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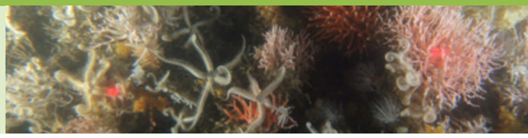
Marine ecosystems in the Mertz Glacier region, Antarctica

Survey investigates impact of break-up of ice shelf



Jodie Smith

In his account of the Australasian Antarctic Expedition of 1911–14, Sir Douglas Mawson (1915) described his encounter with large icebergs, resembling ice walls, during the voyage south to Adélie Land in January 1912: 'a south-south-east was blowing as we came abreast of the 'ice island', which, by the way, was discovered to have drifted several miles to the north, thus proving itself to be a free-floating berg'. They were to later learn that the ice formation was 'nothing more than a high iceberg measuring forty miles in length'.

The following day, Mawson wrote 'the *Aurora* was in calm water under another mighty ice face trending across our course. This wall was precisely similar in appearance to the one with which we have been in touch during the preceding days, and might well have been a continuation of it. We were afterwards to learn that this was not so'. It was then noted that this new shelf-ice formation was found to be a floating tongue sixty miles in length, the seaward extension of a large glacier which was named the Mertz Glacier, after Mawson's ill-fated colleague Dr Xavier Mertz (figure 1).

Almost 100 years later, in early 2011, the Mertz Glacier region was visited once again by Australian scientists, this time on board the *Aurora Australis*. Little has changed in this environment during the past 100 years, with 'the atmosphere foggy', 'the water merely littered with fragments of ice' and a 'mighty ice face' trending across the course, just as Mawson described it back in 1912.

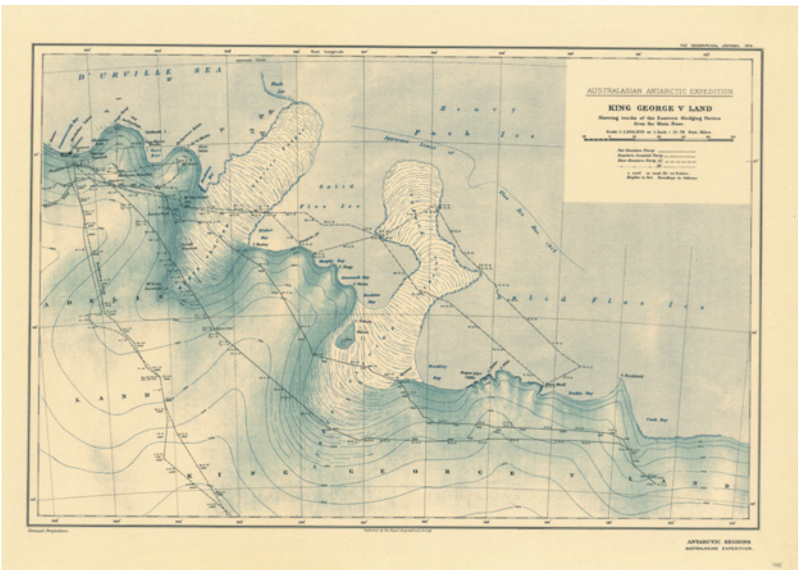


Figure 1. Historical map of King George V Land showing the Mertz Glacier from the Australasian Antarctic Expedition 1911–1914 (Map courtesy of the Australian Antarctic Division and reproduced from the Royal Geographic Society).

The Mertz Glacier region

The Mertz Glacier region plays an important role in the global ocean over-turning circulation and is one of the few places in the ocean where dense, salty water forms at the surface and sinks to the deep ocean. Polynyas (areas of open-water or low sea ice concentration) in the region produce about 25 per cent of the Antarctic Bottom Water, and this sinking of dense water drives the deep over-turning circulation of the global ocean, carrying oxygen and nutrients to depth in all ocean basins (Young et al 2010).

The area around the glacier is one of the 'biological hotspots' of the Antarctic and Southern Ocean ecosystem (Gutt et al 2010). The ice-free waters of the polynya allow light to reach the ocean surface and stimulate primary production. The high biological productivity attracts whales, penguins and seals to feed on plankton in one of the few areas not covered by ice in the Antarctic winter. The region is also home to some unique marine communities such as deep water hydrocorals (Post et al 2010).

