Annex H

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

Members: Jackson (Convenor), Archer, Baker, Bannister, Bell, Brownell, Butterworth, Campbell, Carlson, Castro, Cerchio, Charrassin, Clapham, Double, Feindt-Herr, Findlay, Friedlaender, Ivashchenko, Johnson, Kaufman, Kelly, Kishiro, Lang, Leslie, Marcondes, Mate, Matsuoka, Melcón, Moore, Øien, Olson, Palacios, Palazzo, Pastene, Reeves, Reyes, Rodríguez-Fonseca, Rosenbaum, Ross-Gillespie, Seakamela, Širović, Thuok, Wade, Weinrich, Willson, Zerbini.

1. INTRODUCTORY ITEMS

1.1 Opening remarks
Jackson welcomed participants.

1.2 Election of Chair
Jackson was elected Chair.

1.3 Appointment of Rapporteurs
Bell, Clapham, Findlay and Zerbini undertook the duties of rapporteuring.

1.4 Adoption of agenda
The adopted agenda is given in Appendix 1.

1.5 Documents available
Documents identified as containing information relevant to the sub-committee were: SC/66a/SH01-SH30, SC/66a/SD05, SC/66a/BRG13, Attard *et al.* (2015), Carroll *et al.* (2015), Mahanty *et al.* (2015), Pomilla *et al.* (2014), Minton *et al.* (2015), Alexander *et al.* (In prep), Curtice *et al.* (2015), Moore and Barlow (2014) and Torres-Florez *et al.* (2015).

2. SOUTHERN OCEAN RESEARCH PARTNERSHIP

SC/66a/SH08 reported on the activity of the Southern Ocean Research Partnership (SORP) since SC/65b. Progress on the five primary IWC-SORP science programmes (SC/66a/SH08, annexes 1-5) is summarised below.

SC/66a/SH08 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. The project cooperated on two voyages to the Southern Ocean in 2015: (1) a joint New Zealand-Australia Antarctic Ecosystems voyage to the Balleny Islands, Ross Sea and Terra Nova Bay (SC/66a/SH07); and (2) a voyage to the western Antarctic Peninsula led by Argentina (SC/66a/SH20). Data are augmented with sightings information from ships of opportunity, which are contributed to the online reporting system[1]. Seven papers have been submitted to SC/66a outlining the results of these surveys. Further sub-committee discussion of this initiative is given under Item 5.2.1.

SC/66a/SH08 annex 2 reported on progress on the project to identify the distribution, relative abundance, migration patterns and foraging ecology of three ecotypes of killer whales in the Southern Ocean. Four surveys were conducted in 2014/15, in McMurdo Sound, the West Antarctic Peninsula, part of the Weddell Sea, Marion Island and Terra Nova Bay. This project is of primary relevance to the Sub-Committee on Small Cetaceans and their discussion can be found in Annex L.

SC/66a/SH08 annex 3 summarised progress on the project to determine foraging ecology and predator-prey interactions between baleen whales and krill: a multi-scale comparative study across Antarctic regions. This project has completed a very successful Antarctic field season, with 130 skin biopsies and >75 photo-identifications collected from humpback whales, and seven satellite tags and two video-recording suction cup tags deployed. Further sub-committee discussion of this project is given in Item 3.1.4.

SC/66a/SH08 annex 4 reported progress on the project to determine the distribution and extent of mixing of Southern Hemisphere humpback whale populations around Antarctica. The first phase of this project is focussed on East Australia/Oceania. Since SC/65b, the team has focussed on planning the 2015 voyage to Raoul Island, New Zealand, where they will collect skin biopsies for DNA profiling and isotope analysis, collect photo-identifications and deploy satellite tags, to determine the Antarctic feeding grounds used by Oceania humpbacks. IWC-SORP gratefully acknowledges the South Pacific Whale Research Consortium (SPWRC) for their contribution to this project.

SC/66a/SH08 annex 5 summarised progress on the project to measure acoustic trends in abundance, distribution, and seasonal presence of Antarctic blue whales and fin wales in the Southern Ocean. The IWC-SORP Acoustic Trends Working Group have published a series of recommendations regarding instruments and settings required to record focal species (Van Opzeeland *et al.*, 2014) with additional information on moorings and logistics for prospective collaboration (see Item 5.2.3). Two passive acoustic recorders deployed by the Australian Antarctic Division in 2013/14 were recovered in 2014/15 with preliminary analysis indicating that these were functional throughout the deployment period. Two more recorders were deployed in 2014/15 off Casey Station and on the Kerguelen Plateau for recovery during the 2015/16 season. A deep-water Automated Acoustic Recorder (AAR) mooring, was also deployed by South African researchers and recovered in January 2015.

In total, IWC-SORP researchers submitted 19 research papers to SC/66a. To date, the outputs from the five research projects total 73 peer-reviewed papers in scientific journals, with 32 of these published since SC/65b.

At its 65th Annual Meeting (SC/65b), the IWC approved a contribution of £13,000 towards the salary of an IWC-SORP coordinator for the period 2014/15 and 2015/16. The contribution of these funds toward the salary of the incumbent coordinator (Dr Elanor Bell) was subsequently approved by the IWC-SORP Scientific Steering Committee.

[1]*http://www.marinemammals.gov.au/sorp/sightings.*

SC/66a/SH24 reports on expenditure against this contribution since 1 July 2014. The coordinator has been the point of communication between the IWC-SORP researchers, Scientific Steering Committee and Secretariat, and the wider scientific community. She has written applications for vessel time to support IWC-SORP field research, pursued funding and voluntary contributions to IWC-SORP, supported the preparation and implementation of two Southern Ocean SORP research cruises, promoted use of the IWC-SORP sightings portal, coordinated submission of images and associated data, managed and implemented the exchange and archiving of biopsy samples and associated data, engaged in outreach to other Southern Ocean organisations, and carried out Secretariat duties including budget management, coordination of data sharing agreements, letters of support and endorsement and coordination of IWC-SORP Scientific Steering Committee activities (summarised in SC/66a/SH08).

The sub-committee noted the many achievements of the IWC-SORP program, and the contributions that this highly collaborative project has made to both the Scientific Committee and to understanding of whales in general. The sub-committee also noted the importance of images and sightings data contributed to IWC-SORP by CCAMLR fisheries observers and Currey was thanked for his facilitation of this, as well as the importance of images and data received from ships of opportunity.

The sub-committee noted that the Government of the Netherlands has generously agreed to contribute €25,000 Euros (*ca*. £17,700 GBP) to the IWC-held SORP fund. Discussions are ongoing about the use of this money, but it is likely that it will be directed toward the development of non-lethal cetacean research methods that can be applied across species and geographical region. The IWC-SORP coordinator sincerely thanked the Government of the Netherlands for its generous contribution and support of IWC-SORP. The sub-committee thanked Bell for her coordination of SORP efforts; she in turn noted her appreciation to the many Principal Investigators involved. The sub-committee encouraged the continued progress of these projects.

3. SOUTHERN HEMISPHERE HUMPBACK WHALES

The IWC Scientific Committee currently recognises seven humpback whale breeding stocks (BS) in the Southern Hemisphere (labelled A to G; IWC, 1998), which are connected to feeding grounds in the Antarctic. An additional population that does not migrate to the Antarctic is found in the Arabian Sea.

Intersessionally, a synthesis of the assessment results and unresolved questions was undertaken, in order for the sub-committee to identify areas of substantial uncertainty in the concluded assessments and recommend focal areas for future assessment effort. This discussion is summarised in Item 3.2.2.

3.1 Review new information

3.1.1 Breeding stock B

SC/66a/SH30 presented the results of a dedicated dual-vessel cetacean survey cruise targeting humpback whales off the western coast of South Africa between 28 October 2014 and 8 November 2014. The primary objective of the cruise was to determine the distribution of whales between Dassen Island (33°25'34.32'S, 18°5'20.04'E) and Groenriviermond (30°51'53.78'S, 17°34'40.52'E) using both vessel-based observations and satellite telemetry across areas of known humpback whale low-latitude feeding aggregations. The survey followed an adaptive systematic parallel line-transect design within the 150m depth contour limit with survey lines between 15 and 25 n.miles apart and oceanographic process stations between 5 and 20 n.miles apart. Oceanographic sampling and cetacean observations were conducted on board the *RV Algoa* of the South African Government Department of Environmental Affairs while whale-targeted components such as tagging, photo-identification and genetic sampling were conducted from the *FRS Ellen Khuzwayo* (South African Government Department of Agriculture, Forestry and Fisheries). A total of 314 conductivity, temperature, and depth (CTD) samples and 50 Multi-net samples were collected from 50 oceanographic stations, whilst the partial pressure of carbon dioxide (pCO2) was measured using an autonomous underway measuring system. A total of 62 sightings of an estimated 80 humpback whales was made during the survey. Other cetaceans sighted included dusky dolphins (14 sightings, 148 individuals) and Heaviside dolphins (eight sightings, 12 individuals). Satellite-linked tags were deployed on eight adult humpback whales, and movements of the tagged whale were monitored over a three-month period. The tagged whales locally moved between three known upwelling areas of the southern Benguela Current system before migrating southward along a similar and parallel migratory route towards Bouvet Island, from where they dispersed widely between 15°W and 35°E.

The sub-committee welcomed these interesting results in light of uncertainty regarding the migratory destinations of whales from Breeding Stock B. It was noted that there was evidence that animals off western South Africa appeared to be divided into early-season (July-October) and late-season (November-February) whales, each group having different levels of differentiation from whales breeding off Gabon (Carvalho *et al.*, 2014). It would be useful to understand which group the whales observed in the survey belonged, to assist with possible stock identity. Skin biopsies collected from the satellite tagged whales tracked in this study and other un-tagged individuals will help to address this question. The fact that there were few calves observed in the survey suggests that these were not whales that had calved during the study season off Gabon or elsewhere. It was also noted that the migratory destination of some of the tagged whales which headed to the middle of the South Atlantic suggested the possibility of feeding ground overlap with humpbacks from Breeding Stock A (Brazil). In addition, the easterly movement of some whales to ~35°E might indicate overlap with the Breeding Stock C feeding ground. The fact that most whales did not migrate as far south as the ice edge appears to be a pattern for South Atlantic humpbacks (Zerbini *et al.*, 2011) and may in some cases be related to the Weddell Gyre across the South Atlantic.

3.1.2 Breeding stock D/E/F

SC/66a/SH02 examined the distribution of humpback whales in Hervey Bay in relation to depth and distance from shore. Patterns of area use of mother-calf dyads (MC dyads) were of particular interest, being vulnerable to human-related disturbances. Between August-September 2013, MC dyads showed a preference for shallow waters and specific areas within the eastern side of the bay compared to non-calf groups. These areas overlap with human activities (e.g. whalewatching). Understanding habitat preference and patterns of habitat use of humpback whales in Hervey Bay is a prerequisite for effective management of this critical habitat and tourism operations (including recent swim-with-whale trials).

Paper SC/66a/SH01 introduced a new website, 'Match My Whale' (MMW) that has been developed by Pacific Whale Foundation (PWF) in collaboration with Centre for Whale Research (CWR) using South Pacific humpback whale photo-IDs contributed by both organisations. The large size of humpback whale fluke photo-identification (ID) catalogues is both a strength and a challenge. Catalogue size grows continuously, rendering the task of pairwise matching all individuals exponentially more difficult. MMW uses crowdsourcing and tests the theory that an online citizen scientist fluke matching platform will be more effective than the current method(s) of individuals manually searching for a match, or relying on complicated computer software. Crowdsourcing can offer the effort and redundancy needed for scientists to manage their current catalogues, and facilitate the integration of multiple catalogs from different organisations and facilitates comparisons across large photo-identification catalogues.

The sub-committee expressed its appreciation for the work presented, noting that this initiative makes matching of large catalogues very manageable. The financial contributions of the Pacific Whale Research Foundation and Australian Government were acknowledged.

In discussion, it was noted that for many automatic photo-identification matching systems the photograph uploading process is slow and uploading of large catalogues is therefore time consuming. With citizen science matching, upload can be much more rapid since additional matching software is not required. The authors also commented that location data is uploaded during photo-identification submission, enabling downstream activities such as mark-recapture analysis.

3.1.3 Breeding stock G

A comparison between the Ecuadorian Humpback Whale Identification Catalogue (n=2,131) and a catalogue of the Instituto Baleia Jubarte, Brazil for waters between 54°-59°S and 26°-38°W (n=23), resulted in one match between 56°16'S, 27°32'W and the Machalilla National Park in Ecuador (SC/66a/SH27).

Whales from Ecuador are known to feed typically off the Antarctic Peninsula; accordingly, this movement to the feeding area of Breeding Stock A in the Scotia Sea constitutes the easternmost known migration point for Breeding Stock G, and is the longest humpback whale migration registered, over 10,000km. It indicates some overlap between feeding areas of Breeding Stocks A and G, requiring new studies of migratory movements and biological relatedness of the stocks.

In discussion, other long-distance migrations were noted, including the movement of individually identified humpback whales from Brazil to Madagascar (Stevick *et al.*, 2011), and another from Ecuador to Brazil (Stevick *et al.*, 2013). It is not yet clear whether such movements are common or extreme outliers, and the results underscore the great value of comparing photo-identification catalogues, even from areas which are not currently thought to be connected.

SC/66a/SH13 examined changes in the composition of whales around the western Antarctic Peninsula (WAP) over time, and attempted to determine the migratory apportionment to breeding grounds; this was a large collaborative study which compared individual whales from the WAP (n=118) to Oceania (n=1,009), Colombia (n=95) and Brazil (n=103) breeding populations. Using the mitochondrial DNA control region (mtDNA, 470bp) and 15 microsatellites, the study determined that feeding aggregations of whales in the WAP were composed of multiple haplotypes, suggesting group-feeding behaviours or associations are not based exclusively on maternal kin. An AMOVA of mtDNA confirmed significant genetic differentiation between the WAP and each of the breeding grounds except Colombia (overall F_{ST}=0.035, p<0.001). The study also compared the WAP samples to a WAP dataset from 15 years earlier (n=54) and found no significant difference between them. Bayesian mixed-stock analyses revealed a large apportionment from the WAP to Colombia (mtDNA 97.5%, C.I.93-99%) with a small apportionment to French Polynesia/Samoa (mtDNA 1.5%, C.I.0.0-6.5%), supporting the strong connection between a breeding ground and feeding area in the southern hemisphere. Moreover, connectivity to French Polynesia was documented by a genotype match of an individual female from the WAP in the Society Islands: the first genotype match of French Polynesia to a feeding area. Due to the rapidly changing environment and high krill density in the WAP, understanding the genetic composition and demography in this area will continue to highlight the complex structure and patterns of humpback whales. As data collection is continued and enlarged over this area in the next decade the results of the study will serve as a baseline for humpback whale population structure and aid in future management considerations for humpback whales that utilise the WAP foraging grounds.

The sub-committee welcomed the results discussed in this paper. The genetic methods used in this study were discussed in Annex I, Item 3.2. No genetic differentiation was found within the WAP, which is consistent with satellite telemetry tracks showing whale movement across this region (Curtice *et al.*, 2015). The author noted that there may also be geographic stratification across the wider WAP feeding ground by whales from the French Polynesia and Colombia breeding grounds which is still to be investigated. For example, whales from French Polynesia may feed to the south of whales from Colombia. With additional sample collection along the WAP it will be possible to explore this; samples will be collected by the authors over the next five years, as far south as Marguerite Bay. It was noted that similar feeding-breeding ground mixed stock analyses will soon be available for Breeding stocks A, B and C incorporating both mtDNA and microsatellite genotypes.

The sub-committee discussed the connectivity of BSG with BSA across the Antarctic feeding ground. Both SC/66a/SH13 and Engel *et al.* (2008) report significant F_{ST} and Φ_{ST} differentiation between BSG and BSA, suggesting long-term differentiation between these two breeding grounds. This picture contrasts with the BSG photo-identification re-sighting at 56°16'S, 27°32'W reported in SC/66a/SH27, and raises the question of the feeding ground limits of these stocks. Unpublished satellite track movements indicate that whales tagged in Gerlache Strait remain in this region and do not spend a significant amount of time north and east of the Bransfield Strait and in the Scotia Sea, suggesting spatial separation between BSA and BSG feeding grounds. However several satellite tagged animals cross the Bransfield Strait at the end of the feeding season, so there may be late-season eastward movement just before the whales travel north. The sub-committee **encouraged** further telemetry work in the northern Antarctic Peninsula area to investigate the apparent differentiation between breeding stocks occurring in the area.

It was suggested that it would be useful to explore further subdivisions within BSG with this mixed stock analysis, for example including genetic data from whales seen in Panama and the Magellan Straits, if such are available. The sub-committee **encouraged** the formation of such a collaborative group to address this. The authors agreed to make efforts to consolidate their samples with those from other regions and researchers to address issues of connectedness that cross ocean basins and international boundaries. At the Southern Hemisphere scale it may now be possible to consider constructing a catalogue for humpback mitochondrial haplotypes, in order to standardise nomenclature and provide a reference database for future work. Substantial Southern Hemisphere datasets have been assembled from breeding grounds (Jackson *et al.*, 2014; Rosenbaum *et al.*, In review) which can be linked with feeding ground mtDNA datasets. The sub-committee **encouraged** the development of such a catalogue and formed an intersessional email group to progress this task.

