SC/62/O12

ANTARCTIC WHALE EXPEDITION

Preliminary science field report and summary.

R.V. Tangaroa Feb/Mar 2010

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Southern Ocean Research Partnership

1. ABSTRACT

The joint Australian-New Zealand Antarctic Whale Expedition (AWE) completed its six week, non-lethal whale research voyage to Antarctic waters onboard the New Zealand Research Vessel *Tangaroa* on March 15th 2010 in Wellington, New Zealand. The research voyage was the first major activity of the Australian-led International Whaling Commission initiative in support of the multi-national Southern Ocean Research Partnership (SORP). The voyage objectives were to contribute directly to the research projects that are currently being developed for SORP.

Major accomplishments of the AWE research voyage include:

- Completion of the first successful non-lethal whale research voyage which directly contributes towards the core research projects of the Southern Ocean Research Partnership.
- Demonstration of a successful model of using small boats, working around a capable ship, for non-lethal whale research in high latitude high seas.
- The collection of over 60 biopsy skin samples, and over 60 individually identifiable tail fluke photographs from humpback whales on their Southern Ocean feeding grounds.
- The satellite tagging of 30 humpback whales on their Southern Ocean feeding grounds.
- The demonstration of the use of passive acoustics to track and locate vocalizing Antarctic blue whales beginning at a distance of over 100 nautical miles.
- The recording of humpback whale 'songs' on the feeding grounds. Prior to this, such songs have only been shown to occur on lower latitude breeding grounds and nearby migratory routes.
- The detection of sounds most likely associated with Antarctic minke whales; a species that has been historically difficult to define acoustically.
- The collection of hydro-acoustics data of whale prey in regions of high and low whale densities which can be used to better define the correlations between krill and whales in the Southern Ocean.

2. INTRODUCTION

The joint Australian-New Zealand Antarctic Whale Expedition (AWE) was conducted from 2 February 2010 to 15 March 2010. The voyage was the first dedicated non-lethal whale research expedition conducted under the Southern Ocean Research Partnership (SORP). This Partnership will run at least from 2009-2014 and is intended to provide an effective mechanism for the delivery of prioritised, non-lethal research into the IWC to provide the scientific basis for sound conservation and management of Southern Ocean whales.

Logistic and scientific planning for the AWE has been underway for approximately two years. Scientific objectives were developed to directly address agreed IWC research priorities and to support the core research projects developed by the SORP members.

The overall objective of the AWE voyage was to add substantially to our understanding of aspects of the population structure, distribution, movement patterns, trophic and environmental linkages and ecological role of whales in the Southern Ocean ecosystem. It was to do this by contributing directly to the research projects that are currently being developed for SORP.

The AWE voyage is unique in its operational approach of using small boats, operated from an ice-capable ship, as a method for working with whales on the high seas in challenging high latitude environments. Consequently the voyage is an important pilot study by which the feasibility of this approach can be assessed. An adaptive approach to research and decision making was required whereby the research was prioritised within each methodology by species. The overall primary priority was the deployment of satellite tags. Research decisions were based on progress against each research methodology.

The New Zealand research vessel *Tangaroa* was chartered from New Zealand's National Institute of Water and Atmosphere (NIWA) by the Australian and New Zealand Governments. New Zealand provided approximately one third of the charter costs through Land Information New Zealand's (LINZ) Ocean Survey 20/20 Program. Australia provided the remaining charter costs and all research costs as a part of its

Aus$32M five year commitment to national and international cetacean conservation and research priorities. Approximately half of these Australian funds have been allocated to Australia's commitment to the five year SORP Program. Scientists and science support personnel from Australia (n = 11), New Zealand (n = 5) and France (n = 1) were represented.

The AWE voyage operated from the home port of Wellington, New Zealand. The planned research area for the voyage was 150ºW to 150ºE, which covers most of IWC Area V and includes the waters across the north of the Ross Sea and off the coasts of Oates Land and George V Land (Figure 1).

3. RESEARCH OBJECTIVES AND AIMS

The research objectives focused primarily on humpback whales, Antarctic minke whales and Antarctic blue whales. Specific priority tasks were to:

- Improve our understanding of mixing patterns on Antarctic feeding grounds of populations of humpback whales from the endangered Oceania populations and the population that breeds off eastern Australia, .
- Improve our understanding of linkages between Antarctic feeding grounds and lower latitude breeding grounds for humpback whales and Antarctic minke whales.
- Improve our understanding of the relationship between whales, sea-ice, krill and other environmental parameters (particularly for Antarctic minke whales and humpback whales).
- Improve our understanding of movement patterns, population structure, distribution and behaviour of endangered and poorly recovered populations of Antarctic blue whales.

Research methodologies to achieve these objectives are detailed in the AWE Science Plan.

4. PRELIMINARY RESEARCH RESULTS AND DISCUSSION

4.1. Operational aspects of the research

4.1.1. Area Coverage

The voyage coverage was close to that planned and included most of the intended region between 150ºW to 150ºE (Figure 1). Transit from Wellington to 60ºS took just under 5 days, with a similar duration for the transit home. Consequently about 30 days were spent south of 60ºS within the research area during which *Tangaroa* covered approximately 5,800nm.

4.1.2. Weather and ice conditions

In order to conduct small boat operations safely and to effectively sight whales from *Tangaroa* good weather conditions, with relatively calm sea states and good visibility were required.

Of the 30 days spent in the research area, workable sea states (as defined by winds of < 18kn) were experienced about 39% of the time during the 12hr working days (approximately 0700hrs – 1900hrs). Significant fog, with substantially reduced visibility, was experienced on nearly half of the days in the research area, further reducing opportunities for small boat operations.

Poor weather is clearly an expected feature of operations in these latitudes. The IWC – Southern Ocean Whale and Ecosystem Research Program (IWC – SOWER), which has conducted primarily sightings surveys for whales around Antarctica for the previous three decades requires similar conditions to conduct its work (i.e. visibility to the horizon and <20kn wind speed). In general, they experience 45 – 55% of workable weather during their research voyages (P. Ensor, personal communication). By contrast, the AWE voyage experienced a disproportionate amount of poor weather, consequently imposing some higher operational limits of work that might have been expected.

Research work in close association with sea-ice was only conducted during the first half of the voyage in the northern area of the Ross Sea. Generally poor weather conditions allowed for very limited small boat work in this region.

