MARINE FAUNA OBSERVER'S REPORT DURING LORD HOWE RISE MARINE SEISMIC SURVEY

2ND APRIL 2016 TO 11TH MAY 2016

Prepared by:

RPS

Level 2, 27-31 Troode Street, West Perth WA 6005
PO Box 170, West Perth WA 6872

T: 618 9211 1111
F: 618 9211 1122
E: operations01@rpsgroup.com.au
W: rpsgroup.com.au

Report No: AOE07135
Version/Date: Rev 0, July 2016

Prepared for:

GEOSCIENCE AUSTRALIA

Cnr Jerrabomberra Ave and Hindmarsh Drive,
Symonston ACT 2609

PO Box 378, Canberra 2601

T: 1800 800 173
F: +61 2 6249 9346
E: scott.nichol@ga.gov.au
W: ga.gov.au

Document Status

Version	Purpose of Document	Orig	Review	Review Date	Format Review	RPS Release Approval	Issue Date
Draft A	For Internal Review	RL, SS, PL, TL	MH	20.05.16	SN 18.05.16		
Draft B	For Internal Review		VS	23.05.16	DC 07.07.16	08.07.16	
Rev 0	Final For Issue						08.07.16

Initials

RL: Rebecca Lindsay
SS: Scott Sheehan
PL: Patrick Lyne
TL: Tim Lewis
SN: Sandie Newman-Laws
KC: Kerrie Coombe
MH: Margaret Hallett
VS: Verity Steptoe
DC: Doris Clarke

EXECUTIVE SUMMARY

Geoscience Australia (GA) and the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), undertook a collaborative scientific marine seismic survey on the Lord Howe Rise between 23rd March and 11th May 2016 on the Research Vessel *Kairei*. To minimise the risk of acoustic disturbance from the seismic source on cetaceans, as well as other marine fauna, GA commissioned RPS Energy Pty Ltd (RPS) to provide two Marine Fauna Observers (MFO) and two Passive Acoustic Monitoring (PAM) operators for the period of seismic data acquisition (2nd April – 11th May). Seismic acquisition and source operational procedures were undertaken in accordance with the Environmental Protection and Biodiversity Conservation (EPBC) Act Policy Statement 2.1 *Interaction between offshore seismic exploration and whales* (DEWHA 2008), and as outlined in EPBC Referral Decision 2015/7623. This report identifies activities undertaken by visual and passive acoustic monitoring observers and provides details of marine fauna sightings and detections recorded during the period in which seismic operations were conducted.

The role of the MFOs was to undertake dedicated daylight visual observations for cetaceans and other marine fauna during the survey, coordinate mitigation activities during seismic, multibeam echosounder (MBES) and sub-bottom profiler (SBP) operations, and deliver formal inductions of scientific crew and associated vessel personnel on the implementation of mitigation measures as outlined in EPBC Act Policy Statement 2.1. Given the potential of encountering sperm whales in the region, two dedicated and experienced PAM operators also maintained 24-hour acoustic monitoring for cetaceans during periods of seismic acquisition.

Monitoring effort was conducted over a period of 39 days and included a total of 442 hours and 33 minutes of visual observations and 456 hours and one minute of passive acoustic monitoring. A total of 29 marine fauna sightings and 50 marine fauna detections were recorded during this time. Of these, sperm whales accounted for 21 (72%) of the 29 sightings and 35 (70%) of the 50 acoustic detections. A total of seven seismic source shutdown and nine MBES/SBP shutdown events were instigated by an applicable species detected within the 2 km and 500 m mitigation zones, respectively. Cumulatively, the seismic shutdown events were responsible for 24 hours and 33 minutes of lost production time. There were two separate instances of non-compliance: The first involved deployment and testing of the seismic gear outside the approved survey area, and the second involved a re-start at full power following shutdown. For all other operations, the conditions described in the EPBC Referral Decision (2015/7623) and EPBC Act Policy Statement 2.1 were met.

TABLE OF CONTENTS

Page

TABLES

(contained within report text) **Page**

FIGURES

(contained within report text) **Page**

APPENDICES

APPENDIX 1: EPBC Act Policy Statement 2.1 (PDF)

APPENDIX 2: Referral decision 2015/7623 (PDF)

APPENDIX 3: CheckPoint exported data (.xml)

APPENDIX 4: CheckPoint exported data (PDF)

APPENDIX 5: MFO Effort Data (.xls)

APPENDIX 6: MFO Operations Log (.xls)

APPENDIX 7: Marine Fauna Detections (acoustic and visual) (.xls)

APPENDIX 8: Multibeam Echosounder and Sub-bottom Profiler Operations Log (.xls)

APPENDIX 9: Seismic Operations Log (.xls)

APPENDIX 10: Screen Images of Acoustic Detections (.docx)

APPENDIX 11: Soft Starts and Gun Tests (.docx)

1.0 INTRODUCTION

Geoscience Australia (GA), in collaboration with the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), undertook a two-dimensional (2D) multi-channel seismic survey on the Lord Howe Rise between 23rd March and 11th May 2016. The survey was undertaken on the Research Vessel (RV) *Kairei*, operated by JAMSTEC and crewed with scientific personnel from JAMSTEC, GA and collaborators (University of Sydney and GNS Science New Zealand). Seismic data was acquired along an east-west transect up to 900 km in length across the Lord Howe Rise, and at six sites being considered for stratigraphic drilling as part of the IODP proposal (Figures 1 and 2). In addition to seismic data acquisition, 100 Ocean Bottom Seismometers (OBS) were deployed at 100 locations along a portion of the 900 km east-west seismic transect. Multibeam echosounder (MBES), sub-bottom profiler (SBP), gravity and magnetic data were also acquired across all survey sites and on transits, outside 12 nautical miles (NM) from the east Australian coast.

The Lord Howe Rise marine seismic survey consisted of three survey legs:

- Leg One: 23rd March–30th March 2016.
- Leg Two: 2nd April–20th April 2016.
- Leg Three: 22nd April–11th May 2016.

Leg One involved OBS deployment and MBES/SBP operations, while Legs Two and Three involved OBS retrieval, MBES/SBP operations and seismic operations. Seismic acquisition was initiated on 3rd April 2016 at 01:32 hours Universal Coordinated Time (UTC), with an airgun test at 27°06.97”S and 155°26.51”E. Seismic acquisition was completed on 9th May 2016 at 20:46 hours UTC at 27°15.74”S and 155°48.29”E. MBES operations commenced on 2nd April 2016 at 05:38 hours UTC at 26°58.23”S and 153°44.17”E and were completed on 10th May 2016 at 18:10 hours UTC at 26°54.86”S and 153°42.48”E. SBP operations commenced on 3rd April 2016 06:13 hours UTC at 27°15.29”S and 155°37.18”E and were completed on 10th May 2016 at 18:10 hours UTC at 26°54.86”S and 153°42.48”E.

This report identifies activities undertaken by visual and passive acoustic monitoring observers during the period of seismic operations, and provides details of marine fauna sightings and detections recorded during Leg Two and Leg Three of the survey. It describes in detail all MFO and PAM observational effort and the overall conduct of the survey in its adherence to operational procedures as defined in EPBC Act Policy Statement 2.1 – *Interaction between offshore seismic exploration and whales* (Part A – Standard Management Procedures and Part B – Additional Management Procedures) (Appendix 1) and as set out in the EPBC Referral Decision 2015/7623.

2.0 SURVEY AREA

The survey area was located in offshore eastern Australia (Figure 1). It was focused primarily on the Lord Howe Rise, but extended from the Tasman Basin and Dampier Ridge in the west to the New Caledonia Trough in the east, covering approximately 140,000 square kilometres (km^2) (Figures 1 and 2). At its closest, the survey area was approximately 200 km east of Brisbane. Water depths within the survey area ranged from approximately 1,100 metres (m) to 4,800 m.

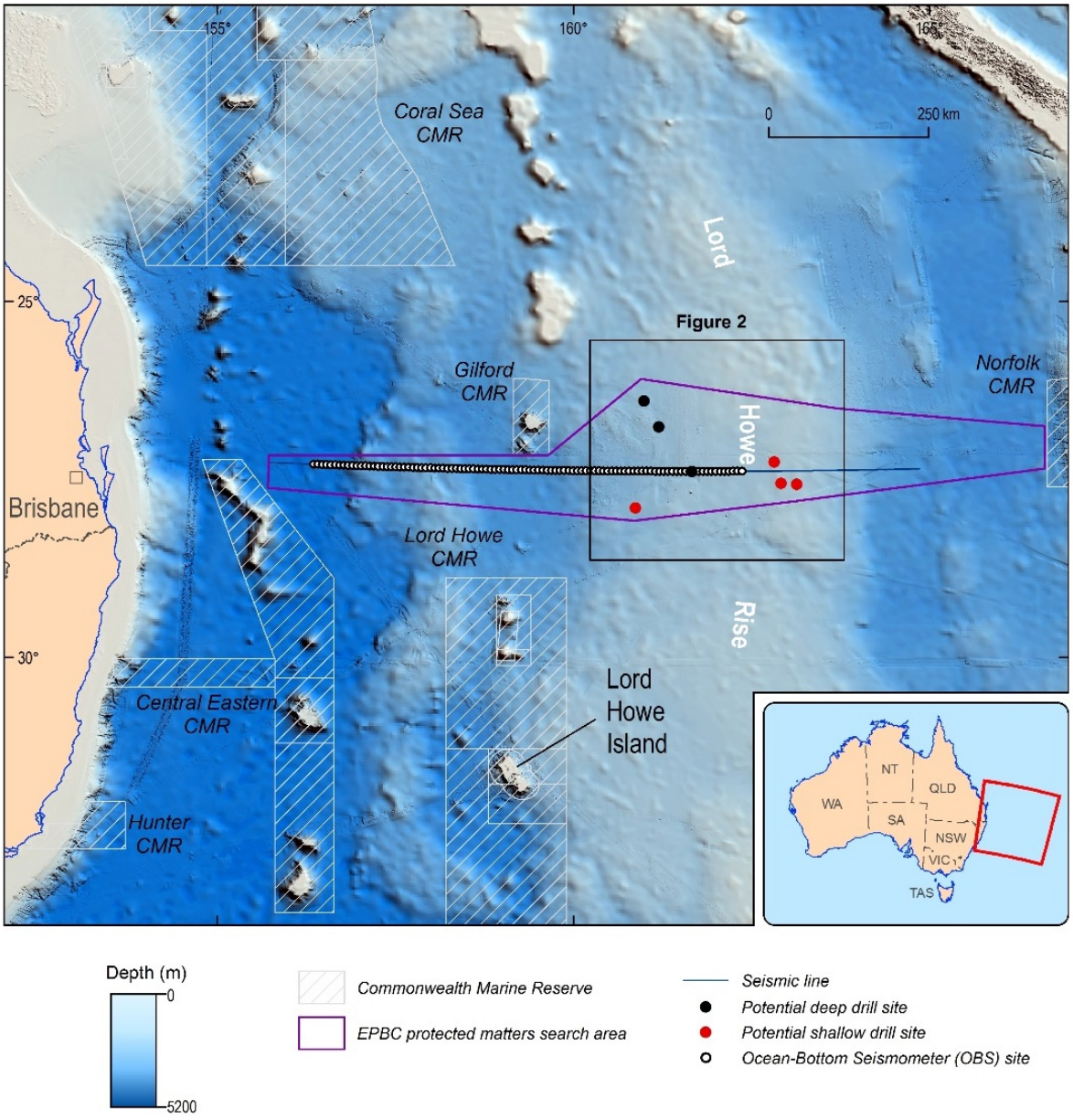


Figure 1: Survey area of the Lord Howe Rise marine seismic survey (from Referral 2015/7623)

