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Mr David Sullivan
Committee Secretary
Senate Foreign Affairs,
Defence and Trade References Committee

Dear Mr Sullivan,

Thank you for your letter of 4 April 2014, inviting Geoscience Australia (GA) to make a written submission to the Senate Standing Committee on Foreign Affairs, Defence and Trade inquiry on *Australia's future activities and responsibilities in the Southern Ocean and Antarctic waters*. GA welcomes the opportunity to contribute to this Senate inquiry.

The attached submission represents a whole-of-agency perspective on Australia's future engagement in Australia's Antarctic and sub-Antarctic marine jurisdictions. In addressing the Terms of Reference, our submission outlines the case for a comprehensive priority-driven marine geoscience mapping program, ongoing geophysical monitoring activities, and the ongoing maintenance and reinforcement of our maritime jurisdictional boundaries.

We have provided a map that summarises the priority areas for targets marine geoscience activities within Australia's Antarctic and sub-Antarctic marine jurisdictions. Outcomes of these activities will support Australia's national priorities and strategic interests in Australia's sub-Antarctic and Antarctic marine jurisdictions as well as contributing to Australia's international visibility, influence, and future interaction within the Antarctic Treaty System and associated marine environmental management protocols.

Should you require any additional information, my contact officer on this matter is Dr Clinton Foster, Chief Scientist

Regards

Dr Chris Pigram
Chief Executive Officer
Date: 30/6/14.

Australian Government
Geoscience Australia

Submission to the Standing Committee on Foreign Affairs, Defence and Trade – *Australia's future activities and responsibilities in the Southern Ocean and Antarctic waters*

Key Recommendations

- Australia develop and undertake a priority-driven marine geoscience program of the Southern Ocean and Antarctic waters, as defined in this submission, south of 50° S.
  - regions specifically included are the Australian Antarctic Marine Jurisdiction and the sub-Antarctic marine jurisdictions of Macquarie Island and Heard and McDonald Islands
  - these marine jurisdictions remain largely unmapped. The mapping initiative will provide information essential for marine environmental management, fisheries regulation, and effective demonstration of sovereignty (particularly in reference to the Australian Antarctic Marine Jurisdiction) and supplement Australia's claim over regions of unconfirmed Extended Continental Shelf.

- Australia develops a program to monitor change of ice-bordered coastlines for the purpose of revising and maintaining Australia's maritime boundaries in the Antarctic and sub-Antarctic regions

- Australia maintains its geophysical monitoring observatories in the Antarctic and sub-Antarctic; these are key nodes in a global network, and are essential for:
  - accurate navigation (maritime, terrestrial and aeronautical),
  - providing a key component of the Australian Tsunami Warning System,
  - benchmarking geospatial and marine geophysical surveying and
  - underpinning Australia's international treaty obligations.

If implemented, these programs would:

- further strengthen Australia's physical presence and international visibility within the Australian Antarctic and sub-Antarctic marine jurisdictions
- support Australia's contributions and obligations to the international Antarctic Treaty System and associated marine environmental protocols (including fisheries management)

Contents

Executive Summary

Geoscience Australia (GA) is the national geoscience agency that provides geoscientific advice to the Australian Government to support national priorities for Australia and external territories. Underpinning that advice, GA conducts a diverse range of terrestrial, marine and spatial science research and monitoring activities, provides geoscience products and services that address national issues and contributes to the evidence base for informed policy development and decision-making.

Geoscience Australia provides geoscience information and advice on the Australian Antarctic Territory (AAT) and adjacent marine jurisdiction, supporting Australia's Antarctic strategic interests and obligations under the international Antarctic Treaty System (ATS). GA also operates geophysical monitoring observatories in the AAT that form key components of Australia's scientific infrastructure, and contribute to Australia's international treaty obligations.

Against this background, GA presents this submission for the Standing Committee on Foreign Affairs, Defence and Trade *Australia's future activities and responsibilities in the Southern Ocean and Antarctic waters*.

This submission recommends a comprehensive seafloor mapping program and continued support for Australia's Antarctic and sub-Antarctic geophysical observatories. Seafloor mapping is an effective means of demonstrating territorial sovereignty (of particular relevance for the Australian Antarctic Marine Jurisdiction), provides critical support for a diversity of end-users, including science, logistics, fisheries management and policy support and development and, as such, represents a central component of this submission. Seafloor mapping can identify key natural assets, provide information essential for informed marine environmental and fisheries management and minimises risk for maritime operations. Accurate seafloor maps are particularly important for sustainable management of high-use, near-shore areas adjacent to Australia's research stations in the Antarctic and sub-Antarctic. Marine geoscience surveys also provide information on sedimentary processes and subsurface geology, essential for defining maritime boundaries in areas of extended continental shelf. In addition, the changing nature of the Antarctic ice-fringed coast requires ongoing monitoring as the location of the coastline has direct implications for the position of Australia's Antarctic maritime boundaries.

Ground-based geophysical and geospatial observatories managed by Geoscience Australia provide essential navigational standards that underpin the safety of all land-based, marine and airborne transport, field activities and geophysical surveys. The seismic observatories (Macquarie Island and on the Antarctic continent) provide a critical monitoring function (required under international treaty) and an essential component of the Australian Tsunami Warning System, which informs Australia, and her regional neighbours, of potentially tsunamigenic earthquakes.