4.1.3. Personnel
The research team, voyage management and the ships crew are listed in Appendix 1.

An excellent team was assembled for the AWE voyage. The research team comprised an ideal range of technical expertise, and all members worked harmoniously and whole-heartedly towards achieving the research objectives – often in difficult conditions. Flexibility and tolerance were exhibited in moving between the roles of observing for whales, small boat operations, scientific procedures onboard *Tangaroa* and data management. The science group worked closely and effectively with the voyage management – in particular Anthony Hull – in ensuring that operational activities were safe and opportunities to conduct work were maximised.

The ship's crew could not have been more supportive and helpful in achieving the voyage objectives. In particular, the Master, Andrew Leachman, was approachable, attentive and focused upon achieving the voyage effectively and safely. The deck crew – under the leadership of the Bosun, Glen Walker, were instrumental in safely launching and retrieving the small boats and personnel during all reasonable workable opportunities.

4.1.4. Small boat operations
A major component of the research undertaken on this voyage required the use of small boats. Comprehensive Job Safety Analyses and Standard Operating Procedures were developed and applied, and boats were well equipped to ensure safe and effective operations.

Two small boats were used. One – *Remora* – was purpose built by the AAD for this voyage. This 6.3m aluminium hulled, inflatable Naiad was equipped with a substantial bow-sprit from which whales could be tagged. A working crew of 5 people operated *Remora*, each with a specified task (coxswain, satellite tagging, biopsy, photo-ID and data recording). The second boat – *Beluga* – is a 6.3m Gemini which was leased for the AWE voyage and was similarly equipped with a bow-sprit for tagging whales. As *Beluga* has less working space the tasks of photo-ID and data recording were merged, so a crew of only 4 was required.

Remora was the primary work boat and was generally launched when only one small boat was required. Small boats were launched on 14 of 30 days in the research area, with both boats being used on 5 days. *Remora* was used for a total of about 61hrs, and *Beluga* for about 22hrs. Both boats proved ideal for their purpose. Equipment and procedures developed for launching and retrieval proved similarly successful.

Overall, despite the generally poor weather, the operational approach of using small boats for whale research – operating from a well equipped ship – proved highly successful. While some opportunities to collect photographs and biopsies from *Tangaroa* proved effective – with one satellite tag also being deployed from the ship's deck – the small boat work was key to facilitating tag deployment, biopsy collection and photo-ID.

Small boats were launched whenever weather conditions permitted and whales were sighted from *Tangaroa*. Figure 2 demonstrates the tight correlation between small boat usage patterns and whale sightings rates. Figure 3 shows the distribution of small boat work effort. It is notable that most small boat work occurred in the second half of the voyage, in the western half of the survey area.

4.2. Research results and discussion

4.2.1. Sightings surveys
Sightings surveys for whales and seabirds were maintained for up to 14 hours on each day of the voyage, including during the transit legs. As seabird sightings were not a primary objective of this voyage the full data, which includes records of at least 47 species, will be reported separately by P. Sagar.

Whale sightings data from the AWE voyage were not designed to be used for abundance or density estimation. As the priority was to search areas for whales, and then close on pods for small boat operations, synoptic surveys were not possible. Consequently the cetacean sighting data from this voyage provide a qualitative overview of species and numbers encountered.

Individual or group sightings (pods) of whales were sighted on 326 occasions, accounting for at least 624 individual animals. At least eight species were sighted including humpback whales (129 pods, 276 individuals), Antarctic minke whales (128 pods, 222 individuals), fin whales (29 pods, 59 individuals), sperm whales (5 pods, 5 individuals), southern bottlenose whales (1 pod, 1 individual), sei whales (6 pods, 8 individuals), killer whales (1 pod, 1 individual), hourglass dolphins (3 pods, 16 individuals) and an unidentified beaked whale (1 pods, 4 individuals). Despite numerous acoustic detections of blue whales, none were sighted.

The distribution of sightings of large baleen whales is provided in Figure 4. As can be seen in the figure, the substantial majority of minke whales were sighted in the Ross Sea region in associated with sea ice. Humpback whales – the most commonly encountered species – were sighted most commonly in the region of the Balleny Islands. As humpback whales were a priority species for this voyage, the most time was spent in this region.

Data from the sightings surveys will contribute, at least in part, towards the SORP core project 'Distribution and extent of mixing of Southern hemisphere humpback whale populations around Antarctica'.

4.2.2. Satellite tagging

The major research questions addressed by this activity were to:

- Determine meso-scale movement patterns on high latitude feeding grounds and investigate relationships with the biological and physical environment.
- Determine linkages between high latitude feeding grounds and low latitude breeding grounds.

Humpback whales were the highest priority species for tagging studies. Thirty animals were tagged between 12th February and 8th March, with nearly all tagging effort being in the region of the Balleny Islands where humpback whales were encountered in the greatest density and numbers.

The first 18 tags deployed were from a new batch of satellite tags purchased from Wildlife Computers specifically for the AWE voyage. All but two of these tags were deployed on the 21st February, after which it was discovered that very few were providing any data through the Argos satellite system. Some rapid troubleshooting of the tags, with email correspondence with the manufacturer suggested that the problem may lie with a newly designed salt-water switch on the back end of the tag. This switch effectively tells the tags when to transmit as the whale reaches the water surface. Under advice from Wildlife Computers, ten tags were modified with a small additional 'stopper' at the back end of the tag and adjustments were made to a salinity threshold for the salt water switch. Three of these 'modified' tags were subsequently deployed on 22nd, 27th and 28th February without any improvement in performance. We had 11 satellite tags from a different batch, also manufactured by Wildlife Computers, but with a different back end configuration and salt water switch assembly. Nine of these tags were deployed between 22nd February and 8th March. All worked well on deployment and provided data via the Argos satellite system.

At the time of completing this report (25th May 2010) only one tag was still transmitting (84 days). The whale was still in Antarctic feeding grounds south of 60ºS. Of the 21 tags from the newly designed batch, 12 failed to provide any Argos signals at all. The remaining 9 provided various amounts of location data for an average of 35.8 ± 26.1 days (mean ± sd) (Range: 1 – 76), which was very similar performance to the 9 older versions of tags that transmitted for 23.6 ± 26.4 days (Range: 1 – 84).

