Can Flooding Rainfall Events Be Revealed In Oceanic Coral Cores?

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1. Introduction

● In 2008, flooding from high intensity rainfall in upper catchments of the Nogoa River system paralysed the mining industry in the Central Highlands of Queensland.

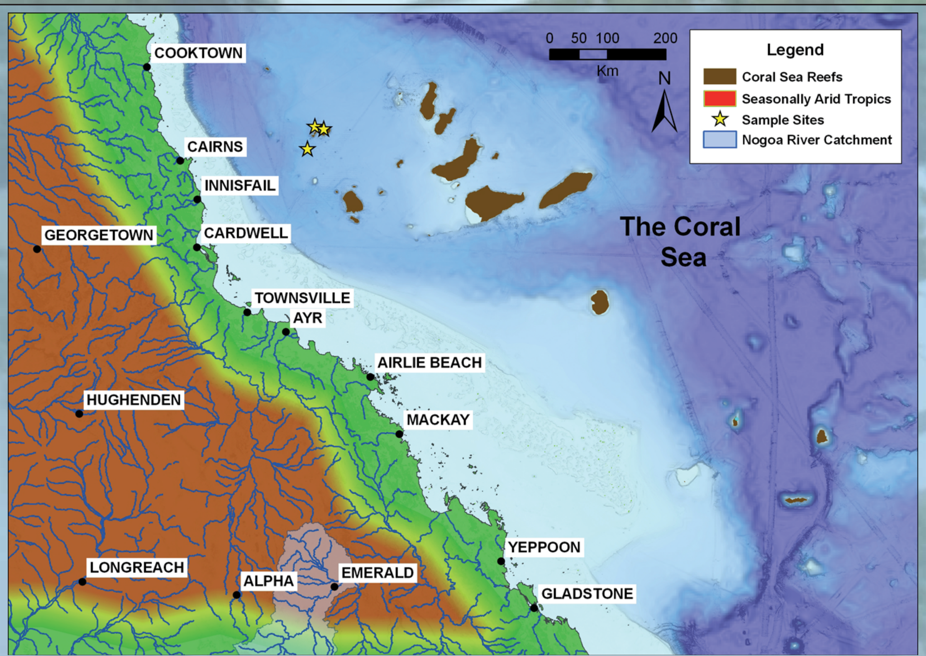

Figure 1: Location map of Coral Sea Reefs & Cays, sample sites and the region defined as the seasonally arid tropics

● In 2010/2011, similar rainfall patterns were experienced in Queensland, New South Wales, Victoria, South Australia and the Northern Territory, covering most of eastern Australia.

● Within the seasonally arid tropics of Queensland, rainfall patterns follow either the southward migration of the Inter-Tropical Front and / or the development of cyclonic activity.

● A study of BOM cyclone records and associated rainfall patterns[1] revealed that cyclones crossing the northeast coast Queensland coast, originating in the Coral Sea, have the largest overall impact on rainfall patterns throughout the state. (Figure 1).

● The structure and composition of corals' aragonite skeleton provides a surrogate record of the environmental conditions in which the coral has grown. Due to the longevity of massive corals, many different palaeoclimatic tracers within the skeletal matrix of these corals are used to evaluate past climates[2].

2. Methods and Results

● In October 2010, seven samples of *Porites lutea?* were obtained from the Flora Reef, East Holmes Reef and West Holmes Reef 190-220 km offshore in the Coral Sea (Figure 1 & Figure 2)[3].

● The sampling sites had low coral cover over predominantly juvenile corals, thus these samples were collected from small communities, at depths ranging from 11 m to 32 m depth (Table 1).

● The seven samples were all bleached to remove soft tissue, halved longitudinally, and a 2 mm slice was taken from the centre of each core. These slices were X-rayed and both viewed and photographed under ultraviolet light (Table 1 & Figure 3).