1 Australia's Antarctic and sub-Antarctic Maritime jurisdictions

1.1 Geographic scope of Geoscience Australia's submission

For the purposes of this submission, discussion will be limited to the following Australian marine jurisdictions south of 50º S (see Fig. 1.1):

- The Australian Antarctic Marine Jurisdiction (Fig. 1.1; adjacent to the *Australian Antarctic Territory*, includes the Territorial Sea (TS, 12 nautical mile limit from the Territorial Sea Baseline[1]) and Exclusive Economic Zone (EEZ, 200 nautical mile limit from the Territorial Sea Baseline) and adjacent regions of Extended Continental Shelf (ECS, beyond the EEZ)
- The sub-Antarctic Marine Jurisdictions (Fig. 1.1) which include the
  - TS and EEZ surrounding *Heard and McDonald Islands* and the associated areas of ECS (*Kerguelen Plateau* as adopted by the Commission on the Limits of the Continental Shelf[2])
  - TS and EEZ surrounding *Macquarie Island* (to Tasmania) and associated area of ECS (*Macquarie Ridge* as adopted by the Commission on the Limits of the Continental Shelf)

We also explicitly consider, in this submission, the area of extended continental shelf (Williams Ridge, east of Heard Island, Fig. 1.1) for which Australia has an option to make a new or revised submission to the Commission on the Limits of the Continental Shelf (CLCS) with *additional* geoscience evidence that would support such a claim (for further detail, see section 2.4.2). We acknowledge that the region of ECS adjacent to the Australian Antarctic Marine Jurisdiction is, at Australia's request, not to be considered for the time being by the CLCS, on the basis of the special legal and political status of Antarctica under the Antarctic Treaty System (Fig. 1.1). Incidentally, we highlight that the Protocol on Environmental Protection to the Antarctic Treaty and related domestic legislation (*Antarctic Treaty [Environmental Protection] Act 1980* as amended) prohibits any activity relating to non-living resource extraction in the Antarctic, including within the EEZ along the Australian Antarctic Territory.

It should be noted that the Australian Antarctic and sub-Antarctic marine jurisdictions discussed in this submission are substantial geographic areas, as outlined below:

- The Australian Antarctic Marine Jurisdiction is ~**2.21 million km^2** (~15% of Australia's total confirmed marine jurisdiction). The adjacent ESC is an additional **0.68 million km^2**
- Heard Island and McDonald Island sub-Antarctic Marine Jurisdiction and adjacent ESC of Kerguelen Plateau is ~**1.55 million km^2** (~11% of Australia's total confirmed marine jurisdiction)
- The Williams Ridge ESC adjacent to the Kerguelen Plateau (for which Australia has the option of submitting a new/revised claim to CLCS) is ~**0.06 million km^2** in area
- Macquarie Island sub-Antarctic Marine Jurisdiction and associated ESC of Macquarie Ridge is ~**0.56 million km^2** (~4% of Australia's total confirmed marine jurisdiction)

[1] For Australian purposes, the normal Territorial Sea Baseline corresponds to the level of Lowest Astronomical Tide (LAT)
[2] Symonds, Alcock and French '*Setting Australia's limits: Understanding Australia's marine jurisdiction'* 2009, AUSGEO News, 93, 1-8