The catastrophic failure of a large proportion of a whole batch of satellite tags is a serious issue and investigations into the source of the fault are underway by Wildlife Computers. All unused tags from this batch have been returned to Wildlife Computers for assessment and re-design.

While the failure of a large proportion of deployed satellite tags to provide any or regular location data represents a substantial disappointment, the data from the 18 tags which did provide location data have provided valuable data on foraging behaviour of this species in this region. We have collected a total of 534 'foraging days' for humpback whales which are currently being analysed using a range of models to assess patch searching and feeding patterns for this species. This is the first time that humpback whales have been tagged in eastern Antarctica. Figure 5 shows the distribution of tag deployments and tracking data collected up until 25th May 2010.

Satellite tags were not deployed on any other species due to a lack of opportunities. Tagging of Antarctic minke whales remains an important priority, but a combination of poor weather and whale distribution meant that there were very few opportunities to attempt approaches to minke whales in small boats. From the limited experience gained on this voyage, it is apparent that groups of feeding minke whales will offer the most likely tagging opportunities. Tagging of this species will likely only be achieved with a significant investment of effort.

Satellite tagging data will contribute primarily towards the SORP core project 'Distribution and extent of mixing of Southern hemisphere humpback whale populations around Antarctica'.

4.2.3. Biopsy sampling

The major research questions addressed by this activity were to:

- Determine the allocation of humpback breeding stocks to Antarctic feeding areas V and VI using mtDNA haplotypes and mixed stock analysis.
- Genetically assign humpback whale individuals from Antarctic feeding areas V and VI to low-latitude breeding grounds using genotype matching.
- Determine the population structure of humpback whales in the Antarctic feeding grounds between 150 deg East and 150 deg West.
- Compare the sex composition of humpback whales in the Antarctic feeding grounds to those migrating along the East Australian coast using a molecular genetic technique.
- Determine the sex and provenance of humpback whales that are satellite tagged.

Sixty-four biopsy samples were collected from humpback whales and one sample from a fin whale. The small boats were the primary platform for collection of biopsies and, as noted earlier, humpback whales were the main species encountered in weather conditions that allowed small boat work. On some occasions when *Tangaroa* was slowed down humpback whales approached the ship and facilitated 8 of the biopsies being taken from the ship. This was not possible for other species. The distribution of the collection of biopsy samples is provided in Figure 6. Of the 30 humpback whales that had satellite tags attached, 25 had biopsy samples collected.

The biopsy samples collected during the Antarctic Whale Expedition will be curated and stored at the Australian Antarctic Division. Sub-samples of each biopsy will be preserved under different conditions to ensure the samples are suitable for the various biochemical analyses that could be applied.

DNA and RNA will be extracted from each biopsy for genetic studies. The
RNA will be used in a study of age-related gene expression which could lead to a non-lethal aging method for baleen whales. The DNA will be used to generate mitochondrial DNA sequence data and microsatellite genotypes for each individual sampled. These data will be used in population genetic analyses to determine the likely breeding population to which some or all of the

individuals belong. Such analyses will require comparisons with existing genetic datasets from the humpback whale breeding populations of eastern and western Australia and the western Pacific.

Mitochondrial DNA data will be derived from the single fin whale sample and submitted to a public genetic database as reference data for the Southern Hemisphere form of the species.

Genetic data derived from the biopsy samples will contribute primarily towards the SORP core project 'Distribution and extent of mixing of Southern hemisphere humpback whale populations around Antarctica'.

4.2.4. Photo Identification

The major research question addressed by this activity was:

- What are the linkages between humpback whales in Antarctic waters and their breeding grounds and migratory paths outside Antarctic waters?

Sixty-one individual humpback whales were identified using photographs of the underside of the tail flukes. The pigmentation patterns of humpback whale tail flukes are unique and a great deal of effort over the past few decades has been invested in developing large catalogues of photographs of humpback whales on their lower latitude breeding grounds. Relatively few photographs have been collected from high latitude feeding areas, where whales from different breeding populations mix.

The humpback whale photo-IDs have been made available to all scientists with catalogues of photographs of humpback whale tail flukes in the Australasian and South Pacific region. Access to the catalogue can me achieved through the web on: http://data.marinemammals.gov.au/photoid/.

Matches from photographs taken on the feeding grounds to those taken on breeding grounds will provide further important evidence of the nature and extent of mixing patterns between breeding populations on the common feeding grounds around Antarctica. Figure 6 shows the distribution of collection of humpback whale photo-ID data.

Data from the photo-ID research will contribute primarily towards the SORP core project 'Distribution and extent of mixing of Southern hemisphere humpback whale populations around Antarctica'.

4.2.5. Passive acoustics

The major research questions addressed by this activity were:

- What are the sounds produced by marine mammals in this region of the Antarctic and are they distinct from sounds produced in other regions of the Southern Ocean?
- What is the relative distribution of vocalising marine mammals across the study area?

Sonobuoys were deployed opportunistically depending on vessel operations. During long transects where the *Tangaroa* was moving consistently, deployments occurred regularly and without regard to sightings of whales in order to independently acoustically survey for distributions of vocalising whales. When the *Tangaroa* was in the vicinity of whales sonobuoys were deployed opportunistically in order to attempt to record sounds from the species known to be in the immediate area (e.g. humpback, minke, fin whales). One hundred and eleven sonobuoys were deployed during the voyage. Deployment locations over the length of the voyage are illustrated in Figure 7.

Analyses at this stage are preliminary and are based on initial monitoring that occurred in real-time for most sonobuoy deployment sessions. Other recording sessions have yet to be analysed and all recordings will be reanalysed to refine the results. At this stage the species recorded include blue, humpback, minke, fin, sperm, and presumably an unidentified beaked whale.

Blue whales—Blue whales were the most commonly recorded species by far, occurring on over half (n=54) of all successful (103) sonobuoy deployments. The sounds recorded were similar to the sounds recorded from blue whales at other locations around the Antarctic. The distribution of where blue whales were detected across the study area is illustrated in figure 8 and can be compared with all sonobuoy deployment locations in figure 7.

