



Australian Government

Department of the Environment, Water, Heritage and the Arts

Marine and Tropical Sciences Research Facility (MTSRF) Project Milestone Report, 2 June 2009

Program 1:	Status and Trends of Species and Ecosystems in the Great Barrier Reef
Project 1.1.4:	Dating and mapping historical changes in GBR coral communities http://www.rrrc.org.au/mtsr/theme_1/project_1_1_4.html
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Report Summary

This report provides details of progress to date and a plan for completion of Year 4 activities (2009/2010).

Milestone Reporting Requirements

2008/2009 Outputs Milestones	Date
Report 3 submission: <ul style="list-style-type: none">• Description and interpretation of results obtained for surface rubbles and cores from central GBR with appropriate attribution of MTSRF funding [UQ];• Report on fieldwork in northern GBR [UQ];• Final summary of communication activities undertaken through the course of Year 3 of project [UQ]; and• Plan for completion of out-year activities [UQ].	2 June 2009

Project Results

- **Description and interpretation of results obtained for surface rubbles and cores from central GBR with appropriate attribution of MTSRF funding.**

A substantial number of U-series dates (~200) have been generated for surface rubble (mainly branching coral fragments), dead *Porites* short cores (10-30cm each), inshore-reef sediment cores (2-5m long each), and cyclone-transported coral boulders/reef blocks from Palm (Townsville), Keswick (Mackay) and Heron (Gladstone) regions in the central-southern GBR. Cores from live corals of known ages were dated to assess the accuracy of the age determination as well as the non-radiogenic Th isotopic compositions for age corrections. Additional analyses (including ecological and geochemical analyses) were also conducted on the surface rubble and inshore-reef sediment cores.

From these results, the following important findings or understandings can be drawn:

1. Ecological surveys of live and dead coral assemblages at Pelorus Reef (Palm Islands) revealed that sites with low coral cover are dominated by dead branching Acroporid rubble, whereas adjacent sites show high living cover of *Pavona sp.* and *Millepora sp.* U-Series dating of in-situ dead coral rubble from these sites suggests that the mortality of the Acroporid corals occurred between 1920 and 1960 AD, with no signs of recovery since. In contrast, the adjacent communities of healthy live *Pavona sp.* are apparently stable, with low rates of mortality occurring since 1981 AD. Sediment cores extracted from the *Pavona* sites suggests a historical dominance of Acropora assemblages from the 10th century to the early 20th century, prior to a mortality event and subsequent shift to a *Pavona* dominated community. Collectively, our results imply a collapse of Acroporid communities at Pelorus Reef following European settlement, resulting in a shift in coral communities not observed during the last 1,000 years. These results are currently in a draft manuscript, awaiting further U-Series dates prior to submission. We have already expanded this study to five additional reefs in the Palm Islands, in order to determine variability in historical mortality events at a regional scale. Preliminary evidence from U-Series dates from surface coral rubble samples from Pandora reef suggests that the Acroporid mortality may have occurred later than at Pelorus Reef (1960-1970).
2. We have extracted over forty sediment cores from Pandora and Havannah reefs to date, with ~120 U-Series dates completed for these cores. The longest cores (4-5m length) date to ~1,000 years ago, allowing high resolution records of coral community structure at decadal – millennial resolution. The results suggest that coral communities from these inshore reefs undergo long periods of stability, followed by shifts in coral community structure to alternate states. U-Series dates from the upper cores indicate an unprecedented mortality event in Acropora dominated communities at Pandora Reef, coinciding with a loss of diversity and dominance of *Goniopora spp.* in Havannah Reef. Further analysis of coral community structure using CT scans, along with further U-Series dates will elucidate long term changes in inshore reefs prior and following European settlement, providing an invaluable baseline for the restoration of coral communities at local and regional scales.
3. U-Th isotope measurements of live coral core samples of known ages from Mackay region suggest ²³²Th levels in live coral skeleton are less than 1 ppb. With this level of non-radiogenic Th, age precisions and accuracy up to ±1 year can be achieved.
4. A clear trend in sea-water ²³²Th and ²³⁰Th/²³²Th was seen between sites. Based on U-Th isotope measurements of known-age live coral core samples from Round Top (~5 km from the coast) and Keswick (~30 km from the coast) Islands, sea-water ²³²Th level is significantly higher and ²³⁰Th/²³²Th ratio lower at Round Top Island than at Keswick Island, consistent with greater terrestrial input in sites closer to shoreline. This finding suggests that live-coral ²³²Th level and ²³⁰Th/²³²Th ratios can be used as a water-quality proxy.
5. In contrast to live corals, both branching and massive corals from the surface death assemblages and sediment cores contain on-average much higher ²³²Th, suggesting post-mortem incorporation of terrestrial sediment contaminants, which have a serious impact on the precision and accuracy of U/Th dates, as a significantly higher proportion of non-radiogenic ²³⁰Th is present in such samples, and its correction will significantly magnify the age uncertainties. In order to improve the age precisions, we have designed a vigorous cleaning procedure involving the use of H₂O₂ and ultrasonic cleaning to remove sediment contaminants. This procedure has proven to be very effective in reducing ²³²Th levels in the dirty coral materials. More samples using this cleaning procedure will be dated in the near future.

