Report of the Scientific Committee

Bled, Slovenia, 24 April-6 May 2018

Annex H

Report of the Sub-Committee on Other Southern Hemisphere Whale Stocks

**This report is presented as it was at SC/67b.
There may be further editorial changes (e.g. updated references, tables, figures) made before publication.**

International Whaling Commission

Bled, Slovenia, 2018

Annex H

Report of the Sub-Committee on Other Southern Hemisphere Whale Stocks

Members: Jackson (Convenor), Andriolo, Archer, Baker, Branch, Brandão, Brierley, Brownell, Burkhardt, Buss, Butterworth, Carroll, Castro, Cerchio, Charlton, Cholewiak, Clapham, Collins, Cooke, Coscarella, Crespo, Cubaynes, Dalla Rosa, de la Mare, Di Tullio, Double, Elwen, Fortuna, Galletti Vernazzani, Iñíguez, Irvine, Ivashchenko, Kato, Lang, Lauriano, Leaper, Lundquist, Mallette, Matsuoka, Minton, Øien, Olson, Pastene, Reyes, Rodriguez-Fonseca, Sironi, Širović, Taguchi, Taylor, Torres, Torres-Florez, Vermuelen, Weinrich, Yoshida, Zerbini.

1. INTRODUCTORY ITEMS

1.1 Convenor's opening remarks

Jackson welcomed participants.

1.2 Election of Chair

Jackson was elected Chair, with co-Chair support from Olson.

1.3 Appointment of rapporteurs

Carroll, Clapham and Buss undertook the duties of rapporteuring.

1.4 Adoption of Agenda

The adopted agenda is given in Appendix 1.

1.5 Review of documents

Documents identified as containing information relevant to the sub-committee were: SC/67b/SH01-24, SC/67b/PH01-02, SC/67b/PH04, SC/67b/ASI07, SC/67b/SP08, Riekkola *et al.*, (2018), Carroll *et al.*, (In press), Attard *et al.*, (2018), Miller and Miller (2018), Charlton *et al.*, (In prep), Bedriñana-Romano *et al.*, (2018).

2. IWC-SOUTHERN OCEAN RESEARCH PARTNERSHIP

SC/67b/SH21 reports on the activity of the Southern Ocean Research Partnership (IWC-SORP) since SC/67a. Progress on the five primary IWC-SORP science themes (SC/67b/SH21, Annexes 1-5) is summarised below:

SC/67b/SH21 Annex 1 described progress on the '*Antarctic Blue Whale Project*'. The objective of this project is to improve understanding of the status of Antarctic blue whales following exploitation, to investigate the role of these whales in the Antarctic ecosystem, and to measure the circumpolar abundance of Antarctic blue whales and their rate of recovery from whaling. Over the last year, the project cooperated on a voyage to the western Antarctic Peninsula led by Argentina which generated sightings and acoustic information for several cetacean species.

Analysis of data from the 2015 New Zealand-Australia Antarctic Ecosystems Voyage (Double *et al.*, 2015) was conducted to describe the distribution of Antarctic blue whales in relation to their main prey species, Antarctic krill. Results suggest that Antarctic blue whales are more likely to be present within the vicinity of krill swarms detected at night, those of higher internal density, greater vertical height, and those found shallower in the water column (SC/67b/EM06).

Matching of new photographs of Antarctic blue whales contributed to the Antarctic Blue Whale Catalogue yielded a total of 17 new identifications, bringing the total number of photo-identified Antarctic blue whales up to 458 whales, represented by 342 left sides and 332 right sides (SC/67b/PH02; SC/67b/SH08).

Data from research voyages are augmented with sightings information from ships of opportunity which are contributed to the online reporting system: *www.marinemammals.gov.au/sorp/sightings*.

Ongoing analyses of beached blue whale bones are contributing to an assessment of genomic diversity and population differentiation of historical Antarctic blue whales (SC/67b/SH02). Further sub-committee discussion of this project is given in Item 3.2.

SC/67b/SH21 Annex 2 reviewed progress on the project to identify the 'Distribution, relative abundance, migration patterns and foraging ecology of three ecotypes of killer whales in the Southern Ocean'. Analysis has been completed on the extensive collection of killer whale photographs from McMurdo Sound and the status of type C killer whales documented (Pitman *et al.*, 2018). Field work around the western Antarctic Peninsula used an unmanned hexacopter to collect high resolution vertical images of all three ecotypes of killer whales (Type A, B1 and B2) found in the Peninsula area. In addition to morphometric data, these images will be used to assess health and body condition of individual killer whales. Examination of photographs of B1 and B2 killer whales 2016-2018 revealed individuals in surprisingly poor body condition. The hexacopter was also used to collected vertical images and blow exhalate samples from humpback whales (n=21) and, in a world first, Antarctic minke whales (n=7). Biopsy samples were collected from nine type B2 killer whales, one type B1 killer whale, 11 humpback whales and two Antarctic minke whales.

Analysis of data from Terra Nova Bay, Ross Sea, is underway to assess the dynamics and role of ecotype C killer whales in this highly local productive marine ecosystem.

The project cooperated on a voyage to the western and northern Antarctic Peninsula led by Brazil which generated sightings information. 1,903 photographs were taken for individual identification. At least 56 Type A individuals and over 140 individuals of both Type B1 and B2 have been identified to date.

Building on, and set within, the long-term killer whale research at sub-Antarctic Marion Island, research on the movement and foraging ecology of killer whales is ongoing. Genetic analysis of biopsy samples (n=66), in conjunction with photo-identification association data (90,000 images; 63 individuals identified), has shown that Marion Island killer whales form small, fairly stable social units. Over a period of 5 years, 32 satellite tags were deployed and these have revealed seasonal site fidelity as well as rapid, long-distance movements and deep diving over seamounts.

SC/67b/SH21 Annex 3 summarised progress on the project to determine 'Foraging ecology and predator-prey interactions between baleen whales and krill: a multi-scale comparative study across Antarctic regions'. Between 1 January and April, 2018, a constant presence and active research were maintained around the Antarctic Peninsula. Effort focused on deploying reusable video-recording suction cup tags on both humpback (10 deployments) and Antarctic minke (10 deployments) whales, measuring prey and sea ice, and using UAS to generate estimates of body condition and animal size.

LIMPET-SPLASH tags were deployed on 13 humpback whales and one Antarctic minke whale. Regular echo sounder surveys of krill abundance were performed to allow the local abundance of whales to be related to changes in the availability of prey locally. Analyses describing the migratory behaviour and patterns of baleen whales from the west Antarctic Peninsula continue (SC/67b/EM04; SC/67b/07; Riekkola *et al.*, 2018; de la Mare *et al.*, In press). Further Scientific Committee discussion of this project is given under Item 3.2 in Annex L.

IWC-SORP sincerely thanks One Ocean Expeditions, WWF-Australia, the Antarctic and Southern Ocean Coalition (ASOC) and the Hogwarts Running Club for their contributions to fieldwork and financial support of tagging and analyses during the 2017/18 season.

SC/67b/SH21 Annex 4 reported progress on the project to 'Determine the distribution and extent of mixing of Southern Hemisphere humpback whale populations around Antarctica'. The focus of the 2017/18 research was five-fold: (1) Opportunistic genetic and photo-identification of whales migrating past the Kermadec Islands on their southern migration (Riekkola *et al.*, 2018); (2) a 2017 pilot trip to Fiordland, southwest New Zealand to identify the breeding ground origins of whales on their southern migration; a 2018 multi-disciplinary voyage to the Ross Sea region feeding grounds to collect photo-identification images and biopsy samples of humpback whales; (3) a voyage to the Chesterfield-Bellona archipelago to genetically identify individuals and determine genetic linkages to assess the origin of the whales (SC/67b/SH17; SC/67b/SH21 Annex 6); and (4) two surveys on the Great Barrier Reef breeding ground complex to genetically profile this breeding stock and determine genetic linkages to Oceania (SC/67b/SH18). The outcomes of the research will allow for an improved understanding of the structure and status and migratory paths and feeding grounds of the Oceania humpback whales, will result in an improved assessment of status, and lead to better estimates of pre-whaling abundance and assessment of recovery.

IWC-SORP gratefully acknowledges the South Pacific Whale Research Consortium (SPWRC) for their enormous contribution to and continued collaboration on this project. As well as 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), the New Caledonian Government, the Ministère de la Transition Ecologique et Solidaire, the World Wildlife Fund for Nature, and Opération Cétacés.

SC/67b/SH21 Annex 5 summarised progress on the project to measure 'Acoustic trends in abundance, distribution, and seasonal presence of Antarctic blue whales and fin wales in the Southern Ocean'. In 2017/18 the Acoustic Trends Working Group conducted high-level review of the project work completed to date and synthesised a three-year work plan focused on continuation and expansion of long-term data collection, and development of novel, efficient, and standardised analysis of acoustic data collected in the Antarctic. Standardised analysis methods include the creation of an Annotated Library that will be completed this year (SC/67b/SH18).

Three autonomous recording devices were deployed in the Southern Ocean at three different recording sites, and two previously deployed autonomous recorders were recovered (data volume of approximately 18,000 hours of underwater sound). A number of autonomous recorders have also been deployed at low and mid-latitudes in the Indian, Atlantic, and Pacific oceans, and the data from these instruments are expected to value-add and supplement those from the Southern Ocean Hydrophone Network (SOHN). In December 2017, the IWC-SORP Acoustic Trends Working Group became a Capability Working Group of the Southern Ocean Observing System (SOOS), and presented our work to members of the International Quiet Ocean Experiment (IQOE). This marks the first official joint IWC-SORP/SOOS working group.

Overall, IWC-SORP projects have produced 126 peer-reviewed publications to date and 125 IWC-SORP related papers have been submitted to the Scientific Committee, 22 of which have been considered by the IWC Scientific Committee this year. Moreover, a substantial amount of vessel time has been granted to IWC-SORP researchers this year and for 2019.

SC/67b/SH18 provided an update on funds allocated from the IWC-SORP Research Fund in 2016. £144,058 GBP were allocated to 10 projects during an open, competitive grants round. Details of these allocations and project progress reports are presented in SC/67b/SH18.

A full financial report of the IWC-SORP Research Fund can be found in SC/67b/01. £641,828 GBP remain unallocated and unspent in the fund. A new Call for Proposals was opened in 2017. Nineteen research applications were received. An independent assessment process, endorsed by the Scientific Committee last year and detailed in Appendix 1 of IWC (2018c), was undertaken. The proposed allocation of funds to successful projects will be presented to the Scientific Committee for endorsement. Endorsement of the agreed allocation will then be sought from the F&A Committee prior to IWC/67. IWC-SORP sincerely thanks all contributors to the IWC-SORP Research Fund for their voluntary contributions.

The sub-committee expressed considerable appreciation to Bell and others administrating IWC-SORP and **commended** the hard work involved in the coordination and execution of the project. It was agreed that the SORP project has continued to be extraordinarily productive in terms of the broad increase in knowledge and the number of refereed publications resulting from the many studies that IWC-SORP has supported. The sub-committee recognised that IWC-SORP's fostering of numerous collaborations across a wide area has become a model for shared scientific endeavours and for a broader scientific vision in the Southern Hemisphere and elsewhere, and **strongly encouraged** that the project be continued.

Several papers arising from projects which have been supported with IWC-SORP funds were available for the sub-committee to review, including Miller and Miller (2018) which was not discussed due to insufficient time.

Riekkola *et al.,* (2018) combined innovative analytical tools to assess the distribution and population structure of *Megaptera novaeangliae* throughout their migratory range. Using genotype and photo-identification matches, they conducted a genetic mixed-stock analysis to identify the breeding ground origins of humpback whales migrating past the Kermadec Islands, New Zealand. Satellite tracking data and a state-space model were used to identify the migratory paths and behaviour of 18 whales. Additionally, they conducted progesterone assays and epigenetic aging to determine the pregnancy rate and age-profile of the population. Humpback whales passing the Kermadec Islands did not originate from a single breeding ground, but instead came from a range of breeding grounds spanning ~3,500km of ocean. Surveyed whales ranged from calves to adults of up to 67 years of age, and a pregnancy rate of 57% was estimated from 30 adult females. The whales migrated to the Southern Ocean (straight-line distances of up to 7,000km) and spanned ~4,500km across their Antarctic feeding grounds. All fully tracked females with a dependent calf (n=4) migrated to the Ross Sea region, while 70% of adults without calves (n=7) travelled east to the Amundsen and Bellingshausen Seas region. Their results indicate a population recovering from exploitation, and their feeding ground distribution serves as an indicator of the resources available in these environments.

SC/67b/SH17 presents results from the first large-scale multidisciplinary surveys of the Chesterfield-Bellona archipelago. The Chesterfield-Bellona archipelago is a vast reef complex located halfway between the East Australian coast (BSE1) and New Caledonia (BSE2). It was one of the primary whaling sites in Oceania during the 19th century. Surveys were conducted in 2016 and 2017, combining observations at sea through line-transects and focal-follows, genetics, photo-identification, acoustics and satellite tracking. Humpback whales were observed in both years, showing behaviours typical of a breeding/nursing area, and in densities similar to those found in the neighbouring breeding ground of the New Caledonia South Lagoon. Surprisingly, the sex-ratio was skewed towards females and many females with a calf were encountered. Genetic analysis and photo-identification suggest a connection to the New Caledonian population, whereas satellite tracking indicates movements towards the East Australian migratory corridor. The genetic comparison between whales sampled in Chesterfield-Bellona and the Great Barrier Reef should bring light to the large-scale connectivity between these South Pacific stocks.

The sub-committee noted that this is an impressive array of data collected in an area of the Southern Hemisphere where humpback whale breeding stocks are complex and boundaries are still poorly understood.

3. PRE-ASSESSMENT OF SOUTHERN HEMISPHERE BLUE WHALES

In SC/66a, the sub-committee began the process of identifying and summarising datasets (acoustic and genetic) relevant for assessing population structure among non-Antarctic Southern Hemisphere blue whales (Item 5.1, IWC 2016). Initial results of this assessment were presented at SC/67a (Item 3.1, IWC 2017).

3.1 Southern Hemisphere population structure and catch allocation

SC/67b/SH11 presents an update to the blue whale song biography for Southern Hemisphere (see Fig.1). This is the continuation of the review started in 2016 (IWC 2017), and over this time new information has been acquired on published records allowing consolidation of the total number of songs present in the SH. There were three main changes to the previous analysis. The data from the Solomon Sea were obtained from the authors of the original paper and after evaluating characteristics of the signals, it was decided that this was not likely a blue whale song. Likewise, following further review of the SWI2/9B song ('Diego Garcia' signal by McDonald *et al.*, (2006)) these are now not considered to be blue whales. In both cases, the more likely source of these signals would be Omura's whale or Bryde's whale. Finally, the song recorded in South Atlantic (near the islands at 54°26'00"S/36°33'00"W) was identified as a faint version of the SEP2 song commonly recorded off Chile. Similar signal has also been recorded off Ascension Island, indicating this occurrence of SEP2 song in the South Atlantic may be a regular occurrence. This brings the total number of ‘pygmy’ blue whale songs in SH to six. An additional song regularly heard both at low and high latitudes in the SH is Antarctic blue whale song. It has been recorded both circumpolarly and in all of the SH ocean basins, with peak singing in the Southern Ocean in late austral summer and during autumn, while peak singing at lower latitudes typically occurs during the austral winter.

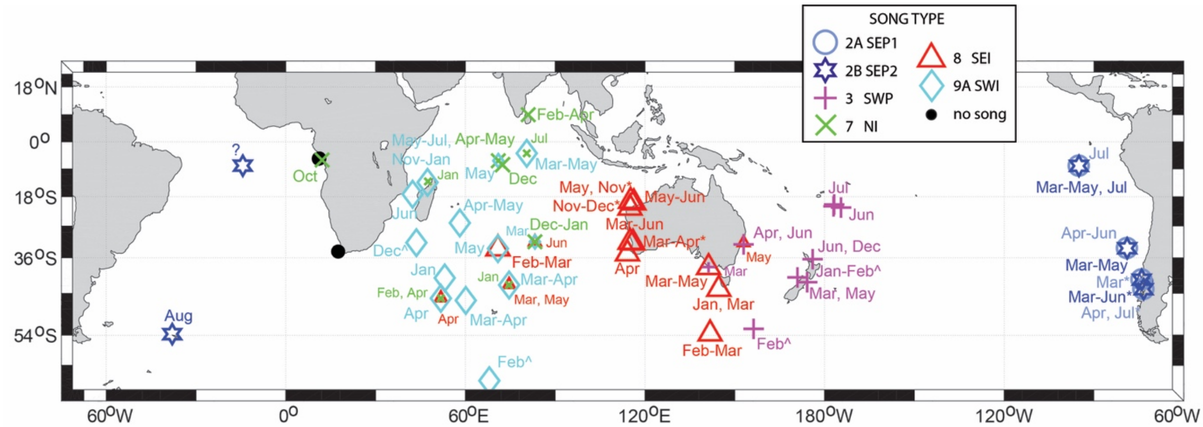


Fig. 1. Locations of non-Antarctic blue whale songs reported for the Southern Hemisphere (between the equator and 60°S) in the literature, summarised in SC/67b/SH11. Each symbol and colour denote a song type. Months included for each site indicate peak months of detection. In most cases year-round recordings were available. If three or more months of recording were missing per year, those peak months are marked with *. At locations marked with ^, recordings were collected with sonobuoys or dipping hydrophones and generally data were only available during indicated month(s). The black dot marks a location where full year of recording exists and no non-Antarctic blue whale songs were recorded.

In discussion, it was questioned how detection distance of the calls varied geographically, and whether some areas had more distant call propagation than others. In response, it was noted that call detection distance can be affected by the depth of the hydrophone in or near to deep water channels, where sound propagation distances are greatest. In particular, the apparent overlap of different call types in the central southern Indian Ocean may reflect the fact that sound recorders in this region have been deployed in deep water channels, and may therefore be receiving very distant calls. This has implications for catch allocation, as discussed below.

The detection of Chilean blue whales in the southwest Atlantic was discussed, and it was questioned whether there is evidence that Chilean blue whales were included in the historical catch records. The sub-committee was informed that the Grytviken historical catches contain an over-abundance of 70-80 foot blue whales, which are short relative to mature Antarctic blue whales but long relative to pygmy blue whales and could possibly be the Chilean form (see SC/67b/SH23). It was also noted that occasional sightings of putative pygmy blue whales are made in the vicinity of 54°26’S; 36°33’W (some are held in the Antarctic blue whale catalogue), and that there is at least one haplotype in the bone collection from former whaling stations that is associated with the pygmy blue whale form (see SC/67b/SH02). Catch allocations explored to date in SC/67b/SH23 have assumed all catches from this region to be from Antarctic blue whales. This may still be a reasonable assumption, because oceanographic conditions have varied substantially over the 20th century and blue whale feeding distributions are strongly tied to areas of primary productivity rather than fixed locations (e.g., Fiedler *et al.*, 1998; Gill 2002). Further analysis of the blue whale bones may be helpful to better establish the past distribution of these stocks. It was noted that Chilean blue whale song detection in the vicinity of 54°26’S; 36°33’W was made during the austral winter (August), while historical whaling there was particularly intense during the summer months, so detections of these occurrences within the catch record might be limited. The sub-committee were informed that the British Antarctic Survey have deployed an acoustic mooring in waters west of 54°26’S; 36°33’W during the 2016/17 season, and will be analysing the acoustic data received from this over the next two years.