SC/66a/SH16 reported on work in the Gulf of Chiriqui in western Panama (located at ~8°N), which previous research has shown is an important reproductive area for IWC Breeding Stock G (BSG) (Rasmussen *et al.*, 2007; Rasmussen and Palacios, 2013). This area is unique because it harbours the northernmost breeding area of any Southern Hemisphere humpback whale population (with whales migrating approximately 8,300km from the feeding areas), and is also used by whales migrating from feeding areas off California-Oregon-Washington in the eastern North Pacific between December and April. This is the only known breeding area in the world that hosts two populations from distinct hemispheres (Rasmussen *et al.*, 2012). In 2014 the project continued its long-term monitoring effort based out of the Secas Islands in the Gulf of Chiriqui. The year saw the study's largest effort to date in terms of number of days (35 days compared to the previous highest of 28), but the total distance surveyed was similar to previous years (~2,000km). In 2013 higher encounter rates and larger group sizes were seen, and this trend continued in 2014 with even higher encounter rates and group sizes. With two years of data now showing similar results the authors believe it indicates that more whales are visiting the Gulf of Chiriqui. This may be due to a shift in habitat use, an increase in population size, or possibly a combination of these factors. The percentage of mother/calf pair sightings was 54%, slightly higher than the overall average of 52% recorded in previous years, but still much higher when compared with other wintering areas (which range between 8% and 28%); this indicates that the Gulf of Chiriqui is an important nursery area for BSG, despite the unusually long migration. The additional 126 new photo-identifications have increased the image catalogue by 36%, bringing the total to 476 individuals. Of these, only 21% had been seen previously, indicating that the majority of this population has not yet been sampled. The results of comparisons with other catalogues were published in 2007 (Acevedo *et al.*, 2007; Rasmussen *et al.*, 2007); although these are somewhat outdated, they have yielded matches with feeding areas in the Straits of Magellan (Chile) and to the Antarctic Peninsula, and with other breeding areas in Colombia and Ecuador. More recent matching results with the Antarctic Humpback Whale Catalogue should be published soon. The following recommendations were outlined in the paper: (1) the continuation of annual monitoring efforts to determine if the results reported the past two years in terms of encounter rate and group size are part of an on-going trend for this population; (2) the continuation of these efforts will also provide information regarding how environmental conditions influence the patterns of humpback whale occupation and population trends for BSG; and (3) a new comprehensive regional comparison effort should be conducted among current catalogues from Antarctica, Chile, Peru, Ecuador, Colombia, and Costa Rica, to look at sub-stock geographic structuring.

In discussion, it was noted that there was work previously conducted to the west of the study area (Rasmussen *et al.*, 2012) and ongoing photo-identification work occurring within the Gulf of Panama (Guzman *et al.*, 2014); the authors noted that there had been no recent comparison of photo-identification catalogues from the two areas. The sub-committee **recommended** that such a comparison be undertaken. It was also suggested that a mark-recapture estimate of abundance of calculated using existing photo-identification data; in response it was noted that while this should be done, the mark-recapture model should be robust to the sampling biases that were known to exist. A similar comparison between Costa Rica, the Magellan Straits and the Antarctic Peninsula, using data collected by Friedlaender's group, was suggested.

3.1.4 Feeding grounds

SC/66a/SH20 summarised visual and acoustic data gathered during the 2015 SORP voyage. This survey was conducted on board the Argentinian vessel *Tango SB-15* in Antarctic and sub-Antarctic waters from 28 January to 13 February 2015. Active sighting effort corresponded to 11 days, during which 85h 52min were devoted to visual survey effort, and 769.5 n.min were covered. A total of 158 sightings included four mysticetes (humpback, fin, sei and Antarctic minke whales) and four odontocetes species (dusky, Peale's and hourglass dolphins, as well as killer whales) were positively identified. Humpback whales were the most frequently seen species in the western Antarctic Peninsula with a sighting frequency of 0.4 whales/n.miles, increasing to 0.9 and 0.4 within Gerlache Strait and Bransfield Strait/Mar de la Flota, respectively. Fin whales were the second-most observed cetacean with a sighting frequency of 0.2 whales/n.miles within the western Antarctic Peninsula, and 0.3 around the South Shetland Islands. Seventeen acoustic detections were recorded with the towed hydrophone array, including narrow band high-frequency echolocation signals produced by hourglass dolphins and possibly Peale's or Commerson's dolphins. Sperm whales were acoustically detected on two occasions as well as clicks from unidentified odontocete species were registered. Beaked whale frequency-modulated (FM) signals were detected on three occasions and correspond to the recently described BW29 signal type.

Curtice *et al.* (2015) applied a novel space-time utilisation distribution method to test the hypothesis that humpback whale distribution around the Western Antarctic Peninsula (WAP) reflects that of krill: spread broadly during summer with increasing proximity to shore and associated embayments during fall. Humpback whales instrumented with satellite-linked positional telemetry tags (n=5) show decreased home range size, amount of area used, and increased proximity to shore over the foraging season. The study applies a new method to model the movements of humpback whales in the WAP region throughout the feeding season, and presents a baseline for future observations of the seasonal changes in the movement patterns and foraging behaviour of humpback whales (one of several krill predators affected by climate-driven changes) in the WAP marine ecosystem. As the WAP continues to warm, it is prudent to understand the ecological relationships between sea-ice dependent krill and krill predators, as well as the interactions among recovering populations of krill predators that may be forced into competition for a shared food resource.

The sub-committee welcomed these two papers, which contribute new information about the feeding ground associated with BSG.

3.2 Review of Southern Hemisphere humpback whale assessments

3.2.1 Results of intersessional modelling work

In 2011, the sub-committee initiated the re-assessment of BSE and BSF: see Fig. 1 of IWC (2015). These stocks correspond, respectively, to humpback whales wintering off Western Australia (BSD), Eastern Australia (BSE1), and the western Pacific Islands of Oceania (herein referred to as BSO). BSO includes New Caledonia (sub-stock BSE2), Tonga (sub-stock BSE3), the Cook Islands and French Polynesia (sub-stock BSF2).

The assessment of these breeding stocks was completed last year (IWC, 2015), concluding the Comprehensive Assessment of Southern Hemisphere humpback whales. However some outstanding elements of the regional assessment were identified, and three intersessional email groups were formed to discuss them further.

3.2.1.1 INTERSESSIONAL EMAIL GROUP ON MIXED STOCK ANALYSIS

Jackson summarised the progress of an intersessional email group on mixed stock analysis. In 2014 the sub-committee discovered some appreciable differences (particularly for Oceania) between the high latitude catch allocations that best fitted the BSD/BSE1/BSO three-stock population model, and the results of a mixed-stock analysis allocating high latitude mitochondrial DNA samples to low latitude breeding grounds (IWC, 2015). This difference was marked, even when the mixed stock proportions were used to inform the catch allocations directly in the likelihood. Further work on genetic mixing proportions was suggested, for comparison with the Oceania model outputs. The mixed stock models were proposed to be re-run as follows.

(1) Excluding New Caledonia from the Oceania sample, for comparative purposes, since the very high New Caledonia trend reported by Orgeret *et al.* (2014) suggests that East Australian whales have immigrated into New Caledonia waters (or transit through there) recently, so New Caledonia may be a mixed rather than ‘pure’ breeding stock.

(2) Use Valsecchi *et al.* (2010) mtDNA samples in addition to Tasmania samples (n=135 haplotypes available from Valsecchi *et al.* (2010), table 1) for East Australia. This provides combined East Australia breeding stock data from two migratory streams so may be more representative of whales using the EA wintering ground.

In both analyses it is recommended to include Oceania breeding stocks as separate source entities (Pastene *et al.*, 2011) rather than grouping as ‘Oceania’, and derive the ‘Oceania’ signal for comparison with the assessment outcomes by summing over the allocations from the individual breeding stocks. This work could not be conducted during SC/66a and so will be completed intersessionally by Kitakado (see work plan, Item 10.1). There was some discussion of the value of combining mtDNA and microsatellite datasets from low and high latitudes across Oceania, in order to increase the resolution of mixed stock analysis. This is currently challenging to implement, since the microsatellite datasets have been generated independently, and there is substantial work and time required to error check and standardise allele bins between the datasets.

Future multi-stock population assessments could usefully incorporate a mixed stock model directly into the likelihood function for the population model, in order to provide information about high latitude mixing for catch allocation; this approach was already taken in the assessment of BSD/BSE2/BSO. It would be useful to further develop the mixed stock model that is in use so that it can incorporate uncertainty associated with un-sampled haplotypes and small sample sizes (Pella and Masuda, 2001).

The sub-committee discussed the uncertain breeding stock provenance of samples collected from the migratory stream off East Australia. Since genetic samples are not available from the Great Barrier Reef (GBR)/Coral Sea breeding ground, it is currently not known whether samples collected from the migratory stream travel to this breeding ground as a final destination. Twelve whales satellite tracked while migrating northward off Evans Head all travelled to the GBR (Smith *et al.*, 2012), supporting the idea that this migratory stream is connected to the East Australian breeding ground, but this sample size is small. The sub-committee agreed that while the provenance of the migratory stream is not known, adding additional samples from further north along the migratory stream (as proposed above) might improve the quality of the mixed stock analysis. It was commented that the proposed additional BSE1 samples were collected in 1992 and may not be representative for a comparison with samples collected at a later date from Evans Head and the feeding grounds if temporal changes in population structure have occurred.

Discussion then turned to how best to proceed with stock assignment if one or more putative source breeding populations is a mixture. It was commented that if ‘source’ breeding stocks are not well characterised, this can bias mixed stock analysis. Approaches that can evaluate this include the unconstrained mixture model developed by Smouse *et al.* (1990) which can accommodate unsampled populations, or an implementation of STRUCTURE where some samples are allocated source locations and some are not. However these require multi-locus nuclear markers, rather than datasets restricted to mtDNA, as considered in the current case. It was noted that such an investigation would be of interest for New Caledonia as well as Australia, since New Caledonia has experienced a recent influx of whales, most likely from east Australia (Orgeret *et al.*, 2014). It was cautioned that defining source populations is of paramount importance in mixed stock assignment, and important to achieve good sampling of these before proceeding to conduct MSA.

The integration of a mixed-stock analysis (MSA) directly into the assessment model can be easily achieved using a Pella Masuda model (Pella and Masuda, 2001). This treats source populations explicitly as samples, accounting for sampling error. However, given that there is still uncertainty around the identity of some Southern Hemisphere ‘source’ breeding stocks, it was recommended that further work be done to identify these before attempting such an integration.

The problems associated with identifying source populations could be aided by the use of multi-locus nuclear data (such as microsatellites or Single Nucleotide Polymorphism data) instead of, or in addition to, mtDNA, since these increase the resolution for identifying distinct source populations. However, the use of non *a priori* clustering methods like STRUCTURE typically require data from populations with reasonable differentiation (e.g. F_{ST}>0.02). Differentiation among some breeding stocks in the Southern Hemisphere is much weaker than this (Schmitt *et al.*, 2013). While there will be standardisation issues with attempting this across the Southern Hemisphere, building such a dataset for a subset of samples (e.g. such as that presented in SC/66a/SH13) could be sufficient to investigate source population identities in more detail.

3.2.1.2 DEFINING A MINIMUM ABUNDANCE FOR BSD

Discussions in SC/65a had identified some problems with the absolute abundance estimate described in Hedley *et al.* (2011); for example sightings made on this survey were somewhat unusual as observers did not focus search effort perpendicular and forward of the aircraft and sightings behind the plane were included. As a consequence, this abundance estimate was not used in the 2014 assessment of west Australia (BSD). Instead, a minimum estimate of abundance was derived from a strip transect analysis of aerial survey data from Shark Bay, Australia. However, there were concerns about the aerial search protocol employed which makes it difficult to use the standard assumptions about detection probabilities for a strip transect analysis, see IWC (2015, p.198). Further work was urgently **recommended** to better define this minimum abundance value. More details are given in the work plan in Item 10.1.

Discussion then focussed on the possibility of conducting a new survey to estimate abundance off west Australia (BSD). It is challenging to estimate abundance for the northward-travelling migratory corridor because the migratory stream is broad, limiting land based counts. A report on the feasibility of different west Australia survey locations and survey methods was discussed (DuFresne *et al.*, 2014). This report suggested that conducting 'circle-back' aerial approaches at Dirk Hartog Island, or land-based surveys off the Northwest Cape were the best available options for future surveys.

The sub-committee cautioned that land based surveys off the Northwest Cape were challenged both by the broad migratory stream and the substantial number of whales milling in the survey area. They also noted that the circle-back method could be problematic given the high density of whales in the migratory stream, suggesting that a double platform may be a more effective approach. It was also suggested that there may be a good land based survey site available on Dirk Hartog Island, although Hedley *et al.* (2012) have reported that inter-annual variability in the distance of migrating whales from shore may make land-based counts from such a site unpredictable. The sub-committee **recommended** that these sightings data be re-analysed with a view to determining the most appropriate survey method.

3.2.1.3 INTERSESSIONAL POPULATION MODELLING

In SC/66a/SH05, the three stock model approach with mixing on feeding grounds, which was implemented in 2014 to assess the BSD, BSE1 and BSO breeding stocks, was applied in a similar manner to the BSE1, BSO and BSG breeding stocks. This was intended as a first step in applying this approach consecutively around the globe to check for consistency of results in circumstances of uncertainty in the allocation of feeding ground catches. Compared to earlier assessments of the BSE1, BSO and BSG breeding stocks in partly separate analyses, there was an appreciable change in that the pre-exploitation level was estimated higher for BSE1and lower for BSO; correspondingly, BSE1 was estimated as less and BSO as more recovered towards those pre-exploitation levels. Comparable likelihoods did not differ greatly for data for these stocks used in both the 2014 BSD+BSE1+BSO and the 2015 BSE1+BSO+BSG assessments, suggesting that the data used here do not contain sufficient information to distinguish these rather different results.

In discussion, it was noted that with this model only 35% of the Oceania humpback breeding stocks are allocated catches from Area VI (the rest of the catches go to East Australia), with the remaining 65% allocated catches from Area I. The model is biologically very unlikely given the substantial feeding-breeding connectivity data linking Oceania with areas V and VI. This analysis highlights the importance of integrating additional biological data (such as mixed stock analysis) to better inform catch allocation on the feeding grounds.

In SC/66a/SH04, the existing three-stock model for Breeding Stock D (West Australia or BSD), Breeding Stock E1 (East Australia or BSE1) and the collection of Oceania breeding sub-stocks was used to simulate future data which might be collected for these stocks, to ascertain which data types have the best potential to improve estimates of precision of key quantities associated with the population dynamics. For BSD, a future estimate of absolute abundance in 2017 and a series of relative abundance estimates each year from 2016 to 2020, where all estimates have CVs of 0.25, are considered. For BSE1, a similar further relative abundance series is considered, as well as new mark-recapture data for the years 2016 to 2020, where sighting probabilities are taken to be half the average achieved previously. Sighting probabilities are dealt with in a similar manner for future mark-recapture data considered for BSO. Both the further absolute abundance estimate for BSD and especially more mark-recapture data for BSO show some potential for providing improved precision in parameter estimates. However, there seems to be little increase in precision to be gained from further relative abundance data, bearing in mind that these results presume the current three-stock model to be correct. The three-stock model is further used to demonstrate the ability to generate ranges of future observations that could be expected to be observed given the model assumptions. Actual data collected in future could be compared to such ranges to check on the model's ability to continue to reflect reality.

In discussion it was noted that including already existing mark recapture records in the simulation exercise would improve the precision of the trend further. The authors explained that this is challenging to implement in the model and observed that the outcomes in this simulation exercise therefore underestimate the power of future data, because they are not accounting for data already collected. It was highlighted that the capture probabilities of mark recapture data simulated from Oceania were low (~2.5%) which does not enable good precision in standard mark recapture models. It was noted that future survey efforts are likely to have different yields for photo-identification records relative to genetic data, since photo-identification can be collected more rapidly and easily than genetic data. Therefore assumptions of a simple reduction in capture probabilities in future surveys may not be met in reality.

It was commented that this study recommends a measure of absolute population abundance for BSD in the near future. The feasibility of obtaining a new abundance estimate for BSD was discussed under Item 3.1.3.2.

Carroll *et al.* (2015) updates analyses previously presented to this sub-committee (Carroll *et al.*, 2013) to investigate the power of future survey designs to measure abundance and trend in Oceania. A previous capture-recapture study, based on DNA profiles, estimated that the IUCN-listed Endangered Oceania population of humpback whales had a super-population size of 4,329 whales (95% CL 3,345, 5,315) and λ=1.03 (95% CL 0.90-1.18) for the period

Table 1

Predicted abundance, recovery and population growth estimates for all Southern Hemisphere humpback populations projected to 2015, with 2015 recovery levels calculated relative to pre-exploitation abundance in 1900.

