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Australian Antarctic Division

Antarctic Blue Whale Voyage 2013: Science report

FV Amaltal Explorer January to March 2013
17th March 2013

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Australian Antarctic Division

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1. EXECUTIVE SUMMARY

The Australian Government sponsored the 2013 Antarctic Blue Whale Voyage to develop methods and initiate research that will lead to a new estimate of abundance for blue whales (*Balaenoptera musculus intermedia*) in the Southern Ocean. Commercial whaling decimated this species, and the state of its recovery is currently unknown. The 65-m *FV Amaltal Explorer* was chartered for a 47-day voyage leaving from and returning to Nelson, New Zealand and conducting studies in Antarctic waters between 135° E and 170° W. This voyage was conducted as part of the Antarctic Blue Whale Project (ABWP) of the Southern Ocean Research Partnership (SORP). SORP is a consortium of ten countries working together on six collaborative research programs under the auspices of the International Whaling Commission (IWC). The 2013 voyage was conducted by Australia in the expectation that it would be the first in a series of such voyages by SORP partners that would, collectively, produce a new estimate of abundance for Antarctic blue whales.

The main purpose of the 2013 Antarctic Blue Whale Voyage was to evaluate methods that can be used to estimate blue whale abundance and to initiate the collection of necessary data. Prior research shows that mark-recapture methods using photographic and genetic identification may be the most cost-effective method to estimate Antarctic blue whale abundance (Kelly *et al.* 2012). However these methods depend on the collection of sufficient identification photographs (photo-IDs) and biopsy samples. Blue whales make extremely loud, low frequency sounds that travel for hundreds of kilometres, and can be used to find areas where blue whales are concentrated. The 2013 Voyage was designed to test whether acoustic detection and localisation of blue whales can facilitate the collection of an adequate sample of photo-IDs and biopsies to serve as a foundation for a new estimate of Antarctic blue whale abundance.

A list of eight prioritised objectives was developed for the 2013 voyage:

Objective 1. To assess and refine passive acoustic methods for locating Antarctic blue whales

Objective 2. To collect photographic data and biopsies for individual identification of blue whales

Objective 3. Linking blue whale calls to their behaviour and environment

Objective 4. Collect distance sampling data for regional abundance estimate of cetacean species

Objective 5. Deploy satellite tags to describe the movement and behaviour of blue whales

Objective 6. Collect Antarctic krill (*Euphausia superba*) for krill ecological genomics study

Objective 7. Testing of kite-antenna for improved sonobuoy radio reception

Objective 8. Evaluate the body condition of humpback whales from biopsy samples

All eight objectives were met. Most importantly, disposable directional hydrophones (DIFAR sonobuoys) were able to detect concentrated areas of blue whale abundance at distances of hundreds of kilometres. Following acoustic bearing angles, these concentrations of Antarctic blue whales were located and sampled. Photographs of 57 individuals and biopsy samples from 23 individuals were obtained from the *Amaltal Explorer* and an outboard-powered launch. Approximately thirty hours of detailed behavioral data were collected to help link acoustic behavior to a broader context of Antarctic blue whale behavior. Rigorous sighting surveys detected 39 sightings of 84 individual Antarctic blue whales in 10 595 km of searching in the survey area (530 sightings of 1 313 all species of cetaceans, including Antarctic blue whales). Two satellite tags were deployed on Antarctic blue whales, the first in history. Over 100 Antarctic krill were collected for a study of krill population genetics being conducted at the Australian Antarctic Division. A kite-antenna was tested, and sufficient information was obtained to suggest design changes to the system which would enable the improvement of sonobuoy radio reception. Finally, eight biopsy samples were obtained for a study of humpback whale nutritional condition at Griffith University.

Analyses of the samples and other data collected on the 2013 Antarctic Blue Whale Voyage will continue for several years, but several important conclusions are immediately clear:

- DIFAR sonobuoys can detect areas of high blue whale density from distances of hundreds of kilometers, and can be used to direct the ship to those areas for efficient photographic and biopsy sampling.
- Photo-IDs and biopsies can be effectively obtained from a large ship or a small boat. For the vessels used in 2013, Antarctic blue whales were easier to approach with the large ship, but in high-density areas the most efficient sampling was with both vessels.
- Antarctic blue whales can be satellite tagged, but most are very evasive in the presence of a small boat. The best success was obtained with larger groups of whales.
- The distribution of other whale species was highly correlated with the distribution of blue whales, and acoustically directed search for blue whales was not random with respect to the distribution of other baleen whales. The estimation of regional abundance for other species from visual distance sampling data (Objective 4) will be challenging and may not be feasible.
- Both acoustic detections and satellite tag deployments indicated that Antarctic blue whale distribution extends north of 60°S in late summer, which has not been shown in previous survey data.

2. INTRODUCTION

The Antarctic Division of the Australian Government conducted the Antarctic Blue Whale Voyage from the end of January to mid-March 2013. This voyage was the first in a series of voyages that are part of the Antarctic Blue Whale Project (ABWP). The AWBP is an international initiative which aims ultimately to deliver a new circumpolar estimate of abundance for Antarctic blue whales (*Balaenoptera musculus intermedia*). Additional objectives are to improve our understanding of their population structure and linkages between breeding and feeding grounds, and to characterise their behaviour in the feeding grounds. The ABWP is a flagship research program of the Southern Ocean Research Partnership (SORP), a consortium of six collaborative research programs, led by Australia under the International Whaling Commission. Nations in the partnership to date include Argentina, Australia, Brazil, Chile, France, Germany, New Zealand, Norway, South Africa and the United States.

During the Twentieth Century, approximately one third of a million Antarctic blue whales were taken during commercial whaling in the Southern Hemisphere. With Antarctic blue whales close to extinction, in 1964 the International Whaling Commission banned the hunting of Antarctic blue whales, although some were still caught by illegal operations until 1973. Today, the Antarctic blue whale is classified as critically endangered by the International Union for Conservation of Nature, and is of global interest as one of the most at-risk species of baleen whale in the Southern Ocean.

The catch records from the whaling fleets and subsequent Antarctic sightings surveys provide a clear picture of the rapid depletion and very slow recovery of Antarctic blue whales, but a new precise abundance estimate is required to assess the current status of these whales. As systematic sightings surveys are no longer conducted around Antarctica, this project’s first objective is to identify the most appropriate and efficient approach to derive a new abundance estimate for Antarctic blue whales. Initial analyses suggest that mark-recapture based on photographic and genetic identification is the most feasible method to estimate abundance. This approach will also provide an opportunity to collect important information on the project's secondary objectives of investigating population structure, migratory movements and behaviour on the feeding grounds. However, further development of mark-recapture survey techniques will be required. The ABWP is ambitious and will require coordinated and sustained international cooperation to deliver the necessary data to achieve a new abundance estimate for Antarctic blue whales.

3. RESEARCH OBJECTIVES AND AIMS

The eight prioritised research objectives for the 2013 Antarctic Blue Whale Voyage were:

Objective 1. To assess and refine passive acoustic methods for locating Antarctic blue whales

Objective 2. To collect photographic data and biopsies for individual identification of blue whales

Objective 3. Linking blue whale calls to their behaviour and environment

Objective 4. Collect distance sampling data for regional abundance estimate of cetacean species

Objective 5. Deploy satellite tags to describe the movement and behaviour of blue whales

Objective 6. Collect Antarctic krill (*Euphausia superba*) for krill ecological genomics study

Objective 7. Testing of kite-antenna for improved sonobuoy radio reception

Objective 8. Evaluate the body condition of humpback whales from biopsy samples

4. PRELIMINARY RESEARCH RESULTS AND DISCUSSION

4.1. Operational aspects of the research

The 47-day voyage departed from Nelson, New Zealand on 30 January 2013 and returned to Nelson on 17 March 2013. The voyage schedule (Table 1) included an 8-day transit to the survey area. During this transit time observation training, acoustic trials and small boat training occurred. The 29 days spent at longitude > 60°S were completed 8 March 2013. During the survey time objectives 1–4 were undertaken and objectives 5–8 were addressed opportunistically. The nine-day transit back to Nelson commenced on 8 March 2013.

4.1.1. Area Coverage

Antarctic blue whales were studied in a survey region west and north of the Ross Sea (below 60°S between 135°E–170°W, Figure 1). The transit to the survey area (60°S) took seven days and covered 3 217 km. During the31 days spent south of 60°S within the survey area, the *FV Amaltal Explorer* covered approximately 10 595 km. The transit north took six days and covered 2 493 km (up to 15.03.2013).

4.1.2. Weather and ice conditions

From 07 February through 08 March, while surveying for Antarctic blue whales, a wide range of sea conditions and visibility were experienced, from Beaufort 1-7 and visibility 100 m in fog or snow to >12 km on clear days. The amount of swell also varied widely, from no swell near the ice edge to 6 m in height.

We searched acoustically for blue whales in all weather conditions. The visual search was curtailed when wind speeds were greater than 35kts. This differs from the IWC IDCR-SOWER Antarctic cruises for minke whales where standardized survey conditions were limited to Beaufort <5 and a visibly clear horizon. During the IDCR-SOWER surveys, 50% down time due to unsuitable weather conditions was experienced.

Based on satellite imagery, this Austral summer's ice edge was further north than average. There was more pack ice in the northern portion of the Ross Sea than usual.

The ice edge encountered by the *Amaltal Explorer* was comprised of melted first year floes and brash ice; the concentration ranged from 1/10 to approximately 5/10. As is typical of the pack ice edge in the north of the Ross Sea region the pack ice was in scattered belts of ice separated by ice-free water. We delineated the ice edge as where there was too much ice was present for the vessel to maintain normal searching speed of 10 kts or for the vessel to follow whales closely.

4.1.3. Personnel

The Antarctic Blue Whale Voyage was managed through the Australian Antarctic Division's voyage management procedures. Chris Galloway was Voyage Leader and Margaret Lindsay acted as Deputy Voyage Leader. Jay Barlow, as Science Coordinator, led all aspects of the research work. The research team, voyage management and the ship's crew are listed in Appendices 1-3.

The research team comprised a range of technical expertise. The science group worked closely with the voyage management, Talley's crew and the Gardline executive master, ensuring that operational activities were safe and opportunities to conduct work were maximised.

From a science perspective, there were four key teams:

1. Science leadership team:
   Jay Barlow (lead), Mick Davidson, Paul Ensor, Russell Leaper, Brian Miller, Paula Olson, and Victoria Wadley.
2. Acoustics team:
   Brian Miller (lead), Jay Barlow, Susannah Calderan, Kym Collins, and Russell Leaper.
3. Observations team:
   Paula Olson (lead), Virginia Andrews-Goff, Cath Deacon, David Donnelly, Paul Ensor, Margaret Lindsay, Carlos Olavarria, Kylie Owen, Melinda Rekdahl, Natalie Schmitt, and Victoria Wadley.
4. Small boat team:
   Mick Davidson (watercraft coordinator), Virginia Andrews-Goff, David Donnelly, Melinda Rekdahl, and Natalie Schmitt.

The ship's crew were very supportive and helpful in achieving the voyage objectives. The Master, John Whitlock, the mates Paul Reeve and Sam Williams were approachable, attentive and focussed on achieving the objectives effectively and safely. The crew were instrumental in safely launching and retrieving the small boats and personnel during all workable opportunities and were very successful at modifying and fixing scientific equipment.

4.1.4. Survey Vessel Specifications and Suitability

The primary vessel used for the voyage was the 65 m *FV Amaltal Explorer*, a factory stern-trawler registered in and operating from New Zealand. The command and crew of this vessel were extraordinarily helpful and supportive of the scientific mission, and this was a major factor contributing to the success of the voyage. The vessel itself proved to be capable of fulfilling all or our essential needs and was, in many ways, perfect for the mission. The vessel is rated to travel in broken ice (Class 1D, second lowest rating). Use of a smaller vessel would have increased the number of days lost to weather, and a larger vessel would have been less manoeuvrable around whales. The observation heights from the flying bridge (7.9 m), bridge (10 m) and mast (16 m) observation stations were typical for this sized vessel. The bridge and mast positions allowed excellent 360-degree views, but observation from the flying bridge was limited to the forward 220 degrees (approximately). The vessel was equipped with direct diesel drive engine and a single variable pitch propeller. Engine speed was kept constant at 750 RPM, and pitch was varied to change vessel speed. The maximum speed was approximately 10 kts. The vessel has three rudders, which aided in its manoeuvrability. The acoustic team judged this vessel to have more underwater noise than other vessels they have used. The vessel was largely clean of extraneous electro-magnetic noise, and the acoustics team obtained clean signals without any special accommodations. All NMEA feeds were opto-isolated for clean signals. The forward mast and aft gantry provided good heights for the sonobuoy antennas (18 and 21 m, respectively), and typical sonobuoy detection ranges (12 - 18 nmi) were greater than obtained on most vessels.

The main observation stations on the flying bridge were in two plywood boxes built for this purpose. These boxes and the wind dams built into them helped shield observers from cold and wind buffeting. The boxes were, however, not aligned with the centerline of the vessel (which made angle estimation more difficult) and were too far from the centerline to provide equal coverage of both sides of the vessel. The mast position was used for the vessel guide who directed the ship during close approaches for photos and biopsies; this position provided ample space for three observers who could effectively search for whales in any direction. Excellent photo-ID and biopsy platforms were provided on the bow, and the bow was an appropriate height for biopsies. The ship's crew provided rails in front of these stations, which added a margin of safety. The height of the hull at the boat deck was adequate for recovering biopsy darts with very long-handled dipnets, but was higher than ideal.

Accommodation on the *Amaltal Explorer* were basic but adequate for scientific purposes. Although the ship surrendered their officer's mess and lounge for scientist use and created a lab space for biopsy staging and processing, scientific lab space was still limited. Interior storage space for sonobuoys and other gear was generous.

RECOMMENDATIONS

- Consideration should be given to vessel noise when selecting an acoustic survey vessel. Generally ships with fixed propellers and diesel-electric drives are quieter than vessels with diesel direct drives and variable pitch propellers.
- For visual surveys, 360-degree visibility is desired for the bridge, flying bridge and mast observation stations.

- Sufficient lab space is needed for computer stations, printers, and other workspace.
- Greater speed might be an advantage in some situations, but a 10-kts cruising speed is ideal for visual and acoustic surveys.
- Vessel rating of ice class 1D is the minimum level of ice hardening to safely allow night transits and some travel in broken ice. Pursuing whales in ice for photo-ID and biopsy was not generally feasible, so a higher level of ice rating would not be necessary.
- A chart plotter, gyro repeater and/or large-screen, stand-alone GPS on the flying bridge would improve the situational awareness there.
- A public address system in key areas (eg. bow, mess, lounge, flybridge) would be useful to assemble teams quickly when whales are present.
- A pedestal-mounted 15X or 25X binocular ("Big-eyes") should be considered for long-range species identification.

4.1.5. Rigid Hull Inflatable Boat operations

A major component of the research undertaken on this voyage was the use of a rigid hull inflatable boat (RHIB) to obtain biopsies and to attach satellite tags. Comprehensive Standard Operating Procedures were developed and applied, and required safety equipment was installed.

Two AAD RHIBs were carried onboard. The first, *Remora,* was purpose-built by the AAD for this type of voyage. This 6.3 m aluminium Naiad RHIB was powered by twin 100hp Suzuki four-stroke outboard engines and equipped with a substantial bowsprit from which whales could be tagged. A working crew of five people operated *Remora*, each with a specified task (coxswain, satellite tagging, biopsy, video recording, photo-ID and data recording). The second, *Swift,* RHIB was carried as an emergency replacement, to be used if the primary vessel *Remora* became unserviceable. This 5 m aluminium RHIB was powered by twin 50 hp Yamaha two-stroke outboard engines.

The *FV Amaltal Explorer* also carried a rescue boat/tender to be used in case of emergency. It was manned by the ship's crew and was on standby whenever *Remora* was launched.

Remora was launched 17 times on 12 days and used for a total of 40 hours (Figure 2). Launch times averaging ten minutes from notification of its crew. While opportunities to collect photographs and biopsies from *FV Amaltal Explorer* proved effective, the small boat was necessary for the deployment of satellite tags and aided in biopsy collection and photo-ID.

4.2. Research results and discussion

The eight science objectives for the voyage were all met. Details are provided below for each objective.

4.2.1. Objective 1. To assess and refine passive acoustic methods for locating Antarctic blue whales

Brian Miller, Jay Barlow, Susannah Calderan, Kym Collins, and Russell Leaper

During the *2013 Antarctic Blue Whale Voyage*, we developed, tested, and refined acoustic methods to find Antarctic blue whales. Sightings of blue whales were rare on previous visual surveys in the Antarctic, such as on the SOWER cruises. Visual methods alone are unlikely to give an adequate sample size to estimate the abundance of whales by mark-recapture methods. Software tools were developed and tested prior to the voyage to facilitate the use of DIFAR sonobuoys (disposable directional hydrophones which transmit their signals to the ship by VHF radio) to find blue whales (Miller 2012). The methods were used and refined during the 2013 voyage.

RESULTS

We present an overview of the results of the passive acoustic research component of the 2013 Antarctic Blue Whale Voyage. These results are preliminary, and a more detailed report including specific methods, detailed results, and detailed discussion of technical aspects of this work will follow in a stand-alone report to be completed later in 2013. It should be noted that the data presented in this Voyage Report contain only outputs from 'real-time' acoustic data streams, and that raw audio recordings have been collected which will allow for both more detailed analysis and the development of additional methods in post-processing.