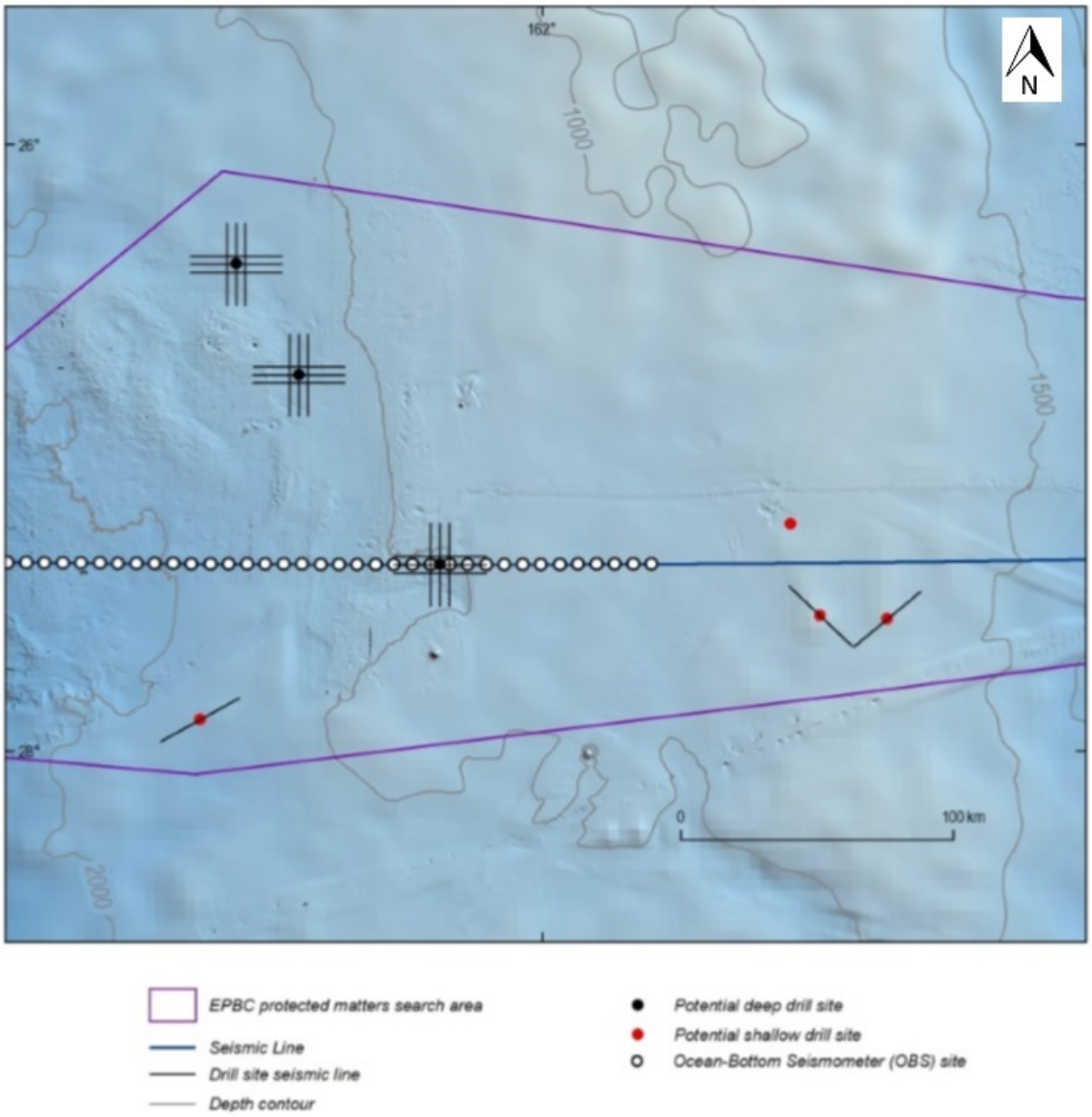


Figure 2: Location of potential drill sites for planned seismic acquisition (from Referral 2015/7623)

3.0 EQUIPMENT AND METHODS

3.1 Seismic Equipment and Sound Emissions

The seismic source array comprised 32 individual airguns providing a total source volume of 7,800 cubic inches (in^3). However, the deployment depth of the seismic source differed between the east–west OBS transect and the drill sites (Table 1). The R/V *Kairei* deployed the seismic array at a depth of 10 m for acquisition along the east–west OBS line and at a depth of 6 m for acquisition at the drill sites. The source operated at frequencies ranging between 15–70 Hertz (Hz). The total discharge pressure was approximately 2,000 pounds per square inch (psi), with a shotpoint (SP) interval of 200 m for the east–west OBS transect and 50 m for the drill sites. The nominal centre of the towed array (COS) was located 175 m from the R/V *Kairei* Bridge where the MFOs were stationed for visual observations.

Seismic reflections from subsurface layers were detected via hydrophones mounted along the Sercel Sentinel digital marine seismic streamer cable. Cable levellers (or "birds") were placed along the length of the streamer to maintain vertical positioning at a depth of 12 m for acquisition of the east–west OBS transect and at a depth of 8 m at the drill sites. A tailbouy was deployed at the end of the streamer to provide a relative range and bearing using radio telemetry.

Table 1: Lord Howe Rise Seismic Acquisition Parameters

Parameter	Value for East–West OBS Transect	Value for Drill Sites and East–West MCS Transect
No. of Streamers	1	1
Streamer Length	6,000 m	6,000 m
Streamer Depth	12 m	8 m
Acquisition Speed	~5.0 knots (kn)	~5.0 knots (kn)
Streamer Type	Sercel Sentinel digital streamer	Sercel Sentinel digital streamer
Number of Active Airguns in Array	32	32
Size of Seismic Energy Source Array	7,800 in^3	7,800 in^3
Nominal Source Pressure	2,000 psi	2,000 psi
Seismic Energy Source Depth	10 m	6 m
Peak Sound Pressure Level (SPL)	265 dB re 1µPa at 1 m	264 dB re 1µPa at 1 m
Frequency Range (peak -3 dB)	15–50 Hz	20–70 Hz
Shotpoint Interval	200 m	50 m
Minimum Depth	1,360 m	1,172 m

3.2 Multibeam Echosounder and Sub-Bottom Profiler Operations

A SeaBeam 3012 full ocean depth MBES mounted in the hull of the R/V *Kairei* was utilised throughout the survey. The system operates at 12 Kilohertz (kHz) in water depths ranging from 50 m to 11,000 m, at survey speeds of up to 12 kn. It has a maximum swath width of 140° and each of the beams covers a 1–2° arc of the sea floor. The pings were of relatively short duration: 0.7–15 milliseconds (ms). Additionally, SBP data was acquired along all transits and seismic survey lines using a hull-mounted SyQwest Bathy-2010 SBP.

3.3 Passive Acoustic Monitoring Equipment

A PAM system was supplied by Seiche Measurements Limited (http://www.seiche.com) and installed by the PAM operators prior to commencement of the survey. The PAM operator controlled and monitored the PAM system from the PAM base-station located in the instrument room, on the hangar deck of the R/V *Kairei* (Figure 3).

The hydrophone system consisted of a 100 m deck cable connected to a 230 m heavy-duty tow cable, which was in turn connected via an underwater connector to a detachable 20 m hydrophone section. The deck cable connected the PAM hydrophone array to the PAM processing and analysis base-station. The hydrophone section consisted of four spherical hydrophones, two (H1 and H2) with an operational range of 200 Hz to 200 kHz and a sensitivity of -166 dB re 1V/µPa and two (H3 and H4) with an operational range of 2 kHz to 200 kHz and sensitivity of -157 dB re 1V/µPa. The hydrophone element spacing was optimised for the target bandwidth of each pair of elements (H1-H2: 2 m, H3-H4: 0.25 m, with the distance between the two pairs, H2-H3, of 13 m) (Figure 4). The towed array terminated with a depth sensor and a 5 m rope drogue to minimise array weave.

The PAM base-station consisted of:

- a buffer box providing power to the hydrophone array
- A National Instruments (NI) USB 6251 Data Acquisition Card (DAQ) that provided high-frequency sound processing and digitisation up to a sample rate of 500 kHz per channel on two channels
- a Fireface 800 sound card for low and medium frequency signal processing and digitisation up to a sample rate of 192 kHz
- a Measurement Computing USB-1208LS analogue to digital converter board for digitising the depth sensor signal and sending to the PC (personal computer) and PAMGuard via USB
- a serial to USB (universal serial bus) converter to connect to the vessel's National Marine Electronics Association (NMEA) Global Positioning System (GPS) serial feed

- a rack-mounted PC with an Intel Core(TM) i5-3570 3.4 GHz CPU × 4, 8 GB RAM (random access memory) and a 64-bit operating system, running Windows 7, with slide-out monitor, keyboard and mouse

- PAMGuard v1.13.02 Beta software installed on the computer, which allowed signal analysis of digitised high and low frequency sound and provided a variety of tools and display formats that allowed the operator to view and analyse marine mammal vocalisations in real-time. The software also allowed conditioning of the sound output, in particular, to remove the seismic source for acoustic monitoring during seismic operations

- dual, flat screen monitors with mouse and keyboard to view PAMGuard

- Sennheisser HD 280 Pro and HD215 stereo headphones for monitoring sounds within the human auditory range (e.g. direct sounds from the elements, amplified sound direct from the sound card or sound processed through PAMGuard)

- a JTS SIEM-101T radio link system that provided a radio connection between the PAM station and the headphones, which could be used to monitor sounds away from the base-station. This system also provided a cable connection feed to a second pair of headphones that allowed dual monitoring of sound at the base station (i.e. for monitoring by an additional person)

- a complete spare system (100% redundancy) as backup in case of failure or damage to the equipment.

