RV *Investigator* Voyage Plan

Voyage #:	**IN2017_V01**		
Voyage title:	Interactions of the Totten Glacier with the Southern Ocean through multiple glacial cycles.		
Mobilisation:	Hobart, Friday, 13 January 2017		
Depart:	10:00 Hobart, Saturday, 14 January 2017		
Return:	Hobart, Sunday, 5 March 2017		
Demobilisation:	Hobart, Monday, 6 March 2017		
Voyage Manager:	Doug Thost	Contact details:	dougthost@yahoo.com.au
Chief Scientist:	Assoc. Prof. Leanne Armand		
Affiliation:	Macquarie University	Contact details:	leanne.armand@mq.edu.au
Principal Investigators:	Mr Philip O'Brien (Macquarie University, Australia) Prof. Amy Leventer (Colgate University, USA) Prof Eugene Domack University of South Florida, USA) Dr Frederica Donda (National Institute of Oceanography and Experimental Geophysics (OGS), Italy) Prof. Laura De Santis (National Institute of Oceanography and Experimental Geophysics (OGS), Italy) Dr Carlota Escutia Dotti (Instituto Andaluz de Ciencias de la Tierra, Spain) Dr Alix Post (Geoscience Australia, Australia) Dr Bradley Opdyke (Australian National University, Australia)		
Project name:	as above		
Affiliation:	Macquarie University	Contact details:	leanne.armand@mq.edu.au

Scientific objectives

The physical interaction between the Totten Glacier and the Southern Ocean during periods of warming and ice sheet retreat is poorly understood. Recent observations suggest that the Totten Glacier is rapidly thinning in a manner similar to the Pine Island Glacier in West Antarctica. A rapid retreat of the Totten Glacier into the large Aurora Basin from which it drains could cause an accelerated draw down of the East Antarctic Ice Sheet and matching acceleration in sea level rise. The Aurora Basin contains the thickest ice in Antarctica.

The increased loss of ice from Antarctica is mostly due to the rapid thinning and retreat of glaciers, driven by the enhanced melting of ice shelves that fringe the continent. It has been proposed that the Totten Glacier is melting because of intrusion of warm Circumpolar Deep Water onto the continental shelf, as is happening in Pine Island Bay.

This study will gather data to examine the physical interaction between the Totten Glacier and Southern Ocean through multiple glacial cycles by:

1. Mapping sediment deposited on the continental shelf and slope by the Totten Glacier and using this to understand sediment deposition processes
2. Sampling long sediment cores from the continental shelf and slope, and using the deposition model to interpret their formation processes
3. Directly measuring a suite of ocean water and surface sediment properties, including microorganisms, trace elements and isotopes, to allow for accurate interpretation of sediments
4. Mapping benthic habitats in the area, including studies of seafloor biota and geomorphological characteristics, using underwater video and still imagery.

Voyage objectives

The continental shelf and slope contain sediment in places that will provide records of how the Totten Glacier behaved in the past and also how ocean currents and sea ice distribution changed during the same periods. Previous research on glaciated continental margins, has shown that when the ice sheet is at its greatest extent, terrigenous sediment is delivered from the ice to the top of the slope. These sediments then move down slope in gullies and canyons as slumps and turbidity currents. Coarse material moves in the canyons while the silt and clay fractions can spill over the canyon walls or be picked up by along-slope currents and deposited in levees and contourite mounds. During warm phases, when the ice retreats from the shelf, the slope receives sediment formed from the rain out of dead plankton from the water column.

We will identify sediments types using multibeam bathymetric mapping, sub-bottom profiling and seismic reflection profiling. We will map the geomorphology of the slope and the internal geometry of sediment bodies in order to understand which deposits contain records of the most recent glacial cycles.

Existing low resolution seismic reflection profiles show submarine canyons, submarine fans, landslide deposits and mounds formed by currents sweeping sediments along the slope (contourite mounds). Systematic multibeam surveys provide the best information on sediment body geometry; subbottom profiler data will show which deposits formed during the last few glacial cycles.

Sediments will be sampled by kasten coring and filmed (where feasible) to determine the suitability for long piston core acquisition. Interpretation of the sediments will be calibrated using water samples for microorganisms, trace elements and isotopes and by taking surface sediment samples using the multicorer.

The following specific voyage objectives are discussed with reference to areas identified on the location map (Figures 1 and 2) and major sampling/observing equipment on board the RV Investigator.

The primary voyage objectives are:

1. To survey and map, using multibeam, subbottom profiler, bioacoustics echosounder and gravity profiling, by priority, the;
   a) Continental slope of the Sabrina coast margin, which are presumed to contain the canyons fed by outflow from the Totten Glacier.
      i) Area A4.
      ii) Area C4.
   b) Sabrina coast shelf region, which links the Totten Glacier to the slope, where sea ice free conditions permit.
      i) Area B.
2. To undertake seismic strike and dip lines, by priority, on the;
   a) continental slope of the Sabrina coast margin, using Italian and MNF seismic equipment, in day-light hours with respect to permitted Marine Mammal Observation protocols, in;
      i) Area A4.
      ii) Area C4.
3. To retrieve slope and shelf sediments, for a variety of palaeoceanographic, micropalaeontological, genomic and geochemical studies (as approved by ATEP and AMLR permits) on the;
   a) continental slope of the Sabrina coast margin (Priority Area A4 and C4).
   b) Sabrina coast shelf region (Area B), where sea-ice free conditions permit.
4. To retrieve water samples, for a variety of palaeoceanographic, microbiological, genomic and geochemical studies (and approved by AMLR permit), with reference to hydrochemical characterisation on the;
   a) continental slope of the Sabrina coast margin (Priority Area A4 and C4).
   b) Sabrina coast shelf region (Area B), where sea ice free conditions permit.
5. To record video and still imagery of the seafloor biota and geomorphological characteristics, for habitat mapping using deep tow video systems and multi-corer video on the;
   i. continental slope of the Sabrina coast margin (Priority Area A4 and C4),
   ii. Sabrina coast shelf region (Area B), which links the Totten Glacier to the slope, where sea ice free conditions permit.
6. To collect oceanographic and climatic parameters using expendable bathymetric (XBT), ADCP and underway instruments.

Appendix 1 details all the national and international funded operational scientific support grants enabling the analysis of samples and data retrieved from IN2017_V01.

Operational Risk Management

Our perceived and known risks on the listed activities above and contingencies around them are given in the **Table 1** below. **Appendix 2** details scientific team identified high risk operations and the MNF or ASP triggered procedure responses.

Table 1. Impacts on the mission and contingencies to achieve priorities.

Risk	Activities Impacted	Contingency Management
Major storms	All activities except intake water sampling and potentially swath mapping – dependent on conditions.	Re-planning of surveying and coring priorities within the days available for scientific activities. A meeting will be held between the CS and major PIs. The re-prioritised plan will then be discussed with the Voyage Manager and the Master.
Sea-ice cover	Surveying and water sampling/characterisation objectives in Area B.	Area A4 is the priority of this voyage. In the event of sea-ice cover persisting in any part of Areas A4 or C4 we will modify the survey region accordingly. In the event that satellite images or radar suggest that new sea-ice or icebergs pose any risk whatsoever to the ship and its occupants, all activities will halt in any planned Area and the voyage will move into safer regions in Area A4 and C4 as determined in discussions with the Voyage Manager and the Master. In the event of Area B being covered with sea ice we will spend more time in Area C4.
No sea-ice cover	Surveying and sampling objectives in Area C4.	In the event that Area B is sea-ice free (as in 2016) we will attempt to survey and conduct limited water and sea floor characterisation. This will mean a loss of time in surveying and sampling in Area C4 as determined in discussions with the Voyage Manager and the Master.
Whale sightings during seismic activities	Seismic surveying	Airgun seismic reflection data will only be collected during daylight hours. The survey personnel will include a certified Marine Mammal Observer (V. Pirotta) who will be on the Bridge / Observation Room during seismic operations so that mitigation methods set out in EPBC Act Policy Statement 2.1 (refer to detail in **Appendix 3**), will be applied. When seismic operations are shut down, a meeting will be held by the CS and major PIs.

Risk	Activities Impacted	Contingency Management
		The re-prioritised plan will then be discussed with the Voyage Manager and Master. If the whale persists in the region, then normal surveying will continue until we move to the next seismic site. The site where the disruption occurred may be returned to at a later date or an alternate seismic site may be planned if scientific time permits.
Equipment loss or failure or lack of spare parts/consumables	Variety of sampling activities	In the event that equipment is lost to the seafloor during sampling, equipment fails or is deemed broken, or consumables are exhausted. Sampling will be affected. Contingencies can in most cases be put in place for alternative sampling (i.e. gravity in lieu of piston; box in lieu of multicorer). Contingencies will be discussed between affected PIs, CS, MNF Tech support and Voyage Manager.
Access to decks	All seismic and coring activities.	In the event the Master indicates that the access to deck are closed due to poor weather, wind, snow-covered or frozen decks, seismic and coring activities (and potentially CTD) will not take place. Contingency plan is to continue surveying and taking samples by intake line until conditions ameliorate. Where conditions persist surveying will replace coring activities first and seismic operations second.

This voyage will be strongly influenced by weather and ice conditions. With this in mind, we have planned the survey as multiple areas of descending priority so the program can be modified as conditions evolve.

Activity Plan for first 24 hours at sea.

14 January 2017

All scientific personnel to be on ship evening prior. No scientific personnel to leave ship without Chief Scientist and Voyage Manager approval.

Where possible 7am departure (latest 10am, if we need to wait for urgent late freight).

Transit to Area A4; weather dependent fastest and safest route chosen by Master.

Anticipated activities.

1. Continue and complete tie down activities before leaving Derwent River.

2. Commencement of gravity meter recording.

3. Complete evacuation information, drills and safety inductions as determined by ASP.
4. Intake water line sampling commences from Bruny Island/exit of Derwent River ~43°S. IT support and ship sensor parameters required.
5. Undertake first planning meeting between Chief and co-Chief Scientists, Master and Voyage manager.
6. Chief Scientist led scientific personnel meeting update.
7. Commencement of swath mapping for general collection purposes on crossing EEZ.
8. Seismic team set-up to be priority with MNF technical support.
9. Scientific personnel free to rest or continue lab set-up preparations or testing of equipment (IT and electrical support) for remainder of day.
10. If 12-hour watches by Captain and crew in operation, then Chief and Co-Chief will follow suit and commence hand-over meeting schedule in evening (i.e. every 12 hours).

We anticipate in that testing of the CTD and potentially the multi corer will be undertaken within the first 48 hours at a shallow location to be decided by the CS and Voyage Manager (between the shelf and the Polar Front).

Voyage track example

We provide a figure of the potential voyage track to the operation area (**Figure 1**). The voyage transit to and from the port of Hobart should be as direct as is acknowledged as being subject to weather conditions on the day of departure and those forecast for the following eight days.

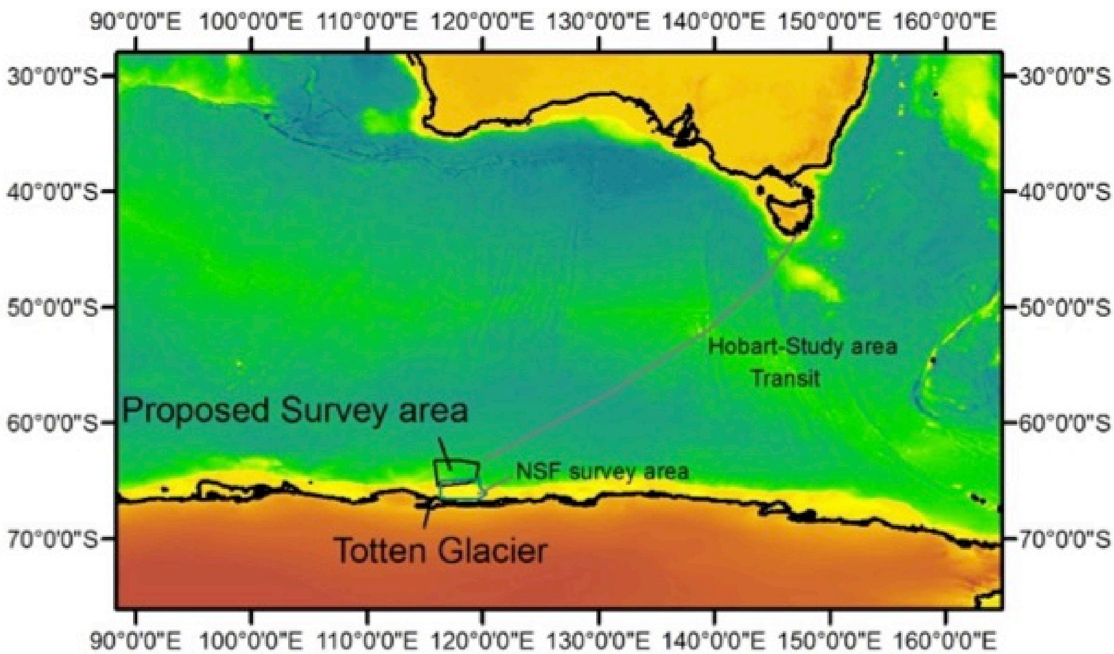


Figure 1. Potential voyage track to broad operation area.

Survey Plan Assumptions

The survey plan is based on our following assumptions:

1. Transit speed will be 10 knots. This allows for weather issues on the way south.
2. Survey speed is assumed to be 5 knots. This is a safe operating speed in sea ice affected waters and is the anticipated seismic survey speed. While we will not be entering sea ice, occasional sea ice floes and growlers are possible so we have assumed a safety-first policy.
3. We assume winch speeds around 50 m/minute.
4. We have used the Australian Antarctic Division's estimate of an 8-day transit to Casey Station, to the west of our Sabrina Coast survey region, as a reasonable estimate of transit time to the survey area A4, which accounts for weather conditions etc.
5. We have used an estimate of swath width of 3 times water depth.
6. We have assumed deployments at each sampling station totalling ~**12** hours per station:
   i. Video/Stills
   ii. Multicorer, Box or Grab
   iii. Kasten or gravity corer
   iv. Piston corer (this may not be used at all sites).
   v. CTD with three depth stations (this may not be used at all sites). Water depths will depend on the stations chosen based on data acquired during the survey.
   vi. Plankton Net (this may not be used at all sites).
7. Strike seismic lines would be collected during swath mapping passes along slope so only dip lines are budgeted separately.

Priority areas

This mission anticipates surveying three areas as identified in **Figure 2** and with Area waypoints detailed in **Table 2**. The three areas are described below and activity-timing breakdowns, where possible, are detailed in **Tables 3 and 4**.

Area A4

This is the highest priority area in that it contains the canyons fed by outflow from the Totten Glacier and likely contains the deposits, which contain the best record of Totten interaction with the Southern Ocean.

