Annex H

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

Members: Jackson (Convenor), Archer, Baba, Baker, Bironga, Brownell, Buss, Butterworth, Castro, Charlton, Collins, Cooke, Debrah, Fujise, Goetz, Goto, Hall, Hakamada, Herr, Holm, Iñíguez, Lang, Leaper, Lee, Mallette, Marcondes, Matsuoka, Minton, Morita, Moronuki, Murase, Naylor, Nelson, Nio, Øien, Panigada, Pastene, Punt, Razzaque, Reeves, Reyes Reyes, Robbins, Seakamela, Seyboth, Širović, Stack, Suydam, Suzuki, Taguchi, Takahashi, Urbán, Vermeulen, Walters, Weinrich, Willson, Yaipen-Llanos, Yasokawa, Zerbini.

1. INTRODUCTORY ITEMS

1.1 Convenor's opening remarks

Jackson welcomed participants. She noted that because the Photo-Identification Working Group is not meeting this year, the Southern Hemisphere sub-committee's agenda would include documents and updates related to photo-identification catalogues and matching (see SC/68A/SH/07, SC/68A/SH/09 and Items 3.2, 5.3 and 6.3), with the intention that progression on these topics would be resumed by the Photo-Identification Working Group at SC/68B.

1.2 Election of Chair

Jackson was elected Chair.

1.3 Appointment of rapporteurs

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/68A/SH/01-15, SC/68A/SP/01, SC/68A/ASI/02, SC/68A/CMP/08, Monnahan *et al.* (2019), Charlton *et al.* (2019b), Charlton *et al.* (2019a), Stamation *et al*. (2020), Pastene *et al*. (2020) and Barlow *et al*. (2018).

2. IWC-SOUTHERN OCEAN RESEARCH PARTNERSHIP

SC/68A/SH/10 reports on the activity of the Southern Ocean Research Partnership (IWC-SORP) since SC/67b. Progress on the six primary IWC-SORP science themes (SC/68A/SH/21, Annexes 1-6) is summarised below:

SC/68A/SH/10 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 led the *ENRICH* Voyage (Euphausiids and Nutrient Recycling in Cetacean Hotspots) to the Southern Ocean, aboard the RV *Investigator*. This was the first time that a survey of Antarctic blue whales has been conducted alongside a structured survey of their prey, Antarctic krill. Live krill were collected for use in experiments both on board and on land and krill swarms were mapped in 3D using a multi-beam echosounder and a sonar. A passive acoustic survey for marine mammals was undertaken throughout the duration of the voyage. Directional sonobuoys were used to conduct 295 listening stations, which resulted in 806 hours of acoustic recordings and the detection of 33,435 Antarctic blue whale calls. Over 300 hours of sightings effort, led to 36 encounters with blue whales and identification of 25 individuals. There were no within-season re-sights of the 25 individuals. All identification photographs are being compared to the Antarctic Blue Whale Catalogue. Moreover, hundreds of experiments were conducted on water samples to determine the impact of Antarctic blue whales and krill on local biogeochemical recycling.

The project also cooperated on a voyage to the western Antarctic Peninsula led by Argentina aboard the ARA *Almirante Irizar* which generated sightings and acoustic information for several cetacean species, and contributed to the development of a photo-identification catalogue for fin whales.

The Antarctic Blue Whale Catalogue totals 458 photo-identified Antarctic blue whales, represented by 342 left sides and 332 right sides. Opportunistic photos contributed by both research and citizen scientists will be compared to the catalogue during the coming year.

IWC-SORP continues to benefit from partnerships with ships of opportunity and citizen scientists. Funding was contributed toward production of an ID-placard (downloadable from *https://iwc.int/sorp*) for use on tour vessels and at tourist destinations. This initiative has already substantially increased image contributions.

SC/68A/SH/10 Annex 2 reviewed progress on the theme to identify the 'Distribution, relative abundance, migration patterns and foraging ecology of three ecotypes of killer whales in the Southern Ocean'.

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=70), in conjunction with photo-identification association data (105,000 images; 69 individuals identified), has shown that Marion Island killer whales form small, fairly stable social units. Over a period of 6 years, 34 satellite tags have been deployed and these have revealed seasonal site fidelity as well as rapid, long-distance movements and deep diving over seamounts. Funding is also being sought to continue fieldwork in the Ross Sea in 2019/20.

SC/68A/SH/10 Annex 3 summarised progress on the theme to determine 'Foraging ecology and predator-prey interactions between baleen whales and krill: a multi-scale comparative study across Antarctic regions'. In 2018/19, the team focused on deploying suction cup tags on both humpback and minke whales, measuring prey and sea ice, and using UAS to generate estimates of body condition and animal size. This very successful effort resulted in: 10 suction

cup tag deployments on minke whales and 10 deployments on humpback whales. Additionally, 13 LIMPET tags were deployed on humpback whales and one on a minke whale. Several articles have been published this year that specifically show the dynamic nature of humpback whale foraging behaviour throughout the feeding season, and the spatio-temporal overlap between humpback whale foraging areas and the krill fishery around the Antarctic Peninsula.

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 2018/19 season.

SC/68A/SH/10 Annex 4 reported progress on the theme to 'Determine the distribution and extent of mixing of Southern Hemisphere humpback whale populations around Antarctica'. The focus of the 2018/19 research was two-fold: (1) ongoing investigation of Oceania feeding ground behaviour and the environmental variables influencing it (the Kermadec Islands have been identified as a diverse region for mixing of whales from Oceania breeding grounds as they migrate to a wide expanse of Southern Ocean); and (2) a study of genetic connectivity of whales on the Great Barrier Reef (GBR) breeding grounds (breeding stock E1). Sightings and acoustic surveys were conducted this year, and 113 genetic samples have now been collected from the E1 breeding stock within the Great Barrier Reef Marine Park. Further fieldwork will be carried out in 2019/20. These studies will allow for an improved understanding of the structure, status, migratory paths and feeding grounds of Oceania humpback whales 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/68A/SH/10 Annex 5 summarised progress on the theme to measure 'Acoustic trends in abundance, distribution, and seasonal presence of Antarctic blue whales and fin wales in the Southern Ocean'. In 2018/19 the team continued work to create an annotated library of acoustic detections. Details of planned and completed work can be found in SC/68A/SH/11. Funding was secured for a 14-month postdoctoral researcher to develop a standardised analytical framework for robustly detecting circumpolar call density trends in passive acoustic data for Antarctic blue and fin whales (SC/68A/SH/11).

Theme members serviced 17 annual recording stations continuing multi-year records. The data volume from all instruments recovered in 2018 totalled approximately 230,000 hours of underwater recordings. 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).

SC/68A/SH/10 Annex 6 summarised progress on the theme: 'The right sentinel for climate change: linking foraging ground variability to population recovery in the southern right whale'. This new theme was endorsed by IWC/67 and involves researchers from Argentina, Australia, Brazil, New Zealand and South Africa. Its objectives are to: (1) increase our understanding of southern right whale foraging habitats and ecology; (2) update our knowledge on southern right whale population dynamics in a comparative framework; (3) pursue integration of health assessment indicators with long-term monitoring data; and (4) investigate the impact of climate variation at foraging grounds on population recovery. Work commenced in early 2019; detailed reports can be found in SC/68A/SH/01; SC/68A/SH/11-13; Charlton *et al*. (2019a,b); and Stamation *et al.* (2020).

Overall, IWC-SORP projects have produced 144 peer-reviewed publications to date and 133 IWC-SORP related papers have been submitted to the IWC Scientific Committee including 8 this year. Moreover, a substantial amount of vessel time has been awarded to IWC-SORP researchers this year and for the upcoming 2019/20 field season.

SC/68A/SH/11 provided an update on funds allocated from the IWC-SORP Research Fund following two open, competitive grants rounds. In 2016/17, £144,058 GBP were allocated to 10 projects; in 2018/19, £489,154 GBP were allocated to a further 15 projects. Details of these allocations and project progress reports are presented in SC/68A/SH/11.

A full financial report of the IWC-SORP Research Fund is presented in SC/68A/SH/05. £135,497 GBP remain unallocated and unspent in the fund. A new Call for Proposals will be opened in late 2019.

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 IWC-SORP initiative 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.

In relation to the work presented in SC/68A/SH/10, Annex 2, it was confirmed that the researchers under this theme have applied for additional funding from the Italian Antarctic Programme to continue this project until 2022. In relation to the work presented in SC/68A/SH/10, Annex 3, it was queried whether these data would also be presented to the CCAMLR Scientific Committee who are currently carrying out a review of krill density and impacts from krill predators in the western Antarctic Peninsula region. Bell agreed to follow up with the authors about this.

In relation to SC/68A/SH/10, Annex 4, it was noted that this new genetic information from the Great Barrier Reef represents a significant step forward in understanding the population identity of the east Australian breeding grounds (breeding stock E1) for humpback whales. This is because previous genetic data used to represent breeding grounds of E1 are associated with coastal migratory corridors, which may include mixed stocks (Olavarría *et al.*, 2006; Schmitt *et al.*, 2013). In this regard, the committee noted that comparisons between the Great Barrier Reef and other Pacific wintering grounds showed levels of mtDNA differentiation similar to those previously found in comparison of coastal east

Australian sites and Pacific breeding grounds. Furthermore, comparisons of Great Barrier Reef to coastal east Australian sites showed no differences in differentiation of mtDNA. These preliminary results support the assumption that the east coast migratory corridor of Austalia is likely to be mostly composed of breeding stock E1 animals (i.e. animals destined for breeding grounds in the Great Barrier Reef).

Bell also made the sub-committee aware of a joint IWC-SORP and Scientific Committee for Antarctic Research (SCAR) meeting planned to be held in Hobart in 2020, which they hope many IWC-SORP members will attend. The sub-committee were also informed that a workshop has been proposed to be held during the World Marine Mammal Conference (December 2019, Barcelona), bringing together international participants to discuss new research and technology to develop the new IWC-SORP southern right whale Theme 6. It was suggested that Bell contact Conference organisers to assess the feasibility of including an IWC-SORP themed session of talks within the Conference.

In discussion, it was noted that the ASI Standing Working Group have encouraged Japan and IWC-SORP to collaborate on their non-lethal whale research activities in the Southern Ocean in future (Item 4, Annex Q). IWC-SORP welcomes new members.

Attention: SC, G
*The Committee **reiterated** the great value of the IWC-SORP (Southern Ocean Research Partnership) programme and **commended** their work. The Committee **reiterated** that they:*
*(1) strongly **encouraged** the continuation of the Southern Ocean Research Partnership programme;*
*(2) **commended** 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;
  (c) the hard work involved in the coordination and execution of the project; and
*(3) **encouraged:***
  (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.

During SC/67b, the Scientific Committee recommended the development of photo-identification placards for circulation on Southern Ocean-bound vessels, in order to assist citizens to collect marine mammal photographs that could be used in photo-identification studies and promote the submission of images to *happywhale.com* for photo-identification matching (Item 7.1.1.1; IWC, 2019). The IWC-SORP provided funding support towards personnel time for the development of the placards, and EU BEST Project 1594 covered the publication costs. A placard and placard brief were developed during 2018. The placard describes the different species commonly seen in the Antarctic Peninsula and Scotia Arc regions, with examples of poor and good photo-identification images. Four hundred laminated and foldable placards were printed, providing a pocket-sized and waterproof reference guide. The placard brief informed citizens of the various different research groups that would receive images submitted to *www.happywhale.com*, emphasising the overarching contribution of their images towards research. Both documents can be downloaded at *https://iwc.int/sorp.* Placards were circulated widely among International Association for Antarctica Tour Operators (IAATO) staff, and distributed to tourist ships, private operators, national operators, fishery and fishery observer vessels, the Port Lockroy Post Office and Grytviken museum. Total HappyWhale photo-identification submissions have increased substantially in the past year, which may be attributable to the placard circulation. In 2017/18, submissions from the Antarctic Peninsula and Scotia Arc region (for all cetaceans) were 788 and during 2018/19, 1,038 submissions were received (a 32% increase). Within this figure, a record number of humpback whale submissions were received by HappyWhale during 2018/19 (927 submissions) compared to the 2017/18 season (703 submissions), while submissions for other cetaceans rose from 85 to 111.

The sub-committee **welcomed** this report, which delivers on a recommendation made in SC/67b (Item 7.1, IWC, 2019). The developers were **encouraged** to continue this activity in future and report results back to the Photo-Identification Working Group. In discussion, it was noted that the placards were currently waterproofed using a lamination process that uses plastic, and the developers were advised to seek plastic-free means of developing these placards in future seasons.

Attention: SC, G, CG-A
*The Committee **welcomed** the progress made on engaging Antarctic tourists with photo-identification, and **reiterated** their advice from 2018, that they **encouraged** continued opportunistic photo-identification data collection in the Antarctic to assist with developing estimates of population abundance for this subspecies.*

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3. PRE-ASSESSMENT OF SOUTHERN HEMISPHERE BLUE WHALES

Širović provided an update on progress on the Southern Hemisphere blue whale song library; see Širović (2018) for the 2018 update. The final steps still required to implement the library via a web interface are to: (1) finalise the agreement on the format for the library (Širović and IWC Secretariat); (2) request bids from outside developers (IWC Secretariat); (3) build and test the database (selected developer); and (4) implement and launch (Širović and IWC Secretariat). There are two main aspects that need to be ensured for the library's functionality: (a) ease of review of existing songs for interested researchers; and (b) contribution (upload) of new songs for approval and addition to the library. As the implementation of this library has been identified as one of the high priority tasks by the Scientific Committee, the goal is to have it completed before SC/68B. Intersessionally, Širović will investigate the possibility of creating a DOI for the library to create a permanent link to it.

The sub-committee welcomed this update and **encouraged** the proposed work be done to complete this initiative.

3.1 Antarctic blue whales

3.1.1 Cruise reports

SC/68A/ASI/02 reported the result of the dedicated sighting survey conducted in the eastern part of Area III by Japan (035°E-070°E; south of 60°S). The total searching distance in the research area was 2,960.6 n.miles. A total of 15 schools (25 individuals) of blue whales were sighted. A total

of 24 individuals were photographed and biopsy samples were collected from 9 individuals. These data were stored in the Institute of Cetacean Research (ICR) database and will be analysed in the near future.

SC/68A/SP/01 reported the sighting of blue whales by the sighting and sampling vessels in Area III (0°E-070°E; south of 60°S) under the 2018/19 NEWREP-A programme. The total search distance was 3,907.0 n.miles, and a total of 11 schools (12 individuals) of blue whales were sighted. No photo-identification or biopsy samples were collected.

In discussion, it was noted that the new Antarctic blue whale photo-identifications collected (SC/68A/ASI/02) are now stored in the ICR database and will in the future be compared to the IWC Antarctic blue whale catalogue using appropriate data sharing procedures.

The sub-committee were made aware of a recent IWC-SORP survey conducted between 60°S-67°S and 138°E-152°E which focussed on Antarctic blue whales and their prey, Antarctic krill (*Euphausia superba*). More details are provided under Item 2. The data collected on this voyage will be analysed over the coming year and detailed reports will be presented at SC/68B.