SC/67b/SH23 examined historical catches of blue whales in the Southern Hemisphere and northern Indian Ocean to identify pygmy blue whale catches, and separate these into individual populations (see Fig. 2). Antarctic blue whales are found circumpolar-wide especially south of 60°S, while Chilean blue whales are caught off Chile and Peru through to the Galapagos. Shore station catches off south-western Africa and at Durban are assigned to Antarctic blue whales based on substantial numbers greater than 24.2m in length, reductions of around 99% in catch numbers, and winter timing of catches. Durban is the most ambiguous with at least four pygmy blue whale catches evidenced by pregnant females of lengths typical of pygmy blue whales. Pygmy catches are separated into northern Indian Ocean (NIO), south-west Indian Ocean (SWIO), south-east Indian Ocean (SEIO), and south-west Pacific Ocean (SWPO) populations based largely on acoustic records of distinctive call types made by each population. Off Somalia, foetal lengths with a southern conception date suggest SWIO blue whales occur up to 2°N, while pygmy blue whales north of 9°N there have aseasonal reproduction and are assigned to the NIO population. Pelagic catches were divided between Antarctic and pygmy blue whales based on very distinct separation in catch length frequencies, with the southern boundary of 52°S or 53°S and longitudinal boundaries of 20°E eastwards to 180°. Within these boundaries there were virtually no mature females longer than 24.2 m, while south of this boundary more than 90% of mature females were longer than 24.2m. Catches off western Australia were SEIO; those between eastern Australia and New Zealand were SWPO. The vast majority of pygmy blue whale catches (97%) came from pelagic Japanese expeditions in 1959/60-1963/64 (21% of the total) and Soviet expeditions in 1962/63-1971/72 (76% of the total). A GAM model was fitted to geographic occurrence of blue whale song type (and the fetal length data) to estimate the probability that a pygmy blue whale belonged to each of the four populations. A major area of overlap was identified in the southern Indian Ocean where NIO, SWIO, and SEIO blue whales all had some probability of occurrence; another area of overlap was north and east of Tasmania between SEIO and SWPO blue whales. Catch time series were developed from these analyses, with total pygmy blue whale catches of 12,184 and totals for each population of 1,228 (NIO), 6,889 (SWIO), 3,646 (SEIO), and 421 (SWPO).

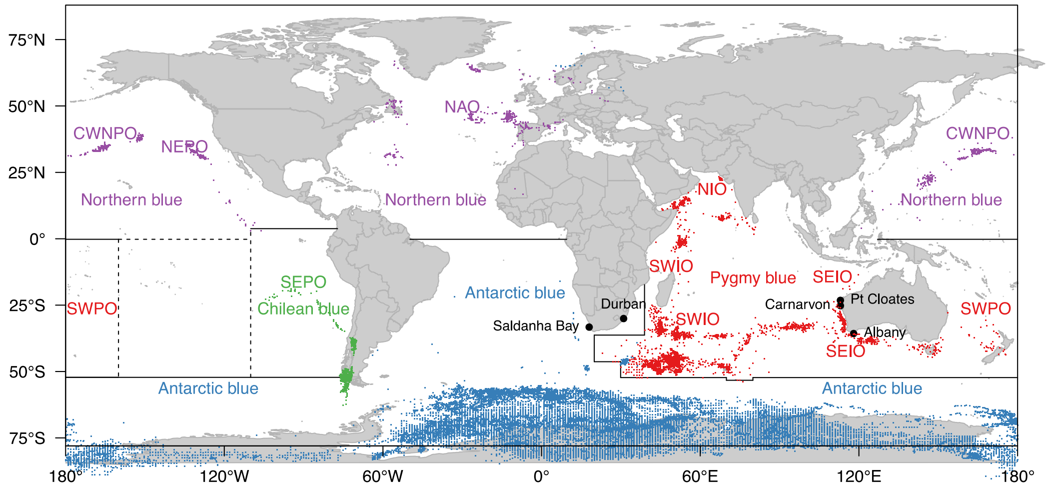


Fig. 2. Global blue whale catches of each of the four generally accepted subspecies (northern blue, Chilean blue, Antarctic blue, and pygmy blue), showing assumed boundaries in black used to enclose catches of each. Dashed boundaries enclose an area in the South Pacific with no known blue whale data. Individual populations are shown by acronyms for pygmy blue whales: northern Indian Ocean (NIO, Sri Lanka), south-west IO (SWIO, Madagascar), south-east IO (SEIO, Australia/Indonesia), south-west Pacific Ocean (SWPO, New Zealand); Chilean blue whales (SEPO); northern blue whales: north-east PO (NEPO, California/Mexico), central and western north PO (CWNPO, Japan to Gulf of Alaska), north Atlantic Ocean (NAO). Selected land stations are labelled.

The sub-committee commended the authors for this comprehensive and useful paper, which arises from IWC Scientific Committee funding support awarded during SC/66b (see Item 10.2.2, IWC 2017).

In discussion, the latitudinal band of offshore catches west of Australia (Fig. 2) was highlighted, and the reasons for allocation of this catch to the Australian population (as shown in Fig. 3) were queried. It was noted that there are few acoustic recordings from this area to inform the population model, but the small number of Australian calls recorded out to 40°E have influenced the model fitting. Several other call types have been recorded in the central southern Indian Ocean (Fig. 1) so the allocation of these catches is rather uncertain, especially considering the deployment of recorders in deep sound channels. It was queried whether it would be possible to incorporate data on the acoustic propagation levels of each recorder into the inferences being made here about blue whale distribution. In response, it was commented that call propagation modelling would be required as well as full access to primary data from all locations; this would be technically challenging to implement, and is further complicated by changing propagation distances over depth and latitudes. A general review of the sound propagation patterns in the south central Indian Ocean could however be useful for better establishing the likely range of these calls. At present the catch allocation in this region is challenging because a large number of catches were made but few sound recorders have been deployed to monitor these calls. The sub-committee **encouraged** the deployment of more recorders in the south central Indian Ocean region to help resolve these ambiguities.

The catch boundaries applied to the area south of Durban (South Africa, Fig. 2) was discussed, as they are extended slightly into the Indian Ocean. The author noted that this was a challenging area for catch allocation because data were not reliably recorded and very few measurements of mature females exist in the catch record. Considering that the catch patterns from Salandha Bay are similar to those off Durban, he has assumed similar occurrences of Antarctic blue whales in the two areas.

The sub-committee considered the assumption of this assessment that recent (acoustically-inferred) blue whale distribution is similar to blue whale distribution during the whaling period. They noted that blue whales are often strongly associated with oceanographic features rather than occurring in static locations (e.g., Calambokidis *et al.*, 2009), and highlighted that this spatial flexibility must be considered in the process of developing an assessment. In this regard, the best approach for developing a 'high case' catch scenario for each putative population was discussed, and how best that could take into account this distributional uncertainty. The authors also noted that they plan to use a bootstrapping approach to better accommodate the distributional uncertainty inherent in the use of an assemblage of acoustic recordings. It was also cautioned that the use of relative strength of acoustic signals to weight catch allocations in overlap areas is problematic as relative frequencies of whales in those areas may reflect different levels of past exploitation, rather than a long-term, stable dynamic. It was suggested that oceanographic data could be informative about changes in local conditions and could improve model inference.

Some minimum and maximum catch allocations were suggested for pygmy blue whales (see Appendix 2), to bound the catch uncertainty in the context of population assessments. It was highlighted that the maximum population boundaries define very broad ranges for the NIO, SEIO and SWIO populations and that the data guiding the maximum range for each population is based on contemporary data. For example, the allocation of catches at Bass Strait could be explored as the current model shares catches between the South-East Indian Ocean and South-West Pacific Ocean populations (Fig. 3d), reflecting the co-occurrence of the two call types in this area (although the South-East Indian Ocean call type appears predominant). The sub-committee **agreed** that further discussion on catch allocation scenarios was needed in order to agree some cases, to be facilitated via an intersessional correspondence group convened under Branch (see Item 7.1.1). The sub-committee also **agreed** that regional population modelling should be commenced with these catch series in order to explore assessment parameters and population recovery levels for pygmy blue whales.

Torres-Florez summarised intersessional efforts to identify and standardise microsatellite loci used in Southern Hemisphere blue whale research across labs. Only four loci were used in common across labs, and data summarising these were presented.

The group was thanked for this important work. Sample depletion remains a concern given the speed of technological change and repeated analyses from the same samples. Many participants highlighted that the IWC Antarctic blue whale samples are very valuable, and proposals should be carefully considered to reduce duplication. There was discussion amongst the group on the best genomic applications of the remaining samples. Further discussion, including the idea of whole genome sequencing of remaining blue whale samples, was held in the SD-DNA Working Group and is summarised under Item 4.4.2 of Annex I. The sub-committee **strongly encouraged** that the different groups that make use of the same samples (e.g. IWC) make their associated metadata available including the voucher number of the sample (e.g. Southwest Fisheries Science Center).

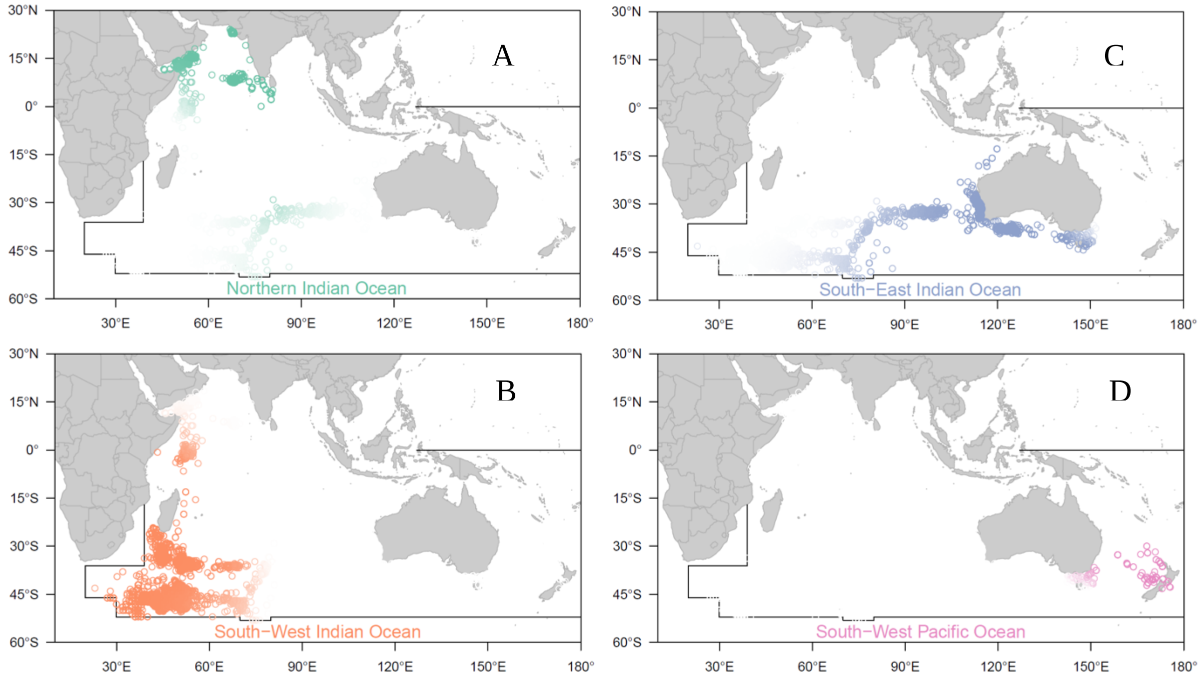


Fig. 3a-d. The probability that each pelagic catch is assigned to one of the four pygmy blue whale populations. High color intensities represent high probabilities that each catch was assigned to that particular population, while catches in colors fading to white represent low to near-zero probabilities.

3.2 Antarctic blue whales

SC/67b/SH02 summarises progress on a project to investigate potential loss in genetic diversity and change in stock structure of Antarctic blue whales. This project builds on previous analyses of bones from former whaling stations at Grytviken and the Antarctic Peninsula (e.g., Sremba *et al.*, 2015). The authors report on efforts to use next-generation sequencing to reconstruct the whole mitogenome from 30 bones previously identified as originating from blue whale. Whole-genome, shotgun sequencing with an Illumina HiSeq 3000 was used to generate an average of 24 million paired-end reads of 150 bp in length for each sample. Sequences of the mitogenome were extracted computationally from the whole genome sequences and proved sufficient for high-quality reconstruction of near-complete mitogenomes from 20 of the bones. From these 20 full sequences, the authors identified 18 unique mitogenomes, and compared these to 53 unique mitogenomes from 73 contemporary samples. From this alignment and comparison, only 2 of the mitogenome haplotypes were shared between the contemporary and historical samples. The authors suggest that the low level of sharing of mitogenomes between the contemporary and historical samples suggests a loss of maternal lineages as a result of the severe population bottleneck due to 20th century whaling. Further analysis is underway to test for this loss of diversity or change in population structure and to evaluate the potential for investigating loss in diversity of the nuclear genome.

This progress report was welcomed, with the Chair noting that these analyses have been funded by IWC-SORP. In discussion, it was suggested that the population genetic survey of these whales might usefully be expanded to include samples from southeast Pacific, considering that Chilean blue whale calls have been detected off the islands at 54°26'00"S; 36°33'00"W (see Item 3.1). In this regard, the presence of haplotype 'q' (a haplotype often seen in the eastern Pacific, LeDuc *et al.*, 2007) was also noted. This reinforces the idea that Chilean blue whales may occur in the waters at 54°26'00"S; 36°33'00"W, although it was also cautioned that haplotypes shared at the control region level may turn out to be distinct when whole mitogenomes are sequenced. The authors noted that they are conducting genomic analysis of this sample to better establish its population origins.

Three apparently divergent, basal lineages shown in the phylogenetic tree (Fig. 1 of SC/67b/SH02) were discussed; the authors clarified that these samples definitely represent blue whales and that the tree was rooted with fin whale sequences which are not shown in the phylogeny. Branch lengths are relatively short across this phylogeny (e.g. compared with those of the fin whales presented in SC/67b/SH13), so it is hard to interpret whether these lineages have any taxonomic significance with the current data.

There was discussion about how to determine whether the results showed substantive loss of genetic diversity due to whaling. This is not simple to measure because there are two dimensions to consider: temporal differences and spatial differences or stock structure, which confounds analyses in one dimension. The exact methodology to test for changes in diversity and structure in both time and space has not yet been identified, but the authors noted that the low level of shared haplotypes suggests a loss of diversity or change in population structure since the whaling era (e.g., see Sremba *et al.*, 2012). Whilst current Antarctic blue whale diversity is relatively high (Sremba *et al.*, 2012), modelling of the population trajectory for this subspecies still suggests that many haplotypes were lost, with current haplotype diversity levels consistent with the number of whales (~360) that survived the exploitation bottleneck (Branch & Jackson 2008; Sremba *et al.*, 2012).

Recognising the immense value of these historical datasets, the sub-committee highlighted the importance of utilising bone collections for documenting the loss of genetic diversity and shifts in population structure, and **encouraged** these and related collection efforts to continue in order to inform stock structure and assessment.

Brownell summarised ongoing work at the Smithsonian Natural History Museum on baleen whale plates that were shipped to the USA from Japan in the 1940s. After some initial work to curate and catalogue these samples, it was established that there are baleen plates from 1,626 individual baleen whales (likely 50:50 blue: fin whales). Lang advised that preliminary results from a pilot study on 11 blue and 1 fin whales showed that DNA extraction and mtDNA sequencing can be successfully conducted on these baleen whale plates. The sub-committee were informed that additional analyses, including stable isotope and hormone analysis, are planned for these samples. The researchers were also **encouraged** to measure the lengths of these baleen plates, because Antarctic blue whales are currently lacking such a reference set, for comparison with pygmy blue whale baleen samples and to assist with sub-specific characterisation of unknown baleen samples.

3.2.1 Cruise reports

SC/67b/SH07 described an IWC-SORP 49-day research voyage that will be conducted from 17 January to 6 March 6 2019. The voyage's objective is to describe the density, distribution, and fine-scale 3D structure of krill swarms relative to predator density and distribution estimated through visual surveys and passive acoustics. In addition, through measurements of the abundance and speciation of whale faecal iron the voyage will assess the new hypothesis of iron-fertilisation by whales and determine whether iron concentrations are higher within aggregations of feeding whales than within krill-only aggregations or than in adjacent areas. The data collected on this voyage will develop further the research described in SC/67b/EM06 that indicates krill swarm characteristics can predict the occurrence of Antarctic blue whales.

SC/67b/ASI07 reports the results of the systematic whale sighting survey conducted by two vessels in the Antarctic Areas VE (south of 60°S, 165°E-170°W including the Ross Sea) and VIW (170°W-145°W) under the NEWREP-A in 2017/18 austral summer. The survey was conducted under two survey modes based on IWC IDCR/SOWER survey procedures (Normal Passing mode (NSP), and an Independent Observer mode (IO)) from 10 December 2017 to 20 February 2018. The total searching distance in the research area was 5,196.6 n.miles, including 2,441.2 n.miles covered in NSP and 2,755.4 n.miles in IO modes. A total of 13 schools (23 individuals) of blue whales were sighted in the research area. They were mainly distributed in Area V. Several blue whales were sighted in the Ross Sea (south of 69S). Four biopsy samples (skin and blubber) were collected.

SC/67b/SP08 reports the sightings of fin whales by the sighting and sampling vessels during the NEWREP-A conducted in Area VI (south of 60°S, 170°W-120°W) during 2017/18 austral summer. The total searching distance was 4,164 n.miles, and a total of 8 schools (13 individuals) of blue whales were sighted. Two individuals were photographed and one biopsy sample was collected. Results of these data including multi-year data will be analysed and submitted to the NEWREP-A review meeting in the future.

The sub-committee thanked the authors for this new information. In discussion, it was commented that one of the aims of the work presented in SC/67b/SH07 is to describe the distribution of blue whales and how strongly they are aggregated in space and time. The aggregations shown in Area V (figure 3a, SC/67b/ASI07) were noted in this context, and it was queried whether there was scope to do finer scale sightings survey to study blue whale aggregations in more depth. The response was that based on previous cruises, the whales appear to be broadly (rather than tightly) distributed across Areas II-VI south of 60°S.

3.2.2 Progress toward population assessment

SC/67b/SH08 used photo-identification data of Antarctic blue whales from 1990/91 to 2014/15 in a capture-recapture analysis to produce estimates of super-population abundance for the circumpolar Antarctic. Population estimates were made separately based on the left and right-side photos. The R package RMark version 2.1.12 was used as an interface to the program MARK version 8.0; the POPAN is an open-population model. The circumpolar estimates of Antarctic blue whales were 4,629 (95% CI 2,563 to 8,558) using left side photographs and 4,485 (95% CI 2,514 to 8,192) using right side photographs.

The sub-committee thanked the authors for this work which represents important new information for measuring abundance of Antarctic blue whales. During review during the ASI Standing Working Group (Item 3.1.1.9), the authors were **encouraged** to re-run the models exploring suggestions made by the Working Group. It was cautioned that super-population estimates produced from re-sight data spanning 25 years may be biased high since no mortality is assumed, and recommended that point estimates of abundance be produced, and these results presented to SC/68a.