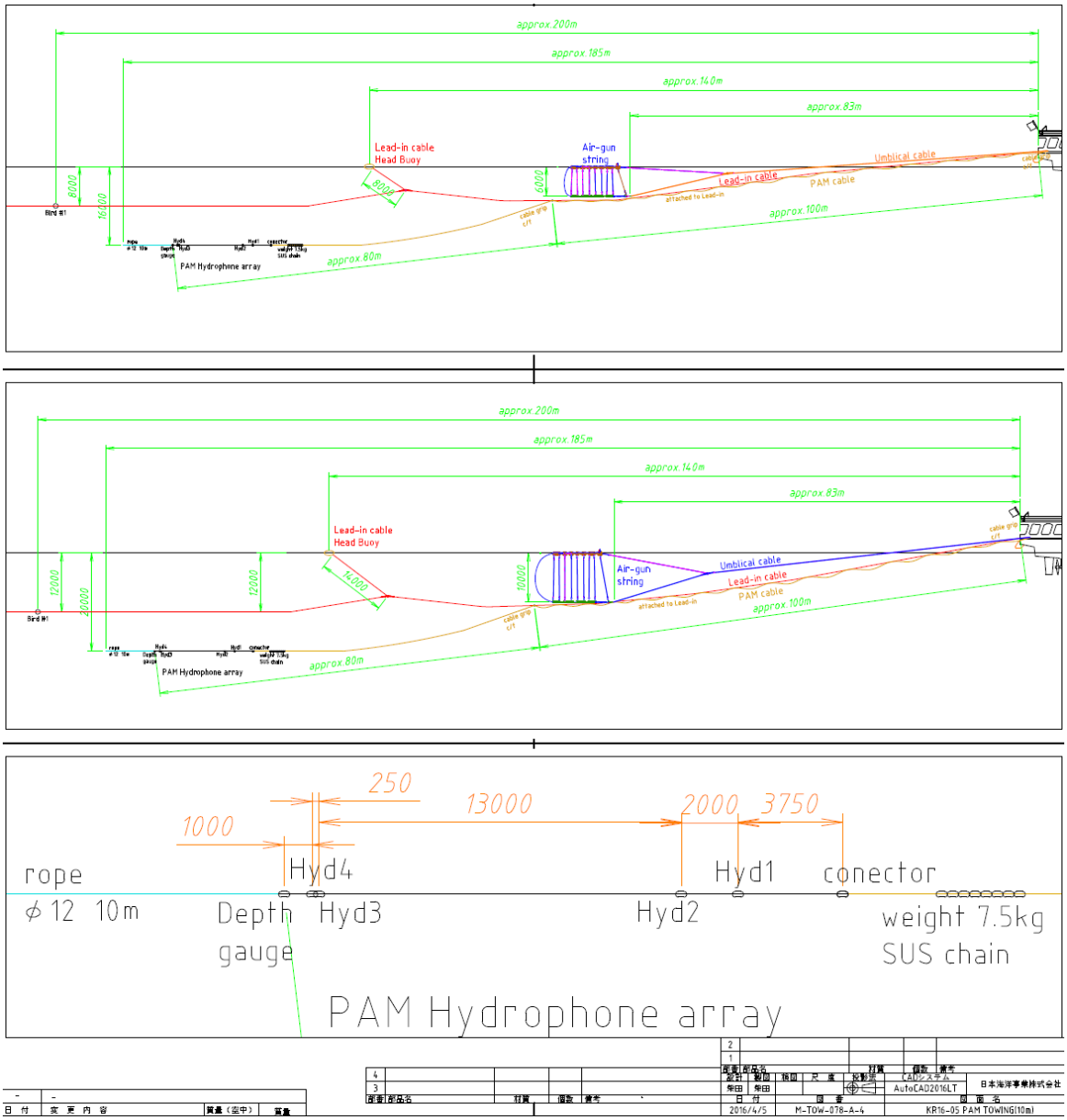
Figure 3: PAM base-station on the R/V *Kairei*

3.3.1 System Configuration

The high-frequency digitised sound (400 kHz sample rate on two channels) from the NI 6251 DAQ of the PAM base-station was re-routed to the backup computer system which performed high-frequency sound processing, analysis and, when required, recording. This reduced the processing demands on the base-station and provided a third operating screen on which to view high-frequency clicks. The base-station computer then processed and analysed sound at the higher than usual rate of 96 kHz sample rate, allowing analysis of sounds up to 48 kHz, i.e. to include frequencies used by beaked whales.

3.3.2 Hydrophone Deployment

The hydrophone cable was deployed from the centre stern back deck of the R/V *Kairei* by hand (Figure 4). The rope drogue was shortened to 5 m prior to first deployment to reduce the possibility of entanglement with seismic equipment. The Vessel Reference Point to stern is 76.7 m. The last 60 m of the tow cable, the 20 m hydrophone section and the 5 m rope drogue were streamed free. A 7.5 kilogram chain was taped to the hydrophone tow cable 5 m from the wet end. This allowed for a total of 85 m of PAM cable and rope free in the water. A further 100 m of PAM tow cable was then attached to the streamer lead-in by tape, with the free-swimming section attached to the seismic streamer by a Chinese finger. This resulted in the total deployment of 185 m of cable which allowed the hydrophone section to reach a depth of about 16 m and 20 m when the seismic streamer was towed at depths of 6 and 10 m respectively, thereby avoiding the first bird on the streamer located at 200 m. The cable was towed at speeds of approximately 4.5–5.0 kn.



(Source: JAMSTEC)

Figure 4: PAM array deployment configuration

3.4 Marine Mammal Survey Methods

3.4.1 Visual Observation

Two MFOs maintained daylight visual observations for cetaceans and other marine fauna, for the duration of the seismic survey. Visual observations were predominantly undertaken from the bridge (approximately 12.5 m eye height above sea level) and compass deck (approximately 15.5 m eye height above sea level), of the R/V *Kairei* which provided panoramic views around the entire vessel. Visual observations commenced approximately 30 minutes before sunrise and concluded 30 minutes after sunset each day.

GA and JAMSTEC opted to treat the 2 km “low power” zone described in the EPBC Policy Statement 2.1 as a “shutdown” zone as an additional mitigation measure. The shutdown zone for MBES and SBP operations was 500 m, as described in Referral Decision 2015/7623 (Appendix 2). Visual observations were focussed on the 2 km seismic source shutdown zone and the 500 m MBES/SBP shutdown zone, however these zones extended out to 3 km and beyond when possible (contingent upon weather conditions), as per the requirements under Section A.3.1 of EPBC Policy Statement 2.1 (DEWHA 2008).

Communication protocols were established between the MFOs and seismic operators prior to the commencement of the survey. Requests for instantaneous shutdowns and commencement of soft starts after a mitigation event were communicated using handheld UHF (ultra-high frequency) radios between MFOs/PAM operators and the seismic operations team.

Distance to marine fauna was determined with the use of 7 × 50 reticule binoculars. The reticule measurements were entered into an Excel® spreadsheet that had a trigonometric formula pre-loaded. This formula triangulated the distance between the sighted cetacean and the centre of the acoustic source array, providing results in metres.

According to the EPBC Act Policy Statement 2.1, mitigation was to be implemented for the protection of applicable marine species, which includes baleen whales and larger toothed whales such as beaked whales, sperm whales, killer whales, pilot whales and false killer whales.

For each marine fauna sighting event, the UTC time and the Australian Eastern Standard Time (AEST), distance, true bearing, species, number of animals, presence of calves, direction of animal movement, animal behaviour, vessel’s position and heading, water depth and source status were recorded within the software “CheckPoint” (version 12.1.3.706). Species were identified to the lowest taxonomic group possible with reference to Shirihai and Jarrett’s *Whales, Dolphins and Seals, a field guide to the marine mammals of the world* (2006). If the observed animal could not be identified to species level due to the distance of the animal to the observer or due to unfavourable environmental conditions, then a record was made noting as many characteristics as possible (e.g. unidentified pilot whale). Visual observation effort, environmental conditions, and source operations were also recorded using CheckPoint (Appendices 3 and 4) and in customised electronic spreadsheets (Appendices 5, 6 and 7). Seismic crew provided daily logs containing seismic operation times and corresponding geographic coordinates (Appendix 9) which were cross-checked with MFO records to ensure operational compliance.

3.4.2 Passive Acoustic Monitoring

PAMGuard software was configured to show analysed sound in a variety of formats to assist the PAM operator with detection, identification and localisation of marine mammal vocalisations. On the low–medium frequency (96 kHz sample rate), sounds were plotted on spectrograms with clicks being plotted on time-bearing, waveform, spectrum and Wigner plot (detailed spectrogram). For high-ultrasonic frequencies (200 kHz sample rate) sounds were plotted on a click detector with time, bearing, waveform, spectrum, and Wigner plot displays. Automatic and manual detections were then plotted on a map display (with vessel, hydrophone, seismic array and mitigation zones plotted) and on a radar-type display.

Continuous recordings were made whenever the PAM system was deployed, mostly at 96 kHz sample rate (two channels), although there were periods during Leg 2 when the system became overloaded with noise from the seismic equipment when this was reduced to 48 kHz. Selected recordings (e.g. during periods of interest), were also made at 200 kHz sample rate (two channels). Samples of screen images were made during marine mammal acoustic detections when possible.

The seismic operators notified the PAM operator at least 30 minutes prior to initiating planned seismic source operations. The PAM operator then communicated this information to the MFO during daylight observation times via UHF radio. Immediately prior to the commencement of all seismic data acquisition, the seismic operators requested an “All Clear" to commence from the PAM operator. Provided there were no whales detected within the 2 km mitigation zone, an “All Clear” was given by either both the PAM operator and MFO, during daylight, or by the PAM operator during night-time operations. During night-time operations, the PAM operator was solely responsible for monitoring and mitigation actions (i.e. pre-seismic source start-up watches and monitoring during periods when the source was active).

