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Annual Report of the Southern Ocean Research Partnership (IWC-SORP) 2020/21

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ABSTRACT

The Southern Ocean Research Partnership (IWC-SORP) was established in 2009 with the aim of developing a multi-lateral, non-lethal scientific research programme that would improve the coordinated and cooperative delivery of science to the IWC. There are 13 member countries in the Partnership: Argentina, Australia, Belgium, Brazil, Chile, France, Germany, Italy, Luxembourg, New Zealand, Norway, South Africa, and the United States. This paper reports on the continued progress of IWC-SORP and its seven Commission endorsed research themes[1] since the Scientific Committee meeting in 2020. This progress includes the production of at least 41 peer-reviewed scientific papers in 2020/21, bringing the total number of peer-reviewed publications related to IWC-SORP produced since the start of the initiative to ca. 206. Moreover, 163 IWC-SORP related papers have been submitted to the Scientific Committee, 18 of them this year. The COVID-19 pandemic has caused major disruption to most of the IWC-SORP projects through the closure of laboratories, cancellation of voyages and disruption of fieldwork. Nevertheless, limited fieldwork was undertaken in the western Antarctic Peninsula and sub-Antarctic Marion Island, and successful expeditions undertaken to the Auckland Islands Maungahuka in New Zealand sub-Antarctic, to the Falkland Islands /Islas Malvinas, and to the Southern Ocean (62°S–68°S and 55°E–80°E). Southern right whale aerial surveys were conducted in South Africa and Australia. Images for photo-identification have been collected, satellite tags have been deployed on southern right and fin whales. Biopsy samples have been collected from southern right and humpback whales; and hundreds of hours of cetacean acoustic recordings have been made and analysed. IWC-SORP funded projects have had extensions to their timelines approved to account for COVID-19 pandemic related disruptions.

KEYWORDS: SOUTHERN OCEAN RESEARCH PARTNERSHIP, IWC-SORP, ANTARCTICA, ABUNDANCE, ACOUSTICS, BIOPSY SAMPLING, PHOTO-IDENTIFICATION, SATELLITE TAGGING, MOVEMENT, CONNECTIVITY, RESEARCH VOYAGE, BLUE, KILLER, HUMPBACK, MINKE, SOUTHERN RIGHT, FIN, WHALE

INTRODUCTION

In 2008, the development of regional non-lethal cetacean research partnerships was proposed to the International Whaling Commission (IWC). 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. Subsequently, the Southern Ocean Research Partnership (IWC-SORP), a multi-lateral, non-lethal, scientific whale research program was established in March 2009 and has been supported by financial contributions from the Governments of Australia, the United States of America, Chile, the Netherlands, France and the NGOs WWF-Australia and International Fund for Animal Welfare. The aim of IWC-SORP is deliver coordinated and cooperative Southern Ocean science to the IWC. Partnership members include Argentina, Australia, Belgium, Brazil, Chile, France, Germany, Italy, Luxembourg, New Zealand, Norway, South Africa, the United States of America. IWC-SORP is an open Partnership that welcomes new members. Its ethos is one of open collaboration, communication and data sharing.

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. Project plans (SC/63/O13) were presented to the IWC in 2011 and 2012 and reports summarising the activities of IWC-SORP research themes (formally termed projects) have been presented annually to the Scientific Committee (SC/63/O12; SC/64/O13; SC/65a/O11; SC/65b/SH12; SC/66a/SH8Rev2; SC/66b/SH10Rev2; SC/67a/SH04Rev1; SC/67b/SH21; SC/68a/SH10; SC/68b/SH04Rev; this paper).

This paper reports on the progress and results of the seven Commission endorsed research themes[1] since the last meeting of the Scientific Committee in 2020. The seventh theme, *Recovery status and ecology of Southern Hemisphere fin whales*, was agreed by the Scientific Committee at SC/68a and endorsed by Commission following a postal vote in July 2020. Further details of all seven IWC-SORP themes can be found at https://iwc.int/sorp.

IWC-SORP RESEARCH FUND

In 2020, £129,955 GBP were allocated to 6 of the 9 eligible proposals submitted during an open, competitive grants round (7 October 2019-10 January 2020). An independent assessment process, endorsed by both the Scientific Committee and the Commission, was undertaken. The Commission endorsed allocation of funds to the successful projects following a postal vote which concluded in July 2020. Details of the allocations and project progress reports are presented in SC/68a/SH11, SC/68b/SH05 and SC68c/SHXX.

A further £1328.46 GBP were allocated intersessionally by the IWC-SORP Scientific Steering Committee (SSC) to Dr Fannie Shabangu of the Acoutic Trends Working Group, to support the freight of an acoustic instrument from France to South Africa and the purchase of consumables. The instrument will be deployed off Marion Island in June 2021 and will contribute data to both the IWC-SORP Acoustic Trends and Killer Whale Themes over a number of years.

A financial report of the IWC-SORP Research Fund is detailed in the IWC Research Fund Financial Report (SC/68c/O0X). **£25,243.91 GBP** remain unallocated and unspent. This figure includs interest and bank fees.

IWC-SORP sincerely thanks the Governments of Australia, the Netherlands, France, WWF-Australia and the International Fund Animal Welfare for financial contributions to the IWC-SORP Research Fund.

VESSEL TIME

The COVID-19 pandemic has meant that a number of IWC-SORP related voyages that would have taken place in the 2020/21 austral field season have been postponed or cancelled.

The following vessel time has been awarded to IWC-SORP researchers and either has taken place or will when the COVID-19 pandemic is over:

1. Yacht *Evohe*, expedition to the Auckland Islands Maungahuka, New Zealand sub-Antarctic - August 2020.
2. *RV Investigator*, TEMPO Voyage to the Southern Ocean (62°S – 68°S and 55°E –80°E) - 29 January-24 March 2021.
3. *Pelagic Australis*, expedition to Elephant Island – April 2021
4. Voyage to the Auckland Islands, New Zealand sub-Antarctic – July/August 2021
5. Argentinean *ARA Almirante Irizar* voyage along Western Antarctic Peninsula – 2021/22 (Iniguez et al.)
6. *Cancelled in 2020/21 due to COVID-19*: NSF-funded voyages to the Antarctic Peninsula – 2020 (Friedlaender et al.)
7. *Cancelled in 2020 due to COVID-19*: Argentinean *ARA Almirante Irizar* voyage along Western Antarctic Peninsula – 2020/21 (Iniguez et al.)
8. *Postponed due to COVID-19: RV Maria S. Merian* (Voyage MSM90) to the shelf area from the South Orkney Islands/ Las islas Orcadas del Sur to the South Shetland Islands/ Las islas Shetland del Sur - 19 March-23 April 2020 (Herr et al.)

[1]There are currently seven IWC-SORP Themes (formerly referred to as Projects) covering 1) blue whales, 2) killer whales, 3) baleen whale foraging, 4) humpback connectivity, 5) blue and fin whale acoustics, 6) southern right whales and 7) fin whales.

EXECUTIVE SUMMARY OF PROGRESS WITHIN IWC-SORP THEMES

Brief summaries of progress on each of the seven ongoing IWC-SORP research themes in 2020/21 are given below. Full project reports are included in Annexes 1 to 7.

IWC-SORP Theme 1: Antarctic Blue Whale Project (ABWP)

The objectives of the Antarctic Blue Whale Project are to improve our understanding of the status of Antarctic blue whales after 50 years of protection from exploitation, investigate the role of these whales in the Antarctic ecosystem, and ultimately to deliver a new circumpolar Antarctic blue whale abundance estimate and determine rate of recovery. During 2020/21, Antarctic Blue Whale Project efforts have focused on the planning and execution of IWC-SORP research on voyages, the ongoing analysis of data collected during previous voyages, analysis of movements of Antarctic blue whales from recent and historic data, photo-identification of whales from research datasets and platforms of opportunity.

2019 ENRICH voyage to the Southern Ocean

The 2019 IWC-SORP *ENRICH* Voyage (**E**uphausiids and **N**utrient **R**ecycling in **C**etacean **H**otspots), was conducted from 19 January-05 March 2019, aboard the CSIRO Marine National Facility research vessel *Investigator*. The voyage departed from and returned to Hobart, Tasmania, Australia, and conducted most marine science operations in the area between 60°S – 67°S and 138°E – 152°E, covering 13,000 kilometres. The voyage was led by the Australian Antarctic Program and involved 28 international scientists. The voyage represented the first time that a survey of Antarctic blue whales has been conducted together with a structured survey of their prey, Antarctic krill. A full voyage report can be found in SC/68c/SHXX.

The data and samples continue to be analysed and detailed reports will be presented at the next face-to-face meeting of the IWC Scientific Committee (mooted for 2022). *ENRICH* voyage multidisciplinary research will contribute to the improvement of ecosystem-based management of the Antarctic krill fishery via the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) and the conservation of endangered Antarctic blue whales.

2021 TEMPO voyage to the Southern Ocean

In 2021, TEMPO Voyage (**T**rends in **E**uphausiids off **M**awson, **P**redators and **O**ceanography) was conducted from 29 January-24 March 2021, aboard the CSIRO Marine National Facility research vessel *RV Investigator*. The voyage departed from and returned to Hobart, Tasmania, Australia, and conducted most marine science operations in the area between 62°S – 68°S and 55°E –80°E, covering 16,000 kilometres. The voyage was led by the Australian Antarctic Program and involved 20 scientists from Australia and New Zealand. Unfortunately, international scientists were not able to participate directly in the voyage due to the COVID-19 pandemic. However, subsequent analyses and publications will involve international collaborations.

The primary objective of the TEMPO voyage was to help ensure orderly development of the krill fishery by updating the biomass estimate to revise the catch limit for Antarctic krill in CCAMLR Division 58.4.2-East in the Indian Ocean sector. Results from the TEMPO voyage will be presented to SC-CAMLR during 2021, and hopefully to IWC-SC at the next in-person meeting (tentatively planned for 2022). Many of the data products and metadata are publically available on the CSIRO Marine National Facility data trawler (search IN2021_V01). It is anticipated that the TEMPO voyage multidisciplinary research will contribute to the improvement of ecosystem-based management of the Antarctic krill fishery, and the conservation and management of several cetacean species in the waters off East Antarctica.

Baleen and toothed whales in the Scotia Sea and the western Antarctic Peninsula

Since 2014, seven summer season cruises to the Antarctic have been conducted on board Argentinean vessels. Unfortunately, due to the COVID-19 pandemic, the 2020 austral summer fieldwork was suspended and no progress has been made since March 2020. Planning for an austral summer campaign in 2022 is underway and scientific publications are in preparation.

Antarctic blue whale photo-identification

Photo-identification of Antarctic blue whales was undertaken previously during the 2013 and 2015 Antarctic Blue Whale Voyages, the IWC-SORP ENRICH 2019 voyage, and during IWC IDCR/SOWER surveys. Photographs from these voyages, and from those collected from other sources, are compiled in the Antarctic Blue Whale Catalogue (e.g. Olson et al., 2016; Olson et al., 2020). During 2020/2021, 35 new IDs (26 left sides, 27 right sides) were added to the catalogue from photographs collected during the cetacean survey at South Georgia conducted by the British Antarctic Survey in 2020 (Kennedy et al., 2020), and from photographs collected opportunistically by naturalists aboard tourist vessels. The current total number of identified blue whales in the catalogue is 552, represented by 414 left side and 409 right side photographs.This represents 25% of the most recent population estimate of 2,280 (Branch, 2007). These photo-ID data are being used in a new capture-recapture estimate of abundance, presented to the Scientific Committee during the SC/68c meeting (SC/68c/PHXX). These data are also being used, in combination with Discovery tag data, in an investigation of intra- and inter-annual movement patterns of Antarctic blue whales (See Project 28, SC/68c/SHXX).

Sex ratios of Antarctic blue whales

Whaling records were analysed for sex ratios in both foetal and postnatal data. General theory predicts sex ratio should be close to equality, and therefore sex ratios were examined for deviations from this prediction. Deviations were small in all cases, with a slight (but significant) preference for males in foetal (51.3%) and postnatal (52.1%) catches. There were small but significant deviations over time from male to female domination in catches, slight deviations in daily sex ratios at the three main land stations, and some spatial variation in sex ratios in catches. As expected from sexual dimorphism in size due to females growing to great lengths, more males were caught at intermediate lengths but more females among the longest individuals. Among foetal data, many more males were reported at the smallest fetal size, best explained by misidentification of females as males; but in addition there was a gradual and significant decline in percent males with increasing foetal length, suggestive of greater prenatal male mortality. A model of prenatal growth in length by day of the year was built and is able to reproduce the general pattern observed in fetal length distributions by day of the year. This foetal growth model will allow for a determination of whether some blue whales in the northern Indian Ocean have aseasonal reproduction or conception dates six months out of phase with other pygmy blue whale populations or Antarctic blue whales. A length-based model of postnatal growth was developed, based on limited age data, and was able to mimic the pattern in sex ratios by length. Age data were also obtained from both Japanese and Soviet whaling operations for pygmy blue whales (and some limited data for Antarctic blue whales) that will be used to better parameterize the length-based model (See Project 13. SC/68c/SHXX for details).

Other

Work also continues to infer the demographic history of blue and fin whales in the Antarctic using mitogenomic sequences generated from historical baleen (Project 18, SC/68c/SHXX); to develop statistical and technical methods to support the use of long-range UAVs to assess and monitor cetacean populations in the Southern Ocean (Project 21, SC/68c/SHXX) and to investigate the use of remote aerial deployment and sampling as a new sampling platform for large cetaceans (Project 26, SC/68c/SHXX).

19 peer-reviewed publications have been generated related to the Antarctic Blue Whale Project to date. A full IWC-SORP Antarctic Blue Whale Project report is included in Annex 1, pp. 18-27.

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

The IWC-SORP killer whale theme is investigating the ecosystem impact the five different ecotypes of killer whales that occur in Antarctic and adjacent waters, by focusing on their systematic relationships, abundance, demographics, distribution, movement patterns, health, and prey preferences.

Terra Nova Bay, Ross Sea, Antarctica

Due to the COVID-19 pandemic, no fieldwork was conducted during the 2020/21 austral summer but funding is sought to continue the project in the future.

West Antarctic Peninsula and Powell Basin

Due to the COVID-19 pandemic, no fieldwork was conducted during the 2020/21 austral summer. Funding is sought to continue this fieldwork in 2020/21.

Marion Island, sub-Antarctic

Data on habitat use, feeding ecology, population connectivity, historical population dynamics and regional patterns of diversity in killer whales (*Orcinus orca*) are being integrated using state-of-the-art methodologies. The focus is on three locations in the southern Atlantic and Indian Oceans, significant because they represent a region of potential transition between temperate and polar waters, and include the South African region, proposed to reflect much greater genetic diversity for killer whales than seen anywhere else so far investigated around the world.

New results indicate that the survival and reproduction rates of killer whales at the Prince Edward Islands are similar to those of killer whale populations in other locations, but subtle differences are likely the result of local differences in resource abundances, historical impacts on social structure and/or stressors. Further, seasonal changes in the social structure parameters of killer whales at the Prince Edward Islands have been identified.

An updated analysis of photographic identification data from the Crozet, Kerguelen and Prince Edward EEZs shows that, among the 188 individuals recorded in the Crozet EEZ since 2003, 22 (12%) were also photographed in the Kerguelen EEZ, 13 (7%) in the Prince Edward/Marion EEZ and 13 (7%) in adjacent international waters. Updated information on the distribution and hunting behaviour of killer whales in South African waters is being collated and genetics results from two South African killer whales are being analysed in the context of 8 other killer whale genomes.

Overall, 40 peer-reviewed publications and three theses/dissertations have been generated by the IWC-SORP killer whale theme to date. Details of project work funded from the IWC-SORP Research Fund can also be found in SC/68c/SHXX (see Project 22). A full theme report is included in Annex 2, pp. 28-38.

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

Quantifying the linkages between predators and their prey are fundamental to understanding ecosystem function. The goals of Theme 3 are to use tag technology and concurrent oceanographic and prey mapping methods to study the relationships between humpback and minke whales and their prey around the Antarctic Peninsula. Short-term multi-sensor suction cup tags and long-term satellite-linked tags are used to study the foraging behaviours and movement patterns of baleen whales in relation to the distribution and abundance of krill and oceanographic variables.

In 2020/21, research activities were significantly curtailed due to the COVID-19 global pandemic. Despite field efforts effectively being grounded for the season work and data analysis has continued as far as working conditions allowed. Two personnel were deployed in the western Antractic Peninsula region with limited capacity to work. To date they have collected 59 humpback whale biopsy samples and will return with these plus the collection of samples that have been stored at Palmer Station for the last year. Research activities beginning to ramp up again as well as the ability to work collectively. It is anticipated that next year will return to more normal field work and output.

75 peer-reviewed publications have been generated by the IWC-SORP baleen whale foraging ecology theme and one thesis to date. Details of project work funded from the IWC-SORP Research Fund can also be found in SC/68c/SHXX. A full theme report is included in Annex 3, pp. 39-48.

Friedlaender et al. received funding from the IWC-SORP Research Fund in 2016/17 and 2018/19. These projects are detailed in SC/67b/SH18, SC/68a/SH11, SC/68b/SH05 and SC/68c/SHXX. *IWC-SORP sincerely*

thanks WWF-Australia for their ongoing and invaluable support of this IWC-SORP Theme, as well as the Antarctic and Southern Ocean Coalition (ASOC), Hurtigruten and previous funders for research under this theme. Cheeseman Ecological Safari trips are also thanked.

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

There were three ongoing research projects focused on humpback whale distribution and connectivity throughout the Oceania – east Australia region during the 2020/21 period, which continue the work encompassing South America, the West Antarctic Peninsula and also as part of a circum-polar analysis. The research is focused on interchange, fecundity and movements of whales, areas that increasingly will add complexity to determining the recovery rates of different populations. The reason for the variation in the recovery of the Oceania (Eii – F) and East Australia (Ei) populations remains unknown but we know they have different migration paths (Riekkola et al. 2020), different feeding grounds (Andrews-Goff et al., 2018; Riekkola et al., 2019) and some of the whales migrating past East Australia forage *en route* (Owen et al., 2016). We do not yet understand the influence of climate change on the whales' feeding grounds, although some work has been done on the breeding grounds (Derville et al. 2019). With the east Australian Ei breeding stock at pre-whaling abundance, determining pregnancy rates of Oceania whales (Riekkola et al., 2018) and those from other Southern Ocean feeding grounds (Pallin et al. 2018) will contribute important information about recovery.