In discussion, it was noted that the estimates produced by this work are similar in magnitude to the 1997 IDCR-SOWER estimate of abundance (Branch 2007). Considering the morphological similarities of the two sub-species it was queried whether some of the photographs contributed to this catalogue might potentially be from pygmy blue whales. The author responded that she has thoroughly reviewed each photograph and is confident that only the Antarctic type has been used in the mark recapture study. The sub-committee **strongly encouraged** the continuance of this work and looked forward to receiving an updated abundance estimate at SC/68b.

3.3 Non-Antarctic Southern Hemisphere blue whales

SC/67b/SH16 reports on preliminary results of 2017 IWC comparisons among Southern Hemisphere Blue Whale Catalogues off Australia, New Zealand and Sri Lanka regions. Until 2017, this regional sub-catalogue included photographs of 698 individuals comprising 510 left side IDs, 493 right side IDs, and 60 photo-IDs from flukes. Comparisons of left sides were fully completed and comparisons of right sides are underway. Fourteen matches were found between the areas in Australia. Photo-identified Australian whales were found within all three sub-areas: Geographe Bay, the Perth Canyon and the Bonney Upwelling, representing a high level of connectivity between these areas and thus, strengthening the hypothesis of one distinct population of Australian whales. Two whales were seen in three different years. The longest re-sighting period was 12 years and corresponds to a whale that was first seen in 2003 in the Perth Canyon and re-sighted in 2015 in the Bonney Upwelling. Two matches were found in the whales photographed off New Zealand. Matches off New Zealand have been found between the northwest coast and the northeast coast of the South Island. No match was found between whales off Australia and New Zealand, or between whales off Sri Lanka and Australia or New Zealand. These results also support the hypothesis of an isolated New Zealand blue whale population from the Australian population.

In discussion, it was commented that the New Zealand matches described here have been reported in SC/67b/SH05, and support the idea that the New Zealand population is relatively small. The Chair commented that the movements shown by these data are concordant with what is known about these populations from genetics and acoustics, and highlighted the importance of collecting photo-ID data for measuring population connectivity and abundance. The sub-committee thanked the authors for this update and **agreed** that the Southern Hemisphere blue whale catalogue should continue to be compiled. This is an item that has financial implications for the Scientific Committee. Further details are given in Item 7.1.1.

SC/67b/SH12 presented a progress update on the development of the blue whale song library, which was funded intersessionally by the IWC following a recommendation at SC/66b. The team (Miller, Samaran, and Širović) have worked out the definitions of the terms for the library: definition of song and variant, naming structure, and ways of submitting new samples. They have also developed metadata requirements for submissions. An important feature will be inclusion of 'perfect' examples of the song, but also 'average' (i.e. most commonly recorded) examples to illustrate effects of propagation and facilitate identification. Currently underway is the process of implementation of the library to the IWC web server with the IWC IT staff. Once the library is ready, it will be announced to colleagues through listserves such as MARMAM and bioacoustics. Addition to the library will occur after peer-review acceptance of new songs and will be reviewed by a committee that will be selected to maintain quality control on the submissions.

In discussion, the recent application of these acoustic data to infer blue whale stock structure was highlighted (see SC/67b/SH11 and Fig. 1). Considering the limited availability of genetic samples to infer stock structure, the utility of this alternative measure was acknowledged and the sub-committee **encouraged** further work to develop this initiative. The sub-committee were made aware that there will be ongoing maintenance costs of server hosting for the IWC Secretariat, which are currently being calculated and will need to be explicitly accounted for in Scientific Committee budgets going forward (see Workplan Item 7.1.1).

3.3.1 Southeast Pacific blue whales

SC/67b/SH03 presented the results of a morphometric analysis on Chilean blue whales. The taxonomic status of pygmy blue whales is in flux, with debate about whether northern Indian Ocean blue whales (pygmy) and Chilean blue whales each should be listed as separate subspecies. Length frequencies of sexually mature female blue whales from several regions of the Southern Hemisphere, call type, and genetics, have been used to propose that Chilean whales are a separate subspecies from pygmy blue whales throughout the Indian Ocean. This interpretation has been accepted by the Society for Marine Mammalogy's List of Marine Mammal Species and Subspecies. SC/67b/SH03 provided crucial morphometric data to directly address this taxonomic question that were obtained in a biological survey during the 1965/66 Chilean whaling season by a Japanese whaling company. The data for this season consist of sex, total body length, length from tip of snout to center of eye, and length from notch of flukes to anus for 60 blue whales ranging from 21.2 to 24.9m in total length. The data provide strong evidence that maximum body length, fluke-anus measurement, as well as the ratio of fluke-anus to total body length, are different among Antarctic, pygmy and Chilean blue whales, with the values of the Chilean blue whales being intermediate between pygmy and Antarctic blue whales. These results are similar to those obtained for the distribution of total body length of sexually mature females, and they are also consistent with the available genetic data and differences in song types among regions, and strongly support the suggestion that Chilean blue whales should be considered a separate subspecies.

The authors were thanked for this contribution which responds to a recommendation made in 2016 (Item 3.1, IWC 2017). In discussion, the authors were asked if it would be possible to compare these length data with measurements from the northeast Pacific, to assess any length differentiation between Chilean and northeast Pacific whales (as genetic data suggest they are closely related, e.g., LeDuc *et al.*, 2017). It was noted that these two populations appear to be similar in length although a formal comparison has not been done. No information on the sources of measurement data in the northeast Pacific was available for the sub-committee. Therefore the sub-committee **encouraged** Pastene, Brownell and Branch to work intersessionally to compile this information. See Work Plan Item 7.1.1.

Bedriñana-Romano *et al.*, (2018) evaluated the use of different data types within a hierarchical Bayesian framework to model the abundance and distribution of a small and highly migratory population of blue whales summering in Chilean Northern Patagonia (CNP). Analyses showed that distance to areas of high chlorophyll-*a* concentration during spring (AHCC-s) was the most important and consistent explanatory variable for assessing blue whale abundance and distribution in CNP. Despite the limited and heterogeneous data, the hierarchical species distribution model showed good capacity to integrate the different data types. Results indicate that AHCCs, and possibly thermal fronts, could modulate blue whale abundance and distribution patterns in CNP. Preliminary model-based delimitations of possible priority conservation areas for blue whales in CNP overlap with highly used vessel navigation routes and areas allocated for aquaculture.

The authors were thanked for presenting this work. The fluctuations in abundance of blue whales in CNP shown here are also seen in the local mark recapture data (Galletti Vernazzani *et al.*, 2017). Potential use of the local abundance estimate presented in this paper was discussed, but it was cautioned that this area is unlikely to represent the whole Chilean blue whale population. In this regard, the collection and matching of regional photo-IDs was discussed, and the sub-committee welcomed news that the next priority for the Southern Hemisphere blue whale catalogue is to match all newly contributed photos from the southeast Pacific. This may help to improve understanding of population connections. Following recent discussions in the ASI Standing Group, it was highlighted that new methodologies now exist (e.g., McClintock 2015) whereby data from multiple mark sources can be incorporated in a mark recapture framework; this may be particularly useful for blue whales where left and right side photos are used for photo-ID. The usefulness of other methodologies to investigate distribution and abundance were discussed, and the sub-committee **encouraged** more satellite tracking and surveys to do photo-ID and assess the distribution and abundance of blue whales in Chile.

3.3.2 Madagascar blue whales

SC/67b/SH14 reported on passive acoustic monitoring for baleen whales off the northwest coast of Madagascar at approximately 13.3°S latitude, monitoring in the Mozambique Channel. Three passive acoustic recorders were deployed during four 4-month deployments starting in December 2016 and ending in April 2018, anchored off the shelf break at depths ranging from 225-275m. Review of data from December 2016 to November 2017 revealed extensive documentation of both SWIO (Madagascar) pygmy and Antarctic blue whale song-types, fin whales and Antarctic minke whales. SWIO pygmy blue whale song was present bi-modally with peaks of singing activity during May-July and October-January, suggesting a previously unrecognised migratory corridor between summer feeding and winter breeding grounds south and north of Madagascar respectively. Antarctic blue whale song was present throughout the Austral winter from June to September, suggesting a previously unrecognised breeding season aggregation area. NIO (Sri Lanka) blue whale song, as well as a potentially new and previously undescribed blue whale song, were detected for short periods between January and May. Fin whale song was present during the late Austral winter, from early August to mid-September. The 20Hz pulses included a single secondary frequency peak at 94-96Hz; this appears to be distinct from the different types previously reported from the Southern Ocean, however further analysis and direct comparisons are necessary. The timing of fin whale song suggests a later arrival than Antarctic blue whales and a lower rate of occurrence and occupancy, potentially representing the northern extent of breeding habitat. Antarctic minke whale pulse trains representing three distinct song types, were found to be very common in the higher bandwidth. Although a systematic browse above 100Hz has not yet been completed, Antarctic minke whales were present from at least early July to early November, so remaining seasonally later than Antarctic blue or fin whales. In addition, the monitoring has also documented the expected seasonal presence of humpback whales and year-round presence of Omura's whales. These new discoveries highlight the importance of the northern Mozambique channel as wintering habitat for several Southern Hemisphere migratory baleen whales, and emphasises the need for continued and more in-depth research and monitoring.

The authors were thanked for this work, which was carried out with financial support from the Scientific Committee following a recommendation during SC/66b (IWC 2017). These data are particularly welcome because they provide new information on the migratory movements and distribution of poorly understood blue whale stocks in the Indian Ocean. The sub-committee **agreed** that the work presented in SC/67b/SH23 should be updated intersessionally to include this new information.

It was noted that fin whale song was also recorded during surveys, which could be contributed to the fin whale acoustic analysis proposed in Item 7.1.1. In discussion, it was clarified that the lack of reports of fin whale calls at lower latitudes than 13°S may be due to the focus on blue whale detection rather than an absence of fin whales, to these may also be present further north than this location.

SC/67b/SH24 reports on a baleen whale song type that, to the best of available knowledge, has not been previously described. The song was recorded at two disparate locations in the western Indian Ocean separated by approximately 3,500km, off Oman in the western Arabian Sea and off northwest Madagascar in the Southwest Indian Ocean, during independent efforts of long-term (one complete year) passive acoustic monitoring. The acoustic and temporal characteristics of the song were described to allow comparison with existing records throughout the Indian Ocean and assess whether it has been recorded in other areas or confused with a previously reported type. The song was relatively scarce on deep water recorders off Madagascar, whereas much more prominent off Oman given a temporal distribution of detections between November and June, a relatively high number of hours with detections, and the incidence of multiple singers. Although it is impossible to definitively attribute this song to a species, we suspect it is almost certainly a new blue whale (*Balaenoptera musculus ssp.*) song type, based upon its acoustic structure and temporal characteristics, along with supporting circumstantial evidence of blue whale sightings off Oman during days when songs were detected. If this species attribution is correct, this song would represent that of a previously undefined population of blue whales in the western Indian Ocean, that may be more associated with the North Indian Ocean and the Arabian Sea, and only an occasional visitor in the Southwest Indian Ocean and the Mozambique Channel. Given that this song type has not been previously reported in studies that documented the Sri Lanka song type, and that no Sri Lanka song types were detected in data off Oman, then there may be a longitudinal division of these populations between: (a) the Western Arabian Sea and western Indian Ocean in general; and (b) the eastern Arabian Sea / Bay of Bengal and central Indian Ocean in general. The presence of this population off the coast of Oman during the Boreal winter is congruent with the timing of Soviet catches in the region (Mikhalev 1997) and observations off Oman; thus the large numbers of blue whales caught in Soviet whaling operations in the Gulf of Aden and Arabian Sea, may represent a population of blue whales that is distinct from that represented by the Sri Lanka song type, or a combination of two distinct populations. Continued work is recommended including: deep water acoustic monitoring in combination with boat-based surveys off the coast of Oman to validate these observations and allow definitive attribution to species; evaluation of existing acoustic datasets throughout the Indian Ocean for the presence of this song type; and reconsideration of current data and discussions on Northern Indian Ocean pygmy blues (e.g., SC/67b/SH23) in light of the possibility of two distinct populations in the NIO.

In discussion, the authors confirmed that no Sri Lanka call types have ever been detected in recordings from Oman, suggesting that they have a more easterly distribution. Since this call has not been recorded at moorings further south or east, it was hypothesised that the 'Oman' call type may represent a non-migrating population of blue whales inhabiting the western Arabian Sea. The authors were thanked for this new information, which has implications for the current catch allocations (see SC/67b/SH23) that are currently based on a single blue whale 'stock' in the Northern Indian Ocean. It was observed that a number of catches were made by Soviet whalers in the local vicinity of these calls, while few catches were made in the northeastern Indian Ocean suggesting that this unknown population may have been the more exploited of the two hypothetical NIO stocks.

The sub-committee **strongly encouraged** further acoustic work in the region, in deeper water in order to obtain high quality recordings and further information about the distribution, seasonality and overlap of these calls in the western Indian Ocean and Arabian Sea. It was noted that deployment of acoustic recorders in the Gulf of Aden, Somalia and Yemen would be particularly useful and that collection of full propagations in close proximity would be helpful for fully characterising these calls.

The sub-committee also discussed the availability of genetic data from surveys and strandings in the Indian Ocean in order to better establish the population connectivity between blue whales using the west and eastern latitudes of this ocean. Some Sri Lankan samples are now available from strandings and collection of faecal samples during surveys, while offshore of Oman sloughed skin samples have been collected and 3-4 tissue samples from strandings have been obtained. The sub-committee **strongly encouraged** the collection and analysis of available samples for analysis of genetic population structure, including whale sloughed skin and faecal samples, which are not subject to CITES restrictions.

3.3.3 Indonesia/Australia blue whales

Attard *et al.,* (2018) used a genomic dataset of 8,294 single nucleotide polymorphisms (SNPs) to assess population structure in pygmy blue whales from the Bonney Upwelling and Perth Canyon feeding aggregations in Australia. The study built upon Attard *et al.,* (2010), which found no evidence of population structure within or between these aggregations using 10 microsatellites and the mtDNA control region. This lack of evidence could be due to no population structure or insufficient power to detect low levels of population structure. To determine this, 8,294 SNPs were developed using a standard double-digest restriction-site associated DNA sequencing (ddRAD) protocol (Peterson *et al.,* 2012). Power analyses showed that the SNP dataset was able to detect genetic differentiation (F_{ST}) as little as 0.001, whereas the microsatellite dataset could only detect a F_{ST} as low as 0.015. So, F_{ST} as well as analyses that do not require *a priori* putative population groupings were conducted on the SNP dataset. The latter included FASTSTRUCTURE (Raj *et* *al.,* 2014), Discriminant Analysis of Principal Components (DAPC) (Jombart *et al.,* 2010), and Principal Components Analysis (PCA). All analyses on the SNPs found no evidence of population structure. This is corroborated by growing photo-ID matches between the two feeding aggregations (see SC/67B/SH16 for Southern Hemisphere Blue Whale Catalogue update). Of additional interest, related individuals were detected using the SNP dataset with much greater power than the microsatellite dataset (see Attard *et al.,* (2018) which uses these datasets as a case study). The SNP dataset also allowed Attard *et al.,* (2018) to investigate the potential for adaptive differences between the feeding aggregations, but found no such evidence. In summary, the powerful 8,294 SNP dataset confirms previous inferences from a smaller 10 microsatellite and mtDNA dataset that the pygmy blue whales feeding in Australia are one population. For a similar study on Antarctic blue whales, see the IWC-SORP report (SC/67b/SH21).

In discussion, it was highlighted that these data are concordant with the photo-ID results reported in SC/67b/SH16. It was noted that the uncertain stock allocation (to New Zealand or Australia) of blue whale catches which occurred between Tasmania and mainland Australia is not resolved by these data, since no genetic samples are included from this region.

In 2008, a mark recapture estimate of blue whale abundance in Perth Canyon was presented to the Scientific Committee (Jenner *et al.,* 2008). Further work on this estimate was recommended (p237, IWC 2009), but has not yet been received. There are now plans underway to reanalyse these data and provide a new mark recapture abundance estimate for Perth Canyon at SC/68a. The sub-committee **encouraged** the authors to present an update of this work.

3.3.4 New Zealand blue whales

SC/67b/SH09 provides preliminary results from a voyage undertaken this summer to attach satellite tags to pygmy blue whales in the Taranaki region of New Zealand. The aim of this voyage was to examine the movement and habitat utilisation of pygmy blue whales in New Zealand waters. In total, the research team spent 72.51 hours (1,637.54km) actively searching for blue whales over eight survey days. Eleven blue whale sighting events were made of a total of 16 animals and 14 unique individuals. Overall, blue whales were found further south than anticipated, in lower numbers, and were not observed surface feeding, likely due to the La Niña anomalous oceanographic conditions, which resulted in sea surface temperatures 4-6°C higher than average, reduced west wind flows, and consequent reduction in upwelling, significantly impacting the high productivity characteristic of the Taranaki region. Photo-identification data were collected for 11 individual blue whales. All photo- identification data will be provided to the Southern Hemisphere Blue Whale Catalogue, and collaborations have been established with other researchers to share and compare data. Six skin/blubber samples were collected from four blue whales, and will be used to confirm the sub-species of the whales. Two satellite tags were successfully deployed and the preliminary track data are shown in Figure 5. One of the two animals circumnavigated the South Island over the subsequent ~6 weeks. Due to the small sample size and La Niña conditions, it is uncertain how representative these movements are for blue whales in New Zealand waters.

This report was welcomed as it provides useful movement data for blue whales in a region currently being considered for population assessment. In discussion, it was noted that some of these whales went into the South Taranaki Bight area, an area which appears to be important habitat for blue whales (see SC/67b/SH05). The satellite telemetry also suggested that an area west of Westport (on the northwest coast of the South Island) was visited, supporting previous opportunistic and anecdotal sightings which suggest this area may also be a habitat that blue whales visit regularly. This area is not too distant from the South Taranaki Bight, suggesting possible continuity of habitat use between these areas within the broader Taranaki Bight ecosystem. Broader movement patterns made by two whales suggest that blue whales may use other habitats around New Zealand, and supports the notion that whales surveyed in the South Taranaki Bight may be relatively representative of the population using the New Zealand ecosystem more broadly. However, it was cautioned that La Niña created unusual oceanographic conditions in this region during the 2017/18 austral summer, and habitat use patterns may consequently have been perturbed.

Papers SC/67b/SH04 and SC/67b/SH05 are from the same research group and focus on the South Taranaki Bight region of New Zealand. These papers were presented together.

SC/67b/SH05 reports on a multidisciplinary assessment of blue whales in New Zealand using survey data in the South Taranaki Bight (STB) region, photo-ID, genetic tissue analysis, and acoustic data from an array of five hydrophones. Results indicate a genetic differentiation of a blue whale population that occurs in New Zealand waters year-round, with a conservative abundance estimate of 718 individuals (95% CI 279-1926), and multiple individual re-sightings within New Zealand waters across multiple years and a lack of photo-ID matches with blue whales from neighboring regions. These results support the hypothesis of Torres *et al.,* (2013) that this newly documented blue whale population is largely resident to New Zealand, although excursions beyond New Zealand waters may occur. The authors conclude that the STB region is an important area for New Zealand blue whales, particularly for foraging, which has important management implications given the high level of industrial presence in this area.

