RV *Investigator* Voyage Plan

Voyage #:	**IN2020_V01**
Voyage title:	Development of William's Ridge, Kerguelen Plateau: tectonics, hotspot magmatism, microcontinents, and Australia's Extended Continental Shelf
Mobilisation:	BAE Henderson/Fremantle, 0700 Wednesday 8 January 2020
Depart:	BAE Henderson/Fremantle, 0800 Wednesday 8 January 2020
Return:	BAE Henderson/Fremantle, 0800 Friday 6 March 2020
Demobilisation:	BAE Henderson/Fremantle, Friday 6 March 2020
Voyage Manager:	Tegan Sime
Chief Scientist:	Prof Millard (Mike) Coffin
Affiliation:	IMAS/University of Tasmania
Principal Investigators:	A/Prof Joanne Whittaker[1], A/Prof Nathan Daczko[2], Dr Jacqueline Halpin[1], Ms Kim Picard[3], Dr Sascha Brune[4], Prof Sally Gibson[5], Prof Kaj Hoernle[6], Prof Anthony Koppers[7], Prof Michael Storey[8], Dr Gabriele Uenzelmann-Neben[9]
Project name:	Same as voyage title
Affiliation:	[1]IMAS/University of Tasmania
Affiliation:	[2]Dept of Earth and Planetary Sciences, Macquarie University
Affiliation:	[3]Geoscience Australia
Affiliation:	[4]GeoForschungsZentrum (GFZ) Potsdam, Germany
Affiliation:	[5]University of Cambridge, UK
Affiliation:	[6]GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany

Affiliation:	[7]Oregon State University, USA
Affiliation:	[8]Natural History Museum of Denmark, Denmark
Affiliation:	[9]Alfred Wegener Institute for Polar and Marine Research, Germany

Scientific objectives

The voyage has two principle scientific objectives:

1. To gain important new knowledge of the rifting, breakup, and initial separation of tectonic plates. The project constitutes the first-ever case study of conjugate oceanic plateau end-members – the formerly contiguous and subaerial, but now separated and submarine Kerguelen Plateau and Broken Ridge in the southern Indian Ocean – to investigate these phenomena.
2. To acquire, analyse, and interpret data and samples necessary for Australia to make a new or revised submission to the UN Commission on the Limits of the Continental Shelf (CLCS). The purpose is to extend our marine jurisdiction to include William's Ridge, an extension of the Central Kerguelen Plateau, under the UN Convention on the Law of the Sea (UNCLOS).

The project leadership team comprises four CIs from the University of Tasmania (UTAS; **Coffin**, **Whittaker**, **Halpin**) and Macquarie University (MQU; **Daczko**), and one PI each from Geoscience Australia (GA; **Picard**), the University of Cambridge (UC; **Gibson**), three German Helmholtz Centres (the Alfred Wegener Institute for Polar and Marine Research (AWI; **Uenzelmann-Neben**), the German Research Centre for Geosciences (GFZ; **Brune**), and GEOMAR Helmholtz Centre for Ocean Research Kiel (GEOMAR; **Hoernle**), Oregon State University (OSU; **Koppers**), and the Natural History Museum of Denmark (NHMD; **Storey**). **Coffin** will lead and oversee the entire project, both at sea and ashore.

The shipboard team that will acquire the geophysical data and geological samples includes **Coffin** (Chief Scientist), **Bernardel** (GA; Co-Chief Scientist), **Gardner** (MQU; petrologist/geochemist), **Dürer** (University of Queensland; structural geologist); **Dong** (Institute of Oceanology, Chinese Academy of Sciences; marine geophysics), four **PhD students (UTAS, ANU, GFZ)**, three **Honours students**, and nine **undergraduate students**.

The post-voyage team will involve everyone listed above. **Coffin**, **Whittaker**, **Picard**, **Uenzelmann-Neben**, **Bernardel**, the **UTAS PhD student**, and the **ANU PhD student** will focus on multibeam bathymetry/ backscatter, sub-bottom profile, seismic reflection, gravity, magnetic, and deep-tow camera data acquisition, processing, analysis, and interpretation. **Daczko**, **Halpin**, **Gardner**, **Dürer**, and the **UTAS PhD student** will conduct petrologic and geochemical analyses of dredged rocks, undertake geochronological and microstructural analyses of metamorphic rocks, and interpret analytical data from continental rocks. **Gibson** will carry out volatile analysis of dredged igneous rocks, and they and **Hoernle** will interpret the analytical data from oceanic rocks. **Koppers** and **Storey** will perform geochronological analyses of dredged igneous rocks. **Brune** and the **GFZ PhD student** will undertake geodynamic modelling.

Voyage objectives

To address the scientific objectives of the project, the voyage objectives encompass acquiring and initially processing multibeam bathymetry/backscatter, water-column echo-sounding, sub-bottom profile, seismic reflection, deep-towed camera, gravity, and magnetic data acquisition; and acquiring rock samples by dredging. The acoustic data will be used to determine the locations of the seismic reflection profiles, and the acoustic and seismic data will be used to determine locations of dredging sites. In more detail, we will undertake the following activities, grouped in order of priority:

1a. Multibeam bathymetry/backscatter: we will acquire multibeam data along William's Ridge, the conjugate portion of Broken Ridge not covered by the *MH370 search data, and associated seafloor topographic features. Anticipated water depths range from ~500 m to ~4500 m, so the primary system will be the EM122, complemented by the EM710 in water depths less than ~1500 m. Track orientation will be along the strike of the two ridges, parallel to their axes, to maximise data acquisition efficiency and coverage. Near-real-time multibeam data will be utilised to create maps to identify optimal locations for dredging (e.g., steep slopes) and seismic reflection profiling (e.g., smoothest topography), during which multibeam data will also be acquired. Multibeam data have not been acquired previously from William's Ridge; available bathymetry is calculated from satellite altimeter data, yielding a resolution of ≥5000 m.