4.0 RESULTS

4.1 Survey Operations

Survey operations were continuous throughout Legs Two and Three of the survey with the exception of two periods of operational downtime. Firstly, high sea state conditions prevented the deployment of seismic gear between 25th and 29th April 2016 and MBES/SBP operations from 26th April 2016 AEST until 27th April 2016 AEST. The second instance of downtime occurred on 7th May 2016 when an unresponsive fishing vessel towing a longline ahead of the R/V *Kairei* resulted in a decision to shut down the seismic source at 17:54 hours AEST in order to undertake a large turn to avoid coming into contact with the vessel or its equipment. Seismic data acquisition resumed on 8th May 2016 at 08:45 hours AEST (N.B. MBES/SBP operations were continuous during this time).

4.1.1 Seismic Operations

Seismic operations commenced with a gun test on 3rd April 2016 at 1:32 hours UTC in position 27°06.97"S and 155°26.51"E (see Section 5.6). The final shotpoint was made on 9 May 2016 at 20:46 hours UTC at 27°15.74"S and 155°48.29"E.

Over the course of the survey, 39 sequences were acquired through 32 soft start procedures, followed by 33 full power operations (see Section 5.6). Each of the soft start procedures ran for a minimum of 30 minutes (Appendix 11). Overall, the seismic source was operational for a total of 247 hours and 7 minutes comprising 47 minutes of gun tests, 18 hours and 22 minutes of soft starts and 227 hours and 58 minutes at full power (Table 2).

Table 2: Seismic Operations during the Lord Howe Rise 2D MSS

Operation Type	Leg Two		Leg Three		Total	
	Number	Duration (Hours:Minutes)	Number	Duration (Hours:Minutes)	Number	Duration (Hours:Minutes)
Gun tests	2	00:19	4	00:28	6	00:47
Soft starts	17	09:54	15	08:28	32	18:22
Full power	18	139:23	15	88:35	33	227:58
Total		149:36		97:31		247:07

4.1.2 Multibeam and Sub-bottom Profiler Operations

MBES operations commenced on 2nd April 2016 at 05:38 hours UTC at 26°24.74"S and 160°52.80"E and were completed on 10th May 2016 at 18:10 hours UTC at 26°54.86"S and 153°42.48"E. Overall, the MBES was active for a total of 828 hours and 07 minutes (Table 3). SBP operations commenced on 3rd April 2016 at 06:13 hours UTC at 27°15.29"S and 155°37.18"E and were completed on 10th May 2016 at 18:10 hours UTC at 26°54.86"S and 153°42.48"E. Overall, the SBP source was operational for a total of 754 hours and 55 minutes (Table 3). A full log of MBES and SBP operations is provided in Appendix 8.

Table 3: MBES and SBP Operations during the Lord Howe Rise 2D MSS

Operation Type	Duration Leg Two (Hours:Minutes)	Duration Leg Three (Hours:Minutes)	Total Duration (Hours:Minutes)
MBES	409:57	418:10	828:07
SBP	338:33	416:22	754:55

4.2 Visual Observation Effort

Visual monitoring was conducted over a total period of 39 days, within the survey area and during transits. Visual observations were carried out whilst the seismic, MBES and SBP sources were active and during periods of gear deployment, equipment maintenance, line turns and transits. A total of 442 hours and 33 minutes of visual observation effort was conducted by the two MFOs throughout the survey. Of the total visual observations, 4.8% (20 hours and 55 minutes) consisted of pre-start-up observations prior to activation of the seismic source, 2.7% (12 hours and seven minutes) consisted of soft starts and gun tests, 31.7% (140 hours and five minutes) consisted of full power observations and 60.8% (268 hours and 55 minutes) consisted of routine observations involving no seismic operations. The seismic source was active for 34.5% (152 hours and 12 minutes) of the total MFO observation effort (Table 4 and Figure 5).

Table 4: Visual Observation Effort by Seismic Source Status

Visual Monitoring Effort Type	Leg Two Duration (Hours:Minutes)	Leg Three Duration (Hours:Minutes)	Total Duration (Hours:Minutes)
Pre-start-up observations	11:46	9:13	20:55
Soft start observations (including gun tests)	7:18	4:49	12:07
Full power observations	67:27	72:38	140:05
Routine observations	134:36	134:19	268:55
Total time source active during visual observations	74:45	77:27	152:12

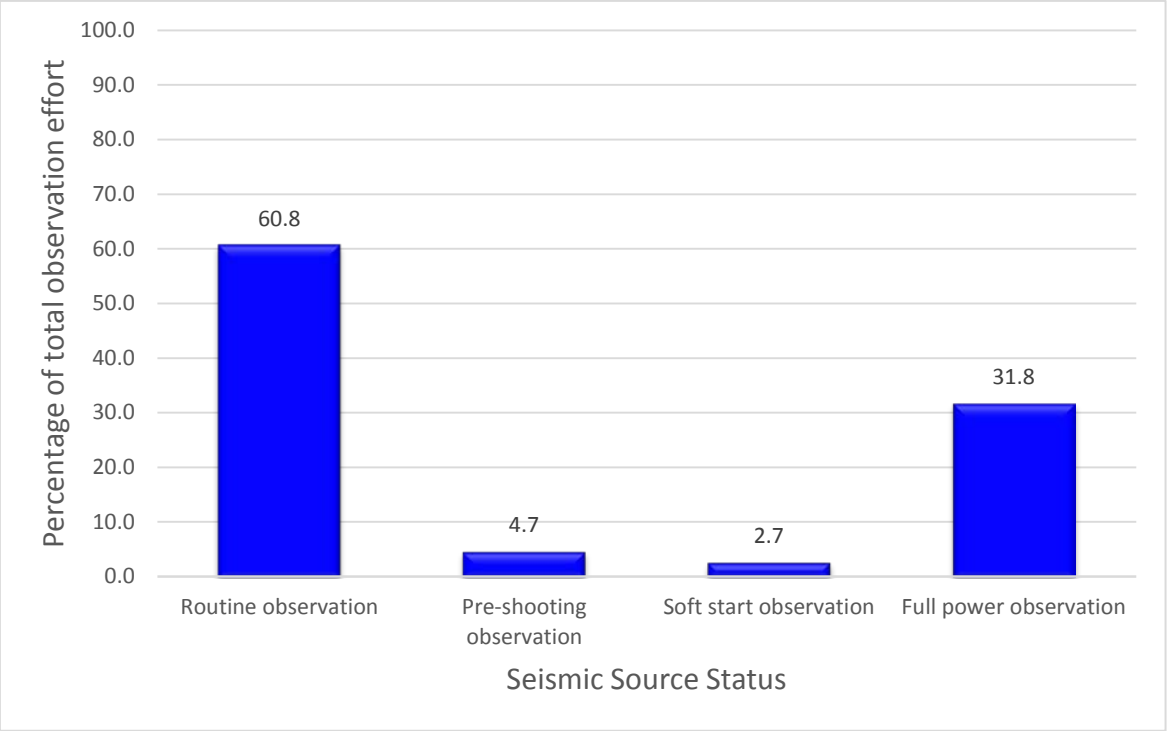


Figure 5: MFO observation effort as a function of seismic source status

4.3 Environmental Conditions

Environmental factors such as sea state, swell height, sun glare, haze and precipitation can affect the ability of an observer to sight cetaceans and other marine fauna. Sighting conditions over the course of the survey ranged from good to very poor. The Beaufort wind force scale ranged from 2 to 7 during periods of visual monitoring, with 48.3% of time spent observing in favourable conditions (Beaufort ≤3; Figure 6). Overall, 90.2% of observations recorded a visibility range of 3 km or more (i.e. mitigation zones could still be effectively monitored), however observations were hampered 53.2% of the time as a result of high winds, sea state and darkness. Wind direction was predominantly from the south-east over the course of the survey, with occasional easterly winds (Figure 7). Sun glare affected visibility; 42.8% of observation hours were hindered to some extent by medium to bad glare (Figure 8). Swells were predominantly from an easterly direction and swell heights were recorded <2 m for 86% of monitoring effort (Figure 9).

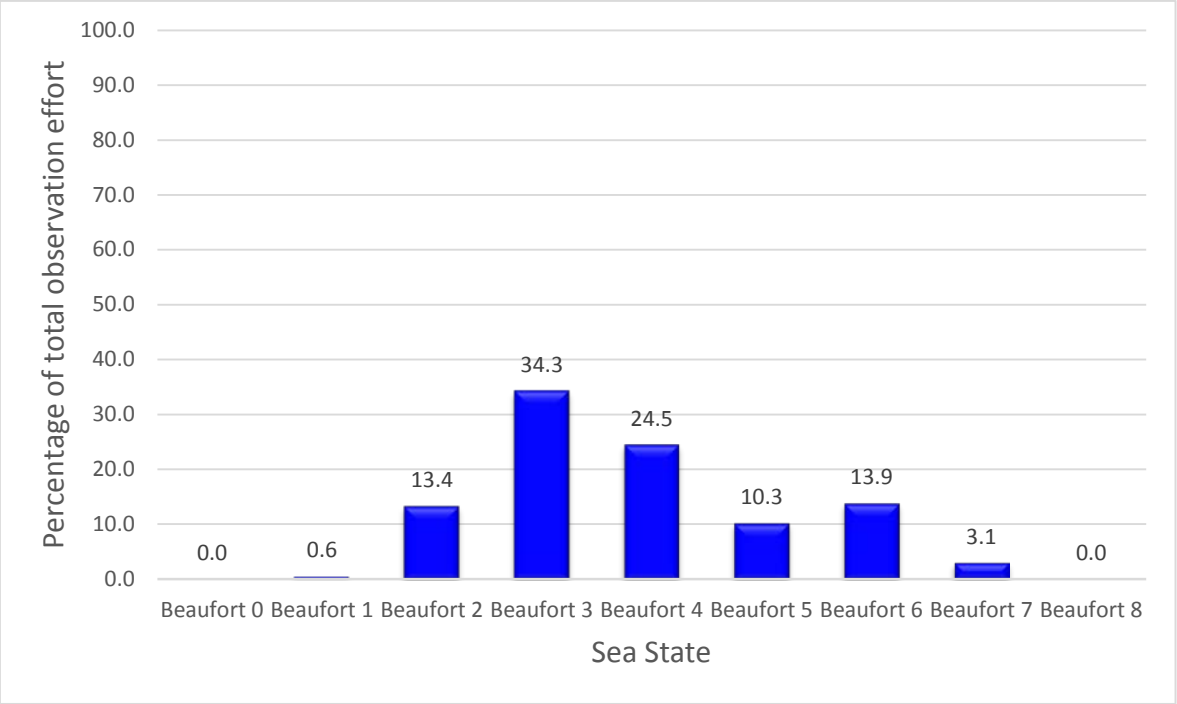


Figure 6: Percentage of MFO monitoring effort undertaken relative to Beaufort Wind Force Scale