During the Antarctic Blue Whale Voyage, the main focus of the passive acoustics team was to direct the research vessel to groups of vocalising Antarctic blue whales. Groups of whales that were detected and pursued were considered *target* whales, while those that were detected, but not pursued, were considered *tracked* whales. The acoustics team typically operated 24 hours a day for the duration of the voyage. A total of 305 sonobuoys was deployed both in transit to 60° South and south of 60° S in order to *track* and *target* whales, yielding 626 hours of acoustic recordings (Table 2). Sonobuoy deployments continued on the return transit from 60° S, but are not covered by this report. Sonobuoys were deployed at 30 nmi intervals, or adaptively as needed during targeting and tracking.

In transit there were five encounters with blue whales along the New Zealand coast, and three sonobuoys were deployed in the presence of these whales. Audio recordings from these sonobuoys yielded detections of a low-frequency four-part call, first described by Kibblewhite *et al.* (1967), and subsequently presumed to be blue whales (McDonald *et al*. 2006, 2009). This may be the first time that these sounds have been recorded in the presence of blue whales; it is the first time that they have been recorded on the west coast of New Zealand. Subsequent sonobuoys detected similar vocalisations as far as 52° S. Vocalisations from Antarctic blue whales were first detected during the transit to the study area on 3 February 2013 (sonobuoy #22, 51.95° S, 157.55° E). Antarctic blue whale vocalisations continued to be detected during the transit on all sonobuoys south of 52° S.

Antarctic blue whale calls were detected on all 239 sonobuoys that were deployed south of 60°S. Calls were broadly classified as 26 Hz tones, Z calls, and D calls (Rankin *et al*. 2005). Z calls and D calls appeared only to be received when relatively close to the location of encounters with Antarctic blue whales, while 26 Hz tones (comprising the most intense element of the Z call) appeared to be audible throughout the study area (Figure 3) and much of the transit.

Forty three groups of whales were *targeted,* of which 25 yielded visually confirmed encounters with the vocalising whale or whales which had been *targeted*. In addition, eight targets yielded encounters with Antarctic blue whales that were not the vocalising whales, but were believed to be associated with the acoustically *targeted* whale (see the subsequent discussion section on acoustic 'hotspots' for further explanation). Five of the 43 *targets* were classified as aborted. *Targets* were considered *aborted* when the *target* could still be tracked, but operational or environmental constraints prevented an approach to the whale. Three *targets* were aborted because the whales were in ice flows that were not passable, one was aborted due to poor weather, and one *target* was aborted in order to continue visual survey in a different area. Finally, six of the *targets* were missed. Five targets were missed because the whale stopped vocalising and could no longer be acoustically located, while the remaining missed target appeared to be moving away from us faster than we were able to follow (Table 2). Whilst it was not always explicitly recorded as an acoustic target, there were several occasions where visual contact with targeted whales was lost due to poor sighting conditions, snowstorms, and/or fog, and continued acoustic tracking allowed the whale to be located again.

Relatively few recordings of species other than Antarctic blue whales were made (Figure 4) on an opportunistic basis. Detection and logging of other species during *targeting* and *tracking* was possible only when it did not interfere with the primary objective of acoustically tracking Antarctic blue whales. Thus, the analysis presented here is neither a complete nor thorough representation of the entirety of the recordings. However, this map should serve as a good starting point for a more in-depth analysis. Notable recordings of other species include sonobuoy #179 which was deployed near a group of fin whales, sonobuoy #323 which was deployed in the presence of a sei whale, and sonobuoys #245-254 which contain recordings of humpback whale social sounds.

DISCUSSION

Passive acoustic monitoring was extremely effective at detecting and locating Antarctic blue whales. 26 Hz tones were detected on every sonobuoy deployed south of 52^{o}S. By using directional sonobuoys we were able to conduct long-range targeting of whales by following the direction of 26 Hz tones using only a single active sonobuoy per listening station. Following 26 Hz tones eventually led to the detection of D and Z calls, which, in conjunction with close-range targeting strategies ultimately led us to groups of vocalising Antarctic blue whales (Figure 3).

While 26 Hz tones were detected on all recordings south of 52°S, the direction of these vocalisations was indicative of a handful of acoustic ‘hotspots’ that contained moderately-sized aggregations of whales rather than a uniformly random distribution of small groups of whales. Existence of acoustic ‘hotspots’ is further supported by the fact that all visual sightings of blue whales were either acoustically *targeted* whales or believed to be associated with a vocalising group of whales. These results demonstrate the potential for acoustic monitoring to locate Antarctic blue whales from distances of tens to hundreds of nautical miles, much greater than with visual methods. Acoustic localization methods often lead to visual detections of larger aggregations of blue whales, many of which were not vocalizing. There were no sightings of Antarctic blue whales outside of the identified acoustic ‘hot spots’. Survey methods that optimise a combination of visual and acoustic techniques may potentially be used to generate estimates of abundance.

RECOMMENDATIONS

While expired military sonobuoys are often generously provided to cetacean researchers, it is likely that the number of sonobuoys required for acoustic targeting may require the purchase of supplementary sonobuoys. Sonobuoy manufacturers require a lead time of six months to one year, and obtaining an export license for sonobuoys in countries other than their country of production can add additional delays.

- We recommend that future voyages planning to conduct acoustic targeting should secure as many sonobuoys as possible as far in advance of the voyage as practical.
- We recommend purchasing depassivated, out-of-life HIDAR (SSQ 955) sonobuoys. These sonobuoys have a good success rate and are smaller and lighter than 53D and 53F buoys. The smaller size and weight not only means less waste, but also reduced transport costs and

easier handling. Parachutes from these buoys can also be removed without affecting their operation.

- We recommend attempting to obtain GPS integrated sonobuoys. Such sonobuoys may provide accurate locations of the sonobuoy as it drifts, and may be used to obtain more accurate localisations and facilitate better measurements of source levels of sounds, but are not required for successful targeting.

The utility of an acoustic recording system is only as good as the weakest component. As the hydrophone and radio transmitter within sonobuoys are standardized, and the researcher will follow the above recommendation to secure as many sonobuoys as possible, the next potential point of failure lies within the receiving and recording system.

- We recommend investing in high quality VHF receivers capable of 20 kHz audio bandwidth and a flat frequency response. We had a good experience with WiNRADiO G39WSBe sonobuoy receivers.

- We recommend using high quality VHF preamplifiers placed as close to the VHF antenna as possible and using low-loss cable to connect preamplifiers to VHF receivers. We had good experience with Minicircuits ZX60-33LN-S+ amplifiers.

- We recommend that the VHF antenna be placed as high as possible on the research vessel in order to obtain the greatest radio horizon. Ideally the antenna should be isolated from other communications equipment such as RADAR, other radios, and physical obstructions. For this voyage the antenna was placed at the top of the gantry, which was approximately 21 m high.

- We recommend avoiding VHF transmitters for shipboard communications to avoid radio-frequency interference and suggest using handheld UHF radios as a potential replacement.

In addition to sonobuoys, we recommend having a variety of recording devices for opportunistic recording of other species.

- We recommend considering a towed array in order to better survey for sperm whales and beaked whales, particularly if a relatively quiet vessel is being used for the research.

- We recommend considering calibrated hydrophones with portable recording devices for both the research vessel and small boat in order to record humpback, fin, and killer whales as well as pinnipeds.

We recommend further development of the real-time analysis software in order to simplify and automate analysis where possible. Particular improvements include:

- Integration of software programs into a single program.

- Development of a classifier to allow automatic detection of Z calls and 26 Hz tones.

- Integration of sightings, acoustic detections, radar, AIS, ice imagery, and position/track of research vessel into a single real-time display and database.

The extensive experience of the acoustics team was a major factor that contributed to the high number of successful tracks. In addition to assembling a highly experienced team, we recommend conducting trial voyages to test equipment and protocols before embarking upon a long Antarctic survey. No significant acoustic monitoring time was lost on this trip due to hardware or software problems or failures. This can be partly attributed to a system that was thoroughly tested on trial voyages.

4.2.2. Objective 2. To collect photographic data and biopsies for individual identification of blue whales

Objective 2. A. To collect photographic data for individual identification of blue whales

Paula Olson

Photographs of distinctively marked individuals can be used in a mark-recapture approach to estimating abundance. These data also provide information on blue whale population structure and movement. Individual blue whales are identifiable from unique patterns of mottled pigment in the area of the dorsal fin on both sides of the body, and also from variations in dorsal fin shape and any permanent scars that may be present. Methods for the collection of identification photos of individual blue whales are described in the Antarctic Blue Whale Voyage 2013: Science Plan (Double *et al.* 2013).

During the voyage, when the *Amaltal Explorer* approached Antarctic blue whales in good weather, two photographers and two biopsiers worked from the bow. When weather permitted, biopsy effort was conducted in conjunction with photography. In the roughest weather only photography was attempted. When the *Remora* was deployed, one photographer worked from the *Remora* in conjunction with biopsy and tagging efforts, and one photographer worked from the *Amaltal Explorer's* bow. Two primary cameras were used during photo-ID operations: a project Nikon D90 with an image stabilized 28-300 mm lens, and a personally owned Canon 7D with an image stabilized 100-400 mm zoom lens. Additional images were collected by scientists on other platforms using their personal cameras. Photographs of blue whales were judged to meet minimum criteria of quality based on distance to the subject (whale), focus, angle, and lighting. Photographs meeting these criteria were considered suitable for identifying individual blue whales.

Photographs of humpback flukes were collected opportunistically during the voyage. Fluke photographs are used for the identification of individual humpback whales; photo-ID data are used in determining migratory patterns of humpbacks from Antarctic waters and population structure (Constantine *et al*. 2011). Photographs of killer whales were also collected opportunistically; these photographs are useful in determining the distribution of different morphotypes of killer whales in the Antarctic region (Pitman and Ensor 2003).

RESULTS

During the transit south, four groups of blue whales were photographed off the west coast of New Zealand; during the transit north five groups were photographed off New Zealand's east coast. The whales were photographed from the *Amaltal Explorer*. These groups were identified acoustically as being New Zealand blue whales; their taxonomic relationship to recognized blue whale subspecies is currently uncertain. Photographs meeting the minimum quality criteria were obtained from 15 blue whales, comprised by 12 left side photographs and ten right side photographs (Table 3). Both left and right side photographs were obtained from seven blue whales.

Thirty three groups of Antarctic blue whales were approached for photo-ID: ten groups approached by both the *Amaltal Explorer* and the *Remora*, 22 groups by the *Amaltal Explorer* only and one group by the *Remora* only. A total of 70 individual blue whales were photographed. Fifty-seven individual blue whales were identified from photographs meeting the minimum quality criteria (Figure 5), comprising by 44 left side photos and 46 right side photos (Table 3). Both left and right side photographs were obtained from 33 Antarctic blue whales. Of the 90 best Antarctic blue whale left side and right side photographs, 70 were collected from the *Amaltal Explorer* and 20 from the *Remora*.

Fluke photographs were obtained from 29 humpback whales (Figure 5), and three groups of killer whales (all Type A, Pitman and Ensor 2003) were photographed.

DISCUSSION

The identification photographs of 15 pygmy blue whales off New Zealand will provide baseline data on a little-studied population of blue whales. The total of 57 photo-identified Antarctic blue whales is substantial and surpasses the minimum number required for analysis (50) as described by Kelly *et al*. (2012). The ability of the acoustic team to locate whales and the expertise of an experienced ship guide directing approaches to blue whales contributed greatly to the success in obtaining this number of identification photographs.

We strove to obtain photographs every time blue whales were encountered. During some encounters conditions were poor (including strong wind, snow, fog, heavy swell, and low evening light); these circumstances explain the photographs of 13 whales that did not meet the minimum quality criteria for identifying individuals.

Systematic comparison of photos within the voyage is yet to be conducted and may yet yield re-sights within the voyage that reduce the total number of unique individuals. During IWC-SOWER voyages with more than 20 Antarctic blue whales photo-identified (e.g. 2004/2005, 2005/2006, 2006/2007), within season re-sighting ranged from 11% to 22% (Olson 2010).

Generally, the *Amaltal Explorer* yielded better quality photos for blue whales than those collected by the *Remora* platform. Given the challenges the *Remora* encountered when approaching blue whales, and the obstructed view from within the boat (other than from bowsprit), it was difficult for the photographer to obtain quality ID photos during approaches and especially during biopsy attempts. The *Amaltal Explorer* provided a more stable platform for photography and the blue whales appeared to react less to the *Amaltal Explorer*, allowing for closer and better-angled approaches for photography. A strategy that worked well during the voyage was using the *Amaltal Explorer* to collect identification photos first, before launching the *Remora* to focus on biopsy and tagging.

Ultimately the blue whale identification photographs collected during this voyage will be utilised for mark-recapture analysis by comparing them to the Antarctic Blue Whale Catalogue (Olson, 2012). Identification photographs will also be contributed to the internationally collaborative Southern Hemisphere Blue Whale Catalogue (of which the Antarctic Blue Whale Catalogue is a part; IWC 2008).

RECOMMENDED EQUIPMENT FOR PHOTO-ID

- If the small boat is used during survey, three SLR camera/lens systems are needed: two for the small boat (with 100-300 mm lenses) and one for large ship (with 100-400 mm lens, no heavier than 2 kg).

- Space for a dedicated computer monitor and laptop with high quality screens for exclusive use as a photo-id workstation.

Objective 2. B. To collect biopsy samples for individual identification of blue whales

Natalie Schmitt

Biopsy collection team – Melinda Rekdahl, David Donnelly, Paul Ensor, Carlos Olavarría, Jay Barlow, Virginia Andrews-Goff and Natalie Schmitt

Genetic analysis from biopsy samples is a well-established method that enables the identification of individuals from genetic markers such as microsatellites or single nucleotide polymorphisms (SNPs). This individual identification allows the production of sightings histories required for a mark-recapture approach to estimating abundance. Genetic data can also be combined with data from previous IWC SOWER voyages to assess population structure and can be used to determine the sex of whales.

RESULTS

Twenty-three biopsy samples were collected from 39 sightings (84 animals) of Antarctic blue whales over a 29-day period (Table 4; Fig. 6). Both the small boat '*Remora*' and the ship, the FV *Amaltal Explorer*, were successful platforms for the collection of biopsy samples. Both vessels were able to approach within sampling range when blue whale behaviour and weather conditions were favourable. The small boat was used initially as the primary vessel for biopsy however, as blue whales were found to exhibit disturbed behaviour soon after deployment on the first few occasions, biopsy sampling was then attempted first from the ship along with the collection of photo ID. The small boat was deployed only when weather conditions were favourable, biopsy attempts from the large vessel were unsuccessful or satellite tagging was attempted. Thirteen blue whale samples were obtained by biopsying from the small boat using a Paxarms modified rifle and ten samples from the bow of the large vessel using a Larsen rifle. No tether system was used to retrieve the dart after sampling Antarctic blue whales. Biopsy samples were collected for the two whales that were satellite tagged.

Most samples included sufficient tissue (biopsy plugs averaged ~ 5 cm in length) to divide and preserve in three ways to maximise analysis potential (All Protect, 70% ethanol, and freezing in liquid Nitrogen). The protocol we used to store and preserve each sample is included in Appendix 6. One sample was partially eaten by a Cape Petrel.

All Antarctic blue whales biopsied were also photographically identified with the exception of two individuals for which we could not obtain clear photographs due to snow (Table 4).

Fourteen biopsy attempts of Antarctic blue whales were unsuccessful due to a combination of human error, darts remaining embedded in the animal, broken darts or other reasons (Table 5).

The biopsy samples collected during the Antarctic Blue Whale Voyage 2013 will be curated and stored at the Australian Antarctic Division. A section of these samples will also be stored and archived at the NOAA Southwest Fisheries Science Center, La Jolla, California.

DISCUSSION

The DNA extracted from each biopsy sample will be used to generate mitochondrial DNA sequences, as well as microsatellite and SNP genotypes. Genotypes at multiple loci can then be matched to previously typed individuals from IWC SOWER voyages in the Southern Ocean and also within the present survey to determine between-season and within-season movement, respectively. This analysis combined with a complementary analysis based on photo-identification data collected during this survey will improve our understanding of Antarctic blue whale movement.

RECOMMENDATIONS

- Ensure all rifles are correctly sighted and biopsy systems (darts, tethers, scopes) are tested prior to voyage departure at a rifle range at departure location (with all authorized shooters and with tether systems).
- Have two barrels for each gun so that a spare barrel can be pre-prepared with a dart for quick replacement after firing. This will aid in the ability to reload quickly.
- Consider methods for deterring birds from the samples (change colour of darts, rock salt in a sling shot, water cannon, snow balls etc.).
- Investigate and test tethering system for guns to reduce time in retrieving darts and to increase sample size by encouraging shooters to be less conservative with their choice of shots.
- Consider adding tethered crossbows to the biopsy arsenal as a back-up to firearms.

4.2.3. Objective 3. Linking blue whale calls to their behaviour and environment

Russell Leaper, Susannah Calderan and Kylie Owen

The voyage offered a unique opportunity to carry out acoustic and visual observations of Antarctic blue whales simultaneously. Such data are important for understanding the behavioural context of blue whale vocalisations to allow better interpretation of acoustic recordings. This understanding will also add significant value to autonomous recordings collected as part of the SORP Acoustic Trends project. Although there has been preliminary investigation of the behavioural context of North Pacific blue whale sounds (Oleson *et al.* 2007) and blue whales sounds in the North Atlantic (Boisseau *et al.* 2008), limited data have been collected on the behavioural context of Antarctic blue whales sounds (Rankin *et al.* 2005).

