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The potential impact of bedform migration on seagrass communities in Torres Strait, northern Australia

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ABSTRACT

Seagrass communities in the northwest of Torres Strait are known to disappear episodically over broad areas. Sediment mobility surveys were undertaken within two study areas during the monsoon and trade wind seasons, in the vicinity of Turnagain Island, to find out if the migration of bedforms could explain this disappearance. The two study areas covered sand bank and sand dune environments to compare and contrast their migration characteristics. Repeat multibeam sonar surveys were used to measure dune-crest migration during each season.

Our results show that seagrass beds occur in the troughs of sediment-starved dunes, but no seagrass occurs in association with full-bedded dunes that are superimposed on large sand bank features. The coincidence of seagrass beds with the sediment-starved dunes is in spite of the fact that they migrate faster (0.59 m day^{-1}) than full-bedded dunes (0.13 m day^{-1}), which indicates that some other factor (other than dune migration rate) limits seagrass growth within Torres Strait. We suggest that seagrasses are unable to colonise full-bedded dunes because of the semi-continuously transported sand that characterises this environment. In contrast, the troughs of sediment-starved dunes experience only limited bedload transport and are less hostile for seagrasses. A conceptual model is presented to explain the occurrence of seagrass beds in relation to their proximity to migrating sand dunes. Based on our analysis, we conclude that the widespread dieback of seagrasses documented for the Turnagain Island region was not caused by dune migration.

1. Introduction

Seagrasses are known to occupy a wide range of sandy littoral habitats. In a review of seagrass habitats of northeast Australia, Carruthers, et al. (2002) identified four specific habitats: river estuaries, coastal, deep water, and reef, with each having a key 'factor' limiting their growth (runoff, physical disturbance, low light and low nutrients, respectively). The dynamics of tropical seagrasses are heavily influenced by weather patterns, flood and cyclone events. The influence of weather events on the seabed (disturbance) or the water column (turbidity/low light) is known to make the distributions of seagrass temporally and spatially variable (Marba and Duarte, 1995; Carruthers et al., 2002; Waycott et al., 2004).

The presence of seagrass is, however, indicative of a seabed that has been stable for a period long enough for colonisation to occur (a rate that is variable among seagrass species). Seagrasses are also known to occur in areas with active subaqueous dunes and/or sand banks. Dunes and sand banks are indicators of active bedload transport and their lateral movement poses a threat to the seagrass communities (Harris, 1989; Marba and Duarte, 1995; Walker et al., 1996).

In Torres Strait, seagrass communities are an important habitat for dugong, sea turtles, and commercially important fish species (Long and Poiner, 1997; Long and Skews, 1997). Both seasonal and episodic seagrass dieback occurs in the Torres Strait. Mellors et al. (2008) observed that seasonal variation in seagrass cover was climate related. Generally, seagrass abundance increased during the northwest monsoon, possibly a consequence of elevated nutrients, lower tidal exposure times, less wind and higher air temperatures. Low seagrass abundance coincided with the presence of greater winds and longer periods of exposure at low tides during the southeast trade winds. Episodes of 'widespread' seagrass dieback have been reported from Torres Strait from the early 1970s but as recently as 1991, 1999 and 2001 (Long et al., 1997; Marsh et al., 2004). Seagrass dieback from the 1991 event was estimated at 1199 km^2 within a study area of 4388 km^2 (Long et al., 1997) and was reportedly due to high turbidity from flooding river(s) in PNG during a coincident ENSO event (Poiner and Peterken, 1996). A high turbidity event in 2001 was also

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reported in Marsh et al. (2004) as far south as Turnagain Island (but not observed during surveys in 1987, 1991, and 1996). Sediment movement has also been suggested as a mechanism for seagrass dieback in the Torres Strait (Johannes and MacFarlane, 1991). Re-colonisation after large scale losses of seagrasses communities in Australia is known to take up to a decade or more (Poiner and Peterken, 1996).

This paper presents the results of dune migration surveys in Torres Strait, at locations known to have previously undergone seagrass dieback in an attempt to provide a link between habitat stability with the presence and migration of bedforms and thus asses the potential threat that bedforms pose to seagrass communities. The study uses repeat multibeam surveys to generate accurate, high-resolution digital elevation models (DEMs) of the seabed. Rates of dune migration are measured from overlapping DEMs and when combined with seabed surveys and data from oceanographic sensors allowed an assessment of the potential for bedforms to impact on seagrass communities within Torres Strait. This assessment is presented in the form of a conceptual model illustrating four key sedimentary environments within Torres Strait and their associated level of 'threat' to seagrass communities.

