Australian Government
Department of the Environment, Water, Heritage and the Arts

Marine and Tropical Sciences Research Facility Milestone Report, April 2008

Program 7: **Halting and Reversing the Decline of Water Quality**

Project 3.7.2: **Connectivity and risk: Tracing materials from the upper catchment to the reef**

Project Leader: **Jon Brodie, Australian Centre for Tropical Freshwater Research (ACTFR), James Cook University**

Part 1: **ANU and JCU Component**

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Results

Coral coring – Townsville to Cairns region

A coral core from Dunk Island which was collected in 1988 has been analysed by laser ablation ICP-MS. Preliminary results are presented in Figure 1. The Sr/Ca ratios provide a proxy of sea surface temperatures and the peaks and troughs in the record coincide with winter and summer respectively, although in Figure 1 the scale has been reversed so that the summer values represent the peaks. The Sr/Ca ratios display strong seasonality allowing a robust chronology to be developed. The Ba/Ca record provides a proxy of sediment export from the nearby Tully River. The peaks in the Ba/Ca ratios generally coincide with the summer months from the start of the record up until ~1980; thereafter there is an upward shift in the ratios and the peaks do not coincide with the summer months (but typically occur in winter/spring). In other parts of the GBR such as the Whitsunday Islands, the peak Ba/Ca ratios also do not coincide with summer and thus appear not to be directly associated with high river discharge events (see Lewis *et al.* 2009: MTSRF Milestone Report for Project 3.7.2 Objective [c]). Several reasons have been postulated for the non-summer Ba/Ca ratio peaks including trichodesmium blooms, incorporation of barite in phytoplankton blooms, coral spawning or release from mangrove sediments during higher spring tides (see Sinclair 2005; Alibert *et al*. 2003).

Another possibility is that the bulk of sediment discharge in the Tully River may occur in the later months following abnormal spring rainfall events. Normally the discharge from the Tully River in summer flow events has suspended sediment concentrations at ~20 mg/L (see Faithful et al. 2008), although in September 2007, abnormally high rainfall occurred in the Tully catchment and the Tully River contained much higher suspended sediment concentrations (V. Veitch pers comm., 2007). The cause of this high sediment is probably related to the newly cultivated bare-ground paddocks prior to planting and green cane trash blanketing. Historical land use change records will be investigated to help better interpret the Ba/Ca record.

A long coral core collected from Dunk Island with a growth record spanning back to the 1800's will be analysed and new cores will be taken from this region in 2009. These cores will provide valuable insights into the disturbance regime that these reefs have endured and also examine changes in

sediment and nutrient export from the Tully River due to past land-use change. Extensive coral mortality/bleaching were observed around Dunk Island and the Family Islands Group in March 2009, following prolonged flooding in the region that caused lowered salinities and elevated suspended sediment, nutrient and herbicide concentrations which also coincided with relatively high water temperatures (K. Fabricius pers com., 2009; M. Devlin pers comm., 2009). Coral geochemical records from this flood event will be correlated with water quality datasets collected by the Australian Centre for Tropical Freshwater Research, JCU for the Great Barrier Reef Marine Park Authority Marine Monitoring Program.