Breeding stock	Median K	Median N_{min}	Baseline year of abundance estimate[2]	Projected abundance 2015	Recovery $N2015/K$	Assessment model type	Reference
BSA	24,558 (22,791-31,118)	502 (232-3,951)	2005[4]	11,672 (6,649-16,864)	0.47 (0.22-0.73)	Single stock	IWC (2007)
BSB1	18,282 (13,435-36,452)	1,510 (366-6,363)	2006[5]	12,973 (9,709-15,096)	0.74 (0.29-0.97)	Model IIa	IWC (2012a)
BSB2	4,351 (244-6,573)	72 (26-183)	2007[5]	484 (138-860)	0.13 (0.03-0.88)	Model IIa	IWC (2012a)
BSC1	8,440 (7,072-14,631)	688 (286-4,578)	2003[4]	8,045 (6,756-9,656)	0.97 (0.58-0.97)	Sabbatical with BSC3	IWC (2010)
BSC3	8,854 (6,906-16,106)	1,885 (533-6,094)	2006[5]	7,972 (6,409-10,228)	0.96 (0.48-1.00)	Sabbatical with BSC1	IWC (2010)
BSD	21,686 (19,016-29,383)	824 (461-4,051)	2008[3,4]	20,337 (18,415-24,918)	0.95 (0.80-0.99)	Three-stock, no exchange	IWC (2015)
BSE1	26,114 (21,590-29,011)	237 (203-272)	2010[4]	19,614 (17,644-21,454)	0.76 (0.69-0.84)	Three-stock, no exchange	IWC (2015)
BSO	14,103 (10,190-19,630)	132 (103-250)	2004[5]	6,404 (5,491-7,595)	0.47 (0.29-0.66)	Three-stock, no exchange	IWC (2015)
BSG	11,584 (10,590-14,878)	732 (238-2960)	2006[4]	9,687 (8,520-10,202)	0.93 (0.74-0.98)	Single stock	IWC (2007)
Total[1]	137,972 (111,833-197,781)			96,675 (78,041-117,527)	0.70		

[1]Totals are the sums of medians and 95% probability intervals calculated for individual breeding stocks. [2]Model projections are based on abundance estimates summarised in Table 2. [3]Minimum bound on 2008 abundance imposed. [4]Abundance derived from sightings surveys. [5]Abundance derived from mark recapture data fitted into the population assessment model.

1999-2005. This low estimate of λ contrasts with the high estimated λ of the neighbouring east Australia population (1.11; 95%CL 1.05-1.13). A future assessment of Oceania humpbacks through capture-recapture methodology has been proposed to meet three objectives: (1) estimate population size with a coefficient of variation (CV) of <20%, and detect if λ is significantly different from (2) 1.00 or (3) λ of east Australia. The proposed survey design involves identifying whales through DNA profiles on principal breeding grounds within Oceania in proportion to the abundance of whales on these grounds over the 10-12 week wintering period, to minimise heterogeneity between individuals and to maximise capture probabilities. Simulations of the idealised survey design incorporating data from the previous surveys (1999-2005) with three new survey years were conducted under a range of scenarios for the 'true' demographic status of the population. Simulations of the entire Oceania region showed that the proposed design will give sufficient power to meet: (1) under all scenarios; meet (2) if the true λ≥1.05; and meet (3) if the true λ ≤1.05. Region-specific simulations suggested there was scope to test for differences in recovery between principal breeding sites within Oceania.

The sub-committee welcomed this as new and useful information to assist with mixed stock analyses. It reiterated that although to date BSO has been assessed as a single block, it contains three distinct breeding areas: New Caledonia (sub-stock BSE2), Tonga (sub-stock BSE3), the Cook Islands and French Polynesia (sub-stock BSF2). The latter remains the most challenging population for assessment because there is no precise abundance estimate. In discussion it was noted that the key elements to note here pertain to whether the survey data can reject the λ=1.10 (10% growth rate) and constant population size (λ=1.0) scenarios for Oceania for a given range of true growth rates between 0-5%. It was noted that it would be useful to see the estimates of λ given with associated error rather than simulated as absolute values.

3.2.2 Synthesis review and future directions for humpback assessments

SC/66a/SH09 summarises Southern Hemisphere specific publications on humpback whale distribution, abundance, trend, connectivity, genetic resources, threats and impacts which have become available since the Scientific Committee comprehensive assessment of each relevant breeding stock and sub-stock. This summary was compiled from documents submitted to the IWC Southern Hemisphere sub-committee, publications in the *Journal of Cetacean Research and Management*, and a search of 'humpback whale' on Web of Science, dated back to 2006. Breeding stocks BSD and BSE1 are not listed, as no new relevant studies/datasets have been identified as becoming available since their assessment in 2014. This summary has been updated to 2015 and is provided as Appendix 2.

In discussion it was noted that Appendix 2 is intended to act as a marker of assessment-relevant studies conducted to date on Southern Hemisphere humpback whales, identifying those populations for which new assessments may be required. Among all breeding stocks, substantial new information on BSG suggests that a sub-structured assessment of this region (similar to that conducted for BSB; IWC, 2012a) may be possible, but it was cautioned that significant additional work would be required to conduct such an assessment, including reconciling regional photo-identification catalogues and genetic datasets, and obtaining trend data if possible.

The Southern Hemisphere Comprehensive Assessment was concluded at SC/65b in 2014. An intersessional correspondence group was formed to synthesise the results of the assessment. The result of this synthesis is presented in SC/66a/SH03, which summarises the results of the Comprehensive Assessments on Southern Hemisphere humpback whales, comments on the methodological developments that occurred during the assessment and provides unresolved questions still to address for future assessments of Southern Hemisphere humpback whales. Assessments suggest around 140,000 humpback whales were present in the Southern Hemisphere prior to modern whaling, and reveal contrasting patterns of population recovery across the Southern Hemisphere oceans. All Comprehensive Assessment models were re-run with the goal of providing predicted abundance estimates for 2015

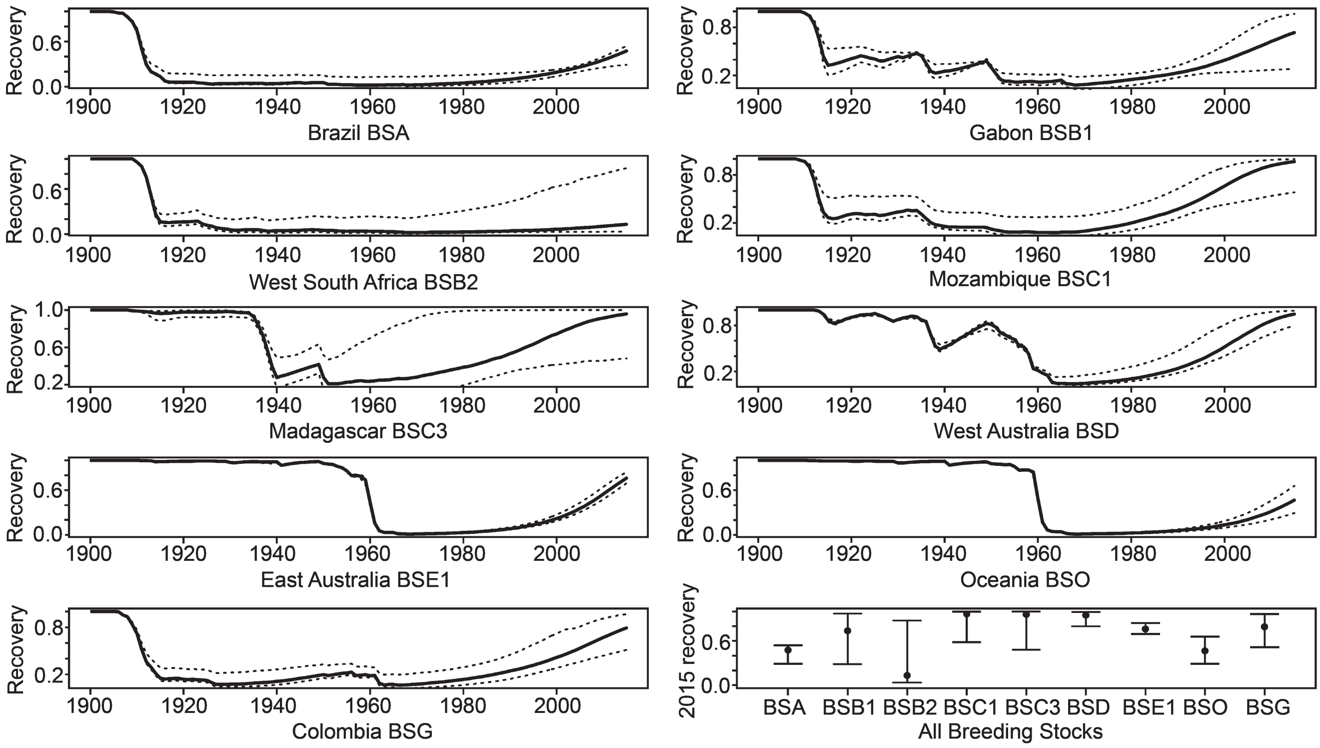

Fig. 1. Southern Hemisphere humpback whale recovery levels (relative to 1900 abundance) plotted by ocean from 1900 to 2015. Relative recovery levels in 2015 are shown for all breeding stocks

for comparison among all breeding stocks (Table 1, Fig. 1). However it is important to note that these model projections are based on estimates of abundance from distance surveys or mark recapture records that are, in some cases, more than ten years old (Table 2).

In discussion, the sex bias towards males on breeding grounds was discussed. Since these sex ratio data often come from migratory streams (Brown *et al.*, 1995) they may reflect sex specific differences in migratory behaviour, for example if the females migrate further offshore than the males. However it was also noted that a male bias is found on wintering grounds as well as migratory streams (Constantine *et al.*, 2012; Pomilla and Rosenbaum, 2006).

The prior and posterior distributions of the r_{max} parameter for the Southern Hemisphere humpback breeding stocks are shown in Fig. 2. Inspection of the posterior distributions (or alternatively the probability intervals) for BSA, BSB and BSC3 reveals that the uninformative prior distributions for these stocks are not strongly updated through the data and model. The posterior r_{max} distribution for BSE1 is notably narrow, and it is likely that this narrow distribution is influencing the posterior r_{max} estimate for BSO, which is high.

In discussion it was noted that future population assessments might be better modelled using a meta-prior on r_{max} to capture the range of trend information now available for Southern Hemisphere humpback whales (Thorson *et al.*, 2015). This could capture multiple sources of growth rate information.

3.2.3 Conclusions and recommendations

The Comprehensive Assessment of Southern Hemisphere humpback whales concluded at SC/65b in 2014. During SC/66a, a working group was formed to discuss how to prioritise data gaps identified by the synthesis review (Table 3, SC/66a/SH03) and to identify modelling needs for future humpback assessments. The working group agreed that a prioritisation approach which weights existing knowledge about the likely level of impact on assessment outcomes against the threat level for each stock (e.g. in the form of a risk-reward matrix) would be useful. However during SC/66a there was insufficient time to fully specify this prioritisation process beyond an initial outline. An intersessional email group was therefore formed to progress on this prioritisation exercise and agree a process, as well as to provide some suggested prioritisations for the sub-committee to consider at SC/66b.

One significant absence from the current Southern Hemisphere humpback assessment is data on population trend from BSB, BSC3, Oceania and BSG, which is a key component required for each population assessment. In reviewing the comparative plots of prior and posterior r_{max} distributions used in the assessments (Fig. 2), it was also noted that the posterior distribution on r_{max} is also not substantially updated from the prior within the BSA assessment because the indices of abundance are short term. Trend data collection is a long-term exercise, and so the sub-committee **recommended** such data collection continues in order to inform future humpback assessment.

The sub-committee also recognised that future assessments of Southern Hemisphere humpback whales will likely be conducted with multi-stock models, which require understanding of regional population structuring to inform catch allocation. Therefore, the sub-committee **recommended** additional sampling (e.g. of genetic data) to improve understanding of Southern Hemisphere population connectivity, both across breeding grounds and between breeding and feeding grounds. In relation to this, further progress on the concept of using mixed stock assignment methods to identify breeding-feeding ground connections for allocating high latitude catches was also **recommended**.

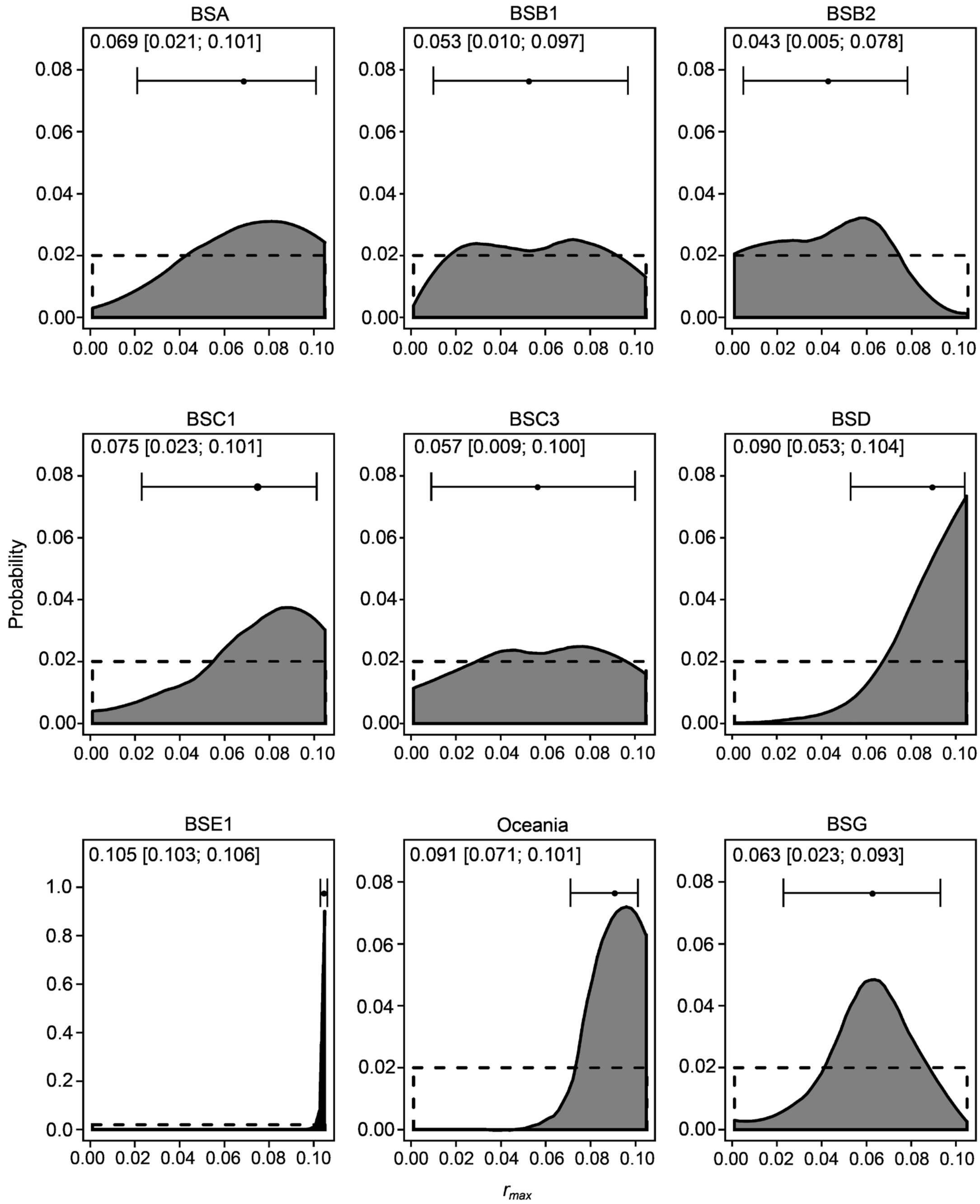

Fig. 2. Prior and posterior distributions for the growth rate parameter are given for the majority of the Southern Hemisphere humpback whale breeding populations, in order to illustrate the extent to which the parameter is updated by the data and model. For each breeding stock, the prior distribution is indicated by the dashed line, while the posterior distribution is shown by the shaded grey area. R_{max} medians and 95% probability intervals are shown above each plot.

4. ARABIAN SEA HUMPBACK POPULATION

4.1 Review new information

SC/66a/SH17 summarised a project on the western coast of India (funded by the IWC) to examine the presence of baleen whales in Indian waters (Gujarat, Maharashtra and Kerala), and to understand the ecology of the humpback whales in the region. Visual and acoustic surveys are being made from platforms of opportunity, and local interviews of fishermen and cargo vessel crews to investigate whether these can be useful sources of information. The interviews indicate that the presence of Arabian Sea humpback whales is most probable along the Saurashtra and Kachchh coasts of northern Gujarat. The majority of stranding reports were from Maharashtra and the species most commonly reported was the Bryde's whale, with at least five strandings reported in 2015 alone. Sightings of baleen whales in northern Gujarat are mainly reported in the winter months from November to March. In Maharashtra the sightings of fishermen are correlated with the presence of sardine shoals. Dedicated baleen whale surveys using visual and acoustic methods would greatly help to fill the large gaps of knowledge on baleen whales and cetaceans in the offshore waters of India, and systematic effort to examine baleen whale carcasses is required to understand the causes and seasonality of mortalities. This requires the collaboration of local administrative authorities along with the forest department and trained veterinarians licenced to carry out necropsies or deal with live strandings. Moreover an organised database of all records in a shared standard format needs to be used to make the data available to range countries of these baleen whales. The current constraints on the collection of samples for further analyses, particularly for genetics should also be rectified as soon as possible.