With the documentation of a New Zealand blue whale population (SC/67b/SH05), including an important foraging ground in the industrial region of the South Taranaki Bight (STB) region, comes the need for improved ecological data to inform conservation management action. As the New Zealand government moves forward with the establishment of a marine mammal sanctuary in the STB region to protect blue whales from industrial activity, there is a need for robust information on blue whale distribution patterns and response to noise disturbance. SC/67b/SH04 reports two projects underway to fill these knowledge gaps and inform management decisions.

(1) Describe the fine-scale blue whale habitat use patterns during summer months in the STB region. They plan to

develop predictive species distribution models of blue whales using *in-situ* oceanographic data, echosounder prey availability data, blue whale survey data, and remotely sensed SST and chl-*a* images.

(2) Large-scale blue whale distribution patterns in the STB region and response to acoustic disturbance. Using two years of acoustic data from an array of five hydrophones the spatial and temporal distribution of blue whale calls will be described over an annual cycle relative to remotely sensed environmental conditions and vessel traffic patterns, and the distributional response of blue whales to seismic airgun noise will be assessed.

The authors were commended for the range of work presented, which includes abundance and stock structure data useful for population assessment of New Zealand blue whales. The ASI Standing Group discussed this abundance estimate during SC/67b (see Item 3.1.1.9) and will conclude their categorisation of this assessment during SC/68a. In discussion, it was noted that further New Zealand photo-identifications have been submitted to the Southern Hemisphere blue whale catalogue and could be informative for measuring population abundance at the regional scale. The sub-committee **agreed** to form a small intersessional group to progress photo-identification upload to the SHBWC (see Workplan Item 7.1.1), for informing a broader mark recapture estimate of abundance which can be compared with the South Taranaki Bight estimate presented in SC/67b/SH05.

It was noted that one of the sightings included in this dataset was made at Raoul Island in the Kermadec Islands. There were no photo-IDs collected of this animal so the sub-species identity of this sighting is unknown.

4. PRE-ASSESSMENT OF SOUTHERN HEMISPHERE FIN WHALES

The Scientific Committee is currently encouraging the submission of new information on fin whale population structure, movements, abundance and habitat use, with a view to possible assessment of population recovery in the next ten years.

4.1 Southern Hemisphere population structure

SC/67b/SH15 summarised available data pertaining to fin whale stock structuring around the Southern Hemisphere. This comprised mostly sightings, catch, acoustic and genetic data, with a little movement information provided by satellite tracking off Chile and southeast Pacific Discovery mark deployments. The small amount of available genetic data shows no evidence of population structuring across the Southern Hemisphere, but acoustic data suggests more than one call type is present. Given the limited data currently available, the following work was proposed: (i) a comprehensive review of fin whale calls from Antarctica as well as lower latitudes to investigate fin whale call variation across the Southern Hemisphere; (ii) a focus on collecting genetic samples alongside good quality photo-ID (and ideally photogrammetry analysis of length), in order to co-identify individuals morphologically and genetically; (iii) a review of catch length statistics, particularly for catches taken at lower latitudes by the Japanese in the 1960s compared to earlier catches from the Antarctic, (iv) isotope analyses to investigate trophic differences in feeding; (v) a global review of museum holdings of Southern Hemisphere bone/baleen and corresponding external morphs, including genetic sampling from the fin whale subspecies holotypes, particularly *patachonica.*

In discussion, it was noted that IWC Management Areas I-V were originally delineated based on the distributions of fin and blue whale catches from Norwegian whalers, suggesting distinct aggregations across the high latitudes of the Southern Hemisphere (reviewed in Donovan 1991). The sub-committee **encouraged** the provision of an updated fin whale distribution using all available catches. This will be completed intersessionally by De la Mare, using the method he has developed using catch per unit effort (CPUE) data to provide an index of relative abundance that is reasonably related to true density (de la Mare 2014). The sub-committee also **encouraged** construction of a histogram of catches by longitude, to help identify high latitude aggregations.

Prospects for additional genetic studies of fin whale stock structure were discussed. Pastene highlighted the work on Antarctic fin whale structure reported by Goto *et al.,* (2014) which included 55 high latitude samples and showed some significant differentiation between Antarctic Areas IV and V using microsatellites (see SDWG review p229 in IWC 2015). New analyses of these data are being conducted. It was also noted that a new study of fin whale population structure expanding on the geographic sampling in Archer *et al.,* (2013) is also close to completion. The sub-committee **encouraged** the presentation of these two stock structure analyses for review during SC/68a.

Širović noted that fin whale songs are a potential tool for distinguishing populations. Distinguishing fin whale song features in the North Pacific include spectral structure of individual pulses, their patterning, and the inter-pulse interval (Širović *et al.,* 2017). In the Southern Ocean and the Mediterranean Sea, an additional distinguishing feature is a higher frequency component of the pulses (Gedamke 2007; Širović *et al.,* 2009; Castellote *et al.,* 2012). In 2004, the calls in eastern Antarctica contained a higher frequency component at 99 Hz whereas the calls in the vicinity of the Western Antarctic Peninsula contained that same component at 89 Hz, possibly indicating two distinct populations in the Southern Ocean (Širović *et al.,* 2009). High frequency components of fin whale song have also been reported at mid-latitude monitoring stations in the Southern Hemisphere (Gedamke 2007). Baleen whale songs are known to undergo both gradual and abrupt shifts; a recent example has been reported from the North Pacific (Širović *et al.,* 2017). Therefore, Širović noted that a study to analyse fin whale acoustic structuring should focus on the same year of recording from multiple locations, in order to minimise confounding due to song shifts. Such data has recently become available through the work of the IWC-SORP Acoustic Trends Working Group, which has concurrent data collection from several sites between 2014 and 2016.

The sub-committee welcomed this news and **agreed** that analyses of concurrently collected acoustic recordings should be carried out in order to assess fin whale song variation around the Southern Hemisphere. This recommendation has financial implications for the sub-committee (see Item 7.1.2 for more details).

SC/67b/SH13 reports the results of a study using genetic data from the southeast Pacific, specifically from a feeding area in the north-central coast of Chile (*ca.* 29°02'S, 71°36'W), to measure fin whale genetic differentiation between the southeast Pacific and southeast Atlantic. Currently, three sub-species of fin whales are considered valid, *Balaenoptera physalus physalus* in the Northern Hemisphere (NH), *B. physalus quoyi* and *B. physalus patachonica* in the Southern Hemisphere (SH). The latter is described as a pygmy-type sub-species and proposed to be located mainly in low to mid latitudes in SH (Clarke 2004). Recently, Archer *et al.,* (2013) detected a strong genetic differentiation between North Pacific and North Atlantic fin whales, suggesting a taxonomic subdivision at the sub-species level. Little information was available, however, for the South Pacific and South Atlantic oceans, impeding a global taxonomic revision of this taxon. Mitochondrial DNA analysis (D-loop) of 19 biopsy samples collected in north-central Chile recovered 17 different haplotypes, with only two shared between individuals. A haplotype diversity (*h*) of 0.97 and nucleotide diversity (π) of 0.8% were estimated at a local level. At a global scale, phylogeographic analyses, including different ocean populations (*sensu* Archer *et al.,* 2013), showed a clear genetic differentiation between Southern and Northern Hemispheres as has been previously reported, as well as between North Pacific and North Atlantic Oceans. However, a low and unidirectional genetic direction from the South to North Pacific was detected. In contrast, no significant genetic structure was detected when comparing populations from the Southern Hemisphere (South East Pacific with that from the Atlantic Southern Ocean; Φ_{ST}=0.01539, p=0.1333), even considering samples that would represent the putative pygmy fin whale sub-species (*B. physalus patachonica*), suggesting the existence of a single evolutionary unit in this area. Therefore, these results might challenge the validity of the proposed pygmy fin whale sub-species and propose the existence of three taxonomic units (two for the Northern Hemisphere and one for the Southern Hemisphere).

The authors were thanked for their contribution. The sub-committee noted the very limited work carried out to date to examine fin whale stock structure in the Southern Hemisphere. The authors plan to sequence 20 further samples and present their analyses to SC/68a. Interpretation of the ϕ_{ST} results presented in this paper was cautioned given the high diversity seen in the dataset, which can obscure low levels of population structure. The sub-committee recommended that a network diagram would be a more appropriate descriptor of the diversity, and that for such diverse data, unsupervised clustering methods (e.g., Rodriguez & Laio 2014) may be better able to detect distinct haplotype clusters than standard F-statistic approaches. It was also noted that the phylogenetic tree showed very weak resolution with low bootstrap scores, perhaps reflecting the low power of control region sequences to resolve deeper nodes within the phylogeny. The possibility of replicate samples was raised, but it was noted that diversity was so high (17 haplotypes in 21 samples) that duplicates were unlikely. The Working Group **encouraged** collection of more samples and sequencing of more loci to improve the chances of detecting subtle geographic influences on population structure.

The population and demographic identity of the coastal fin whales was discussed. Fin whale calls recorded off the coast of Chile match those recorded in the Antarctic (Buchan, pers comm). Coastal recordings would be helpful to ascertain if those calls match those heard offshore and at high latitudes. Cooke highlighted that body length measurements of past catches off the coast of Chile (Appendix 3) showed that fin whales taken in these waters were particularly short, corresponding to one-year-old juvenile Antarctic fin whales in terms of body length. The fin whales biopsied in the current study may therefore be a juvenile cohort of the Southern Hemisphere fin whale population. A similar pattern can be seen off the west coast of South Africa, where predominantly juvenile Antarctic blue whales were caught (see Item 3.3, SC/67b/SH23; Mackintosh & Wheeler 1929). Co-collection of photo-IDs along with genetic samples, and use of hexacopters to measure body length was **strongly encouraged**, to help better understand the identity of these coastal whales.

In discussing the conclusions of the paper that there is no genetic differentiation between the eastern Pacific and eastern Atlantic, it was noted that despite the apparent lack of large-scale structure, recent satellite telemetry work off Isla Chañaral suggested a degree of site fidelity, with five of the six tagged animals remaining in Chañaral during the summer (Sepulveda *et al.,* 2017). In some areas fin whales are also seen aggregating year-round, possibly indicating residency (Toro *et al.,* 2016). However, long-distance movements from these grounds have also been reported; of 11 Discovery marks deployed off Chile, four were recovered in Antarctic Area II (South Atlantic), revealing fin whale movements from the Pacific to the Atlantic (Clarke 1962). This may be concordant with the idea elaborated in Appendix 3 that the Chilean ground is mostly inhabited by juveniles who may travel south when they mature. In contrast to the Pacific, Discovery mark deployments in the Atlantic showed more traditionally longitudinal movements of fin whales to high latitudes (Brown 1962). The sub-committee **agreed** to conduct a review of all Discovery mark data published on fin whales to assess population connectivity patterns, although they note that contemporary linkages may differ from those seen historically due to various factors, including changing oceanographic conditions and disruption of regular behaviours due to intense exploitation.

Evidence for the existence of a distinct subspecies *B. physalus patachonica* (see Clarke 2004 for a review) was discussed and considered to be weak. However *B. p. patachonica* is currently recognised as a subspecies (Committee on Taxonomy 2017), so the veracity of this identification must be addressed. The sub-committee **reiterated** its previous recommendation that the Secretariat provide a letter of support to assist Archer in gaining approval to sample the *B. p. patachonica* holotype in the Buenos Aires museum, to establish the genetic identity of this specimen. They were also informed that another possible *B. p. patachonica* type specimen is held in Vienna Museum. Plans are underway for genetic sampling of this specimen. The sub-committee further noted that the size distribution of fin whales taken by whaling in the Antarctic and Subantarctic did not appear to support the notion of a smaller form of fin whales at lower latitudes (Table 1).

Table 1

Size (m) of fin whales taken in Southern Hemisphere (pelagic whaling and (sub-)Antarctic land stations)

Latitude	Mean (m)	SD	*N*
North of 60°S	20.3	1.7	297,493
South of 60°S	20.4	1.6	311,443

Source: IWC Catch Data Base v6.1

While the sub-committee generally felt that the evidence for *B. p. patachonica* being a distinct subspecies is weak, some members noted that there may be some latitudinal population structuring within Southern Hemisphere fin whales. Such latitudinal structuring might still suggest two distinct forms, including a poorly known high latitude type which may have been heavily exploited at higher latitudes early in the whaling period. The chief line of evidence for this comes from the distribution of past catches: ~300,000 catches were made south of 60°S, inconsistent with the contemporary hypothesis that fin whales are mainly concentrated north of 60°S. Plots generated by de la Mare using his relative density model were reviewed in 2017 (see Appendix 3, IWC 2018a) and show a shift from high latitude fin whale catches before 1935, to a high-density band of lower latitude catches in the 1970s. However, it was highlighted that this pattern also reflects the effort foci of the whale fishery, which initially targeted Antarctic blue whales at the ice edge, only later shifting focus to fin whales.

The sub-committee **agreed** that Southern Hemisphere fin whale stock structure is currently inconclusive, and **encouraged** further work using satellite telemetry, photo-identification, acoustics, biopsy sampling and length measurements to better understand fin whale population structure, movements and habitat use.

4.2 Southern Hemisphere distribution

SC/67b/SH10 reports the first confirmed stranding of a fin whale in Tierra del Fuego, Argentina, and provides information about the possible cause of death. No superficial lesions were found but the subcutaneous and visceral fat deposits were in bad condition and the stomach was empty. Histological sections of lungs and respiratory tract showed characteristics compatible with an initial stage of acute pneumonia. Although none of the pathological findings can convincingly explain the stranding, the pneumonia in combination with a bad physical condition, may have contributed to its death.

The authors were thanked for this information, which is from an area where fin whales are rarely seen. In discussion, it was noted that since this report there has been another fin whale stranding in Patagonia, and tissue samples from both strandings will be genetically analysed.

SC/67b/SH09 provided an update on meta-data collections for Southern Hemisphere fin whales. During the intersessional period (2017/18) nine new datasets have been added, 12 updated and two corrections have been made to existing datasets with one dataset being deleted. In total, 69 datasets have been identified, of which, 32 are from the West Antarctic Peninsula and Scotia Sea, whilst 37 are from other southern hemisphere regions. These datasets include a broad range of surveying methods, including, visual and acoustic surveys, biopsies, stranded specimens, photo identification and telemetry. The table presented here is the most recent overview of available data sets on Southern Hemisphere fin whales.

The sub-committee welcomed this update to work previously presented at SC/67a (Appendix 2, IWC 2018a). The sub-committee **encouraged** the next phase of this work, a meta-analysis of the Western Antarctic Peninsula and Scotia Sea sightings data to measure recent fin whale distribution, density and habitat use. This information will be helpful for understanding current fin whale distribution patterns in relation to environmental features, and for comparison with past distributions inferred from whaling data (e.g. Appendix 3, IWC 2018a).

Dalla Rosa informed the sub-committee about the recent work of the cetacean team of the Brazilian Antarctic Programme (PROANTAR), who have been conducting research in the Antarctic Peninsula region since 1997. Dedicated fin whale research has been conducted since 2013, including collection of sightings data, photo-identifications, biopsy samples, and satellite telemetry deployments. A total of 27 biopsy samples have been collected for studies on genetics, contaminants and stable isotopes. Six satellite tags have been deployed, providing new information on movements and dive behavior of fin whales around the Antarctic Peninsula. They currently hold a fin whale photo-ID catalogue for the Antarctic Peninsula, which numbers ~80-100 individuals. All these data have been collected with the main aim of helping to assess the population structure of Southern Hemisphere fin whales. He noted however that the current PROANTAR project will end at the end of the year, with no ship time or funding secured for 2019 onwards.

The sub-committee welcomed this update on the work of PROANTAR and **strongly encouraged** the continuance of this research program for the purpose of understanding fin whale population structure, movements and habitat use.

Fin whale song was also detected in the Northern Mozambique Channel during the late austral winter (see SC/67b/SH14) and discussed in Item 3.3.2.

4.3 Southern Hemisphere abundance

During SC/67a, the sub-committee requested a review of data from the post-CPIII IDCR/SOWER surveys to determine whether the data are of any use for informing on whale trend or abundance. They have since been informed that a regional abundance estimate has been generated for fin whales by Matsuoka and colleagues using CPIII data which is in the process of being published. The sub-committee **recommended** that this estimate be reviewed at SC/68a to determine suitability for use in population assessment.

SC/67b/PH01 reported on the compilation of a new photo-identification catalogue of Antarctic fin whales A total of 30 identifications were obtained; 28 from Areas III, IV, and V during SOWER cruises and 2 from 2018 during a Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) fisheries research voyage at the South Orkney Islands. There were no matches between any of the identified individuals from different dates. Photographs were scored categorically in order to assess the suitability of Antarctic fin whales for photo-ID. Results of the scoring analyses confirmed that Antarctic fin whales are marked well enough to serve as subjects for photo-ID projects. Another 20-24 identifications are expected from SOWER 2006/07 photographs that are currently missing from the IWC archives. The catalogue serves as a foundation for future photo-ID studies.

The sub-committee welcomed this update which indicated that Southern Hemisphere fin whale photo-identifications could potentially be useful to measure abundance using mark-recapture methodologies, and **encouraged** further photo-ID data collection. It was noted that the largest quantity of fin whale photographs is likely being collected in the Antarctic Peninsula, and that encouragement of tourists and naturalists to collect good quality photo-identifications during their Antarctic expeditions could be very helpful with developing this dataset. It was noted that fin whales are extremely difficult from which to collect good photo-identification images. In this regard, the sub-committee was informed that a matching protocol is currently under development for Omura's whales which may also be of assistance for fin whale matching. This option will be explored intersessionally.

4.4 Cruise reports

SC/67b/ASI07 reports the results of the systematic whale sighting survey conducted by two vessels in the Antarctic Areas VE (south of 60°S, 165°E-170°W including the Ross Sea) and VIW (170°W–145°W) under the NEWREP-A in the 2017/18 austral summer. The survey was conducted under two survey modes (Normal Passing mode (NSP), and an Independent Observer mode (IO)) based on IWC IDCR/SOWER survey procedures from 10 December 2017 to 20 February 2018. The total searching distance in the research area was 5,196.6 n.miles, including 2,441.2 n.miles covered in NSP and 2,755.4 n.miles in IO mode. A total of 66 schools (106 individuals) of fin whales were sighted in the research area. They were widely distributed in the western sector of Area VI. A biopsy sample (skin and blubber) was collected in Area VIW from one animal. Results of these data including multi-year data will be analysed and submitted to the NEWREP-A review meeting in the future.

SCSP/08 reports the sightings of fin whales from the sighting and sampling vessels operating in Area VI (south of 60°S, 170°W-120°W) under the NEWREP-A, during the 2017/18 austral summer. The total search distance was 4,164 n.miles, and a total of 115 schools (272 individuals) of fin whales were sighted. No biopsy samples were collected. Results of these data including multi-year data will be analysed and submitted to the NEWREP-A review meeting in the future.

The sub-committee thanked the authors for this new information.