In February 2010, a massive iceberg designated B09B collided with the Mertz Glacier tongue—a section of the glacier that protruded about 100 kilometres from the Antarctic coastline. The collision precipitated the calving of the glacier tongue, producing a new massive iceberg, C28. This calving event removed about 80 per cent of the tongue, leaving only a 20 kilometre-long stub and exposed a large section of the sea floor, about 80 kilometres long and over 30 kilometres wide (figure 2). The calving event fundamentally changed the geography of the region, with, as yet, unknown consequences for ocean circulation patterns, sea ice production and biological productivity.

Less than a year after the spectacular calving event, scientists were collecting valuable data from this newly exposed area of the seafloor and the surrounding waters. The 2011 marine survey involved scientists from a number of research institutions, working collaboratively across a number of different projects. The overall aim of the survey was to conduct a coordinated and comprehensive study to measure and monitor the impact of the Mertz Glacier calving event on the local and regional environment (Pyper et al 2011). Collecting data as soon as possible after the calving event means that any physical, chemical and biological changes in response to the new conditions can be monitored over time.

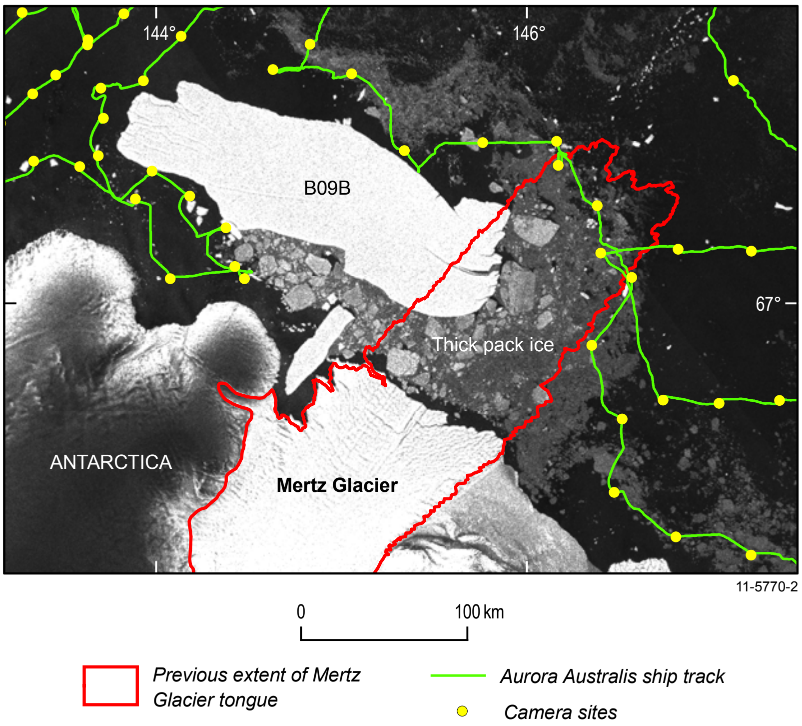


Figure 2. Ice conditions, ship track (green line) and camera stations (yellow dots) in the Mertz Glacier region during the Marine Science Voyage (VMS) in Janurary 2011. The satellite image (Envisat high-resolution radar image, 12 Janurary 2011) shows the position of iceberg B09B to the west of the Mertz Glacier tongue and the thick ice pack backed up behind it in the area previously covered by the glacier tongue (outlined in red).

A team of scientists and technicians from Geoscience Australia and the Australian Antarctic Division conducted a benthic (or seafloor) community survey during the voyage (Smith and Riddle 2011). The purpose of the survey was to collect high-resolution still images of the sea floor to investigate:

- benthic community composition in the area previously covered by the Mertz Glacier tongue and, to the east, an area previously covered by approximately 30 metres of fast ice
- benthic community composition (or lack thereof) in areas of known iceberg scours
- the lateral extent of dense hydrocoral communities along the shelf break.