3.1.2 Population abundance

Progress on the Antarctic blue whale catalogue was discussed. During 2018, ICR-Japan made available hundreds of photographs; dozens of photos were contributed by citizen scientists and opportunistic research platforms; and 25 IDs were collected during the recent IWC-SORP *ENRICH* voyage. In all, these photographs represent an estimated 60-70 ID's. Progress on the Antarctic Blue Whale Catalogue during 2018/19 was intermittent due to time constraints related to other projects, family illness, and delayed funding. Catalogue work resumed in April 2019 and a report will be submitted to SC/68B.

During SC/67b some methodological recommendations were made to assist development of a capture-recapture estimate of circumpolar Antarctic blue whale abundance (Olson *et al.*, 2018). Some intersessional work was conducted, and will resume following addition of the new photo-identification data. The authors will work on a revised estimate intersessionally.

The sub-committee **strongly encouraged** the continuance of this work by Olson and looked forward to receiving an updated abundance estimate at SC/68B.

In discussion of the geographical spread of the Antarctic blue whale catalogue, it was noted that the largest numbers of identified individuals (>200) are in Area III (see Appendix 2), reflecting the area where greatest regional effort has been made to date. In principle it is therefore possible to assess Area III abundance, but the level of population connectivity between different Antarctic Areas is likely to be high (previously reviewed in IWC, 2017). These discussions motivated a recommendation for a new review of the evidence for Antarctic blue whale population structure, see Item 3.1.3.

Attention: SC, G, CG-A

*The Committee **welcomed** the progress being made towards being able to undertake a new population assessment of Antarctic blue whales, and **reiterated** their advice from last year that they **strongly encouraged** further work to update the abundance estimate for Antarctic blue whales, following Committee recommendations.*

3.1.3 Population structure

The sub-committee discussed whether distinct areas of higher blue whale density occur around the Southern Hemisphere, given the Area divisions described by Donovan (1991). These may be informative about possible regional structure. Analyses of the IDCR-SOWER survey data were conducted by Kelly *et al.* (2011; 2012) in order to assess possible Antarctic blue whale hotspots while investigating the feasibility of new abundance surveys. Their latitudinal assessment of sightings per km of effort showed peaks in sightings between 30°W and 60°E, consistent with historical areas of elevated catch density (Branch *et al.*, 2007b). All other parts of the Antarctic were relatively uniform in terms of sightings, likely reflecting their very low abundance during the surveys. An assessment of past aggregations would require re-analysis of past catches where effort data are available. For example, analysis could include: (1) whaling data up to 1960, with effort reflected by locations of all baleen catches; (2) JSV data, using noon day positions for effort; (3) Soviet whaling 1958-73 where effort is locations of all baleen catches; (4) SOWER data south of 60°S (see Kelly *et al.*, 2012); and (5) acoustic data, using hours examined as a proxy for effort, with observations as hours of calls. In regard to the genetic evidence for population structuring, Southern Hemisphere blue whale genetic patterns have previously been reviewed by the IWC (IWC, 2017). A synoptic review of population structure (i.e. considering multiple lines of evidence) is now required in order to properly assess possible stock delineations around the Antarctic. For example, previous mtDNA genetic work shows a pattern of weak but significant differentiation (Sremba *et al.*, 2012). The sub-committee **agreed** to form an intersessional email group under Lang, to assess all available evidence for regional population structure within Antarctic blue whales (Table 1). This will include genetics, Discovery marks, acoustics, satellite tags, photo-identifications, sightings and catch patterns.

3.1.4 Progress toward population assessment

A proposal for a new population assessment of Antarctic blue whales was received and is shown in Appendix 3. The sub-committee **recommended** that the proposed work be carried out, and then discussed possible sensitivity analyses to compare with the reference case assessment.

In discussion of whether regional assessments should be conducted (i.e. within one or a few Antarctic Areas), the sub-committee were divided over the utility of this approach, noting that the available evidence for regional population structuring suggests is weak but significant (Attard *et al.*, 2016; Sremba *et al.*, 2012). It was also noted that even if there is true structuring between Antarctic blue whale breeding areas (i.e. in the lower latitudes of the Atlantic, Pacific and Indian Oceans), no breeding ground abundance estimates are available. Since the Southern Ocean likely represents a mixed-stock feeding area (reviewed in IWC, 2017), feeding ground abundance estimates across the six Antarctic Areas (i.e. from IDCR-SOWER surveys) are therefore unlikely to be representative of breeding ground abundance. The sub-committee **agreed** to review the available evidence for population structure (Item 3.2.3) before deciding if regional assessments should be included as sensitivity analyses.

In discussion of how the minimum constraint on population abundance ('*Nfloor*') could be incorporated into the population model (Jackson *et al.*, 2008), the sub-committee agreed with Branch's proposal to use 3x the number of mtDNA haplotypes as previously agreed by the IWC to provide a conservative floor on minimum abundance

that accounts for males and sub-adults in the population at the bottleneck point (IWC, 2012). It was also noted that additional information on haplotype diversity exists from during the exploitation period, including from the large collection of baleen plates obtained from whaling in the 1940s and currently being analysed at the Smithsonian (IWC, 2016). The sub-committee agreed that it is useful to explore including these in the population assessment model, as they could provide additional information constraining the population trajectory over the exploitation period.

In discussion of catch allocations, the sub-committee discussed the possibility of including a catch sensitivity to explore the possibility that Chilean blue whales were present in the blue whale catches at Grytviken (i.e. near the islands at 54°55'S, 36°45'W). This was briefly discussed during SC/67b, since: (1) genetic identification of 20 bones collected near Grytviken from the early whaling period identified one whale with a mitochondrial DNA haplotype ('*q*') only found in the Chilean blue whale population to date (IWC, 2019), and (2) a Chilean blue whale call was acoustically detected near the islands at 54°55'S, 36°45'W (IWC, 2019) during the austral winter (Pangerc, 2010). However, global blue whale population structuring is complex and likely under-sampled with respect to extant diversity with some haplotypes found to be shared between Antarctic and Chilean blue whales (LeDuc *et al.*, 2017). Therefore the identified haplotype may also be present in Antarctic blue whales, and Antarctic blue whales can also be found off Chile, complicating our understanding of the identity of samples collected there. The Chilean blue whale call occurred on only one of 60 days examined (Pangerc, 2010), suggesting the whale may have been a vagrant. Furthermore, Antarctic blue whale catches were only made in summer months, and no Chilean blue whales have been acoustically detected during this period.

Branch *et al.* (2007a) examined catch length frequencies of sexually mature females caught near Grytviken (i.e. near the islands at 54°55'S, 36°45'W), aiming to separate pygmy and Antarctic blue whales. Chilean blue whales were exactly intermediate in length between (Indian Ocean) pygmy and Antarctic blue whales, but Grytviken catches did have a fair number of anomalously short sexually mature females. As a result, Grytviken estimates included an estimated 10.4% (95% 0.09-11.9%) pygmy blue whales in the early period before 1937/38 (out of 31,939 catches; 2,710 sexually mature); but only 1.9% (95% 0.1-6.0%) in the late period from 1937/38 onwards (1,572 catches; 160 sexually mature). However, Grytviken catches were characterised by a very high proportion of lengths being rounded to the nearest 5-ft interval (14.3% in the early period; 7.8% in the late period), which was much higher than in other areas except for those taken near 62°00'S, 58°00'W. This kind of rounding was much more prevalent in early years, indicating inaccurate length measurements, and undermining the conclusion that the shorter length whales were pygmy blue whales. Branch also noted that Mackintosh and Wheeler (1929) examined thousands of blue whales in great detail using accurate and consistent methods. There was apparently no separate length frequency distribution for sexually mature females in Mackintosh and Wheeler (1929) but the estimated length at 50% maturity (23.7m) was far greater than for Chilean blue whales, and matches that estimated from other regions and more recent collections (e.g. 23.4m, Branch and Mikhalev, 2008). Notably, the morphometric measurements of blue whales in the area of the islands at 54°55'S, 36°45'W did not differ appreciably from Chilean blue whales in the relative proportion of total length for fluke-notch-to-anus measure, nor in the snout-to-eye measurement (Pastene *et al.*, 2020).

The sub-committee were informed by Olson that there are currently 11 blue whales with photo-identification from the area near the islands at 54°55'S, 36°45'W in the Antarctic blue whale catalogue, and that three of them (all photographed on 28 February 2015) have characteristics of non-Antarctic blue whales (length of tail, condition of skin). The other six look definitely Antarctic and three are undetermined. In addition, there are another eight blue whales with photo-identification from nearby locations in the Southwest Atlantic. The sub-committee **encouraged** those photo-identifications which have pygmy blue whale characteristics to be matched with the Chilean blue whale catalogue in order to assess possible connections. They noted that this work has a cost implication for the Committee (see Appendix 5).

In discussion of the proportion of catch that could be assigned to non-Antarctic blue whales, the sub-committee **encouraged** Branch to compare Mackintosh and Wheeler (1929) length data to those from more recent Norwegian catches which are held in the IWC Catch Database, to obtain an estimate of the proportion of possible pygmy blue whales in these catches. The sub-committee **encouraged** Branch to run mixture models using the female length data from Mackintosh and Wheeler (1929), assuming either: (i) pure Antarctic blue whales; or mixtures of (ii) Antarctic and pygmy blue whales; or (iii) Antarctic and Chilean blue whales, to provide an estimate to use in the catch sensitivity. It was noted that this sensitivity is unlikely to impact model outcomes for the Antarctic blue whales, but when considered in the context of the upcoming Chilean blue whale assessment, this catch allocation scenario may impact Chilean blue whale population recovery estimates.

Attention: SC, G, CG-A
*The Committee **recommended** that a new assessment of Antarctic blue whales be carried out within the next four years, and in order to progress this topic:*

*(1) **agreed** to review all available evidence for stock structure, to identify possible population units within the subspecies;*
*(2) **encouraged** matching of the Chilean blue whale catalogue with blue whale photo-identifications collected in the Scotia Sea with non-Antarctic blue whale characteristics, to assess possible inter-ocean connections; and*
*(3) **encouraged** a re-assessment of length data in blue whale catches made near Grytviken (i.e. near the islands at 54°55'S, 36°45'W) in order to estimate the potential proportion of Chilean blue whales in this catch record.*

3.2 Non-Antarctic 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 (IWC, 2016). Initial results of this assessment were presented at SC/67a (IWC, 2017).

Papers SC/68A/SH/04 and SC/68A/SH/09 pertain to the Southern Hemisphere blue whale catalogue and were taken together. SC/68A/SH/04 reports on preliminary results of 2018/19 IWC photo-identification comparisons within Southern Hemisphere Blue Whale Catalogues off Australia, New Zealand and Sri Lanka regions. Comparisons of 698 photo-identified blue whales from seven different research

groups working in the Perth Canyon (western Australia), Geographe Bay (western Australia), Bonney Upwelling (southern Australia), around New Zealand, and Sri Lanka provided eighteen whales resighted between different areas. Matches were found within Australian catalogues and within New Zealand catalogues but no matches were found between regions. Some blue whales initially sighted in the Perth Canyon, Geographe Bay and the Bonney Upwelling were subsequently resighted between regions, representing a high level of connectivity among these sites and suggesting that there is one panmictic population of blue whales in Australia. During May 2018 to April 2019, SHBWC work focused on finalising photo comparisons between catalogues from Australia, New Zealand and Sri Lanka (described in SC/68A/SH/09). A considerable amount of new photo-identifications (+300 IDs) from South America, Australia, New Zealand and Sri Lanka have also been received and/or are in the process of being uploaded.

The sub-committee thanked the authors for this update and **agreed** that the Southern Hemisphere blue whale catalogue should continue to be compiled, as it provides population connectivity information useful for upcoming regional blue whale assessments.

The sub-committee also noted that at SC/67b the Southern Hemisphere blue whale photo-identification catalogue was about to complete a planned transfer to the IWC for long-term storage, with new operating systems installed and servers purchased; however due to intersessional budget cuts, this activity could not be completed. The Chair **agreed** to raise this issue with the IWC Secretariat, to seek a solution which might enable this migration to go ahead.

In discussion, it was queried whether there are plans to include Gulf of California blue whales in the Southern Hemisphere blue whale catalogue, since this area is mentioned in the summary table of catalogues (Table 1, SC/68A/SH/09). In clarification, the author explained that this location had historically been included in the geographical summary of the eastern central and south Pacific blue whale catalogue, but that catalogue holders had not been invited to join the Southern Hemisphere blue whale catalogue and no matching had been undertaken. It was noted that there is a hiatus in blue whale sightings between 2°S and 6°N, possibly reflecting the edge of range of animals from the two hemispheres, making a connection unlikely. However some in the sub-committee considered that it would be useful to extend matching to this region, noting that photo-identification and satellite telemetry have linked Chilean blue whales to wintering grounds near the Galápagos Islands (Hucke-Gaete *et al.*, 2016; Torres-Florez *et al.*, 2015), a location also connected to the Costa Rica dome area by one photo-identification re-sighting (Cascadia Research Collective, unpublished). The Costa Rice dome is part of the northeast Pacific blue whale wintering ground and closely connected to the Gulf of California via satellite telemetry and photo-identification (Bailey *et al.*, 2009).

The sub-committee **encouraged** the addition of photographs from the Gulf of California to the SHBWC in order to assess population connectivity with this region, but recognised that this was a long-term goal, and currently low priority relative to the work required for the current blue whale assessment.

In discussion of the current catalogue status, the Southern Hemisphere blue whale catalogue team were encouraged to compile a summary of the temporal and spatial spread of data currently available for each region, to assist with assessment of their readiness for future mark recapture analysis.

Baker informed the sub-committee that the developer of Flukebook (see Item 6.3) is interested in developing an automated matching system for blue whales. In order to do this, they require access to a large, fully matched photo-identification catalogue to use as a training dataset, which may be provided by Cascadia Research Center (USA). They are currently looking at mixing texture and fin shape matching, and can use multiple algorithms to develop the matching system.

The sub-committee welcomed this update, and **encouraged** updates on this development to be provided to the Photo-identification Working Group at SC/68B.

Attention: SC, G
*In order to facilitate regional population assessments of pygmy and Chilean blue whales, the Committee **reiterated** its advice from last year that it **agreed** 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.*

3.2.1 Regional information

3.2.1.1 SOUTHEAST PACIFIC BLUE WHALES

Completion of photo-identification matching of the Southeast Pacific photo-identification catalogue will be conducted intersessionally (410 left and 406 right sides, SC/68A/SH/09). Quality coding will then be required in order to develop a mark recapture dataset ready for regional abundance analysis. The sub-committee **encouraged** this quality coding to be carried out, noting that this work has a cost implication for the Committee (see Appendix 6).

Pastene *et al.* (2020) presented the results of morphometric analyses comparing Chilean, southern Indian pygmy and Antarctic blue whales. In the Southern Hemisphere, blue whales are currently divided into two subspecies, Antarctic blue whales (*Balaenoptera musculus intermedia*) and pygmy blue whales (*B. m. brevicauda*), but there is some debate about whether Chilean blue whales should also be considered as a separate subspecies. This study provided novel morphometric data (total length, snout-eye length and fluke-anus length) to directly address this taxonomic question from a biological survey of 60 blue whales taken during the 1965/66 Chilean whaling season. Two comparative analyses were conducted among Antarctic, pygmy, and Chilean blue whales. First, the measurements of total length, snout-eye length and fluke-anus length were examined independently from each other. In this case only sexually mature whales were used for the analysis (non-parametric statistical tests were conducted). Second, the measurements of snout-eye length and fluke-anus length were examined in relation to the total length. In this case both mature and immature whales were used for the analysis (graphical, Allometric model and Random Forest analyses were conducted). The data showed that maximum body length and mean body length of both sexually mature female and male Chilean blue whales are intermediate between pygmy and Antarctic blue whales; and that fluke-anus lengths of Chilean blue whales are significantly different from pygmy blue whales, but not necessarily from Antarctic blue whales. There is also some support from the data that snout-eye measurements are different between all three groups. These data provide further confirmation that Chilean blue whales are a distinct population requiring separate management from other blue whale populations, and are also consistent with the suggestion that Chilean blue whales are not in the same subspecies as pygmy blue whales

The sub-committee welcomed this work, noting that it addresses a catch comparison recommended by the Scientific Committee in 2016 (IWC, 2017).