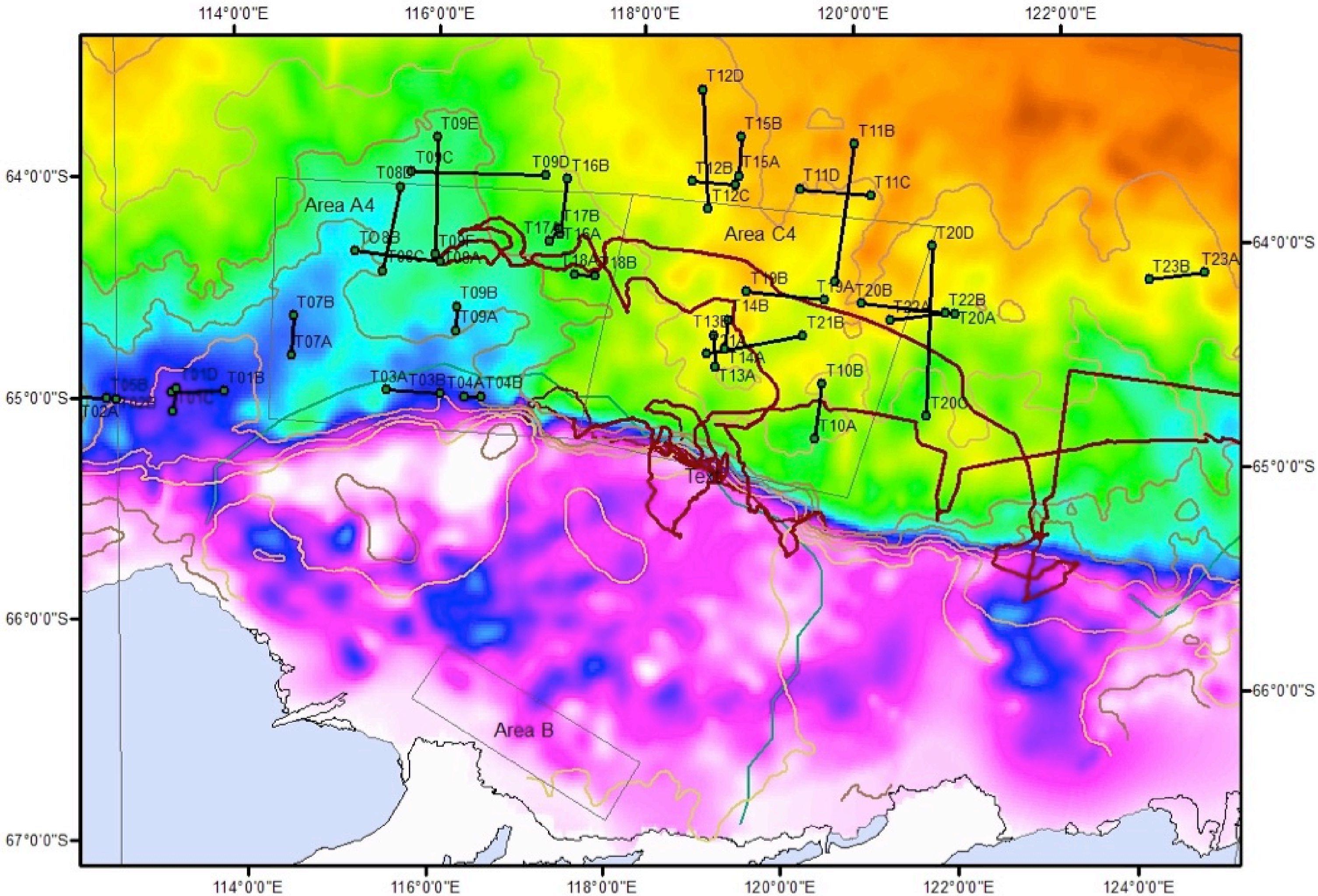
Area B

This area is included because data from this area would be key to many questions regarding the Totten Glaciers past, present and future behaviour. A number of surveys have attempted to reach it but so far only one has managed a single transect with single beam bathymetry and a few oceanographic casts. The area is within the median sea ice edge but was ice-free for most of the 2015-2016 summer. Therefore, we include it as a contingency in case of a repetition of favourable conditions.

Area C4

Area C4 is to the east of A4 and the area fed by ice shelves east of the Totten Glacier, which will provide a control on the proxy signatures from the Totten drainage basin. It would be surveyed if time permitted.

Figure 2. Detailed survey areas. Includes existing seismic lines. T numbers refer to target areas identified on existing seismic lines (see **Appendix 4** for images of the pre-existing seismic data).



Waypoints and stations

The survey is based around swath mapping of roughly three rectangular areas. We have not determined detailed way points for the swath surveys as these will need to be worked out with the MNF staff and probably modified depending on conditions at the time (e.g. effective swath width). The survey area corners are listed in **Table 2a**, whilst the suggested transit waypoints into and out of Area B are listed in **Table 2b**. These later way points are related to a request from Dr Jamin Greenbaum to enable collaborative gravity measurements from the US aerogeophysical program (**Appendix 5**). In **Table 3** we list the estimated transit time between the first and last survey areas and Hobart port.

Table 2a. Area waypoints for the three survey regions

Area	NE corner	SE corner	SW corner	NW corner
A4	117.945, -64.075	117.51, -65.19	114.293, -65.117	114.393, -64.027
B*	118.324, -66.658	117.983, -66.899	115.836, -66.393	116.177, -66.136
C4	121.001, -64.109	120.359, -65.372	117.51, -65.19	117.945, -64.075

*Area B is an area on the shelf, which is of extreme interest to the scientific community. It has only been accessed once before because it is generally covered with fast ice or sea ice. We have included it because during the summer of 2015-2016, the area was entirely ice free (Appendix 6), with no ships in the vicinity. We have flagged it so that if such conditions occur again, it can be incorporated in the survey plan.

Table 2b. Suggested way point tracks for transit to and from Area B.

Latitude	Longitude
-64.81205001	116.477498
-65.06877175	116.3364327
-65.32558897	116.1923395
-65.58249418	116.0451215
-65.83947969	115.8946781
-66.09653753	115.7409043
-66.35164902	115.5938766
-66.45691283	116.2007965
-66.55962024	116.8132507
-66.6597331	117.4311734
-66.58486548	117.6815469
-66.32602265	117.538947

Latitude	Longitude
-66.06727638	117.3995163
-65.80863387	117.2631517
-65.55010212	117.1297549
-65.29168792	116.9992313
-65.03339785	116.8714904

Table 3. Estimated Transit steam hours to and from the port and the survey areas.

Location	Decimal Latitude	Decimal Longitude	Distance (nm)	Total Distance (nm)	Steaming time (hrs)	Total Steam (hrs)
Hobart	-42.87	147.35				
NE corner, Area A4	-64.075	117.945	1581.533	1581.533	158.9’	158.9’ (6 days)
SE corner Area C4	-65.372	120.359				
Hobart	-42.87	147.35	1624.19		162.25’	

Time estimates

The Table 4 provides indicative time estimates based on a steaming speed of **10 knots** and seismic surveying and Area B survey speeds of **5 knots.**

Table 4. Time estimates between Hobart port and Area A4, transit within Area B and return transit from Area C4 to Hobart Port.

Area & Date	Transits	Swath & Strike seismic lines	Seismic dip lines	Stations	Total Time in Transit/Area
Hobart 14 Jan 17	8 days	underway swath only	none	none	8 days
A4 21 Jan 17	2 days	12.5 days	3 allocated; 3 days	max 6 allocated; 3 days	20 days

Area & Date	Transits	Swath & Strike seismic lines	Seismic dip lines	Stations	Total Time in Transit/Area
*B 9 Feb 17	- inward 14 hours @ 5 knots for 70.1944nm (130 km) - between stations 15 hours @ 5 knots. - outward 14 hours @ 5 knots.	7 days swath only	none	max 3 allocated; 1.5 day	10 days
C4 18 Feb 17	1 day	12 days	2 days	max 3 allocated; 1.5 day	16.5 days
Hobart 27 Feb 17	7 days	underway swath only	none	none	7 days
TOTALS	~19.5 days	31 days	5 days	6days	61.5 days#

* Area B survey contingent on favorable ice conditions, which should be known before reaching Area A4.

Total time: 61.5 days (40 = science). This exceeds the total science times but we would reduce or increase time in Area C4 depending on the access to Area B.

Piggy-back project

1. Polar Cell Aerosol Nucleation (PCAN)

Project Chief: Dr Ruhi Humphries

PI: Dr Melita Keywood, Mr Paul Selleck, Dr Sarah Lawson, Mr Jason Ward, A/Prof. Stephen Wilson, Dr Zoran Ristovski, Dr Robyn Schofield.

Student sailing on voyage: Mr Jack Simmons; University of Wollongong.

Objectives:

Atmospheric aerosol populations in the Antarctic and Southern Ocean regions are key components of the global radiative balance and represent one of the few places on earth relatively untouched by anthropogenic influence. Recent investigations have shown that the region of the Polar Cell just north of the Antarctic continent is atmospherically distinct from those either north in the Southern Ocean, or on the continent itself. This region has only been measured a handful of times previously, and remains largely uncharacterised, yet the small number of observations showed unexpected properties uncharacteristic of the region. The objectives of this study are therefore to:

- Increase the number and quality of atmospheric observations in a region that remains largely uncharacterised.
- Characterise the chemical and physical properties of atmospheric aerosol populations in the northern region of the Antarctic Atmospheric Polar Cell

- Understand the seasonal changes of the Polar Cell aerosol populations by comparing to springtime measurements at the same location taken in 2012 (AAD project #4032)
- Observe the aerosol formation processes in the pristine atmosphere of the Antarctic polar cell.
- Better understand the aerosol cloud interactions in the southern part of the Southern Ocean, which exhibits the largest biases in radiation.
- Coordinate with measurements made as part of the Swiss-funded Antarctic Circumpolar Expedition (ACE) and NASA's ATom mission to better understand the aerosol properties of the Southern Ocean in its entirety.

Data Collection

All instruments run continually during the voyage, and are automatically controlled by built-in control boards or PCs. They will sample of the RV *Investigator's* air inlet which runs continually at sea. Permanent instrumentation is maintained by the SIT support team (MNF) as part of their regular sea-going duties.

Additional instrumentation will be prioritised based on reliability and requirements for maintenance. Two instruments will be included if we can find someone to check the instruments (a few minutes per week), while remaining instruments will only be included if an additional berth is obtained. All instruments are very reliable and have been run on numerous voyages during 2016 and require only minimal maintenance (~ 30 minutes per day for a thorough check of everything assuming nothing is wrong).

Project Team:

Name	Project Role	Affiliation	City	Country	Going South
Humphries, Dr. Ruhi Ruhi.Humphries@csiro.au	Chief investigator	CSIRO	Aspendale	Australia	No
Keywood, Dr. Melita Melita.Keywood@csiro.au	Co-investigator	CSIRO	Aspendale	Australia	No
Selleck, Mr. Paul Paul.W.Selleck@csiro.au	Co-investigator	CSIRO	Aspendale	Australia	No
Ward, Mr. Jason Jason.Ward@csiro.au	Co-investigator	CSIRO	Aspendale	Australia	No
Wilson, A. Prof. Stephen swilson@uow.edu.au	Co-investigator	University of Wollongong	Wollongong	Australia	No
Murphy, A. Prof. Clare clarem@uow.edu.au	Co-investigator	University of Wollongong	Wollongong	Australia	No
Ristovski, Dr. Zoran z.ristovski@qut.edu.au	Co-investigator	Queensland University of Technology	Brisbane	Australia	No
Schofield, Dr. Robyn Robyn.Schofield@unimelb.edu.au	Co-investigator	University of Melbourne	Melbourne	Australia	No
Simmons, Mr Jack js828@uowmail.edu.au	Co-investigator	University of Wollongong	Wollongong	Australia	Yes
Smirnov, Dr Alexander Alexander.Smirnov-1@nasa.gov	Co-investigator	NASA/Goddard Space Flight Centre	Greenbelt	USA	No

Name	Project Role	Affiliation	City	Country	Going South
Edwards, Dr. Grant grant.edwards@mq.edu.au	Co-investigator	Macquarie University	Sydney	Australia	No
Protat, Dr. Alain Alain.protat@bom.gov.au	Co-investigator	Bureau of Meteorology	Melbourne	Australia	No

Instrumentation

Instrument	Measurement	Owner	Ship location	Current location
CCNC	Cloud condensation nuclei number concentration	MNF	Aerosol lab	Ship
CPC 3772	Aerosol number concentration > 10 nm diameter	MNF	Aerosol lab	Ship
SMPS Nano	Aerosol size distribution 5 - 150 nm	MNF	Aerosol lab	Ship
Nephelometer	Aerosol optical properties - scattering	MNF	Aerosol lab	Ship
MAAP	Aerosol optical properties – absorption	MNF	Aerosol lab	Ship
Ozone	O_3 mixing ratio (ppb)	MNF	Aerosol lab	Ship
Radon	Radon concentration	MNF	Aerosol lab	Ship
GHGs	Concentrations of greenhouse gases (CO, CO_2, CH_4, H_2O)	MNF	Air chem lab	Ship
CPC 3776	Aerosol number concentration > 3 nm diameter	CSIRO	Aerosol lab	Ship
[redacted]				
ToF-ACSM	Real-time aerosol chemical composition	CSIRO	Air chem lab	Ship
SMPS long	Aerosol size distribution 14 - 650 nm	CSIRO	Aerosol lab	Ship
APS	Aerosol size distribution 0.5 - 10 µm	CSIRO	Aerosol lab	Aspendale
MAX-DOAS	Atmospheric vertical profiles of trace gases (BrO, IO, CH_2O, O_3, O_4) and aerosols	University of Melbourne	Deck 5	Sydney?
Aerosol filters	Filters of air samples for analysis of aerosol chemical composition	CSIRO	Air chem lab	Aspendale
Tekran	Total gaseous mercury concentrations	Macquarie University	Aerosol lab	Sydney
Mercury filters	Speciated mercury	Macquarie University	Deck 5?	Sydney
Microtops photometer	Handheld sun photometer for measurements of aerosol optical depth	NASA	Accommodation cabin	USA
Cloud LIDAR	Aerosol and cloud occurrence and vertical profiles	Bureau of Meteorology	Foredeck in container	Ship (big hatch below deck level

Instrument	Measurement	Owner	Ship location	Current location
				in its travel box)

Dates:

Continuous measurements as a piggy-back project on IN2017_V01:

Setup and instrument training – required for calibration of long-term instrumentation, and training of staff.	9-12 Jan, 2017	Jack Simmons Ruhi Humphries Paul Selleck (partial) Grant Edwards (partial)
Mobilisation	13 Jan, 2017	Jack Simmons Ruhi Humphries
Voyage	14 Jan – 5 Mar, 2017	Jack Simmons
Demobilisation	6 Mar, 2017	Jack Simmons Ruhi Humphries Paul Selleck Grant Edwards

Location:

Around the Totten Glacier ice field, approximately 65°S, 120°E.