The objectives of the visual behavioural data collection were (i) to record the location of each sighted surfacing to allow these to be compared with acoustically-derived bearings and locations of calling animals and (ii) to record estimated swimming directions, blow rates, dive times and observed behaviours. In addition to comparing observations of behaviour at the surface with vocal behaviour, accurate locations of surfacing whales can also facilitate estimation of source levels for different types of blue whale calls.

The voyage Science Plan established a protocol whereby a Tracker on the visual team would make behavioural observations of a focal group or individual which was being targeted for a close approach using video tracking equipment (Leaper and Gordon 2001) and a Searcher would record the locations of any other blue whales in the vicinity. In practice this did not occur for the majority of encounters. However, whenever possible, video tracking of the focal group was conducted by off-duty members of the acoustics team. For the latter part of the voyage, the Ship Guide’s assistant also used a voice recorder to record times with estimated distances and angles of surfacing events, which were then transcribed. The data recorder on the bridge also attempted to record as much information as possible about each re-sighting directly into the Logger data entry system.

Whenever possible, video tracking and audio commentary commenced as soon as a potential blue whale blow was sighted in order to try to document as much undisturbed behaviour as possible during the approach by the vessel. Sightings which were found on closer approach to be of other species were discarded.

RESULTS

It had been anticipated that blue whales would be sighted at ranges of several miles, allowing a number of undisturbed dive cycles to be observed in the time between the initial sighting and the vessel approaching to a distance from the whale at which responsive behaviour was likely to be tracked. However, weather conditions were frequently poor and many blue whales were first sighted when already quite close to the vessel. This resulted in a very limited time period to collect undisturbed behavioural data before a close approach was made for photo-id and biopsy. No dedicated ship time was given to behavioural observations except for the last encounter of the cruise when the vessel remained at a distance of around 1 km for 15 minutes before attempting a close approach.

A total of just over 30 hours of video tracking data was collected (Table 6), comprising 25 encounters. These varied from less than ten minutes to over four hours (with an average of approximately one hour). Many of these tracks were of behaviours following close approaches and could not be considered representative of undisturbed behaviour. Nevertheless they provided locations of whales for comparison with the acoustic data. Track numbers 1 and 2 were in the presence of blue whales off the coast of New Zealand at the start of the voyage. The first stage of analysis was to replay all the videos, grab suitable images for distance measurement and to create a table of times and events from the video commentary. This stage of analysis was completed on the voyage for about half the tracks. The next stage of analysis was to take measurements from the images of bearing angle and angle of dip from the horizon to the whales. This allowed the track of the whale to be generated.

Approximately 12 hours of transcribed commentaries were recorded by the ship guide's assistant from ten different encounters (Table 7). These recordings ranged from 32 minutes to just over two hours of observations. In addition to the focal follow sampling of the main group, these recordings also include some *ad libitum* observations of other groups of large baleen whales observed and the distance and bearing to these groups.

DISCUSSION

Different groups of whales showed markedly different reactions to both the main research vessel (*Amaltal Explorer*) and the small boat (*Remora*). This may be due to previous experience of ship noise and some level of habituation for some individuals, as well as the manner in which the vessel(s) approached the whales (such as making sharp turns or rapid increases in speed). In general, the blue whales encountered appeared to show stronger aversive behaviour to vessels than is seen in other areas and a stronger response to the *Remora* than to the *Amaltal Explorer*.

RECOMMENDATION

- When choosing a ship, consideration should be given to underwater noise levels. If no measurements are available then it is likely that vessels with controllable pitch propeller (CPP) drives will generate high levels of underwater noise (particularly at slow speeds) because of excess cavitation when operating at different to design speed. If small boat use is being considered then noise levels for the small boat should be measured prior to the cruise and these may influence the choice of vessel and propulsion system. Any changes in course and/or speed should be made as gradually as possible.

The time taken to obtain photo-id and biopsy samples from an individual or group was typically several hours, during which time whale behaviour was disturbed to some extent. An additional 15-30 minutes of observation time at distances of around 1 km prior to a close approach should not significantly reduce the chance of a successful close approach and adds minimal additional time to the overall encounter (given an average of one or two close approaches a day for the research period in blue whale areas). Given that the animals were almost always also being tracked acoustically, the risk of losing contact with the group during this time is also low. A slow approach may also allow whales to become slightly more habituated to the vessel and enable the Ship Guide to get a better feel for the overall patterns of behaviour.

The protocol followed on the last encounter, of standing off before closing for a close approach with the *Amaltal Explorer* or launching the small boat, allowed behavioural observations of a group of whales over several dive cycles. These whales were unusually active at the surface but this activity did not appear to be a response to the vessel. In this instance, if a close approach had been made immediately, there may have been concerns that the surface activities were a response to the vessel(s).

RECOMMENDATION

- 15-30 minutes of tracking and observation time at distances of around 1 km prior to a close approach should be implemented, unless conditions make this unfeasible.

Collecting video tracking data on the VWhale voyage relied on off-duty acoustics personnel being available. This sometimes caused a delay in responding to possible blue whale sightings. This delay could be minimised on future surveys if visual observers routinely used the video tracking equipment for recording all sightings and switched to tracking when a possible blue whale was sighted. Use of video methods provides for accurate measurements of distances and angles which greatly improve distance sampling data (Leaper *et al.* 2011).

RECOMMENDATION

- Measurement of distances and angles should be incorporated into the implementation of observer protocols. This would allow observers to switch to tracking once a possible blue whale had been sighted with no time delay.

4.2.4. Objective 4. Collect distance sampling data for regional abundance estimate of cetacean species

Russell Leaper, Paula Olson, and Paul Ensor

The main objectives of the study were to find blue whales and to approach these for photo-identification and biopsy. Visual searching protocols are detailed in Appendix 5. Vocalisations from Antarctic blue whales were audible on all sonobuoys deployed south of 52°S and the course of the vessel was always influenced by the available acoustic data. Hence none of the vessel's route could be considered as independent of knowledge of whale locations and was not intended to be used for design-based line-transect density estimation for blue whales. There were around seven acoustic 'hot spots' for blue whales encountered south of 60°S and the acoustic monitoring allowed the vessel to head directly between these hot spots and towards locations of groups of blue whales.

Early in the cruise it also became apparent that there was a strong correlation between distribution of blue whales and other species, particularly fin and minke whales. The level of spatial correlation effectively precludes design-based line-transect density estimation for any baleen whale species and will require analyses that take the spatial correlation into account.

Systematic sightings data including quantified effort, environmental co-variates that may affect detection probability and initial locations relative to the vessel of all sightings were collected whenever possible. These data have the potential to contribute to analyses of the following:

(i) Distribution patterns and localised density of other baleen whale species (humpback, fin and minke whales) with respect to aggregations of blue whales and other co-variates such as distance from ice edge;

(ii) Blue whales that were seen but not heard provide data on acoustic detection probability;

(iii) Spatial scale and density of blue whales within aggregations including comparisons with acoustic data and average group size; and

(iv) Comparisons of observed locations of fin and humpback whales with bearings of vocalisations heard on sonobuoys to enable better descriptions of the acoustic repertoire of these species in the Southern Ocean.

RESULTS

The visual effort in the different survey modes for the transit to 60°S and in the area south of 60°S is given in Table 8. Sightings on the Transit to 60°S are given in Table 9. There were 40 sightings of Antarctic blue whales (Table 10, Figure 7). The radial distances to initial sightings of blue whales are shown in Figure 8. The large number of close sightings can be explained by acoustic tracking to locate animals in poor weather conditions. Sightings of all cetaceans other than Antarctic blue whales are listed in Table 11.

A preliminary investigation of the apparent spatial correlation of blue whales with other species (Figure 9) indicated that 70% (235/337) of fin whales (Figure 10) encountered were within 30 km of the nearest blue whale sighting (see Figure 6), although there appeared to be some separation in the species distribution at smaller spatial scales (only 3% of fin whales encountered were within 5 km of the nearest blue whale). The median distance of fin whale groups to the nearest blue whale sighting was 28.5km. Of a total of 16 Antarctic minke whales (Figure 11), 13 (81%) were within 30 km of the nearest blue whale sighting. The median distance for each minke whale group (mean group size = 1.2) was 11.2 km from the nearest blue whale sighting. There were many more encounters with humpback whales (238 groups; see Figure 12) than either fin or minke whales and less of an apparent correlation with blue whale sightings (Figure 9). 45% of humpback whale individuals sighted (215/475) were within 30 km of blue whales with a median group distance of 42.3 km from the nearest blue whale sighting. Humpback whales were the only species for which it may be possible to estimate a detection function related to perpendicular distance. The observed perpendicular distances for sightings of humpback whales are shown in Figure 13.

There were very few sightings of any odontocetes, and these were insufficient for density estimation. As with other joint visual and acoustic surveys, sperm whales were heard much more frequently than they were seen. Killer whales were seen on five occasions and three groups were approached for photo-identification.

DISCUSSION

Direct comparisons of sighting rates with other surveys such as IDCR-SOWER will be difficult for any species because of the spatial correlations with blue whales targeted acoustically and the generally low sighting rates. Because we were often following acoustic bearings towards blue whales, search effort often continued in conditions that would not have been considered workable during the IDCR-SOWER surveys. Further analysis is needed to determine whether the sightings of humpback whales were correlated with blue whales, and if it appears that the distributions are independent then density estimates may be possible since there were sufficient sightings of humpback whales to allow estimation of an overall detection function.

Blue whales were frequently tracked acoustically overnight and so the vessel was often positioned close to blue whales when visual observations commenced during the day. Following close approaches to blue whales there was often a gap in visual effort as observers rested while the vessel proceeded towards a new location. Data analysis will need to allow for the potential of a correlation between visual effort and whale distribution close to locations of blue whales.

RECOMMENDATIONS

See recommendations in Section 3.

4.2.5. Objective 5. Deploy satellite tags to describe the movement and behaviour of blue whales

Virginia Andrews-Goff

Antarctic blue whale movement has been described using static location information such as that derived from the retrieval of discovery-tagged whales, photo identification (see Branch *et al.* 2007) or acoustic data (Stafford *et al.* 2004). These techniques however are unable to provide a continuous record of actual movements, instead inferring movement from two (or more) known locations at two (or more) separate points in time. Actual movements of the whale between these points in time are not known. As such, movements including large scale migration between breeding and feeding grounds or even fine scale movement within a feeding ground remain poorly understood. Satellite-linked tags can provide detailed, long-term movement data that cannot be provided by any other method.

RESULTS

Two satellite tags were deployed using a compressed air gun (modified ARTS, Restech) (Gales *et al.* 2009). Air pressure was increased from 7.5 bar for the first tag deployment to 8.5 bar for the second to achieve improved tag implantation. Retention teeth on a purpose-designed projectile carrier grip a metal ring fitted to the end of the tag allowing the tag to be fired from the air gun. When the tag makes contact with the whale, the rapid deceleration of the tag and the projectile carrier withdraws the retention teeth releasing the projectile carrier (Double *et al.* 2010). The metal ring then falls off in time to reduce the drag of the tag. Once the tag is immersed in salt water, the salt water switch activates and the tag begins to transmit locations via the Argos satellite system. Each tag was deployed from the bow-sprit of the *Remora*.

Details on tag performance and the movements of each whale can be found in Table 12. The tag deployed on “Markus” transmitted for a total of 17 days. Following tagging, “Markus” remained at the approximate tagging location for 41 hours and then proceeded to travel north, covering a distance of 616 km in seven days (Figure 14). “Markus” then travelled west for the remaining ten days covering an additional 1571 km. Battery voltage and light level transmitted by the tag remained constant throughout the deployment period.

At the time of writing this report, the tag deployed on “Henry” was still transmitting. Following tag deployment, Henry proceeded to travel 385 km directly south east over 3 days, pausing for a couple of hours at 66.2°S, 173.8°E and then proceeding on the same south east track for another day (Figure 14). After four days, Henry travelled eastwards and then as far south as 68.04°S, 178.95°E. At the time of writing this report, Henry was travelling westwards and had covered more than 800 km in 7 days.

DISCUSSION

To our knowledge, satellite tags have not been deployed on Antarctic blue whales prior to this voyage. As such, the data from these two tags contribute new and valuable information on the small and large scale movements of Antarctic blue whales. The satellite tag-derived movements of “Markus” and “Henry” differed greatly. “Markus” travelled northwards and then west, approximately parallel to the polar front. In direct contrast, “Henry” travelled southeast at a greater average speed than “Markus.” Further analysis may assist in determining the nature of these contrasting movements, which could be a result of contrasting behaviours.

Further analyses will be performed once tag transmission ceases. Of particular interest are general movement descriptions (e.g. rate and direction of travel) with a long tag deployment potentially resulting in the first detailed description of the movement between feeding and breeding grounds. Given sufficient data quality, the data can be filtered/smoothed to account for Argos location error and to assign behavioural states to the observed movements (e.g. state space modelling). These behavioural states can then be used to identify the environmental characteristics of potential feeding, breeding and transit locations.

Both tags deployed performed well often transmitting in excess of ten locations per day. Just prior to tag failure, “Markus” spent approximately five days located in a low pressure system that generated high winds and swell. Throughout this time tag transmissions and location quality decreased markedly. Whilst this may have simply been a result of the tag placement at the time, further investigation into the impact of weather on tag transmissions and location quality would be valuable. Consistent light level readings transmitted from the tag indicated that the tag did not travel deeper into the body of the whale. In addition, consistent battery voltage levels indicated that the battery did not fail. Therefore it is likely this tag ceased transmitting due to tag rejection from the body of the whale.

RECOMMENDATIONS

Throughout the VWHALE voyage, it was rare to encounter Antarctic blue whales suitable for tagging. The small boat was not often able to get within tagging distance of animals due to their fast and/or erratic direction of travel. The ability to get within tagging range appeared to improve with increasing group size with both tag deployments occurring on individuals within pod sizes of four and five respectively. On both occasions, these pods appeared to be “distracted.” On the first occasion the pod seemed to be feeding whilst on the second occasion the pod was exhibiting behaviours which, in humpback whales, is usually associated with competitive groups.

- Therefore, satellite tagging attempts that target pods not employed in directed travel may result in more successful tag deployments.

4.2.6. Objective 6. Collect Antarctic krill (*Euphausia superba*) for ecological genomics study

Margaret Lindsay

The krill collected during the Antarctic Blue Whale Voyage will be used for genetic analysis at the Australian Antarctic Division (part of Australian Antarctic Science Program project 4015: Krill ecological genomics). This project is looking at krill circumpolar population genetic structure and is currently lacking samples from the region surveyed during the Antarctic Blue Whale Voyage. Sampling for adult krill occurred opportunistically during the voyage near the ice edge. The net was deployed on four occasions when large surface swarms were visible or when a large aggregation of krill was observed on the echo sounder (Simrad ES 60, single frequency at 38 KHz, to a maximum depth of 300m) during the night.

The successful trawls were undertaken at 67.525° S and 178.197° E on 24 February 2013 at 0244 and at 69.412° S and 177.700° E on 27 February 2013 at 0113. The krill samples were stored in ethanol at ambient temperature. The krill will be analysed on return to the Australian Antarctic Division.

4.2.7. Objective 7. Testing of kite-antenna for improved sonobuoy radio reception

Brian Miller and Russell Leaper

During this voyage, improvements to the existing real-time acoustic tracking system focused on increasing the VHF reception range for each sonobuoy. Improving the VHF reception range would allow monitoring of each sonobuoy for a longer amount of time, and thus improve efficiency by deploying fewer sonobuoys overall. Experiments to improve the VHF reception range used an antenna that was attached to a kite. Initial tests took place during the transit to the survey area when the vessel maintained a relatively stable course with respect to the wind.

RESULTS

The kite antenna was tested on only one occasion during the transit to the study area. During this test, the kite was lofted successfully by the crew from the top of the rear gantry. Launching the kite from the deck of the vessel proved difficult because of turbulence caused by the superstructure. The gantry was higher than any other point of the vessel and thus the kite could be launched into a relatively clean air flow. The VHF antenna was successfully attached to the kite-line once the kite achieved stable flight. The kite was flown while steaming at a constant course and speed and appeared to be stable enough to be left unattended.

After attaching the antenna, the kite was then anchored to the top of the gantry to achieve maximum height. Unfortunately, even with a substantial height advantage over the gantry VHF antenna, the kite antenna provided inferior reception relative to the fixed antennae. Signals from the kite antenna were not usable for acoustic analysis. There were no additional attempts at deploying the kite due to lack of time and limited availability of personnel. In addition, the wind often changed rapidly in strength and direction particularly in the area of operation south of 60°S.

DISCUSSION

During the voyage there was little time to test the kite antenna, and the results were mixed. The flowform kites were able to fly stably so long as the apparent wind speed and direction remained favourable, and the kite was also able to lift the payload with no problems. Signal reception may have been improved by using a heavier low-loss cable, but the wind-drag on the cable would be a concern and having a sufficiently large size kite to overcome the drag might not be feasible. Launching the kite also required a clean air flow. The gantry on the *Amaltal Explorer* provided a good platform for launching the kite but similar elevated structures may not be available on all vessels. Launching direct from the deck is likely to be problematic from many vessels.

While the antenna and associated electronics functioned adequately during bench tests, real-world performance was below that of the 3 dB antenna mounted on the gantry. Further investigation is needed to determine how performance can be brought up to useful levels. Initial investigation suggests that there may be a combination of mechanical and electrical issues responsible for sub-optimal performance. Electrical issues to be addressed include verifying the performance of the VHF preamplifiers and the signal attenuation due to the impedance of the coaxial cable. Mechanical issues to be investigated include stabilising the antenna so that it remains orientated vertically for optimum reception of the polarised radio signal.