Phase 1 of the IWC-SORP humpback whale research has been summarised in the 2020 IWC-SORP Annual Report (SC/68b/SH05). Three ongoing research projects now shift this Theme's focus from within Oceania to understanding genetic connections to the breeding grounds (G) of South America and to the feeding grounds of the West Antarctic Peninsula (Baker et al., Project 11, SC/68c/SHXX); understanding reproductive rates of humpback whales on different migration paths (Friedlaender et al., Project 14, SC/68c/SHXX); and the circum-polar analysis of humpback satellite tag data to determine feeding ground use of humpback whales from breeding areas Ei – F (Friedlaender, Constantine, Reisinger et al. Project 16, SC/68c/SHXX). This moves the humpback connectivity to other regions that require greater knowledge of connectivity between their populations and stock recovery.

COVID-19 has slowed progress on these projects. However, all the required samples have been collected, and it is now a matter being able to undertake laboratory work and facilitate the physical movement of samples from one country to another.

23 peer-reviewed publications have been generated by the IWC-SORP Oceania humpback whale theme to date. Details of project work funded from the IWC-SORP Research Fund can also be found in SC/68c/SHXX (see Projects 11, 14 and16). A full theme report is included in Annex 4, pp. 49-58.

IWC-SORP gratefully acknowledges the South Pacific Whale Research Consortium (SPWRC) for their substantial and collaborative contribution to this project. IWC-SORP gratefully acknowledges contributions from Pew Charitable Trusts, the New Zealand Ministry for Business, Innovation and Employment, the New Zealand Department of Conservation, the Australian Antarctic Division, the University of Auckland and the International Fund for Animal Welfare (IFAW). Constantine et al. and Paton et al. were both awarded grants from the IWC-SORP Research Fund in 2017 to support this Theme; see SC/67b/SH18 and SC/68a/SH11 for more details. Expedition MARACAS 3 is a component of the WHERE Project funded by the New Caledonian Government, the Ministère de la Transition Ecologique et Solidaire, the World Wildlife Fund for Nature, and Opération Cétacés.

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

Despite the global COVID-19 pandemic, 2020/21 was a surprisingly productive year for the Acoustic Trends Working Group (ATWG). The group conducted seven intersessional meetings, some of which included members of the secretariat of the Southern Ocean Observing System. Group members contributed 13 papers, including *in preparation* and *in press* manuscripts, and conference presentations. 2020 saw the addition of two new group members, the conclusion of the first version of the IWC-SORP Annotated library of blue and fin

whale sounds, the development of two different Deep Learning detectors for blue whale sounds, and completion of a framework for standardised circumpolar analysis of long-term data from moored recorders. The group has provisionally agreed on a 3-year work plan, but completion of this plan is contingent on securing additional funding.

In 2020, group members retrieved 12 datasets of long-term recordings, and deployed nine instruments to be recovered in future years. The ATWG has revised and formalised new Terms of Reference and Mission statement. One of the changes to the group's policies is that the group will broaden the spatial scope of its work to include the entire distribution range of Southern Hemisphere blue and fin whales. Previously the ATWG had restricted the scope of work to acoustic data south of 60°S. When taken together, the improved detection algorithms, standardised analysis framework, continued long-term data collection and other work of the group, represent a step-change in the ATWG's ability to deliver on the promise of using passive acoustics to monitor trends in Antarctic blue and fin whales throughout the Southern Hemisphere.

The IWC-SORP acoustic trends theme has generated 47 peer-reviewed publications to date (three are also listed under the Antarctic Blue Whale Project) and four theses/dissertations. Details of project work funded from the IWC-SORP Research Fund can also be found in SC/68c/SHXX (see Projects 17, 20 and 29). A full theme report is included in Annex 5, pp. 59-71.

IWC-SORP Theme 6: The right sentinel for climate change: linking foraging ground variability to population recovery in the southern right whale

The specific objectives of Theme 6 are to, 1) Increase our understanding of southern right whale foraging habitats and ecology; 2) Update our knowledge on southern right whale population dynamics in a comparative framework; 3) Pursue integration of health assessment indicators with long-term monitoring data; 4) Investigate the impact of climate variation at foraging grounds on population recovery.
The Theme is led by Emma Carroll and Els Vermeulen, in close collaboration with colleagues from Argentina, Australia, Brazil, New Zealand and South Africa. In 2020/21, work has been undertaken against all four objectives including:

The analyses and further collation of available stable isotope data. 775 samples have been selected to date.

A pilot study on generating isotope data from historical bone samples has provided good results. Three southern right whale samples produced collagen that gave good d13C and d15N isotope values. Concurrent genetic analysis on the samples was used for species ID (see Remedios et al. SC/68C/SH01).

The satellite tracking results of six southern right whales off Australia and New Zealand (range: 29 to 150 days) were published by Mackay et al. (2020). Additionally, in August 2020, satellite transmitters were deployed on six adult southern right whales at the Auckland Islands Maungahuka (sub-Antarctic New Zealand) to investigate the migratory routes and offshore feeding grounds of the whales that winter in New Zealand. As of 1 March 2021, the tags transmitted for an average of 125 days (range: 40-209 days). At the time of writing this report two tags were still transmitting

Progress has been made towards IWC-SORP funded project, *Multi-ocean assessment of southern right whale demographic parameters and environmental correlates*, including development of a southern right whale consortium, a common demographic model, collation of major datasets, and the creation of a common biological model) (see Project 30, SC/68c/SHXX).

Progress has also been made on undertaking regional and inter-regional assessments of health and body condition, including development of a global standardized visual health assessment protocol for IWC endorsement. Moreover, assessment of the location of contemporary SRW feeding grounds, and investigation of climate variates for assessing links to demographics, health and foraging ecology are ongoing.

The IWC-SORP southern right whale theme has generated 6 peer-reviewed publications to date. Details of project work funded from the IWC-SORP Research Fund can also be found in SC/68c/SHXX (see Projects 24, 30 and 31). A full theme report is included in Annex 6, pp. 72-83.

IWC-SORP Theme 7: Recovery status and ecology of Southern Hemisphere fin whales

Currently, fin whale theme effort focuses around the Antarctic Peninsula and Western Antarctic. Data from several research groups working around the Antarctic Peninsula and Scotia Arc region have been compiled for a joint analysis. To investigate distribution and abundance based on a very heterogeneous data set, a combination of a random forest model for abundance prediction adjusted by a maximum entropy probability of presence was successfully tested. This approach was able to handle the considerable share of opportunistically collected and presence-only data, providing reasonable predictions of fin whale distribution and abundance throughout the year. A few more data submissions are expected, thereafter the final model runs will be commenced.

Two cruises to the Antarctic Peninsula region in 2018 (*RV Polarstern*) and 2019 (*Pelagic Australis*) were dedicated to investigating the repeatedly reported aggregations of fin whales around Elephant Island. Both expeditions re-encountered large aggregations of fin whales. A dedicated aerial survey during the *RV Polarstern* voyage estimated fin whale abundance in the area. High resolution footage of the aggregations was captured by a professional media team. Visual inspection of high resolution aerial imagery of fin whales around Elephant Island generally suggested their health status to be good, with no signs for emaciation, severe injury or parasitic infestations. A high number of cookie-cutter shark bite lesions suggest migration of fin whales to latitudes lower than 40°S, providing thr first hints of their migratory destinations.

A tagging initiative to deploy up to 13 SPLASH tags on fin whales around Elephant Island is underway aboard the *Pelagic Australis* at the time of writing this report.

The IWC-SORP fin whale theme has generated 1 published and 2 submitted peer-reviewed publications to date. Details of project work funded from the IWC-SORP Research Fund can also be found in SC/68c/SHXX (see Project 15). A full theme report is included in Annex 7, pp. 84-88.

IWC-SORP PUBLICATIONS

Overall, IWC-SORP themes have produced at least 41 peer-reviewed papers in 2020/21, bringing the total number of peer-reviewed publications related to IWC-SORP produced since the start of the initiative to ca. 206. Moreover, 163 IWC-SORP related papers have been submitted to the Scientific Committee, 18 of which will be considered by the IWC Scientific Committee this year. References to these publication can be found in Annexes 1-7.

List of IWC-SORP related papers submitted to SC/68c for consideration[2]

SC/68C/SHXX Agrelo M, Sironi M, Groch K, Vilches F, Marón C, Rowntree V, Cooke J (2021) Working plan for assessing movement rates between breeding grounds of southwest Atlantic southern right whales applying multi-state analysis.

SC/68c/ForInfo08 Barlow DR, Torres LG, Hodge KB, Steel D, Baker SC, Chandler TE, Bott N, Constantine R, Double MC, Gill P, Glasgow D, Hamner RM, Lilley C, Ogle M, Olson PA, Peters C, Stockin KA, Tessaglia-Hymes CT, Klinck H (2018) Documentation of a New Zealand blue whale population based on multiple lines of evidence. Endangered Species Research. doi: https://doi.org/10.3354/esr00891

SC/68c/SHXX Bell E (2021) Annual Report of the Southern Ocean Research Partnership 2020/21.

SC/68c/SHXX Bell E (2021) IWC-SORP Research Fund: progress reports.

SC/68C/SHXX Butterworth D, Cooke J, Charlton C, Vermeulen E, Ross-Gillespie A, Brandão A, Groch K, Meaper R, Rayment W, Rowntree V, Sironi M, Agrelo M, van den Berg G, Watson M, Carroll EL, Carlyon K, Burnell S, Double M, Jackson J (2021) Progress report: Multi-ocean assessment of southern right whale demographic parameters and environmental correlates.

SC/68c/SH03 Carroll EL, Steel D, Constantine R, Andrews-Goff V, Baker CS, Cole R, Riekkola L, Van Der Reiss A, Stuck E, Zerbini AN, Harcourt R, Olavarría C, Torres L, Childerhouse S (2021)

[2] *The COVID-19 pandemic has meant that a number of IWC-SORP related papers that would have been presented at IWC/SC 68c (a virtual meeting with strictly prioritised agenda) have been deferred until the next face-to-face meeting of the Scientific Committee.*

Tohorā nō aotearoa - New Zealand southern right whale Auckland Islands expedition report, with genotype matching to 1995-2009 catalogue.
SC/68C/SHXX Charlton C, Vermeulen EL, Hoerbst, Gregory, Christiansen F, Findlay K, Moore M, Leslie, Minton G, Hamilton P, Pettis H (2021) Global, standardised southern right whale qualitative visual health assessment protocol.
SC/68c/SHXX Double MC, Bell EM, Miller BS, Kelly N, Westwood K et al. (2021) Report of the 2019 IWC-SORP ENRICH Voyage
SC/68c/ForInfo13 Jenner C, Jenner M, Burton C, Sturrock V, Salgado Kent C, Morrice M, Attard C, Möller L, Double MC (2021) Mark recapture analysis of Pygmy Blue Whales from the Perth Canyon, Western Australia 2000-2005.
SC/68c/O0X IWC Secretariat (2021) Research Fund Financial Report.
SC/68c/PHXX Olson PA, Kinzey D, Double MC, Matsuoka K, TBD, Findlay K (2021) Capture-recapture estimates of abundance of Antarctic blue whales.
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ANNEX 1 – IWC-SORP THEME 1 PROGRESS REPORT – 2020/21. 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.

Currently our understanding of Antarctic blue whale ecology, behaviour and post-exploitation recovery is very poor. Only two abundance estimates for Antarctic blue whales (ABW) have been derived since 1964, each with low precision. The Antarctic Blue Whale Project is a coordinated, international research programme, focused on applying a multi-disciplinary approach to understand both the recovery of Antarctic blue whales and their important role in the Southern Ocean ecosystem through an investigation of their foraging ecology, distribution, movements and habitat preferences. These data will ultimately contribute toward a precise estimation of Antarctic blue whale circumpolar abundance and their rate of recovery.

Overall 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;
- Develop and refine methods to improve survey efficiency;
- Deliver a new circumpolar Antarctic blue whale abundance estimate;
- Improve understanding of Antarctic blue whale population structure;
- Improve understanding of linkages between Antarctic blue whale breeding and feeding grounds;
- Characterise the behaviour of Antarctic blue whale on the feeding grounds.

Project activities in 2020/21

Work on the Antarctic Blue Whale Project has focused on the planning and execution of IWC-SORP research voyages, the ongoing analysis of data collected during previous voyages, analysis of movements of Antarctic blue whales from recent and historic data, photo-identification of whales from research datasets and platforms of opportunity.

2019 ENRICH voyage to the Southern Ocean

The 2019 IWC-SORP *ENRICH* Voyage (**E**uphausiids and **N**utrient **R**ecycling in **C**etacean **H**otspots), was conducted from 19 January-05 March 2019, aboard the CSIRO Marine National Facility research vessel *Investigator*. The voyage departed from and returned to Hobart, Tasmania, Australia, and conducted most marine science operations in the area between 60°S – 67°S and 138°E – 152°E, covering 13,000 kilometres. The voyage was led by the Australian Antarctic Program and involved 28 international scientists. The voyage represented the first time that a survey of Antarctic blue whales has been conducted together with a structured survey of their prey, Antarctic krill. A full voyage report can be found in SC/68c/SHXX.

The data and samples = continue to be analysed and detailed reports will be presented at the next face-to-face meeting of the IWC Scientific Committee (mooted for 2022). It is anticipated that the *ENRICH* voyage multidisciplinary research will contribute to the improvement of ecosystem-based management of the Antarctic krill fishery via the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) and the conservation of endangered Antarctic blue whales.

IWC-SORP sincerely thanks WWF-Australia for a contribution of $10,000 AUD toward participation of Paula Olson on the IWC-SORP ENRICH voyage. We gratefully acknowledge the CSIRO Marine National Facility staff and vessel crew for their incredible support before and during the voyage.

2021 TEMPO voyage to the Southern Ocean

The 2021 TEMPO Voyage (Trends in Euphausiids off Mawson, Predators and Oceanography) was conducted from 29 January-24 March 2021, aboard the CSIRO Marine National Facility research vessel Investigator. The voyage departed from and returned to Hobart, Tasmania, Australia, and conducted most marine science operations in the area between 62°S – 68°S and 55°E –80°E, covering 16,000 kilometres. The voyage was led by the Australian Antarctic Program and involved 20 scientists from Australia and New Zealand. (Unfortunately, international scientists were not able to participate directly in the voyage due to the Covid-19 pandemic. However, subsequent analyses and publications will involve international collaborations.)
The primary objective of the TEMPO voyage was to help ensure orderly development of the krill fishery by updating the biomass estimate to revise the catch limit for Antarctic krill in CCAMLR Division 58.4.2-East in the IO sector. A number of Krill Observational Moorings for Benthic Investigation (KOMBI) system were deployed during the survey to further monitor seasonal dynamics of krill in the seasonally ice covered area. Furthermore, the survey was also designed to improve understanding of the connectivity of the krill population, and overlap between krill and predators, in addition to biological oceanographic processes. A team of marine mammal observers on board undertook line transect distance sampling and detected over 1,400 cetaceans throughout the entire voyage. Furthermore, several hundred sonobuoys were deployed regularly during the voyage, and blue and fin whales were commonly detected. A deeper understanding of all species and processes studied during the TEMPO voyage will support the design of a tractable and sustainable long-term monitoring plan and spatial management (small-scale management unit) of the krill fishery in East Antarctica (CCAMLR's Conservation Measure 51-03).

Results from the TEMPO voyage will be presented to SC-CAMLR during 2021, and hopefully to IWC-SC at the next in-person meeting (tentatively planned for 2022). Many of the data products and metadata are publically available on the CSIRO Marine National Facility data trawler (search IN2021_V01).
It is anticipated that the TEMPO voyage multidisciplinary research will contribute to the improvement of ecosystem-based management of the Antarctic krill fishery, and the conservation and management of several cetacean species in the waters off East Antarctica.

Habitat use, seasonality and population structure of baleen and toothed whales in the Scotia Sea and the western Antarctic Peninsula using visual and passive acoustic methods and genetics

Since 2014, seven summer season cruises to the Antarctic have been conducted on board Argentinean vessels. Five of them were undertaken with Coast Guard vessels to the western part of the Peninsula, with the first one additionally including the Mar del Scotia/ Scotia Sea and Islas Orcadas del Sur/ South Orkney Islands (SOI), and two of them on-board the Navy icebreaker *ARA Almirante Irizar*. These last two included the north-eastern part of the Peninsula, Mar del Scotia/ Scotia Sea, Mar de Weddell/ Weddell Sea and Islas Orcadas del Sur/ South Orkney Islands with the latest one also including the southern area of the Mar de Weddell/ Weddell Sea.

Unfortunately, due to the COVID-19 pandemic the 2020 austral summer fieldwork was suspended and no progress has been made since March 2020. Moreover, some of the equipment used during the 2020 fieldwork is still in storage in Antarctic depots in Buenos Aires.

Planning for an austral summer campaign in 2022 is underway and two scientific publications are in preparation.

IWC-SORP and PIs of this project would like to thank the following persons and institutions: Ministry of Foreign Affairs of Argentina, Dirección Nacional del Antártico, Instituto Antártico Argentino, Dirección de Consejería Legal, COCOANTAR, Capitán de Navío Maximiliano Mangiaterra and crew of the icebreaker "ARA Almirante Irizar", Dr. Antonio Curtosi, colleagues from Fundación Cethus, ECOPELAGOS/PROANTAR (Brazil), Centro Ballena Azul/ Universidad de Chile, Scripps Institution of Oceanography and Whale and Dolphin Conservation. This work was funded by the IWC/SORP funds, the Prince Albert II of Monaco Foundation and the Whale and Dolphin Conservation. This project is under the Programa Antártico Argentino / Plan Annual Antártico 2019 – 2020.

Platforms of opportunity

Partnerships with tourist ships, fishing vessels and naval vessels are essential for augmenting data for the circumpolar estimation of Antarctic blue whale abundance and other IWC-SORP projects. The COVID-19 pandemic has reduced such opportunities but it is anticipated that the use of platforms of opportunity by IWC-SORP researchers will increase again in coming years, once international travel resumes.