5. SOUTHERN HEMISPHERE RIGHT WHALES NOT SUBJECT TO CMP

Last year the Scientific Committee conducted a prioritisation exercise and decided that population assessment of southern right whales from southwest and southeast Australia was a top work priority for completion in the next 2-5 years (see Item 9, IWC 2018a). In order to progress towards regional southern right whale assessments, a summary of abundance and trend data reported from across the range of the species was compiled (Table 2). These data have not yet been reviewed by the Standing Working Group on Abundance Estimates, Status of Stocks and International Cruises (ASI), so are not yet officially endorsed by the Scientific Committee. Review of these estimates is proposed to occur during SC/68a.

Table 2
Southern right whale abundance and trend data

Population[A]	Method	Time series	Demographic parameters	Notes	Citation
New Zealand	Boat based photo-ID and genotype mark recapture estimates using POPAN and lambda-POPAN models	1995-1998 and 2006-2009	Super-population size for 1995-2009: 2169 (95% CI: 1836, 2563); 2009 abundance for females: 1074 (95% CL 812, 1339); Annual growth rate 1995-2009: 7% per annum (95% CI; 5%, 9%)	Includes NZ sub-Antarctic, Mainland NZ	Carroll *et al.*, (2011; 2013)
Southeast Australia	(1) Aerial survey and population size estimated as correction to the number of reproductive females, assuming (a) consistent number of females per year and (b) correction factor of 3.94 (IWC 2001) and (c) correcting for availability bias derived from proportion of time spent diving.	2013-2014	250-300 whales; 257 (CV 0.367)	Results were extrapolated from two years of survey	Watson *et al.*, (2015)
Southwest Australia	Aerial survey with trend estimated as simple exponential regression and total population size estimated as correction (x3.94) to the number of reproductive females in last three cohorts (IWC 2001)	1993- 2016	Total population size for 2016: 2195 (No CIs available); Annual growth rate for all animals of 5.55% (95% CI 3.78, 7.36%)		Bannister (2017)
Head of Bight sub-area of Southwest Australia	Cliff-based counts with trends estimated using compound annual growth rate (CAGR) and linear regression analysis (LR)	1992-2016	Trend over time series: CAGR: 5.5% (SD 2.5%); LR: 3.2% (CI +/- 1.3%)		Charlton *et al.*, (In prep)
South Africa	Photo-ID from aerial survey integrated into population demographic model that estimates population parameters using female reproductive cycle; total population size found by adding estimated numbers of mature and juvenile females and then using a 50:50 ratio to include males	1979-2017	Total population size for 2017: 6116 whales (SE 446); Annual growth rate 6.5% (SE 0.3%);	Estimate relates to southern Cape coast breeding ground with linkages to Namibia, and possibly Mozambique, but does not account for whales historically seen around Tristan da Cunha	SC/67b/SH22
Argentina – Península Valdés	Photo-ID from aerial survey integrated into population demographic model that includes the female reproductive cycle and estimates population parameters and total population size	1970-2010;	Annual growth rate 2000-2010: 6.5% (SE 0.2%); Mature females in 2010 1,578 (SE 72); aged 1+ population size in 2010 4,765 (SE 243)		Cooke *et al.*, (2015)
	Aerial survey count	1999-2016	Number of calves in survey area, rate of increase: 0.5%		SC/67b/CMP05
Brazil	Photo-ID from aerial survey with trend estimated as linear regression of the natural log number of females with calves identified each year; population parameters using female reproductive cycle	(1) 1987-2003; (2) 1987-2011;	(1) Annual growth rate: 14% per year (95% CL 7.1, 20.9) for time series 1 (2) Annual growth rate for time series 2: 12.0% (CI 8.514.2%); Population size in 2010: 197 mature females (CI 146-234).		(1) Groch *et al.*, (2005); (2) IWC (2013)

[A]Note that there is no new information available for Chile/Peru or the Central Indian Ocean.

5.1 Southern Hemisphere population structure

The 1998 Workshop on the Comprehensive Assessment of Right Whales: A Worldwide Comparison (IWC 2001) agreed to divide the Southern Hemisphere into 11 management units for southern right whales based on the distribution pattern and locations of breeding aggregations. These units were: (1) sub-Antarctic New Zealand, (2) mainland New Zealand/Kermadec, (3) Australia, (4) Central Indian Ocean, (5) Mozambique, (6) South Africa, (7) Namibia, (8) Tristan da Cunha, (9) Brazil, (10) Argentina, and (11) Chile/Peru (IWC 2001). The 2011 southern right whale workshop (IWC 2013) **agreed** to the hierarchy of stocks/habitats summarised in Table 1 of that report.

With this background, the sub-committee reviewed currently available information on population structure in southern right whales, aided by a genetic study summarised in Carroll *et al.*, (In press). The authors of this paper noted that in southern right whales, patterns of genetic diversity are likely influenced by the glacial climate cycle and recent history of whaling. The study used a dataset of mitochondrial DNA (mtDNA) sequences (n=1,327) and nuclear markers (17 microsatellite loci, n=222) from major wintering grounds to investigate circumpolar population structure and historical demography. Analyses of nuclear genetic variation identified two population clusters that correspond to the South Atlantic (Argentina and South Africa) and Indo-Pacific (New Zealand and Australia) ocean basins that have similar effective breeder estimates. In contrast, there was significant differentiation among wintering grounds for mtDNA, and to a lesser extent, microsatellite loci, but no sex-biased dispersal was detected using the microsatellite genotypes. An approximate Bayesian computation (ABC) approach with microsatellite markers compared scenarios with gene flow through time, or isolation and secondary contact between ocean basins, while modeling declines in abundance linked to whaling. Secondary-contact scenarios yielded the highest posterior probabilities, implying that populations in different ocean basins were largely isolated and came into secondary contact within the last 25,000 years, However, the role of whaling in changes in genetic diversity and gene flow over recent generations could not be resolved. The authors hypothesised that these findings were driven by factors that promote isolation, such as female philopatry, and factors that could promote dispersal, such as oceanographic changes. These findings highlight the application of ABC approaches to infer connectivity in mobile species with complex population histories and currently low levels of differentiation.

The Chair complimented the authors on the range of data and analyses presented in this paper. In discussion, it was noted that the mitochondrial haplotype network pattern (Fig 3d, Carroll *et al.*, In press) suggests that the South Pacific and South Indo-Pacific haplotypes originated from the South Atlantic (i.e. a 'founder' effect), with the South Atlantic appearing more ancestral and more diverse than the South Pacific, but historical and bottleneck ABC estimates of effective size are similar for both populations. This may point to further population complexity, and further ABC analyses to explore founder population hypotheses could be useful. In response, the author highlighted that this was noted in the manuscript and that comparisons of more complex population hypotheses are poorly distinguished using the available microsatellite loci, but upcoming genomic work on these populations should provide more capacity for such testing.

Levels of population differentiation and migration between calving grounds can provide useful information for regional population assessments. It was noted that the whales in southeast Australia were not significantly differentiated from those in New Zealand, but were differentiated from those in southwest Australia. It was queried whether the small sample size available from southeast Australia might limit stock discernment. However, the authors responded that the 12 samples collected were from Warrnambool, the only regular calving ground in southeast Australia. The samples represent perhaps a third of the total breeding females (Watson *et al.*, 2015), so are likely to be relatively representative of this stock. They also highlighted the different abundance trajectories observed in the two regions of Australia (see Table 1), which also suggest a degree of demographic isolation.

The broad confidence intervals on some ABC parameter estimates were noted, although the authors highlighted that confidence intervals on the inter-ocean migration rates were relatively precise, and that precision of these estimates is likely to be improved when genomic analyses of the samples are conducted.

5.1.1 New Zealand right whales

Carroll informed the sub-committee of a plan to conduct surveys in the Auckland Islands in 2020/21 to estimate abundance (updating the last estimate from 2009), to assess trend and population age structure, as well as changes in genetic diversity. The project will use a close-kin mark-recapture approach (Bravington *et al.*, 2016). It was cautioned that implementation of this approach is challenging and the assumptions of the method have to be very well understood and accounted for (see Item 6.2.1, IWC 2018b). Carroll responded that they recognise this issue and are undertaking a feasibility study and power analysis, including epigenetic work in collaboration with Jarman.

5.1.2 Australian right whales

Double reported the latest results from John Bannister's long-term monitoring program (1993 to 2017) of Australia's western population of southern right whales. The 2017 aerial survey from Cape Leeuwin (Western Australia) and Ceduna (South Australia) recorded 847 individuals, of which 303 were cows accompanied by calves of the year. The 2017 counts were the highest yet in the series. Application of a simple multiplication factor to the total count of cow/calf pairs seen over the last three years of survey produces an estimate of the total population size of approximately 2,474 individuals. Although the counts are highly variable between years an exponential increase of approximately 6% per year remains the best description of the data. The Australian Government has agreed to fund this survey for a further three years through its National Environmental Science Program.

The sub-committee recognised the value of these long-term monitoring programs and the value of these datasets for the work of the Scientific Committee and for conservation management, and **recommended** that this monitoring continue.

Charlton *et al.*, (In prep) examined demographic parameters for southern right whales off South Australia using 26 years of photo identification (ID) mark recapture data and 25 years of count data. An annual cliff-based photo-ID and count study was completed at the Head of the Great Australian Bight, South Australia from 1991 to 2016. Annual aerial photo-ID and count surveys were completed for the 'western' sub-population of right whales from 1993 to 2016. At Head of the Bight, the estimated mean rate of increase for all right whales was 3.17% per annum (R^2=0.54, ±1.3, 95% CI), and for females with calves was 4.6% (R^2=0.57, ± 1.7, 95% CI) (1992-2016). Owing to cohort structure and pulses in calf production, the annual maximum count was highly variable among years (mean=39, SD=17.8). The Head of the Bight photo-ID database includes 1,186 non-calf individuals, of which 459 are reproductive females with 471 recorded inter-annual calving intervals. Southern right whales sighted at Head of the Bight represent 21-48% of the 'western' sub-population in Australia, where this fraction decreased over the study period. Mean photo-ID success of 92% and a mark recapture rate of 70% was recorded for females with a calf. The estimated apparent mean calving interval was 3.3 years (SD=0.8, ± 0.3, 95% CI), although this changed to 4 years in the latter part of the study. The mean observed age at first parturition was 9.3 years (n=22, SD=2.1, ± 0.9, 95% CI), with the minimum at 6 years. The oldest whale was approximately 50 and the oldest female with a calf 41, indicating that females continue to reproduce at least into their 40's. Natal site fidelity was recorded for 33% of known-age individuals. These SRW demographics data provide information for monitoring recovery, population status, species conservation management and global comparative studies.

In discussion, it was noted that the number of unaccompanied adults was not growing at a rate that would be expected from an increasing population; this might be due to habitat specialisation, with mothers and calves preferentially occupying the Head of the Bight area and other adults spending less time there. The rate of increase in Head of the Bight is lower than reported from South Africa and Argentina; this may reflect density dependence operating at the Head of the Bight and suggests that this is an open population.

The issue of why calving intervals appear to have lengthened to a mean of four years was also discussed; further analysis might examine correlations between oceanographic indices and calving intervals, as has been shown for the North Atlantic (Greene *et al.*, 2001) and Southwest Atlantic (Leaper *et al.*, 2006; Seyboth *et al.*, 2016). During 2014-16 there was a similar increase in calving interval in this region and in South Africa (see SC/67b/SH01 and SC/67b/SH22), suggesting a phenomenon that may affect much of the Southern Hemisphere. The sub-committee were informed that a workshop is planned to study calving intervals and body condition in right whales and other balaenids in November 2018 at New England Aquarium which could prove informative (see Annex G). There was considerable discussion regarding factors affecting or potentially biasing apparent calving intervals. Previous entanglement has also been shown to be a factor in diminished reproductive success in the North Atlantic, but there is no evidence that this is a problem for whales in Australian waters. It was noted that as calving intervals increase, the practice of excluding apparent calving intervals of >6 years from analysis might be problematic as it could downwardly bias the calving interval estimate. The sub-committee **agreed** that these calving data would most usefully be analysed in a modelling framework which can accommodate this uncertainty, and that the model implemented by Cooke (*e.g.*, Appendix 1 of SC/67b/ASI02) would be the best approach for analysing population trends across all calving grounds.

Carroll reported that an aerial survey was conducted in south-eastern Australia that covered the area from Ceduna to Sydney including Tasmania, updating the earlier survey reported in Watson *et al.*, (2015). The 2013 survey found that 91.5% of the 59 individually identified whales recorded during the survey were not previously known. While the study provided an abundance estimate of 200 animals, the authors acknowledged the limitation of just two years of survey effort and that they could not fully address issues related to the detectability of whales within the surveyed region.

The sub-committee **encouraged** further work on these data in order to measure abundance of this population. It was noted that most survey work to date has been concentrated in the vicinity of Warnambool, and that survey effort in other areas of Australia would be useful to establish whether the high recapture rates seen in this region are also found elsewhere. Opportunistic photographs collected from the region may help to establish whether this local population estimate is representative of the wider southeast Australia region.

Double informed the sub-committee that the Australian Government has recently allocated funds, through its National Environmental Science Program, to a two-year project that will provide an abundance estimate for Australia's two southern right whale populations. It will also investigate life history characteristics as well as connectivity between breeding areas on the eastern, southern and western coasts of Australia. Information on population abundance and movements will allow an assessment of the status of right whales in Australian waters and determine if conservation and management efforts are effectively coordinated between regions. This is a highly collaborative project that is made possible through the cooperation of many photo-identification catalogue holders and engagement with leading analysts.

5.1.3 South Africa right whales

SC/67b/SH01 reported the results of the 2017 photo-ID aerial survey of southern right whales, flown across the southern Cape coast of South Africa. The survey, which has been operated with a photo-ID component since 1979, has in recent years shown a marked decline in the presence of unaccompanied adults (since 2010) and cow-calf pairs (since 2015), for unknown reasons. To continue monitoring and investigate the trend, aerial surveys were conducted in the whale calving and nursing season (June to December) of 2017. The annual photo-identification aerial survey was flown as usual in

October 2nd to 10th) with the aim of counting all southern right whales and photographing all females with calves and individuals with a brindle or grey blaze colouration, between the area of Nature's Valley and Muizenberg. In total, 182 groups comprising 183 cow-calf pairs (366 animals) and 82 groups comprising 161 unaccompanied adults were observed. The number of cow-calf pairs represents the second-to-lowest count in the last 17 years of survey. The 2017 count of unaccompanied adults represents the highest presence since 2010, although levels remain significantly lower than those observed pre-2010. Additional aerial surveys to count cow-calf pairs were flown in July, September and November, covering the main calving areas. Results suggest a peak presence of cow-calf pairs along this stretch of coastline in early September, opposed to the previously assumed peak in October (when the annual photo-identification survey is conducted). Analysis of photo-ID data indicated an increasing occurrence of 4- and 5-year calving intervals post-2014. Current data suggest two working hypotheses to explain the continued low presence of southern right whales on the South African calving ground: 1) a temporal shift in seasonal presence and 2) a decreased calving success. The authors stressed the importance of continuing the aerial survey series and an in-depth assessment of the resulting demographic parameters to monitor the status of this population.

SC/67b/SH22 extended the analyses of Brandão *et al.*, (2013) that applied the three-mature-stages (receptive, calving and resting) model of Cooke *et al.*, (2003) to photo-identification data available from 1979 to 2012 for southern right whales in South African waters, by taking five additional years of data into account. The lower counts of calving females over 2015 to 2017 are indicated to be a reflection of time variability in the probability that a resting whale rests another year, rather than of any mass mortality. The 2017 number of parous females is estimated to be 1,765, the total population (including males and calves) 6,116, and the annual population growth rate 6.5%. This reflects a small decrease from the 6.6% increase rate estimated previously; this is the case even given the lower numbers of whales observed in recent years compared to previously. Information from re-sightings of grey-blazed calves as adults with calves allows estimation of the first-year survival rate at 0.852, a slight increase from the previous estimate of 0.850, compared to a subsequent annual rate of 0.988. It appears that 2009 was the year when a decrease in the calving rate commenced, for unknown reasons. The variation in calving rate in South Africa is broadly similar to that observed in Australia, with similar timing for high and low values, reinforcing the idea that examining broad-scale environmental correlates might prove to be a productive approach.

In discussion, it was noted that addition of the time-varying β parameter (probability that a resting mature whale rests for a further year) has improved fit to the data, but the β parameter varies substantially between years and may be better fitted using environmental correlates to inform this value. The substantial change in this value after 2009 was highlighted, suggesting a significant shift in the dynamics of this population. The sub-committee noted the common features of this population trend when compared with those presented in Charlton *et al*., (In prep). The sub-committee **recommended** those responsible for the different southern right whale studies consider using an integrated dataset and (as far as possible) a common modelling framework to explore broader-scale analyses, including incorporation of environmental correlates (see Item 5.2).

5.1.4 Feeding grounds

In paper SC/67b/SH06, genetic markers ('tags') were employed to identify individual southern right whales to assess their site-fidelity and sex-specific ranges in Antarctic Area IV. In total, 157 biopsy samples were collected from whales during fourteen summer surveys. Each sample was sexed, genotyped at fourteen microsatellite loci, and sequenced for 430 bp of the mtDNA control region. The overall probability of identity was estimated at 1.95 x10^{-10}. After removal of duplicate samples, the number of individuals was reduced to 153. Eight 'mark-recapture' incidences were detected (four males and four females). Individual matching by multi-locus genotypes was supported by mtDNA, sex determination, and in two cases by photo-identification. These eight recaptures suggested that individual whales tended to return to the same location in the Antarctic in subsequent years. The average longitudinal dispersal ranges were 13°06' and 7°15' in males and females, respectively. The time span between the 'mark' and the 'recapture' ranged from 3 to 13 years, with an average of 7.3 years. Preliminary application of a mark-recapture method based on an open population model, resulted in abundance estimates in Area IV similar to those obtained using line-transect-based sighting survey data. For example, the estimate of abundance by the genetic 'mark-recapture' method was 1,619 (95% CI: 868-3,151) individuals for 2015/16, similar to the most recent (2007/08) sighting survey abundance estimate of 1,557 (95% CI: 871-2,783) in the same area. The authors emphasised that these estimates correspond to the fraction of the total population migrating into the Antarctic feeding ground of Area IV.

The authors were thanked for bringing forward this information and **encouraged** to conduct further mark recapture analyses and present estimates of abundance to SC/68a, noting that southwest Australia is currently a priority area for population assessment (Item 9, IWC 2018a). In discussion, it was noted that this inter-annual feeding ground fidelity is consistent with regional stable isotope and genetic analyses (including in southwest Australia) which show that whales feeding in similar areas are more closely related to each other (Carroll *et al.*, 2015). In this context, it was queried whether the current microsatellite data are able to discern sibling relationships and whether genotype error rates have been calculated, given that probability of identity for siblings should also be considered when judging the certainty in the genotype matches. The authors responded that genotypic error rates were ~0.1 and that work to assess relationships between individuals is now underway. It was also suggested that permutation tests could help establish whether the resighted whales were geographically closer to each other than one might expect from a random pair of sightings. The authors informed the sub-committee that photo-identifications have also been collected from this area and will also be analysed in a mark recapture framework.

