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Abstract

Fin whales (*Balaenoptera physalus*) have been understudied in the Southern Hemisphere for the last several decades. An apparent increase in sighting numbers and acoustic detections around the Antarctic Peninsula has created a need to investigate the species' abundance, habitat use and behaviour in the area. In this paper, we outline a proposal for a dedicated fin whale study in the greater area of the West Antarctic Peninsula and Scotia Sea.

Background

Fin whales (*Balaenoptera physalus*) have been the target of only relatively limited research in the Southern Hemisphere over the past several decades. In the Southern Ocean, they were reduced to 2% of their pristine population size during the times of commercial whaling (Clapham & Baker 2001). Until today, recovery rates of the population remain unknown and they are listed as 'endangered' on the IUCN red list of threatened species (Reilly et al. 2013).

Very little is known about their abundance and distribution, as well as ecology and habitat use in the Southern Hemisphere (Leaper & Miller 2011; Edwards et al. 2015). Fin whales are assumed to be extensively distributed in latitudes between 40°S and 60°S (Reilly et al. 2013), and less common south of 60°S. They have thus played a rather minor role in recent Antarctic cetacean research. Fin whales presumably perform seasonal migrations to Antarctic waters in order to feed on krill, but their migratory routes and breeding grounds are unknown (Reilly et al. 2013; Edwards et al. 2015).

Today, much of the understanding of circumpolar post-whaling distribution and abundance of whales is based on the International Whaling Commission's (IWC) International Decade of Cetacean Research (IDCR) and Southern Ocean Whale Ecosystem Research (SOWER) cruise programmes carried out in three circumpolar sets of surveys between 1978 and 2004. Based on IDCR/SOWER data from surveys between 1991 and 1998, circumpolar fin whale abundance south of 60°S was last estimated at 5,445 (95 % CI 2,000–14,500; CV = 0.53) individuals (Branch & Butterworth 2001). However, since some unknown – but potentially substantial – proportion of the population is thought to range north of 60°S during the summer months, and surveyed areas did not represent their complete summer distributional range, this estimate almost certainly represents an unknown fraction of the total abundance. Highest densities of fin whales in the Scotia Sea were estimated around 60S by Williams et al. (2006), underlining the importance to include the latitudes around 60° in a dedicated fin whale assessment in order to cover the full range of fin whale summer distribution.

Recently, high sighting numbers and observations of large aggregations of fin whales in the West Antarctic Peninsula (WAP) have been reported (Burkhardt & Lanfredi 2012; Joiris & Dochy 2013; Santora et al. 2014; Reyes Reyes et al. 2014, 2015; Baumann-Pickering et al. 2015; Edwards et al. 2015; Orgeira et al. 2015). Santora et al. (2014) described re-occurring fin whale aggregations in the WAP; a ship-based helicopter survey provided a minimum abundance estimate of 4,898 (95% CI 2,221–7,575) fin whales around the South Shetland Islands in March 2013 (Herr et al. 2016) and Viquerat & Herr (in press) reported high densities of fin whales from the continental shelf waters around the South Orkney Islands and Elephant Island in February 2016.

Given the new information on the potential increases in fin whale numbers in the areas around the Antarctic Peninsula and Scotia Sea, a greater interest and need now exists to investigate the abundance of the species and better understand their behaviour in the region and elsewhere in the Southern Hemisphere.

The aim of this paper is to outline a proposal for a dedicated fin whale study in the West Antarctic Peninsula and Scotia Sea, as the region where fin whales have been observed in increasing numbers over the past few years (and were once known to be very abundant, see Kemp and Bennet 1932, Fig 1). Apart from a need to further investigate the driving factors behind fin whale aggregations in the WAP and Scotia Arc region, the presumed high density area provides a rare opportunity to conduct an ecological study of fin whales for the first time, using a suite of state-of-the-art research methods to better understand how the distribution and behaviour of the species is related to its physical and biological habitat.

Proposal for a dedicated fin whale study in the West Antarctic Peninsula and Scotia Sea

Recent observations (Burkhardt & Lanfredi 2012; Joiris & Dochy 2013; Santora et al. 2014, Herr et al. 2016; Viquerat & Herr, *in press*) suggest the area from the South Shetland Islands to the South Orkney Islands to be an important fin whale feeding habitat with increasing numbers of animals and re-occurring large feeding aggregations over the past few years. This area and its surroundings, which were historically known for high fin whale numbers (Kemp and Bennett 1932, Fig 1) should therefore be the target of dedicated fin whale research in the near future, which aims to: investigate the locations of persistent fin whale aggregations, characterising the oceanographic setting of these aggregation areas, understand the movement patterns and behaviour of whales in relation to their environment, identifying driving factors behind the aggregations, and track migratory pathways. A dedicated research proposal could achieve these goals through a combination of traditional surveying, oceanographic sampling and state-of-the-art research methods to investigate their feeding ecology, acoustic repertoire, genetics, behaviour and habitat utilisation for baseline knowledge on ecology and recovery status of Southern Hemisphere fin whales.