1b. Sub-bottom profiling: we will acquire SBP120 data continuously multibeam data acquisition. These near-real-time data will contribute to identifying the best locations for dredging (e.g., absence of shallow sediment) and seismic reflection profiling (e.g., presence of shallow sediment), during which we will also acquire SBP120 data. Sub-bottom profiling data have not been acquired previously from William's Ridge.

1c. Seismic reflection: we will utilise the MNF's new seismic system, currently consisting of a 40-channel, 500-m-long, 12.5-m group spacing streamer and two GI airguns. We will acquire approximately five ~60-nautical-mile-long profiles perpendicular to the strike of William's Ridge, four ~45-nautical-mile-long profiles perpendicular to the strike of Broken Ridge, and one 60-nautical-mile-long profile along the strike of Broken Ridge on its crest. Seismic reflection data acquisition will be undertaken at 4 kts, each deployment and retrieval of the system will take approximately 30 minutes, and transits between the lines will be conducted at 9 kts. Modern seismic reflection data have not been acquired previously from William's Ridge.

1d. Dredging: recovery of continental, hotspot-related, and/or oceanic rocks forming the basement of William's Ridge and associated topographic features in the Labuan Basin, in multiple locations, is the goal, complemented by sampling the conjugate basement of Broken Ridge. Utilizing the near-real-time multibeam, sub-bottom profiling, seismic reflection, and total magnetic field data, we will select dredging sites in water depths as great as ~5500 m. We will dredge sites on William's Ridge, associated features in the Labuan Basin, and Broken Ridge. At sea we will employ the rock saw to cut rock samples, providing

fresh rock surfaces so that we can undertake preliminary petrographic descriptions and catalogue the samples. No igneous or metamorphic rocks have been dredged from William's Ridge. Rock dredges typically recover benthic biota as bycatch (see 'Supplementary Project' below) as well as sand in the dredge bucket; we will concentrate heavy minerals using a gold pan, and assess the heavy mineral concentrates for datable minerals such as zircon.

2a. Single-beam and multi-beam water column echo-sounding: we will collect EK60 and ME70 data throughout the entire voyage. The near-real-time data will reveal any acoustic plumes emanating from the seafloor, which we will target for dredging possible active submarine volcanoes. No water column echo-sounding data have been acquired over William's Ridge or Broken Ridge. If acoustic plumes are emanating from the seafloor, William's Ridge and/or Broken Ridge may be volcanically active.

2b. Deep tow camera: on the basis of dredges and water column echo-sounding data, we will acquire still and video photography at locations characterized by mixed hotspot-related/oceanic/continental rocks and acoustic plumes emanating from the seafloor. Deep tow camera footage has not been acquired over William's Ridge; if we observe acoustic plumes emanating from the seafloor, such footage could help confirm that active volcanism is the source of the plumes.

3a. Gravity: gravity data will be acquired by the shipboard gravity meter during the entire voyage. No modern shipboard gravity data have been acquired over William's Ridge.

3b. Magnetics: we will acquire total magnetic field data using the towed proton precession magnetometer on the transits and throughout multibeam/sub-bottom profiling data acquisition. Near-real-time magnetics data will help distinguish oceanic (highly magnetized) and continental (weakly magnetized) rocks for the selection of dredging sites. Modern magnetics data have not been acquired over William's Ridge.

*We will fully incorporate the MH370 search data, which is limited to multibeam bathymetry/backscatter, in this project. We have already published some of these data (Picard et al., 2017; 2018).

Lost time will be dealt with by reducing or eliminating 2b and 3b first, and then, if necessary, by reducing the areas of 1a and 1b.

Operational Risk Management

The new MNF seismic reflection system has been commissioned and tested, but IN2020_V01 will be its first scientific deployment. The system and associated procedures, however, have not been deployed in the Roaring Forties and Furious Fifties of the Southern Ocean, and the MNF may wish to consider deployments, operations, and recoveries of the system during the voyage as 'tests'.

Two members of the science team (Lau and Moroni) will have completed online training (https://training.scanningoceansectors.com/) as Marine Mammal Observers (MMOs), specifically the Marine Mammal Observer Course SoS and the Australian MMO Course. An experienced cetacean researcher (Jones) is also a member of the science team. If a whale is

sighted during the seismic surveys, Jones is required to stand by with Lau and Moroni. Jones will watch the whale(s) continuously with Lau and Moroni as long as the cetaceans are in sight.

No potentially high risk work has been identified outside standard operations.

We note, however, that RV *Sonne* voyage SO272 (Dr Gabriele Uenzelmann-Neben, Chief Scientist, and PI on IN2020_V01) will be working along the Central Kerguelen Plateau and William's Ridge in January/February 2020. Multibeam sonar and seismic reflection data, and piston cores, are scheduled to be acquired during SO272. All effort will be made to maintain open communication, to share data, and to avoid duplicative research during the two voyages.