2. Study area

Torres Strait is a shallow epicontinental seaway in northern Australia, about 150 km in width (from north to south) separating the Cape York Peninsula (northern Australia) from Papua New Guinea (Fig. 1). The topography of the strait is characterised by a shallow ridge of basement rock, containing numerous scattered islands, sand banks, and coral reefs. The strait is generally shallow with water depths rarely exceeding 25 m (Harris, 1988). Torres Strait experiences two distinct seasons. The trade wind season lasts for ~7 months (May–November) and is characterised by relatively low rainfall and strong southeasterly winds. The monsoon season lasts for ~5 months (December–April) and is characterised by relatively high rainfall and weaker northwesterly winds (Fig. 2; Wolanski, 1986).

Semidiurnal tides propagate into Torres Strait from the Coral Sea in the east and diurnal tides propagate from the Gulf of Carpentaria in the west. However, only 30% of the tidal wave energy approaching from the east or west is transmitted through the strait due to friction and attenuation of the tidal waves by the complex bathymetry (Wolanski et al., 1988). Daily current patterns in Torres Strait are dominated by east–west flowing currents that attain surface speeds of up to ~2 m s^{-1} within narrow passages during spring tides (Wolanski et al., 1988) and broad areas occur across central Torres Strait where peak spring tidal current speeds exceed 0.85 m s^{-1} (Harris, 1994). Superimposed on the tidal currents are wave-induced currents, storm surges, ocean currents, and wind-driven currents. While tides produce the strongest near-bed currents (Wolanski and Thompson, 1984; Wolanski, 1986), the relatively weak (~0.2 m s^{-1}) wind-driven currents also play a key role in

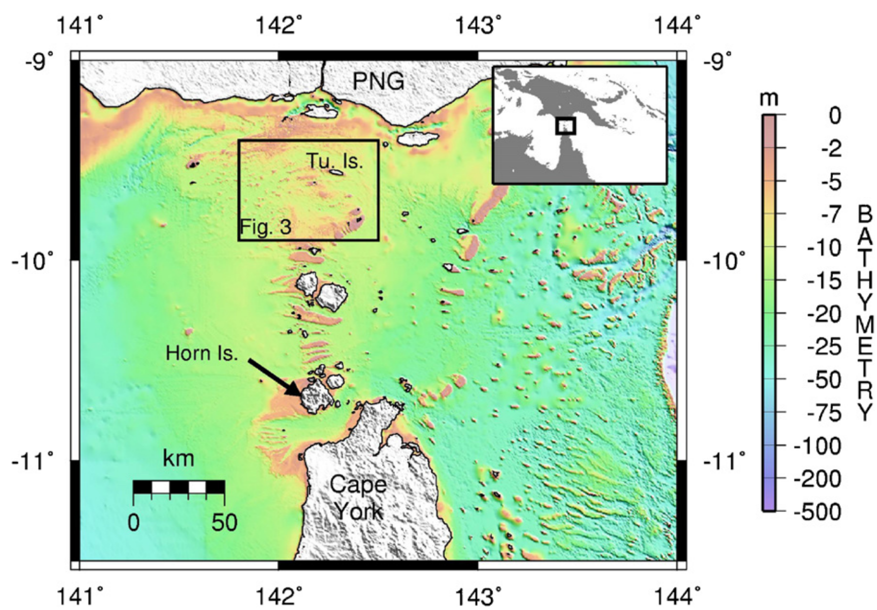

Fig. 1. Bathymetry of the Torres Strait region (Turnagain Island is marked Tu. Is).

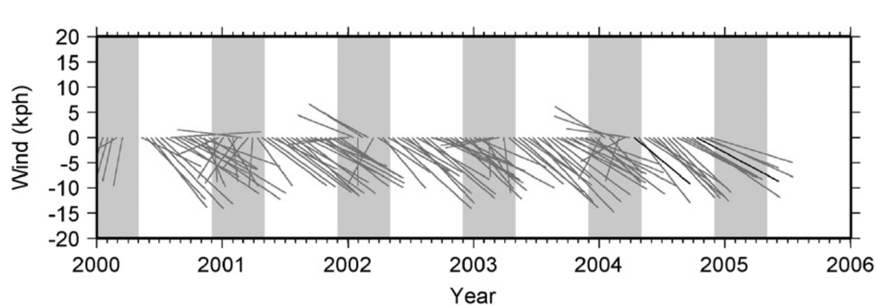

Fig. 2. Average fortnightly wind vectors from Horn Island for the years 2000–2005. Pale grey shades indicate the months of the monsoon season (December–April). The two vectors coloured black indicate the vectors corresponding to the monsoon and trade wind surveys.