Annual Report of the Southern Ocean Research Partnership (IWC-SORP) 2013/14

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ABSTRACT

The Southern Ocean Research Partnership (IWC-SORP) was proposed to the International Whaling Commission (IWC) in 2008 with the aim of developing a multi-lateral, non-lethal scientific research program that will improve the coordinated and cooperative delivery of science to the IWC. There are now 10 member countries in the Partnership: Argentina, Australia, Brazil, Chile, France, Germany, New Zealand, Norway, South Africa and the United States. A framework and set of objectives for IWC-SORP were presented to the IWC in 2009, where they were endorsed. Six international research projects were selected to form the basis of IWC-SORP research and progress reports were presented to the IWC in 2010 and 2011. One of these projects, the Living Whales Symposium, held in Chile in March 2012 has been completed. This paper reports on the continued progress of IWC-SORP and that of the five ongoing research projects since the Scientific Committee meeting in 2013.

KEYWORDS: SOUTHERN OCEAN RESEARCH PARTNERSHIP, IWC, IWC-SORP, ANTARCTICA, ABUNDANCE ESTIMATE, ACOUSTICS, BIOPSY SAMPLING, PHOTO-ID, SATELLITE TAGGING, MOVEMENT

INTRODUCTION

In 2008 Australia proposed to the International Whaling Commission (IWC) the development of regional non-lethal cetacean research partnerships. These research partnerships would use modern, non-lethal, scientific methods to provide the information necessary to best conserve and manage cetacean species. The proposal was received very positively by IWC member nations. The Australian Government has subsequently supported the Southern Ocean Research Partnership (IWC-SORP), established in March 2009. The aim of IWC-SORP is to develop a multi-lateral, non-lethal scientific whale research program that will improve the coordinated and cooperative delivery of science to the IWC. Current Partnership members include Argentina, Australia, Brazil, Chile, France, Germany, New Zealand, Norway, South Africa and the United States of America.

The objectives, research plan, and procedural framework for the partnership were developed through a workshop held in Sydney, Australia in March, 2009. Subsequently, a framework and set of objectives for IWC-SORP were endorsed by the IWC at its Annual Meeting in June 2009. An Annual Report of IWC-SORP (SC/63/O12; SC/64/O13) and revised project plans (SC/63/O13) were presented to the IWC in 2011 and 2012 which summarised progress within IWC-SORP and the six IWC-SORP research projects. One of these projects, the Living Whales Symposium, held in Chile, was completed in March 2013 and reported to the Scientific Committee in 2012 (SC/64/O14). This paper reports on IWC-SORP progress and the results of the five ongoing research projects since the 65th Meeting of the Scientific Committee (IWC/SC/65a) in 2013.

BRIEF SUMMARY OF PROGRESS

The following items detail the major progress that has been made by IWC-SORP since the 65th Annual Meeting of the Scientific Committee (IWC/SC/65a). Further details of this work can be found on the IWC-SORP website presently hosted by the Australian Antarctic Division at http://www.marinemammals.gov.au/sorp.

IWC-SORP Special Session at the 20th Biennial Conference on the Biology of Marine Mammals

IWC-SORP researchers presented work at the 20th Biennial Conference on the Biology of Marine Mammals, 9-13 December, Dunedin, New Zealand. Six oral presentations were made during a IWC-SORP Special Session chaired by the IWC-SORP Coordinator. Three additional oral presentations on IWC-SORP projects were made in concurrent sessions throughout the conference and two IWC-SORP project poster presentations were made during poster sessions.

IWC-SORP Research Projects

Brief summaries of progress on each of the five current IWC-SORP research projects are given below. Full project reports are included in Annex 1.

IWC-SORP Project 1: Antarctic Blue Whale Project (ABWP; formerly known as the 'Year of the Whale' project)

The Antarctic Blue Whale Project is a major initiative of the Southern Ocean Research Partnership. Its objectives are to describe our current understanding of the status of the Antarctic blue whales after fifty years of protection from exploitation, the role of these whales in the Antarctic ecosystem and what scientific information is now required to assist in the ongoing conservation and management of this iconic animal.

The international partnership of the Antarctic Blue Whale Project (ABWP) has recently cooperated on five voyages to the Southern Ocean: 1) the 2013 Voyage to the Ross Sea, led by the Australian Antarctic Division, 2) the 2013/14 Whale Song Antarctic Voyage for Ecosystem Studies (WAVES) Expedition, led by the Centre for Whale Research, Australia, 3) the 2014 voyage to the Antarctic Peninsula, an initiative of the South American Consortium led by Argentina, 4) The South African voyage to the Weddell Sea, and 5) a Voyage to the Dumont d'Urville Sea led by France. Voyage participants have refined and standardised methods for non-lethal research and advanced statistical approaches to the estimation of abundance.

Further voyages are planned over the next twelve years to collect sufficient samples to realise the ambitious aims of this Project and ships of opportunity are contributing sightings information to the online reporting system: www.marinemammals.gov.au/sorp/sightings. A sustained international effort under IWC-SORP will be necessary; the skilled team from many nations is collaborating to build capacity and maintain the active network of researchers in the Project.

The IWC-SORP non-lethal approach to research is built on robust, quantitative methods for the estimation of whale abundance. This year, statistical research has compared line transect and mark-recapture methods for deriving a circumpolar abundance estimate for Antarctic blue whales. Recent research includes augmenting Antarctic blue whale surveys with genetics for close-kin relationships and relative age, increasing the value of biopsy samples by combining powerful genetic techniques with traditional methods. Papers have been published on using acoustics to identify sub-populations and track and locate Antarctic blue whales in real-time; Unmanned Aerial Vehicles to study marine vertebrates; and an acoustic-assisted mark-recapture survey method for whales.

Publications from the recent voyages of the Antarctic Blue Whale Project confirm that locating and sampling Antarctic blue whales is possible using non-lethal methods, within the parameters required for a new estimate of abundance. Further, the voyages have demonstrated that all the objectives of the Project are achievable. Refinement of the methods and assessment of data is essential as the Project develops. Circum-Antarctic sampling from research vessels will need to continue for at least twelve years, to deliver sufficient samples to reach an acceptable coefficient of variation on the estimate of abundance. A full Antarctic Blue Whale Project report is included in Annex 1.

IWC-SORP Project 2: Distribution, relative abundance, migration patterns and foraging ecology of three ecotypes of killer whales in the Southern Ocean

The IWC-SORP killer whale project has had a productive year since SC/65a. Fieldwork has been undertaken in the Ross Sea, western Antarctic Peninsula and around Marion Island, sub-Antarctic.

Since 2009, Pitman and Durban have been conducting research on killer whales in Antarctic waters, mainly in the Antarctic Peninsula area but also in the southern Ross Sea (McMurdo Sound). To date they have described five morphologically distinct types of killer whales from Antarctic waters (Pitman and Ensor, 2003; Pitman et al. 2007; Pitman 2011; Pitman et al. 2011), including three sympatric types in the coastal waters of the Antarctic Peninsula. The team rarely sees groups of killer whales now, either in person, or from other peoples' photos, that have not been encountered before, which means they have high capture probabilities and resighting rates that will provide robust and precise population estimates of killer whales in the Antarctic Peninsula area from their photo-ID efforts. The team are currently investigating the systematics and ecology of these different types using satellite tagging, photo-identification, biopsy sampling, acoustic recordings and focal follow behavioural studies.

Field research on killer whales planned for McMurdo Sound, Ross Sea, was cancelled this year due to the unanticipated shut-down of the US Government and its impact on operations at McMurdo Station. Operations have been rescheduled for next year (2014/15) when Pitman and Durban expect to continue satellite tagging, biopsy, and photo-identification of killer whales in McMurdo Sound. In addition, satellite LIMPET tags provided by IWC-SORP will also be deployed on Antarctic minke whales that also occur along the ice edge at McMurdo.

In the Antarctic Peninsula area, Pitman and Durban participated as 'guest scientists' during 5 separate expeditions (4 x 10 days, 1 x 21) on board the tour vessel M/V National Geographic Explorer during December 2013 – February 2014. During the cruises they recorded 18 separate sightings of killer whales (4 type A, 1 large type B1, 10 small type B2, and 3 unidentified to type – the latter too distant to identify). A total of 235 individual whales were photographed for inclusion in the Western Antarctic Peninsula killer whale photo-id catalog; satellite tags were attached to 2 type A and 5 small type B killer whales, and biopsies were taken from 2 type A and 2 small type B individuals. In addition, 2 Antarctic minke whales were satellite-tagged and one biopsied.

During February 2014, Luciano Dalla Rosa and colleagues involved in Projeto Baleias, Brazilian Antarctic Program, surveyed the waters of the Bransfield and Gerlache Straits, western Antarctic Peninsula, and part of the Weddell Sea, including the Powell Basin, aboard the Brazilian Navy's Polar ship, *Almirante Maximiano*. A total of 318.6 nautical miles (39 hours) of cetacean search effort was conducted, resulting in 141cetacean sightings, three of which corresponded to killer whales. A further two killer whale sightings were made off effort. Projeto Baleias has been approved for another three years; ship time and some funding have been secured for cetacean research in the next two Antarctic field seasons (2014/15 and 2015/16).

De Bruyn and colleagues are currently on Marion Island in the sub-Antarctic conducting dedicated research on killer whales. Killer whales return predictably to the island during much of the year, with specific peak occurrences during September to December and April to May, associated with prey species presence. Land-based research on killer whales was consolidated within a dedicated killer whale programme in 2006. Field personnel are based permanently on Marion Island and conduct consistent structured observations, genetic- and photo-identification, and photogrammetry of killer whales. These observations have delivered published insights into social structure, abundance, diet and preliminary assessments of ecological role. Since 2011, satellite tagging has been conducted. Results suggest that killer whale movements are localised during spring and autumn, but range more widely during late winter and summer, with some individuals heading north of the island towards the South African south-east coast. Since inception of the long-term sun-Antarctic killer whale project, there have been:

- 6,800 hours of dedicated land based observation
- 20,000 images taken for photographic mark-resight

- 57 catalogued individual killer whales
- 25 biopsy samples collected from 21 individuals
- 15 killer whales tracked with satellite devices for longer than 24hrs
- 7 tracks lasting longer than 10 days
- 2 time-depth-recording (TDR) satellite trackers deployed.

A full project report is included in Annex 2.

IWC-SORP Project 3: Foraging ecology and predator-prey interactions between baleen whales and krill: a multi-scale comparative study across Antarctic regions

The main objectives of this research project are to conduct ecological research on cetaceans around the Antarctic Peninsula and develop methodological tools that can be applied across Antarctic regions to better understand the short and long term movement patterns and behaviours of baleen whales in relation to prey and environmental variability; and develop a research proposal for the National Science Foundation to apply tag and prey mapping technologies to further quantify the relationships between humpback and minke whales and krill.

From 29 December 2013 – 7 February 2014 Dr. Ari Friedlaender and Ms. Heather Foley participated in the National Science Foundation's Long Term Ecological Research cruise to the western side of the Antarctic Peninsula (www.pal.lternet.edu). During the cruise, visual sighting surveys were conducted while the ship transited between pre-determined sampling stations along the continental shelf waters. Biopsy samples and photo-ID images were also collected throughout the cruise. The survey data will be used in a long-term data base to determine how the distribution and abundance of cetaceans relates to environmental conditions within the LTER study area and how these change relative to changing ocean and sea ice conditions. Biopsy samples are collected to support a number of long-term research objectives. These include: determining the proportion of different breeding stocks represented within the LTER study region, understanding the population demographics of whales in the LTER study region by measuring sex ratios and pregnancy rates, and measuring stable isotopes to test for regional differences in feeding preferences. A total of 104 biopsy samples were collected: 101 humpback and 3 minke whale samples.

Based on satellite tags provided by the Australian Antarctic Division and deployed during the 2012/2013 Palmer LTER research cruise, the following results have been obtained (also, see the abstract by Curtice et al. to be presented in May 2014 and submitted for publication in June 2014 to *Movement Ecology).* The hypothesis of this research is that the long-term movement patterns and home-ranges of humpback whales in Antarctic waters will reflect the broad scale distribution and movement patterns of Antarctic krill, becoming smaller and more coastal throughout the feeding season. Our data support this hypothesis, and the figures below illustrate two measures of animal movement, minimum convex polygons and kernel home ranges.

In March 2014, Dr. Friedlaender was invited to join the Palmer Long-Term Ecological Research group in the renewal of their National Science Foundation sponsored research. Dr. Friedlaender will join the Palmer LTER as a Co-Investigator and lead a cetacean component with support for 6 years. An exurb from the proposal explaining the cetacean research that will be part of the upcoming LTER program can be found in the full project report in Annex 3.

IWC-SORP Project 4: What is the distribution and extent of mixing of Southern Hemisphere humpback whale populations around Antarctica? Phase 1: East Australia and Oceania

The humpback connectivity project has focused on the goals of understanding the genetic links between the whales of New Zealand and American and Independent Samoa to other Oceania regions and east Australia. Preliminary analyses show that whales from the Samoa's mainly match to the eastern South Pacific, and the whales primarily on their northern migration past New Zealand match to east Australia and New Caledonia, in the western South Pacific. This research supports the plan to satellite tag whales on their southern migration past Raoul Island and from their American Samoa breeding ground. The results are likely to provide a more thorough understanding of the location of the Oceania whales' Antarctic feeding grounds. Technical issues with the satellite tags have delayed this research by a year but it is hoped that tagging will be undertaken in 2014. A full project report is included in Annex 4.

IWC-SORP Project 5: Acoustic trends in abundance, distribution, and seasonal presence of Antarctic blue whales and fin whales in the Southern Ocean

In 2011/2012, after the preliminary analysis of all the available acoustic data showing the geographic and seasonal occurrence of blue and fin whales around the Antarctic, the IWC-SORP Acoustic Trends Working Group (hereafter the ATW Group) concluded that a coordinated effort to collect new acoustic data using consistent spatial and temporal coverage, instruments and analytical methods, would be the best way forward to achieve the aims of the project. To best utilise passive acoustic methods for monitoring purposes in the future, the ATW Group proposed the placement and maintenance of a circumpolar Antarctic monitoring system with at least one hydrophone in each of the six IWC management areas. To facilitate and promote participation of other nations in implementation of the Southern Ocean Hydrophone Network (SOHN), it was decided to provide guidelines and recommendations for instrument choice, hardware configurations and analysis methods to propose how data might be best collected and analyzed in a uniform manner to best address the specific research questions for both blue and fin whales. The first technical report addresses the recording hardware and mooring requirements for prospective collaborators (further referred to as ‘the white paper’), whereas a second report that is currently in preparation will address the analyses methods for Antarctic blue and fin whale calls (hereinafter referred to as ‘the blueprint’). In September 2013, a meeting of the ATW Group took place in Paris. The purpose was to discuss the whitepaper and the preparatory work conducted by the Alfred-Wegener Institute and PELAGIS Observatory using existing blue whale acoustic datasets for the blueprint. Furthermore, the poster that the group presented at the 20th Biennial Conference of the Biology of Marine Mammals in Dunedin, New Zealand (9-13 December 2013) was drafted during the Paris meeting. The whitepaper was submitted for publication to Polarforschung in February 2014 and is currently under revision. The ATW Group will submit the blueprint before the end of 2014. Since 2011, the ATW Group has developed a strong, interdisciplinary and international team to continue to move this program into the future. Further efforts will focus to find collaborators and funding to deploy and operate the circumpolar Antarctic monitoring network. A full project report is included in Annex 5.