Photo-identification of Antarctic blue whales

One of the research objectives of the IWC-SORP Antarctic Blue Whale Project is to collect identification photos of Antarctic blue whales at a number sufficient to allow the estimating abundance using mark-recapture methods. Obtaining a current estimate of abundance is considered fundamental for the assessment of the status of the Antarctic blue whale population and in monitoring its recovery (Bell, 2019).

Photo-identification of Antarctic blue whales was undertaken previously during the 2013 and 2015 Antarctic Blue Whale Voyages, the IWC-SORP ENRICH 2019 voyage, and during IWC IDCR/SOWER surveys. Photographs from these voyages, and from those collected from other sources, are compiled in the Antarctic Blue Whale Catalogue (e.g. Olson et al., 2016; Olson et al., 2020). During 2020/2021, 35 new IDs (26 left sides, 27 right sides) were added to the catalogue from photographs collected during the cetacean survey at South Georgia conducted by the British Antarctic Survey in 2020 (Kennedy et al., 2020), and from photographs collected opportunistically by naturalists aboard tourist vessels. The current total number of identified blue whales in the catalogue is 552, represented by 414 left side and 409 right side photographs.This represents 25% of the most recent population estimate of 2,280 (Branch, 2007). These photo-ID data are being used in a new capture-recapture estimate of abundance, presented to the Scientific Committee during the SC/68c meeting (SC/68c/PHXX). These data are also being used, in combination with Discovery tag data, in an investigation of

intra- and inter-annual movement patterns of Antarctic blue whales (For more details see Project 28, SC/68c/SHXX).

Sex ratios of Antarctic blue whales

Whaling records were analysed for sex ratios in both foetal and postnatal data. General theory predicts sex ratio should be close to equality, and therefore sex ratios were examined for deviations from this prediction. Deviations were small in all cases, with a slight (but significant) preference for males in foetal (51.3%) and postnatal (52.1%) catches. There were small but significant deviations over time from male to female domination in catches, slight deviations in daily sex ratios at the three main land stations, and some spatial variation in sex ratios in catches. As expected from sexual dimorphism in size due to females growing to great lengths, more males were caught at intermediate lengths but more females among the longest individuals. Among foetal data, many more males were reported at the smallest fetal size, best explained by misidentification of females as males; but in addition there was a gradual and significant decline in percent males with increasing foetal length, suggestive of greater prenatal male mortality. A model of prenatal growth in length by day of the year was built and is able to reproduce the general pattern observed in fetal length distributions by day of the year. This foetal growth model will allow for a determination of whether some blue whales in the northern Indian Ocean have aseasonal reproduction or conception dates six months out of phase with other pygmy blue whale populations or Antarctic blue whales. A length-based model of postnatal growth was developed, based on limited age data, and was able to mimic the pattern in sex ratios by length. Age data were also obtained from both Japanese and Soviet whaling operations for pygmy blue whales (and some limited data for Antarctic blue whales) that will be used to better parameterize the length-based model (For more details see Project 13, SC/68c/SHXX for details).

Other

Work also continues to infer the demographic history of blue and fin whales in the Antarctic using mitogenomic sequences generated from historical baleen (Project 18, SC/68c/SHXX); to develop statistical and technical methods to support the use of long-range UAVs to assess and monitor cetacean populations in the Southern Ocean (Project 21, SC/68c/SHXX) and to investigate the use of remote aerial deployment and sampling as a new sampling platform for large cetaceans (Project 26, SC/68c/SHXX).

Project outputs

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https://gacetamarinera.com.ar/el-irizar-arribo-a-ushuaia/ (includes video images of staff working)
https://gacetamarinera.com.ar/finalizo-la-segunda-etapa-de-la-campana-antartica-de-verano-2/ (includes video images of staff working)
https://gacetamarinera.com.ar/cientificos-a-bordo-del-irizar/
https://www.facebook.com/FundacionCethus/ post from 28/02/2020

The successful 2015 Joint New Zealand-Australia Antarctic Ecosystems Voyage attracted considerable media attention. The voyage webpage including voyage sitreps and news items can be found here:
http://www.antarctica.gov.au/science/southern-ocean-ecosystems-environmental-change-and-conservation/wildlife-conservation/new-zealand-australia-antarctic-ecosystems-voyage-2015
and
http://www.niwa.co.nz/antarctic-ecosystems-voyage

ABWP scientists conducted a feature interview on the ABC Radio programme Off Track AMMC's Antarctic blue whale research and Antarctic blue whale song:
http://www.abc.net.au/radionational/programs/offtrack/the-biggest-underwater-choir-in-the-world/6914940

and
http://www.abc.net.au/radionational/programs/offtrack/antarctic-blue-whale-song-worlds-biggest-choir/6919222

The ABWP was represented at the sold-out panel discussion, Discovering the Deep, at the World Science Festival in Brisbane, Australia:
http://www.worldsciencefestival.com.au/program/events/discovering-the-deep/

Antarctic Circumnavigation Expedition (ACE):
http://www.antarctica.gov.au/news/2016/australian-scientists-to-join-international-colleagues-for-antarctic-circumnavigation-voyage
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ANNEX 2 – IWC-SORP THEME 2 PROGRESS REPORT – 2020/21. Distribution, relative abundance, migration patterns and foraging ecology of three ecotypes of killer whales in the Southern Ocean

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Introduction

Five different ecotypes of killer whales have been described in Antarctic waters, any or all of which could eventually be recognized as separate species. Killer whales are large apex predators that are commonly found in Antarctic waters; although relatively little is known about the distribution, abundance, habitat and prey preferences of each of the different ecotypes, cumulatively they are expected to play a key role in the Antarctic marine ecosystem. This Theme is investigating the ecosystem impact the different ecotypes of killer whales that occur in Antarctic and adjacent waters, by focusing on their systematic relationships, abundance, demographics, distribution, movement patterns, health, and prey preferences.

Progress and results for 2020/21

Giancarlo Lauriano and Simone Panigada, Terra Nova Bay, Ross Sea, Antarctica

Introduction

Knowledge on the distribution, foraging habits and the abundance of Type B (both pack ice and Gerlache) and Type C (Ross Sea) killer whale ecotypes in the Antarctic is scant. Moreover, information on the species seasonal distribution and occurrence, as well as its and residency patterns in the region, are lacking. The impact of killer whales on the ecosystem depends on their movements, abundance, diet and prey requirements. A decrease in the prevalence of Type C individuals has been inferred following the depletion of Antarctic toothfish, *Dissostichus mawsoni*, as one of the main prey; this would force the species to compete more directly with other top predators.

In 2004, an Italian research project in Terra Nova Bay (TNB) described the presence of both Type B (seals eater) and Type C (fish eater) killer whale types around Cape Washington and near the Italian base Mario Zucchelli Station (MZS). Following on from this, research was funded by the Italian National Antarctic Research Programme (PNRA) (Lauriano et al. 2007, 2011). The aim of the research was to assess the dynamics and role of killer whales in the highly local productive marine ecosystem of TNB, through the understanding of their fine and large scale movements (satellite tagging), prey-related distribution (photo-ID and behavioural sampling), dietary preferences (fatty acids and stable isotopes), toxicological status, and to estimate their abundance (mark recapture).

Results

No fieldwork was conducted during the 2019/20 austral summer.

Outlook for the future

Funding is sought to continue this work.

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. Research on killer whales has included line transect surveys to investigate distribution and relative abundance, photo-identification, acoustics, and biopsy sampling for genetics, contaminant and stable isotope analyses.

Objectives

The specific objectives include investigating killer whale distribution and relative abundance around the Antarctic Peninsula; investigating the species-habitat relationships, and their acoustics; biopsy sampling for genetics, contaminant and stable isotope analyses; photo-identification.

In addition, ongoing cetacean satellite tagging efforts, which have focused on fin whales, may opportunistically include killer whales depending on ecotype and area.

Results

No fieldwork was conducted in 2020/21 due to the COVID-19 pandemic.

Outlook for the future

Long term cetacean research is expected to continue in the northern Antarctic Peninsula. Additional funding and ship time is sought for 2021/22 and future seasons.

P.J.N. (Nico) de Bruyn and Ryan R. Reisinger, Marion Island, sub-Antarctic

Introduction

Killer whales (*Orcinus orca*) are alpha predators which can exert significant top-down influences on marine ecosystems (e.g., Reisinger et al. 2011b). However, their influence on ecosystems is modulated by their movement patterns, diet and abundance, since these determine the structure and dynamics of their trophic linkages with other species. Given killer whales' high mobility (e.g., Reisinger et al. 2015) and dietary flexibility (reviewed in de Bruyn et al. 2013), these factors become even more important in determining what impacts killer whales may have.

There is an additional layer of complexity in that the population structure of killer whales is driven in part by their foraging specialisations in different environments, in conjunction with their social structure (Hoelzel et al. 2007, Moura et al. 2014a, 2014b, 2015). For example, in the eastern North Pacific three sympatric but genetically distinct killer whale populations ('ecotypes') occur, which have different diets, behaviour and social structure (reviewed by de Bruyn et al. 2013). In the Antarctic, at least four ecotypes have been identified based on morphology, diet and behaviour (Pitman et al. 2007, Pitman & Durban 2010, 2012) and these are also genetically distinguishable (Morin et al. 2010, Foote et al. 2011a). A fifth type, which seems morphologically and genetically distinct, has recently been described mainly from at-sea observations in the sub-Antarctic (Pitman & Ensor 2003, Pitman et al. 2011, Foote et al. 2013). Along the South African coast, Best et al. (2014) recently described a second regional killer whale morphotype, which appears to be a dietary specialist. A global analysis of killer whale mitochondrial DNA revealed exceptionally high genetic diversity among samples from South Africa, in contrast to low diversity observed in other populations (Moura et al. 2014b). This led to the hypothesis that South Africa hosted a relatively abundant refugial population of killer whales during the Last Glacial Maximum (Moura et al. 2014b). This phylogeographic mosaic has prompted different evolutionary

explanations, debate about the relative roles of various evolutionary drivers, and questions about the global patterns and consequences of ecological specialization among killer whales (Foote et al. 2011b, de Bruyn et al. 2013, Moura et al. 2014a, 2014b, 2015, Foote & Morin 2016, Hoelzel & Moura 2015, 2016).

The vast Southern Ocean is dotted with a few small islands. Two such island groups are South Africa's Prince Edward Islands and France's Crozet Islands, situated ~1,000 km apart (at a similar latitude) in the Indian Ocean sector of the Southern Ocean. These two archipelagos are similar in hosting massive populations of land-breeding seals and seabirds which attract killer whales to their inshore waters (Guinet 1991, Reisinger et al. 2011c). These two killer whale populations have a similar diet including elephant seals, fur seals and penguins, and – at the Crozets – fishes and large cetaceans (Guinet 1991, Reisinger et al. 2011c). Depredation of Patagonian toothfish (Dissostichus eleginoides) from longline fishing vessels occurs around both archipelagos (Williams et al. 2009, Guinet et al. 2015 and references therein). The killer whale populations frequenting the inshore zone of the islands are quite small, numbering ~37 (95% CI 32-62) in 1998-2000 at the Crozets (Poncelet et al. 2010) and ~37 (95% CI 29-44) in 2006-2007 at the Prince Edwards (Reisinger et al. 2011a). The populations exhibit the same seasonal occurrence pattern, with peak inshore abundance in summer and a secondary peak in autumn (Reisinger et al. 2011c).

Despite the proximity of the two archipelagos (which is well within the movement range of killer whales – Durban & Pitman 2012, Reisinger et al. 2015), photographic mark-recapture data reveal that only a few (~8) individual killer whales have been recorded at both archipelagos (Reisinger & de Bruyn 2014; Tixier et al. 2014a). Further, satellite tracking of killer whales from the Prince Edward Islands shows movements only in the region of that archipelago, or rapid northward movements towards and beyond the Subtropical Front (Reisinger et al. 2015).

There is a significant gap in our understanding of the structure, movement and distribution of killer whale populations in the sub-Antarctic and how their movements, dietary specialisation and phylogenetics interact as drivers or consequences of the observed population structure. Of particular interest is any ecotype divergence or convergence in response to environmental conditions, which could address the proximate mechanisms responsible for ecotype dynamics in this species.

The Prince Edward Islands, Crozet Islands and South African coastal waters provide a regional system with environmental similarities and contrasts that will allow us to test hypotheses about the mechanisms that determine population structure in the context of environment and ecology. This is facilitated by long-term photographic identification studies (Guinet et al. 2015, Reisinger et al. 2017), which provide socio-demographic context (e.g., Reisinger et al. 2015, 2016, 2017, Tixier et al. 2015, 2017) together with existing telemetry (Reisinger et al. 2015) and genetic data (Moura et al. 2014; A.R. Hoelzel, unpubl. data).

Objectives

- To provide sufficient integrative data on ecology (through stable isotope, photo-identification and telemetry data), population history and connectivity (through genetic analyses) to test alternative hypotheses about the evolutionary mechanisms that determine population structure and dynamics in this region. The relatively high diversity found off South Africa in contrast to lower levels at the Prince Edward Islands and the Crozet Islands permits a key hypothesis to be tested about the relative importance of long-term demographic stability and population mixing.

- To consider the transferable inference from these data in the context of extensive data on the ecology and population genetics of killer whales elsewhere in the world. While regional systems differ (e.g. strong natal fidelity in the piscivorous ecotype in the North Pacific, not seen to the same extent elsewhere), it is not yet understood if the key drivers are associated with resource use or ancestry or some other combination of factors.

- Provide data with direct relevance to the conservation and management of regional killer whale populations through the provision of data on their distribution, population connectivity and evolutionary diversity (including diversity at functional loci).

Results

Detailed results from 2020/21 work are provided in the IWC-SORP Research Fund: 2021 progress reports from funded projects, Project 22 (SC/68c/SHXX).

Conclusions

Analysis of photographic identification data from the subantarctic are providing updated information on demographic parameters, social structure and population connectivity. Analyses of data from South Africa are yielding novel longitudinal data on individuals in this region. Genetic results will soon give insights into the comparative ecology of killer whale populations in the southern Atlantic and Indian Oceans.

Challenges

The COVID-19 pandemic has caused significant disruptions to the research project. Fieldwork in South Africa and on Marion Island has faced disruptions and delays and genetics analyses were delayed due to university closures. In the past year it has been challenging to deploy any satellite tags.

Outlook for the future

Given disruptions and delays due to COVID-19 impacts, as anticipated in our 2020 report we expect the project outputs to be delayed by one year. However, fieldwork at Marion Island will resume this year and we will be conducting two months of dedicated field work in April and May this year in South Africa, with the aim of collecting biopsy samples and deploying satellite tags.

The funds for the purchase of SPLASH10-292B tags and to assist with travel and fieldwork expenses were awarded from the IWC-SORP Research Fund (SC/67b/SH18; SC/68a/SH11; SC/68b/SH05; SC/68c/SHXX).

Project outputs

Peer-reviewed Papers

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ANNEX 3 – IWC-SORP THEME 3 PROGRESS REPORT – 2020/21. Foraging ecology and predator-prey interactions between baleen whales and krill: a multi-scale comparative study across Antarctic regions

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Executive summary

Quantifying the linkages between predators and their prey are fundamental to understanding ecosystem function. The goals of our research program are to use tag technology and concurrent oceanographic and prey mapping methods to study the relationships between humpback and minke whales and their prey around the Antarctic Peninsula. We use short-term multi-sensor suction cup tags and long-term satellite-linked tags to study the foraging behaviours and movement patterns of baleen whales in relation to the distribution and abundance of krill and oceanographic variables.

To date we have deployed each type of tag on both humpback and minke whales and are completing comprehensive ecological analyses. From fine-scale tag and prey data, we have found that humpback whales feed in a manner consistent with optimal foraging theory: humpback whales feed when krill become available in the upper reaches of the water column in larger but less dense patches. However, within these patches, the deeper the whales feed the denser the krill density that they target.

We have also found that the feeding rates of minke whales are greater than those of any other baleen whale and that their foraging strategies, while similar to humpback whales in some respect, also include species-specific behaviours that indicate under sea-ice feeding. This information on the underwater behaviour of minke whales is the first of its kind for the species. From long-term satellite-linked tags, we have found that humpback whales range over broad spatial regions in the continental shelf waters of the Western Antarctic Peninsula. There is evidence that the size of their home ranges decreases throughout the feeding season in relation to the spatial distribution of krill. All of the humpback whales that have migrated while still carrying active tags have travelled up the western side of South America. Antarctic minke whales were tagged for the first time in 2013 and we continue to build a database from satellite tag deployments, including four LIMPET tag deployments in March 2016 as part of an Australian Antarctic Division and Oregon State University collaboration in the Western Antarctic Peninsula. The data are still being analysed but include a variety of movement patterns. While some animals remained in close proximity to nearshore bays for over 120 days, other whales moved from the Antarctic Peninsula into both the Weddell Sea to the north and east and the Bellingshausen Sea to the south and west. There is also evidence to support migration of some whales to tropical areas.

While the main analytical focus of this work is to understand ecological linkages, the practical focus has been to develop methodologies that can be transported in a manner so as to replicate this research with international collaborators in a variety of regions around Antarctica. International collaboration and regional research studies are at the core of the IWC's Southern Ocean Research Partnership and we continue to develop both our research methods and collaborative relationships towards this goal.

Introduction

Recent technological advances in the miniaturisation of sensors have allowed for the development of tags that can measure, in fine detail, the underwater movement patterns and behaviours of marine mammals. Likewise, satellite-linked telemetry and analytical tools have advanced to allow for greater understanding of how the broad scale movement patterns and behaviours of marine mammals link to changes in the physical and biological seascape. Understanding both fine and broad scale behaviour of baleen whales in Antarctic waters is critical to understanding the ecological role of cetaceans and how these are being affected by climate-driven changes to their environment.

Objectives

The objectives of our research program are to use technological advances in animal biotelemetry to elucidate the behaviour and ecological role of cetaceans in the nearshore waters around the Antarctic Peninsula, and to relate these to climate-driven changes that are currently occurring.

Results

In 2020/21, our research activities were significantly curtailed due to the COVID-19 global pandemic. While our field efforts were effectively grounded for the season we have continued to, as best as we can given the working conditions, work and analyse data. We have had a total of two people in the field this season with limited capacity to work. To date they have collected 59 humpback whale biopsy samples and we are eager for their return home with all of our collective samples that were stored at Palmer Station for the last year. We are currently beginning to ramp up research activities and our ability to work collectively and anticipate that next year will return to more normal field work and output. Below are additions to the list of publications from the previous year that contribute to this program's goals and objectives.