Media Activities

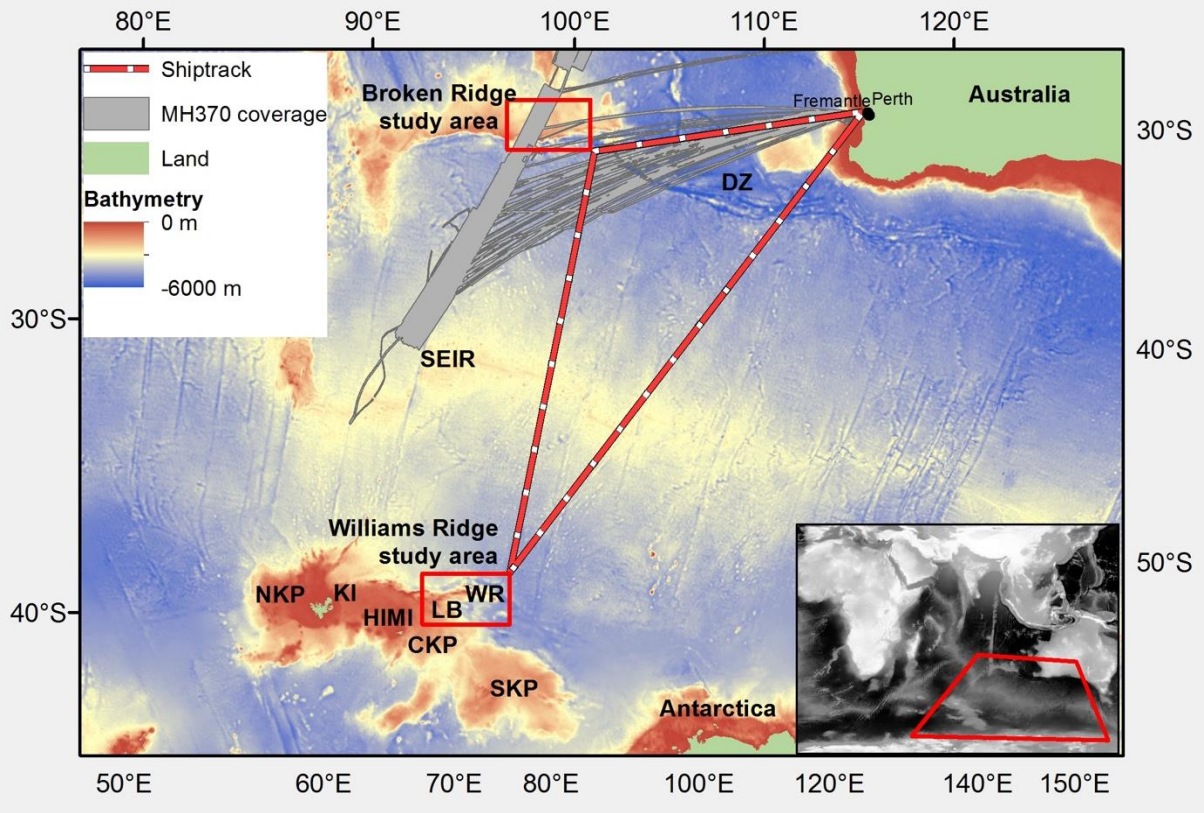
The MNF will seek to pursue opportunities that arise during the voyage to promote the science, scientists and ship, via conventional and social media channels, in consultation and/or collaboration with the relevant ship user.

Organisation	Activities	Timing	Responsible person
MNF	Media engagement for print story describing ship capabilities and current voyage highlights.	Opportunistically	TBN
IMAS/UTAS	Chief Scientist undertaking interviews with networks to discuss science being undertaken	Pre-departure	Prof Mike Coffin
IMAS/UTAS	Live cross to network and a range of stories and blogs to be released.	Throughout voyage	Prof Mike Coffin
MNF	Post voyage media engagement on wharf apron with technical support personnel and Voyage Manager	Post Voyage	TBN
IMAS/UTAS	Post voyage media engagement	Post Voyage	Prof Mike Coffin

Overall activity plan including details for first 24 hours of voyage

The first 24 hours at sea will be entirely transit from Fremantle to the southeastern tip of William's Ridge, which is a distance of 1966 nm. At 9 kts heading into the Antarctic Circumpolar Current (ACC), the transit will take ~219 hours (~nine days). During the transit we will test the seismic reflection system, underway acoustic, and other geophysical systems.

Voyage track



Voyage Track Map. Australian-Antarctic region showing the Kerguelen Plateau (Central Kerguelen Plateau, CKP; Southern Kerguelen Plateau, SKP; Northern Kerguelen Plateau, NKP), its surmounting islands (Kerguelen Isles, KI; Heard and McDonald islands, HIMI), William's Ridge (WR), Labuan Basin (LB), Southeast Indian Ridge (SEIR), Broken Ridge (BR), and Diamantina Zone (DZ) and. Voyage track: Fremantle->William's Ridge->Broken Ridge->Fremantle. Grey shading indicates coverage of multibeam/backscatter data acquired in the search for Malaysia Airlines flight MH370; these data were made public on 19 July 2017.