Within the study area, wind speed and direction were highly variable, and thus there were limited opportunities to fly the kite for any length of time. It would not have be practicable to use the kite during targeting or tracking blue whales due to the need to frequently change course or speed in addition to changes in wind speed and direction. However, during transit the kite could potentially increase VHF reception range. A doubling of VHF reception range in transit would save roughly 30-40 sonobuoys over the course of a voyage with no decrease in the time spent monitoring for Antarctic blue whales.

While the gantry of the *Amaltal Explorer* provided a high platform (21 m) for VHF reception which provided average reception of sonobuoy VHF signals of 15 nmi, not all ships may have such capabilities. Thus, further development of the kite-antenna is warranted. A properly functioning kite-antenna may particularly allow for better VHF reception from much smaller vessels which could open up further research possibilities for using sonobuoys under a wide array of scenarios. Enhancing VHF radio reception may also have other applications in marine mammal research such as allowing signals from VHF tags to be received at greater ranges from small vessels or monitoring AIS transmissions to estimate shipping density.

RECOMMENDATIONS

- Effort should be made to further develop the antenna portion of the kite-antenna system.
- Lab and field tests should be conducted to verify correct functioning of the entire kite-antenna system, preferably using transmissions from actual sonobuoys.
- Having a high antenna is key to the success of any voyage using sonobuoys. Other ways of using rigid masts to increase antenna height should also be considered

4.2.8. Objective 8. Evaluate the body condition of humpback whales from biopsy samples

Natalie Schmitt and Carlos Olavarría

Eight shallow biopsies were collected from humpback whales (*Megaptera novaeangliae*) for a collaborative research project with Griffith University, “Development of a Non-lethal Method for the

Evaluation of Nutritional Condition in Humpback Whales (*Megaptera novaeangliae*); Facilitating Chemical and Environmental Risk Assessment". This project will evaluate and apply a novel biochemical marker for the assessment of nutritional condition in humpback whales. Findings will be applied to research questions concerning elevated chemical risk associated with a migratory life history and the role of nutritional stress as a co-factor in rising humpback whale stranding events observed in some Southern Hemisphere populations.

This research will be conducted in parallel with ongoing toxico-kinetic modelling and risk-assessment projects within the research team and inherently draws upon close collaborations between humpback whale researchers, thus representing a cost-effective strategy for advancing our understanding of the species and broadly disseminating outcomes and findings.

RESULTS

Eight biopsies were collected from 238 sightings (475 animals) of humpback whales (Table 13). The geographic distribution of the samples is given in Figure 5. Of the eight sampled humpback whales, five were biopsied from the small boat using either a Paxarms or Larsen rifle and three from the large vessel using the Larsen rifle only. Three sampled individuals were sub-adults with two of these members of a pair, and five were adults with one from a cow/calf pair, one an escort to a cow/calf pair and three part of a non-competitive trio. Fluke identification photographs were also obtained for four of the eight sampled animals. Based on their girth, all individuals were considered to be in very good condition.

Humpback whale samples were preserved following the protocol provided by Susan Bengsten-Nash from Griffith University and stored at -20C in a liquid nitrogen cryo-shipper, with and without preservation using RNA-later. All samples were processed after 20 min of collection, so the alternative protocol of storage was used (see details in S. Bengston-Nash protocol). Additionally, small portions of these samples were also kept for the AMMC and were preserved in All Protect (two pieces of 5mm^3 tissue each in separate vials and boxes).

Nine biopsy attempts of humpback whales were unsuccessful due to a combination of human error, darts remaining embedded in the animal, tethers breaking and issues with the Paxarms biopsy rifle, which are discussed in the section 4.2.2 of this report and listed in Table 14.

DISCUSSION

Humpback whale biopsy samples collected during the Antarctic Blue Whale Voyage 2013 will be sent to Griffith University for analysis on the evaluation of nutritional condition.

A small portion of skin will be curated and stored at the Australian Antarctic Division. These samples will be included in ongoing mixed-stock analyses to determine the allocation of humpback whale breeding populations to Antarctic feeding areas in the Southern Ocean, based on mitochondrial DNA sequences, microsatellite and SNP genotypes. The samples will also be used to genetically assign humpback whale individuals from Antarctic feeding areas to low-latitude breeding grounds using genotype matching.

4.2.9. Data management

The voyage has generated over 3TB of data. For details of data streams and backup locations, see Table 15.

4.2.10. Media

Victoria Wadley

The Antarctic Blue Whale Voyage has attracted considerable media interest, due to the high profile of the Antarctic Blue Whale Project as a flagship project of the Southern Ocean Research Partnership of the International Whaling Commission. The charisma of whales, scenic operations in the Southern Ocean and pioneering of innovative non-lethal research methods provided a unique appeal to a wide audience.

During the voyage, the media duties were undertaken only after the science responsibilities had been completed; there was no dedicated time or staff for media work. On the ship, cooperation with scientists and crew was excellent and facilitated the media agenda. We thank all involved for their support and understanding.

Still photographs: A total of 11 GB of still photographs were taken for media purposes.

Videos: Scientific activities around the ship and on the *Remora* were recorded on video. Interviews of key scientists about their role on the voyage were captured while at sea. A total of 50 GB of GoPro and 25 GB of Sony Handycam videos were captured.

Publicity: During the voyage, 17 blogs with photos were posted on the Australian Marine Mammal website Voyage web site:

http://www.marinemammals.gov.au/sorp/expeditions/antarctic-blue-whale-voyage-2013

The blogs were visited on average 749 times per week, with the most popular being “Blue whale ballet” followed by “Satellite tag deployed on Antarctic blue whale.” Newspaper articles and reviews on the voyage were printed, and more are already in preparation. A media package was prepared at sea, with images, videos, interviews and text, ready for a presentation to the Minister for the Environment, the Hon. Tony Burke. A media release, newsprint, TV, radio and articles will publicise the voyage. A summary document will be prepared for the Scientific Committee of the International Whaling Commission in June 2013.

RECOMMENDATIONS

- The guidance, training and resources of the AAD Multimedia Unit were instrumental to the successful media work on the voyage; this support will be important for other voyages.
- For future voyages with high-profile media requirements like this voyage, the seagoing staff need dedicated time to complete their media duties.
- The ship’s facilities for email and internet communication should be established prior to departure as meeting a minimum agreed standard.

- The importance of media operations at sea deserves recognition as an integral part of the reporting, communication and funding aspects of high-cost research in the Southern Ocean.

5. CONCLUSIONS

Analyses of the samples and other data collected on the 2013 Antarctic Blue Whale Voyage will continue for several years, but several important conclusions are immediately clear:

- DIFAR sonobuoys can detect areas of high blue whale density from distances of hundreds of kilometers, and can be used to direct the ship to those areas for efficient photographic and biopsy sampling.

- Photo-IDs and biopsies can be effectively obtained from a large ship or a small boat. For the vessels used in 2013, Antarctic blue whales were easier to approach with the large ship, but in high-density areas the most efficient sampling was with both vessels.

- Antarctic blue whales can be satellite tagged, but most are very evasive in the presence of a small boat. The best success was obtained with larger groups of whales.

- The distribution of other whale species was highly correlated with the distribution of blue whales, and acoustically directed search for blue whales was not random with respect to the distribution of other baleen whales. The estimation of regional abundance for other species from visual distance sampling data (Objective 4) will be challenging and may not be feasible.

- Both acoustic detections and satellite tag deployments indicated that Antarctic blue whale distribution extends north of 60°S in late summer, which has not been shown in previous survey data.

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8. TABLES

Table 1. Antarctic Blue Whale Voyage schedule

Details	Location	Arrive	Depart	Time allocation
On hire; load cargo	Nelson, NZ	28-Jan-2013	30-Jan-2013	2 days
Transit		30-Jan-2013	8-Feb-2013	8 days
Science Objectives 1 to 4	135°E –170°W	8-Feb-2013	08-Mar-2013	29 days
Science Objectives 5 to 8	135°E –170°W	5-Feb-2013	08-Mar-2013	Opportunistic
Transit		08-Mar-2013	17-Mar-2013	9 days
Unload cargo; off hire	Nelson, NZ	17-Mar-2013	18-Mar-2013	2 days

Table 2. Acoustic tracking and targeting metrics while in transit and south of 60°S

Measure	**Transit to 60°S**	**South of 60°S**	**Total**
Sonobuoys deployed	35	260	295
Number of failed buoys	7	31	38
Audio recorded (hours)	61.7	564.4	626.1
Audio from 2 simultaneous buoys (%)	19.1%	58.1%	54.1%
ABW calls analysed in realtime	539	26,006	26,545
Triangulated locations	0	3,146	3,146
Targets pursued	0	43	43
Targets successful	0	25	25
Associates of targets successful	0	8	8
Targets aborted	0	5	5
Targets missed	0	6	6
Visual survey hours	64.1	346.6	410.7
Visual survey distance (km)	1,229	6,078	9,298

Table 3. Summaries of photo-identified blue whales during the Antarctic Blue Whale Voyage 2013 stratified by date and sighting number.

Species & UTC Date	Sighting no.	group size	# new whales photo-ID'd	# left side ID photos	# right side ID photos	Biopsy samples	Satellite tag #
New Zealand Blue							
30 Jan	006	2	2	0	2		
31 Jan	009	2	2	1	1		
31 Jan	012	6	6	5	2		
31 Jan	015	1	1	1	0		
12 Mar	710	1	1	1	1		
14 Mar	715	2	2	2	2		
14 Mar	718	1	1	1	1		
14Mar	720	1	1	1	1		
Total		**16**	**15**	**12**	**10**		
Antarctic Blue							
07 Feb	065	1	1	1	1	BW13001	
08 Feb	073	1	1	1	1		
09 Feb	128	1	1	1	1	BW13002	
09 Feb	132	2	2	2	2	BW13003	
12 Feb	179	2	2	1	2		
12 Feb	186	1	1	1	1	BW13004	
13 Feb	190	5	3	2	2		
13 Feb	193,194	8	9	6	7	BW13006,007,008 ,009	
14 Feb	199	2	1	0	1		
14 Feb	211	4	4	3	3	BW13010,011,012	123223
14 Feb	215	2	2	0	2	BW13013	
14 Feb	217	1	0	1	0	BW13014	
18 Feb	276	1	1	1	1		
20 Feb	288	4	2	2	0		
20 Feb	291	2	1	0	1		
20 Feb	292	3	3	2	3		
20 Feb	294	4	0	0	0	BW13018	
21 Feb	297	1	0	0	0		
23 Feb	377	2	0	0	0		
24 Feb	395	3	2	0	2		
24 Feb	412	4	3	3	2		
25 Feb	428	1	0	0	0		
25 Feb	429	1	1	1	1		
25 Feb	456	1	1	1	1		
25 Feb	458	4	2	2	2		
25 Feb	466	3	0	0	0		
27 Feb	542	2	1	1	0		
27 Feb	552	1	1	1	1		
01 Mar	580	1	1	1	1		
01 Mar	590	2	2	2	1		
01 Mar	595	2	2	2	2	BW13024	
03 Mar	640	3	0	0	0		
08 Mar	687	6	7	6	5	BW13025,026,027 ,028,029,030,031	121205
Total		**81**	**57**	**44**	**46**		

Table 4. Summary information on Antarctic blue whale biopsies. Vessels are small boat (SB) and ship (SH). South latitudes are negative.

Sample #	Date (local)	Vessel	Sighting #	Latitude	Longitude	Firearm	All Protect	EtOH	Nitrogen	Photo - id
BW13001	8/02/2013	SB	65	-62.3491	142.3162	Paxarms	✓	✓	✓	✓
BW13002	8/02/2013	SB	73	-62.5858	143.9334	Paxarms	✓	✓	✓	✓
BW130	9/02/2013	SH	132	-64.8824	143.5081	Larsen	✓	✓	✓	✓
BW13004	13/02/2013	SH	186	-62.2877	147.5171	Larsen	✓	✓	✓	✓
BW13005	14/02/2013	SH	194	-62.4133	146.8056	Larsen	✓	✓	✓	×
BW13006	1402/2013	SB	194	-62.3569	146.8219	Paxarms	✓	✓	✓	✓
BW13007	14/02/2013	SB	94	-62.3287	146.8158	Paxarms	✓	✓	✓	✓
BW13008	14/02/2013	SH	194	-62.3408	146.6778	Larsen	✓	✓	✓	×
BW13009	14/02/2013	SB	194	-62.2166	146.7416	Paxarms	✓	✓	✓	✓
BW13010	14/02/2013	SB	21	-62.0215	149.0155	Paxarms	✓	✓	✓	✓
BW13011	14/02/2013	SB	211	-62.0104	49.0266	Paxarms	✓	✓	✓	✓
BW13012	14/02/2013	SB	211	-62.0059	149.0136	Paxarms	✓	✓	✓	✓
BW13013	15/02/2013	SH	215	-62.042	149.3945	Larsen	✓	✓	✓	✓
BW13014	15/02/2013	SH	217	-62.6041	149.975	Larsen	✓	✓	✓	✓
BW13018	21/02/2013	SH	294	-64.379	167.0643	Larsen	✓	×	×	✓
BW13024	2/03/2013	SH	595	-69.8369	-170.355	Larsen	✓	✓	✓	✓
BW13025	8/03/2013	SH	687	-63.9251	168.0531	Larsen	✓	✓	✓	✓
BW13026	8/03/2013	SH	687	-63.913	167.9778	Larsen	✓	✓	✓	✓
W13027	8/03/2013	SB	687	-64.0154	168.1577	Paxarms	✓	✓	✓	✓
BW13028	8/32013	SB	687	-64.0353	168.2616	Paxarms	✓	✓	✓	✓

BW13029	8/03/2013	SB	687	-64.059	168.3612	Paxarm s	✓	✓	✓	✓
BW13030	8/03/2013	SB	687	-64.058	168.3913	Paxarm s	✓	✓	✓	✓
BW13031	8/03/2013	SB	687	-64.0692	168.4303	Paxarm s	✓	✓	✓	✓

Table 5. Summary of missed biopsy attempts on Antarctic blue whales. Vessels are small boat (SB) and ship (SH). South latitudes are negative.

Species	Vessel	Missed shot?	Reason for miss	Stuck dart
blue whale	SB	yes	human error	no
blue whale	SH	yes	human error	no
blue whale	SH	yes	human error	no
blue whale	SH	yes	human error	no
blue whale	SB	no		yes
blue whale	SH	no		yes
blue whale	SH	yes	human error	no
blue whale	SB	yes	faulty sight	no
blue whale	SB	yes	human error	no
blue whale	SH	yes	human error	no
blue whale	SH	yes	human error	no
blue whale	SB	yes	human error	no
blue whale	SH	no		yes
blue whale	SH	no	dart broke	yes

Table 6.Time periods of tracking effort using the video tracking system.

TrackNumber	VideoTrackStart	Duration (Hours:minutes)
1	30/01/2013 22:52	00:21
2	31/01/2013 02:55	00:35
3	07/02/2013 20:48	03:12
4	08/02/2013 05:58	01:26
5	09/02/2013 04:24	01:07
6	13/02/2013 00:03	00:14
7	13/02/2013 19:24	01:48
8	14/02/2013 00:04	00:45
9	14/02/2013 01:13	01:48
10	18/02/2013 18:15	00:08
11	18/02/2013 19:19	00:38
12	18/02/2013 22:31	00:25
13	20/02/2013 00:59	00:52
14	20/02/2013 21:33	01:00
15	24/02/2013 18:20	02:03
16	25/02/2013 02:20	00:36
17	25/02/2013 03:52	01:04
18	25/02/2013 18:36	01:41
19	27/02/2013 00:30	00:58
20	27/02/2013 06:28	00:29
21	01/03/2013 05:59	01:36
22	01/03/2013 18:34	01:39
23	01/03/2013 22:25	00:36
24	07/03/2013 21:52	04:08
25	08/03/2013 03:44	00:49

Table 7. Time periods of the transcribed commentaries from the Ship Guide's assistant. Number of animals is given as the largest number of animals observed in the focal pod during the focal follow. Number of pods is given as a total number observed including other large baleen whale species and pods only seen on one occasion.

Date Time	Sighting number	Recording length (hh:mm:ss)	Number of animals	Number of pods
24/02/2013 18:20	410	02:05:58	2	6
25/02/2013 18:33	456	00:56:13	1	1
25/02/2013 19:53	458	00:38:20	3	3
25/02/2013 22:44	466	01:17:28	5	11
27/02/2013 06:27	542	00:57:18	2	5
27/02/2013 20:15	552	02:03:22	1	2
01/03/2013 06:26	580	01:08:26	1	1
01/03/2013 22:03	595	00:56:05	2	1
03/03/2013 03:06	640	00:32:53	2	1
07/03/2012 21:49	687	01:54:10	6	3

Table 8. Visual *s*urvey effort by different modes on Transit to 60^{o}S and south of 60^{o}S. See Appendix 5 for description of survey modes.

	Transit to 60^{o}S		South of 60^{o}S	
Survey modes	Dist (km)	Time (hours)	Dist (km)	Time (hours)
AB	126	7	2045	107
BO	380	21	590	35
CA	0	0	867	72
OF	1686	94	4517	396
SA	0	0	89	5
VB	30	2	50	3
VT	693	35	1882	94
WW	0	0	555	30

Table 9. Cetacean sightings in transit from New Zealand to 60°S

Species Name	# Sightings	# Individuals
Fin whale	2	3
Sei whale	2	2
Antarctic minke	1	1
New Zealand blue whale	5	12
Like New Zealand blue	1	1
Like blue whale	3	3
Common dolphin	4	73
Pilot whale	2	7
Cruciger dolphin	1	8
Unid large baleen	7	11
Unid large whale	1	6
Unid small whale	3	3
Unid whale	1	1
Unid dolphin	3	16
Ziphiidae	1	10

Table 10. Sighting times, locations and initial estimates of group sizes for Antarctic blue whales. South latitudes are negative.