In 2019/20, we continued our work through the NSF LTER program with personnel deploying on the *LM Gould* and at Palmer Station. We continued our collaboration with tour operators including conducting research on Hurtigruten and Cheeseman Ecological Safari trips. We currently are working on several projects supported by IWC-SORP Research Fund grants (see SC/68b/SH05 for more details), and have also received support from WWF to further our ability to determine the ecological role of cetaceans and the impacts of climate change and human activities on them. Due to the COVID-19 pandemic, a majority of the samples collected during the 2019/20 field season are still in the field, being held at Palmer Station; as are a number of our tags containing critical data. Below is a basic summary of our field operations at Palmer Station and from a trip with Hurtigruten.

We have also updated our publications for the previous year including articles using data from this IWC-SORP theme section. During an exceptional year, 12 papers were published in numerous journals including: *Science, Nature, Proceedings of the National Academy of Sciences, and Annual Review of Marine Science.*

IWC-SORP sincerely thanks WWF-Australia for their ongoing and invaluable support of this IWC-SORP Theme, as well as the Antarctic and Southern Ocean Coalition (ASOC), Hurtigurten and previous funders for research under this theme.

Project outputs

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Social Media

Blog Stats
Direct links to our most popular blog posts:
Steady Hands
Welcome to Minke City
Tagging Days
The full blog can be accessed here: medium.com/in-search-of-minkes
It currently features eight published posts, and will continue to be updated with new content for the remainder of the trip, and periodically over the next year.
Since the beginning of the trip, the blog has received over 1,500 views.

Twitter
The main accounts generating original tweets from our content are:
@MarineUAS
@Goldbogenlab
@mlparkermedia
So far, over 100 tweets have been posted about the trip. Here are a few examples of our most impactful tweets/content:
On Feb 28, @MarineUAS posted this tweet including an aerial photo of humpback whales, which generated 38 retweets and 137 likes.
On March 1, @Goldbogenlab posted this tweet showing video of tagging a minke whale which generated 98 retweets, over 220 likes, and over 5,000 views of the video.
On March 7, @mlparkermedia posted this tweet highlighting a blog post about our field work, which generated 20 retweets, 61 likes, and 275 views of the blog.

@AntarcticReport (which has over 17,500 followers) has also tweeted some of our content.
On March 8, they tweeted our photo which generated 35 retweets and 87 likes.
On March 6, they tweeted our photo which generated 30 retweets and 88 likes.

It should also be noted that @MarineUAS won the #Tech4Wildlife challenge hosted by @WILDLABSNET by posting about our work in Antarctica.

Instagram
The main accounts generating original Instagram posts using our content are:
@insearchofminkes
@emmahattonlevy

@mlparkermedia
@marine_uas
The official Instagram account for the research group helps drive traffic to our blog site. The account currently has 150 followers and gains new followers each day. One of our most recent photos (of a tagged minke whale) received 50 likes. So far, the #insearchofminkes hashtag has 85 posts. The most popular post received 186 likes and 17 comments.

Media

National Geographic Channel Documentary Series: *Continent 7*
Antarctic Edge: 70° South

- Best in Festival, Princeton Environmental Film Festival 2015
- https://beyondtheice.rutgers.edu/
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http://news.sky.com/story/tiny-cameras-monitor-humpback-whale-feeding-habits-in-antarctic-10833509
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ANNEX 4 – IWC-SORP THEME 4 PROGRESS REPORT – 2020/21. 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

There were three ongoing research projects focused on humpback whale distribution and connectivity throughout the Oceania – east Australia region during the 2020/21 period, which continue the work encompassing South America, the West Antarctic Peninsula and also as part of a circum-polar analysis. The research is focused on interchange, fecundity and movements of whales, areas that increasingly will add complexity to determining the recovery rates of different populations. The reason for the variation in the recovery of the Oceania (Eii – F) and East Australia (Ei) populations remains unknown but we know they have different migration paths (Riekkola et al. 2020), different feeding grounds (Andrews-Goff et al., 2018; Riekkola et al., 2019) and some of the whales migrating past East Australia forage *en route* (Owen et al., 2016). We do not yet understand the influence of climate change on the whales' feeding grounds, although some work has been done on the breeding grounds (Derville et al. 2019). With the east Australian Ei breeding stock at pre-whaling abundance, determining pregnancy rates of Oceania whales (Riekkola et al., 2018) and those from other Southern Ocean feeding grounds (Pallin et al. 2018) will contribute important information about recovery.

Phase 1 of the IWC-SORP humpback whale research has been summarised in the 2020 IWC-SORP report (SC/68b/SH05). Here we briefly summarise the three research projects that shift the focus from within Oceania to understanding genetic connections to the breeding grounds (G) of South America and to the feeding grounds of the West Antarctic Peninsula (Baker et al., Project 11, SC/68c/SHXX); understanding reproductive rates of humpback whales on different migration paths (Friedlaender et al., Project 14, SC/68c/SHXX); and the circum-polar analysis of humpback satellite tag data to determine feeding ground use of humpback whales from breeding areas Ei – F (Friedlaender, Constantine, Reisinger et al. Project 16, SC/68c/SHXX). This moves the humpback connectivity to other regions that require greater knowledge of connectivity between their populations and stock recovery.

Objectives

The focus of the 2020/21 research was:

1) A circum-polar analysis of the foraging behaviour of humpback whales in Antarctica using satellite tag data spanning all ocean basins; led by Rochelle Constantine, Alex Zerbini, Ari Friedlaender and Ryan Reisinger.

2) Determining whether there are changes in the migratory connectivity of humpback whales in the Central and Eastern Pacific using a decadal comparison of DNA profile data from Oceania, South America and the Wet Antarctic Peninsula; led by C. Scott Baker and Debbie Steel.

3) Understanding the reproductive rates of humpback whales from the Antarctic Peninsula, Oceania breeding grounds and migratory corridors and implications for population recovery across populations; led by Ari Friedlaender, Logan Pallin, C. Scott Baker, Claire Garrigue, Jooke Robbins and Rochelle Constantine.

Results

Circum-polar analysis of foraging behaviour of humpback whales in Antarctica (refer to IWC-SORP Project #16, SC/68c/SHXX)

To understand the environmental drivers influencing humpback whale behaviour on their Southern Ocean feeding grounds, a circum-polar dataset of 378 humpback whale tracks have been aggregated from 11 different research programmes (2002 – 2019, Table 1). After filtering tracking data, fitting state-space models and move persistence models (Jonsen et al., 2019), there were 184 track segments from 162 tracks analysed (Figure 1). These were used to investigate regional difference in habitat use of whales by broad geographic region. There are differences in the southern extent of whale movement with whales from some areas, e.g., Prydz Bay and Bellingshausen Sea regions travelling over 15° further south than whales from the broader South Georgia, Scotia Sea region (Figure 1). There was significant regional variation in behaviour related to environmental variable, e.g., proximity to ice-edge (Pacific region whales were close but Atlantic whales were far away), slope (East Pacific whales were close to the slope, with most others far away) and water depth (East Pacific whales were in shallower waters). Hierarchical GAMs revealed that whales use similar habitats in slightly different ways (Reisinger et al. under review).

IWC catch and sightings data were used as an independent validation test of a new approach to get more accurate habitat selection models. An ensemble modelling approach including regional predictions and environmental covariates resulted in better model outcomes (Reisinger et al., submitted).

Table 1. Table summarising the number of tracks contributed to the dataset by various providers from different regions.

Dataset name	Deployment region	Contributor	IWC breeding stock	n
AMMC	Australia (west and east), East Antarctica	Andrews-Goff & Double	D (west Australia) E1 (east Australia)	32
Constantine_Raoul_2015	Raoul Island	Constantine	E2 - F (Oceania)	20
CWR_WAVES_2014	East Antarctica	Jenner & Jenner	D (west Australia)	6
DallaRosa_AP	Antarctic Peninsula	Dalla Rosa	G	10
Friedlaender	Antarctic Peninsula	Friedlaender	G	58
New-Caledonia-HW	New Caledonia	Garrigue	E2 (Oceania)	2
Oceans&Coasts_Seakamela	South Africa	Seakamela	B2 (west South Africa) C1 (east South Africa)	27
OSU_2007ANT	Antarctic Peninsula	Mate & Palacios	G	12
Rosenbaum	Gabon	Rosenbaum	B1	2
WA_Fisheries	Australia (west)	Andrews-Goff, Double & How	D (west Australia)	56
Zerbini	Brazil	Zerbini	A	153

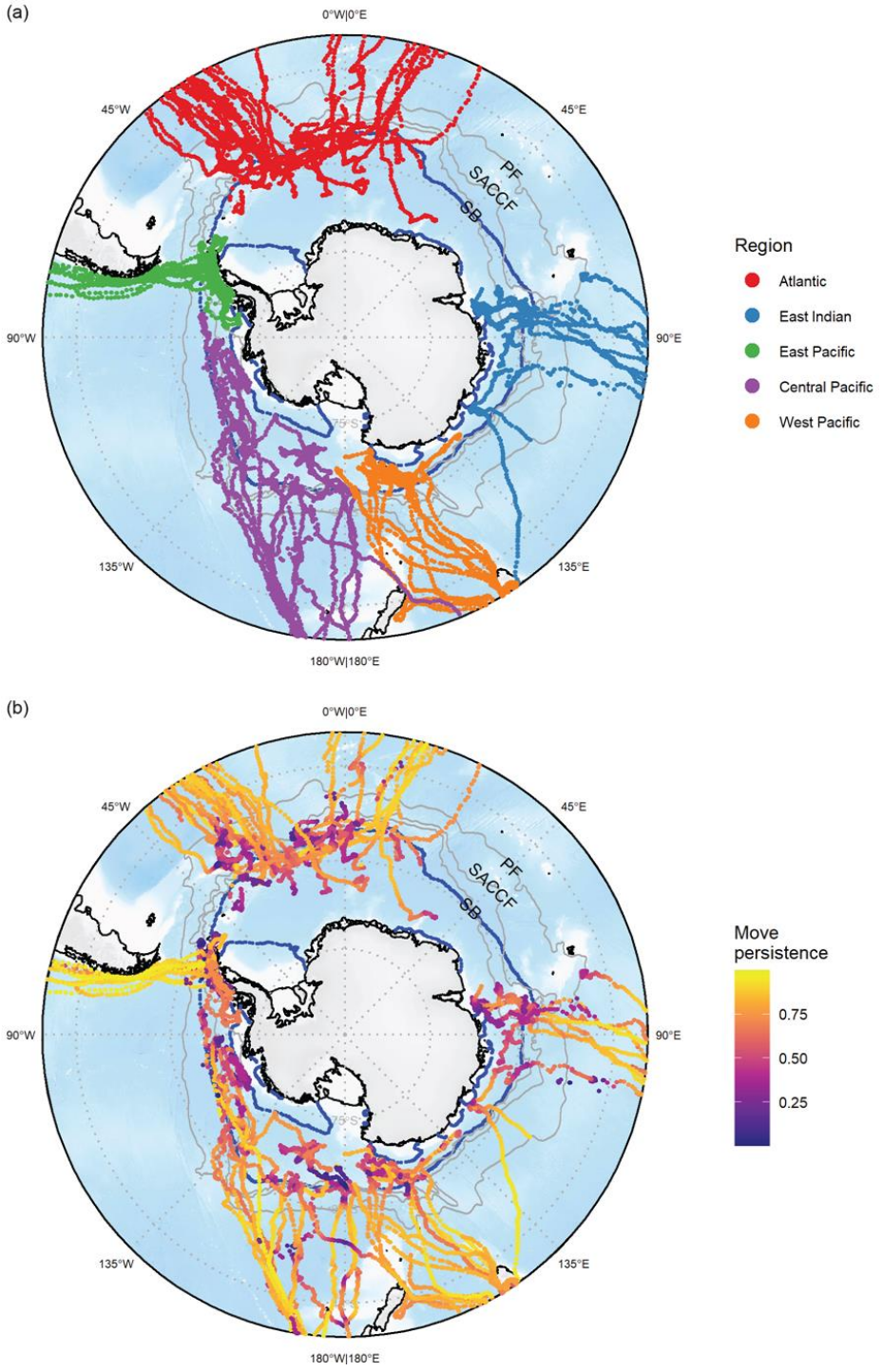

Figure 1 Humpback whale tracks (n = 162) in the Southern Ocean. A) shows how we assigned tracks to five regions. B) shows estimated move persistence along the tracks. Move persistence is estimated from a movement persistence model (Jonsen et al. 2019) fitted to state-space filtered tracking data. Move persistence captures autocorrelation in speed and direction. Higher values are associated with faster, straighter movements indicative of travel/transit, whereas low values are associated with slower, more tortuous movements indicative of area restricted search behaviour. Blue lines indicate the monthly median sea ice edge (1981-2010) in February (minimum extent) and September (maximum extent) (Fetterer et al. 2017). Grey lines indicate oceanographic fronts associated with the Antarctic Circumpolar Current; from north to south: Antarctic Polar Front (PF), southern Antarctic Circumpolar Current front (SACCF), southern boundary of the Antarctic Circumpolar Current (SB) (Park et al. 2019).

Is migratory connectivity of humpback whales in the Central and Eastern Pacific changing? A decadal comparison by DNA profiling (refer to IWC-SORP Project # 11, SC/68c/SHXX)

The DNA profiles of humpback whales from the South Pacific, spanning Breeding Stocks Ei – G, and Southern Ocean have been combined into a single, curated DNA register, representing more than 4,500 individuals (Table 2) with 626 samples pending importation and/or analysis. This includes samples from a range of Central and South America and Oceania breeding grounds, as well as remote migratory corridors such as the Kermadec Islands and Pitcairn Island. To date there have been 19 records of migratory interchange between the Central and Eastern South Pacific region and the Antarctic Peninsula (e.g., Caballero et al., 2020). There are no records of interchange with the inclusion of 130 individuals from Brazil suggesting low likelihood of connectivity between the Atlantic and Pacific regions.

Table 2. Additional DNA profiles now integrated into the existing DNA register of humpback whales for the South Pacific and Southern Ocean (Steel et al., 2018), with samples still pending profiling and analysis. Regions in bold are the focus of the proposed comparison. * indicates totals comprising both numbers of individuals and numbers of samples.

	Profiled individuals now		Samples still to be added		Total
Region	Years	individuals	Years	samples	
French Polynesia	**2006-2012**	**228**	**2013-16**	**197**	**425***
Panama	**2016**	**3**	**2017-19**	**196**	**199***
Pitcairn Islands	**--**	**--**	**2018**	**2**	**2**
Antarctic Peninsula	**2010-17**	**737**	**--**	**--**	**737^**
Colombia	**2015-18**	**137**	**--**	**--**	**137**
Ecuador	**2006-10**	**49**	**--**	**--**	**49**
A Samoa/Samoa	**2010-19**	**125**			**125**
New Caledonia	2006-12	644	--	--	644
Eastern Australia	2003-17	209	--	--	209
New Zealand	2008-18	202	--	--	202
Kermadec Islands	**2015-17**	**116**	**--**	**--**	**116**
Brazil	**1999-2011**	**130**	**--**	**--**	**130**
Total		2,580		442	2,975*

^Additional DNA profiles available from Antarctic Peninsula (2018 and 2019) through collaborative agreement with A. Friedlaender and L. Pallin.

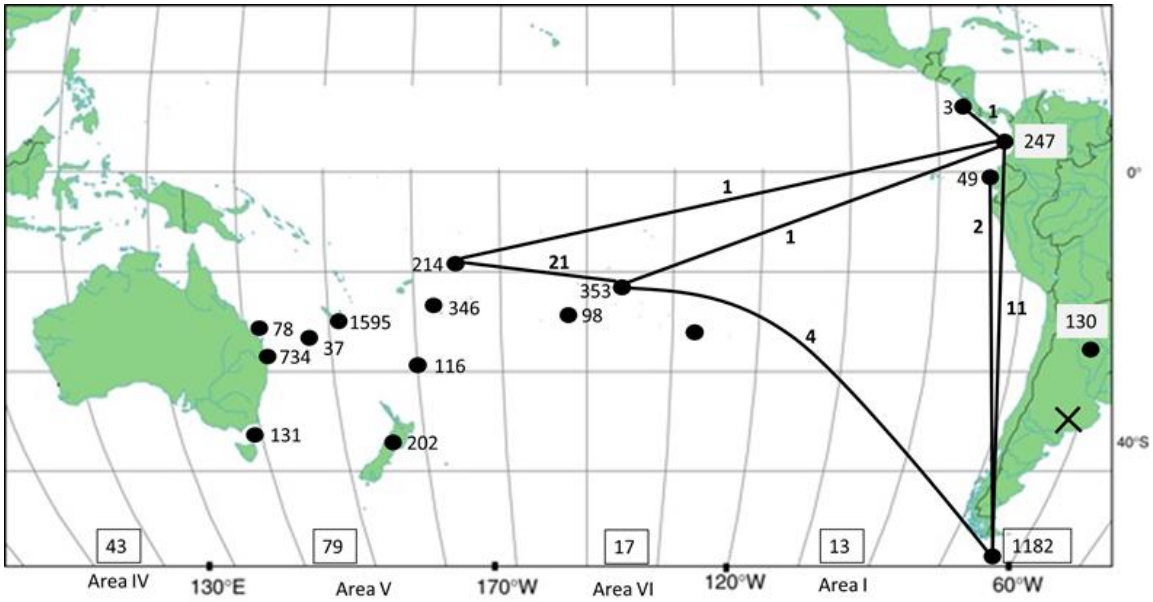

Figure 2 Migratory interchange between Breeding Stock G (Panama, Colombia and Ecuador) and the Antarctic, and interchange between the eastern Pacific and Oceania as documented through initial integration with the DNA register. Note, absence of any interchange with Breeding Stock A (Brazil), based on comparison of genotypes with IWC-SORP partner, Cypriano-Souza et al. (2017). Regional sample sizes are shown adjacent to locations, numbers of individuals moving between locations shown adjacent to lines connecting destinations.

