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R/V Kairei Cruise Report
KR17-15C (GA0363)

Lord Howe Rise Site Survey 2017 for proposed IODP Drilling

Acquisition of high-resolution seismic data, shallow sub-surface profiles, seafloor bathymetry, seabed samples and imagery data

Lord Howe Rise off the East Coast of Australia

Oct.29, 2017 – Jan.11, 2018

Japan Agency for Marine-Earth Science and Technology

Geoscience Australia

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1. Preface

(1) List of Onboard Scientists, Technicians and Crew

1) Science Party

[Leg 1]

Kan Aoike	Chief Scientist/ Geologist Center for Deep Earth Exploration (CDEX), JAMSTEC
Yukari Kido	Geophysicist Center for Deep Earth Exploration (CDEX), JAMSTEC
Yosaku Maeda	Engineer Marine Technology and Engineering Center (MARITEC), JAMSTEC
Scott Nichol	Geoscientist Geoscience Australia (GA)
Maggie Tran	Marine Ecologist Geoscience Australia (GA)

[Leg 2-1]

Kan Aoike	Chief Scientist/ Geologist Center for Deep Earth Exploration (CDEX), JAMSTEC
Takamitsu Sugihara	Geologist Center for Deep Earth Exploration (CDEX), JAMSTEC
Brian Boston	Geophysicist R&D Center for Earthquake and Tsunami (CEAT), JAMSTEC
Scott Nichol	Geoscientist Geoscience Australia (GA)
Maggie Tran	Marine Ecologist Geoscience Australia (GA)

[Leg 2-2]

Kan Aoike	Chief Scientist/ Geologist Center for Deep Earth Exploration (CDEX), JAMSTEC
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Yosaku Maeda	Engineer Marine Technology and Engineering Center (MARITEC), JAMSTEC
Brian Boston	Geophysicist R&D Center for Earthquake and Tsunami (CEAT), JAMSTEC
Scott Nichol	Geoscientist Geoscience Australia (GA)
Rachel Przeslawski	Marine Ecologist Geoscience Australia (GA)

[Leg 3]

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Yoshinori Sanada	Geophysicist Center for Deep Earth Exploration (CDEX), JAMSTEC
Kazuya Shiraishi	Geophysicist R&D Center for Ocean Drilling Science (ODS), JAMSTEC
Brian Boston	Geophysicist R&D Center for Earthquake and Tsunami (CEAT), JAMSTEC
Ron Hackney	Geoscientist

	Geoscience Australia (GA)
George Bernardel	Geophysicist
	Geoscience Australia (GA)

2) Marine Fauna Observers and Passive Acoustic Monitoring Operators

[Leg 3]

Dan Godoy	Blue Planet Marine (BPM)
Patrick Lyne	Blue Planet Marine (BPM)
David Donnelly	Blue Planet Marine (BPM)
Corey Lardner	Blue Planet Marine (BPM)

3) Marine Technicians

[Leg 1]

Yusuke Sato	Marine Works Japan, Ltd. (MWJ)
Ei Hatakeyama	Marine Works Japan, Ltd. (MWJ)
Yuji Fuwa	Marine Works Japan, Ltd. (MWJ)
Yuki Miyajima	Marine Works Japan, Ltd. (MWJ)
Mika Yamaguchi	Marine Works Japan, Ltd. (MWJ)
Takehiro Kanii	Marine Works Japan, Ltd. (MWJ)
Kento Fukahori	Marine Works Japan, Ltd. (MWJ)
Yohei Katayama	Marine Works Japan, Ltd. (MWJ)
Takuya Onodera	Nippon Marine Enterprises, Ltd. (NME)
Mamoru Sano	Nippon Marine Enterprises, Ltd. (NME)

[Leg 2-1]

Yusuke Sato	Marine Works Japan, Ltd. (MWJ)
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Takehiro Kanii	Marine Works Japan, Ltd. (MWJ)
Kento Fukahori	Marine Works Japan, Ltd. (MWJ)
Takuya Onodera	Nippon Marine Enterprises, Ltd. (NME)

[Leg 2-2]

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Keita Suzuki	Nippon Marine Enterprises, Ltd. (NME)
Hidenori Shibata	Nippon Marine Enterprises, Ltd. (NME)
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Ikumasa Terada	Nippon Marine Enterprises, Ltd. (NME)
Toshimasa Nasu	Nippon Marine Enterprises, Ltd. (NME)
Eri Sakamoto	Nippon Marine Enterprises, Ltd. (NME)

4) Crew

[Leg 1 ~ Leg 2]

Nippon Marine Enterprises, Ltd. (NME)

Shiya Ryono	Captain
Naoto Kimura	Chief Officer
Hidehiko Konno	2nd Officer
Syunsuke Fujii	3rd Officer
Tomohiro Yukawa	Jr. 3rd Officer
Minoru Tsukada	Chief Engineer
Daisuke Gibu	1st Engineer
Yoichi Yasue	2nd Engineer
Yoshinobu Hiratsuka	Jr. 2nd Engineer
Yuna Kaino	3rd Engineer
Hiroyasu Saitake	Chief Electronic Operator
Takayuki Mabara	2nd Electronic Operator
Yohei Sugimoto	3rd Electronic Operator
Kazuo Abe	Boat Swain
Yasuo Konno	Quarter Master
Shuichi Yamamoto	Quarter Master
Daisuke Yanagitani	Quarter Master
Yasunobu Kawabe	Sailor
Toshiya Saga	Sailor
Eishin Sato	Sailor
Yukihiro Yamaguchi	No.1 Oiler
Masaki Tanakai	Oiler
Ryo Sato	Oiler
Daiki Sato	Oiler
Shotaro Sumitomo	Assistant Oiler
Seiya Watanabe	Assistant Oiler
Ryuei Takemura	Chief Steward
Toru Wada	Steward
Masaru Sugiyama	Steward
Takahiro Abe	Steward
Kina Abe	Steward

[Leg 3]

Nippon Marine Enterprises, Ltd. (NME)

Shiya Ryono	Captain
Naoto Kimura	Chief Officer
Hidehiko Konno	2nd Officer
Syunsuke Fujii	3rd Officer
Tomohiro Yukawa	Jr. 3rd Officer
Minoru Tsukada	Chief Engineer
Daisuke Gibu	1st Engineer
Yoichi Yasue	2nd Engineer
Yoshinobu Hiratsuka	Jr. 2nd Engineer
Yuna Kaino	3rd Engineer
Hiroyasu Saitake	Chief Electronic Operator
Takayuki Mabara	2nd Electronic Operator

Yohei Sugimoto	3rd Electronic Operator
Kazuo Abe	Boat Swain
Yasuo Konno	Quarter Master
Shuichi Yamamoto	Quarter Master
Daisuke Yanagitani	Quarter Master
Yasunobu Kawabe	Sailor
Toshiya Saga	Sailor
Eishin Sato	Sailor
Yukihiro Yamaguchi	No.1 Oiler
Masaki Tanakai	Oiler
Ryo Sato	Oiler
Daiki Sato	Oiler
Shotaro Sumitomo	Assistant Oiler
Seiya Watanabe	Assistant Oiler
Ryuei Takemura	Chief Steward
Toru Wada	Steward
Masaru Sugiyama	Steward
Takahiro Abe	Steward
Kina Abe	Steward

(2) Cruise Proponents

Shin'inchi Kuramoto	CDEX/JAMSTEC	Principal Investigator
Shuichi Kodaira	CEAT/JAMSTEC	Project Manager
Kan Aoike	CDEX/JAMSTEC	Onboard Chief Scientist of Legs 1~3
Yukari Kido	CDEX/JAMSTEC	Leg 1
Takamitsu Sugihara	CDEX/JAMSTEC	Legs 2-1 & 2-2
Yoshinori Sanada	CDEX/JAMSTEC	Leg 3
Seiichi Miura	CEAT/JAMSTEC	
Yasuyuki Nakamura	CEAT/JAMSTEC	
Gou Fujie	CEAT/JAMSTEC	
Yuka Kaiho	CEAT/JAMSTEC	Leg 3
Tetsuo No	CEAT/JAMSTEC	
Yasuhiro Yamada	ODS/JAMSTEC	
Saneatsu Saito	ODS/JAMSTEC	
Kazuya Shiraishi	ODS/JAMSTEC	Leg 3
Ron Hackney	GA	Leg 3
Scott Nichol	GA	Legs 1, 2-1 & 2-2
Andrew Carroll	GA	
George Bernardel	GA	Leg 3
Maggie Tran	GA	Legs 1 & 2-1
Rachel Przeslawski	GA	Leg 2-2

Acknowledgments

We greatly appreciate Captain Shinya Ryono, all the officers and crew, Chief Technicians Messrs. Takuya Onodera and Shusuke Machida, Lead Technician for Deep Tow and sediment sampling operations Mr. Yusuke Sato, all the marine technicians, PAM Operators Messrs. Dan Godoy and Patrick Lyne, and Marine Fauna Observers Messrs. Corey Lardner and David Donnelly, for their helpful suggestions and skillful support. We should also like to express our grateful thanks to all quarters concerned on shore for their kind assistance.

2. Executive Summary

The KR17-15C cruise was planned and executed under a Collaborative Project Agreement between Geoscience Australia (GA) and the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) as the second phase site survey for a scientific drilling project on the Lord Howe Rise (LHR). The LHR, located off the east coast of the Australian continent, constitutes part of Zealandia which has recently attracted scientific attention as the suggested seventh largest but most submerged continent on Earth (Campbell and Mortimer, 2014) and is a continental ribbon created by breakup of eastern Gondwana during the Late Cretaceous. The sedimentary basins formed on the LHR are expected to preserve excellent records of tectonic processes involved in the formation of the LHR continental ribbon, paleoclimate change with ocean biogeochemical cycles in the southern hemisphere, and evolution of subseafloor microbial life from the Cretaceous onwards. To solve scientific questions relevant to these themes, a drilling project for the International Ocean Discovery Program (IODP) (IODP Proposal 871-CPP) titled "First deep stratigraphic record for the eastern Gondwana margin: Tectonics, paleoclimate and deep life on the Lord Howe Rise high-latitude continental ribbon" has been proposed. This proposal was developed at the initiative of GA and JAMSTEC and plans to use *D/V Chikyu* for deep riser drilling. The proposal was accepted by the IODP in January 2017 and was then officially designated as a Chikyu project by the Chikyu IODP Board.

The first phase site survey for this drilling project, cruise KR16-05 (GA0354), was conducted in 2016, with seismic data acquisition targeting regional and local crustal structures of the LHR across the proposed drill sites. The second phase site survey, cruise KR17-15C (GA0363), focused on obtaining data to assess geotechnical, safety and environmental issues around the proposed drill sites. Based on the results of the first site survey, the primary drill site was revised from DLHR-3A to DLHR-5A. Due to this change, seismic transects to image the regional crustal structures through the revised primary drill site, DLHR-5A, were also scheduled.

The KR17-15C cruise commenced on October 29, 2017 and ended on January 11, 2018 including inbound and return transits between the quay of JAMSTEC Headquarters and the Port of Brisbane. This cruise initially consisted of three legs. However, Leg 2 was subdivided into two sub legs due to the necessity for an additional port call to address mechanical issues that occurred during Leg 1. With this revision to the voyage plan, the cruise was divided into Leg 1 (November 14 ~ 21), Leg 2-1 (November 22 ~ 27), Leg 2-2 (November 29 ~ December 5) and Leg 3 (December 7 ~ December 27). The following activities were carried out during this cruise: high-resolution acoustic and visual seafloor mapping with a deep-tow system (Legs 1 and 2-2); piston coring; seafloor sediment sampling (Leg 2-1); high-resolution shallow 2D multi-channel seismic (HR-MCS) reflection grid survey; deep 2D MCS reflection survey and seismic refraction survey using ocean bottom seismometers (OBS) (Leg 3). In addition, acquisition of bathymetry, sub-bottom profiler, gravity and geomagnetic data was performed using shipboard observation systems along with the main surveys.

During Legs 1 and 2-2, we acquired high resolution bathymetry, side scan images and sub-bottom profiles with the deep-tow 6KSDT system, covering approximately 2 nm x 2 nm around riser site DLHR-5A and 1.8 nm x 1.8 nm around riser site DLHR-4A. Following the sonar surveys, a camera survey was conducted around drill sites DLHR-5A, DLHR-4A and BLHRB-3A, within a 1.1 nm x 1.1 nm area for each site, taking stereophotographic and video images of the seafloor for environmental assessment. Mapping and camera surveys at other planned sites, DLHR-3A, BLHRB-4A, BLHRB-1B and BLHRV-1B, were cancelled due to time lost with the additional port call during Leg 1.

During Leg 2-1, we conducted sediment sampling at two riser sites, DLHR-5A and DLHR-3A. At each site, two cores of 6 to 7 m length, composed of calcareous ooze, were successfully recovered with a piston corer. Coring indicated that there was a refusal zone at 6~7 m below seafloor. Recovered cores were cut into 1-m sections, but were not split. From the lower two sections, 24 whole-round core samples 30 cm in length were taken for soil strength testing onshore and brought back to Japan. All remaining core sections were transported to Geoscience Australia for archiving. Box coring was performed twice at site DLHR-3A, yielding one well preserved seabed sample. The box corer sample and most of pilot corer samples taken along with the piston coring were used for biological elutriation on board. Box coring at DLHR-5A and DLHR-4A was cancelled because of the lack of time.

During Leg 3, we successfully deployed and recovered 64 OBSs distributed over 160 km of the 223 km long ENE-WSW regional survey line, Line-N1, passing through site DLHR-5A. The OBSs were placed at 6-km intervals at the outer limits of the line, but had a denser spacing of 800-m around DLHR-5A. The HR-MCS survey was completed successfully around riser drill sites DLHR-5A, DLHR-4A and DLHR-3A. Data at each drill site were acquired in a grid pattern along 25 survey lines with a spacing of 300 m. Lines were 12 km or 14.8 km long, including 4.5-km approach and 1-km runout.

To generate seismic energy applicable to HR-MCS, the configuration of the Kairei's Annular Port Gun (APG) array system was modified: two gun arrays were deployed at a towing depth of 1.5 m and only four 100 cubic inch air guns (400 cu.in. total), were activated. The APG gun arrays in this new configuration generated waveform patterns with dominant frequencies (40-80 Hz) and bandwidth (10-400 Hz) as expected.

For this survey, Kairei's seismic streamer cable was shortened to 3 km with 216 hydrophones. The streamer cable was towed primarily at 3 m depth at the beginning of acquisition, but later at 4 ~ 8 m depth in response to bubble noise levels. In spite of the small air gun volume, we obtained high-resolution seismic reflection images, not only of shallow sedimentary sections, but also of the deeper sedimentary succession to the top of basement.

After completion of the HR-MCS survey and the OBS deployment, the OBS-MCS survey was successfully completed along Line-N1. Full sets of the APG gun arrays, consisting of four arrays of 1950 cu. in. (7800 cu.in. total), were deployed at a towing depth of 10 m. The same streamer cable was used, deployed to a towing depth of 12 m. Two series of air gun shooting were performed at intervals of 200 m and then at 50 m. While shooting at 50-m intervals, two short survey lines, centered on the lines of the HR-MCS survey grids in the area of DLHR-5A and DLHR-4A, were added to extend velocity structural analysis around this area to 3D.

To mitigate the impact of seismic activities on marine fauna, the survey deployed a passive acoustic monitoring (PAM) system (towed along with the streamer), and undertook visual marine mammal observations. These operations were performed by trained observers provided by the service company Blue Planet Marine. No whale instigated shutdown of the air guns was required during both the HR-MCS and OBS-MCS surveys. Because there were no whale instigated shutdowns, no wait-on-weather, very limited mechanical downtime and smooth operations, the planned seismic acquisition was completed without using any of the planned contingency days.

Besides these main surveys, bathymetry mapping with the shipboard multi-beam echo sounder (MBES) system was conducted during transit or time lost due to mechanical issues on leg 1. In particular, an unnamed seamount south the Gifford Seamount (a guyot) in the Gifford Marine Park (Habitat Protection Zone) was mapped during Legs 1 and 2-2. Part of the Dampier Ridge, which bounds the eastern margin of the Tasman Sea but did not have any existing MBES data, was also mapped extensively late in Leg 3.

Through this cruise, we successfully obtained essential data and samples for the assessment of drilling safety, geotechnical and environmental issues in implementing drilling operations at the primary riser drill site, DLHR-5A, and alternate drill sites DLHR-4A, DLHR-3A and BLHRB-3A. Furthermore, acquisition of OBS-MCS data for crustal structure analysis along the regional transect through DLHR-5A was also successfully completed as planned. Although no data for environmental assessment were acquired at three riserless drill sites, we are confident that an assessment at these sites can be adequately undertaken on the basis of existing information and other data newly acquired during this cruise.

3. Geological Background

The LHR is part of Zealandia, arguably the seventh largest but most submerged continent on Earth (Campbell et al., 2012, Mortimer et al., 2017). This vast, submerged continental ribbon is located east of Australia in water depths up to 3,000 m, extending approximately 1,600 km from southwest of New Caledonia to the Bellona Trough (Fig. 3.1). It is currently understood to have detached from eastern Gondwana by the Late Cretaceous and has been largely submerged since that time. The extensional history of the LHR continental ribbon caused submergence, with thinning and cooling of the continental crust. The LHR, the largest extant crustal ribbon, presents an opportunity to study the origin and development of a large, detached continental ribbon that is unaffected by deformation and is not deeply concealed by younger deposits.

The timing and setting of rifting to produce the LHR remain unclear. The eastern Gondwana margin preserved onshore in Australia records a pre-history of subduction-related magmatism, sedimentation, and tectonism during the Paleozoic to Early Triassic (Crawford et al., 2003). The Jurassic–Cretaceous history is, in contrast, dominated by large-volume intraplate and rift-related volcanism (Bryan et al., 1997; Bryan et al., 2012), particularly along strike to the north of the LHR, where extensional faulting was active by at least 120 Ma (Och et al., 2009). Widespread extension along the eastern Gondwana margin could therefore have been initiated at approximately 130 Ma by emplacement of the Whitsunday Silicic Large Igneous Province in northeastern Australia and equivalents further south (Bryan et al., 1997; Bryan et al., 2012). Rifting in the east– west Otway/Gippsland basin system in southeast Australia, that trends into the LHR, had begun by the Late Jurassic, suggesting that at least the southern parts of the LHR might have a slightly earlier extensional imprint. Seismic interpretations of the sediment fill in LHR basins indicate rocks at least of Early Cretaceous age (Bache et al., 2014; Higgins et al., 2014), but presently there are no direct constraints on the age or provenance of the deep sediments or basement.

Another perspective, however, is also possible by directing attention to the geology of New Zealand, to the east of the LHR, where Jurassic through Cretaceous igneous rocks interpreted to be subduction-related are preserved (Stampfli et al., 2002). It is unclear whether subduction, if it was occurring off the eastern Gondwana margin, was Andean-style or intra-oceanic in the Early Cretaceous (Matthews et al., 2011). In the former case, the eastern LHR would have been more proximal to the active margin, although in the latter it would have been a passive margin and potentially facing a back-arc basin. In this scenario, rifting would have evolved rapidly after a major plate reorganization that occurred around 105–100 Ma (Matthews et al., 2012; Seton et al., 2012) with a subsequent switch from a convergent-margin setting to a subduction regime involving slab roll-back and trench retreat. The onset or an acceleration of rifting might be linked to this plate reorganization when eastward movement of eastern Gondwana slowed, stopped at 55–50 Ma, and then shifted to a more northerly direction.

Drilling in the LHR region is very limited and does not penetrate any deeper than 860 m below seafloor (mbsf). A near-complete stratigraphic record for the latest Cretaceous – Cenozoic was revealed by data from boreholes drilled by the Deep Sea Drilling Project (DSDP) (Burns and Andrews, 1973; Kennett et al., 1986). DSDP Site 208 intersected bathyal Oligocene – recent calcareous chalk and ooze, and Late Maastrichtian – Eocene siliceous and calcareous chalk, marl, and chert. Rhyolite intersected at the base of DSDP Site 207 on the southern LHR has been dated at 97 Ma (McDougall and van del Lingen, 1974; Tulloch et al., 2009), which suggests that the Whitsunday Silicic Large Igneous Province extends onto the LHR and therefore played a role in forming the LHR continental ribbon (Bryan et al., 1997). Recently, Expedition 371 of the International Ocean Discovery Program (IODP) revisited the LHR region and drilled at five sites through dominantly post-Cretaceous strata (Sutherland et al., 2018). New data from these sites provides constraints on regional tectonic history, including evidence for reverse faulting and folding during the late Eocene (or somewhat earlier) to early Oligocene, and regional uplift and subsidence during the Eocene and Cenozoic (Sutherland et al., 2018).

Pre-Cenozoic dredge samples in the region are very limited because of the cover of Cenozoic post-rift sediments over the region. However, a small number of samples provide some insight into the Cretaceous history of the LHR. For instance, dredge samples from the central LHR yielded 97 Ma rhyolite that is similar to DSDP Site 207 core samples (Higgins et al., 2011). Moreover, 216–183 Ma granitoid pebbles and detrital zircons in sandstone suggest the continuation of the Cretaceous magmatic arc from New Zealand (Median Batholith) into the LHR (Mortimer et al., 2015). Material recovered to date does not provide constraints on any potential Cretaceous subduction or for the subduction–rifting transition.

Limited petroleum industry reconnaissance during the 1970s and subsequent data acquisition surveys by the governments of Australia, New Zealand, New Caledonia, France, and Germany have led to sparse regional coverage of seismic reflection, gravity, magnetic, and multibeam bathymetry data (Hackney, 2010; Sutherland et al., 2012). The highest quality and density of data exists for sedimentary basins on the northern LHR (the Capel and Faust basins) within the Australian maritime jurisdiction (Fig. 3.1). For these basins, the GA-302 survey (2006–2007) recorded 6,000 km of seismic reflection data to 12 s two-way time along 23 lines with spacing of 15–35 km (Kroh et al., 2007), and the GA-2436 survey (2007) acquired 24,000 km^2 of multibeam bathymetry and 11,000 line km of gravity and magnetic data with line spacing of 3–4 km (Heap et al., 2009). The GA-302 seismic reflection data are interpreted to show a variable pre-rift basement (sedimentary, volcanic, intrusive, and metamorphic), two Cretaceous syn-rift mega-sequences comprising various sediment types and volcanics, and a Late Cretaceous – Recent post-rift sequence that can be tied to DSDP Site 208 (Colwell et al., 2010; Higgins et al., 2014).

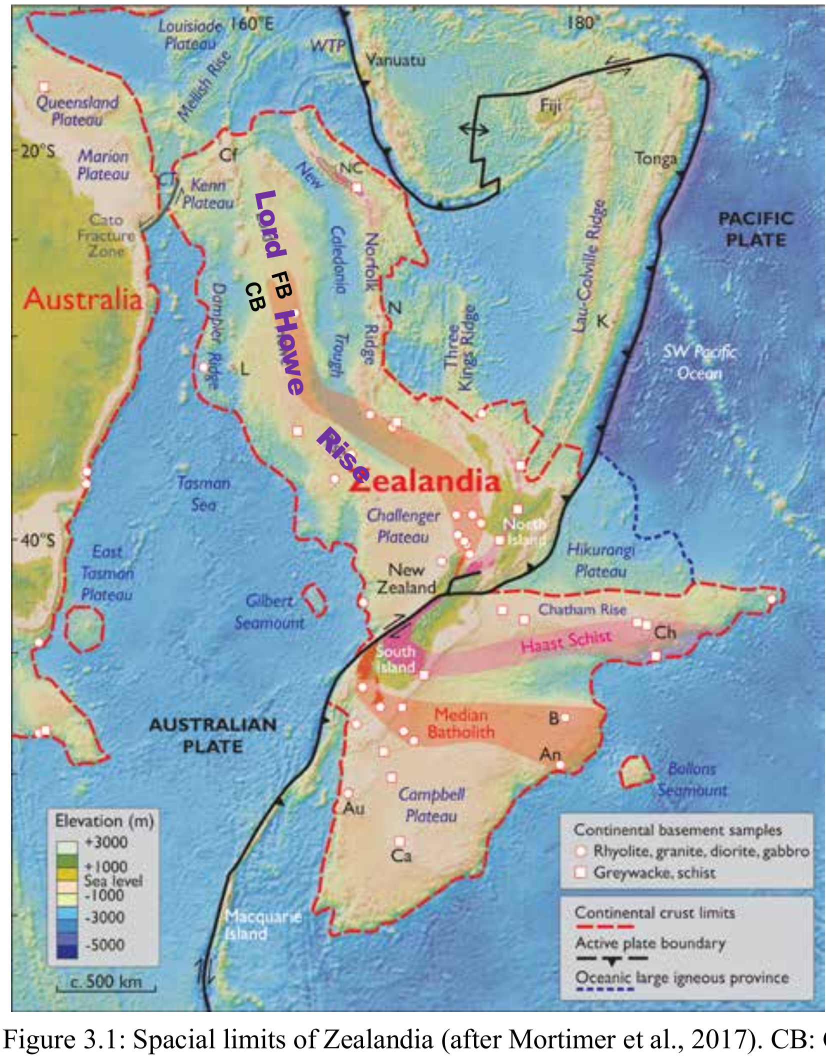

Figure 3.1: Spacial limits of Zealandia (after Mortimer et al., 2017). CB: Capel Basin, FB: Faust Basin.

