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GREAT *Barrier Reef Marine Park sedimentology revealed*

New research into inter-reefal environments will assist reef managers

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Geoscience Australia has completed a detailed spatial analysis of seabed environments in the Great Barrier Reef (GBR) Marine Park. The analysis was based on a new dataset of more than 3000 samples, which is accessible online from Geoscience Australia's marine samples database.

The results, to be published later this year (Mathews & Heap 2006), represent the first regional assessment of postglacial sediments across the entire GBR since Maxwell's pioneering work in 1968, and provide the first quantified comparisons in a spatial framework. The information can be used by managers and planners to make better decisions in Australia's highest profile World Heritage Area.

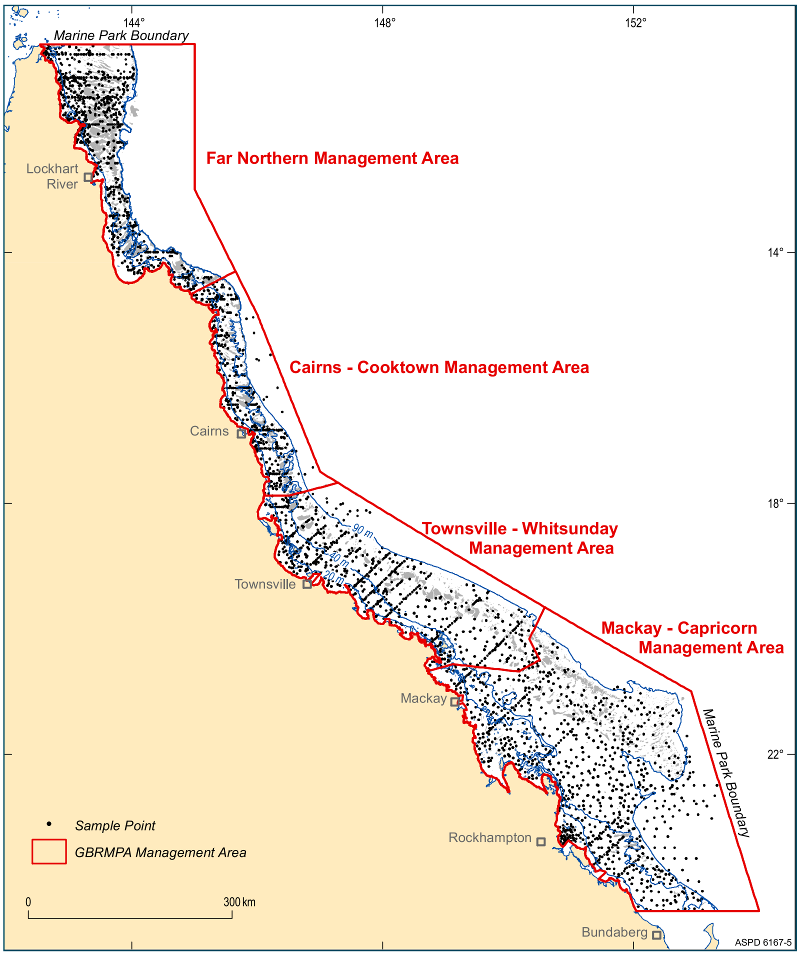

Figure 1. Location of samples collected within the Great Barrier Reef Marine Park.

Spatial study

A quantitative spatial study of the seabed sediments comprising inter-reefal environments gives important clues about the sources of sediment, their relative influence on GBR ecosystems, and sediment distribution by hydrological processes.

The study also contributes to our understanding of the evolution during the past 18 000 years of the northeast Australian margin, the largest tropical mixed siliciclastic–carbonate margin on Earth and the modern type case used to compare ancient rocks from similar environments elsewhere on the Earth.

Inter-reefal environments cover 327 950 square kilometres or 95% of the total area of the GBR Marine Park but are much less studied than the reefs. They form a connected network of habitats that support a wide range of biological communities in addition to the reefs (Chin 2003). Spatial changes in the composition and texture of seabed sediments help to characterise the benthic environments covered by the existing GBR Marine Park planning scheme.