Due to poor weather and visibility preventing small boat operations, there was an approximately 36 hour period where we were able to use acoustics to attempt to guide the ship to vocalising blue whales. The acoustic bearings calculated and sonobuoy deployment sites during this exercise are shown in figure 8. The *Tangaroa* closed to within a few miles of the acoustically calculated location of the vocalizing blue whales, but poor visibility prevented the visual sighting of these whales. It appears that we initially began getting acoustic bearings to this aggregation (assuming it was the same whales) at a distance of over 100nm and were able to use acoustics to travel to and locate the aggregation over a period of 36 hours.

Humpback whales—During the sonobuoy deployments that occurred independently of whale sightings, humpback whales were rarely recorded. There were, however, two regions (surrounding the Balleny Islands and approximately 120nm to their southwest) with large concentrations of sighted humpback whales where a large number of sonobuoys were deployed. Humpback whale song, with the repetition of distinct stereotypic phrases, was recorded. As far as we are aware, this is the first instance where structured song-like sounds have been recorded from humpback whales on their Southern Ocean feeding grounds. This runs counter to the notion that humpback whales sing only during their migration to and from, and while on their breeding grounds. Further analysis will be necessary to determine which humpback breeding stocks, if any, produce these recorded phrases.

Minke whales—Minke whales have been notoriously difficult to acoustically monitor during their summer feeding season due to a lack of understanding of their vocal repertoire. On the AWE voyage, there was one particular instance when a sonobuoy was deployed in the midst of an aggregation of minke whales. A pulsed vocalisation was recorded that is very similar to repetitive song-like sounds often recorded in long term Southern Ocean acoustic datasets. To date, the source of this ‘song’ has remained unknown. The bearing to this sound from the sonobuoy was in the same direction as where minke whales were sighted, supporting the likelihood that minke whales are the source of this ‘song’.

Data from the passive acoustics surveys will contribute primarily towards the SORP core project ‘Distribution and extent of mixing of Southern hemisphere humpback whale populations around Antarctica’ and ‘Distribution, seasonal occurrence, abundance and trends of Antarctic blue and fin whales in the Southern Ocean’.

4.2.6. <u>Active acoustics</u>

Acoustic data using hull-mounted SIMRAD split-beam EK60 echosounders were recorded continuously throughout the expedition. These sounder operated at five acoustic frequencies (18, 38, 70, 120 and 200 kHz). A total of more than 115 Gigabytes of data has been stored. Data during transit to and from Antarctica were recorded to depths of 1000 m at ping intervals of 3-4 seconds. In Antarctic waters, data were recorded down to 500 m at ping intervals of 1-2 seconds. Along with large scale patterns of prey distribution along the general survey track, search patterns for whales in specific areas, particularly along the shelf edge (February 14-16) and around the Balleny Islands, will enable more detailed assessment of meso-scale variability, as many acoustic tracks were recorded in a smaller area. In addition to these, synoptic surveys were conducted overnight on five occasions over aggregations of krill in areas where feeding behaviour of humpback whales was observed. These were located around and to the south-east of the Balleny Islands and consisted of a series of equally-spaced parallel transects, with each transect ranging from 4 to 12nm in length.

Several aggregations of krill (*Euphausia superba*) have been observed along our survey track. Patches of discrete and dense schools were typically found around whale aggregations. The largest of these schools were near the surface (down to 60-70 m depth) and were approximately 1 km across. Throughout the survey a 1 m diameter hoop drop-net (mesh size = 2 mm) was deployed on 16 occasions to collect organisms from the water column. Specimens of krill (ranging from 5 to 50 mm in length) were collected on several of these deployments, along with a variety of other invertebrate species (including salps, copepods, amphipods, prawns, and a cranchiid squid paralarva).

Mesopelagic fish (most likely myctophids of the *Electrona* genus) were observed along our survey track, particularly on the eastern side (notwithstanding the transit to and from Antarctic waters). Strong backscatter signals were also observed all around the Balleny Islands, particularly along their shelf edge. Based on the shape and distribution of these marks, preliminary analyses of acoustic frequency response, and the lack of krill caught in these aggregations, it is believed that they consist of Antarctic silverfish (*Pleurogramma Antarctica*).

Profiles of water temperature and salinity down to depths of 200-300 m were collected on 10 occasions using a Seabird SM37 CTD. These will be used notably to estimate sound speed and acoustic absorption in Antarctic waters. Calibration of all five echosounders was performed in Palliser Bay (NZ) on January 28th prior to departure.

4.2.7. Phytoplankton and prey sampling

Phytoplankton samples for stable isotope (C and N) analyses have been collected since departure from Wellington harbour. These samples were obtained by filtering 1 to 2 litres of waters from *Tangaroa's* underway system. During the steam to and from Antarctica, samples were collected four times daily, roughly at 06:00, 12:00, 18:00, and 00:00. During the survey in Antarctic waters, samples were collected 3 times daily, roughly at 06:00, 12:00, and 18:00, irrespective of position. This means that several sites may have been sampled more than once (replication) when the vessel operated in the same area for extended times. These samples will be useful to estimate local variability in stable isotope signatures.

At each combination of sample site and time, three replicates were collected: two of these will be used for stable isotope analyses, while the third sample will be used for chlorophyll a analysis in the Ocean colour dataset. All phytoplankton samples have been preserved in a freezer at -20 ºC. A total of 135 sites have been sampled (405 individual samples have been collected). In addition to the phytoplankton samples, whale prey items (krill and other invertebrates) have been collected for stable isotopes from 11 of the 16 drop-net samples obtained throughout the survey. These were also preserved in a freezer at -20 ºC.

A total of 65 whale skin biopsies have been collected for analyses. The $\delta^{13}C$ and $\delta^{15}N$ signatures found in the whale skin will be compared to those obtained from phytoplankton and prey items to determine the whale diet and feeding locations.

5. ACKNOWLEDGEMENTS

Very many people contributed to the success of this voyage – far too many to list and risk offence through omission. For operational and shipping support, thanks to all those at the AAD and NIWA who worked so hard to develop the contract and facilitate an efficient and effective voyage. For science support, thanks to all the scientists and support staff on the voyage who contributed to every facet of the scientific achievements of the voyage. Particular thanks are due to the voyage management team for their tireless work prior to, during and after the voyage and to all the excellent and professional crew of the *Tangaroa*.

Fig 1. AWE voyage track, with sea ice extent as of 25th February 2010.