Time	Group size	Latitude	Longitude
07/02/2013 20:19	1	-62.2866	142.283
07/02/2013 20:18	1	-62.2886	142.2872
07/02/2013 20:10	1	-62.3065	142.2958
08/02/2013 05:45	1	-62.5448	143.9044
09/02/2013 04:32	1	-64.6914	143.5223
09/02/2013 08:15	2	-64.9688	143.4499
12/02/2013 18:36	2	-62.4238	147.0771
12/02/2013 22:58	1	-62.2573	147.3744
13/02/2013 01:53	4	-62.4245	147.4657
13/02/2013 18:34	5	-62.473	146.8482
13/02/2013 19:03	4	-62.4872	146.9217
14/02/2013 01:15	1	-62.0591	147.3713
14/02/2013 07:09	4	-62.0016	148.872
14/02/2013 18:27	1	-62.0256	149.3958
14/02/2013 18:37	2	-62.021	149.4
14/02/2013 21:47	1	-62.0077	149.3581
18/02/2013 21:56	1	-63.7258	163.2845
20/02/2013 00:23	4	-64.5464	168.0167
20/02/2013 03:09	2	-64.4594	168.1559
20/02/2013 05:59	3	-64.4933	168.1254
20/02/2013 22:28	4	-64.3902	167.0419
21/02/2013 01:50	1	-64.4398	166.8535
23/02/2013 20:22	2	-67.7031	179.6689
24/02/2013 06:31	3	-67.7273	-179.976
24/02/2013 19:42	4	-67.7308	-179.495
25/02/2013 00:47	1	-67.9583	-178.696
25/02/2013 03:32	1	-67.9757	-178.32
25/02/2013 04:19	1	-67.9475	-178.249
25/02/2013 18:09	1	-68.4622	-177.686
25/02/2013 19:35	3	-68.413	-177.583
25/02/2013 22:35	3	-68.4648	-177.128
27/02/2013 06:18	2	-68.5912	-176.521
27/02/2013 19:33	1	-68.241	-176.647
01/03/2013 01:50	1	-68.8292	-170.658
01/03/2013 05:13	1	-69.3502	-171.191
01/03/2013 18:24	2	-69.8426	-170.427
01/03/2013 18:27	2	-69.8407	-170.435
01/03/2013 21:59	2	-69.846	-170.355
03/03/2013 02:57	3	-69.499	-176.795
07/03/2013 21:35	5	-64.0188	168.0919

Table 11. Numbers of sightings and total individuals for all cetaceans other than blue whales south of 60°S.

Species Name	**# Sightings**	**# Individuals**
Fin whale	59	338
Like fin whale	8	31
Humpback whale	238	475
Like humpback whale	67	110
Antarctic minke whale	6	7
Like Antarctic minke	3	4
Undetermined minke	7	9
Like minke	6	14
Sperm whale	3	3
Like sperm whale	3	3
Killer whale	5	59
S bottlenose whale	1	1
Cruciger dolphin	3	24
Unid large baleen	43	76
Unid dolphin	2	11
Unid whale/dolphin	1	2
Unid large whale	19	38
Unid small whale	7	7
Unid small cetacean	4	7
Unid whale	2	4

Table 12. Summary information on two satellite tags deployed on Antarctic blue whales.

	"Markus"	*"Henry"*
Argos PTT number	123223	121205
Date deployed	14/2/2013 8:21 UTC	8/3/2013 2:39 UTC
Location deployed	62.00°S, 149.01°E	64.04°S, 168.29°E
Air pressure	7.5 bar	8.5 bar
Shot distance	5m	8m
% implant	80	98
Locations per day (mean ± se; range)	10.8 ± 1.73; 2 - 23	16.38 ± 2.40; 3 - 25
Track distance	1571km	822km
Speed (mean ± se; range)	4.46 ± 0.24 kmh^{-1}; 0.22 – 30.66 kmh^{-1}	5.58 ± 0.74 kmh^{-1}; 2.88 - 8.60 kmh^{-1}
Last transmission date	3/3/2013 19:06	NA
Last transmission location	57.61°S, 139.13°E	NA

Table 13. Summary information on humpback whale biopsy samples. South latitudes are negative.

Sample #	Date (local)	Platform	Sighting #	Latitude	Longitude	Firearm	All Protect	Photo - id
HW13015	16/02/2013	SB	237	-64.7506	150.7656	Larsen	✓	✗
HW13016	16/02/2013	SB	240	-64.791	150.7971	Larsen	✓	✗
HW13017	6/2/2013	SB	240	-64.79	150.801	Larsen	✓	✓
HW13019	25/02/2013	SB	413	-67.7114	-179.552	Paxarms	✓	✗
HW13020	25/02/2013	SB	413	-67.7121	-179.61	Paxarms	✓	✗
HW13021	2/03/2013	SH	593	-69.852	-170.497	Larsen	✓	✓
HW13022	2/03/2013	SH	593	-69.8684	-170.499	Larsen	✓	✓
HW13023	2/03/2013	SH	593	-69.8746	-170.492	Larsen	✓	✓

Table 14. Summary of missed humpback whale biopsy attempts. Vessels are small boat (SB) and ship (SH).

Species	Vessel	Mssed shot?	Reason for miss	Stuck dart
humpback whale	SB	yes	human error	no
humpback whale	SB	no		yes
humbackwhale	SH	yes	human error	no
humpback whale	SH	yes	tether broke	no
humpback whale	SH	yes	Paxarms issue	no
humpback whale	SH	yes	Paxarms issue	no
humpback whale	SH	yes	tether broke	no
humpback whale	SH	no		yes
humpback whale	SH	yes	Paxarms issue	no

Table 15. Summary of the voyage data stream

	Data type	Primary data entry	Data form	Data entry location	Data file final	Data file final location	Data back-up to
1	Obs data - sightings, environment, sea temperature	Logger	Electronic	Logger computer - bridge	Logger Access database	Logger laptop *c:/Logger_1_retired/BlueWhale2013_1.mdb* *c:/Logger_2_current/BlueWhale2013_2.mdb*	HDD – Logger1 HDD – Logger2
2	NMEA feed – ship's GPS, heading, speed	Automatic - Logger	Electronic	Logger computer - bridge	Logger Access database Daily folder	Logger computer *c:/Logger_1_retired/BlueWhale2013_1.mdb* *c:/Logger_2_current/BlueWhale2013_2.mdb* *c:/NMEA dump*	HDD – Logger1 HDD – Logger2
3	Video footage	Video camera	Electronic	Flying Bridge, Bridge	Video folders by day and camera	RL's laptop	HDD – VideoTracking1 HDD – VideoTracking2
4	Video footage transcription	Whale Voc & Behaviour Datasheet	Electronic	Flying Bridge, Bridge	Whale Behaviour Datasheet	RL's laptop	HDD – VideoTracking1 HDD – VideoTracking2
5	Sonobuoy audio	Audio daily folder	Electronic	Acoustic workstation	Audio daily folder	Acoustic workstation c:/Data/	HDD - Acoustics1 HDD – Acoustics2
6	Sonobuoy deployment	Logger	Electronic	Logger computer - bridge	Logger Access database	Logger computer *c:/Logger_1_retired/BlueWhale2013_1.mdb* *c:/Logger_2_current/BlueWhale2013_2.mdb*	HDD – Logger1 HDD – Logger2
7	Sonobuoy deployment	Sonobuoy Deployment Log	Electronic	Acoustic workstation	Sonobuoy Deployment Log	Acoustic workstation c:/Data/	HDD - Acoustics1 HDD – Acoustics2
8	Sonobuoy deployment	Sonobuoy Event Log	Written	Acoustic workstation	Sonobuoy Event Log	Hardcopy	n/a
9	Whale tracking	Whale Tracking Log	Written	Acoustic workstation	Whale Tracking Log	Hardcopy	n/a
10	Acoustics GPS text file	Automatic - csv file	Electronic	Acoustic workstation	GPS files	Acoustic workstation c:/Data/	HDD - Acoustics1 HDD – Acoustics2
11	Photo-ID images	Cameras	Electronic	Flying Bridge, Bridge, Bow	Photo by species and sighting number	HDD – Photo ID *E:/13BW_PhotoID_images*	HDD – PhotoID2 HDD – PhotoID3
12	Reconciled photo-ID images	Datasheet	Electronic	Photo ID computer	Spreadsheet	HDD – Photo ID *E:/13BW_PhotoID_alldata.xlsx*	HDD – PhotoID2 HDD – PhotoID3
13	Photo-ID data	Photo-ID Datasheet	Written	Acoustics lab	Weekly spreadsheets	HDD – Photo ID *E:/13BW_PhotoID_alldata.xlsx*	HDD – PhotoID2 HDD – PhotoID3
14	Biopsy events (ship)	Logger	Electronic	Logger computer - bridge	Logger Access Database RHIB & Biopsy Access Database	Logger laptop *c:/Logger_1_retired/BlueWhale2013_1.mdb* *c:/Logger_2_current/BlueWhale2013_2.mdb* Photo ID computer *c:/SightingsDatabase/CetaceanSightingDatabase_ABWV.mdb*	HDD – Logger1 HDD – Logger2 HDD – Sightings db & GPS
15	Biopsy events (RHIB)	RHIB Field Datasheet	Written	RHIB	RHIB & Biopsy Access Database Logger Access Database	Photo ID laptop *c:/SightingsDatabase/CetaceanSightingDatabase_ABWV.mdb*	HDD – Sightings db & GPS HDD – PhotoID3
16	Biopsy samples summary	Biopsy Samples Spreadsheet	Electronic	Acoustics lab	Spreadsheet	Photo ID laptop *c:/SightingsDatabase/Biopsy_info_ABWV2013.xlsx* *c:/SightingsDatabase/Biopsy_info_ABWV2013(hbw).xlsx*	HDD – Sightings db & GPS HDD – PhotoID3
17	RHIB GPS location data	RHIB GPS	Electronic	RHIB	Gpx files – track and waypoint by date and biopsy sample number	Photo ID laptop *c:/SightingsDatabase/Small boat GPS*	HDD – Sightings db & GPS HDD – PhotoID3
18	RHIB sightings, tagging	RHIB Field Datasheet	Written	RHIB	RHIB & Biopsy Access Database	Photo ID laptop *c:/SightingsDatabase/CetaceanSightingDatabase_ABWV.mdb*	HDD – Sightings db & GPS HDD – PhotoID3
19	Krill collection	Logger event	Electronic	Logger computer - bridge	Logger Access database	Logger laptop *c:/Logger_1_retired/BlueWhale2013_1.mdb* *c:/Logger_2_current/BlueWhale2013_2.mdb*	HDD – Logger1 HDD – Logger2
20	Satellite tag location data	Automatic - Argos system	Electronic	Automatic - Argos system	Enterprise database - AAD Data Centre	AADC Database	Data farm
21	Incidental media – video	Cameras	Electronic	Flying Bridge, Bridge, Bow	Files by event	Communal laptop *c:/ABWV_2013_movies*	HDD – Multimedia mac HDD – PhotoID3
22	Incidental media - photos	Cameras	Electronic	Flying Bridge, Bridge, Bow	Photo folders by photographer	Media laptop *c:/201302_Explorer_Media_Photos_Best_of*	HDD – Multimedia mac HDD – PhotoID3; DVDs

23	Delivered sea ice data – University of Bremen	n/a	Electronic	n/a	As original	VAG's laptop *C:\ Documents\ArcGIS\ABW_2013_GIS\Ice images\Neal Young*	HDD – Logger1 HDD – Logger2
24	CTD deployments	Logger event	Electronic	Logger computer - bridge	Logger Access database	Logger computer *c:/Logger_1_retired/BlueWhale2013_1.mdb* *c:/Logger_2_current/BlueWhale2013_2.mdb*	HDD – Logger1 HDD – Logger2
25	CTD deployment data	Automatic CTD	Electronic	Automatic CTD	CTD files	Acoustic workstation c:/Data/	HDD - Acoustics1 HDD – Acoustics2 MS – VWHALE CTD MS – VWHALE CTD BACKUP
26	Weather	Ship's log	Written	Bridge	As original	Hardcopy	
FILES NOT OVERWRITTEN DURING BACKUP							

9. FIGURES

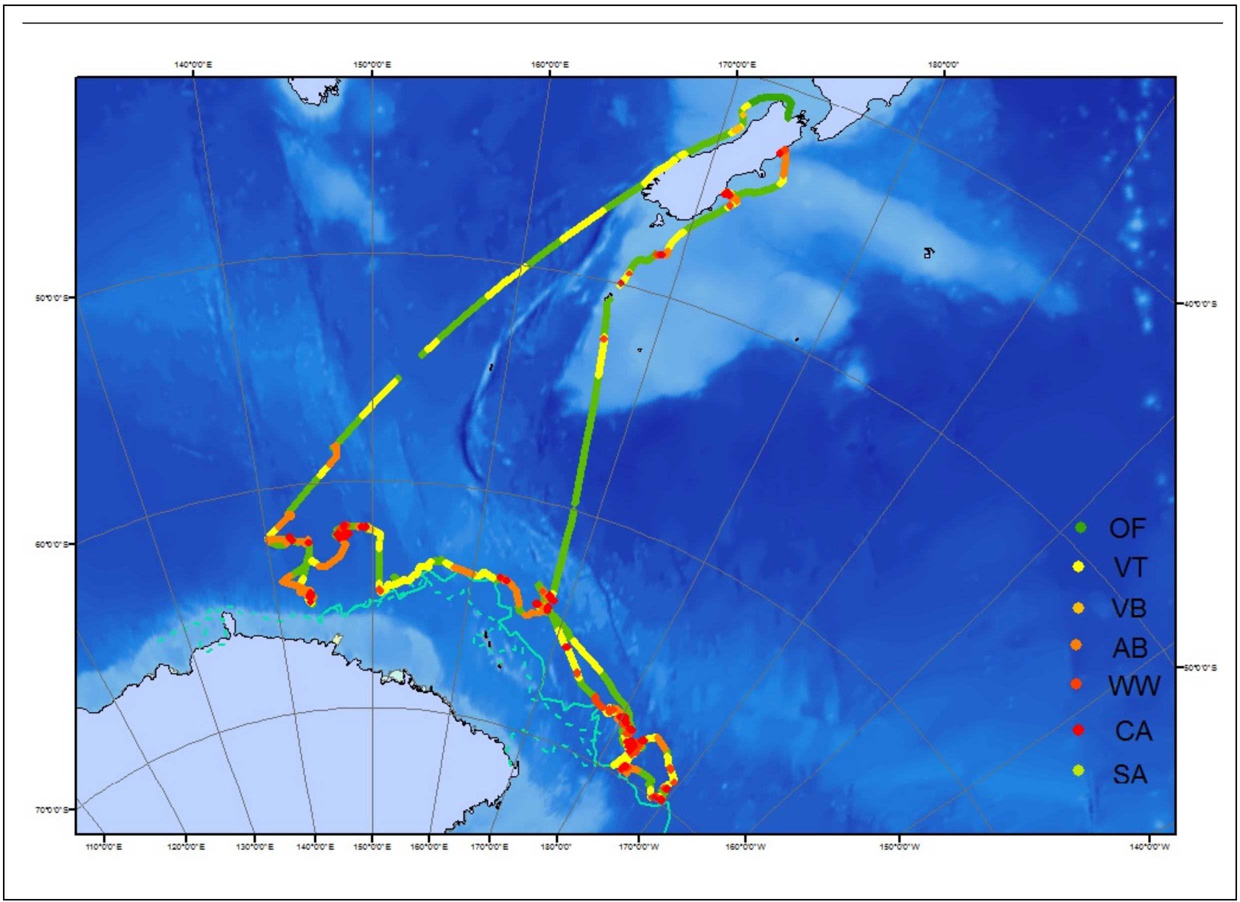

Figure 1. VWHALE ship track detailing associated observational modes (see Appendix 5). The maximum (7/3/2013) and minimum (15/2/2013) ice extent experienced during the voyage is represented by the solid and dashed lines adjacent to the Antarctic coastline.