Table 1 Calculated area of % sediment concentrations in the Great Barrier Reef Marine Park

Sediment attribute	km^2	Per cent
Gravel %		
0–20	196,050	56.8
20–40	23,100	6.7
40–60	8,400	2.4
60–80	3,000	0.9
80–100	2,500	0.7
Sum:	**233,000**	**67.5**
No data:	**112,150**	**32.5**
Sand %		
0–20	10,140	2.9
20–40	24,940	7.2
40–60	57,010	16.5
60–80	81,370	23.6
80–100	59,560	17.3
Sum:	**233,010**	**67.5**
No data:	**112,170**	**32.5**
Mud %		
0–20	120,190	34.8
20–40	59,050	17.1
40–60	33,640	9.8
60–80	14,400	4.17
80–100	5,730	1.7
Sum:	**233,020**	**67.5**
No data:	**112,160**	**32.5**
Bulk carbonate %		
0–20	14,580	4.2
20–40	28,680	8.3
40–60	43,310	12.6
60–80	66,170	19.2
80–100	86,560	25.9
Sum:	**239,300**	**69.3**
No data:	**105,880**	**30.7**
Carbonate sand %		
0–20	15,720	4.6
20–40	20,960	6.1
40–60	29,160	8.5
60–80	41,230	11.9
80–100	99,880	29.0
Sum:	**206,960**	**60.0**
No data:	**138,220**	**40.0**
Carbonate mud %		
0–20	16,800	4.9
20–40	34,870	10.1
40–60	36,130	10.5
60–80	39,400	11.4
80–100	50,660	14.7
Sum:	**177,870**	**51.5**
No data:	**167,310**	**48.5**
Marine Park total	**345,180**	**100.0**

* Calculations were made using Albers Equal Area Projection.

Largest sediment database

The study is based on more than 3000 surface sediment samples collected in the GBR Marine Park since 1984 and represents the largest sediment database assembled for any part of the shallow tropical Australian shelf (figure 1). Nearly half of the samples were collected between 2003 and 2005 by six regional surveys conducted by the Australian Institute of Marine Science and CSIRO for the GBR Seabed Biodiversity Project, a program run by the Reef CRC in Townsville. Geoscience Australia's contribution to this program was to produce a quantitative regional synthesis of the seabed sedimentology from a systematic analysis of the texture and composition of the samples. The new data are part of a fundamental national marine dataset maintained by Geoscience Australia.

Regional sedimentology

Previous work from the GBR shows that postglacial sediments are essentially made up of a mixture of calcium carbonate from the skeletal remains of marine organisms (molluscs, foraminifers, corals and algae) and siliciclastic sediments mainly derived from sources on land (Maxwell 1968, 1969; Maxwell & Swinchatt 1970; Flood & Orme 1988).

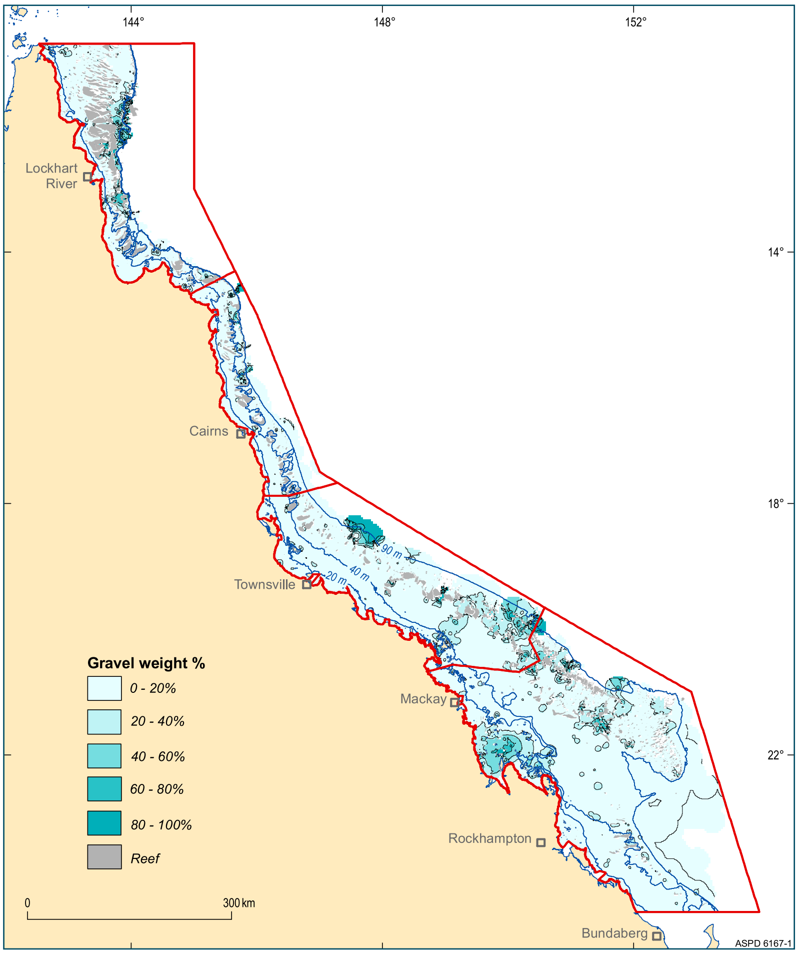

Figure 2. Map of the % gravel weight concentration in sediment.