During SC/67b, the authors were encouraged 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 population-level rather than subspecies differences, LeDuc *et al.*, 2017). A summary of the available evidence to date is provided in Appendix 4, with length data from different sources suggesting that mature female Chilean blue whales differ in lengths by ~0.5m from those in the eastern North Pacific, which is similar to the difference in lengths between northern Indian Ocean pygmy blue whales and pygmy blue whales in the southern Indian Ocean (Branch and Mikhalev, 2008)

In discussion it was noted that length differences between the anus and posterior edge of the dorsal in the southeast Pacific population might be available from the Ichihara data recently found by Omura, allowing for a better correction for different measurement approaches between the southeast and northeast Pacific. The sub-committee **encouraged** Brownell and Branch to progress these discussions intersessionally. The sub-committee also **encouraged** Archer to apply a Random Forest approach to the genetic data collected from both regions, to evaluate the genetic evidence for sub-species.

Attention: SC, G

In view of the ongoing uncertainty regards the level of population or subspecific distinctiveness between northeast and southeast Pacific blue whales, the Committee:

(1) ***encouraged*** *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;*

(2) ***encouraged*** *random forest analysis of genetic data available for northeast Pacific and Chilean blue whales, to assess diagnosability of southeast Pacific and northeast Pacific blue whales with mitochondrial DNA.*

(3) ***encouraged*** *plans for further photo-identification catalogue matching and quality coding within the eastern Pacific to assist with regional abundance estimation.*

3.2.1.2 INDONESIA/AUSTRALIA BLUE WHALES

Catalogue matching within the Southern Hemisphere blue whale catalogue for Australia is nearly complete (SC/68A/SH/04). The next steps are to: (1) complete quality coding; and (2) obtain all outstanding information on the year of collection for the photo-identifications that have been uploaded to date. The sub-committee **encouraged** an assessment of the suitability of these data for mark recapture analysis, to be done intersessionally by Jackson after these tasks are completed.

At SC/67b, the Scientific Committee encouraged Jenner *et al*. (2008) to revise their original mark recapture estimate of abundance for Perth Canyon, incorporating the recommendations provided by the Scientific Committee (IWC, 2009, p.237). Considering that the Australian component of the Southern Hemisphere blue whale catalogue has now been fully matched and includes photo-identifications from three regions (Perth Canyon, Geographe Bay and the Bonney Upwelling), the sub-committee considered that instead it was higher priority to assess the utility of the combined catalogue data for generating a new mark recapture abundance estimate, as this may provide a more representative estimate of blue whale abundance across Australia.

3.2.1.3 NEW ZEALAND BLUE WHALES

Compilation of the Southern Hemisphere blue whale catalogue for New Zealand is ongoing, as additional images are still in the process of being uploaded to the catalogue (SC/68A/SH/04). The sub-committee **encouraged** collaborators to submit their images in order to assist with regional assessment of blue whale abundance.

A multidisciplinary assessment of blue whales in New Zealand was presented to the Scientific Committee by Barlow *et al.* (2018) which included a regional abundance estimate (IWC, 2019). The ASI Standing Working Group have discussed this estimate and recommended further work in order for the estimate to be suitable for endorsement by the Scientific Committee (see Annex Q, item 2.1.3). The sub-committee **strongly encouraged** the authors to address these recommendations and submit an updated estimate of abundance to SC/68B.

Attention: SC, G

With respect to population assessment of blue whales off New Zealand, the Committee ***reiterated*** *its advice from 2018 that it* ***encouraged*** *New Zealand photo-identifications to be combined with others within the Southern Hemisphere Blue Whale Catalogue, to provide the fullest possible assessment of regional abundance and connectivity.*

The Committee also ***strongly encouraged*** *further work to update the abundance estimate for New Zealand blue whales, following Committee recommendations.*

3.2.1.4 NORTHERN INDIAN OCEAN BLUE WHALES

The authors summary for SC/68A/CMP/08 can be found in Annex O, item 6.2.2, together with a series of recommendations to the Scientific Committee. SC/68A/CMP/08 summarised the findings of opportunistic surveys that have been conducted in the Hallaniyats Bay, in the Sultanate of Oman between March 2018-April 2019. The surveys yielded a number of blue whale sightings and associated photo-identifications and faecal and acoustic sampling. Further detail from this report can be found in Item 6.2.2, Annex O, together with a series of recommendations to the Scientific Committee

During discussion, the authors were commended for delivering on the work they were encouraged to do at SC/67b (IWC, 2019), including collecting acoustic data to better understand the distribution, seasonality and overlap of blue whale calls, and collecting biopsy and tissue samples to better understand regional population structuring. The authors were **encouraged** to submit their photo-identifications to the Southern Hemisphere blue whale catalogue for matching. The authors were asked what analyses they have planned for their tissue collection, and explained that they are making tentative arrangements to send their biopsy samples to the Southwest Fisheries Science Centre, USA, so that the population identity of these samples can be assessed within the global blue whale genetic dataset recently published by LeDuc *et al*. (2017). The authors noted that their surveys were during March/April, which was timed to maximise encounters with humpback whales rather than blue whales.

The sub-committee thanked the authors for this update and **encouraged** them to collect further information on blue whale acoustics and genetics from this region, suggesting

that surveys be organised in December/January, the period of peak blue whale density as indicted by acoustic data from Oman (presented to SC/67b).

Attention: SC, G, CG-A
*The Committee welcomes the intersessional progress on their 2018 recommendations and **reiterated** their advice from last year that the distribution and population isolation of blue whales is poorly understood in the northern and western Indian Ocean. They **encouraged**:*
(1) further acoustic work in the western Indian Ocean and Arabian sea to better understand the distribution, seasonality and overlap of blue whale calls;
(2) 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) submission of photo-identifications to the Southern Hemisphere blue whale catalogue for matching.

3.2.2 Progress towards population assessment
Since SC/67a, the Scientific Committee have supported Branch to conduct an analysis of blue whale catches (pelagic estimates and land stations) using the 2016 IWC catch databases to delimit population structure, boundaries, and regions of possible overlap across the Southern Hemisphere and northern Indian Ocean. Initial results of this work were presented in Branch *et al.* (2018) and have been updated in SC/68A/SH/15, which presented further analyses to separate pygmy blue whale catches by population. The underlying idea is to fit a spatially smoothed surface to song type measured in different locations, which is considered to be unique to each blue whale population, under the assumption that current spatial patterns in song type reflect population distribution during whaling. Data were collected from a wide variety of hydrophones throughout the Indian Ocean, Southern Ocean and western South Pacific, in the form of number of hours examined, and number of hours with detections of each song type, by month, although the analysis presented combined data from all months. The analysis focused on four populations of blue whales: northern Indian Ocean (NIO), south-western Indian Ocean (SWIO), south-eastern Indian Ocean (SEIO), and south-western Pacific Ocean (SWPO). The best spatial models involved over-dispersion in the form of beta-binomial likelihood functions predicting the proportion of hours with songs at each location, for each population separately. The resulting four models were combined to estimate the proportion of each song type at a given location, and applied to historical catches to estimate that total catches from each population were 1,796 (NIO), 7,674 (SWIO), 2,310 (SEIO), and 404 (SWPO), with 97.6% of the overall total of 12,184 occurring between 1959/60 to 1971/72. Further work is needed to: (1) fit separate models to each month of data; and (2) account for uncertainty through bootstrapping of the underlying data. In addition, there is a fifth song type ('Oman' blue whale) that needs to be modelled when permission is received to include those data, which would split the current NIO catches into two groups: north-western Indian Ocean, and north-central Indian Ocean.

In discussion, it was noted that the further work proposed in SC/68A/SH/15 is anticipated to be completed by SC/68B, as well as development of regional population assessment models for South Australia, Madagascar, Sri Lanka and the southeast Pacific. The sub-committee **encouraged** this work to continue.

The sub-committee noted that further division of catches within the Northern Indian Ocean will require access to new acoustic data describing the 'Oman' blue whale song type (Cerchio *et al.*, 2018), since this is thought to represent a distinct north-western Indian Ocean blue whale stock (IWC, 2019). They **encouraged** the work presented in SC/68B/SH/15 to be updated intersessionally, and for the acoustic researchers to make these data available for the purposes of catch allocation.

Attention: SC, G
*In order to progress its work towards an assessment of pygmy blue whales, the Committee **reiterated** their advice from last year that they **encouraged**:*
(1) further work to finalise high and base case catch scenarios for pygmy blue whales;
(2) population modelling to assess pygmy blue whale populations; and
(3) catch allocations of blue whales be revised to include the new blue whale song in the northwest Indian Ocean as a potentially distinct 'stock'.

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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 Population structure

At SC/67b, 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. They **re-iterated** these recommendations.

Two documents were received on the topic of fin whale genetic population structure (SC/68A/SH/02 and SC/68A/SH/05); these were reviewed during a joint session of the Southern Hemisphere sub-committee and Stock Definition Working Group. Discussions of these papers can be found in Annex I, item 4.3.1. Although both included samples from a broad longitudinal range, neither study found conclusive evidence of Southern Hemisphere population structuring: samples in SC/68A/SH/02 spanned 210° of the Indo-Pacific between 0°E and 150°W and were tested for mtDNA and microsatellite genotype differentiation, while SC/68A/SH/05 primarily compared mtDNA samples available at ~75°W with those at 10°E. The sub-committee **encouraged** further work to understand fin whale population structure, noting also that the high diversity in the dataset might obscure weak population structuring using standard F_{ST} measures of differentiation, and suggesting the authors might employ unsupervised clustering methods to see if geographically distinct haplotype clusters are retrieved.

The sub-committee were informed that an acoustic analysis of Southern Hemisphere fin whale song variation, endorsed at SC/67b and led by Širović, could not be progressed due to Scientific Committee budgetary constraints. This work was intended to investigate whether acoustics can be used as a tool for distinguishing fin whale populations. Širović will try to progress the planned analyses

via student projects, using acoustic data available from the western Antarctic Peninsula as a starting point. The sub-committee **encouraged** further work on this topic.

The Scientific Committee have previously recommended that the holotype of the disputed sub-species *B. p. patachonica* described by Clarke (2004) be sampled by Archer for comparison with the global fin whale genetic dataset. In this regard, the sub-committee **reiterated** its previous request that the Secretariat provide a letter of support to the Argentine Commissioner to the IWC, to assist Archer in gaining approval to sample the *B. p. patachonica* holotype in the Bernardino Rivadavia Natural Sciences Museum (MACN) in Buenos Aires, to establish the genetic identity of this specimen.

During SC/67b, the sub-committee **agreed** to conduct a review of all Discovery mark data published on fin whales to assess population connectivity patterns. This analysis has not yet been completed, so the sub-committee **re-iterates** its recommendation that this work be done.

Attention: SC, G, S

*Knowledge of population structure is essential to future efforts to assess Southern Hemisphere fin whales. The Committee welcomed the new work presented, recognising that further work is required to fully address previous recommendations, and enable assessment. The Committee therefore **reiterated** their recommendations from last year, which **encouraged**:*

(1) analysis of concurrently collected acoustic recordings of fin whales, to assess song variation around the Southern Hemisphere;
(2) analysis of fin whale distribution and geographic aggregations using all available catches; and
(3) strategic biopsy sampling and analysis to measure the genetic differentiation of fin whales around the Southern Hemisphere.

*The Committee **reiterated** that it **agreed** a review of all Discovery mark data published on fin whales should be conducted to assess population connectivity patterns.*

*The Committee also **reiterated** its **request** 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 MACN in Buenos Aires.*

4.2 Distribution

The sub-committee were informed that a ship-based helicopter survey for fin whales has been conducted around the northern tip of the Antarctic Peninsula during the Expedition PS 112 of the German research vessel *Polarstern* between 23 March and 24 April 2018. Distance sampling data was collected along 3,250km of track-lines, recording 105 sighting of a total of 139 individuals. In addition to effort related sightings, large aggregations of feeding fin whales were observed, particularly around Elephant Island. Distance sampling methods and density surface modelling were applied to analyse fin whale distribution and density in the survey area. Fin whale minimum density, uncorrected for $g(0)$ was estimated at 0.024 (95% CI 0-0.121) animals/km^2, confirming high fin whale densities around the northern tip of the Antarctic Peninsula in late austral summer. These results provide additional support for fin whales returning to a pre-whaling feeding ground, potentially indicative of population recovery. The models are still preliminary and further analyses are being undertaken, particularly including analyses from a concurrently conducted krill survey.

It was noted that the fin whale density estimates provided for the northern Antarctic Peninsula were not provided with coefficients of variation, but have a very broad confidence interval suggesting substantial uncertainty. In response, the author explained that the estimate presented is very preliminary and is currently subject to revision.

The sub-committee was provided an update on visual and acoustic surveys of cetaceans conducted aboard the Argentinean Navy icebreaker, ARA *Almirante Irizar*, from 22 February to 22 March 2019, navigating along the northeastern Antarctic Peninsula in the Weddell Sea, and through the Scotia Sea as far as 60°38.42'S 45°14.52'W. Visual surveys were conducted over a total of 64.5 h and 518 nm. Fin whales were the most frequently observed species with 51 encounters totalling 104 individuals (mean group size 2±1.1). The largest concentration of fin whales was detected in the Scotia Sea with a mean encounter rate of 0.50±0.96 whales/n.mile. A photo-identification catalogue of Antarctic fin whales was compiled using photographs taken on the Argentinean cruises from 2013 to 2019; nine individual whales were catalogued, and will be compared to other catalogues. Further analysis of visual and acoustic data collected during previous years are being conducted in order to determine which environmental parameters affect distribution and relative abundance of the species north of the Antarctic Peninsula. Ship time has been secured for 2019/20 with the Argentinean Navy vessel. Researchers will deploy an autonomous acoustic recorder which will collect sounds throughout the year, continue line-transect surveys during summer, increase the number of individuals in the Antarctic fin whale photo-identification catalogue, and collect biopsy samples (see SC/68A/SH/10). This project is partially funded by IWC-SORP and Whale and Dolphin Conservation, and a full report will be presented to SC/68B.