6. U/Th dates for surface rubble from both Keswick and Palm Island regions were mostly less than 200 years old, suggesting multiple episodes of coral mortality events since European settlement. However, the age population is clearly significantly different from that of Moreton Bay near Brisbane, where the bulk of the surface rubbles dated to mid-late Holocene.
7. The age of mortality in branching corals appear to correlate with those of coexisting dead massive *Porites* colonies, but more data are needed to confirm this.
8. There is evidence to indicate that the frequency of mortality on regional scale is correlated with the Pacific Decadal Oscillation, implying the role of climatic factors, in addition to water-quality influences.
9. Major cyclone occurrences can be reconstructed through high-precision U-Th dating of uplifted reef blocks/coral boulders (e.g. a significant group of uplifted coral boulders yield surface-mortality ages analytically indistinguishable from the time of Tropical Cyclone *Larry*). This approach, when combined with grain-size analysis of lagoon sediment cores, can be used to reconstruct cyclone activity over the past few thousand years (plan is underway to collect lagoon cores from One Tree reef for this purpose).

- **Report on fieldwork in the northern Great Barrier Reef**

As planned, PhD student Tara Clark participated in the AIMS expedition to far northern Queensland over the period 3-22 December 2008 and collected surface death assemblages. Detailed report on this trip and associated sample collections was already presented in the milestone report submitted in January 2009. Tara is currently in the process of dating selected samples collected during this trip.

Our plan to collect lagoon cores from Heron reef in March 2009 was further delayed, due to sudden worsening of weather conditions. Consequently, we decided to collect such cores from One Tree reef only fifteen kilometres southeast of Heron reef. We are now in the process of applying for permit extension through GBRMPA to allow us to collect samples from One Tree reef and then carry out fieldwork in August. As the Research Station on One Tree Reef is inside the reef lagoon, it is easy to drill lagoon cores from this site regardless of weather conditions and tidal parameters.

- **Final summary of communication activities undertaken through the course of Year 3 of the project**

Jez Roff presented data from the project at the ICERS conference in Florida in July 2008.

Tara Clark's confirmation seminar was held on 31 October 2008 at The University of Queensland.

An extended abstract titled "Dating and mapping historical changes in Great Barrier Reef coral communities" by Clark *et al.* was published in the 2008 MTSRF Annual Conference proceedings (http://www.rrrc.org.au/publications/2008_proceedings.html).

Pandolfi, Done, Roff and Clark attended the 2009 MTSRF Annual Conference at the end of April 2009 and Pandolfi presented a report on Project 1.1.4, which attracted media attention (Zhao was unable to attend as he was overseas during that period).

Yu, Zhao, Roff, Clark and Pandolfi presented the new results of U-Th dating of cyclone-uplifted reef blocks at the Heron Island Research Station Open Day in February 2009.

Two papers acknowledging the support of MTSRF Project 1.1.4 have been published:

Zhao J. X., Neil D. T., Feng Y. X., Yu K. F., and Pandolfi J. M. (2009) High-precision U-series dating of very young cyclone-transported coral reef blocks from Heron and Wistari reefs, southern Great Barrier Reef, Australia. *Quaternary International* 195, 122-127.

Zhao J. X., Yu K. F., and Feng Y. X. (2009) High-precision ^{238}U - ^{234}U - ^{230}Th disequilibrium dating of the recent past – A review. *Quaternary Geochronology*, DOI: 10.1016/j.quageo.2009.01.012.

- **Plan for completion of out-year activities**

1. Complete U-Th dating of over seventy samples using the new cleaning method (which is currently in progress).
2. Perform fieldwork and coring in the Palm Island area in August 2009 (plan to collect more back-reef sediment cores and short cores of dead massive corals).
3. Perform fieldwork and coring from the lagoon of One Tree reef fifteen kilometres southeast of Heron reef in September 2009 (unable to drill lagoon cores from Heron due to access problems constrained by weather conditions and tidal parameters).
4. Complete dating of coral samples from northern GBR as well as those collected during new fieldwork.
5. Roff to submit his PhD thesis in March 2010.
6. Submit a number of papers for publication.

Explanation of Activity Changes

1. Tara Clark was unable to attend the EGU conference due to lack of sufficient funding for her travel (although the abstract was accepted).
2. We had to cancel planned fieldwork to Heron reef to collect lagoon cores in March 2009 due to sudden worsening of weather conditions. Because of this, we have decided to collect lagoon cores from One Tree reef some fifteen kilometres southeast of Heron reef. Application for research permit is in progress.
3. Planned fieldwork and sampling in Palm Island area was postponed to August 2009.
4. We will release all U-Th data so far obtained to the Risk, Resilience and Response Atlas (http://www.rrrc.org.au/mtsr/theme_1/project_1_1_5.html) once we finished the dating of the current batch of samples.
5. We postponed the drafting of several papers for publication; because we found most dead coral rubble contain much higher ^{232}Th than the live coral of the same species, suggesting the influence of post-mortem sediment contamination. Thus we need to look into this issue more closely and develop a more efficient cleaning procedure to reduce the level of such contamination and improve the precision and accuracy of the data.

Problems and Opportunities

It has proven more difficult than expected to date branching coral rubble from the surface death assemblages due to incorporation of terrestrial sediments after mortality. Because of this, we have developed new cleaning procedures to deal with this contamination problem. The effort has been proven to be successful. Nevertheless, this problem has slowed down our progress, due to a substantial increase in the amount of time needed for such treatment. Since this problem, our lab has pioneered an innovative method for U-Series dating of young corals (<100yrs), which we aim to publish.

Tara Clark was offered a GBRMPA student travel award. She is going to use it to fund her further sampling in the Palm Island area.

Other issues

Ana Rodendo Rodriguez arrived and commenced PhD studies at The University of Queensland in February 2009.

Forecast of variations to planned milestones

We anticipate a slowdown in the delivery and publication of the results due to the requirement for substantial physical cleaning of sediment detrital contamination prior to U/Th dating. Vetting of suitable materials for dating is quite time-consuming. As nobody else has ever dated 'dirty' coral rubble of such young ages in the world, this issue only emerged in the process of our pioneering research.