Living on the Edge: Resilience of nearshore turbid-zone corals to extreme environments

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KIMBERLEY MARINE RESEARCH PROGRAM

1.3.1 KIMBERLY GEOMORPHOLOGY AND REEF GROWTH HISTORY
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BARDI JAWI, MAYALA, DAMBIMANGARI
JAMES BROWN (KIMBERLEY MARINE RESEARCH STATION)
1.3.1 Research Questions

• It is not known whether reefs are thin veneers over rock platforms or significant long-lived accretionary structures (Barry Wilson 2013)

  When did reefs first become established in the Kimberley? ✓

  Do Kimberley reefs represent significant geological structures or more simple coral communities? ✓

  How does reef geomorphology, internal architecture, aerial extent vary regionally (i.e., inshore vs. offshore; N/S) and comparatively (i.e., Kim vs. GBR)? ✓
Approach and Methodology

1. Satellite and aerial remote sensing
   • *Mapping reefs and islands and spatial habitat assessments*

2. Multibeam, sidescan, and subbottom sonar surveys
   • *Reef topography and internal reef architecture*

3. Coral reef coring (54 cores) and geochronology
   • *Palaeoecological records and reef growth records*
Photo: Montgomery Reef (Photos courtesy of Scott Whiting DBCA)
Tallon Island reef core (branching corals in muddy matrix)
Kimberley inshore reefs represent a natural turbid reef system. Often considered to have a lower functional state compared to their clear water cousins.
### Present extent of Kimberley reefs

<table>
<thead>
<tr>
<th>Parameters</th>
<th>KIM</th>
<th>GBR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>13.0° S – 17.0° S</td>
<td>9.5° S – 24.5° S</td>
</tr>
<tr>
<td>Marine park area</td>
<td>GKMP = 18,450 km²</td>
<td>348,000 km²</td>
</tr>
<tr>
<td>Mainland coastline length</td>
<td>5,300 km</td>
<td>2300 km</td>
</tr>
<tr>
<td>Number of islands</td>
<td>2400</td>
<td>617</td>
</tr>
<tr>
<td>Number of reefs</td>
<td>853</td>
<td>2900</td>
</tr>
<tr>
<td>Total reef area (km²)</td>
<td>1950 km²</td>
<td>20,000 km²</td>
</tr>
<tr>
<td>Total reef coverage</td>
<td>3.20%</td>
<td>5.70%</td>
</tr>
</tbody>
</table>
Seismic Surveys
Reef growth initiated approximately 9000 years ago

54 reef cores from 4 reef sites, reef growth history constrained by 60 radiocarbon coral dates

Percussion and rotary coring methods
Kimberley reefs tallest in the World

- Highest surveyed reef flat has a mean elevation of +0.25 m above mean sea level
- Reef flat is exposed for longer than it is submerged

Kimberley Reef Geomorphology

Lowe et al., 2015
Dr Zoe Richards (Curtin University) Coral Biodiversity Survey

WAM-Woodside Collection Project 2009-2015

- 181 survey stations
- 2200 skeletal & molecular specimens
- Quantitative Data
- 4 x 15m biodiversity belt transects

- 449 Coral Species in the Kimberley (unpublished)
- 362 species GBR, DeVantier, et al. 2006 (599 sites)
- 411 species GBR, https://coraltraits.org
- 225 species in intertidal zone Bonaparte Archipelago

Regional variability in Kimberley reef Geomorphology

Key management limitation

- Is the unique southern Kimberley reef morphology a function of…

- broader Kimberley biogeographic region, or

- driven at a local level by the extreme tidal amplitudes?
Sea Level Rise and landscape evolution in the Kimberley

A geomorphological perspective of coral reef growth

Holocene Sea Level Curve

Modified from Lennock et al. PNAS 2014
Sea Level Rise and landscape evolution in the Kimberley