Access to the Aerosol Lab:

Access to aerosol lab will be performed according to the MNF Safe Operating Procedure, which involves calling the bridge before and after going to the aerosol lab. As well as this, a safety camera, viewable from the bridge, has recently been installed which provides a live feed from the remote lab.

Investigator equipment (MNF)

(i) Standard laboratories and facilities

Name	Essential	Desirable
Aerosol Sampling Lab	X	
Air Chemistry Lab	X	
Preservation Lab	X	
Constant Temperature Lab – horizontal core storage	X	
Underway Seawater Analysis Laboratory	X	
GP Wet Lab (dirty)	X	
GP Wet Lab (Clean)	X	
GP Dry Lab (Clean)	X	
Sheltered Science Area	X	
Observation deck 07 level	X	
Walk in Freezer	X	
Clean Freezer		
Blast Freezer		
Ultra-Low Temperature Freezer (-80°C)	X	
Walk in Cool Room	X	

(ii) **Specialised laboratory and facilities**

May require additional support

Name	Essential	Desirable
Modular Radiation Laboratory		
Modular Trace Metal Laboratories		
Modular Hazchem Locker		
Deck incubators		X
Stabilised Platform Container		X
Coldwater Clothing Container	X	
Coring container	X	

(iii) **Standard laboratory and sampling equipment**

Name	Essential	Desirable
CTD - Seabird 911 with 36 Bottle Rosette		
CTD -Seabed 911 with 24 Bottle Rosette	X	
LADCP		X
Sonardyne USBL System		
Milli -Q System	X	
Laboratory Incubators	X	
Heavy Duty Electronic Balance	X	
Medium Duty Electronic Balance		X
Light Duty Electronic Balance	X	
Surface Net		
Bongo Net		
Vertical haul net: 335 microns	X	
Smith Mac grab	X	
Dissecting Microscopes	X (x1)	

(iv) **Auxiliary CTD sensors**

Name	Essential	Desirable
Dissolved oxygen sensor		X
Altimeter		X
PAR sensor (Biospherical QCP-2300)		X
Transmissometer (wetlabs C-Star 25cm)		X
Fluorometer – Chlorophyll-*a* (Chelsea Aquatracka III – 430/685nm)		X
Fluorometer – CDOM		
Nephelometer (Seapoint Turbidity Meter)		X
ECO - Triplet		
Nitrates		X

(v) **Specialised laboratory and sampling equipment**

May require additional support

Name	Essential	Desirable
TRIAXUS – Underway Profiling CTD		

Name	Essential	Desirable
Continuous Plankton Recorder (CPR)		
Deep Towed Camera	X	
Piston Coring System	X	
Gravity Coring System	X	
Multi Corer	X	
Karsten corer	X	
XBT System	X	
Trace Metal Rosette and Bottles		
Sherman epibenthic sled		
Trace- metal in-situ pumps		
Rock Dredges		
EZ Net		
Rock saw		
Portable pot hauler		
Beam Trawl		
Trawl doors (pelagic or demersal)		
Stern Ramp Cover	X	
Trawl monitoring instrumentation (ITI)		
Radiosonde		

(vi) **Equipment and sampling gear requiring external support**

May require additional support from applicants

Name	Essential	Desirable
Seismic compressors & manifold system	X	
Airguns (2 x 3.44 litre GI gun	X	
GPS feed for seismic gun controller & acquisition system	X	

(vii) **Underway systems**

Acoustic Underway Systems

Name	Essential	Desirable
75kHz ADCP	X	
150kHz ADCP	X	
Multi Beam echo sounder EM122 12kHz (100m to full ocean depth)	X	
Multi Beam echo sounder EM710 70-100kHz (0-1000m approx.)	X	
Sub-Bottom Profiler SBP120	X	
Scientific Echo Sounders EK60 (6 bands, 18kHz-333kHz)	X	
Gravity Meter	X	

(viii) **Atmospheric Underway Sensors**

Name	Essential	Desirable
Nephelometer	X	
MAAP (multi angle absorption photometer)	X	
SMPS (scanning mobility particle sizer)	X	
Radon detector		X

Name	Essential	Desirable
Ozone detector		X
Manifold instrumentation (intake temperature and humidity)		X
Picarro spectrometer (analysis of CO2/CH4/H2O)		X
Aerodyne spectrometer (analysis of N2O/CO/H2O)		X
O2 analyser		X
Manifold instrumentation (intake temperature and humidity)		
CCN (Cloud Condensation Nuclei)	X	
MOUDI (Micro-Orifice Uniform Deposit Impactors)	X	
NOx monitor		X
Polarimetric Weather Radar		X

(ix) **Underway Seawater Instrumentation**

Name	Essential	Desirable
Thermosalinograph	X	
Fluorometer	X	
Optode	X	
PCO2	X	
Trace metal clean sea water		

User Equipment

Equipment	PI responsible
Seismic cable and winch (Figure 2)	Caburlotto
Gun bundle	Caburlotto
Cables controlling seismic system to be run from lab or computer space to back deck	Caburlotto
Airgun (High resolution, 1 x 0.98 litre GI gun)	Caburlotto
Seismic gun controller and acquisition system (require bench space in computer room or laboratory plus GPS feed.	Caburlotto
Container (Microbial sorting van for transfer of goods – no microbial sorting equipment)	Armand
Core trays and racks	Armand/Post GA sourced
Microscope (Compound) x1	Armand
Microscope (Inverted) x1	Armand
Microscopes (Inverted) x1	Leventer
Microscope	Noble
Magnetic susceptibility loops and meter	Leventer
ISD mineral analyser	Post
GA Box corer	Post
UV lamp box for curing UV glued microscope slides.	Armand
Geoteck core logger	Armand
Spectrophotometer for Chl *a*	Armand/ Armbrecht/Focardi
Small surface skim plankton nets (20-150µm), ~1m long.	Armand/Armbrecht
Peristaltic pump	Armbrecht/ Focardi
Air pump for filtration unit	Armbrecht/ Focardi

Equipment	PI responsible
Rechargeable drill, Electric saw and other assorted tools	Armand
Small weigh scale	Armand/ Armbrecht/Focardi
Slide warmer	Armand/Armbrecht
Microcentrifuge	Armand/Armbrecht
Tof-ACSM (Time of flight -Aerosol Chemical Speciation Monitor)	Simmons/Humphries
SMPS system with long column (TSI)	Simmons/Humphries
Condensation Particle counter(TSI CPC 3776)	Simmons/Humphries
APS	Simmons/Humphries
Aerosol filters	Simmons/Humphries
Microtops handheld AOD photometers	Simmons/Humphries
Isoprene Sensor	Simmons/Humphries
MAX-DOAS	Simmons/Humphries

Special Requests

Item	Scientific Team Recommendations	MNF Actions
Seismic cable winch fixed to deck	It weighs 960 kg and has a foot print of 200 cm by 125 cm.	M. Lewis (MNF) to confirm.
Diesel powered winch requires refuelling on aft deck	Refuelling SOP provided by Italian Team on page 25	Refuelling procedure to be decided by CS/MNF/Master.
Hot and cold water and hoses available on aft deck	.	Will be available (MNF).
Liquid Nitrogen	Place on aft deck in cage as recommended by M. Lewis. L. Armbrecht is liaison for LN use.	

Permits

1. No foreign clearances required (i.e. DFAT).
2. Environmental Approvals have been obtained through the AAD and include:
   - Permit Antarctic Marine Living Resources AMLR 16-17-ARMAND INVESTIGATOR IN2017-V01
   - Permit Antarctic Treaty (Environmental Protection) ATEP 16-17-ARMAND INVESTIGATOR IN2017-V01
   - Notice of Determination and Authorisation- Antarctic Treaty (Environmental Protection).

3. Seismic operations have been obtained under the Environmental Protection and Biodiversity Conservation (EPBC) Act, and are issued under the Cetacean Permit # 2016-005.

4. Quarantine permits will be required to bring samples into Australia from Antarctica, and are the responsibility of each PI.

Quarantine or Import Permit #	Issued to Organisation covering PIs on board	Valid from ; Expiry date	For samples
IP15003958	Macquarie University (Armand, O'Brien, Armbrecht, Focardi, Lawler).	18 Jun 2015 to 18 June 2017	Water, sediments, genetic
0000917277	Geoscience Australia (Post)	14 Nov 2016 to 14 Nov 2018	Soil and water
IP5013655	University of Tasmania (Noble)	1 Oct 2015 to 1 Oct 2017	Sediment, water
IP15006497	Australian National University (Opdyke)	27 May 2015 to 25 May 2017	Soil and water samples, microorganisms, sea shells.

The import of invertebrates preserved in 70% ethanol does not require a permit as indicated by the following comments by Jo Haley from the Dept of Agriculture and Water Resources, Animal and Biological import Assessments Branch, to Geoscience Australia (11 Nov 2016).

Cnidarians (including coral), echinoderms and tunicates do not require an import permit provided they are clean and non-viable. Search BICON for Cnidarians and go to the BICON case: **Cnidarians, echinoderms and tunicates - Other than human consumption** for import conditions**.**

Marine organisms that have been fixed by a department approved method do not require an import permit e.g. fixed in 70% alcohol (ethanol). Search fixed in BICON and select **Preserved and fixed animal and human specimens**. This will provide a number of options including those for 'Animals and invertebrates' AND 'Phytoplankton or zooplankton'.

5. No radioactive source use – no permits required.

6. No permits or certificates required for Unmanned Aerial Vehicles (UAVs) or weather balloons or notice to mariners for buoys and moorings.

7. Marine Mammal Observer certification undertaken by Ms V. Pirotta Sept 2016. Formal certification awarded September 2016.

Personnel List

1.	Doug Thost	Voyage Manager	CSIRO MNF
2.	Nicole Morgan	SIT Support	CSIRO MNF
3.	Ben Baldwinson	SIT Support	CSIRO MNF
4.	Mark Lewis	SIT Support - Deck Mechanic	CSIRO MNF
5.	Jason Fazey	SIT Support - Deck Mechanic	CSIRO MNF
6.	Tara Martin	GSM Support	CSIRO MNF
7.	Stuart Edwards	GSM Support	CSIRO MNF
8.	Hugh Barker	DAP Support	CSIRO MNF
9.	Karl Malakoff	DAP Support	CSIRO MNF
10.	Peter Hughes	Hydrochemistry Support	CSIRO MNF
11.	Dr Sheri Newman	Doctor	Aspen Medical
12.	Asaesja Young	Comms / Photographer	CSIRO MNF
13.	Leanne Armand	Chief Scientist	Macquarie University
14.	Phil O'Brien	Co-chief Scientist	Macquarie University
15.	Alix Post	Benthic habitat mapping	Geoscience Australia
16.	Bradley Opdyke	Sedimentologist	Australian National University
17.	Taryn Noble	Geologist	University of Tasmania
18.	Linda Armbrecht	Diatomist-Ancient DNA	Macquarie University
19.	Amaranta Focardi	Microbiologist	Macquarie University
20.	Vanessa Pirotta	Marine Mammal Observer	Macquarie University
21.	Kelly-Anne Lawler	Student - Master	Macquarie University
22.	Amy Leventer	Diatomist	Colgate University
23.	Andrea Caburlotto	Seismic	National Institute of Oceanography and Experimental Geophysics
24.	Diego Cotterle	Seismic	National Institute of Oceanography and Experimental Geophysics
25.	Roberto Romeo	Seismic	National Institute of Oceanography and Experimental Geophysics
26.	Thomas Connell	Master Student – Seismics	Macquarie University
27.	Aaron Flint	Master Student - Seismics	Macquarie University
28.	Sarah Tynan	Student - PhD	Australian National University
29.	Liam Holder	Student - PhD	Australian National University
30.	Rushi Perera	Student - Honours	Australian National University
31.	Meghan Duffy	Student - Undergraduate	Colgate University
32.	Dimitrios Evangelinos	Student – PhD Geologist	Instituto Andaluz de Ciencias de la Tierra, Uni of Granda, Spain
33.	Adrian López Quirós	Student – PhD Geologist	Instituto Andaluz de Ciencias de la Tierra, Uni of Granda, Spain
34.	Jack Simmons	Atmospheric student	University Wollongong

35.	Stuart Gifford	CSIRO Educator	Taroona High School, Hobart

Signature

Your name	Leanne Armand
Title	Chief Scientist
Signature	Leanne Armand
Date:	19 December 2016

List of additional figures and documents

FEATURES AND TECHNICAL SPECIFICATIONS	
Engine	4 HP gasoline Lombardini or 3 kW Electric motor
Drum diameter	1.5 m
Winch Weight	650 kg
Overall Weight (winch + 300 m long streamer + tow cable)	960 kg
Dimensions	200 cm X 125 cm X 200 (H) cm
	The GeoEel streamer wrapped around the winch drum

Figure. Seismic cable winch

<u>SOP Refuelling of winch engine</u>

This is the Winch Refuelling Procedure:

1. ask to the Bridge the permit to work aft deck
2. turn off the winch diesel engine
3. fill a bottle with diesel fuel with low temperatures additive
4. open the tank cap
5. use a funnel to pour the fuel into the tank
6. close the cap
7. clean with a rag
8. turn on the engine to test it

PPE to be worn: gloves and goggles

The tank is around 5 L.

We use the engine only twice a day, that is, as a whole, around 1 hour/day, only to deploy and recovery operations.

A full tank of fuel lasts about 10 days.

Appendix 1. National and international funded operational scientific support grants enabling the analysis of samples and data retrieved from IN2017-V01.

A1.1. Project aims of approved science support projects.

1) **Australian Antarctic Science Project #4333** *Interactions of the Totten Glacier with the Southern Ocean through multiple glacial cycles.* (PI: Armand, L.K. co-PI's: O'Brien, P., Post, A., Goodwin, I., Opdyke, B., Leventer, A., Domack, E., Escuita-Dotti, C. and DeSantis, L.)

The scientific aims under this grant are:

To understand the interaction of the Totten Glacier and its ice drainage basin with the Southern Ocean during periods of warming and ice sheet retreat. This will be achieved by:

- Mapping and surveying the continental slope by the Totten Glacier;
- Collecting surface sediments and long sediment cores from the continental slope;
- Studying these cores (sedimentological, biological and geochemical analyses) to define how environmental biotic and abiotic factors changed in response to varying climate cycles;
- Interpreting findings from core analyses to give an understanding of when the Totten Glacier advanced and retreated during previous climate cycles;
- Delivering independently sourced data to enable corroboration between ice core (atmospheric, cryogenic) and modelling (oceanic) results; and
- Provide additional mapping of regional benthic habitats in support of proposed international Marine Protected area listing.