Waypoints and Time Estimates

Waypoint	Activity	Lat (S)	Long (E)	Speed (kt)	Time for Activity (hr)	Date	Time
1	Fremantle depart	31°56.23'	115°45.06'		0.0	8/01/20	15:00
2		55°41.87'	083°24.32'	9	218.5	17/01/20	17:29
3	Dredge Target 1	55°33.32'	082°56.69'	9	2.0	17/01/20	19:27
	Dredging			9	12.0	18/01/20	07:27
4		55°21.04'	082°16.98'	9	2.9	18/01/20	10:19
5	Dredge target 2	55°22.78'	081°39.52'	9	2.4	18/01/20	12:41
	Dredging			9	12.0	19/01/20	00:41
6		55°09.58'	081° 53.80'	9	1.7	19/01/20	02:25
7		55°02.51'	082° 31.67'	9	2.5	19/01/20	04:57
8	Dredge Target 3	55°12.74'	082° 57.11'	9	2.0	19/01/20	06:55

	Dredging			9	12.0	19/01/20	18:55
9		55°24.86’	083° 27.26’	9	2.3	19/01/20	21:15
10		54°36.95’	083° 06.44’	9	5.5	20/01/20	02:45
11		53°11.78’	078° 25.93’	9	20.7	20/01/20	23:25
12		53°05.50’	078° 27.36’	9	0.7	21/01/20	00:07
13		54°32.90’	083° 07.94’	9	20.8	21/01/20	20:56
14		54°29.33’	083° 08.98’	9	0.4	21/01/20	21:20
15		52°58.69’	078° 29.56’	9	21.0	22/01/20	18:17
16		52°51.21’	078° 32.20’	9	0.9	22/01/20	19:08
17		54°25.51’	083° 10.25’	9	21.1	23/01/20	16:15
18		54°21.25’	083° 11.67’	9	0.5	23/01/20	16:44
19		52°47.80’	078° 33.52’	9	21.1	24/01/20	13:49
20		52°43.40’	078° 34.94’	9	0.5	24/01/20	14:19
21		54°16.93’	083° 12.85’	9	21.1	25/01/20	11:26
22		54°12.76’	083° 14.20’	9	0.5	25/01/20	11:54
23		52°38.84’	078° 36.88’	9	21.1	26/01/20	09:02
24		52°34.02’	078° 38.97’	9	0.6	26/01/20	09:35
25		54°08.83’	083° 15.55’	9	21.2	27/01/20	06:45
26		54°05.77’	083° 16.60’	9	0.3	27/01/20	07:05
27		52°30.16’	078° 40.40’	9	21.2	28/01/20	04:18
28		52°27.10’	078° 41.37’	9	0.3	28/01/20	04:38
29		54°02.62’	083° 17.43’	9	21.2	29/01/20	01:51
30		53°59.97’	083° 18.15’	9	0.3	29/01/20	02:09
31		52°23.48’	078° 42.58’	9	21.3	29/01/20	23:24
32		52°20.09’	078° 44.00’	9	0.4	29/01/20	23:48
33		53°55.88’	083° 19.36’	9	21.2	30/01/20	21:01
34		53°52.56’	083° 20.52’	9	0.4	30/01/20	21:24
35		52°17.00’	078° 45.47’	9	21.2	31/01/20	18:37
36		52°13.33’	078° 46.87’	9	0.4	31/01/20	19:02
37		53°48.29’	083° 22.02’	9	21.2	1/02/20	16:15
38		53°44.59’	083° 23.46’	9	0.4	1/02/20	16:40
39		52°09.77’	078° 48.25’	9	21.2	2/02/20	13:54
40		52°05.67’	078° 49.81’	9	0.5	2/02/20	14:22
41		53°40.52’	083° 24.03’	9	21.2	3/02/20	11:34
42	Dredge Target 4	53°31.67’	082° 58.47’	9	2.0	3/02/20	13:31
	Dredging				12.0	4/02/20	01:31
43		53°13.65’	082° 39.29’	9	2.4	4/02/20	03:53
44	Seismic Profile 1 end	54°10.09’	082° 02.31’	4	15.1	4/02/20	19:02
45	Dredge Target 5	54°02.79’	081° 37.60’	9	1.8	4/02/20	20:50
	Dredging				12.0	5/02/20	08:50
46		53°54.46’	081° 09.38’	9	2.1	5/02/20	10:54
47	Seismic Profile 2 end	52°54.20’	082° 02.95’	4	17.1	6/02/20	03:58
48	Dredge Target 6	52°55.36’	081° 56.05’	9	0.5	6/02/20	04:27