The sub-committee welcomed this new information, which has been obtained with IWC support, and represents the first year of a two-year survey project. In discussion of the sampling constraints, it was noted that this is most likely to be achieved in collaboration with government scientists. Efforts to collaborate with government scientists on future work in the region were **encouraged**.

Mahanty *et al.* (2015) summarised the results of a study of humpback whale sounds in the south-eastern Arabian Sea, detected by using an autonomous ambient noise measurement system, during the period January to May 2011. Seven types of sounds were detected. These were characteristically upsweeps and down-sweeps along with harmonics. Sounds produced repeatedly in a specific pattern were referred to as phrases (PQRS and ABC). Repeated phrases in a particular pattern were referred to as themes, and from the spectrographic analysis, two themes (I and II) were identified. The variation in the acoustic characteristics such as fundamental frequency, range, duration of the sound unit, and the structure of the phrases and themes are discussed. Sound units were recorded from mid-January to mid-March, with a peak in February, when the mean SST is ~28°C, and no presence was recorded after mid-March. The temporal and thematic structures strongly determine the functions of the humpback whale song form. Given the use of song in the south-eastern Arabian Sea, this area may be used as an active breeding habitat by humpback whales during the winter season. The authors were not present to discuss this paper.

A question was raised regarding where the humpback whales from the eastern Arabian Sea feed; the only information on this comes from Soviet catches in November 1966, which showed whales feeding off north-western India (Mikhalev, 1997). Willson commented that ecological niche modelling (not yet published) supports the hypothesis that Gujarat represents a feeding area.

Pomilla *et al.* (2014) analysed 11 microsatellite markers and mitochondrial DNA sequences extracted from 67 Arabian Sea humpback whale tissue samples, and compared them to equivalent datasets from the Southern Hemisphere and North Pacific. Results show that the Arabian Sea population is highly differentiated; estimates of gene flow and divergence times suggest a Southern Indian Ocean origin but indicate that it has been isolated for approximately 70,000 years, remarkable for a species that is typically highly migratory. Genetic diversity values are significantly lower than those obtained for Southern Hemisphere populations and signatures of ancient and recent genetic bottlenecks were identified. Many of these results were originally presented to this sub-committee in Pomilla *et al.* (2010). New results from STRUCTURE and a Bayesian Skyline Plot in the published paper reinforced the previous results presented to the sub-committee. These findings suggest this is the world's most isolated humpback whale population, which, when combined with low population abundance estimates and anthropogenic threats, raises concern for its survival, particularly given the current and projected increase in anthropogenic activities.

In discussion, the sub-committee highlighted the fact that the Arabian Sea humpback whale population is small, year round, non-migratory, and highly differentiated with no known connection to other populations. Given the level of emerging threats documented in the region (SC/66a/SH17, SC/66a/SH22-SH23, Mahanty *et al.*, 2015; Minton *et al.*, 2015) the sub-committee **reiterated** its serious concern about the endangered status and threats to this distinct population. Comments related to the genetic analyses presented are summarised in Annex I, Item 3.1.

It was queried whether the individual humpback whales from Oman with a genotype reflecting mixed ancestry (figure 4b in Pomilla *et al.*, 2014) might be first generation migrants from the Southern Hemisphere. The authors stated in the paper that gene flow seems to have occurred after divergence, but that it was unlikely that migrants are currently being exchanged between the Arabian Sea and the Southern Indian Ocean stocks. **The authors further commented that it would be interesting to look at the corresponding** mtDNA identity of these individuals to see if it is private to Oman or shared with Southern Hemisphere populations. However they noted that the probability of identity for these individuals is low, and this coupled with the estimated divergence of these populations suggests that the signal of admixture might be ancestral rather than recent.

SC/66a/SH22 reported the results of satellite tags deployed on three adult male humpback whales encountered off the southern coast of Oman during March 2015. This represents the second year of a telemetry study that began with the tagging of three whales in 2014 and forms part of a broader scientific research programme initiated in 2000 to understand the population biology and spatial ecology of Endangered Arabian Sea humpback whales. Tags were deployed in an area commonly associated with the seasonal presence of singing whales. Resightings of whales tagged in 2014 (n=3), supported by photographic evidence of two animals, showed normal healing of epidermal tissue around the tag site over a period of nine to 11 months. A repeat tagging of one known individual (tagged in 2014) as well as two other known individuals in the Oman photo-identification database provides further evidence for high site fidelity of males to the tagging site as well as the Gulf of Masirah. The authors noted that habitat utilisation inferred from telemetry and vessel survey data have confirmed the urgent need for mitigation measures in high-risk areas and that this has led to an improved understanding of humpback whale spatial ecology across the wider region. The authors also recommended the requirement to continue with tagging to address spatial and temporal gaps in the study of whale movements.

Given that humpbacks are observed off western India and Oman at similar times, the question was raised whether this might indicate the existence of separate populations. Although this possibility cannot be ruled out, the distance between the two areas (approximately 500 n.miles) is well within the range of a single feeding population of humpbacks; the Soviet catches of 1966 took place over a short period of time and took whales in both regions (Mikhalev, 1997). The importance of collecting genetic data from humpback whales off western India was highlighted, as this will enable more in-depth investigation into the population composition of humpbacks across the Arabian Sea.

4.2 Progress toward the development of a Conservation Management Plan and other conservation initiatives

Minton *et al.* (2015) reported the results of a workshop to begin developing a unified, collaborative research and conservation strategy that could be readily communicated to governments, intergovernmental organisations non-governmental organisations, donors and research colleagues. Researchers and international experts presented summaries of what is known about the distribution, biology and threats to humpback whales in each of the represented Arabian Sea range states, as well as information about research techniques and tools for collaboration that could facilitate the implementation of a regional conservation-based research strategy. Participants identified the main threats to whales in the region and knowledge gaps that must be filled in order to assess and protect Arabian Sea humpback whales. Almost all current knowledge about this population is based on data collected in the Sultanate of Oman, which is the only country in which dedicated humpback whale research has taken place in recent years. The shortage of information on the population's full range and population size outside of Oman is one of the most significant impediments to the pursuit of a regional conservation strategy. The workshop made a number of recommendations to improve conservation management; many of these focused on harnessing the formal and informal networks and capacity of participants to fill major knowledge gaps.

The sub-committee welcomed the information from the workshop, and **agreed** to endorse the recommendations made by the workshop (Appendix 3), although it was recognised that there are currently significant logistical and political obstacles to formalising any inter-governmental collaborative network. It was noted that the Ministry of the Environment in Oman has recently requested training relative to disentanglement and stranding, which often leads to additional population data.

SC/66a/SH23 discussed the role of industry in conservation efforts on Arabian Sea humpback whales in the Gulf of Masirah, Oman. Research over the past 15 years has revealed that the Gulf of Masirah is a hot spot for this endangered population and the only part of its known range where males and females are found at near parity. This information has been used by a partnership of industry, consultancy and NGO in Oman to develop mitigation related to port operations and hydrocarbon exploration (including seismic surveys) in the area. This has included the development of a Whale Management and Mitigation Programme to be implemented by the Port of Duqm Company, as well as mitigation procedures that were used by a seismic survey contractor (including 14 shutdowns of airgun operations) in late 2014. Impacts to whales nevertheless remain, including a collision between seismic equipment and a whale in December 2014, suggesting that further development of protection measures for the Arabian Sea humpback whale is still required.

In response to a question, it was noted that not enough was known about the temporal occurrence of humpback whales in the Gulf of Masirah to determine whether a period of low whale abundance could be identified in which to concentrate seismic operations. More information on the occurrence of whales was needed (including during the monsoon when field work was difficult) in order to better refine mitigation actions. It was noted that past survey work has shown that humpback whales are present in the region during the summer period (Minton *et al.*, 2011). The sub-committee **agreed** that more work was necessary to refine understanding of humpback whale ecology and habitat use in Oman with a view to developing more useful management of this small population.

Work on the Arabian Sea humpback whales (ASHW) has been presented at several sub-committees during SC/66a (summarised in Annexes H, M and K). Willson highlighted a series of urgent conservation concerns for the Arabian Sea humpback whales.

(1) The population is listed as Endangered on the IUCN Red-list based on a population abundance estimate of 82 (95% CI 60-111) for animals sighted in Oman (Minton *et al.*, 2008). Recent genetic analyses also suggest that ASHW have been isolated for millennia (*ca.* 70,000 years) and have low genetic diversity; other indices suggest the population is in decline (Pomilla *et al.*, 2014).
(2) Five ASHW strandings were recorded in Oman in the five month period January to May 2015 (SC/66a/SH22).
(3) 22% of catalogued ASHW in Oman display evidence of tattoo-like skin disease, with an increasing trend from 2000 to 2012 (15.6-30%) (Van Bressem *et al.*, 2014).
(4) Images of whales photo-identified in Oman between 2000 and 2003 demonstrate that 30-40% have scarring consistent with entanglement in fishing gear (Minton *et al.*, 2011).
(5) Several studies of ASHW habitat preferences demonstrate that the Gulf of Masirah and Hallaniyats Bay in Oman provide critical habitat (SC/66a/SH22). Developments emerging in these areas include: (i) seismic surveys; (ii) drilling of test wells for offshore oil production; (iii) startup of a large multipurpose port and dry dock facility; (iv) construction of a new city for 100,000 people; (v) expansion of fisheries including construction of Oman's largest fishing port; (vi) fast ferry routes from new terminals; and (vii) possible expansion of the whalewatching industry.
(6) Positional data from satellite tagged whales indicates localised use of areas coincident with offshore shipping routes (Willson *et al.*, 2014).

The report on a regional workshop to stimulate research collaboration between range states highlighted significant ASHW knowledge gaps and identified current and potential threats (Minton *et al.*, 2015). An informal network of researchers agreed to collaborate to raise funds and implement a research work plan for the ASHW. However the population's extreme vulnerability and the scale of current threats merit the establishment of an independent Advisory Panel, equivalent in scale and prominence to that for the western gray whale population.

The sub-committee **endorsed** this proposal and **recommended** the formation of an Advisory Panel along the lines of that developed for the western gray whale. It was noted that the Advisory Panel work will focus on key areas where threats are occurring concurrently. Range states that this is relevant to include Oman, the United Arab Emirates, Iran, Pakistan, Maldives, India and Sri Lanka.

5. ASSESSMENT OF SOUTHERN HEMISPHERE BLUE WHALES

It was noted that the last abundance estimate for Antarctic blue whales was produced for 1997, the mid-point of the IDCR/SOWER circumpolar CPIII abundance surveys (Branch, 2007). Following CPIII, some additional surveys were conducted south of Africa and in the Indian Ocean, sightings data from which are available from the IWC Secretariat. There was some discussion of whether these data could be used to update the regional trend and abundance estimates from the CPIIII surveys. It was noted that while post-CPIII surveys in the Indian Ocean were conducted using the traditional SOWER sightings survey protocol, surveys south of Africa did not follow this protocol and instead steamed along the ice edge, where many blue whales were encountered. It is therefore very difficult to convert these survey data into a comparable abundance estimate. The sub-committee **recommended** a systematic review of available photo-identification and line transect data collected since CPIII, and formed a working group to progress on this topic convened under Kelly. Details are provided in the work plan, see Item 10.2.

5.1 Southern Hemisphere population structure

Brownell described progress on a collaborative initiative with Japan to identity the geographic origins of baleen plates collected from 797 blue whales and 269 fin whales hunted on the *Nisshin-Maru* and the *Hashidate-Maru* during the 1946/47 Antarctic season, referring accession numbers attached to each plate back to the original whaling records. A pilot project will be conducted at SWFSC to sequence whole mitogenomes from a small sample, with a view to sequencing all samples eventually. Details are given in Appendix 4.

The sub-committee welcomed this discovery and observed that it is of great importance for understanding the population history of this species. In discussion, it was noted that the discovery has potential to be very informative regarding pre-exploitation blue whale genetic diversity and population structuring, and so is both timely and relevant for the Antarctic blue whale assessment. The pre-exploitation abundance estimate provided by Branch (2008) was around 50,000 blue whales, and this collection represents over 1% of this number, a very significant sample. This dataset may also provide an opportunity to test whether genetic estimates of pre-exploitation size (using the diversity metric Θ; Roman and Palumbi, 2003; Ruegg *et al.*, 2013) are of similar magnitude to estimates provided by population assessments. Previous attempts to reconcile the two were challenged by uncertainty in the historical catch record and complex population structuring. It was noted that recent DNA sequencing from bones discarded during the whaling era was successful (Sremba *et al.*, 2015), suggesting good chances for this project. The sub-committee **strongly encouraged** this exciting collaboration between Japan and the US to continue. Brownell and Kato formed a working group to progress this project (see work plan, Item 10.2).

SC/66a/SH19 and SC/66a/SH06 were presented together. SC/66a/SH19 provides new information on the genetic identity of blue whales around New Zealand based on *n*=9 samples of blue whales collected in 2014 from the South Taranaki Bight, a foraging area off western coast of the New Zealand North Island (about 40°S), three from biopsy samples collected elsewhere in New Zealand and *n*=11 from strandings collected over the last 20 years. An associated report, SC/66a/SH06, includes preliminary genetic analysis, as well as results of a multidisciplinary study of habitat use and population identity. Sequencing of the mtDNA control region from the 23 New Zealand samples resolved five haplotypes, the most common of which (haplotype d) is shared with both subspecies (at low frequencies) and all populations (except the small sample from the Maldives). The five mtDNA haplotypes from the 23 New Zealand samples were included in a phylogenetic reconstruction with published sequences from three other regions in the Southern Hemisphere: southeast Pacific Chilean coast (*n*=113), Australia (*n*=28) and the Southern Ocean (assumed to represent Antarctic blue whales, *n*=183). The New Zealand haplotypes grouped with other haplotypes reported to be common in the sample from Australia. Despite the lack of phylogenetic distinctiveness, the New Zealand sample was highly differentiated from the southeast Pacific Chilean pygmy and Southern Ocean Antarctic blue whale population, but not from the west Australian population. To confirm the subspecies identity of the New Zealand samples, microsatellite genotypes (*n*=14 loci) were compared to those previously reported for the Antarctic blue whales (Sremba *et al.*, 2012) using the program STRUCTURE. The program gave highest likelihood to *k*=2 populations, corresponding to the New Zealand blue whales and the Antarctic blue whales. All the New Zealand whales were excluded from the population representing the Antarctic blue whales, but one individual considered to be an Antarctic blue whale in the IDCR/SOWER dataset appears to be misclassified and one appears to be a potential hybrid/admix of New Zealand and Antarctic. These require further investigation.

Comments related to the genetic analyses presented are summarised in Annex I, Item 3.2. In discussion of SC/66a/SH19, it was noted that blue whales from New Zealand and Australia (Perth Canyon) have distinct acoustic calls, but there is no mtDNA differentiation between the two foraging grounds, suggesting substantial connectivity. It was cautioned that while peer-to-peer song sharing is known for species such as humpbacks (Garland *et al.*, 2011), this behaviour has not been observed for blue whales, so acoustic differences may not be informative about connectivity. Discussion turned to potential breeding grounds since these are likely to be the source of any observed connectivity. Satellite tracking of Australian blue whales foraging off Perth Canyon (West Australia) and the Bonney Upwelling (South Australia) revealed westerly movements along the south coast and northward movements along the west coast of the continent, with the final destination of Perth Canyon whales to be the Banda Sea, Indonesia (Double *et al.*, 2014). Tracking of Bonney Upwelling whales is ongoing but suggests the same final destination. The migratory destinations of blue whales foraging off southeast Australia and in New Zealand waters are unknown. There has been speculation that the Solomon Islands might be a breeding ground destination, since whaling catches were made there. However a recent Solomon Islands field survey revealed very different blue whale acoustic calls from those found in New Zealand (Frank and Ferris, 2011), which rejects this hypothesis.

In relation to the SC/66a/SH06 view that South Taranaki Bight represents a foraging hotspot for blue whales, it was noted that marine mammal observers working from petroleum exploration vessels in 2014 reported blue whales feeding all along the west coast of North Island, suggesting that the blue whale feeding ground off New Zealand may be broad. It was noted that blue whale foraging sites often show good correspondence with oceanographic features, for example Torres (2013) shows that Taranaki blue whales are closely associated with an upwelling point to the west of Farewell Spit. The survey coverage was patchy but covers a broad area and may be informative about other blue whale foraging hotspots. The sub-committee **agreed** it would be useful to investigate these blue whale sightings in the context of upwelling foci off the New Zealand coast and **encouraged** this work.

Attard *et al.* (2015) explored whether the relatively low genetic diversity of pygmy blue whales (*Balaenoptera musculus brevicauda*) in Australia is due to natural causes or overexploitation. They apply recently developed analytical approaches in the largest genetic dataset ever compiled to study blue whales (297 samples collected after whaling and representing lineages from Australia, Antarctica and Chile). They find that low levels of genetic diversity in Australia are due to a natural founder event from Antarctic blue whales

(*Balaenoptera musculus intermedia*) that occurred around the Last Glacial Maximum, followed by evolutionary divergence. Historical climate change has therefore driven the evolution of blue whales into genetically, phenotypically and behaviourally distinct lineages.