LIST OF IWC-SORP RELATED PAPERS SUBMITTED FOR CONSIDERATION TO SC/65b

SC/65b/SH Bell (2014) Annual report of the Southern Ocean Research Partnership (IWC-SORP) 2013/14.

SC/65b/SH Bravington MV, Jarman S, Skaug H (2014) Antarctic Blue Whale surveys: augmenting via genetics for close-kin and relative age.

SC/65b/Forinfo Double MC, Andrews-Goff V, Jenner CS, Jenner M-N, Laverick SM, Branch TA, Gales NJ. (2014) Migratory Movements of Pygmy Blue Whales (*Balaenoptera musculus brevicauda*) between Australia and Indonesia as Revealed by Satellite Telemetry. PLoS One10.1371/journal.pone.0093578

SC/65b/SH01 Findlay K, Thornton M, Shabangu F, Venter K, Thompson I, Fabriciussen O (2014) Report of the 2013/14 South African Antarctic blue whale survey, 000° - 020°E.

SC/65b/Forinfo Friedlaender AS, Tyson RB, Stimpert AK, Read AG, Nowacek DP (2013) Extreme diel variation in the feeding behavior of humpback whales along the Western Antarctic Peninsula in autumn. Marine Ecology Progress Series 494: 281-289.

SC/65b/IA Herr H, Kelly N, Kock K-H, Viquerat S, Scheidat M, Williams R, Lehnert LS, Siebert U (2014) German helicopter surveys provide insights in temporal and spatial variability of minke whale densities in ice.

SC/65b/SH Iñiguez M (2014) Report of the *Tango* voyage to the Antarctic Peninsula.

SC/65b/IA Kelly N, Peel D, Bravington MV (2014) Distribution and abundance of Antarctic minke whales in sea ice regions of East Antarctica: a summary of results.

SC/65b/SH Kelly N, Bravington MV, Peel D (2014) Predictions of encounter rate with changing abundance: a case study in Antarctic blue whales.

SC/65b/Forinfo Miller BS, Collins K, Barlow J, Calderan S, Leaper R, McDonald M, Ensor P, *et al*. (2014) Blue whale vocalizations recorded around New Zealand: 1964–2013. Journal of the Acoustical Society of America 135: 1616–1623.

Peel D, Miller BS, Kelly N, Dawson S, Slooten E, Double MC (*In press*) A simulation study of acoustic-assisted tracking of whales for mark-recapture surveys. PLoS One.

SC/65b/Forinfo07 Miller BS, Leaper R, Calderan S, Gedamke J (*Submitted*) Red shift, blue shift: Doppler shifts and seasonal variation in the tonality of Antarctic blue whale song. PLoS One.

SC/65b/SH Miller BS, Gedamke J, Calderan S, Collins K, Johnson C, Miller E, Samaran F, Smith J, Double MC (2014) Accuracy and precision of DIFAR sonobuoys for acoustic localisation: Calibration and comparative measurements from three SORP voyages.

SC/65b/SH Miller B, Wotherspoon S, Calderan S, Leaper R, Collins K, Double MC (2014) Localizing blue whales using DIFAR sonobuoys. Effects of receiver drift.

SC/65b/SH Miller BS, Gillespie D, Weatherup G, Calderan S, Double MC (2014) Software for the localisation of baleen whale calls using DIFAR sonobuoys: PAMGuard DIFAR.

SC/65b/SH Peel D, Bravington MV, Kelly N, Double MC (2014) Examination of a future mark-recapture study of Antarctic Blue Whales.

SC/65b/Forinfo Risch D, Gales N, Gedamke J, Kindermann L, Nowacek D, Read A, Siebert U, Van Opzeeland I, Van Parjis S, Friedlaender AS (2014) Mysterious 'bioduck' signal attributed to the Antarctic minke whale. Biology Letters 10: 20140175. http://dx.doi.org/10.1098/rsbl.2014.0175

SC/65b/SH Steel, D., Gibbs, N., Carroll, E., Childerhouse, S., Olavarria, C., Baker, C.S., Constantine, R. (2014). Genetic identity of humpback whales migrating past New Zealand.

SC/65b/Forinfo Van Opzeeland IC, Samaran F, Stafford KM, Findlay K, Gedamke J, Harris D, Miller BS (2014) The Southern Ocean Hydrophone 1 Network (SOHN): Circum-Antarctic passive acoustic monitoring of Antarctic blue and fin whales.

IWC-SORP RELATED PAPERS SUBMITTED TO SC IN PREVIOUS YEARS

SC/61/SH17 Gales N, Double M, Robinson S, Jenner C, Jenner M, King E, Gedamke J, Paton D, Raymond, B. (2009) Satellite tracking of southbound East Australian humpback whales (*Megaptera novaeangliae*): challenging the feast or famine model for migrating whales.

SC/62/SH3 Garrigue C, Peltier H, Ridoux V, Franklin T, Charrassin J-B (2010) CETA: a new cetacean observation program in East Antarctica.

SC/63/O12 Childerhouse S (2011) Annual Report of the Southern Ocean Research Partnership 2011.

SC/63/O13 Childerhouse S (2011) Southern Ocean Research Partnership Revised project plans.

SC/63/SH16 Constantine R *et al.* (2011) Comprehensive photo-identification matching of Antarctic Area V humpback whales.

SC/63/SH10 Steel D et al. (2011) Initial genotype matching of humpback whales from the 2010 Australia/New Zealand Antarctic Whale Expedition (Area V) to Australia and the South Pacific.

SC/64/O13 Bell E (2012) Annual Report of the Southern Ocean Research Partnership 2011/12.

SC/64/O14 Baker CS, Galletti B, Childerhouse S, Brownell RL Jr, Friedlaender A, Gales N, Hall A, Jackson J, Leaper R, Perryman W, Steel D, Valenzuela L and Zerbini A (2012) Report of the Living Whales Symposium: Advances in non-lethal research techniques for whales in the Southern Hemisphere.

SC/64/IA10 Kelly N, Murase H, Kitakado T, Kock K-H, Williams R, Feindt-Herr H and Walløe L (2012) Estimating abundance and distribution of Antarctic minke whales within sea ice areas: data requirements and analysis methods.

SC/64/SH10 Kelly N, Miller B, Peel D, Double MC, de la Mare W and Gales N (2012) Strategies to obtain a new circumpolar abundance estimate for Antarctic Blue Whales: survey design and sampling protocols.

SC/64/SH11 Miller BS, Kelly N, Double MC, Childerhouse SJ, Laverick S and Gales N (2012) Development of acoustic methods: cruise report on SORP 2012 Antarctic Blue Whale voyages.

SC/64/SH12 Miller BS (2012) Real-time tracking of Blue Whales using DIFAR sonobuoys.

SC/64/SH13 Wadley V, Lindsay M, Kelly N, Miller N, Gales N, de la Mare W and Double MC (2012) Abundance estimation of Antarctic Blue Whales: preliminary voyage plan for SORP in March 2013.

SC/64/SH14 de la Mare WK (2012) Estimating relative abundance from historic Antarctic whaling records.

SC/64/SH15 Schmitt NT, Double MC, Baker CS, Steel D, Jenner KCS, Jenner M-NM, Paton D, Gales R, Jarman SN, Gales N, Marthick JR, Polanowski AM and Peakall R (2012) Low levels of genetic differentiation characterize Australian humpback whale (*Megaptera novaeangliae*) populations.

SC/64/SH26 Peel D and Kelly N (2012) Exploratory analyses of potential encounter rates for an acoustic tracking survey method for blue whales.

SC/65a/SH03 Andrews-Goff V, Olson PA, Gales NJ and Double MC (2013) Satellite telemetry derived summer movements of Antarctic blue whales.

SC/65a/O11 Bell (2013) Annual report of the Southern Ocean Research Partnership (SORP) 2012/13

SC/65a/SH25 Bell (2013) Report of the Southern Ocean Research Partnership Conference, 31 May - 2 June, 2013.

SC/65a/O10 Best PB, Findlay K, Thornton M and Stafford K (2013) SORP research report: the South African Blue Whale Project.

SC/65a/SH21 Double (2013) Cruise report of the 2013 Antarctic blue whale voyage of the Southern Ocean Research Partnership.

SC/65a/IA12 Gales N, Bowers M, Durban JW, Friedlaender AS, Nowacek DP, Pitman RL, Read AJ and Tyson RB (2013) Advances in non-lethal research on Antarctic minke whales: biotelemetry, photo-identification and biopsy sampling.

SC/65a/Forinfo08 Kelly N (2013) A new circumpolar abundance estimate for Antarctic blue whales: potential survey methods.

SC/65a/SH18 Miller BS, Barlow J, Calderan S, Collins K, Leaper R, Kelly N, Peel D, Olson P, Ensor and Double MC (2013a) Long-range acoustic tracking of Antarctic blue whales.

SC/65a/SH19 Miller BS, Barlow J, Calderan S, Leaper R, McDonald M, Ensor P, Olson P, Olavarria C and Double MC (2013b) Blue whale songs recorded around South Island, New Zealand.

SC/65a/SH11 Olson PA, Ensor P, Schmitt N, Olavarria C and Double MC (2013a) Photo-identification of Antarctic blue whales during the SORP Antarctic Blue Whale Voyage 2013.

SC/65a/SH12 Olson PA, Ensor P, Olavarria C, Schmitt N, Childerhouse S, Constantine R, Miller BS and Double MC (2013b) New Zealand blue whales: initial photo-identification of a little-known population.

SC/65a/Forinfro09 Peel D (2013) Examination of an acoustic-assisted mark recapture survey method for whales.

SC/65a/SH10 Reyes MV, Iñíguez M. (2013) Occurrence of cetaceans in the Scotia Sea during February-March 2013.

SC/65a/SH05 Robbins J, Zerbini AN, Gales N, Gulland FMD, Double M, Clapham PJ, Andrews-Goff V, Kennedy AS, Landry S, Mattila DK and Tackaberry J (2013) Satellite tag effectiveness and impacts on large whales: preliminary results of a case study with Gulf of Maine humpback whales.

ANNEX 1 - PROGRESS REPORTS ON THE IWC-SORP RESEARCH PROJECTS FOR 2013/14

IWC-SORP Project 1. Antarctic Blue Whale Project (ABWP)

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Introduction

About a third of a million Antarctic blue whales (*Balaenoptera musculus intermedia*) were taken during commercial whaling in the Southern Hemisphere. In 1964 the International Whaling Commission banned the hunting of blue whales, although some were still caught illegally until 1973. The Antarctic blue whale is currently 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 Project was started after the end of the systematic circumpolar sightings surveys in 2003/04, to address the lack of a strategy to assess the status and recovery of this severely impacted, rare and iconic species.

Objectives

The objectives of the Antarctic Blue Whale Project are:

- to identify the most appropriate and efficient method to deliver a new circumpolar abundance estimate of Antarctic blue whales;
- to develop and refine methods to improve survey efficiency;
- to deliver a new circumpolar abundance estimate;
- to improve understanding of population structure;
- to improve understanding of linkages between breeding and feeding grounds;
- to characterise the behaviour on the feeding grounds.

Results

Preliminary voyages to develop passive acoustic methods
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. Two preliminary voyages in 2011/12 off south-east Australia provided methods for real-time acoustic tracking, using a case-study of pygmy blue whales. This research was instrumental in the successful use of passive acoustics to subsequently track Antarctic blue whales in and around the Ross Sea.

Statistical innovations
The IWC-SORP non-lethal approach to research is built on robust, quantitative methods for the estimation of whale abundance. This year, statistical research has compared line transect and mark-recapture methods for deriving a circumpolar abundance estimate for Antarctic blue whales. Recent research includes augmenting Antarctic blue whale surveys with genetics for close-kin relationships and relative age, increasing the value of biopsy samples by combining powerful genetic techniques with traditional methods. Papers have been published on using acoustics to identify sub-populations and track and locate Antarctic blue whales in real-time; Unmanned Aerial Vehicles to study marine vertebrates; and an acoustic-assisted mark-recapture survey method for whales.

2013 Voyage to the Ross Sea region – FRV Amaltal Explorer – led by Australia
The results of this 47 day voyage were reported to SC/65a and are currently being published in the scientific literature (SC/65a/SH3,11, 18,19,21 and project outputs below). The voyage demonstrated that disposable directional hydrophones (DIFAR sonobuoys) can be used to detect concentrated areas of blue whale abundance at distances of hundreds of kilometres. Following acoustic bearing angles, these concentrations of blue whales can then be located and sampled. During the 2013 voyage, recordings of 43 vocalising Antarctic blue whales yielded 25 visual sightings of one or more whales. Photographs of 57 individuals and biopsies from 23 individuals were obtained. Two satellite tages were deployed on Antarctic blue whales.

The sampling protocols employed on the *FRV Amaltal Explorer* provide a template for uniform protocols for future voyages. The vessels will use acoustic tracking to increase encounter rates with Antarctic blue whales, combined with satellite tagging and identification of individuals by genetic and photographic methods.

The ABW identification photographs from the voyage have been contributed to the IWC-SH catalogue, curated by Paula Olson (Convenor of the ABWP Technical Committee on identification of individuals - photographs). The biopsy samples have been analysed at the Australian Antarctic Division and sub-samples sent for future analysis to the IWC repository at National Marine Fisheries Services, La Jolla USA, under the care of Dr Aimee Lang (Convenor of the ABWP Technical Committee on identification of individuals - genetics).

2013/14 Voyage to the Southern Ocean – RV Whale Song – led by Australia
The WAVES (Whale Song Antarctic Voyage for Ecosystem Studies) Expedition, led by the Centre for Whale Research, spanned 31 days from December 30, 2013 until January 29, 2014. Departing Hobart, Australia, the *RV Whale Song* and her crew of 10 commenced Transit 1 which reached the ice-edge after nine days. Transit 2 travelled along the ice-edge for a further nine days and Transit 3 was from the Ice-edge to Fremantle (14 days). Pygmy blue whale and Antarctic blue whale calls were detected with DIFAR sonobuoys, however there were no confirmed sightings of Antarctic blue whales.

Blue whale calls were detected during Transit 1, south of the Antarctic convergence, indicating whales were to the southwest. Two Antarctic blue whale calls (Z calls) were detected while travelling westward along the ice-edge but their position inside a bay where *RV Whale Song* could have become caught in ice prevented investigation. During this voyage no blue whales were observed at the soft ice-edge where many humpback whales were seen. On Transit 3, while travelling back to Fremantle and crossing the Sub-Tropical Convergence Zone (STCZ), two blue whales were encountered, one Antarctic blue whale and one pygmy blue whale – both were photo-identified but not tagged or biopsied due to sea conditions.