4. Outline of Cruise

(1) Cruise Information

1) Cruise ID
KR17-15C / GA0363

2) Name of Vessel
R/V Kairei

3) Title of Cruise
Lord Howe Rise Site Survey 2017 for proposed IODP Drilling

4) Subtitle of Cruise
Acquisition of high-resolution seismic data, shallow sub-surface profiles, seafloor bathymetry, seabed samples and imagery data

5) Cruise Periods and Port Calls

Departure:	29 October 2017 (Yokosuka)
Outward Transit:	29 October 2017 ~ 11 November 2017 (Yokosuka – Brisbane)
Port Call 1:	11 November ~ 14 November 2017 (Brisbane)
Leg 1:	14 November ~ 21 November 2017
Port Call 2:	21 November ~ 22 November 2017 (Brisbane)
Leg 2-1:	22 November ~ 27 November 2017
Port Call 3:	27 November ~ 29 November 2017 (Brisbane)
Leg 2-2:	29 November ~ 5 December 2017
Port Call 4:	5 December ~ 7 December 2017 (Brisbane)
Leg 3	7 December ~ 27 December 2017
Port Call 5:	27 December ~ 30 December 2017 (Brisbane)
Return Transit:	30 December 2017 ~ 11 January 2018 (Brisbane – Yokosuka)
Arrival:	11 January 2018 (Yokosuka)

6) Research Area
Lord Howe Rise, off the east coast of Australia

7) Research Maps

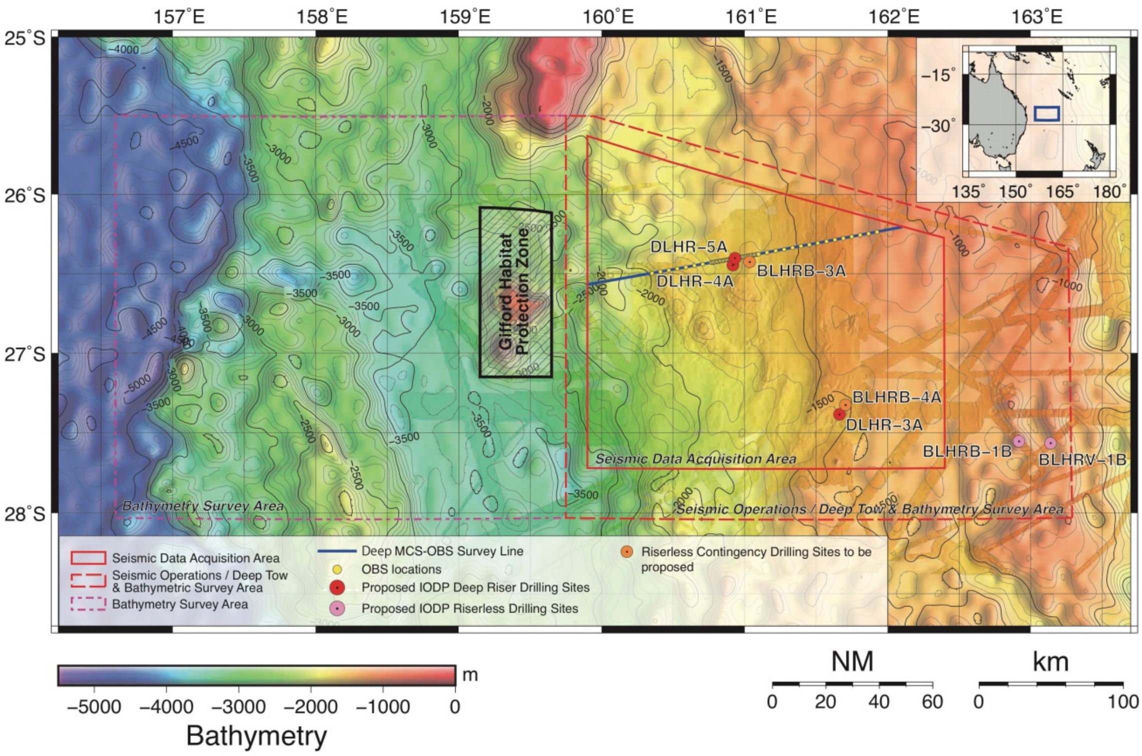

Figure 4.1: Overall map of the KR17-15C cruise survey area.

Table 4.1: Positions of proposed drill sites that were the survey targets of the KR17-15C cruise.

Site Name	Latitude	Longitude	Water depth (m)	Note
DLHR-5A	26°24.242'S	160°55.899'E	1671	Riser drill site
DLHR-4A	26°26.824'S	160°55.091'E	1691	Riser drill site
DLHR-3A	27°23.088'S	161°39.784'E	1535	Riser drill site
BLHRB-4A	27°19.601'S	161°42.412'E	1499	Contingency riserless drill site
BLHRB-3A	26°25.653'S	161°02.202'E	1620	Contingency riserless drill site
BLHRB-1B	27°33.174'S	162°55.118'E	1208	Riserless drill site
BLHRV-1B	27°33.874'S	163°08.385'E	1215	Riserless drill site

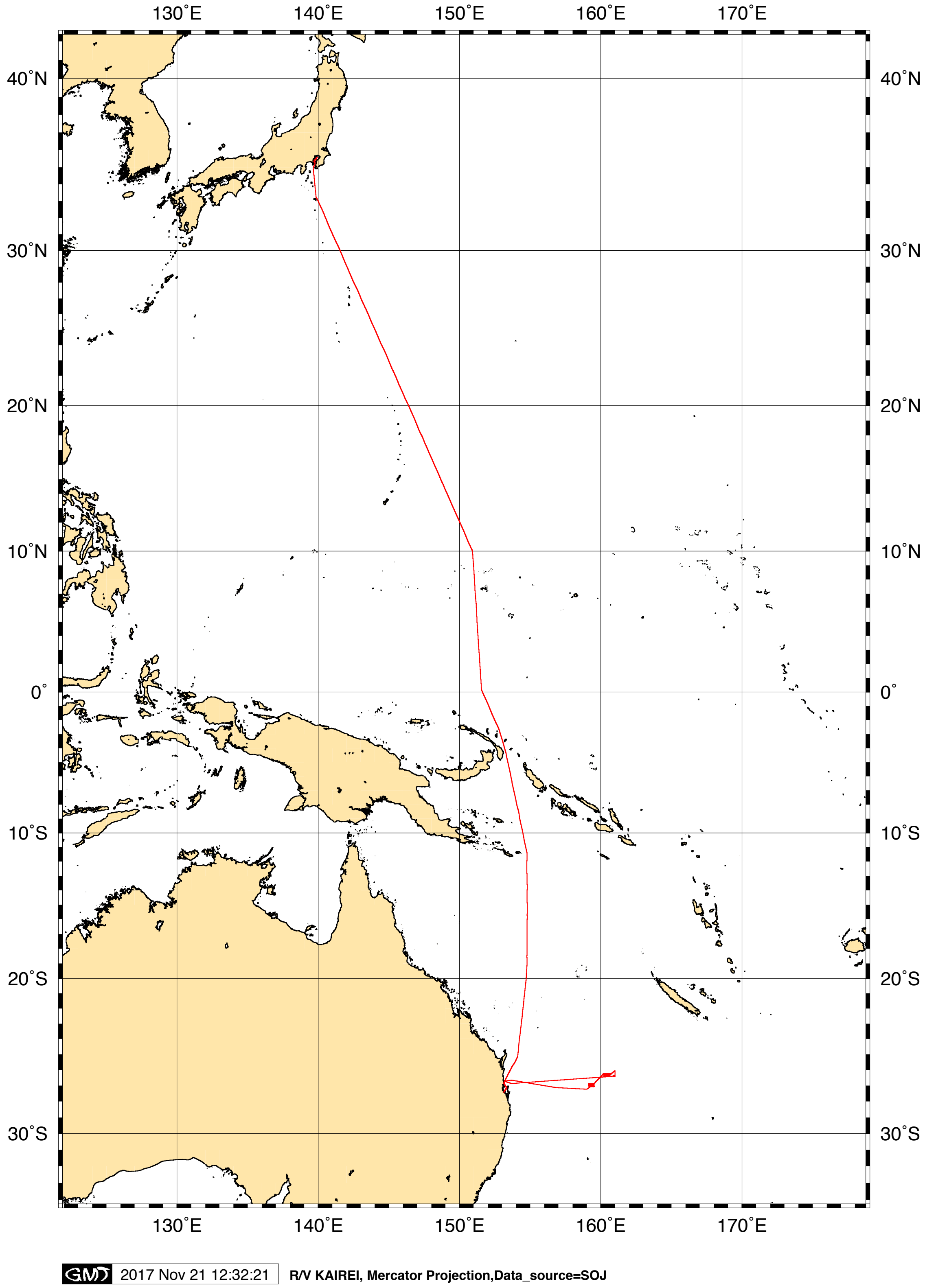

Figure 4.2: Cruise track of KR17-15C Leg 1 including the outward transit from Japan to Australia.

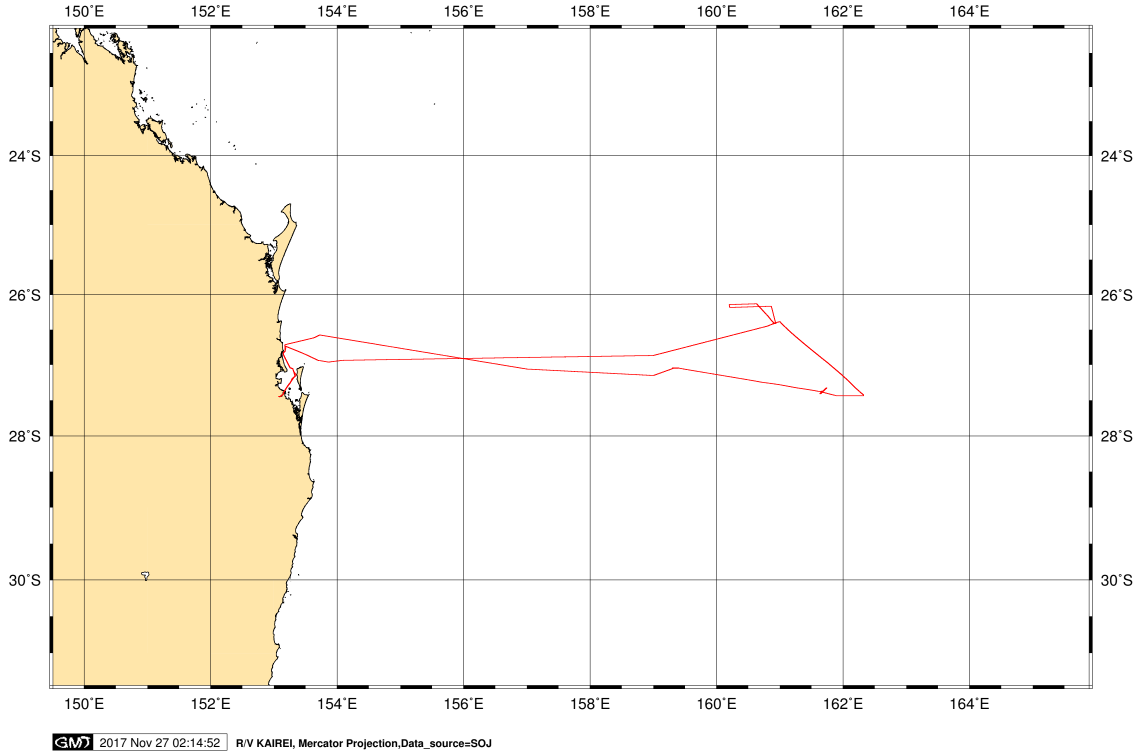

Figure 4.3: Cruise track of KR17-15C Leg 2-1.

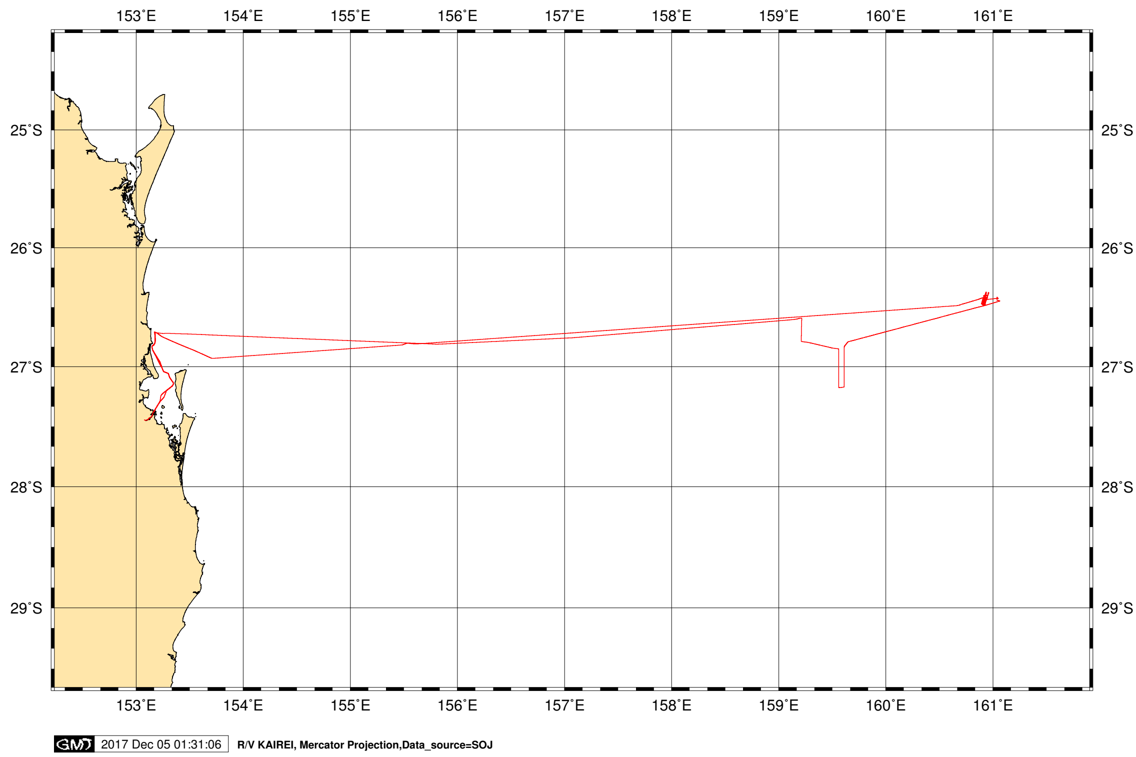

Figure 4.4: Cruise track of KR17-15C Leg 2-2.

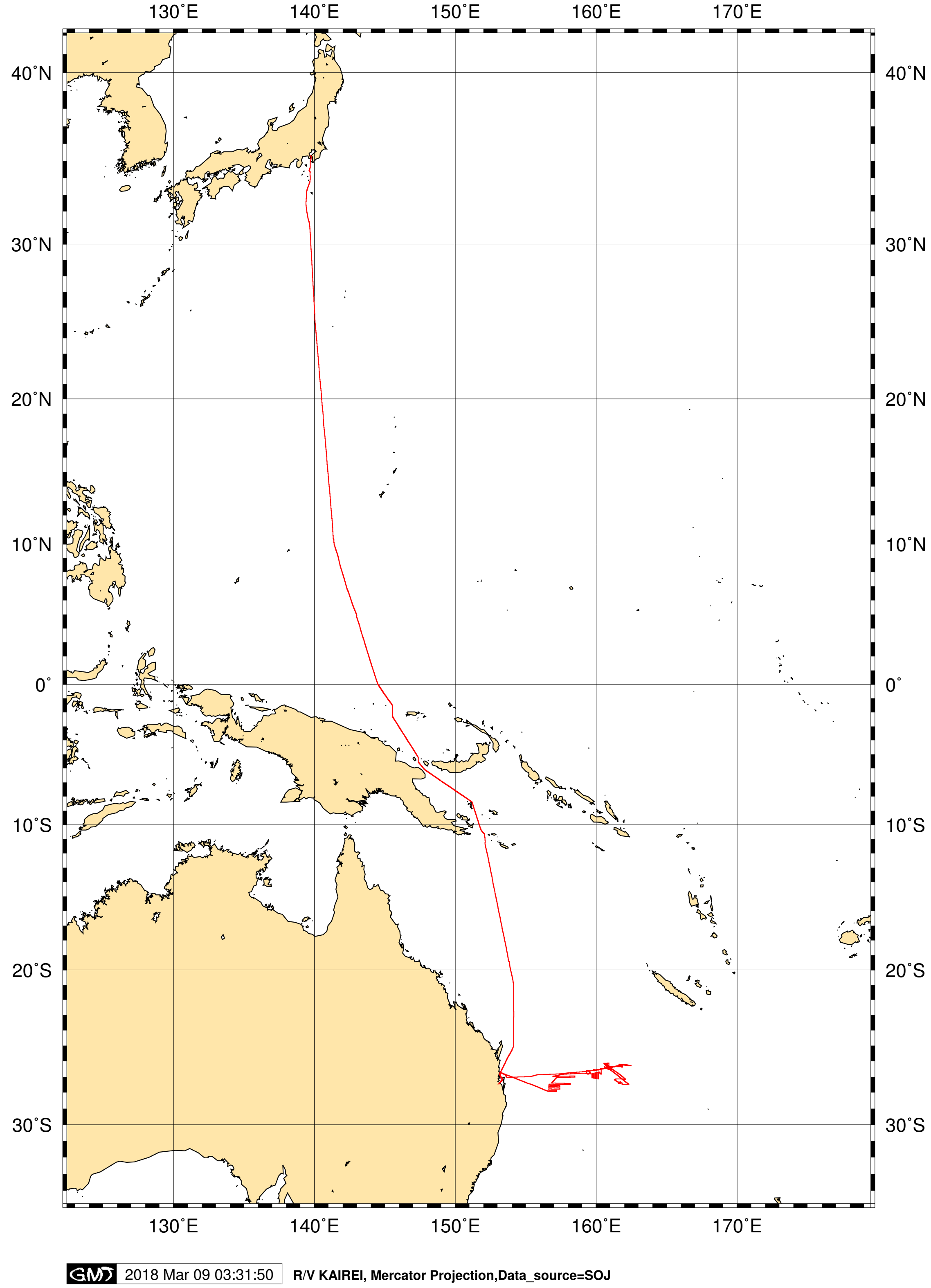

Figure 4.5: Cruise track of KR17-15C Leg 3 including the return transit from Australia to Japan.

8) Cruise Log

Table 4.2: Daily Activities of Leg 1, including outward transit and port call.

Date (LT)		Activities
Oct. 29	Sun	Departure from JAMSTEC Headquarters, Yokosuka, then typhoon stand-by in Tokyo Bay
Oct. 30	Mon	Departure from Tokyo Bay
Nov. 1	Tue	Transit
Nov. 10	Fri	
Nov. 11	Sat	Arrival at General Purpose Wharf, Fisherman Island, Port of Brisbane
Nov. 12	Sun	Rig-up
Nov. 13	Mon	Rig-up
Nov. 14	Tue	Departure from General Purpose Wharf, Fisherman Island, Port of Brisbane
Nov. 15	Wed	Transit, then 6KSDT sonar survey in DLHR-5A area
Nov. 16	Thu	6KSDT sonar survey in DLHR-5A area
Nov. 17	Fri	6KSDT sonar survey in DLHR-5A area
Nov. 18	Sat	MBES mapping
Nov. 19	Sun	MBES mapping
Nov. 20	Mon	Transit
Nov. 21	Tue	Arrival at QUBE bulk berth in Hamilton, Port of Brisbane

Table 4.3: Daily Activities of Leg 2-1, including port call.

Date (LT)		Activities
Nov. 22	Wed	Departure from QUBE bulk berth in Hamilton, Port of Brisbane
Nov. 23	Thu	Transit
Nov. 24	Fri	Piston coring at DLHR-5A
Nov. 25	Sat	Piston coring and box coring at DLHR-3A
Nov. 26	Sun	Transit
Nov. 27	Mon	Arrival at QUBE bulk berth in Hamilton, Port of Brisbane
Nov. 28	Tue	Rig-up

Table 4.4: Daily Activities of Leg 2-2, including port call.

Date (LT)		Activities
Nov. 29	Wed	Departure from QUBE bulk berth in Hamilton, Port of Brisbane
Nov. 30	Thu	Transit
Dec. 1	Fri	6KSDT sonar survey in DLHR-5A and DLHR-4A areas
Dec. 2	Sat	6KSDT sonar and camera surveys in DLHR-5A and DLHR-4A areas
Dec. 3	Sun	6KSDT camera survey in DLHR-4A and BLHRB-3A
Dec. 4	Mon	Transit
Dec. 5	Tue	Arrival at AAT wharf, Fisherman Island, Port of Brisbane
Dec. 6	Wed	Rig-up

Table 4.5: Daily Activities of Leg 3, including return transit and port call.

Date		Activities
Dec. 7	Thu	Departure from AAT wharf, Fisherman Island, Port of Brisbane
Dec. 8	Fri	Transit and OBS deployment
Dec. 9	Sat	HR-MCS survey in DLHR-5A/4A area
Dec. 10	Sun	HR-MCS survey in DLHR-5A/4A area
Dec. 11	Mon	HR-MCS survey in DLHR-5A/4A area
Dec. 12	Tue	HR-MCS survey in DLHR-5A/4A area
Dec. 13	Wed	HR-MCS survey in DLHR-3A area
Dec. 14	Thu	HR-MCS survey in DLHR-3A area

Dec. 15	Fri	OBS deployment
Dec. 16	Sat	OBS deployment and OBS-MCS (200-m interval shooting)
Dec. 17	Sun	OBS-MCS survey (200-m interval shooting)
Dec. 18	Mon	OBS-MCS survey (200-m interval shooting)
Dec. 19	Tue	OBS-MCS survey (50-m interval shooting)
Dec. 20	Wed	OBS-MCS survey (50-m interval shooting) and OBS retrieval
Dec. 21	Thu	OBS retrieval
Dec. 22	Fri	OBS retrieval
Dec. 23	Sat	OBS retrieval and MBES survey
Dec. 24	Sun	MBES survey and PAM standalone survey
Dec. 25	Mon	MBES survey
Dec. 26	Tue	MBES survey
Dec. 27	Wed	Arrival at AAT wharf, Fisherman Island, Port of Brisbane
Dec. 28	Thu	Shifting to QUBE bulk berth in Hamilton and loading
Dec. 29	Fri	Loading
Dec. 30	Sat	Departure from QUBE bulk berth in Hamilton, Port of Brisbane
Jan. 1	Sun	Transit
Jan. 10	Wed	
Jan. 11	Thu	Arrival at JAMSTEC Headquarters, Yokosuka

(2) Observations

1) Deep Tow sonar survey

Deep Tow sonar seafloor mapping survey was carried out during Legs 1 and 2-2. Areas around two riser drill sites, 2 nm x 2 nm for Site DLHR-5A and 1.8 nm x 1.8 nm for Site DLHR-4A, were mapped (Fig. 4.6). The 6000-m Super Deep Tow system, 6KSDT, equipped with three types of seafloor survey sonars, a multibeam echo sounder (MBES: SeaBat7125), two sets of side scan sonars (SSS: 2200-M with 120 kHz and Furuno sonar with 38/42 kHz) and a sub-bottom profiler (SSS: DW-106), was deployed for high-resolution acoustic seabed mapping. Sonar data were acquired every 600 milliseconds. Since a malfunction was found in the transponder (SGK) before the first deployment, another transponder (OKI) stored on the vessel was mounted to the towfish instead. Navigation data of the towfish were acquired both by an inertial navigation system with Doppler velocity logger (phins DVL) and by the shipboard Acoustic Navigation System (ANS). However, the DVL was deactivated during Leg 1 survey because it was assumed that the target towing altitude was out of range for the DVL in the beginning. Sonar data were acquired every 600 milliseconds. When tracing survey lines, the towfish was towed to maintain an altitude of 100 m ± 10 m above the seabed and a ground speed of about 2 kt. The survey lines were aligned with a spacing of 200 m and in a NNE-SSW direction (parallel to a MCS survey line from the KR16-05 cruise). For data correction during post-cruise processing, a line perpendicular to the other lines was also planned in each survey area, but only Line D5A_D22 was traced. Due to serious damage to the towing winch (No.15 winch) and an additional port call for its repair, Leg 1 was shortened and the sonar survey was separated into Legs 1 and 2-2.