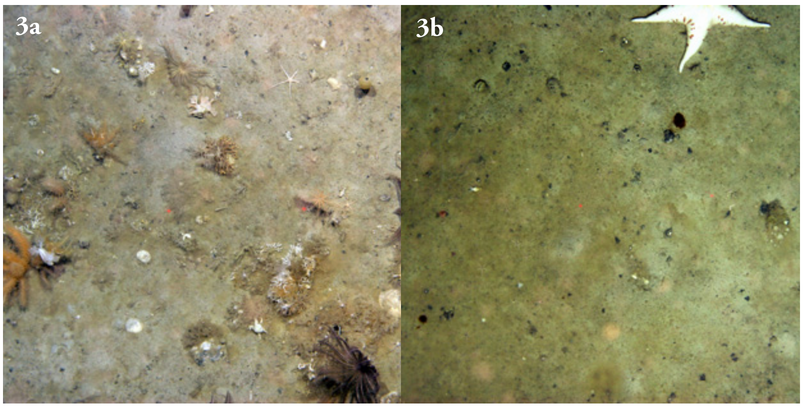
Using a digital camera inside a waterproof casing, over 1800 still images of the sea floor were collected at depths ranging from 170 to 2300 metres. Because there is little or no light reaching the sea floor at these depths, two strobe lights were used to illuminate the bottom. The position from the seafloor was monitored using an altimeter attached to the frame. The target depth was four to five metres from the seafloor. Parallel laser pointers set 50 centimetres apart were used to provide a scale for the images (figures 3a, 3b).

The benthic images from the voyage will be analysed in detail to identify the organisms and communities at each site. Bathymetric data, satellite images, substrate information and physical and chemical oceanographic datasets will be used to examine the relationship between the benthic communities and the physical and chemical environment.

Sub-ice shelf communities

A widespread but unique habitat in Antarctic waters lies beneath floating ice shelves that cover one-third of Antarctica's continental shelf. This expansive marine setting remains largely unexplored because of general inaccessibility. It has long been recognised that benthic organisms exist under ice shelves, sometimes at substantial distances from the open water. However, any marine organisms living on the sea floor in these areas do not have the same opportunity for food as in the open ocean, where there is a regular supply of phytoplankton from the surface waters. These populations must be sustained by horizontal advection (or horizontal currents) of their primary food source. Because of the ice cover, there are few opportunities to study ecosystems that are able to exist in such situations. In addition, little is known about the potential biological impacts of ice shelf collapse.

The calving event has enabled access to an area where no information on benthic communities or seafloor substrate currently exists. Unfortunately, access during the 2011 voyage to areas previously under ice (that is, under the Mertz Glacier tongue and to the east) was limited by the ice conditions at the time of the voyage.



Figures 3a, 3b. Life under the Mertz Glacier tongue includes sea pens, bryozoans, gorgonians, brittle stars, anemones, holothurians, sponges, urchins, crinoids and sea stars. The seafloor is scattered with dropstones which have fallen from the glacier above. (Photo from Australian Antarctic Division underwater camera).

The large iceberg B09B was in a stationary position just to the west of the Mertz Glacier tongue. Because of the current and wind regime and the size of the iceberg, a large amount of pack ice built up behind the iceberg, restricting ship access to the region previously covered by the Mertz Glacier tongue (figure 2). As a result, the benthic camera could be deployed at only three stations in the area previously under the Mertz Glacier tongue.

Benthic life under the Mertz Glacier tongue was found to be similar to that in the adjacent areas, although more sparse. A diversity of marine animals was observed, including sea pens, bryozoans, anemones, gorgonians, holothurians, urchins, brittlestars, crinoids, sponges, and even a sea star that was more than half a metre across (figures 3a, 3b). These benthic communities must source their food from particles carried by currents that flow beneath the Mertz Glacier tongue. The sea floor under the glacier tongue is comprised mostly of mud with pebbles and cobbles ('dropstones' from the glacier above) scattered across the surface.

It should be noted that the three camera stations were located less than 20 kilometres from the edge of where the ice tongue extended prior to its calving (figure 2). Therefore, the benthic communities found at these stations may not resemble those further from the ice edge and closer to the grounding line of the glacier.