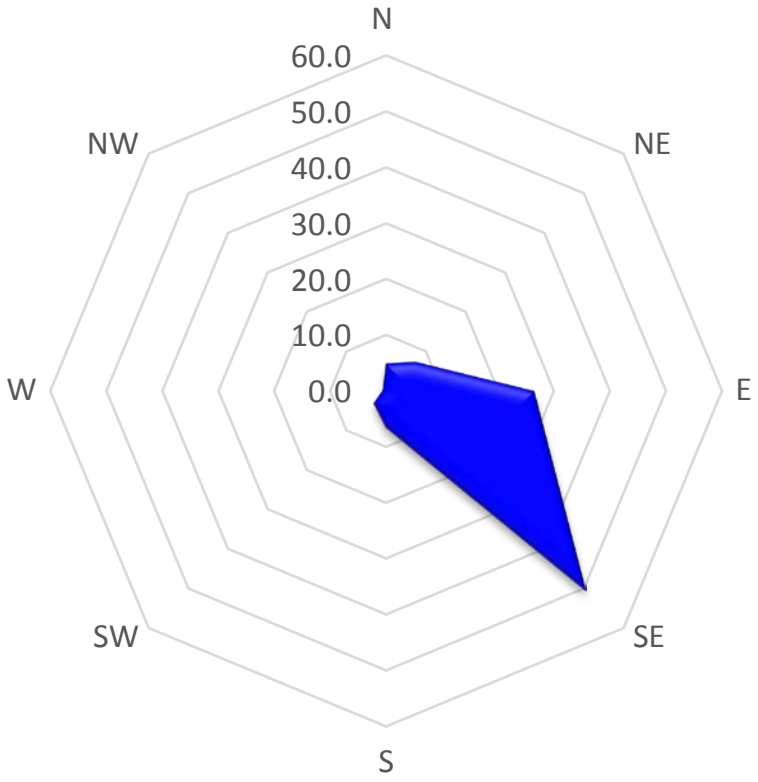


Figure 7: Wind Rose displaying predominant wind Direction during MFO monitoring effort

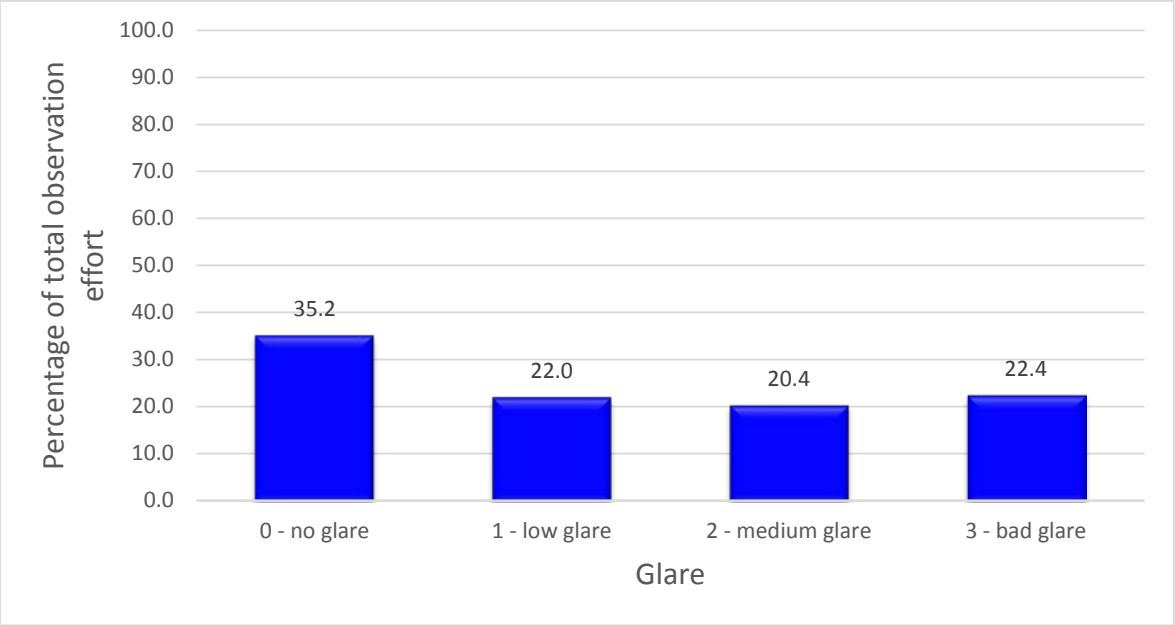


Figure 8: Percentage of MFO monitoring effort undertaken relative to sun glare

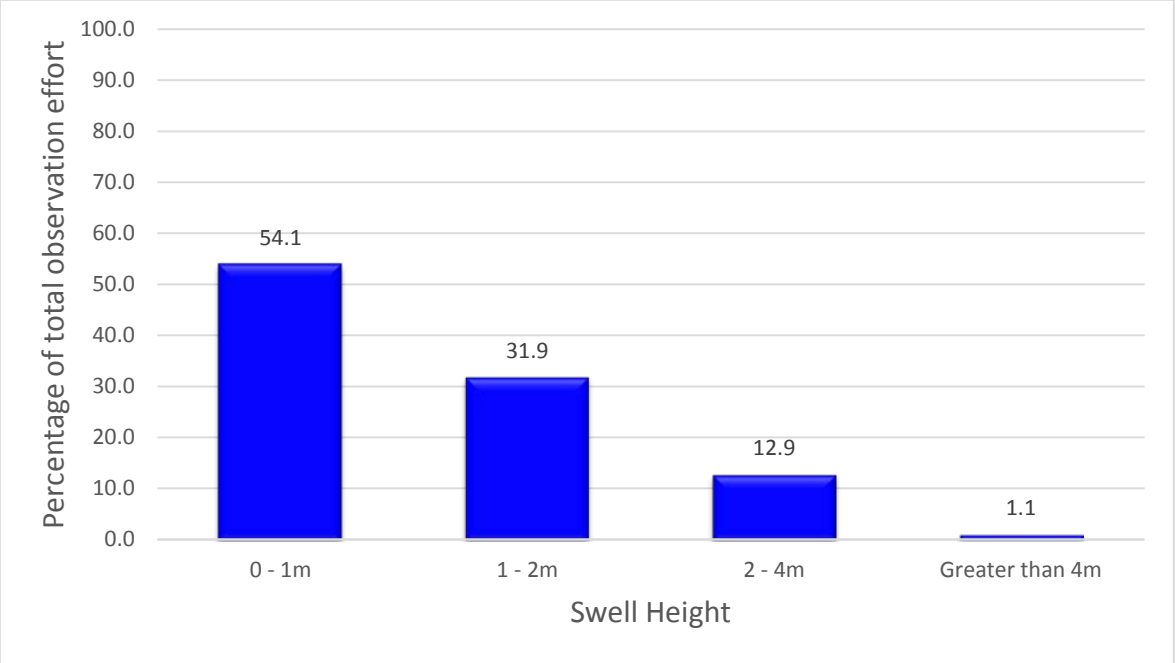


Figure 9: Percentage of MFO monitoring effort undertaken relative to swell conditions

4.4 Passive Acoustic Monitoring Effort

PAM was conducted over a total period of 24 days. Overall, this totalled 456 hours and one minute of effort undertaken by the two PAM operators. Of the total time spent monitoring, 64.7% (294 hours and 50 minutes) occurred when the seismic source was active and 35.3% (161 hours and 11 minutes) occurred when the seismic source was not active (i.e. during periods of pre-start-up acoustic observations and line turns).

4.5 Marine Fauna Distribution and Occurrence

The MFOs and PAM operators observed and monitored for the presence of applicable cetacean species (DEWHA 2008), however sightings of other marine fauna including sharks and sea turtles were also recorded. A total of 29 marine fauna sightings and 50 marine fauna detections were recorded throughout the survey (Figures 10 and 11).

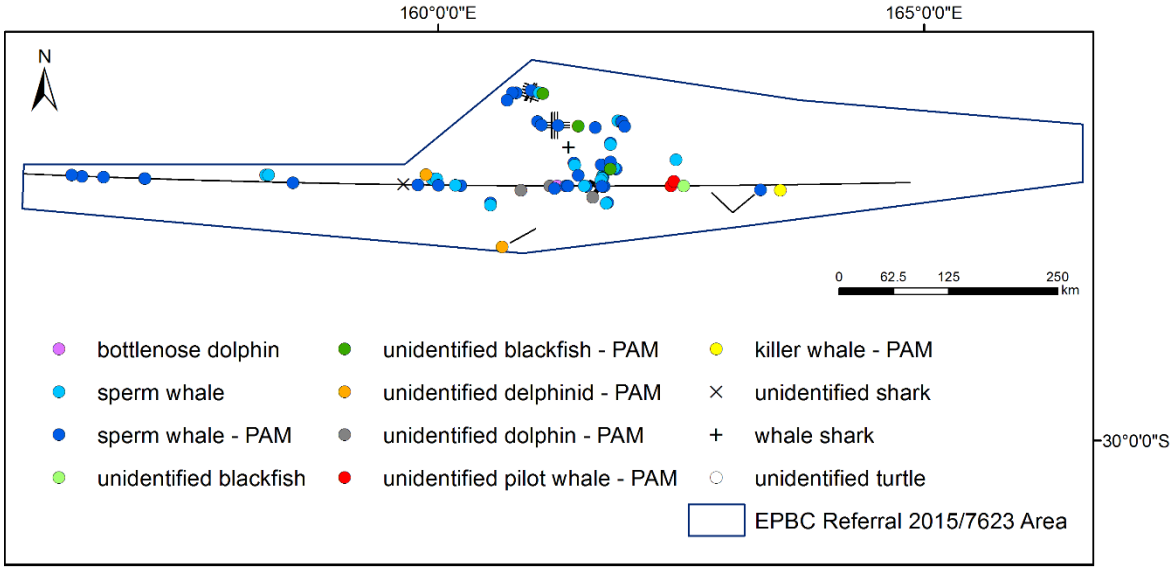


Figure 10: Geographic location of all marine fauna sightings and detections during the Lord Howe Rise marine seismic survey