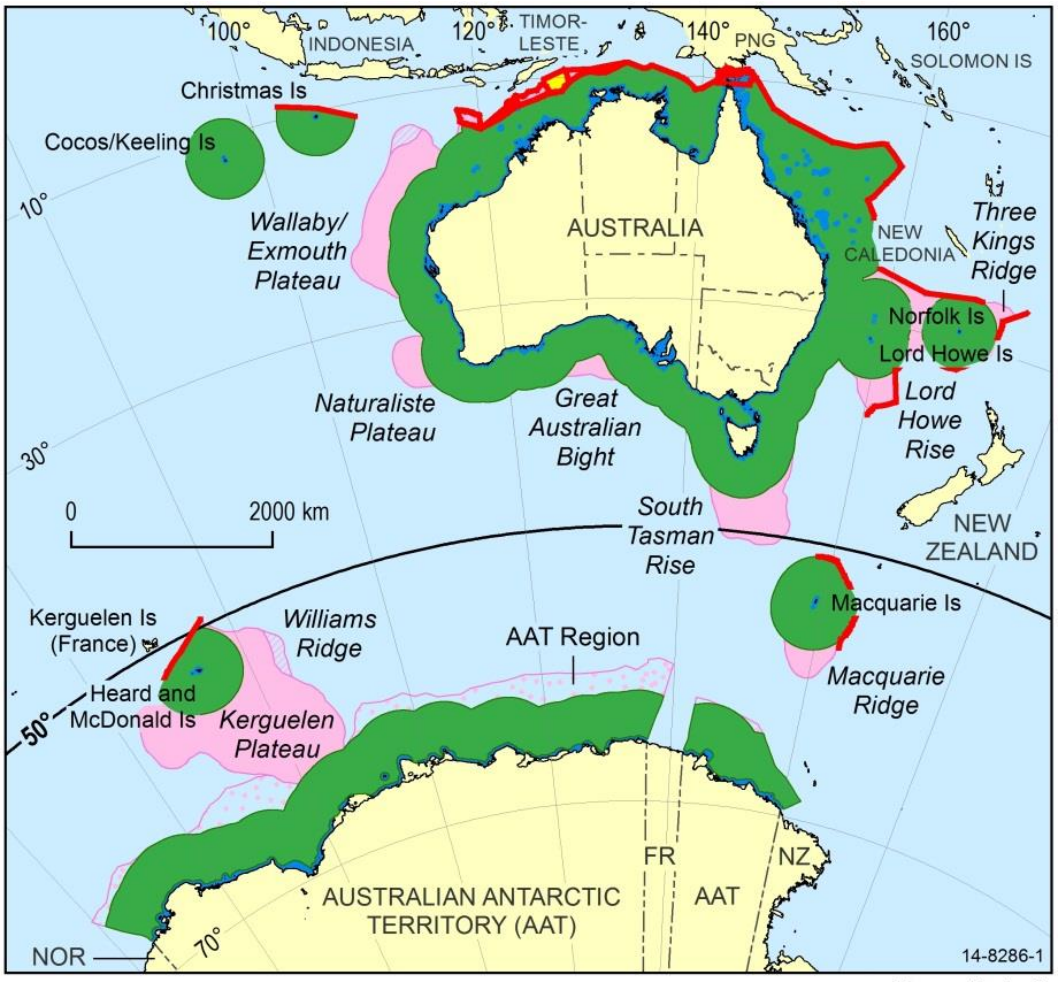

Figure 1.1 Australia's Marine Jurisdictions. This submission only considers Australia's Marine Antarctic and sub-Antarctic marine jurisdictions south of 50º S as described in the text (note that the 50º S line of latitude is highlighted in the figure as a solid bold line), marine jurisdictions north of 50° S are not considered. Figure modified from Symonds et al 2009 (© Geoscience Australia).

1.2 The Terms of Reference

This submission addresses the Terms of Reference (ToR) as per the Letter of Invitation (4 April 2014; addressed to Dr Chris Pigram, CEO, Geoscience Australia) to provide a submission to the Senate Standing Committee on Foreign Affairs, Defence and Trade inquiry on *Australia's future activities and responsibilities in the Southern Ocean and Antarctic waters.*

2 Australia's Future Activities and Responsibilities in the Southern Ocean and Antarctic waters

Marine geoscience activities produce fundamental benchmark products, such as seafloor and coastal maps, which support a diverse range of strategic operational requirements (e.g. identification of important or unique environmental features, infrastructure development and facilitating search, rescue and recovery operations and maintenance of Australia's maritime boundaries), science end-users (e.g. oceanography, benthic ecology, paleoclimate studies and ice sheet dynamics) and, importantly, enhance Australia's presence and influence in the Antarctic Treaty System (e.g. informing marine environmental and fisheries management). These field-based activities also provide effective, tangible and demonstrable evidence of Australia's sovereignty, particularly relevant within the Australian Antarctic Marine Jurisdiction. The datasets derived from marine seafloor mapping activities can also be utilised to develop modern up-to-date accurate nautical charts by the relevant responsible authority (Australian Hydrographic Service and the Royal Australian Navy) to reduce risk to maritime operations.

Furthermore, the Antarctic and Southern Ocean are important regions, sensitive and vulnerable to the impact of global-scale human activities. Apart from the importance of monitoring the state of the polar environment and protecting these regions in their own right, the environmental indicators from these regions can act as a 'canary in the cage', pre-empting the effects of climate change *within Australia*, to enable timely and effective domestic mitigation and management strategies and inform domestic environmental policy development.

Marine geoscience[3] information of the Antarctic and sub-Antarctic marine jurisdictions (Fig. 1.1) are therefore critical for Australian national interests in supporting the following objectives:

1. Australia's long-term strategic national interest of effective demonstration of sovereignty (particularly in the Antarctic regions) and the maintenance and reaffirmation of maritime jurisdictional boundaries
2. Facilitating informed domestic policy development and decision-making
3. Contributing to our knowledge of marine environmental assets and stewardship of the marine environment
4. Ongoing assessment of marine ecosystems to monitor changing environmental stresses and conditions associated with human activities on local, regional and global scales
5. Contributing to international fisheries industry management under CCAMLR[4]
6. Enhancing Australia's capacity for influence under the Antarctic Treaty System and associated marine environmental protection protocols (CCAMLR).
7. Minimising risks to maritime activities and facilitating search and rescue operations

[3] Geoscience, for the purposes of this submission, broadly encompasses geology (study of the rocks that comprise the Earth), geomorphology (study of surface landforms), geophysics (study of the physical properties of the Earth) and geospatial (measurement of the location and vertical and lateral movements of continents).

[4] Commission for the Conservation of Antarctic Marine Living Resources (a convention under the Antarctic Treaty System). Australia is a signatory to the ATS and CCAMLR.

2.1 Existing and future capabilities ('*ToR…other related matters*')

The Australian Antarctic Division (AAD; Department of the Environment) has commenced a procurement process to the replace the Australia's ageing Antarctic research and supply vessel (RSV *Aurora Australis*). This new vessel will have the capability, equipment and technology needed to map and sample the seafloor primarily along the Australian Antarctic Territory continental shelf and slope as well as the adjacent deep ocean abyssal basins.

Similarly, the new Marine National Facility research vessel, the RV *Investigator*, due to be commissioned in mid-2014, will support marine research as far south as the Antarctic sea-ice edge. Marine geoscience capabilities of both the replacement icebreaker and the RV *Investigator* are intended to be 'seamless', in that, subject to the specialised design requirements necessary for an icebreaker, both vessels will be equipped with similar equipment and instrumentation.

Together, these vessels will provide Australia with a modern marine research capability that can support the primary marine geoscience objectives listed over the next 20-30 years.