A report is being prepared on how this experience can benefit future ABWP voyages. Further expeditions south of Australia are planned and will focus on determining where blue whales are during January, and understanding the timing of their movements to the soft ice-edge.

2014 Voyage to the Antarctic Peninsula – RV Tango – South American consortium led by Argentina
The three-week voyage to South Orkney and the western Antarctic Peninsula has been reported separately to SC65b (Iñiguez *et al*. SC/65b/SHxx). One Antarctic blue whale was sighted. The voyage was an initiative of the IWC-SORP-ABWP South American Consortium, announced at workshop held on 17-18 April 2013 in Buenos Aires, Argentina (SC/65a/O11).

A second voyage of *RV Tango* is planned for January 2015. In preparation for the voyage, a capacity-building workshop is planned for late 2014 in Chile. The IWC-SORP-ABWP funds have been utilised for this workshop and providing a coordinator for the South American Consortium.

2014 Voyage to the Weddell Sea – RV Agulhas II – led by South Africa
During the voyage of SANAE 53, 13 days were dedicated to whale research in January 2014. The location in the Weddell Sea was highly prospective for Antarctic blue whales; 17 groups of 26 Antarctic blue whales were sighted. Refer to SC/65b/SH01 for a full voyage report.

2014 Voyage to Dumont d'Urville Sea – RV l'Astrolabe – led by France
As part of the CETA ecosystem research on cetaceans and their ecosystem, the voyage of L'Astrolabe in January 2014 was undertaken by French colleagues the under direction of Jean-Benoit Charassin and voyage leader Claire Garrigue.The IWC-SORP provided logistic support including survival suits etc. for the voyage. As predicted for this region, there were no encounters with Antarctic blue whales. Contributions of the voyage to other IWC-SORP projects are reported separately. The French scientists on the L'Astrolabe voyage will contribute to IWC-SORP again in 2015.

Ships of opportunity
Partnerships with tourist ships, fishing vessels and naval vessels are yielding data for the circumpolar estimation of abundance. This year, a special presentation was made to fishing vessels by kind invitation from the Coalition

of Legal Toothfish operators (COLTO) under the Commission for the Conservation of Antarctic Living Marine Resources (CCAMLR).

Presentations have been delivered to encourage Antarctic expeditioners, tourists on cruise ships, and others who may encounter whales to report their sightings. Posters have been distributed to announce the new on-line reporting system, with detailed instructions for photography and data upload: www.marinemammals.gov.au/sorp/sightings

To date, Australia, New Zealand, United Kingdom and United States are participating in this activity.

Conclusions

Publications from the recent voyages of the Antarctic Blue Whale Project confirm that locating and sampling Antarctic blue whales is possible using non-lethal methods, within the parameters required for a new estimate of abundance. Further, the voyages have demonstrated that all the objectives of the Project are achievable. Refinement of the methods and assessment of data is essential as the Project develops. Circum-Antarctic sampling from research vessels will need to continue for at least twelve years, to deliver sufficient samples to reach an acceptable coefficient of variation on the estimate of abundance.

Challenges

The four Technical Committees of the Project are refining the uniform sampling protocols, under the direction of the international Scientific Steering Committee. During 2014, voyages of the research icebreakers *L'Astrolabe* (France), *Whale Song* (Australia), *Agulhas II* (South Africa) and *Tango* (Argentina) participated in the Project using the protocols. Collaboration by ABWP research teams on these and other vessels will continue during the coming summer 2014/15.

In future years, the Project will remain an integral part of IWC-SORP, although the position of Scientific Coordinator of the Antarctic Blue Whale Project will cease at the end of June 2014. In preparation for the Project to continue for the twelve years necessary to meet its objectives, the website has been redesigned. Project participants are encouraged to access website materials to pursue their research using the latest non-lethal methods at
www.marinemammals.gov.au/sorp The project overview developed by the Scientific Steering Committee has been posted, to facilitate research proposals and bids for sea time.

Outlook for the future

The future guidance for the project will continue under the Scientific Steering Committee of five leading cetacean researchers, with Professor Philip Hammond as Chair. Four technical Committees report to the Scientific Steering Committee on sampling methods, passive acoustic methods and identification of individual whales by photography and genetics from biopsies.

The uptake of new advances in statistics and genetic analyses has the potential to influence and accelerate the research. Proposals for international voyages will maximise the use of ship-time to integrate these advances into the Project.

With international cooperation and coordinated research voyages over future years, the Project will assess the rate of recovery of the population, following last century's intensive industrial whaling.

Project outputs

Papers

Calderan S et al. (*Submitted*) Vocalisations recorded in the presence of sei whales (*Balaenoptera borealis*) in the Southern Ocean (Submitted to JASA Express Letters).

Jenner KC, Jenner M-N (*In preparation*) Whale Song Antarctic Voyage for Ecosystem Studies 2014 (WAVES).

Miller BS, Collins K, Barlow J, Calderan S, Leaper R, McDonald M, Ensor P *et al*. (2014) Blue whale vocalizations recorded around New Zealand: 1964–2013. Journal of the Acoustical Society of America 135: 1616–1623.

SC/65b/Forinfo07 Miller BS, Leaper R, Calderan S, Gedamke J (*Submitted*) Red shift, blue shift: Doppler shifts and seasonal variation in the tonality of Antarctic blue whale song. PLoS One.

SC/65b/SHxx Bravington MV, Jarman S, Skaug H (2014) Antarctic Blue Whale surveys: augmenting via genetics for close-kin and relative age.

SC/65b/SH01 Findlay K, Thornton M, Shabangu F, Venter K, Thompson I, Fabriciussen O (2014) Report of the 2013/14 South African Antarctic blue whale survey, 000° - 020°E.

SC/65b/SHxx Kelly N, Bravington MV, Peel D (2014) Predictions of encounter rate with changing abundance: a case study in Antarctic blue whales.

SC/65b/SHxx Miller BS, Gedamke J, Calderan S, Collins K, Johnson C, Miller E, Samaran F, Smith J, Double MC (2014) Accuracy and precision of DIFAR sonobuoys for acoustic localisation: Calibration and comparative measurements from three SORP voyages.

SC/65b/SHxx Miller B, Wotherspoon S, Calderan S, Leaper R, Collins K, Double MC (2014) Localizing blue whales using DIFAR sonobuoys. Effects of receiver drift.

SC/65b/SHxx Miller BS, Gillespie D, Weatherup G, Calderan S, Double MC (2014) Software for the localisation of baleen whale calls using DIFAR sonobuoys: PAMGuard DIFAR.

SC/65b/SHxx Peel D, Bravington MV, Kelly N, Double MC (2014) Examination of a future mark-recapture study of Antarctic Blue Whales.

Peel D, Miller BS, Kelly N, Dawson S, Slooten E, Double MC (*In press*) A simulation study of acoustic-assisted tracking of whales for mark-recapture surveys. PLoS One.

Conference presentations

Miller BS, Barlow J, Calderan S, Collins K, Leaper R (2013) Long-range acoustic detection and localisation of Antarctic blue whales. 6th International Conference on the Detection, Classification, Localisation, and Density Estimation of Marine Mammals using Passive Acoustics: St. Andrews, Scotland, UK, June 2013.

Miller BS, Kelly N, Peel D, Barlow J, Calderan S, Collins K, Leaper R, Olson P, Ensor P, Andrews-Goff V, Wadley V (2013) Real-time acoustic tracking of Antarctic blue whales in the Southern Ocean: Towards a precise abundance estimate. Oral presentation at the Biennial Conference on Marine Mammals, Dunedin, New Zealand, 9-13 December 2013.

Thomisch K, Boebel O, Clark CW (2013) Spatio-temporal patterns of Antarctic blue whale (*Balaenoptera musculus intermedia*) vocal behaviour in the Weddell Sea. Oral presentation at the Biennial Conference on Marine Mammals, Dunedin, New Zealand, 9-13 December 2013.

Olson P, Ensor P, Andrews-Goff V, Double M (2013) Inter-annual and within season movements of photo-identified Antarctic blue whales. Oral presentation at the Biennial Conference on Marine Mammals, Dunedin, New Zealand, 9-13 December 2013

Collins K, Miller B, Ensor P, Olson P, Calderan S, Leaper R, Barlow J, McDonald M, Olavarria C, Childerhouse S, Constantine R, Van de Linde M, Double M (2013) New Zealand blue whales: Distribution, confirmation of acoustic identity, and a nascent photographic identification catalogue. Oral presentation at the Biennial Conference on Marine Mammals, Dunedin, New Zealand, 9-13 December 2013.

Posters

Andrews-Goff V, Olson PA, Gales NJ, Zerbini AN, Double MC (2013) Movements of satellite tagged Antarctic blue whales. Poster presented at the Biennial Conference on Marine Mammals, Dunedin, New Zealand, 9-13 December 2013.

Papers submitted to the Scientific Committee

Please refer to p 6 of this document for a list of the ABWP-related papers submitted to the Scientific Committee this year.

Popular articles

Cahalan S (2013) Protecting the icons of the deep. International Innovation: Environment April 2013.
Cahalan S (2013) Out of the Blue. Island, Issue 133.
Pyper W (2012) Listening to the blues. Australian Antarctic Magazine, Issue 23.
Pyper W (2013) Songs reveal elusive giants. Australian Antarctic Magazine, Issue 24.

Media

The successful 2013 Blue Whale Voyage attracted considerable media attention, including 24 items in print/online, 36 radio broadcasts, 5 television broadcasts, a video on YouTube and 38,291 users on Twitter.

ANNEX 2 - PROGRESS REPORTS ON THE IWC-SORP RESEARCH PROJECTS FOR 2013/14

IWC-SORP Project 2. Distribution, relative abundance, migration patterns and foraging ecology of three ecotypes of killer whales in the Southern Ocean

Robert L. Pitman[1], John W. Durban[1], Luciano Dalla Rosa[2], P.J.N. (Nico) de Bruyn[3]

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Robert Pitman and John Durban, West Antarctic Peninsula

Introduction
Since 2009, Pitman and Durban have been conducting research on killer whales in Antarctic waters, mainly in the Antarctic Peninsula area but also in the southern Ross Sea (McMurdo Sound). To date we have described five morphologically distinct types of killer whales from Antarctic waters (Pitman and Ensor, 2003; Pitman et al. 2007; Pitman 2011; Pitman et al. 2011), including three sympatric types in the coastal waters of the Antarctic Peninsula. We are currently investigating the systematics and ecology of these different types using satellite tagging, photo-identification, biopsy sampling, acoustic recordings and focal follow behavioural studies. Below is a summary of our field work during 2013-14.

Objectives
Our main objectives are to describe killer whale diversity in Antarctica and to quantify their overall impact through trophic interactions within the Antarctic ecosystem. Our research methods include compiling observations of foraging behaviour and prey preferences (Pitman and Durban, 2010; 2012), school sizes, and habitat associations; collecting skin and blubber biopsy samples for ongoing phylogenetic analyses of taxonomic status (LeDuc et al. 2008.; Morin et al. 2010; Foote et al. 2011; Morin et al. submitted) and chemical analyses to infer diet (Krahn et al. 2008), deploying satellite tags to learn of about movements and diving behaviour (Andrews et al. 2008; Durban and Pitman 2012); and photographing individuals to estimate their abundance and demography (e.g. Durban et al. 2010; Fearnbach et al. 2012), study movements and residency times (e.g., Durban et al. 2000), and estimate life history parameters .

Results
Field research on killer whales planned for McMurdo Sound, Ross Sea, was cancelled this year due to the unanticipated shut-down of the US Government and its impact on operations at McMurdo Station. Operations have been rescheduled for next year (2014/15) when we expect to continue satellite tagging, biopsy, and photo-identification of killer whales in McMurdo Sound. In addition, satellite LIMPET tags provided by IWC-SORP will also be deployed on Antarctic minke whales that also occur along the ice edge at McMurdo.

In the Antarctic Peninsula area, Pitman and Durban participated as 'guest scientists' during 5 separate expeditions (4 x 10 days, 1 x 21) on board the tour vessel M/V National Geographic Explorer during December 2013 – February 2014. During the cruises they recorded 18 separate sightings of killer whales (4 type A, 1 large type B1, 10 small type B2, and 3 unidentified to type – the latter too distant to identify). A total of 235 individual whales were photographed for inclusion in the Western Antarctic Peninsula killer whale photo-id catalog; satellite tags were attached to 2 type A and 5 small type B killer whales, and biopsies were taken from 2 type A and 2 small type B individuals. In addition, 2 Antarctic minke whales were satellite-tagged and one biopsied. Six of the 7 killer whale satellite tags are still transmitting as of this date (22 March 2014). One tag that stopped transmitting after 40 days and two tags have transmitted for 105 days and are still operational. Of the minkes tagged, one tag lasted 15 days and the other is still transmitting after 37 days. Tags deployed on the killer whales included 3 depth/location tags (Wildlife Computers SPLASH tags) and 4 location-only tags (WC SPOT); both minkes were tagged with SPLASH tags, yielding unprecedented data on diving behavior (Gales et al. 2013).

In addition to the photos that we took, we had contacts on 13 other tour vessels operating in the Peninsula area this year; they compiled photos from killer whale encounters to send to us at the end of the season. These additional photos are still coming in but we anticipate several thousand photos will be submitted, representing at least 25 separate killer whale encounters. A private source has donated funds to cover the cost of a 1-yr post-doc at the La Jolla laboratory to organize our photo archive for the Antarctic killer whale photo-ID catalog and database, and to use these data to estimate abundance and population structuring. That person has been hired and we expect by this time next year to have preliminary population estimates for the 3 different types of killer whales that occur in the Peninsula area, as well as a detailed record of movements, home ranges and habitat preferences for all 3 types.

Conclusions
We rarely see groups of killer whales now, either personally, or from other peoples' photos, that we have not encountered before, which means we have high capture probabilities and resighting rates that will provide robust and precise population estimates of killer whales in the Antarctic Peninsula area from our photo-ID efforts. Our satellite tracking data show quite clearly the different habitat use for the 3 different types of killer whales that are broadly sympatric in the Peninsula area and our feeding observations continue to confirm prey specializations hypothesized for each of the different types. Notably we are also documenting ecotype-specific dive profiles among the different types: mammal-eaters (types A and big B) mainly staying within relatively shallow waters (< 50 m) with an occasional deeper dive; this is in contrast to known and presumed fish-eating forms (type C and small type B2, respectively) which dive regularly to 300-400 (maximum 700+) m. We have now documented long-distance, round trip migrations for all 4 killer whale types that we regularly document in Antarctic waters, and have shown that they are all strongly philopatric on their Antarctic feeding grounds.