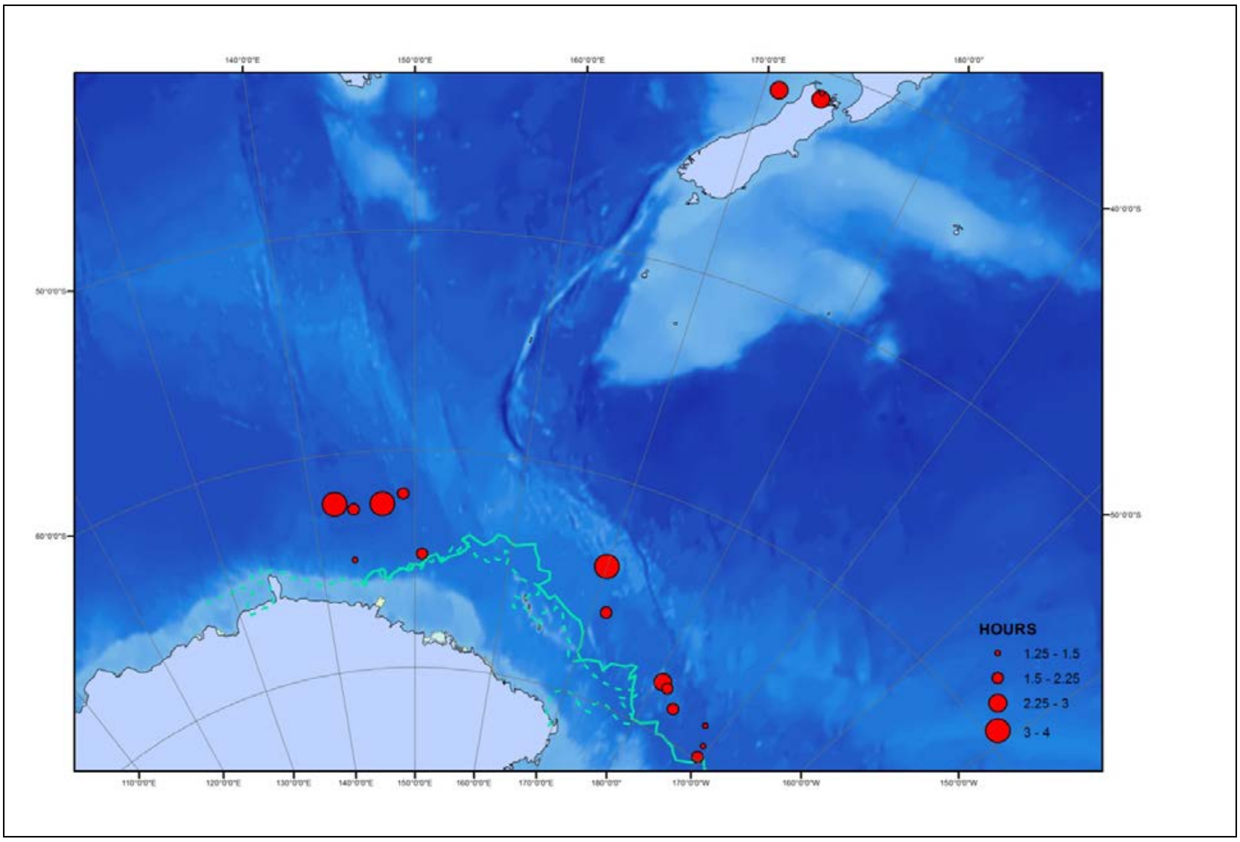

Figure 2. Distribution of small boat effort throughout the VWHALE voyage. The maximum (7/3/2013) and minimum (15/2/2013) ice extent experienced during the voyage is represented by the solid and dashed lines adjacent to the Antarctic coastline. Note: small boat deployments north of 60°S were for training purposes only.

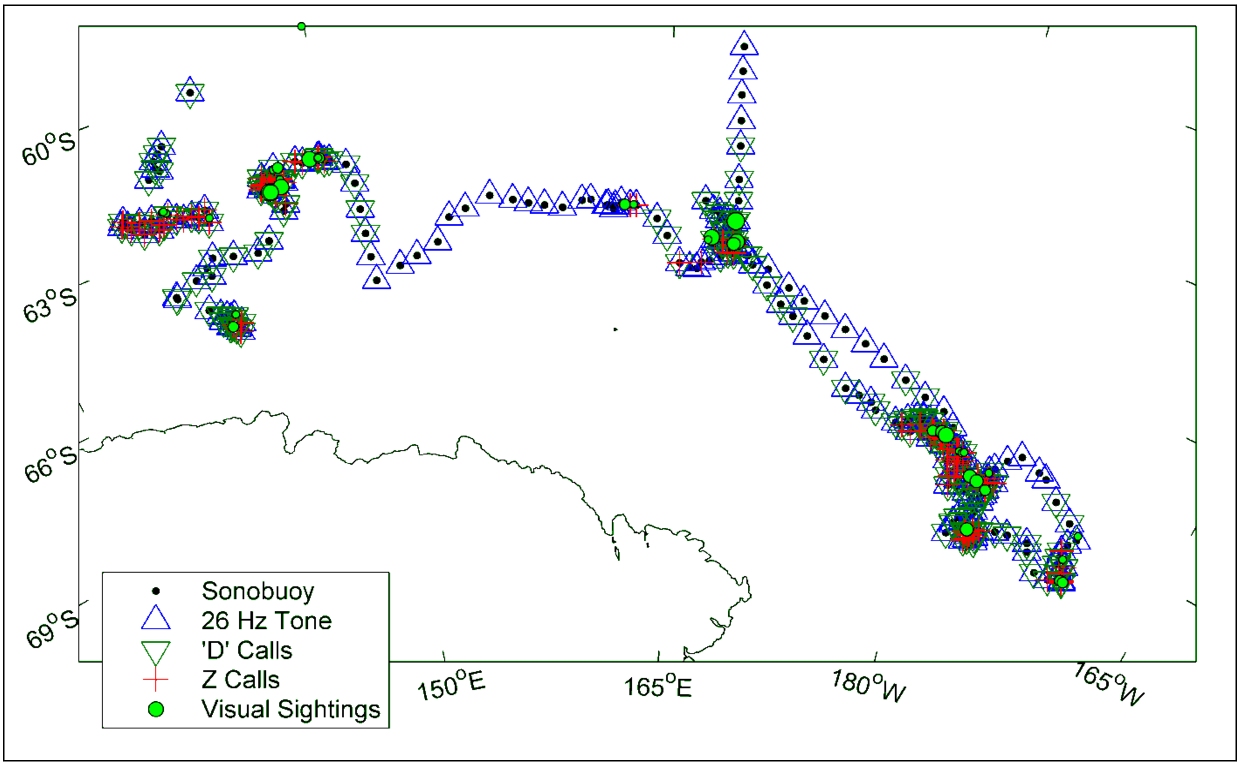

Figure 3. Map of detections of Antarctic blue whale vocalisations south of 60°S. 26 Hz tones (blue triangles) were detected on every sonobuoy deployed south of 60°S, while 'D' calls (green triangle) and Z calls (red cross) were detected only on sonobuoys that were nearer to whales (based on visual sightings or acoustic tracking).

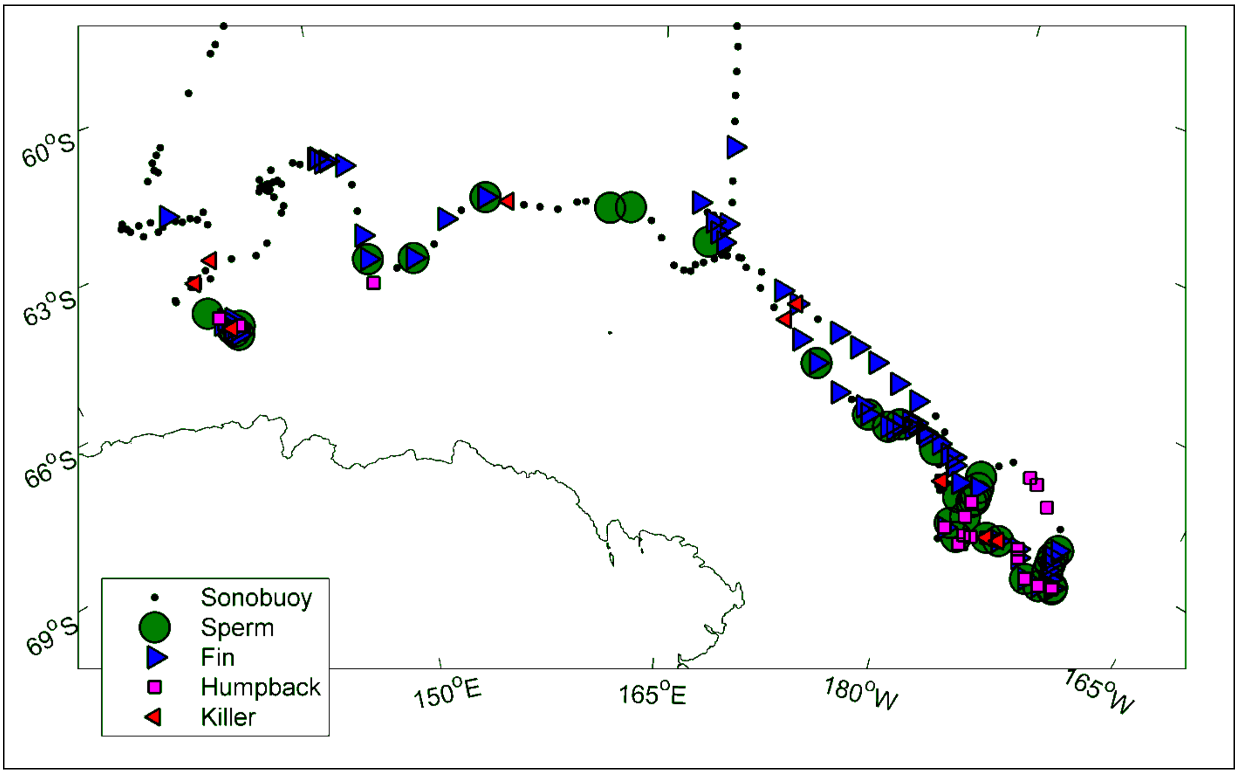

Figure 4. Acoustic detections of sperm whales (green circle), fin whales (blue triangle), humpback whales (pink square), and killer whales (red triangle). Note: this map was generated using only preliminary detections during real-time monitoring and further analysis is required to confirm presence and absence of species presented here.

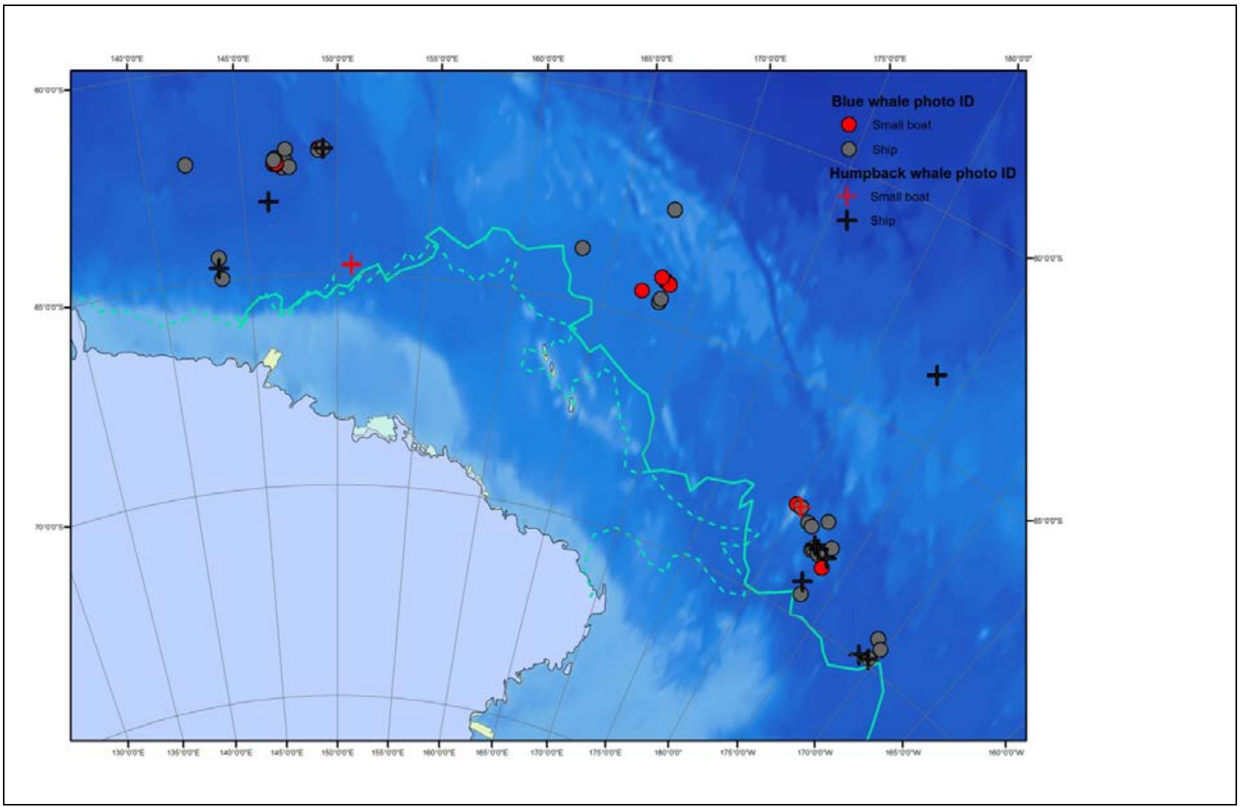

Figure 5. Distribution of Antarctic blue and humpback whale photo IDs collected from the ship and small boat throughout the VWHALE voyage. The maximum (7/3/2013) and minimum (15/2/2013) ice extent experienced during the voyage is represented by the solid and dashed lines adjacent to the Antarctic coastline.

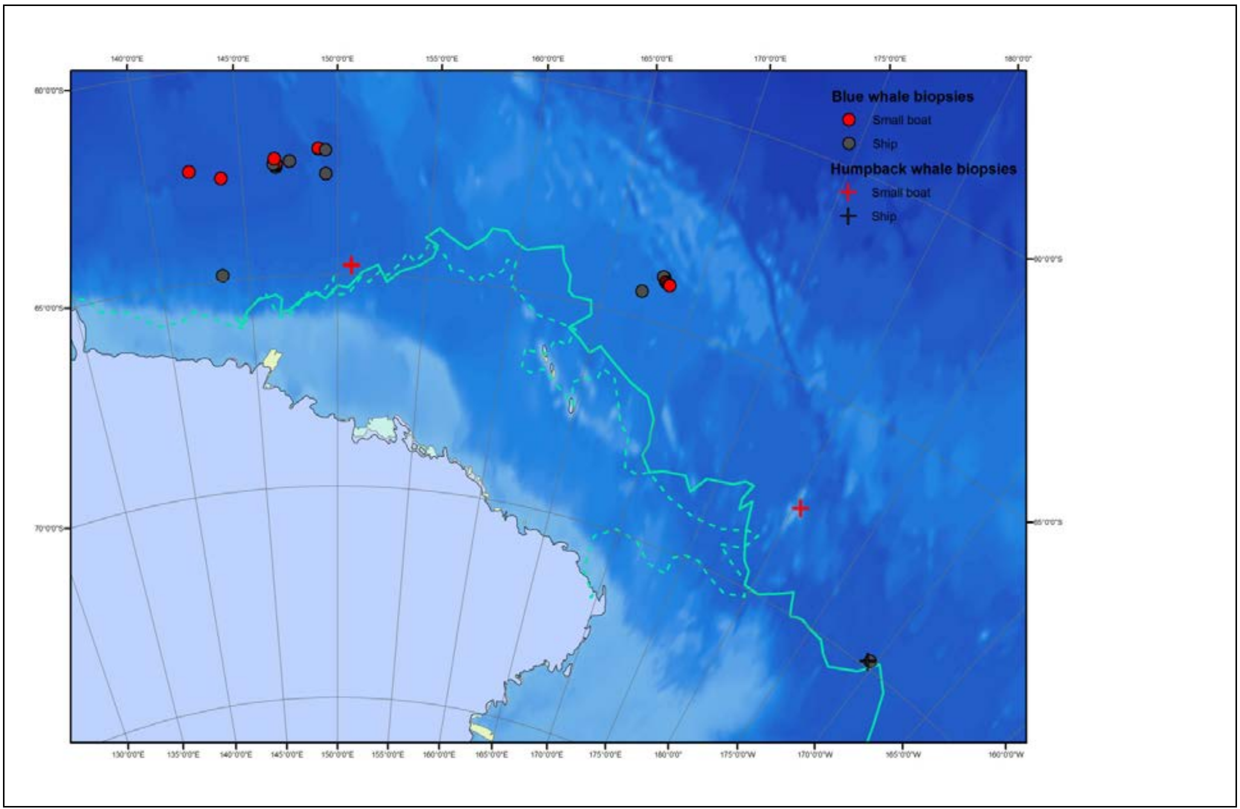

Figure 6. Distribution of Antarctic blue and humpback whale biopsies collected from the ship and small boat throughout the VWHALE voyage. The maximum (7/3/2013) and minimum (15/2/2013) ice extent experienced during the voyage is represented by the solid and dashed lines adjacent to the Antarctic coastline.

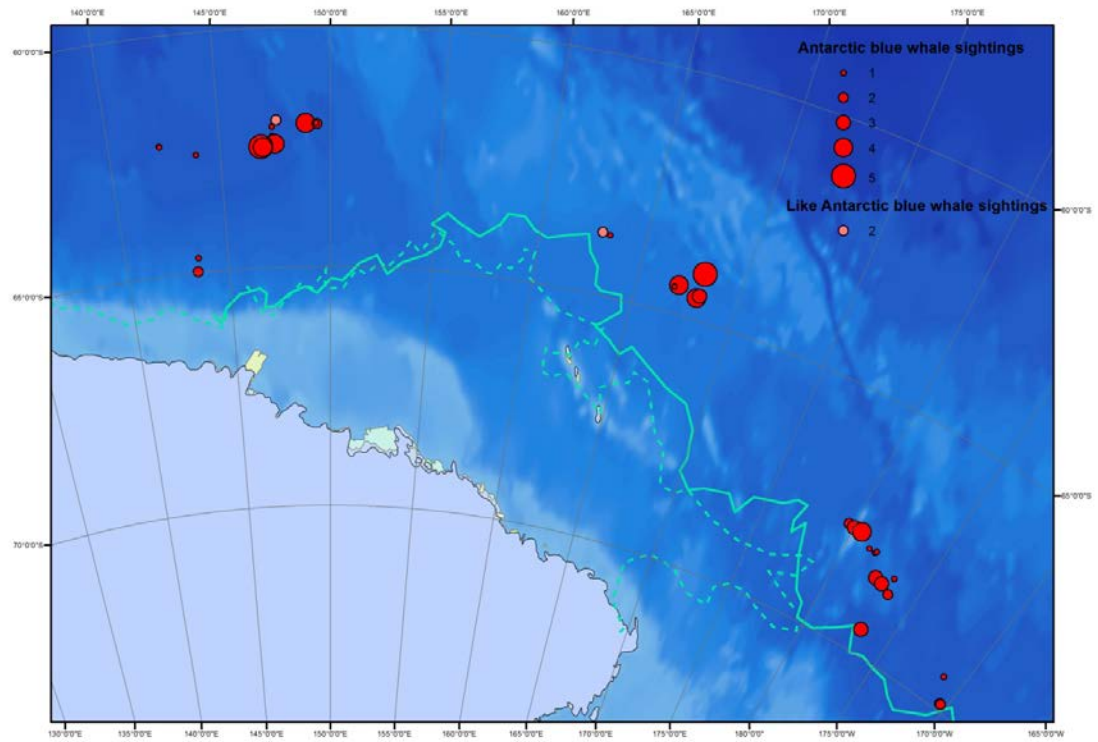

Figure 7. Distribution of Antarctic blue whale sightings throughout the VWHALE voyage. The maximum (7/3/2013) and minimum (15/2/2013) ice extent experienced during the voyage is represented by the solid and dashed lines adjacent to the Antarctic coastline.

