastal Research Group’s new ARC Discovery funded project to recover fossil reef cores from One Tree and Heron Reef.

Sediment architecture and evolution of the upper slope of the Great Barrier Reef margin.

Supervisor: Jody Webster (USYD) jody.webster@sydney.edu.au

The project will investigate the sediment architecture and evolution of the upper slope (~150-500 m) of the Great Barrier Reef margin. The project will involve the analysis of new high-resolution multibeam bathymetry and seismic data from four different sites along the GBR margin. Multibeam bathymetry data will be used to generate high-resolution 3D maps of the upper slope and investigate morphologic characteristics of the margin. Seismic reflection data will be used to investigate the nature of the subsurface including internal structure and geometry of subsurface reflectors and large scale sediment slope architecture. We will use the state-of-the-art industry KINGDOM™ software suite to fully integrate all bathymetry, seismic, and available sediment core data sets. This will provide the comprehensive 3D spatial framework needed to build new models of the sediment architecture and evolution of the upper slope in response to sea level variations. This project is part of the Geocoastal Research Group’s large ARC Discovery funded project to support work on IODP Exp. 325 http://publications.iodp.org/preliminary_report/325/index.html.

A high resolution Topas seismic reflection profile showing a cross section through the upper slope of the central Great Barrier Reef. Note the complex system of stacked fluvial? channel systems.
The project will investigate the sediment architecture and evolution of abundant but poorly studied Halimeda mounds in the Great Barrier Reef. The project will involve the analysis of new high-resolution multibeam bathymetry and seismic data from four different sites along the GBR margin and sediment cores through the mounds. Multibeam bathymetry data will be used to generate high-resolution 3D maps of the mounds. Seismic reflection data will be used to investigate the nature of the subsurface including internal structure and geometry of subsurface reflectors and large scale sediment architecture. Sediment cores will be used to understand their sedimentologic and chronologic evolution. We will use the state-of-the-art industry KINGDOM™ software suite to fully integrate all bathymetry, seismic, and sediment core data sets. This will provide the comprehensive 3D spatial framework needed to build new sedimentary models of the evolution of the Halimeda mounds in response to environmental changes.
Great Barrier Reef phase shift: Gardner Bank to Gardner Reef?

Supervisor: Jody Webster (USYD) jody.webster@sydney.edu.au; Rob Beaman (JCU) robin.beaman@jcu.edu.au

The project will investigate modern benthic habitats and the geomorphic evolution of the Gardner Bank off Fraser Island. This represents a unique sub-tropical setting that could be affected by future global climate changes that could see the extension of the Great Barrier Reef southwards. The project will involve the analysis of recent high-resolution multibeam bathymetry and seismic data collected from a RV Southern Surveyor cruise.