During July 2018, the CCAMLR Working Group on Ecosystem Monitoring and Management welcomed the initiation of a new synoptic krill survey across the high latitudes of the South Atlantic, to be conducted during the austral 2018/19 summer season. The survey was designed to cover most of CCAMLR subareas 48:1-4. The last survey of this geographical scale was conducted in 2000 and was jointly coordinated with the IWC (Hedley *et al.*, 2001; Reilly *et al.*, 2004); efforts were made to include marine mammal observers on all legs of the survey, in a collaboration between the British Antarctic Survey (BAS) and the Norwegian Institute of Marine Research. The primary aim of these cruises was primarily to collect data on the abundance of krill, and the cetacean survey was therefore not designed according to principles established for the assessment of cetacean abundance using Distance sampling methods (Buckland *et al.*, 2001). However, a common cetacean sighting survey protocol was developed and efforts were made to replicate as far as practically possible the methods applied during the SOWER-2000 survey (Hedley *et al.*, 2001; Reilly *et al.*, 2004) in order to compare estimates of the distribution and relative abundance of cetaceans in the study area. Sightings data from the three cruises have not yet been fully collated, but initial data indicate elevated densities of humpback whales in the northern Scotia Arc and Antarctic Peninsula regions, while fin whale densities were highest in the region of the islands at 60°35'S, 45°30'W. Work is now underway to measure regional density and abundance for humpback and fin whales, and to coordinate analyses of density across surveys. A full report will be provided to SC/68B. Further analysis of sightings data in relation to krill density and other environmental parameters is planned in the future.

In discussion, it was queried whether these recent data suggesting elevated fin whale densities off the islands at 60°35'S, 45°30'W were also reflected in the historical catch record. The sub-committee were informed that de la Mare (2014) has investigated effort-stratified fin whale catch densities around the Southern Ocean, and found elevated catch densities in this region during 1935-41, but not during every catch period. The sub-committee was informed that under the proposed new SORP fin whale theme (focused on fin whales in the Scotia Arc and Antarctic Peninsula regions), there are plans to compare modern sightings data with past catches in an effort-stratified framework, and also to conduct joint analyses of fin whale sightings data collected in relation to environmental variables, to assess the environmental drivers of fin whale distribution.

The proposed analyses were **welcomed** as they may provide insights into changing habitat use patterns by fin whales over the past century, and may help to identify persistent hotspots and key environmental drivers. There is further discussion on this topic under Item 4.3.

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 behaviour of fin whales around the Antarctic Peninsula. They currently hold a fin whale photo-identification 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 ended in early 2019 with no ship time or funding secured for 2019 onwards, so the present work cannot be continued if no alternative funding is achieved.

The sub-committee welcomed this update, **expressed concern** about the loss of funding for this important long-term program and **strongly encouraged** the continuance of this research program for the purpose of understanding fin whale population structure, movements and habitat use.

Attention: SC, G, CG-A
*The Committee **reiterated** that they **strongly encouraged** continued work by the Brazilian Antarctic Program towards the understanding of fin whale population structure, movements and habitat use.*

4.3 Abundance

At SC/67b, the sub-committee received information that an estimate of circumpolar fin whale abundance (using IDCR-SOWER CPIII data) is in preparation for publication in the Journal of Cetacean Research and Management, and **recommended** that this analysis be reviewed by the ASI Standing Group to determine suitability for use in a population assessment. This work is not yet complete, so the sub-committee **re-iterates** its recommendation for this work to be reviewed by the ASI Standing Group during SC/68B, noting that it will need to be submitted one month before the meeting date in order for ASI to pre-review.

The sub-committee discussed the substantial number of datasets now collated with fin whale sightings data from the Antarctic Peninsula and Scotia Arc regions (IWC, 2018). They re-iterated that they **encourage** this work to continue, but note that it is currently very difficult to quantitatively compare or combine these datasets, due to the variety of sightings platforms and survey designs and methodologies employed. In this regard, the sub-committee **recommended** that under the new SORP fin whale theme standard survey protocols be developed, to assist collaborators working in the region to collect data which may be more easily comparable between surveys and over time. This work will be progressed intersessionally via an email group convened under Herr (see Annex T).

In discussion of the use of sightings data to measure fin whale density, it was noted that vessel-based sightings rates for this species may be negatively biased. Abundance estimates for cetacean species can be downwardly biased if they have a track line detection probability (i.e. '$g(0)$') of less than one, for example due to their surfacing behaviour. North Atlantic fin whales have been estimated to have $g(0)=0.77$ (CV=0.1) from a combined platform study during the 2007 North Atlantic Sightings Survey (Pike *et al.*, 2008). The sub-committee **encouraged** researchers conducting sightings surveys of Southern Hemisphere fin whales (including those working under the new IWC-SORP theme) to consider this possible bias in their survey designs, to better understand Southern Hemisphere fin whale $g(0)$ values and where possible ensure it is adequately accounted for in density and abundance studies.

Attention: SC, G, CG-A
*In order to understand circumpolar and regional fin whale abundance for consideration in upcoming assessments, the Committee **reiterated** their previous advice that they:*

*(1) **recommended** presentation of a new abundance estimate for fin whales for review at next year's meeting; and*
*(2) **encouraged** meta-analysis of the Antarctic Peninsula and Scotia Sea sightings data, to measure recent fin whale distribution, density and habitat use;*

*In order to maximise the value of fin whale sightings datasets, the Committee also **recommended** that a sightings survey protocol be developed, to assist researchers to measure fin whale distribution, density and habitat use in a comparable way across platforms.*

4.4 Cruise reports

SC/68A/ASI/02 reported the result of 2018/2019 NEWREP-A dedicated sighting survey which conducted in the eastern part of Area III (35°E-70°E; south of 60°S). A total searching distance was 2,960.6 n.miles and a total of 216 schools (499 individuals) of fin whales were observed. Biopsy samples from two individuals were collected in this area.

SC/68A/SP/01 reported the sighting of fin whales by the sighting and sampling survey conducted in Area III (0°E-70°E; south of 60°S) under the 2018/19 NEWREP-A. The total searching distance was 3,907.0 n.miles, and a total of 72 schools (152 individuals) of fin whales were sighted. Biopsy samples from two individuals were collected. These data were stored in the ICR database and will be analysed in the near future.

A dedicated IWC-SORP fin whale research cruise on the German research vessel *Maria S. Merian* is scheduled for March/April 2020, targeting an area along the northern tip of the Antarctic Peninsula. Planned activities of the voyage include a visual cetacean survey, krill and oceanographic sampling, satellite telemetry and biopsy sampling of fin whales, photo-identification and UAV-supported behavioural observations.

5. SOUTHERN HEMISPHERE RIGHT WHALES NOT SUBJECT TO CMP

In 2017 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, 2018).

5.1 Review new information on population structure

Document SC/68A/SH/06 was summarised and discussed in Annex I, item 4.3.3. This provides new information on the population identity of southern right whales feeding near the South Atlantic islands at 54°55'S, 36°45'W and of the critically endangered Chile-Peru population, genetically linking the latter slightly more closely to the Indo-Pacific than to the South Atlantic. The sub-committee **welcomed** this information, particularly as very little is known about the origins of the Chile-Peru population, and whether it is a remnant population or a result of recent colonisation; the data presented in SC/68A/SH/06 suggest the former.

5.2 Regional information

5.2.1 New Zealand right whales

SC/68A/SH/03 describes preliminary results for the extraction and quantification of two steroid hormones, progesterone and cortisol, from blubber biopsy samples collected incidentally along with skin samples from southern right whales in the Campbell Islands in 2014. Well-established steroid extraction and ELISA methods were used to estimate the minimal sample mass required and the effect of sample storage in ethanol on hormone concentrations. In this study the method was validated for cortisol with good repeatability and parallelism to a standard curve but not for progesterone, probably because the concentration of this hormone in the samples was too low. It was also established that phosphate buffered saline was an appropriate sample diluent. However, further work is needed to fully validate this approach using small biopsy samples. Nonetheless, these initial results suggest these tissues can be used to determine steroid and perhaps other physiological state biomarkers that are fundamental for assessing individual health, and by extension, population health and resilience to environmental and anthropogenic pressures.

In discussion, it was queried whether faecal or spout samples might also be useable for hormone quantification. The authors noted that faecal samples have been used for hormone analysis before (e.g. Hunt *et al.*, 2019) but that biopsy is preferable due to higher sample quality. They highlighted the difficulty in quantifying hormone levels from spout samples as there is currently not a protocol to measure the amount of spout material present in the collected sample vial. The relative quantity of hormone per unit of tissue is vital for identifying heightened levels of cortisol or other hormones of interest. Further work needs to be done to reliably normalise hormone concentrations.

The sub-committee welcomed this work, noting its relevance to ongoing studies of the response of southern right whales to anthropogenic stresses.

Emma Carroll (University of Auckland), Will Rayment (Otago University) and the New Zealand Department of Conservation (DOC) are launching a new push for collection of data on mainland NZ southern right whales during June/July 2019. This will involve engaging the public to report sightings and contribute photos, as well as DOC staff collecting photo-identification photos and skin biopsy samples. The last assessment of mainland NZ southern right whales was for the period 2003-10 (Carroll *et al.*, 2014), so this effort is intended to provide a revised assessment for the period 2011-21, including three years of greater public awareness and engagement from 2019-21 that they hope will result in greater data collection.

In discussion, the sub-committee **commended** these researchers for initiating this drive, noting the absence of southern right whales from New Zealand mainland waters for over 50 years, making this now one of the best documented examples of the loss and recolonisation of a whale breeding habitat. The sub-committee noted the importance of these data collections for contributing to regional assessment of this species.

5.2.2 Australian right whales

The sub-committee were informed about two southern right whale projects currently funded by Australia's National Environmental Science Program (NESP).

The first continues John Bannister's long-term aerial surveys of right whales between Cape Leeuwin in Western Australia to Ceduna in South Australia. The 2018 aerial survey was conducted successfully, and two more years of funding are available (2019/20). This project is now led by a small consortium from the Western Australian Museum, Murdoch University and the Australian Antarctic Division. Work continues to process and enter John Bannister's aerial survey data into the Australasian Right Whale Photo Identification Catalogue (ARWPIC).

The second NESP funded project is led by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and aims to collate and reconcile data from Australia's major right whale photo-identification catalogues into the Australasian Right Whale Photo-Identification Catalogue (ARWPIC) and then conduct an analysis to assess population structure, abundance and status. The project is nearing completion of the data collation stage, with near complete submission from the Head of Bight (led by Claire Charlton) and SE Australia catalogues (led by Mandy Watson). This project is due to be completed in 2020.

The sub-committee recognised the value of these long-term monitoring programs and of these datasets for the work of the Scientific Committee and for conservation management, **recommended** that this monitoring continue and **encouraged** an update to be provided to SC/68B.

Charlton *et al.* (2019b) assessed southern right whale seasonal trends in distribution and relative abundance, peak abundance and packing density, using 25 years of sightings data at the Head of the Great Australian Bight ('Head of Bight') calving ground in South Australia. Annual cliff-based surveys were undertaken between June and October from 1992 to 2016. A total of 805 daily surveys were completed from 1992 to 2016, with an average of 35 surveys per year, and we collected over 42,000 whale sightings. Southern right whales were primarily distributed within a 15km by 2km area within the 10m depth contour. Peak abundance occurred between mid-July and end-August. Up to 28% of female and calf pairs are at the site before mid-June, and 61% remain at the site at the end of September, which provides important information on sensitive migration periods for risk assessment. Based on nearest neighbour distances of 150m, the area occupied by 95% of southern right whales at Head of Bight reached a packing density at 68 female and calf pairs. Results suggest that the primary aggregation area at Head of Bight may have reached its packing density and that distribution into adjacent habitat can be expected as the population increases. This paper provides important information for management of the marine protected area and for impact assessment of proposed oil and gas activities

in the region. The long term southern right whale monitoring program at Head of Bight is now in its 29th consecutive year, with funds secured until 2020.

Charlton *et al*. (2019a) reported increased abundance of southern right whales at Fowlers Bay, South Australia, a site previously used for shore-based whaling. Southern right whale inter- and intra-seasonal trends in relative abundance, changes to the relative proportion of the south western subpopulation represented by southern right whales at Fowlers Bay, distribution, and occupancy were assessed. Sighting and photo identification data were collected during annual aerial (1993-2016) and vessel surveys (2014-16). The total number of female and calf pairs was three during 1993-2003 and 63 during 2004-14. Despite high variability in annual relative abundance, the rate of mean increase from 1993 to 2016 (29.0% yr-1 95% CI=0, 54.2 exceeded the maximum biological rate for the species (6%-7% yr). Peak relative abundance was recorded in July/August. Southern right whales at Fowlers Bay represent an increasing proportion of the southwestern subpopulation (range=0.9%-7.4%). Mean occupancy was 23d (range=1-75) for female and calf pairs and 2d (range=1-15) for unaccompanied adults. This paper highlights the importance of Fowlers Bay as a calving ground for southern right whales. Further research into the movement and connectivity of southern right whales is needed to understand drivers of habitat dispersal in Australia.

The sub-committee noted that this work provides an example of the spatial expansions seen as southern right whales recover from exploitation. These expansions have implications for long-term population modelling, as re-sight probabilities and apparent calving intervals decrease at traditionally monitored sites. Mark recapture assumptions will be violated by reductions in capture probability due to a change in space use over time, and increases in apparent calving interval may be due to more calving events taking place outside the monitoring range. Range expansion and recolonisation to new areas has been observed for other southern right whale populations, such as Brazil (Danilewicz *et al.*, 2016; Groch *et al.*, 2005), Argentina (Arias *et al.*, 2017; Rowntree *et al.*, 2001), Uruguay (Costa *et al.*, 2005), South Africa (Barendse and Best, 2014), New Zealand (Carroll *et al.*, 2014) and Campbell Islands (Torres *et al.*, 2016). The sub-committee noted that this will be an important issue to discuss during development of a common population dynamics framework for southern right whales (Item 5.5).

The authors noted that while whales regularly use both Fowlers Bay and Head of Bight (65% of Fowlers Bay animals that matched to other areas were previously seen calving at Head of Bight), 40% of calving females were also inter-annually re-sighted in Fowlers Bay, suggesting site fidelity by some whales (Charlton, 2017). They also noted that one long-distance re-sight had also been made between Fowlers Bay and the New Zealand Auckland Islands, and that one animal seen in Head of Bight had previously been re-sighted multiple times in southeast Australia, further highlighting the need for a quantitative assessment of regional population connectivity patterns, which is underway via the NESP photo-identification collation and analysis initiative described above.

Stamation *et al.* (2020) provided an estimate of population size and rate of increase of southern right whales in south-eastern Australia. Southern right whales in Australian waters form two genetically distinct populations: a western population in South Australia and Western Australia; and an eastern population in south-eastern Australia (Tasmania, Victoria and New South Wales). Although delineation of the two populations is complex, due to mixing in the migratory corridor, they show contrasting patterns of recovery since whaling ceased. Results estimated a population abundance of 268 individuals, increasing at a rate of 4.7% per annum, between years 1996-2017. Results are critical for assessment of population status and recovery of southern right whales off Australia. The project directly addresses key objectives of the Australian Commonwealth Conservation Management Plan for the southern right whale.

The sub-committee agreed that because this paper includes an estimate of population abundance, it should be reviewed by the ASI Standing Group intersessionally, with a report anticipated for SC/68B.

The sub-committee then discussed the assessment context of the abundance estimate presented here. While genetic data suggest that the south-eastern Australia calving ground represents a remnant stock, rather than a recolonisation from south-western Australia or New Zealand (Carroll *et al.*, 2011), there is also evidence for ongoing movements of animals between south-eastern Australia and neighbouring grounds. If this area is considered to be a distinct breeding stock within the upcoming population assessment, population connectivity will have to be explicitly considered in the model. The sub-committee **endorsed** on-going efforts to measure population connectivity between south-eastern Australia, south-west Australia and New Zealand.