The Australian Government will, in the near future, have the capability to support the recommendations articulated within this submission over the Antarctic and sub-Antarctic marine jurisdictions as described in section 1.1

2.2 Australia's management and monitoring of the Southern Ocean in relation to illegal, unreported and unregulated fishing

Geoscience Australia provides marine datasets that support fisheries management and regulation in Antarctic and sub-Antarctic waters. Essential datasets such as seafloor morphology, substrate type, bathymetry, and benthic ecosystem assessments are provided to the Australian Antarctic Division (Department. of the Environment). This information is, in turn, utilised and considered by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR)[5] to enable effective and evidence-based decisions on regulating the fishing industry, marine environmental management and monitoring the state of Antarctic and sub-Antarctic marine ecosystems.

The application of high-resolution multibeam sonar seafloor mapping provides detailed information on the morphology or 'submarine topography' on the seafloor. Such seafloor information is invaluable for informed assessment of likely habitats for benthic and pelagic biological communities and for understanding the influence of submarine topography on ocean currents, especially nutrient-rich currents. This information is fundamental to robust assessments of the spatial distribution of fish stocks and for the monitoring and surveillance of illegal fishing activities.

Furthermore, seafloor morphology information, provided by Geoscience Australia to the AAD, has been used to support a joint submission by Australia, France and the European Union for the nomination of four Marine Protected Areas along the Australian Antarctic Territory coastline. The provision of these datasets represents a key element of Australia's contribution to the ATS and CCAMLR. The four nominated Marine Protected Areas are still under consideration by CCAMLR.

[5] CCAMLR is a convention within the Antarctic Treaty System (ATS). Australia is a signatory of both CCAMLR and the ATS

However, high-resolution seafloor mapping coverage of Australia's Antarctic and sub-Antarctic marine jurisdictions is, in general, sparse. In particular, although a bathymetric compilation exists for the region around Heard and McDonald Islands and parts of the adjacent Kerguelen Plateau[6], data coverage for this region (known for illegal fishing activities of, for example, Patagonian Toothfish) is insufficient to provide the necessary level of detail to assess marine benthic and pelagic ecosystem habitats (e.g. location of seamounts) for informed fisheries regulation. A dedicated multibeam sonar seafloor survey of the Heard and McDonald Islands EEZ and the adjacent ECS of Kerguelen Plateau (rather than random swathes opportunistically collected by passing ships) will greatly improve Australia's ability to monitor and regulate fishing in that region.

Paucity of adequate bathymetry data also limits the effectiveness of current fisheries management practise. For example, CCAMLR declared that a 2009 fishing conservation measure[7] (22-08) prohibits fishing (using any technique) of certain species (*Dissostichus* ssp., or Toothfish) in waters shallower than 550m in all CCAMLR management zones[8]. Currently, due to poor bathymetric data, the exact location of the 550 m contour is unknown. Improved seafloor mapping coverage can precisely locate the 550m bathymetric contour and enable better fisheries management within Australia's Antarctic and sub-Antarctic marine jurisdictions, contributing to Australia's marine environmental management commitments under CCAMLR.

2.2.1 Recommendation

Australia develops and undertakes a systematic and dedicated comprehensive priority-driven seafloor mapping program (more completely articulated in section 2.4.1)

2.3 Cooperation with international partners on management and research under international treaties and agreements

In November 2013, Geoscience Australia signed a bilateral collaborative agreement with the Japanese National Institute of Polar Research (NIPR, who are responsible for delivery of the Japanese Antarctic Program) to cooperate on terrestrial and marine Antarctic geosciences. It is hoped that GA-NIPR will be able to share logistics and intellectual and technical expertise in order to develop collaborative geoscience programs as the relationship matures. For example, the NIPR is planning marine science voyages to the shelf adjacent to Enderby Land (the western-most regions of the Australian Antarctic Marine Jurisdiction), providing an opportunity for collaborative marine geoscience surveys in an area for which little is known and rarely visited by Australian Antarctic operations.

Furthermore, the Australian Antarctic Division (AAD, Department of the Environment) also have, and actively maintain, formal agreements with the NIPR. The AAD also directly engages and collaborates with French Antarctic operations regularly, the most recent example of which was a logistical and scientific collaborative deep field terrestrial paleoclimate ice-drilling program inland from *Casey*.

[6] Beaman & O'Brien '*Kerguelen Plateau Bathymetric Grid, November 2010*' Geoscience Australia Record 2011/22

[7] http://www.ccamlr.org/sites/drupal.ccamlr.org/files//22-08.pdf

[8] CCAMLR management zones include all of the Australian Antarctic Marine Jurisdiction adjacent to the AAT, the EEZ around Heard and McDonald Islands, and the ECS of Kerguelen Plateau. CCAMLR management zones do not cover the EEZ around Macquarie Island or the associated ECS of Macquarie Ridge.

These agreements reaffirm one of the Governments key policy priorities for Australia's engagement in the Antarctic:

> "*Pursuing collaborative science and logistics relationships with states active in east Antarctica focussing on Australia's key bilateral partners*'.

With increasing activity from other nations, such as Russia, China, India, and Italy (for example) within the Australian Antarctic Territory and adjacent waters, opportunities for bilateral and multilateral marine programs are possible. As such, we propose that Australia should engage in, and make available suitable resources and logistics, for developing mutually beneficial, equitable, collaborative programs with nations currently active within the Australian Antarctic Maritime Jurisdiction and Australia's sub-Antarctic marine jurisdiction.

2.3.1 Recommendation

Australia should continue to pursue and develop mutually beneficial multilateral relationships with other nations operating in the nations currently active within the Australian Antarctic Maritime Jurisdiction and Australia's sub-Antarctic marine jurisdiction.