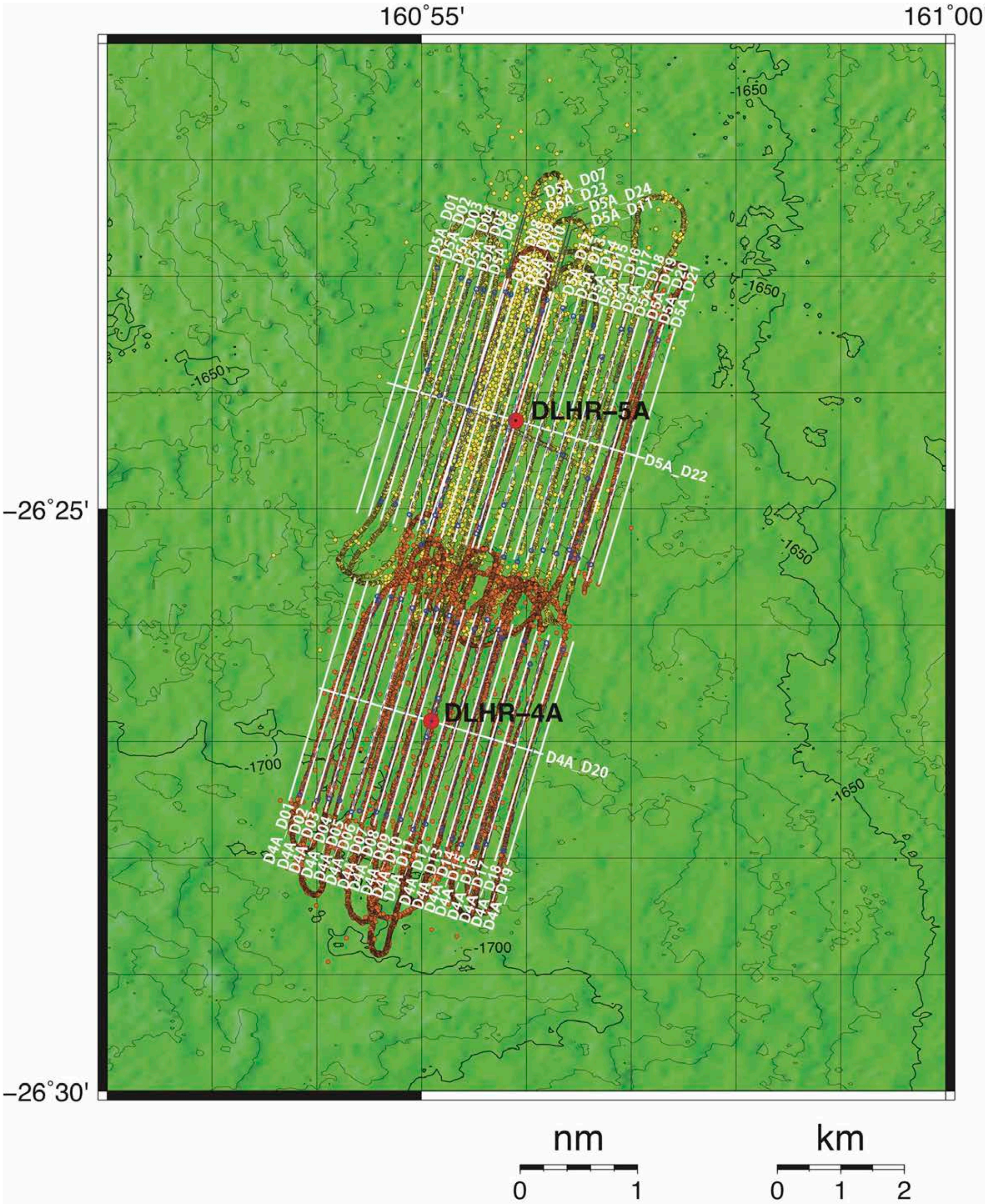

Figure 4.6. 6KSDT sonar survey planned lines and way points. White thick lines are planned survey lines. Yellow and orange dots are way points of the towfish during Leg 1 and Leg 2-2, respectively, as positioned by the shipboard Acoustic Navigation System (ANS). Blue dots are end points of surveyed lines positioned by ANS.

Table 4.6: Deep Tow Sonar Survey Lines

Dive Number	Location Name	Line ID	Start		End		Line Length (km)
			Latitude	Longitude	Latitude	Longitude	
6KSDT-0004	DLHR-5A	D5A_D00	26°25.1828'S	160°55.0893'E	26°23.1288'S	160°55 8317'E	4.0
		D5A_D02	26°23.8086'S	160°55.0579'E	26°22.9290'S	160°55.1474'E	1.6
		D5A_D03	26°24.9367'S	160°54.6107'E	26°23.0173'S	160°55.3768'E	3.8
		D5A_D04	26°24.9619'S	160°54.7499'E	26°23.0432'S	160°55.4538'E	3.7
		D5A_D05	26°23.1127'S	160°55.5235'E	26°25.0481'S	160°54.8830'E	3.7
		D5A_D06	26°23.1174'S	160°55.5898'E	26°25.1107'S	160°55.0131'E	3.8
		D5A_D07	26°23.1393'S	160°55.6935'E	26°24.1531'S	160°55.4494'E	1.9
		D5A_D08	26°23.1589'S	160°55.8513'E	26°24.9739'S	160°55 1829'E	3.5
		D5A_D09	26°25.1437'S	160°55.3476'E	26°23.4644'S	160°56.0172'E	3.3
		D5A_D10	26°25.3090'S	160°55.4050'E	26°23.1239'S	160°56.1195'E	4.4
		D5A_D11	26°25.1654'S	160°55.5551'E	26°23.2059'S	160°56.1940'E	3.8
		D5A_D12	26°24.9690'S	160°55.7860'E	26°23.2750'S	160°56.3470'E	3.3
		D5A_D13	*26°23.345'S*	*160°56.447'E*	26°25.4120'S	160°55.7820'E	4.0
		D5A_D14	26°23.3618'S	160°56.5251'E	26°25.4550'S	160°55.9150'E	4.0
		D5A_D15	26°23.4254'S	160°56.6407'E	26.25.3600'S	160°56.0473'E	3.7
		D5A_D16	26°23.6951'S	160°56.7217'E	*26°25.353'S*	*160°56.160'E*	3.2
		D5A_D18	26°25.3516'S	160°56.4089'E	26°23.4592'S	160°56.9891'E	3.6
		D5A_D19_1	26°23.4558'S	160°56.9037'E	26°25.3861'S	160°56.2886'E	3.7
		D5A_D22	26°24.5358'S	160°56.3440'E	26°24.0276'S	160°55.1693'E	2.2
6KSDT-0005	DLRH-4A	D4A_D02	26°25.7530'S	160°54.5784'E	26°27.4578'S	160°53.8370'E	3.4
		D4A_D03	26°25.7904'S	160°54.5904'E	26°27.5094'S	160°54.0010'E	3.3
		D4A_D04	26°27.4900'S	160°54.1171'E	26°25.7555'S	160°54.7091'E	3.4
		D4A_D05	26°27.5057'S	160°54.2158'E	26°25.7754'S	160°54.8019'E	3.3
		D4A_D06	26°25.8534'S	160°54.9109'E	26°27.6015'S	160°54.3291'E	3.4
		D4A_D07	26°25.8770'S	160°55.0433'E	26°27.5938'S	160°54.4079'E	3.3
		D4A_D08	26°27.6040'S	160°54.5686'E	26°25.8611'S	160°55.1404'E	3.4
		D4A_D09	26°27.6326'S	160°54.6633'E	26°25.9179'S	160°55.2647'E	3.3
		D4A_D10_1	26°25.9800'S	160°55.3397'E	26°26.9587'S	160°55.0492'E	2.0
		D4A_D10_2	26°27.6695'S	160°54.7974'E	26°26.6307'S	160°55.1582'E	2.0
		D4A_D11	26°26.0348'S	160°55.5031'E	26°27.7564'S	160°54.9193'E	3.3
		D4A_D12	26°27.7081'S	160°55.0373'E	26°25.9520'S	160°55.6277'E	3.4
		D4A_D13	26°27.7621'S	160°55.1905'E	26°26.0390'S	160°55.7355'E	3.3
		D4A_D14	26°26.1069'S	160°55.7667'E	26°27.8339'S	160.55.2917'E	3.3
		D4A_D15	26°26.1355'S	160°55.9817'E	26°27.8847'S	160°55.3788'E	3.4
		D4A_D16	26°26.3338'S	160°56.0342'E	26°27.9069'S	160°55.5246'E	3.0
		D4A_D17	26°27.8799'S	160°55.6124'E	26°26.1535'S	160°56.1911'E	3.3
		D4A_D18	26°27.9390'S	160°55.7799'E	26°26.2075'S	160°56.3530'E	3.3
	DLHR-5A	D5A_D19_2	26°25.4098'S	160°56.4260'E	26°23.4750'S	160°57.1868'E	3.8
		D5A_D20	26°23.5525'S	160°57.2565'E	26°25.4783'S	160°56.6125'E	3.7
		D5A_D23	26°25.0525'S	160°55.1293'E	26°23.1363'S	160°55.8034'E	3.7
		D5A_D24	26°23.2986'S	160°56.1489'E	26°25.2123'S	160°55.5182'E	3.7

Coordinates are based on positioning by ANS, but those in italics are target end points due to lost or invalid transponder signal.

2) Deep Tow camera survey

The Deep Tow camera survey was carried out during Leg 2-2. The camera-mode 6KSDT was used for visual seafloor mapping around the riser and riserless drill sites, DLHR-5A, DLHR-4A and BLHRB-3A, to collect data for environmental assessment. In camera-mode, one HDTV camera with three LED lights facing 45° downward and two still cameras on both sides with two LED lights facing straight down were turned on. For this deployment, the skid on which MBES and SBP are mounted was removed from the towfish. The still camera system took seabed photo images every 6 seconds in automatic mode. Navigation data of the towfish were acquired both by the phins DVL on the towfish and the shipboard ANS. Visual seafloor observations were performed along two 2-km survey lines normal to each other passing through each site and one 1.4-km connecting line with the two lines (Fig. 4.7). For DLHR-4A, one additional oblique line was surveyed. When tracing the survey lines, the towfish was towed to maintain an altitude of 3-5 m above the seabed with a ground speed of 0.7-0.8 kt.

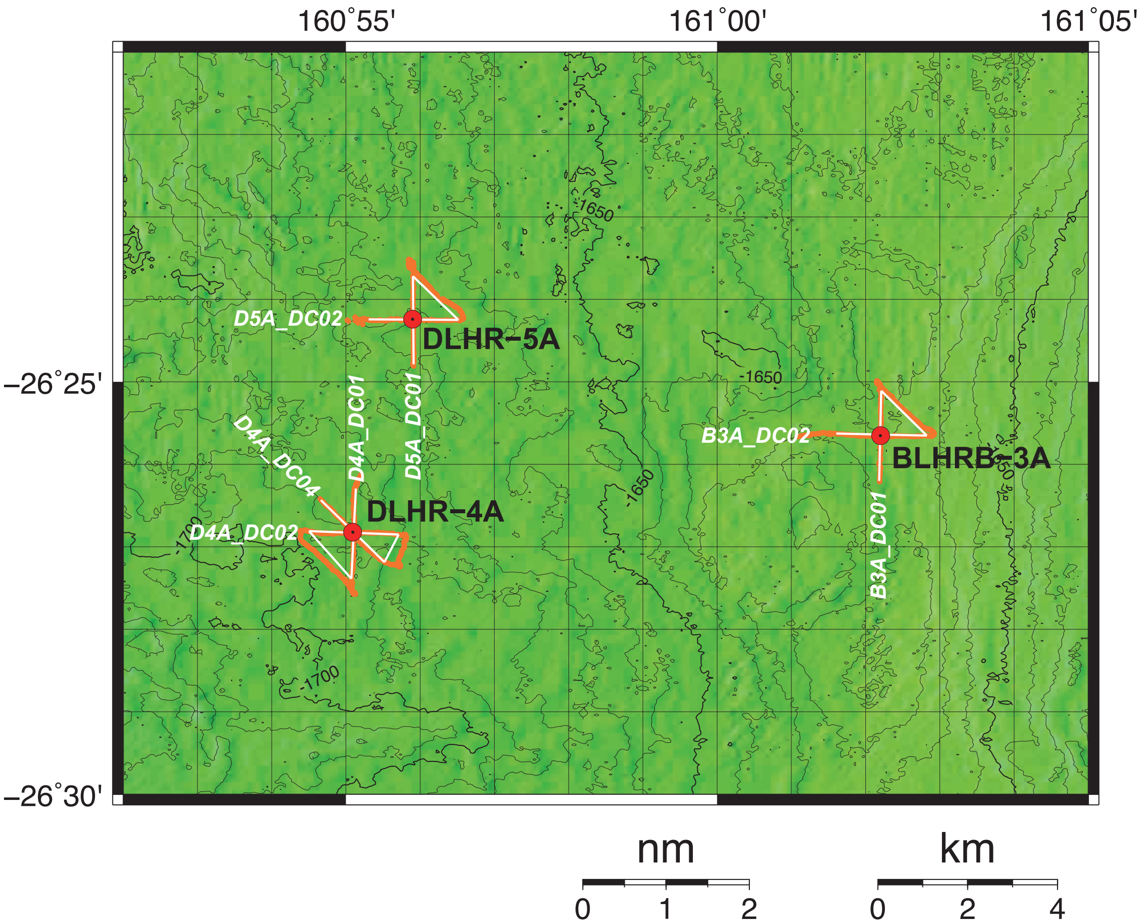

Figure 4.7: 6KSDT camera survey way points. White thick lines are planned survey lines. Orange dots are way points of the towfish positioned by phins DVL.

Table 4.7: Deep Tow Camera Survey Lines

Dive Number	Location Name	Line ID	Start		End		Line Length (km)
			Latitude	Longitude	Latitude	Longitude	
6KSDT-0006	DLHR-5A	D5A_DC02	26°24.2432'S	160°55.3046'E	26°24.2495'S	160°56.5147'E	2.0
		(Transit line)	26°24.2495'S	160°56.5147'E	26°23.7197'S	160°55.9025'E	1.4
		D5A_DC01	26°23.7197'S	160°55.9025'E	26°24.7879'S	160°55.9106'E	2.0

	DLHR-4A	D4A_DC01	26°26.2946'S	160°55.1334'E	26°27.3880'S	160°55.0741'E	2.0
		(Transit line)	26°27.3880'S	160°55.0741'E	26°26.8107'S	160°54.5017'E	1.4
		D4A_DC02	26°26.8107'S	160°54.5017'E	26°26.8516'S	160°55.7089'E	2.0
		(Transit line)	26°26.8516'S	160°55.7089'E	26°27.1870'S	160°55.5193'E	0.7
		D4A_DC04	26°27.1870'S	160°55.5193'E	26°26.4341'S	160°54.6615'E	2.0
	BLHRB-3A	B3A_DC02	26°25.6277'S	161°01.6043'E	26°25.6520'S	161°02.8245'E	2.0
		(Transit line)	26°25.6520'S	161°02.8245'E	26°25.1088'S	161°02.2104'E	1.4
		B3A_DC01	26°25.1088'S	161°02.2104'E	26°26.2023'S	161°02.1833'E	2.0

Coordinates are based on positioning by ANS. Camera survey was continued along transit lines

3) Piston coring

Piston coring operations were conducted at two riser drill sites, DLHR-5A and DLHR-3A, during Leg 2-1. Two sediment cores at each site, in total four cores, were taken by using a 20-m piston corer. Although 15~20-m core barrels were deployed, recovered core lengths were 6~7 m and the core barrels were bent slightly. This indicated that there was a refusal zone at 6~7 m below seafloor. The recovered cores, composed of calcareous ooze, were cut into 1-m sections and stored without splitting. Undrained shear strength measurement was performed on each bottom side section end by using a handheld penetrometer. Six whole-round core (WRC) samples of 30 cm length from the lower two sections of each core, in total 24 WRC samples, were taken after the sectioning. Those samples will be used for post-cruise soil tests including triaxial compression tests to assess the shallow formation strength at the riser drill sites. In addition to the main cores, short cores were taken by a 50-cm pilot corer: three of four pilot cores were recovered. The pilot cores were consumed for biological elutriation on board. The main cores, except for the WRC samples, were offloaded at Brisbane and sent to GA's core repository.

Table 4.8: Piston coring summary

Location Name	Core ID	Water Depth (m)	Latitude	Longitude	Core Length (m)
DLHR-5A	01PC01	1,668	26°24.2372'S	160°55.8915'E	6.36 / 20
	01PC001				0.20 / 0.5
	01PC02	1,672	26°24.2387'S	160°55.8900'E	6.61 / 15
	01PC002				0.57 / 0.5
DLHR-3A	02PC03	1,537	27°22.9906'S	161°39.8604'E	7.02 / 20
	02PC003				0.40 / 0.5
	02PC04	1,537	27°23.0847'S	161°39.7980'E	7.06 / 20
	02PC004				0.00 / 0.5

Core IDs are assigned in accordance with the GA's standard. Core length: Recovered length (m) / Corer length (m).

4) Box coring

Box coring operations were attempted at two riser sites during Leg 2-1, but due to sea conditions and time limitations, were conducted only at DLHR-3A. The box corer was provided by GA, equipped with a box measuring 50 cm (L) x 50 cm (W) x 60 cm (D). Box coring was executed twice. The first attempt was successful with recovery of well-preserved seafloor sediment. The second attempt resulted in no recovery. The recovered sediment was used up for biological elutriation on board.

Table 4.9: Box Coring Summary

Location Name	Core ID	Water Depth (m)	Latitude	Longitude	Recovery (cm^3)
DLHR-3A	02BC01	1,538	27°23.1434’S	161°39.7635’E	50 x 50 x 10~15
	02BC02	1,538	27°23.0788’S	161°39.8324’E	0

Core IDs are assigned in accordance with the GA’s standard.

5) OBS deployment and retrieval

OBS deployment and retrieval was carried out during Leg 3. We successfully deployed 64 OBSs along an ENE-WSW regional survey line, Line-N1, passing through DLHR-5A. All OBSs were retrieved. The OBSs were deployed over 160 km of the 223-km-long Line-N1. OBS01 to OBS08 and OBS50 to OBS64 were deployed at 6-km intervals, while OBS08 to OBS50 around DLHR-5A were deployed at 800-m intervals. Five OBSs (OBS01, 08, 51, 57 and 64) were equipped with a hydrophone with reduced sensitivity to record sound in the water column: the data acquired will be used to test the sound modeling previously undertaken when determining the mitigations required to minimize the environmental impact of the seismic source. Prior to OBS deployment, seabed bathymetry at each point was checked with the shipboard MBES. Deployed positions were calibrated by ANS positioning after landing was confirmed.

Table 4.10: Calibrated deployed positions of OBSs

OBS Position Number	Latitude	Longitude	Water depth (m)	OBS Position Number	Latitude	Longitude	Water depth (m)
OBS01	26°29.8981'S	160°21.0515'E	1805.7	OBS33	26°23.9519'S	160°57.7949'E	1651.2
OBS02	26°29.3333'S	160°24.6094'E	1772.2	OBS34	26°23.8566'S	160°58.2642'E	1647.0
OBS03	26°28.7542'S	160°28.1973'E	1804.1	OBS35	26°23.7650'S	160°58.8174'E	1646.2
OBS04	26°28.1792'S	160°31.7305'E	1762.5	OBS36	26°23.7008'S	160°59.2254'E	1644.6
OBS05	26°27.5996'S	160°35.2611'E	1709.4	OBS37	26°23.6277'S	160°59.6964'E	1644.7
OBS06	26°27.0189'S	160°38.8222'E	1770.6	OBS38	26°23.5249'S	161°00.1870'E	1643.9
OBS07	26°26.4347'S	160°42.3674'E	1844.3	OBS39	26°23.4629'S	161°00.6746'E	1634.7
OBS08	26°25.8788'S	160°45.9310'E	1750.7	OBS40	26°23.3575'S	161°01.1775'E	1623.2
OBS09	26°25.8079'S	160°46.4001'E	1749.3	OBS41	26°23.2956'S	161°01.6109'E	1620.2
OBS10	26°25.7292'S	160°46.8698'E	1751.4	OBS42	26°23.2043'S	161°02.1026'E	1619.8
OBS11	26°25.6587'S	160°47.3416'E	1734.0	OBS43	26°23.1336'S	161°02.5479'E	1622.4
OBS12	26°25.5809'S	160°47.7992'E	1731.6	OBS44	26°23.0459'S	161°03.0536'E	1623.6
OBS13	26°25.5010'S	160°48.2817'E	1720.5	OBS45	26°22.9687'S	161°03.5226'E	1623.9
OBS14	26°25.3996'S	160°48.7492'E	1704.1	OBS46	26°22.9053'S	161°03.9848'E	1630.6
OBS15	26°25.2676'S	160°49.3292'E	1678.1	OBS47	26°22.8370'S	161°04.4512'E	1635.0
OBS16	26°25.2387'S	160°49.7499'E	1708.9	OBS48	26°22.7050'S	161°04.8907'E	1692.4
OBS17	26°25.1592'S	160°50.2221'E	1690.8	OBS49	26°22.6557'S	161°05.3713'E	1718.2
OBS18	26°25.0588'S	160°50.7129'E	1674.6	OBS50	26°22.5861'S	161°05.8595'E	1758.7
OBS19	26°24.9876'S	160°51.1860'E	1671.1	***OBS51***	26°21.9965'S	161°09.3831'E	1681.8
OBS20	26°24.8646'S	160°51.6724'E	1691.2	OBS52	26°21.3810'S	161°12.9358'E	1702.1
OBS21	26°24.8424'S	160°52.1390'E	1665.4	OBS53	26°20.7931'S	161°16.4890'E	1634.0
OBS22	26°24.7491'S	160°52.6256'E	1672.2	OBS54	26°20.2016'S	161°20.0794'E	1620.1
OBS23	26°24.6864'S	160°53.0745'E	1669.7	OBS55	26°19.6117'S	161°23.6198'E	1565.4
OBS24	26°24.6163'S	160°53.5307'E	1672.5	OBS56	26°19.0219'S	161°27.1598'E	1500.1
OBS25	26°24.5566'S	160°54.0417'E	1690.3	***OBS57***	26°18.4306'S	161°30.7232'E	1465.6
OBS26	26°24.4199'S	160°54.4713'E	1673.4	OBS58	26°17.7917'S	161°34.2673'E	1451.0
OBS27	26°24.3860'S	160°54.9419'E	1672.2	OBS59	26°17.2229'S	161°37.8572'E	1399.3
OBS28	26°24.3116'S	160°55.4019'E	1676.1	OBS60	26°16.6031'S	161°41.4257'E	1428.0
OBS29	26°24.2449'S	160°55.8893'E	1669.1	OBS61	26°16.0015'S	161°45.0046'E	1423.7

OBS30	26°24.1662'S	160°56.3600'E	1664.0	OBS62	26°15.3772'S	161°48.4915'E	1429.1
OBS31	26°24.0907'S	160°56.8365'E	1672.0	OBS63	26°14.7882'S	161°52.0777'E	1440.3
OBS32	26°24.0393'S	160°57.3318'E	1653.9	***OBS64***	26°14.1733'S	161°55.6293'E	1293.4

Sensitivity of OBSs shown in bold italics was reduced to -194 dB re 1V/µPa.

6) HR-MCS survey

The HR-MCS survey was carried out around three riser drill sites, DLHR-5A, DLHR-4A and DLHR-3A, during Leg 3. Grid survey lines comprising five parallel survey lines with 300-m spacing and another five parallel crossing survey lines with the same spacing (in total 25 survey lines), were arranged around each drill site (Figs. 4.8 and 4.9). Lengths of the survey lines were nominally 12 km but those of the five lines extending to both the DLHR-5A and the DLHR-4A areas were 14.8 km long. These lengths include 4.5-km approach and 1-km run-out parts at either end.