	Dredging				12.0	6/02/20	16:27
49		52°40.49’	081° 03.65’	9	3.9	6/02/20	20:20
50	Seismic Profile 3 end	53°42.02’	080° 13.27’	4	17.1	7/02/20	13:29
51	Dredge Target 7	53°33.65’	079° 43.39’	9	2.2	7/02/20	15:39
	Dredging				12.0	8/02/20	03:39
52		53°25.13’	079° 13.01’	9	2.2	8/02/20	05:53
53	Seismic Profile 4 end	52°29.65’	079° 47.45’	4	14.8	8/02/20	20:42
54	Dredge Target 8	52°26.81’	079° 27.47’	9	1.4	8/02/20	22:05
	Dredging				12.0	9/02/20	10:05
55		52°24.87’	079° 13.97’	9	0.9	9/02/20	11:02
56	Seismic Profile 5 end	53°12.70’	078° 38.58’	4	13.1	10/02/20	00:08
57	Dredge target 9	52°38.27’	079° 09.21’	9	4.3	10/02/20	04:29
	Dredging				12.0	10/02/20	16:29
58		32°32.58’	096° 49.43’	9	158.7	17/02/20	07:13
59		32°41.26’	101° 51.60’	9	28.3	18/02/20	11:32
60		32°32.34’	101° 52.02’	9	1.0	18/02/20	12:32
61		32°23.81’	096° 54.07’	9	28.0	19/02/20	16:29
62		32°15.56’	096° 58.44’	9	1.0	19/02/20	17:30
63		32°22.95’	101° 52.44’	9	27.6	20/02/20	21:08
64		32°16.31’	101° 52.74’	9	0.7	20/02/20	21:52
65		32°09.11’	097° 01.86’	9	27.4	22/02/20	01:15
66		31°13.64’	096° 44.96’	9	6.4	22/02/20	07:37
67	Seismic Profile 6 end	31°21.92’	097° 53.92’	4	14.9	22/02/20	22:30
68	Dredge target 10	32°20.42’	097° 38.55’	9	6.7	23/02/20	05:10
	Dredging				12.0	23/02/20	17:10
69		32°07.38’	097° 53.93’	9	2.0	23/02/20	19:13
70	Seismic Profile 7 end	33°08.89’	097° 54.85’	4	15.4	24/02/20	10:36
71	Dredge Target 11	32°26.46’	098° 26.48’	9	5.6	24/02/20	16:10
	Dredging				12.0	25/02/20	04:10
72		33°02.48’	098° 58.97’	9	5.0	25/02/20	09:11
73	Seismic Profile 8 end	32°04.11’	099° 01.19’	4	14.6	25/02/20	23:48
74	Dredge Target 12	32°24.41’	099° 26.20’	9	3.3	26/02/20	03:04
	Dredging				12.0	26/02/20	15:04
75		32°03.76’	099° 57.14’	9	3.7	26/02/20	18:46
76	Seismic Profile 9 end	33°03.95’	099° 50.61’	4	15.1	27/02/20	09:53
77	Dredge Target 13	33°06.10’	100° 45.30’	9	5.1	27/02/20	14:59
	Dredging				12.0	28/02/20	02:59
78		33°11.29’	101° 08.76’	9	2.3	28/02/20	05:15
79	Seismic Profile 10 end	32°11.10’	101° 15.60’	4	15.1	28/02/20	20:23
80	Dredge Target 14	32°27.55’	101° 37.80’	9	2.8	28/02/20	23:09
	Dredging				12.0	29/02/20	11:09
81	Fremantle arrive	31°56.23’	115° 45.06’	9	79.7	3/03/20	18:53
	Contingency				70.0	**6/03/20**	**16:53**

It is important to note that with the exception of waypoints 1, 2, and 81, all other waypoints are indicative and subject to change. Dredge targets will be selected on the basis of the new multibeam and seismic reflection data that we will acquire during the voyage; multibeam line spacing and possibly length will depend on water depth and weather conditions; and seismic reflection line locations will be selected on the basis of the new multibeam and sub-bottom profiling data that we will acquire during the voyage.

The total IN2020_V01 track length is 9641 nm. In summary, the total of 36 days of science comprises 24 days of work on William's Ridge, 12 days of work on Broken Ridge, and 3 days of contingency. Transits total 19 days.

Supplementary projects

1. ***Using samples from the Kerguelen Plateau to date past West Antarctic ice sheet collapse***, A/Prof Jan Strugnell.

This project aims to determine the timing of the most recent collapse of the West Antarctic Ice Sheet by examining the genomic signatures of benthic marine species with circumpolar distributions. Specifically, we aim to:

a. Develop panels of genomic markers for investigating genetic variation within target species

b. Establish demographic models of genetic connectivity through trans-west Antarctic seaways that may have existed during the warmer than present Last Interglacial (LIG), 125ka, based on the most probable Antarctic ice sheet reconstructions from models and geological data

c. Distinguish between these demographic models by testing their fit to genomic data
This proposal will enable discovery of when marine animals last migrated through historic seaways crossing the Antarctic continent, thereby indicating the most recent date of West Antarctic Ice Sheet collapse.

This proposal will take full advantage of rock dredging during voyage IN2020_V01, and will require no deviations off route or additional time. Benthic animals have been retrieved this way for previous rock sampling on IN2016_V01 to the Kerguelen Plateau (Coffin et al). Therefore we anticipate that benthic samples will be obtained using the sampling protocols of IN2020_V01, including dredges and possibly Smith-Mac grabs.

To assist keeping animals in good condition before sampling, buckets of seawater can be chilled prior to receiving samples. These may also be kept in the walk-in freezer until required. Organisms must be sampled as soon as possible to achieve best results for genetic studies. All samples will be sorted, identified, photographed, and preserved in 95% ethanol. Samples will be stored in -80°C freezer (small organisms and tissue subsamples), or for larger organisms, in a walk in freezer in dangerous goods approved plastics, held within barrels. If this is not possible for ethanol (not spark-proof facility), larger samples will be kept in the Haz Chem container along with the stock ethanol and ethanol waste. All samples will be entered into a Filemaker Maker Pro field database for onboard management.

2. ***Argo Float Deployment***, Ms Rebecca Cowley.