Pregnancy rates in Southern Ocean humpback whales and the implications for population recovery across multiple populations (refer to IWC-SORP Project # 14, SC/68c/SHXX)

To date, analysis of progesterone levels in humpback whales on the breeding grounds (New Caledonia and American Samoa), migratory pathways (Kermadec Islands and mainland New Zealand) and feeding grounds (West Antarctic Peninsula and Ross Sea) are characterised by a high proportion of pregnant females (Figure 3). Research has focused on the ~1200 New Caledonia samples collected since 1995, with the 199 2016-2019 samples quantified and extracted. Preliminary analyses reveal patterns of progesterone, testosterone and oestradiol consistent with sex and age-class. A temporal analysis of hormone levels throughout the breeding season will inform interpretation of these hormone levels and facilitate comparisons with whales when on the Southern Ocean feeding grounds (see Pallin et al., 2018). These samples are primarily from the West Antarctic Peninsula but there are also samples from the Ross Sea region.

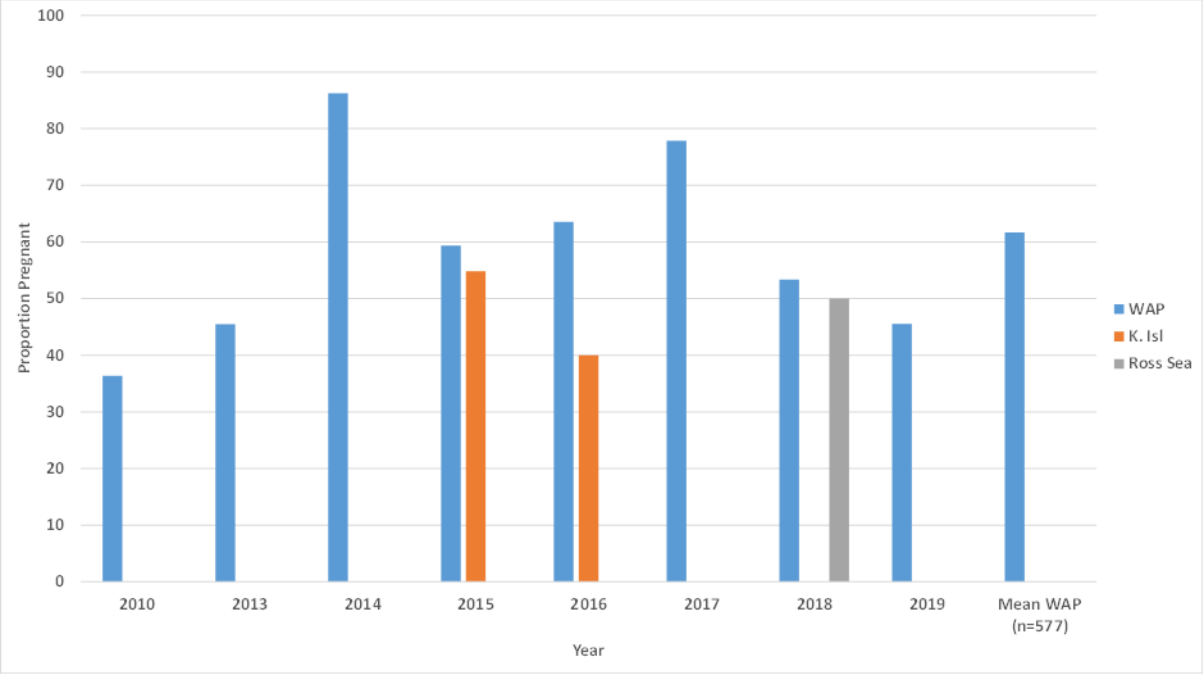

Figure 3 Inter-annual variation in the pregnancy rate of female humpback whales sampled along the Western Antarctic Peninsula (WAP), the Kermadec Islands, and in the Ross Sea.

Conclusions

The expansion of Phase 1 of the IWC-SORP project: Humpback Whale Connectivity has revealed the value of large-scale collaborative efforts to advance our understanding of whale distribution, behaviour, genetic connectivity and reproduction. In the case of Friedlaender, Constantine, Reisinger et al., (Project 16, SC/68c/SHXX) the work has expanded to other feeding grounds. The recovery of most southern hemisphere humpback whale stocks is encouraging but it is clear from the early findings from these research projects that habitat use, behaviour and calving success are variable by Southern Ocean region. How this variability will be affected by climate change is an important consideration for future research.

COVID-19 has slowed progress on these projects as is the case for most research. However, we have all the samples required and it is now a matter of people being able to undertake laboratory work and facilitate the physical movement of samples from one country to another.

Outlook for the future

We now have the opportunity for the Humpback Whale Connectivity research to move to another ocean basin. The circum-polar analysis of tag data establishes a platform upon which we can use changes in Southern Ocean productivity to understand the future mixing of stocks and movements of whales. The large, collaborative partnerships formed to date, alongside well established regional collaborations in other regions mean there is a bright future for data sharing and open access arrangements to inform management of humpback whales into the future.

IWC-SORP gratefully acknowledges the South Pacific Whale Research Consortium (SPWRC) for their substantial and collaborative contribution to this project.

Project outputs

Peer-reviewed papers

Andrews-Goff V, Bestley S, Gales NJ, Laverick SM, Paton D, Polanowski AM, Schmitt NT, Double MC (2018) Humpback whale migrations to Antarctic summer foraging grounds through the southwest Pacific Ocean. Scientific Reports 8:12333.

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Meeting presentations

An update on samples and preliminary results of migratory interchange was presented to regional collaborators at the 2019 meeting of the South Pacific Whale Research Consortium (Auckland, New Zealand, 4-6 February, 2019).

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ANNEX 5 – IWC-SORP THEME 5 PROGRESS REPORT – 2020/21. 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: Susannah Buchan[1], Franciele Castro[1], Ken Findlay[2], Danielle Harris[2], Brian Miller[4], Flore Samaran[5], Ana Širović[6], Fannie Shabangu[7], Kathleen Stafford[8], Ilse Van Opzeeland[9]

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Executive summary

Despite the global pandemic, 2020 was a surprisingly productive year for the Acoustic Trends Working Group (ATWG). The group conducted 7 intersessional meetings, some of which included members of the secretariat of the Southern Ocean Observing System. Group members contributed 13 papers, including in-prep, and in-press manuscripts and conference presentations. 2020 saw the addition of two new group members, conclusion of the first version of the IWC-SORP Annotated library of blue and fin whale sounds, the development of two different Deep Learning detectors for blue whale sounds, and completion of a framework for standardised circumpolar analysis of long-term data from moored recorders. The group has provisionally agreed on a 3-year work plan, but completion of this plan is contingent on securing additional funding. In 2020 group members retrieved 12 datasets of long-term recordings, and deployed 9 instruments to be recovered in future years. The ATWG has revised and formalised new Terms of Reference and Mission statement. One of the changes to the group's policies is that the group will broaden the spatial scope of its work to include the entire distribution range of Southern Hemisphere blue and fin whales. Previously the ATWG had restricted the scope of work to acoustic data south of 60°S. When taken together, the improved detection algorithms, standardised analysis framework, continued long-term data collection, and other work of the group represent a step-change in the ATWG's ability to deliver on the promise of using passive acoustics to monitor trends in Antarctic blue and fin whales throughout the Southern Hemisphere.

Introduction

The Acoustic Trends Project and Acoustic Trends Working Group (ATWG) was one of the original five IWC-SORP projects that commenced in 2009. The focus of this project has been to deliver on the promise of using passive acoustics to monitor and discover trends in Antarctic blue and fin whales. Blue and fin whales are well-suited to passive acoustic studies because they frequently make distinctive, loud, low-frequency sounds that can be detected over large distances. Since conception, group members have built capacity for passive acoustics through supervision of 5 students, development of novel analytical methods, and expansion of data collection efforts.

Objectives

In June 2020, the group reviewed previous objectives and the work plan that was developed at the 2017 Workshop in Bled, Slovenia. Broadly, the ATWG objectives fall into four output streams: generation of biological/ecological knowledge; development of methods and protocols; collection of data; and building capacity & strategic links for future work. Progress was made on all objectives (see Results section of this document for more details).

In 2020 the group developed a revised Mission Statement/Terms of Reference, and work plan, which we present in Appendix A. In brief the group's overarching objective/mission statement remains to "address key knowledge gaps for Antarctic blue whales and southern hemisphere fin whales using passive acoustics".

The group has identified four key knowledge gaps: 1). Distribution & occupancy 2). Population structure 3). Animal behaviour 4). Abundance & density estimation.

Results

Generation of knowledge

Miller et al. (in prep) analysed call-density of D-calls from blue whales recorded on sonobuoys during the 2017 Antarctic Circumnavigation Expedition. This survey was the largest longitudinal search for Antarctic blue whales in a single season since the end of commercial whaling. The density of D-calls was highest in Antarctic sectors of IWC management area VI (central Pacific sector of Southern Ocean), and this suggests that this poorly studied region may be of equal importance as other regions with historically high catch and sighting rates (e.g. Area III). Portions of the voyage with highest D-call densities were not the same those with highest D-call detection rates. This discrepancy was driven by spatially variable noise levels and detection ranges.

Method development

Annotated library

In 2020 the IWC-SORP funded Annotated Library of Blue and Fin Whale Sounds was completed, including both a publicly available dataset, and similarly titled peer reviewed publication (Miller et al. 2020, 2021). Standardised Framework.

Dr Franciele Castro joined IWC-SORP Acoustic Trends Project (ATP) as a post-doctoral scholar in April last year (Primary supervisor Buchan; co-supervised by Harris and Miller). Her work has been funded by IWC-SORP grant titled "A standardized analytical framework for robustly detecting trends in passive acoustic data: A long-term, circumpolar comparison of call-densities of Antarctic blue and fin whales" (see SORP grant report for details). She is working on addressing some long-standing shortcomings inherent in nearly all prior passive acoustic studies of ABW and fin whales, namely the challenges presented by incredibly variable noise levels and sound propagation that affect detectability of the blue and fin whale sounds.

The key advance of this framework is the focus on call-density instead of detection rates. The methods are based on Küsel et al., (2011) and have been adapted for long-range baleen whale calls (detailed in Harris, 2012). Call-density is more appropriate metric than detection rates because call density inherently accounts for the detection area, which can vary by orders of magnitude for blue and fin whale calls. The framework is agnostic to detector, instrument, call-type, and site – so if improved detectors or instruments are developed, the framework will directly benefit (e.g. improved precision, reduction in analyst time spent validating detections). Additionally, the framework allows us to robustly address and incorporate all of the sources of variability that are known to affect acoustic detections (detection range, instrument, site, noise, acoustic propagation, detector performance, etc). In simple terms, the output of the framework is a call density with associated error bars, and we believe this metric will be fit-for-purpose for meaningful comparisons and allow for robust statistical testing for trends/differences in call-density. Lastly, the exact relationship between call density and animal density still needs to be established for blue and fin whales in the Southern Ocean, but if that can be quantified, then the ultimate outputs may become animal density and abundance.

Improved detectors

Several group members have participated in projects with a goal of delivering improvements to detection algorithms. These include improvements to traditional or established signal processing techniques, and the implementation of newer machine learning algorithms, e.g. Deep Learning algorithms.

Under the scope of the AI for Good research lab (Microsoft), Kate Stafford, and Maelle Torterotot of Flore Samaran's lab, have been working with Microsoft engineer Ming Zhong on a deep learning approach to detect blue whale calls from the southern Indian Ocean for all four of the previously identified acoustic signals from

that region. This project used manual annotations from a small portion of audio recordings (350 hours of recordings) from the underwater hydrophones in the Indian Ocean to build a Siamese Network (SN) model to detect, classify, and count the calls from four acoustic song types. The Siamese Network is a class of neural network architectures that is used to find the similarity of the inputs by comparing its feature vectors. During the project, a Convolutional Neural Network (CNN) was also developed but SN outperformed the CNN with a 2% accuracy improvement in population classification and 1.7% - 6.4% accuracy improvement in call count estimation for each blue whale population. SNs appear to be an effective way to automatically mine large acoustic data sets for blue whale calls. The manuscript describing the approach is currently under review at the Journal of the Acoustical Society of America. Data from new datasets will need to be trained on the SN if the noise environment of the new data is dissimilar to that on which the SN was developed. Upon publication, the code to run the SN on other data sets will be made publicly available by Microsoft.

A postdoctoral scholar, Dr Jeppe Rasmussen, working for Ana Širović, worked on the development of machine learning detection and classification approach for automated extraction of blue and fin whale social calls (D and 40 Hz calls, respectively). The manuscript describing the approach is currently under review at the Journal of the Acoustical Society of America. The performance of both detectors was evaluated on recordings with high- and low density of calls and, when selecting for detections with high classification scores, they were shown to have precision ranging from 54%-57% with recall ranging from 72%-78% for 40 Hz and precision ranging from 62%-64% with recall ranging 70-73% for D calls. The precision of the second-step classifier was 98.8% for 40 Hz calls and 95.9% for D calls. While the initial development was not using the IWC-SORP annotated library, the testing of this new approach with that library will be straightforward and can ultimately lead to efficient extraction of blue and fin whale social signals from various data sets from the southern hemisphere.

Dr Maelle Torterotot, of Flore Samaran's Lab, worked on the adaptation of detection algorithm based on dictionary learning and sparse representation (Socheleau et al., 2018) to detect non- stereotyped blue whale calls (D-Calls). This Sparse Representation based Detector is particularly well adapted for the detection of D-calls, using dictionaries that take D-calls' time-frequency variability into account. The algorithm was tested on the OHASISBIO long term data set in the southern Indian Ocean. D-calls were detected at all sites, which extend from 24° S to 56° S, but the majority of the calls were detected at the two southernmost sites at 46° S and 56° S. We observed a latitudinal shift in their seasonal occurrence, with more D-calls detected in the north during austral autumn and winter and in the south during austral spring. The geographic occurrence of D-calls compared to that of songs indicates that blue whale acoustic behavior switches from song-intensive and sparse-D-call emission in the north to song-moderate and more intensive D-call emissions in the south. The manuscript describing the approach and results is currently under review in the journal Marine Mammal Science. While the study area extends beyond Antarctic waters, results could help to understand the global picture of blue whale song and D call occurrence and seasonal patterns in the southern hemisphere.

Automated methods are crucial to help processing long-term recordings of marine bioacoustics. To evaluate the efficiency of such methods, it is essential to develop large-scale annotated datasets in addition to the one developed by the ATWG. However, besides being laborious and resource intensive, recent studies have suggested that such a task could also be highly subjective with the generation of annotator specific errors. Paul Nguyen Hong Duc (Phd Student at Sorbonne University and Ensta Bretagne Flore Samaran's Lab) has investigated the question of inter-annotator agreement from a multi-annotator annotation campaign performed on a marine bioacoustics' dataset. After providing quantitative evidence of inter-annotator variability, this study investigates potential sources on both the user annotation practice and the annotation data and task to better understand why and how such variability occurs. Results reveal that the acoustic event type, the Signal-to-Noise Ratio of the acoustic event and the annotator profile are three examples of critical factors impacting the annotation results of a multi-annotator campaign.

Maximising the use of existing and new monitoring technologies

While fixed instruments are widely used, new technologies are becoming more prevalent for collecting acoustic data. Danielle Harris was a Co-PI and project manager for a 4-year international collaborative project funded by the US Office of Naval Research (ONR), ending in June 2019. The project investigated estimating cetacean population densities using underwater drones, specifically ocean gliders and the final results are currently being published. This year, a comparison of fin whale 20 Hz calls detected on ocean gliders and bottom-moored instruments was published (Fregosi et al., 2020). Further, an investigation into the potential of ocean gliders for use in distance sampling surveys (a standard method used to estimate animal population abundances and

densities) was conducted as part of the project. This was achieved by assessing the capabilities of gliders against the main assumptions of distance sampling, and used data from previous glider deployments, as well as simulation studies. This paper is currently in review at the Journal of Remote Sensing in Ecology and Conservation (Harris et al., in review).

In addition, the ATWG is interested in maximising the use of opportunistic and existing monitoring technologies. Ocean Bottom Seismometers (OBS), used to detect earthquakes, also detect blue and fin whales and are a great potential source of opportunistic monitoring data (e.g., Harris et al., 2013; Dréo et al., 2019). ATWG members are actively engaged in continuing research into the use of OBS for monitoring blue and fin whales. In the last year, a collaboration involving Danielle Harris (supported by ONR funding) published research relating to the estimation of fin whale vocalizing depth from OBS data (Pereira et al., 2020). Though the data were not collected in the Southern Ocean, a natural next step would be to see whether similar methods can be implemented in the Southern Ocean. Understanding the behaviour relating to call production, including animal depth when calling, is important information, which contributes to the density estimation methods framework.

Data collection in 2020

Antarctic data collection (>60°S)/Southern Ocean Hydrophone Network: 2019/20

The Australian Antarctic Division (AAD) recovered three moored recorders. Recovered instruments were located the Southern Kerguelen Plateau site which now has data from 2005, 2006, 2014-2020; the Dumont d'Urville site in collaboration with IPEV and ENSTA Bretagne, and this site now has long-term recordings made in 2006, 2018, 2019; and at a new site on the Scott Seamount in collaboration with NIWA. The AAD deployed AAD-Moored Acoustic Recorders at the South Kerguelen Plateau and Dumont d'Urville sites.

The AAD collected data from sonobuoys deployed during the AAD's 2021 krill survey voyage titled TEMPO. The study area of TEMPO spanned 55-80° E and 62°S to the ice edge. Sonobuoys were deployed at 30 nmi intervals during transit from Hobart to the study area, as well as every 30 nmi on during the Antarctic krill survey. The survey lines of TEMPO repeat the eastern half of the BROKE-West survey (Gedamke & Robinson 2010). No real-time analysis of sonobuoy data was conducted beyond ensuring that the sonobuoy recording system appeared to be functioning correctly.

Low-latitude data collection (<60°S) 2018/19

ENSTA Bretagne in collaboration with Institut Universitaire Européen de la Mer (IUEM) Géosciences Océan - UMR 6538 UBO-CNRS recovered 9 and redeployed 7 long term autonomous hydrophones in the Indian Ocean between 24° to 56° South and from 52° to 83° East. This network of hydrophones has been in place since 2009/2010.