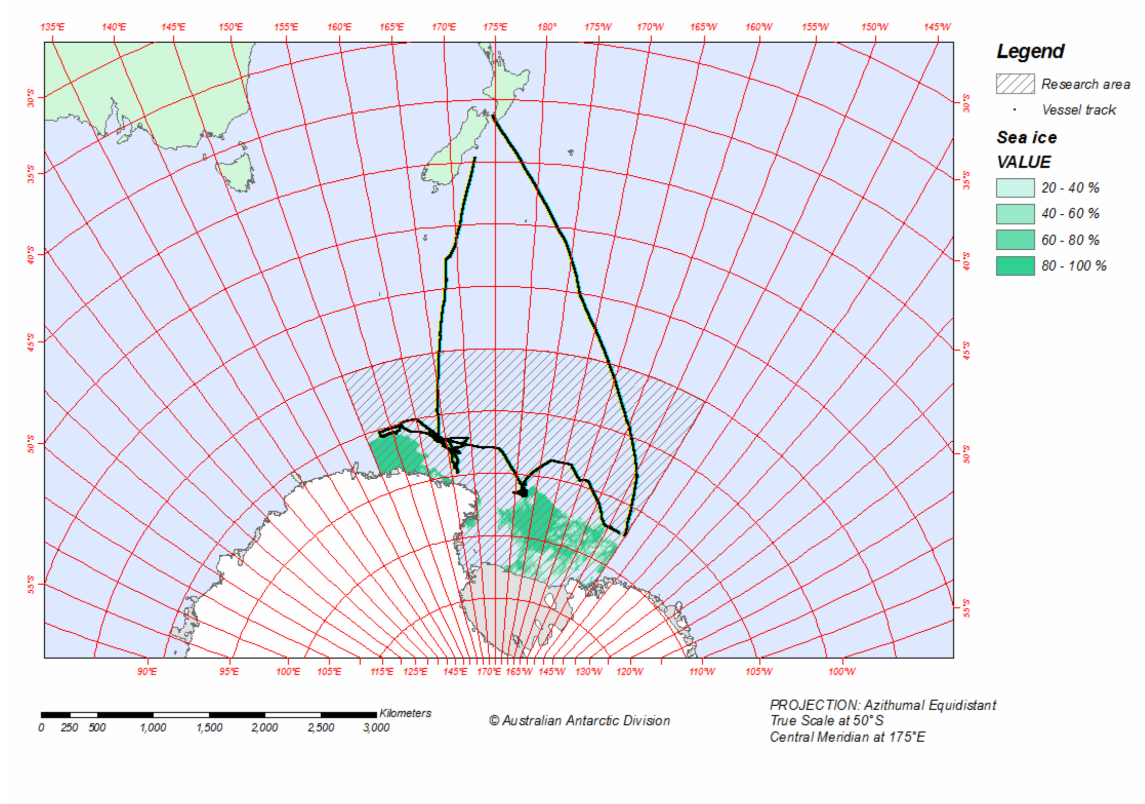


Fig 2: Relationship between small boat usage patterns and whale sighting rates

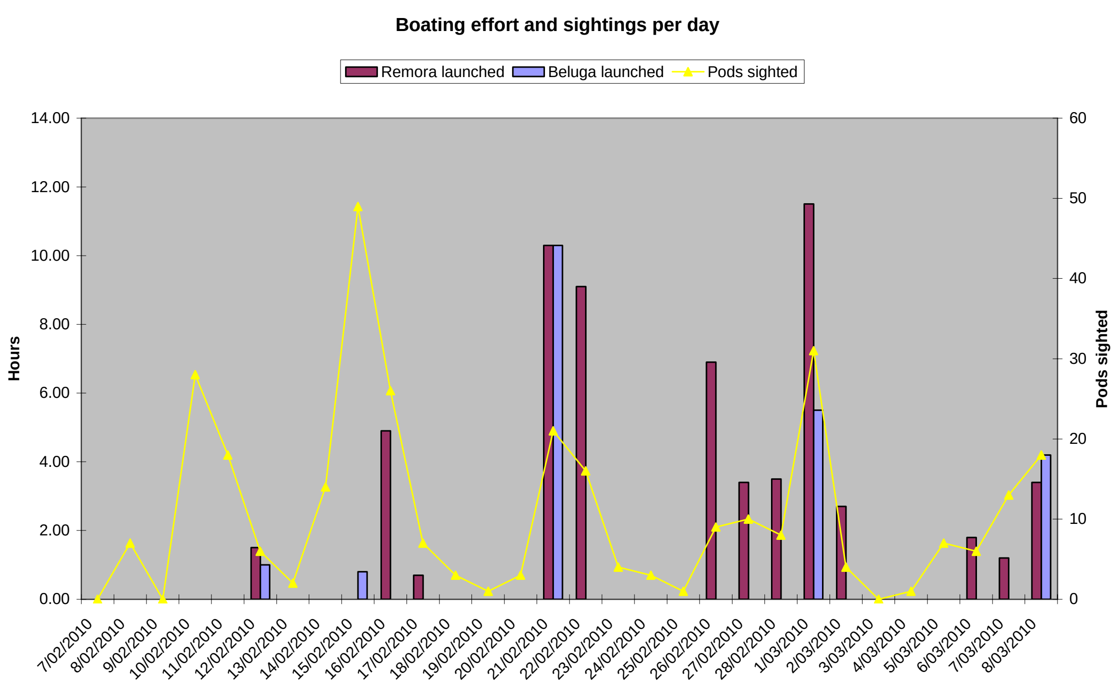


Fig 3. Distribution of small boat effort during the AWE voyage.