We will deploy nine Argo floats during the voyage in the following approximate locations:

	Latitude	Longitude
Float 1	-45.5	92
Float 2	-47	91
Float 3	-50	88.6
Float 4	-52	87
Float 5	-32.5	112.5
Float 6	-32.6	110
Float 7	-33.00	107.00
Float 8	-33.00	103.00
Float 9	-33.30	100.00

3. ***SOCCOM Float Deployment***, Prof Lynne Talley

Six SOCCOM (Southern Ocean Carbon and Climate Observations and Modeling) floats will be loaded on RV *Investigator* at BAE Henderson. An Argo float engineer from the University of Washington, Anill Rick Rupan, will be at BAE Henderson just before sailing to dock-check the floats and load them (without boxes). We will talk with the Chief Scientist, whomever is in charge of float deployments, and whomever will actually deploy the floats during the voyage. We will deploy three or four floats at a speed of 1-2 kts in the following approximate locations; latitudes are critical, while longitudes will depend upon the ship's track.

	Latitude	Longitude
*Float 1	-38.0	~109.0
Float 2	-37.0	~93.0
Float 3	-46.0	~86.0
Float 4	-53.0	~82.0

*to be deployed either on IN2020_V01 or IN2020_T01/CAPSTAN

Permits

Required permits include:

1. Australian Antarctic Division | Department of the Environment and Energy: Environmental Approvals Application Form |Territory of Heard and McDonald Islands | Environment Protection and Management Ordinance 1987 | Environment Protection and Biodiversity Conservation Act 1999 | Environment Protection and Biodiversity Conservation Regulations 2000 (application submitted by Coffin on 17 June 2019)

2. Australian Antarctic Division | Department of the Environment and Energy: Environmental Approvals Application Form | Antarctic Treaty (Environment Protection) Act 1990 | Antarctic Marine Living Resources Conservation Act 1981 (application submitted by Coffin on 6 October 2019)
3. Department of the Environment and Energy: General Permit Application for: Threatened species and ecological communities (section 201) | Migratory species (section 216) | Whales and dolphins (section 238) | Listed marine species (section 258) (MNF blanket application approved, as advised by Megan Dykman on 10 July 2019)
4. Australian Antarctic Division | Department of the Environment and Energy: Environmental Approvals Application Form | Antarctic Treaty (Environment Protection) Act 1990 | Antarctic Marine Living Resources Conservation Act 1981 (application submitted by Strugnell)
5. Import permit for biological samples for supplementary project 1. *Using samples from the Kerguelen Plateau to date past West Antarctic ice sheet collapse*, A/Prof Jan Strugnell (application submitted by Strugnell)

List of additional figures and documents

Figure 1. William's Ridge study area.
Figure 2. Broken Ridge study area.

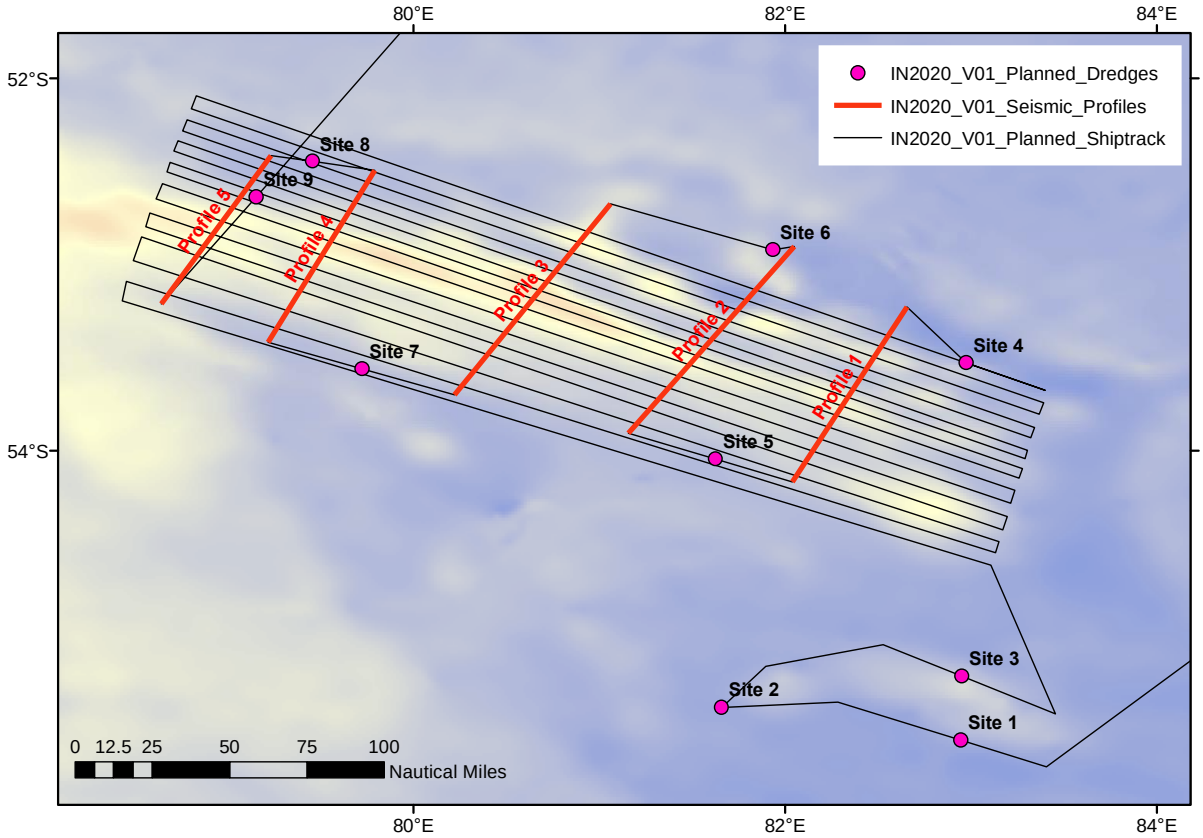


Figure 1. William's Ridge study area. Black lines depict indicative locations of multibeam sonar, sub-bottom profiling, water-column echo-sounding, gravity, and deep-towed camera system data acquisition; final locations will depend on water depth and sea state. Red lines and purple dots depict indicative locations of seismic reflection profiles and dredges,

respectively; final locations of both will depend on shipboard analysis of multibeam sonar and sub-bottom profiling data. Deep-towed camera system locations will depend on shipboard analysis of water-column echo-sounding data.