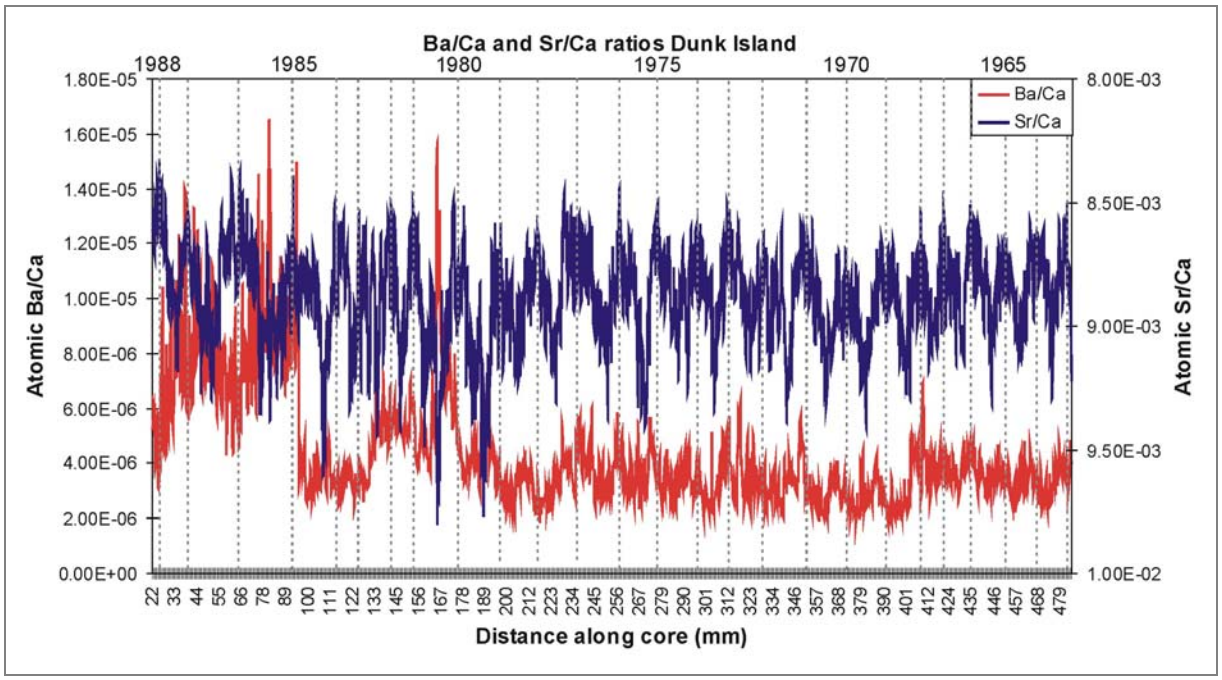

Figure 1: Coral Sr/Ca and Ba/Ca ratios from a coral core collected from Dunk Island. The Sr/Ca data display excellent seasonality and the peaks (actually troughs - note inverse scale) coincide with summer. A large shift in the Ba/Ca data occurs shortly after 1980 and then ~1985 where after this time, Ba/Ca peaks appear to not coincide with river discharge events.

Changes to planned project activities

A new Post Doctoral staff member Dr Jennie Mallela was appointed commencing in February 2009. For the 2009 period she will work on the MTSRF project in the Hinchinbrook to the Dunk Island region. Dr Mallela has begun working on laser ablation of the Dunk Island cores. Preliminary findings are presented here, further results will be forthcoming.

Due to the January and February 2009 floods collection of coral cores has been delayed until later in the year. It is hoped that the 2009 flood signals will be incorporated into the coral cores that will be collected later in the year.

Part 2: JCU Component

Task Leader: Jon Brodie
Australian Centre for Tropical Freshwater Research, JCU

Results

Preliminary results from suspended sediment tracing in the Burdekin catchment

Encouraging results have been received for the sediment tracing component of Project 3.7.2. Selected samples from major sub-catchments of the Burdekin River were analysed for Sr, Nd and Pb isotopes at the University of Queensland's Centre for Microscopy and Microanalysis and for Rare Earth and Yttrium (REY) trace element distributions. The results clearly show distinctive signatures in the isotopic composition of suspended sediments exported from the Upper Burdekin, Cape, Suttor and Belyando Rivers (Figure 2a-b). Three distinctive groups cluster out in the various isotopic analyses including the Upper Burdekin, Bowen-Suttor and Belyando-Cape. Both the Bowen-Suttor and Belyando-Cape catchments border each other and have overlaps in the geological materials associated with each catchment. This would explain these groupings. The lead (Pb) isotopes reveal possible sources for the material in the Burdekin Falls Dam overflow with the dam sample having a similar signature to the Upper Burdekin catchment and a possibly minor contribution from the Cape and/or Belyando catchments. The rare earth elements and yttrium (REY) distribution patterns also reveal distinctive catchment fingerprints in the Burdekin sub-catchments. The REY plots (normalized to the mud from Queensland composite shales: MUQ) reveal changes between the light rare earths (e.g. La, Ce, Pr) to the heavy rare earths (e.g. Tm, Yb, Lu). For example, most of the samples display patterns where the lighter rare earths (REE) are relatively more enriched to the heavy REE; however, the Belyando River is an exception being enriched in the heavy REE. In addition, subtle changes also appear between singular REE including La, Ce, Y/Ho and Eu which are termed anomalies. These anomalies also provide valuable information to directly trace these suspended sediments. We note that, while very promising, these trace element and isotope results are very preliminary data and more analysis is required to develop strong fingerprints within the Burdekin River catchment. A further batch of samples are being prepared for mineralogical, trace element and isotope analyses. We also note that particle size analysis has also revealed interesting trends between the Burdekin catchments and has been reported in previous MTSRF milestones.

