Cruise report on SORP 2012 blue whale voyages: Development of acoustic methods

BRIAN S. MILLER[1,#], NATALIE KELLY[1,2], MICHAEL C. DOUBLE[1], SIMON J. CHILDERHOUSE[1,3], SARAH LAVERICK[1] AND NICK GALES[1]

[1]Australian Marine Mammal Centre, Australian Antarctic Division, DSEWPaC, Hobart, Australia
[2]CSIRO Mathematics, Informatics and Statistics and Wealth from Oceans National Research Flagship, Castray Esplanade, Hobart, Tasmania, 7000, Australia
[3]Current address: Blue Planet Marine, 40 Hutchins Street, Kingston, Tasmania, 7050, Australia.
[#]Corresponding author: Brian.Miller@aad.gov.au

ABSTRACT

The Antarctic Blue Whale Project (ABWP; an initiative within the Southern Ocean Research Partnership) has the primary aim of estimating circumpolar abundance of Antarctic blue whales (*Balaenoptera musculus intermedia*). Mark-recapture methods, using genetics and photo-ID, will form the foundation of future blue whale circumpolar abundance estimates produced by the ABWP, but the success of these methods require a high number of encounters with these animals. In the Southern Ocean, acoustic detection ranges of blue whales far outstrip visual sighting ranges, so real-time acoustic tracking can be used to increase the total number of whale sightings, thus making more efficient use of expensive ship time. Before undertaking an Antarctic blue whale research program that features acoustic tracking, instrumentation and methods specific to acoustic tracking of blue whales must be developed, and the capabilities and limitations of such an acoustic tracking system should be quantified. With the aim of testing methods and instruments to acoustically track blue whales, the Australian Antarctic Division undertook two voyages, both three weeks in length, in January and March, 2012, respectively. The surveys targeted the Bonney Upwelling, along the south-east coast of Australia, an area known to be a summer (Nov-May) feeding ground for pygmy blue whales; the surveys focussed on the area bounded by 141.0-143.0ºE and 38.0-39.5ºS. Of the six weeks allocated across both surveys, weather allowed for a total of 20 survey days (ten for each survey). The tracking system operated continuously during the voyages recording nearly 500 hours of audio, while acousticians processed over 7000 blue whale calls all in "real-time". During the voyages 33 vocalising blue whales were pursued via acoustic tracking and of these 28 yielded visual sightings of groups of one or more whales, giving a combined acoustic success rate of 85%. Sighting effort was 785 n.miles during the January voyage and 669.6 n.miles during March voyage, over 127.0 and 104.7 hours, respectively. The first voyage yielded 37 sightings of blue or like blue whales; a total of 70 animals. During the second voyage there were 15 sightings of blue or like blue whales; 34 animals in total, in addition to three sightings of unidentified large baleen whales. Other noteworthy sightings include groups of Shepherd's beaked whales (*Tasmacetus shepherdi)* on both surveys; a sei whale in the first survey; and a fin whale in the second survey. Photo-ID during the first voyage identified 24 individuals; there were 24 individuals identified during the second voyage as well. There was one animal re-sighted between the two voyages, leaving 47 individuals identified in total.

Introduction

The Antarctic Blue Whale Project (Kelly *et al.* 2011) has the primary aim of estimating circumpolar abundance of Antarctic blue whales (*Balaenoptera musculus intermedia*) in the Southern Ocean. However, given that encounter rates of blue whales during the recently completed IDCR/SOWER survey programme were low, and the precision of the resultant abundance estimates also relatively low (Branch 2007), it is not likely that repeating this method will yield quality circumpolar abundance estimates in the near future. This is particularly the case given that the amount of ship time available for this project is not likely to approach that dedicated to the IDCR/SOWER programme.

Mark-recapture methods, using genetics and photo-ID, will form the foundation of future blue whale circumpolar abundance estimates produced by the ABWP, but the success of these methods requires a high number of encounters with these animals (Kelly *et al.* 2011). As such, we need to develop methods to greatly increase the number of encounters relative to a sighting survey design;

we need to actively locate the animals and sample them, which is very different from traditional survey approaches. In the Southern Ocean, Antarctic blue whales can be heard, using hydrophones, many tens or hundreds of miles away (Sirović *et al*. 2007) and it seems that this is a promising way to find them in order to increase encounter-rates, potentially making more efficient use of expensive ship time. The theoretical basis for real-time tracking has been demonstrated McDonald (2004), however there are substantial differences between the test scenario described by McDonald (2004), and a fully-operational, dedicated, real-time, tracking program. Tracking of blue whales with passive acoustics is intended to be a key component of the ABWP, and is also a key tool for research conducted as a part of the Southern Ocean Research Partnership (SORP). Before undertaking an Antarctic blue whale research programme that features acoustic tracking, instrumentation and methods specific to acoustic tracking of blue whales must be developed, and the capabilities and limitations of such an acoustic tracking system should be quantified.

To begin the process of testing acoustic tracking to locate blue whales, two separate surveys were conducted off the southern coast of Australia. In particular, the surveys targeted an area called the Bonney Upwelling, in the west part of Bass Strait, which is an annual summer feeding ground (Nov-May) for animals thought to be pygmy blue whales (Gill *et al.* 2011). The research investigated the capabilities and limitations regarding acoustic tracking of pygmy blue whales, a species that makes low-frequency vocalisations broadly similar to those of Antarctic blue whales (McDonald *et al*. 2006). Two three-week long surveys, one in January and the other in March, 2012, were planned to both account for any seasonal changes in blue whale density and to allow potential improvements in the acoustics method and equipment prior to beginning the second voyage. The surveys featured both acoustic tracking and visual survey components in order to estimate the improvement to sighting rates that acoustics methods bring, in addition to a photo-ID component.

Survey Goals

The primary research objective for these voyages was the development and assessment of acoustic methods for the detection, localisation and tracking of blue whales. These voyages were undertaken in order to address the practicalities of 24-hour/day real-time acoustic tracking. Achieving these goals requires characterising the capabilities of the acoustic tracking system, assessing the practicality and performance of different survey protocols, and integrating acoustic tracking with visual survey methods and mark-recapture methodologies (Table 1).