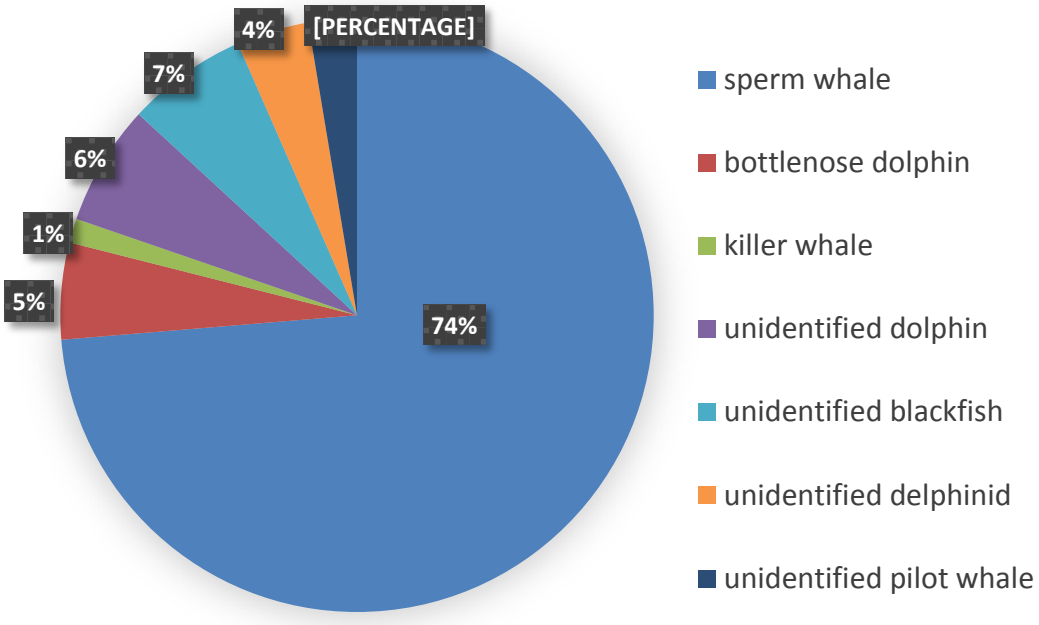


Figure 11: Breakdown of all cetacean species sighted and detected during the Lord Howe Rise marine seismic survey

Of the total number of sighting records, 62 records could be positively identified to the species level. The remaining 17 were recorded as unidentified cetaceans or dolphins. Difficulties in identifying the animals to the species level resulted mainly from their distance from the observer, sighting conditions experienced (predominantly relating to sea state), as well as the brevity of the sighting event. There were also a number of noise sources produced by the vessel, which, to some extent, compromised the ability of the PAM operators to detect and identify cetaceans (Figure 12). A complete list of all marine fauna sightings and acoustic detections is included in Appendix 7.

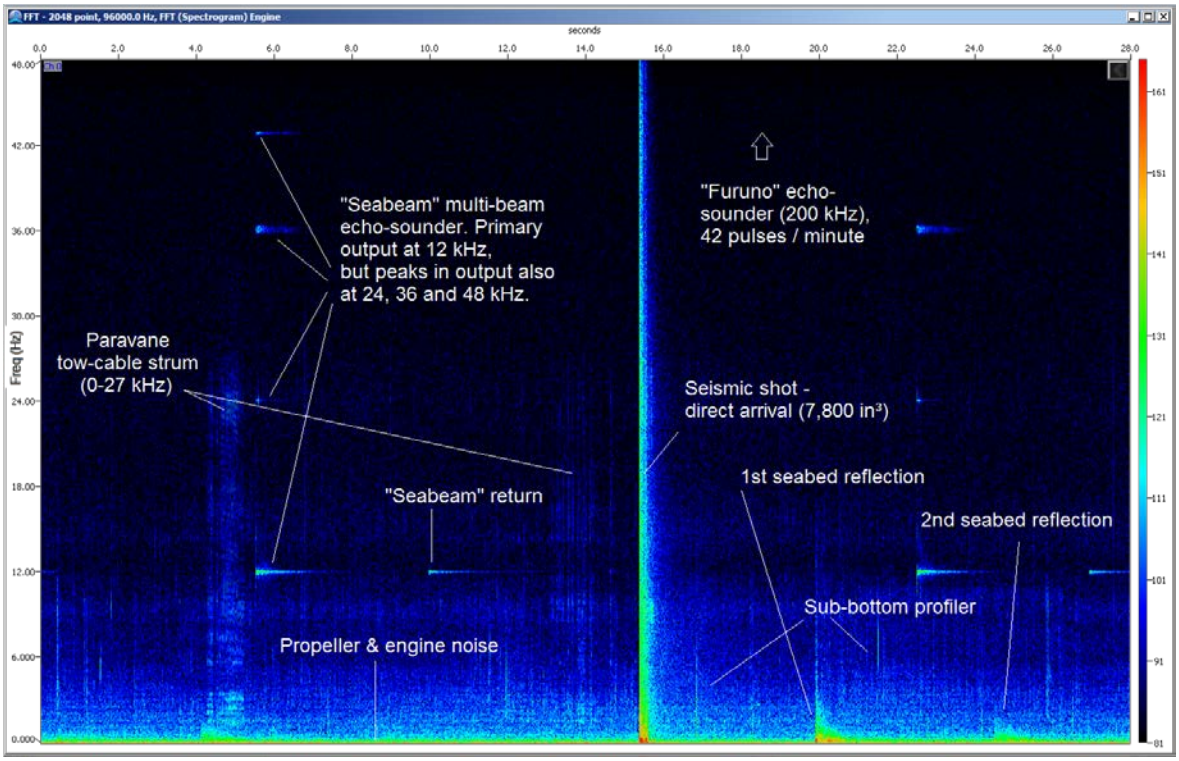


Figure 12: Spectrograph showing annotated summary of noise sources that may have contributed to difficulties in detecting/identifying vocalising cetaceans

4.5.1 Cetacean Sightings

A total of 26 cetacean sightings were recorded throughout the course of the survey (including one sighting of a mixed species pod composed of unidentified blackfish and bottlenose dolphins). Sperm whales were the most frequently observed cetacean, accounting for 21 sightings (Figure 11; Table 5; Plates 2–4).

Table 5: Cetacean Sightings Recorded during the Lord Howe Rise marine seismic survey

Species	No. of Sightings Leg Two	No. of Sightings Leg Three	Total
Bottlenose dolphin *(Tursiops sp.)*	2	2	4
Sperm whale *(Physeter macrocephalus)*	7	14	21
Unidentified blackfish	0	1	1
Total	9	17	26

Plate 1: Bottlenose Dolphin Visual Detection (VD) 13

Plate 2: Sperm Whale VD16

Plate 3: Sperm Whale VD17

Plate 4: Sperm Whale VD19

4.5.2 Other Marine Fauna Sightings

In addition to whales and dolphins, other marine fauna including a turtle, a whale shark and an unidentified shark were sighted during the survey (Table 6).

Table 6: Other Marine Fauna Sighted during the Lord Howe Rise Marine Seismic Survey

Species Sighted	No. of Sightings Leg Two	No. of sightings Leg Three	Total
Unidentified turtle	1	0	1
Whale shark	1	0	1
Unidentified shark	1	0	1
Total	3	0	3

4.5.3 Passive Acoustic Monitoring Detections

A total of 50 detections of vocalising cetaceans were recorded throughout the course of the survey (including one detection of a mixed-species pod composed of unidentified blackfish and unidentified delphinid). Sperm whales were the most frequently heard cetacean, accounting for 35 detections (Figure 11; Table 7). PAM spectrogram screenshots corresponding to all acoustic detections are available in Appendix 10.

Table 7: Passive acoustic monitoring detections during the Lord Howe Rise marine seismic survey

Species Detected	No. of Detections Leg Two	No. of Detections Leg Three	Total
Killer whale	0	1	1
Sperm whale	16	19	35
Unidentified blackfish	0	4	4
Unidentified delphinid	0	3	3
Unidentified dolphin	5	0	5
Unidentified pilot whale	1	1	2
Total	22	28	50

5.0 COMPLIANCE WITH GUIDELINES

5.1 Pre-start-up Observations

5.1.1 Seismic Operations

Of the 39 total initiations for either gun tests or soft starts, 27 pre-start-up observations of 30 minutes or more were undertaken during daylight hours, thus were conducted concurrently by the MFO and PAM operator (Table 8). Additionally, the PAM operators conducted 12 pre-start-up acoustic observations of 30 minutes or more, prior to the commencement of all night-time seismic source activity. All pre-start-up observation periods were compliant and are provided within the survey operations effort in Appendix 6.

Table 8: Number of pre-start-up observations prior to commencement of seismic operations

Pre-start-up Observation Type	Leg Two Number	Leg Three Number	Total
Daylight (MFO and PAM)	14	13	27
Night-time (PAM only)	6	6	12
Total	20	19	39

5.1.2 Multibeam Echosounder and Sub-bottom Profiler

Of the 17 times the MBES source was activated, the MFO conducted seven pre-start-up visual observations of at least 10 minutes. Of the 21 times the SBP source was activated, the MFO conducted 10 pre-start-up visual observations of at least 10 minutes (Table 9). All daytime pre-start-up observation periods were compliant and are provided within the MBES and SBP operations of Appendix 8.

Table 9: Number of pre-start-up visual observations prior to commencement of MBES and SBP operations

Operation	Leg Two Number	Leg Three Number	Total
Multibeam echosounder	4	3	7
Sub-bottom profiler	6	4	10

5.2 Start-up Delay

Start-up delay procedures were carried out in full accordance with the EPBC Act Policy Statement 2.1 and Referral Decision 2015/7623. Throughout the course of the survey, three start-up delay procedures were implemented (Table 10). Each start-up delay event is described below and shown geographically in Figure 13.