Challenges
We expect that Lindblad Expeditions/National Geographic Society will continue to provide logistical support for us as 'guest scientists' on board the National Geographic Explorer for the foreseeable future. Our main challenge is to source funds to gain access to a dedicated research vessel so that we can work full time on the whales that we find, and also to support the purchasing of equipment for tagging, acoustic and photogrammetry studies.

Outlook for the future
We hope that at some time in the near future we will secure dedicated research vessel time to conduct focussed research on Antarctic killer whales. In the meantime, our support on the Explorer guarantees us access to killer whales in Antarctica for tagging, photographing and biopsy sampling. In addition to working in the Peninsula area next season (2014-15) on type A, big B1 and small B2 killer whales, we will also be returning to the Ross Sea (McMurdo Sound) to continue our killer whale research there on type C killer whales under our current NSF support. We will also be submitting a proposal to NSF in April, along with a long list of collaborators, requesting support for us to work on killer whales in the Ross Sea for the next 3 yrs. as part of multi-disciplinary project to study the ecology of the Ross Sea. We expect to continue our work on Antarctic killer whales in the long term.

Luciano Dalla Rosa, West Antarctic Peninsula and Powell Basin

Introduction
Luciano Dalla Rosa and colleagues (Projeto Baleias, Brazilian Antarctic Program) have been conducting cetacean research around the Antarctic Peninsula since 1997. Although research focused mainly on humpback whales until recently, data on killer whale distribution and relative abundance have been collected throughout, along with photo-identification data.

Objectives
Our specific objectives on killer whales include investigating their distribution and relative abundance around the Antarctic Peninsula, investigating the species-habitat relationships, and their acoustics. We also conduct biopsy sampling for genetics, contaminant and stable isotope analyses, and have continued our photo-identification efforts, all of which contribute to the IWC-SORP killer whale project. Satellite tagging of killer whales is also planned for the upcoming seasons.

Results
During February 2014, Luciano Dalla Rosa and colleagues surveyed the waters of the Bransfield and Gerlache Straits, western Antarctic Peninsula, and part of the Weddell Sea, including the Powell Basin, aboard the Brazilian Navy's Polar ship, *Almirante Maximiano*. A total of 318.6 nautical miles (39 hours) of cetacean search effort was conducted, resulting in 141 cetacean sightings three of which corresponded to killer whales. A further two killer whale sightings were made off effort.

Challenges
Funding for equipment, including satellite tags, is limited. Furthermore, ship time is divided among other projects, so depending on weather conditions, all projects may have their activities restricted to some level. This year's activities were considerably affected due to poor weather conditions that persisted for most of the month.

Outlook for the future
Projeto Baleias has been approved for another three years; ship time and some funding have been secured for cetacean research in the next two Antarctic seasons (2014/15 and 2015/16).

P.J.N. (Nico) de Bruyn, Marion Island, sub-Antarctic

Marion Island provides one of the few platforms for dedicated research on killer whales within the sub-Antarctic zone. Killer whales return predictably to the island during much of the year, with specific peak occurrences during September to December and April to May, associated with prey species presence. Land-based research on killer whales was consolidated within a dedicated killer whale programme in 2006. Field personnel are based permanently on Marion Island and conduct consistent structured observations, genetic- and photo-identification, and photogrammetry of killer whales. These observations have delivered published insights into social structure, abundance, diet and preliminary assessments of ecological role. Since 2011, satellite tagging has been conducted. Results suggest that killer whale movements are localised during spring and autumn, but range more widely during late winter and summer, with some individuals heading north of the island towards the South African south-east coast.

The key objectives of the Marion Island project are:

- To build on significant work already underway on Marion Island. This work includes photo-identification (for population dynamics & social organisation studies), dedicated and opportunistic predation observations, remote biopsy sampling (for genetic, isotopic and fatty acid analysis to augment social organisation and foraging studies).
- To further an understanding of killer whale foraging ranges and movements related to resources on Marion Island, particularly in relation to nearby Crozet Island and the South African mainland.
- Use this knowledge to develop a broader study on sub-Antarctic killer whales (development to be undertaken by de Bruyn in 2013) that will potentially include satellite tracking of killer whales at Îsles Crozet, Macquarie Island and at sea in the Southern Ocean.
- To investigate the evidence for dietary specialisation of sub-Antarctic killer whales in the context of optimal foraging theory.

Since inception of the long-term project in April 2006, there have been:

- 6,800 hours of dedicated land based observation
- 20,000 images taken for photographic mark-resight
- 57 catalogued individual killer whales
- 25 biopsy samples collected from 21 individuals
- 15 killer whales tracked with satellite devices for longer than 24hrs
- 7 tracks lasting longer than 10 days
- 2 time-depth-recording (TDR) satellite trackers deployed.

Researchers are currently on Marion Island continuing this research and increasing the abovementioned totals.

During the period October to December 2013, Dr de Bruyn undertook a sabbatical at the Australian Antarctic Division to collaborate with IWC-SORP researchers in the Australian Marine Mammal Centre and others.

Project outputs

Papers

de Bruyn PJN, Tosh CA, Terauds A (2013) Killer whale ecotypes: is there a global model? Biological Reviews 88(1): 62-80. doi: 10.1111/j.1469-185X.2012.00239.x

Durban JW, Pitman RL (2011) Antarctic killer whales make rapid, round-trip movements to sub-tropical waters: evidence for physiological maintenance migrations? Biology Letters doi: 10.1098/rsbl.2011.0875

Gales N, Bowers M, Durban JW, Friedlaender AS, Nowacek DP, Pitman RL, Read AJ, Tyson RB (2013) Advances in non-lethal research on Antarctic minke whales: biotelemetry, photoidentification and biopsy sampling. Paper SC/65a/IA12 presented to the IWC Scientific Committee 2013.

Morin PA, Foote AD, Parsons MK, Archer FI, Robertson KM, Durban JW, Pitman RL, Ford JK, Barrett-Lennard LG, Ford M, Matkin C, Ellis GM, Peterson SD, Ferguson SH, Ávila-Arcos MC, Visser IN, Dalla Rosa L, Gilbert MTP, Wade PR (*Submitted*) Global radiation of an apex predator: Genomic insights into killer whale diversification. Molecular Ecology.

Moura AE, Janse van Rensburg C, Pilot M, Tehrani A, Best PB, Thornton M, Plön S, de Bruyn PJN, Worley KC, Gibbs RA, Dahlheim ME, Hoelzel AR (2014) Killer whale nuclear genome and mtDNA reveal widespread population bottleneck during the last glacial maximum. Molecular Biology and Evolution doi: 10.1093/molbev/msu058.

Pistorius PA, Meÿer MA, Reisinger RR, Kirkman SP (2012) Killer whale predation on subantarctic fur seals at Prince Edward Island, Southern Indian Ocean. Polar Biology 35(11): 1767-1772. doi: 10.1007/s00300-012-1216-1

Reisinger RR, de Bruyn PJN, Bester MN (2011) Predatory impact of killer whales on pinniped and penguin populations at the Subantarctic Prince Edward Islands: fact and fiction. *Journal of Zoology* 285(1): 1-10. doi: 10.1111/j.1469-7998.2011.00815.x

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Reisinger RR, de Bruyn PJN, Tosh CA, Oosthuizen WC, Mufanadzo NT, Bester MN (2011) Prey and seasonal abundance of killer whales at sub-Antarctic Marion Island. African Journal of Marine Science 33(1): 99-105. doi: 10.2989/1814232X.2011.572356

Popular articles

Pitman RL (ed.) (2011) Killer whale: the top, top predator. Whalewatcher (Journal of the American Cetacean Society) 40(1):1-67

Conference presentations

Durban JW, Pitman RL, Friedlaender AS, 2013. Out of Antarctica: Dive data support 'physiological maintenance migration' in Antarctic killer whales. Oral Presentation at the 2013 Biennial Conference on Marine Mammals, Dunedin, New Zealand.

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Durban JW, Pitman RL (2012) Antarctic killer whales make rapid, round-trip movements to subtropical waters: evidence for physiological maintenance migrations? Biology Letters 8 (2): 274-277.

Durban JW, Parsons KM, Claridge DE, Balcomb KC (2000) Quantifying dolphin occupancy patterns. Marine Mammal Science 16(4): 825-828.

Durban J, Ellifrit D, Dahlheim M, Waite J, Matkin C, Barrett-Lennard L, Ellis G, Pitman R, LeDuc R, Wade P (2010) Photographic mark-recapture analysis of clustered mammal-eating killer whales around the Aleutian Islands and Gulf of Alaska. Marine Biology 157(7): 1591-1604.

Fearnbach H, Durban J, Parsons K, Claridge D (2012) Photographic mark-recapture analysis of local dynamics within an open population of dolphins. Ecological Applications 22(5): 1689-1700.

Foote AD, Morin PA, Durban JW, Pitman RL, Wade P, Willerslev E, Gilbert MTP, da Fonseca RR. Positive selection on the killer whale mitogenome. Biology letters 7(1): 116-118.

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LeDuc RG, Robertson KM, Pitman RL (2008) Mitochondrial sequence divergence among Antarctic killer whale ecotypes is consistent with multiple species. Biology Letters 4(4): 426-429.

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Pitman RL (ed.) (2011). Killer whale: the top, top predator. Whalewatcher. Journal of the American Cetacean Society 40:1-67.

Pitman RL, Durban jw (2010) Killer whale predation on penguins in Antarctica. Polar Biology 33(11): 1589-1594.

Pitman RL, Durban JW (2012) Cooperative hunting behavior, prey selectivity and prey handling by pack ice killer whales (*Orcinus orca*), type B, in Antarctic Peninsula waters. Marine Mammal Science 28(1): 16-36.

Pitman RL, Perryman WL, LeRoi D, Eilers E (2007) A dwarf form of killer whale in Antarctica. Journal of Mammalogy 88(1): 43-48.

Pitman RL, Durban JW, Greenfelder M, Guinet C, Jorgensen M, Olson PA, Plana J, Tixier P, Towers JR (2011) Observations of a distinctive morphotype of killer whale (*Orcinus orca*), type D, from subantarctic waters. Polar Biology 34(2): 303-306.

ANNEX 3 - PROGRESS REPORTS ON THE IWC-SORP RESEARCH PROJECTS FOR 2013/14

IWC-SORP Project 3. Foraging ecology and predator-prey interactions between baleen whales and krill: a multi-scale comparative study across Antarctic regions

Dr. Ari S. Friedlaender[1]

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Introduction

Little is known regarding the ecological relationships between baleen whales and their prey, specifically in the Antarctic. Recent advances in tag technology and analytical methods allow for detailed understanding of the underwater movement and behaviour of cetaceans to quantify feeding behaviour at fine spatio-temporal scales. Linking these with concurrent measurements of krill provides a means for understanding how the distribution and abundance of prey affects the behaviour of baleen whales. As well, satellite-linked telemetry and time-depth recording tags can offer insights into the movement and behavioural patterns of cetaceans at broad spatio-temporal scales that are extremely valuable.

Around Antarctica, there are regional differences in oceanographic and sea ice conditions and prey abundance. Furthermore, there are differences in the types and abundance of baleen whales in these regions. Generating quantitative, repeatable methodologies for conducting ecological research on the foraging ecology of baleen whales is critical for understanding local predator-prey relationships and for being able to compare how these relationships are affected regionally.

Objectives

The main objectives of our research are to:

1) conduct ecological research on cetaceans around the Antarctic Peninsula and develop methodological tools that can be applied across Antarctic regions to better understand the short and long term movement patterns and behaviours of baleen whales in relation to prey and environmental variability; and

2) to apply tag and prey mapping technologies to further quantify the relationships between humpback and minke whales and krill.

Results

The results of our research program have been and are currently being published in the peer-review literature. A summary of many of our results can be found in SC/65a/O11, which provides the abstracts and significant figures for much of our published research to date. Further information can be found in Friedlaender *et al.* (2014, SC/65b/Forinfo), Gales *et al*. (2013, SC/65a/IA12), and Risch *et al.* (2014, SC/65b/Forinfo). Below are a list of some of the major accomplishments and findings since SC/65a:

From 29 December 2013-7 February 2014, Dr Ari Friedlaender and Ms Heather Foley participated in the National Science Foundation's Long Term Ecological Research cruise to the western side of the Antarctic Peninsula (www.pal.lternet.edu). During the cruise, visual sighting surveys were conducted while the ship transited between pre-determined sampling stations along the continental shelf waters. Biopsy samples and photo-ID images were also collected throughout the cruise. The survey data will be used in a long-term data base to determine how the distribution and abundance of cetaceans relates to environmental conditions within the LTER study area and how these change relative to changing ocean and sea ice conditions. Biopsy samples are collected to support a number of long-term research objectives. These include: determining the proportion of different breeding stocks represented within the LTER study region, understanding the population demographics of whales in the LTER study region by measuring sex ratios and pregnancy rates, and measuring stable isotopes to test for regional differences in feeding preferences. A total of 104 biopsy samples were collected: 101 humpback and 3 minke whale samples.

Based on satellite tags provided by the Australian Antarctic Division and deployed during the 2012/2013 Palmer LTER research cruise, the following results have been obtained: Humpback whales (*Megatptera novaeangliae)* are the most abundant baleen whale found in the nearshore waters around the Antarctic Peninsula. As a migratory animal, they must acquire enough energy during the summer months in the resource-rich feeding grounds around Antarctica to fuel their migrations to breeding and calving grounds in tropical waters in winter, where resource are limited.

Previous work has shown that the distribution and abundance of humpback whales is best predicted by that of Antarctic krill, the primary component of humpback whale diets in Antarctic waters. Since humpback whales are mobile predators with high energetic demands, it stands to reason that humpback whales will seek out areas with increased prey abundance, changing their distribution to reflect krill distribution changes throughout the feeding season. During summer months, krill are distributed broadly from nearshore to beyond the continental shelf. In autumn, krill are thought to move inshore and toward deep coastal waters in sheltered bays where they coalesce into large aggregations that will be covered by sea ice formation, minimizing predation risk from diving predators, including humpback whales. Given the known distribution of whales in summer months and the ultimate distribution of both whales and krill later in the feeding season, we hypothesized that the movement patterns and home ranges of humpback whales reflect concurrent changes in the distribution of Antarctic krill: home ranges of humpback whales will decrease in size during the austral summer and fall, and the overall distribution of humpback whales will move significantly closer to shore over this time period.

To evaluate these hypotheses, six whales were instrumented with Platform Transmitting Terminals (PTTs) during January of 2012. We applied a new product kernel method over the full date range of location data (1/3/2012 – 6/14/2012, 162 days). On every fifth day, we calculated the Utilization Density (UD) for each whale whose track existed on that date. The 95% isopleth was used as the extent for the home range. To explore the hypotheses that humpback whale home range area and distance to mainland both decrease during the summer and fall months we used linear mixed effects models to assess humpback home range area and distance from land. Both Julian date and month were used as predictors, and the PTT was used as a random effect to examine individual variation between whales. Home ranges were created for 75 specific days, with between one to five whales having tracks on each day used for the model. We found that distance to mainland was significant indicating that with each increase in month there was a corresponding decrease of 41.43 km in the distance to mainland. Home range area was not significantly different over time. This suggests that the whales may be following the krill closer to shore, but may not be reducing the total area in which they feed.