Table 1 - Survey goals

Goals	Specific Questions to Answer
Characterise capabilities of passive localisation system	1. Can the existing acoustic system locate blue whales? 2. What is the precision/accuracy of acoustic localisations? 3. What proportion of acoustic detections yield encounters? 4. What is necessary for 24 hour acoustic operations?
Assess practicality and performance of survey protocols	5. Acoustically assisted tracking and targeting of whales ("phase 1") 6. Line transect survey with acoustic monitoring ("phase 2")
Integrate acoustics with other research	7. Visual survey 8. Mark-recapture methods

Methods

The survey was undertaken on the MV Eastern Voyager, a 24 m charter fishing vessel, with a typical cruising speed of 6-8 knots (see Figure 1). The surveys operated out of Portland, Victoria (38º 21' 33'' S 141º 36' 11'' E), on the southern coast of Australia. The surveys were within an area bounded by 141.0-143.0ºE and 38.0-39.5ºS, and focussed on areas with a seafloor depth of 50-250 m, which is generally considered to be the feeding habitat for blue whales in the Bonney Upwelling (Gill *et al.* 2011).

Throughout both the January and March surveys AN/SSQ DIFAR 53D sonobuoys were deployed in Bass Strait. Audio from sonobuoys was monitored in real-time, and audio clips of blue whale sounds were analysed with custom Matlab scripts to obtain bearings to the sound source in near-real time.

Two survey modes, dubbed phase 1 and phase 2 were in operation during the voyages. During “phase 1”, acousticians directed the research vessel in order to intercept the vocalising “target” whale. During “phase 2” acousticians continued to track whales acoustically but did not alter the course of the vessel substantially from the predetermined survey course. The term “acoustic track” was used to denote any set of bearings that were believed to come from a whale or group of whales in the same location. “Targets” were defined as “acoustically tracked” whales that were pursued by the research vessel in an attempt to encounter. “Targets” were considered “aborted” when pursuit was abandoned due to inclement weather, gear failure, or encountering other whales. “Targets” were considered “missed” when the whale stopped calling and the visual team failed to sight a whale in the area where the whale was last heard. Targeting was considered “successful” upon visual confirmation of the “target”.

A visual survey team operated in parallel to the acoustics team during daylight hours when sighting conditions were favourable. During the first voyage, there were usually three observers on effort, with another two observers available to rotate through. On the second voyage, there were four observers on effort, with another observer available for rotation. Observers scanned an arc of 180° degrees forward of the vessel. The visual team maintained a constant lookout to both locate “targeted” whales and visually detect any blues whales that were not vocalising. There were two observing platforms on the Eastern Voyager: the foredeck, which was at a height of 3.5 m, and the flybridge, located above the bridge, at a height of 5.7 m. Most observations were made from the flybridge as it gave the furthest viewing distance, but some observing occurred from the foredeck when wind direction and speed pushed diesel exhaust fumes over the flybridge platform.

All sightings, effort and weather were stored using Logger 2000 software (developed by the International Fund for Animal Welfare), which stores data in a Microsoft Access database. Weather and sighting conditions were recorded every hour, or when conditions changed.

During the March voyage, a prototype of a moored acoustic recorder was trialled. The moored recorder was deployed for three days and then recovered to test deployment and recovery procedure in addition to the internal electronics. Deep water (i.e., nearing 1000 m) was selected to be similar to deployment depths expected in the Southern Ocean. The location of deployment was selected so as to be away from known shipping lanes in the area.

Results

Visual sightings

The first survey started ran between 12 and 25 of January, 2012; the second between 13 and 30 March, 2012. Health and safety requirements dictated that the vessel be away from port during bad weather, so of the six weeks allocated across both surveys, weather allowed for a total of 20 survey days (10.5 days in January and 9.5 days in March).

The total number of hours and distance covered of active sighting effort is given in Table 2. Both surveys achieved a similar amount of effort. The survey track covered seafloor depths between 30-3000m.

Table 2 - Amount of sighting effort per voyage: total time and distance covered.

	January Voyage	March Voyage
Distance on effort	784.5 n.miles	669.6 n.miles
Hours on effort	127.0 hrs	104.7 hrs

As a proportion of all time the visual survey team were on effort, sighting conditions were better during the March voyage as compared to the January voyage. The sea state was generally calmer during the March voyage as well. The time spent in various sightability and Beaufort sea state categories are given in Figures 3 and 4, respectively.

The first voyage yielded 37 sightings of blue or like blue whales; a total of 70 animals. During the second voyage there were 15 sightings of blue or like blue whales; 34 animals in total, in addition to three sightings of unidentified large baleen whales. Other noteworthy sightings include groups of the rare Shepherd's beaked whales (*Tasmacetus shepherdi*) on both surveys; a sei whale in the first survey; and a fin whale in the second survey. Location of all sightings, across both surveys, are given in Figures 5-8.

Acoustics

A total of 131 sonobuoys were deployed, and more than 500 hours of audio was monitored in real-time yielding nearly 7000 bearings to blue whales in total (see Figures 9 and 10). Sixty *acoustic tracks* were obtained and 39 whales were *targeted* in total. Seven *targets* were aborted due to bad weather and were excluded from further analysis. Three *targets* were *missed* and 29 *targets* were found, yielding a total targeting success rate of 91%. Most of the metrics of acoustic effort were comparable between January and March similar numbers of sonobuoys, hours of recording, whale calls processed, and number of targets (Table 3).

The real-time passive acoustic tracking and targeting system was shown to be highly effective at locating blue whales. The acoustic tracking system operated continuously around the clock throughout both voyages, and was able to guide the research vessel to vocalising blue whales. These two research voyages have demonstrated the viability of real-time acoustic tracking of blue whales, and support the use of passive acoustic tracking as a means for locating blue whales in the Southern Ocean. Technical details of the acoustic tracking system are reported in Miller (2012; SC/64/SH12).

Table 3 - Acoustic tracking and targeting metrics

	January	March	Total
Number of active sonobuoys	68	63	131
Hours of audio monitored	234.7	268.8	503.5
Whale calls processed	3667	3331	6998
Acoustic tracks	31	29	60
Targets chased	19	20	39
Targets aborted	3	4	7
Targets missed	2	1	3
Targets successful	14	15	29

Acoustic Mooring

The mooring was deployed at 26 March (process took around 90 minutes) and then recovered on 29 March (in low sea and wind conditions; process took around 40 minutes in total), near the 800 m depth contour, and the acoustic releases rested at an approximate depth of 760 m. The mooring appeared to sink and ascend > 100 m/min. The location of deployment was selected so as to be away from known shipping lanes in the area; see Figure 11. A photograph of the acoustic mooring is given in Figure 12.