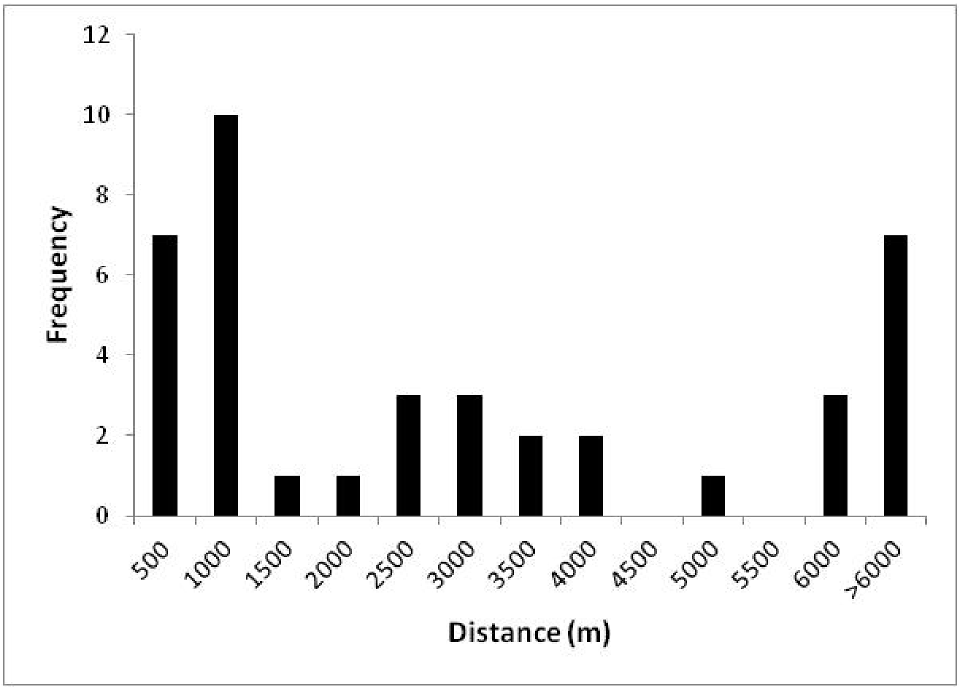

Figure 8. Distribution of radial distances to initial sightings of blue whales. The horizon was at approximately 12 km. Sightings greater than 6 km (less than 0.1 binocular reticles) were pooled in this figure.

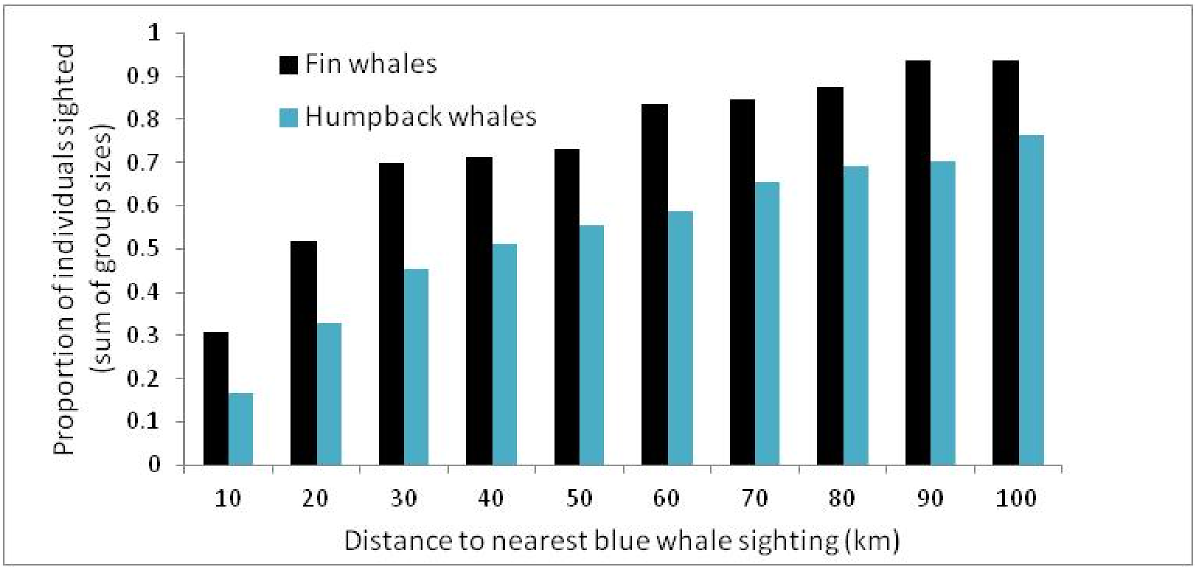

Figure 9.Proprtions of fin and humpback whale sightings within each distance category from the nearest blue whale sighting

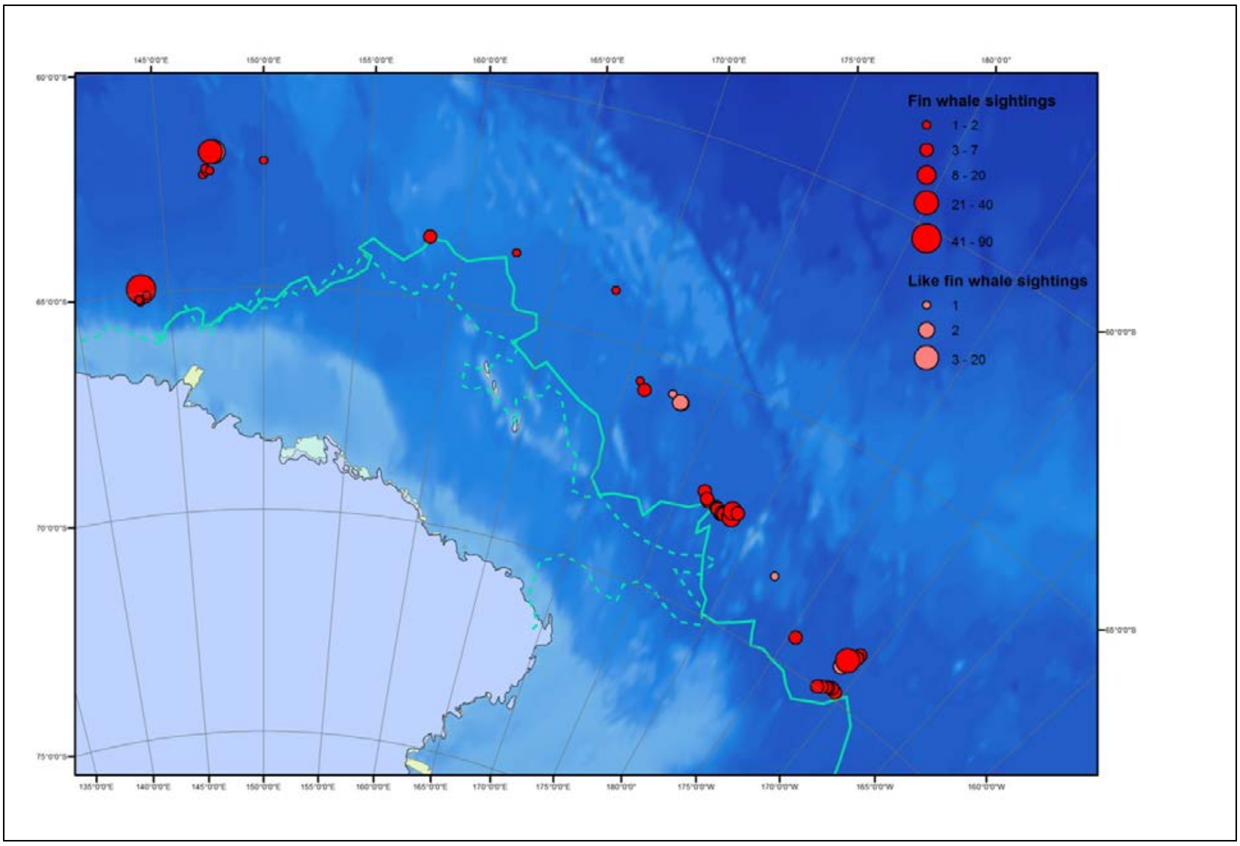

Figure 10. Distribution of fin whale sightings throughout the VWHALE voyage. The maximum (7/3/2013) and minimum (15/2/2013) ice extent experienced during the voyage is represented by the solid and dashed lines adjacent to the Antarctic coastline.

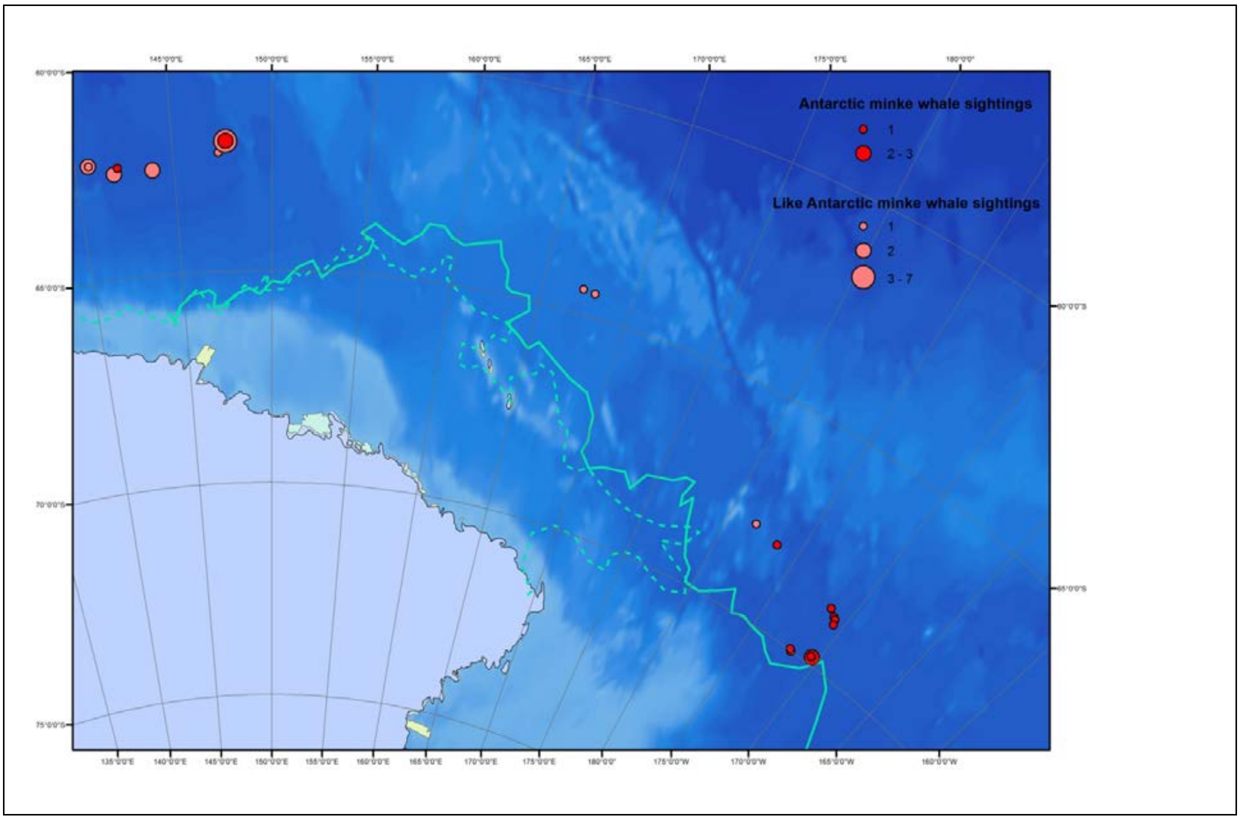

Figure 11. Distribution of Antarctic minke whale sightings throughout the VWHALE voyage. The maximum (7/3/2013) and minimum (15/2/2013) ice extent experienced during the voyage is represented by the solid and dashed lines adjacent to the Antarctic coastline.

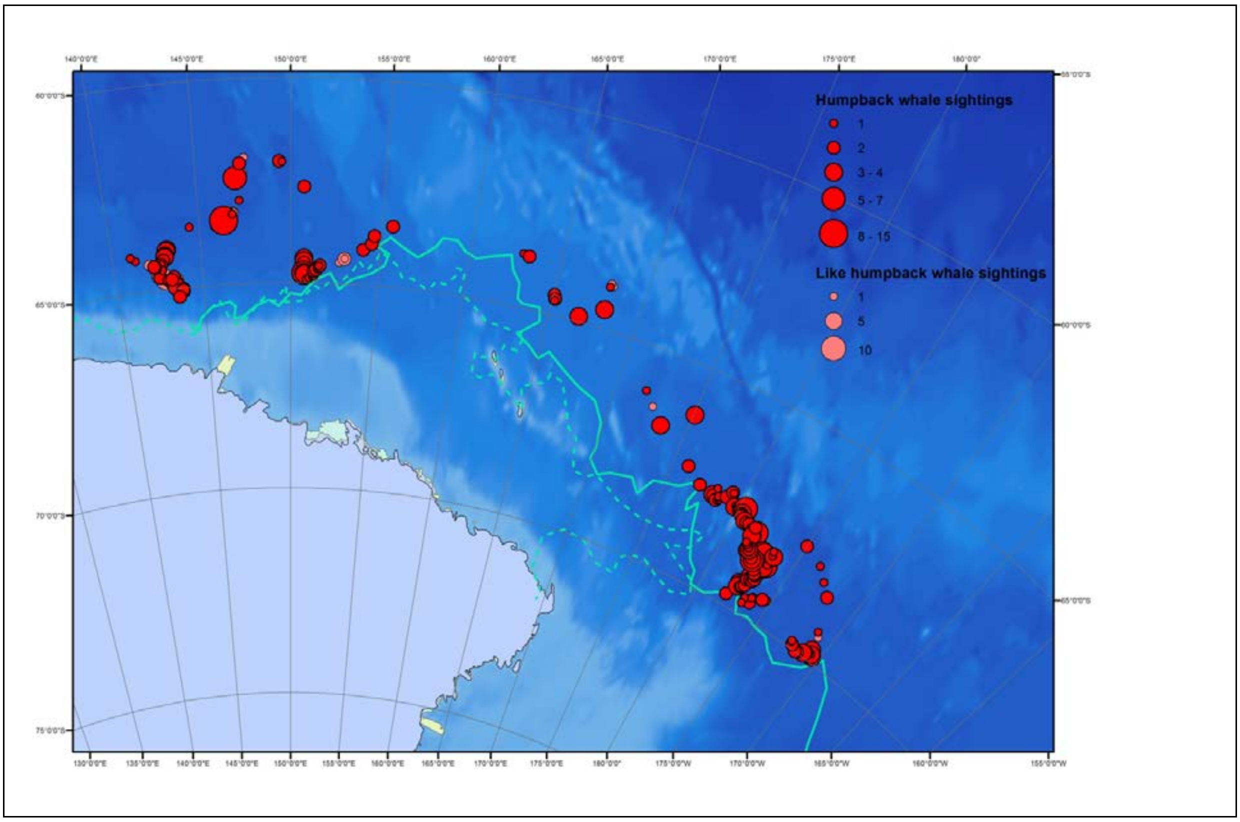

Figure 12. Distribution of humpback whale sightings throughout the VWHALE voyage. The maximum (7/3/2013) and minimum (15/2/2013) ice extent experienced during the voyage is represented by the solid and dashed lines adjacent to the Antarctic coastline.