To fulfil these aims, this international team of experts will:

a. Collect and culture specific diatoms from the seasonal sea-ice zone for HBI, molecular and genetic analyses, and compare these to Arctic species known to contain HBIs by identifying:
   i. taxon-specific lipid composition and variability using advanced macromolecular techniques;
   ii. the HBI cellular biosynthesis pathways from cultured natural samples;
   iii. potential genes associated with the lipid biosynthesis placed in context with targeted diatom genera and sea-ice evolution.
b. Determine horizontal and vertical distributions of HBIs in the water column and relate these to diatom assemblages. We will analyse water and seafloor samples from locations representing open ocean and seasonally sea-ice covered conditions.
c. Generate critical continuous palaeo sea-ice data over a million years by:
   i. analysing cores for HBIs and other molecular biomarkers (summer sea ice and seasonal sea-ice extent), and diatom fossils (winter sea-ice extent);
   ii. building predictive models relating HBI concentration to Raman and infrared active molecular biomarkers.

2) **Italian Antarctic program support PNRA TYTAN Project (PdR 14_00119)**: *Totten Glacier dYnamics and Southern Ocean circulation impact on deposiTional processes since the mid-lAte CeNozoic (TYTAN)* (PI: F. Donda: fdonda@inogs.it; A. Caburlotto: acaburlotto@inogs.it).

The scientific aims under this grant are:

- to provide insights for reconstructing the depositional environment of the continental margin off the Totten Glacier starting from the Miocene, when temperatures and CO2 levels were more similar to those predicted for the next century. Focus will be on the identification of features indicative of variations in the glacial regimes.
- The TYTAN seismic grid will also provide the site survey for the IODP proposal that is in preparation by the international team involved into the Australian project.
- Selected lines will also be analyzed to detect seawater column reflectivity by means of seismic oceanography, to understand the relationship between bottom water circulation and sea bed morphology.
- The participation in the analysis of the sediment cores, focused on diatom assemblages, will provide high resolution constrain on the Pleistocene-Holocene depositional setting of the study area.

3) **Spanish Ministry of Economy and Competitivity (MINECO) Reference: CTM2015-60451-C2-1-P** The Tasman and Drake gateways and the Antarctic Circumpolar Current: origin, evolution and its effect on climate and Antarctic ice sheet evolution. (TASMANDRAKE) and **CTM2015-60451-C2-2-P** Geodynamic Evolution of the Tasman and Drake Gateways: onshore-offshore tectonic correlation of continental margins and oceanic basins (TASMANDRAKE) (CI: C. Escutia-Dotti).

4) U.S. National Science Foundation's Polar Program - Antarctic Integrated System Science. *Totten Glacier System and the Marine Record of Cryosphere - Ocean Dynamics*.

#1143834, 1143836, 1143837, 1143843, 1313826. (PIs: A. Leventer, D. Blankenship, G. Domack, S. Gulick, B. Huber, A. Orsi, A. Shevenell).

The overall objective of this cruise is to conduct a reconnaissance survey of the region of the Totten Glacier System, including the Moscow University Ice Shelf (Sabrina Coast, East Antarctica) in February 2014 in order to:

a) evaluate the recent behavior of the glacial system, based on seafloor morphology, sub bottom profiling, high-resolution seismic imaging and marine sediment core evaluation,

b) to elucidate the longer term role of the Totten Glacier as it responded to late Quaternary changes in climate and sea level, and

c) assess the present day physical oceanographic and particulate dynamic processes associated with the Totten Glacier tongue and the deep basins that surround it.

5) **ANZIC Special Analytical Support Grant 2016** *Using ancient phytoplankton communities and genes to illuminate future ocean responses* (PI: L. Armand, Co-PI's L. Armbrecht, M. Ostrowski, & S. George).

The scientific aims under this grant are:

- we will determine phytoplankton species composition and their part of the biological carbon pump over geological timescales, from fossil primary producers encapsulated in seafloor sediments.

- our ancillary aim is to train young Australian researchers in IODP projects as well as in ancient phytoplankton DNA analyses.

6) **Australian Antarctic Science Project #4320** *Characterising East Antarctic seabed habitats*, (PIs: Post, A.L., Smith, J.)

The scientific aims under this project are:

- to understand seafloor habitats on the East Antarctic margin;
- Seafloor habitats will be characterised based on physical properties from sediment samples, multibeam bathymetry, backscatter characteristics, physical and chemical properties of the water column, and analysis of seafloor imagery.

7) **ARC Discovery Project DP170100557** *Applying multidisciplinary methods to resolve past Antarctic sea-ice extent* (CI: L. Armand, PI's: S George, S Belt, P Heraud, C Bowler, J Beardall).

This project will for the first time chronicle seasonally recurrent boundaries of Antarctic sea ice from environmentally-characteristic lipid biomarkers. Our hypothesis is that the lipid composition of fossilised diatoms can be used as an effective proxy for the extent of past summer sea ice and seasonality. To test this hypothesis, our project's aims are to:

a) determine the composition of highly branched isoprenoid (HBI) lipids in specific Southern Ocean diatoms;

b) relate the distributions of HBIs to environmental conditions in which the diatoms are found;

c) test the robustness of HBIs in fossilised seafloor sediments as a proxy for the extent of summer sea ice; and

d) explore predictive models that further relate HBI content to Raman- and infrared-active molecular markers.

<u>A1.2. Project aims of submitted and under review science support projects.</u>

8) **Australian Antarctic Science Project #4443** *Marine ecosystem proxy development using ancient DNA from core sediments: geomicrobiology innovations in palaeoclimate research* (CI: L. Armand, PI's: George, S., Ostrowski, M. & Armbrecht, L.). Under current assessment, result due in January 2017.

This project aims to establish novel relationships between varying atmospheric carbon dioxide (CO_2) concentrations, ocean warming and biological processes over geological time-scales.

This will be achieved by the:

a) Determination of phytoplankton community changes and activity variations over geological time-scales through the innovative combination of ancient DNA analyses and microbiological techniques.

b) Isolation of the RuBisCO gene (rbcL; the key enzyme in photosynthetic phytoplankton involved in atmospheric and oceanic carbon cycling) from sediments.

c) Insertion of the isolated gene in a modern host organism (Escherichia coli; bacteria) via synthetic bio-engineering, so as to determine the gene's rate of evolution as a direct response to past changes in atmospheric carbon dioxide and ocean warming.

d) Comparison of past and present RuBisCO activity to produce the world-first species-specific data set that will enable the testing of future oceanic ecosystem impact and adaptation with direct reference to the rate of ocean warming.

9) Australian Antarctic Science Project #4419 *Response of the Totten Glacier to past climate warming* (CI Noble, T., PI's: Armand, L., Chase, Z., & Halpin, J.). Under current assessment, result due in January 2017.

This project has two aims. First, to understand how the Totten Glacier behaved during past warming events during cold glacial to warm interglacial climate transitions. Second, to constrain the geological characteristics of the rocks eroded by the Totten Glacier. The five objectives below detail how these aims will be met. All of the objectives relate to analyses proposed on sediment cores to be recovered from the scheduled RV *Investigator* voyage (MNF IN2017-01 "Totten Interactions") in January 2017.

1. Develop robust age models for the sediment records using radiocarbon dating of bulk acid-insoluble organic matter, and the Ramped PyrOx method (Rosenheim et al., 2008) where the sedimentary carbon budget is more complex. Magnetic susceptibility and 230Th normalised detrital flux will also be used to verify the radiocarbon age model.
2. Identify abrupt changes in ice and ocean dynamics using high resolution X-ray fluorescence scanning of sediment cores and ice rafted debris concentrations.
3. Develop a region-specific calibration of geochemical proxies used to distinguish water mass properties, by comparing tracers in surface sediment data to co-located seawater samples.
4. Identify changes in water mass characteristics during past warming using redox sensitive trace metals and Nd isotopes to understand the response of the Totten ice shelf to ocean-driven forcing.
5. Reconstruct changes in the sediment provenance (i.e. where the sediment came from) and age of the basement rock transported from Wilkes Land subglacial basins by the Totten Glacier.

Appendix 2. High risk operations

In **Appendix 2 - Table 1** we highlight potential high risk operations, our Scientific team recommendations and leave space for triggered MNF procedures or non-triggered responses to perceived risks.

Table 1. Scientific Team considered high risk operations and MNF procedures.

Planned Potential High Risk Operations	Scientific Team Recommendations	Triggered MNF Procedures
Undertaking science in Antarctic waters	**1)** The survey team have daily access to weather conditions. **2)** The survey team (senior scientists and vessel management) meet at least twice per day (at shift change) to ensure voyage plans are modified to suit conditions and communicated. **3)** Pre-voyage information for Scientific personnel on items that should be packed ready in an Antarctic oceanic environment evacuation bag. **4)** Pre-departure training and drill for all Scientific personnel on Antarctic emergency evacuations - lead by MNF and Master/Chief Officer (noting that an evacuation gathering point outside in the elements may not be safe in very poor conditions). **5)** Weekly evacuation drills whilst on the voyage. **6)** Communication of medical information to the MNF/ASPEN doctor and protocols/decision making authorities clearly outlined pre-voyage with respect to medical incidents that would trigger a medical evacuation and pre-mature cancellation of the voyage	1) Information the ship has in respect to weather conditions will be communicated to the management team and via white boards in the ops room and lounge. 2) Daily meetings between the voyage management team are part of the SOP and the number of meetings and timing can be determined amongst the management team at the initial meeting. 3) Requirements for a 'grab bag' are not specified by the MNF, as there are many considerations with such an item. Consideration to essential medication and warm clothing are key items that sea survival courses talk about, and such training could be considered should you feel it. MNF through ASP provide an immersion suit and PFD and the ship has adequate life rafts with included emergency equipment to deal with an evacuation situation. 4) This is part of the ship's sea going induction and muster drill on day 1. Alternative Muster stations, should they be required will be at the discretion/advice of the Master/ASP crew. 5) ASP SOP will be followed: ASP conduct a drill on day 1 and then again mid-voyage for trips longer than 4 weeks. 6) The need for a medivac will be determined by the on-board doctor and Master (and with onshore

Planned Potential High Risk Operations	Scientific Team Recommendations	Triggered MNF Procedures
		consultation where required) as the need arises. In the event of a situation requiring external assistance and depending on the position of the vessel at the time, the voyage would be terminated.
Surveying or coring in sea-ice and iceberg affected regions.	**7)** The survey team have daily access to satellite imagery of ice conditions. **8)** The Master and Voyage Manager communicate presence of icebergs identified by radar or other means.	7) Imagery will be part of the voyage tools available to the ship and science team, however imagery type and frequency is currently being finalised between MNF, ASP and IMAS. 8)SOP
Seismic operations	**9)** The seismic survey team, MMO, Voyage Manager, Master and Crew are familiar with the EPBC Act 2.1 operation procedures, in the event of whale sightings during seismic operations. To be communicated by the Chief Scientist to the seismic survey team, the MMO and the MNF. The MNF should transmit the permit and EPBC Act documentation to the Master, who must by law hold a copy of the permit for the ship. **10)** Manual handing of seismic equipment from the aft deck between the Italian seismic participants, the MNF technical support team and the crew, with assistance/communication of the Voyage Manager and Chief or Co-Chief Scientists. **11)** Pre-cruise information on Italian Standard Operating Procedures (SOPs) for the seismic deployment and operation, via the Chief Scientist to the MNF Technical support team, the Chief Engineer and Master. **12)** Italian seismic team to have access to aft deck for seismic deployment or recovery	9) Noted. 10) Deck operations will be carried out in accordance with ASP's requirements and relevant safety documentation and procedures (SWI, JHA, toolbox meeting etc) for the specific activity. It is anticipated that relevant science personnel will work with ASP crew and MNF personnel to undertake the seismic component of the voyage activities. 11) Please continue to forward all information on SOPs for planned activities to facilitate discussions and alignment of processes between all relevant parties. 12) Protocols for access to deck and operations will be determined through discussions between MNF, ASP and the relevant science team personnel. This is anticipated, however will be carried out in accordance with ASP's guidance/instruction at the time. 13) Tethering requirements for work on back deck is determined through a risk assessment for the operations to be undertaken and conditions. ASP's feedback (paraphrased) on

Planned Potential High Risk Operations	**Scientific Team Recommendations**	**Triggered MNF Procedures**
	operations alongside MNF Technical support and crew. **13)** Appropriate tethering of all personnel undertaking seismic deployment or recovery operations on the aft deck.	requirement of tethers for the planned operations on V01 are: Due to the inherent risk involved with deploying seismic guns over the stern tethers will be required. The A-frame can get the bulk of the guns on and off the ship but there are occasions where personnel need to reach the guns at the deck edge and simple fixed tethers are essential piece of safety gear when operating at the stern with the gates open. This isn't a standard procedure, will be part of the JSA for seismic gear deployment and recovery. This would also apply for any other ops needing access over the stern with open gates such as gravity piston cores. If we use the deep coring boom we'll need tethers or a safety net to cover the open gap in the bulwarks.
Deck operations relative to weather and freezing conditions	**14)** Pre-voyage information on protocols for closure of operations on any deck from MNF and Master. **15)** Pre-voyage information on protocols on access when weather conditions are fine but decks are frozen/snow covered.	14) Advice from ASP: Decks apart from the 02 level muster area/smoking area are restricted during inclement weather, as in rough seas or water over the bow and are posted as such on the inside of accommodation doors and on public whiteboards. If a particular job requires access to a deck then at least two people need to go out and they inform the bridge when they're going out and when they're back in, after requesting and receiving approval from the Master. These requirements are covered during ship inductions. 15) As above. If a particular area on a deck requires frequent access for a particular job we can rig up a hand line to the area. This might be the case for a job like XBT launches off the quarters particularly if there's a large amount of ice or snow on deck.
Coring activities	**16)** Pre-voyage information on MNF Standard Operating	16) Deployment and retrieval of MNF scientific equipment is undertaken by

Planned Potential High Risk Operations	**Scientific Team Recommendations**	**Triggered MNF Procedures**
	Procedures (SOP) for all coring or sediment sampling devices to Chief Scientist for circulation to relevant scientific PIs.	MNF Technical Support Team and ASP deck crew and they operate with the guidance of procedures and JSAs. The processing of the samples, post deployment/retrieval of this equipment, is where the science team will become involved and your processing SOPs will be developed by your relevant participants. If you have specific requests or concerns please discuss these with MNF Technical Support, through your VOM.
CTD activities	**17)** Pre-voyage information on MNF SOP for CTD operation to Chief Scientist for circulation to relevant scientific PIs.	17) Deployment and retrieval of MNF scientific equipment is undertaken by MNF Technical Support Team and ASP deck crew and they operate with the guidance of procedures and JSAs. The processing of the samples, post deployment/retrieval of this equipment, is where the science team will become involved and your processing SOPs will be developed by your relevant participants. If you have specific requests or concerns please discuss these with MNF Technical Support, through your VOM.
Plankton net activities	**18)** Pre-voyage information on MNF SOP for plankton net operation to Chief Scientist for circulation to relevant scientific PIs.	18) Deployment and retrieval of MNF scientific equipment is undertaken by MNF Technical Support Team and ASP deck crew and they operate with the guidance of procedures and JSAs. The processing of the samples, post deployment/retrieval of this equipment, is where the science team will become involved and your processing SOPs will be developed by your relevant participants.