In discussion it was noted that this work contributes to the growing mtDNA dataset for Southern Hemisphere pygmy blue whales. However, a point was raised about the need for standardised nomenclature for haplotypes, which will be required for building a combined dataset in future assessments. Because blue whale tissue samples have been loaned from Southwest Fisheries Science Center (SWFSC) to several researchers, there is the potential for replicate submissions to *GenBank* of mtDNA sequences obtained from the same tissue samples. Identifying and labelling these duplicates and agreeing a common haplotype nomenclature is an important goal for the Southern Hemisphere blue whale genetics community. The codes presented in LeDuc *et al.* (2007) were agreed to be a useful framework as these are still in application at SWFSC. An intersessional email group was formed under Lang to address these issues (see work plan, Item 10.2.2).

The author summary of SC/66a/SD05 is given in Annex I, Item 3.1. It was also presented to this sub-committee in order to report on recent progress with DNA sequencing of blue whales at SWFSC, and planned investigations into population structure.

Discussion focussed on the low genetic differentiation between the eastern North and eastern South Pacific (ESP) feeding grounds compared to strong differentiation between the ESP and Indian Ocean feeding grounds, suggesting strong population connectivity across the equator. It was suggested that other species might exhibit similar patterns of connectivity across the Pacific equator; for example dusky dolphins (*Lagenorhynchus obscurus*) off Chile may be more closely related to Pacific white-sided dolphins (*L. obliquidens*) off California than they are to dusky dolphins off Argentina. Humpback whales also share mtDNA haplotypes across the eastern Pacific equator, suggesting occasional gene flow (Baker and Medrano-Gonzalez, 2002). It was queried whether the eastern North Pacific blue whale population was derived from the Chilean blue whale population; the authors have not yet investigated this question.

5.2 Antarctic blue whales

5.2.1 Cruise reports

SC/66a/SH07 summarised the New Zealand-Australia Antarctic Ecosystems Voyage, a 42-day research expedition to the Ross Sea region between the 29 January and 11 March 2015. The focus of the voyage was multi-disciplinary ecological studies of marine food webs of importance to top predators. The paper primarily described research related to the Antarctic Blue Whale Project of the IWC-Southern Ocean Research Partnership. Two phases of blue whale research occurred during the voyage (8-14 February and 24 February-2 March). During these periods the ship's position was guided by bearings to calling blue whales detected using DIFAR sonobuoys. The voyage deployed 310 sonobuoys that detected over 40,000 individual blue whale calls over 520 hours of recordings. These calls identified 4,000 triangulated positions of calling blue whales. There was a marked increase in the rate of blue whale calling after 8 February. Total visual sightings effort was 467 hours yielding a total of 480 sightings of approximately 1,297 cetaceans, including 29 confirmed sightings of approximately 81 Antarctic blue whales. Photo-identification data were collected from 58 blue whales. The acoustic and visual data suggest the blue whales were very strongly aggregated in a region approximately centred around 69°S, 178°W. Photogrammetry was used to describe the behaviour of the blue whales and active acoustic surveys, meso-pelagic trawling and oceanographic data were collected to describe the prey field and habitat characteristics of the blue whale aggregation. Preliminary analyses of the active acoustic surveys suggest that the blue whale aggregation was associated with an area populated by very dense but patchily distributed krill swarms at depths of less than 100m.

The question was raised regarding whether all of the blue whales observed were unequivocally Antarctic blues; in response it was explained that species identity was assessed only when visual observation was sufficient to establish this. The author also emphasised the great efficiency and value of the acoustic tracking method in locating blue whales for photo-identification, biopsy and other operations. Currently, there are no confirmed plans for future cruises, though it was noted that equipment and expertise would be available if anyone else was able to mount such a survey. The sub-committee recognised the importance of this work, as well as the significant contribution it has made to the Antarctic blue whale catalogue, and **recommended** that future surveys be supported by national governments.

SC/66a/SH11 reported on sightings made during the RV *Polarstern* PS 89 (ANT-XXX/2) expedition from Cape Town to Atka Bay and back. Twenty sightings of 26 individual blue whales were recorded in Antarctic waters west of the Greenwich Meridian between 16-20 January 2015. These observations suggest a more westerly extension of a reported hot spot between the Greenwich Meridian and 20°E.

SC/66a/SH12 reported results of a dedicated cetacean sighting surveys following distance sampling methodology from *R/V Polarstern* between 2 December 2014 and 1 February 2015. The cruise had mechanical and weather problems which limited survey effort. The survey used the crow's nest (shipboard survey) and on-board helicopters (aerial survey) as survey platforms along the 0° meridian on a return track from Cape Town to *Neumayer Station III*. During the aerial survey, a total of 7 minke whales (*Balaenoptera acutorostrata* or *B. bonaerensis*), 2 fin whales and 15 humpback whales were recorded along 2,994km of effort during 13 survey flights. From the crow's nest a total of 855km were covered in 55 hours 'on effort'; there were observations of 30 minkes, 13 fin whales, 18 humpbacks and 3 blue whales. The voyage crossed an area of high blue whale density, where 20 individual sightings were recorded opportunistically between 8°W and the Greenwich meridian as the vessel passed Lichtner Seamount and Maud Rise on 15 and 17 January 2015.

The sub-committee welcomed this information and noted that these data provide useful additional information on blue whale distribution, advancing the on-going IWC and SORP efforts to estimate distribution and abundance of this species.

5.2.2 Acoustic studies

SC/66a/SH15 reported on a component of the 2015 New Zealand-Australia Antarctic Ecosystems Voyage, on which acoustic real-time localisation and tracking of Antarctic blue whales was carried out using DIFAR sonobuoys and open-source PAMGuard software. A module in this software was specifically developed to facilitate analysis of the signals from DIFAR sonobuoys. This voyage was the first time the DIFAR capability of this software had been used in the field. The software performed well, and allowed over

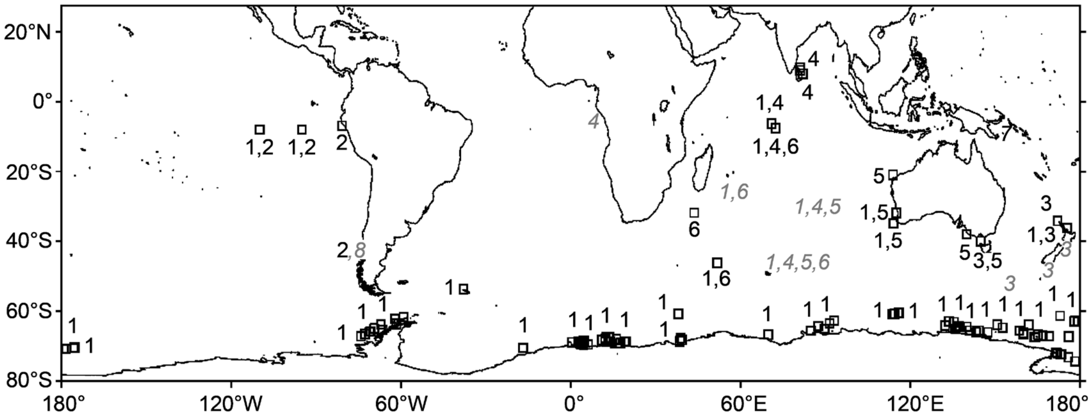

Fig. 3. Positional information of blue whale stocks from acoustic recordings, reproduced from Branch *et al.* (2007). Acoustic locations are annotated with the call type using numbers: Antarctic (1), South-east Pacific (2), New Zealand (3), Sri Lanka (4), Australia (5) and Madagascar (6); these numbers are consecutive if two or more call types were recorded at a single location. Updates to this figure from Samaran *et al.* (2013), Buchan *et al.* (2014), Cerchio *et al.* (2010), Frank and Ferris (2011) and Miller *et al.* (2014) are shown in grey.

40,000 Antarctic blue whale calls to be processed during more than 520 hours of operation. The authors noted that the software constitutes a key advance in the accessibility of DIFAR methodology to locate baleen whales, and they presented an update on the functionality of the software, and demonstrated how effective it was for real-time tracking of Antarctic blue whales.

The sub-committee welcomed this information and noted that this software has broad application potential for localising a number of cetacean species.

In SC/66a/SH18, cetacean presence was documented with a passive acoustic recorder deployed near Elephant Island, Antarctica from March to July 2014, with a focus on fin whales and beaked whales. Fin whale acoustic activity, measured as acoustic index from a continuous noise band due to extensive, simultaneous calling, persisted at very high levels. Their acoustic index started to decrease in early June and was still strong by the end of the recording period in mid-July. If blue whale signals occurred throughout the recording period, they were masked by the fin whale activity and only started to be detectable by mid-June as the fin whale acoustic index decreased. Three different beaked whale frequency-modulated (FM) pulse types were classifiable. BW29 was the most frequently encountered FM pulse type, followed by BW37. A new FM pulse type, BW58, was also detected. BW29, possibly from southern bottlenose whales, and BW37, perhaps from Gray's beaked whales, occurred throughout the recording period with seemingly alternating presence. Sperm whales, killer whales, and as yet unidentified dolphins were detected, but their occurrence still needs to be quantified. There was no sea ice cover over the instrument site during the recording period, and the sea ice edge was still approximately 100km away in July, thus sea ice was unlikely to drive the shifts in relative abundance during the recording period. These are the first broadband, long-term acoustic findings collected near Elephant Island that encompass most cetacean species expected to occur in these waters. The acoustic record is on-going and will lead to a better understanding of seasonal relative abundance and habitat use of the shelf break area by cetaceans.

In discussion the authors noted that the acoustic recorder remains at this location to accrue data this coming season.

5.3 Pygmy-type blue whales

SC/66a/SH21 reviewed available information on pygmy-type blue whales in the Southern Hemisphere in preparation for a preliminary assessment to be conducted at SC/66a. Call types, as described and labeled in McDonald *et al.* (2006), were used as a proxy for identifying populations, and (unless otherwise noted) catch records were derived from the IWC database. Goals of the preliminary assessment are to: (1) provide an updated catch series split by sub-species and call type/area; (2) collate positional data from sightings, catch, acoustic sources, and satellite tags; and (3) identify important feeding areas for pygmy-type blue whales in the Southern Hemisphere. Positional information on blue whale distribution from acoustic recordings is shown in Fig. 3.

The sub-committee thanked the author for this comprehensive summary. It was noted that no pygmy blue whales have been recorded off west South Africa (see Fig. 3). After detecting a single singing blue whale (Sri Lanka song type) off northern Angola, a year-long deployment was conducted in 2012/13 offshore of Cabinda (northern Angola, ~5.5°S), in part to test for the presence of blue whales. No definitive blue whale vocalisations were detected, suggesting that Antarctic blue whales do not regularly range that far north, and if there is a population of southeast Atlantic pygmy blue whales with an as yet unknown song type, they either do not range off Cabinda or are too few in number to be reliably detected with acoustic monitoring.

Noting that the stock delineation used in SC/66a/SH21 was based on blue whale call types reported by McDonald *et al.* (2006), the question was raised as to whether call types or genetic analyses of mitochondrial DNA would best be used to delineate these stocks prior to assessment. It was **agreed** that a joint SD-SH session at SC/66b would be valuable to assess pygmy blue whale stock structuring, and an intersessional group was convened under Lang to progress this (see work plan, Item 10.2).

The sub-committee **agreed** that the prioritisation of pygmy blue whale stocks for future comprehensive assessments would best be informed from the reviews provided in SC/66a/SH21 in terms of the extent of available data. Two key elements to consider are the regional data available to proceed to assessments, and the level of threats faced by each stock. With respect to the former, most data are currently available for the Chile/Peru and Indonesian/Australian stocks. In the latter regard, the northern Indian Ocean was considered an urgent priority for further information gathering. In the interim, the sub-committee **agreed** to proceed with compiling data for a Chile/Peru assessment first, to **encourage** collection of assessment related data from the northern Indian Ocean, and to revisit assessment priorities in SC/66b following intersessional email discussions of SC/66a/SH21 in a group convened under Brownell (see work plan, Item 10.2).

It was noted that while it is important to consider assessment timeframes in terms of levels of available data, there may be some stocks more threatened than others, and considering these elements was also important. For example the non-migratory northern Indian Ocean/Arabian Sea blue whale stock was subject to Soviet whaling, with almost 1,300 whales killed. However genetic samples for assessing connectivity are lacking, and current data are too sparse to enable an assessment. The few available genetic samples are poor quality, collected from stranded animals. The status of more recent survey work in Sri Lanka was queried; de Vos reported that while genetic sampling in the 1990s was precluded by government restrictions, such sampling could commence in the near future. It was noted that some blue whale photo-identifications were collected in the 1980s, but their current whereabouts is unknown. The sub-committee **recommended** this work be convened under Brownell.

Highest assessment priority was accorded to the Peru/Chile pygmy blue whale stock and the Indonesian/Australian pygmy blue whale stock. Both are acoustically and genetically differentiated from each other, although their differentiation from other Southern Hemisphere stocks is still unknown. The lack of genetic differentiation between the Indonesian/Australian and New Zealand stocks was noted (e.g. SC/66a/SH19); the significance of this finding in terms of population boundaries is not yet understood. The sub-committee agreed it would be difficult at this stage to prioritise the other stocks due to data paucity, although a tiered approach could be followed as more data are collected.

5.3.1 Chilean blue whales

SC/66a/SH10 reported the results of nine years of photo-identification surveys of Chilean blue whales feeding in the waters off Isla de Chiloé in southern Chile (2004-11), and Isla Chañaral, northern Chile (2012). From 1,070 blue whale encounters, a dataset of 318 and 267 left and right side photographs of unique whales was generated. Mark recapture analysis of left and right side photographs collected from Isla de Chiloé from 2006-11 using open population models provide POPAN super-population abundance estimates of 711 (95% CI=574-848) and 549 (95% CI=442-656) for left and right side datasets respectively. Pradel and POPAN trend estimates reveal strong variation in abundance, peaking in 2009 and suggesting fluctuating use of this feeding area over time. When the 2012 survey from Isla Chañaral is included, larger POPAN super-population abundances were estimated overall (n=1,353, SE=453 and n=1,060, SE=283 for left and right side datasets respectively), which may be more representative of the population of whales feeding along the Chilean coast. High inter-annual re-sighting rates off the Isla de Chiloé indicate that this southern feeding ground has long-term importance to a significant component of the Chilean blue whale population, and is therefore a habitat of critical importance for protection.

In discussion, it was noted that whales were not feeding off Isla Chiloé during the 2012 season, possibly due to anomalous warm oceanographic conditions. Such shifts in feeding aggregations are consistent with blue whale behaviour elsewhere. The low apparent survival estimates reported in the paper were highlighted (~0.85); if they reflect high mortality, they are inconsistent with the positive growth rates estimated from these data. The authors commented that since apparent survival is a combination of emigration and mortality, they expect emigration to be a strong contributory factor, since this is a feeding ground and not likely to be a closed population. The difficult environmental conditions under which these photo-identification samples are collected were noted. In discussion of whether genetic material could be associated with photo-id (to enable identification of sex, for example), it was reported that some 60 biopsy samples have been collected during this project. The sub-committee **recommended** the continuation of this work, including the collection of associated genetic material, although noting the limitations in available resources.

Torres-Florez *et al.* (2015) reports the first documented inter-seasonal movement for a blue whale in the southeastern Pacific Ocean, establishing a migratory link between a mid-latitude feeding ground in the Corcovado Gulf, Chile and a potential breeding ground in the Eastern Tropical Pacific near the Galapagos Islands. A single female blue whale was first sampled in November 1998 just west of the Galapagos Islands, and then subsequently in February 2006 and February 2008 in the Corcovado Gulf, Chile. This is the longest latitudinal movement reported for a Southern Hemisphere blue whale (5,200km). Based on one individual a conclusion cannot be made with certainty that the Eastern Tropical Pacific corresponds to the breeding destination for the Chilean population of blue whales. Yet this match does provide the first direct evidence of a possible migratory destination for these whales, a destination that is supported by other lines of evidence such as genetics and acoustics. It was noted that this was a timely finding given the initiation of the pygmy blue whale assessment for the Southern Hemisphere.

The sub-committee welcomed this first report of a link between the Chilean blue whale population and the Galapagos Islands. A recent match identified between the Galapagos and the Costa Rica dome (Cascadia Research Collective, unpublished) suggests a potential Southern Hemisphere link to this region also. It was noted that some 26% of whales identified from California have been linked to the Costa Rica Dome in winter. The identity of the 'unknown' portion of the aggregation of blue whales occurring at the Costa Rica Dome is hypothesised to be a resident population or to be seasonal migrants from the Southern Hemisphere, or both. It was noted that the photo-identification material from the Costa Rica Dome and Galapagos regions is held in the USA and includes ~90 individuals. The sub-committee strongly **encouraged** the continuance of photo-identification matching between these catalogues.

6. REVIEW NEW INFORMATION ON SPERM WHALES

The sub-committee noted the on-going effort to consider future assessments of sperm whales and sought information in the following categories: (1) population structure within ocean basins; (2) population size within ocean basins and abundance in smaller areas; (3) catch history; and (4) consideration of the development of a new assessment model. A review group was originally set up to assess data needs for Southern Hemisphere sperm whales, but hemispheric boundaries are not likely to be appropriate for this species and stock structuring is still poorly understood, so at present all oceanic data useful for considering a future sperm whale assessment are considered.

