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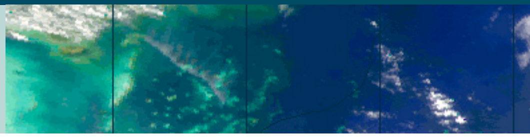
LET *there be light*

Turbidity modelling in Torres Strait explains seagrass dieback



Frederic Saint-Cast

More than 1400 square kilometres (equivalent to 175 000 football fields) of seagrass was lost between 1989 and 1993 in Torres Strait, where around one quarter of Australia's seagrass resources is situated.

Local islanders are concerned about widespread seagrass dieback because they believe it is causing declines in populations of dugong and turtles, which feed on the seagrasses. Seagrass beds also provide shelter for small fish and act as nurseries for fish and crustaceans such as crabs, lobsters and prawns, including many commercially important species.

Geoscience Australia scientists, working as part of the Torres Strait Cooperative, believe seagrass dieback is largely a response to low light levels, which have resulted from extended periods of elevated turbidity. Local communities in Torres Strait are concerned that seagrass die back has have been caused by increased sediment load from the Fly River in the Gulf of Papua since the opening of the giant Ok Tedi gold and copper mine in 1984 (figure 1).

Satellite images show that high turbidity is restricted to the south coast of Papua New Guinea (PNG) during the season of southeasterly trade-winds, and only extends into the northern Torres Strait during the northwesterly monsoon season.

Simultaneous measurements of turbidity and bottom light levels in Geoscience Australia Survey 266 and six months later in Survey 273 indicate that the seagrass resilience threshold was reached at the end of the monsoon but not at the end of the trade-wind season (figures 2a, b and c).

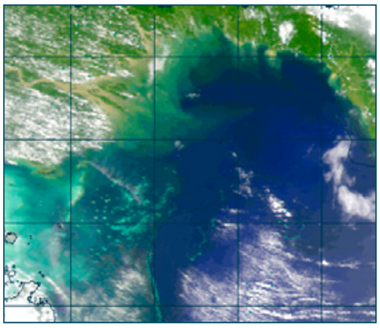


Figure 1. Satellite image of elevated turbidity in the Gulf of Papua.

Figure 2a. Bottom sediment grab – Geoscience Australia Survey 273.

Figure 2b. Water sample collection – Geoscience Australia Survey 273.

"Computer simulations show that sediment transport and turbidity in Torres Strait are controlled mainly by wind-driven currents"

Although we recognised the importance of seasonal changes in turbidity in seagrass dieback, our basic understanding of the sediment transport processes was hampered by the lack of information on water and sediment movements at the regional scale in Torres Strait and adjacent seas and gulfs.

For the first time, a computer simulation was developed to reveal sediment pathways throughout the complex shallow shelf

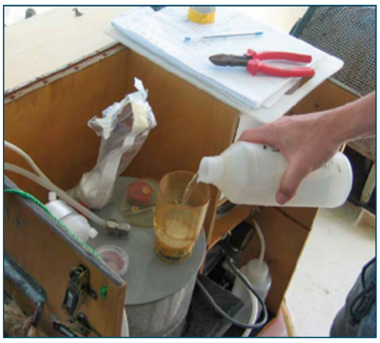


Figure 2c. Water sample analysis from Geoscience Australia Survey 273.

environment of Torres Strait, including the Gulf of Papua, the northern Great Barrier Reef and the northeastern Gulf of Carpentaria. A sediment dynamic model was embedded into a circulation model that incorporated realistic atmospheric and oceanographic forcing, including winds, waves, tides and large-scale ocean circulation. Calibrated simulations covered a hindcast period of eight years, allowing the tidal, seasonal and interannual flow characteristics to be investigated.

> "Seagrasses are able to recover from a few weeks of reduced light caused by elevated turbidity"

Computer simulations show that patterns of net sediment transport and turbidity in Torres Strait are controlled mainly by wind-driven currents associated with the trade-wind and monsoon seasons, even though instantaneous water movements are strongly dominated by the tide and its spring–neap cycle.

The fine sediments (<0.63 µm) responsible for the turbidity move back and forth through Torres Strait according to the strong seasonal conditions. These sediments tend to accumulate to the west of Torres Strait over the nine-month trade-wind season (March–November) while they are swept back to the east over the three-month monsoon period (December–February). Over the course of a year, the relatively stronger currents during the trade-wind season result in the predominantly westward transport of sediment (figure 3).

Seabed samples collected during our surveys confirm that sediment in Torres Strait is finer and more easily picked up by near-bed currents after the monsoon, while at the end of the trade-wind season the bed sediment is coarser and requires more energy to be resuspended (figure 4).