Planned Potential High Risk Operations	**Scientific Team Recommendations**	**Triggered MNF Procedures**
		If you have specific requests or concerns please discuss these with MNF Technical Support, through your VOM.
Cold room/freezer usage	**19)** Pre-voyage information and on-board safety induction for scientific personnel accessing cold room or freezer storage areas. Safety procedure if locked in.	19) Part of induction to ship. VM can provide additional information to users of this equipment as required.
Chemical use	**20)** Pre-voyage information and on-board safety induction for scientific personnel accessing chemical stores, fume cabinets and secured temporary waste disposal areas.	20) MNF recommend the CS appoint a lab manager for the voyage to oversee general lab usage and assist with the safe efficient running of these workspaces. This is carried out alongside the information the VM and ASP will provide on specific activities. VM briefing will cover basic lab guidelines and also hazmat storage, disposal etc.

Appendix 3. Marine Mammal Observations with respect to seismic operations.

Excerpted procedural expectations and mitigation methods set out in the EPBC Act Policy Statement 2.1 - Interactions between offshore seismic exploration and whales, Australian Government, Department of Environment, September 2008 (pages 7-11). That will be followed and reported on.

A.3. DURING SURVEYS

All seismic survey vessels operating in Australian waters must undertake the following basic procedures during surveys irrespective of location and time of year of survey:

- Pre start-up visual observation
- Soft start
- Start-up delay
- Operations
- Power- down and Stop work

These procedures are defined and described in greater detail below.

A.3.1 Pre Start-up-Visual Observation

During daylight hours, visual observations (using binoculars and the naked eye from the bridge on the survey vessel or preferably a higher vantage point) for the presence of whales should be undertaken by a suitably trained crew member for at least **30 minutes** before the commencement of the Soft Start Procedure (see A.3.2). Observations should, where visibility allows, extend to 3+ km (the *Observation* zone) from the vessel but with particular focus on the *Low power* and *Shut-down* zones around the acoustic source (see Diagrams 1 and 2).

During these 30 minute observations, the observer should make observations around the whole of the vessel (360°) and towed array out to a 3km distance and, if possible, beyond 3kms.

A.3.2 Soft Start Procedure (also known as ramp-up)

If no whales have been sighted within the *Low power* and *Shut-down* zones during the pre start-up procedure, the soft start procedure outlined below may commence.

Soft start procedures should be used each time the acoustic sources are initiated, gradually increasing power over a **30-minute period**. Initiate soft start procedures by firing a single airgun. The preferred airgun to begin with should be the smallest airgun, in terms of energy output and volume. Additional acoustic source components should gradually be added in sequence until operating level is achieved. The full power operating level should be the minimum acoustic energy output that is necessary to achieve the survey's objectives.

A sequential ramp-up of the acoustic source is considered to be industry best practice, and is known as a 'soft start'. The slow increase in acoustic energy may alert whales in the area to the presence of the seismic array and enable animals to move and avoid (or stand off) at distances where injury is unlikely.

During daylight hours, visual observations by trained crew should be maintained continuously during soft starts to identify any whales within the precaution zones.

A.3.3 Start-up Delay Procedure

If a whale is sighted within the 3km observation zone during the soft start an additional trained crew member or marine mammal observer should also be brought to the bridge to continuously monitor the whale whilst in sight. If a whale is sighted within or is about to enter the *Low power* zone, the acoustic source should be powered down to the lowest possible setting (e.g. a single gun). If a whale is sighted within or is about to enter the *Shut-down* zone, the acoustic source should be shut down completely.

Soft start procedures should only resume after the whale has been observed to move outside the *Low power* zone, or when 30 minutes have lapsed since the last whale sighting. September 2008: EPBC Act Policy Statement 2.1 – Interaction between offshore seismic exploration and whales 11

A.3.4 Operations Procedure

During daylight hours, trained crew should undertake visual observations continuously during survey operations.

Operators should power down the acoustic source to the lowest possible setting when not collecting data, or undertaking soft start procedures (e.g. during line turns or when moving to another part of the survey area).

The firing of a single gun during turns is an industry standard and is generally considered a reasonable precaution. This sound source may alert whales in the area to the presence of the seismic array and reduce chances of entanglement or contact.

If the array is completely shut down or reduced to low power (e.g. for operational reasons or during line turns), observations for whales should continue. To restart the array the following procedures should take place:

- If no whales are sighted during the shut-down/low power period then start-up may commence using A.3.2 Soft Start Procedure and A.3.3 Start-up Delay Procedure.
- If whales are sighted during the shut down/low power period, or if observations for whales ceased, then start-up should not begin until pre start-up visual observations have been conducted, as outlined in A.3.1. Start-up may then commence using A.3.2 Soft Start Procedure and A.3.3 Start-up Delay Procedure.

A.3.5 Stop Work Procedure

If a whale is sighted within the 3km observation zone an additional trained crew member or marine mammal observer should also be brought to the bridge to continuously monitor the whale whilst in sight.

If a whale is sighted within or is about to enter the *Low power* zone, the acoustic source should be powered down to the lowest possible setting. If a whale is sighted or is about to enter the *Shut-down* zone, the acoustic source should be shut down completely.

Power-up of the acoustic source with soft-start procedures should only occur after the whale has been observed to move outside the *Low power zone*, or when 30 minutes have lapsed since the last whale sighting.

A.3.6 Night-time and Low Visibility Procedures

At **night-time** or at other times of **low-visibility** (when observations cannot extend to 3km from the acoustic source, e.g. during fog or periods of high winds), the following measures apply for start up and operations:

Start up may be commenced according to A.3.2 Soft-Start Procedure:

- provided that there have not been 3 or more whale instigated power-down or shut-down situations during the preceding 24 hour period; or
- if operations were not previously underway during the preceding 24 hours, the vessel (and/or a spotter vessel or aircraft) has been in the vicinity (approximately 10km) of the proposed start up position for at least 2 hours (under good visibility conditions) within the preceding 24 hour period, and no whales have been sighted.

Operations may proceed provided that there have not been 3 or more whale instigated power-down or shut-down situations during the preceding 24 hour period.

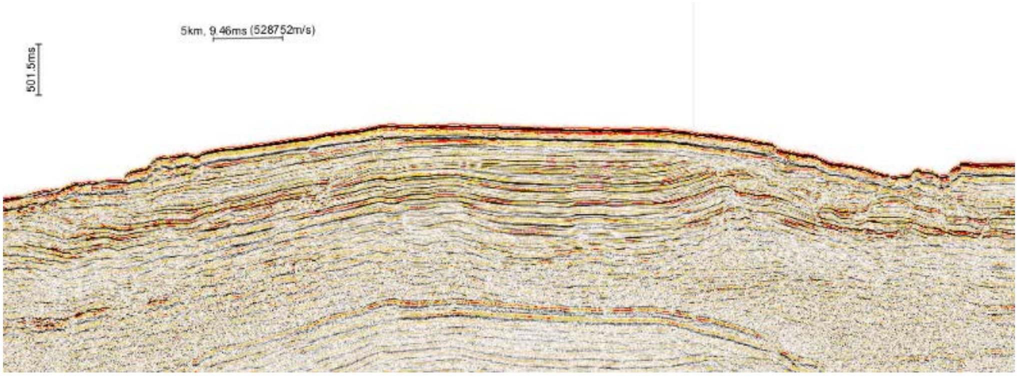
During **low visibility**, where conditions allow, continuous observations to spot whales should be maintained with a particular focus on the *Low power* and *Shut-down* zones. If whales are detected then the procedures outlined in A.3.5 Stop Work Procedures should apply.

If sightings of whales have been frequent or are higher than were anticipated during the planning of the survey, the proponent should contact the Department to discuss appropriate night-time provisions and whether additional management measures should be employed for day and/or night-time operations.

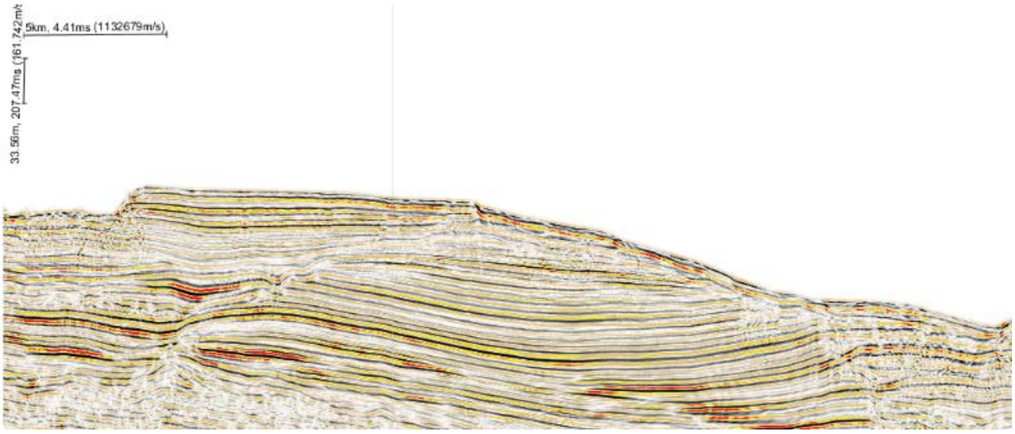
Appendix 4. Potential coring target regions based on pre-existing seismic data illustrated on document Figure 2.

T01

Seismic Line TH83-12 SP 5055-5503.



RAE 5005 SP 7192-7422

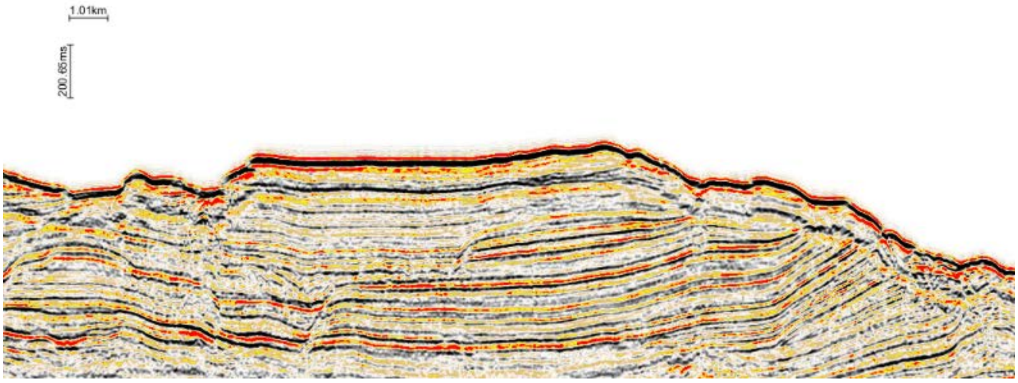


Water depth 1285-1371 m.

Shallow plateau surrounded by deeper water on all sides. Could have a drape of pelagic sediment with calcareous fossils.

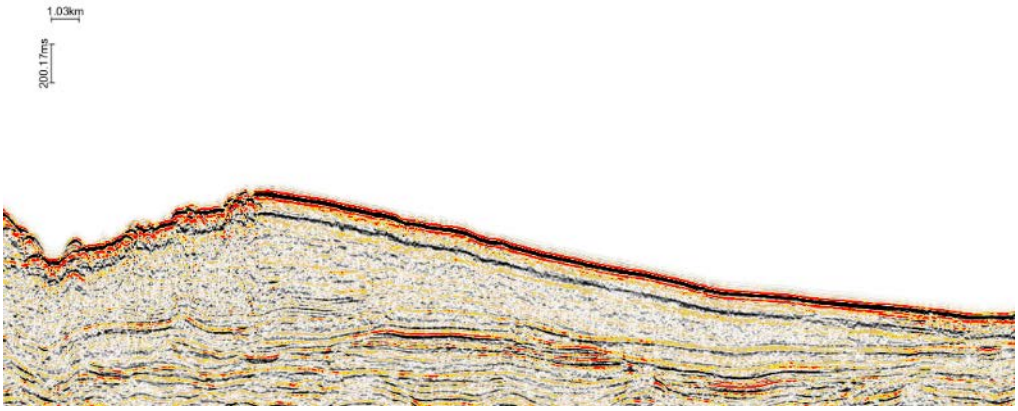
T02

TH83-12, SP 4522-4700. Depth 1544 m. Similar to T01 but no cross lines.



T03

TH83-12, SP 7025-7491. Depth 1532 m. West sloping levee sourced from canyon to the east.

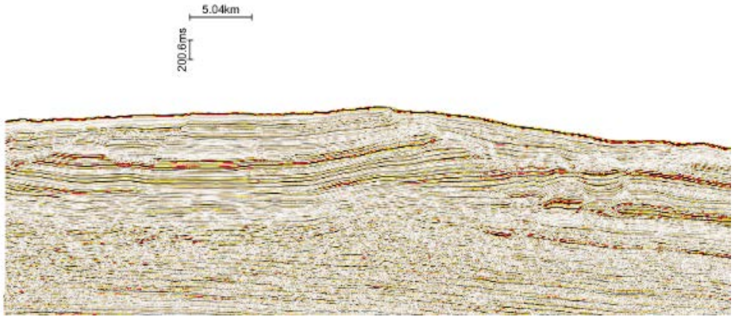


T04-T06

Older sediment in canyon walls

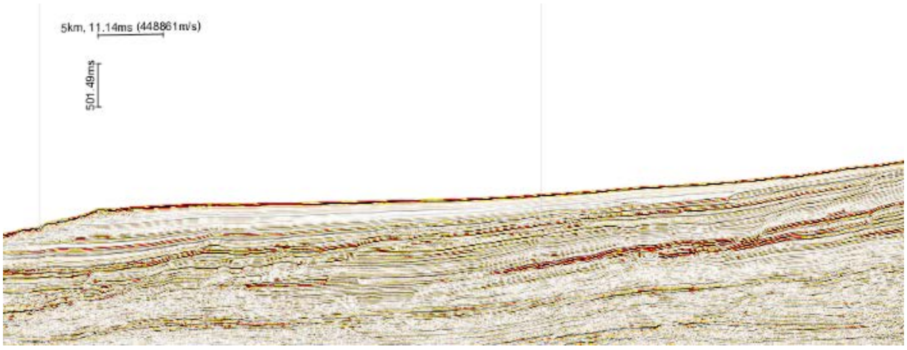
T07

RAE5006, SP-84-399, Depth 1748 m. Possible terrace.

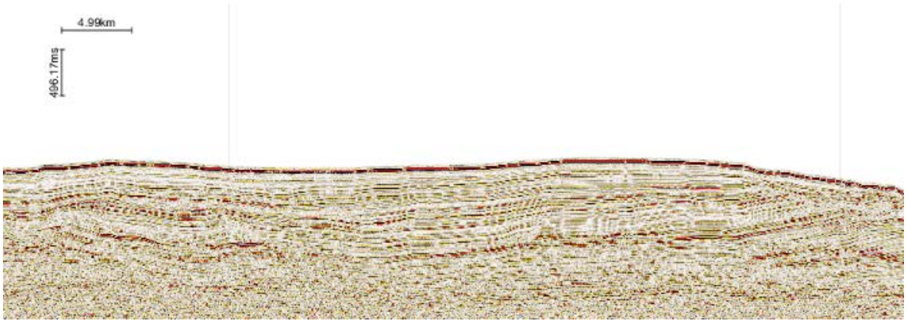


T08

Line RAE5108, A-B, SP 1317-13983, Depth 2052-2258 m. Internal levee deposit on west side of canyon with well-defined reflectors.