A dedicated fin whale study in the West Antarctic Peninsula and Scotia Sea Area is needed to

- a) Characterise the whales in the aggregations acoustically and genetically to determine the population identity of whales using this area (a single breeding stock vs. multiple stocks mixing)
- b) Explore the spatio-temporal extent of the aggregations and estimate density and abundance of aggregating fin whales
- c) Investigate the feeding ecology and prey dependencies, identifying vulnerabilities
- d) Track movements and habitat use of fin whales in the area
- e) Identify migration routes and destinations

To achieve these objectives, we will rely on a number of methods, technologies, and analytical tools that have been used extensively by the authors in a number of locations, including the WAP and other Antarctic regions. We propose the following work be conducted:

- 1) Evaluation of available information (acoustic & visual data) on fin whale occurrence around the WAP to
 - approximate the onset of increasing fin whale densities in the area (historically as well as seasonally)
 - describe the temporal and spatial range of the aggregations and approximate the boundaries of the aggregation area
 - compare to historical data (e.g. catch records)
- 2) Dedicated visual surveys in the WAP and the Scotia Sea area for
 - detailed analyses of the spatial distribution and density of fin whales within the area
 - snapshot estimates of abundance of fin whales in the WAP and Scotia Arc area
- 3) Habitat models of fin whales in the WAP and Scotia Sea area based on new and old survey data to
 - characterise important fin whale habitat
 - understand relationships between fin whale densities and habitat characteristics
 - identify driving parameters of fin whale distribution

- 4) Acoustic monitoring of fin whales in the area by means of moored recorders and sonobuoy deployment in order to
 - acoustically characterise the aggregation and
 - analyse the seasonal presence and density of fin whales in the area
 - better describe the vocal repertoire of fin whales for comparison to repertoires in other areas (in the Southern Hemisphere and worldwide)
- 5) Investigation of prey distribution in the area in relation to large-scale distribution of fin whales and fine- and meso-scale analyses of foraging behaviour in relation to prey through multi-sensor tag analysis, in order to
 - characterise ecological predator-prey relationships
 - identify prey dependencies and vulnerabilities
 - investigate how fin whales exploit their prey
- 6) Long-term telemetry/tracking of fin whales in the aggregation area in order to
 - analyse habitat utilisation, foraging ecology and movements of fin whales in the area
 - assess presence of Area-Restricted Search (ARS) behaviour (which is usually associated with intense feeding) in the area
 - track migration routes when leaving the area at the end of the feeding season
 - deduce migratory destinations
- 7) Collection of biopsy samples of fin whales to investigate
 - population structure & connectivity, including sex ratios and pregnancy rates
 - feeding ecology
 - health status
 - genetic diversity
- 8) Collection of Photo-ID data in order to
 - identify individual fin whales
 - Develop a catalogue of Antarctic fin whales for mark-recapture purposes
 - match identified fin whales to individuals in the IWC photo collection and catalogues from South America in order to track migration and movement, as well as to investigate population connectivity
 - contribute toward a new abundance estimate

Already planned surveys & data collection opportunities

For the prospects of a broad scale fin whale study, it is noteworthy that limited fin whale research efforts are already underway. Several fieldwork campaigns and upcoming cruises will be collecting fin whale data over the next few years. Few of these data collections are dedicated to fin whales, but could contribute opportunistically collected data on fin whales. Moreover, ship time for dedicated fin whale research has been secured on two voyages in March 2018 and March 2019 or 2020. Details of planned research are listed below.

Surveys

Ship time for dedicated fin whale research has been secured on

1) *RV Polarstern*, WAP, March – May 2018 (Herr et al.), 7 weeks, team of 2
Helicopter surveys will be conducted in the WAP during a CCAMLR krill cruise along a fixed transect design by a team of two observers. Data will be collected concurrently to a standardized krill net sampling survey along a set of stations. This cruise will contribute to objectives 2, 3 and 5 by collecting for minimum abundance estimation of fin whales in the area stretching from the Gerlache Strait to Elephant Island and providing a data base for habitat models. Information on krill distribution and composition at the time of the survey will be available for comparisons of predator-prey distribution.