Acousonde deployments on fin whale in Chilean waters

In 2019, the University of Concepcion, University of Washington, CEAZA and Ensta Bretagne started a new collaboration to investigate acoustic and foraging behaviour of blue and fin whale in Chile and the acoustic behavior of these species by deploying Acousonde loggers on whales. These tags provide acoustic recordings paired with accelerometer and time-depth data. A test pilot season occurred at the beginning of 2020 with 5 usable deployments on fin whales. The longest deployment revealed resting/socializing behaviors: the tagged whale remained mostly at the surface (maximum dive at 30 m depth) and produced calls in the presence of another individual. For the remaining deployments, whales were silent, foraging with lunge feeding events described through acceleration data between 150 to 230 m depth. At the beginning of 2021, a second field season period took place. Preliminary results include deployments on 12 fin whales and including one blue whale. These deployments will be used to provide cue rates for foraging blue and fin whales to add to the database of acoustic behavior that can be used for ultimately determining blue and fin whale densities from acoustic data.

Conclusions

The improved detection algorithms, standardised analysis framework, and continued long-term data collection, are each individually strong achievements. However, when taken together, they also represent a step-change in the ATWG's ability to deliver on the promise of using passive acoustics to monitor trends in Antarctic blue and fin whales throughout the Southern Hemisphere.

Challenges

While new detectors should improve the ability to obtain detection rates, the standardised framework for call density still requires an expert practitioner to operate. Thus, funding remains the major challenge for the ATWG and ATP. Participation in ATWG by most steering group members is conducted as an in-kind contribution. The group has increased capacity for acoustic analysis by training PhD students and employing Post-Doctoral fellows, however, additional funding is now required to fully leverage this increase in capacity for knowledge generation.

Outlook for the future

See the work-plan section in Appendix A for a high-level overview of work that will be conducted in the near future. Provided that the group can obtain sufficient funding, the next steps will be to begin to apply the new detection algorithms, and the standardised framework for call-density to circumpolar datasets to investigate and quantify any spatio-temporal trends in call density of blue and fin whale sounds.

Given the central importance of the standardized analytical framework postdoctoral project carried out by Dr Franciele Castro, ATWG is currently actively seeking funds for this work to continue for a further two years to apply the framework to all acoustic datasets in the Southern Ocean.

Project outputs

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Annex 5, Appendix A
IWC-SORP Acoustic Trends Working Group Terms of Reference 2020

Mission statement
Address key knowledge gaps for Antarctic blue whales and southern hemisphere fin whales using passive acoustics.

Key ecological research topics for Antarctic blue and fin whale acoustics

1. Distribution & Occupancy
2. Population-structure
3. Animal behaviour
4. Abundance

Integrated & multidisciplinary approach

Engineering	Statistical survey methods	Data collection	International collaboration
• Instrument design & integration • Detection, classification, localisation of sounds • Acoustic measurements of signals and noise • Leverage emerging platforms (drifters, gliders, USVs, vector sensors, acoustic tags, etc)	• Maximising value of acoustic data • Density estimation • Long-term population trends • Integration of passive acoustics with complimentary data streams (e.g. remote sensed data, visual observations from voyages, telemetry tags, photo ID, genetics)	• Maintain long-term decade-scale focus • Expand moored hydrophone network towards circumpolar Antarctic coverage and throughout mid & low latitudes of the southern hemisphere • Collect supplementary passive acoustic data where possible (e.g. on voyages, from tags, USVs, OBSs)	• Research with global focus (entire southern hemisphere) • Develop standards for collection, collaboration, and analysis of acoustic data • Provide advice on best and emerging practices

Terms
1. Group members will follow IWC-SORP ethos to create an integrated, collaborative consortium for non-lethal whale research. Group membership and leadership will be open, inclusive, and equitable.
2. The ATWG will maintain an integrated and responsive relationship with the Scientific Committee of the International Whaling Commission (IWC).
3. Research conducted by the ATWG will acknowledge contributions of the ATWG, IWC-SORP, and co-authorship will be offered to individual group members who have made substantial contributions to that research. Provision of datasets is usually considered a substantial contribution.
4. Projects undertaken by the ATWG will focus on questions that have a global/southern hemisphere focus and that cannot be addressed practically by a single partner.

Implementation
Implementation of ATWG objectives will occur via three broad themes:

1. analysis and interpretation of acoustic datasets from the Southern Ocean and southern hemisphere,
2. the development and implementation of an ongoing network of long-term circumpolar underwater listening stations, and
3. development of novel and efficient methods for standardized analysis of acoustic data collected in the Antarctic and sub-Antarctic

Specifically, the group will:

- Provide advice and support for maintaining and expanding the Southern Ocean Hydrophone Network.
- Establish linkages with existing and emerging programs of relevance to this working group.
- Convene focussed sessions at national and international meetings, and facilitate synthesis products, to increase the awareness of the scientific community to the importance of the activities and outcomes of this working group.

- Provide practical recommendations to guide and support passive acoustic data collection in Antarctic waters.
- Develop standardized passive acoustic data from different areas for accurate and efficient analysis and interpretation.
- Develop capacity for passive acoustic research via training and supervision of students and early career researchers

Participation

- Most group business is conducted via email, and via ad-hoc communication amongst group members for specific projects.
- At a minimum, the group also aims to meet quarterly via teleconference, to discuss ATWG business and provide updates for the whole group.
- Contributions (of data, expertise, logistical support, analytical support, funding, etc.) are welcome. To-date, most contributions to the group have been voluntary and in-kind.
- Sharing of data is highly encouraged, and the expectation is that sharing of data will be reciprocal where possible.

Work plan 2020-2023

A. Virtual Workshop/Conference: Latest research and new directions for Antarctic blue and fin whale acoustic trends (working title)
B. ATWG terms of reference and work-plan 2020-2023 (this document) submitted to IWC-SC meeting 68C (virtual meeting)
C. IWC-SORP funded project: *A standardized analytical framework for robustly detecting trends in passive acoustic data: A long-term, circumpolar comparison of call-densities of Antarctic blue and fin whales.*
    - Manuscripts describing the "Standardized analytical framework" will be written and submitted.
    - Seek funding to extend post-doc beyond Feb 2021
D. IWC-SORP funded project: *A comparison of acoustic population identifiers for fin whales off Chile and in the Southern Ocean: a passive acoustic monitoring approach for gaining insights into population structure*
    - Milestone 1 TBD
    - Milestone 2 TBD
E. IWC funded project: *Assessing regional variation in Antarctic blue whale regional song calls from mid-latitude sites in the Southern Hemisphere*.
    - Milestone 1 TBD
    - Milestone 2 TBD
F. Other work

Timeline

Milestone/output	**Estimated Date**
Virtual workshop: Latest research & new directions	Dec 2021
Standardized analytical framework manuscripts	Mar 2021
ATWG terms of reference and work-plan 2020-2023 (this document) submitted to IWC-SC meeting 68C (virtual meeting)	Apr 2021
Acoustic pop. ID for fin whales – milestone 1	Sep 2021
Acoustic pop. ID for fin whales – milestone 2	Mar 2022
ABW song variation in mid-lat – milestones	Mar 2022

ANNEX 6 – IWC-SORP THEME 6 PROGRESS REPORT – 2020/21. The right sentinel for climate change: linking foraging ground variability to population recovery in the southern right whale

Macarena Agrelo[1,2], C. Scott Baker[3], Anabela Brandão[4], Stephen Burnel[5], Doug Butterworth[4], Kris Carlyon[6], Emma Carroll[7], Claire Charlton[8], Simon Childerhouse[9], Fredrik Christiansen[10], Ass. Professor Rochelle Constantine[7], Justin Cooke[11], Prof Steve Dawson[12], Mike Double[13], Glenn Dunshea[14, 15, 16], Ken Findlay[17], Brittany Graham[18], Karina Groch[19], Darren Gröcke[20], Professor Robert Harcourt[21], Pavel Hulva[22,23], David Johnson[12], Natalie Kelly[13], Russell Leaper[24], Petra Neveceralova[23], Seth Newsome[25], Professor Larissa Rosa de Oliveira[26], Professor Paulo Henrique Ott[27], Professor Per Palsbøll[28], Will Rayment[12], Andrea Ross-Gillespie[4], Vicky Rowntree[29], Jon Seger[29], Mariano Sironi[29,2], Joshua Smith[30], Leigh Torres[3], Luciano O Valenzuela[31,32], Els Vermeulen[33]*, B. Galletti Vernazzani[34], Mandy Watson[35], Caroline Weir[36], Alexandre Zerbini[37]*

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Executive summary

IWC67 endorsed the IWC-SORP research theme 6: *The right sentinel for climate change: linking foraging ground variability to population recovery in the southern right whale*.

The specific objectives of the theme are to, 1) Increase our understanding of southern right whale foraging habitats and ecology; 2) Update our knowledge on southern right whale population dynamics in a comparative framework; 3) Pursue integration of health assessment indicators with long-term monitoring data; 4) Investigate the impact of climate variation at foraging grounds on population recovery

The Theme is led by Emma Carroll and Els Vermeulen, in close collaboration with colleagues from Argentina, Australia, Brazil, New Zealand and South Africa. Work has been undertaken against all four objectives including:

- Analyses and further collation of available stable isotope data
- Progress towards IWC-SORP funded project 'multi-ocean assessment of southern right whale demographic parameters and environmental correlates', including development of a southern right whale consortium, a common demographic model, collation of major datasets, and the creation of a common biological model)
- Undertaking regional and inter-regional assessments of health and body condition, including development of a global standardized visual health assessment protocol for IWC endorsement
- Further assessment of the location of contemporary SRW feeding grounds, and investigating climate variates for assessing links to demographics, health and foraging ecology

Introduction

The IWC-SORP Southern Right Whale Theme 6 was established at the 2018 following endorsement at IWC67. It aims to provide an over-arching research programme linking southern right whale population dynamics and health with foraging ecology, and assessing these linkages on a global scale. Its main goal is to leverage the existing long-term datasets from the primary wintering grounds with new knowledge on the species' foraging ecology and linkages between migratory habitats, with the ultimate goal of investigating the impact of past and future climate variation on right whale recovery.

There are currently two IWC-SORP funded projects that feed directly into IWC-SORP Theme 6, these include:

1. Circumpolar foraging ecology of southern right whales: past and present (SC/68a/SH11, SC/68b/SH05, Project 31, SC/68c/SHXX)
2. Multi-ocean assessment of southern right whale demographic parameters and environmental correlates (Project 30, SC/68c/SHXX).

This report provides a high level update on the progress of the two IWC-SORP funded projects under Theme 6, as well as progress made towards addressing the objectives under this theme that are not funded by IWC-SORP.

Objectives

The Objectives of IWC-SORP Theme 6 can be summarised as follows;

1. Increase our understanding of southern right whale foraging ecology
2. Update our knowledge on southern right whale population dynamics in a comparative framework
3. Pursue integration of health assessment indicators with long-term monitoring data
4. Investigate the impact of past and future climate variation at foraging grounds on population recovery

Results

Objective 1: Increase our understanding of southern right whale foraging ecology

During the 2018 IWC-SORP Call from Proposals, the first research project was funded under the auspices of IWC-SORP Theme 6, entitled, *Circumpolar foraging ecology of southern right whales: past and present* (see

SC/68a/SH11, SC/68b/SH05 and Project 31, SC/68c/SHXX for details). This project involves 21 researchers from 10 countries. Several updates from this project are available and include:

New collaboration on isoscape and assignment methods

The project welcomes the collaboration of Chris Somes (Biogeochemical Modelling, Helmholtz Centre for Ocean Research Kiel) and Hannah Vander Zanden (University of Florida). Chris Somes has provided monthly carbon and nitrogen isoscapes for the project, which come from modelling work he leads. Hannah Vander Zanden provides expertise on isoscape assignment methods for the project. Combined this provides key tools and techniques to move the project forward.

Stable isotope analyses

The lead researchers (Carroll, Valenzuela, Vander Zanden, Newsome, Torres) have completed the selection of 775 samples to include in the analysis, after considering isotopic incorporation rate and sampling date, age classes, and other factors (Table 1 and Figure 2).

Table 1 Summary of wintering ground of origin and age class of samples selected for isotope analysis.

Wintering ground	Adult	Cow	Juvenile
Argentina	35	131	46
Auckland Islands	251	130	0
Brazil	10	11	4
NZ Mainland	17	7	2
South Africa	5	60	4
Southeast Australia	21	8	2
Southwest Australia	9	19	3
Total	348	366	61

Pilot study on generating isotope data from historical bone samples provided good results. Three southern right whale samples produce collagen that gave good d13C and d15N isotope values. Concurrent genetic analysis on the samples was used for species ID (see Remedios et al. SC/68C/SH01).

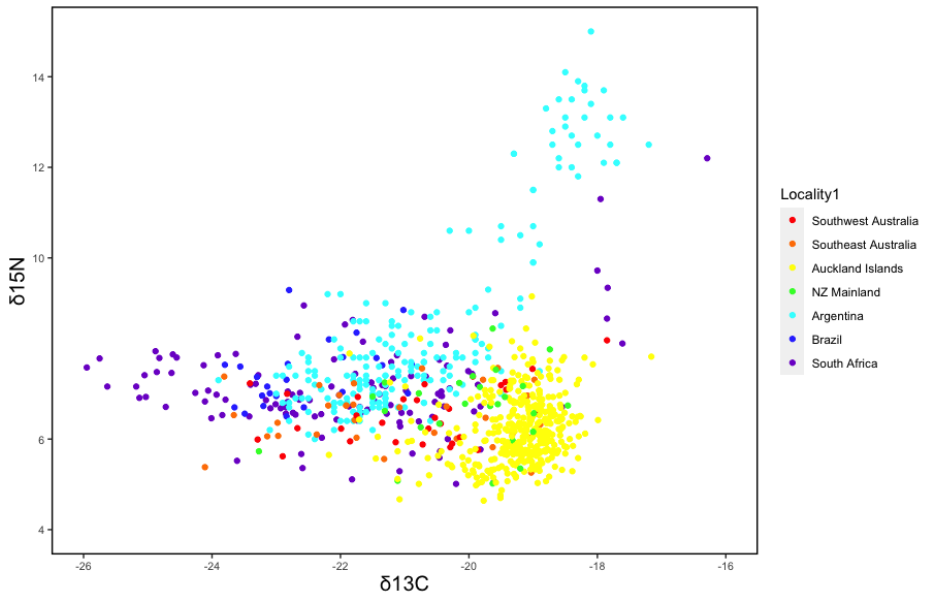

Figure 1 d15N and d13C values of samples selected for IWC-SORP southern right whale project isotope analysis.

Results of the stable isotope analyses of South African southern right whale skin biopsy samples, collected in the 1990s and 2010s, revealed a northward shift, and diversification, in foraging strategies over these two decades. This work was published in Global Change Biology in December 2020. From the abstract '*Bayesian mixing model results suggest that during the 1990s, South African SRWs foraged on prey isotopically similar to South Georgia/Islas Georgias del Sur krill. In contrast, in the 2010s, South African SRWs foraged on prey isotopically consistent with the waters of the Subtropical Convergence, Polar Front and Marion Island. We hypothesize that this shift represents a response to changes in preferred habitat or prey, for example, the decrease in abundance and southward range contraction of Antarctic krill. By linking reproductive decline to changing foraging strategies for the first time in SRWs, we show that altering foraging strategies may not be sufficient to adapt to a changing ocean*.' For the full paper please see van den Berg et al. SC/68c/SH/ForInfoXX and Figure 2.

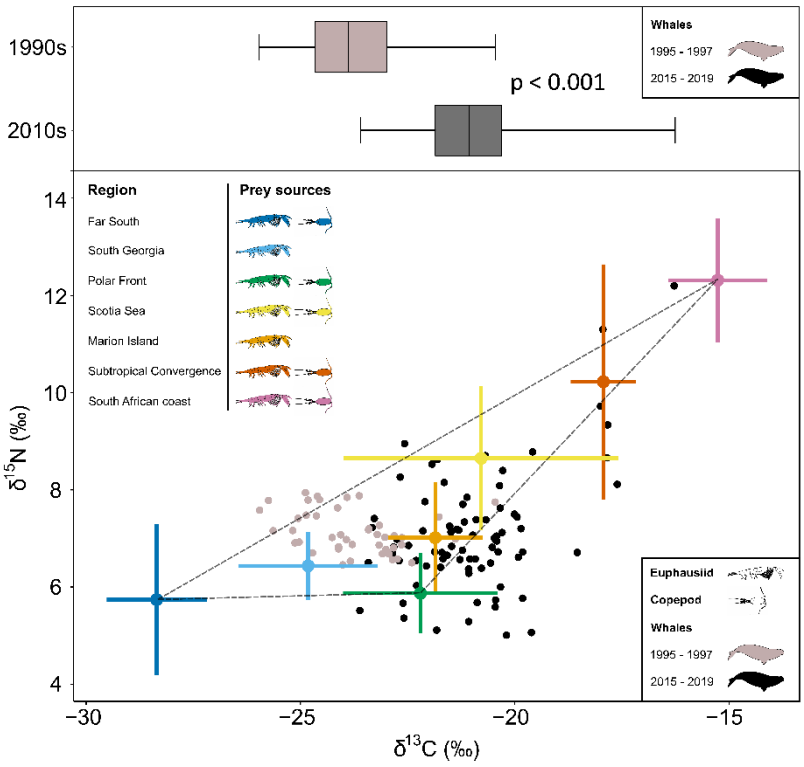

Figure 2 Top: Stable isotope values ($\delta^{13}C$) from 122 southern right whale skin biopsy samples, grouped per decade. Bottom: MixSIAR isotope mixing polygon (isospace) for mixing model 1 (M1) illustrating source (prey groups) and southern right whale isotope signatures. δ13C and δ15N values of southern right whale skin biopsy samples are grouped by decade (1990: grey dots, 2010: black dots). Each source is corrected for trophic level. Sources are colour coded by region and prey source composition is indicated by euphausiid and copepod clipart.

South Africa: Building on the above, 22 South African southern right whale baleen, stored at the Natural History Museum (IZIKO) of Cape Town, the Department of Environment, Forestry and Fisheries and the MRI Whale Unit, have been sampled at 2-2.5cm intervals for further analyses at the University of Pretoria. Although such analysis was meant to occur during 2020 with an international student at MRI Whale Unit, the COVID-19 pandemic has inhibited progress on this project. At present, national students have been assigned to the project and labs have reopened (with reduced chance of renewed closure). Therefore, stable isotope profiles will be assessed in the coming months in the scope of an MSc project, building on the results published by (Best and Schell 1996), and (van den Berg et al. 2021 SC/68C/ForInfoXX). Additionally, male (testosterone) and female (oestrogen and progesterone) hormonal profiles from these baleen will be assessed, as well as 14C profiles to assess the Oceanic 14C offset in the location of migrations.