The mooring recorded continuously for the entire duration of deployment and analysis of whale sounds are presently underway. The success of this trial paves the way for longer duration deployments, with the eventual goal of a fleet of acoustic moorings each recording continuously at different locations in the Southern Ocean for durations of up to 18 months per deployment.

Photo ID

The photo-ID activities yielded 24 individuals in the first survey and 24 in the second. One of these individuals was resighted in the second survey, so there were 47 identified in total.

As to be expected, blue whales were easier to approach and photograph when they were feeding on the surface, as opposed to feeding at depth or travelling. The average time to get adequate photographs of most members of a sighting group was around 76.9 mins (sd=41.4 mins). See Figure 13 for example photographs. Images from the voyages will be added to the Southern Hemisphere Blue Whale Catalogue.

Acknowledgements

This work would not have been possible without the hard work and dedication of the acousticians: Susannah Calderan, Kym Collins, Catriona Johnson, Elanor Miller, Flore Samaran, Josh Smith; the visual observers: Virginia Andrews-Goff, Dave Donnelly, Paul Ensor, Paula Olson, Natalie Schmitt, Rob Slade. We send a big thank you to Australian Antarctic Division Shipping and Supply Services, in particular, Leanne Millhouse, Andrew Deep, Simon Cash and Mike Clarke. Thanks also to David Peel for help analysing the data; and to Peter Gill for background knowledge of the Bonney Upwelling. Thanks to the crew of the Eastern Voyager and the staff from Blue Planet Marine for two excellent voyages. These voyages were supported by the Australian Antarctic Division, and funded by the Australian Government.

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Appendix 1 Personnel

The scientific contributors to the voyage included the leaders: Mike Double and Natalie Kelly; acousticians: Susannah Calderan, Kym Collins, Catriona Johnson, Elanor Miller, Flore Samaran and Josh Smith; and visual observers: Virginia Andrews-Goff, Dave Donnelly, Paul Ensor, Paula Olson, Natalie Schmitt, and Rob Slade. The crew of the MV Eastern Voyager are gratefully acknowledged: Chris, Bill, Danny, Nathan, Jason and Toby.

Figures

Figure 1 The MV Eastern Voyager; a charter fishing vessel, approximately 24 m in length. (Photograph: D. Donnelly)

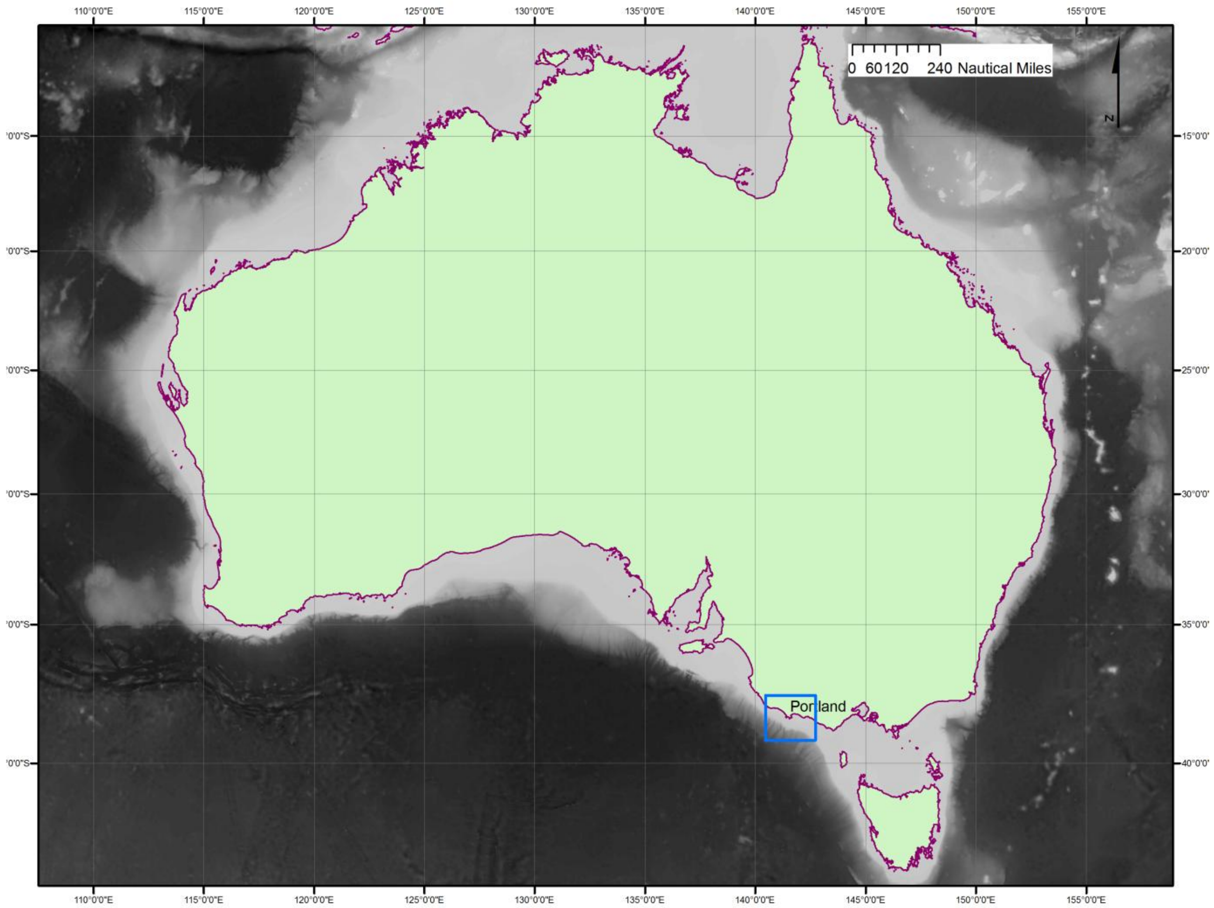

Figure 2 Bonney Upwelling research area (blue square), along the southern coast of Australia.