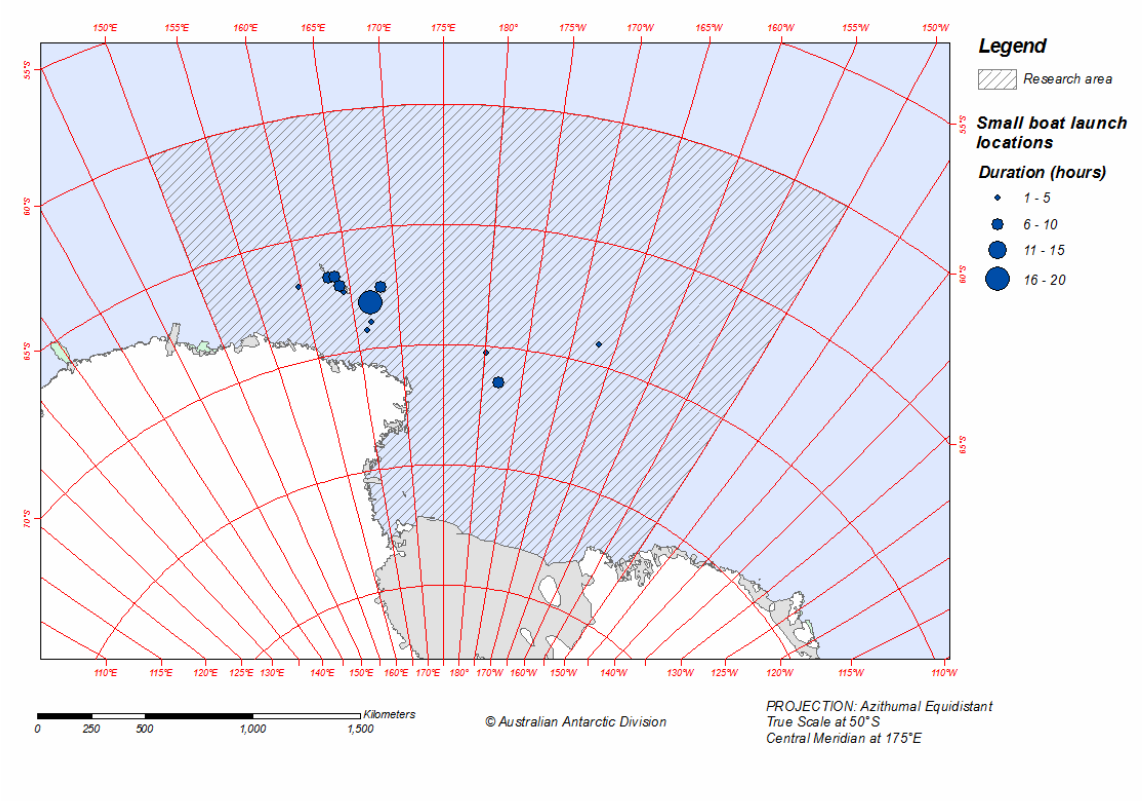


Fig 4. Distribution of large baleen whales sightings during the AWE voyage.

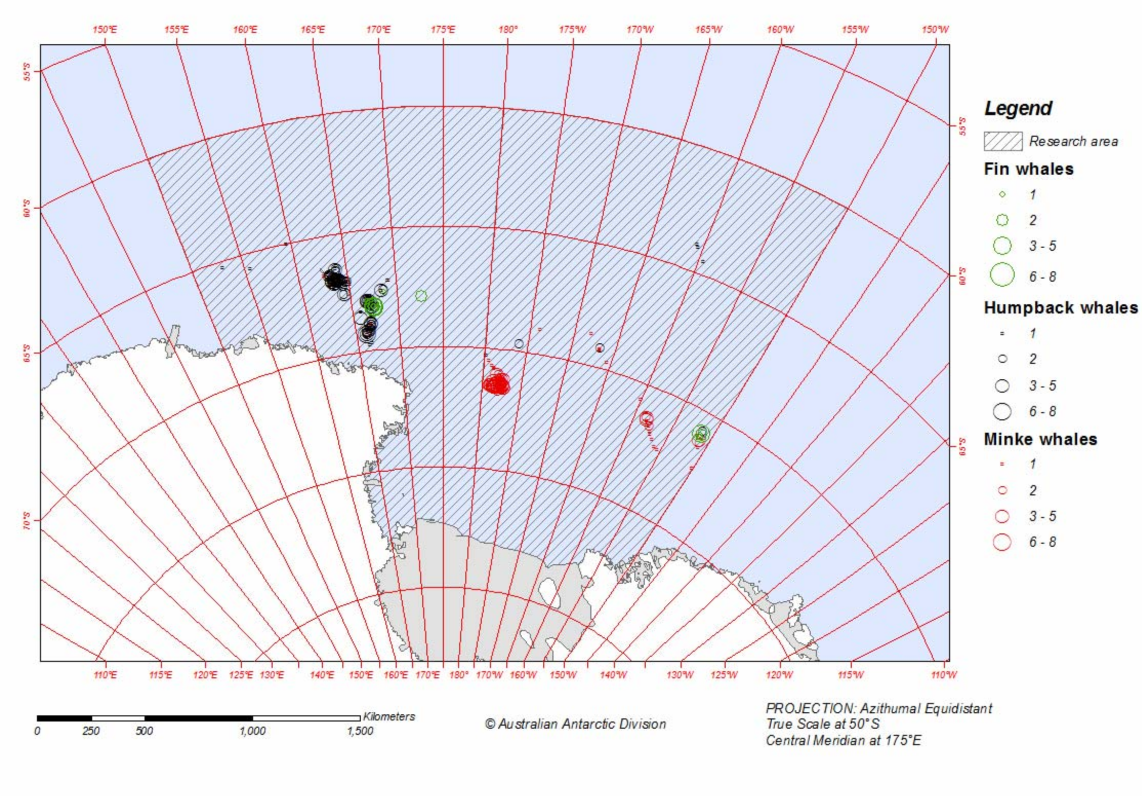


Fig 5. Distribution of tag deployments and animal movement data as of 25th May 2010