New Zealand: A project that will use stable isotopes to investigate the foraging locations and diet of New Zealand southern right whale - tohorā began in 2021. The project will use samples collected from the Auckland

Islands from 1995 to 2020. The research will be done by MSc student Annabelle Cranswick and supervised by Emma Carroll, Rochelle Constantine and Seth Newsome.

Satellite tracking

COVID-19 permitting, discussions have resumed to commence satellite tracking of southern right whales on the South African breeding ground in 2021, to assess migration patterns and feeding distributions. For this, ethics and research permits as well as funding are in place.

Satellite tracking results of six southern right whales off Australia and New Zealand (range: 29 to 150 days) were published in Plos One, *Satellite derived offshore migratory movements of southern right whales (Eubalaena australis) from Australian and New Zealand wintering ground*, by Mackay et al. in 2020. No additional satellite tracking is currently funded for southern right whales off Australia, however it remains a key priority in the National conservation management plan to understand offshore movements and foraging ecology.

DNA metabarcoding

Euphausiid and copepod specific DNA metabarcoding of southern right whale scat from South Africa and New Zealand did not produce any meaningful results. As the methods and analysis did provide results for Bryde's and sei whale samples analysed concurrently, it suggests the whales were feeding on different prey items than previously suspected. The analysis will be repeated with universal metazoan (18S) primers and those that target a broad range of crustaceans, which will allow identification of prey not previously considered right whale food. The analysis was done by Emma Carroll, Richard O'Rorke and Laura Zantis at the University of Auckland and samples provided by Will Rayment, Otago University, and Stephanie Plön, Bayworld Centre for Research and Education (BCRE).

Auckland Island expedition

In August 2020, an 18 day expedition to the Auckland Islands Maungahuka, New Zealand sub-Antarctic, aboard the yacht *Evohe* was undertaken as the first of two field seasons to investigate the recovery and foraging ecology of Tohorā nō Aotearoa - New Zealand southern right whales. This is the continuation of genetic monitoring work on Aotearoa New Zealand SRW initiated by the University of Auckland in 1995, spanning the austral winters of 1995-1998 and 2006-2009.

Satellite transmitters were deployed on six adult southern right whales at the Auckland Islands Maungahuka (sub-Antarctic New Zealand) to investigate the migratory routes and offshore feeding grounds of the whales that winter in New Zealand. As of 1 March 2021, the tags transmitted for an average of 125 days (range: 40-209 days), although note that at the time of writing this report two tags were still transmitting. The tags provided data on long-distance migration for five of the tagged individuals, while one tag did not transmit long enough to capture migratory movements. Tracking data showed a general south and westward migration patterns, not obviously towards the assumed feeding grounds for New Zealand's SRWs located east and northeast of mainland New Zealand, but instead towards likely feeding areas south of Australia. The movement patterns of the tagged whales showed both individual variation and similarities between whales. While four individuals moved south and southwest after tagging, one whale initially travelled southeast to Campbell Island prior to migrating west, ending up traveling within a day and within few kilometres of another tagged whale. All five whales with migratory data moved towards similar areas south of Australia, however one individual (with a long tag duration) continued migrating to Antarctica. These findings better our understanding of the contemporary migratory routes and destinations of SRWs wintering in New Zealand waters, and reveal that this population inhabits vast extensions of the South Pacific, South Indian Ocean as well as the Southern Ocean and likely feed in the offshore waters south of Australia. These findings also have implications for catch allocation scenarios for SRW, as the east-west movement (up to 5800 km) suggests that catches in the Indian Ocean may have been linked to New Zealand breeding stocks. This work is discussed in IWC Report: Riekkola et al. SC/68c/SH02.

The eight-person research team collected 220 skin biopsy samples, 21 of which are linked to individual whales with photogrammetry measurements (i.e. length, width), deployed six satellite tags, and undertook drone surveys in the Port Ross area. The expedition found a relative increase in the proportion of cow-calf pairs in the area compared with previous years. This is likely due to the COVID-19-related delay in our survey, meaning the trip coincided with the previously described peak abundance of cow-calf pairs, and missed the peak abundance

of adult whales seen earlier in the season. Regardless, the importance of Port Ross to cow-calf pairs, the demographic class of SRWs most vulnerable to human disturbance, highlights the need for continued conservation and management of the region. Of the 220 skin biopsy samples, 210 provided genotypes that passed QC and represented 179 unique individual whales. Of these 179, 21 had been seen previously in the Auckland Islands, 1 in Campbell Island, 1 in mainland New Zealand, and 1 potential match was also made to New South Wales, Australia. There were 16 females recaptured across surveys in the Auckland Islands, two of which were seen as females with calves in all three decadal surveys. This work forms the basis of a planned close kin mark recapture study and stable isotope and satellite tag based investigation into foraging ecology of NZ SRW. This work is discussed in IWC Report: Carroll et al. SC/68c/SH03.

A project to collect new skin biopsy samples to use stable isotopes to investigate the foraging locations and diet of right whales in Santa Catarina State, southern Brazil, began in 2020. This is supported with funding from Petrobras, the Brazilian Oil Company, to Projeto Franca Austral/Instituto Australis. The project started to collect samples in September 2020, with 7 samples collected (from 4 females and 3 calves). The project will continue in 2021. The research is been coordinated by MSc Thaise Albernaz, and will be subject of her Doctoral research to be started in 2021.

Objective 2: Update our knowledge on southern right whale population dynamics in a comparative Framework

In 2018 (SC67b), a working group was formed and endorsed entitled, *Multi-ocean assessment of southern right whale demographic parameters and environmental correlates*, (see Project 30, SC/68c/SHXX). This project involves 22 researchers from 7 countries, and aims to compare population demographics across the main Southern Hemisphere wintering grounds, by applying a common demographic model to the populations in each region (South Africa, Argentina/Brazil, Australia, New Zealand), in order to eventually investigate correlations between reproductive success and environmental variables. The IWC-SORP funding proposal related to this WG, submitted in January 2020 (SC/68b/O01), was successful. Work has therefore been able to progress substantially, and various updates are available, including:

A Memorandum of Understanding is being finalized for the formation of a southern right whale consortium, in which partners agree to collaborate with the ultimate goal to generate scientific data on the species on a circumpolar scale, which would not be achievable by individual research groups, in the scope of the IWC-SORP Theme 6. The first project under this consortium relates to the collation of long-term photo-identification and sighting history datasets to allow for a comprehensive assessment of the global population status of southern right whales under a common statistical and biological model. For more information, please see Vermeulen et al SC/68c/PHXX.

Figure 3 Logo of the Southern Right Whale Consortium

Common SRW biological model

Specification of the common SRW biological model (common model) is largely complete. This will allow various demographic parameters (e.g. true calving intervals and their changes over time, population growth rates) to be estimated for the different SRW populations. This work was facilitated through holding a number of virtual intersessional meetings (approximately 1 per month). Major datasets have been provided for model input from Argentina/Brazil, Australia and South Africa. New Zealand dataset will be requested once model trials are complete for datasets from regions listed above. The draft common model is based on Cooke et al. (2001; 2015)

and Brandão et al. (2018). For more information see progress update of the relevant intersessional working group (Butterworth et al., Project 30, SC/68c/SHXX).

A desktop review is being conducted at present by an honours student, collating all published and available information on southern right whale sightings south of 40°S since between 1980 and 2020. The resulting database will assist in the identification of contemporary feeding grounds, and will be essential to further develop foraging ground habitat models and identify environmental variables to be compared between populations which show differences in their demographic parameters (strong vs weak recovery, strong vs weak fluctuations in calving output, etc.) as per Objective 4 of the IWC-SORP Theme 6.

Australasian Right Whale Photo Identification Catalogue (ARWPIC)

Significant progress was made to update the Australasian Right Whale Photo Identification Catalogue (ARWPIC), Managed by the Australian Antarctic Division with major Australian photo ID catalogues, and that the data contributes significantly to the IWC-SORP funded project, *Multi-ocean assessment of demographic parameters and links to climate variates*.

South African annual aerial survey

The South African annual aerial photo-identification survey was allowed to continue as planned, despite COVID-19 related restrictions. A total of 12 hours and 53 minutes of flight operations were required to complete the survey, of which 9 hours and 27 minutes were flown as search effort, and 3 hours 26 minutes were flown in transit to and from the survey start and end-points. In total, 67 cow-calf pairs of southern right whales (134 animals) and 31 unaccompanied adults were observed, leading to a total of 165 southern right whales. This the second-lowest number of cow-calf pairs along the South African coastline since 1986 (after the extreme low numbers of 2016 (55 pairs)). For unaccompanied adults, this marks the fourth-lowest count since the commencement of the aerial surveys. For more information, please see Vermeulen et al. SC/68c/SH04.

Flukebook

Flukebook successfully implemented multi-feature matching and new AI techniques for right whales in the past year. Multi-feature matching allows right whales to be matched by aerial photos of their heads (deepsense), lateral photos of their heads (Pose Invariant Embeddings), fluke photos (new CurvRank v2), and scarring on their peduncles (HotSpotter). This capability to apply new forms of AI and match an individual North Atlantic right whale from multiple poses and marks has then been successfully cross-applied to orcas and Southern right whales in Flukebook.

Falkland Islands /Islas Malvinas winter surveys

In the Falkland Islands /Islas Malvinas, two years of winter surveys have been completed, with small boat work running from June to August/early September. This work confirms the regular annual concentration of SRWs in this area, and provides novel data that an occurrence is maintained throughout winter season. In total, around 90 biopsy samples were collected and will be processed for genetic and stable isotope profiles. Additionally, >36,000 photo-ID images were collected, which are being catalogued. For more information, see Weir et al. SC/68c/SHXX. A Darwin funding application was submitted to satellite tag 10 southern right whales in the region in the next few years. Results of this funding application will be available in June.

Argentina and Brazil

Multi-states analysis for assessing movements rates between Península Valdés and southern Brazil: An analysis of photo-ID data to assess SRW movement rates between the main calving grounds in Argentina and Brazil was proposed by SH sub-committee during IWC SC 2020. We present a working plan to assess the dispersion and other population parameters of SRW between the two areas (Agrelo et al. SC/68c/SHXX). Considering the 124 matches of SRW individuals recorded at southern Brazil and Península Valdés between 1971 and 2017 (Rowntree et al. 2020, SC/68B/CMP/20), multi-states analysis will be applied to estimate the transition probability between regions, as well as to estimate region-specific survival and recapture probability. Models will include the effect of transients, heterogeneity in recapture probability and the influence of time on these parameters. The influence of covariates such as micropredation by kelp gulls at Península Valdés, breeding

success (high calf mortality) and density-dependent processes at Península Valdés (number of whales) on movement probability will be also addressed. The analysis will be done by Macarena Agrelo and Justin Cooke with the collaboration of Mariano Sironi, Victoria Rowntree, Karina Groch, Carina Marón and Florencia Vilches. Results will be presented in IWC/SC69 (2022).

Australian SRW photo-ID

Calf photo-IDs in have been collected in south west Victoria, Australia, using drones 2017, 2018, 2019 in effort to improve detection and understand movement and survival of calves born in this region. Catalogued in the South East Australian Southern Right Whale Photo-ID Catalogue (SEA SRW PIC) and ARWPIC.

Opportunistic photo-ID collection across southeast Australia continues via a citizen science project. We have an online portal for the public to lodge images and sightings data. The Portal is being re-branded this year as WhaleFace and will be promoted in the Australian states of Victoria, New South Wales and Queensland prior to this coming whale season.

South African mortality rates

In order to evaluate mortality rates of southern right whales in South Africa, the work of Best et al. (2001) and Best et al. (2011) was updated, collating all recorded SRW mortalities along the South African coast between 1999 and 2019, as well as all reported ship-strikes and entanglements which did not result in a mortality. Data showed a decrease in recorded mortality since 2010, in alignment with the decrease of sightings of SRWs along the SA coast. Data further showed that incidences such as ship-strikes and entanglements do not pose a major threat to the species in the country. Please see Vermeulen et al. SC/68c/SHXX for detailed information.

Objective 3: Pursue integration of health assessment indicators with long-term monitoring data

A global, standardised southern right whale visual health assessment protocol has been finalised and presented for endorsement at the present SC meeting (see Charlton et al. SC/68c/SHXX). The protocol builds on the visual health assessment completed by (Pettis et al. 2004) for North Atlantic right whales and Hörbst et al. (2018; SC/68A/SH/13) and includes visual health scoring indices (qualitative body condition, skin condition, predation marks and cyamids around blowhole).

A project is currently underway to compare the visual health of southern right whales from South Africa and Australia. To date, images have been sorted and extensive scoring undertaken to assess inter-scorer agreement. Upon endorsement of the IWC global, standardised southern right whale visual health assessment protocol, the scoring will be completed and analysis commence. A report will be prepared for IWC SC 2022.

Analysis of quantitative body condition of 51 South African right whales sampled in 2019 following the methods of Christiansen et al. (2018), has been delayed due to the personal impact of COVID-19 on the relevant master student. However, preliminary results of a comparison of these contemporary data to those whales measured in 1988 and 1989 by Best and Ruther (1992) suggests a decreased body condition over time. A full report will be presented to the scientific committee (SH) in 2022. Fieldwork in 2020 had to be cancelled due to COVID-19 restrictions and the low number of southern right whales on the South African breeding ground. Nonetheless, funding has been obtained to cover fieldwork costs of at least two more years of data-collection of southern right whale body condition, to allow for comparison of the different female cohorts.

The qualitative body condition photogrammetry study in Australia at Head of Bight was postponed in 2020 due to COVID-19 pandemic. The 5th research season will go ahead in 2022 with the overall objective to sample all breeding female cohorts and provide data for comprehensive analysis of southern right whale body condition and links to reproduction.

Planning is underway for a combined photo-ID and health assessment of SRW cows and calves in south-west Victoria during the 2021 season in collaboration with Deakin University involving monthly drone flights to capture adult and calf IDs as well as body condition parameters as per Christiansen et al photogrammetry methodology. Visual health indices as per the draft Global standardised protocol will also be collected.

Objective 4: Investigate the impact of past and future climate variation at foraging grounds on population recovery

Due to complications in the population demographic models, and the resulting lack of comprehensive estimates of expected calving output (and deviations), no progress has been possible in assessing possible linkages between South Africa's southern right whale reproductive success and Southern Ocean climate conditions and productivity. However, as such estimates have recently been produced, it is aimed to progress on this matter in the next few months, building on (van den Berg et al. 2018; SC/68a/SH12) and the existing knowledge of similar linkages found for the populations off Argentina and Brazil (Leaper et al. 2006; Seyboth et al. 2016). Similarly, a regional assessment is underway for Australian southern right whales to assess the links between increased mean calving intervals since 2015, and climate variates including Oceanic Niño Index, Antarctic Oscillation and Antarctic sea ice extent and productivity. As stipulated in Objective 4 of IWC-SORP Theme 6, the aim is that these data are eventually integrated into global models of population dynamics.

Aiming at linking climate change and SRW population dynamics, mark-recapture methods were applied to the sightings of individual SRW identified at Península Valdés, Argentina, between 1971 and 2017. Considering that El Niño events are projected to become more frequent and intense during the next 100 years, we used the relationship between El Niño and SRW survival to forecast how climate change would affect southwest Atlantic SRW population recovery throughout the 21st century. This work was developed by Macarena Agrelo, Fábio G. Daura-Jorge, Victoria Rowntree, Mariano Sironi, Philip S. Hammond, Simon N. Ingram, Carina Marón, Florencia Vilches, Roger Payne and Paulo Simões-Lopes as part of Macarena Agrelo's PhD thesis. The analysis is a collaboration between researchers from four countries, Argentina, Brazil, United States and United Kingdom. A paper reporting the results was submitted to a scientific journal and it is under review. The results will be included in the IWC-SORP Annual Report for IWC/SC69 (2022).

Conclusions

Despite the COVID-19 related hurdles which affected all research groups (see point 5 below), substantial progress has been made in SRW research globally in 2020, as reflected in this report. Our understanding of SRW foraging ecology, including changes over time, has improved, and progress was made in the collection of further skin and baleen samples, and satellite tracking data of SRWs in Australia and New Zealand. A common biological and demographic model was developed to improve our understanding of SRW population dynamics on a global scale, and the collation of photo-identification data continues. Projects have further developed to advance in our assessment of SRW health, including the development of a global standardised SRW visual health assessment protocol. Least progress was made towards the final objective of SORP Theme 6, which aims to link SRW population dynamics to climate change, although arguably previous steps will eventually contribute to this final objective as well.

Challenges

Fieldwork and funding has been inhibited and/or in many research sites due to the COVID-19 pandemic. Some of the most notable challenges are listed below:

1. Annual aerial survey in Argentina was not able to be conducted
2. Planned satellite tagging effort in South Africa was cancelled
3. Third stream funding in South Africa was reduced, limited boat-based fieldwork
4. Body condition photogrammetry field season in Australia was cancelled

Outlook for the future

The past year did not only result in progress towards data analyses, progress was also made in the collection of new data, the establishments of new collaborations as well as the submission of funding applications to ensure progress in the foreseeable future. Immediate advancement in various big milestones, which will aid the project substantially, is expected, including the development of carbon and nitrogen isoscapes, continued and new satellite tracking data, finalization and application of a common biological and demographic model and the endorsement of a standardised visual health assessment protocol. Funding is available to progress with various

of the IWC-SORP Theme 6 objectives, including through two related projects funded under IWC-SORP, and other needed funding will be sourced and/or (jointly) applied for.

Project outputs

Peer-reviewed papers

Charlton C, Bannister J, McCauley R, Brownell RL Jr, Ward R, Salgado Kent C, Burnell S (*In press*) Demographic parameters of Southern right whales (*Eubalaena australis*) off Southern Australia. Aquatic Conservation Marine and Freshwater Ecosystems.