The southern right whale distribution in Antarctic Area IV was discussed. IDCR-SOWER surveys suggest their distribution is concentrated between 90-130°E and south of 60°S (Matsuoka & Hakamada In press), similar to the feeding area for humpback whales associated with west Australia breeding stock D (Branch 2011). In discussion of the preliminary abundance estimate presented, it was noted that the most recent estimate of abundance for western Australia (~2,500 whales, see Item 5.1.2) was substantially higher, supporting the stable isotope-driven hypothesis that different components of the calving ground population feed in different places (Carroll *et al.,* 2015). In this regard, it was suggested that these high latitude data be compared with mtDNA haplotype frequencies and sequences associated with the western Australia stock to investigate what component of that population is using this high latitude area.

SH/67b/SH20 reported the results of a visual and acoustic survey of southern right whales off the islands at 54°26'00"S/36°33'00"W, in January/February 2018. During 19 days of expedition time in these waters (totalling 76 hours where weather conditions were suitable for survey), right whales were sighted 15 times (an estimated 31 whales), yielding 21 right whale photo-identifications (left and right sides). Three right whale biopsy samples were collected. Work is now underway to assess the body condition of the whales sighted during the cruise. Analysis of right whale sightings data in relation to oceanographic features is also in progress. During the survey, 27 sonobuoys were deployed and right whales were detected by 19 of these, the most commonly heard call types being upcalls <200 Hz, as well as some gunshots. A second right whale research expedition to 54°26'00"S/36°33'00"W is planned for January/February 2019.

5.2 Progress towards population assessment

Jackson summarised recent increases in knowledge of southern right whale catches, including newly available information from projects analysing historical whaling logbook data, notably from American and British whaleships (e.g., Smith *et al.,* 2012; Carroll *et al.,* 2014; Roux *et al.,* 2015) and work on numbers of whales struck-but-lost by the different fisheries (e.g.,, Carroll *et al.,* 2014), which is important for upwardly correcting landed catches to account for whales lost at sea. She suggested that it would be timely and valuable to hold a workshop bringing together (among others) individuals involved in these data recovery efforts, in order to better assess the situation with regard to catches, and discuss ways to fill gaps in the record.

The sub-committee **supported** the proposal for this workshop. They also agreed that this should focus on collation of catch data, and subsequently consider how to utilise this information within the context of an assessment. This proposal has financial implications for the Scientific Committee. Further details are provided in Item 7.1.3.

Following the discussions in Item 5.1.2, Charlton introduced a proposal to complete a comparative study of demographic data using common models generated by Cooke *et al.,* (2015) and SC/67b/SH22, for Southern Hemisphere right whale populations. Specifically, demographic parameters include: abundance trend, calving intervals, age of first parturition, survival and mortality. The project would also investigate correlations between SRW abundance trends/calving intervals and environmental variables in the Southern Ocean. The sub-committee **agreed** that this work proceed. This proposal has financial implications for the Scientific Committee. Further details are provided in Item 7.1.3.

6. SOUTHERN HEMISPHERE HUMPBACK WHALES

6.1.1 Progress towards assessment of Breeding Stock D

Last year, the sub-committee encouraged a survey of humpback whales off Western Australia for the purpose of producing a new abundance estimate, although it remains unclear if this is feasible either financially or logistically. The sub-committee hoped that such a survey would occur at some point and **reiterates** their recommendation from SC/67a that a re-analysis of the pilot study conducted by duFresne *et al.,* (duFresne *et al.,* 2014) be carried out to assess the feasibility of future surveys.

7. WORK PLAN AND BUDGET REQUESTS FOR 2019-20

The sub-committee assessed and prioritised funding requests for the biennial period, 2018/19 and 2019/20, against Scientific Committee criteria and sub-committee priorities identified during the course of this meeting. Sub-Committee recommendations for funding are detailed in the following Workplan (unless otherwise indicated). A summary of the Workplan is in Table 3.

7.1 Work plan for 2019-20

The sub-committee **recommended** development of photo-ID outreach material to circulate amongst IAATO operators, naturalists and citizen scientists, to enhance citizen-contributed photo-ID for key catalogues including the Antarctic blue whale, Southern Hemisphere fin whales, Southern Hemisphere blue whale catalogues and regional southern right whale catalogues. This is relevant for all high latitude Southern Hemisphere species (details of this discussion are in Annex S, Item 4.1 and 8). The cost for the Scientific Committee would be £1,000 in 2018/19 for the creation of this guide, as well as provision of Powerpoint materials and guidance notes for naturalists.

7.1.1 Blue whales

7.1.1.1 ANTARCTIC BLUE WHALES

Work on the Antarctic Blue Whale Catalogue is ongoing. During the upcoming year photographs contributed from various sources will be examined and quality coded, including ~45 individual Antarctic blue whales photo-identified during ICR cruises 2014-2017. The sub-committee **agreed** to support continued work on this catalogue, to be conducted by Olson, with a budget allocation of £3,000 for 2018/19 and £800 for 2019/20.

The sub-committee **encouraged** further mark-recapture modelling by Olson using resight data from the Antarctic blue whale catalogue in order to address the suggestions made by the ASI Standing Group (Annex Q, Item 3.1.1.9).

An intersessional email group formed under Brownell and Kato in SC/66a is still in progress in order to progress work on the baleen plates from whales caught during the 1946/47 Antarctic season and currently stored at the Smithsonian with the Japanese whaling logs. Details are given in Appendix 4 of IWC (2016).

Attention: SC, G, CG-A

*The Committee **welcomes** the progress being made towards being able to undertake a new population assessment of Antarctic blue whales. The Committee:*

*(1) **encourages** further work to update the abundance estimate for Antarctic blue whales following Committee recommendations;*
*(2) **strongly encourages** continued opportunistic photo-ID data collection in the Antarctic to assist with developing estimates of population abundance for this subspecies; and*
*(3) **encourages** continued collection and analysis of bone and baleen from historical Antarctic commercial whaling samples and sites to evaluate loss of genetic diversity and shifts in population structure.*

7.1.1.2 NON-ANTARCTIC SOUTHERN HEMISPHERE BLUE WHALES

Preparation for Southern Hemisphere pygmy blue whale assessments is still underway. The sub-committee **encouraged** a number of intersessional initiatives in support of this.

(1) Further work on the allocation of catches to acoustically distinct putative pygmy blue whale populations, including; (i) incorporating the new data presented in SC/67b/SH25 into the catch allocation model; (ii) bootstrapping of acoustic recordings to better account for distributional uncertainty; (iii) development of high case catch allocations for all stocks; (iv) modelling of regional population exploitation trajectories where sufficient abundance and trend data are available to allow preliminary population assessment; (v) Alternative assessments based on extrapolation of abundance estimates using: (1) ratio of the area surveyed to geographic range; and (2) ratio of catch in area surveyed to catch in geographic range of each population. This work would require a budget allocation of £6,185 GBP in 2018/19 and £12,865 GBP in 2019/20.
(2) Discussion on catch allocation scenarios to inform pygmy blue whale population modelling, to be held intersessionally in an email group convened under Branch and composed of Jackson, Brownell, Širović, Buss, Olson and Cerchio.
(3) Work to continue on the Southern Hemisphere Blue Whale Catalogue. Work to be conducted by Galletti and associated researchers with a budget allocation of ₤16,810 GBP for 2018/19 and ₤3,000 GBP for 2019/20. The following work is planned: (i) conduct matching with new photos from the Eastern Tropical Pacific and southeast Pacific; (ii) integrate new IWC database requirements into SHBWC software; and (iii) update the User Manual. If further photographs are submitted to the catalogue intersessionally from Australia, New Zealand and Sri Lanka, funds calculated based on matching costs (likely range within £5,000-£10,000) will be requested at SC/68a in order to continue within-region matching efforts, if funds are available. Hosting of the catalogue on the IWC servers has an ongoing cost of £900 per year in 2018/19 and 2019/20 to cover web and database hosting, other infrastructure, back-up storage and software licensing.
(4) Complete development of the blue whale song library, to be hosted on IWC servers. This completes a project funded by the IWC during SC/66b (Item 10.2.2, IWC 2017). This development also has an associated cost of £450 per year in 2018/19 and 2019/20 for the Secretariat to cover web and database hosting, other infrastructure, back-up storage and software licensing.
(5) Re-analysis by Jenner of the Perth Canyon mark recapture estimate of blue whale abundance presented to the IWC in 2009 (Jenner *et al.*, 2008), with assistance from Double and Jackson.
(6) Intersessional email group (shared with the Photo-Identification Working Group) to progress the upload of photo-IDs collected around New Zealand to the Southern Hemisphere blue whale catalogue for the purpose of mark recapture abundance estimation (composed of Galletti, Torres and Olson, convened under Olson). See Workplan of Annex S. Item 8.1.
(7) Intersessional email group to investigate the different morphometric measurements made for pygmy, Chilean and North Pacific blue whales during the whaling period, assess comparability of these measurements and address whether the Chilean blue whales are most similar in length to the northeast Pacific blue whales. Group composed of Pastene, Brownell and Branch (convened under Brownell).

Attention: SC, G

In order to progress its work towards an assessment of pygmy blue whales, the Committee:

*(1) **agrees** that further work is needed to identify high and base case catch scenarios for pygmy blue whales;*
*(2) **encourages** deployment of more acoustic recorders in the southern Indian Ocean;*
*(3) **agrees** that further population modelling is needed to assess pygmy blue whale populations;*
*(4) **strongly encourages** blue whale research groups to publish the metadata associated with their sequences in order that levels of sample overlap can be established and datasets compared; and*

(5) ***agrees*** *that the Southern Hemisphere Blue Whale Catalogue should be continued to help understand blue whale movements, with a priority focus on matching photographs within regions to measure regional abundance of pygmy blue whales.*

Attention: SC, G

The Committee ***encourages*** *analysis to provide an estimate of Australian blue whale abundance using mark-resight data.*

Attention: SC, G, CG-A

The Committee notes that the distribution and population isolation of blue whales is poorly understood in the northern and western Indian Ocean. The Committee therefore:

(1) ***strongly encourages*** *further acoustic work in the western Indian Ocean and Arabian sea to better understand the distribution, seasonality and overlap of blue whale calls;*
(2) ***strongly encourages*** *the collection and analysis of available tissue samples for analysis of genetic population structure in this region to assist with characterising these populations; and*
(3) ***agrees*** *that catch allocations of blue whales be revised to include the new blue whale song in the northwest Indian Ocean as a potential distinct 'stock'.*

Attention: SC, G

With respect to information on blue whales off New Zealand, the Committee:

(1) ***welcomes*** *this work to understand abundance and connectivity, which will contribute towards the pygmy blue whale population assessments; and*
(2) ***agrees*** *that New Zealand photo-identifications should be combined with others within the Southern Hemisphere Blue Whale Catalogue to provide the fullest possible assessment of regional abundance and connectivity.*

Attention: SC, G

In view of the recent identification of movements of Chilean blue whales into the South Atlantic and ongoing questions about the distribution of this population, the Committee:

(1) ***encourages*** *further satellite tracking and surveys (including collection of photo-ID and genetic data) to assess the population limits, habitat use and abundance and sub-species identity of blue whales in Chile;*
(2) ***encourages*** *compilation of morphometric data available for northeast Pacific blue whales and comparison with Chilean data, to assess morphological differentiation of these whales in the eastern Pacific and evaluate sub-species identity; and*
(3) ***welcomes*** *plans for further photo-ID catalogue matching within this region to assist with regional abundance estimation.*

7.1.2 Fin whales

In view of the absence of available data to inform Southern Hemisphere fin whale stock structure, the sub-committee **encouraged** further work using satellite telemetry, photo-identification, acoustics, biopsy sampling and length measurements to better understand fin whale population structure, movements and habitat use. They also **strongly encouraged** the continued work of the Brazilian Antarctic Program on these questions in the Antarctic Peninsula. Given that there are two sub-species of fin whales proposed to occur in the Southern Hemisphere (Clarke 2004; Committee on Taxonomy 2017), further work to understand the genetic and morphological identity of fin whales across their range was encouraged.

In particular, the sub-committee:

(1) **agreed** to conduct a review of available fin whale acoustic data and analysis to analyse fin whale call types and their distribution patterns across the Southern Hemisphere. This would cost the sub-committee £12,000 to undertake during 2019/20.
(2) **strongly encouraged** the co-collection of photo-IDs along with genetic samples, and use of hexacopters to measure body length by Chilean researchers working in Chilean waters;
(3) **encouraged** further sampling and sequencing of multiple nuclear loci from Chile and other Southern Hemisphere locations to investigate subtle population structure patterns;
(4) **agreed** to conduct a review of all published and unpublished Discovery mark data on fin whales to assess population connectivity patterns to be conducted by Pastene and Jackson;
(5) **reiterated** their previous recommendation that the IWC Secretariat provide a letter of support for Archer (Southwest Fisheries Science Center, USA) to obtain a sample for establishing the genetic identity of the type specimen of *B. p. patachonica* currently held in the Buenos Aires museum;
(6) **encouraged** continued compilation and meta-analysis of Western Antarctic Peninsula and Scotia Sea sightings data to measure recent fin whale distribution, density and habitat use;

(7) **encouraged** the calculation of fin whale distribution maps using all available catches and applying the relative density model developed by de la Mare (2014). This work will be conducted inter-sessionally by de la Mare, The sub-committee also **encouraged** construction of a histogram of catches by longitude, to help identify high latitude aggregations.
(8) The sub-committee **requested** that the Secretariat provide a letter of support to assist Archer in gaining approval to sample the *B. p. patachonica* holotype in the Buenos Aires museum, to establish the genetic identity of this specimen.

A new estimate of fin whale abundance from the IDCR-SOWER CPIII surveys is anticipated to be available shortly and the sub-committee **recommended** that this estimate be reviewed at SC/68a to determine suitability for use in population assessment. The sub-committee also **encouraged** initiatives to enhance collection of photo-identifications from high latitudes in order to enhance data collection for the Southern Hemisphere fin and Antarctic blue whale catalogues.

Attention: SC, G, S
Knowledge of population structure is essential to future efforts to assess Southern Hemisphere fin whales. To determine the differentiation and potential sub-species structure among fin whales the Committee:
(1) agrees that analysis of concurrently collected acoustic recordings of fin whales, to assess song variation around the Southern Hemisphere, is a priority;
(2) agrees that a review of all Discovery mark data published on fin whales to assess population connectivity patterns should be carried out; and
(3) requests that the Secretariat provide a letter of support for a study examining the evidence for B. physalus patachonica, which requires access to the holotype for this species from the Bernardino Rivadavia Natural Sciences Museum in Buenos Aires.

*The Committee also **encourages**:*
(1) analysis of fin whale distribution and geographic aggregations using all available catches;
(2) strategic biopsy sampling and analysis to measure the genetic differentiation of fin whales around the Southern Hemisphere;
(3) further biopsy sampling and sequencing of multiple nuclear loci to establish Chilean fin whale differentiation patterns, with co-collection of photo-IDs and body length measurements to establish population identity;
(4) satellite telemetry to discern seasonal movements; and
(5) photo-identification to understand site fidelity and residency patterns and linkages between high- and low-latitude grounds.

Attention: SC, G, CG-A
With respect to obtaining information on the distribution, movements and abundance of Southern Hemisphere fin whales for use in an assessment, the Committee:
*(1) **encourages** a meta-analysis of the Antarctic Peninsula and Scotia Sea sightings data, to measure recent fin whale distribution, density and habitat use,*
*(2) **strongly encourages** continued work by the Brazilian Antarctic Program towards the understanding of fin whale population structure, movements and habitat use,*
*(3) **recommends** presentation of a new abundance estimate for fin whales for review at next year's meeting,*
*(4) **welcomes** news that fin whales can be used in photo-ID studies, and **encourages** further photo-ID data collection at high latitudes.*

7.1.3 Southern right whales
The sub-committee **agreed** to support work applying the modelling framework developed in SC/67b/SH22 to other southern right whale populations, in particular the southwest Atlantic, Head of the Bight and southwest Australia calving grounds, in order to measure regional demographic parameters and investigate commonalities in the population dynamics of these populations. This work would require a budget allocation of ₤13,600 GBP for 2018/19 and ₤13,600 GBP for 2019/20.

The sub-committee **supported** a proposal for a southern right whale catch series workshop to be held during 2019/20, to update regional estimates of Southern Hemisphere right whale catch using the substantial additional offshore voyage data which has recently become available (see Item 5.2). This work is anticipated to require 10-12 invited participants, and would cost £15,800 to hold in 2019/20.

Attention: SC, G, C-A, CG-A
*The Committee is **concerned** that the future of the exemplary long-term monitoring programme of right whales in South African waters remains uncertain. The Committee therefore **reiterates** that they:*

*(1) **strongly recommend** continuation of the survey;*
*(2) **request** the Commission to urge South Africa to do all it can to ensure the long-term future of this vital monitoring programme; and*
*(3) **encourage** South African scientists to investigate the offshore movements and locations of southern right whales with future surveys.*

Attention: SC, G, CC, CG-A

*The Committee **recognizes** the value of the Australian long-term right whale monitoring programs to understand right whale population trends and dynamics, and **recommends** that this monitoring continue.*

*In regard to right whales in southeast Australia, the Committee **reiterates** concerns expressed in 2017 that abundance remain low despite this area having been a significant historic calving ground. The Committee therefore:*

(1) recommends an assessment of the likely effects of fish farms and other developments in hindering population recovery in this region; and

(2) encourages further work to estimate the abundance of the southeast Australia population.

Attention: SC

*The Committee **encourages** further mark recapture analysis of the genotype data of the 14-year dataset collected in the high latitudes of Area IV, to estimate the abundance in this feeding area.*

Attention: SC, G

To better understand patterns of right whale population dynamics around the Southern Hemisphere, and further the work on updated assessments, the Committee:

*(1) **agrees** that analysis of the three southern right whale calving grounds (Head of the Bight and southwest Australia, southwest Atlantic and south Africa) should be undertaken using the same life-history model, to estimate regional demographic parameters and investigate commonalities in the population dynamics of these populations; and*

*(2) **supports** the compilation of new data on pre-modern right whale catches, and organization of a workshop to measure regional right whale catches and rates of whales struck but lost by fisheries, in order to proceed toward regional population assessments.*

7.1.4 Humpback whales

The sub-committee **reiterated** their recommendation that a re-analysis of the pilot study conducted by duFresne *et al.*, (2014) be carried out to assess the feasibility of future abundance surveys off West Australia.

Attention: SC, G, CG-R

*The Committee **agrees*** that *obtaining a reliable estimate of absolute abundance for humpback whale Breeding Stock D (west Australia) is a priority for any future in-depth assessment. The Committee **reiterates** its recommendation that an evaluation of abundance survey feasibility be carried out for this population, focusing in particular on the study conducted by du Fresne et al. (2014), with a view to implementing a new survey of this population in the future.*

7.1.5 IWC-SORP

IWC-SORP activities planned for 2018/19 and 2019/20 include but are not limited to: (1) Continued analysis of data/samples from previous IWC-SORP voyages/fieldtrips; (2) The planning and execution of several research voyages to the Southern Ocean; (4) the continued use of ships of opportunity to conduct cetacean research; (4) retrieval and redeployment of passive acoustic recorders.