The distribution of these two major components shows a cross-shelf variation wherein the siliciclastic sediments are restricted to the inner shelf regions close to the coast, and the carbonate sediments are dominant on the middle and outer shelves (Belperio, 1983).

This 'model' provided a useful regional framework for the current study, which adds essential detail by characterising the grain size of the bulk sediment and quantifying the areas of shelf comprising different proportions of gravel (>2 mm), sand (63 µm–2 mm), and mud (<63 µm) in both the bulk and carbonate fractions. The result is our most up-to-date representation of postglacial sediments for this margin.

Key findings

The GBR Marine Park is generally gravel-poor, with sediments comprising less than 20% gravel covering 196 050 square kilometres or more than 56% of the total marine park area (figure 2; table 1). Relatively high gravel concentrations (more than 40%) cover an area of 13 900 square kilometres (4% of total area), and are restricted to a few areas next to the outer-shelf reefs and in Broad Sound on the inner shelf.

Most of the sediment in the GBR Marine Park is composed of sand, with concentrations of more than 60% covering 140 900 square kilometres of the marine park, or more than 40% of the total area (figure 3; table 1). Sand concentrations show very high spatial variability across the marine park (much higher than previously reported) and are generally higher on the outer shelf and in the south. This high degree of spatial variability is also a feature of the carbonate concentrations and principally reflects the in situ production of carbonate by marine organisms.

Across the entire GBR Marine Park, mud concentrations above 60% cover 20 150 square kilometres (6%) of the marine park (figure 4; table 1). North of Townsville, mud comprises a relatively small amount of the middle and outer shelf sediments, with highest concentrations reaching 40% on the inner shelf. South of Townsville, similar mud concentrations occur only on the middle shelf, and extend into the Capricorn Channel.

Carbonate is the dominant sediment type, with concentrations above 60% covering 152 700 square kilometres (45%) of the marine park (figure 5; table 1). Concentrations increase from more than 20% near the coast to more than 80% on the middle and outer shelves. Concentrations of less than 20% occur in embayments north of the Burdekin, Pioneer, and Fitzroy rivers, which currently deliver the highest quantities of siliciclastic sediment to the inner shelf, and on the southern border of the marine park where siliciclastic sands are transported north into the park from Fraser Island and Hervey Bay.

> "This new study adds considerably more detail to the model of postglacial sedimentology for the northeast Australian margin"

A classification of sediment types has revealed that the Marine Park is dominated by gravelly, muddy sand, which covers 53 350 square kilometres or 16% of the marine park. Other common sediment types include gravelly sand and slightly gravelly, muddy sands, which cover 48 830 square kilometres (15%) and 46 650 square kilometres (14%), respectively. The most scarce sediment types include the gravels and muds, with muddy gravel covering 600 square kilometres and slightly gravelly mud covering 1100 square kilometres; both make up less than 1% of the total marine park area.