Figure 2: Core sample collection (Photo: Faichney 2010)

	01TC01	01TC02	02TC03	02TC04	03TC05	03TC06	03TC07
Site	Holmes West	Holmes West	Holmes East	Holmes East	Flora	Flora	Flora
Date	24/10/10	25/10/10	25/10/10	25/10/10	27/10/10	27/10/10	27/10/10
Depth	7.3 m	11.2 m	10.4 m	6.3 m	17.0 m	10.2 m	7.2 m
Length	100 mm	105 mm	90 mm	130 mm	105 mm	95 mm	90 mm
Lum. Bands	23	10	12	23	15	16	18
X-Ray Bands	27	11	15	27	17	18	16

Table 1: Core sample collection data

● Analysis of the coral core slices under UV light revealed that four of the seven samples (01TC01, 02TC03, 03TC05 and 03TC06) exhibited luminescent bands (Figure 3a).

● Each of the four samples showing luminescent bands reveal a brighter band approximately half way down each core (marked in red in Figure 3a). For each sample, this higher luminescent band is the eleventh band from the live surface of the core.

● Eleven years before sample collection in October 2010 corresponds with the wet-season of 1998/1999, when Cyclone Rona (System au199899_09u) passed directly over the Holmes Reefs (Figure 4).

● X-Ray images of the core slices reveal density bands for each core including the cores without luminescent bands (Figure 3b).