Attention: SC, G, CC, CG-A
*The Committee **reiterated** their earlier comments that they **recognise** the value of the Australian long-term right whale monitoring programs to understand right whale population trends and dynamics, and **recommended** that this monitoring continue.*

5.2.3 South African right whales

SC/68A/SH/01 reports on the South African southern right whale aerial surveys conducted in 2018. The survey methodology has remained constant for the past 39 years, as detailed in the report. A total of 36 hours and 40 min of flight operations were needed to complete this survey. In total, 480 groups comprising 537 cow-calf pairs and 25 groups of 34 unaccompanied adults were observed, totalling 1,108 southern right whales. This reflects an all-time high of cow-calf pair presence along the South African coast since the commencement of the surveys. However, this also reflects the third lowest count of unaccompanied adults since 1990. Two additional aerial surveys were flown covering the main nursery grounds, which indicate a peak presence of cow-calf pairs in mid-August, as opposed to the previously observed peak in October. This is the second year to observe an apparent temporal shift in peak presence of calves. Analysis of the 2018 photo-identification data revealed the identification of 426 unique female southern right whales. Data from the recaptures indicated increased calving intervals to 4- and 5-years, in line with the observed increase in calving intervals since 2014. It is believed that this increase in calving interval is linked to Southern Ocean climate and productivity, as detailed in document SC/68A/SH/12. However, the all-time peak in cow-calf presence observed this year could be a first indication of a general recovery of the poor feeding conditions, and a reorganisation of the female calving cohorts. However, the incessant low number of unaccompanied adults raises doubts about the degree of such a recovery, or suggests this part of the

population may be dependent on different feeding grounds or prey items. Regardless, the high number of calves observed indicates mating activities are ongoing and successful.

In discussion, the authors noted that funding had been secured for the 2019 aerial surveys and that funding bids are currently underway to secure the funding for these aerial surveys for the next four years. The sub-committee thanked the authors for this interesting work and noted that this provides regional trend data important for the upcoming population assessment of southern right whales.

SC/68A/SH/12 reports on the assessment of the role of Southern Ocean climate and productivity on the large fluctuation of cow-calf pairs in the South African breeding ground in recent years (detailed in SC/68A/SH/01). The climate indices used were the Oceanic Niño Index, the Antarctic Oscillation and the September Antarctic sea ice extent. The impacts of these climate indices are all thought to be mediated through their influence on southern right whale prey availability, like Antarctic krill. Summer chlorophyll *a* concentrations were obtained for three putative southern right whale feeding grounds in the Southern Ocean, as these concentrations have been found to correlate with densities of southern right whale prey. To analyse the data, a wavelet analysis was used, combined with Autoregressive Integrated Moving Average (ARIMA) models. Significant model performance improvement was found through the inclusion of the Oceanic Niño Index (ONI) and the Antarctic Oscillation, separately, each with a lag time of up to 2 years. Additionally, a combination of environmental variables was investigated, and significant model performance improvement was found when including the Oceanic Niño Index, with up to a 3 year lag and Antarctic Sea ice, with up to a 4 year lag. The results suggest that the combined effect of several climatic drivers may have led to poor feeding conditions in southern right whale feeding grounds in the Southern Ocean. This is likely to have played a major role in not only the drastic drops in cow-calf pairs along the South African shores between 2015 and 2017, but also the increasing calving intervals seen in females since 2015. Going forward, funding has been obtained to continue with an in-depth assessment of South African population dynamics in relation to foraging ecology, based on stable isotope data and habitat modelling.

In response to a question about possible confounding correlations among the multiple environmental indices examined, the authors explained that prior investigation showed strong collinearity between ONI and the Southern Oscillation Index, so the latter was removed from the investigation, but no correlations were seen between the other retained environmental variables. It was also suggested that the authors consider conducting analysis of fatty acids as well as stable isotopes, as the former can better help discriminate between prey sources on feeding grounds (Iverson *et al.*, 2007).

The sub-committee noted that it was extremely useful to consider environmental drivers of population dynamics, but cautioned against the use of raw calf counts as a proxy for reproductive effort because they can be confounded by the non-independence of individual calving rates between years. They recommended instead including transition probabilities through the different reproductive stages as response variables in the model (e.g., as estimated in SC/68A/SH/14) as these are a less biased representation of reproductive trends, i.e. expected calving output. They advised that time variation in this trend should then be accounted for (i.e. the long-term trend in increased population size), with the residuals of this variation investigated in relation to environmental correlates (e.g., Leaper *et al.*, 2006). The sub-committee **encouraged** further work to address these comments, and welcomed an update at SC/68B.

SC/68A/SH/13 reports on a study conducted in South Africa to assess the visual health of parous females, based on overhead photographs from the annual aerial southern right whale surveys (from SC/68A/SH/01), in order to detect annual variation, and potential links between the visual health condition and increased calving intervals as well as environmental indices of the Southern Ocean. The method used was adapted from a visual health assessment method developed for northern right whales by Pettis *et al.* (2004), adjusted in collaboration with southern right whale researchers from Australia. Although the study was limited by several factors, results indicated 2008 and 2014 as years with a significant decreased visual health, the years prior to the crash in the numbers of unaccompanied adults and cow-calf pairs respectively (see SC/68A/SH/01). No direct link between visual health condition and calving intervals could be found, but preliminary results suggests a link between southern right whale visual health condition and Southern Ocean climate conditions and productivity. It is believed that the standardisation of a methodology for visual health assessments would allow for comparison of results on a global scale. Nonetheless, it is suggested that the survey methods also be standardised across populations to ensure even better comparisons, including a quantitative assessment of the body condition of South Africa's southern right whales, which will be done in 2019.

In discussion, the sub-committee noted that the development of a global, standardised and IWC-endorsed protocol for these health assessments would be extremely beneficial for ensuring comparability of assessments between regions and over time, and **encouraged** this to be developed. The authors agreed to bring their standardised protocol as a report to SC/68B for discussion and endorsement. It was also noted that this visual assessment approach can also be helpful for better understanding the impacts of satellite tagging on animal health. For example using these health assessment criteria, one animal previously tagged in Australia was re-sighted post tagging in good body condition and had been successfully reproductive (calved on a 4-year interval) after the tagging event had occurred (Charlton *et al.*, In prep). It was noted that Argentina are planning to conduct health assessments next season in order to assess animal health following earlier satellite tag deployments (e.g. Zerbini *et al.*, 2018).

The sub-committee welcomed future updates, and **endorsed** efforts to develop a standard protocol for this activity.

On a related topic, the sub-committee were informed that a comparative assessment of southern right whale body condition is currently underway in Australia, Argentina, New Zealand and South Africa, as well as for the North Atlantic right whale (*Eubalaena glacialis*). This is being undertaken by Christiansen and colleagues in collaboration with Murdoch University, Otago University, Woods Hole, NOAA, Instituto de Conservación de Ballenas, the University of Pretoria, and other collaborators. Plans are also being made to conduct a combined visual health assessment of South African and Australian southern right whales, using the methods described in SC/68A/SH/13.

In SC/68A/SH/14, the assessment of southern right whales in South African waters was updated to include a further year's data collected in 2018. After three preceding years of very low sightings of females with calves, 2018 saw these numbers increasing to reach a record level of 426.

This pattern of results was best explained by variation with time in the probability that a resting female rests again the following year, where this probability increased substantially after 2008, but seems to have fallen back to earlier levels from 2017. Another surprising feature of the data is three extremely low estimates of the probability of sighting a female with calf after 2015. The low estimates do not seem compatible with near unchanged survey conduct for the years concerned, so a penalty term has been added to the assessment to force these to be closer to earlier values. The resultant population trajectory suggests an annual increase rate of 6.1% from 1979 to 2008 which dropped to 3.9% for the following decade, with the current abundance (including calves) totalling 5,838 whales.

In discussion, the sub-committee **agreed** that the model should rather be modified by including variation in calf survival in order to better account for low number of sightings of females with calves over 2015 to 2017 (e.g. Cooke *et al.*, 2015); the possibility of linking such variations to environmental covariates should also be explored. The sub-committee **recommended** that this further model development be carried out intersessionally, and welcomed an update for SC/68B.

The sub-committee also noted that SC/68A/SH/14 presents an abundance estimate for South African right whales. Given the further model development required, the sub-committee agreed that reference of such an abundance estimate to the ASI Working Group for acceptance should first await more progress on this development.

Attention: SC, G

*In order to understand the climate drivers underlying South African southern right whale population dynamics, the Committee **encouraged** further work assessing the impact of these drivers on southern right whale calf productivity, following Committee recommendations.*

*In order to provide a synoptic assessment of southern right whale health across the Southern Hemisphere, the Committee **encouraged** the development of a global, standardised and IWC-endorsed health assessment protocol.*

*The Committee **recommended** further development of the South African southern right whale population dynamics model in order that it provides a good representation of the underlying dynamics of the population.*

5.2.4 Feeding grounds

SC/68A/SP/01 reported the southern right whale sightings by the sighting and sampling survey under the 2018/19 NEWREP-A. A total of 5 schools (8 individuals) of southern right whales were sighted during the transit survey to the research area (during 1 Dec. to 5 Dec. 2018; between 35°S-37°S and 89°E-95°E). All individuals were photographed and biopsy samples collected. These data were stored in the ICR database and will be analysed in the near future.

In response to a question, the authors confirmed that the biopsy samples were collected in the middle latitudes of Area IV and would be contributed to several ongoing analyses regarding southern right whale diversity. The sub-committee were informed that an update on recent surveys in the southern right whale feeding ground in the South Atlantic was provided in Annex O, item 6.1.2.

5.3 Progress towards population assessment

At SC/67b, the Scientific Committee **agreed** to support a proposal to conduct a comparative study of southern right whale demographic data (IWC, 2019), using a common model framework similar to that generated by Cooke *et al.* (2015) and Brandão *et al.* (2018). The project would also investigate correlations between southern right whale abundance trends/calving intervals and environmental variables in the Southern Ocean. Due to a lack of funding, intersessional progress on this topic has been limited, but the work is planned to continue within the new SORP right whale theme (Annex 6, SC/68A/SH/20). Regional work on population dynamics has been progressed and is described in Items 5.1 to 5.4, including an update of the various regional photo-identification catalogues. A proposal has also been submitted to hold a workshop at the upcoming World Marine Mammal Conference (December 2019, Barcelona), on the topic: 'Roadmap for the right sentinel for climate change: developing an action plan to achieve the IWC-SORP southern right whale theme objectives' which is intended to progress project discussions and develop an action plan for future work to be presented at SC/68B.

In reviewing the elements of this project that were requested for funding during SC/67b, the sub-committee identified that the most urgent task at present was to reconcile the Brazilian and Argentinean photo-identification catalogues, a significant data gap as the southwest Atlantic wintering ground (spanning Brazil, Argentina and Uruguay) is likely to represent a single, expanding population, and is currently being monitored via two separate national datasets. The sub-committee **endorsed** this project and **encouraged** it to proceed. This has cost implications for the sub-committee and the full proposal is provided in Appendix 7.

The sub-committee **agreed** to progress project development via an intersessional email group, to identify work priorities and funding opportunities, including development of a funding proposal in the next available SORP call (October 2019). Funding will be sought to progress regional project activities (i.e. catalogue compilation), to develop the comparative model, and to support a pre-IWC workshop at SC/69A (in 2021), or at an appropriate endpoint, to assist project completion once regional activities have been finalised and the model framework is in place. The intersessional email group will be convened under Charlton (see Annex T).

The sub-committee were informed about new work by Christin Khan and colleagues, who participated in a competition to develop an algorithm to automate the identification of North Atlantic right whales, based on 7,000 aerial images. Some details of FlukeBook and its matching algorithms are described in SC/68A/SH/06. The new algorithm developed by deepsense.ai showed initial capacity to identify individuals with 87% accuracy, using a series of convolutional neural networks. Leveraging the existing infrastructure by Wild Me, the developers of Flukebook, they are creating a website platform that allows biologists with no machine learning expertise to automatically identify right whales. New models will be generated using both the deepsense.ai algorithms, and the Wild Me HotSpotter algorithm (used for humpbacks, jaguar, giraffe, and other species). Their goal is to extend this identification system to southern right whales, and they are currently planning to incorporate the largest long-term photo-identification catalogues including over 400,000 images from the United States and Canada curated by the New England Aquarium; 12,311 images from Australia from Curtin University; 8,461 images from South Africa from the University of Pretoria; 8,952 images from Argentina from the University of Utah; 5,473 images from Brazil from Instituto Australis; and 2,913 images from New Zealand from the University of Otago.

The sub-committee **welcomed** this new information, noting that as this technology develops it may prove extremely useful for future right whale assessments, by reducing the time and cost of inter-catalogue matching.

In discussion the sub-committee noted that 87% matching accuracy suggests this currently works as a matching-assist program, and queried whether the goal was to obtain accuracy >97%, as would be more suitable for developing mark-recapture abundance estimates. In response it was noted that this value came from the initial competition winning algorithm and had been improved subsequently. The sub-committee was unsure what the 87% value represented in terms of matching accuracy (i.e. did this represent matches missed, false matches found, or a mixture?). In discussion of the types of photographs required, it was noted that this algorithm is designed to work with aerial photographs and dorsal callosity patterns. The first priority (phase one) for the developers is to develop the algorithm for aerial photographs; in the second phase, they plan to incorporate side-on images. Current accuracy is such that researchers are currently using it as a match-assist program, and note that it also carries out quality control, saving researcher time. The sub-committee noted that at present this algorithm may work well for new additions to an extant catalogue but may not yet be useful for automatically assessing new sets of unreconciled photographs. They **encouraged** Khan and colleagues to provide a more detailed update on this topic to the Photo-Identification Working Group at SC/68B.

The sub-committee were informed that a catch history workshop organised by Jackson and Carroll was still planned to be held as a pre-meeting before SC/68B, in order to help develop regional catch histories for southern right whale populations (IWC, 2019). With the sad recent loss of two experts in this field (Bannister and Best), an intersessional email group was proposed, including regional collaborators in Australia and South Africa, to determine what catch related data are held in their respective archives which could be contributed to this meeting (Annex T). This review group were also advised to revisit the archives held by Bill Dawbin in Australia as further pre-modern catch data may be located there.

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 **reiterated** that it:*

*(1) **agreed** that analysis of the southern right whale calving grounds (Head of the Bight and southwest Australia, southwest Atlantic, south Africa and New Zealand) 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) **supported** the compilation of new data on pre-modern right whale catches, and organisation 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.*

*The Committee also **encouraged** the matching of photo-identification catalogues between Brazil and Argentina in order to progress regional assessment of the recovery of the southwest Atlantic southern right whale population.*

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6. SOUTHERN HEMISPHERE HUMPBACK WHALES

6.1. Progress towards assessment of Breeding Stock D

The Comprehensive Assessment of Southern Hemisphere humpback whales was concluded in 2015. In this assessment the available abundance data for west Australia (Breeding Stock D, BSD) presented two challenges: (1) there were few data to inform a correction for surface availability; and (2) there was a potential inconsistency between observer protocols and the Distance-based approach employed to estimate abundance. See IWC (2016) for a detailed discussion of these issues. In 2017, the sub-committee agreed that there was no strong case to further re-analyse past survey data for BSD because of the absence of success despite the efforts of two experienced modellers. Rather efforts should focus on designing and implementing a new 'survey' of the population (perhaps using new approaches, as provided by drones for example).