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Media interest - South Africa

Date	Journal	Title
20200907	Cape Argus	Experts warn of ongoing threat to marine species
20200905	The Saturday Star	Expert's letter calls for action to save cetaceans
20200907	Independent online	Expert's letter calls for action to save cetaceans
20200914	PDBY	UP Whale Institute researcher organises open statement against marine life extinction
20200923	Conservation Magazine	Protecting Whales and Dolphins from Extinction: Call for Global Action
20200929	Cape Times	Surveying SRW in SA

20200929	Yiba	UP Whale Unot to gather data on dwindling southern right whale populations
20201002	RSG radio	Live interview with Gideon Van den Berg
20201002	Times Live	Whale numbers off SA down again as scientists warn of ecosystem turmoil
20201007	The Village News	Whale survey findings published
20201007	Hermanus times	Whale numbers down by half
20201014	Amazonanws (Pril)	Whales are washing up along Cape coast
20201014	Netwerk 24	Minder walvisse langs SA kus weens klimaat - opname
20201019	JuniorTukkie	2020 Annual Aerial Survey of southern right whales
20201019	Science at One	Interview - South African southern right whales
20201209	Cape Talk	Decline in whale migration is due to less calving and lack of energy, say UP researchers
20201209	Cape Times	Alarm over slump in number of visiting southern right whales
20201209	Amazonaws	Study tackles the decline in the migration of whales to South Africa
20201210	eNCA	TV interview - South Africa's southern right whales

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ANNEX 7 – IWC-SORP THEME 7 PROGRESS REPORT – 2020/21. Recovery status and ecology of Southern Hemisphere fin whales

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Executive summary

Currently, the fin whale theme effort focuses around the Antarctic Peninsula and Western Antarctic. Data from several research groups working around the Antarctic Peninsula and Scotia Arc region have been compiled for a joint analysis. To investigate distribution and abundance based on a very heterogeneous data set, a combination of a random forest model for abundance prediction adjusted by a maximum entropy probability of presence was successfully tested. This approach was able to handle the considerable share of opportunistically collected and presence-only data, providing reasonable predictions of fin whale distribution and abundance throughout the year. Currently, a few more data submissions are being expected, after which the final model runs will be commenced.

Two cruises to the Antarctic Peninsula region in 2018 (*RV Polarstern*) and 2019 (*Pelagic Australis*) were dedicated to investigating the repeatedly reported aggregations of fin whales around Elephant Island. Both expeditions re-encountered large aggregations of fin whales. A dedicated aerial survey during the *RV Polarstern* voyage estimated fin whale abundance in the area. High resolution footage of the aggregations was captured by a professional media team.

Visual inspection of high resolution aerial imagery of fin whales around Elephant Island revealed a generally good health status of fin whales with no signs for emaciation, severe injury or parasitic infestations. A high number of cookie-cutter shark bite lesions suggest migration of fin whales to latitudes lower than 40°S, providing first hints on migratory destinations.

A tagging initiative to deploy up to 13 SPLASH tags on fin whales around Elephant Island is being carried out aboard the *Pelagic Australis* at the time of writing this report.

Introduction

Southern Hemisphere fin whales (SHFW) were severely exploited and nearly depleted by 20th century commercial whaling. Until today, recovery rates of the population remain unknown. Fin whales have been the target of relatively limited research in the Southern Hemisphere over recent decades. Very little is known about their population structure, ecology, habitat use and migratory behaviour.

The fin whale theme aims to integrate different fields of fin whale research to work towards elucidating the population status of Southern Hemisphere fin whales in the post-whaling era. It aims to bring together information on population structure, migratory behaviour and destinations, current population numbers and feeding ecology.

Objectives

The Southern Hemisphere fin whale theme aims to bring together research results from past, current and future projects providing an opportunity for coordination, cooperation and joint outcome analyses. While little dedicated research has been conducted on fin whales in the Southern Hemisphere, several research groups have been collecting data on fin whales opportunistically during other research efforts. One objective of this theme is to collate these data from different groups and sources, and to analyse them together. Despite their value, these data will likely be limited in their scope and ability to be assessed quantitatively, mainly due to their opportunistic nature. Therefore, dedicated SHFW research is also required in particular to estimate SHFW abundance, to gain insights into population structure between oceans, to investigate ecological drivers of fin whale distribution and to understand their movement patterns and migratory pathways. The results from these

research efforts will be pulled together to enhance our understanding of current SHFW population status and recovery.
The specific objectives are:

1. Enhancing the understanding of distribution patterns and local abundance estimates of SHFW
2. Investigation of the population structure of SHFW
3. Identification of SHFW migration routes and migratory destinations
4. Understanding SHFW feeding ecology: drivers for fin whale distribution, spatial relationships between fin whale and krill distribution, prey selectivity

Results

Joint Data collection

Until now, a total of 5,542 fin whale records for were compiled from 12 different data holders / sources. Of these, 2,203 records were recorded after 1976, the cut-off point for the analyses of recent data, marked by the end of commercial whaling on fin whales in 1976 (Figure 1).

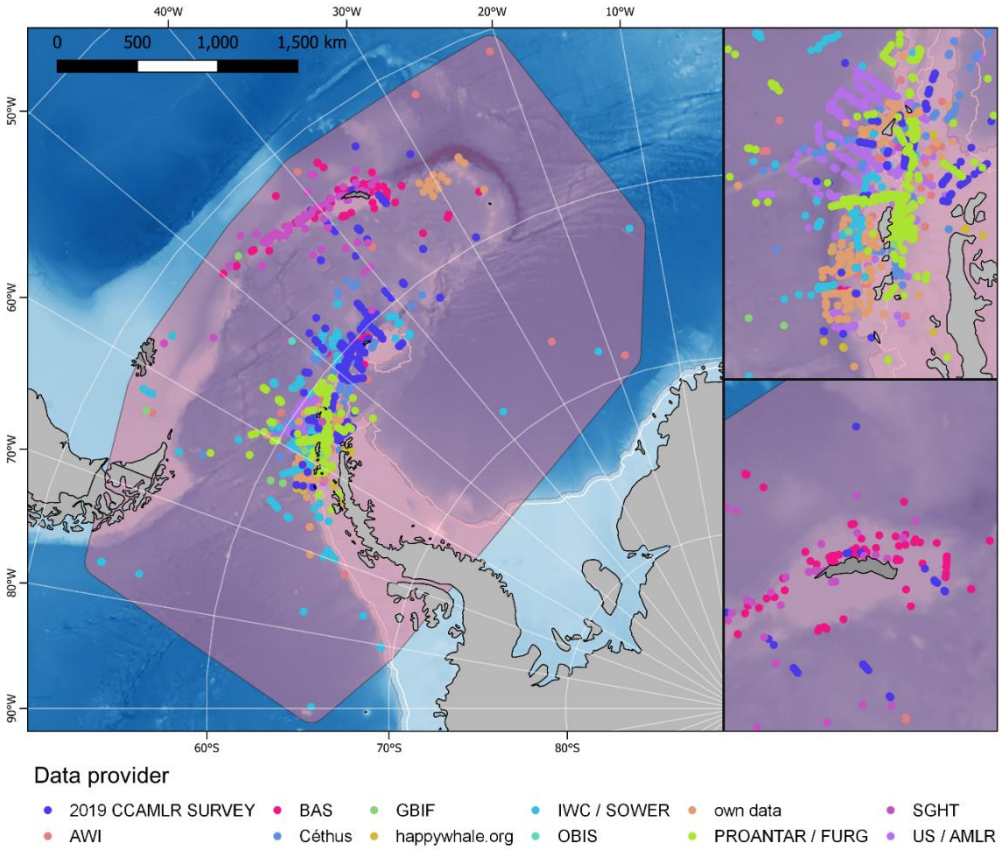

Figure 1 Distribution of sightings (after 1976) based on current data set. Inserts show maps around South Orkney Islands and South Georgia. The purple background indicates the preliminary study boundary (generated automatically by buffering the convex hull of records).

Using a combination of a random forest model for abundance prediction adjusted by a maximum entropy probability of presence, fin whale abundance and distribution was estimated per month (e.g. February, Figure 2, Table 1). This approach was able to handle the high share of opportunistically collected presence-only data and allowed for abundance estimation based on a very heterogeneous data set. Results are still preliminary and currently represent a proof of concept. A few more data sets have been announced to be submitted shortly. After their inclusion, a next iteration of the model will be run and results finalised.

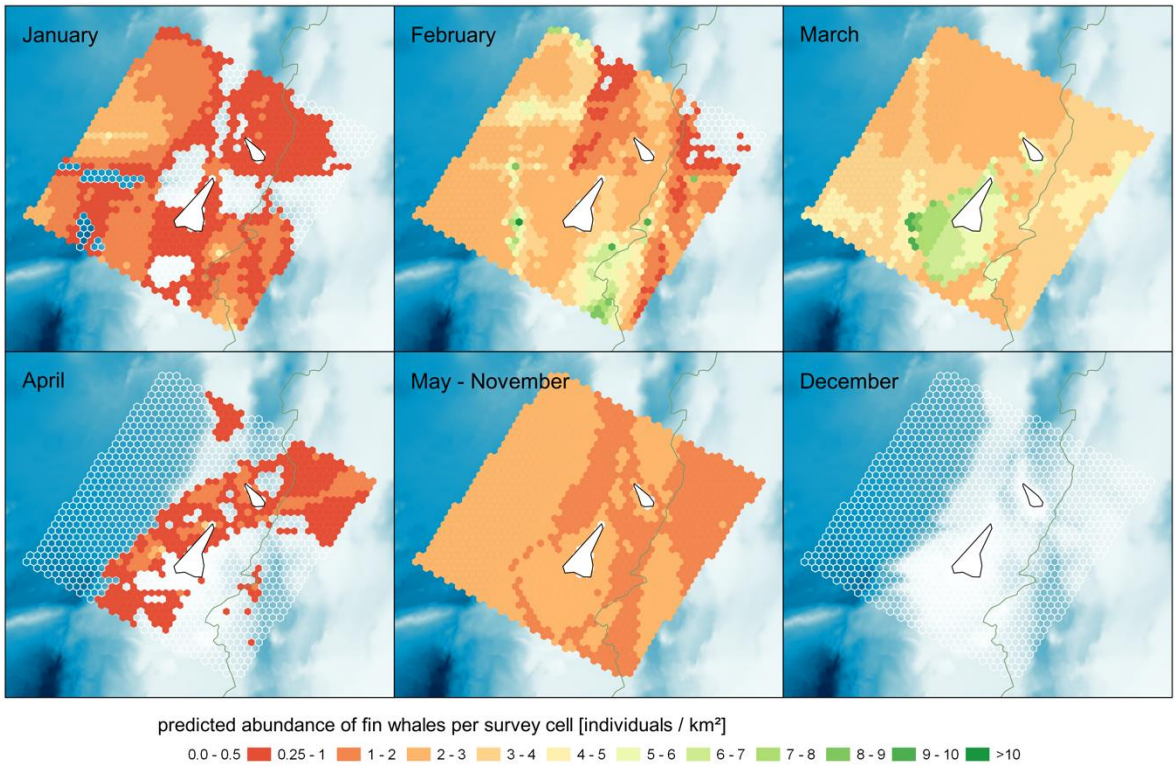

Figure 2 predicted number of fin whales per square kilometre around Elephant Island throughout the year. Estimates are based on simulated draws from MaxEnt models and random forest classifier.

Table 1 summary statistics on Elephant Island. $p_{occurence}$: median probability of occurrence from MaxEnt model for Elephant Island; $p_{non\text{-}random}$: median probability of soft hurdled probability of occurrence from MaxEnt for Elephant Island; I_{sum}: total number of predicted fin whales around Elephant Island; I per km²: average number of fin whales per square kilometre (average density of fin whales).

	$p_{occurence}$	$p_{non\text{-}random}$	I_{sum}	I per km²
Jan	0.7957	0.4387	1,207	0.4262
Feb	0.8285	0.4428	3,408	1.2035
Mar	0.9423	0.4549	4,664	1.6471
Apr	0.6144	0.3156	342	0.1207
May-Nov	0.7849	0.4549	2,599	0.9177
Dec	0.0911	0	0	0

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- Natalie Kelly, Australian Antarctic Division, Kingston, Tasmania, Australia
- Christian Reiss, NOAA Fisheries, La Jolla, California, USA
- Jarrod Santora, University of California, Santa Cruz, California, USA

- Eduardo Secchi, Universidade Federal do Rio Grande, Rio Grande, Brazil
- Claire Waluda, British Antarctic Survey, Cambridge, UK
- Fundacion Cethus
- South Georgia Heritage Trust

New data collections

Two expeditions in 2018 (*RV Polarstern*) and 2019 (*Pelagic Australis*) collected sighting records and video imagery of fin whales around the Antarctic Peninsula. A dedicated aerial survey during the *RV Polarstern* expedition estimated a minimum density of fin whales in the survey area at the tip of the Antarctic Peninsula of 0.0124 (CI 95% 0.001 – 0.0561) individuals / km^2. Densities concentrated in hotspots around the islands with estimated local densities of 0.0710 (0.0388 – 0.1475) individuals / km^2. During the two cruises, seven aggregations of 30+ fin whales were encountered, with the largest one numbering around 150 individuals. High resolution video imagery was recorded documenting the aggregations. These results have recently been submitted for publication.

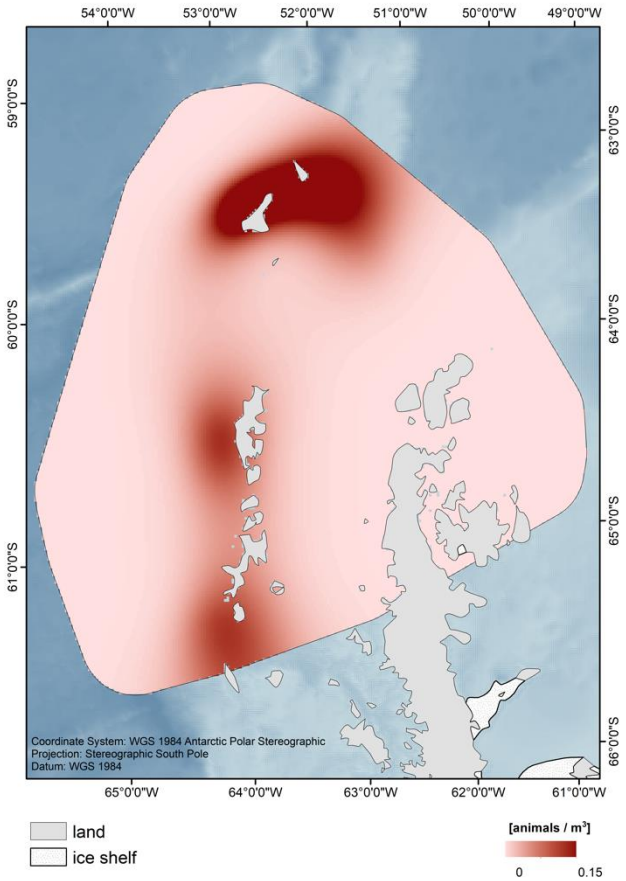

Figure 2 Prediction of fin whale distribution in the survey area. Fin whale distribution concentrated around the islands, with hotspots containing the majority of all predicted fin whales in the area.

High resolution aerial footage of fin whales collected during the *RV Polarstern* expedition was used to visually assess the body and skin condition of fin whales gathering at Elephant Island. Analysis revealed no serious health issues and a generally good health condition as can be judged by visual inspection. About two thirds of the inspected fin whales had cookie-cutter shark (*Istius* spp.) bite lesions. With cookie-cutter shark distribution restricted to tropical and subtropical warm waters, these findings provide first hints to migratory destinations of fin whales feeding at Elephant Island. These results are currently under revision for publication.

At the time of writing this report, an expedition (*Pelagic Australis*, project FinEphant) was underway to deploy SPLASH tags on fin whales to obtain data on movement and behaviour of the animals gathering at Elephant Island.

Conclusions

As the youngest of all IWC-SORP themes, the fin whale theme is still comparably small in regards of number of projects contributing. However, ongoing research and first results are very promising. The joint data analysis demonstrates the power of scattered data collected by different research groups, if looked at together. The compilation now constitutes the first and largest harmonised data set of fin whale sightings in the Southern Ocean. In addition, the data call and communication among all data contributors managed to identify a group of active fin whale researchers and created a reliable network for future efforts to progress our knowledge on Southern Hemisphere fin whales.

Outlook for the future

Ongoing tagging activities provide a promising outlook for the coming year. Hopefully we will be able to track the movements and to analyse the behaviour of several fin whales tagged at Elephant Island. Furthermore, the joint data evaluation will be finalised this year, providing us with an overview of fin whale distribution and abundance in the wider Antarctic Peninsula and Scotia Arc region. Altogether, the next year looks promising for some gain in knowledge on fin whales feeding at the Antarctic Peninsula.

Project outputs

Peer-reviewed papers

Herr H (2020) Rückkehr der Finnwale in die Antarktis - 30 Jahre nach Beendigung des kommerziellen Walfangs (Return of the fin whales to Antarctica). Biologie in unserer Zeit 50(5): 338-345. https://doi.org/10.1002/biuz.202010716

Herr H, Viquerat S, Naujocks T, Gregory B, Lees A, Devas F (*Submitted*) Life-history features of Antarctic fin whales documented by high-resolution aerial footage. Mammalian Biology.

Herr H, Viquerat V, Lees A, Wells L , Devas F, Gregory B, Meyer B (*Submitted*) Fin whale feeding aggregations at the Antarctic Peninsula suggest onset of population recovery 35 years after the end of commercial whaling in the Southern Ocean. Proceedings of the Royal Society B.

Reports

Herr H, Viquerat S, Kesselring T, Krieger C, Gischler M, Zillgen C, Richter R, Santos V (2019) Large whale distribution around South Georgia and the South Sandwich Islands in the post-whaling era. In: Bohrmann G (Ed) The Expedition PS119 of the Research Vessel POLARSTERN to the Eastern Scotia Sea in 2019. Berichte zur Polar- und Meeresforschung (= Reports on polar and marine research) Bremerhaven, Alfred Wegener Institute for Polar and Marine Research, 736, 236 p. doi: 10.2312/BzPM_0736_2019

Conference presentations

Herr H, Viquerat S, Lees A, Devas F, Meyer B (2019) Return of the fin whales: Feeding aggregations of fin whales around the Northern Antarctic Peninsula (oral). World Marine Mammal Conference 2019, 9-12 December, Barcelona, Spain.