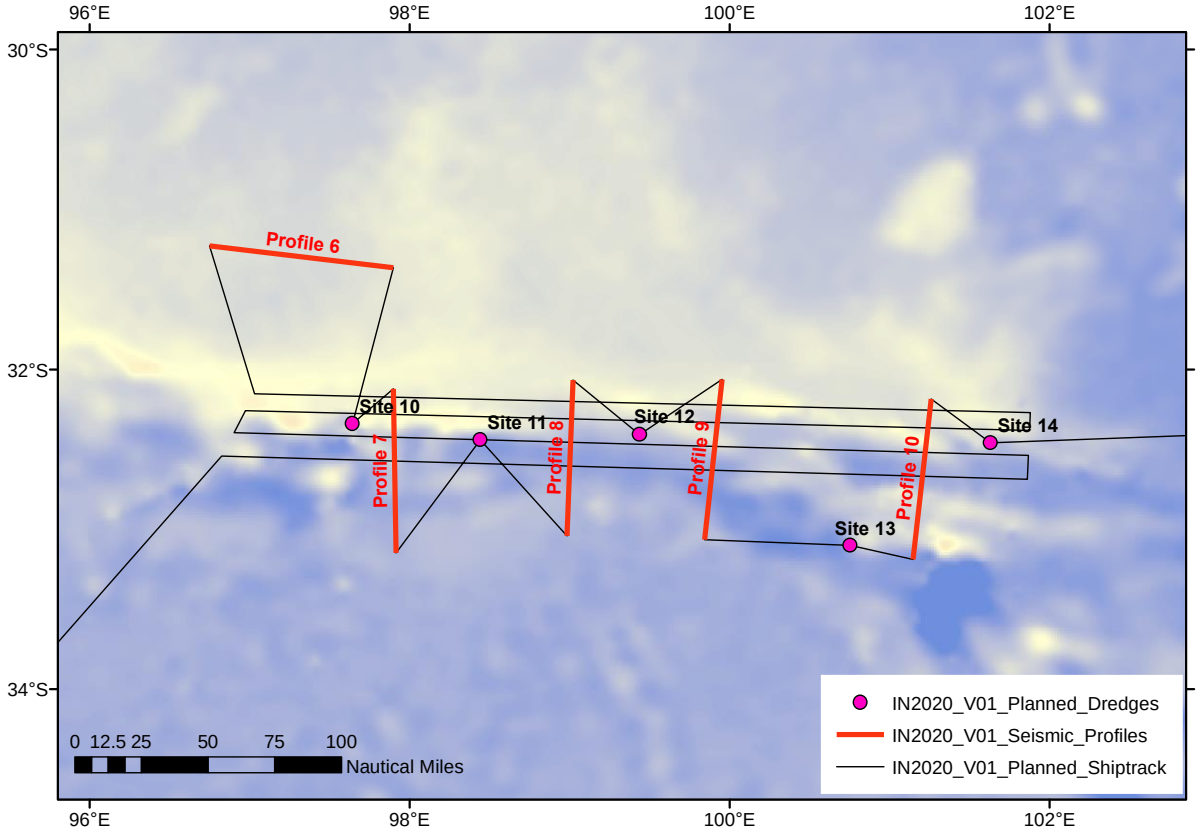


Figure 2. Broken Ridge study area. Black lines depict indicative locations of multibeam sonar, sub-bottom profiling, water-column echo-sounding, gravity, and deep-towed camera system data acquisition; final locations will depend on water depth and sea state. Red lines and purple dots depict indicative locations of seismic reflection profiles and dredges, respectively; final locations of both will depend on shipboard analysis of multibeam sonar and sub-bottom profiling data. Deep-towed camera system locations will depend on shipboard analysis of water-column echo-sounding data.

Appendix A

Scientific equipment and facilities provided by the Marine National Facility

Some equipment items on the list may not be available at the time of sailing. Applicants will be notified directly of any changes. Indicate what equipment and facilities you require from the Marine National Facility by placing an **X** in the relevant box.