Attention: SC, G

The Committee reiterates the great value of the IWC-SORP (Southern Ocean Research Partnership) programme to its work. The Committee:

*(1) **encourages** the continuation of the Southern Ocean Research Partnership programme;*

(2) commends the researchers involved who are key to the overall success of the Partnership in IWC-SORP for:

- *(a) the impressive quantity of work carried out across diverse member nations;*
- *(b) their contributions to the work of the Committee; and*

*(3) **encourages**:*

- *(a) the continued development, testing and implementation of leading edge technology; and*
- *(b) the continued development of collaborations between ships of opportunity and external bodies that can provide platforms for research and/or contribute data, inter alia, photo-identification data, to IWC-SORP and the wider Committee.*

Table 3
Proposed work plan.

Topic	Intersessional 2018/19	2019 Annual Meeting (SC/68a)	Intersessional 2019/20	2020 Annual meeting
Antarctic blue whales				
Catalogue matching	Catalogue matching of 45 photo-IDs from 2014-2017 ICR cruises (Olson convenor)	Report	Catalogue matching (opportunistic photos from citizen scientists and collaborators)	Report
Abundance estimation	Mark recapture modelling work to update SC/67b/SH08 (Olson convenor)	Report		
Photo-ID outreach material	Create photo-ID information booklets for distribution via IAATO operators	Report		
SH non-Antarctic blue whales				
Population assessment	Improve catch separation model and explore alternative catch allocation models (Branch convenor)	Report	Population assessment to analyse minimum and extrapolated recovery status for all pygmy blue whale populations for which abundance is available	Report
Catalogue matching	Catalogue matching of photo-IDs within southeast and central east Pacific (Galletti convenor)	Report	Catalogue matching (opportunistic photos from citizen scientists and collaborators) if funds are available	Report
Blue whale song library	Complete development of blue whale song library (Širović convenor)	Report		
Perth Canyon abundance estimate	Analyse Perth Canyon blue whale abundance using mark recapture data (Double convenor)	Report		
SH fin whales				
Fin whale acoustic structure	Review fin whale call patterns across Southern Hemisphere and investigate call variation (Širović convenor)	Report		
Discovery marks	Review available published and unpublished Discovery mark data on fin whales (Pastene and Jackson)	Report		
Catch maps	Update fin whale catch model to include Soviet catch data (de la Mare)	Report		
Southern right whales				
Modelling	Measure southern right whale demographic parameters (South Africa, southwest Atlantic, south and southwest Australia) using Cooke modelling framework (Charlton convenor)	Two meeting reports:	Further development of modelling framework and comparison of demographic parameters between areas	Two meeting reports
Workshop	Organise right whale catch series workshop (Jackson and Carroll)		Workshop (convened under Jackson & Carroll)	Workshop report
SH humpback whales				
Survey feasibility	Reanalyse pilot study to assess feasibility of future West Australia surveys (Kelly)	Report		
IWC-SORP				
Analyses	Continued analysis of data/samples from previous IWC-SORP voyages/fieldwork	Report	Continued analysis of data/samples from previous IWC-SORP voyages/fieldwork	Report
Voyages	Argentine coastguard '*Tango*' voyage along Western Antarctic Pensinsula (early 2019)	Cruise report		
	Almirante Maximiano voyage along Western Antarctic Pensinsula (early 2019)	Cruise report		
	Australian-led *RV Investigator* voyage to Ross Sea (early 2019)	Cruise report		
	New Zealand-led *RV Tangaroa* voyage to Ross Sea (early 2019)	Cruise report		
	German-led *RV Polarstern* voyage to Scotia Sea (early 2019)	Cruise report		
	Baleen whale and krill research voyages along Western Antarctic Peninsula	Reports	Baleen whale and krill research voyages along Western Antarctic Peninsula	Report
Ships of opportunity	Continued use of ships of opportunity to conduct cetacean research	Reports	Continued use of ships of opportunity to conduct cetacean research	Report
Acoustics	Retrieval and redeployment of passive acoustic recorders	Report	Retrieval and redeployment of passive acoustic recorders	Report
	Completion of annotated library of acoustic detections	Report		

7.2 Budget requests for 2019-20

Table 4

Summary of the 2-year budget request for Southern Hemisphere sub-committee.

RP no.	Title	2019 (£)	2020 (£)
Meetings/Workshop			
1	Southern right whale catch series workshop	-	15,800
Modelling/Computing			
2	Multi-ocean analysis of southern right whale demographic parameters	13,600	13,600
Research			
3	Analysis of fin whale song variability across the Southern Hemisphere	-	12,000
12,4	Updated catch series and assessments of four pygmy blue whale populations	6,185	12,865
Database/Catalogues			
5	Photo-Identification Information Placards for Naturalists and Citizen Scientists	1,000	-
6	Southern Hemisphere Blue Whale Catalogue 2019/2020	16,810	3,000
7	Southern Hemisphere Blue Whale Catalogue IWC host cost	900	900
8	Antarctic blue whale catalogue 2019/2020	3,000	800
9	Blue whale song library IWC host cost	450	450
Total request		**52,495**	**46,965**

8. ADOPTION OF REPORT

The report was adopted at 18:41 on 2nd May 2018. The Chair thanked the rapporteurs for all their hard work.

REFERENCES

Archer F. I., Morin P. A., Hancock-Hanser B. L., Robertson K. M., Leslie M. S., Bérubé M., Panigada S., Taylor B. L. (2013). Mitogenomic phylogenetics of fin whales (*Balaenoptera physalus* spp.): Genetic evidence for revision of subspecies. *PLoS One* 8(5), e63396.

Attard C. R. M., Beheregaray L. B., Jenner C., Gill P., Jenner M., Morrice M., Bannister J., LeDuc R., Möller L. (2010). Genetic diversity and structure of blue whales (*Balaenoptera musculus*) in Australian feeding aggregations. *Conserv. Genet.* 11(6), 2437-2441.

Attard C. R. M., Beheregaray L. B., Möller L. (2018). Genotyping-by-sequencing for estimating relatedness in nonmodel organisms: avoiding the trap of precise bias. *Molecular Ecology Resources*.

Attard C. R. M., Beheregaray L. B., Sandoval-Castillo J., Jenner K. C. S., Gill P. C., Jenner M. M., Morrice M. G., Moller L. M. (2018). From conservation genetics to conservation genomics: a genome-wide assessment of blue whales (*Balaenoptera musculus*) in Australian feeding aggregations. *R Soc Open Sci* 5(1), 170925.

Bannister J. 2017. Project A7- Monitoring population dynamics of 'western' right whales off southern Australia 2015-2018. In. Final report to the National Environment Science Program, Australian Commonwealth Government.

Bedriñana-Romano L., Hucke-Gaete R., Viddi F. A., Morales J., Williams R., Ashe E., Garcés-Vargas J., Torres-Florez J. P., Ruis J. (2018). Integrating multiple data sources for assessing blue whale abundance and distribution in Chilean Northern Patagonia. *Divers. Distrib.* 001-14.

Branch T., Jackson J. A. 2008. Minimum bottleneck abundance of Antarctic blue whales based on current mtDNA diversity. Paper SC/60/SH10 presented to the IWC Scientific Committee, May 2008 (unpublished). 7pp. [Available from http://www.iwc.int/.].

Branch T. A. (2007). Abundance of Antarctic blue whales south of 60°S from three complete circumpolar sets of surveys. *J. Cetacean Res. Manage.* 9(3), 253-262.

Branch T. A. (2011). Humpback abundance south of 60°S from three complete circumpolar sets of surveys. *J. Cetacean Res. Manage. (Special Issue)* 353-70.

Brandão A., Butterworth D. S., Ross-Gillespie A., Best P. B. 2013. Application of a photo-identification-based assessment model to southern right whales in South African waters, now including data up to 2012. Paper SC/65a/BRG17 presented to the IWC Scientific Committee, May 2013 (unpublished). 15pp. [Available from http://www.iwc.int/].

Bravington M. V., Skaug H. J., Anderson E. C. (2016). Close-Kin Mark-recapture. *Statistical Science* 31(2), 259-274.

Brown S. G. (1962). A note on migration in fin whales. *Norsk Hvalfangst-Tidende* 51(1), 13-16.

Calambokidis J., Barlow J., Ford J. K. B., Chandler T. E., Douglas A. B. (2009). Insights into the population structure of blue whales in the Eastern North Pacific from recent sightings and photographic identification. *Mar. Mamm. Sci.* 25(4), 816-832.

Carroll E. L., Alderman R., Bannister J. L., Berubé M., Best P. B., Boren L., Baker C. S., Constantine R., Findlay K., Harcourt R., et al. (In press). Incorporating non-equilibrium dynamics into demographic history inferences of a migratory marine species. *Heredity*.

Carroll E. L., Baker C. S., Watson M., Alderman R., Bannister J., Gaggiotti O. E., Gröcke D. R., Patenaude N. J., Harcourt R. (2015). Migratory traditions shape the genetic structure of southern right whales around Australia and New Zealand. *Sci Rep-Uk* 516182.

Carroll E. L., Childerhouse S. J., Fewster R. M., Patenaude N. J., Steel D., Dunshea G., Boren L., Baker C. S. (2013). Accounting for female reproductive cycles in a superpopulation capture-recapture framework: application to southern right whales. *Ecol. Appl.* 23(7), 1677-1690.

Carroll E. L., Jackson J. A., Paton D., Smith T. D. (2014). Two Intense Decades of 19th Century Whaling Precipitated Rapid Decline of Right Whales around New Zealand and East Australia. *PLoS One* 9(4), e93789.

Carroll E. L., Patenaude N. J., Childerhouse S. J., Kraus S. D., Fewster R. M., Baker C. S. (2011). Abundance of the New Zealand subantarctic southern right whale population estimated from photo-identification and genotype mark-recapture. *Mar. Biol.* 158(11), 2565-2575.

Castellote M., Clark C. W., Lammers M. O. (2012). Fin whale (Balaenoptera physalus) population identity in the western Mediterranean Sea. *Mar. Mamm. Sci.* 28325-344.

Charlton C., Bannister J., McCauley R. D., Brownell Jnr R. L., Ward R., Salgado Kent C., Burnell S. (In prep). Demographic parameters of southern right whales (Eubalaena australis) off Australia.

Clarke R. (2004). Pygmy fin whales. *Mar. Mamm. Sci.* 20(2), 329-334.

Clarke R. (1962). Whale observation and whale marking off the coast of Chile in 1958 and from Ecuador towards and beyond the Galapagos Islands in 1959. *Norsk Hvalfangst-Tidende* 51265-287.
Committee on Taxonomy. 2017. List of marine mammal species and subspecies. In: 2018 SfMMwmocotA, editor.
Cooke J., Rowntree V., Payne R. 2003. Analysis of inter-annual variation in reproductive success of South Atlantic right whales (*Eubalaena australis*) from photo-identification of calving females observed off Peninsula Valdés. Paper SC/55/O23 presented to the IWC Scientific Committee, May 2003 (unpublished). [Available from http://www.iwc.int/].
Cooke J., Rowntree V., Sironi M. 2015. Southwest Atlantic right whales: interim updated population assessment from photo-id collected at Península Valdéz, Argentina. Paper SC/66a/BRG23 presented to the IWC Scientific Committee, May 2015 (unpublished). 10pp. [Available from http://www.iwc.int/].
de la Mare W. K. (2014). Estimating relative abundance of whales from historical Antarctic whaling records. *Can. J. Fish. Aquat. Sci.* 71106-119.
de la Mare W. K., Friedlaender A., Goldbogen J. A. (In press). Developing functional responses using an individual-based energetics model for rorqual foraging dives. *Funct. Ecol.*
Donovan G. (1991). A review of IWC stock boundaries. *Report of the International Whaling Commission (Special Issue)* 1339-68.
Double M. C., Miller B. S., Leaper R., Olson P., Cox M. J., Miller E., Calderan S., Collins K., Donnelly D., Ensor P., et al. 2015. Cruise report on blue whale research from the NZ/Australia Antarctic Ecosystems Voyage 2015 of the Southern Ocean Research Partnership. Paper SC/66a/SH7 presented to the IWC Scientific Committee, May 2015 (unpublished). [Available from http://www.iwc.int/].
duFresne S., Hodgson A., Smith J., Bennett L., Burns D., MacKenzie D., Steptoe V. 2014. Final report: Breeding stock 'D' humpback whale pilot surveys - methods and location. Prepared for the Australian Marine Mammal Centre. 67pp. In.
Fiedler P. C., Reilly S., Hewitt R. P., Demer D., Philbrick V. A., Smith S., Armstrong W., Croll D. A., Tershy B. R., Mate B. R. (1998). Blue whale habitat and prey in the California Channel Islands. *Deep Sea Res. (II Top. Stud. Oceanogr.)* 45(8-9), 1781-1801.
Galletti Vernazzani B., Jackson J. A., Cabrera E., Carlson C., Brownell Jr R. L. (2017). Estimates of abundance and trend of Chilean blue whales of Isla de Chiloé, Chile. *PLoS One* 12(1), e0168646.
Gedamke J. 2007. Seasonal occurrence of low frequency whale vocalisations across eastern Antarctic and southern Australian waters, February 2004 to February 2007. Paper SC/59/SH05 presented to the IWC Scientific Committee, May 2007 (unpublished). 11pp. [Available from http://www.iwc.int/].
Gill P. (2002). A blue whale (*Balaenoptera musculus*) feeding ground in a southern Australian coastal upwelling zone. *J. Cetacean Res. Manage.* 4(2), 179-184.
Goto M., Kanda N., Pastene L. A. 2014. Update on the genetic analysis on stock structure of fin whales in the Antarctic based on mitochondrial and microsatellite DNA. Paper SC/65b/SD03 presented to the IWC Scientific Committee, May 2014 (unpublished). 8pp. [Available from http://www.iwc.int/].
Greene C. H., Pershing A. J., Kenney R. D., Jossi J. W. (2001). Impact of climate variability on the recovery of endangered north Atlantic right whales. *Oceanography* 16(4), 98-103.
Groch K. R., Palazzo Jr. J. T., Flores P. A. C., Adler F. R., Fabian M. E. (2005). Recent rapid increases in the right whale (Eubalaena australis) population off southern Brazil. *Latin Am. J. Aquat. Mammals* 4(1), 41-47.
IWC. (2018a). Annex H: Report of the Sub-Committee on Other Southern Hemisphere Whale Stocks. *J. Cetcean Res. Manage. (Supp.)* 19193-221.
IWC. (2009). Annex H: Report of the Sub-Committee on Other Southern Hemisphere Whale Stocks. *J. Cetcean Res. Manage. (Supp.)* 11(1), 220-247.
IWC. (2016). Annex H: Report of the Sub-Committee on Other Southern Hemisphere Whale Stocks. *J. Cetcean Res. Manage. (Supp.)* 17250-282.
IWC. (2017). Annex H: Report of the Sub-Committee on Other Southern Hemisphere Whale Stocks. *J. Cetcean Res. Manage. (Supp.)* 18230-263.
IWC. (2015). Annex I: Report of the Working Group on Stock Definition. *J. Cetcean Res. Manage. (Supp.)* 16222-235.
IWC. (2018b). Annex I: Report of the Working Group on Stock Definition and DNA Testing. *J. Cetcean Res. Manage. (Supp.)* 19222-235.
IWC. (2018c). Annex V: Matters related to working methods. *J. Cetcean Res. Manage. (Supp.)* 19418-423.
IWC. (2013). Report of the IWC Workshop on the Assessment of Southern Right Whales, Buenos Aires, Argentina, 13-16 September 2011. *J. Cetcean Res. Manage. (Supp.)* 14439-462.
IWC. (2001). Report of the Workshop on the Comprehensive Assessment of Right Whales: A Worldwide Comparison. *J. Cetacean Res. Manage. (Special Issue)* 21-60.
Jenner C., Jenner M. N., Burton C., Sturrock V., Salgado Kent C., Morrice M., Attard C., Möller L., Double M. C. 2008. Mark recapture analysis of pygmy blue whales from the Perth Canyon, Western Australia 2000-2005. Paper SC/60/SH16 presented to the IWC Scientific Committee, May 2008 (unpublished). 9pp. [Available from http://www.iwc.int/].
Jombart T., Devillard S., Balloux F. (2010). Discriminant analysis of principal components: a new method for the analysis of genetically structured populations. *BMC Genet.* 11(94), 1-15.
Leaper R., Cooke J., Trathan P., Reid K., Rowntree V., Payne R. (2006). Global climate drives southern right whale (*Eubalaena australis*) population dynamics. *Biol. Lett.* 2289-292.
LeDuc R. G., Archer E. I., Lang A. R., Martien K. K., Hancock-Hanser B., Torres-Florez J. P., Hucke-Gaete R., Rosenbaum H. R., van Waerebeek K., Brownell Jr R. L., et al. (2017). Genetic variation in blue whales in the eastern Pacific: implication for taxonomy and use of common wintering grounds. *Mol. Ecol.* 26(3), 740-751.
LeDuc R. G., Dizon A. E., Goto M., Pastene L. A., Kato H., Nishiwaki S., LeDuc C. A., Brownell Jr R. L. (2007). Patterns of genetic variation in Southern Hemisphere blue whales and the use of assignment tests to detect mixing on the feeding grounds. *J. Cetacean Res. Manage.* 9(1), 73-80.
Mackintosh N. A., Wheeler J. F. G. (1929). Southern blue and fin whales. *Discovery Reports* 1(257-540).
Matsuoka K., Hakamada T. (In press). Estimates of abundance south of 60S for southern right whales (*Eubalaena australis*) in the Antarctic Area IV (80-130E) based on 1998/99 SOWER survey data. *J. Cetacean Res. Manage. (Special Issue)*.
McClintock B. T. (2015). Multimark: An R package for analysis of capture-recapture data consisting of multiple 'noninvasive' marks. *Ecol. Evol.* 54920-4931.
McDonald M. A., Mesnick S. L., Hildebrand J. A. (2006). Biogeographic characterisation of blue whale song worldwide: using song to identify populations. *J. Cetacean Res. Manage.* 8(1), 55-66.
Mikhalev Y. A. (1997). Humpback whales *Megaptera novaeangliae* in the Arabian Sea. *Mar. Ecol. Prog. Ser.* 14913-21.
Miller B. S., Miller E. J. (2018). The seasonal occupancy and diel behaviour of Antarctic sperm whales revealed by acoustic monitoring. *Sci Rep* 8(1), 5429.
Peterson B. K., Weber J. N., Kay E. H., Fisher H. S., Hoekstra H. E. (2012). Double Digest RADseq: An Inexpensive Method for De Novo SNP Discovery and Genotyping in Model and Non-Model Species. *Plos One* 7(5).
Pitman R. L., Fearnback H., Durban J. W. (2018). Abundance and population status of Ross Sea killer whales (*Orcinus orca*, type C) in McMurdo Sound, Antarctica: Evidence for impact by commercial fishing? *Polar Biol.*
Raj A., Stephens M., Pritchard J. K. (2014). fastSTRUCTURE: variational inference of population structure in large SNP data sets. *Genetics* 197(2), 573-589.
Riekkola L., Zerbini A. N., Andrews O., Andrews-Goff V., Baker C. S., Chandler D., Childerhouse S., Clapham P., Dodémont R., Donnelly D., et al. (2018). Application of a multi-disciplinary approach to reveal population structure and Southern Ocean feeding grounds of humpback whales. *Ecol. Indicators* 89455-465.
Rodriguez A., Laio A. (2014). Clustering by fast search and find of density peaks. *Science* 344(1492), 1492-1496.
Roux J.-P., Braby R. J., Best P. B. (2015). Does disappearance mean extirpation? The case of right whales off Namibia. *Mar. Mamm. Sci.* 31(3), 1132-1152.