C-D, GA227-1805, SP 672-1824, Depth 2102 m.

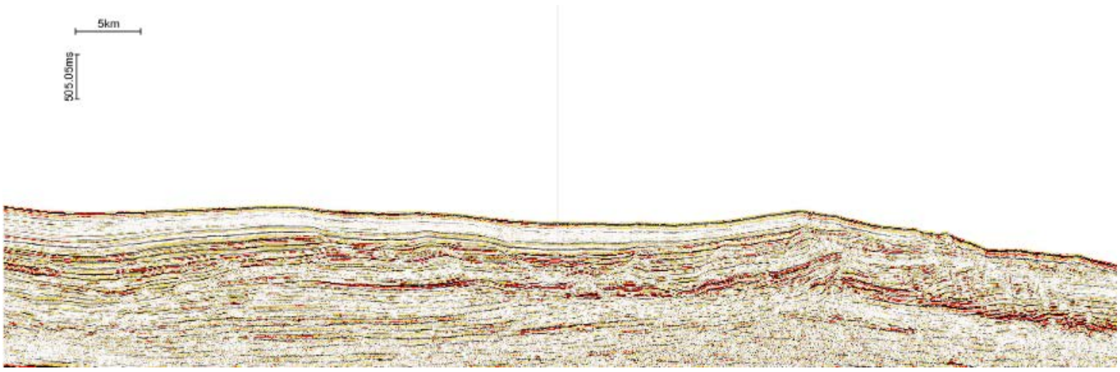


T09

RAE5101, A-B, SP 73-336, Depth 1884-2014 m. Large east-sloping levee deposit.

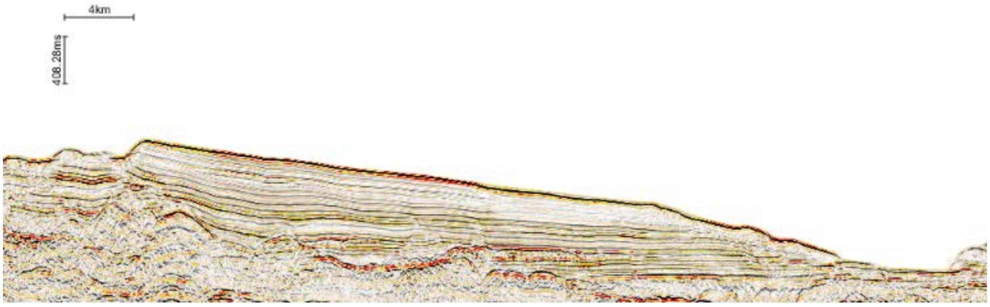
TH94-07, C-D, SP 759-2011, Depth 2223-2938 m

TH94-06, E-F, SP 3428-4609, Depth 2266-2314 m



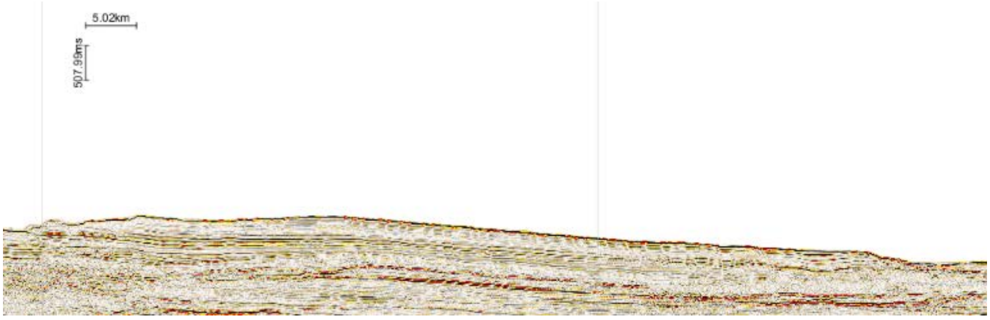
T10

RAE5103, A-B, SP 938-1501, Depth 2655-3066 m. Levee on bend in canyon

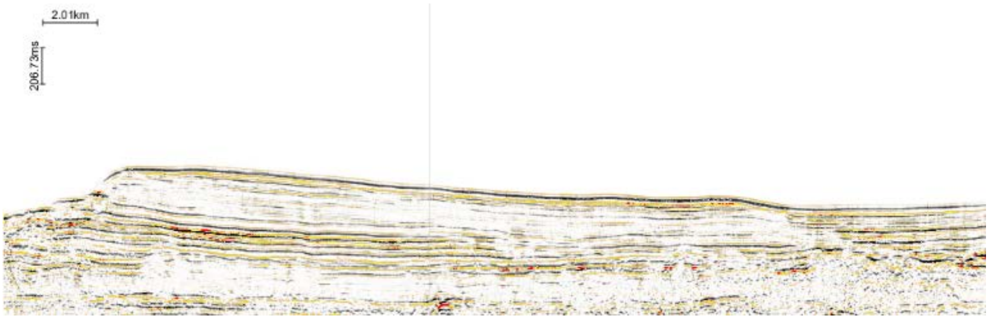


T11

RAE5103, A-B, SP 2544-3933, Depth 3242-3637 m. Levee/fan surface.

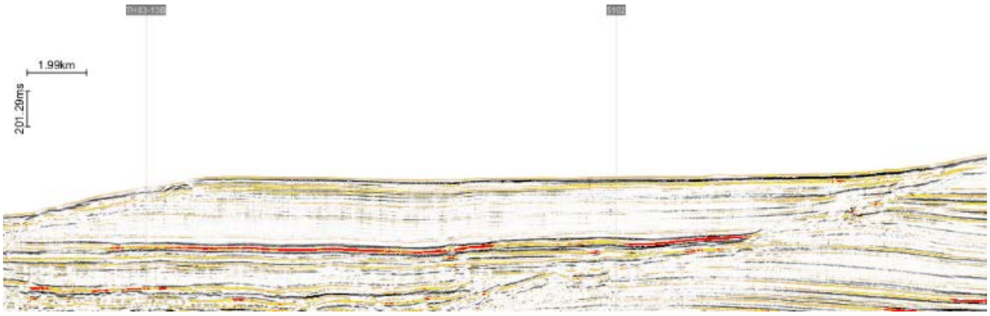


TH94-36, C-D, SP 1203-1851, Depth 3406-3538 m.



T12

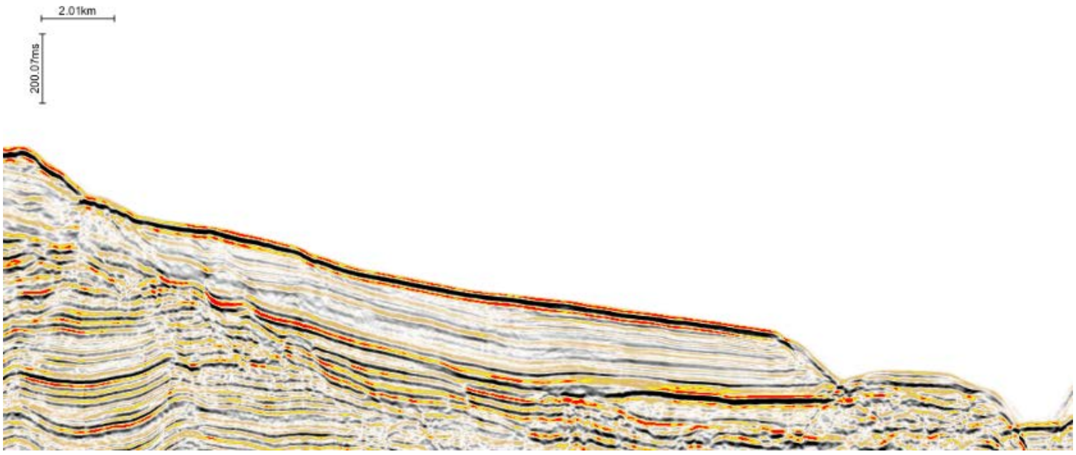
TH94-36, A-B, SP 110-548, Depth 3350 m. Deep water levee/fan surface.



RAE5102, C-D, SP 4714-5911, Depth 3281-3492 m.

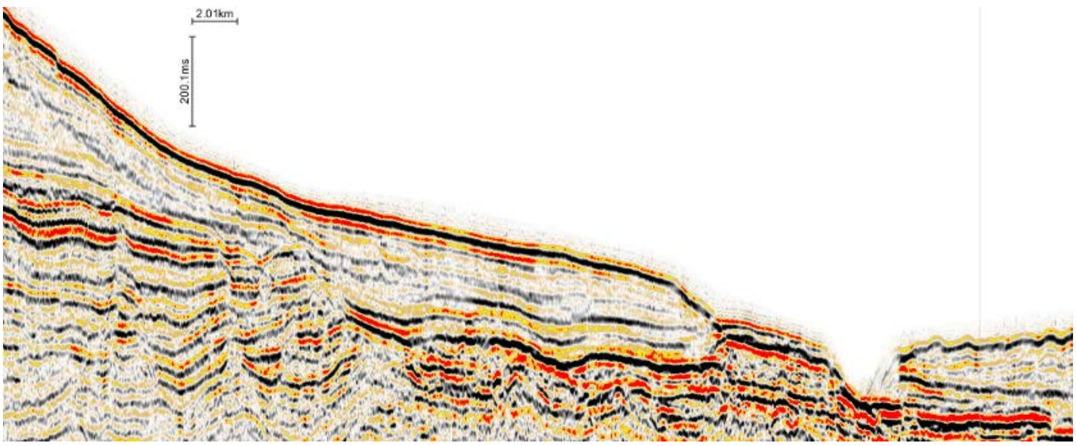
T13

RAE5102 A-B, SP 7229-7535, 3013-3225 m. Perched levee at foot of upper slope.



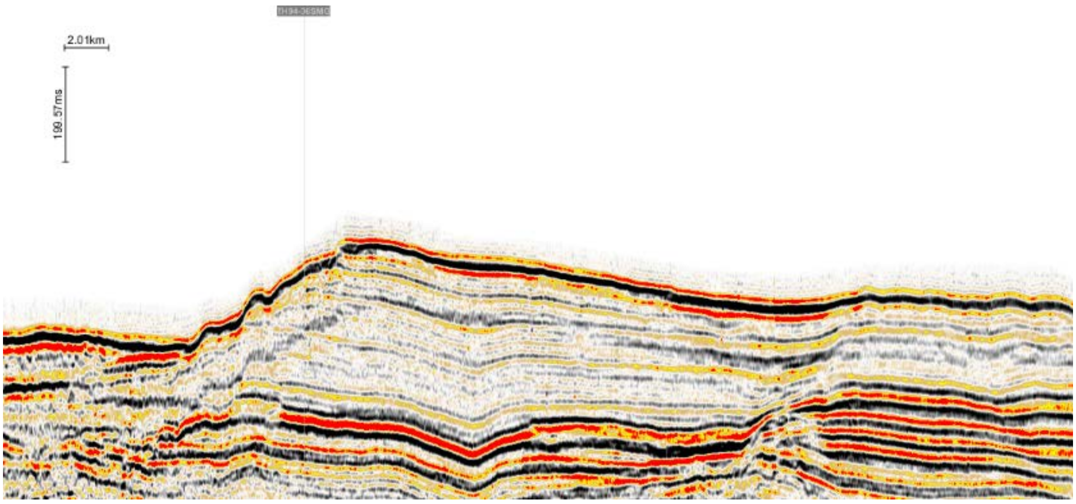
T14

TH83-13B, A-B, SP 3263-3607, Depth 3172-3306 m. Perched levee at foot of upper slope.



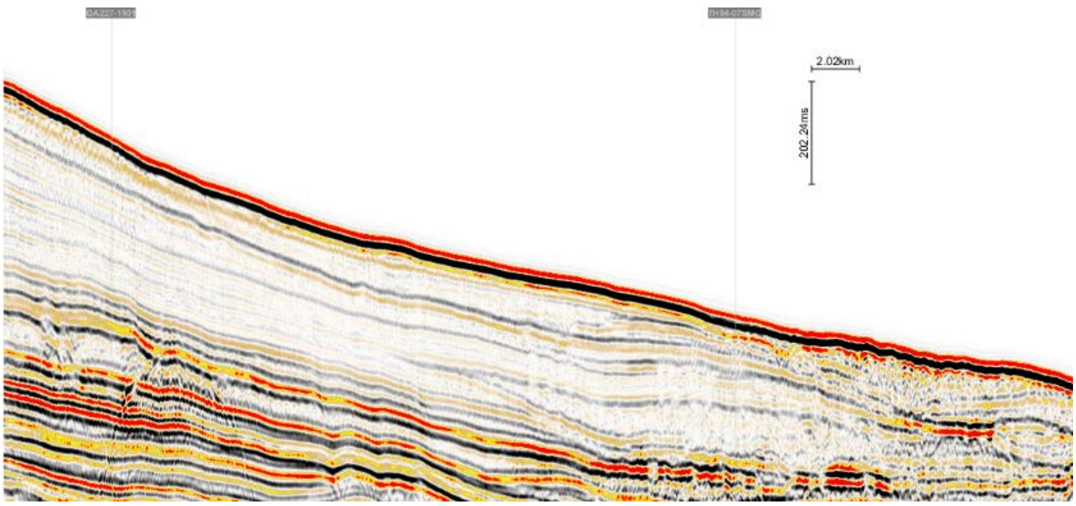
T15

TH83-13B, SP 4993-5405, Depth 3369-3453 m. Levee on the N side of canyon. Target is the part with the best reflectors and smoothest surface.



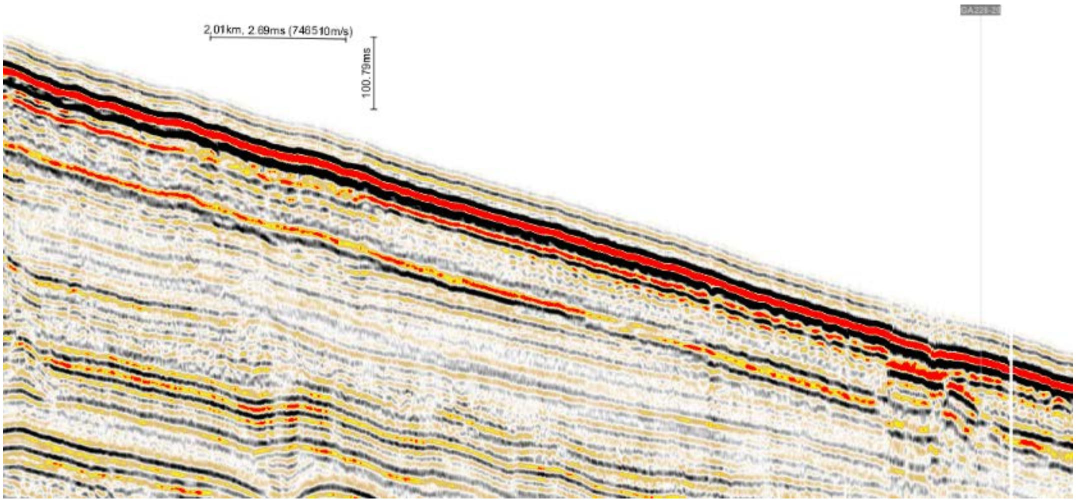
T16

GA228-20, SP 7558-8126, Depth 2698-3025 m. Smooth N-sloping surface. Downslope end is edge of slump.