(i) Standard laboratories and facilities

Name	Essential	Desirable	Notes/Comments
Aerosol Sampling Lab			
Air Chemistry Lab			
Preservation Lab			
Constant Temperature Lab			• Please indicate the required setpoint temperature
Underway Seawater Analysis Laboratory			
GP Wet Lab (Dirty)	X		
GP Wet Lab (Clean)	X		
GP Dry Lab (Clean)	X		
Sheltered Science Area	X		
Observation deck 07 level			
Walk in Freezer			
Blast Freezer			
Ultra-Low Temperature Freezer (-80^{0}C) X2			
Walk in Cool Room	X		
Salt water ice machine			

(ii) Specialised laboratory and facilities *(may require additional support)*

Name	Essential	Desirable	Notes/Comments
Modular Radiation Laboratory			
Modular Trace Metal Laboratory (TM1-blue)			
Modular Trace Metal Laboratory (TM2-white)			• Cannot be overstacked
Trace metal rosette and bottles			• 10 foot container
Modular Hazchem Locker			
Deck incubators			
Stabilised Platform Container			
Clothing container			• The use of this container will be identified by MNF

(iii) Standard laboratory and sampling equipment

Name	Essential	Desirable	Notes/Comments
CTD - Seabird 911 with 36 Bottle Rosette			
CTD - Seabird 911 with 24 Bottle Rosette			
Lowered ADCP			
Sonardyne USBL System			
Milli-Q System			
Laboratory Incubators			
Heavy Duty Electronic Balance (80kg)			
Medium Duty Electronic Balance (15kg/5g resolution)			
Light Duty Electronic Balance (3kg/1g resolution)			
Surface Net (mouth area 1m^2)			• Please specify 335 micron, 500 micron, or 1,000 micron mesh
Bongo Net (not instrumented) ring diameter 485mm 0.018m^2			• 500 micron mesh only
Smith Mac grab	X		
Dissecting Microscopes (x4)			• Please specify number required

(iv) Specialised laboratory and sampling equipment

Name	Essential	Desirable	Notes/Comments *(These items may require additional MNF support staff)*
TRIAXUS – Underway Profiling CTD			
Desired towing profile:			
Continuous Plankton Recorder (CPR)			
Deep towed camera	X		
Piston Coring System			
Gravity Coring System			
Multi Corer			
Kasten Corer			
XBT System	X		• 2 per day provided
Trace Metal Rosette and bottles			
Sherman epibenthic sled			
Brenke Sled			
Rapid Cast SVP	X		•
Magnetometer	X		Science party will bring software for processing magnetics data.
Drop Camera			•
Trace- metal in-situ pumps (x6)			
Rock Dredges	X		• Six rock dredges needed
EZ Net (maximum of 10 nets for depth stratified sampling. Mouth area of 1m^2)			• Please specify 335 micron, 500 micron, or 1,000 micron mesh
Rock saw	X		• Requires trained science personnel
Portable pot hauler			
Beam Trawl			
Pelagic trawl system (net, doors)			• Contact MNF to discuss net and mesh dimensions
Demersal trawl system (net, doors)			• Contact MNF to discuss net and mesh dimensions
MIDOC (multiple opening/closing codend system for pelagic trawl)			
Stern Ramp (please select exposed *OR* installed)		**Deck covers installed**	

(iv) Specialised laboratory and sampling equipment

Name	Essential	Desirable	Notes/Comments *(These items may require additional MNF support staff)*
Trawl monitoring instrumentation (ITI) (2,000m depth limit) Radiosonde Receiver System			

(v) Equipment and sampling gear requiring external support *(may require additional support from applicants)*

Name	Essential	Desirable
Seismic compressors	X	
Seismic acquisition system	X	

(vi) Underway systems

Acoustic Underway Systems

Name	Essential	Desirable	Notes/Comments
75kHz ADCP			
150kHz ADCP			
Multi Beam echo sounder EM122 12kHz (100m to full ocean depth)	X		Science party will bring licences for ArcGIS, Fledermaus, and other relevant MB software.
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		
Multibeam Scientific Echo Sounder ME70 (70-100 kHz)	X		
Omnidirectional Echo Sounder SH90			
Gravity Meter	X		Science party will bring software for processing gravity data.

Atmospheric Underway Sensors

Name	Essential	Desirable	Notes/Comments
Nephelometer			
Multi Angle Absorption Photometer (MAAP)			
Scanning Mobility Particle Sizer (SMPS)			
Radon detector			
Ozone detector			
Condensation Particle Counter (CPC)			
Picarro spectrometer (analysis of CO_2/CH_4/H_2O)			
Aerodyne spectrometer (analysis of N_2O/CO/H_2O)			
Cloud Condensation Nuclei (CCN)			
Polarimetric Weather Radar			

Underway Seawater Systems and Instrumentation

Name	Essential	Desirable	Notes/Comments
Thermosalinograph	X		
Fluorometer			
Optode			
pCO2			

Seawater systems

Name	Essential	Desirable	Notes/Comments
Trace metal clean seawater supply			
Scientific clean seawater supplied to laboaratories	X		
Raw seawater available on deck and in laboratories.	X		

Non MNF Owned Equipment which may be accessed

Name	Essential	Desirable	
D & N Francis winch			• 13mm electro-optical cable
Box Corer			
UTAS In-Situ Pumps (x2)			
EM2040			• Shallow water multibeam echosounder system

Special Requests – MNF Scientific Equipment and Facilities

Videoconferencing needed for communication with shore-based PIs Whittaker, Daczko, Halpin, Picard, Brune, Gibson, and Hoernle, and RV *Sonne*-based PI Uenzelmann-Neben.

Appendix B

User Supplied Equipment

The table below will be a list of all the user supplied equipment that will be brought on board for a specific voyage. It will be populated, by the **Voyage Operations Manager**, from the *Voyage Specific Equipment Manifest*, which will be provided to the Chief Scientist during the planning process. The Chief Scientist will then coordinate the completion of this form with all Principal Investigators and forward the completed form to the Voyage Operations Manager.

This information will also be used for the mobilisation list and for a deck plan for the voyage.

Owner	Item name	Weight	Dimensions	Location on Vessel