In 2017, the sub-committee:

(1) encouraged the development of a new survey off Western Australia for the purpose of producing a new abundance estimate, although it remains unclear if this is feasible either financially or logistically; and

(2) recommended an assessment of the feasibility of a new 'survey' be carried out, noting that detailed consideration of past survey feasibility analyses (notably following duFresne *et al.*, 2014), are necessary before any new fieldwork could be considered.

The sub-committee **reiterated** their recommendations from SC/67a and SC/67b that a re-analysis of the pilot study conducted by duFresne *et al.* (2014) be carried out to assess the feasibility of future surveys and hopes that an abundance survey would occur subsequently. Kelly has indicated that she is able to conduct this analysis intersessionally. This proposal has cost implications for the sub-committee and the full proposal is provided in Appendix 8. The sub-committee **endorsed** this proposal.

Attention: SC, G, CG-R

*The Committee **agreed** 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 **reiterated** 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.*

6.2 New abundance estimates

Monnahan *et al.* (2019) provided a new abundance estimate for a feeding aggregation of southeastern Pacific humpback whales in the Magellan Straits. Abundance was estimated using photographic data from 2004-16, representing 204 whales, using Bayesian robust-design mark-recapture models. The population trend was shown to increase albeit at a very low rate and concerns were raised over the significant overlap between humpback distribution and a busy shipping lane.

The sub-committee noted that humpback whale abundance estimates are not currently a high priority topic (with the exception of Breeding Stock D) but agreed to progress review of the estimate provided by Monnahan *et al.* (2019), given the significant uncertainty associated with population recovery assessment for Breeding Stock G (IWC,

2016). This abundance estimate has therefore been passed onto the ASI Standing Working Group and will be reviewed intersessionally, with feedback provided at SC/68B.

6.3 New photo-identification technology to support population assessments

Updates were provided on two types of globally recognised automated photo-identification recognition software (*Flukebook.org* and *happywhale.com*). Both use algorithms to match humpback whale individuals from photo-identification catalogues.

SC/68A/SH/07 describes recent developments to *Flukebook.org*, an instance of the Wildbook open source platform that is tailored to facilitate cetacean photoidentification and data archiving at a regional and global scale. Current project collaborators include NOAA, Cascadia Research Collective, Dominica Sperm Whale Project, Arabian Sea Whale Network, Indian Ocean Network for Cetacean Research (IndoCet), and Sarasota Dolphin Research Program, and others. While humpback whales were the first species for which computer vision matching algorithms were developed, the model has been applied to several additional species, with multiple algorithms for some species (humpback whales, bottlenose dolphins, sperm whales and right whales), and a growing number of algorithms that can be adapted/re-trained for an even wider range of species in the near future. IWC funding granted in 2016 was matched by other regional stakeholders in the Arabian Sea and allowed the development of other new functions that allow data archiving of cetacean sightings records without associated photo-identification data. IndoCet has also invested in the Flukebook Platform to refine the way in which it can be used to facilitate matching between research catalogues within the Western Indian Ocean, resulting in more robust data handling and protocols that help to address the assumptions of mark-recapture (photo quality and distinctiveness scoring, improved export of sighting history data, the ability to include multiple project ID's for a matched individual, etc.).

The sub-committee discussed the data sharing approach employed by Flukebook, noting that it allows for the inclusion of other types of metadata besides photo-identification, for example microsatellite genotypes of individuals during the North Pacific 'SPLASH' project, although there are cost implications for any bespoke database additions requested. Catalogue holders are also able to keep their catalogues private, with matches between catalogues identified by the matching algorithm but access to matches between catalogues only provided if both catalogue holders agree. A new development is that each whale is given one 'core' Flukebook master ID, which is the same for all instances of the same animal across its catalogues; this can be helpful for providing a common ID when research groups match between catalogues. New export functions have recently been added to enable a user-friendly interface allowing researchers to proceed easily data entry to quality scoring to exporting mark-recapture data via spreadsheet.

The sub-committee **welcomed** this update and **encouraged** further reports on Flukebook development to be reported to the Photo-Identification Working Group.

The sub-committee were informed about the use of a web platform developed by Cheeseman and colleagues, Happywhale (*www.happywhale.com*). This was originally developed for South Pacific photo-identification of humpback whales and is now expanding its efforts globally. This effort builds upon increasing engagement from contributing citizen scientists, and also involves a collaborating group of scientists whose humpback whale research efforts have resulted in collecting fluke photo-identification images from the South American west coast, west Antarctic Peninsula, Oceania and eastern coast of Australia. The platform uses automated image recognition software for humpback fluke identification that has achieved extremely accurate matching success. The platform recently implemented the 'Kaggle' photo-identification algorithm which enabled them to successfully compare flukes between eastern Australia and the southeastern Pacific Ocean. Furthermore, high match rates were found between the breeding grounds of southern Costa Rica, Panama, Columbia and Ecuador to the West Antarctic Peninsula. Notable but rare matches were observed between the following: Tonga and Costa Rica; Tonga, French Polynesia and the West Antarctic Peninsula; French Polynesia and Panama; and the Straits of Magellan and the West Antarctic Peninsula.

The sub-committee thanked Cheeseman and the founders of Happywhale for this update, noted the immense amount of new information that can be gained from these matching efforts and encouraged further reports on Flukebook development to be reported to the Photo-Identification Working Group.

The sub-committee noted that while both Flukebook and Happywhale programmes have similar underlying architecture for automated matching, Happywhale is fully open access (all images can be viewed) while FlukeBook has privacy options. Noting the importance of these automated matching developments for future IWC assessments, the sub-committee proposed that the Photo-Identification Working Group agree next year at SC/68B to start a regular dialogue with these two developers, to receive updates and deliver feedback in future.

7. SOUTHERN HEMISPHERE SEI WHALES

7.1 Review new information on population structure

SC/68A/SH/08 was reviewed by the Stock Definition Working Group (Annex I, item 4.3.4). This provided new information on the stock structure of sei whales in the Southern Hemisphere, with high levels of mtDNA control region differentiation suggesting that Northern and Southern Hemisphere sei whales are highly divergent. Additionally, genetic and isotopic work led by Buss (University of Cambridge) presented new information on the genetic diversity and differentiation of a sei whale feeding ground located near the islands at 51°40'-53°00'S, 57°40'-62°00'W in the southwest Atlantic, which shows similarly high diversity to those reported in SC/68A/SH/08. Further genetic and isotopic analysis are ongoing to understand sei whale feeding ecology and to investigate the impact of whaling on foraging ecology and genetic diversity. The sub-committee was informed that Southern Hemisphere sei whale researchers are collaborating with Oregon State University in order to ensure their microsatellite genotypes are comparable across multiple Southern Hemisphere locations, including Brazil, Chile and the southwest Atlantic.

The sub-committee welcomed an update on this work at SC/68B.

8. WORK PLAN

8.1 Blue whales

8.1.1 Antarctic blue whales

(1) The sub-committee **strongly encouraged** the continuance of work on the Antarctic blue whale catalogue by Olson and looked forward to receiving an updated abundance estimate at SC/68B.

(2) The sub-committee **agreed** to form an intersessional email group under Lang, to assess all available evidence for regional population structure within Antarctic blue whales. This will include genetics, Discovery marks, satellite tags, photo-identification, acoustics and sightings and catch patterns.
(3) Appendix 3 describes a new population assessment of Antarctic blue whales, considering the subspecies as a single circumpolar unit and integrating IDCR-SOWER surveys and mark recapture data into a Bayesian population model. The sub-committee **recommended** that the proposed work be carried out by Branch in 2020-22, following completion of the non-Antarctic Southern Hemisphere blue whale assessment.
(4) In light of the difficulties assigning the proportion of catch at Grytviken (and nearby whaling stations as appropriate) to non-Antarctic blue whales, the sub-committee **encouraged** Branch to: (i) compare Mackintosh and Wheeler (1929) length data to those from more recent Norwegian catches which are held in the IWC Catch Database; (ii) to obtain an estimate of the proportion of possible pygmy blue whales in these catches; (iii) to run mixture models using the female length data from Mackintosh and Wheeler (1929); assuming either (i) pure Antarctic blue whales; (ii) mixtures of Antarctic and pygmy blue whales; or (iii) mixtures of Antarctic and Chilean blue whales.
(5) The sub-committee **encouraged** Olson to match the Scotia Arc photo-identifications which have pygmy blue whale characteristics with the Chilean blue whale catalogue in order to assess possible movements of Chilean blue whales into the southwest Atlantic.

Table 1
Work plan 2019/20.

Item	Intersessional 2019/20	2020 Annual Meeting (SC/68b)
Antarctic blue whales		
Population structuring	Review evidence for population structuring within Antarctic blue whales (Convenor: Lang)	Report
Catalogue matching	Catalogue matching of 45 photo-IDs from 2014-17 ICR cruises (Convenor: Olson)	Report
Abundance estimation	Mark recapture modelling work to update report SC/67b/SH08 (Convenor: Olson)	Report one month ahead of SC/68b for ASI review
Progress towards population assessment	Assess catch length data using mixture models to measure possible Chilean blue whale component in catches at the islands at 54°15'S, 36°45'W (Convenor: Branch)	Report
	Match photo-IDs of putative pygmy whales at the islands at 54°15'S, 36°45'W with Chilean catalogue, if additional funds are available (Convenor: Olson)	Report
SH non-Antarctic blue whales		
Catalogue matching	Complete matching and quality coding of photo-IDs from Australia. Complete matching of photo-IDs from Chile. Complete quality coding if additional funds are available (Convenor: Galletti)	Report
Abundance	Provide updated abundance estimate for New Zealand blue whales following ASI SWG recommendations (Convenor: Barlow)	Report one month ahead of SC/68b for ASI review
Catch allocation	Finalise catch separation model and explore alternative catch allocation models (Convenor: Branch)	Report
SH fin whales		
Population structure	Review available published and unpublished Discovery mark data on fin whales (Convenor: Pastene and Jackson)	Report
Catch densities	Update fin whale catch model to include Soviet catch data (Convenor: de la Mare)	Report
Population abundance	Abundance estimate using IDCR-SOWER data (Convenor: Matsuoka)	Report one month ahead of SC/68b for ASI review
Progress towards population assessment	Develop common survey protocol to assist comparable future data gathering via SORP fin whale theme (Convenor: Herr)	Report
Southern right whales		
Population structure	Compare photo-ID catalogues between Brazil and Argentina, if funding is available (Convenor: Rowntree and Groch)	Report
Population abundance	Population modelling of South African right whale abundance and trend, to be reviewed by ASI at SC/68b (Convenor: Butterworth)	Report, ASI review at SC/68b
	Population abundance estimate of SE Australian right whales	ASI intersessional review with report to SC/68b
Body condition	Develop a protocol to use for conducting health assessments of southern right whales using overhead images (Convenor: Vermeulen)	Protocol in report, requesting endorsement by IWC at SC/68b
Catch records	Right whale catch series workshop (Jackson and Carroll)	Pre-meeting before SC/68b; meeting report.
SH humpback whales		
Population abundance of Breeding Stock G (central and southeastern Pacific)	Assess western Antarctic Peninsula abundance estimate for future assessments of BSG (Convenor: Monnahan)	ASI intersessional review with report to SC/68b.
Survey feasibility for Breeding Stock D (west Australia)	Reanalyse pilot study to assess feasibility of future West Australia surveys if funds are available (Convenor: Kelly)	Report
IWC-SORP		
Analyses	Continued analysis of data/samples from previous IWC-SORP voyages/fieldwork	Report
Voyages	Baleen whale and krill research voyages along Western Antarctic Peninsula	Report
Fieldwork	Continued fieldwork around Marion Island and the GBR	Report
Ships of opportunity	Continued use of ships of opportunity to conduct cetacean research	Report
Acoustics	Retrieval and redeployment of passive acoustic recorders	Report

8.1.2 Non-Antarctic Southern Hemisphere blue whales

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

(1) Acoustic researchers Cerchio and Willson to make available acoustic data recently collected from northwest Indian Ocean blue whales (Cerchio *et al.*, 2018), to help inform the acoustically-informed catch allocation model being developed by Branch (SC/68A/SH/15).
(2) Continued development by Branch of regional population assessment models for South Australia, Madagascar, Sri Lanka and the southeast Pacific by Branch *et al*. (SC/68A/SH/15), including the acoustic data in (1) above.
(3) Completion of the blue whale song library being developed by Širović and collaborators (Širović, 2018).
(4) Continued compilation of the Southern Hemisphere blue whale catalogue under Galletti, as it provides population connectivity information useful for upcoming regional blue whale assessments.

Due to intersessional budget cuts, transfer of the Southern Hemisphere blue whale catalogue onto servers hosted by the IWC in Cambridge was not complete. The Chair **agreed** to raise this issue with the IWC Secretariat, to seek a solution which might enable this migration to go ahead.

In order to progress regional assessments, the sub-committee also **encouraged**:

(1) An intersessional assessment of the suitability of the Australian blue whale photo-identification catalogues for mark recapture analysis of regional population abundance by Galletti, Jackson and Olson.
(2) New Zealand Southern Hemisphere blue whale collaborators to submit their images to the Southern Hemisphere blue whale catalogue in order to assist with regional assessment of blue whale abundance.
(3) The authors of Barlow *et al*. (2018) to re-submit a revised regional abundance estimate for New Zealand blue whales one month prior to SC/68B, addressing ASI Standing Working Group recommendations (Item 2.1.3, Annex Q).
(4) Chilean Southern Hemisphere blue whale collaborators to submit their images to the Southern Hemisphere blue whale catalogue, in order to assist with regional assessment of blue whale abundance.
(5) Collection of further information on blue whale acoustics, genetics and photo identification from the northwestern Indian Ocean, particularly off Oman, and submission of photo-identifications to the Southern Hemisphere blue whale catalogue for matching.

To better understand the population structuring of blue whales across the eastern Pacific, the sub-committee **encouraged**:

(1) Application of a Random Forest approach to assess diagnosability of southeast Pacific and northeast Pacific blue whales with mitochondrial DNA.
(2) Gulf of California blue whale catalogue holders to share their photo-identification data with the Southern Hemisphere blue whale catalogue, in order to assess population connectivity across hemispheres in the Pacific.

The sub-committee also **encouraged** further updates on the development of automated matching systems for blue whale photo-identifications, to be provided to the Photo-Identification Working Group at SC/68B.

8.2 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-identifications, 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 **reiterated** their previous recommendations, which were as follows.

(1) **Encouraged** acoustic analysis of fin whale song variation across the Southern Hemisphere, as this may provide insights into population structuring.
(2) **Encouraged** further sampling and sequencing of multiple nuclear loci from Chile and other Southern Hemisphere locations to investigate subtle population structure patterns.
(3) **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.
(4) **Recommended** 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 MACN in Buenos Aires.
(5) **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.
(6) **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 intersessionally by de la Mare.

A new estimate of fin whale abundance from the IDCR-SOWER CPIII surveys is anticipated to be available shortly and the sub-committee **reiterated** that they **recommended** that this estimate be reviewed at SC/68B to determine suitability for use in population assessment.

The sub-committee also **reiterated** that they **encouraged** initiatives to enhance collection of photo-identifications from high latitudes in order to further develop the Southern Hemisphere fin and Antarctic blue whale catalogues.