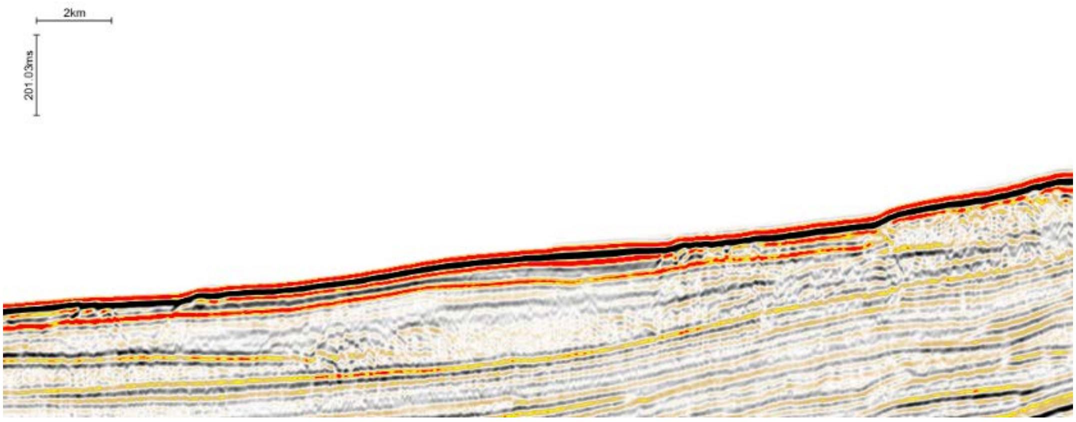
T17

GA227-1901, SP 188-388, Depth 2571-2730 m. Upslope extension of slope in T16.



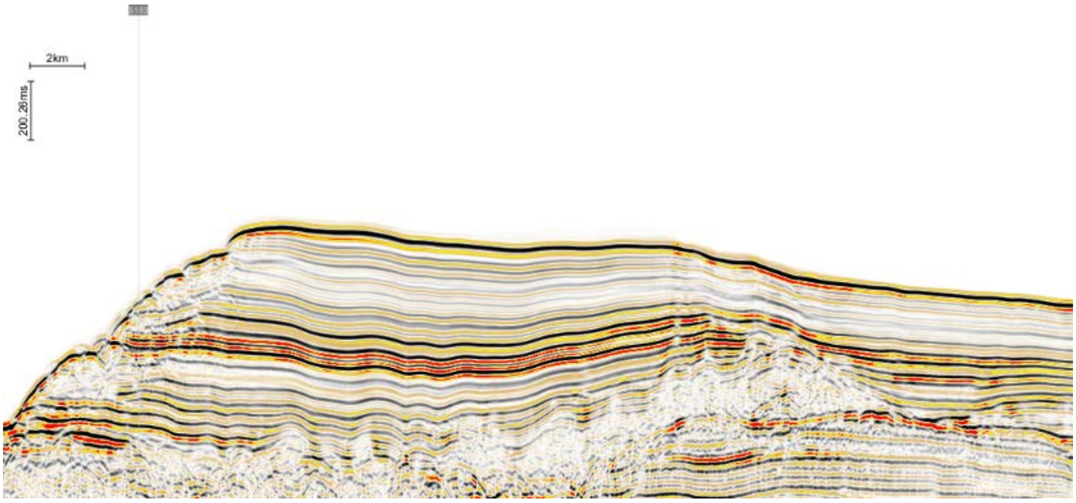
T18

RAE5108, SP 11637-11859, 2775-2863 m. Small smooth patch on the flank of a large mound with evidence of mass movement.



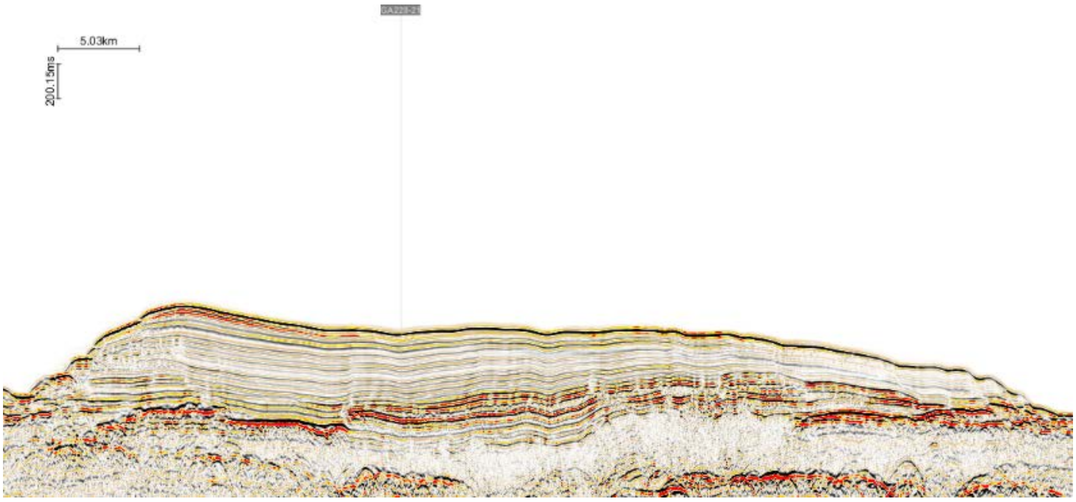
T19

RAE5108, SP 9415-10176, Depth 3132-3332 m. Overbank deposits between 2 canyons.

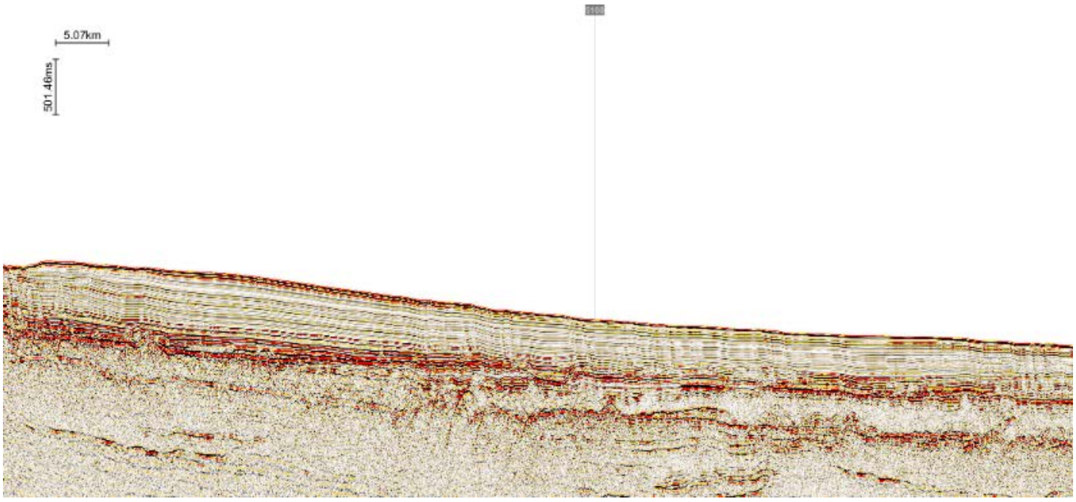


T20

RAE5108, A-B, SP 8123-9046, Depth 3145-3430 m. Mound between 2 canyons.

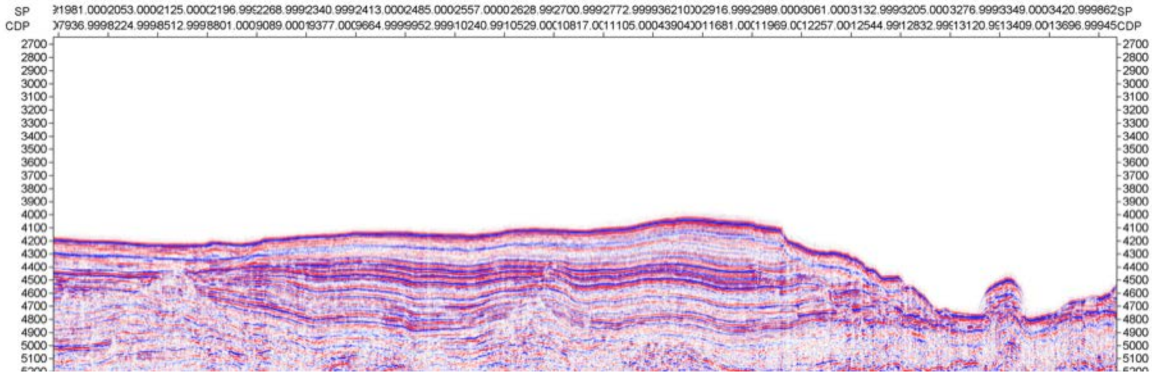


GA228-21, C-D, SP 190-1886, Depth 2883-3401 m. Least disturbed part of large mound.



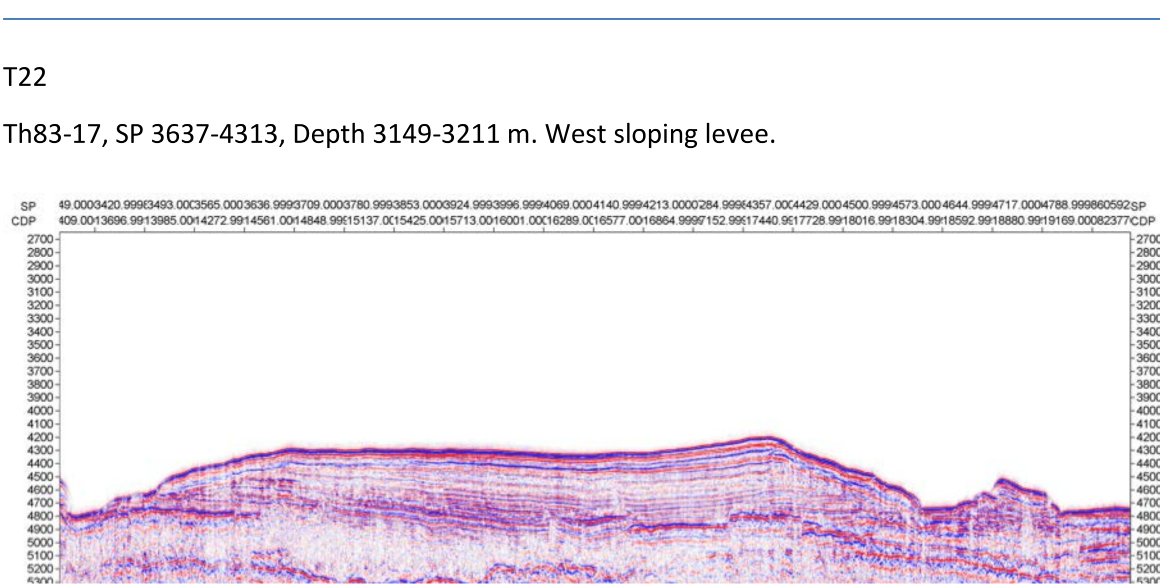
T21

TH83-17, SP 1891-2831, Depth 3021 m. Levee, moderately well laminated.



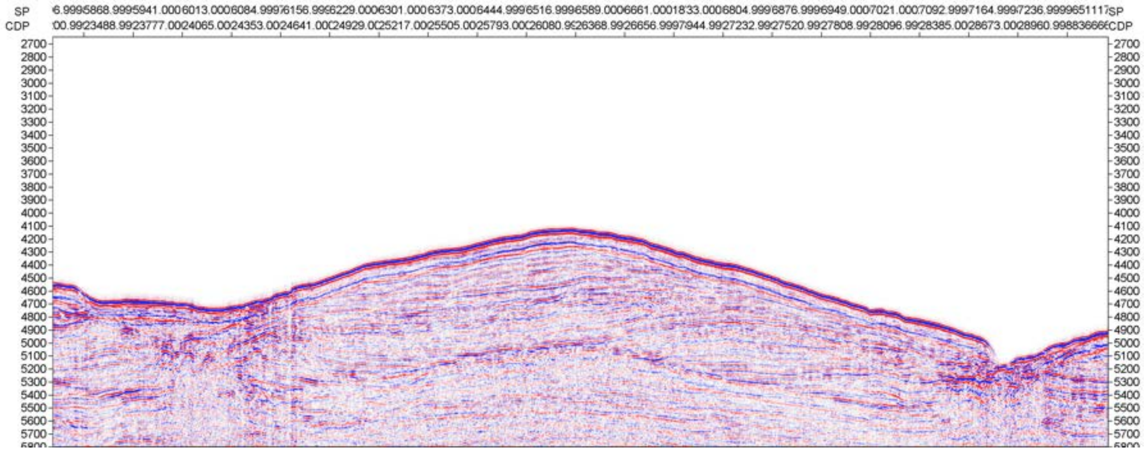
T22

Th83-17, SP 3637-4313, Depth 3149-3211 m. West sloping levee.



T23

TH83-17, SP 6220-6704, 3265-3294 m. Contourite mound or levee.



Appendix 5. Justification for transit route to Area B

The north-central Sabrina Coast Continental Shelf area has not been directly surveyed with marine platforms due to typically heavy sea ice. Aerogeophysical flights conducted by the University of Texas Institute for Geophysics (UTIG) in close collaboration with the Australian Antarctic Division have been conducted over a large area of the region to infer bathymetry from airborne gravity. The result provides a regionally-consistent result with ~5km resolution. Recent data acquired in the 2015/2016 summer will expand the coverage in the area shown in Figure 1. Ambiguities inherent in gravity interpretations and the associated uncertainty in subsequent inversions are greatly reduced with even sparse direct bathymetry observations. As a result, the Investigator may be in a unique position to connect and register the airborne observations with known depths in an otherwise uncharted area, especially if sea ice conditions are similar to the 2015/2016 summer. The waypoints corresponding to the proposed aerogeophysical flights are provided in **Table 3b** in the main document.