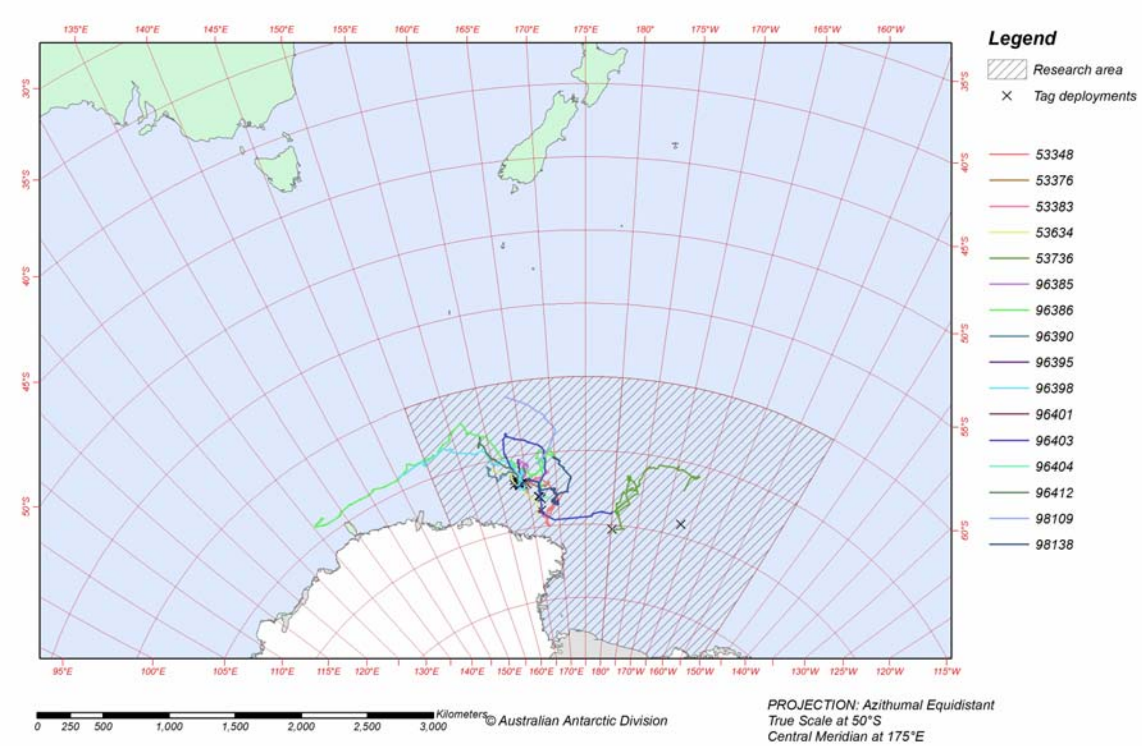


Fig 6. Distribution of collection of biopsy and photo-ID.

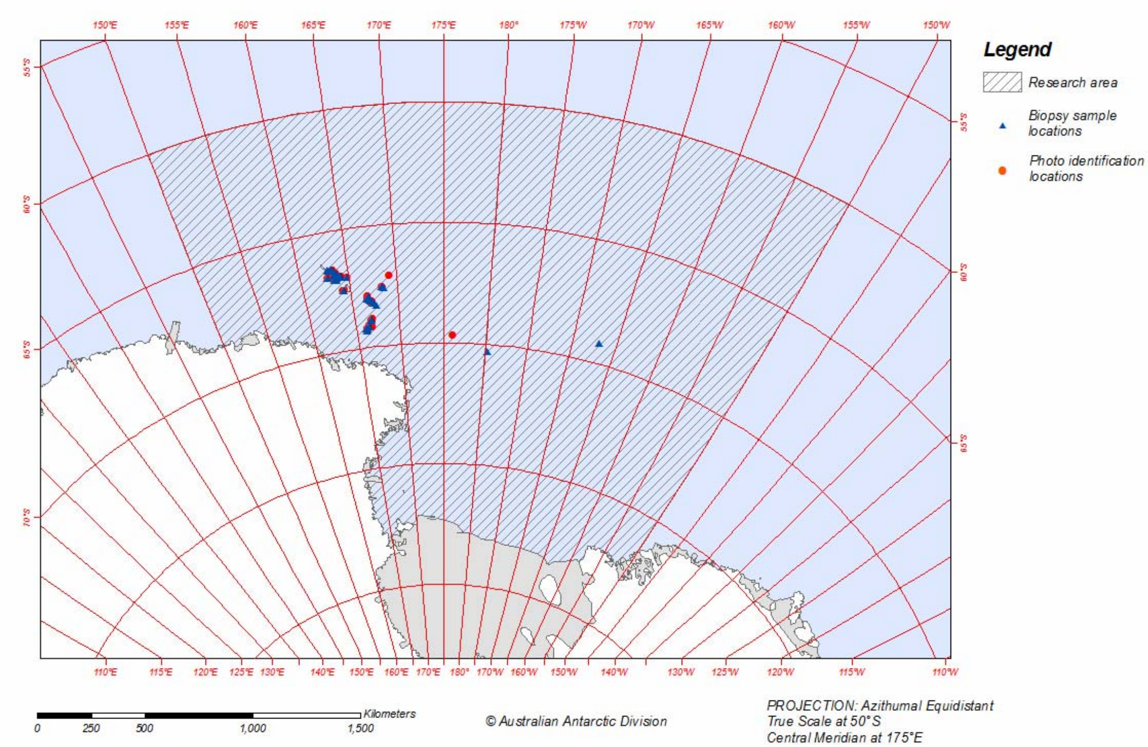


Fig 7. Distribution of deployment of Sonobuoys.