With the aim to obtain high-resolution seismic reflection images of shallow formations down to at least 1000 m below seafloor, we modified the configuration of the Kairei's Annular Port Gun (APG) array system. In the modified configuration, two gun arrays were deployed at a towing depth of 1.5 m and only four 100 cu.in. air guns (400 cu.in. total) were activated. Observed frequency characteristics of the generated seismic energy fully satisfied our expectations. The APG gun arrays in this new configuration generated waveform patterns with dominant frequencies (40-80 Hz) and bandwidth (10-400 Hz) comparable to those from a simulation done prior to the cruise. Air gun shooting was performed at intervals of 25 m, towing at the target log speed of 4.5 kt and not more than 5.0 kt. The record length was 6 seconds. The streamer cable was about 3 km long with 216 hydrophones channels at 12.5 m intervals. The towing depth of the streamer cable was controlled by 12 or 13 attached birds. The target depth of the streamer cable was initially 3 m, but it was set deeper to 5 m, 6 m or 8 m due to difficulty in maintaining the 3 m target depth and a frequently unacceptable level of bubble noise when sea condition were worse than very calm.

In spite of the small air gun volume, we obtained high-resolution seismic reflection images not only of the shallow sedimentary section, but also of the deeper section down to the top of the basement. Unplanned retrieval of the gun arrays for repair was twice necessary due to no-fire and air leak troubles.

A passive acoustic monitoring (PAM) cable was towed along with the streamer and acoustic and visual marine mammal observations were performed by the service company (Blue Planet Marine: BPM) during air gun shooting. No whale instigated shutdown of the air guns was necessary during the survey.

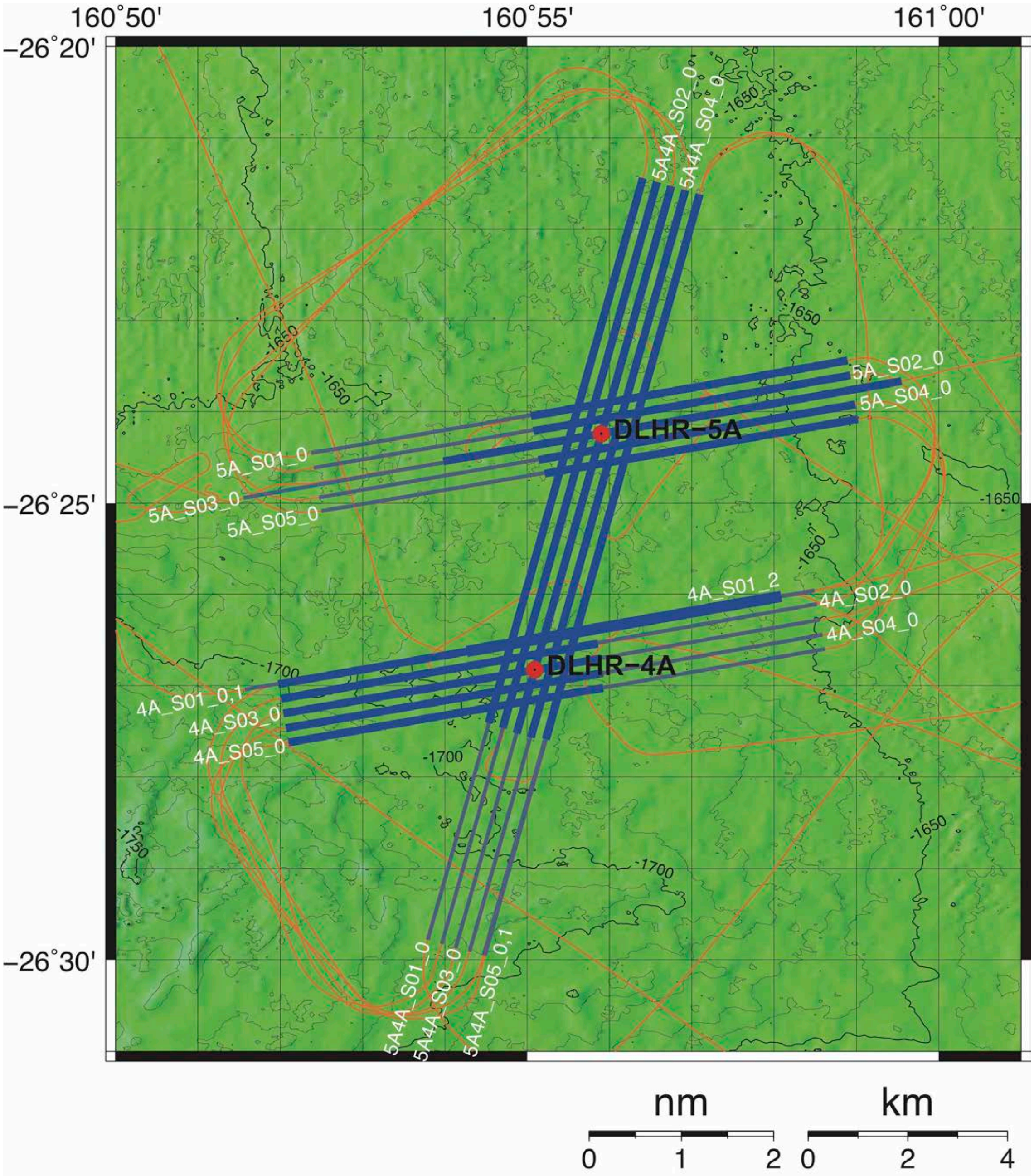

Figure 4.8: HR-MCS survey lines in the DLHR-5A/4A area. Blue thin and thick lines indicate regions of air gun shooting with partial volume and full volume, respectively. R/V Kairei's track during the OBS-MCS survey is shown by the orange line.

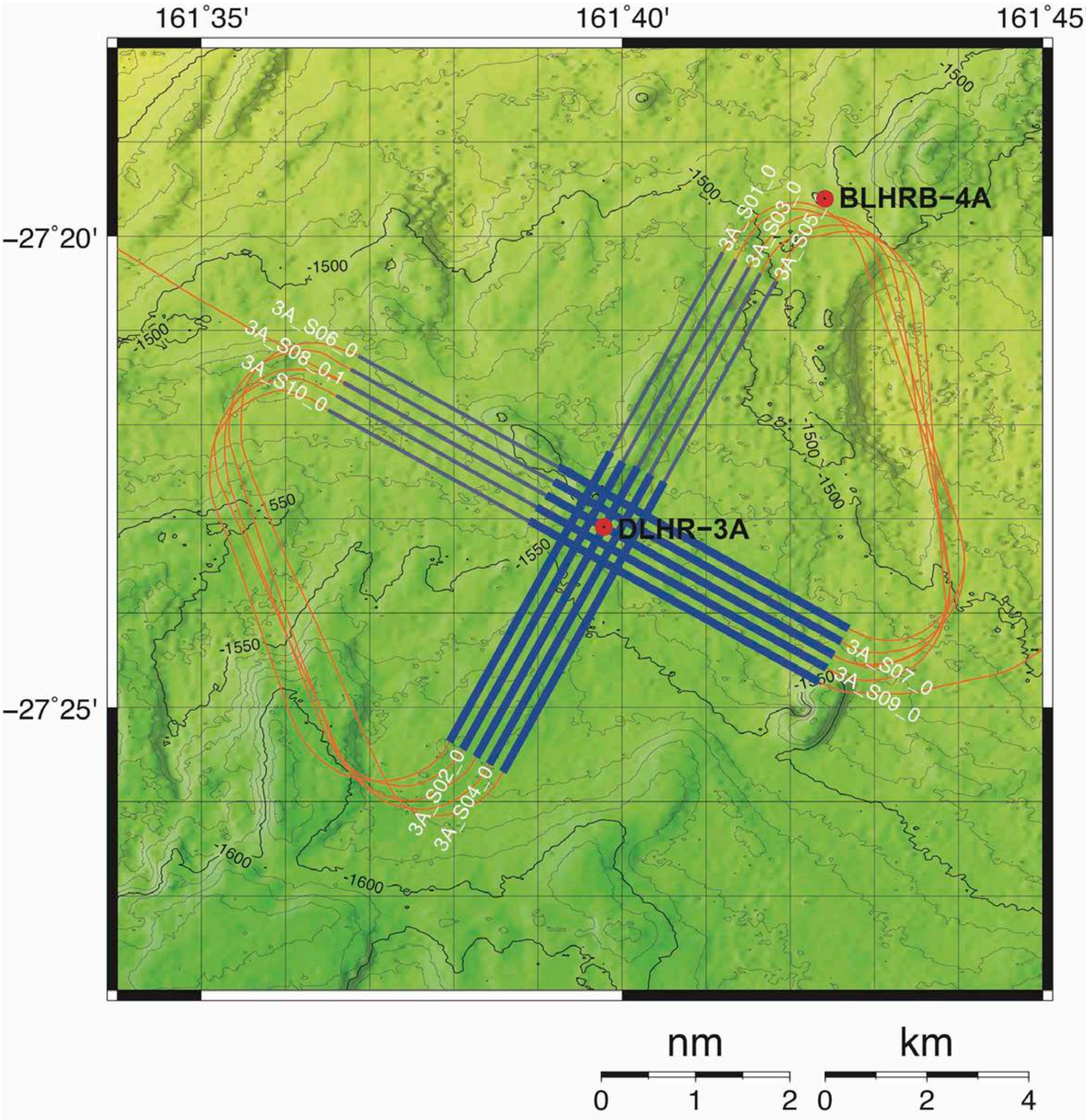

Figure 4.9: HR-MCS survey lines in the DLHR-3A area. Blue thin and thick lines indicate regions of air gun shooting with partial volume and full volume, respectively. R/V Kairei's track during the OBS-MCS survey is shown by orange line.

Table 4.11: HR-MCS survey lines.

Line ID	Start		End		Line Length (km)	Shot Interval (m)
	Latitude	Longitude	Latitude	Longitude		
5A_S01_0	26°24.45306'S	160°52.37541'E	26°23.43899'S	160°58.89326'E	11.0	25
5A_S02_0	26°24.61400'S	160°52.40652'E	26°23.60197'S	160°58.92490'E	11.0	25
5A_S03_0	26°24.94411'S	160°51.55473'E	26°23.66519'S	160°59.54773'E	13.5	25
5A_S04_0	26°24.93823'S	160°52.46929'E	26°23.92032'S	160°58.98682'E	11.0	25
5A_S05_0	26°25.08808'S	160°52.49823'E	26°24.07984'S	160°59.01777'E	11.0	25
4A_S01_0	26°25.95792'S	160°58.49375'E	26°26.98265'S	160°51.97560'E	11.0	25
4A_S01_1	26°25.95624'S	160°58.49344'E	26°26.51316'S	160°54.95316'E	6.0	25
4A_S01_2	26°27.04113'S	160°51.56682'E	26°26.02120'S	160°58.08599'E	11.0	25

4A_S02_0	26°26.10468'S	160°58.52240'E	26°27.14238'S	160°52.00661'E	11.0	25
4A_S03_0	26°26.27800'S	160°58.55600'E	26°27.30276'S	160°52.03763'E	11.0	25
4A_S04_0	26°26.44233'S	160°58.58802'E	26°27.46394'S	160°52.06881'E	11.0	25
4A_S05_0	26°26.59743'S	160°58.61822'E	26°27.62020'S	160°52.09910'E	11.0	25
5A4A_S01_0	26°29.77974'S	160°53.79157'E	26°21.44126'S	160°56.40566'E	16.0	25
5A4A_S02_0	26°29.82310'S	160°53.96184'E	26°21.48504'S	160°56.57745'E	16.0	25
5A4A_S03_0	26°29.86639'S	160°54.13196'E	26°21.52916'S	160°56.75084'E	16.0	25
5A4A_S04_0	26°29.90888'S	160°54.29874'E	26°21.57267'S	160°56.92158'E	16.0	25
5A4A_S05_0	26°29.95207'S	160°54.46839'E	26°21.61715'S	160°57.09615'E	16.0	25
5A4A_S05_1	26°29.95627'S	160°54.48486'E	26°21.61683'S	160°57.09479'E	16.0	25
3A_S01_0	27°20.16879'S	161°41.19856'E	27°25.36640'S	161°37.94638'E	11.0	25
3A_S02_0	27°20.24454'S	161°41.35108'E	27°25.44523'S	161°38.10510'E	11.0	25
3A_S03_0	27°20.32496'S	161°41.51287'E	27°25.52583'S	161°38.26731'E	11.0	25
3A_S04_0	27°20.39177'S	161°41.64757'E	27°25.60304'S	161°38.42288'E	11.0	25
3A_S05_0	27°20.48017'S	161°41.82540'E	27°25.68328'S	161°38.58431'E	11.0	25
3A_S06_0	27°21.27096'S	161°36.86459'E	27°24.16419'S	161°42.69322'E	11.0	25
3A_S07_0	27°21.41319'S	161°36.77580'E	27°24.30193'S	161°42.60729'E	11.0	25
3A_S08_0	27°21.55036'S	161°36.69031'E	27°24.44756'S	161°42.51669'E	11.0	25
3A_S08_1	27°21.55624'S	161°36.68663'E	27°24.44425'S	161°42.51869'E	11.0	25
3A_S09_0	27°21.69165'S	161°36.60220'E	27°24.58310'S	161°42.43214'E	11.0	25
3A_S10_0	27°21.84546'S	161°36.50616'E	27°24.72744'S	161°42.34219'E	11.0	25

From first to last shot points.

7) OBS-MCS survey

The OBS-MCS survey was carried out along Line-N1, with a length of 223 km, during Leg 3 (Fig. 4.10). The full set of the APG gun arrays, consisting of four arrays each of 1950 cu.in. (total 7800 cu.in.), were deployed for this survey. The same streamer cable, about 3 km long with 216 hydrophone channels at 12.5 m intervals, was deployed at a depth of 12 m. Two series of air gun shooting were performed at intervals of 200 m westward from the east end (OBS acquisition) and 50 m eastward from the west end of Line-N1 (MCS acquisition), with a towing depth of 10 m, and log speeds of around 4.5 kt, not exceeding 5.0 kt. The reason for sparse shooting at 200 m is that a large time interval can suppress the effects of the water waves in OBS recordings that were generated by earlier shots at offset distances of up to about 100 km.

The record lengths were 80 and 15 seconds for the 200-m and the 50-m shooting intervals, respectively. During the 50-m interval shooting, two short survey lines, centered on the HR-MCS survey grids for Sites DLHR-5A and DLHR-4A, were added because the survey proceeded ahead of schedule. Unplanned retrieval of the gun arrays for repair happened once during the 200-m interval shooting due to no-fire and air leak trouble.

The PAM cable was also towed along with the streamer and acoustic and visual marine mammal observations were performed by BPM during all air gun shooting. No whale instigated shutdown of air guns occurred during the survey. Because there were no whale instigated shutdowns, no wait-on-weather, very limited mechanical downtime and smooth operations, the planned seismic acquisition was completed without using any of the planned contingency days.

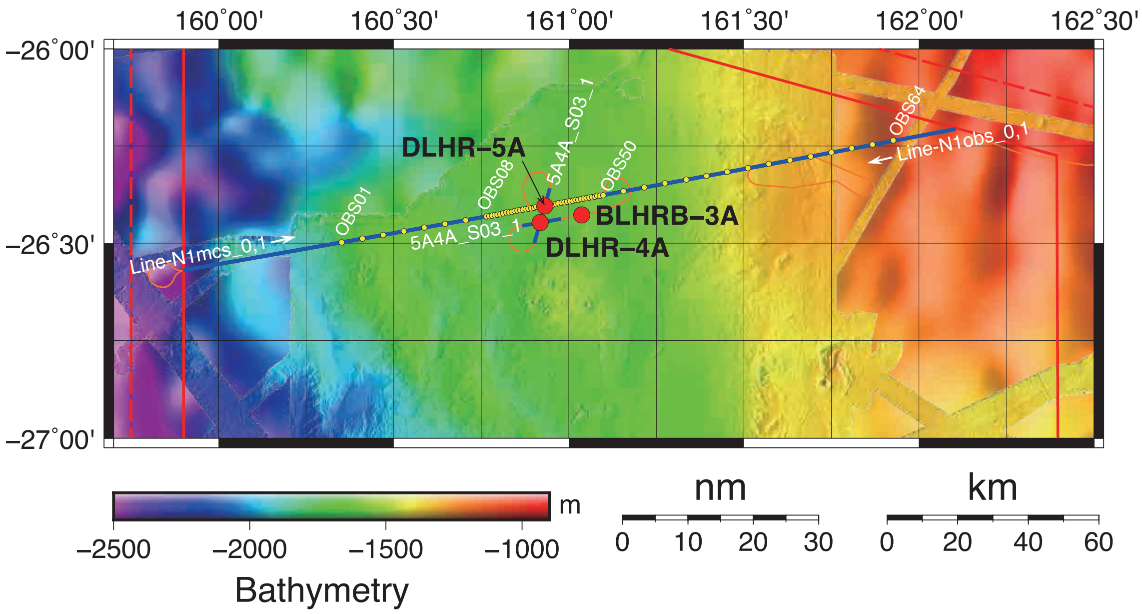

Figure 4.10: OBS-MCS survey lines (blue lines) and deployed OBS positions (yellow dots). R/V Kairei's track during the OBS-MCS survey is shown by orange line.

Table 4.12: OBS-MCS survey lines.

Line ID	Start		End		Line Length (km)	Shot Interval (m)
	Latitude	Longitude	Latitude	Longitude		
Line-N1obs_0	26°12.41837'S	162°06.08359'E	26°18.29643'S	161°31.64025'E	58.3	200
Line-N1obs_1	26°17.28233'S	161°37.63633'E	26°34.16897'S	159°53.96275'E	175.0	200
Line-N1mcs_0	26°34.13883'S	159°54.16483'E	26°23.63476'S	160°59.57575'E	110.3	50
Line-N1mcs_1	26°24.40171'S	160°54.87183'E	26°12.38284'S	162°06.28372'E	120.8	50
4A_S03_1	26°26.25529'S	160°58.69578'E	26°27.30320'S	160°52.02916'E	11.2	50
5A4A_S03_1	26°29.98684'S	160°54.08337'E	26°21.52109'S	160°56.74992'E	16.3	50

From first to last shot points.

8) PAM standalone survey

A PAM standalone survey was carried out around the Gifford Seamount to monitor the activity of marine mammals around this important habitat. The PAM cable was towed at 6 kt along a circuitous survey line of about 54 nm in length.

9) Bathymetry survey with shipboard MBES

Bathymetry and backscatter data acquisition with shipboard MBES was carried out along 6KSDT, HR-MCS and OBS-MCS survey lines, while in transit in the area east of around 153°45'E and in other specific areas of interest (Fig. 4.11). The areas northwest of Sites DLHR-5A and 4A, east of Site DLHR-3A and over the unnamed seamount in the Gifford Marine Park were mapped at 8 kt. It became evident that the seamount was a guyot as with the Gifford Seamount in the north. Part of the Dampier Ridge, which bounds the eastern margin of the Tasman Sea, and transit lines were mapped at around 12~15 kt.

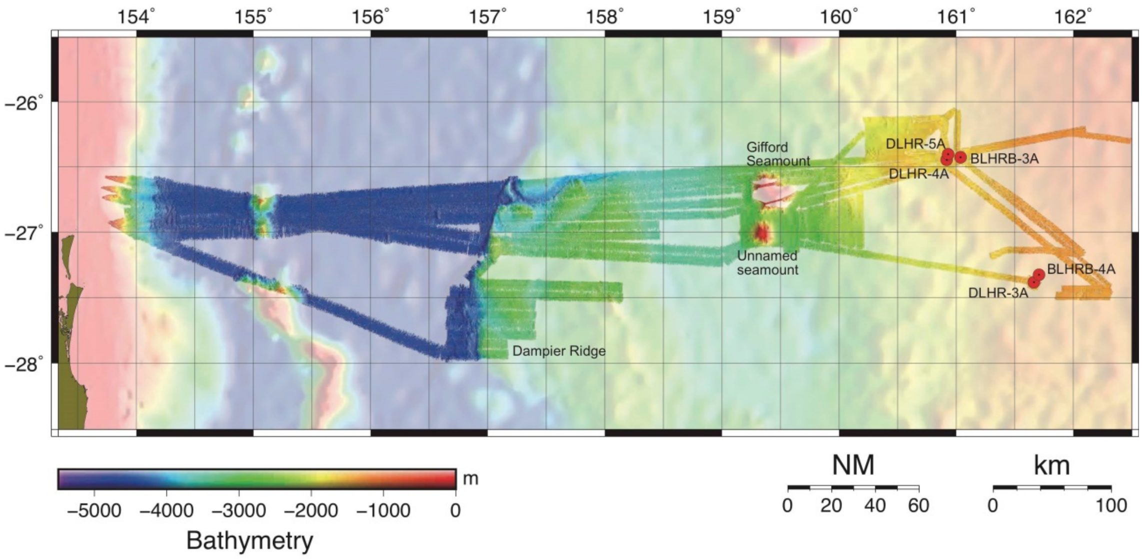

Figure 4.11: Map showing newly acquired multibeam bathymetry data during the KR17-15C cruise. The background light bathymetry is generated from ETOPO1.

10) Sub-bottom profiling survey with shipboard instrument

Shipboard SBP data was acquired along with the HR-MCS survey. Data acquisition started in the middle of the HR-MCS survey in the DLHR-5A/4A area, but the SPB was turned off during nighttime in that area. Therefore, additional SBP acquisition was carried out in the DLHR-5A/4A area after the HR-MCS survey along five remaining lines (5A_S01, 5A_S02, 4A_S02, 5A4A_S02 and 5A4A_S05) within the 3.6 km interval centered at DLHR-5A and DLHR-4A. Data were not acquired along the three center lines of the grids (5A_S03, 4A_S03 and 5A4A_S03) because data were previously acquired during the KR16-05 cruise.

11) Gravity survey with shipboard gravity meter

Gravity data acquisition with the shipboard gravity meter was carried out during the entire cruise. Gravity data calibration was performed using a portable gravity meter at the quay and the gravity reference station of the JAMTEC Headquarters at the beginning and end of the cruise. Calibration measurements were also undertaken during port calls in Brisbane (except between Legs 1 and 2-1) at quay sides and the gravity reference station at Northshore Riverside Park in Brisbane (station 2016909147 of the Australian Fundamental Gravity Network).

12) Geomagnetics survey with shipboard magnetometer

Geomagnetic data acquisition with the shipboard magnetometer was carried out during the entire cruise. During Legs 1 and 2-1, figure eight calibration maneuvers of the vessel were performed at three locations, 16 nm northwest of DLHR-5A, DLHR-5A and DLHR-3A, to acquire data for correcting the vessel's magnetic signature. The vessel traced a figure eight at 8~9 kt for about 20 minutes.

13) XBT and XCTD measurements

XBT and XCTD measurement surveys were carried out to correct for acoustic velocities of water in MBES, SBP and MCS data. XBT measurements were performed four times prior to: commencement of the 6KSDT survey at DLHR-5A, the first OBS deployment, the HR-MCS surveys in the DLHR-5A/4A area and the HR-MCS survey in the DLHR-3A area. XCTD measurements were conducted just after completion of OBS deployment and recovery near both ends of OBS deployment region.

5. Cruise Narrative

October 29:

R/V Kairei (hereinafter referred to as “the vessel”) departed from the quay of JAMSTEC Headquarters, Yokosuka, at 09:00 (JST: UTC + 9), but subsequently remained in Tokyo Bay for evacuation from a typhoon.

October 30:

The vessel sailed out from the Tokyo Bay at 13:00 (JST).

November 1 ~ November 10:

Transit to Brisbane

November 11:

The vessel arrived at the Port of Brisbane and was alongside General Purpose Berth of the Fisherman Island at 11:10 (LT: UTC + 10). Nine technicians and Chief Scientist, Kan Aoike, came on board and started rigup for Leg 1.

November 12:

Rigup for Leg 1 continued. The 6KSDT control unit, which had been shipped separately, was loaded. The kingpost, the streamer cable elevator and the MCS container, which are to be used in Leg 3, were offloaded. Function tests of the 6KSDT were performed after setting up the control unit. Onboard scientists, Scott Nichol and Maggie Tran (GA); Yukari Kido and Yosaku Maeda (JAMSTEC); visitors, Andrew Carroll (GA) and Yoshihisa Kawamura (JAMSTEC) came on board. An EPBC compliance lecture was given by A. Carroll and the survey plan of Leg 1 was presented by K. Aoike to scientists, technicians and crew. It was explained that areas and line spacing for sonar survey would be reduced from those shown in the voyage plan because the actual MBES swath width might be narrower than expected. Therefore a test run was planned to check the MBES coverage at the beginning of the 6KSDT survey.