Our data support our hypothesis, and the figures below illustrate two measures of animal movement, minimum convex polygons and kernel home ranges (Curtice et al. 2014 submitted to *Movement Ecology* for publication in June 2014).

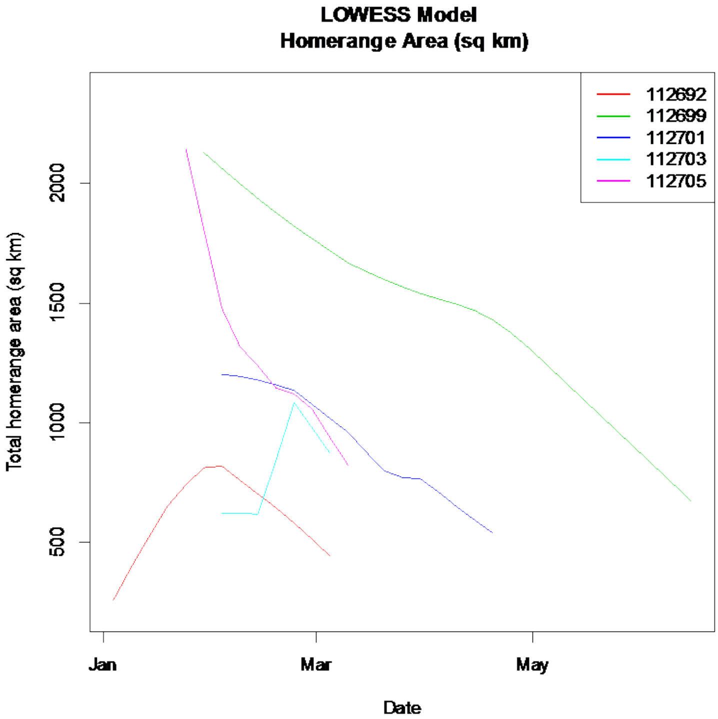

Figure 3 Smoothed home range area size plots for five humpback whales tagged along the Western Antarctic Peninsula in 2012. Three of the tags show decreases in home range area over time, while two tags (112692 and 112703) show initial increases, then decreases until transmissions cease on 8 March.

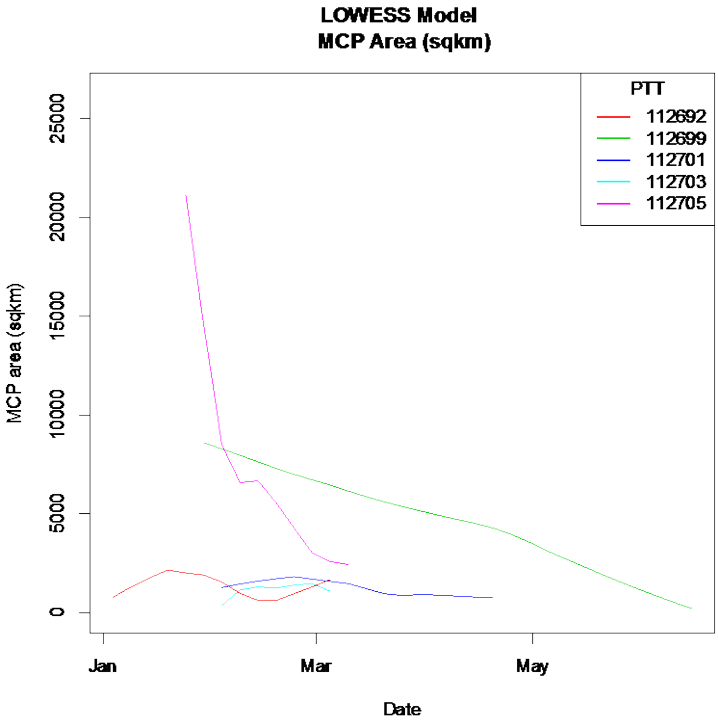

Figure 4: Smoothed Minimum Convex Polygon (MCP) area size plots for five humpback whales tagged along the Western Antarctic Peninsula in 2012. Two of the tags show decreases in (MCP) area over time (112699, 112705), while three tags (112692, 112701, 112703) show more variation.

Table 1: Mixed-effects model to predict changes in HR (home range) area and MCP (minimum convex polygon) Area for humpback whales as a function of time and distance to shore. The significant model to predict decreases in HR area includes month and distance to shore, while decreases in MCP area are best fit with a model including month.

Model	Fixed Effects	Random Effects	Random Slope	AIC	Intercept	Value	Stnd Error	Chi^2	Degrees of Freedom	P-value compared to Null model
HR Area	Month	PTT	Month|PTT	1092	1566.15	-215.7	36.79	7.68	1	0.00558
	Month + Dist Shore	PTT	Month|PTT	1091	1405	-214.9 2.687	38.266 1.361	11.277	2	0.003558
	Julian Date	PTT	Julian Date/PTT	1094	1404.88	-5.849	1.316	2.268	1	0.132
	Julian Date + Dist Shore	PTT	Julian Date/PTT	1090	1239	-6.544 3.412	1.222 1.310	11.277	2	0.0176
MCP Area	Month	PTT	Month|PTT	1452	7850	-1686	417	4.662	1	0.03084
	Month + Dist Shore	PTT	Month|PTT	1452	6705.21	-1678.64 19.18	446.04 16.00	6.03	2	0.049
	Julian Date	PTT	Julian Date/PTT	1454	6353	-42.12	14.46	2.9554	1	0.08559
	Julian Date + Dist Shore	PTT	Julian Date/PTT	1454	5067.9	-43.85 24.09	14.17 15.46	5.2193	2	0.074

The Palmer Long-Term Ecological Research program

In March 2014, Dr. Friedlaender was invited to join the Palmer Long-Term Ecological Research group in the renewal of their National Science Foundation sponsored research. Dr. Friedlaender will join the Palmer LTER as a Co-Investigator and lead a cetacean component with support for 6 years. Below is an exurb from the proposal explaining the cetacean research that will be part of the upcoming LTER program.

Top-down controls and shifting baselines

Motivation. This research theme encapsulates two constructs: one is empirical evidence that humpback whales are regaining their former ecological role in the WAP following near-extirpation due to commercial whaling; the other is the long-standing but controversial hypothesis that changes in whale abundance regulate the demography of other top predators, such as penguins, through top-down competitive interactions for shared prey resources such as krill. PAL is uniquely positioned to investigate these dynamics using its regional sampling grid, which is coherent spatially and temporally with populations of whales and penguins. A long term approach is necessary to study these long-lived species.

Background. This research theme represents a new research initiative and the addition of a new research component to PAL. This initiative is proposed because of our own recognition of its scientific importance and in response to comments in proposal and midterm reviews expressing concern that we were neglecting a major ecosystem component and a major source of krill mortality. We invited cetacean scientists to participate in our last three annual cruises to determine if our current cruise design could accommodate cetacean research. Dr. Ari Friedlaender was a member of the cetacean ecology group at the Duke University Marine Laboratory for the past 7 years and recently moved to Oregon State University. He will continue to collaborate with colleagues at Duke. Addition of the OSU/Duke group gives PAL unprecedented coverage of the Antarctic marine ecosystem, from the smallest to largest organisms on the planet.

Another rationale for adding a cetacean component was the recent reemergence (Trivelpiece et al. 2011) of a long-standing debate regarding the roles of whales in regulating the demography of other top predators, such as penguins and seals. In this context, two main hypotheses have been proposed. The first hypothesis draws on top-down processes, in which changes in whale abundance directly regulate population trends of other predators through competition for krill (Laws 1977). The second focuses on bottom-up processes, in which climate-induced changes in sea ice dynamics mediate a host of biophysical interactions that affect predator populations, including, but not limited to, the extent to which whales may affect the demography of other krill-dependent predators (Fraser submitted, Fraser et al. 1992). These hypotheses are not mutually exclusive, but the contrast between bottom-up and top-down perspectives provides a rich ecological backdrop for understanding the response of these ecosystem components to climate change, recovery of depleted predator populations, and other processes with profound consequences to society. Indeed, it is these different perspectives on the role of whales in ecosystem dynamics that guide the hypotheses and objectives expressed in this research theme. Adélie penguins have been the focal top predator in our program since its inception, but during the last decade we have added gentoo and chinstrap penguins in response to their increasing regional populations (Fig. 1D). These species exhibit different affinities to sea ice (Adélies are ice-obligate, gentoos and chinstraps are ice-intolerant), so they are an ideal guild with which to test hypotheses of WAP ecosystem dynamics within the context of bottom-up forcing (Fraser et al. 1992). We now propose to add humpback whales to our observational network. In the 20th century, over 200,000 humpback whales were killed in the Southern Ocean, most of which were taken from the nearshore waters of the Antarctic Peninsula (Burnett 2012, Hart 2006). Humpback whales are now repopulating their former range in the WAP (Friedlaender et al. 2006, Johnston et al. 2012, Nowacek et al. 2011) in the same areas that are inhabited by our three focal penguin species (Cimino et al. 2013).

Top-down processes are posited to have operated through competitive release, in which the massive removal of baleen whales from the Southern Ocean created a “krill surplus” that was subsequently taken up by other consumers such as seals, penguins and other seabirds (Laws 1977). This theoretical framework is still being advanced, but now “in reverse.” Thus, it is hypothesized that whale populations have increased to the point that they are once again competing directly with penguins and thus depressing their populations (Trivelpiece et al. 2011). However, as Fraser et al. (1992) noted in their first rebuttal to this theoretical framework, its application is challenged by inconsistencies within and between regions and species. Thus, while chinstrap and Adélie penguin populations are decreasing in the northern WAP, they are increasing in the southern WAP, and gentoos are increasing throughout the WAP, even in northern sectors where they are sympatric with decreasing chinstraps and Adélies.

These inconsistencies are relevant to our proposed research for three reasons. First, krill are the major component of the diets of all three species of penguins throughout the WAP (Williams 1995). Second, there is no evidence to suggest that the intensity of whale predation along the WAP varies regionally. Instead, the movements of baleen whales, such as humpbacks, reflect the seasonal distribution of krill over the entire WAP shelf (Friedlaender et al. 2006, Johnston et al. 2012, Nowacek et al. 2011). Indeed, our pilot study of humpback whale movements using satellite telemetry suggests that these animals can cover hundreds of km/week, and individuals observed feeding in the southern WAP one day can be found feeding in the northern WAP 7 days later. Finally, the WAP continues to undergo significant and rapid warming (Vaughan et al. 2003), faster than any other region on Earth, resulting in a north to south shift in ecosystem properties such that the original cold, polar marine environment is being replaced by a warmer, sub-polar system. This shift in system function is apparent at every level, from the formation of winter water and the duration of the sea ice season to the changing composition of its phytoplankton, prey and top predator communities (See above, Results/Prior). Thus, while the ecological reoccupation of the WAP by humpback whales is not regionalized, changes in the marine environment do exhibit strong regional characteristics. How such shifting baselines affect our understanding of how ecosystems work is emerging as one of the most important scientific issues of our time (Ainley & Pauly 2013, Pauly 1995, Pauly et al. 1998, Schrope 2006).

Our new component brings to our program some of the most comprehensive data available on the ecology of baleen whales in the WAP. For humpback whales in particular, we already have a preliminary understanding of their patterns of regional distribution and abundance (Friedlaender et al. 2006, Johnston et al. 2012, Nowacek et al. 2011), fine-scale foraging behavior (Friedlaender et al. 2014, Ware et al. 2011), and seasonal migration patterns beyond the WAP (Dalla Rosa et al. 2008, Friedlaender et al. in preparation). With these data we have begun to explore niche theory in the context of not only understanding if and how whales may actually compete for krill with penguins, an assertion that has never been demonstrated, but also as a necessary first step to help us integrate and guide our proposed research. An important preliminary finding is that although the niche of foraging humpback whales appears to be defined primarily by krill, the niches of Adélie penguins are linked more to their physical environment (land and sea ice) and secondarily to krill (Friedlaender et al. 2011), likely as a result of fundamental differences in evolved life history strategies. Humpback whales are unconstrained by reliance on a solid platform for rest or reproduction and move considerable distances within a feeding season to respond to local changes in krill abundance. In contrast, Adélie penguins are central place foragers and, therefore, their movements are constrained due to parental duties during summer, or available daylight during winter (Erdmann et al. 2011, Fraser & Hofmann 2003). The implication that whales track krill directly while penguins track habitat features that provide predictable access to krill (a focal question addressed during our last funding period, see above) provides a basic framework for using niche and competition theory to explore how top-down versus bottom-up forcing may structure top predator communities in the WAP.

Proposed Research. Our fundamental objective is to investigate how our focal predator guild (humpback whales, Adélie, gentoo and chinstrap penguins) partitions the marine environment in space and time. We envision a sampling program that will capitalize on proven methodologies and permit us to compare movement and distribution patterns and foraging ecology; and allow us to monitor demographic parameters in our penguin study populations that may be sensitive to competition from whales (e.g., foraging trip durations, which may affect chick growth and survival; Fraser and Hofmann 2003). No breeding populations of krill-dependent pinnipeds exist near Palmer Station and, because the logistical constraints of working with sparsely distributed ice-obligate species, we have chosen not to include pinnipeds in our research program.

Cetacean Research, Broad-Scale (Cruise-based). We will establish a research program on the demography, habitat use, and ecological role of humpback whales using a combination of proven methodologies, including visual line transect surveys, biopsy sampling and satellite-linked tag deployments, when the ship occupies the LTER survey grid each January. We will use conventional distance sampling methods (Barlow 2006) and model-based approaches (Hedley & Buckland 2004, Katsanevakis 2007) to estimate the density of humpback whales each year within the PAL region (Fig 3B) (Johnston et al. 2012, Thomas et al. 2010). We will augment these methods with photographic and genetic capture-recapture techniques and independently estimate density from our satellite telemetry deployments as in Whitehead and Jonsen (2013). Over time, we will develop a time-series of density surfaces that will allow us to compare humpback whale distribution to the suite of ecological parameters measured during the cruises and to examine annual overlap with the observed foraging ranges of penguins within the region. We will test how interannual changes in the environment (e.g. sea ice cover) affect whales in a spatio-temporal framework using the methods initially developed by Friedlaender et al. (2006, 2011). We hypothesize that the density of humpback whales within the LTER study region will increase over the study period but that the relationship between the distribution of whales and the physical environmental parameters that provide the greatest access to krill will remain constant over this period, as whales track intra- and inter-annual variation in the distribution of their prey.

We will collect skin and blubber samples from whales each year using conventional remote biopsy sampling techniques. We will use these samples to determine the sex of individual whales, estimate pregnancy rates, and confirm that their diet is comprised entirely of krill. Over time, this information will provide a baseline for the population of humpback whales around the Western Antarctic Peninsula as it recovers from commercial whaling.