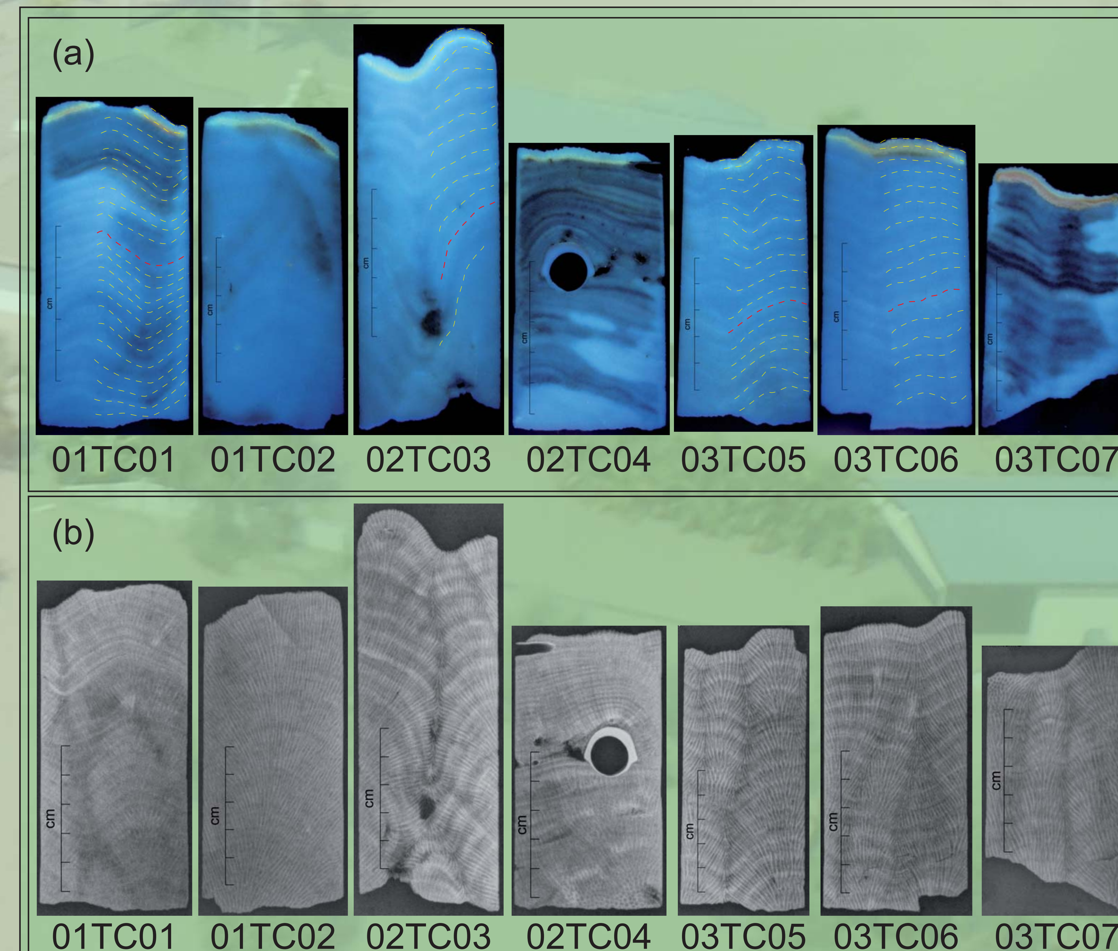

Figure 3: Core slices showing growth bands: (a) the UV spectrum reveals a luminescent proxy for freshwater influence, marked in yellow, and (b) the X-Ray spectrum reveals density banding

3. Discussion

● The timing of the bright band that is present within four of the samples is consistent with these bands being markers for the elevated freshwater input of rainfall associated with cyclone Rona. Figure 4 shows the path of the cyclone passing directly between the two Holmes Reefs, and immediately north of Flora Reef.

● Thus far, studies of luminescent coral banding as a proxy for freshwater influence[4] within Queensland have largely been restricted to the coastal riverine flows within the Great Barrier Reef[5,6,7,8].

● By utilising the same techniques[2] for coral communities on reefs and cays within the distal Coral Sea, riverine and other terrestrial influence can be discounted. In this way, freshwater anomalies within the coral communities are most likely associated with rainfall from major tropical storm cells such as cyclones.

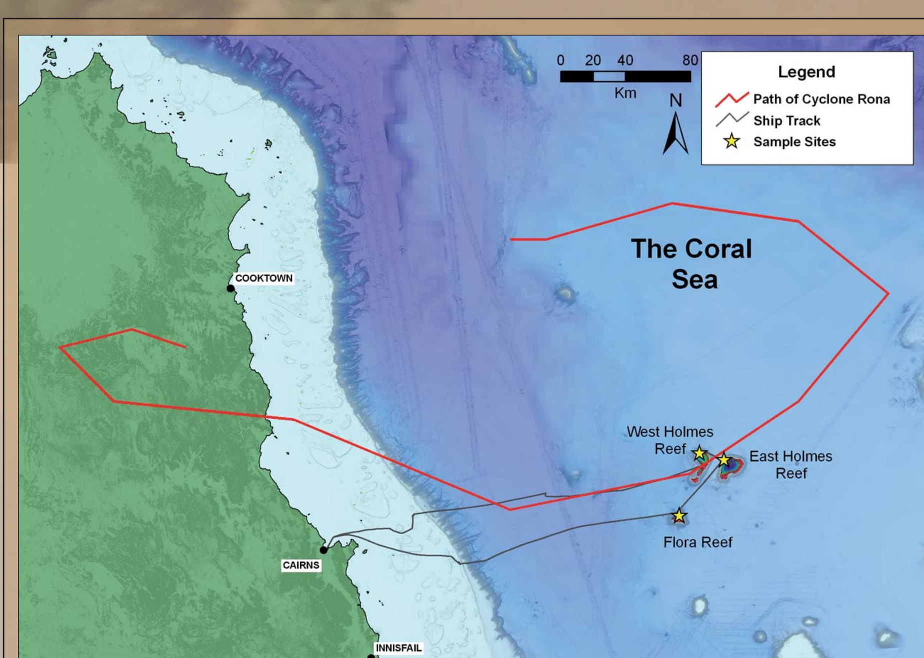

Figure 4: Relative positions of the cruise ship track sample site locations and the path of Cyclone Rona

● The double luminescent band that corresponds with cyclone Rona indicates that this proxy is a valid tool for recognition of past large rainfall events offshore, distal of riverine and onshore influence. The four samples that record the double bands were collected from 7.3, 10.4, 17 and 10.2 metres of depth, indicating that the freshwater rainfall plume from a cell such as cyclone Rona has an influence within the top 20 m of the water column, meaning that samples collected down to a depth of 20 m are applicable as a proxy.