November 13:

Rigup of the vessel and operation check of 6KSDT continued. The EPBC compliance table, in which requirements/restrictions for the surveys to be conducted during this cruise were described and explained to Captain and Chief Scientist by A. Carroll and S. Nichol. Captain, Chief Scientist and GA representative consented to the requirements/restrictions and signed the table item by item. For accurate calibration of the shipboard gravity meter (MGS-6), in accordance with GA’s recommendation, the portable gravity meter (CG5) was brought out and gravity measurement was performed at a gravity datum point at Northshore Riverside Park, near the QUBE bulk berth in Hamilton, as well as at the quay side.

November 14:

The vessel departed from Fisherman Island at 09:00. The shipboard scientists, K. Aoike, Y. Kido and Y. Maeda (JAMSTEC); S. Nichol and M. Tran (GA); and nine technicians embarked as planned. Safety induction and then ship drill took place for the scientists and the technicians from 10:00. Embarkation to life boats was included in the ship drill. Operation check and conditioning of 6KSDT continued. Shipboard MBES data acquisition started from east of 153°48’E upon a request by GA.

November 15:

The vessel arrived at the DLHR-5A area at 15:30. 6KSDT in the sonar survey mode was deployed at 16:35 once but recovered soon as alignment of phins DVL (inertial navigation system with Doppler velocity logger) had not been made before deployment. Alignment of the phins DVL was attempted after recovery; but failed because the internal battery of phins DVL had been undercharged (alignment needed to be done with external power supply off for safety). The towfish was deployed again at 17:14 and the alignment was conducted in water with external power supply being fed (as a result it was less than successful). At 360 m in payout depth of the winch, it was found that no signal was sent from the transponder (SGK) when using the external power supply, while it functioned normally with the internal battery. As duration of the internal battery was less than 24 hours, shorter than the expected survey time, the towfish was retrieved again. The retrieved transponder was checked but no malfunction was found in the external power supply. As the transponder seemed to be working properly, the towfish was deployed again at 20:10. However, once again no signal was received from the transponder, even at 100 m depth. The towfish was retrieved again and on deck at 21:05. Another transponder (OKI), which was stored on the vessel, was prepared as an alternative in parallel with examination of the SGK transponder. In the SGK transponder, it was found that the internal battery was abnormally depleted (8 V while 39V in full charge). A modification was made to feed only from the external power supply, however, the cause of the trouble was still unclear. Finally, we decided to use the OKI transponder, which has a long battery life (~20 days at one-ping per 8 seconds), instead of the SGK transponder. Deck crew mounted the OKI transponder on the towfish. 6KSDT was deployed again at 23:40.

November 16:

Deployment of 6KSDT continued. Alignment of phins DVL was performed in water even though it was undesirable. As phins DVL is referenced to SSBL positioning from the shipboard acoustic navigation system (ANS), positioning by phins DVL was subject to significant drift when SSBL positioning was lost. The towfish reached 100 m above seabed at 00:50 and arrived on Line D5A_D00 from the north at 01:14 for a test run. The altimeter was turned off afterwards since altimeter pings showed interference with MBES. SBP was turned down to half power or turned off due to interference with the SSBL. The first towing showed that the actual half swath width of the MBES was ~110 m, so we decided to reduce the line spacing to 200 m from the run after the next (each line length was 2 nm). The towfish ended the survey line at 02:32, was run in again to same line from south at 04:02, and run out at 05:14. Afterwards, the 6KSDT followed lines in the central part of the DLHR-5A survey area. Three lines, D5A_D08, D5A_D09 and D5A_D13 were traced by 11:55. Since the towfish tended to rise at 2 kt, the winch cable was paid out over 2000 m to keep the altitude of 100 m. Accordingly it took about 1 hour for a line turn. SSBL positioning was frequently lost in southward runs while relatively stable in northward runs. After stopping to use the thruster, it improved somewhat; but there were some periods during which SSBL positioning was lost or so varied. Lines D5A_D10, D5A_D14, D5A_D11, D5A_D15 and D5A_D12 were traced by 22:18. The towfish was positioned on Line D5A_D16 at 23:10.

November 17:

Towing the 6KSDT continued. Six full lines and two half lines, that is, Lines D5A_D16, _D18, _D17, _19-1 (southern half), _D22 (perpendicular line), _D02 (northern half), _D04, _D05 and _D03 were traced by 15:48. SSBL positioning was sometimes lost for long periods. Line turns became shorter with each succeeding line as the crew became used to the necessary maneuvering. At 17:09, halfway along Line D5A_D07, the HDTV monitor and then all communication with the towfish was lost. Smoke and burnt smell were emitted from the High Voltage Power Supply (HVPS). The secondary voltmeter in HVPS had burnt out due to overcurrent generated from an unknown cause. The towfish was retrieved to check its integrity and on deck at 18:19. Investigations into the cause of the trouble were performed from 18:20 to 23:00. As a result of inspections, two major problems were found in the main pressure-resistant container and in the No.15 winch for towing 6KSDT: the latter problem proved to be fatal. In the main pressure-resistant container, it turned out that an electrical insulation failure occurred. However, the main cause of the trouble was damage to the No.15 winch. It was identified that the communication blackout was primarily caused when the optical cable rotary joint dropped off the slip ring and the optical and the electrical cables inside were twisted off. We concluded that it was impossible to continue the 6KSDT survey unless the winch was repaired and there was no way to repair it on board. Afterwards, the vessel sailed at full speed to remove soot in the engines.

November 18:

MBES bathymetry mapping (8 kt) was carried out all day in the northwest of DLHR-5A, from 01:11. From 19:09-19:29, a figure-eight maneuver (for ship magnetization correction) was performed at a location 16 nm northwest of DLHR-5A. Meanwhile, the No 15 winch cable and each 6KSDT sensor were inspected to ensure that communications were still possible. As a result, it was confirmed that the cable was intact from the damaged point onwards and that each of the 6KSDT sensors was functioning correctly. We discussed countermeasures with JAMSTEC Headquarters, including a plan to change the cruise schedule and to offload the No.15 winch for repair.

November 19:

MBES bathymetry mapping (8 kt) was continued all day in the northwest of DLHR-5A and then in the southwest, mainly around an unnamed seamount in the Gifford Marine Park from 03:12. Meanwhile, a change to the cruise schedule was confirmed: Leg 1 was shortened by 3 days and bottom sampling was to be undertaken ahead of schedule as Leg 2-1 while the No.15 winch was being repaired in port. Preparations to offload the No.15 winch, function testing of each 6KSDT sensor, and inquiries into the cause of the electrical insulation failure of the main pressure-resistant container were performed.

November 20:

MBES bathymetry mapping (8 kt) was continued around the unnamed seamount in the Gifford Marine Park until 06:40. The vessel then started to sail back to Brisbane following a transit route parallel to a KR16-05 cruise track in order to expand MBES coverage (15 kt). Meanwhile, testing of each 6KSDT sensor and inquiries into the cause of the electrical insulation failure of the main pressure-resistant container were continued, and preparation of Leg 2-1 commenced.

November 21:

The vessel continued to sail to Brisbane while acquiring MBES data. After passing 153°48’E, MBES was turned off. The vessel arrived at the QUBE bulk berth in Hamilton at 10:30. Magnetometer data acquisition was stopped at 11:50. Deck configuration was changed from 6KSDT setup to setup for sediment sampling. The No.15 winch and the gimbal sheave were offloaded, the 6KSDT was moved to the funnel deck, and GA’s box corer was loaded. After box corer operation instruction given by Ian Atkinson (GA), MWJ technicians made sure of the operation procedure. Shipboard scientists, Y. Kido and Y. Maeda (JAMSTEC), two MWJ and one NME technicians disembarked. A shipboard scientist for Leg 2-1 ~ Leg 3, Brian Boston, visited the vessel.

November 22:

Two new shipboard scientists, B. Boston and Takamitsu Sugihara (JAMSTEC), embarked. The vessel departed from the QUBE bulk berth in Hamilton at 09:00 and started to sail toward DLHR-5A along a route in between the outward and return transit routes of Leg 1. After passing 153°48’E, MBES data acquisition started. A safety induction and then ship drill took place for the scientists and the technicians from 10:00. Technicians then engaged in preparations for sediment sampling. It was recognized that the box corer required further maintenance and some accessories (kinked wires, rusted and adhered shackles and a rusted swivel) needed to be replaced with new ones, so preparations for the replacement of those parts commenced.

November 23:

The vessel continued to sail toward DLHR-5A. Although the expected arrival time was 17:30, we prepared for piston coring after sunset according to the Captain’s suggestion that there was slim hope for good sea conditions and that we should therefore complete the highest-priority sampling as soon as possible. However, at 17:15, the coring operation for that evening was cancelled due to rough sea conditions (>16 m/s in wind speed and > 2 m in wave height). Alternatively, an eight-figure magnetic calibration maneuver at DLHR-5A and then MBES survey (8 kt) in the east of DLHR-5A were conducted. Meanwhile, the Box Corer was maintained and it was found that the spare main wires provided by the manufacturer were not compatible. Therefore the deck department agreed to make and provide new compatible main wires.

November 24:

MBES survey in Area-A continued until 03:10. The vessel sailed back to DLHR-5A and it was judged that the coring operation could be executed at 05:20. The first piston coring operation with a 20-m core barrel commenced at 05:45. The core barrel landed at 07:20 and came back on the deck, slightly bent, at 08:19. The expected penetration was 9.0 m and the recovered core length was 6.36 m. It took a long time (2.4 hours) to remove and section the whole core because the upper part of the core liner was deformed and stuck in the core barrel. The core consisted of light gray (lower part) and pale yellow (upper part) calcareous oozes. The pilot core, 0.2 m in recovered length, was wholly consumed on onboard by biological elutriation. Penetrometer testing was conducted at the bottom of each section. For the second piston coring, a 15-m core barrel was used since the first one was slightly bent. The second coring operation at almost the same location commenced at 10:45. The core barrel landed at 11:59 and was retrieved on the deck, with the upper third considerably bent, at 12:53. The expected penetration was 8.7 m and the recovered core length was 6.75 m. It took a long time (1.5 hours) to remove and section the whole core for the same reason as the first core. The lithology was also the same. Since double penetration was suspected in the pilot core, 0.55 m in recovered length; only the upper 10 cm was used for biological elutriation. As with the first core, penetrometer testing was conducted at the bottom of each section. During the second coring operation, the sea condition became worse and operations were on standby until 16:00. Meanwhile, we made preparations for the next sediment sampling. The sampling tool, however, was switched from the Box Corer to the Grab sampler, because it was found that the alternate new main wires prepared by the deck department needed to be modified (the eye termination was too thick). Eventually, the wind speed and wave height increased to more than 16 m/s and 2 m, respectively: further sediment sampling at this site was cancelled and the decision made to move to DLHR-3A. During transit, preparations for the next day's sediment sampling were made. The eye termination of the main wires that was too thick was modified so as to pass the Box Corer. Since the spare swivel and the shackles for it provided by GA were incompatible in size, we replaced the shackles with those provided by MWJ. The vessel then transited to the east of DLHR-3A for MBES mapping.

November 25:

The vessel arrived at the area in the east of DLHR-3A and then conducted MBES mapping (8 kt) from 01:01 to 03:51 along one survey line. After the MBES mapping, the vessel then moved to DLHR-3A. At 5:00, the Captain decided to execute the sampling operations. The first piston coring operation with a 20-m core barrel commenced at 05:50. The core barrel landed at 07:10 and came back on deck, again slightly bent, at 08:08. The expected penetration was 9.3 m and the recovered core length was 7.0 m. The upper part of the core liner was deformed and stuck in the core barrel (sectioning finished by 11:00). The core comprised light gray (lower part) and pale yellow (upper part) calcareous oozes, as with the DLHR-5A cores. The pilot core, 0.4 m in recovered length, was wholly consumed for biological elutriation. Penetrometer testing was conducted at the bottom of each section. We then switched to box coring. The Box Corer for the second sampling was prepared from 09:00, deployed into the water at 09:29, landed at 10:11 and came back on deck at 10:54. A seabed sediment sample, 10~15 cm thick, comprising pale yellow calcareous ooze with burrows, was recovered and wholly consumed for biological elutriation. The third sampling, again with the Box Corer, was prepared from 11:05. It was deployed into water at 12:00, landed at 12:39 and came back on deck at 13:20, but there was no recovery. The forth sampling was switched to piston coring. The Piston Corer, again with a 20-m core barrel, was prepared from 14:50, landed at 15:59 and came back on deck at 16:59 with slight bending. The expected penetration was 9.7 m and the recovered core length was 7.06 m. The upper part of the core liner was deformed and again stuck in the core barrel. The core comprised light gray (lower part) and pale yellow (upper part) calcareous oozes, as with the first core. Sectioning of the core finished by 19:00. After that, another figure-eight-magnetic calibration maneuver was performed above DLHR-3A for 20 minutes from 19:32. The vessel then started to transit to Brisbane.

November 26:

On the way to Brisbane, from 04:08 to 05:58, MBES mapping of the unnamed seamount south of the Gifford seamount was performed along three lines in order to fill in an area not covered during Leg 1. Preparation to offload the sediment sampling apparatuses was carried out in the daytime. Meanwhile, sampling of whole round core (WRC) samples for post-cruise triaxial compression testing was performed. Since the penetration lengths were short, no overpull indication had been observed when the piston corer was picked up and consequently flow-in (sucking) was not expected; all WRC samples were taken from the bottom two sections of each core as planned. Three WRC samples from each section, each 30 cm in length and totaling 24 WRC samples, were cut off from 4 cores.

November 27:

The vessel continued to sail to Brisbane with MBES mapping to 153°48’E. She arrived at the port and came alongside the QUBE bulk berth in Hamilton at 11:40. Preparation of rig-up for Leg 2-2 was performed. For the 6KSDT, the mounting position of phins DVL was changed so that a trial to obtain towfish log speeds could be undertaken. The failure in the main pressure-resistant container was fixed by replacing the said parts with new ones that were sent from Japan. We then finally made sure of proper functioning of 6KSDT. Meanwhile, gravity calibration with the portable gravity meter (CG5) was performed at both the gravity datum point in Northshore Riverside Park near the QUBE bulk berth in Hamilton and the quay side. A Leg 2-2 onboard scientist, Rachel Przeslawski (GA), visited the ship. An onboard scientist of Legs 1 and 2-1, M. Tran (GA), disembarked.

November 28:

The vessel shifted 15 m along the same quay from 07:20 to 08:00. Cargo works were then carried out until 10:00. The sediment sampling equipment was offloaded and in turn the No.15 winch and the gimbal sheave were loaded. The towfish of 6KSDT was moved from the funnel deck to the afterdeck. The No.15 winch, the gimbal sheave and the 6KSDT system were then set up. Proper communication and functioning of the whole 6KSDT system was finally confirmed by 16:00.

November 29:

The vessel departed the QUBE bulk berth in Hamilton at 09:00. All scientists and technicians on Leg 2-2 embarked by 08:15. A safety briefing, ship drill and a science meeting took place from 10:00 to 11:00. A lecture on EPBC compliance for crew was given by S. Nichol (GA) from 15:00 to 15:15. Meanwhile, maintenance and a function check of the 6KSDT were performed. MBES data acquisition commenced at 16:00 (after passing the edge of the continental shelf) and the vessel continued to sail to the DLHR-5A area. We reconsidered the survey plan based on the preliminary data processing result from Leg 1 and the remaining survey time for Leg 2-2. The navigation data for the first three lines, when the thruster was used during the survey, almost overlapped with each other and were too scattered for use in post-cruise processing and considerable coverage gaps were expected in MBES data. It was therefore decided to survey an additional three and half lines in the DLHR-5A area before going to DLHR-4A. In addition, the survey area for DLHR-4A was reduced to 1.8 nm x 1.8 nm.

November 30:

The vessel continued to sail to the site, however, at lower speed than expected due to opposing wind and current and also probably due to a full load of water and fuel. Meanwhile, maintenance and function checks of the 6KSDT were performed. The vessel arrived at the start point of the first survey line (D5A_D23) at 19:15. The 6KSDT was deployed at 19:53 and reached the altitude of 100 m at 20:39. The sonar survey started from 20:40. Positioning from ANS and phins DVL was satisfactory.

December 1:

The 6KSDT sonar survey for DLHR-5A was continued and finished at 04:16. The vessel moved to the start point of the first line (D4A_D02) at DLHR-4A and then the sonar survey in the DLHR-4A area started from 05:21. The survey proceeded smoothly along lines D4A_D02, _D04, _D06 and _D08. When the towfish passed the midpoint of D4A_D10 from the north, the circuit breaker tripped and the control system of each sonar was shut down at 13:19. A burnt smell came from the HVPS. We confirmed that the secondary voltmeter, the same component that previously failed, was burnt out. We removed this problematic component from the HVPS, as the operation could continue without the secondary voltmeter. At 13:50, the sonar survey was resumed with an approach to line D4A_D10 from the south. Meanwhile, we found that DVL could measure ground speeds even at altitudes of around 100 m and positioning with phins DVL was quite consistent with that of the ANS. The first 1/5 of SBP data on line D4A_D18 was not recorded due to a delay in starting the ping.

December 2:

The 6KSDT sonar survey for DLHR-4A was continued and completed at 14:27. Eight lines were surveyed since midnight. Although a partial gap of 50 m in MBES data was expected between D4A_D14 and _D15, we decided not to fill this data gap. The 6KSDT was retrieved and came on deck at 15:14. The configuration of the deep tow was changed from sonar-mode to camera-mode. The skid on which SBP and MBES systems were mounted was removed and the position of phins DVL was shifted. After function testing of all systems in camera-mode, a GoPro camera in a pressure resistant container was mounted on a front frame. The towfish in camera-mode was deployed at 16:47. The seabed was sighted at 17:28 and the camera survey for DLHR-5A started from 17:30 with the towing speed of 0.7 kt and the altitude of about 5 m. The seabed was flat and covered by ooze with many burrows. Fishes, shrimps, sea cucumbers were sighted at times, but there were few recognizable larger benthic organisms. Although the portside still camera froze 2~3 times per hour, we continued the survey while trying to fix the problem. Despite the best efforts to maintain altitude, the towfish landed once due to large heave. The camera survey for DLHR-5A was finished at 23:13 and then the vessel moved to DLHR-4A with the cable wound up to 1500 m at 2 kt.

December 3:

The vessel arrived at the start point at 00:44 and the camera survey for DLHR-4A commenced. The seabed was flat, covered by ooze with many and various burrows. Fishes, shrimps, sea cucumbers, coral, urchins and starfishes were sighted at times. As spare time was expected, one line was added after the two planned lines. The survey for DLHR-4A finished at 09:04 and the vessel moved to BLHRB-3A with the cable wound up to 1200 m at 2 kt. The vessel arrived at a location near the start point of the first line at 12:08. The seabed was sighted at 12:19. The seabed was flat, covered by ooze with many and various burrows. Fishes, shrimps, sea cucumbers, coral, urchins and starfishes were sighted at times. The survey for BLHRB-3A was completed at 17:50 and the towing cable was wound up for retrieval. The towfish came on deck at 18:32. No leak was seen in the GoPro container after retrieval. The vessel left the site and started to sail toward Brisbane at 19:05. From 19:57, in the middle of transit, additional MBES mapping (8 kt) in the Gifford Marine Park was conducted to fill in remaining gaps on the unnamed seamount (guyot).

December 4:

The vessel continued MBES mapping (8 kt) of the unnamed seamount in the Gifford Marine Park until 08:28 and then started to sail toward Brisbane with MBES mapping at 15~16.5 kt along the transit route.

December 5:

The vessel continued to sail for Brisbane. MBES data acquisition stopped at 04:13. The vessel arrived alongside the AAT No.3 wharf at Fisherman Island, Port of Brisbane, at 10:45. Rig-down of the 6KSDT system and preparation for rig-up of MCS/OBS operations took place. I. Atkinson (GA), 13 NME marine technicians and onboard scientists of Leg 3, Y. Kaiho, Y. Sanada and K. Shiraishi (JAMSTEC) visited the ship from 11:30, 12:00 and 13:20, respectively. As the local agent informed us that no quarantine check was required, GA collected the core samples and elutriated samples after they were offloaded to the quay side. A shipboard scientist for Leg 3, Ron Hackney (GA) visited the vessel at 16:00. Meanwhile, gravity calibration with the potable gravity meter (CG5) was performed at both the gravity datum point in Northshore Riverside Park near the QUBE bulk berth in Hamilton and the quay side. Onboard scientists, S. Nichol, R. Przeslawski (GA), T. Sugihara (JAMSTEC) and 4 MWJ/NME marine technicians disembarked.

December 6:

Loading and offloading works took place using quayside and shipboard cranes from 10:00 to 13:30. The 6KSDT control container, the No.15 winch, the gimbal sheave, GA’s materials and box pallets were offloaded. The MCS container, the kingpost and the streamer cable elevator were loaded. The 6KSDT towfish was shifted to the funnel deck. I. Atkinson (GA) visited and collected their chemicals. Four BPM members, R. Hackney and S. Nichol (GA) visited. Meanwhile, preparation of the MCS/OBS, PAM and MMO was carried out. NME technicians assisted BPM to set up the PAM system and to lay out the cable to the dry laboratory. A working table was prepared for the MMOs on the bridge.

December 7:

All Leg 3 scientists, marine technicians and BPM members embarked by 08:00. The vessel left the AAT No.3 wharf at 09:00 and sailed for the first OBS deployment point. A charging test of the air guns was performed, however, an air leak was found and faulty parts were replaced. A safety briefing and ship drill took place from 13:00 to 13:30. A lecture on marine fauna mitigation for EPBC compliance was given by BPM and an explanation of the survey plan of Leg 3 was provided by K. Aoike to onboard scientists, technicians and executive crew from 15:00 to 15:50. MBES mapping started at 15:23 after passing the continental shelf edge. Immediately after that, MBES shutdown was ordered twice at 15:27 and 15:52, because whales (pilot whale) were sighted within the 500-m shutdown radius.As no more whales were sighted until termination of MMO’s observation at 18:40 and the total number of whale instigated shutdown was only 2 within the previous 24 hours, MBES mapping was allowed to continue beyond sunset. In accordance with BPM’s request, we changed the air gun shooting procedure in the MCS-OBS survey so that shooting volume is increased stepwise as gradually as possible (adding steps of 1100 cu.in. and 1600 cu.in. before 1950 cu.in.).

December 8:

The vessel continued to sail for the first OBS deployment point. Meanwhile, whales were sighted twice beyond the 3-km radius when the vessel was passing above the Gifford Seamount in the morning. MBES mapping terminated at 14:37. As the vessel neared the first OBS location point, an XBT measurement was performed from 15:15 for 8 minutes. OBS01 at the westernmost point was deployed at 15:43. After that, each OBS in 6-km intervals (OBS02 ~ OBS07) was deployed about every 40 minutes and finished at 19:47. MMO observation terminated at 18:10. From OBS08, two OBSs were deployed at 800-m intervals at a rate of about one every 1.5 hours. Deployment of OBS15 finished at 23:42 (confirmed landing at 24:03). All positions of deployed OBS were calibrated based on ANS positioning.

December 9:

The vessel sailed toward the area northwest of DLHR-5A and conducted MBES mapping at 8 kt along one line from 02:06 to 03:55. The vessel then moved to the east of DLHR-5A for the HR-MCS survey in the DLHR-5A/4A area. Soon after sunrise, whales were sighted beyond the 3-km radius. XBT measurement was performed twice from 06:53 to 07:27 because the saving of data from the first measurement was unsuccessful. HR-MCS operations commenced at 08:00 with deployment of the starboard paravane. Following deployment of the paravanes, the PAM cable (170 m) was deployed alone for watching whales during an air gun shooting test. The air gun arrays were deployed to the planned towing depth of 1.5 m from 09:25. The air gun shooting test (100 cu.in. x 4) was performed gun by gun and was successfully completed at 10:30. The PAM cable was then retrieved. Deployment of the ~3 km streamer cable was carried out from 10:45 to 13:35. Starting with deployment of the tail buoy, the streamer cable was paid out with a total of 12 depth controllers, "birds", attached. The PAM cable was deployed again together with the streamer cable from the last 170 m section and was attached to the streamer cable with a chinese finger and tape from the last 100 m section, and finally fixed with a chinese finger on the stern deck. Prior to commencing air gun shooting, pre-start observations by MMO and PAM took place for 30 minutes. The vessel entered Line 5A_S03 and air gun shooting (100 cu.in. x 4) at 25-m intervals in soft start mode commenced at 14:17. Full volume shooting was performed from 15:04 to 15:58. As the #1 and #2 birds in the foreside tended to sink, we retrieved the streamer cable (and the PAM cable) up to the lead-in float to replace the 8 m depth adjustment rope with one 5 m long. After redeployment, air gun shooting resumed on Line 5A4A_S03 with soft-start at 17:43. Even with the shortened depth adjustment rope, there was no improvement in the sinking tendency of the two foreside birds. Data acquisition of 5A4A_S03 was continued until 22:22.