The first start-up delay event occurred on 1st May 2016 at 11:23 hours AEST. Approximately 20 sperm whales were detected through PAM (Acoustic Detection (AD) 27), prior to the commencement of a gun test. Some of these whales were also visually detected (Visual Detection (VD) 21, 22, 23). These whales were last seen within the mitigation zone at 12:03 and were acoustically tracked leaving the mitigation zone at 12:20. The gun test commenced at 12:44. No production loss was associated with this mitigation event as the vessel was undertaking a long lead-in to the next line of almost 24 hours.

The second start-up delay event occurred on 6th May 2016 at 18:45 hours AEST. Prior to commencement of soft start for line BV2A, sporadic clicks of approximately two unidentified delphinids were detected through PAM (AD42). Although the animals were not localised within the 2 km mitigation zone and it could not be determined if this was an applicable species for mitigation, the vessel voluntarily delayed soft start by slowing down until the animals had passed astern and behind the vessel. Soft start commenced at 18:48. No production loss was associated with this mitigation event as the delay to soft start was absorbed through slowing the vessel down.

The third start-up delay event occurred on 10th May 2016 at 01:24 AEST. Following a seismic shutdown event caused by detection (AD48), a new pod of approximately six sperm whales (AD49) was detected via PAM at 01:18. At 01:24, it was determined these whales were within the 2 km mitigation zone and a start-up delay was requested. The whales were last detected within the mitigation zone at 02:13. A 30-minute pre-start-up acoustic observation was then undertaken to ensure all whales were clear of the mitigation zone. Soft start commenced at 02:43.

5.3 Soft Start Procedures

Soft start procedures were carried out in accordance with the EPBC Act Policy Statement 2.1 (DEWHA 2008) and Referral Decision 2015/7623. Soft starts were achieved through a steady ramp-up in the number of guns fired and ran for a minimum 30 minutes' duration prior to full power of the airgun array (Appendix 11). There were 32 soft start procedures throughout this survey, totalling 18 hours and 32 minutes (Table 2). Gun tests did not require full soft start procedures due to the low array volume during testing. However, best practice was followed through initiating the test with the smallest airgun and ramping up the test volumes in the same manner as a soft start (Appendix 11). A total of six gun tests were conducted throughout the survey, accounting for 47 minutes of total acoustic source use (Table 2). Due to the low output volume of the MBES and SBP, soft starts were not required with these operations.

5.4 Stop Work Procedures

5.4.1 Seismic Operations

During the survey, seven stop work procedures were implemented due to an applicable cetacean species being sighted or detected within the designated 2 km mitigation zone during seismic operations (Table 10). Each stop work event is described below and shown geographically in Figure 13.

Table 10: Cetacean Detections that Resulted In Mitigation Action of Seismic Source

Date	Time AEST	Sighting/ Detection	Species	Closest Point of Approach (CPA) to Source	Source Status	Action Taken	Estimated Production Loss
7/4/2016	19:34	AD5	Sperm whale	814 m	Full power	Shut down	111 minutes
8/4/2016	04:06	AD6	Unidentified pilot whale	1,100 m	Full power	Shut down	9 minutes
10/4/2016	11:19	VD6 (=AD11)	Sperm whale	1,691 m	Full power	Shut down	370 minutes
11/04/2016	19:14	AD15	Sperm whale	428 m	Full power	Shut down	370 minutes
1/05/2016	11:23	AD27	Sperm whale	358.2 m	No source	Delay start	0
5/05/2016	14:40	VD25 (=AD37)	Sperm whale	1138 m	Full power	Shut down	90 minutes
5/05/2016	17:45	AD38	Sperm whale	800 m	Full power	Shut down	372 minutes
6/05/2016	18:45	AD42	Unidentified delphinid	2100 m	No source	Delay start	0
10/05/2016	00:49	AD48	Sperm whale	192.5 m	Full power	Shut down	35 minutes
10/05/2016	01:24	AD49	Sperm whale	214.7 m	No source	Delay start	116 minutes

The first stop work event occurred on 7th April 2016 at 19:34 hours AEST while acquiring data at full power on-line EWobs. A pod of approximately seven sperm whales (AD5) was detected through PAM at 19:28 and by 19:34 the whales were confirmed to have entered the 2 km mitigation zone. A shutdown was requested and the airguns were confirmed off at 19:34. The animals exited the mitigation zone at 20:38 and a soft start commenced at 20:53.

The second stop work event occurred on 8th April 2016 at 04:06 hours AEST while acquiring data at full power on-line EWobs. A pod of approximately five unidentified pilot whales (AD6) was detected through PAM at 03:34 and by 04:06 the whales were confirmed to have entered the 2 km mitigation zone. A shutdown was requested and the airguns were confirmed off at 04:06. The animals exited the mitigation zone at 04:15 and the airguns resumed at full power at 04:15 (see Section 5.6).

The third stop work event occurred on 10th April 2016 at 11:19 hours AEST while acquiring data at full power on-line D3A-Line5. A pod of approximately two or three sperm whales (VD6) were visually detected at 11:02 and by 11:19 the whales were confirmed to have entered the 2 km mitigation zone. A shutdown was requested and the airguns were confirmed off at 11:19. The PAM operator was concurrently detecting these whales (AD11). The last sighting of a whale within the mitigation zone was at 11:48 and the last acoustic detection within the mitigation zone was at 11:53. A soft start commenced at 16:56 after turning the vessel around in order to acquire data on this line in the opposite direction.

The fourth stop work event occurred on 11th April 2016 at 19:14 hours AEST while acquiring data at full power on-line D1B-Line09. A pod of approximately six sperm whales (AD15) was detected through PAM at 18:51 and by 19:14 the whales were confirmed to have entered the 2 km mitigation zone. A shutdown was requested and the airguns were confirmed off at 19:14. The last detection inside the mitigation zone was at 19:51 and a soft start commenced at 00:51.

The fifth stop work event occurred on 5th May 2016 at 14:40 hours AEST while acquiring data at full power on-line EWmcs. A pod of approximately 12 sperm whales (VD25) was sighted at 13:59 and by 14:40 at least two of the whales were confirmed to have entered the 2 km mitigation zone. A shutdown was requested and the airguns were confirmed off at 14:40. The PAM operator was detecting these whales concurrently (AD37). The last sighting of a whale within the 2 km mitigation zone was at 15:02 and the last detection within the 2 km mitigation zone was at 15:04. A soft start commenced at 15:35.

The sixth stop work event occurred on 5th May 2016 at 17:45 hours AEST while acquiring data at full power on-line EWmcs. A pod of approximately 11 sperm whales (AD38) was detected through PAM at 16:50 and by 17:44 the whales were confirmed to have entered the 2 km mitigation zone. A shutdown was requested and the airguns were confirmed off at 17:45. The last detection inside the mitigation zone was at 18:08. The vessel then looped back to where the shutdown occurred and a soft start commenced at 22:52.

The seventh stop work event occurred on 10th May 2016 at 00:50 hours AEST while acquiring data at full power on-line EWmcs. There were two sperm whales (AD48) detected through PAM at 23:57 (09 May 2016) and by 00:49 the whales were confirmed to have entered within the 2 km mitigation zone. A shutdown was requested and the airguns were confirmed off at 00:50. The last detection inside the mitigation zone was at 01:16. Following this detection, another pod of sperm whales was detected through PAM at 01:18 (AD49) and caused a start-up delay (see Section 5.2). A soft start commenced at 02:43.

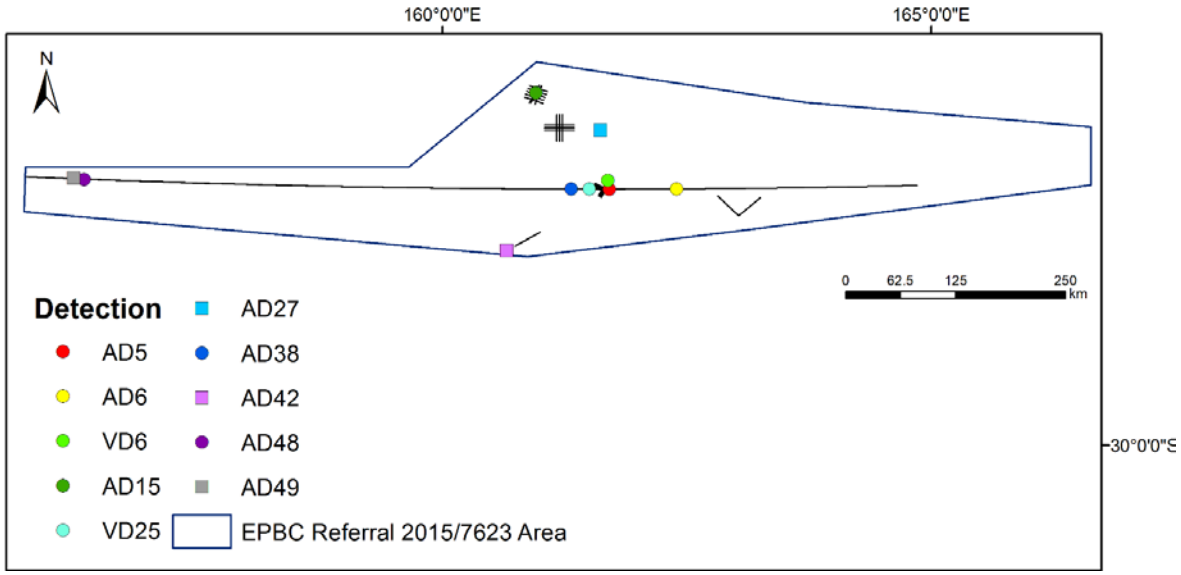


Figure 13: Geographic location of cetacean sightings/detections resulting in mitigation action of the seismic source. Circle denotes a shutdown event, square denotes a start-up delay event

5.4.2 Multibeam Echosounder and Sub-bottom Profiler

While Referral 2015/7623 did not require the use of PAM as a mitigation tool for MBES and SBP operations, it was decided that in instances where the whales were detected within the mitigation zone through PAM, the acoustic sources would be shut down as a measure of best practice.

During the survey, nine stop work procedures were implemented due to whales being detected or sighted within the designated 500 m mitigation zone during MBES and SBP operations (Table 11). Each stop work event is described below and shown geographically in Figure 14.