We will also deploy satellite-linked ARGOS tags (Gales et al. 2009) each year to document seasonal movement patterns and quantify foraging ranges. We will compare the movement patterns of these whales to the foraging ranges of similarly instrumented penguins. Our recent tagging efforts have shown that humpback whales feed widely throughout the PAL study region during summer but that whales become more concentrated in nearshore waters in fall and early winter (Curtice et al. 2014). We will conduct state-space movement analyses (Breed et al. 2009) and develop utilization distributions of tagged animals in three dimensions (x, y, and t – see Keating and Cherry 2009) to determine the location of preferred feeding areas and determine the extent to which these preferred areas overlap with process study sites in deep canyons (Fig. 3B). Importantly, we will also determine to what extent these preferred feeding areas overlap in space and time with the foraging areas of Adélie and other penguins. During the critical chick-rearing period for penguins, we hypothesize that the spatio-temporal overlap between foraging ranges of humpback whales and penguins will decrease from north to south. This is

likely due to a combination of the amount and persistence of sea ice from the previous winter, the timing of migration and return to feeding grounds by whales, and the relative abundance of krill in these areas.
Fine-scale (Palmer Station-based). The unique PAL data on Adélie and gentoo penguin population trends and foraging ecology provide an opportunity to test ecological hypotheses regarding top-down versus bottom-up control within this system. Explicitly, we will test the hypothesis that the relative abundance of humpback whales within the foraging areas of penguins around Palmer Station will impact Adélie penguin foraging performance, while having no effect on gentoo penguins. Inherent in this hypothesis is the assumption that krill is a limiting resource (Milne 1961). It will be difficult to determine whether or not total krill abundance is limiting, but we can look for changes in the distribution, behavior, and breeding success of penguins as proxies for prey availability within their foraging areas (Fraser & Hofmann 2003). Friedlaender et al. (2011) established that the distribution of humpback whales is closely linked with that of Antarctic krill, but the distribution of Adélie penguins is tightly coupled with physical structures (land and sea ice) that offer habitat for nesting and resting. Antarctic minke and humpback whales offer an example of how closely related, sympatric species partition resources to avoid competition (Friedlaender et al. 2009). On the contrary, however, preliminary evidence suggests that when the relative abundance of humpback whales increases near an Adélie penguin foraging area, the foraging effort of the penguins also increases (Friedlaender et al. 2008). Several factors relate to niche overlap between krill predators (Fraser et al. 1992), but there is evidence which supports the notion that the presence of baleen whales can affect the foraging behavior and reproductive success of penguins (Ainley et al. 2009, Ainley et al. 2006).

Thus, we will test the top-down hypothesis that the presence of foraging humpback whales negatively affects the demography of Adélie penguins due to competition for prey, while Gentoo penguins and whales partition prey resources and therefore do not compete. We will establish a long-term whale study at Palmer Station concurrent with the established long-term penguin research program. We will conduct visual line transect surveys from Zodiacs to determine the density and fine-scale distribution of humpback whales in the study area (as discussed above) and augment these surveys with capture-recapture estimates of seasonal abundance. We will compare these metrics of whale density and abundance with foraging trip duration (FTD) for both Adélie and gentoo penguins as determined by existing field methods (cf. Fraser and Hofmann 2003). FTD is a known proxy for foraging effort and can have significant impacts on key aspects of their ecology, such as breeding success and fledging weight, which are key determinants of survival, recruitment and population growth (Chapman et al. 2010, Chapman et al. 2011). We will also deploy multi-sensor suction cup tags (Johnson & Tyack 2003) on humpback whales to collect information on the location, timing, depth, and frequency of feeding events (Friedlaender et al. 2014, Goldbogen et al. 2013, Goldbogen et al. 2012, Ware et al. 2011). Thus, we will determine the feeding behavior of whales spatially (locations of feeding relative to penguin feeding grounds), vertically (depth of feeding in the water column relative to the depth of penguin foraging dives), and temporally (when during day/night whales and penguins forage). Finally, we will conduct acoustic krill surveys using scientific echosounders mounted on Zodiacs (Friedlaender et al. in review-b) (Nowacek et al. 2011) to compare prey patch metrics (e.g. depth, density, size and biomass) targeted by penguins and whales. We have used these methods successfully to determine characteristics of prey patches targeted by whales (Hazen et al. 2009); these observations will allow us to compare how penguins and whales target prey patches to either partition or compete for resources.

Challenges

Challenges still remain in terms of being able to have dedicated vessel time and tags available for work with minke whales around the Antarctic Peninsula and Ross Sea. The other challenges that we face are the support for replicating our research model in other regions due to ship time and financial support from other countries. We have offered as much of our equipment as possible for collaborators to use if dedicated ship time and effort can be allocated.

Outlook for the future

We will continue to submit research proposals to the US NSF to conduct ecological research around the Antarctic Peninsula, with a focus on minke whales and better understanding their ecological role. This would include dedicated ship time to deploy both multi-sensor suction cup and satellite-linked depth recording tags and conduct prey surveys. We will also facilitate similar research with other National Antarctic research programs in other areas of Antarctica (e.g. East Antarctica, Weddell Sea), and will provide as much in-kind support for these efforts as possible and will help develop collaborative research proposals as the opportunities arise. Our goal is to have successfully completed similar ecological research on baleen whales in at least two other Antarctic regions within the 5-year span of our research proposal. The opportunity to be included in the LTER program described above is also an exciting opportunity for the next 6 years.

Project outputs

Papers

Espinase B, Zhou M, Zhu Y, Hazen E, Friedlaender AS, Nowacek DP, Chu D, Carlotti F (2012) Austral fall transition of mesozooplankton assemblages and krill aggregations in an embayment west of the Antarctic Peninsula. Marine Ecology Progress Series. doi:10.3354/meps/09626

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Conference presentations

Curtice C, Friedlaender A, Johnston D, Halpin PN, Gales N, Ducklow H (2013) Spatially and temporally dynamic humpback feeding areas in Antarctica. Oral presentation at the Symposium on Animal

Movement and the Environment, 5–7 May 2014 North Carolina Museum of Natural Sciences in Raleigh, North Carolina.

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Media

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ANNEX 4 - PROGRESS REPORTS ON THE IWC-SORP RESEARCH PROJECTS FOR 2013/14

IWC-SORP Project 4. What is the distribution and extent of mixing of Southern Hemisphere humpback whale populations around Antarctica? Phase 1: East Australia and Oceania

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Introduction

Our understanding of the migratory routes and the summer distribution of humpback whale populations around Antarctica is based on information provided by Discovery tags, photo-identification, individual genotyping and satellite tagging. Generally these data are sparse and therefore patterns of distribution and mixing have not been described well for most of the seven populations.

An improved understanding of the movements and mixing of humpback whales around Antarctica is a priority for the IWC because such information is integral to the Recovery/Stock Assessments, a prerequisite of which is the allocation of catches to particular breeding populations. An improved understanding of the migratory and feeding behaviour of humpback whales would allow the more appropriate allocation of catches made in this region which would improve the accuracy of recovery assessments and estimates of pre-whaling population sizes.

The IWC population assessment process would benefit from a greater understanding of the distribution and mixing of all SH humpback whale populations but priority should now be given to Antarctic Areas V and VI where the complex E (Australia and western Oceania) and F (eastern Oceania and French Polynesia) endangered populations feed. Although this project proposal focuses on these priority areas, coordinated research efforts in other regions would be highly desirable and in time should be developed.

With the success of the genotype and photo-ID matching between Antarctic Whale Expedition (Gales 2010; Constantine *et al.*, 2014) we propose to focus our efforts on using satellite telemetry to understand the connections between Oceania breeding grounds and feeding grounds (Garrigue *et al*. 2010; Gales *et al*. 2009, SC61/SH/17; Hauser *et al*. 2010). Reports from the Raoul Island (part of the Kermadec Island group) show October has a high density of whales passing nearby. Raoul Island is also the southernmost location with a high density of whales travelling south to Antarctica. American Samoa is an interesting area as it sits on the cusp of breeding stocks E3 and F and the whales travel east and west of this area (Garrigue *et al*. 2011b). For these reasons we propose Raoul Island and American Samoa as tentative locations for satellite tagging in 2015.

Objectives

The two main questions are:

1. What is the connection between the humpback whales from Area V feeding grounds and their migratory corridors and breeding grounds in Australia and Oceania?

2. Do whales from Area V represent a single breeding ground or are they a mix of individuals from several distinct breeding grounds?

Results and Conclusions

New Zealand genetic analyses:

Final analysis of humpback whale tissue samples primarily from the New Zealand northern migratory corridor have been presented in Steel *et al.* (2014). In summary, between 1998 and 2013, a total of 211 humpback whale samples were collected from New Zealand from two sources; biopsy samples of whales on their northbound migration past Cook Strait (n = 193) and from stranded specimens (n = 18). Of the 211 samples, 167 unique individuals were identified: 164 whales sampled one or more times within the same year and three sampled at least once in two or more years. Six whales were genetically matched to New Caledonia, five to east Australia and none to any other Oceania breeding ground. Humpback whales passing New Zealand show the least genetic difference to New Caledonia. However, they do not appear to show the same fidelity to the migratory corridor as they do to the breeding grounds, with low rates of between-year resights possible indicating variability in their use of migratory corridors.

American Samoa and Independent Samoa genetic analyses:

Final analysis of humpback whale tissue samples from American Samoa and Independent Samoa have been presented by Robbins *et al.* (2014). In summary, between 2001 and 2012 a total of 131 samples representing 117 unique individual humpback whales (n=9 from Independent Samoa and n=122 from American Samoa) were collected via biopsy sampling. Comparison of the American Samoa-Samoa samples to 96 individual profiles from four Oceania breeding grounds revealed matches to all four regions; one to New Caledonia; 11 to French Polynesia; two to the Cook Islands; four to Tonga and one that was seen in American Samoa, the Cook Islands and Tonga. Whales from American Samoa and Samoa are genetically most similar to French Polynesia, a breeding ground, and the Cook Islands, a migratory corridor. Further investigation of photo-identification matches may reveal patterns to the movements of whales that build on past research in the region (e.g. Garrigue *et al*. 2011).

Antarctic Humpback Fluke Identification Matching:

Photographs of the underside of humpback whale flukes were taken during the 2013 IWC-SORP Antarctic Blue Whale Voyage. There were a total of 110 fluke images used for the data analysis. Of these, 20 individual whales were identified with all whales seen only on a single survey date. These images were matched to the 61 individual whales identified during the 2010 IWC-SORP Antarctic Whale Expedition and CETA voyage (Gales 2010; Garrigue *et al.* 2010; Constantine *et al*. 2014) but yielded no matches. The best image of all individuals identified during the AWE/CETA and the 2013 Antarctic Blue Whale Voyage have now been compiled into a Flukematcher database and the 2013 images will be provided to the Antarctic Humpback Whale Catalogue curated by the College of the Atlantic and made available for matching to other catalogues via the IWC-SORP Secretariat.

Challenges

We continue to have issues with tag design that have delayed the onset of the planned tagging programme. The final year of testing will happen this year and we hope this will result in a more reliable tag; improvements are looking promising (Jooke Robbins and Alex Zerbini are contributing to this work). Funding remains an issue but grants are being pursued to further the research which has now been delayed until 2015.

Outlook for the future

Funding for this research is still required and the Principal Investigators have requested funding from the New Zealand Government which looks very promising as part of the NZ commitment to marine protection in the Ross Sea region. Another funding application will be made in the next financial year but the ongoing support from IWC-SORP member states is appreciated.

Project outputs

Papers

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ANNEX 5 - PROGRESS REPORTS ON THE IWC-SORP RESEARCH PROJECTS FOR 2013/14

IWC-SORP Project 5. Acoustic trends in abundance, distribution, and seasonal presence of Antarctic blue whales and fin whales in the Southern Ocean

The IWC-SORP acoustic trends steering group Flore Samaran[1], Kathleen Stafford [2](Project Coordinators), Ken Findlay[3], Jason Gedamke [4], Danielle Harris [5] , Brian Miller [6]and Ilse Van Opzeeland [7]

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Introduction

The Southern Ocean Research Partnership (IWC-SORP) is an international collaborative initiative that started in 2009 in order to develop novel research techniques and conduct non-lethal research on whales in the Southern Ocean. One of the original five research projects of the IWC-SORP is the *Blue and Fin Whale Acoustic Trends Project,* which aims to implement **a long term acoustic research program that will examine trends in Southern Ocean blue and fin whale population growth, distribution, and seasonal presence through the use of passive acoustic monitoring techniques.**

Sighting surveys are traditionally the means by which cetacean population abundance estimates are obtained. In the Southern Ocean however, such surveys are rarely conducted due to the particularly difficult working environment and the costs of surveys, and are also restricted by the inherent limitations of visual surveys (e.g. daylight, weather, sea ice, visual detection range, etc.; Thomas *et al*. 1986, Leaper and Scheidat 1998). The acoustic techniques proposed here, however, overcome many of these difficulties with data that are relatively inexpensive to obtain, that can be collected continuously both for years on end and under ice cover, and are independent of weather conditions or sea-states. However, obtaining accurate and precise absolute abundance estimates from passive acoustic data is challenging. So far, a suite of statistical methods have been developed (Thomas and Marques 2012, Marques *et al.* 2013) but absolute abundance estimation from passive acoustic data relies strongly on detailed knowledge about the vocal behaviour of the study species. For most cetacean species, including blue and fin whales, vocal behaviour is relatively poorly understood and so accurate and precise absolute abundance estimates from passive acoustic data are currently unobtainable. This highlights the need for further behavioral studies to complement passive acoustic monitoring efforts. However, in the absence of appropriate behavioral information, acoustic datasets can be consistently analysed to provide comparable measures of calls densities, which, under certain assumptions, may be interpreted as measures of relative abundance. Comparisons of relative abundance estimates from individual locations across many years, whether collected by visual surveys (Noad *et al.* 2008) or acoustic surveys as proposed here (*e.g.* Stafford *et al.* 2009), can provide an indication of population development. Comparison of relative abundance estimates within and between locations and years can further be used to assess trends in spatio-temporal distribution over time (Širovic *et al.* 2004, Stafford *et al.* 2009).

In 2011/2012, after the preliminary analysis of all the available acoustic data showing the geographic and seasonal occurrence of blue and fin whales around the Antarctic, the ATW Group concluded that a coordinated effort to collect new acoustic data using consistent spatial and temporal coverage, instruments and analysis methods, would be the best way forward. After a very productive meeting of the ATW Group in fall 2012 and to best exploit passive acoustic methods for monitoring purposes in the future, we proposed the placement and maintenance of a circumpolar Antarctic monitoring system (SOHN Southern Ocean Hydrophone Network) with at least one hydrophone in each of the six IWC management areas. Further, recommendations for analytical methods and instrument choice as well as hardware configurations are being made available to promote collaboration for the coordinated deployment of the hydrophone network and analyses of the passive acoustic data. In 2013/2014, we decided to prioritize writing these documents: the first being the **whitepaper** providing recommendations on instruments and settings suitable to record the focal species, with further information on moorings and logistics for prospective collaboration (technical report) and the second being the **blueprint –**

providing a summary of data analysis methodologies. The ATW Group met again in fall of 2013 to review ongoing student work providing part of the basis for the blueprint paper and to discuss drafts of both papers, as well as the poster that the group presented at the 20th Biennial Conference of the Biology of Marine Mammals in Dunedin, New Zealand (9-13 December 2013).