Holocene Sea Level Curve

20,000 years BP
Key finding of the Kimberley Reef Mapping

• Survey data show Kimberley bioregion contains the second largest reef system in Australia
  • 1/3 the size of the Great Barrier Reef
  • 10 times larger than Ningaloo
  • Far greater diversity of corals compared to Ningaloo and comparable to Northern GBR (Richards)
  • Diversity of Kimberley turbid zone reefs far greater than equivalent systems on the Queensland coast

• Most reefs found along the inner shelf margin (<15 km from the coast), opposite the the GBR where reefs are located along the shelf edge > Kimberley reefs have a far greater potential to be impacted by land use change

• **Key management limitation** > Total reef area of 1950 km², the nature of intertidal Kimberley coral communities are relatively unknown
Do turbid reefs have the potential to function as a coral refugia under future climate change
New and ongoing research

ARC Linkage - Project Coral Resilience and the optimal management of biodiversity (2018-2020)

Cl’s – Zoe Richards, Michael Bunce, Michael Stat, David Miller, Ira Cooke
PI’s – Nerida Wilson, James Gilmour, Jim Underwood, Andrew Halford

- Baselines & Biodiversity: Provide new data about coral biodiversity at regionally significant locations to inform monitoring and management.
- Resilience & Restoration: Explore the genomic basis for resilience and develop a DNA-based toolkit for understanding and managing coral communities.
- Dissemination: Inform managers, stakeholders and the general public about best practice biodiversity conservation.
Acknowledgements

• Research Students: Giada Bufarale, Tubagus Solihuddin, Moataz Kordi
• Researchers: Lindsay Collins, David Blakeway, Iain Parnum
• Traditional Owners: Bardi Jawi (Rangers), Mayala, Dambimangari
• Kimberley Marine Research Station (Cygnet Bay): James Brown
• West Australian Marine Research Institute
• Kimberley Media: Richard Costin
Reef geology, stratigraphy and evolution
Key Outcome and Findings

• Initiation of coral reef growth in the Kimberley occurred very soon after post glacial flooding of the continental shelf, between 7,000 and 8000 years ago

• Inshore reefs were able to sustain growth despite highly turbid waters, as indicated by muddy matrix in reef core samples

• Early reef assemblages were dominated by branching coral species, switching to massive and finally coralline algal assemblages as reefs attained sea level

• While High Reefs show continual vertical aggradation throughout the Holocene, Low Reefs appear to have “turned off” with vertical growth stopping between around 5 to 6000 years ago
Internal Reef Architecture
Seismic (sub-bottom) surveys of southern Kimberley reef systems

<table>
<thead>
<tr>
<th>Reef System</th>
<th>Distance (km)</th>
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<tbody>
<tr>
<td>Sunday and Tallon Island</td>
<td>42</td>
</tr>
<tr>
<td>Cockatoo Island</td>
<td>31</td>
</tr>
<tr>
<td>Bathurst and Irvine Island</td>
<td>49</td>
</tr>
<tr>
<td>Montgomery and Station reefs</td>
<td>53</td>
</tr>
<tr>
<td>Molema Island and Turtle Reef</td>
<td>50</td>
</tr>
<tr>
<td>Brue Reef</td>
<td>13</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>294 km</strong></td>
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</table>

AAE AA201 Boomer SBP system

Seismic Surveys

GPS antenna

Boomer

Hydrophone

Chirp

Seabed
3. Reef Geology and Growth History

Reef facies:
- Unconsolidated carbonate sand with coralline algae fragments, coral debris, and rhodoliths
- Unconsolidated branching coral floatstone
- Coralline algal bindstone with minor coral

Matrix sediment:
- Sand
- Muddy sand
- Sandy mud
- Mud

Tallon Island

MSL

ET 7 Core site

WT 2
WT 1

1ky 2ky 3ky 4ky 5ky 6ky 7ky

0.0 m 0.5 m 1.0 m 1.5 m 0.5 km 1.0 km 1.36 km