2) *RV Maria S. Merian*, WAP, March 2019 or 2020 (Herr, Panigada et al.), 5 weeks, full ship (team of 20)

A design-based visual line-transect survey will be conducted in the shelf waters and shelf edge areas around and between the South Orkney Islands, Elephant Island and the South Shetland Islands. Visual survey work will be interrupted opportunistically by small boat work for biopsy sampling, tagging and photo ID, as well as UAV applications for behavioural observations. Krill will be sampled along a regular grid of 41 krill stations.

Opportunistic sampling

1) *ARSV Laurence M Gould*, WAP, January 2018, 2019, and 2020 (with likelihood of additional annual cruises through 2026), 6 weeks with sighting and biopsy opportunities as part of the US NSF LTER program (Friedlaender)

The LTER program affords Dr. Friedlaender 2 berths annually on an oceanographic survey of the continental shelf waters from Anvers Island to Marguerite Bay. The main cetacean objectives on this cruise is sightings and biopsy work and any fin whales found can be sampled.

2) OneOcean Expeditions, WAP and Scotia Sea, November-March annually (Friedlaender)

Dr. Friedlaender has secured a long-term collaboration with OneOcean Expeditions to dedicate 2 berths on tour boats throughout the Antarctic tour season from November through March. The tour company conducts 12-15 trips annually on each of two platforms and itineraries range between Ushuaia, Stanley, South Georgia, the Scotia Sea and AP. On these trips a dedicated Zodiac is made available for biopsy and tagging work and visual surveys can be conducted en route to landings. This is a new opportunity that often times visits locations with known fin whale sightings and the opportunity to tag and sample whales is high.

3) Systematic collection of opportunistic sighting data from *RV Polarstern* ('WALOG' by AWI)

WALOG on *RV Polarstern* is a continuous project logging sightings and associated information during any voyage in the Southern Ocean. *RV Polarstern* visits the WAP on a regular basis.

Acoustic recordings

1) Acoustic recording by AWI north of Elephant Island will be ongoing until 2018 and a redeployment of the acoustic mooring for 2019 until 2020 is planned.

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Figures

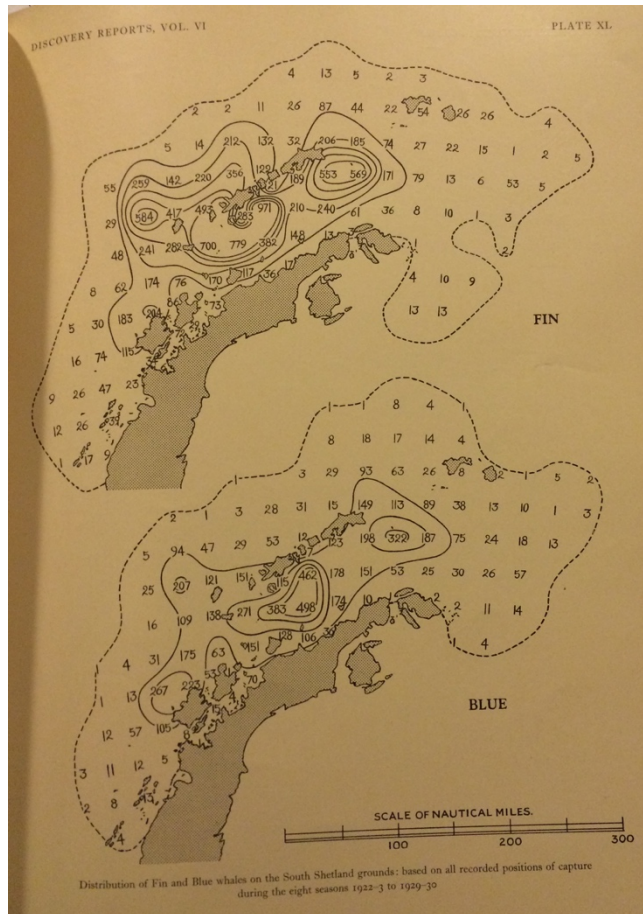


Figure 1: Graphic taken from Kemp and Bennett (1932), showing the distribution of catches of blue and fin whales around the WAP for the decade of the 1920s. It is apparent, that historically fin whales ranged inshore and in the Gerlache and Bransfield Strait in high numbers.