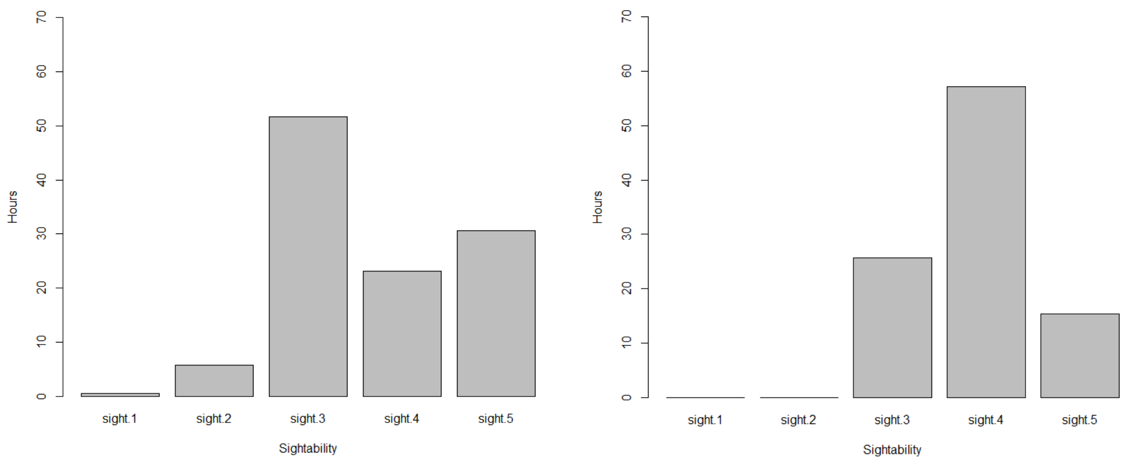

Figure 3 Number of hours spent in each sightability category for the January voyage (left panel) and the March voyage (right panel). (Sightability score: 1 = can see nothing; 2 = poor; 3 = fair; 4 = good; 5 = excellent.)

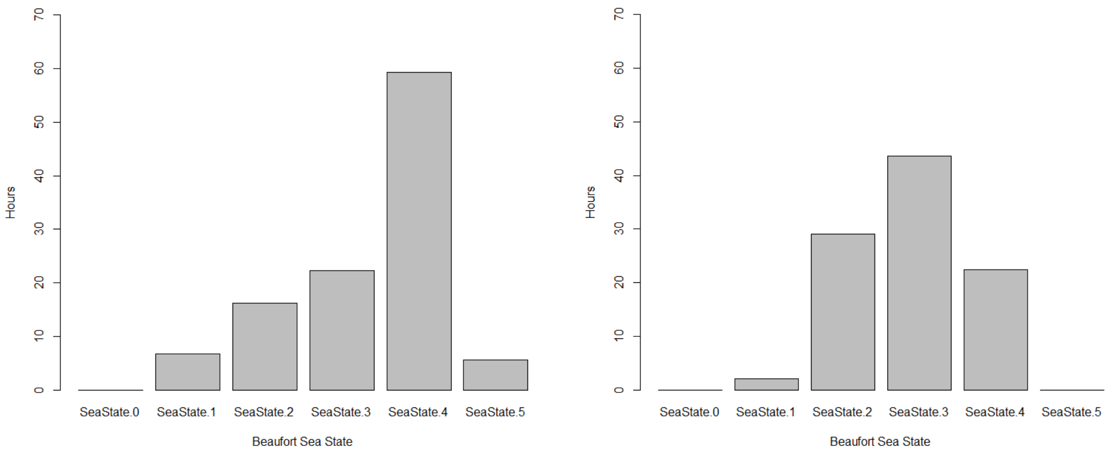

Figure 4 Number of hours spent in each Beaufort Sea State category for the January voyage (left panel) and the March voyage (right panel).