The area to the east of the Mertz Glacier tongue has been covered by annual or multi-year fast ice for varying periods of time. Historical satellite imagery will be used to determine the changes in ice conditions over the last few decades. The benthic photographs collected at stations east of the Mertz Glacier tongue will also be examined to determine if the different ice conditions have had any influence on benthic community composition. Initial observations of the photographs indicate low benthic cover in this area.

Iceberg scouring

Seafloor disturbance due to iceberg scouring is a common form of disturbance of benthic communities on parts of the Antarctic shelf, typically less than 500 metres deep (Barnes and Lien 1988). Iceberg scours (both relict and recent) were identified on the continental shelf in this region at depths of at least 500 metres and benthic communities were found to vary in relation to the age of the scours (Post et al 2011). It has been suggested that it takes the benthic community hundreds of years to recover following disturbance from iceberg scours (Gutt 2000), however, because scours in the Mertz region have not been dated, it is not known how long recolonisation takes.

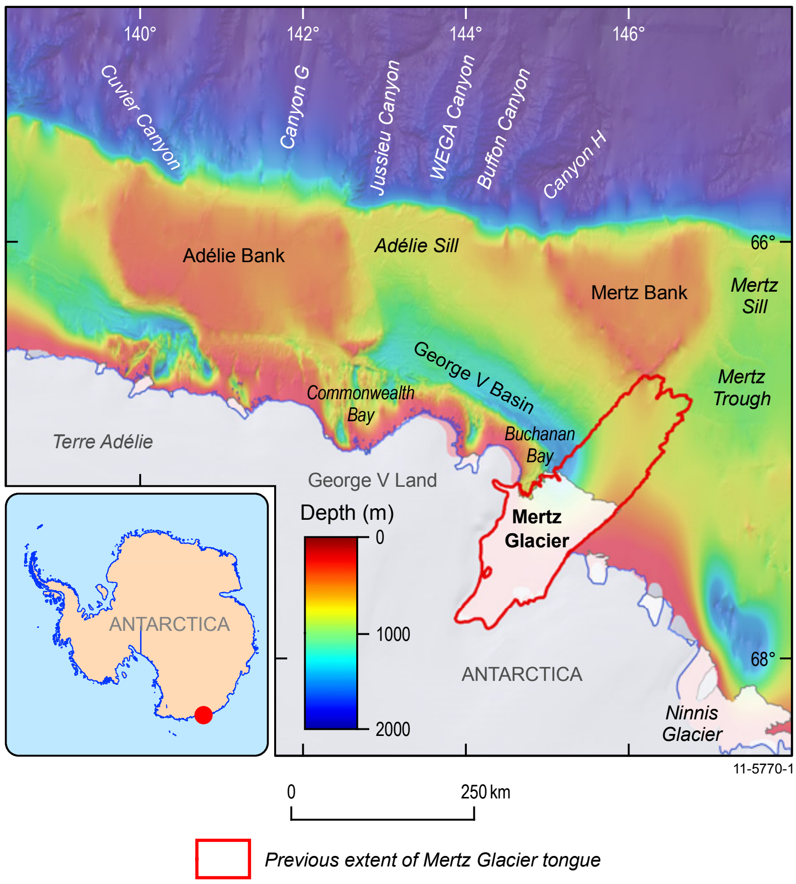


Figure 4. The location and seafloor morphology of George V Land and Terre Adélie shelves. The previous extent of the Mertz Glacier tongue, as of Janurary 2008, is also shown. The bathymetry is from the Beaman et al (2011) 250 metre grid.

Following the calving of the Mertz Glacier tongue in February 2010, the newly-formed iceberg (C28) collided with the Adélie Bank (figure 4) and broke into several sections. This survey aimed to collect baseline information on benthic communities (or lack thereof) in areas of recent scouring, including the point where iceberg C28 collided with the Adélie Bank. This will determine which, if any, benthic organisms have started to recolonise the scoured areas. Understanding how and when recolonisation occurs may assist in better predicting the types of communities that will occur in different areas of the shelf.

