IMPACT OF DROUGHT ON SEDIMENT FLUXES ENTERING THE INNER GREAT BARRIER REEF

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Australia is in the midst of a major drought with many areas having less than 10% to 30% of normal seasonal rainfall (Bureau of Meteorology rainfall data to August 2002). Although the main focus of public attention has been on the loss of agricultural related GNP, equally devastating impacts may soon occur in the GBR. Depending on the character of drought-breaking floods, major increases in suspended sediment loads can be anticipated in river runoff from the two largest river systems that drain into the GBR, the Fitzroy and Burdekin Rivers. These rivers have large semi-arid catchments and hence are particularly susceptible to large-scale erosion due to loss of groundcovers and chronic overstocking that inevitably occurs during periods of drought. What is the likely impact of drought-breaking floods on the GBR?

High-resolution Ba/Ca studies of inshore corals now provide insights into this question. Barium is desorbed from fine grained particles in the estuarine mixing zone, and then advected in river flood plumes and finally partitioned into the coral skeleton. Coral records from Havannah Island reef study site thus show that suspended sediment loads in drought-breaking floods can be 2 to 3 times greater than in floods that occur during non-drought periods. Prominent recent examples include the drought-breaking floods of 1927, 1936, 1968, 1970 and 1988. In contrast, prior to European settlement, the coral record indicates that floods generally carry 0.1 to 0.2 lower concentrations of suspended sediment. The only significant events which are registered in the coral are the drought breaking floods of 1761, 1765, and smaller events in 1795 and 1801.

The five to tenfold increase in suspended sediment entering the inner GBR since European settlement is likely to have major ecological consequences. The Burdekin River typically carries $\sim 10^7$ tonnes of sediment of which $\sim 10^6$ tonnes of fine grained clays will remain entrained in the flood plume and be dispersed to the inner/mid shelfs. A portion of this is likely to be carried directly to mid-reef sites such as Rib and Britomart.. In the inner shelf, supply of sediment available for later resuspension by wind/wave action will also be replenished. This is important as northward current flows of $\sim 0.1 ms^{-1}$ means that such material has only a limited residence time (1-2 years) in Cleveland and Halifax Bays. Coastal progradation in Bowling Green and Upstart Bays will be disproportionately low, as this is mainly controlled rates of sand accumulation, most of which still remains in river channels. Fluxes of total P (90% particle bound) and to a lesser extend N (~40% particle bound) will increase, although particulate P is not released directly into solution, requiring a more protracted cycle of anoxic reduction. Terrestrial runoff into coral reefs needs to be reduced, especially following droughts, if corals are to survive the dual impacts of direct anthropogenic disturbance and coral bleaching due to unusually warm ocean temperatures.

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Geochemical Tracing of Human Impacts on Coral Reefs

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Coral reefs are under threat from both direct human impacts such as high nutrient loads from erosion of soils and fertilizers as well as from climatic stresses such as cyclones and unusually warm ocean temperatures. In 1997-98, exceptionally warm global sea surface temperatures caused widespread. The effects were compounded by the inability of many coral reefs to regenerate due to algal blooms from high levels of nutrients. As a consequence coral cover has decreased globally by ~30% during the past several decades and in some places such as the Caribbean by up to 90%. The dilemma is that by the time clear-cut evidence is found for ecological impacts, a largely irreversible 'phase shift' and large-scale degradation of the reef has occurred. For this reason long-term quantitative records of environmental change are required to decipher man-made impacts from natural variability.

Based on the relatively new technique of high resolution (weekly to fortnightly) laser ablation ICP-MS, continuous scans of the trace element compositions were undertaken on 300-400 year old carbonate coral cores (growth rate of ~1-2 cm per year) from the Great Barrier Reef (GBR) of Australia. During high intensity rainfall events, there are massive discharges of freshwater and suspended sediments into the GBR lagoon. A longstanding and still highly controversial question is how has the water quality changed within the GBR lagoon since European settlement? Ba/Ca ratios in corals, a tracer of suspended sediment load, reveals two distinctive patterns. During the 1770's when Captain Cook first explored the east coast of Australia, there is only limited evidence for flood-plume related suspended sediment fluxes entering the inner GBR. However, immediately following European settlement in 1870, there is a sustained increase in the Ba/Ca ratios during flood events. This is indicative of a significant increase in suspended load being delivered to the inner GBR, coincident with the first grazing activities by European settlers in the river catchments of the GBR. These results therefore provide unequivocal evidence for substantially increased fluxes (x4 to x8) of suspended sediment and hence nutrient fluxes to the inner GBR reef. Sediment fluxes are modulated by land-use intensity and climate, principally droughts. Following the drought of 1968/69, the suspended sediment load increased x3 during the subsequent 1970 flood, presumably due to enhanced erosion of the highly denuded catchments.

This study provides both a 'natural' pre-European baseline as well as a quantitative measure of anthropogenic fluxes against which reduction of sediment loads to the GBR can be targeted. This is essential if coral reefs are to survive the lethal combination of direct anthropogenic impacts and rapid climate change.

CORAL RECORD OF RIVER RUNOFF AND HUMAN IMPACTS ON THE INNER GREAT BARRIER REEF OF AUSTRALIA

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The impact of European settlement on water quality in the Great Barrier Reef (GBR) of Australia is a longstanding and still highly controversial issue. Studies of erosion and sediment transport in river catchments have shown substantial increases since European settlement; a consequence of large-scale modification of the river catchments from grazing, agriculture, mining and associated activities such as land clearing. The magnitude and scale of these anthropogenic induced changes and importantly their impact on the marine environment, however remains highly uncertain. Here we describe a new approach to assist in the quantification of both anthropogenic and natural (pre-European) sediment fluxes entering the GBR. This approach is based on the application of in-situ geochemical tracers in corals and has the advantage of providing a direct quantitative measure of the sediment/nutrient (P) fluxes that are actually reaching coral reefs.

Using the relatively new technique of high resolution (weekly to fortnightly) laser ablation ICP-MS, continuous scans of the trace element compositions were undertaken on 300-400 year old *Porites* coral cores (growth rate of ~1-2 cm per year) from the GBR of Australia. During high intensity rainfall events, there are massive discharges of freshwater and suspended sediments into the GBR lagoon, particularly from the Burdekin River. Barium concentrations in corals, a tracer of suspended sediment load, reveals two distinctive patterns. In the 1770's when Captain Cook first explored the east coast of Australia, there is only limited evidence for flood-plume related suspended sediment fluxes entering the inner GBR. However, immediately following European settlement in 1870, there is a sustained increase in the Ba during flood events. This is indicative of a significant increase in suspended load being delivered to the inner GBR, coincident with the first grazing activities by European settlers in the river catchments of the GBR. These results therefore provide unequivocal evidence for river flood-plumes transporting substantially increased fluxes (x4 to x8) of suspended sediment and hence nutrients into the inner GBR reef. Sediment fluxes are modulated by land-use intensity and climate, principally droughts. Following the drought of 1968/69, the suspended sediment load increased x3 during the subsequent 1970 flood, presumably due to enhanced erosion of the highly denuded catchments. In the 1970's and 1980's sediment loads in the Burdekin River further increased following the introduction of more drought resistant cattle breeds such as *Bos indicus*.

This study provides both a 'natural' pre-European baseline as well as a quantitative measure of anthropogenic fluxes against which reduction of sediment loads to the GBR can be targeted. Reducing terrestrial runoff into coral reefs is essential if they are to survive the lethal combination of direct anthropogenic impacts and now climatic stresses from unusually warm ocean temperatures.