Moore and Barlow (2014) provided abundance and trend estimates for sperm whales in the California (CA) Current based on six visual line-transect surveys conducted between 1991 and 2008. This work was presented as a methodological example of obtaining using Bayesian hierarchical methods to improve inference from a time series of survey data. The model is partitioned into a biological process model (population trend model) and an observation model that relates the parameters of interest (abundance) to the sightings data (number of groups detected and group sizes). In this example, the observation process consists of distance sampling estimators to estimate detection probability. But other data types or observation processes (e.g. acoustics, mark-recapture) could be used instead. The real benefit of the approach is that it maximises use of information contained in the full dataset, so that, for example, the abundance estimate in any one year is partially informed by data from all years rather from only that year's data, since abundance is related through time. For the CA Current dataset, it is estimated that approximately 2,000 whales use the study area. The main trend parameter was estimated too imprecisely to make inference about overall abundance trend, but there is strong evidence that the abundance of adult males has increased since the early 1990s.

The sub-committee thanked the authors for presenting this method, noting that this hierarchical approach may be applicable to other time-series' of sightings surveys. There was some discussion as to whether acoustic data can be used similarly to sightings surveys. The authors commented that these data were useful to detect whale presence but could not be informative about group size, which has to be estimated independently using other methods (e.g. corresponding visual surveys) or by making assumptions about group size in the modelling process. It was queried whether click rates might be used to infer group size; Širović commented that there is some variation in click rate based on group sizes (e.g. group sizes of one, two or 'many' can be distinguished), but the difficulty of counting groups of more than two means such an approach is not feasible. The authors are currently integrating acoustic data with these sightings surveys. Acoustic detection distances vary depending on bandwidth, and can be detected 10-20km away, so potentially provide more detections than visual surveys. It was commented that acoustic-only time series data could potentially be used to infer trend if group size was assumed to remain constant over time, but cautioned that if oceanographic conditions and population demography shift then such an assumption is likely violated.

There is evidence that sperm whale distribution is influenced by oceanographic conditions; changes in oceanographic conditions may therefore influence abundance along the trackline, which means that reproductive processes may not be the only explanation for temporal abundance changes. The authors commented that at present sightings are too sparse to enable spatial modelling of sperm whales with habitat covariates, but that such an approach will be possible as data accrues. It was also commented that if sperm whale group sizes are increasing then this increases detection probability, and with the low numbers of sightings potentially a small number of large groups could upwardly bias abundance estimates. The authors commented that the great variation seen in group sizes is indeed a substantial contributor to the variance in the estimates.

The sub-committee discussed additional surveys that could be analysed in such a framework; the authors noted that they have not yet analysed time series of surveys from the Eastern Tropical Pacific, but are planning to do so using the same approach. The sub-committee **encouraged** the analysis of these data. The feasibility of surveying sperm whales south of Albany (Australia) was briefly discussed, but local weather conditions may be poor which could limit the feasibility of aerial surveys in this region. Acoustic surveys using towed hydrophones have effectively provided absolute estimates of sperm whale density in a number of areas and such surveys were considered a more realistic option for this region. Estimating group size from acoustic data alone can be challenging for large group sizes. Hence survey design may need to consider additional methods to estimate group size.

Alexander *et al.* (In prep) reports on the global population structure of sperm whales with an emphasis on regional populations in equatorial or temperate waters in each of the three ocean basins, including samples from the Voyage of the *Odyssey*, a five-year circumnavigation of equatorial whaling grounds. This document is now in revision for submission in a peer-reviewed journal. Alexander *et al.* (In prep) reports on a worldwide database of mtDNA control region haplotypes (394 base-pairs) from 1,587 sperm whale samples, combining 1,091 previously published samples with newly obtained DNA profiles (mtDNA, sex, 13 microsatellite loci) from 55 stranded individuals, and 441 individuals biopsied in previously under-sampled equatorial waters. The dataset was used to investigate diversity and differentiation between oceans, population structure within oceans, and female philopatry. A few key conclusions can be highlighted from the extensive analyses:

(1) mtDNA diversity of sperm whale is low, as reported previously, but sampling in the Indian Ocean did reveal new haplotypes, including 'private haplotypes' found only in that ocean;
(2) despite the absence of a phylogeographic signal in mtDNA, there is strong differentiation in haplotype frequencies between oceans and between many regions within population, with strong influence of regional fidelity in the previously unsampled Indian Ocean. There was also differentiation among social groups within regional populations, although many social groups include multiple matrilines; and
(3) finally, the results indicate that both geographic fidelity and social philopatry drive genetic structure in the sperm whale, but their relative importance differs by sex and by ocean, reflecting breeding behaviour, geographic features (e.g. marginal seas in the Atlantic) and perhaps a history of social disruption due to whaling in the Pacific.

In discussion it was noted that levels of population differentiation differ markedly between males and females. It is important to consider this aspect in the context of an assessment; matrilines may be the most useful indicator given the strongly matrilineal social structuring of this species. It was queried whether the low differentiation between regions in the North Pacific might suggest a recent expansion of a small population following whaling. In this regard it was noted that sperm whaling has a recent and very intense history in the North Pacific (likely generating a strong population bottleneck) whereas in the North Atlantic it has a much longer history but less intensity. The sub-committee **agreed** that further intersessional discussion of data related to stock structuring and catches of sperm whales would be useful for the upcoming assessment (see work plan, Item 8.2.3).

7. REVIEW PROGRESS ON PHOTO-IDENTIFICATION CATALOGUES

7.1 Antarctic Humpback Whale Catalogue

SC/66a/SH14 presented the interim report of the IWC Research Contract 16, the Antarctic Humpback Whale

Catalogue (AHWC). During the contract period, the AHWC catalogued 668 photo-identification images representing 541 individual humpback whales submitted by 27 individuals and research organisations. Matches made during the contract period to previously sighted individuals include re-sightings between breeding stock G and the Antarctic Peninsula (3). Within-region re-sightings were identified in breeding stock C3 (4), breeding stock G (22) and the Antarctic Peninsula (7). The database now contains records of 343 individuals identified in more than one year, 78 of these with sightings in three or more different years. One individual has been identified over a span of 28 years. There were 174 individuals identified in more than one region. These submissions bring the total number of catalogued whales identified by fluke, right dorsal fin/flank and left dorsal fin/flank photographs to 6,460, 414 and 409 respectively.

The sub-committee thanked the authors for the impressive amount of work presented. In discussion it was clarified that photo-IDs from BSG were from Isla Chiloé and did not include whales from the Magellan Straits. The sub-committee noted that the unusual summer sightings of whales in Cape Verde (*n*=3 whales in catalogue) suggest possible northward extension of the BSB breeding ground. The sub-committee congratulated the authors on this work, recognising the significant contribution of the Catalogue to our understanding of these whales, and **strongly endorsed** the continuance of the catalogue.

It was commented that the AHWC increasingly includes photo-IDs from low latitude Southern Hemisphere wintering grounds. In this regard it was suggested that the Catalogue might be a useful common repository for reconciling independent catalogues collected within wintering grounds, particularly BSG, where multiple catalogues exist from across both breeding and feeding ranges. Earlier multi-catalogue comparisons have suggested some sub-structuring of BSG (Acevedo *et al.*, 2008) and a comprehensive catalogue comparison would therefore be useful for future assessment. Catalogue comparisons are discussed further in Item 7.2.

7.2 Southern Hemisphere Blue Whale Catalogue

SC/66a/SH28 provided a summary of advances made by the SHBWC from June 2014 to May 2015 regarding uploading of catalogues, matching process among Australian catalogues, work conducted by the intersessional email correspondence group (see SC/66a/SH25) and advances in software improvements. A total of 1,101 blue whales are currently in the catalogue. In addition to Australian images, catalogues from South Africa and Madagascar have been added (or are being added) since last year. New catalogues from New Zealand and Sri Lanka are expected to be submitted within the next year. Preliminary results from SHBWC comparisons among Australian, New Zealand and Indonesian photo-identification catalogues are provided in Appendix 5.

The sub-committee welcomed this information, and acknowledged the work of Barbara Galletti in this valuable effort. They **recommended** the continuance of this work. It was noted that the reconciliation of catalogues and removal of duplicate whales before submission to the SHBWC remains a significant challenge for the catalogue. The authors noted that regional catalogues from Sri Lanka, South Africa and New Zealand are expected to be submitted in 2015/16.

SC/66a/SH25 is a compilation of responses from the intersessional email working group established in 2014 to address issues that had arisen related to the administration of the Southern Hemisphere Blue Whale Catalogue. The paper is thorough and detailed; in the interest of time it was summarised for presentation to the sub-committee. Six major topics are discussed in the paper, with each subject or difficulty that is described followed by suggested solutions or with a report of how the issue had been resolved. The six topics are: (1) the uploading of regional catalogues; (2) the internal consolidation of regional catalogues; (3) the matching process; (4) the role of opportunistic contributors; (5) the role of regional coordinators; and (6) software developments and IWC data requirements.

This paper responds to a 2014 IWC recommendation to further develop and reinforce SHBWC protocols and clarify the terms of reference to current, pending and future contributors to the catalogue. The sub-committee thanked the authors.

It was noted that the catalogue is an important source of data for capture-recapture analysis for the upcoming assessment, but complete date and location data associated with each identification are needed. Originally, photos only were required for contribution to the SHBWC since the focus had been on discovering linkages between regions. In order to enable the use of the catalogue for mark recapture, it is necessary to encourage regional data holders to contribute this additional data to the IWC for the purpose of the upcoming assessment. An intersessional email group was formed to determine the best way to approach this. The same intersessional email group will draft a set of guidelines for IWC sponsored photo-identification catalogues (see Item 7.5).

In order for future submissions to the catalogue to be usable for the IWC assessment, a change in the terms of reference for SHBWC submitters was **recommended**. This will be drafted and agreed intersessionally by a SHBWC intersessional email group convened under Jackson. In addition, three additional SHBWC developments were **recommended** for development by this group: (i) improvements to the English user manual; (ii) initiation of a forum to address user issues; and (iii) migration of the SHBWC catalogue to IWC servers for web hosting.

7.3 Antarctic Blue Whale Catalogue

SC/66a/SH26 presents the results of photo-identification effort on Antarctic blue whales during an interdisciplinary research voyage in the northern Ross Sea region of the Southern Ocean in 2015 (see SC/66a/SH07). A total of 46 Antarctic blue whales were photo-identified. The majority of blue whales approached for photo-identification were aggregated in two hotspots near the ice edge, which were surveyed during two time periods, 8-14 February and 24 February-2 March 2015. Thirty-six whales were photo-identified in the first hotspot and nine in the second hotspot (including one re-sight from hotspot 1). Two whales were photographed at the Balleny Islands on 6 February. Seven whales were re-sighted during the voyage; the re-sighting rate was 15%, similar to the re-sighting rates from the 2013 Antarctic Blue Whale Voyage and recent IWC/SOWER cruises. Time intervals between re-sights in 2015 ranged from one to 20 days and straight-line distances between re-sights ranged from 8km to 268km. Photographs of one whale from the voyage matched to the circumpolar Antarctic Blue Whale Catalogue with a time interval of two years and 103km between sighting locations. The 2015 voyage was conducted as part of the Antarctic Blue Whale Project under the SORP. The photo-identification data collected during the voyage will contribute towards a new abundance estimate of Antarctic blue whales using capture-recapture methods.

In discussion the sub-committee noted that this addition increases the size of the current Antarctic blue whale catalogue by 25%, highlighting the great value of acoustic methods for finding whales. Use of the catalogue for population assessment was discussed; do these within-season re-sightings suggest the possibility of regional sub-division within the Antarctic blue whale meta-population? In support, genetic differentiation has been found between most Antarctic Areas for blue whales (Sremba *et al.*, 2012), consistent with data from *Discovery* marks (Hardy, 1940). The author commented that photo-identification matching across all regions is required to evaluate such substructure, noting that SC/66a/SH26 is the second Ross Sea survey and only one whale was re-sighted between surveys. Her experience is that some blue whales are re-sighted locally and others over long distances, suggesting heterogeneity in behaviour within the population. While some genetic samples have been co-collected alongside photo-identification, the sex of 25% of re-sighted whales was not known. The possibility of deriving regional mark recapture abundance estimates from Antarctic Areas with good photo-identification sampling was raised; a proof of concept study is in preparation for estimating blue whale abundance from Area III (Olson and Kinzey, In press). It was noted that since Areas III and V have higher blue whale densities (Branch *et al.*, 2007) these would be good candidates for regional investigation. It was commented that as genetic samples accrue for Antarctic blue whales, it will be useful to evaluate sub-structure via population assignment, without grouping by Antarctic Areas *a priori*.

7.4 Other photo-identification catalogues

SC/66a/BRG13 summarised information from the Australasian Right Whale Photo-Identification Catalogue (ARWPIC), which is a centralised repository for data about individually identified southern right whales, accessed via an online portal[2]. It was developed in response to a need for functional integration of disparate Australasian photo-identification datasets, which are most powerfully used in combination. Those holdings, often collected by individual researchers or managers in isolated local or regionally-based projects, sometimes over many years, have typically been held in different formats in desktop systems. Despite being largely collected with public funds, the data have been largely inaccessible to other researchers, managers, the wider scientific community, and the public.

The sub-committee welcomed this news and expressed appreciation for the development of this new catalogue, which will be useful for studies of Australian right whale life history and abundance. It was noted that the database software developed in SC/66a/BRG13 could be used to develop other whale catalogues and was not restricted to right whales. There was some discussion regarding the open access nature of the database and the level of data protection afforded to catalogue contributors. It was clarified that all location data provided by all catalogue users was retained securely and protected by data availability agreements. It was noted that the photo-identification catalogue is currently composed of large Australian photo-identification collections, and highlighted that small photo-identification databases such as the one collected from southeast Australian right whales will also be important to include because they represent a significant portion of the small population using that area. The authors explained that the project plan was to give initial momentum to the catalogue by including the large photo-identification datasets which are time-consuming to reconcile, and add smaller datasets in after this stage.

[2]*https://data.marinemammals.gov.au/arwpic/.*

7.5 IWC photo-identification catalogue guidelines

The sub-committee **recommended** the development of a set of IWC guidelines for photo-identification catalogues contributing to IWC population assessments. Where catalogues are supported by IWC funds, these guidelines may be imposed as conditions for IWC support.

Features of the guidelines may include, but not be restricted to: (1) conservation and scientific benefits of shared catalogues; (2) conditions for submission by image contributors including minimum quality considerations and levels of associated data that are submitted with the images; (3) conditions under which associated data can be released and to whom (including application protocols to smooth the process); (4) protocols for standard classification of photographs; (5) protocols for regular matching and QA/QC; and (6) a template for annual reporting. An intersessional email group was formed to develop a draft set of guidelines for agreement during SC/66b.

8. UPDATED LIST OF ABUNDANCE ESTIMATES

A list of Southern Hemisphere humpback and blue whale abundance estimates was compiled in response to a Commission request to the Convenors. The following criteria were used in selecting these estimates.

(1) Estimates were reviewed and agreed by the Committee for use in the latest assessments of either blue or humpback whales.
(2) Estimates are as current as possible.
(3) Humpback breeding ground estimates are preferred because of potential mix of stocks in the high latitude feeding areas. These are presented in Table 2.

9. OTHER

SC/66a/SH29 presents the first genetically confirmed documentation of living Omura's whales, including descriptions of basic ecology and behaviour from northwest Madagascar. Species identification was confirmed through molecular phylogenetic analyses of biopsy samples from 23 animals. All individuals shared a single haplotype in a 402bp sequence of mtDNA control region, suggesting low diversity and a potentially small population. Sightings of 44 groups indicated preference for shallow-water shelf habitat with frequent observations of lunge feeding, likely on zooplankton. Observations of five mothers with young calves, and recordings of a stereotyped, repetitive song-like vocalisation uttered in choruses indicated reproductive behavior. Social organisation consisted of loose aggregations of predominantly single individuals that were spatially and temporally clustered. Photographic recapture of an adult female re-sighted the following year with a young calf, and reports of continual presence at least from April to December, suggest a resident population. Our results demonstrate that the species is a tropical whale without segregation of feeding and breeding habitat, and is likely non-migratory. The extension of the range of this rare whale into the western Indian Ocean fundamentally alters the understanding of this potentially widely distributed species, and raises questions about the demography, dispersal, radiation and genetic continuity among populations.

The sub-committee welcomed this new information on a poorly known Southern Hemisphere species. Comments related to the genetic analyses presented are summarised in Annex I, Item 3.1. In discussion, it was noted that genetic surveys of Bryde's whales elsewhere in the northern Indian Ocean have not revealed any Omura's whales (Kershaw *et al.*, 2013), suggesting that the Madagascar population may

Table 2
Proposed Southern Hemisphere abundance estimates.