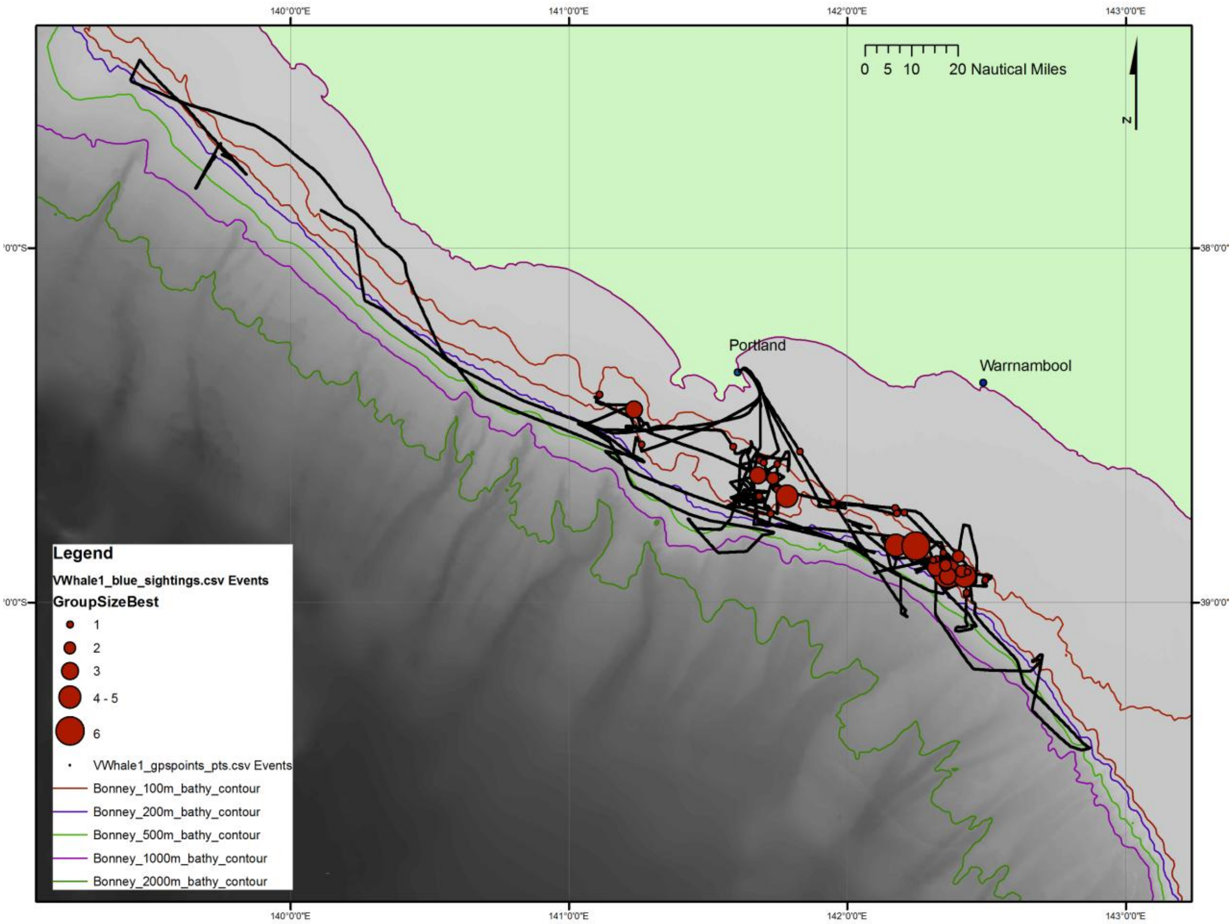

Figure 5 Distribution of blue and like blue sightings for the January voyage; group size (best estimate) indicated by size of circle. Vessel track as solid black line.

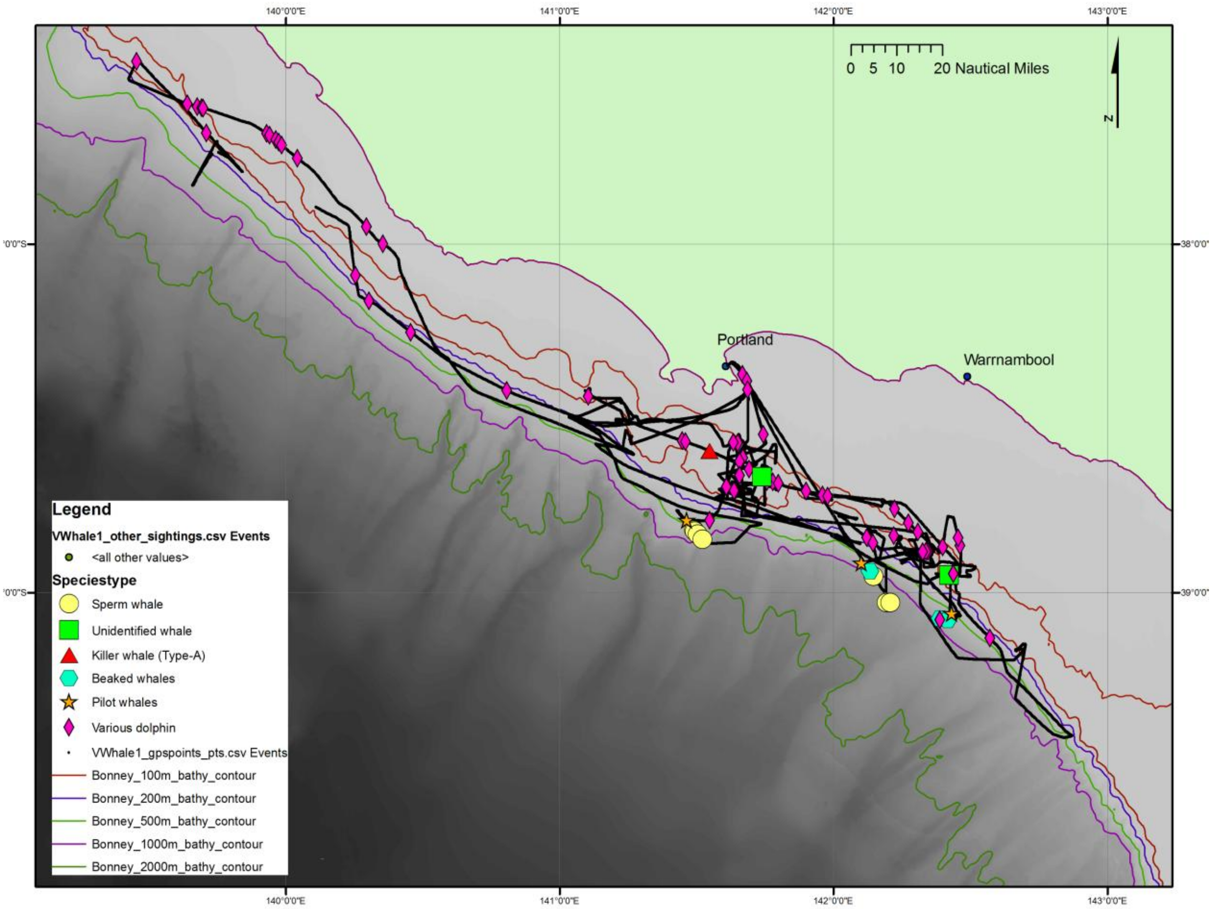

Figure 6 Distribution of sightings of other species for the January voyage. Vessel track as solid black line.

