Environmental trends in the GBR lagoon and Burdekin River catchment during the mid-Holocene and since European settlement using *Porites* coral records, Magnetic Island, QLD.

Volume 1

Thesis submitted by
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Declaration

I declare that this thesis is my own work and has not been submitted in any form for another degree or diploma at any university or other institution of tertiary education. Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references is given.

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Statement of the Contribution of Others

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Abstract

The extent of human influence on the Great Barrier Reef (GBR) is controversial but is essential to understand the environmental parameters of "healthy" inshore coral reefs before European settlement and the agriculturally-modified adjacent land catchments. To provide this evidence, core samples were taken from massive *Porites* corals from Magnetic Island and their annual skeletal growth bands were analysed for trace elements and oxygen isotope composition at sub-annual, 2 and 5 yearly sampling resolutions. This geochemical database was exploited to develop proxies of sea surface temperature (SST), seawater salinity, terrestrial runoff, land practices, sedimentation and turbidity. Data were obtained from four long-lived (~100 years) fossil mid-Holocene corals (~6,000 years old) and three modern coral cores, including one with a growth record from 1812-1986, a record which pre-dates European settlement in the region (c. 1850). In addition, the Holocene evolution of the Nelly Bay (Magnetic Island) reef was examined from C-14 dated sediment cores and biological sea-level indicators to construct a stratigraphic model of Nelly Bay. This model helps to investigate cause of the death for the fossil corals.

The mid-Holocene corals died around 5,790-6,150 calibrated (cal) years BP most probably from burial by terrigenous and biogenic sediments (sedimentation) due to a prograding reef flat. The fossil mid-Holocene corals contained sediment trapped within their final growth bands that was evident from elevated Th concentrations (>3 ppb), lower Y/Ho ratios (< 40) and progressively "flatter" rare earth element and Y (REY) distributions. REY distributions indicate that the sediments within the fossil coral's skeleton came from the local (Nelly Bay) area rather than the Burdekin River catchment.

Sea level rapidly transgressed to + 1.0-1.5 m around 7,000-7,500 cal years BP and may have then oscillated up to four times before settling to its current position approximately 1,250 cal years BP. Sea-level in the region was reconstructed from C-14 ages of a fossil oyster bed from Magnetic Island and by compiling previous sea-level data from eastern Australia.

Average climate variability during the mid-Holocene was similar to the 1812-1986 coral record from the coral proxies of SST (Sr/Ca, Mg/Ca, U/Ca ratios and $\delta^{18}O$ composition). The Sr/Ca ratios in the 1812-1986 coral record were significantly correlated with the instrumental dataset from the central GBR at a 2 yearly sampling resolution, while the long-term averages of the other SST proxies agreed with the instrumental record. In addition, there were significant correlations between the coral Sr/Ca ratio and the coral calcification rate (a physical coral SST proxy) at the 2 and 5 yearly sampling resolutions.

Average seawater salinity (coral $\Delta^{18}O$) during the mid-Holocene was also similar to the 1812-1986 coral record. The $\Delta^{18}O$ record for the 1812-1986 coral showed relatively wetter conditions persisted from 1885-1935 and post-1970, while drier conditions prevailed between 1830-1885 and 1935-1970. These long-term trends agreed with the coral luminescence and the rainfall records and coincide with the Pacific Decadal Oscillation. However, correlations between the coral $\Delta^{18}O$ record and luminescence, rainfall and Burdekin River discharge were not significant, although the coral luminescence record was significantly correlated with rainfall in the Burdekin catchment and Burdekin River discharge records. The lack of correlation between coral $\Delta^{18}O$ and luminescence records indicates these proxies are recording different environmental signals. The 5 yearly resolution coral $\Delta^{18}O$ record reveals subtle, long-term variations in seawater salinity, whereas the luminescence record shows large, short-term variations in seawater salinity from rainfall and river discharge events.

The study supports the finding that sediment and colloidal export to the GBR have increased by 4-5 times in the Burdekin River catchment since the arrival of Europeans, based on coral Ba/Ca ratios, Y, Pr, Sm and Ho concentrations as well as REE distribution patterns in the 1812-1986 record. The Ba/Ca ratios and the Y, Pr, Sm and Ho concentrations were significantly correlated with cattle numbers in the Burdekin River catchment. However, previous claims that the additional sediment exported to the inshore GBR has resulted in an increase in turbidity levels are not supported by the coral Y/Ho ratio, a potential proxy of turbidity. In addition, negligible sediment has been trapped within the 1812-1986 coral skeleton, which was evident from low coral Th concentrations.

This finding indicates that the threat of sedimentation to the Magnetic Island's fringing reefs is low.

An excellent record of historical land-use in the adjacent Burdekin River catchment is provided by coral Mn concentrations. Mn levels in the corals record the establishment and growth of the sheep and cattle industries and provide an exceptional historical account of the development of land since European settlement.

This study has helped to establish a record of natural climate and environmental change on inshore coral reefs to provide a baseline of water quality conditions for "healthy" reef ecosystems. From this baseline, the study has been able to separate the natural variability on Magnetic Island's fringing reefs from the human influence and may assist decisions to manage land runoff to inshore reefs of the GBR.

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