Australian Government
Geoscience Australia

AUSGEO news
ISSUE 105 Mar 2012

Seabed environments of the Joseph Bonaparte Gulf and Timor Sea

Seabed mapping reveals significant habitats and potential hazards

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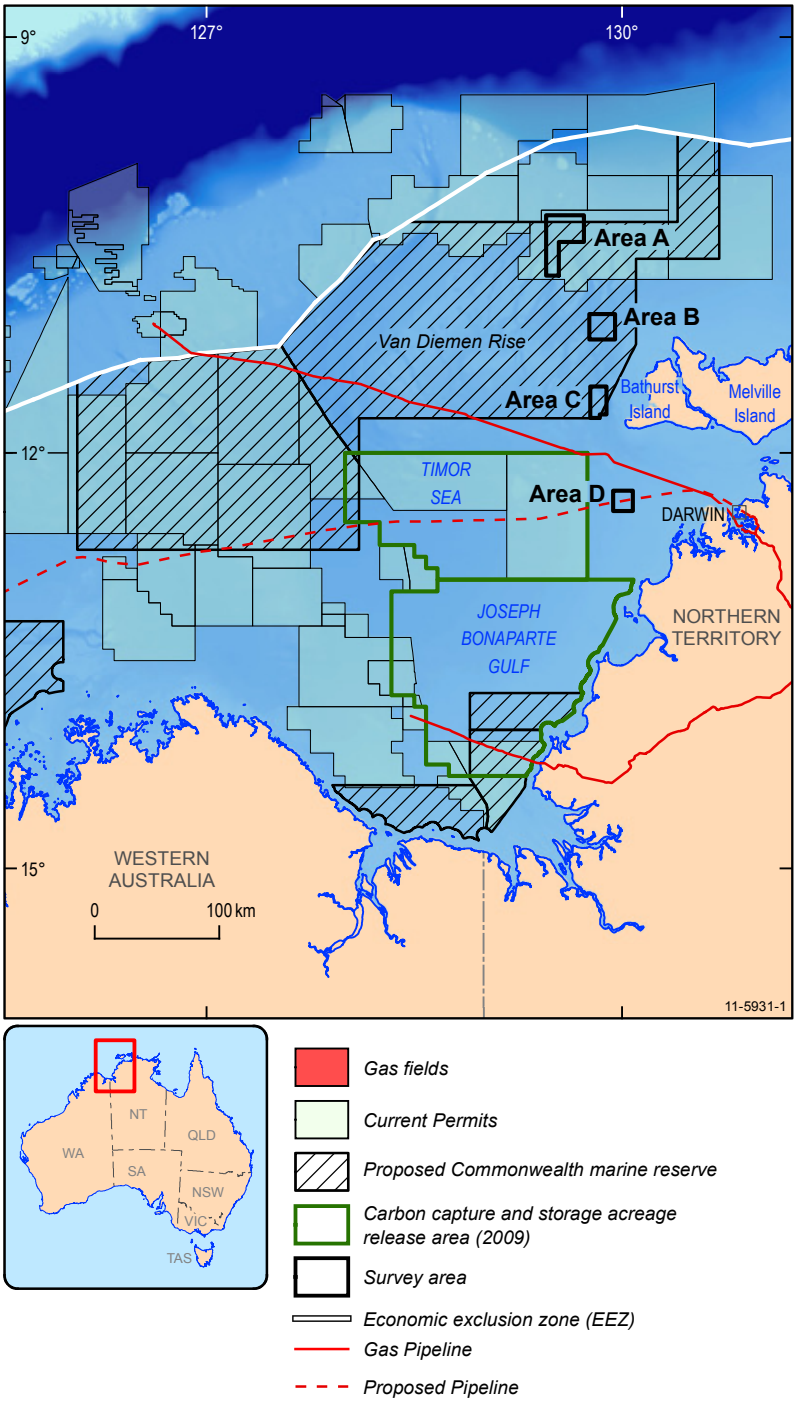

Figure 1. Map of the study area showing petroleum industry and marine research activity in the region. Geoscience Australia Survey areas are indicated by the letters (A, B, C, D).