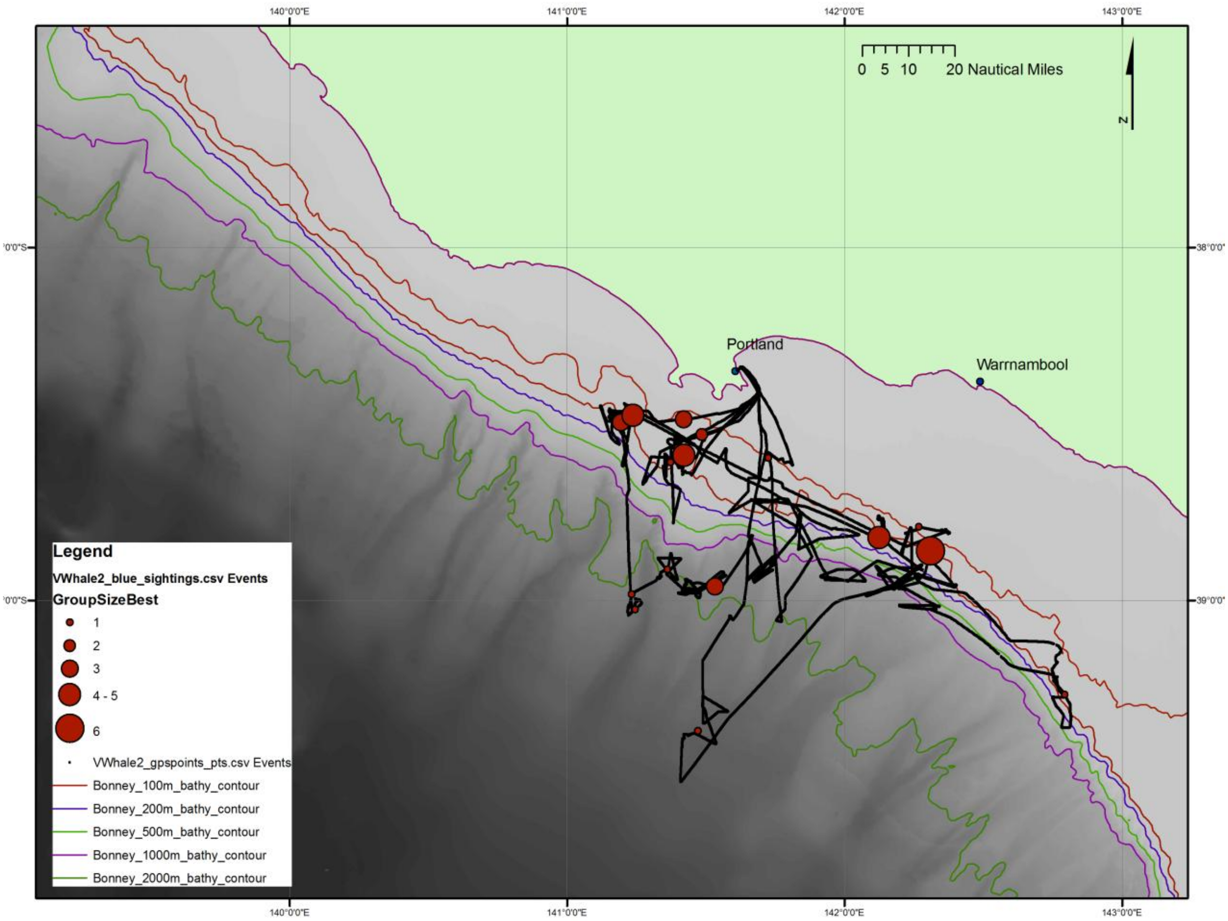

Figure 7 Distribution of blue and like blue sightings for the March voyage; group size (best estimate) indicated by size of circle. Vessel track as solid black line.

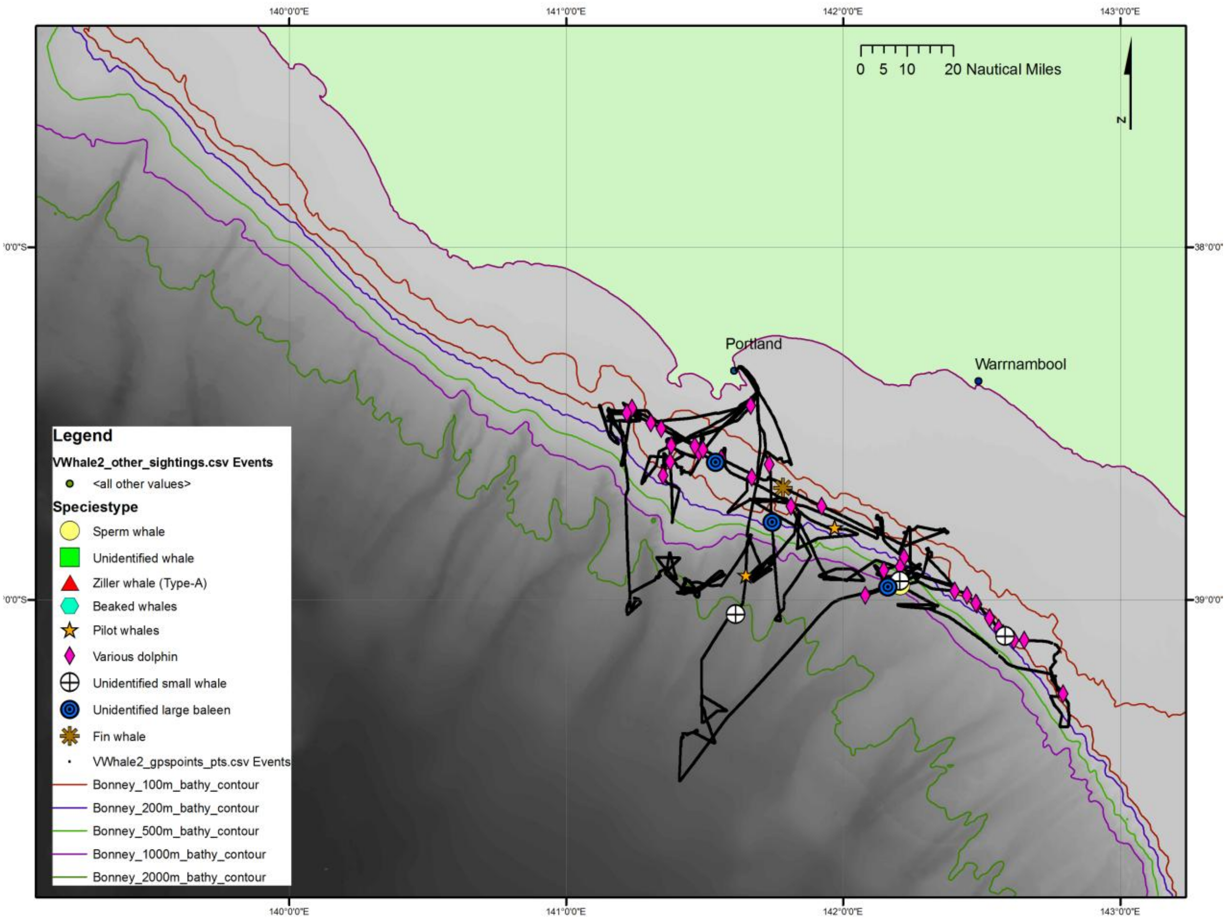

Figure 8 Distribution of sightings of other species for the March voyage. Vessel track as solid black line.