Objectives

Passive acoustic monitoring is a robust means of monitoring blue and fin whales in remote areas, such as the Southern Ocean, over long time periods. The analysis of data sets that are available to date has shown the geographic and seasonal occurrence of blue and fin whales around the Antarctic (SC/64/O13). However, the spatial and temporal lack of overlap in monitoring, and the differences between instruments and analysis methods used, underlines the need for coordinated efforts when using passive acoustic data to monitor trends in abundance. To best exploit passive acoustic data in the long term, the placement and maintenance of a circumpolar Antarctic monitoring system has been proposed (SC/65/O11). The ATW Group is currently focusing on the publication of the **whitepaper** providing recommendations on instruments and settings suitable to record the focal species, with further information on moorings and logistics for prospective collaboration (technical report). Furthermore, a further document, the **blueprint,** will provide a summary of data analysis methodologies and is planned to be submitted for publication by the end of 2014. In the present report, the current status of the network of hydrophones including the moorings of Germany, Australia and South Africa will be presented as prospective collaborators for the SOHN.

Results

a. Notes on the whitepaper (see also Van Opzeeland *et al.* SC/65b/Forinfo)

Due to the high-cost of Antarctic research as well as the broad-spatial and temporal scales over which the Southern Ocean Hydrophone Network (SOHN) will span, international collaboration and coordination are imperative to achieve the project goals. To facilitate international participation in the SOHN, the white paper provides practical recommendations to increase the efficiency of passive acoustic data collection in Antarctic waters. We first outline the requirements of SOHN Acoustic Recorders (AR), and then discuss the potential for integration with oceanographic data collection efforts as well as the potential for servicing of SOHN stations from ships of opportunity. Finally we discuss the benefits and limitations of different types of moorings, acoustic recorders, and recovery aids as well protocols for servicing of SOHN stations.

In addition to providing recommendations that may reduce the cost of data collection, we also provide recommendations regarding standardization of recording locations, devices, and metadata. Standardization of data collection is paramount for accurate and efficient analysis and interpretation of SOHN data, and will facilitate future comparisons with this baseline data set. By introducing efficient and standardized data collection methods we aim to increase participation by partner nations and organizations in the SOHN and Acoustic Trends Projects.

With this whitepaper, we aim to encourage and guide nations participating in the SOHN project with a set of recommendations to standardize the data that will be collected. We discuss deployment and recovery options for ARs, and investigate tradeoffs among different hardware, software, and mooring systems that comprise available ARs. We then provide recommendations regarding recording locations, hardware, and specifications (e.g., sample rate, duty cycling recordings), as well as recommendations with respect to data formats, calibration, and metadata required by the project. Finally, we propose that the data acquired by the SOHN ARs are archived in a central data base, allowing integrative processing of the circumpolar Antarctic data.

As emphasized in previous sections, it is paramount that recording efforts are coordinated both spatially and in time, but also ideally with respect to the type of recording equipment that is used, how ARs are programmed (e.g., sample rate, duty cycle) and the type of acoustic data analyses that are used to extract the relevant information. Provided that a proper funding source can be identified, the ATW aims to create and stock a “library” of calibrated instruments that could be checked out by participating partners for deployments either in an extant mooring or as a stand-alone instrument.

The main items listed of this paper are: Timeframe, Spatial coverage (see Figure 1), Logistical issues, Standardization, Deployment and recovery considerations, Moorings (see Figure 2), Instrument preparation predeployment, Data and metadata storage, Review of ARs for deployments in the Southern Ocean, Archival and management of the SOHN data base.

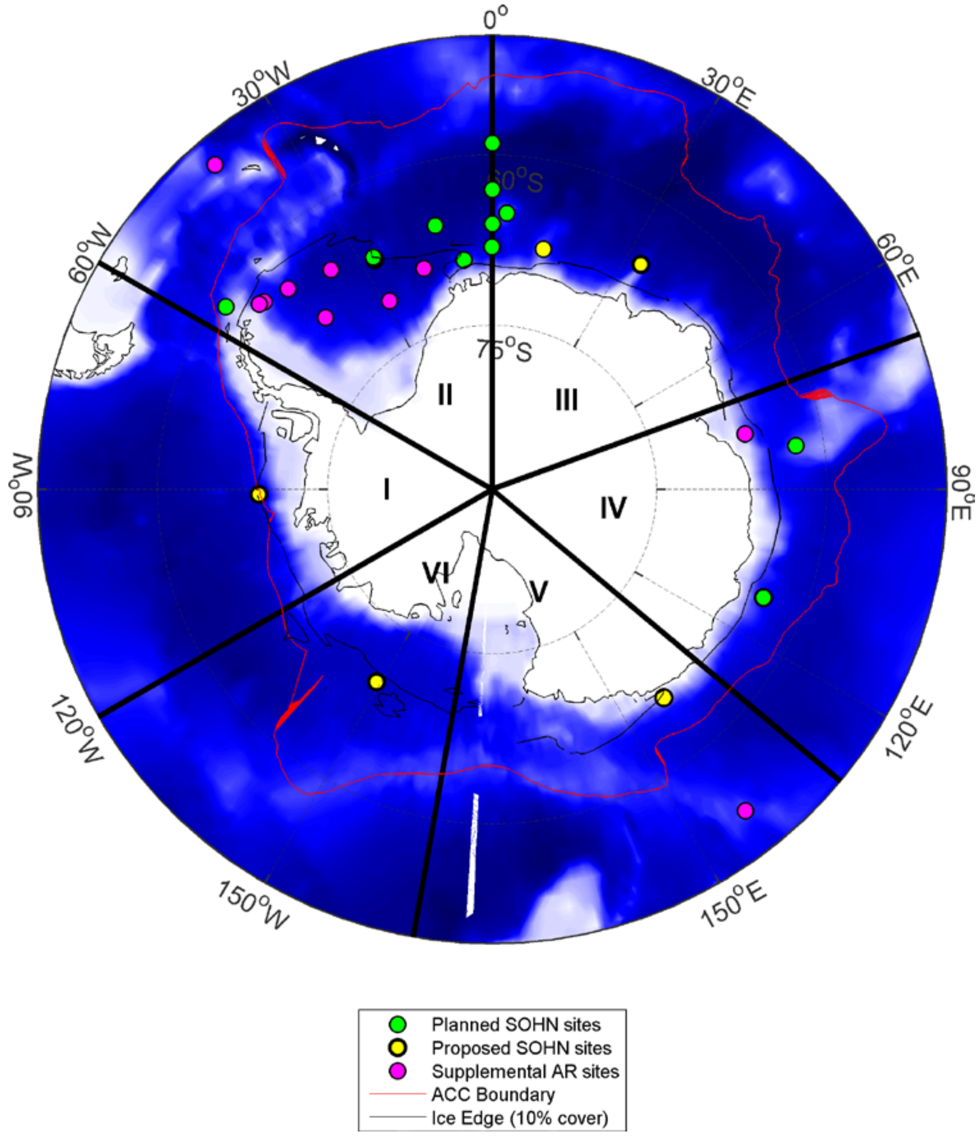

Figure 1: Locations of current recording sites that may be used as part of SOHN (green circles), proposed SOHN recording sites (yellow circles) and supplemental site (pink circles). Thick black lines indicate IWC management areas I-VI. Contours indicate 300 m (light blue), 3000 m (light purple) and 6000 m (dark purple). The red line shows the northern boundary of the Antarctic Circumpolar Convergence (Sokolov & Rintoul 2009). The thin black line is indicative of the edge of the sea ice and corresponds to the monthly average sea-ice cover of 10% in February from 2000-2012 (Maslanik & Stroeve 1999).

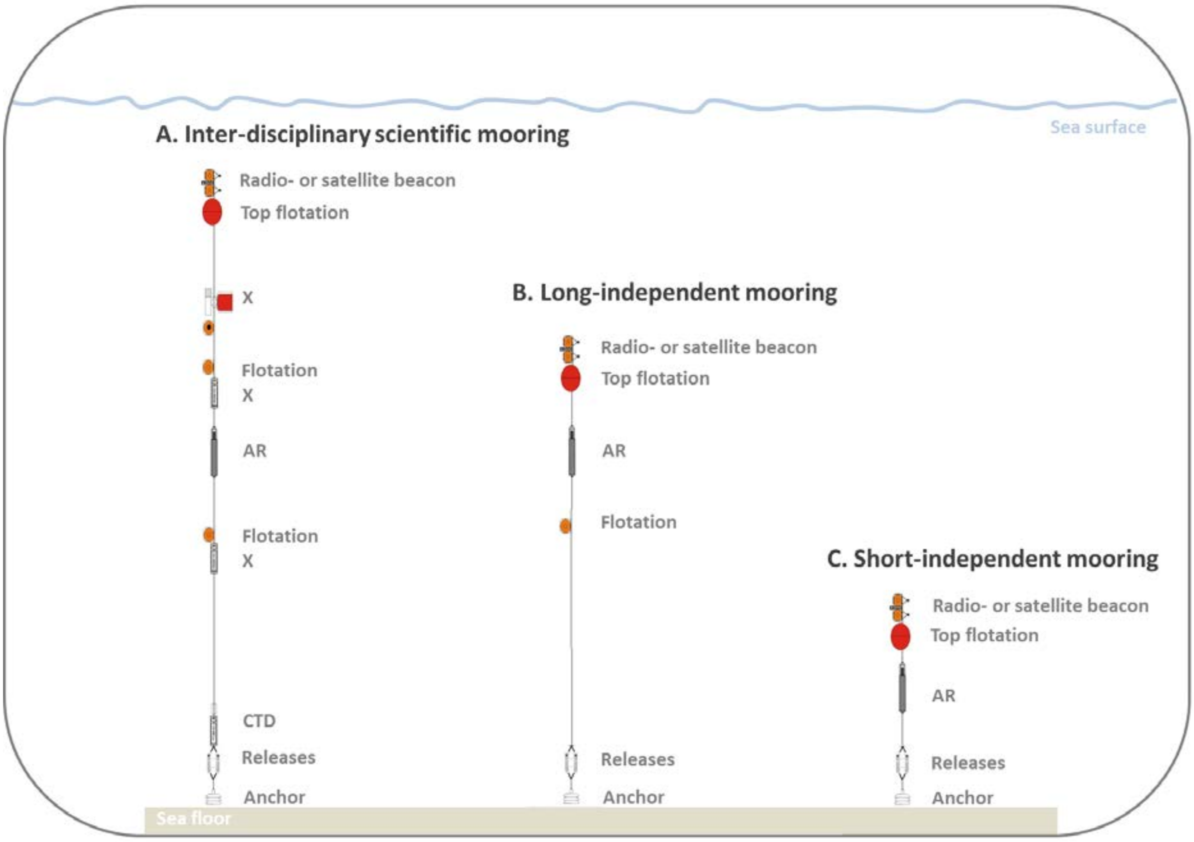

Figure 2: Exemplary mooring set-up for ARs in A) interdisciplinary moorings, B) long-independent moorings, and C) short-independent moorings. X indicates other scientific measurement instruments (e.g., ADCP, current meter, sediment traps). Note that depicted mooring length is not to scale, e.g. short independent moorings may be only 20 – 30 m off the sea floor, whereas long and inter-disciplinary moorings can be 10 or more times as long, depending on their set up and location**.**

b. Notes on the blueprint paper draft (manuscript in preparation)

- **Effects of sub-sampling intervals (case studies on different data collection methods)**

Passive acoustic monitoring is an important tool in marine mammal research, especially in remote areas such as the Southern Ocean. In many cases, logistic and financial constraints to ship time are determining factors for the frequency at which recorders are serviced in high latitude areas, often resulting in time spans of two to three years between recorder deployment and retrieval. However, to date, the majorities of autonomous recording instruments are not equipped with sufficient capacity in terms of battery life and/or data storage to record continuously during the entire deployment period of the device and hence require recordings to be collected according to a certain duty cycle. Here we presented the main results of two studies investigating the effect of various duty cycles on the detection probability of baleen whale calls that were undertaken in 2013:

1) The first case study was undertaken at AWI and was designed to test experimentally if and how sub-sampling of different continuous data sets containing baleen whale vocalizations (i.e., Antarctic blue whales and Northern Right whales, *Eubalaena glacialis*) affects the accuracy with which acoustic presence and hourly call rates can be assessed. These data were presented at the 2013 Biennial Conference on the Biology of Marine Mammals in Dunedin, New Zealand and are being refined as a peer-reviewed manuscript.

Methods: To explore the effects of different duty cycles on baleen whale hourly call counts and acoustic presence, five different passive acoustic data sets were selected and analyzed manually or automatically (using XBat) for vocalizations of the focal species on at least a one minute basis. Each data set exhibited different patterns in the temporal distribution of baleen whale calls comprising i) irregular vocal activity, ii) vocalizations organized in regular song sequences and iii) vocal activity with a diel pattern. Different duty cycles were simulated by choosing different sampling intervals 1 h, 2 h, 3 h, 4 h, 6h, 8h and varying sampling durations.

Results: Both the precision to correctly assess the acoustic presence of baleen whales and the estimation of actual hourly call rates were negatively impacted by decreasing duty cycles. Within same duty cycles, prolonged sampling intervals resulted in increased accuracy of acoustic presence assessments while no marked effect on hourly call rate estimations was observed.

Conclusion: The present case study showed that sub-sampling of passive acoustic data can substantially affect the reliability with which hourly call rates and acoustic presence of the focal species are determined. The extent of this effect depends on the interplay of the sub-sampling strategy applied and the species specific acoustic behavior (i.e., regular calling vs temporally clustered vocal activity). Decisions on using a sub-sampling strategy (or not) should involve information on the focal species vocal behavior. If such information is not available, it may be preferable to collect continuous samples of limited duration across the year, i.e., to apply nested sampling strategies.

2) The second case study undertaken at PELAGIS Observatory was designed to test how a sub-sampling mode at the hourly scale (number of minutes per hour of recording) affects the trend of seasonal variation of detected calls. Indeed, a few ARs (i.e., AURALS) can record with a specific hourly sampling mode, allowing the battery life of the instrument to be extended, while data are still collected every hour.

Methods: To explore the effects of a hourly sub-sampling mode on seasonal variation of acoustic presence of Antarctic blue whales, the number of calls detected (using XBAT) on a simulate sub-sampling regime (10 min ON / 50 min OFF i.e. 16%) from a one year continuous data set were compared to the number of calls detected (using the same automatic detector) on the entire data set (recorded in continuous). In this data set collected in sub Antarctic part of the Indian Ocean, calls were organized in regular song sequences and a strong seasonal occurrence of calls occurred over the course of the year.