Population/ type*	Area	Use category[1]	Evaluation extent[2]	Year	Method[3]	Estimate	95%CI	Original reference	Comments
Humpback whale									
BSA	Brazil	1	1	2005	DS	6,300	4,300-8,600	Andriolo *et al*. (2006)	
BS B1	Gabon	1	1	2005	MR	6,800	4,350-10,400	Collins *et al*. (2010)	
BS B2	West South Africa	1	1	2001	MR	300	200-400	Barendse *et al*. (2011)	This small area estimate is thought to represent an unknown fraction of sub-stock BSB2
BS C1	Mozambique	1	1	2003	DS	6,000	4,400-8,400	Findlay *et al*. (2011)	
BS C3	Madagascar	1	1	2004	MR	7,500	2,100-12,700	Cerchio *et al*. (2009), IWC (2010)	
BS E1	East Australia	1	1	2010	DS	14,500	12,700-16,500	Noad *et al*. (2011)	
BS E2+E3+F	Oceania	1	1	2005	MR	4,300	3,300-5,300	Constantine *et al.* (2012)	
BS G	Ecuador	1	1	2006	MR	6,500	4,300-9,900	Félix *et al*. (2011)	
Arabian Sea	Arabian Sea	1	1	2007	MR	80	60-110	Minton *et al*. (2011)	
Blue whale									
Antarctic type	Antarctic, S of 60°S	1	1	1997	DS	2,300	1,100-4,500	Branch (2008a)	

*BS=Breeding Stock. [1]Use categories: (1) acceptable for use in in-depth assessments or for providing management advice; (2) adequate to provide a general indication of abundance; or (3) use to be determined. [2]Evaluation extent: (1) examined in detail; (2) partially examined but method standard; (3) unclear but method standard; (4) partially examined and new method; and (5) unclear and new method. [3]Method of calculation: DS=distance sampling, MR=mark-recapture.

be geographically isolated, with a disjunct distribution. There may be conservation concerns about this population, given that hydrocarbon exploration is intensifying in this area of the Indian Ocean. It was queried whether Omura's whales could have been subject to whaling, but mis-identified as Bryde's whales. However the Japanese northern Indian Ocean catch of Bryde's whales has been examined in detail and no unusual morphological features were reported (Ohsumi, 1977). The current photo-identification database for this population contains 20-30 whales and there are plans for repeat surveys in October 2015; additional surveys will be informative for mark-recapture analysis of the abundance of this population.

10. WORK PLAN AND BUDGET CONSIDERATIONS

During SC/65b, the Scientific Committee agreed budget allocations for the following two years (2014/15 and 2015/16). Funding was therefore agreed during SC/65b for all budgeted items shown in the following work plan (unless otherwise indicated). More details can be found in IWC (2015). The intersessional e-mail groups described in Items 10.1-10.6 are listed in Table 3.

10.1 Humpback whales

10.1.1 Southern Hemisphere humpback whales

At SC/65b the sub-committee identified two key work items which were important for concluding the 2014 assessment of Australia and Oceania (BSD/BSE1/BSO). These were not completed intersessionally, so are retained in the work plan for completion by SC/66b. These are:

(1) work to evaluate the available genetic data, assumptions and analytical approaches for establishing mixing proportions of breeding stocks in the Antarctic (convened by Jackson); and
(2) measurement of the minimum abundance of BSD, which is only currently available as a preliminary value, but important to the interpretation of assessment results.

The sub-committee also **recommended** that the sightings data reported in DuFresne *et al.* (2014) be re-analysed, with a view to determining the most appropriate survey method for measuring BSD abundance in the future. Double acted as Convenor of this group.

The sub-committee strongly **recommended** these tasks to be completed by SC/66b. Work will be progressed by two intersessional email groups. Terms of reference of these groups and their membership are provided in Table 3.

Modelling work will be undertaken by Butterworth and colleagues with a budget allocation of £2,000 GBP in 2015/16 (see Item 3C in IWC, 2014a) to provide revised population assessments following completion of (1) and (2) above, and to develop a metaprior on r_{max} derived from Southern Hemisphere line transect abundance surveys and mark-recapture data.

Following the humpback whale synthesis review presented in SC/66a/SH03 the sub-committee **agreed** that more work would be required in order to prioritise data collection and modelling needs for future humpback whale assessments. It was **agreed** that this would be best achieved through an intersessional e-mail group led by Jackson, with members and terms of references identified in Table 3. The product of this work would be a summary document to be presented and discussed in SC/66b.

During the synthesis review it was suggested that it would be useful to compile a comprehensive database of mtDNA sequences and their associated nomenclature from across the Southern Hemisphere, to be held at the IWC Secretariat. Initial progress on this task will be achieved intersessionally via an e-mail group led by Baker and Rosenbaum (see Table 3). Compilation of published mtDNA haplotpes from breeding grounds and IDCR/SOWER surveys is anticipated to be complete by SC/66b. Subsequent development of a spatially and temporally explicit, open access, exportable database will be initiated at SC/66b.

The sub-committee recognised the long-term value of photo-identification catalogues to support future assessments and **recommended** that work continue on the Antarctic Humpback Whale Catalogue. This would be undertaken by Carlson and colleagues with a budget allocation of £15,000 GBP in 2016, as agreed during SC/65b. Details can be found in IWC (2014c).

Table 3
Intersessional groups.

Group	Terms of Reference	Membership
Humpback whales		
Estimate minimum abundance of BSD	To further evaluate the preliminary minimum estimate of BSD used in the assessment of humpback whale breeding stocks D/E/F.	Double (Convenor), Bannister, Butterworth, Kelly,
Progress on mixed stock analyses of humpback whales	Continuation of the previously established intersessional email group on mixed stock analysis of humpback whales (see IWC, 2015).	Jackson (Convenor), Baker, Butterworth, Double, Kitakado, Pastene, Ross-Gillespie, Waples, Weinrich
Prioritisation of SH humpback whale data and modelling needs	To decide a prioritisation scheme for work contributing to future SH humpback whale assessments (considering current data gaps and modelling needs), and establish set of draft priorities.	Jackson (Convenor), Baker, Bell, Butterworth, Kaufman, Rosenbaum, Ross-Gillespie, Weinrich, Zerbini
Develop SH humpback whale mtDNA database	To develop a Southern Hemisphere humpback whale mitochondrial DNA sequence database with common nomenclature, hosted by the IWC.	Baker, Allison, Donovan, Double, Kershaw, Rosenbaum, Steel,
Arabian Sea working group	Continuation of the previously established intersessional Arabian Sea working group.	Baldwin (Convenor), Brownell, Carlson, Collins, Findlay, Gales, Leslie, Rosenbaum, Willson, Weinrich, Zerbini
Blue whales		
Track whaling location of Antarctic blue whale baleen plates	Match up the baleen plates at the Smithsonian Institution with the original collection data in Japan.	Brownell and Kato (co-Convenors), Kishiro, Ososky, Potter
Locate missing pygmy blue whale photos	Find pygmy blue whale photo-IDs collected by IWC in the 1980s off Sri Lanka.	Brownell (Convenor), Donovan, Olson
Updated abundance and trends for Antarctic blue whales and fin whales	Inspect post-CPIII sightings data collected for Antarctic blue whales and fin whales, and Antarctic blue whale photo-IDs, with a view to providing updated abundance/ trend estimates.	Kelly (Convenor), Branch, Butterworth, Olson
Establish common mtDNA nomenclature and sample sets for SH blue whales	Identify and label mtDNA sequences from duplicated samples present on GenBank, and agree a common haplotype nomenclature for Southern Hemisphere blue whales	Lang (Convenor), Attard, Baker, Palsbøll, Rosenbaum,
Agree acoustic reference set for Southern Hemisphere blue whales	Reconcile different vocalisations for pygmy blue whales in order to agree a set of calls for comparative purposes	Širović (Convenor), Brownell, Cerchio, Miller
Proceed to an assessment of pygmy blue whale stock structure	Identify datasets (e.g. acoustic and genetic), analyses and studies relevant to assessing blue whale population structure and prepare summaries and reports for SC/66b. Ensure standard nomenclature for geographic regions associated with calls.	Lang (Convenor), Baker, Branch, Brownell, Double, Jackson, Mesnick, Rosenbaum, Zerbini
Discussion of recommendations for future work on pygmy blue whales	Agree set of regional recommendations for future work on pygmy blue whales for discussion at SC/66b.	Brownell (Convenor), Bannister, Branch, Double, Findlay, Galletti, Miller, Zerbini
Update SH blue whale catalogue terms of reference	Update terms of reference for the SH pygmy blue whale catalogue and initiate discussion forum to discuss and fix technical difficulties with catalogue usage. Discuss migrating catalogue to IWC servers.	Jackson (Convenor), Double, Findlay, Galletti, Olson, Salgado Kent, Weinrich
Engage regional catalogue holders from Chile/Peru in the SH pygmy blue whale assessment process.	Identify key contributors, form an email group, communicate IWC needs and organise a group meeting if necessary at the next Latin American Marine Mammal Conference (end 2016) to discuss this further, with a view to contributing photo-identification data to the upcoming IWC assessment.	Zerbini (Convenor), Brownell, Olson, Palacios
Conduct habitat modelling with sightings data from NZ and Australian seismic surveys	Investigate blue whale sightings collected from seismic vessels operating off New Zealand and Australia in the context of upwelling foci/habitat features.	Palacios (Convenor), Double, Lundquist
Investigate Chilean blue whale abundance in context of habitat models	Build regional habitat model and consider options for using abundance estimate to be informative about wider-scale density and abundance of this species.	Redfern (Convenor), Brownell, Galletti, Jackson, Palacios, Zerbini
Sperm whales		
Continue to investigate feasibility of a future sperm whale assessment	Continue to identify data availability and needs to undertake a future assessment of sperm whales. Information would be sought in the following categories: (1) population structure within ocean basins; (2) population size within ocean basins and abundance in smaller areas; (3) catch history; and (4) consideration of the development of a new assessment model.	Brownell (Convenor), Baker, Bannister, Bell, de la Mare, Hoelzel, Kasuya, Kato, Leaper, Mate, Matsuoka, Mesnick, Miyashita, Murase, Palacios, Perrin, Reeves, Smith, Whitehead
Exploratory investigation of sperm whale stock structure	Identify datasets, analyses and studies relevant to assessing sperm whale population structure and prepare summaries and reports for SC/66b.	Mesnick (Convenor), Alexander, Baker, Brownell, Clapham, Ivaschenko, Lang, Moore, Oliveira, Willson
Other		
Develop IWC photo-identification catalogue guidelines	Develop a draft set of IWC guidelines for photo-ID catalogues supported by the IWC and developed for the purposes of stock assessment.	Olsen, Jackson (co-Convenors), Allison, Baker, Bell, Brownell, Carlson, Donovan, Double, Findlay, Galletti, Kaufman, Matsuoka, Weinrich

In view of possible sub-structuring within BSG, differentiating the central American breeding ground from that off Ecuador/Colombia, the sub-committee expressed support for efforts to collect and reconcile photo-identification datasets from central America in order to better investigate that sub-structure. The sub-committee **recommended** that photo-identification comparisons be undertaken within Panama, combining studies conducted to the west of the study area (Rasmussen *et al.*, 2012) and ongoing photo-identification work occurring within the Gulf of Panama (Guzman *et al.*, 2014).

10.1.2 Arabian Sea humpback whales

Since 2014 the sub-committee have supported a combination of exploratory surveys and molecular genetics for the Arabian Sea population, undertaken by Willson, Rosenbaum and colleagues, with a budget allocation of £17,300 GBP in 2015/16. A compilation of humpback whale reports and sightings made off the west coast of India are reported in SC/66a/SH17 and the recommendations of the intersessional Arabian Sea humpback workshop are summarised by Minton *et al.* (2015).

Genetic analyses of new samples (20-30) collected off Oman will be conducted in 2015/16, including microsatellite genotypes in order to compare individuals with the Indian Ocean humpback whale database, and to population-level comparisons. Further details are provided in IWC (2014b).

The sub-committee **recommended** the continuance of the intersessional Arabian Sea working group convened under Baldwin.

10.2 Blue whales

10.2.1 Antarctic blue whales

Work on the Antarctic Blue Whale Catalogue is ongoing. During the upcoming year photographs contributed from various sources will be examined, including those submitted from South African, Japanese, French, German, Dutch and American colleagues, as well as from naturalists working in the Antarctic region. The addition of approximately 45 individuals is expected.

An intersessional email group was formed under Brownell and Kato in order to match the accession numbers of baleen plates from whales caught during the 1946/47 Antarctic season and currently stored at the Smithsonian with the Japanese whaling logs. Details are given in Table 3.

The sub-committee recommended a review of available photo-identification data, and other data from the post CPIII IDCR/SOWER surveys, to determine whether the data are of any use for informing on Antarctic blue whale trend or abundance, noting that the last abundance estimate for Antarctic blue whales dates to 1997 (mid-point of the CPIII survey). This intersessional work would be convened under Kelly (see Table 3).

10.2.2 Pygmy blue whales

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

(1) Work to continue on the Southern Hemisphere Blue Whale Catalogue. Work to be conducted by Galletti and associated researchers with a budget allocation of £18,300 GBP for 2015/16. Details of the proposed work are provided in IWC (2014d).
(2) Work on the SHBWC intersessionally: (i) update the terms of reference for the Southern Hemisphere pygmy blue whale catalogue; (ii) initiate a discussion forum to discuss and fix technical difficulties with catalogue usage; (iii) edit the English user manual; and (iv) organise migration of photo-identification catalogue to IWC web servers. Progress on these tasks are important for future mark-recapture assessments of blue whale abundance and interchange. This intersessional email group will be led by Jackson.
(3) Engage regional catalogue holders from Chile/Peru in the Southern Hemisphere pygmy blue whale assessment process. A working group convened under Zerbini will identify key contributors, form an email group, communicate IWC needs and organise a group meeting if necessary at the next Latin American Marine Mammal Conference at the end of 2016 to discuss this further with a view to contributing photo-identification data to the upcoming IWC assessment.
(4) Establish a common nomenclature for Southern Hemisphere pygmy blue whale mtDNA haplotypes and identify where DNA sequencing from the same individual has been duplicated and published multiple times on *Genbank*. This intersessional email group will be convened by Lang.
(5) Establish a working group to agree on the number of call types and map their distribution in the Southern Hemisphere and northern Indian Ocean for possible use in stock assessments. This group will be convened by Širović.
(6) Establish a working group to gather data useful for informing stock structuring of pygmy blue whales, with particular focus on genetic and acoustic methods. This work will be convened by Lang and presented during a joint SH/SD session at SC/67a.
(7) A series of recommendations for future work on pygmy blue whale stocks was presented in SC/66a/SH21. These will be developed intersessionally via an e-mail group convened under Brownell, for presentation at SC/67a.
(8) Based on the population review in SC/66a/SH21, it is believed that the northern Indian Ocean (NIO) blue whales face the most serious threats due to ship strikes and possible bycatch. This concern relates the massive removals of almost 1,300 whales in the 1960s and the unknown size of the current remaining population. The sub-committee therefore **strongly encouraged** the collection of genetic samples of pygmy blue whales in the waters off Sri Lanka, as this will enable determination of the differentiation of these whales from other Southern Hemisphere stocks. In addition, there is a need to gather in one place all available photos (started by de Vos) for a Sri Lankan photo-identification catalogue, the collected genetic samples and acoustic data for stock delineation, a compilation of sightings data since early 1982, especially from around Sri Lanka, and a reconfirmation of the location for Soviet catches in the NIO. The sub-committee **agreed** to initiate a search for IWC pygmy blue whale photo-IDs collected by researchers in the 1980s off Sri Lanka. Such data would be extremely valuable as photo-IDs from this region are limited. This effort will be convened by Brownell.
(9) The sub-committee **recommended** further investigation of the mark-recapture estimate of abundance obtained off Isla Chiloé (SC/66b/SH10) in the context of local environmental conditions, with a view to developing a habitat model for blue whale use of the waters off Chile. The possibility of using this habitat model to predict feeding ground abundances off Chile more widely will be discussed and evaluated. This group will be convened by Redfern.
(10) It was noted that marine mammal sightings from several recent seismic surveys off the west coast of New Zealand may be informative about blue whale foraging hotspots in the context of oceanographic features. The sub-committee **agreed** it would be useful to investigate these blue whale sightings in the context of upwelling foci identified from satellite imagery off the New Zealand coast and **encouraged** future work on this topic. Marine mammal observer data from seismic surveys conducted off Australia would also be useful to investigate in this regard. An intersessional email group convened by Palacios was initiated to progress this.

10.3 Sperm whales

The sub-committee r**ecommended** the continuation of an intersessional e-mail group to consider the feasibility of a future assessment of sperm whales, convened by Brownell.

The sub-committee also **recommended** the formation of an intersessional e-mail group to gather data useful for informing stock structuring of sperm whales, for discussion at SC/66b as combined SH/SD session. This will be convened by Mesnick.

10.4 SORP

During SC/65b the sub-committee **recommended** the continuation of the five ongoing IWC-SORP research projects. It also **recommended** the continuation of a funded coordinator position within IWC-SORP to achieve the following: (1) ensure the communication of high-calibre scientific research to Scientific Committee, the IWC and the wider scientific community; (2) leverage future funding; and thus (3) sustain the momentum of the collaborative research effort. £13,000 GBP were allocated from the biennial Scientific Committee budget. The 2014/15 expenditure against this budget was £6,960 GBP; the remainder will be expensed intersessionally in continuation of the activities above during 2015/16 (SC/66a/SH24).