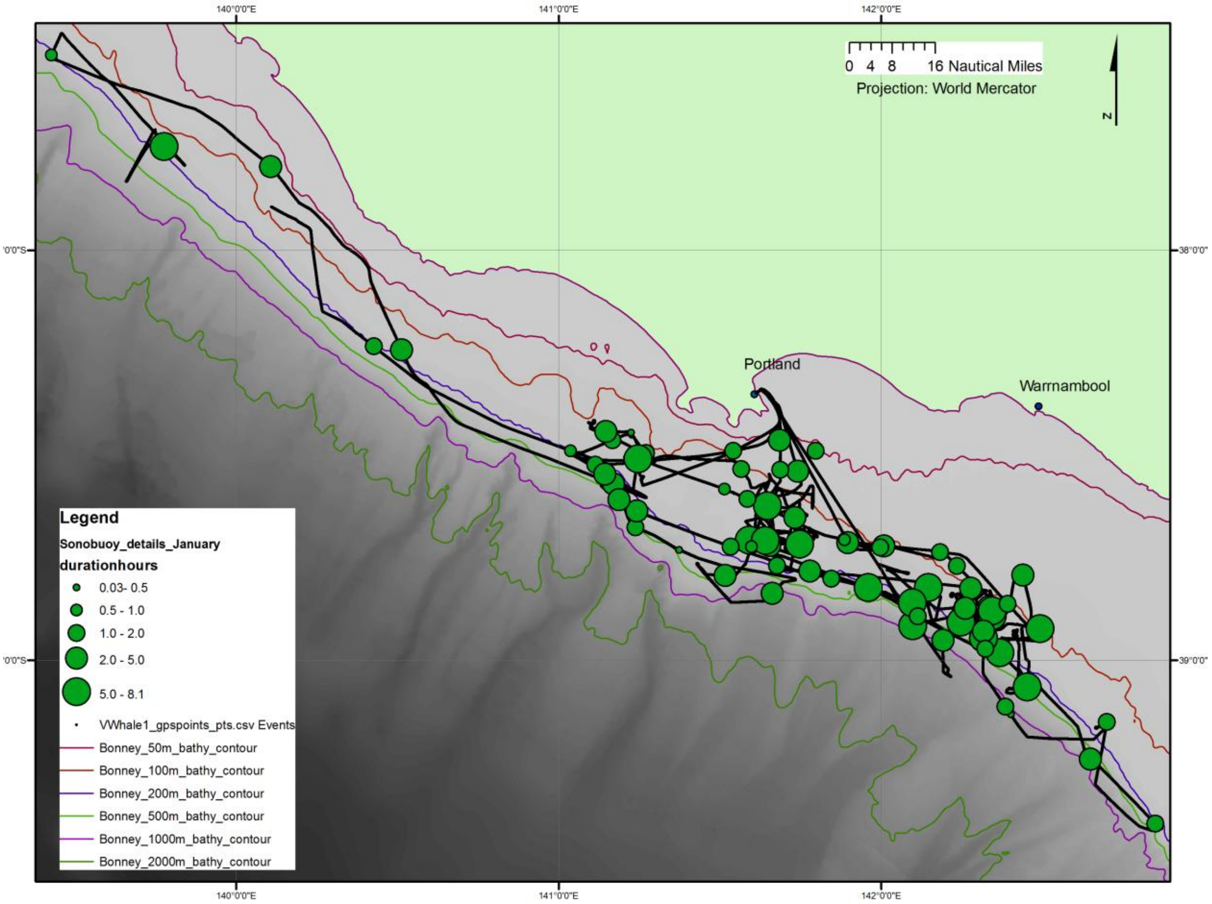

Figure 9 Vessel track from January voyage, and locations of sonobuoy deployments. Size of circle is proportional to the amount of time each sonobuoy was monitored.

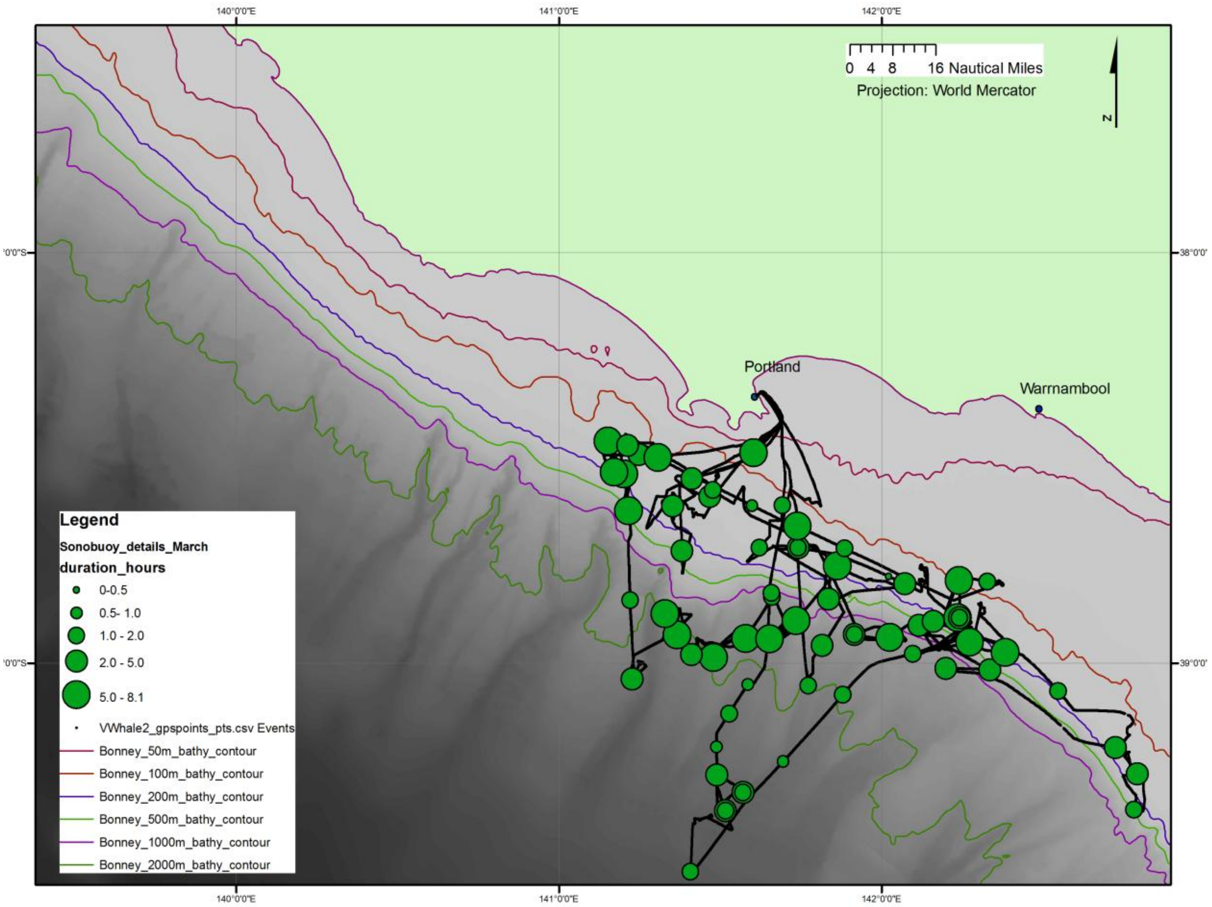

Figure 10 Vessel track from March voyage, and locations of sonobuoy deployments. Size of circle is proportional to the amount of time each sonobuoy was monitored.