We confirmed that the APG gun arrays in the new configuration for HR-MCS generated waveform patterns with expected dominant frequencies (40-80 Hz) and bandwidth (10-400 Hz), comparable to those from a simulation done prior to the cruise. In near trace plots, good reflections were imaged not only in the shallow sediment section but also in the syn-rift sections down to the top of basement.

December 10:

The HR-MCS survey in the DLHR-5A/4A area continued, tracing the survey lines in an unicursal pattern and taking about 9 hours per round. No whale instigated shutdown or mechanical troubles occurred. The streamer tended to rise due to worsening sea conditions from around noon and accordingly this caused some increase in noise. The #3 bird tended to float, while the #1 and #2 birds tended to sink. SBP data acquisition commenced in the middle of Line 5A4A_S02 (6th line) with full power at 06:52. As the SBP ping sound was unacceptably noisy, the power reduced by two steps (-18 dB) (12:50). SPB pinging was performed only during daytime and terminated at 16:23. Just after commencement of soft start for the 11th line, 4A_S01, shooting of the portside gun array was disabled (21:25). A malfunction in the seismic data acquisition system, SPECTRA, was identified. Technicians tried to solve the problem, but the cause was unknown. Both the software and the SPECTRA workstation were rebooted as a temporary countermeasure. Although soft start was commenced again for Line 4A_S01 from 23:27, communication with the portside gun array was lost soon after at 23:43.

December 11:

The HR-MCS survey in the DLHR-5A/4A area was continued with only the operable starboard array until 04:25, since retrieval could only be undertaken in daylight. The quality of the data acquired on two lines (4A_S01 and 5A4A_S05) was unacceptable due to significant noise. The portside gun array was retrieved from 05:00 and on deck at 05:24. It was confirmed that one of the depth adjustment ropes was severed and one of the air gun control modules was damaged (connector pins of the communication cable were broken off). Damaged parts were replaced and the charging test of the air guns was successfully completed after repair. The repaired portside gun was deployed from 07:30 and the shooting test was completed at 08:11. Meanwhile, the streamer cable was retrieved up to the position of the chinese finger to take in potential slack and then set back. The HR-MCS survey resumed from Line 5A4A_S0 at 08:53 and the SBP was also turned on at the same time. As it was difficult to keep the towing depth to 3 m and the data was still very noisy, the target depth of the streamer was set to 4 m, then 5 m while surveying the next line, 5A_S05. Although it was difficult to sink the streamer and it continued its tendency to rise, bubble noise was significantly reduced by deepening the streamer depth (however, the notch frequency shifted to the lower side). SBP was turned off at the end of Line 4A_S05 at 16:39. Lines 5A4A_S05 and 4A_S01, along which the previously-acquired data was unsatisfactory due to the air gun trouble, were resurveyed from 17:57. However, it was recognized that a depth adjustment rope(s) on the starboard gun array was severed in the middle of 5A4A_S05 (18:57), and then the communication with the starboard gun array was lost at 21:54 in the middle of 4A_S01. The survey was discontinued at 22:23. The vessel then moved to the northwest for resumption of the survey on the next day.

December 12:

Both air gun arrays were retrieved from 04:55 to 05:38. No damage was found in the portside gun array, but in the starboard gun array, two depth adjustment ropes were severed and one of air gun control modules was damaged (connector pins of the communication cable were broken off) – the same trouble as the previous day. The damaged parts were replaced with new ones. Following the charging test, the air gun arrays were redeployed from 08:00 and the shooting test was successfully completed at 08:54. Line 4A_S01 was resurveyed from 09:22 to 10:44. The streamer depth, however, was deepened to 8 m to reduce noise because the birds tended to rise above the set depth of 5 m. After completion of Line 4A_S01, all towing equipment was retrieved by 15:37. As SBP data were not acquired on some survey lines, an additional SBP survey was carried out from 15:50 to 20:45 along the remaining five lines (5A_S01, 5A_S02, 4A_S02, 5A4A_S02 and 5A4A_S05) within the 3.6 km interval centered at drill sites DLHR-5A and DLHR-4A. Data were not acquired on the three center line of the grids (5A_S03, 4A_S03 and 5A4A_S03) where data are available from KR16-05 cruise. The vessel sailed towards site DLHR-3A at 20:45.

December 13:

The vessel continued to sail and arrived in the northwest of DLHR-3A at 05:30. An XBT measurement was then carried out and completed by 05:41. Deployment of the towing equipment commenced at 06:00. Both paravanes, the PAM cable and two air gun arrays were deployed and the air gun shooting test was finished at 07:44. The PAM cable was then retrieved. The tail buoy, the streamer cable with 13 birds and then the PAM cable were deployed in the same manner as in the DLHR-5A/4A area from 08:05 to 10:47. The PAM cable was deployed by 10:03, but was retrieved and redeployed due to significant noise probably arising from fluttering of the cable. After redeployment, the noise problem was resolved. The HR-MCS survey in the DLHR-3A area commenced at 11:31. The SPB was turned on at this point and the Captain agreed to continue pinging overnight. Acquisition commenced on Line 3A_S08, but most birds rose immediately to shallower than 2 m and the #7 bird and those behind were unable to sink at all, thus resulting in considerable noise until the end of this line. We made various attempts to sink the birds on the subsequent lines and succeeded in maintaining a depth of 5~6 m, even though the notch frequency shifted naturally to the lower side. After Line 3A_S02, Line 3A_S08 was resurveyed (22:54~24:54).

December 14:

The HR-MCS survey with SBP survey in the DLHR-3A area continued. Eight lines, including the resurvey of Line 3A_S08, were completed by 03:06. In the middle of Line 3A_S09 (7^{th} line), a few whales (sperm whales) were sighted by the MMO, but they remained beyond the 500-m shutdown radius, at 2.4 km (05:09), 2.5 km (05:39) and 1.4 km (05:57). Despite the visual observations, these whales were not detected by PAM. In the middle of Line 3A_S05, a whale (sperm whale) was sighted by the MMO at 3.2 km on the starboard rear side (08:30), but this whale was not detected by PAM. With the end of Line 3A_S10 at 17:37, the survey of all lines in the DLHR-3A area was completed. SPB was also turned off at 17:37. Retrieval of all towing equipment commenced from 17:45. The PAM cable, the lead-in float, and both air gun arrays were retrieved by 18:45. In the portside gun array, it was found that a stainless steel belt on a float above the aft-side 100 cu.in. gun had broken off and consequently this gun was only hanging from a depth adjustment rope. Retrieval of the streamer cable was completed at 21:20. The vessel sailed to a MBES mapping line in the east-southeast of DLHR-3A and started the MBES mapping along the line at 21:46.

December 15:

The vessel completed MBES mapping along a line to the east-southeast of DLHR-3A by 00:50 and then sailed towards OBS16. From 08:12, OBSs were deployed from west to east. Two OBSs were deployed roughly every 1 hour (including positioning time). By 24:00, deployment of 46 OBSs was completed. Meanwhile, the configuration of the air gun arrays was changed back to normal (1950 cu.in. x 4 and towing depth of 10 m) for OBS-MCS acquisition. The PAM cable was also replaced with a spare because it was relatively noisy during the most recent observations.

December 16:

OBS deployment continued. The last OBS64 was deployed at 11:27. Prior to this, some parts (such as recorder, beacon or power supply) were replaced in OBS51, OBS52 and OBS57, but there were no further problems. Immediately following OBS deployment, an XCTD measurement was performed from 11:50 to 12:05

The change in configuration of the air gun arrays for OBS-MCS acquisition continued throughout OBS deployment. The vessel sailed out at high speed for engine maintenance (removing carbon) from 12:05 and arrived back at the starting point of the OBS-MCS survey at 14:00. Deployment of the MCS towing equipment was carried out from 14:00. After deployment of paravanes on both sides, the PAM cable was deployed alone for observing whales during an air gun shooting test. Deployment of the four air gun arrays and a shooting test (gun by gun) were completed by 16:26, and then the PAM cable was once again retrieved. Although a minor air leak was observed in the #4 gun array during deployment of the streamer cable, we decided to continue operations because the leak would probably resolve itself after the first several shots. The streamer cable was deployed from 16:43 to 19:35. Starting with deployment of the tail buoy, the streamer cable was paid out to the depth of 12 m with a total of 13 birds attached. The PAM cable was deployed again along with the streamer cable from the last 170 m section and was attached to the streamer cable from the last 100 m section with a chinese finger and tape and finally fixed with a chinese finger on the stern deck. BPM experienced very high noise levels in the PAM system and the problem could not be resolved. To avoid the condition potentially becoming worse by retrieving the cable, BPM decided to continue using the same cable. The vessel moved to the eastern end of Line-N1 and entered the line at 22:00. Air gun shooting at 200-intervals commenced with soft start at 22:02 and with full volume at 22:44.

December 17:

OBS-MCS survey along Line-N1 continued with air gun shooting at 200-m intervals from east to west. No firing occurred in the starboard #2-5 gun (600 cu.in.) at 00:57 (an air leak was found later). A significant air leak was recognized in the portside #3-5 gun (600 cu.in.) at 05:58. Data acquisition and air gun shooting were stopped at 06:13 at a distance of 51 km from the east end of Line-N1. To fix the problem, the starboard #2 gun array and the portside #3 gun array were retrieved from 07:10. Repair of damaged air guns and a charging test were performed from 08:30 to 11:15. Meanwhile, the PAM cable was retrieved and redeployed to investigate the cause of noise. It was presumed that the PAM cable may have been tangled with the streamer cable. After redeployment with an additional weight, the noise problem was fixed and the depth of the hydrophone became deeper (36 m). The #2 and #3 air gun arrays were redeployed from 11:17 and a shooting test was completed at 12:11. Although a minor air leak was observed again in the #3 gun array, it was expected that the leak would resolve itself after first several shots. From 12:11 to 16:30, the vessel turned to the resumption point 10.5 km east of the last shooting termination point. Air gun shooting resumed with soft start from 16:31 and full volume at 17:08.

December 18:

The OBS-MCS survey along Line-N1 continued with air gun shooting at 200-m intervals from east to west and terminated at 14:44 at the west end of the line. Although the vessel had left the approved seismic acquisition polygon, the last shot point was still situated within the approved polygon. The vessel turned to reenter the same line from 14:44 and entered it at 18:33. Air gun shooting towards the east at 50-m intervals commenced with soft start from 18:33 and came to full volume at 19:05. No fire occurred in the starboard #1-5 gun (600 cu.in.) at 23:40. This gun was deactivated as a spare.

Because the Leg 3 acquisition was proceeding smoothly, leaving more than enough contingency days, we added two short survey lines, 4A_S03 and 5A4A_S03, to the 50-m shooting survey along the center lines of the HR-MCS survey grids of the DLHR-5A/4A area.

December 19:

The OBS-MCS survey along Line-N1 continued with air gun shooting at 50-m intervals from west to east. No fire occurred in the starboard #1-6 gun (400 cu.in.) at 01:30. This gun was deactivated as a spare. An air leak was suspected, but the survey was continued because air pressure was maintained. After sunrise, we decided to retrieve the suspicious gun array #1 to avoid the possibility of a larger leak developing by nighttime. Air gun shooting was terminated at 06:53 at the east end of 5A_S01. Both the starboard #1 and #2 gun arrays were retrieved to make deck works easier from 07:03. Two damaged air guns were repaired by 10:30. The two gun arrays then redeployed and a shooting test was completed successfully. The vessel turned to the east end of Line 4A_S03 from 11:20 and entered the line at 12:58. Air gun shooting resumed with soft start at 12:58 and full volume at 13:36. However, a no fire occurred again at 13:47 in the starboard #1-5 (600 cu.in.) gun that had just been repaired. This gun was deactivated as a spare and the survey continued. Acquisition along Line 5A4A_S03 was finished at 18:48 and the vessel then turned to the reentry point on Line-N1, 8 km to the west of the previous end point. Air gun shooting resumed at 19:47 with soft start and full volume at 20:20. A synchronization error occurred in the portside #4-2 (100 cu.in.) gun at 22:37. This gun was deactivated as a spare.

December 20:

The OBS-MCS survey along Line-N1 was continued with air gun shooting at 50-m intervals from west to east. The survey was completed at 11:09. Retrieval of all towing equipment was carried out from 12:30 to 17:15. During retrieval of the streamer cable, the stretch section with a length of 50 m on the winch side was replaced with new one. The vessel then sailed to the OBS64 location and OBS retrieval was carried out from 19:50. OBS64 to 61 were successfully retrieved by 24:00.

December 21:

OBS retrieval continued. OBS60 to 39 were successfully retrieved by 24:00.

December 22:

OBS retrieval continued. OBS38 to 13 were successfully retrieved by 24:00.

December 23:

OBS retrieval continued. All OBSs were successfully retrieved by 12:43. An XCTD measurement was performed just after completion of OBS retrieval from 12:46 for 10 minutes. The vessel sailed at high speed for engine maintenance (removing carbon) from 13:00 to 15:10 and then carried out MBES mapping at 12 kt in an area to the east of the Gifford Marine Park.

Meanwhile, technicians carried out supplementation of kerosene to the stern side stretch section of the streamer cable. In preparation for the standalone PAM survey planned for the next day, the weight added during the OBS-MCS survey was removed from the PAM cable. A meeting to share awareness on marine fauna mitigation was held with BPM, scientists, Captain, Chief Officer and Chief Electric Operator in attendance from 16:00 for 20 minutes.

December 24:

MBES mapping (12 kt) in the area east of the Gifford Marine Park was continued until 06:39. The MBES system was then turned off. The vessel moved to the Gifford seamount (guyot) for a standalone PAM survey. On the way to the seamount, a group of about eight whales was sighted around 07:00. The PAM cable was deployed from 07:30 to 07:37. Standalone PAM survey was carried out along a route tracing the edge of the flat summit of the guyot from 07:42 to 16:32. The vessel sailed along the route clockwise at 5~6 kt. The PAM cable was retrieved from 16:34 to 16:41. After retrieval of the PAM cable, MBES was turned on. The vessel sailed out for MBES mapping of the Dampier Ridge. Meanwhile, technicians worked on preparations for rig-down in port.

December 25:

MBES mapping of the Dampier Ridge was performed. The ship speed while mapping was kept to 14~15 kt in order to increase coverage of new bathymetry rather than to cover a small area in better resolution. Meanwhile, technicians worked on preparation for rig-down in port and organized the cruise data. In addition, a short Christmas entertainment was put on by BPM members at the Bridge.

December 26:

MBES mapping on the Dampier Ridge continued and was terminated at 17:40. Even though whales were sighted a few times, no shut-down of MBES was ordered because the whales remained beyond the 500-m shutdown radius. The vessel sailed for Brisbane. MBES mapping was terminated at 18:54 before entering the continental shelf. Meanwhile, a science seminar was held with attendance of Captain and crew from 13:00 to 13:30 and R. Hackney (GA) gave a talk on the LHR project. Technicians worked on preparations for rig-down in port and organized the cruise data.

December 27:

The vessel continued to sail to Brisbane and arrived alongside the AAT No.3 wharf, Fisherman Island, Port of Brisbane at 11:00. Rig-down and preparation for the return transit took place. After lunch, items described in the EPBC compliance table were reviewed and Captain, Chief Scientist, GA representative and BPM representative signed the table item by item. All onboard scientists (JAMSTEC x 4 and GA x 2), BPM members (x 4) and marine technicians (x 13) disembarked at 14:00.

December 28:

The vessel shifted to the QUBE bulk berth in Hamilton at 11:00. Loading work was carried out from 13:00 to 16:00. The towfish of 6KSDT was moved to the hanger from the funnel deck. The No.15 winch, streamer cable elevator, gimbal sheave, king post, sampling tools and box pallets were loaded on deck. Gravity calibration with the potable gravity meter (CG5) was performed at both the gravity datum point in Northshore Riverside Park near the QUBE bulk berth in Hamilton and at the quay side.

December 29:

The vessel was moored at the QUBE bulk berth in Hamilton.

December 30:

The vessel departed from the QUBE bulk berth in Hamilton, Port of Brisbane at 09:10 (LT) and sailed for Japan.

December 31~January 10:

Transit to Japan.

January 11:

The vessel arrived in Japan and arrived alongside the quay of JAMSTEC Headquarters, Yokosuka, at 09:00 (JST: UTC + 9).

6. Technical Information

(1) 6000-m Sonar Deep Tow (6KSDT)

6KSDT is a deep tow system capable of surveying the seafloor in water depths up to 6,000 m and was operated during Legs 1 and 2-2. Three types of seafloor survey sonars are equipped on the towfish: two sets of side-scan sonars (SSS), a multibeam echo sounder (MBES) and a sub-bottom profiler (SBP, optionally equipped) (Fig. 6.1). Among these, MBES and SBP are mounted on a removable skid frame. In addition, two types of camera systems with LED lights: one HDTV camera with three 400W LED lights facing 45° downward and two still cameras on both sides with 1kW and a 400W LED lights facing straight down are equipped for visual seafloor observation at the front side of the towfish. 6KSDT was operated in sonar mode during Legs 1 and 2-2 and in camera mode during Leg 2-2.

An acoustic transponder is mounted to track the towfish using the shipboard acoustic navigation system (ANS) (another transponder, which was stored in the vessel, was used instead due to malfunction of the original one). Navigation data from the towfish are acquired both by an inertial navigation system with Doppler velocity logger (phins DVL) and by the shipboard Acoustic Navigation System (ANS). DVL was, however, deactivated during the sonar survey of Leg 1, because it was assumed that the towing altitude (100 m ± 10 m) was initially out of range for the DVL. For the camera-mode survey, the skid is dismantled from the towfish (Fig. 6.2). The still camera system can take seabed photo images at regular intervals in automatic mode (6 seconds in this cruise). Each instrument on the towfish is controlled through an optical-electric composite umbilical cable winch (No.15 winch was used during this cruise: Fig. 6.3) by the control unit on deck (20-ft dry container). Winch control is also conducted from the control unit. Specifications for the instruments on the towfish are summarized in Table 6.1.

During the Leg 1 sonar survey, there was an incident in which the No.15 winch was severely damaged at the optical rotary joint. This incident forced a change to the cruise schedule.

Figure 6.1: 6KSDT towfish in sonar survey mode.

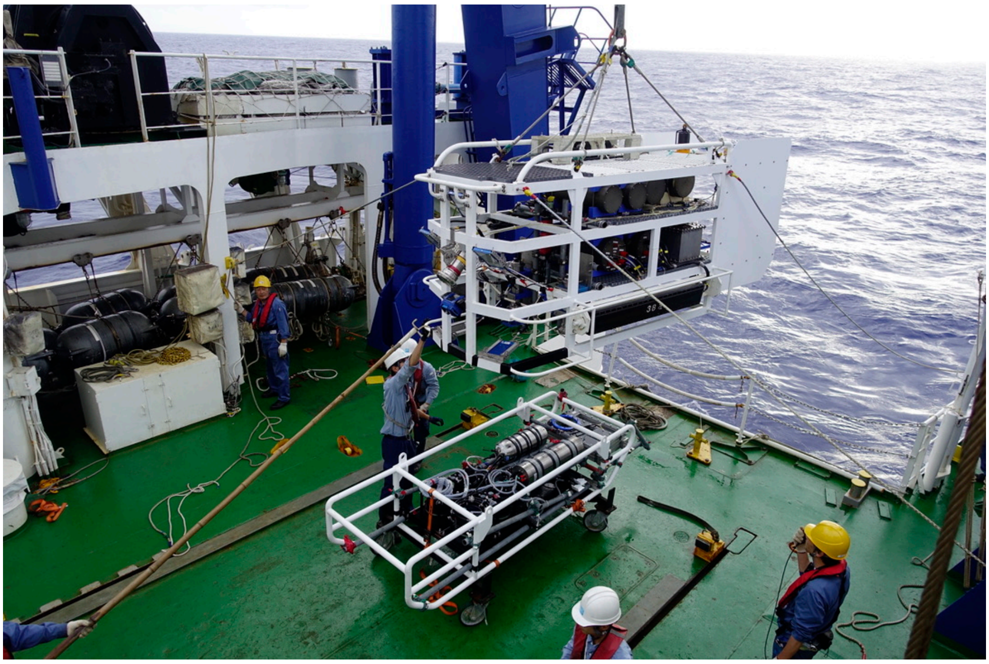

Figure 6.2: 6KSDT towfish in camera survey mode. A skid to which SBP and MBES are mounted is removed from the towfish.

Figure 6.3: Optical-electric composite umbilical cable winch (No.15 winch).

Table 6.1: Specifications of instruments equipped on the 6KSDT towfish.

Sonars

Instrument	Manufacturer	Model	Frequency		Trigger Interval 3)	Delay	Beam Width	Swath Width	Range / Max. Altitude	Sound Pressure Level	Data Format
SSS (default)	Furuno	—	Port	38 kHz	600ms	0ms	2°	500m	300m	227 dB re mPa at 1m	*dsf, *xtf
			Starboard	42 kHz	600ms	0ms	2°	500m	300m		
SSS (additional)2)	EdgeTech	2200-M		120kHz	600ms	0ms	0.8°	500m	300m		*jsf (*geotiff, etc.)
				410 kHz	600ms	0ms	0.5°	400m	200m		
SBP	EdgeTech	DW-106		1-6 kHz	600ms	0ms		-	300m		*jsf (*segy, *jpg etc.)
MBES	RESON	SeaBat7125		400 kHz	600ms	0ms	1°	400m	230m	220 dB re mPa at 1m	*s7k (*xyz, *ascii, etc.)
Phins	iXblue	Phins6000									*txt
DVL	Teledyne RD Instruments	WHN600		600 kHz					90 m		*csv
Altimeter	Kongsberg	1007ALTMET R-6K		120 kHz	600ms	400ms	0.9°		150m	211 dB re mPa at 1m	*csv
Transponder1)	SGK	—	Tx	13 kHz						190 dB re µPa at 1m	—
			Rx	13.5～15.5 kHz						185 dB re µPa at 1m	—
CTD	Seabird	49-0331									*csv
Depth Sensor	Paroscientific	8B7000-2									*csv

1) Another transponder (OKI) stored in R/V Kairei was temporally used due to mulfunction in the SGK transponder.
2) Frequency of 120kHz was activated.
3) Trigger intervals of 600 ms were applied for this cruise

Cameras

Instrument	Manufacturer	Model	Image Sensor	Focal Length	F value	Data Format
Still Camera 1)	Sony	HDR-CX700V	1/2.88 CMOS seonsr	3.8～ 38.0mm	F1.8-3.4	*jpeg
HDTV Camera 2)	Sony	FCB-H11	1/3 CMOS sensor	5.1～ 51.0mm	F1.8～ 2.1	*m2t

1) Still photo images were taken every 6 seconds in automatic mode.
2) Raw files were converted to mp4 files on board after recovery.

Lights

Instrument	Manufacturer	Model	Quantity	Wattage
LED 1000W 1)	NTF	—	1	1000W
LED 400W 2)			4	400W

1) Pointed straight down for the still cameras
2) One was pointed straight down for sthe till cameras and three were pointed to 45° downward for the HDTV camera.

(2) Piston Corer

The Piston Corer is a long and heavy tubular tool designed to take a core sample of seafloor sediment with minimum disturbance of its sedimentary structures. The device consists of the main corer, a trigger arm and a pilot corer (Fig. 6.4). It is possible to extend the length of the core barrel (aluminum sampling pipe) up to 20 m by connecting 5 m pipe sections (Fig. 6.5). The lengths of the core barrel that we used were 20 m (3 cores) and 15 m (1 core). For the pilot corer, we used a 50-cm corer. The weight of the main corer is selectable, but a 1.2-t weight was used during this cruise.

The Piston Corer works as follows: the corer descends to the seabed with the main wire; the end of the trigger arm on the pilot corer side rises when the pilot corer lands on the seabed; the clip ring of the main corer is unhooked from the trigger arm and the main corer falls freely from an altitude of 3~5 m above the seabed; the sampling tube (outer and inner pipes) of the main corer penetrates into the sediment with the piston staying at the seabed; and the main corer with a sediment sample inside is then hauled up to the surface.