8.3 Southern right whales

The sub-committee:

(1) **Encouraged** the development of a global, standardised and IWC-endorsed protocol for SRW health assessments by Vermeulen and colleagues and welcomed an update on this work at SC/68B.
(2) **Encouraged** work applying the modelling framework developed in Brandão *et al.* (2018) 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.
(3) **Encouraged** a southern right whale catch history workshop to be held and reported to SC/68B.

8.4 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.

8.5 IWC-SORP

IWC-SORP activities planned for 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; (3) the continued use of ships of opportunity to conduct cetacean research; and (4) retrieval and redeployment of passive acoustic recorders (see Table 1).

9. ADOPTION OF REPORT

The report was adopted at 16:59 on 18 May 2019. The Chair thanked the rapporteur for all her hard work, and the sub-committee expressed its thanks to the Chair.

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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 Antarctic blue whales
     - 3.1.1 Cruise reports
     - 3.1.2 Population abundance
     - 3.1.3 Population structure
     - 3.1.4 Progress toward population assessment
   - 3.2 Non-Antarctic Southern Hemisphere blue whales
     - 3.2.1 Regional information
       - 3.2.1.1 Southeast Pacific blue whales
       - 3.2.1.2 Indonesia/Australia blue whales
       - 3.2.1.3 New Zealand blue whales
       - 3.2.1.4 Northern Indian Ocean blue whales
     - 3.2.2 Progress towards population assessment
4. Pre-assessment of Southern Hemisphere fin whales
   - 4.1 Population structure
   - 4.2 Distribution
   - 4.3 Abundance
   - 4.4 Cruise reports
5. Southern Hemisphere right whales not subject to CMP
   - 5.1 Review new information on population structure
   - 5.2 Regional information
     - 5.2.1 New Zealand right whales
     - 5.2.2 Australian right whales
     - 5.2.3 South Africa right whales
     - 5.2.4 Feeding grounds
   - 5.3 Progress towards population assessment
6. Southern Hemisphere humpback whales
   - 6.1. Progress towards assessment of Breeding Stock D
   - 6.2 New abundance estimates
   - 6.3 New photo-identification technology to support population assessments
7. Southern Hemisphere sei whales
   - 7.1 Review new information on population structure
8. Work plan
   - 8.1. Blue whales
     - 8.1.1 Antarctic blue whales
     - 8.1.2 Non-Antarctic Southern Hemisphere blue whales
   - 8.2 Fin whales
   - 8.3 Southern right whales
   - 8.4 Humpback whales
   - 8.4 IWC-SORP
9. Adoption of Report

Appendix 2

NUMBER OF IDENTIFIED ANTARCTIC BLUE WHALES, BY AREA

Table 1

IWC Area	No. left side ID's	No. right side ID's	Maximum no. identified blue whales[1]
I	3	6	7
II	33	18	43
III	160	157	202
IV	31	29	33
V	110	124	152
VI	7	3	8
	344	337	445

[1]Individuals have left only, right only, or both sides photographed.
Currently thirteen whales are missing location data.

Appendix 3

POSSIBLE MODELLING FRAMEWORK FOR A NEW ANTARCTIC BLUE WHALE ASSESSMENT

Trevor A. Branch

The most recent assessments of Antarctic blue whales (Branch, 2008; Branch *et al.*, 2004) were more than a decade ago, and found that they had been depleted from 239,000 individuals to just 0.15% of pre-whaling levels before recovering to about 1% of pre-whaling levels (Branch *et al.*, 2004). With the advent of a new abundance estimate from mark-recapture photo-identification data (Olson *et al.*, 2018), it is time to conduct an updated assessment. The key components of an assessment are: (1) population structure; (2) abundance estimates; (3) catch time series; and (4) minimum abundance estimates from mtDNA haplotypes. Each of these components is summarised below.

Population structure

Previous assessments have assumed that Antarctic blue whales comprise a single population, and it is proposed that this assumption continues here. Song types have long been used as the primary source of evidence for separating blue whale populations (SC/68A/SH/15; Branch *et al.*, 2018; McDonald *et al.*, 2006; Monnahan *et al.*, 2014), and there is a single well-defined song type associated with Antarctic blue whales around the entire Antarctic continent in summer, and spread through the Southern Hemisphere in the austral summer (Branch *et al.*, 2007b; Samaran *et al.*, 2013; Širović *et al.*, 2018). Furthermore, long-distance movements have been identified from Discovery marks (Branch *et al.*, 2007b), satellite tags (Andrews-Goff *et al.*, 2013), and photo-identification (Olson *et al.*, 2016), often many thousands of kilometres, including movements 170° of longitude, and linking among all of the IWC Management Areas. Genetic data are more ambiguous: Sremba *et al.* (2012) found significant differentiation among mtDNA diversity and microsatellite alleles around the Antarctic, but STRUCTURE found no evidence of cryptic population structure, suggesting no detection of true population structure. A later study reported three populations that are sympatric on the Antarctic feeding grounds and that by inference occupy three separate breeding regions (Attard *et al.*, 2016), but after a substantive discussion in the SC that year, the SH sub-committee 'found the evidence for three populations of Antarctic blue whales inconclusive and noted that there are more robust methods for analysis.' (IWC, 2017).

At present we suggest best approach for base case is to focus on circumpolar assessment as there is no strong evidence for regional distinction. A review of population structure evidence to date is proposed to be compiled by an SC member with genetics expertise for consideration at SC/68B, in case alternate hypotheses should be explored.

Abundance estimates

The IDCR/SOWER surveys resulted in three absolute abundance estimates for Antarctic blue whales on a circumpolar basis: 453 in a mid-year of 1980/81, 559 in 1987/88, and 2,280 in 1997/98, with associated CVs (Branch, 2007).

Abundance estimates obtained in Area IV and V from the JARPA cruises can be used as a relative index of abundance (Matsuoka *et al.*, 2006), since these two Areas comprise about half of the total circumpolar abundance. Estimates from alternate years were combined into an Area IV+V estimate and used in the 2008 assessment (Branch, 2008), Table 3 of which is reprinted below:

A forthcoming abundance estimate and associated CV will soon be available from Paula Olson, updated from the value presented to the SC last year (Olson *et al.*, 2018) based on suggestions and discussions for improvement. This could be used as a standard abundance estimate with a CV in the model, or could be integrated into the model using the framework described in Johnston and Butterworth (2008).

Catches

For the base case assessment, there is no new information to update the catch time series used in Branch (Branch, 2008), which was based on catch separation analyses in Branch *et al.* (2008).

Catches off Durban, South Africa, are problematic and could be either Antarctic or pygmy blue whales (SC/68A/SH/15; Branch *et al.*, 2008). Plans are underway to deploy a hydrophone off Durban which might shed light on which song type is most prevalent there during different months of the year (F. Shabangu, pers. comm.). Currently these 3,211 catches taken 1910-66 are allocated to Antarctic blue whales, except for one specifically noted as being a pygmy blue whale (Gambell, 1964).

It should also be noted that some of the earlier catches (prior to 1928) taken off the islands at 54°15'S, 36°45'W and 62°00'S, 58°00'W included a fair number of short pregnant females compared to other areas in the Antarctic (Branch *et al.*, 2007a). It has generally been assumed that these were incorrectly measured or that the lengths were misreported entirely, based on letters sent back to the UK from inspectors.

'Table 3' (from Branch, 2008)

Abundance estimates for Antarctic blue whales south of 60°S and from 70°E eastwards to 170°W from JARPA surveys. Each abundance estimate is obtained from two surveys, one in Area IV (70°E-130°E) and the other in Area V (130°E-170°W). In the model, these estimates are treated as relative abundance estimates covering a fraction of the total circumpolar area and occurring in the 'model season' listed below.

Areas	Survey seasons	Model season	*N*	CV	95% CI
IV+V	1989/90-1990/91	1989/90	248	0.758	(66; 928)
IV+V	1991/92-1992/93	1991/92	275	0.602	(92; 818)
IV+V	1993/94-1994/95	1993/94	336	0.525	(128; 883)
IV+V	1995/96-1996/97	1995/96	18	0.590	(6; 53)
IV+V	1997/98-1998/99	1997/98	351	1.286	(51; 2,433)
IV+V	1999/00-2000/01	1999/00	542	0.337	(285; 1,031)
IV+V	2001/02-2002/03	2001/02	443	0.359	(224; 876)
IV+V	2003/04-2004/05	2003/04	567	0.652	(176; 1,822)

Most of these catches were pre-Mackintosh and Wheeler (1929) which standardised measurements. In the data there are a large number of whales rounded to the nearest 5 ft (14% off the islands at 54°15'S, 36°45'W, and 19% off those at 62°00'S, 58°00'W) which seems to indicate numbers not being measured, or not being measured accurately (Branch *et al.*, 2007a). One wrinkle is a single detection of Chilean call types off the islands at 54°15'S, 36°45'W (Pangerc, 2010), which may suggest a mixture of Chilean and Antarctic blue whale at the islands at 54°15'S, 36°45'W. More likely this is just a rare vagrant similar to the isolated Australian whale east of New Zealand, and the isolated NIO whale in northern Angola (Cerchio *et al.*, 2010).

Minimum abundance estimate

Given the large number of mtDNA haplotypes recorded from extant Antarctic blue whales, at least that many females must have survived the genetic bottleneck caused by whaling. Previously, a method was used that attempted to estimate a minimum possible abundance (Branch and Jackson, 2008), but the lead author (Branch) now considers that method not to be reliable. For base case purposes, the agreed IWC approach of using the number of extant haplotypes x 3 as a constraint on minimum abundance is therefore proposed (IWC, 2012).

Proposed assessment timeline

Assuming the mark-recapture estimate has been finalised, Branch could conduct this work over two years during mid-2020 and mid-2021, requiring one month of time in each year, with draft presentation to the Scientific Committee in 2021 and final assessment in 2022.

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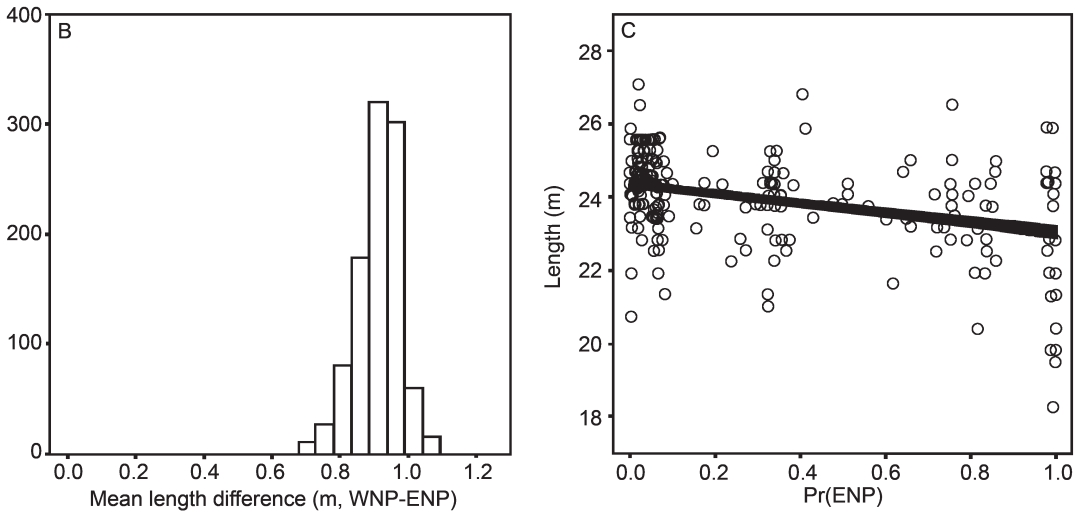
Appendix 4

COMPARISON OF BLUE WHALE BODY LENGTH DATA BETWEEN NORTH AND SOUTHEAST PACIFIC

T.A. Branch, L.A. Pastene, R.L. Brownell

Blue whale body lengths for eastern North Pacific (ENP) and central-western North Pacific (CWNP) were plotted in Monnahan *et al.* (2014). This is a bit complicated, as North Pacific whale identification to ENP or CWNP is probabilistic rather than actual.



As can be seen from *n*=258 data points, the mean length of mature female ENP is smaller than CWNP by about 0.9m. For those whales considered >95% ENP, mean length was 23.0m; for those >95% WCNP, mean length was 24.4m. The Chilean data have a mean of 23.5m (Branch *et al.*, 2007), so lengths are very similar. There are no morphological data for ENP (fluke-anus etc.) from whaling.

Recent photogrammetry work by Ortega-Ortiz *et al.* (2018) shows ENP has tail length similar to that of Antarctic, and different from pygmy in Indian Ocean, with a mode at 24% of body length for ENP and Antarctic and 22% for pygmy blue whales. This measurement is from dorsal fin to fluke notch (dorsal side of whale). The measurement from whaling in Chile is from anus to fluke notch (ventral side of whale). Work is underway by Matthew Leslie (Swarthmore College, USA) to assess whether these two measures (dorsal *vs* ventral) can be related.

In summary, the morphometry are a little ambiguous but could support similarities to ENP or differences. At some level, there are only so many possible mean lengths at sexual maturity possible, and some blue whale populations are going to be of similar length. However the disjunct distribution, distinct genetics, and distinct call types all support ENP and Chilean being distinct populations and/or subspecies.

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Appendix 5

RESEARCH PROPOSAL: USING PHOTO-IDENTIFICATION TO INVESTIGATE THE IDENTITY OF BLUE WHALES NEAR ISLANDS IN THE SOUTH ATLANTIC

BRIEF OVERVIEW OF THE PROPOSAL AND ITS EXPECTED OUTCOME

Blue whale catch records from the islands in the South Atlantic at 54°15'S, 36°45'W are dominated by Antarctic blue whales and generally it has been assumed that all blue whales in that area are of this form (Branch *et al.*, 2007b).

The Antarctic Blue Whale Catalogue contains 11 individually identified blue whales that have been photographed near the islands at 54°15'S, 36°45'W. Three of these whales are consistent in appearance with non-Antarctic blue whales, with a proportionally shorter tailstock and 'bad skin' (prevalent lesions and scarring). They appear similar to Chilean blue whales. All three whales were photographed on 28 February 2015.

Comparing the identification photographs of these three whales to the photo-identifications of Chilean whales (approximately 400 whales, held by the Southern Hemisphere Blue Whale Catalogue) may yield a match between the two regions. If a photographic match is found it would confirm the presence of Chilean blue whales in the research area.

RELEVANT IWC SCIENTIFIC COMMITTEE GROUPS OR SUB-GROUPS

SH – The sub-committee on Southern Hemisphere whale stocks is examining the population structure of Southern Hemisphere blue whales. Results generated from this study will provide relevant information.

PH – Results generated by this project will be archived in the Antarctic Blue Whale Catalogue and the Southern Hemisphere Blue Whale Catalogue.

BRIEF DESCRIPTION OF THE PROPOSAL AND ITS CONNECTION WITH SCIENTIFIC COMMITTEE RECOMMENDATIONS

(a) Background, rationale, and relevance to the priorities identified by the IWC Scientific Committee

Recently acoustic, genetic, and re-evaluated catch data have given evidence that Chilean blue whales may occasionally, if infrequently, be present at the islands at 54°15'S, 36°45'W (Branch *et al.*, 2007a; Pangerc, 2010; Sremba *et al.*, 2015), but this is yet to be confirmed. Confirming the presence of Chilean blue whales there will provide information on the identity of blue whales in the area and provide new data on the movement patterns of Chilean blue whales.