Although significant amounts of terrigenous sediment are delivered by the Fly River to the Gulf of Papua and the southern PNG coast, our computer simulations and field data indicate that there is no

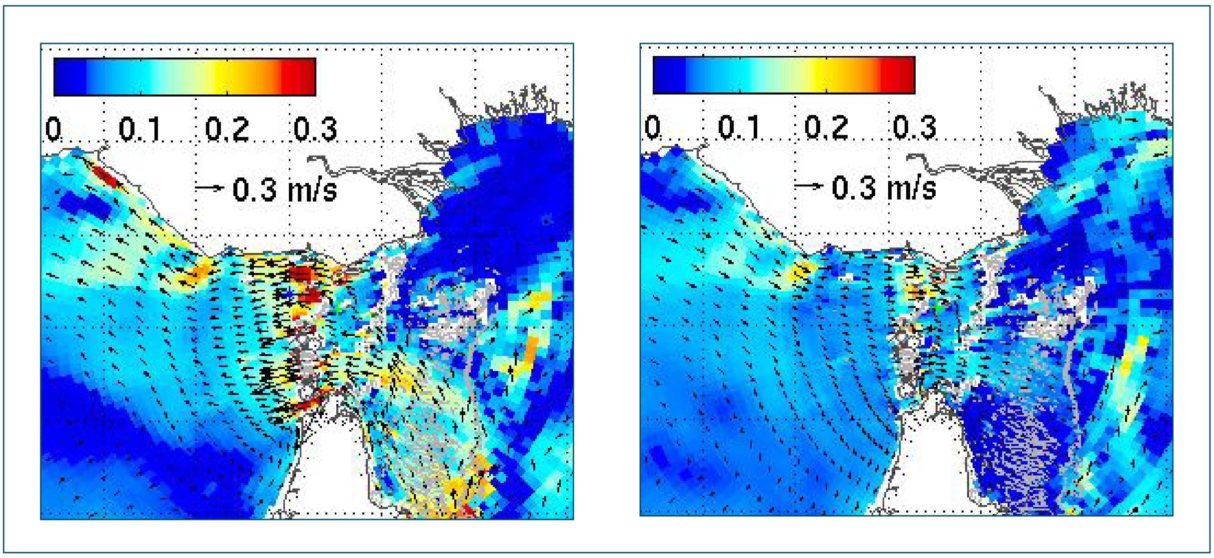


Figure 3. Computer simulation showing the regional flow pattern over the trade-wind season (left) and monsoon season (right). The simulation demonstrates that the flow through Torres Strait is strongly connected with the northern Great Barrier Reef.

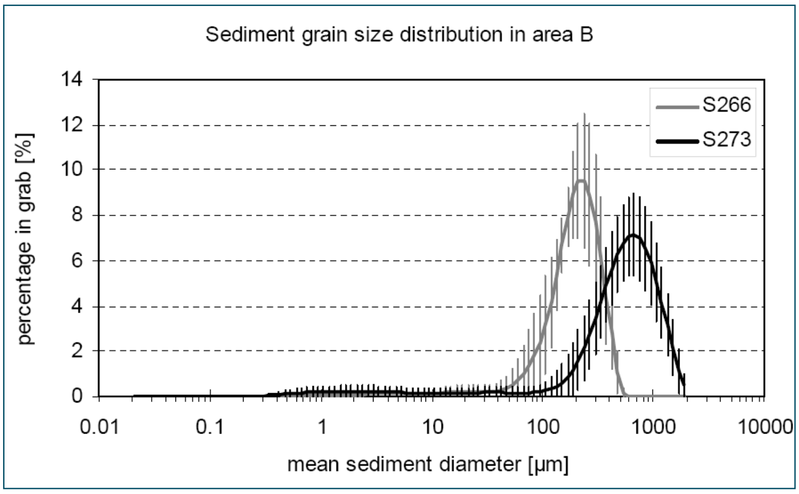


Figure 4. Comparison of sediment grain size distribution in Torres Strait following the monsoon season (Survey 266) and at the end of the trade-wind season (Survey 273).

significant connectivity between those regions and central Torres Strait. Instead, the model reveals that the flow in central Torres Strait strongly connects with the northern Great Barrier Reef.

Rather than increased sediment loads from PNG causing elevated turbidity in the strait, our results indicate that the turbidity is caused by the constant action of waves and tidal currents, which resuspend the bottom sediment in two major depocentres on either side of the strait.

During the trade-wind season, turbidity levels in Torres Strait decrease to a minimum because the relatively clear waters of the northern Great Barrier Reef gradually flush fine sediments to the west of the strait, where they settle in the northeast Gulf of Carpentaria. During the monsoon season, turbidity levels in central Torres Strait increase to a maximum, as fine sediment in the northeastern Gulf of Carpentaria is resuspended and transported eastwards into the strait.

Seagrasses are able to recover from a few weeks of reduced light caused by elevated turbidity, but beyond this resilience threshold they suffer irreversible damage. Over a number of trade-wind seasons, the amount of fine sediment that settles in the northeast Gulf of Carpentaria has certainly increased to such a level that elevated turbidity events during the following monsoons were longer and more severe, which might explain the seagrass dieback in Torres Strait.

This innovative modelling solution to a complex marine environmental problem has been provided as part of Geoscience Australia's contribution to the Torres Strait Cooperative Research Centre to better understand biophysical processes in the strait. We have gained new scientific understanding of underwater habitat disturbance and stability, reinforcing Geoscience Australia's ability to characterise and protect our valuable marine environment.

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