Offshore northern Australia, is a focus for both the energy industry and marine management agencies (figure 1). In particular, the Joseph Bonaparte Gulf and adjacent Timor Sea is a region that supports active petroleum exploration and infrastructure development and includes one of Australia's first acreage releases for carbon storage in an offshore sedimentary basin. Parts of the region are also included in the proposed Commonwealth network of marine reserves due for finalisation in 2012. Consequently, the Joseph Bonaparte Gulf and Timor Sea region offers unique opportunities for marine researchers to provide fundamental environmental information to a range of stakeholders.

Environmental review

Geoscience Australia has recently compiled an integrated description of the seabed environments within the Joseph Bonaparte Gulf. This will provide the offshore petroleum industry with all available information describing the physical characteristics of the seabed and associated biological communities. Particular attention was given to potential geohazards to infrastructure as well as the occurrence of unique and sensitive biota. The study area encompasses

three geologically distinct structures: the Petrel Sub-basin, Darwin Shelf, and Malita Graben. The Petrel Sub-basin was included because it underlies most of the study area, while the Darwin Shelf and Malita Graben were chosen because they incorporate a range of geomorphic features (or undersea landforms) and habitats. These habitats were the focus of two collaborative marine surveys undertaken in 2009 and 2010 by Geoscience Australia and the Australian Institute of Marine Science (AIMS) on the RV Solander (surveys GA-322 and GA-325 respectively; Heap et al 2010, Anderson et al 2011).

During these surveys, the seafloor was mapped with high resolution multibeam sonar which provided the basis for designing a sampling program to collect a range of physical and biological material. The data collected during these surveys was then combined with publicly accessible information about the region to provide a comprehensive environmental review. This regional synthesis will assist industry in their pre and post-bid environmental assessments and emergency planning (Przeslawski et al 2011).

Seabed habitat types

The continental shelf in the Joseph Bonaparte Gulf and Timor Sea is the widest in Australia, extending up to 400 kilometres from the shore. Most of the inner shelf is characterised by relatively flat expanses of soft sediment seabed with localised rocky outcrops, gravel deposits and sand banks. The inner shelf section of the Gulf receives significant loads of sediment from several large rivers including the Daly and Victoria rivers. Circulation and mixing are driven by tidal and wind-generated currents that vary in intensity according to season. Across the mid and outer shelf, the seabed and associated habitats are more complex due to carbonate banks and terraces that flank a network of channels and deep valleys.

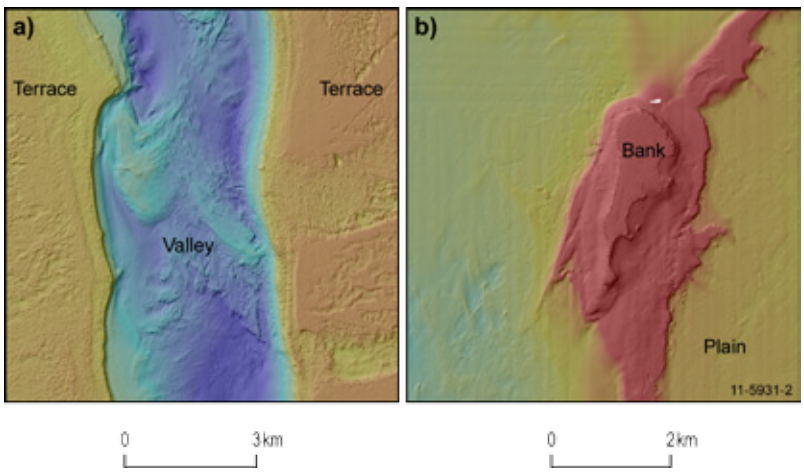

Figure 2. High-resolution false colour bathymetry showing: a) terraces and a valley in Survey Area A; b) a plain and bank (Moss Shoal) in Survey Area B.

Bathymetric grids produced at five metre resolution from the multibeam sonar data obtained during the 2009 and 2010 surveys allowed a new level of detail when the geomorphology of the shelf in representative areas was mapped (figure 2). Using a range of physical and biological datasets collected during the surveys, researchers characterised habitat type and biological communities at each of these geomorphic features:

- *Banks* are the shallowest features in the study area, sitting in water depths between 20 and 40 metres. They are characterised by hard carbonate substrate with localised deposits of carbonate gravel, but they also have sandy sediments with high organic matter content. All of the banks that were mapped and sampled support localised gardens of sponges and octocorals (a group that includes sea fans, sea whips and soft corals).
- *Terraces* are flat-topped features with a discontinuous cover of mixed carbonate sand and gravel. Locally, sand ripples occur interspersed by rocky outcrops. Terraces support moderate numbers of epifaunal species (living on the seafloor) but low numbers of infaunal species (living within loose sediment deposits). Sponge and octocoral gardens occur at some locations, but their distribution is generally patchy.