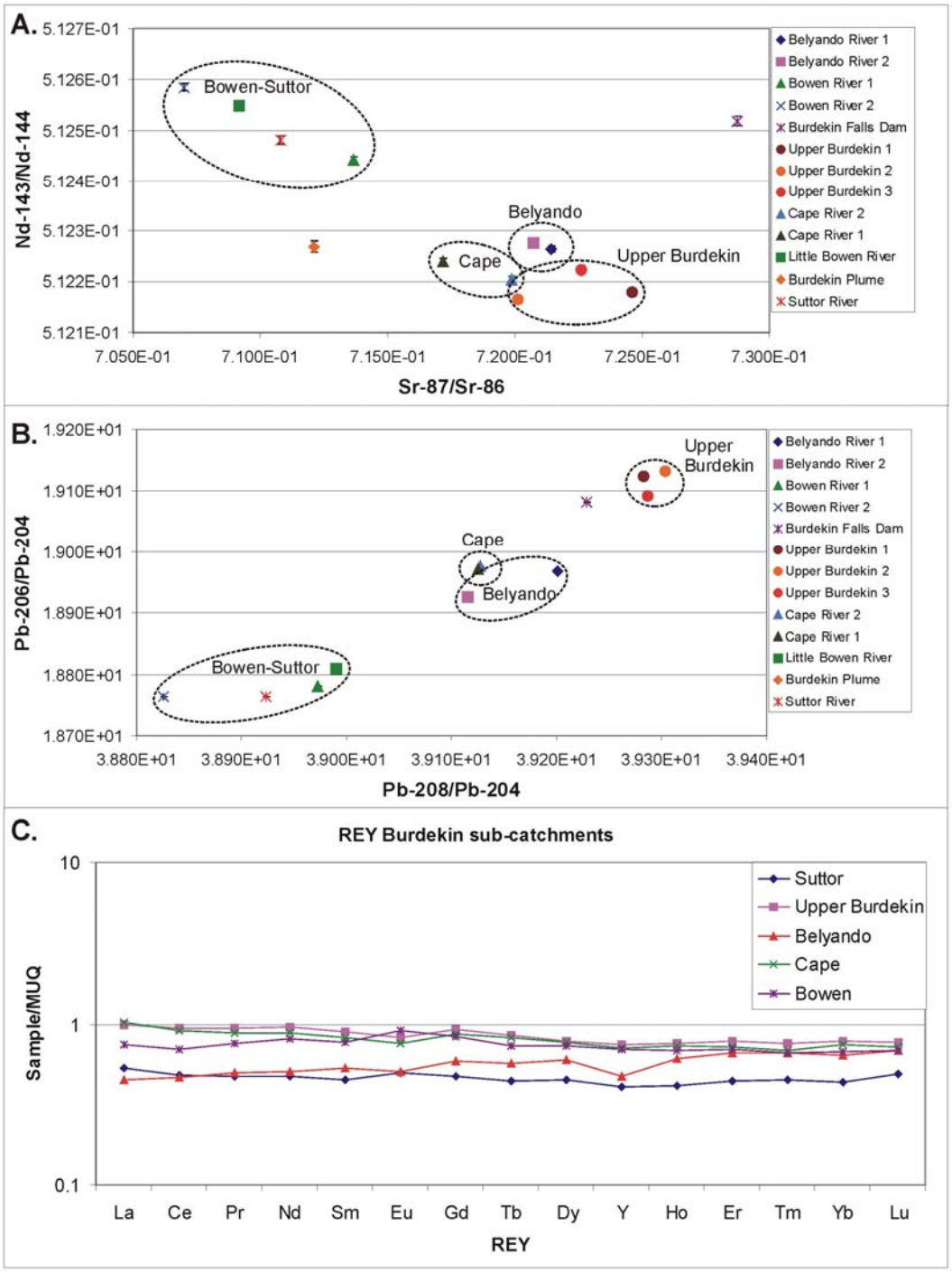

Figure 2: Sr to Nd isotope (a) and Pb isotope (b) analyses on suspended sediment samples from the Burdekin River catchment. The isotopes clearly distinguish three clusters in the Burdekin catchments including the Upper Burdekin, the Cape/Belyando and the Bowen-Suttor. The REY distributions normalized to the mud from Queensland (MUQ) composite shale standard also reveal distinctive trends between the sub-catchment including bulk REY patters and abundances (e.g. light versus heavy REYs – left to right). In addition, subtle changes in the anomalies of particular rare earth elements such as Eu, Ce, La and Y/Ho also reveal differences between the catchment sources.