2.4 Appropriate resourcing in the Southern Ocean and Antarctic territory for research

2.4.1 Seafloor sonar mapping of Australia's Antarctic and sub-Antarctic Marine jurisdictions

Bathymetric maps of the seafloor based on high-resolution multibeam sonar data are increasingly recognised within the Antarctic marine science, operations and environmental management communities as important, fundamental environmental data. Multibeam sonar data of the seafloor is analogous to, and as equally useful as, topographic maps, aerial photographs and satellite data that underpins our understanding of the terrestrial environment.

Coverage of high-resolution multibeam bathymetry of the Australian Antarctic and sub-Antarctic Marine Jurisdictions is essential for a range of science end-users, development of evidence–based marine environmental management practise (including fisheries management), provision of a better inventory of environmentally important natural assets, reduction of risk for maritime operations[9], facilitating search and rescue operations and tsunami modelling. Importantly, seafloor bathymetric mapping is an effective demonstration of physical presence within Australia's marine jurisdictions, reinforcing Australia's sovereignty.

Coverage of adequate bathymetry data in the Australian Antarctic Marine Jurisdiction is sparse (<1%) and predominantly has been collected by other nations (Germany, France, USA, Italy). Coverage of single-beam sonar data in the Australian Antarctic Marine Jurisdiction is limited to the areas immediately adjacent to the three Australian stations. However, even in areas of existing singlebeam data coverage, the minimum track spacing is several kilometres apart and these data are not useful

[9] Note the reported 16th Feb 2014 grounding of the Japanese icebreaker *Shirase* within Australian Antarctic waters of western Enderby Land)

for the purpose of seafloor mapping. Similarly, *detailed* seafloor mapping surveys in the sub-Antarctic marine jurisdictions around Heard and McDonald Islands are also lacking, and the available seafloor maps are based on inadequate data coverage.

A seafloor mapping program could be developed as a multi-agency collaboration, engaging, as necessary, various government and research institutes including Geoscience Australia, Australian Antarctic Division, Royal Australian Navy, the Australian Hydrographic Service and CSIRO (Marine and Atmospheric Research). This would be an effective means of demonstrating sovereignty (in the Antarctic regions in particular), supporting marine science, informing domestic and international marine environmental management strategies and minimising maritime navigational risk to government, commercial and private operators.

2.4.1.1 Recommendation

Australia develops and undertakes a systematic and dedicated comprehensive priority-driven seafloor mapping program (priority regions are outlined in the Appendix) within the Australian Antarctic Marine Jurisdiction (noting the importance of high-use potentially vulnerable areas adjacent to Australia's research stations) and within the Exclusive Economic Zone surrounding Macquarie Island, Heard and McDonald Islands and associated areas of extended continental shelf (Fig. A1).

2.4.2 Law of the Sea and Maritime Boundaries Advice

Geoscience Australia is responsible for defining Australia's maritime boundaries and providing geospatial advice that underpins the legal determination of Australia's maritime jurisdictional limits, including the spatial provisions of domestic legislation and the United Nations Convention on the Law of the Sea (UNCLOS). Geoscience Australia is undertaking a comprehensive mapping program of the territorial sea baseline (TSB) of all of the Australian States and Territories *except the Australian Antarctic Territory*. This program is mapping the Australian coast using remote sensing techniques in anticipation of making a permanent declaration of all of Australia's baselines and maritime limits. It is an important principle of managing Australia's marine spaces that a consistent approach is maintained for all of the Australian jurisdictions and this program should be extended to the AAT. In addition, in the AAT, the baseline is defined in many places by the edge of the permanent ice. This is subject to positional changes, due to natural processes and ice movements. This has direct implications for Australia's maritime boundaries. For areas of unstable coast, such as ice-fringed coastlines, UNCLOS allows the definition of the TSB by identifying the outermost limit of instability. An evaluation of the stability of the ice covered coasts of the Antarctic is an important element of any future program of identifying the TSB of the AAT.

The dynamic nature of the Antarctic ice-sheet causes ongoing changes to the mostly ice-fringed terrestrial Antarctic coastline. These changes need to be monitored via Earth observation techniques (at Geoscience Australia) and Australia's Antarctic maritime boundaries modified accordingly. The AAT coastline was defined for the purposes of delineating maritime boundaries nearly 10 years ago; however there have been numerous changes to the coastline since then, most notably the calving of the 100 km long Mertz Glacier tongue in February 2010. High-resolution satellite images are required to provide spatially accurate and precise positional information of the AAT coastline. Use of recent satellite images that are precise in their position is a cost-effective approach as it reduces the need for field-based survey controls.

An ongoing program that monitors changes in the coastline of Antarctica is needed in order to:

- Develop a complete inventory of islands when they are free of ice coverage (also useful for reducing risk for marine navigation),
- Update the coastline for territorial sea baseline purposes based on variation to the extent and movement of grounded ice

Furthermore, Australia has deferred the option of submitting a claim to UNCLOS for extended continental shelf beyond the outer limit of the 200 nautical mile limit from the territorial sea baseline from the AAT, but has reserved the right to resubmit additional information area when it becomes available. An area to the east of Heard Island (Williams Ridge) has potential to be included in a claim for extended continental shelf but lacks sufficient data to be clearly defined, and UNCLOS will not consider a claim for this area until new information is presented. Therefore we submit that dedicated marine geophysical surveys would include further data collection for better defining the area of ECS to the east of Heard Island (Williams Ridge). As this region lies beyond that in which sea ice is present, marine science surveys can be conducted using any suitable vessel with the necessary geophysical capabilities (e.g. seismic acquisition and multibeam sonar capabilities), including the MNF RV *Investigator* and the replacement to the RSV *Aurora Australis*.