Sepulveda M., Perez-Alvarez M. J., Santos-Carvallo M., Pavez G., Olavarría C., Moraga R., Zerbini A. N. 2017. From whaling to whale watching: identifying fin whale critical foraging habitats off the Chilean coast. Paper SC/67a/WW2 presented to the IWC Scientific Committee, May 2017 (unpublished). 17pp. [Available from http://www.iwc.int/].

Seyboth E., Groch K. R., Dalla Rosa L., Reid K., Flores P. A. C., Secchi E. R. (2016). Southern right whale (*Eubalaena australis*) reproductive success is influenced by krill (*Euphausia superba*) density and climate. *Sci Rep-Uk* 6(28205).

Širović A., Hildebrand J. A., Wiggins S. M. (2009). Blue and fin whale acoustic presence around Antarctica during 2003 and 2004. *Mar. Mamm. Sci.* 25(1), 125-136.

Širović A., Olseon E. M., Buccowich J., Rice A., Bayless A. R. (2017). FIn whale song variability in southern California and Gulf of California. *Sci Rep-Uk* 710126.

Smith T. D., Reeves R. R., Josephson E. A., Lund J. N. (2012). Spatial and Seasonal Distribution of American Whaling and Whales in the Age of Sail. *PLoS One* 7(4), e34905.

Sremba A., Martin A. R., Baker C. S. (2015). Species identification and likely catch time period of whale bones from South Georgia. *Mar. Mamm. Sci.* 31(1), 122-132.

Sremba A. L., Hancock-Hanser B., Branch T. A., LeDuc R. L., Baker C. S. (2012). Circumpolar Diversity and Geographic Differentiation of mtDNA in the Critically Endangered Antarctic Blue Whale (*Balaenoptera musculus intermedia*). *PLoS One* 7(3), e32579.

Toro F., Vilina Y. A., Capella J. J., Gibbons J. (2016). Novel coastal feeding area for eastern South Pacific fin whales (Balaenoptera physalus) in mid-latitude Humboldt current waters off Chile. *Aquat. Mamm.* 42(1), 47-55.

Torres L. G. (2013). Evidence for an unrecognised blue whale foraging ground in New Zealand. *N. Z. J. Mar. Freshwat. Res.* 47(2), 235-248.

Watson M., Westhorpe I., Bannister J., Harcourt R., Hedley S. 2015. Assessment of numbers and distribution of southern right whales in south-east Australia - Year 2. In. Australian Marine Mammal Centre Grants Program Final Report for Project 13/29.

Appendix 1

AGENDA

1. Introductory items
    1.1 Convenor's opening remarks
    1.2 Election of Chair
    1.3 Appointment of rapporteurs
    1.4 Adoption of agenda
    1.5 Review of documents
2. IWC-Southern Ocean Research Partnership
3. Pre-assessment of Southern Hemisphere blue whales
    3.1 Southern Hemisphere population structure and catch allocation
    3.2 Antarctic blue whales
        3.2.1 Cruise reports
        3.2.2 Progress toward population assessment
    3.3 Non-Antarctic Southern Hemisphere blue whales
        3.3.1 Southeast Pacific blue whales
        3.3.2 Madagascar blue whales
        3.3.3 Indonesia/Australia blue whales
        3.3.4 New Zealand blue whales
4. Pre-assessment of Southern Hemisphere fin whales
    4.1 Southern Hemisphere population structure
    4.2 Southern Hemisphere distribution
    4.3 Southern Hemisphere abundance
    4.4 Cruise reports
5. Southern Hemisphere right whales not subject to CMP
    5.1 Southern Hemisphere population structure
        5.1.1 New Zealand right whales
        5.1.2 Australian right whales
        5.1.3 South Africa right whales
        5.1.4 Feeding grounds
    5.2 Progress towards population assessment
6. Southern Hemisphere humpback whales
    6.1 Progress towards assessment of Breeding Stock D
7. Work Plan and budget requests for 2019-20
    7.1 Work plan for 2019-20
        7.1.1 Blue whales
        7.1.2 Fin whales
        7.1.3 Southern right whales
        7.1.4 Humpback whales
        7.1.4 IWC-SORP
    7.2 Budget requests for 2019-20
8. Adoption of report

Appendix 2

MINIMUM AND MAXIMUM RANGES OF PYGMY BLUE WHALE POPULATIONS

TREVOR A. BRANCH

Catch time series have been developed for pygmy blue whale populations based on model surfaces fitted to mostly acoustic receiver data (SC/67b/SH23). These efforts do not characterise the uncertainty in catches, although this is planned in future efforts using bootstrapping of the underlying acoustic recorders. Here I present possible minimum ranges (Fig. 1) and maximum ranges (Fig. 2) for each population of pygmy blue whales that could be used to develop minimum and maximum catch time series for each population.

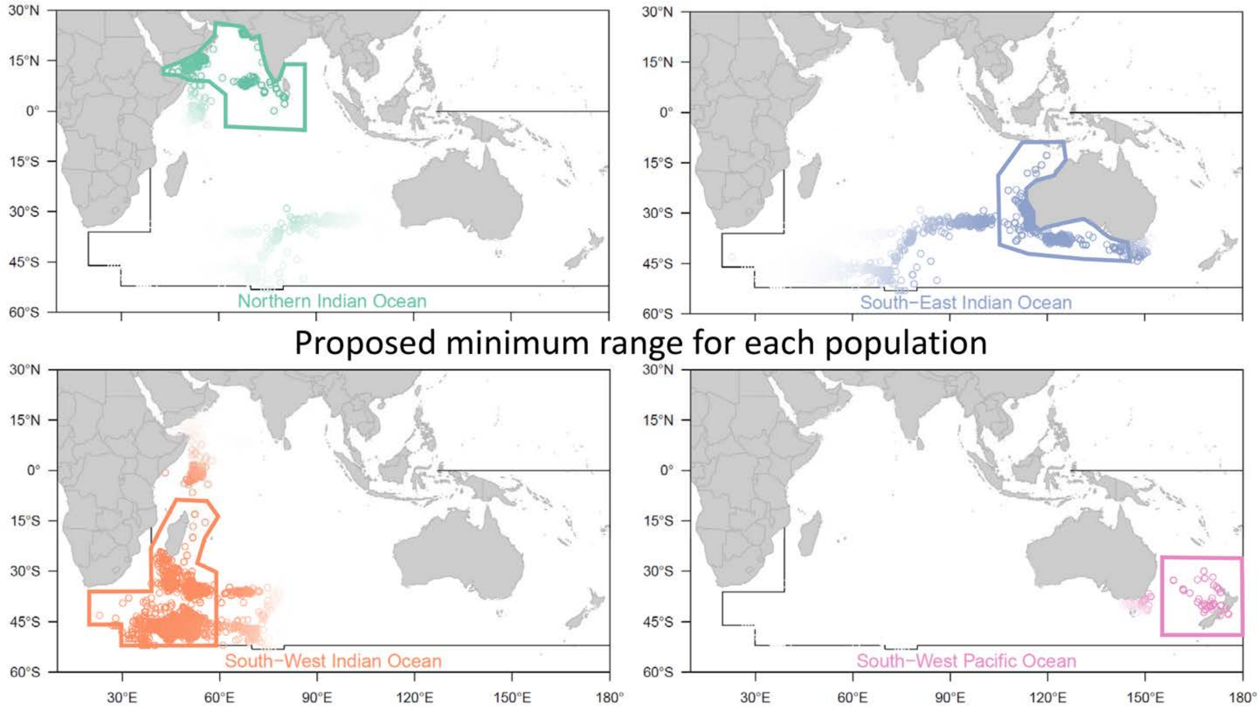


Fig. 1. Possible minimum ranges of each pygmy blue whale population.

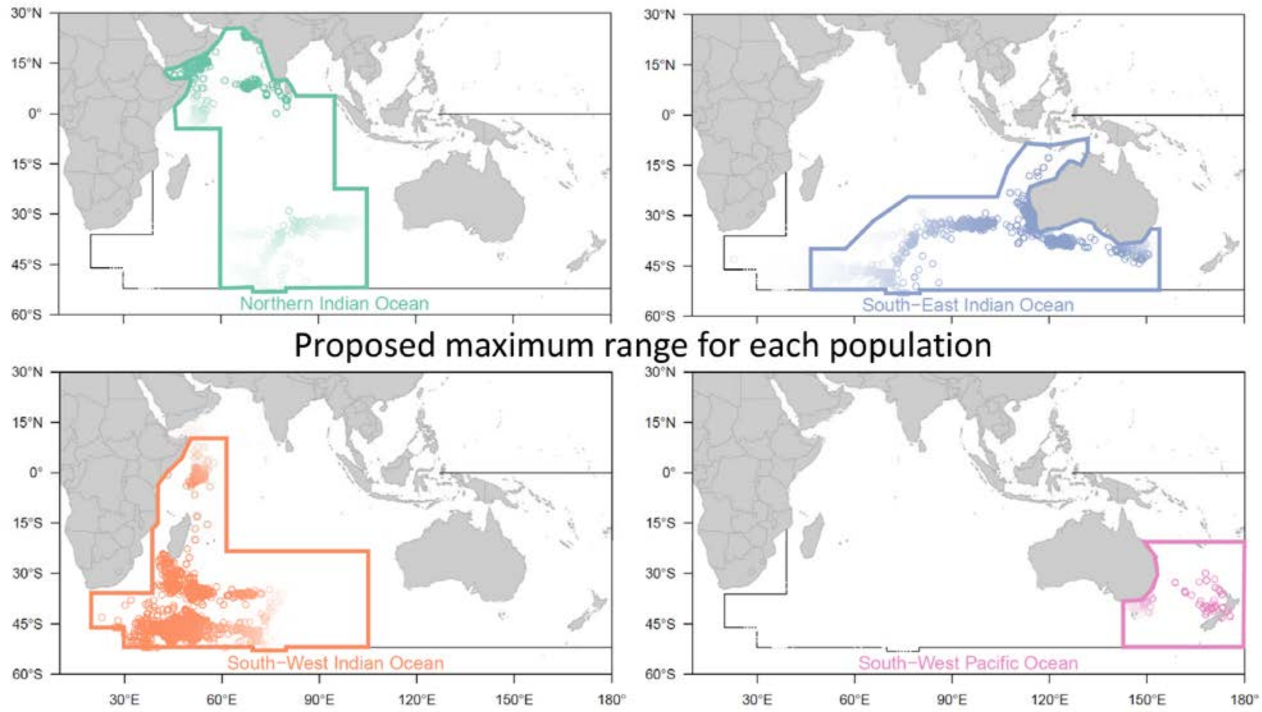


Fig. 2. Possible maximum ranges of each pygmy blue whale population.

Appendix 3

A NOTE ON THE SIZE DISTRIBUTION OF FIN WHALES (*BALAENOPTERA PHYSALUS*) IN THE SOUTHEAST PACIFIC AND IMPLICATIONS FOR THE COMPREHENSIVE ASSESSMENT OF SOUTHERN HEMISPHERE FIN WHALES

J.G. Cooke

Data

A total of 6,785 fin whales are recorded caught by modern whaling off Chile during 1908-83, but with only 6 caught after 1970 (Allison 2017). Body lengths are recorded for 3,310 fin whales. The measured whales were from several stations in three main areas: North (~20°S), Central (30°-38°S), and South (44°S) (Fig. 1). The catches in the South were few and before 1945. The whales were taken in all four seasons, but fewer in winter (Table 1). The length distribution is shown in Fig. 2. The modal length is 16.5m for each sex, with little difference in mean length between seasons, compared with 20.3m (males) and 21.4m (females) for fin whales caught by Antarctic fleets (data from Allison 2017).

If the whales caught off Chile were southern fin whales (*B. p. quoyi*), then the size of 16.5m would correspond to age 1 to 2 years, according to the growth curve estimated by Lockyer (1972). The minimum legal size for catching fin whales that was in effect in Chile during 1954-79 was 15.2m[1].

Toro *et al*. (2016) classed 502 out of 519 fin whale sightings around the Chanaral and Choros Islands (29°S) in summer and fall as 'adults' but used a size criterion of 17m developed for the smaller North Atlantic Fin Whale; the 'adults' could have included whales of any age class except calves of the year. Pacheco *et al*., reported two mother-calf pairs off northern Chile (Mejillones Bay, 23°S) in spring 2006 but obtained no body length estimates.

Discussion

The Chilean whales are much smaller than the measurements given by Clarke (2004) for adults of the putative subspecies *B. p. patachonica. Furthermore, SC/67b/SH13 finds no evidence of genetic differentiation between fin whales sampled of Chile at about 19°S during 2003-17 and fin whales sampled in the Antarctic and off Australia.* Given the recovery in the Antarctic in 1961-62 of four of 11 marks placed in fin whales off Chile between 30°-34°S in 1958 (Clarke 1978), it seems likely that the Chilean fin whale catches were of juvenile Southern Fin Whales.

Different migration patterns for mature and immature animals seem to be fairly common among baleen whales (Leaper *et al.*, 2000). Migration to the Antarctic entails proportionally greater energetic costs for smaller individuals; furthermore, the younger animals are likely to have lower fat reserves such that a long migration with limited feeding en route is less attractive or feasible for them. It is possible that adult Antarctic fin whales also migrate in the southeastern Pacific, but further offshore.

Implications for the comprehensive assessment

If the fin whales feeding along the Chilean coast are indeed mainly juveniles, then current and future data individual identification data (photographic or genetic) will need to be interpreted in this light, because the apparent survival rate will appear to be too low.

Potentially useful research could include photogrammetric measurements (e.g. from drones) to check whether fin whales in Chilean waters today have a similar length distribution to past catches.

REFERENCES

Allison C. 2017. The IWC Catch Database. version 6.1.

Clarke, R. 2004. Pygmy fin whales. *Marine Mammal Science* 20(2): 329-334.

Clarke R., Aguayo C. & Basulto S. 1978. Whale observation and whale marking off the coast of Chile in 1964. *Scientific Reports of the Whales Research Institute, Tokyo* 30: 117–177. icrwhale.org/ScientificReport.html.

Leaper R., Cooke J. & van Waerebeek, K. 2000. Some aspects of the modelling of density-dependent processes in baleen whale populations. IWC Scientific Committee doc. SC/52/RMP20.

Lockyer, C. 1972. The age at sexual maturity of the southern fin whale (*Balaenoptera physalus*) using annual layer counts in the ear plug. *Journal du Conseil International pour l'Exploration de la Mer* 34(2): 276-294.

Pacheco A.S., Villegas V.K., Riascos J.M. & van Waerebeek K. 2015. Presence of fin whales (*Balaenoptera physalus*) in Mejillones Bay, a major seaport area in northern Chile. *Revista de Biología Marina y Oceanografía* 50(2): 383-389. doi: 10.4067/S0718-19572015000300017.

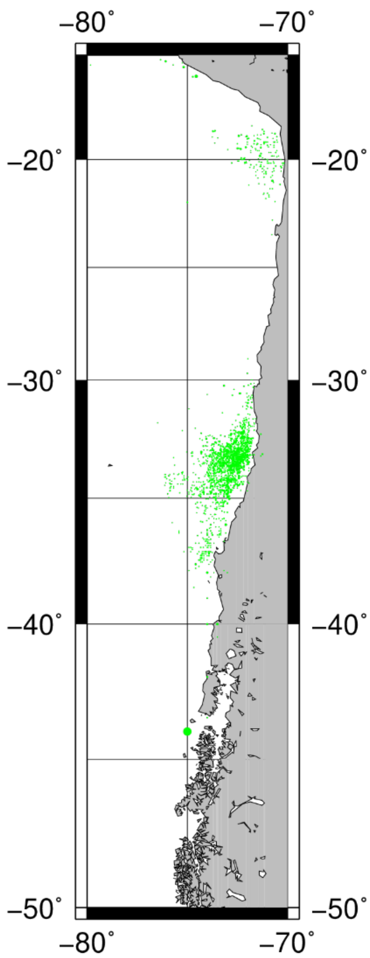
Toro F., Vilina Y.A., Capella J.J. & Gibbons J. 2016. Novel Coastal Feeding Area for Eastern South Pacific Fin Whales (*Balaenoptera physalus*) in Mid-Latitude Humboldt Current Waters off Chile. *Aquatic Mammals* 42(1): 47-55. doi: 10.1578/AM.42.1.2016.47.

[1]Decreto Supremo N° 432 del 23 de septiembre de 1954 (Diario Oficial del 22 de noviembre de 1954).

Table 1. Summary of fin whale lengths (m) in Chilean waters and sub/Antarctic

Season	Sex	N	Mean	SD	Mode
Chilean waters					
Summer	M	745	17.1	1.4	17.0
Jan-Mar	F	677	17.2	1.4	16.5
Fall	M	430	16.7	1.3	16.5
Apr-Jun	F	421	17.0	1.2	16.5
Winter	M	177	17.2	1.2	17.0
Jul-Sept	F	164	17.4	1.6	16.8
Spring	M	393	17.3	1.5	18.0
Oct-Dec	F	303	17.5	2.0	16.5
All	M	1745	17.1	1.4	16.5
Jan-Dec	F	1565	17.2	1.5	16.5
Antarctic (incl. subantarctic)					
All	M	310 246	19.9	1.4	20.4
	F	298 452	20.8	1.8	21.3

Fig 1. Locations of measured fin whale catches in Chilean waters.



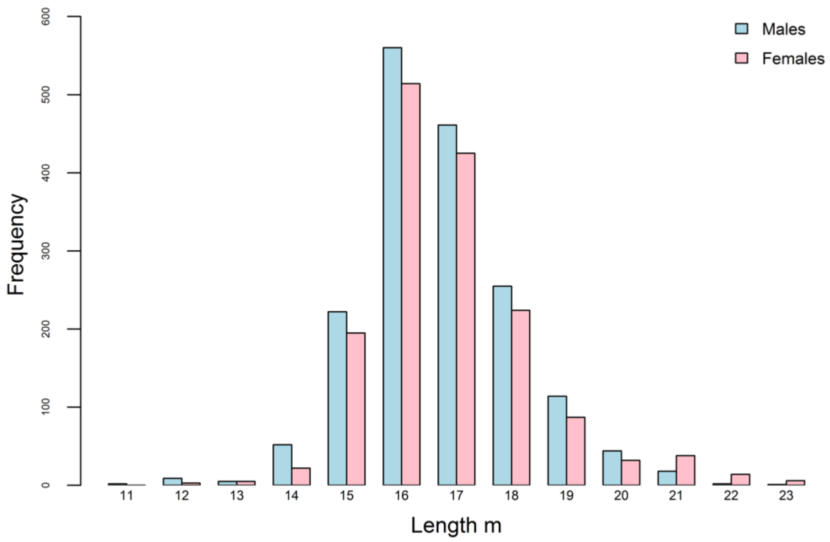


Fig. 2. Length frequency distribution of Chilean fin whales.