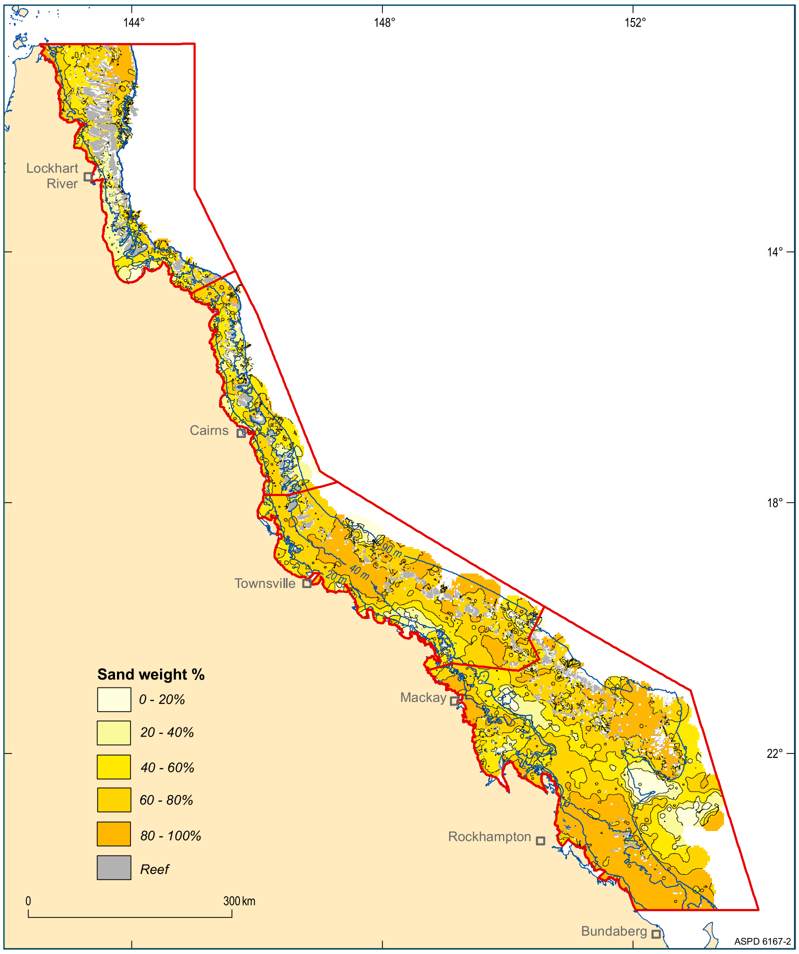

Figure 3. Map of the % sand concentration in sediment.

This new study adds considerably more detail to the model of postglacial sedimentology for the northeast Australian margin, specifically about spatial variability in the distributions of the sediment fractions. While there is a general increase in the carbonate content and a decrease in siliciclastic content across the shelf, as shown by previous studies, our results show that these across-shelf distributions are complex and do not hold for all parts of the margin. Overall, the texture and composition of postglacial sediments show strong correlations with the dominant sediment sources, with overprinting by hydrodynamic processes.

Applications for management

The spatial analysis of seabed sediment in the GBR reveals information about the texture and composition of inter-reefal seabed habitats and their variability. The GBR Marine Park is a unique natural environment of national and international significance, and its managers require detailed mapping to fully understand the nature of the seabed and its habitats. Our quantitative spatial analysis of the seabed sediment texture and composition, and the associated distribution

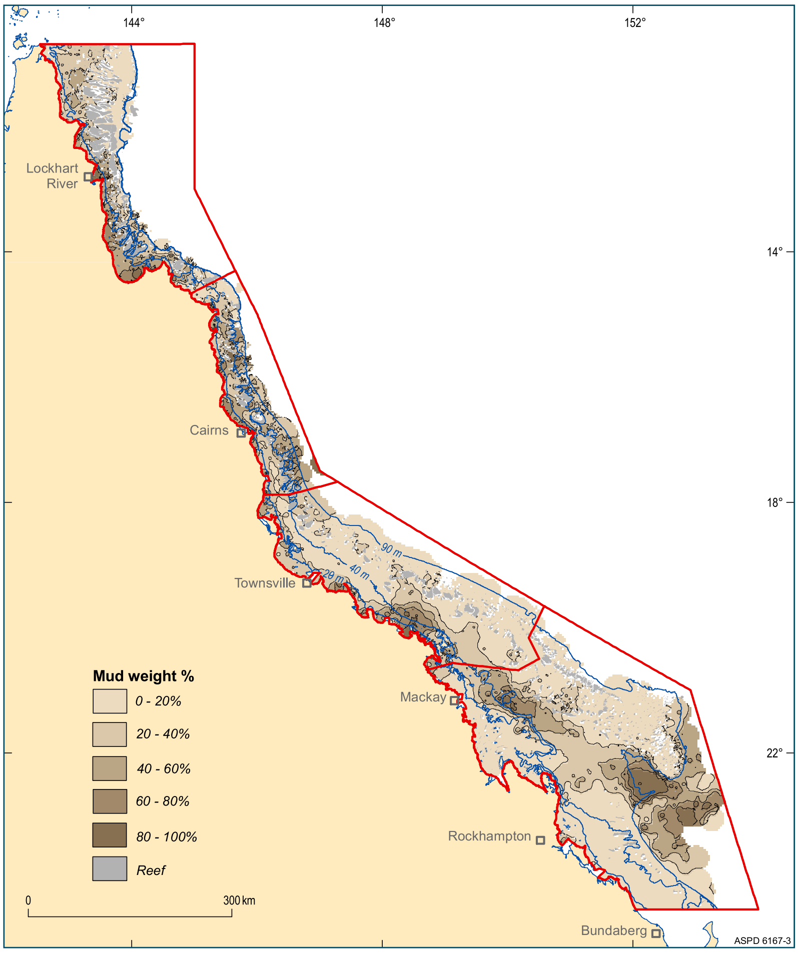

Figure 4. Map of the % mud concentration in sediment.

patterns, gives a systematic seabed classification. These data provide the best possible spatial information for marine park managers to make informed decisions and quantitative comparisons between areas of different habitat types in Australia's highest profile World Heritage Area.