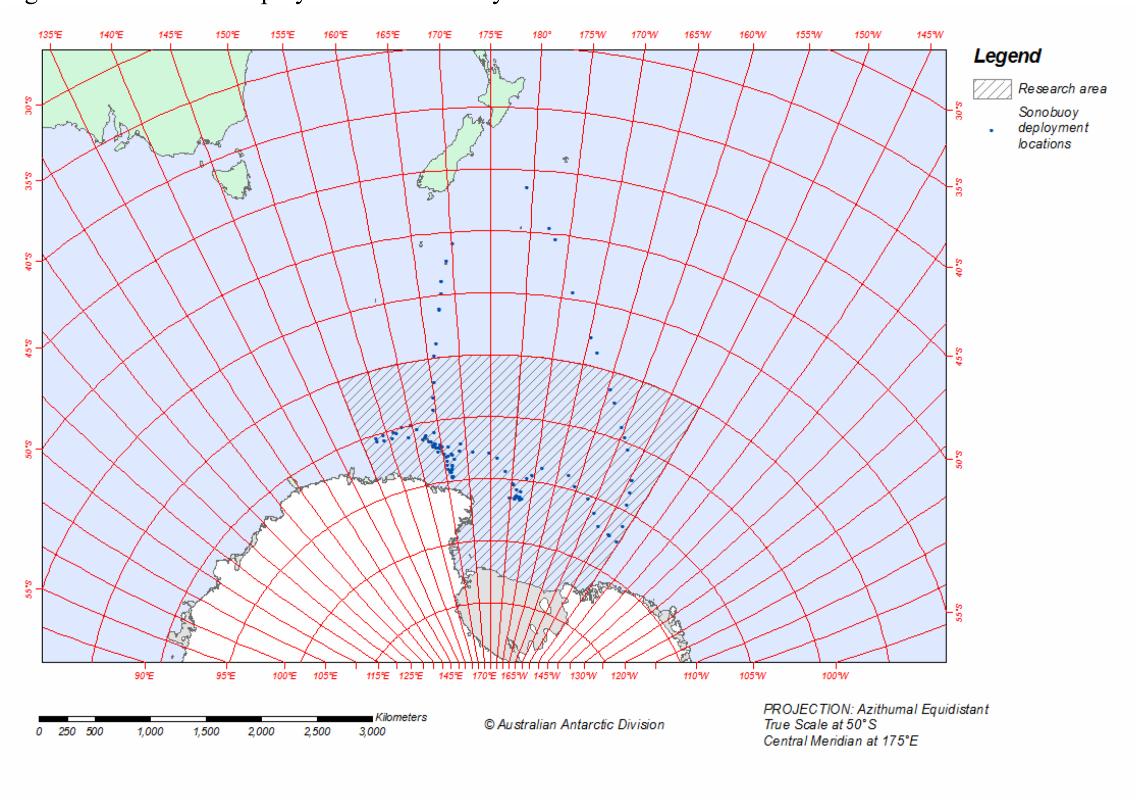
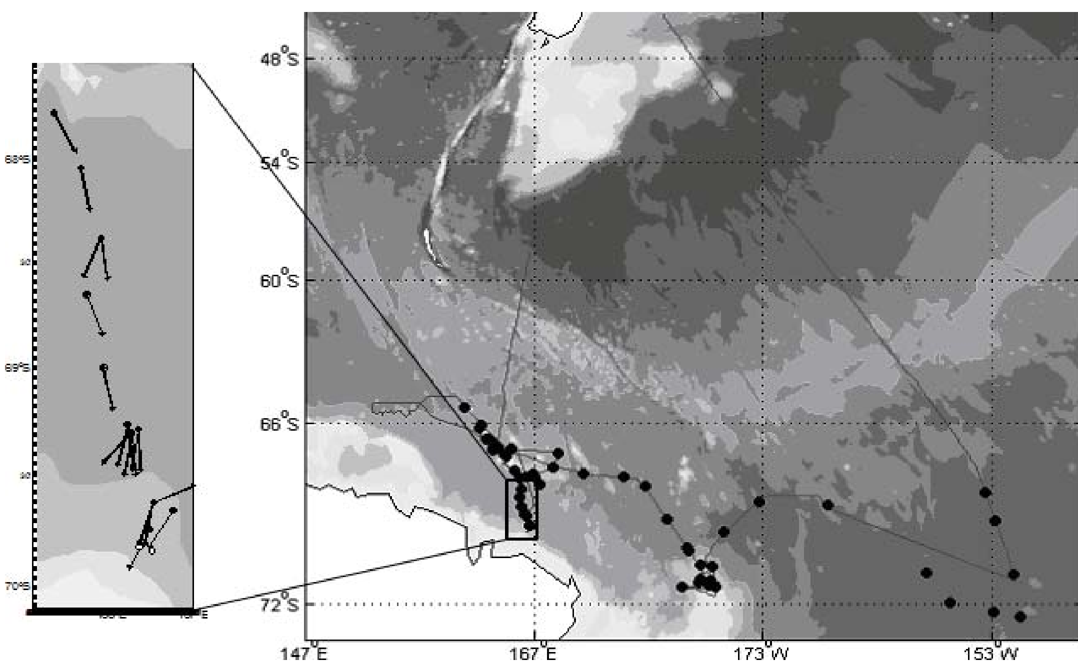


Fig 8. Distribution of blue whale acoustic detections across the study area. The expanded box illustrates the 36 hour acoustic tracking of blue whales with bearings illustrated from each of the sonobuoy deployments. The two small white circles at the southern end show the *Tangaroa's* final location before turning north (left), with the final calculated position of the whales (right) approximately 3-4 nautical miles away.



Appe

Appenndix 1: Personnel

Name	Role	Organisation/Affiliation
	Science and science support personnel	
Dylan Amyes	Electronics engineer	NIWA Science
Jean-Benoit Charassin	Biologist	Natural History Museum, Paris
Simon Childerhouse	Biologist	Australian Antarctic Division
Rochelle Constantine	Biologist	University of Auckland
Mike Double	Geneticist	Australian Antarctic Division
Paul Ensor	Biologist	NZ Whale Researcher
Nick Gales	Science Leader	Australian Antarctic Division
Stephane Gauthier	Acoustician	NIWA Science
Jason Gedamake	Acoustician	Australian Antarctic Division
Anthony Hull	Voyage Leader	Australian Antarctic Division
Curt Jenner	Biologist	Centre for Whale Research, WA
Catriona Johnson	Data management	Australian Antarctic Division
Dave Paton	Biologist	Blue Planet Marine, NSW
Sarah Robinson	Deputy voyage Leader	Australian Antarctic Division
Paul Sagar	Seabird biologist	NIWA Science
Natalie Schmitt	Biologist	Australian Antarctic Division
Michael Woosey	Medical Doctor	Australian Antarctic Division
Max Quinn	Film maker	Natural History New Zealand
	Vessel Personnel	
Andrew Leachman	Master	NIWA Vessel Management
Evan Solly	1st Mate	NIWA Vessel Management
Ian Poppenhagen	2nd Mate	NIWA Vessel Management
Peter Sandison	2nd Mate	NIWA Vessel Management
Lt Luke Taylor	Supernumerary Officer	Royal NZ Navy
John Kirkland	Chief Engineer	NIWA Vessel Management
Lindsay Battersby	2nd Engineer	NIWA Vessel Management
Kim Ashby	1st Cook	NIWA Vessel Management
Brian Samuals	2nd Cook	NIWA Vessel Management
Yvonne O'Neil	Steward	NIWA Vessel Management
Glen Walker	Bosun	NIWA Vessel Management
Shane Harvey	Leading Hand	NIWA Vessel Management
Peter Wall	Deckhand	NIWA Vessel Management
Ian Smith	Deckhand	NIWA Vessel Management
Bruce McIntyre	Deckhand	NIWA Vessel Management
Paul Pascoe	Deckhand	NIWA Vessel Management