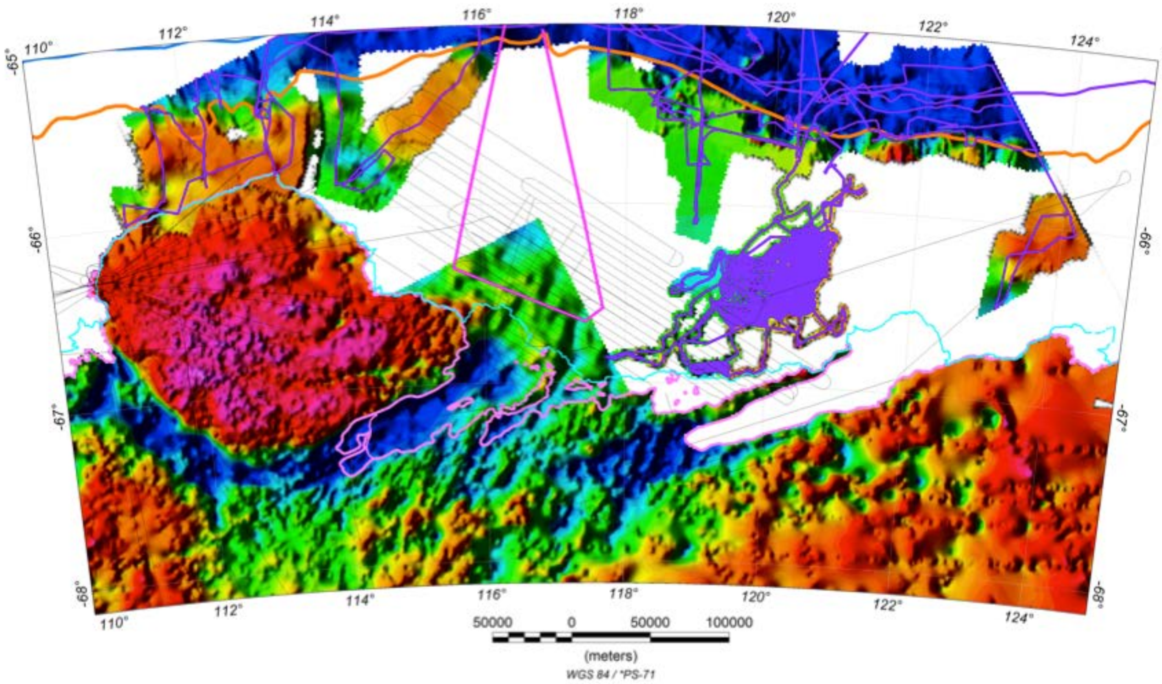


Figure 1 – Compilation of bathymetry observed by marine observations offshore, inferred from airborne gravity observations above and seaward of Totten Glacier, and observed by ice sounding radar data landward of the grounding line (pink). The locations of interpretable gravimetry data acquired using aerogeophysics are shown as thin black lines and the locations of available ship-tracks are shown in purple. The calving front (cyan) and grounding line (pink) are also shown. Proposed entry and exit transects for the Investigator are shown as thick, pink transects.

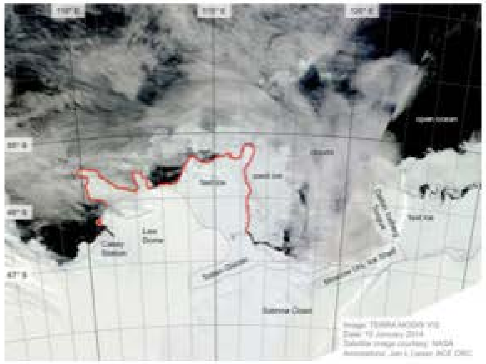
Appendix 6. Previous (2015-2016) regional January to March and current 2017 satellite images.

Images and interpretation courtesy of Dr J. Lieser, Antarctic Gateway Partnership Sea Ice Service.

Previous ship tracks undertaken in the region drawn: 2014- NSF RVIB *N.B. Palmer* voyage, 2015 RVIB *Aurora Australis* voyage.

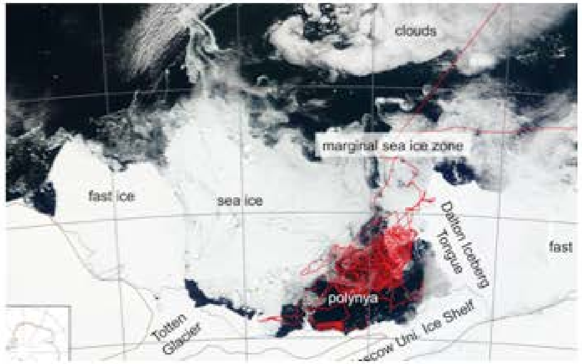
15 January 2014

MODIS scene provided by NASA.



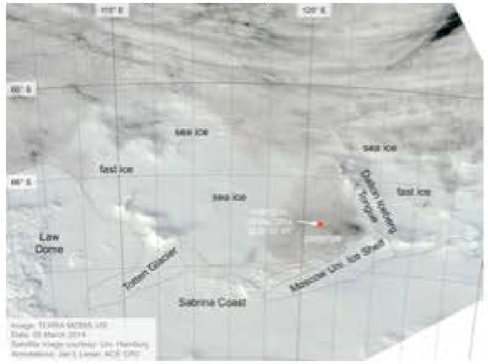
18 February 2014

MODIS scene provided by NASA.



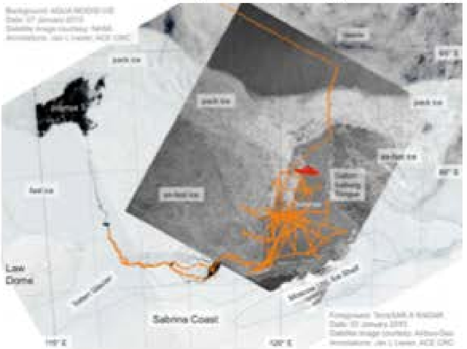
5th March 2014

MODIS scene provided by NASA.



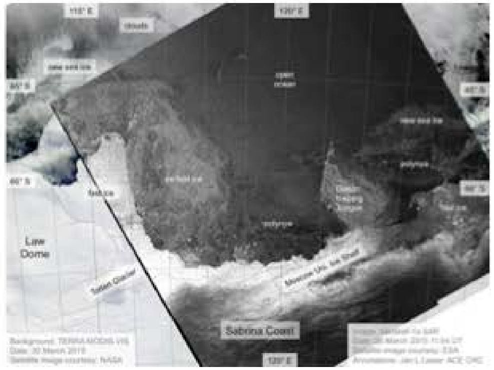
5/7 January 2015

Terra SAR-X image(05/01/2015) provided by Airbus-Geo;
Background: MODIS image (07/01/2015)provided by NASA



31 March 2015

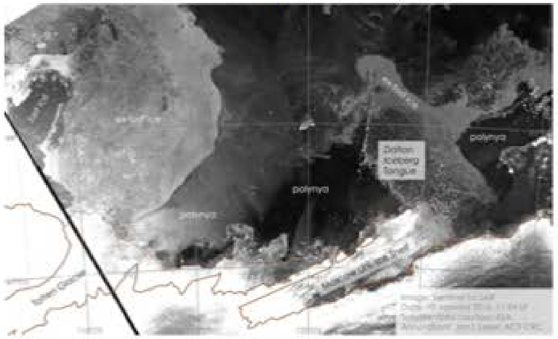
Sentinel-1a scene provided by Polar View



In 2016, the region was largely free of sea ice. Source: Lieser JL, Massom RA & Heil P (2016) Sea ice reports for the Antarctic shipping season 2015–2016. Antarctic Climate & Ecosystems Cooperative Research Centre, Hobart, Tasmania. ISSN 2200–5498.

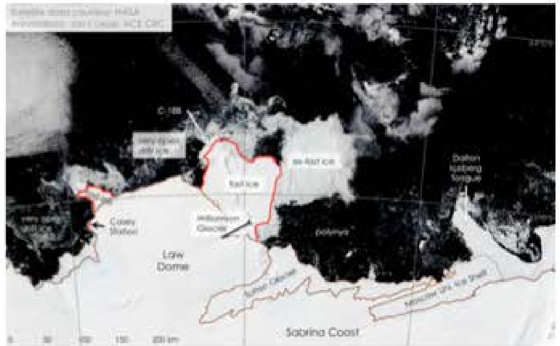
10 January 2016

Sentinel-1a SAR scene provided by ESA.



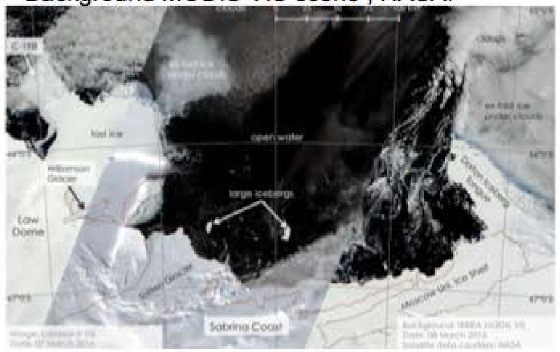
14 February 2016

MODIS VIS scene provided by NASA.

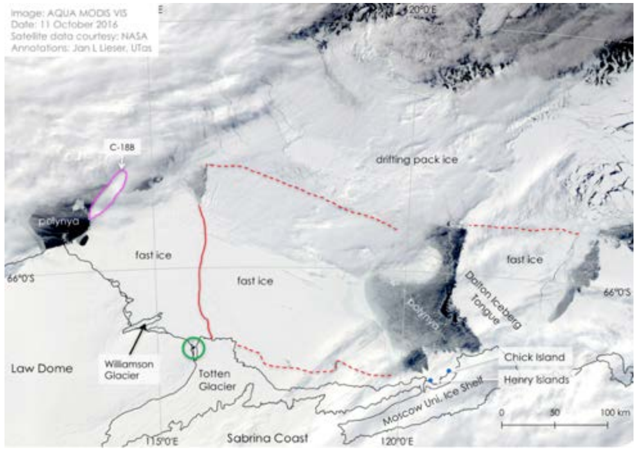


7-8 March 2016

Landsat-8 VIS scene provided by USGS,
Background MODIS VIS scene , NASA.

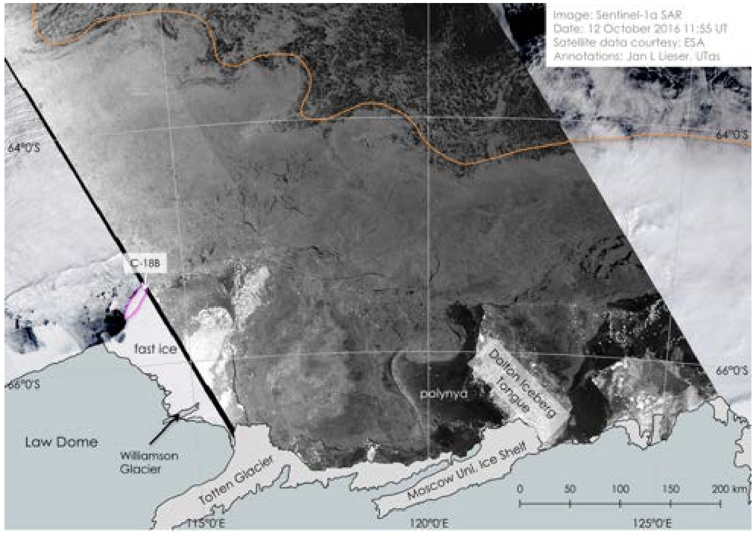


In late 2016, satellite images indicate less than average sea-ice extent for this time of the year and a large and persistent Dalton polynya.



←1. MODIS VIS scene, acquired **11/10/2016** and provided by NASA. The solid red line in the figure separates two distinctively different zones of fast ice; to the west is stable fast ice that remained in-situ for many months, to the east is only temporary fast ice that is subject to frequent break offs. Red dashed lines indicate the northern and southern boundaries of this (not so) land-fast sea ice area.

See next page for new images.



2. Top Left. Sentinel-1a SAR scene, acquired **12/10/2016** and provided by PolarView. Background: AQUA MODIS VIS image, acquired 12/10/2016 and provided by NASA. The boundary between very open drift and high concentration sea ice is approximated by the orange line.

3. Bottom Left. Sentinel-1b SAR scene, acquired on **06/12/2016** and provided by

PolarView. Background: TERRA MODIS VIS scene, acquired on 07/12/2016 and provided by NASA. The yellow line indicates the median sea-ice extent for December. The location of a whale acoustic mooring is given by a green dot (W-Casey). North of the sea-ice edge, many small icebergs can be detected in the SAR scene (approximated by – but not limited to – the purple circle). **The current sea-ice edge is well south of the December median extent** except for a small region, between 108° E and 110° 15' E.

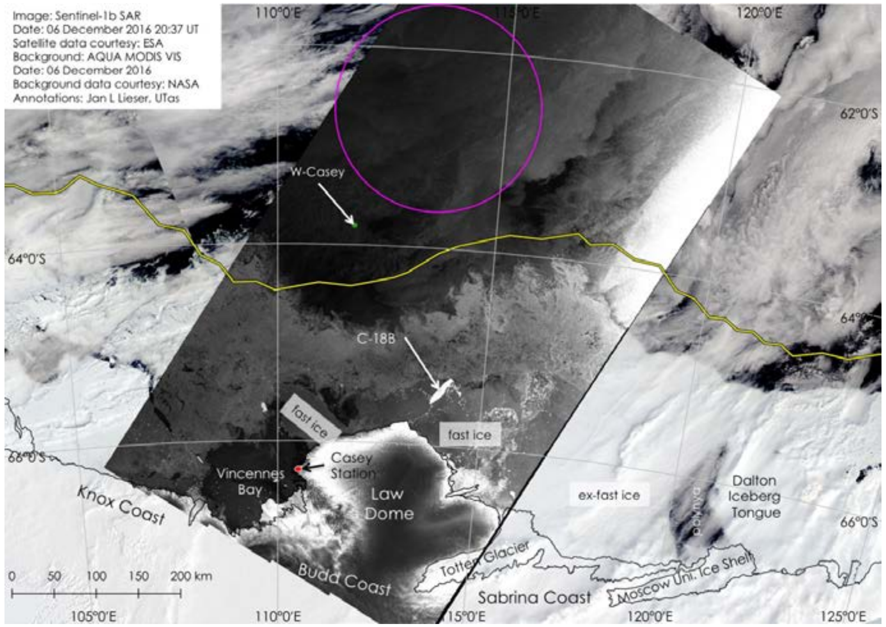


Image: Sentinel-1b SAR
Date: 06 December 2016 20:37 UT
Satellite data courtesy: ESA
Background: AQUA MODIS VIS
Date: 06 December 2016
Background data courtesy: NASA
Annotations: Jan L Lieser, UTas
110°0'E
120°0'E
62°0'S
W-Casey
64°0'S
C-18B
fast ice
fast ice
Casey Station
Vincennes Bay
Law Dome
Knox Coast
ex-fast ice
Dalton Iceberg Tongue
66°0'S
Totten Glacier
Moscow Uni. Ice Shelf
Budd Coast
Sabrina Coast
0 50 100 150 200 km
105°0'E
110°0'E
120°0'E
125°0'E