(b) Specific objectives or ToR and deliverables/outcomes

Objectives:

Compare three individually identified blue whales photographed at the islands at 54°15'S, 36°45'W (with morphological features consistent with Chilean blue whales) with approximately 400 blue whale identification photos from Chile, held by the Southern Hemisphere Blue Whale Catalogue.

Deliverables:

A report to IWC SC meeting in 2020 summarising results.

(c) Methodological approach/work plan/administrative details

Identification photographs will be compared using methods outlined in (Gendron and Ugalde de la Cruz, 2012; Sears *et al.*, 1990). Results will be added to databases of the Antarctic Blue Whale Catalogue and the Southern Hemisphere Whale Catalogue.

TIMETABLE FOR ACTIVITIES AND OUTPUTS

Comparison of blue whale identification photographs from the islands at 54°15'S, 36°45'W and Chile:

Person: Paula Olson

Timing: Start July 2019 – Finish December 2019

Expected output: Paper with results submitted to IWC Scientific Committee meeting SC/68B – April 2020.

RESEARCHERS' (OR STEERING GROUP) NAME(S) AND AFFILIATION

Paula Olson, NOAA – project lead.

TOTAL BUDGET

Salaries (by person): Detailed description of work: Comparison of ID photos, production of report, data submitted to Southern Hemisphere Blue Whale Catalogue: *£390.*

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Appendix 6

RESEARCH PROPOSAL: SOUTHERN HEMISPHERE BLUE WHALE CATALOGUE: CODING PROJECT FOR CHILEAN BLUE WHALE IDENTIFICATION PHOTOS

BRIEF OVERVIEW OF THE PROPOSAL AND ITS EXPECTED OUTCOME

This proposal will provide for a crucial step in the preparation of photo-identification data prior to its use in a capture-recapture estimate of abundance. The entire set of photographs from eastern South Pacific must be quality-coded by the same person (or team of persons trained together) so that there is no subjective bias in the coding of the photos. The responsible person must follow the reference guide on photo-identification quality coding and fill the online form available within the Southern Hemisphere Blue Whale Catalogue. The expected outcome will provide a clean data set of photos for inter-catalogue matching that will in turn provide the data available for encounter histories to be used in an estimate of abundance.

RELEVANT IWC SCIENTIFIC COMMITTEE GROUPS OR SUB-GROUPS

The ultimate goal of producing an abundance estimate for the Chilean blue whale sub-species is a high priority for the SH sub-committee in its assessments of Southern Hemisphere blue whale populations.

Results from future abundance estimates will also be discussed under the ASI standing working group.

4. TYPE OF PROJECT

Research project and database creation/maintenance.

BRIEF DESCRIPTION OF THE PROPOSAL AND ITS CONNECTION WITH SCIENTIFIC COMMITTEE RECOMMENDATIONS

(a) Background, rationale, and relevance to the priorities identified by the IWC Scientific Committee

Since 2006, the IWC Scientific Committee is conducting an in-depth assessment of Southern Hemisphere blue whales, including the yet unnamed subspecies that uses Chilean waters. In 2008, the IWC endorsed a proposal to establish a central web-based catalogue of blue whale identification photographs know as the Southern Hemisphere Blue Whale Catalogue (SHBWC). Results of comparisons among different regions will provide, *inter alia*, important data to model abundance estimates that will greatly contribute to the IWC Southern Hemisphere blue whale assessments.

Substantial contribution of photo-identifications from Chile have been received during 2018 (+300 IDs) and matching between catalogues from this area will become the next priority for 2019-20. The photo-identification data held by the SHBWC for the eastern South Pacific blue whales is now 'complete' with almost all Chilean research groups having contributed their photographic data to this collaborative catalogue. With a data set large enough to proceed with analysis, the next step is to code the photos for quality in a rigorous manner so that data of the highest quality can be extracted for analysis. With this proposal, a data set ready for analysis is expected to be available by 2020.

(b) Specific objectives or ToR and deliverables/ outcomes:

Objectives:

- Quality code 1,500 identification photographs of individual blue whales from Eastern South Pacific waters.

Deliverables:

- Data set of photos coded by quality which provide the basis for using the highest quality data available in a capture-recapture estimate of abundance.
- Report outlining coding methods and results presented to the 2020 annual meeting of the Scientific Committee.

(c) Methodological approach/work plan/administrative details

The photo-identification expert (or small team of experts, trained together) will code all of the 1,500 photographs of blue whales from this region. A reference guide to photo quality based on lighting, focus, and angle to the whale was developed (Olson *et al.,* 2018), used for Australia/ NewZealand/SriLanka regions and should also be used in this project for consistency when coding the photos. Coding identification photos for quality is a standard methodological approach in the use of photo-identification data prior to analysis (Calambokidis *et al.*, 2008; Friday *et al.*, 2000; Mizroch and Harkness, 2003). Photo quality codes will be entered directly into the SHBWC software which will allow for the extraction of the highest quality data for use in analysis.

(d) Suggestions for outreach

Coding of photos will be used to select the most appropriate datasets to use in encounter histories to model abundance estimates. It is expected that abundance estimates using this regional collaborative data will be published once this activity is completed.

TIMETABLE FOR ACTIVITIES AND OUTPUTS

- Photo coding for quality – Galetti, Olson – Start 08/2019; Finish 12/2019
- Report preparation – Galletti, Olson, Jackson – Start 04/2020; Finish 05/2020

Expected outputs

- Data set of photos coded by quality which provide the basis for using the highest quality data available in a capture-recapture estimate of abundance – completion date 12/2019.
- A report outlining coding methods and results presented to the 2020 annual meeting of the Scientific Committee – completion data 05/2020.

RESEARCHERS' (OR STEERING GROUP) NAME(S) AND AFFILIATION

- Barbara Galletti - Centro de Conservacion Cetacea (CCC), Santiago, Chile.
- Jennifer Jackson - British Antarctic Survey, Cambridge, UK – SC Convenor.
- Paula Olson - Southwest Fisheries Science Center, La Jolla, CA, USA – SC Convenor.

TOTAL BUDGET

Salaries (by person): Expert(s) contracted to code photos - £2,437.

DATA ARCHIVING/SHARING

The SHBWC is a collaborative research that has terms of references and data sharing agreements in place and in line with IWC data sharing agreements. Moreover, all SHBWC data may be used for IWC purposes and the IWC will soon host all the SHBWC collections in its servers.

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Appendix 7

PROJECT PROPOSAL: PHOTO IDENTIFICATION COMPARISON OF SOUTHERN RIGHT WHALES IN BRAZIL AND ARGENTINA TO CONTRIBUTE TO IWC PROJECT: MULTI-OCEAN ANALYSIS OF SOUTHERN RIGHT WHALE DEMOGRAPHIC PARAMETERS AND ENVIRONMENTAL CORRELATES

BRIEF OVERVIEW OF THE PROPOSAL AND ITS EXPECTED OUTCOME

This study aims to complete a comparison of southern right whale photo identification catalogues from Brazil and Argentina to provided data for the comparison of population demographics of southern right whales in Southern Hemisphere wintering grounds. This study is a component of the SORP project Theme 6 - The right sentinel for climate change: linking foraging ground variability to population recovery in the southern right whale.

Outcomes

Complete photo identification catalogue comparison between Brazil (1987-2018) and Argentina (1971-2015), in order to compare southern right whale demographic parameters including: abundance trend, calving interval, age of first parturition, survival and mortality.

RELEVANT IWC SCIENTIFIC COMMITTEE GROUPS OR SUB-GROUPS

Conservation Management Plan (CMP) Sub-Committee: South West Atlantic southern right whales.

Southern Hemisphere (SH) Sub-Committee: multi-ocean analysis of southern right whales to compare demographic parameters including abundance trends and changes to calving intervals.

TYPE OF PROJECT

Research project and database creation/maintenance.

BRIEF DESCRIPTION OF THE PROPOSAL AND ITS CONNECTION WITH SCIENTIFIC COMMITTEE RECOMMENDATIONS

(a) Background, rationale, and relevance to the priorities identified by the IWC Scientific Committee:

The SH sub-committee of the IWC SC/67b recommended full catalogue matching between the Brazilian and Argentine catalogues in order to provide the best available data on calving rates, abundance and trend.

Southern right whales are a priority species for the IWC SC/68A. This proposal contributes to key priorities of the IWC to allow for assessment of a multi-ocean, multi-national collaborative project that utilises almost five decades of annual southern right whale photo identification and sightings data from four countries and three continents.

Collating the Brazil and Argentina datasets is a critical step towards a comparative study of population demographics of southern right whales in the SH will improve our understanding of species status, and strengthen information to inform conservation management.

(b) Specific objectives or ToR and deliverables/ outcomes:

Full catalogue matching between the Brazilian and Argentine catalogues (including 925 and 3,500 individuals respectively) to provide the best available data for global comparative assessment of southern right whale demographic data. Deliverables include:

- provision of dataset for modelling with photo-identification resights from the Brazilian (1987-2018) and Argentine (1971-2015) combined catalogues;
- IWC paper – Southern right whale photo-identification comparison of Brazil and Argentina dataset.

(c) Methodological approach/work plan/administrative details

Proposed steps:

- Photo-identification cross matching between Argentine and Brazilian catalogues, containing 3,500 and 925 individuals respectively. These photographs will be processed and matched using the Hiby-Lovell system.
- Presentation to IWC SC 2020.
- Researchers will also contribute to an intersessional working group that will progress the IWC Project: Multi-ocean analysis of southern right whale demographic parameters and environmental correlates.

(d) Suggestions for outreach
Outreach opportunities include:
- intern or student project to generate educational material;
- presentation of results at IWC 2020.

TIMETABLE FOR ACTIVITIES AND OUTPUTS

- Uploading of the Brazilian catalogue to the Hiby-Lovell system: Karina Groch – Start 06/2019; Finish 11/2019
- Catalogue matching using the Hiby-Lovell system: Vicky Rowntree – Start 12/2019; Finish 05/2020

Expected outputs
- Uploading of the Brazilian catalogue to the Hiby-Lovell system – by 11/2019.
- Photo identification cross matching between Argentine and Brazilian catalogues – by 05/2020.
- Presentation to IWC/SC 2020 – 05/2020.

RESEARCHERS' (OR STEERING GROUP) NAME(S) AND AFFILIATION

- Mariano Sironi, Instituto de Conservacion de Ballenas/ Whale Conservation Institute/Ocean Alliance.
- Vicky Rowntree, University of Utah, USA.
- Karina Groch, Projeto Baleia Franca/Instituto Australis, Brazil.
- Miguel Iñíguez, Fundación Cethus, Buenos Aires.

TOTAL BUDGET

Salaries (by person):
- Karina Groch (processing of Brazilian catalogue in the Hiby-Lovell system) - £750
- Vicky Rowntree (catalogue matching between Brazil and Argentina) - £1,250
  Total: £2,000

DATA ARCHIVING/SHARING

Metadata to be provided to IWC.

Appendix 8

RESEARCH PROPOSAL: EXPLORATION OF SURVEY METHODS AND DESIGNS TO RETURN A NEW ABUNDANCE ESTIMATE OF WEST AUSTRALIAN (BSD) HUMPBACK WHALES

BRIEF OVERVIEW OF THE PROPOSAL AND ITS EXPECTED OUTCOME

This project will:
- review the existing survey data/methodology for west Australia humpbacks and identify strengths and weaknesses to help development of a new survey design;
- explore existing 'feasibility studies', *viz*. duFresne *et al.* (2014), particularly to derive updated estimates of availability bias; and
- formulate a new survey design plan for future surveys for west Australian humpbacks, including new technologies, such as long-range unmanned aerial vehicles.

RELEVANT IWC SCIENTIFIC COMMITTEE GROUPS OR SUB-GROUPS

SH, IA (and more generally to methodology for visual/line transect distance sampling).

TYPE OF PROJECT

Modelling.

BRIEF DESCRIPTION OF THE PROPOSAL AND ITS CONNECTION WITH SCIENTIFIC COMMITTEE RECOMMENDATIONS

(a) Background, rationale, and relevance to the priorities identified by the IWC Scientific Committee:
The Comprehensive Assessment of Southern Hemisphere humpback whales was concluded in 2015. However assessment of one stock (BSD, west Australia) could not be completed due to uncertainty over the absolute abundance of this stock. Abundance estimates described by Hedley *et al.* (2011) appear robust (particularly 2008), but include only surfacing animals, and do not no correct for animals that dive out of view (i.e. are not corrected for availability bias). The available abundance data for west Australia (BSD) presented two challenges: (1) there were few data to inform a correction for surface availability; and (2) there was a potential inconsistency between observer protocols and the Distance- based approach employed to estimate abundance. See IWC (2016) for a detailed discussion of these issues. In 2017, the sub-committee agreed that there was no strong case to further re-analyse past survey data for BSD because of the absence of success despite the efforts of two experienced modellers. Rather efforts should focus on designing and implementing a new 'survey' of the population (perhaps using new approaches, as provided by drones for example).

In 2017, the SH sub-committee (IWC, 2018):

(1) encouraged the development of a new survey off Western Australia for the purpose of producing a new abundance estimate, although it remains unclear if this is feasible either financially or logistically.
(2) recommended an assessment of the feasibility of a new 'survey' be carried out, noting that detailed consideration of past survey feasibility analyses (notably following duFresne *et al.* (2014)), are necessary before any new fieldwork could be considered.

(b) Specific objectives or ToR and deliverables/outcomes
This project will:
- review the existing survey data/methodology for west Australia humpbacks and identify strengths and weaknesses to help development of a new survey design;
- explore existing 'feasibility studies', *viz*. duFresne *et al.* (2014), particularly to derive updated estimates of availability bias; and

- formulate a new survey design plan for future surveys for west Australian humpbacks, including new technologies, such as long-range unmanned aerial vehicles.

(c) Methodological approach/work plan/administrative details

A desktop review/study of existing reports/papers/publications, and re-analysis of existing survey data.

TIMETABLE FOR ACTIVITIES AND OUTPUTS

- Review the existing survey data/methodology for west Australia humpbacks: Kelly – Start 07/2019; Finish SC/68B.
- Explore existing 'feasibility studies', *viz*. duFresne *et al.* (2014), particularly to derive updated estimates of availability bias: Kelly – Start 07/2019; Finish SC/68B.
- Formulate a new survey design plan for future surveys for west Australian humpbacks: Kelly – Start 07/2019; Finish SC/68B.

Outputs

- Report delivered to the SC in 2020.
- Potential for *JCRM* publication.

RESEARCHERS' (OR STEERING GROUP) NAME(S) AND AFFILIATION

Natalie Kelly, Australian Antarctic Division, Project lead.

TOTAL BUDGET

Salaries (by person): Dr Kelly requires 5 weeks of time to complete the proposed work. The Australian Antarctic Division hourly rate is $61.50 AUD/hour; including overhead costs of 18%, this is $72.60 AUD/hour. Five weeks of work at 37.5 hours/week is 187.5 hours, costing $13,615 AUD. In GBP this value as of 16/05/19 (*xe.com*) is £7,347. AAD has agreed to match Dr Kelly's time at 45% of her costs, enabling this project to be completed with co-investment of £4,000 GBP.

DATA ARCHIVING/SHARING

The Australian Marine Mammal Centre holds data collected by duFresne *et al*. (2014); this data is basically available upon request.

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