As a further demonstration of Australia's interest and territorial claims in the AAT, collection of geophysical (ship-based seismic and multibeam bathymetry) data covering the continental shelf is a strategy that should be continued and planned for upcoming years. Both the new MNF RV *Investigator* and the replacement icebreaker for the RSV *Aurora Australis* will be capable of supporting marine seismic, bathymetric and sub-bottom profiling surveys. Therefore, Australia will have access to a suitable platform on which to collect data in the Williams Ridge region, and any other areas requiring affirmation of Australia's Antarctic maritime boundaries and jurisdictions.

2.4.2.1 Recommendation

Australia develops a program to align the management of the AAT maritime boundaries with the other Australian Territories and States, including monitoring changes to ice-bordered coastlines and support a dedicated marine geoscience survey over the region of Extended Continental Shelf near Heard Island (Williams Ridge) that would support and supplement Australia's Continental Shelf claims.

2.4.3 Geophysical Monitoring

Geoscience Australia's geophysical monitoring program (of which the Antarctic observatories are an essential component) is critical for a diverse range of applications such as navigation, national planning and developmental activities, cadastral and engineering surveys and topographic mapping. Seismic observatories monitor nuclear explosions worldwide and, as part of a global network, inform Australia and her neighbours, of potentially tsunamigenic earthquakes.

Geoscience Australia operates geodetic, seismic, geomagnetic and infrasound (proposed) observatories at the three continental stations (*Casey*, *Davis* and *Mawson*) and Macquarie Island. These observatories are key nodes in global networks of similar observatories that monitor various Earth processes and are used to derive a number of fundamental scientific datasets and products, many of which are directly relevant to Australia's Antarctic and sub-Antarctic marine jurisdictions.

The AAT offers two primary opportunities for observatory, geodetic and gravity activities. Firstly, Antarctica is a geographically important location for elements of the globally distributed networks of sensors. Secondly, the same sensors assist Antarctic marine and terrestrial science and exploration activities. GA's Observatories program in Antarctica provides a broad range of pivotal Earth and space-based datasets and products such as:

- The International Terrestrial Reference Frame (ITRF) which provides a coordinate foundation for all survey, mapping and Earth monitoring applications, including absolute sea level rise monitoring and marine science programs reliant on satellite positioning.
- The International Geomagnetic Reference Field (IGRF) which provides the angular offset between True North and Magnetic North anywhere on Earth. This is used extensively for land, air and sea navigation, as well as a number of marine and terrestrial science programs.
- The global seismic datasets are gathered by a number of groups including the Incorporated Research Institution for Seismology (IRIS). These datasets are used for monitoring the tectonic state of the Earth and issuing alerts for large earthquake events that, depending on location, can cause tsunamis, earthquake damage and / or loss of life. These data also contribute, as part of a global network, to GA's Australian Tsunami Warning System (operated jointly with the Bureau of Meteorology) facilitating our role of alerting the Australian Government and regional neighbours of potentially damaging tsunamigenic earthquake events.

These fundamental geospatial datasets are essential components to enable scientists to monitor and understand:

- Deformations of the solid Earth (e.g., Glacial Isostatic Adjustment),
- Variations in hydrosphere and cryosphere (e.g., sea-level change, ice sheet dynamics),

Furthermore, the geodetic infrastructure (particularly in regions of the AAT for which there are no Australian geophysical monitoring capability) in collaboration with international collaborators (e.g. Geodetic Infrastructure of Antarctica (GIANT) Expert Group within the Scientific Committee on Antarctic Research) would:

- Enhance the common geospatial reference surface used by all scientists and operators,
- Provide fundamental positioning, navigation and timing data used to better map, monitor and model the AAT and adjacent marine jurisdictions

2.4.3.1 Recommendation

Australia continues to maintain and support its geophysical monitoring observatories in the Antarctic. These observatories include existing geodetic, seismic, geomagnetic and nuclear test monitoring capacity. Data from these ground stations are a key component of the regional tsunami warning network (Australian Tsunami Warning System), benchmarking geospatial and marine geophysical surveying and underpinning Australia's international treaty obligations.

2.4.4 Funding

In order to conduct the range of activities proposed and outlined in this submission, we stress that additional appropriation funding would need to be allocated to Geoscience Australia specifically to undertake these *additional* activities.

In order to conduct the dedicated marine geoscience activities discussed, i.e.

- a dedicated seafloor mapping program (section 2.4.1),
- a dedicated marine geophysical survey to better define Australia's claim on the Extended Continental Shelf of Williams Ridge (section 2.4.2)
- a satellite-based Earth observation monitoring of the Antarctic coastline for maritime jurisdiction maintenance (section 2.4.2)

allocation of additional funding would be necessary. Additional resources would also enable expansion of geographic coverage, technical improvement of existing equipment and ongoing maintenance of the geophysical observatories network (section 2.4.3) within the Australian Antarctic Territory and Macquarie Island.

It would be not possible to conduct the proposed additional programs under existing funding circumstances or arrangements.

Additional logistical capacity and operational funding also should be considered for the Australian Antarctic Division, where necessary, in order to support the necessary field and monitoring programs.

3 Appendix

Priority areas (1 to11) for a future seafloor mapping program (Fig. A1) have been identified and ranked based on:

- the available coverage of bathymetry data and
- scientific and strategic interests (including input into fisheries management through CCAMLR)

The primary drivers and justifications for seafloor mapping outlined below are articulated in the main text (see section 2.4.1 for details) and are re-iterated here.