Event-flow sampling in the Burdekin River catchment 2008/2009

Large flows occurred in the Upper Burdekin catchment in the 2008/2009 wet season resulting in widespread flooding in the catchment area. The Burdekin River at the inland Flinders Highway crossing (Sellheim) peaked at 6 m over the bridge level (river level of 20.5 m – equal third highest on record) and the Burdekin Falls Dam peaked at 6.6 m above the spillway (second highest on record). Over 300 water quality samples were collected by ACTFR staff and volunteers within the Burdekin River catchment including 78 samples from the Burdekin Falls Dam overflow (with more to come) and 52 major sub-catchment samples (i.e. Burdekin River at Inkerman Bridge, Burdekin River at Sellheim, Cape River at Gregory Developmental Road, Belyando River at Gregory Developmental Road, Suttor River at Bowen Developmental Road and Bowen River at Bowen Developmental Road). These data will provide a valuable fourth and final year set to assess the trapping capacity of the Burdekin Falls Dam and to develop a sediment load budget for the Burdekin River catchment. A field trip to the Burdekin Falls Dam was conducted when the dam was ~3.4 m over the spillway to examine the homogeneity of the suspended sediments throughout the dam reservoir. A transect of suspended sediment samples were collected across the dam reservoir and a series of samples were also collected at varying depths in the dam. This research will provide quality assurance to quantify the uncertainties in load calculations. A sub-set of approximately 80 samples from the Burdekin catchment area were analysed for particle size distribution and another batch of samples prepared for X-ray diffraction analysis (to analyse mineralogy of the clay minerals). A total of 6 pesticide samples were collected from the Burdekin sub-catchments to continue the preliminary analysis of tebuthiuron and atrazine residues in the Burdekin Rangelands.

Three separate marine sampling trips occurred to sample the freshwater plume generated from the Burdekin River. A total of 22 water samples were collected including six large volume (50-100 L) water samples to recover the suspended sediments for trace analysis. These samples are currently being recovered by evaporation, although it will be some time before they can be analysed given the large quantify of water being evaporated. In addition, approximately 60 samples were collected for trace metal analysis in both catchment and river plume samples.

Plan of communication outputs and products for year three and summary of any liaison activities

We have produced several outputs/products for year three of the project. A paper on pesticide runoff to the Great Barrier Reef has been accepted in the journal Environmental Pollution entitled ‘Herbicides: a new threat to the Great Barrier Reef’. This paper received favorable reviews and available online as an article in press. A technical report based on this research has also been submitted to MTSRF. Another paper (Pesticide residues in waterways of the lower Burdekin region: Challenges in ecotoxicological interpretation of monitoring data) has been accepted in the Australasian Journal of Ecotoxicology. A draft report on the sediment trapping capacity of the Burdekin Falls Dam has been submitted with some further work required to finalise the manuscript. Once the 2008/2009 sampling results relating to the dam trapping have been processed, a scientific article will be prepared for submission in 2009. A refereed conference proceedings paper on the Burdekin Falls Dam trapping (entitled: Modelling and monitoring the sediment trapping efficiency and sediment dynamics of the Burdekin Falls Dam, Queensland, Australia) has been submitted for the upcoming MODSIM conference in Cairns, July, 2009. This paper was written with collaborative links with Dr. Brad Sherman, CSIRO Land and Water, Canberra, and Dr. Michelle Cooper, Geoscience Australia.

Problems and opportunities

There have been some problems relating to the recovery of sediment samples for mineralogical, trace element and isotope analysis. To avoid contamination issues, the suspended sediment samples need to be recovered by evaporation in an oven set at 50 degrees Celsius. To evaporate off several litres of water takes several weeks and also there is only limited space in the oven. Therefore samples are being prepared in batches of 20-30 at a time.

Communications, major activities and events – during milestone reporting period

We have produced two MTSRF reports on Burdekin Falls Dam sediment trapping and herbicides in the GBR. We have also published a paper on herbicides in the GBR catchment area and lagoon (Environmental Pollution – article in press) and plan to communicate these results extensively.

Communications, major activities and events – during next milestone reporting period

We plan to submit a scientific paper on the results of the Burdekin Falls dam trapping component of MTSRF Project 3.7.2. A presentation and conference paper will be presented at the upcoming MODSIM conference in Cairns in July, 2009. A regional paper reporting sediment sourcing/delivery in the Burdekin River catchment is also being prepared.

Data from the pesticide tracing study will be presented at the 2009 MTSRF conference. Dr Stephen Lewis has also been asked to present the results from the MTSRF pesticide tracing study at an upcoming GBR pesticide workshop being held in May 2009 (Cairns) entitled 'Minimising off-site movement of pesticides and impacts on the Great Barrier Reef'. This workshop is being held jointly by Land and Water Australia, CSIRO, James Cook University, the Australian Government and the Queensland Department of Natural Resources and Water.

We plan to communicate MTSRF research within Project 3.7.2 to Burdekin graziers and sugar cane growers at Landcare and grower group meetings, including the BSES 'GREAT' day.