The targeting of sites affected by iceberg scouring proved to be difficult given the nature of the camera system used, the resolution of the satellite and bathymetry data, and the manoeuvrability of the ship. As such, there was no evidence of iceberg scouring at these camera stations. However, there was evidence of iceberg scouring identified at some other stations. At two camera stations, located east of the glacier tongue, the photos show fracturing of compacted sediments which is consistent with mechanical stress. When disturbed by ice keels, irregular blocks and slabs of compact, overconsolidated mud are ripped loose with angular fracture faces. Other photos show a linear scrape across the surface, a common iceberg scour feature. Water depths at these camera stations are approximately 500 to 550 metres which is considered too deep for modern iceberg scouring. However, relict scours have been found in the region to approximately 600 metres and these most likely date from the last glaciation when sea level was approximately 120 metres lower than present levels (Post et al 2011).

Dense hydrocoral-sponge communities

Dense hydrocoral-sponge communities were identified on the upper continental slope off George V Land during a previous survey (Post et al 2010). In 2008 they were declared Vulnerable Marine Ecosystems (VMEs) by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) and are closed to bottom fishing (CCAMLR 2009a, b). The richest hydrocoral communities were found below 500 metres and in canyons that cut the shelf break and receive Antarctic Bottom Water. Three main factors regarding the distribution of the hydrocoral communities were identified:

- their depth in relation to iceberg scouring
- the flow of organic-rich bottom waters
- their location at the head of shelf-cutting canyons (Post et al 2010).

This survey aimed to test these hypotheses by collecting data from several sites along the continental slope to identify the presence or absence of hydrocoral-sponge communities.

The sites were chosen within two broad areas; those thought to be receiving and not receiving Antarctic Bottom Water. Additionally, within these areas, sites were chosen to include canyons and interfluves. Oceanographic data collected during the voyage provides evidence of descending plumes of Antarctic Bottom Water down the continental slope. Dense and sparse hydrocoral-sponge communities were identified in areas receiving bottom water. The photos collected at these sites show a spectacular display of vulnerable marine life (figure 5). There were no hydrocorals identified in areas where there was no bottom water flow. The new data supports the hypotheses regarding the physical controls on hydrocoral-sponge community distribution (Smith et al 2011). This new information will be used to support the application to CCAMLR for a Marine Protected Area in the Mertz region (Weragoda and Bartley 2011).

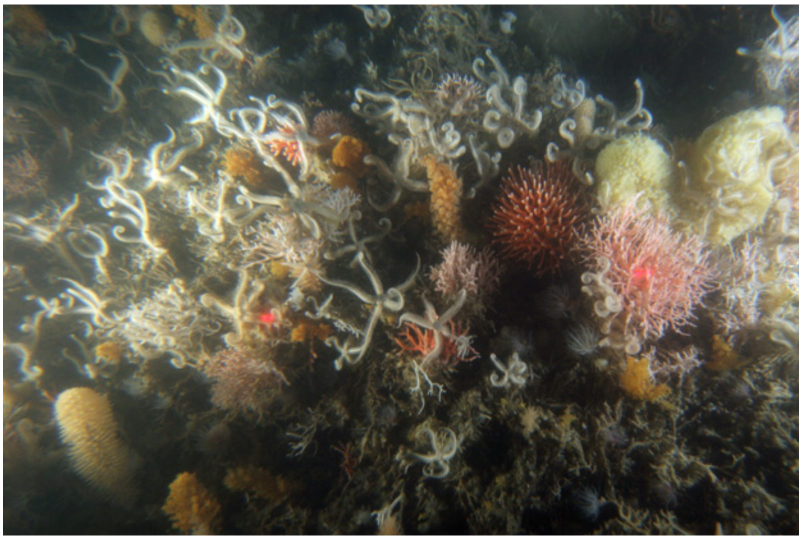


Figure 5. Dense hydrocoral communities inhabit areas along the continental shelf break. These fragile communities, first discovered in this region in 2008, have been declared a Vulnerable Marine Ecosystem by CCAMLR. (Photo from AAD underwater camera).

Conclusions

The survey has provided a major new set of data which will greatly enhance the understanding of Antarctic marine biodiversity and the relationship between physical conditions and benthic communities. This information will be used to help answer some key research questions outlined in the Australian Antarctic Science Strategic Plan relating to ocean acidification and change in marine ecosystems, as well as protecting marine biodiversity. It will also provide a benchmark for tracking future changes in benthic communities in areas previously covered by ice.

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