Coverage of high-resolution multibeam bathymetry of the Australian Antarctic and sub-Antarctic marine jurisdictions is essential for a range of science end-users, development of evidence–based marine environmental management practise (including fisheries management), provision of a better inventory of environmentally important natural assets, reduction of risk for maritime operations, facilitation of search and rescue operations, tsunami modelling, and, perhaps most importantly, reinforcing Australia's sovereign interests.

AREAS OF PRIORITY 'A' FOR MARINE GEOSCIENCE SURVEYING:

- *Casey*, *Davis* and *Mawson* near-shore waters (area 1): Seafloor mapping in the shallow waters (<200 m) immediately adjacent to Australia's research stations (*Casey*, *Davis* and *Mawson*) is the highest priority. These are high-use areas which are vulnerable to both human impacts and climate change but are generally poorly characterised. Preliminary surveys at *Davis* and *Casey* in recent years have demonstrated the invaluable nature of these datasets for understanding the biophysical character of the seafloor. Targeted surveys in these areas will provide the foundational data to support marine science, operational and strategic policy priorities of the Australian Government, resulting in more effective management of these high-use areas.
- Enderby Land (area 2): The western region of the Australian Antarctic Marine Jurisdiction (between 45° E and 62° E), near Enderby Land, displays a paucity of marine geoscience data with only 5 sediment samples (only one collected by Australia), 5 tracks of singlebeam bathymetry data, and one multibeam swath (collected by Germany). The Japanese Antarctic Program has recently collected limited multibeam bathymetry data in this area (although the data extents are not available) and is planning future marine surveys in this region. The Belarusian and Russian Antarctic Programs have been active in this region and Belarus is planning on building a station in Enderby Land which will be resupplied by ship.

  The activity of other nations in this remote area highlights the need for Australia to maintain a visible presence and conduct activities that reinforce the full extent of Australia's territorial claims in the Antarctic. The lack of adequate bathymetric data in the Enderby Land region is a threat to maritime operations, as highlighted by recent events[10]. Furthermore, the lack of seafloor information inhibits development of appropriate marine environmental management, and impacts on our obligations to the Antarctic Treaty, associated protocols and relevant domestic legislation.

[10] Reported 16th Feb 2014 grounding of the Japanese icebreaker *Shirase* within Australian Antarctic waters of western Enderby Land)

- Eastern Sector (area 3): There is a paucity of data available in the far east region of the Australian Antarctic Marine Jurisdiction (between 150° E and 160° E), with only one sediment core (collected by the US) and two tracks of singlebeam bathymetry data (collected by Australia and NZ) in the deep ocean area, and no data from the continental shelf. This region has been rarely visited by the Australia, yet forms a sizeable area within the Australian Antarctic Marine Jurisdiction, highlighting the need for visible presence by Australian operations, conducting mapping activities to reinforce Australia's territorial claims in the Antarctic, reducing risk to maritime activities and collection of seafloor dataset to inform marine management practise.
- Continental Shelf along Wilkes Land and Queen Mary Land (area 4): The continental shelf around much of the Australian Antarctic Marine Jurisdiction (between 82° E and 136° E) has been rarely visited by the Australian Antarctic Program, with the exception of the region directly offshore from Casey station. There is currently no multibeam bathymetry data available in this region and only limited (<20) sediment samples. With the exception of the tracks in and out of Casey station, there are fewer than 10 tracks of singlebeam bathymetry data collected across this section of the continental shelf. This region is of particular interest for understanding changes in the East Antarctic Ice Sheet, which may help predict future changes in the ice sheet behaviour.
- Williams Ridge (area 5): As discussed earlier, Williams Ridge (east of Heard Island) is an area of ECS for which Australia has an option to make a new or revised submission to CLCS with additional geoscience evidence that would support such a claim. A dedicated marine seismic and multibeam sonar bathymetry survey would provide the necessary evidence in support of Australia's claim for this area of ECS.

AREAS OF PRIORITY 'B' FOR MARINE GEOSCIENCE SURVEYING:

- *Mawson* Area (area 6): The region offshore from *Mawson* station (approx. 62° E to 68° E) was the focus for several marine science voyages in the 1990s and early 2000's by Australia and the US. A large number of sediment samples (approx. 50) were collected on the continental shelf and slope, although there are no sediment samples from the deep ocean. Tracks of singlebeam bathymetry data are dense in some areas, particular in and out of *Mawson* station and along the edge of the continental shelf. There is only one multibeam swath (collected by Germany) across this region.
- Deep Ocean along Wilkes Land and Queen Mary Land (area 7): The deep ocean region between 85° E and 136° E has limited marine geoscience data available. There is one multibeam swath (collected by the US) and approximately 20 sediment samples (collected by the French and US). This region is often transited through by the Australian Antarctic Program on the way to Casey and *Davis* stations so there are numerous tracks of singlebeam bathymetry data but these are spaced tens to hundreds of kilometres apart and are not a useful dataset for mapping the seafloor.
- Heard and McDonald Islands sub-Antarctic marine jurisdiction and Kerguelen Plateau (area 8): A bathymetric grid exists[11] for part of this region, mainly within the EEZ surrounding Heard and McDonald Islands; however, data coverage by high-resolution multibeam survey is sparse particularly over the ECS of Kerguelen Plateau. The region is important for the fisheries industry, and improved understanding of the bathymetry and seafloor morphology will improve

[11] Beaman RJ & O'Brien PE '*Kerguelen Plateau Bathymetric Grid, November 2010'* Geoscience Australia, Record 2011/22

Australia's ability to contribute to CCAMLR in order develop appropriate marine management practise for the region.