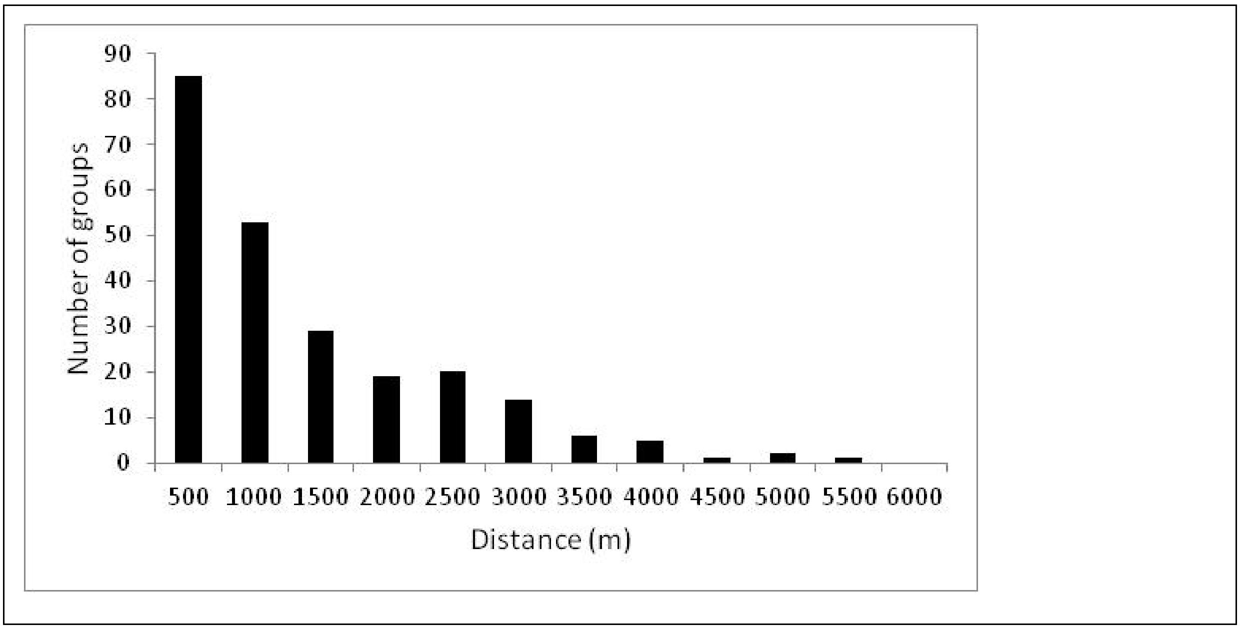

Figure 13. Perpendicular distances to sightings of humpback whale groups (n=238).

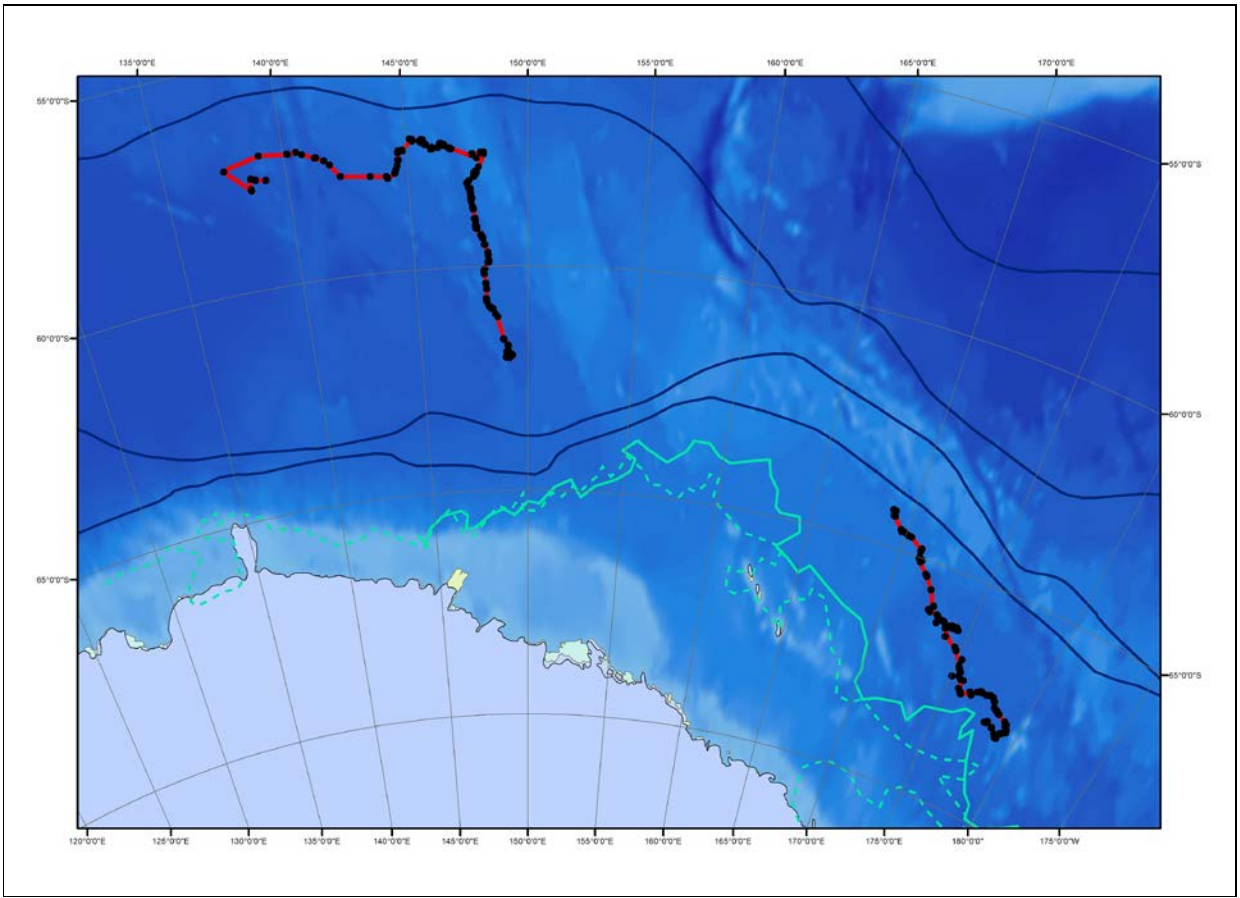

Figure 14. Satellite tag derived movements of two Antarctic blue whales tagged during the VWHALE voyage – “Markus” in the north west and “Henry” in the south east. Both tracks have been filtered and smoothed using the CRAWL package implemented in R (http://cran.r-project.org/). The maximum (7/3/2013) and minimum (15/2/2013) ice extent experienced during the voyage is represented by the solid and dashed lines adjacent to the Antarctic coastline.

10. APPENDICES

Appendix 1. AAD Personnel

The AAD personnel

Number	Name	Primary role	Additional role(s)
1	Chris Galloway	Voyage leader	
2	Margaret Lindsay	Deputy Voyage Leader	
3	Jay Barlow	Science leader	Acoustician
4	Cath Deacon	Doctor	Observer
5	Brian Miller	Lead acoustician	
6	Paula Olson	Lead observer	Biopsy (ship)
7	Mick Davidson	Lead coxswain	Visual media
8	Virginia Andrews-Goff	Data manager	Observer; tagging; biopsy (RHIB)
9	Victoria Wadley	Media liaison	Data manager; observer
10	Susannah Calderan	Acoustician	
11	Kym Collins	Acoustician	
12	Russell Leaper	Acoustician	Observer training
13	Dave Donnelly	Coxswain	Observer; biopsy (ship)
14	Paul Ensor	Observer	Biopsy (ship)
15	Carlos Olavarria	Observer	Acoustician; biopsy (ship)
16	Kylie Owen	Observer	
17	Melinda Rekdahl	Observer	Acoustician; Tagging; biopsy (ship & RHIB)
18	Natalie Schmitt	Observer	Visual media

Appendix 2. Gardline personnel

The GARDLINE

	Name	Role
1	Andy Stammers	Executive master

Appendix 3. Talley's Personnel

	Name	Role
1	John Whitlock	Captain
2	Paul Reeve	First mate
3	Sam Williams	Second mate
4	Pete Collins	Bosun
5	Ragin Jurgens	Engineer
6	Nicholas Cook	Engineer
7	Toby Vincent	Cook
8	Deb Whitlock	Galley assistant
9	Siakia Peti	Crew
10	Sileava'a Afa	Crew
11	Edward Williams	Crew
12	Vern Braid	Crew
13	Joshua Miller	Crew

Appendix 4. Publications

The data and results from the Antarctic Blue Whale Voyage will provide the basis for many publications in the future. Items currently in preparation include but are not limited to: the IWC65 Voyage Science Report; Sonobouy and sighting occurrence of pygmy blue whales – Miller, Barlow, Olson, Ensor; Satellite tags on Antarctic Blue Whales.

Appendix 5. Documentation of visual data collection and entry into Logger database

Included here are details of visual data collection and entry into the Logger database intended as an aid for those that will process or analyse these data.

Observation Stations

Visual surveys were conducted by observers on the open-air flying bridge and in the enclosed bridge. Observers on the flying bridge were stationed in one of two viewing boxes that provided seating, a wind break, and a small shelf with a radial angle board that was used to determine the angle to whale sightings. One box was positioned on the port side and the other on the starboard side of the flying bridge, and the two observers would sit together in the box most leeward from the wind. The boxes were based on a design provided by the Institute of Marine Research, Bergen, Norway. Each box was constructed of plywood with dimensions 150cm wide by 105cm deep and 107cm high. The bridge on the *Amaltal Explorer* has windows 360 degrees although some obstructions break the entire view. The windows provided good visibility for searching when the visual team observed from the bridge. An angle board was positioned in the center of the front window. The Logger data recorder station was set up in the forward starboard corner of the bridge on a high table with an elevated chair and an unimpeded view out a forward window.

MODES

Seven distinct modes of visual survey effort were used during the VWHALE expedition, with different observation positions and priorities. These modes were established with the expectation that different modes would be useful for different purposes during data analysis. Visual survey sighting and effort data (including survey mode) were recorded in a customized data entry program (Logger, made available by the International Fund for Animal Welfare). The seven modes were:

VT- Visual Transect mode was used when the ship's heading was NOT determined by an acoustic bearing to blue whales as selected by the acoustic team. During Visual Transect mode, a team of two observers searched from the flying bridge, and a data logger entered data on a computer station on the bridge. If a cetacean was first detected by the data logger or by other personnel on the bridge, that sighting was entered into Logger, and the observer location was noted as being on the bridge (see "incidental sightings", below). If the same group was seen later by the team on the flying bridge, a new sighting was entered, and its relationship to the sighting made from the bridge was entered in the Notes (see "duplicate sightings", below).

BO- Bridge Only mode was used when poor weather was experienced during Visual Transect. The visual team searched from the bridge. Other personnel on the bridge were informed not to call out a sighting (unless judged to be a blue whale) before the visual team detected it (and to wait until the sighting had passed abeam to give the visual team the full chance of detecting it). In practice, the independence of the observer team while on the bridge was often compromised by enthusiastic bystanders.

AB- Acoustic Bearing mode was used when the acoustic team requested a specific heading for the ship toward acoustically detected whales. When poor weather was experienced during Acoustic Bearing the visual team moved to the bridge. Acoustic Bearing remained entered into Logger as the Mode (in Logger, observer positions were noted as being on the bridge instead of the flying bridge). With observers on the bridge during Acoustic Bearing we did not try to maintain observer team independence as we searched for potential blue whales.

OF- Off effort mode was used during poor weather when one person at the Logger station maintained watch for any cetaceans appearing near the ship and to alert the rest of the visual team when the weather improved. Off effort was also used at the end of the day and on any days when the weather was so poor (>30 kts wind) that we did not keep a Logger watch.

WW- With Whales mode was used when a whale was sighted and the ship turned for approach to confirm species. If the species was a blue whale, Mode was changed to Close Approach as the ship followed the whale(s) for behavioral observations/photo-ID/biopsy or if *Remora* was to be deployed. If the species was not a blue whale, the visual team returned to the appropriate 'starting' Mode: Visual Transect/Bridge Only, Acoustic Bearing, or Off Effort.

VB- Visual Bearing mode was used (only rarely) when the ship was turned to confirm a visual detection. In practice, *With Whales* mode was usually entered into Logger when the ship turned to confirm species following detection of a large baleen whale blow or other cue.

CA- Close Approach was used during approaches to blue whales (or occasionally humpback whales) for behavioral observations/photo-ID/biopsy or if *Remora* was to be deployed.

During the voyage, when selecting Modes in Logger we used a modified version of the flow chart given in the Science Plan for the Antarctic Blue Whale Voyage (Double *et al.* 2013). Each day we started visual effort in one of three Modes: Visual Transect/Bridge Only, Acoustic Bearing, or Off Effort. When whales where detected visually, we would change to a different Modes (further described below). After confirming species (not a blue whale), or after working a blue whale group, the visual team would start once again in one of the three Modes (Visual Transect/Bridge Only, Acoustic Bearing, Off Effort).

SEARCHING

The two observers on the flying bridge alternated searching with unaided eye and binoculars (this differs from the cruise plan that called for one person searching continuously with binoculars and one person searching continuously with unaided eye).

SIGHTING DATA

Estimated Distance

Distance was entered as both the reticle measurement and the estimated distance of the given reticle/platform height. A reticle/distance conversion chart was used to estimate distances (Fig. 1). The chart was created using an averaged observer eye height from the flying bridge and bridge. Platform heights were supplied by the ship's master. Cues detected on the horizon were entered into the reticle field of Logger as "0" and the distance was entered as 12,070 m (flying bridge) or 11,060 m (bridge). When tall blows were seen over the horizon, the reticle field was left blank and the estimated distance was entered in meters.

Group size

Group size was determined by all observers that saw the sighting. The person with the best look estimated the group size, which was not always the observer that made the sighting. Often another person watching was able to determine there were three humpback whales present, for example, instead of 2.

Incidental Sightings

Initially during the voyage, all sightings from the bridge, regardless of who detected them, were entered as Bridge Sightings in Logger. Over time, we entered sightings from the bridge made by off duty personnel as incidental sightings.

Duplicate Sightings

Occasionally whales were sighted by personnel on the bridge before being sighted by the visual team on the flying bridge. These were entered into Logger as bridge sightings or incidental sightings, with a note added later that the bridge sighting was a duplicate of the sighting detected by the flying bridge team.

REVIEWING DATA FOR QUALITY

Every few days the sighting and effort data were reviewed by eye (by VAG or PAO), scanning for obvious errors. This is not the most effective way to catch data entry errors and some are likely to remain in the data file.

Table AA. Distances for Fujinon 7X50 FMTRC-SX binoculars. Average human eye height from *Amaltal Explorer* flying bridge: 11.44m. Average human eye height on *Amaltal Explorer* bridge at Logger station: 9.61m.

RETICLES	Flying Bridge		Bridge	
	km	nm	km	nm
0	12.07	6.52	11.06	5.98
0.1	5.98	3.23	5.32	2.87
0.2	4.55	2.46	4.01	2.20
0.3	3.73	2.02	3.26	1.76
0.4	3.18	1.72	2.77	1.50
0.5	2.78	1.5	2.41	1.30
0.6	2.47	1.34	2.14	1.16
0.7	2.23	1.20	1.92	1.04
0.8	2.03	1.10	1.75	0.94
0.9	1.87	1.01	1.60	0.87
1	1.72	0.93	1.48	0.80
1.5	1.26	0.68	1.07	0.58
2	0.98	0.53	0.84	0.45
2.5	0.82	0.44	0.69	0.37
3	0.69	0.38	0.58	0.39
4	0.53	0.29	0.45	0.25
5	0.43	0.24	0.36	0.20
6	0.36	0.20	0.31	0.17
7	0.31	0.17	0.26	0.14
8	0.28	0.15	0.23	0.13
9	0.25	0.13	0.21	0.11
10	0.22	0.12	0.19	0.10

Reticle 0 is the top line placed on the horizon. Reticles are counted downward from the top line as reticle 1, 2, 3, etc. 0.5 – 0.5 reticles do not have lines inscribed on the ocular.

Appendix 6. Processing protocol for preserving blue whale biopsy samples

Natalie Schmitt

Once a biopsy sample has been obtained, place dart with sample immediately into a zip-locked bag labelled with: location, date, time, sample number and age (calf, sub-adult or adult). Place in a cool location and process as soon as possible.

Unscrew stainless steel punch from plastic floating body using pliers, ensuring most of the sample remains in the punch. Pull out sample with plastic forceps and, using scissors, divide the tissue, making sure that each section contains equal amounts of blubber and skin. Place in screw top labelled vials (see below for preserving). Using plastic forceps, pick off any skin or blubber remaining on the punch or the floating body.

For blue whale or other species (except humpbacks), division of samples should be as follows trying to include both skin and blubber in each division:

One part (100ug of tissue ~ $5mm^3$) in 1ml of All Protect (1 slow pump = 1ml) – Box 1; One duplicate in All Protect – Box 2. Samples in All Protect are refrigerated overnight to allow diffusion into tissue and then placed in -20C freezer. **Be sure to close the All Protect pump (turn clockwise) after use**.

If enough sample is available (>200 ug), then further divide:

Place another fraction of tissue in 70% ethanol and place in -20C freezer – Box 3 If enough tissue is available for a further divide then place in an empty vile in cryoshipper within the basket coloured **red**. Screw the lid on each vial tightly and then place the vials in labelled storage boxes.

Once all the samples have been processed soak the metal dart tips in a dilute bleach solution (only need a small amount of the concentrated bleach) and the plastic floating bodies in warm soapy water (can use a small amount of mucasol). Using a toothbrush ensure all material is removed from the both the dart bodies and heads. Rinse thoroughly and then allow to dry overnight (on foil or kim wipe tissues). Store in a dry place.

Although we would usually keep insurance samples separate from main samples (i.e. in separate rooms, luggage and freezers) on the *Amaltal Explorer* we have no option but to keep them in the wet lab freezer.

LABELLING

Labels are to be written on the sticky labels provided and wrapped around eppendorf tubes with sample number also written on the caps. With samples that will be stored in liquid nitrogen, also write labels on the tubes and on waterproof paper in pencil and place inside tube.

Labels should include: date, sample number, species and preservative.

i.e. 02/02 (2nd of February)

BW13001 (blue whale 2013, sample 1)

AP (All Protect OR it could be EtOH, or N)