"Our quantitative spatial information about seabed sediments provides a planning and management framework from which to assess new planning proposals in the GBR Marine Park, and to monitor habitats"

Assembled seabed sediment information provides a consistent and robust dataset that can be used to help characterise the different management zones making up the GBR Marine Park. Overall, seabed sediments range from gravel-poor with localised high gravel concentrations, to sediments with high sand and carbonate concentrations, and high mud with low carbonate concentrations. Together, this variability in surface sediments shows the potential range of inter-reefal seabed habitats and their physical characteristics. Seagrass meadows, mud and sand flats, and gravel and shoal bottoms are just some of the inter-reef habitats already identified.

The collection and mapping of seabed sediment samples has been undertaken as part of the GBR Seabed Biodiversity Project, which aims to form an inventory of the seabed's characteristics, such as sediment types and fish and invertebrate assemblages (Pitcher et al 2002). Seabed sediment data will be added to existing regional maps of the GBR Marine Park and will provide more detail to help managers conserve significant habitats and biological communities. In areas where biological information is not available, 'proxies' such as seabed sediments can help determine the relationship between physical environments and biology to predict biodiversity.

The main advantage of using sediment data is that they can be determined across broad regions, even in areas that lack biological data. Our quantitative spatial information about seabed sediments provides a planning and management framework from which to assess new planning proposals in the GBR Marine Park, and to monitor

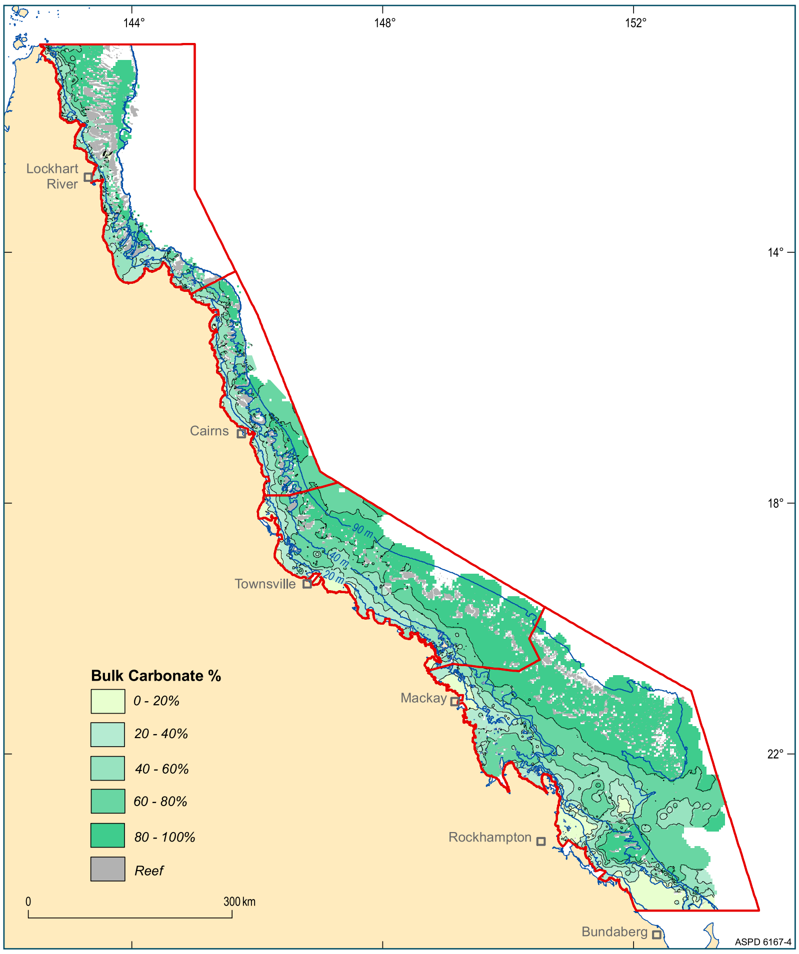

Figure 5. Map of the % bulk carbonate concentration in sediment.

habitats. This approach will improve marine park management and decision making. Further work, investigating the links between sediments, habitats and marine biota in general, is necessary for the conservation and appropriate future management of inter-reefal areas in the park.

The next stage of Geoscience Australia's work will be to characterise and quantify the spatial variability of sediments within the framework of the current GBR planning scheme. By revealing the texture and composition of different management zones, we provide vital baseline information that can be used to monitor potential changes to seabed habitats and biological communities.

Related website

Geoscience Australia's marine samples database
www.ga.gov.au/oracle/mars
link

For more information

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