Table 11: Cetacean Detections that Resulted in Mitigation Action of MBES/SBP Source

Date	Time AEST	Detection	Species	CPA to Source	Action Taken
7 April 2016	20:00	AD5	Sperm whale	398.7 m	Shut down
11 April 2016	19:27	AD15	Sperm whale	428 m	Shut down
11 April 2016	21:17	AD17	Sperm whale	271 m	Shut down
1 May 2016	11:48	AD27	Sperm whale	358.2 m	Shut down
2 May 2016	23:25	AD35	Killer whale	180 m	Shut down
8 May 2016	01:35	AD45	Sperm whale	268 m	Shut down
10 May 2016	00:55	AD48	Sperm whale	192.5 m	Shut down
10 May 2016	01:40	AD49a	Sperm whale	458 m	Shut down
10 May 2016	01:59	AD49b	Sperm whale	214.7 m	Shut down

The first stop work event occurred on 7th April 2016 at 20:00 hours AEST. At 19:28, approximately seven sperm whales were detected through PAM (AD5) and by 20:00 the whales were confirmed to have entered the 500 m mitigation zone. A shutdown was requested and the sources were confirmed off at 20:00. The whales exited the mitigation zone at 20:09 and operations resumed at 20:56.

The second stop work event occurred on 11th April 2016 at 19:27 hours AEST. At 18:51, approximately six sperm whales were detected through PAM (AD15) and by 19:27 the whales were confirmed to have entered the 500 m mitigation zone. A shutdown was requested and the sources were confirmed off at 19:27. The animals exited the mitigation zone at 19:47 and operations resumed at 19:47.

The third stop work event occurred on 11th April 2016 at 21:17 hours AEST. At 21:07, five sperm whales were detected through PAM at (AD17) and by 21:14 the whales were confirmed to have entered the 500 m mitigation zone. A shutdown was requested and the sources were confirmed off at 21:17. The whales were recorded to have exited the 500 m mitigation zone at 21:29 and operations resumed at 21:32.

The fourth stop work event occurred on 1st May 2016 at 11:48 hours AEST. Approximately 20 sperm whales were detected through PAM at 08:27 (AD27) and by 11:47 the whales were confirmed to have entered the 500 m mitigation zone. A shutdown was requested and the sources were confirmed off at 11:48. The whales were last detected within the mitigation zone at 12:03 and operations resumed at 12:33.

The fifth stop work event occurred on 2nd May 2016 at 23:25 hours AEST. Approximately six killer whales were detected through PAM at 23:15 (AD35) and by 23:25 the whales were confirmed to have entered the 500 m mitigation zone. A shutdown was requested and the sources were confirmed off at 23:25. The whales exited the mitigation zone at 23:30 and operations resumed at 23:30.

The sixth stop work event occurred on 8th May 2016 at 01:35 hours AEST. One sperm whale was detected through PAM at 01:12 (AD45) and by 01:34 the whale was confirmed to have entered the 500 m mitigation zone. A shutdown was requested and the sources were confirmed off at 01:35. The whale exited the mitigation zone at 01:46 and operations resumed at 01:50.

The seventh stop work event occurred on 10th May 2016 at 00:55 hours AEST. Two sperm whales were detected through PAM on 9th May 2016 at 23:57 (AD48) and by 00:55 the whales were confirmed to have entered the 500 m mitigation zone. A shutdown was requested and the sources were confirmed off at 00:55. The whales exited the mitigation zone at 01:00 and operations resumed at 01:02.

The eighth stop work event occurred on 10th May 2016 at 01:40 hours AEST. Approximately six sperm whales were detected through PAM at 01:18 (AD49a) and by 01:39 the whales were confirmed to have entered the 500 m mitigation zone. A shutdown was requested and the sources were confirmed off at 01:40. The whales exited the mitigation zone at 01:53 and operations resumed at 01:54.

The ninth stop work event occurred on 10th May 2016 at 01:59 hours AEST. Approximately six sperm whales were detected through PAM at 01:18 (AD49b) and by 01:58 at least one whale from this group was detected within the 500 m mitigation zone. A shutdown was requested and the sources were confirmed off at 01:59. The whale exited the mitigation zone at 02:11 and operations resumed at 02:12.

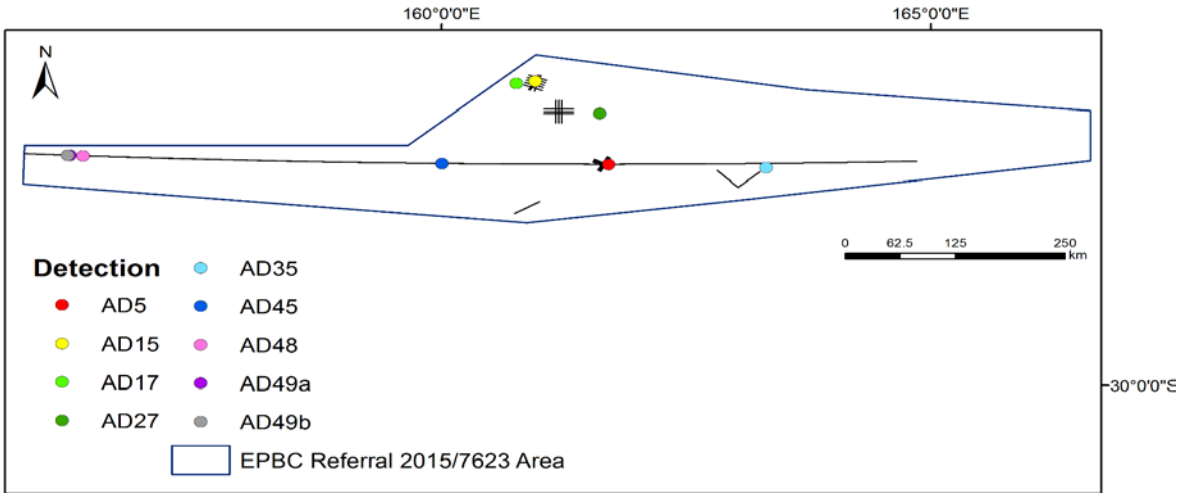


Figure 14: Geographic location of cetacean detections resulting in a shutdown of the MBES and SBP source

5.5 Night-time and Low Visibility Procedures

For those situations that required transit from one area to another for seismic data acquisition, a conservative approach was adopted. This involved organising the survey planning with the aim to arrive at each new site during daylight hours, thus providing the opportunity for both a visual and an acoustic pre start-up observation to be conducted before commencing seismic source activity. However, if the vessel was delayed in reaching the new site due to unforeseen circumstances (such as an airgun malfunction, or a whale-instigated shutdown) then it was decided that the pre start-up observation would be undertaken solely by the PAM operator.

For each occasion that travel to a new area was required, the vessel did arrive at the new site during daylight hours - except in one instance. This occurred on 6th May 2016, when it was intended that the vessel (undertaking transit from the east–west transect to the southern line BV2A) would arrive at the new area during daylight hours. However, a five-and-a-half-hour delay on 5th May 2016 at 17:45 hours AEST due to a whale-instigated shutdown resulted in the vessel arriving at the new site (line BV2A) just after dark. As a result, the pre start-up observation was conducted solely by the PAM operator. However, compliance was still met as seismic operations had been underway during the previous 24 hours, and there had not been three or more whale-instigated shutdowns during that period. Furthermore, not only were the MFOs on constant watch during daylight hours in good sighting conditions prior to the official pre start-up acoustic observation period, but

the final two hours of daylight watch were within 20 km of the start-up location in the new area, and no marine fauna were sighted.

5.6 Non-compliances

There were two separate instances of non-compliance during the survey. The first involved deployment and testing of the seismic gear outside the approved survey area; and the second involved a re-start at full power following a shutdown. These non-compliance events are detailed below.

On 3rd April 2016 deployment of paravanes, gun testing, and initiation of the soft-start procedure occurred in the lead-up to the start of the EW line, with operations commencing approximately 30 km north-west of the bounds of the approved survey area. Full power was reached only once on-line, inside the survey area. To ensure this situation was not repeated all science and ship crew were fully briefed and reminded of the EPBC Referral requirements.

On 8th April 2016 at 04:15 hours AEST a shutdown of the seismic source occurred at 04:06 due to pilot whales entering the 2 km mitigation zone (AD6). By 04:15, the animals were confirmed to have exited the mitigation zone and the seismic source resumed at full power but without a soft start. Following this event, all seismic and environmental crew were debriefed again on the protocol for resuming operations after a shutdown, as described by the EPBC Act Policy Statement 2.1.

6.0 CONCLUSION

The two MFOs and two PAM operators completed 39 days of observations, equating to a total of 898 hours and 34 minutes. Visual observations accounted for 442 hours and 33 minutes, during which there were 29 marine fauna sightings. PAM was active for a total of 456 hours and one minute during which there were 50 acoustic detections of vocalising cetaceans. The use of PAM for this project in detecting sperm whales was highly effective, as reflected by the large number of acoustic detections made throughout the course of the survey.

There were two separate instances of non-compliance; however, the survey was fully complaint with all other conditions described in the EPBC Referral Decision (2015/7623) and EPBC Act Policy Statement 2.1. Pre-start-up observations and soft starts (excluding the non-compliance) were executed according to Part A – Standard Management Procedures EPBC Act 2.1. A total of seven seismic source shutdown events were instigated by an applicable species detected within the 2 km mitigation zones during seismic operations. Cumulatively, the seismic shutdown events were responsible for approximately 24 hours and 33 minutes of lost production time. There were nine MBES and SBP shutdown events instigated by an applicable species detected within the 500 m mitigation zone.

Weather conditions experienced during visual monitoring periods throughout the survey ranged from favourable to challenging for observing marine mammals and marine mega-fauna. When weather conditions deteriorated, it was reflected in the number of sightings made, therefore animals present within the area during times of poor conditions may not have been sighted and subsequently not recorded.

Of the whales that were identified to species level the majority were sperm whales. This is most likely a result of the bathymetry of the survey area where water depths were deep and provided suitable habitat for these animals.

7.0 ACKNOWLEDGEMENTS

The MFOs and PAM operators would like to thank the R/V *Kairei* crew for their generous hospitality and the seismic and scientific crew (Geoscience Australia and JAMSTEC) for their professional conduct and cooperation.

8.0 REFERENCES

Department of the Environment, Water, Heritage and the Arts, Australian Government (2008). *Environment Protection and Biodiversity Conservation Act 1999* (EPBC) Policy Statement 2.1, “Interaction between offshore seismic activities and whales” (2008).

Shirihai, H., and Jarrett, B. (2006). Whales, Dolphins and Other Marine Mammals of the World, Princeton University Press. New Jersey, United States.