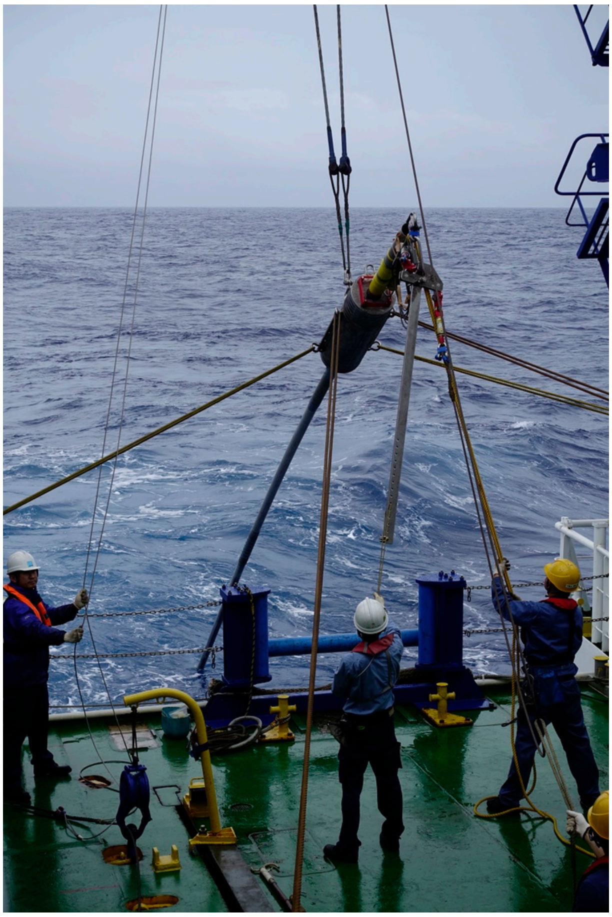
Figure 6.4: Deployment of piston corer


Figure 6.5: Recovered core barrel.

(3) Box Corer

The Box Corer is designed to collect seafloor sediment with minimal disturbance in a fixed area. Once the outer frame has landed at the seabed, the corer penetrates into sediment under its own weight. When the main wire is wound in, the spade is swung down and closes the bottom of the corer to prevent sample loss. For this cruise, GA provided an Oktopus Box Corer 2500 (Figs. 6.7 and 6.8), which is capable of sampling a 50-cm square area. This box corer was used twice for seabed sediment sampling during Leg 2-1. The box corer, however, was in need of further maintenance and replacement of some appurtenances (kinked wires, rusted and adhered shackles, a rusted swivel and inadequate spare parts). Technicians and crew made it operable on board.

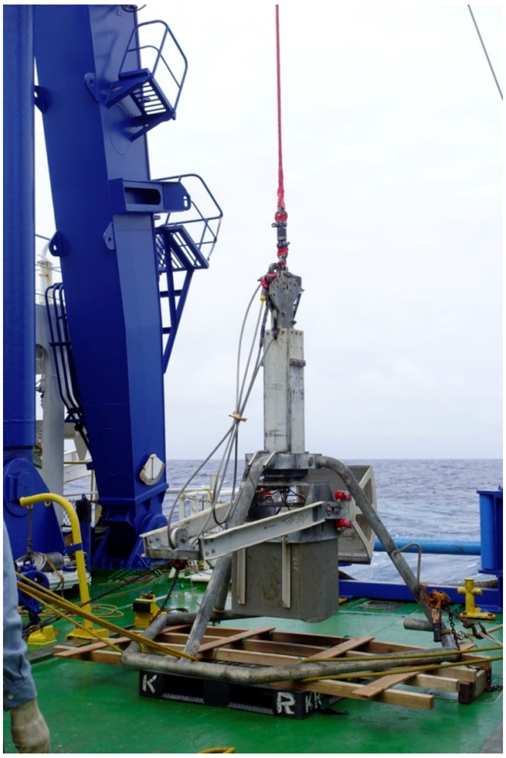

Figure 6.7: Box corer about to be deployed.

Figure 6.8: Box corer recovered. The spade has closed the bottom of the box and is supporting the sediment sample inside.

(4) Airgun array

The airgun array of R/V Kairei has four sub-arrays of 1,950 cu. in. consisting of eight airguns from 100 cu. in. to 600 cu. in. The total volume of the array is 7,800 cu. in. with a multi-channel seismic reflection system (MCS). The airgun model is an annular port airgun (APG) produced by Bolt Inc., comprising cylindrical chambers, housings, and shells containing air and electric junctions (Fig. 6.9). For the MCS-OBS survey during this cruise, this set of gun arrays was used with a towing depth of 10 m. For the HR-MCS survey, however, two arrays with only two 100 cu.in. air guns, in total 400 cu.in., were activated and the towing depth was set to 1.5 m using shortened depth adjustment ropes. This configuration was expected to generate seismic energy with higher dominant frequency and higher notch frequency for high-resolution imaging of shallow formations at least down to 1000 m below seafloor. As a result, we obtained seismic energy as expected with dominant frequencies of 40-80 Hz and a notch frequency of 400 Hz (Fig. 6.10).

Figure 6.9: APG airgun in HR-MCS mode. Short depth adjustment ropes (1.5 m) were used.

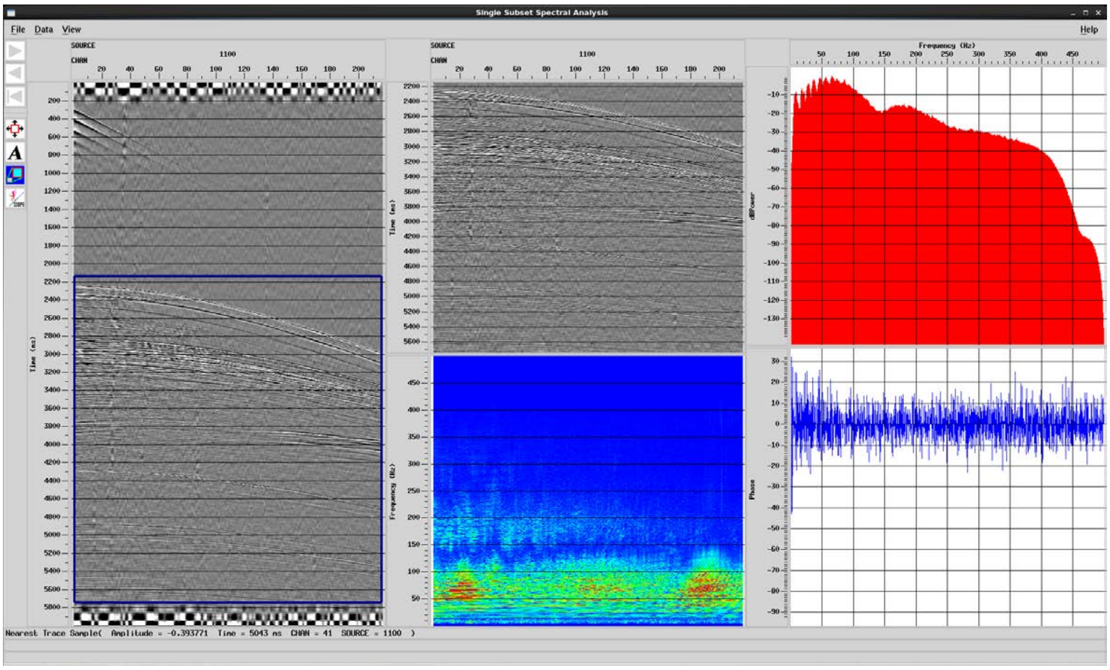

Figure 6.10: An example of shotgather spectrum image for the HR-MCS survey (Line 3A_S01, SP1100).

(5) Multi-channel seismic reflection system (MCS)

The multi-channel seismic (MCS) reflection system consists of an airgun array, a streamer cable containing hydrophones and termination with a tail buoy, a navigation system with global positioning system (GPS) receivers, and a shipboard control system to record the data.

The streamer is a digital streamer (Sentinel; Sercel) with a 12.5-m group interval consisting of 8 hydrophones (Fig. 6.11). The streamer cable used during this cruise was 3 km long, shortened to a half-length of that for normal MCS survey operations. Accordingly the streamer had 216 hydrophones channels in total. A data control module (LAUM) is located every 60 channels. The towing depth of the cable was controlled by 12 or 13 depth controllers called “birds” (Fig. 6.12). Each bird has a depth sensor and a compass sensing its three-dimensional location underwater. The tail buoy has a GPS unit to locate the end of the streamer.

The shipboard control system consists of four main components: navigation control (SPECTRA), airgun control (DigiSHOT), streamer control (Seal System), and other navigation (Fig. 6.13). SPECTRA manages coordinates of seismic lines and shot points, generates System Start signals, and records shot times and locations, as well as geometry information for the airguns, streamer and ship. DigiSHOT controls and monitors performance of airguns including pressure, array depth and near field wave forms. Shot time is recorded in GPS time with milli-second accuracy. Seal System receives System Start signals from SPECTRA and then sends a Recording Start signal to each LAUM. The hydrophone data are collected by the LAUMs and are sent back via the hydrophone streamer to shipboard units. Data are finally recorded on Network Access Storage (NAS) disks and tape media (3590E) in SEG-D format. The other Navigation group consists of differential GPS (DGPS) for the MCS system, relative GPS (RGPS) for the airgun sub-arrays and tail buoy, depths and compass readings for the birds, and navigation information for R/V Kairei based on DGPS using SkyFix XP, gyro compass, SENA Original JAMSTEC (SOJ), and radar. The navigation information is sent to SPECTRA and recorded.

The source and receiver configuration are shown in Figs. 6.14 and 6.15. For the HR-MCS survey, the streamer depth was controlled primarily to 3 m in the beginning but changed later to 4~8 m. For the OBS-MCS survey, streamer depth was set to 12 m. Examples of time migration section images produced by on board preliminary processing for the HR-MCS and the OBS-MCS (50-m shooting interval) data are shown in Figs. 6.16 and 6.17, respectively.

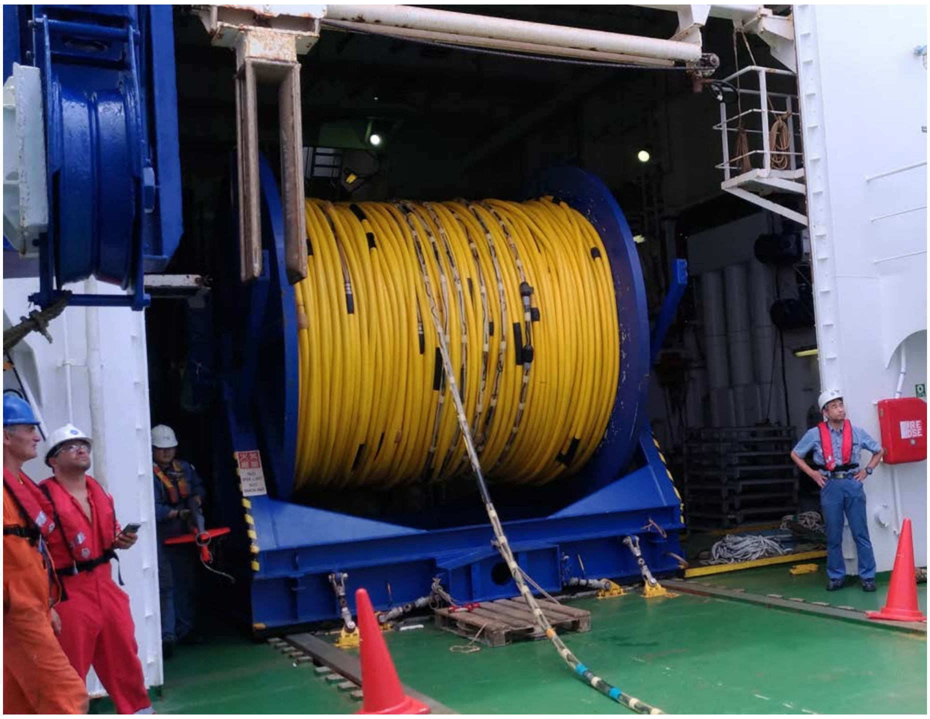

Figure 6.11: Streamer cable and winch.

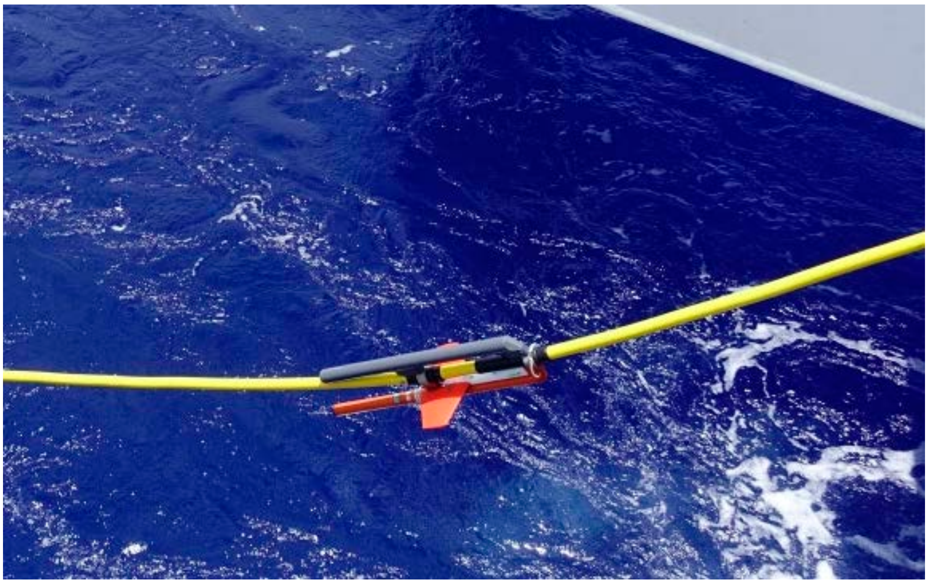

Figure 6.12: Depth controller, “bird”

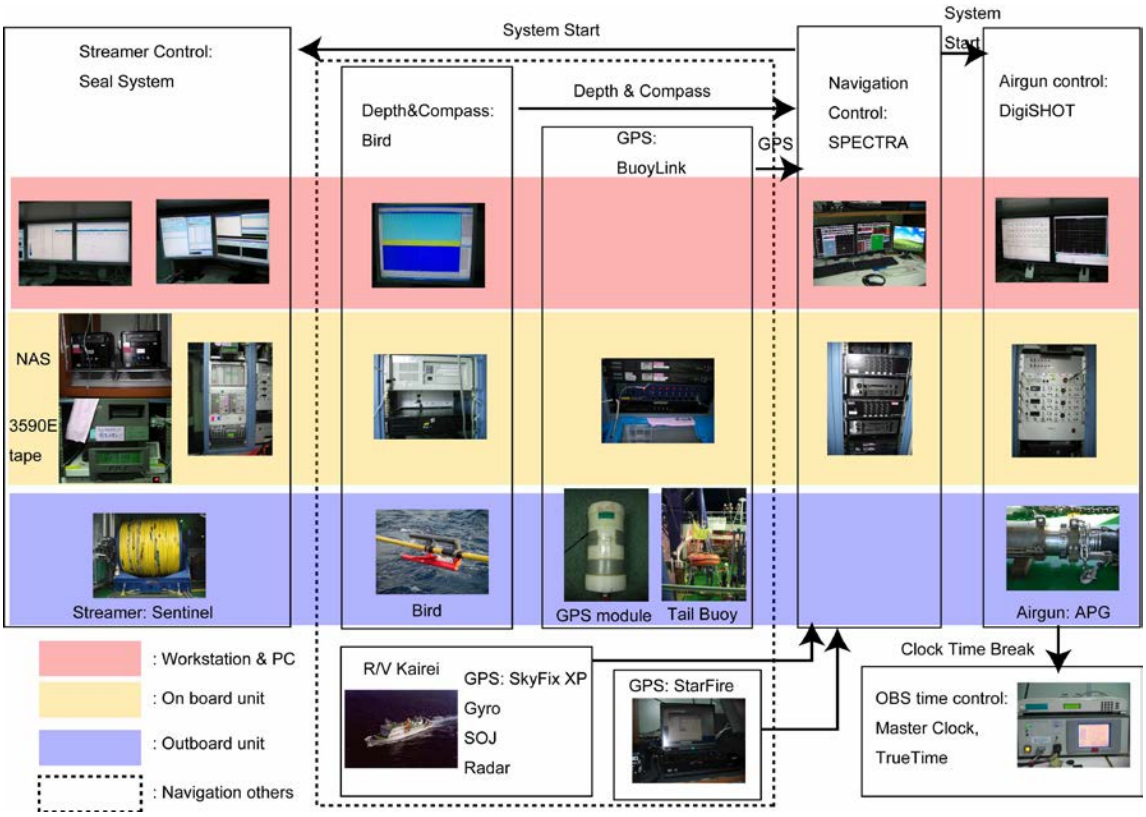

Figure 6.13: MCS system of R/V Kairei

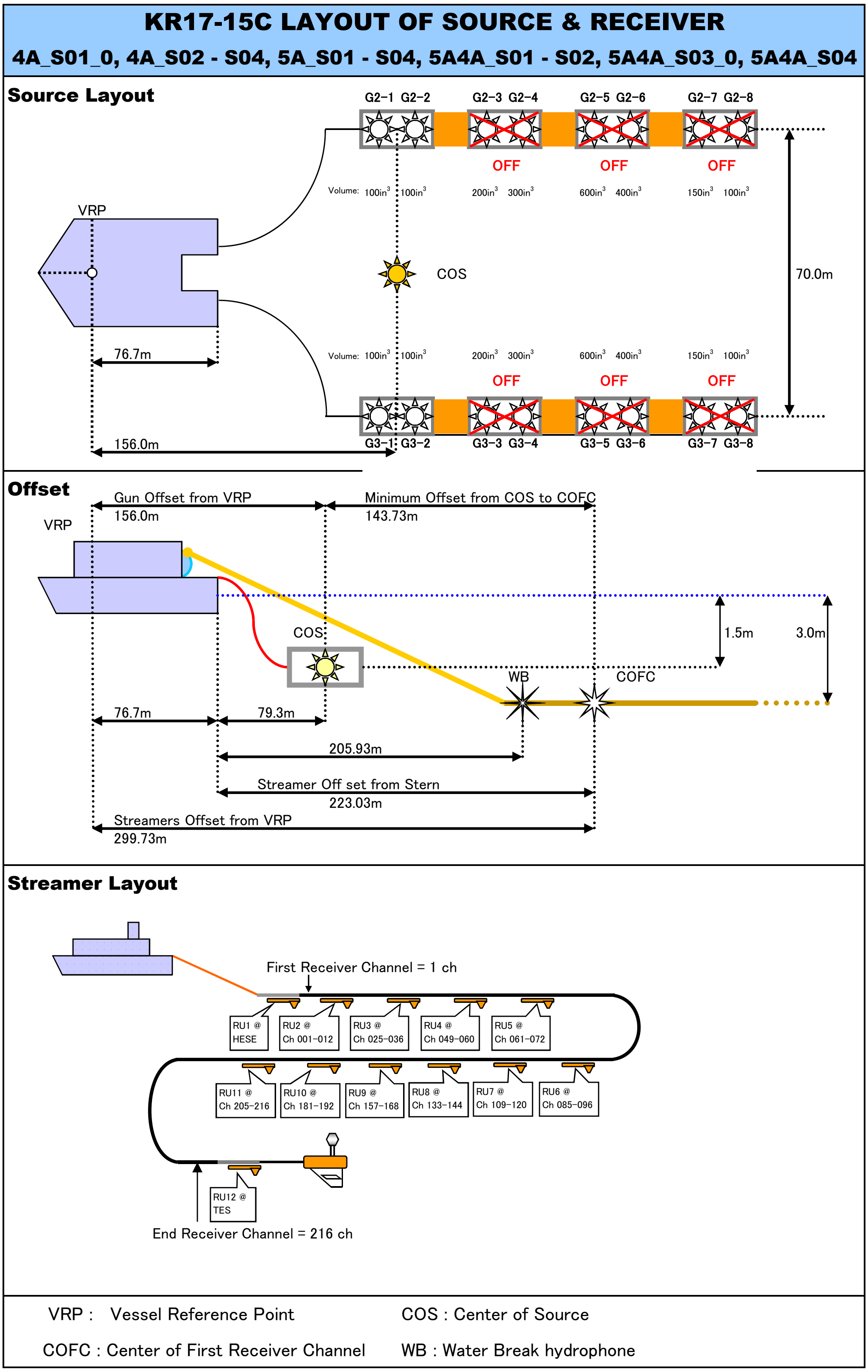

Figure 6.14: Configuration of source and receiver for the HR-MCS survey. Streamer depth was primarily set to 3 m in the beginning but changed to 4~8 m later in response to increased bubble noise. Number of birds was 12 in the beginning, but one bird was added later in an effort to suppress the tendency for the streamer to rise.

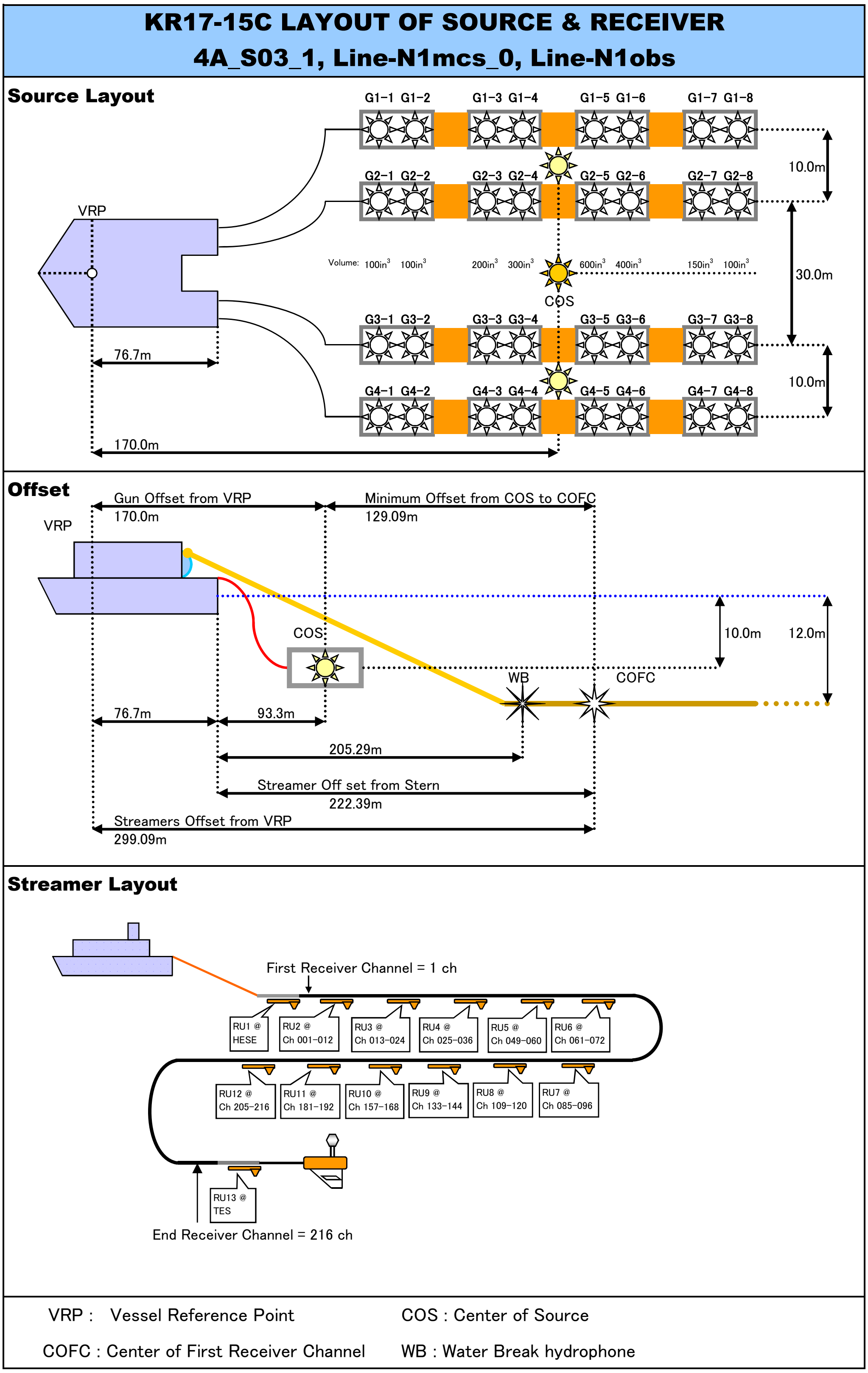

Figure 6.15: Configuration of source and receiver for OBS-MCS survey. During the latter half of the 50-m interval shooting, gun G1-5 was deactivated.