- *Ridges* are narrow elongate features that are generally flat-crested but have shallow channels incised to depths up to 10 metres. Sediments are sandy with local fields of bedforms (for example, sand waves) particularly in channels. Ridges have highly variable numbers of epifaunal species.
- *Plains* are the least complex geomorphic feature in terms of bedform and relief. Physical properties of the sediments are very uniform consisting mainly of very poorly sorted gravelly-muddy sands. Plains have the lowest number of epifaunal species but the highest number of infaunal species.
- *Valleys* are also dominated by flat expanses of soft sediments interspersed with exposed rock in debris-swept channels. Compared to other geomorphic features, they have the greatest variety in substratum types. Epifauna is sparse with the exception of patches of immobile animals fixed to local exposures of rock.

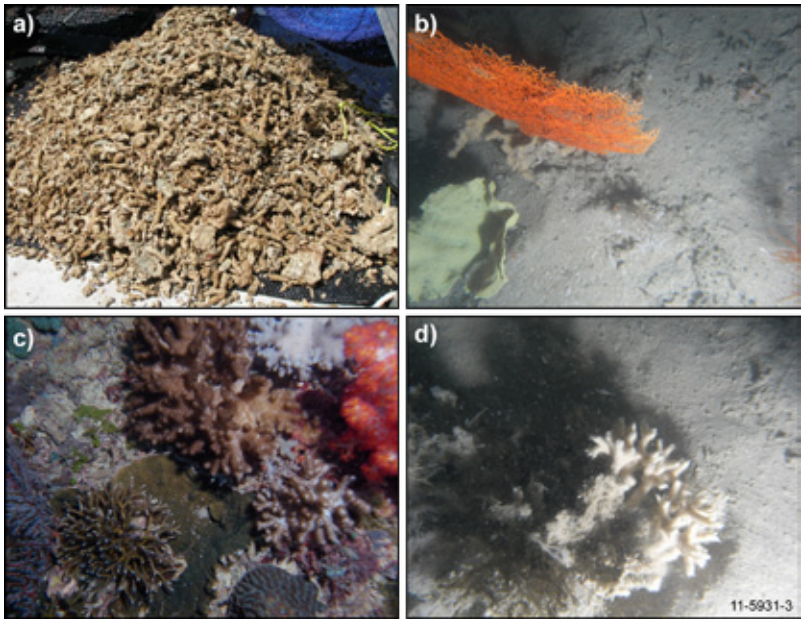

Figure 3. Significant biological communities identified from surveys GA-322 and GA-325: a) Coral rubble (Area A, 90 metres depth); b) sponge and octocoral gardens (Area C, 60 metres depth); c) hard coral communities (Area A, 13 metres depth); d) branching mesophotic coral (Area D, 53 metres depth).

Based on these biophysical characterisations and results from the surveys, researchers identified several significant communities from the Joseph Bonaparte Gulf and Timor Sea (figure 3). Sponges and octocorals are major habitat-forming animals on the seafloor, providing structure to otherwise flat environments and sheltering a range of animals (such as brittlestars, crabs, fish). Many of the observed sponge and octocoral gardens include large species that are long-lived and slow-growing, making them potentially vulnerable to anthropogenic and natural disturbance. Where sponges and octocorals occur in dense gardens, the number of other animals is often also high, and these gardens can thus be indicative of high biodiversity. In the Joseph Bonaparte Gulf and Timor Sea, sponge and octocoral gardens are commonly found on rocky outcrops, a habitat that is particularly common on banks.

Hard corals

For the first time, dense communities of reef-forming hard corals were observed in the offshore waters of Joseph Bonaparte Gulf. Hard corals provide a raised substrate that becomes an important habitat for a range of species, a function that is termed 'ecosystem engineering'. Reef-forming corals are also valued because of their association with high levels of biodiversity, including fish communities. The surveys found hard corals on the shallow banks of the Van Diemen Rise approximately 250 kilometres offshore in Survey Area A. In the same area, samples of dead coral (possibly *Acropora*) were collected at 90 metres depth and observed in underwater video as mounds of coral rubble, possibly reflecting coral reefs that grew here during the sea-level lowstand of the last glacial maximum (around 15 to 18 thousand years ago). Because of their conservation status, some of these hard coral species are included on the International Union for Conservation of Nature

red list list as near threatened, vulnerable, or endangered (*Stylophora pistillata, Turbinaria reniformis, Turbinaria patula,* cf. *Caulastrea* sp., and *Cantharellus* cf. *noumeae*).