AREAS OF PRIORITY 'C' FOR MARINE GEOSCIENCE SURVEYING:

- Macquarie Island and Macquarie Ridge (area 9): Macquarie Island EEZ and the ECS of Macquarie Ridge is well covered by multibeam sonar data (datasets available thru Geoscience Australia).
- Prydz Bay (area 10): The region around Prydz Bay (68° E to 82° E) contains the greatest concentration of marine geoscience data coverage in the Australian Antarctic Marine Jurisdiction. Over 200 sediment samples have been collected in Prydz Bay, mostly on the continental shelf and slope, and mostly by Australia. Coverage of single-beam bathymetry data is dense compared to other regions but importantly, multibeam sonar bathymetry data is limited, with only a few swaths collected by Germany and the US and a small survey (<42 km^2 in area) conducted by Geoscience Australia in collaboration with the AAD and the Royal Australian Navy in the shallow-waters adjacent to *Davis* station.
- George V Land (area 11): The region around the Mertz Glacier near George V Land has been the focus of several marine science voyages by Australia, New Zealand, Italy, France and the US over a number of years. Over 100 sediment samples have been collected from the area, as well as large number of underwater images, and there are several regions of quality multibeam bathymetry data. Areas to the east of the Mertz Glacier tongue, however, remain largely uncharacterised.

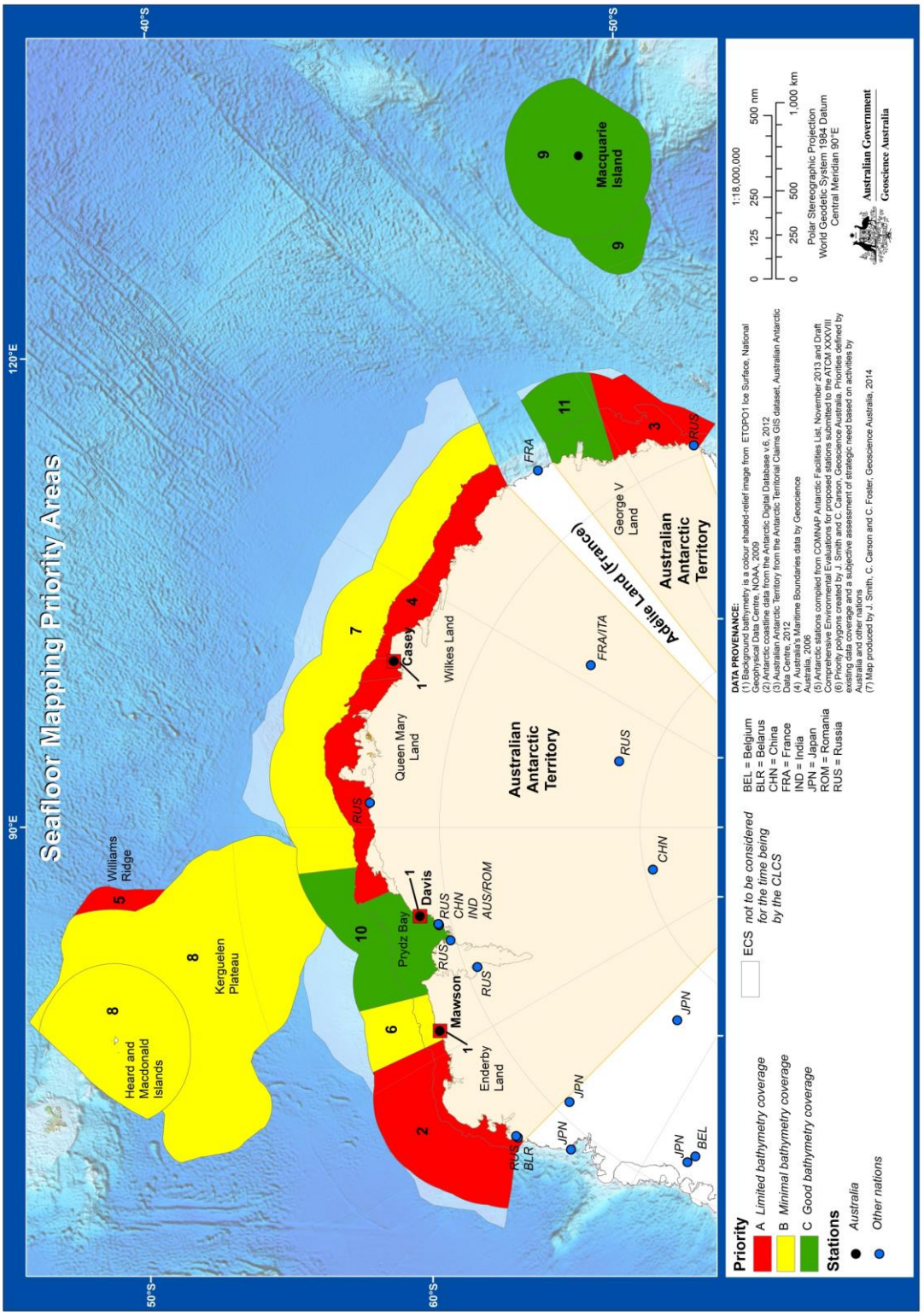

Figure A1. Seafloor mapping priority areas for the Australian Antarctic and sub-Antarctic Marine Jurisdictions. Priority classification (A-B-C) ranked on available data coverage. The proposed survey areas around Mawson, Davis *and* Casey*, ranked as '1', are not resolved at the scale of this map and the indicated survey areas (shown as red squares around the stations) are for illustration only. For further explanation see text.*