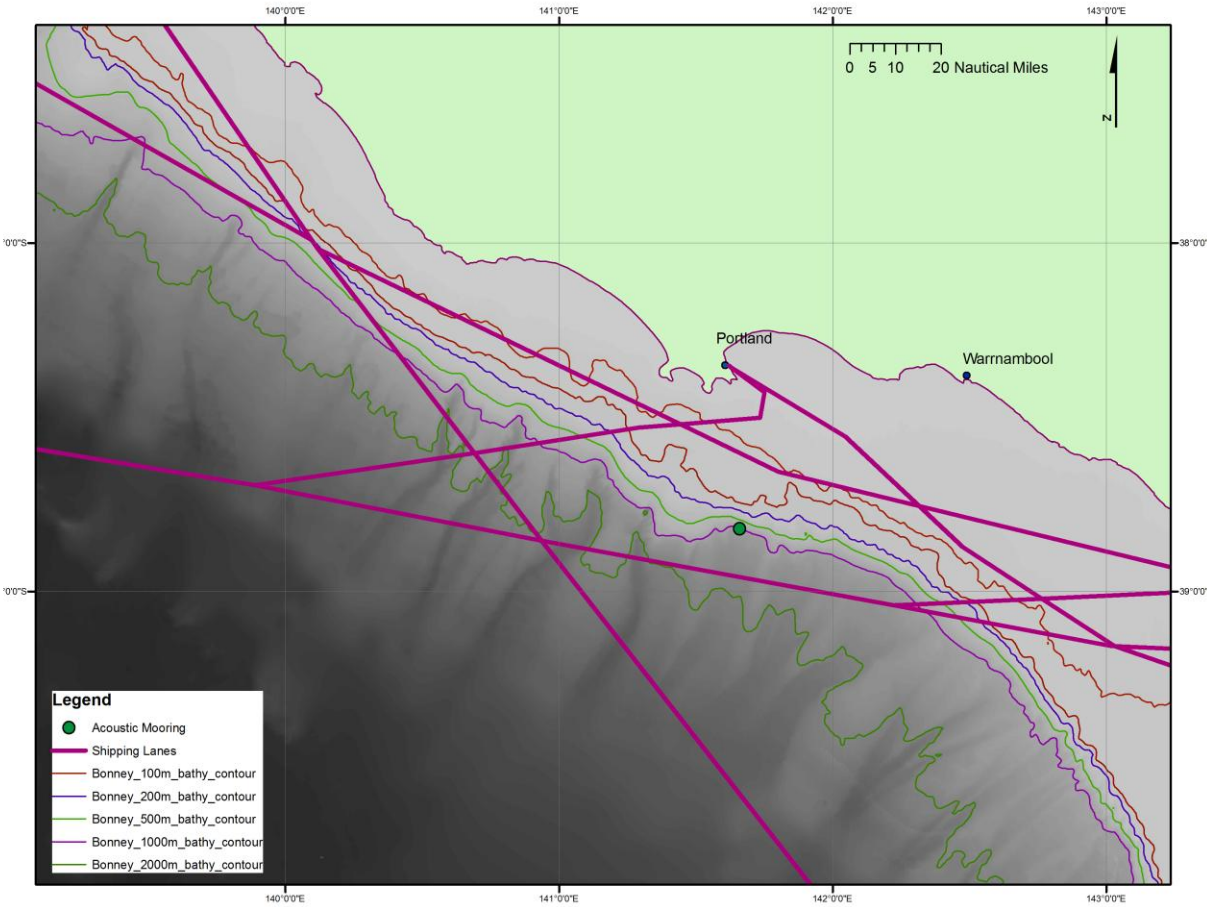

Figure 11 Average positions of shipping lanes, and position of deployment/retrieval of acoustic mooring. Mooring deployed at a depth of approximately 800m.

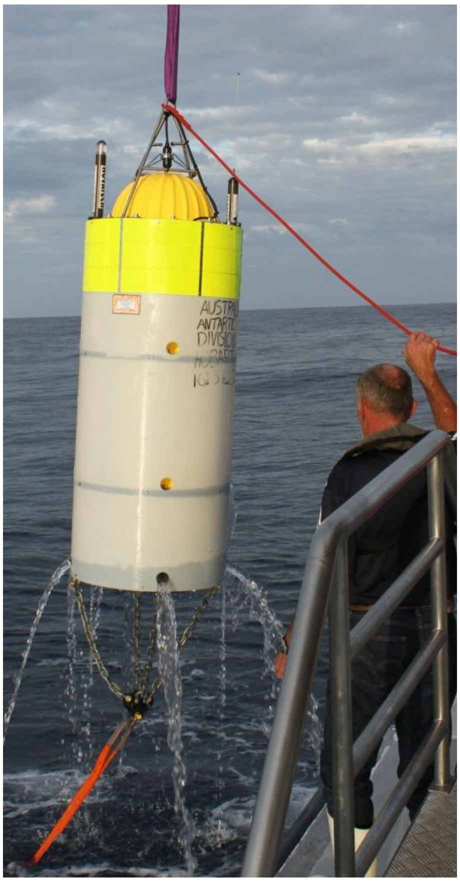

Figure 12 Recovery of the prototype acoustic mooring trialled during the March voyage.

Figure 13 Left and right side of a blue whale, photographed on 16 January, 2012, located around 142 7.9°E 38 49.8°S. (Photographs: Paul Ensor and Dave Donnelly.)