Surprisingly, small isolated specimens of hard corals (possibly *S. pistillata*) were observed growing at five stations on the muddy inner shelf in Survey Area D. These inner shelf waters are mostly soft-sediment and highly turbid, but it appears that even in these conditions limited coral growth is possible for mesophotic species (that is, species which adapted to low light levels).

Overall, the Joseph Bonaparte Gulf and Timor Sea region is characterised by habitats that are distinct at the regional scale when compared to neighbouring regions such as the Big Banks Shoals to the west. In particular, the carbonate banks of the study area seem to represent a regionally distinct habitat since they are dominated by sponges and octocorals. The atolls and banks to the west of the region are dominated by hard corals and *Halimeda* algae (Heyward et al 1997).

Potential geohazards

The development of infrastructure on the seafloor requires basic geomorphological and geological information including water depth, seabed slope, sediment properties and thickness, and sedimentation rates. After consideration of these and other parameters, the potential for hazardous processes such as erosion, faulting, and fluid expulsion can be evaluated. Survey data acquired from multibeam sonar and sub-bottom profiles were used to map the location of steep scarps and sites of possible mass movement on the seabed along the northeastern Joseph Bonaparte Gulf and Timor Sea. As anticipated, these features only occur along the flanks of deep valleys, particularly those on the carbonate banks of the outer shelf. Though there is geomorphic evidence for seabed instability, the age or rate of these potential mass movements remains unknown.

In order to assess the stability of the seabed over time, the Geoscience Australia survey in 2010 re-mapped an area of seabed on the outer shelf that had been mapped in 2009. This area included a complex terrace and valley network with local relief of up to 25 metres. The repeat mapping did not detect any change in the form or position of these features, with their stability over time likely to be attributable to the hard composition of the terraces.

Pockmarks are a pervasive feature of soft sediment areas across the plains and deeper valleys on the continental shelf of the Joseph Bonaparte Gulf and Timor Sea. These circular depressions have diameters of several metres and depths of two to three metres and several hundred occur in some places (figure 4). The origin of the pockmarks is unclear, however it is possible that they are evidence of gas or fluid expulsion from the shallow sub-surface. Despite the pockmarks and the potential for sediment mobility and slope failure (or landslides), the overall risk to industry presented by geohazards in the study area is relatively low.

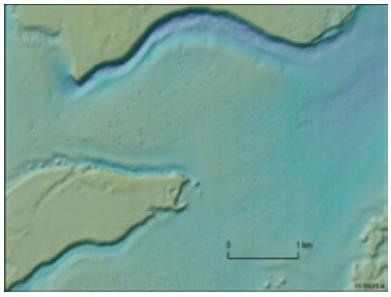

Figure 4. High resolution multibeam sonar image of the seafloor on the outer continental shelf of Joseph Bonaparte Gulf showing pockmarks formed in muddy sands across a valley floor.

Conclusions

The distribution of seabed habitats, communities and geohazards in the study area is regulated by complex interactions between oceanographic, geological, and biological processes. The suite of these processes operating at a given location is affected by distance from the coast and the geomorphic features present.

Many of the observations in this study relate to broad spatial patterns identified from regional-scale data (between ten and several hundred kilometres scale). This scale allows the offshore petroleum industry to put proposed development plans in a regional environment context. Similarly, management of marine reserves requires a regional context regarding the ecosystems found within them.

Both industry and marine management agencies, however, can also benefit from information at the local scale (one to ten kilometres scale). Results from the recent Geoscience Australia surveys indicate that significant habitats, communities, and potential hazards exist at a scale too small to be detected in regional-scale analysis. This point is illustrated by the discovery of reef-forming hard corals and sponge and octocoral gardens on the shallow banks of the Van Diemen Rise. These communities are unique on a regional scale but would not have been identified without sampling at a local scale. Similarly, potential geohazards such as seabed slumps and gas expulsions can only be identified using sub-bottom profiles collected across targeted sites. These results highlight the continued importance of acquiring high-resolution geophysical data and biophysical samples to allow the identification of significant habitats and communities that may otherwise remain undetected.

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