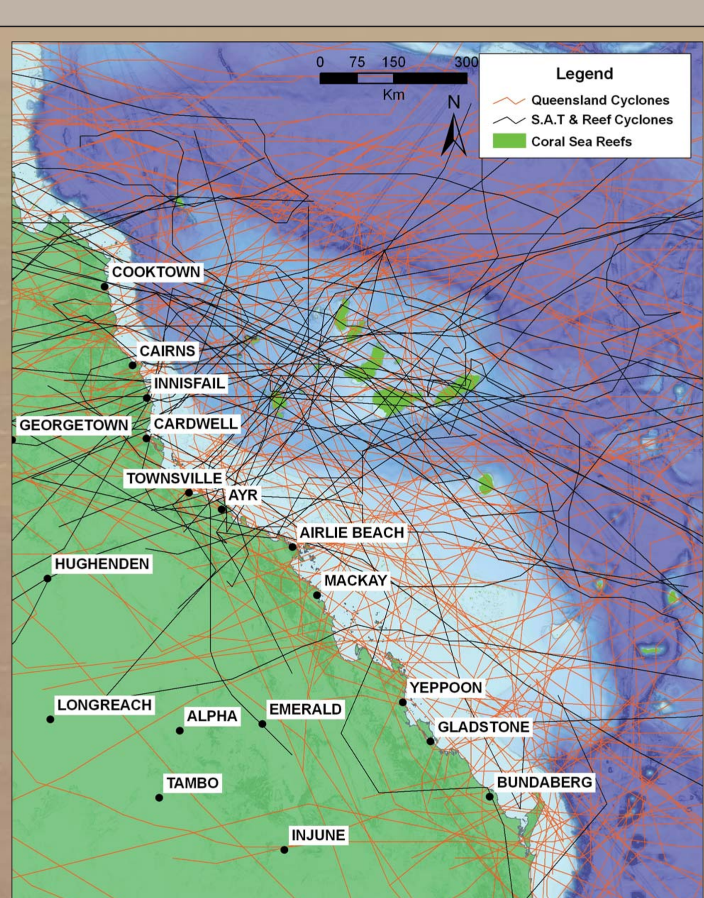

Figure 5: Named storm tracks originating in the Coral Sea are marked in grey, with storms that both cross Coral Sea reefs or cays and move into the seasonally arid tropics marked in black

● The Coral Sea represents a major source of cyclones for the interior of Queensland[1]. More significantly, 19% of the named cyclones crossing the Queensland coast (orange lines) both cross over the reefs and cays of the Coral Sea and cross into the seasonally arid tropics (Figure 5).

● In addition to named storms, tropical rain depressions that do not intensify into cyclones, are not recorded and thus are not considered within this track map, but may still move to the Queensland interior and impact on industries and communities. These systems also provide large freshwater inputs to the reef and cay environments and should also be picked up via proxy analysis.

● Subsequently, these reefs and cays provide a virtually untapped resource for proxies of extreme rainfall events that impact on the seasonally arid tropics, a region where extreme flood events have crippled towns and industries over within recent years.

4. Conclusions and Future Research

● Bright luminescent bands within coral cores are shown to act as a proxy for the significant influence of freshwater associated with storm activity within the growth regime of corals

● Whilst proxies and surrogate measurements such as these are blurred by proximity to the mainland influence in the form of riverine runoff and resultant freshwater plumes, when used on offshore reefs, they can provide another means of analysis of cyclones and rainfall cells.

● Coral geochemistry analyses reveal various proxies of the oceanic water within which the corals developed, including δ18O[9] and Sr/Ca ratios[10]. When combined, these two proxies can be used to reconstruct proxies of evaporation and/or precipitation[11,12].

● It is important to note that whilst visual analysis methods were used in this study, any analysis of coral cores in order to add to historic rainfall records would require quantitative methods[4,13,14,15].

● Further analyses are being undertaken to determine possible discrepancies in the sampled corals, including why some samples do not show luminescent bands (Figure 3a), and comparative analyses of quantitative methods to define an index for these records as a rainfall proxy.

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