Results: Sub-sampling using a duty cycle of 16% with 10 min ON and 50 min OFF resulted in the same overall trend in terms of seasonal variation.

Conclusion: Sub-sampling results in the same trend for song, so hourly sub-sampling is acceptable when looking at seasonal patterns in occurrence, i.e. showing when frequent calling and periods of low vocal activity occur.

Overall conclusions with respect to sub-sampling and the SOHN
Continuous recording is the optimal strategy during the first few years of circumpolar Antarctic monitoring, as too little is known about Antarctic blue and fin whale vocal behaviour on a circum-Antarctic scale. Based on information from the initial project phase, it may be possible to recommend future sub-sampling regimes that suit Antarctic blue and fin whale vocal behavior and that can be used to reliably represent temporal patterns in acoustic behaviour.

- **Evaluation of different call types to represent acoustic presence**

Both Antarctic blue and fin whales produce different call types. Ongoing analyses of various acoustic data sets, comparing patterns in call type usage, will provide the foundation for recommendations in the blueprint about which call types most reliably represent acoustic presence of each species. The blueprint paper also investigates which analysis method works best for specific questions and data, and should ultimately provide a decision tree to help maximize the value of a given set of acoustic data.

- **Analysis of passive acoustic data**

Further work for the blueprint involves evaluation of which analysis techniques are best suitable and recommended for different data scenarios, e.g., data containing single calls or choruses (bouts of energy between 20-28Hz in which no single signatures can be discerned). Among work in progress, acoustic data from past IWC-SOWER Antarctic voyages have been provided to SANAP for a student, Fannie Shabangu, to analyse.

- **Signal to Noise Ratio (SNR), thresholds and automatic detection procedures**

In general, for abundance estimation methods, it does not matter how sensitive the detector is, as long as you can quantify its performance i.e., take a measure of the SNR of the calls that are recorded and detected (and if an automatic detector has been used, the SNR of some calls that were recorded but not detected automatically). Detector thresholds can be adjusted depending on the questions that you are ultimately interested in. For example, for very rare species, detectors ought to be sensitive so that no calls are missed. Conversely, where sample size may be overwhelming and faint calls will only make analyses harder, then a high SNR threshold may be implemented.

- **Detection range, SNR and calibration**

• Detection range

To estimate detection ranges we often require auxiliary data to the recordings, i.e. temperature profiles, bathymetry information and any other relevant oceanographic variables that could influence the detection range of an instrument. Ideally, these data would be collected at the same time as the recording. The auxiliary information from a survey would ideally be submitted to the SOHN data base together with the acoustic data. Deployments of additional XBTs were briefly discussed as an option to obtain in-situ sound speed profiles. Again, information from research voyages conducted via IDCR-SOWER and Antarctic Blue Whale Project will be helpful with regards to source level measurements needed to estimate detection range.

• Calibration (to get absolute SNR)

At present, our focus is to get instruments in the water and not require that they be calibrated between deployments. However, calibration is important in order to use the received levels (either to back-calculate call source levels, or to estimate the range of whale from the instrument). At a minimum, we will ask for calibration curve from instruments or hydrophone manufacturer for each instrument deployed. In this way, we will have the initial calibration curve for each instrument deployed. This calibration curve could be provided by the hydrophone manufacturer or by experimentation in a tank.

c. <u>Additional instrumentation</u>

During our fall Group meeting, we discussed additional instrumentations or technologies that could help to achieve the main objective of the project:

- **Emerging technologies:**

The use of autonomous underwater vehicles or "gliders" instrumented with hydrophones and/or detection and classification schemes to send back detections in real time has become a realistically feasible way to 'survey' remote areas (Baumgartner et al. 2013, Klinck et al. 2012). Gliders would allow large areas to be surveyed, versus fixed instruments, similar to acoustic tags that have been deployed on pinnipeds. However, movement of the surveying animal (e.g., a seal) or gliders in relation to the whales would have to be considered for density/abundance analyses.

Combining surveying techniques, including PAM, visual surveys and short-term tagging may provide information on detection range. One approach could be to test these methods in 'hotspot' areas once overall distribution patterns are known.

- **Historic data**

- Survey/analysis of opportunistic/historic data: there are data available from past cruise and hydrophone deployments that can be used to determine probability of detection: the more instruments, even if they recorded at different times, the better.

- 'Old' data are important particularly when it is not possible to obtain 'new' data from certain regions. (Potentially useful data sets include: acoustic tag data, ocean bottom seismometers (OBSs) and other geophysical experiments, sonobuoy data (SOWER).

- It would be useful to explore available historic/opportunistic data that might of use for the project and OBIS Seamap may be a good source of information.

-The ATW Group should design/propose a circumpolar Antarctic database structure for providing an overview of available/historic PAM data (which could be implemented in the SOOS data base, once established). The compilation of a map with all available historic acoustic data from the Antarctic (south of 60S) would provide an immediate snapshot of where data have been collected in the past.

-Data from triplet hydrophones located in the subantarctic can be used to determine source levels, track individual animals and determine detection range and sound propagation. A student (co-supervised by FS) is working on it since April 2013.

-Using visual and acoustic datasets collected during the AAD Blue Whale Voyages 2014 to assess the context of call production by Antarctic blue whale in Antarctic waters. FS's student (Emmanuelle Leroy) started a 6 months internship in January 2014.

d. Passive Acoustic Monitoring deployments in the Southern Ocean

To study the distribution and behaviour of marine mammals, a number of research groups have deploying passive acoustic recorders in various parts of the Southern Ocean. Although these recording sites are unlikely to all form nodes of the SOHN throughout its proposed ten-year deployment period, information from these sites will provide important information on patterns in occurrence. Here we provide a summary of ongoing passive acoustic monitoring effort in the Southern Ocean.

- The **Ocean Acoustic Lab of the Alfred-Wegener-Institut**, Helmholtz-Zentrum für Polar- und Meeresforschung (AWI) has deployed and maintained moored autonomous passive acoustic recorders throughout the greater Weddell Sea since 2008. The recorders are integrated in oceanographic moorings that compose the HAFOS (Hybrid Arctic/Antarctic Float Observing System) array. The HAFOS system consists of an array of oceanographic moorings to collect information on ocean circulation and hydrography. During the *Polarstern* expedition ANT-XXIX/2 in 2012/13 seven recorders were recovered and 21 recorders were (re)deployed to continue measurements. These 21 recorders will be retrieved and exchanged during the ANT XXX/2 expedition in 2014/15.

- To contribute to the IWC-SORP Acoustic Trends Project, **the Australian Antarctic Division** (AAD) developed an autonomous acoustic recorder (AAR) and mooring to be deployed from platforms of opportunity. The prototype AAD-AAR was deployed in January 2013, and was scheduled to be recovered during the 2013/14 Antarctic Season. However, the prototype AAD-AAR could not be recovered in 2013/14 due to the extreme extent of the summer sea-ice. A final attempt to recover the prototype will occur in the 2014/15 Antarctic Season. Despite the failure to recover the prototype, two additional AAD-AARs were deployed during the 2013/14 season. The locations of these recorders were well beyond the (extreme) extent of the seasonal sea ice which should facilitate their recovery in the 2014/15 season (see Figure 3). The AAD-AARs deployed in 2013/14 also included a new satellite transmitter that will send the location of the mooring upon surfacing via email which should serve to facilitate quick recovery. In addition to the three AAD-AARs presently deployed, four additional AAD-AARs are under construction and should be available for deployment in 2014/15. However, it is unlikely that there will be sufficient ship-time to both retrieve the three deployed AAD-AARs and deploy four additional instruments. While the draft shipping schedule for the 2014/15 Australian Antarctic season has not yet been released (let alone finalized), a realistic allocation of ship time would likely include enough time to deploy only two instruments in 2014/15. Thus, there is potential for the additional two AAD-AARs to be made available to SOHN partners who have the means to deploy them in 2014/15 and preferably recover in 2015/16 or possibly 2016/17.

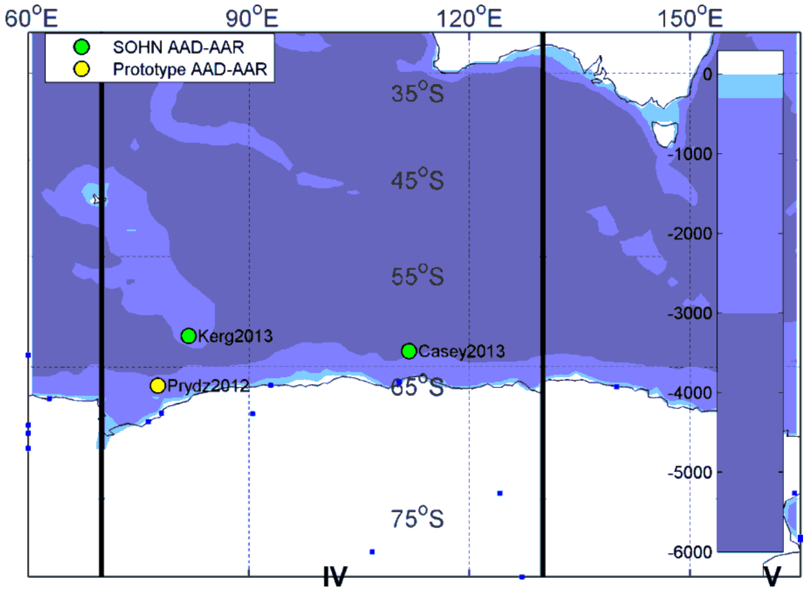

Figure 3 : Location of AAD-AARs in 2014. NB: The prototype (yellow circle) was scheduled to record until the March 2014. Recorders at Kerguelen and Casey (green circles) will record until March 2015 and will be prioritised for annual service as a part of the Southern Ocean Hydrophone Network (SOHN).

- An Autonomous Acoustic Recorder Mooring was deployed from the *SA Agulhas II* by the South African blue whale project under the auspices of the **South African National Antarctic Programme** (SANAP and Environmental Evaluation Decision 14/12/16/5/1 in accordance with Article 2(1) (Environmental Impact Assessment) of the Protocol on Environmental Protection (PEP), 1991) on 12 January on the Maud Rise at position 65°00'S; 002°30'E in water depths of 1200m. This Aural M2 at some 200m below the sea surface will record each hour every day until February 2015 when the mooring (and archived acoustic data) will be recovered and in all likelihood be re-deployed for a further year.

Conclusions

The main objectives of the ATW Group have been clearly aimed towards the collect of new passive acoustic data for fin and blue whales and the best exploitation of these data sets in the long term through guidelines and recommendations. The installation and maintenance of a circum-Antarctic passive acoustic monitoring system (SOHN) and the production of a technical report (the whitepaper) and the blueprint for analysis methods are ambitious projects, but given the ATW Group's multi-disciplinary and international composition, and therefore large network and broad range of expertise, we trust that we may achieve this goal in the near future. This year the group focused on the submission of the whitepaper and the editing of the blueprint. We anticipate that the publication of the whitepaper in the near future will help to involve further international partners from UK, Brazil, Argentina, South Korea etc. Furthermore, the ATW Group aims to distribute the whitepaper within the SOOS community and upload it to the IWC-SORP website to further increase awareness of the project. Additional collaborators and financial support are sought to start to concretize the project's goals and explore possibilities to set-up an instrument library. In addition, and to have a better idea of how variable the animals' acoustic behaviour is and how they change their behavioural states, the ATW Group strongly recommend that D-tags (or an equivalent tool) be deployed on Antarctic blue whales (and fin whales) during next IWC-SORP Blue Whale Voyage. Indeed, concurrent acoustic and behavioural data will help to obtain information on calling behaviour while transiting, foraging or socializing that can be used for absolute abundance estimation, choice of duty cycle etc. Despite the long-term focus of the project, it is expected that there will be substantial output in the form of peer-reviewed publications as well as guidelines and recommendations from the ATW Group.

Challenges

At present, we have a better idea of the deployment strategies, the instrumentations, the timeframe and the spatial coverage needed for a network of instruments. We are still working on recommendations for the analytical methods and archiving the data. The biggest challenge is collaboration and to find funding for the project. To involve further partners and find funding we need to have a better communication of the project through publications, conferences and through the IWC-SORP website.

Outlook for the future

In the autumn of 2014, the Group will organize a further meeting, possibly in Europe since many of the members are based there, which will focus on evaluating the preparatory work for the blueprint manuscript. The aim of this meeting will be also to discuss funding opportunities for the SOHN and the instrument library. Financial support for travel and accommodation will be required for this meeting to ensure all steering group members can attend.

We would like to emphasize that, although this was not a goal of IWC-SORP or the ATW Group, three graduate students have been integrated into the ATW Group and are actively providing information to the group that will be very useful to future studies in addition to training 'new' bioacousticians.

Project outputs

Papers

Samaran F, Stafford KM, Branch T, Gedamke J, Royer J-Y, Dziak RP, Guinet C (2013) Seasonal and geographic variation of southern blue whale subspecies in the Indian Ocean. PLoS One 8(8), p. e71561-e71561

Van Opzeeland IC, Samaran F, Stafford KM, Findlay K, Gedamke J, Harris D, Miller BS (*In review*) The Southern Ocean Hydrophone Network (SOHN) Circum-Antarctic passive acoustic monitoring of Antarctic blue and fin whales. The SORP Antarctic blue and fin whale acoustic trends working group (ATW). Polarforschung.

Miller BS, Leaper R, Calderan S, Gedamke J (*In review*) Red shift, blue shift: Doppler shifts and seasonal variation in the tonality of Antarctic blue whale song. PLoS One. (SC/65b/Forinfo07).

Reports

The SORP acoustic trends steering group. SORP Blue and Fin Whale Acoustic Trends Project: Report of 2013 steering committee meeting.

Conference presentations

Thomisch K , Boebel O, Clark CW, Kindermann L , Rettig S, van Opzeeland I (2013) Spatio-temporal patterns of Antarctic blue whale (*Balaenoptera musculus intermedia*) vocal behaviour in the Weddell Sea. Oral presentation during the IWC-SORP special session at the Biennial Conference on Marine Mammals, Dunedin, New Zealand, 9-13 December 2013.

Van Opzeeland I, Samaran F, Stafford KM, Findlay K, Gedamke J, Harris D, Miller BS (2013) Listen to the BLUE: Towards a pan-Antarctic monitoring system and blueprint of analysis methods to study fin and Antarctic blue whales in the Southern Ocean. Poster presented during the IWC-SORP special session at the Biennial Conference on Marine Mammals, Dunedin, New Zealand, 9-13 December 2013.

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Thomas JA, Fisher SR, Ferm LM, Holt RS (1986) Acoustic detection of cetaceans using a towed array of hydrophones. Report of the International Whaling Commission (Special issue 8): 139-14.