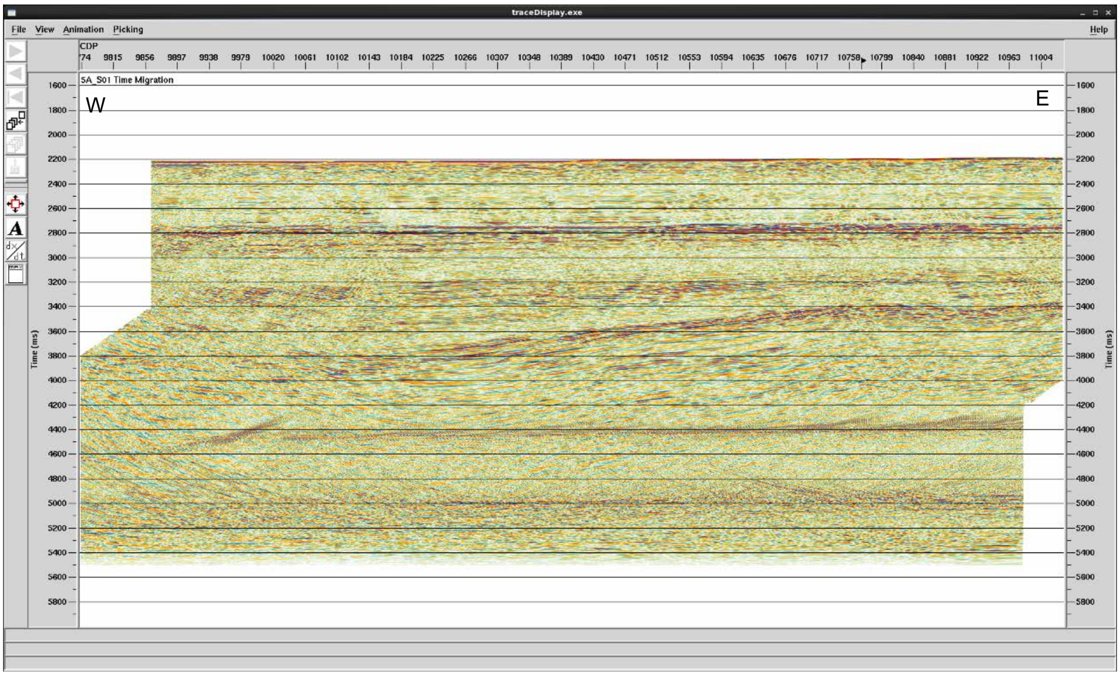

Figure 6.16: Example of HR-MCS time migration section image (Line 5A_S01: 25-m shooting interval) after onboard data processing.

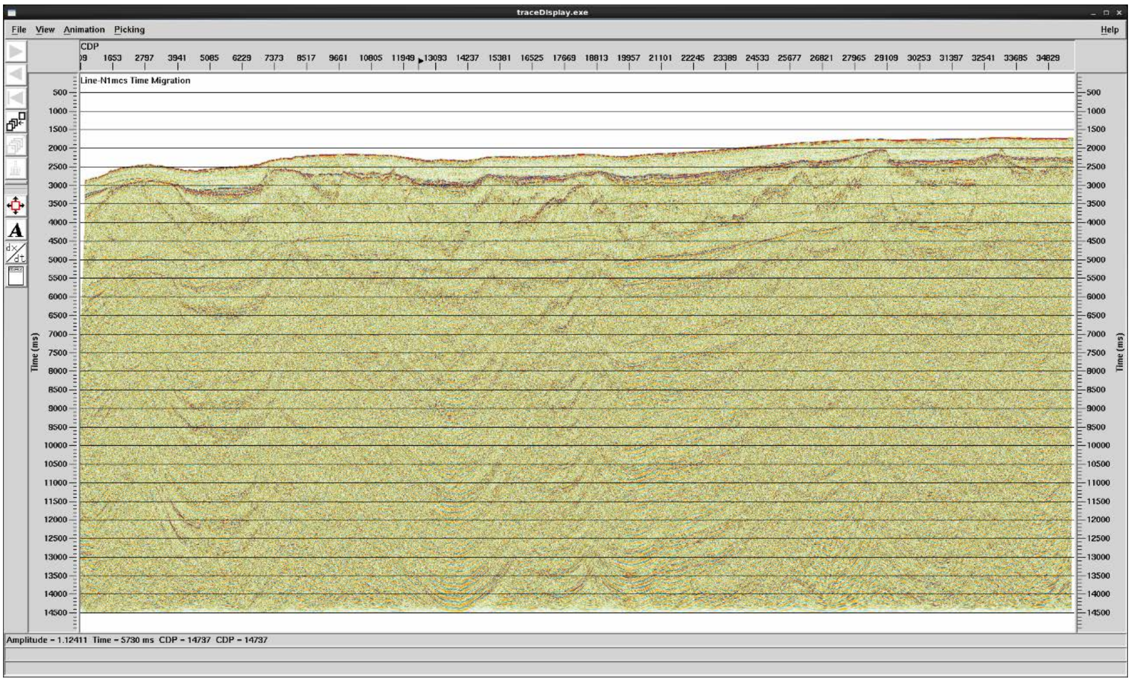

Figure 6.17: Example of OBS-MCS time migration section image (Line-N1mcs: 50-m shooting interval) after onboard data processing.

(6) Ocean Bottom Seismometers (OBS)

The OBSs deployed during this cruise were the POBS-150 model, manufactured by Katsujima seisakusho, that have a 17-inch glass sphere as the pressure vessel. These OBSs are capable of descending to 6,000 m water depth (Fig. 6.18). Inside the glass sphere, a geophone sensor with a gimbal system, a recording unit including pre-amp, an A/D converter, storage media (hard-disk drive), and a set of batteries are enclosed (Fig. 6.19). Each OBS was equipped with either of two types of acoustic communication systems: STD-303 from Kaiyo Denshi Co. Ltd. (KDC) or NATS-6k from System Giken Kogyo Inc. (SGK). The KDC system has a separate transponder that consists of a transducer and a transponder pipe. The SGK system has a monocoque structure that includes both a transducer and a pipe containing electrical parts. Each A/D converter was a 16 bit type with a sampling rate of 100 Hz. Each geophone sensor was a three-component type (with a gimbal case to adjust inclination of the sensors, L-28LBH; Mark Products). A hydrophone (AQ-18; Benthos – Teledyne Technologies Inc. or HTI-99-DY; High Tech Inc.) was mounted outside of the glass sphere. A hydrophone (HTI-99-DY) with reduced sensitivity (-194 dB re 1V/μPa relative to that of other 59 OBSs) was mounted to five OBSs (OBS01, 08, 51, 57 and 64) to record sound in the water column. The aim of these recordings was obtain water column acoustic data to compare to sound modeling undertaken as part of requirements under Australia's Environment Protection and Biodiversity Conservation Act.

Deployment of the OBS is by free-fall from the sea surface to the sea bottom; each OBS has an iron weight of about 40 kg attached underneath, which causes it to sink. The position of each OBS is determined by acoustic communication between the OBS and the Acoustic Navigation System (ANS) with a Super Short Baseline (SSBL) positioning method using a 14 kHz signal. Retrieval of OBSs starts with the release of the iron weight triggered by an acoustic signal from the vessel. As internal clock accuracy is about 10^{-6} seconds, the drift of each clock is adjusted based on drifts before deployment and after retrieval.

Figure 6.18: OBS about to be deployed.

Figure 6.19: OBS sensors in a glass sphere.

(7) Shipboard Global Positioning System (GPS)

R/V Kairei is equipped with a Starfix.XP2 (StarPack, Fugro) Differential Global Positioning System (D-GPS). The vessel position for all geophysical observations, including MBES, gravity, and geomagnetic data, are provided by the Starfix.XP2. For the MCS surveys, another D-GPS system, StarFire (SF-2050M, NAVCOM), is used to control the air-gun shot points and the hydrophone streamer cable. Precision and accuracy of both systems are 10 cm. The Starfix.XP2 can provide GPS data in National Marine Electronic Association (NMEA) format.

(8) Acoustic Navigation System (ANS)

R/V Kairei has underwater acoustic communication and positioning systems, Acoustic Navigation System (ANS), for multiple vehicles and deployed observatories (Table 6.2). ANS is capable of sending and receiving acoustic signals to communicate with underwater acoustic instruments. With an array of acoustic receivers (16 sensors) on R/V Kairei, ANS measures the two-way time between the vessel and the instrument and the incident angle of the acoustic responses based on the phase differences. Together with the GPS data, ANS can quickly ascertain the instrument position. ANS can accommodate two positioning methods, Long Baseline (LBL) and Super Short Baseline (SSBL), and two frequency bands, 7 kHz and 14 kHz bands. During this cruise, only the SSBL method was used for positioning underwater instruments (6KSDT, Piston corer, Box corer and OBSs). The estimated error is 0.35% of slant range when the slant range is 4000 m.

Table 6.2: Major specifications of ANS

Positioning system	SSBL/LBL
Detectable distance	More than 8000 m in slant range
Effective aperture angle	45 deg from the downward vertical direction
Accuracy of positioning	Less than 0.35% when the slant range is 4000 m
Communication frequency	14 kHz-band
band (Vessel)	Transmission: 5.0 kHz – 17.0 kHz Reception: 10.0 kHz – 16.5 kHz 7 kHz-band Transmission: 5.3 kHz, 5.8 kHz, 6.3 kHz Reception: 5 kHz – 7.5 kHz
Transmitted sound pressure	14 kHz: 190 dB 7 kHz: 194 dB
Reception sound pressure	14 kHz: more than -178 dB 7 kHz: more than -178 dB
Number of reception sensors	14 kHz: 16 sensors 7 kHz: 16 sensors Note: 4 sensors are commonly used for both frequency bands.

(9) Shipboard Multi narrow beam Echo Sounder (MBES)

R/V Kairei has a Multi narrow beam echo sounder (MBES), ELAC Seabeam 3012 (ELAC Nautik), for acoustic seafloor mapping (Table 6.3). The MBES system transmits acoustic signals from the transducer and receives their reflections with hydrophone arrays mounted in the keel of the vessel. The system calculates the seafloor bathymetry and its characteristics by consideration of the ship motion and the acoustic velocity in the water. The system simultaneously emits 301 acoustic signals. The maximum swath angle is 140 degrees. The resolution and the width of the swath area are dependent on the water depth: if the water depth is 1,500 m, the expected horizontal resolution is 1m or 0.5% of slant range and the maximum swath width is about 140 degrees in ideal conditions. The accuracy of the water depth derived by the MBES system is dependent on the frequency of the acoustic signals and the sampling intervals.

Table 6.3: Main specifications of the shipboard MBES “SeaBeam 3012”

Measurement Depth	50–11000 m (full ocean depth)
Max swath coverage	140° swath width
Transmission Beam Angle	2° (-3 dB)
Receiving Beam Angle	1.6° (-3 dB)
Number of beams	301
Beam spacing	Equidistance or equiangular
Pulse Length	2–20 ms
Frequency	12 kHz
Roll Angle	±10°
Pitch Angle	±7°
Yaw Angle	±5°

(10) Sub-bottom profiler

The sub-bottom profiler is a system for imaging detailed shallow sedimentary structure using very high frequency acoustic signals. R/V Kairei is equipped with a high-resolution 3.5 kHz CHIRP Sub-Bottom Profiler BATHY-2010 system (Table 6.4). Operational water depth range is 10 m–12,000 m. The vertical resolution within the marine sediment strata is expected to be 8 cm and the maximum signal penetration depth is more than 300 meters. The output data formats are ODC and Standard SEG-Y.

Table 6.4: Major specifications of the shipboard SBP “Bathy 2010”

Operational water depth range	10 m–12,000 m (full ocean depth)
Bottom penetration	300+ m, with up to 8 cm of marine sediment strata resolution
Data format	Raw data or processed data storage in SEG-Y format and ODC format
Correction	DGPS, Heave Compensation and Sound Velocity inputs
Type	CHIRP Sub-Bottom Profiler
Frequency	3.5 kHz
Depth Accuracy	±10 cm to 100 m, ± .3%--6,000 m

(11) Shipboard Three-Component Magnetometer

R/V Kairei is equipped with a three-component magnetometer system, SFG1214 (Tierra Technica Ltd.) (Table 6.5). Three-axis flux-gate sensors with ring-cored coils were fixed about 2 m above the deck above the bridge. Output from the sensors was digitized using a 20-bit A/D converter (1 nT/LSB), and were sampled at 8 times per second. Ship heading data were transmitted directly from a gyro compass for navigation on the bridge and were also sampled at 8 Hz. Roll and pitch data at 8 Hz are provided from an attitude sensor (TVM-4) installed on the floor of the gravity meter room. The ship's position (GPS) and speed data are taken from the LAN every second. Data are stored on the internal hard disk drive of a PC in ASCII format, and are transferred via FTP to a workstation for processing.

Table 6.5: Major specifications of the shipboard 3-component magnetometer “SFG1214”

Magnetic Sensor	System	Flux-gate sensor with ring-cored coils

	Number of components	Three orthogonal components
	Orthogonal Degree	< ±2 min
	Cable Length	50 m
	Size, Weight	φ280×130 H (mm), 5 kg
Measurement Unit	Measurement Range	±100,000 nT
	Resolution	1 nT
	Noise	0.5 nT
	Temperature Stability	0.5 T/°C
	Absolute Accuracy and Linearity	<100 nT
	AD converter	20 bit
	Conversion Rate	8 times/s
	Digital Input	RS232C 3ports
	Size, Weight	480W 150H 430D (mm), 4 kg
Data Recording Unit	Recording Media	Hard disk drive
Attitude Sensor	Measurement Item	Roll angle, Pitch Angle
	Measurement Range	±45°
	Accuracy	±0.2° (<30°)
	Resolution	0.0055°/LSB
	Output	RS422 compliance
	Size, Weight	φ320 180 H (mm), 5 kg
Others	Power Supply	Single Phase AC100 V, 50/60 Hz
	Power Consumption	350 VA

(12) Shipboard Gravity Meter

The shipboard gravity system "MGS-6" (Micro-g LaCoste Ltd.) is installed in the gravity meter room on the second deck (Fig. 6.20). The system consists of two main assemblies: a gyro-stabilized platform with a gravity sensor, and electronic components to control the system and determine gravity values. Acquired data are streamed and stored to a windows PC on the desk adjacent to the MGS-6 system using the PiperPro software provided by the manufacturer. The raw gravity data were logged every second during the cruise. Shipboard gravity data were calibrated by placing a portable instrument in a location with a known gravitational acceleration. The system incorporates the ship's position, speed, and heading through the ship's LAN, performing Etövös corrections in real time. Adjustment of time differences between filtered gravity and the ship's speed and heading might be necessary during onshore data processing.

A portable gravity meter (CG-5; Scintrex Ltd.) is used for calibration of the shipboard gravity sensor (Fig. 6.21). The gravity is measured both at the pier and at an existing reference point where the absolute gravity value has previously been determined. During this survey, measurements were made at the Northshore Riverside Park gravity station in Hamilton, Port of Brisbane during every port call, except the port call between Legs 1 and 2-1.

Table 6.6: Major specifications of onboard gravity meter "MGS-6"

Sensor	Worldwide Measuring Range	+- 500,000 mGal
	Drift Rate	< 3 mGal/month
	Temperature Setpoint	45 – 60 degC
Stabilized Platform	Platform Pitch	+- 25 degC
	Platform Roll	+- 35 degC
	Platform Period	4 – 4.5 min
	Platform Damping	0.707 of critical
Control System	Recording Rate	1 Hz

	Filter	FIR filter (Exact Blackman Window)
	Filter Length	180 second
	Correction Enabled	Etövös Correction
	VCC Coefficient	0
System Performance	Dynamic Range	25,000,000
	Static Repeatability (mGal)	0.02
	Accuracy (mGal)	<= 0.6
	50,000 mGal Horizontal Acceleration (mGal)	0.25
	100,000 mGal Horizontal Acceleration (mGal)	0.50
	100,000 mGal Vertical Acceleration (mGal)	0.25

Table 6.7: Specification of Scintrex Co. Ltd. Micro Gal Auto Gravity Meter “CG5”

Item	Specification
Reading Resolution	0.001 mGal
Minimum Operating Range	8000 mGal, without resetting
Residual Long-term Drift	Less than 0.02 mGal/day
Typical Repeatability in field use	Less than 0.005 mGal standard deviation
Range of Automatic Tilt correction	+- 200 arc second

Figure 6.20: Micro-g LaCoste Marine Gravity Meter “MGS-6” system. The image shows the shipboard gravity measurement system including sensor parts and main body (left) and data acquisition logger on the desk (right).

Figure 6.21: Portable Gravity meter: SCINTREX microGal “CG5”.

(13) eXpendable Bathy Thermograph (XBT)/ eXpendable Conductivity, Temperature, and Depth (XCTD)

An expendable profiling system (XBT/XCTD; Tsurumi Seiki Co. Ltd.) wired to a digital converter (TS-MK130; Tsurumi Seiki Co. Ltd.) was used for correction of velocity structure in the water column. An XBT probe with a T5-type temperature sensor and an XCTD probe with XCTD-2-type sensors for conductivity, temperature and depth, were used in this cruise. For each measurement, a probe is dropped from the stern deck. With the probe descending, seawater temperature and, for XCTD measurements, also conductivity and depth are measured continuously. The maximum depths of the T-5 and XCTD-2 probe are 1830 m.

7. Marine Fauna observation and mitigation

During Leg 3, two Marine Fauna Observers (MFOs), two Passive Acoustic Monitoring Operators (PAMOs) and required equipment were supplied by Blue Planet Marine (BPM) through a contract with GA. The observer team undertook marine mammal impact mitigation and monitoring to minimize the potential impact of noise made by the seismic source on marine fauna, most notably whales. Mitigation was conducted in accordance with EPBC Act Policy Statement 2.1, Interaction between offshore seismic exploration and whales and EPBC Referral Decision Letter 2017/8027.

Visual observations were undertaken by dedicated MFOs from 7 to 27 December 2017. Watches covered all daylight hours (30 minutes before and after sunrise/sunset), except for the first and last day of the survey, when the vessel departed Port of Brisbane after sunrise and arrived at Port of Brisbane before sunset, respectively. MFOs were on duty during transit and within the survey area, including during: periods when seismic, MBES and SBP sources were active; line turns; gear deployment and retrieval; and air gun maintenance and testing.

PAM was conducted for 11 days from 9 to 24 December, listening for cetacean vocalizations. PAM was undertaken during all pre-start, soft start and full power seismic operations. There were several periods when PAM was necessarily retrieved for airgun maintenance to occur, or to disentangle the PAM cable from the seismic streamer. On these occasions, the seismic source was either aboard the vessel or inactive. PAM was conducted, when possible, during transit, within the survey area and during line turns. PAM operated for the duration of the transit through Gifford Marine Park conducted on 24 December 2017 at a time when the seismic source, MBES and SBP were not operating.

Twenty-six visual sightings or acoustic detections of marine mammals were recorded during the survey. Eight visual sightings were recorded outside of the survey areas. The remaining 18 observations were recorded within the survey areas while conducting either: HR-MCS survey at drill sites using the 400 in^3 seismic source; MBES/SBP operations; or during transit through the Gifford Marine Park.

There were two interruptions to MBES operations due to the requirement for marine mammal mitigation actions; both were shutdowns (stop work procedures) of MBES operations and involved short-finned pilot whales. In total, the mitigation events accounted for 27 minutes of lost MBES operations. No mitigation actions were required during seismic or SBP operations.

BPM reported that the operations of the vessel and her personnel were compliant with the requirements of EPBC Act Policy Statement 2.1 and EPBC Referral Decision Letter 2017/8027, and no non-compliances occurred during the survey.

8. References

Bache, F. et al. Seismic stratigraphic record of transition from Mesozoic subduction to continental breakup in the Zealandia sector of eastern Gondwana. Gondwana Research 26, 1060-1078 (2014).

Burns, R. E. & Andrews, J. E. in Initial Reports of the Deep Sea Drilling Project Vol. 21 (ed T. A. Davies) 897–906 (US Government Printing Office, 1973).

Bryan, S. et al. Early Cretaceous volcano-sedimentary successions along the eastern Australian continental margin: implications for the break-up of eastern Gondwana. Earth and Planetary Science Letters 153, 85-102 (1997).

Bryan, S. E. et al. Early-mid Cretaceous tectonic evolution of eastern Gondwana: From silicic LIP magmatism to continental rupture. Episodes 35, 142-152 (2012).

Campbell, H., Malahoff, A., Browne, G., Graham, I. & Sutherland, R. New Zealand Geology. Episodes 35, 57–71. (2012).

Colwell, J. B. et al. Interpretation of seismic data, Capel and Faust basins, Australia's remote offshore eastern frontier. Report No. Record 2010/06, 58 (Geoscience Australia, 2010).

Crawford, A., Meffre, S. & Symonds, P. 120 to 0 Ma tectonic evolution of the southwest Pacific and analogous geological evolution of the 600 to 220 Ma Tasman Fold Belt System. Geological Society of America Special Papers 372, 383-403 (2003).

Hackney, R. I. Potential-field data covering the Capel and Faust basins, Australia's remote offshore eastern frontier. Report No. Record 2010/34, 40 (Geoscience Australia, 2010).

Heap, A. D. et al. Seabed environments and subsurface geology of the Capel and Faust Basins and Gifford Guyot, Eastern Australia - Geoscience Australia TAN0713 post-survey report Report No. Record 2009/22, 182pp (Geoscience Australia, 2009).

Higgins, K., Hashimoto, T., Hackney, R. I., Petkovic, P. & Milligan, P. 3D geological modelling and petroleum prospectivity assessment in offshore frontier basins using GOCAD™: Capel and Faust basins, Lord Howe Rise. Report No. Record 2011/01, 72 (Geoscience Australia, 2011).

Higgins, K. et al. Structural analysis of extended Australian continental crust: Capel and Faust basins, Lord Howe Rise. Geological Society, London, Special Publications 413, SP413. 416 (2014).

Kennett, J. P. et al. Initial Reports of the Deep-Sea Drilling Project, 90. Vol. 90 (US Government Printing Office, 1986).

Kroh, F., Morse, M. P. & Hashimoto, T. New data on Capel and Faust Basins. Preview 130, 22–24 (2007).

Matthews, K. J., Hale, A. J., Gurnis, M., Müller, R. D. & DiCaprio, L. Dynamic subsidence oEf astern Australia during the Cretaceous. Gondwana Research 19, 372-383 (2011).

Matthews, K. J., Seton, M. & Müller, R. D. A global-scale plate reorganization event at 105−100Ma. Earth and Planetary Science Letters 355, 283-298 (2012).

McDougall, I. & van der Lingen, G. J. Age of the rhyolites of the Lord Howe Rise and the evolution of the southwest Pacific Ocean. Earth and Planetary Science Letters 21, 117-126, doi:10.1016/0012-821X(74)90044-2 (1974).

Mortimer, N. et al. Triassic–Jurassic granites on the Lord Howe Rise, northern Zealandia. Australian Journal of Earth Sciences 62, 735-742, doi:0.1080/08120099.2015.1081984 (2015).

Mortimer, N., et al. Zealandia: Earth's Hidden Continent. GSA TODAY, 27. 3, 27-35 (2017).

Och, D., Offler, R., Zwingmann, H., Braybrooke, J. & Graham, I. Timing of brittle faulting and thermal events, Sydney region: association with the early stages of extension of East Gondwana. Australian Journal of Earth Sciences 56, 873-887 (2009).

Seton, M. et al. Global continental and ocean basin reconstructions since 200Ma. Earth-Science Reviews 113, 212-270 (2012).

Stampfli, G. M., von Raumer, J. F. & Borel, G. D. Paleozoic evolution of pre-Variscan terranes: from Gondwana to the Variscan collision, Geological Society of America, Special Paper 364. 263-280 (2002).

Sutherland, R. et al. Compilation of seismic reflection data from the Tasman Frontier region,

southwest Pacific. Report No. 2012/01, 72 (GNS Science Report, 2012).
Sutherland, R. et al. Expedition 371 Preliminary Report: Tasman Frontier Subduction Initiation and Paleogene Climate. International Ocean Discovery Program, https://doi.org/10.14379/iodp.pr.371.2018 (2018).
Tulloch, A. et al. Cretaceous felsic volcanism in New Zealand and Lord Howe Rise (Zealandia) as a precursor to final Gondwana break-up. Geological Society, London, Special Publications 321, 89-118, doi:10.1144/SP321.5 (2009).