Project activities planned for 2015/16

- Analysis of data resulting from the two IWC-SORP voyages conducted in 2015 (SC/66a/SH07; SC/66a/SH20; SC/66a/SH08rev, annex 1).
- Continued field seasons of data collection via the NSF Long-term Ecological Research Program (Friedlaender as Principal Investigator), including a research cruise and dedicated research on cetaceans at Palmer Station. Satellite-linked tags and short-term suction-cup tags will be deployed on humpback whales to study their feeding ecology and behaviour in January 2016, and biopsy samples will be collected for molecular genetic analysis of humpback whale population structure and dynamics (SC/66a/SH08rev, annex 3).
- Preparation and conduct of fieldwork around Raoul Island, New Zealand, October 2015, to collect skin biopsies for DNA profiling and isotope analysis, collect photo-identifications and deploy satellite tags of Oceania humpback whales (BSO) on their southward migration in order to determine their Antarctic feeding grounds (SC/66a/SH08rev, annex 4).
- Retrieval and redeployment of passive acoustic recorders within the Southern Ocean Hydrophone Network (SC/66a/SH08rev, annex 5) off Casey Station and on the Kerguelen Plateau (2016).

10.5 Fin whales

The sub-committee agreed to initiate discussion of Southern Hemisphere fin whales at SC/66b along the lines of the assessment process currently being progressed for blue whales. The sub-committee **recommended** that the post CPIII survey data also be inspected for fin whale sightings with a view to estimating abundance or trend. It was noted that Southern Ocean fin whale acoustic data (SC/66a/SH18) are also being collected by the IWC-SORP acoustic trends project (SC/66a/SH08rev, annex 5) and may be relevant to consider in this exercise. Intersessional discussion of this item is to be combined with the Antarctic blue whale updated abundance and trend e-mail discussion group described in Item 10.2.1 and Table 3.

10.6 Other

The sub-committee **recommended** the development of a set of IWC guidelines for photo-identification catalogues contributing to IWC population assessments (Item 7.5). An intersessional email group was formed to develop a draft set of guidelines for agreement during SC/66b.

11. ADOPTION OF THE REPORT

The report was adopted on 30 May 2015 at 17:15. The Chair thanked the rapporteurs for all their hard work.

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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. Southern Ocean Research Partnership
3. Southern Hemisphere humpback whales
   - 3.1 Review new information
     - 3.1.1 Breeding stock B
     - 3.1.2 Breeding stocks D/E/F
     - 3.1.3 Breeding stock G
     - 3.1.4 Feeding grounds
   - 3.2 Review of Southern Hemisphere humpback whale assessments
     - 3.2.1 Results of intersessional modelling work
       - 3.2.1.1 Intersessional email group on mixed stock analysis
       - 3.2.1.2 Defining a minimum abundance for BSD
       - 3.2.1.3 Intersessional population modelling
     - 3.2.2 Synthesis review and future directions for humpback assessments
     - 3.2.3 Conclusions and recommendations
4. Arabian Sea humpback population
   - 4.1 Review new information
   - 4.2 Progress toward development of a Conservation Management Plan and other conservation initiatives
5. Assessment of Southern Hemisphere blue whales
   - 5.1 Southern Hemisphere population structure
   - 5.2 Antarctic blue whales
     - 5.2.1 Cruise reports
     - 5.2.2 Acoustic studies
   - 5.3 Pygmy-type blue whales
     - 5.3.1 Chilean blue whales
6. Review new information on sperm whales
7. Review progress on photo-identification catalogues
   - 7.1 Antarctic Humpback Whale Catalogue
   - 7.2 Southern Hemisphere Blue Whale Catalogue
   - 7.3 Antarctic Blue Whale Catalogue
   - 7.4 Other photo-identification catalogues
   - 7.5 IWC photo-identification catalogue guidelines
8. Updated list of abundance estimates
9. Other
10. Work plan and budget considerations
    - 10.1 Humpback whales
    - 10.2 Blue whales
    - 10.3 Sperm whales
    - 10.4 SORP
    - 10.5 Fin whales
11. Adoption of the report

Appendix 2

AN UPDATE ON BIOLOGICAL DATA PUBLISHED ON SOUTHERN HEMISPHERE HUMPBACK WHALES FOLLOWING THEIR COMPREHENSIVE ASSESSMENTS 2006-14

This appendix summarises Southern Hemisphere specific publications on humpback whale distribution, abundance, trend, connectivity, genetic resources, threats and impacts which have become available since the Scientific Committee comprehensive assessment of each relevant breeding stock and sub-stock. This summary was compiled from documents submitted to the IWC Southern Hemisphere sub-committee, publications in the Journal of Cetacean Research and Management, and a search of 'humpback whale' on Web of Science, dated back to 2006. Breeding stocks BSD and BSE1 are not listed here, as no new relevant studies/datasets have been identified as becoming available since their assessment in 2015.

SUMMARY

Of all the breeding stocks, BSG is the only one currently with sufficient new information to enable a more in-depth assessment than previously attempted.

[Table on following pages]

Table 1

Data table with all relevant data collected on each Southern Hemisphere humpback whale breeding stock since each assessment was completed.

Population	Assessment date	Distribution information	Abundance and trend information	Population connectivity (BB=breeding-breeding stock, BF=breeding-feeding ground)	Genetic data	Threats and human impacts
Breeding Stock A (Brazil)	2006	Satellite telemetry data on winter humpback distribution and habitat use shows widespread movement along Brazilian coast (de Castro *et al.*, 2014). Humpback whales sighted off Trindade Island (20.3°S, 29.19°W) July-August 2007. Un-known whether resident or migratory (Siciliano *et al.*, 2011b).	2008 aerial survey along Brazilian coast, ($g(0)$=0.68) yields N_{2008}=9,330, CV=0.16 (Wedekin *et al.*, 2010). IWC SC concerns over accounting for perception bias. Correct $g(0)$ for the survey unknown.	BB: Female movement from BSA to Madagascar (BSC3) (n=1) (Stevick *et al.*, 2011). BB: Photo-ID resight of female between BSA and Colombia (BSG) (Stevick *et al.*, 2013). BF: Satellite telemetry tracks from Abrolhos Bank show strong connection (n=7 of 11 tracked whales) to 22-24°W and southern boundary of ACC. One whale travelled east towards mid-Atlantic ridge, then south (Zerbini *et al.*, 2011). BF: Photo-ID resight (n=1) between Abrolhos Bank and Shag Rocks (37'7°W) (Stevick *et al.*, 2006).	~300bp of mtDNA control region sequ-ences from 158 humpback whale bones collected from old Antarctic whal-ing stations (Sremba *et al.*, 2015).	Wintering ground not protected by MPAs in majority of its range (de Castro *et al.*, 2014). Unusual mortality event, apparent spike in strandings in 2010, cause unknown. Annual strandings highest Sep.-Oct., majority of stranded animals immature and pre-dominantly male. *Vibrio* detected but unclear whether causative, or product of poor health (Fulgencio de Moura *et al.*, 2012; Siciliano *et al.*, 2011a). Entanglements recorded in fishing gear (n=3) (Fulgencio de Moura *et al.*, 2012). Parasite *Cyamus boopis* identified in six humpbacks as part of parasitological study of Brazilian cetaceans (Carvalho *et al.*, 2015).
Verdict: *New breeding-feeding ground connections consistent with high latitude catch allocations used in 2011 assessment. New data not likely to significantly change 2006 assessment outcomes.*						
Breeding Stock B (BSB1, BSB2) (west coast of Africa)	2012	Northwestern component of BSB1 described in waters off Guinea, Guinea-Bissau, The Gambia, Senegal. Equivalent search effort with no humpbacks encountered off Mauritania, western Sahara and Morocco (Van Waerebeek *et al.*, 2012). June/July humpback whale sightings in Cape Verde suggest possible northward extension of BSB into Northern Hemisphere breeding ground (Hazevoet *et al.*, 2011). Whales satellite tracked in Gabon moved throughout Gulf of Guinea, including two cow-calf pairs travelling north late season, potentially to another breeding area to the northwest (Rosenbaum *et al.*, 2014). Eight whales satellite tracked from west South Africa feeding ground end of October travelled to Southern Ocean via Bouvet Island. Three were tracked to ~14°W, one to ~37°E. Both are areas of mixing with adjoining breeding stocks (SC/66a/SH30).	-	BF: Satellite telemetry from Gabon shows southward migratory movement along Angolan coast, and movement offshore close to Walvis Ridge, tracking that oceanographic feature (Rosenbaum *et al.*, 2014). Photographs of flukes, dorsal fins and cookie-cutter scars collected from Namibia during northbound migration suggest Namibia is visited on migration, with high incidence of fresh cookie cutter scars (compared to low incidence in WSA) suggesting whales join coastline at Namibia from high latitude feeding grounds, rather than passing through WSA (Elwen *et al.*, 2014).	Population struct-uring of BSB1 and BSB2 investigated using mtDNA and microsatellite mark-ers, shows WSA summer feeding gro-und and late season migrants to be sign-ificantly differen-tiated from Gabon (Carvalho *et al.*, 2014).	Satellite telemetry suggests Gulf of Guinea wintering habitat is coincident with oil platforms and shipping (Rosenbaum *et al.*, 2014).
Verdict: *Some updates on data available during 2012 assessment, with sightings information from Namibia suggesting a BSB1/BSB2 mix, or predominantly BSB1 whales on northward migration. Range of low latitude catch allocations (between BSB1/BSB2) explored in 2012 assessment (e.g. Sen B4 - IWC (2012) with little impact on r, K and recovery. Therefore new data not likely to significantly change 2012 assessment outcomes.*						
Breeding Stock C1 (east coast of Africa)	2010	Satellite tracking indicates use of waters off Somalia, northern Kenya, Aldabra (see connectivity) (Cerchio *et al.*, 2013).	-	BB: Satellite telemetry shows direct movements between eastern Madagascar (BSC3) and northern BSC1 waters off Somalia, Northern Kenya, Aldabra (Cerchio *et al.*, 2013).	-	-
Breeding Stock C2 (Mozam-bique Channel)	2010 assessed as part of BSC3 in 2010 assessment	-	-	BB: Satellite telemetry shows one within-season movement between BSC2 and BSC3 (Fossette *et al.*, 2014). BF: Satellite telemetry shows some BSC2 whales migrate south along Madagascar west coast (Fossette *et al.*, 2014). Tracks (n=2) end at Crozet Plateau (48°E), and also 27°E, west of 'core' BSC feeding grounds.	-	-

Population	Assessment date	Distribution information	Abundance and trend information	Population connectivity (BB=breeding-breeding stock, BF=breeding-feeding ground)	Genetic data	Threats and human impacts
Breeding Stock C3 (eastern Madagascar)	2010	Satellite telemetry reveals widespread wintering habitat along east coast of Madagascar (Cerchio *et al.*, 2013).	-	BB: Of 320 fluke photo-IDs collected from Reunion (BSC4), three match with BSC3, suggesting some exchange (Dulau-Drouot *et al.*, 2011).	-	-
Breeding Stock C4 (Mascarene Islands)	-	-	-	See BSC3 above.	-	-
Verdict: *Catch allocations in 2010 assessment consistent with breeding-feeding ground connections observed by satellite telemetry (one in core area, one in B/C mixing area 10-30°E). Supports potential BSB/BSC joint assessment in future, to better allocate catches on common high latitude grounds. Additional connections between sub-stocks BSC2/3 and BSC3/4 have been established by photo-ID matching since the 2010 assessment, but at present no abundance/trend for BSC2 to enable distinct assessment of this sub-stock or explicit inclusion in future assessment model. BSC4 may be migratory route for BSC3; further work required. Current data not likely to significantly change 2010 assessment outcomes or enable a more fine-scale assessment of the breeding sub-stocks.*						
Breeding Stock E1 (East Australia)	2014	-	-	BF: One photo-ID match with Adélie Land	-	-
Breeding Stock E2 (New Caledonia)	2014 (grouped as 'Oceania' single stock with E2, E3 and F2)	-	Trend derived from photo-ID 1996-2012 in southern lagoon of New Caledonia, (and surveys from southerly seamounts 2008-11) (Orgeret *et al.*, 2014). Trend=15% p.a (95% CI 11-20%), above biologically plausible natural reproductive limits.	-	-	-
Breeding stock F2 (French Polynesia)	As above	Winter survey of Tuamotu/Gambier Islands 2010: photo-IDs (n=7 unique IDs) and biopsy samples (n=10) collected (Poole *et al.*, 2013). Winter survey of Austral islands 2013: photo-IDs (n=22 unique IDs) and biopsy samples (n=34) collected (Poole *et al.*, 2014).	-	See BSG mixed stock analysis below (SC/66a/SH13). One genotype match between French Polynesia and the west Antarctic Peninsula (WAP) suggests possible east Oceania feeding ground connectivity with the WAP, as previously indicated by Robbins *et al.* (2011).	-	-
Verdict: *The 2014 assessment grouped the Oceania breeding sub-stocks BSE2, BSE3 and BSF2 as one unit. In order to assess the sub-stocks separately, abundance (and trend where possible) are required from individual Oceania breeding grounds. Continued collection of photo-identifications and biopsy samples to build a mark-recapture dataset for French Polynesia is particularly important, as the mark recapture abundance estimate for French Polynesia has the poorest precision (Constantine et al., 2010). There is no data here that will change the 2014 assessment outcomes or enable a more fine-scale assessment of breeding stocks.*						
Breeding Stock G (Central America, Ecuador, Colombia, Peru)	2006 (repeated with updated abundance estimate in 2011)	Satellite telemetry of n=15 whales off Panama shows widespread use of wintering ground and within-season connectivity with Colombia (Guzman *et al.*, 2014). 2007 photo-ID/sighting survey in Panamanian waters yields no recaptures with previous years (Rasmussen, 2008). 2002-12 surveys of waters of Gulf of Chiriqui, western Panama yield n=267 unique photo-IDs, with an inter-annual re-sight rate of 9% (Rasmussen and Palacios, 2013). Updated to n=396 unique photo-IDs in 2013 with average resight rate of 13% (Rasmussen and Palacios, 2013). Updated to 492 unique photo-IDs in 2014, with 21% of new whales seen in previous years (SC/66a/SH16).	Photo-IDs from 2003-09 in La Perlas Archipelago, Panama used with open population model. N_{2009}= 1,041 (95%CI 664-1,546) (Guzman *et al.*, 2014). Annual abundance and trend estimated for Magellan Strait feeding ground with fluke photo-IDs 2002-12 using a Complete Data Likelihood mark recapture model. N_{2012}=88 (95% PI 81-95). Median growth 2004-12=3.2% (95% PI 1.9-	BB: No mtDNA genetic differentiation detected between Ecuador and Colombia (Félix *et al.*, 2012). BB: Photo-ID comparison across BSG reveals four matches between Ecuador (n=1,289) and Costa-Rica/Panama (n=98) (Félix *et al.*, 2009). BB: Photo-ID comparison Ecuador (n=1,470) and Peru (n=96) yields two matches (Castro *et al.*, 2011a). BF: No genetic differentiation between Ecuador and Antarctic Peninsula; significant F_{ST}/Φ_{ST} differentiation between Ecuador and Magellan Strait (Félix *et al.*, 2012). BF: Photo-IDs from Ecuador (n=1,172) compared with rest of BSG, n=56 matches with WAP, n=4 matches with Magellan Straits (Castro *et al.*, 2008a). Updated: n=1,560 photo-IDs from Ecuador reveal 64 matches with WAP	mtDNA from n=182 whales collected 2002-08 off Ecuador (Félix *et al.*, 2012).	Entanglements n=13 off Santa Elena Peninsula, 2004-08, consequence of two ports and intense artisanal fishing (Félix and Botero-Acosta, 2009). Photo catalogue from Ecuador examined for unusual skin conditions: 160 anomalous cases, 45 considered in detail. Study speculates on possible origins of these conditions (Castro *et al.*, 2011b). Ship strikes are a potential threat for humpback whales in Panamanian waters and in the Magellan Straits. A simulation study indicates that with the current population parameters, one adult whale collision every three years could generate a population decline on the Magellan Strait feeding ground (Gende *et al.*, 2014).

Population	Assessment date	Distribution information	Abundance and trend information	Population connectivity (BB=breeding-breeding stock, BF=breeding-feeding ground)	Genetic data	Threats and human impacts
		A 2009-11 sighting survey from Punta Avita, Costa Rica characterises local distribution (Palacios-Alfaro *et al.*, 2012). 1996-2007 photo-ID survey from Machalilla National Park, Ecuador, *n*=1,172 identified whales - 7% recaptured over survey period (Castro *et al.*, 2008b). Distribution of humpbacks characterised around Santa Elena Peninsula, Ecuador 2001-08 (Félix and Botero-Acosta, 2009). Sightings surveys in Galapagos indicate possible year-round presence (Castro and Merlen, 2009). Distribution and habitat survey in waters of northeastern Peru indicates this area is also used for breeding/calving (Guidino *et al.*, 2014). Feeding ground: summer sightings north of Magellan Straits suggest possible feeding off Isla de Chiloe, Corcovado Gulf, may be northern extent of Magellan Strait feeding ground (Acevedo *et al.*, 2008a; Vernazzani *et al.*, 2008). Feeding ground: Satellite telemetry of 11 whales on WAP feeding grounds shows WAP (BSG) feeding range includes western Weddell Sea (*n*=1 tracks east to 50°W) (Dalla Rosa *et al.*, 2008).	4.5%) but appears constant from 2005 (Gende *et al.*, 2014).	(*n*=611) and two with Magellan Straits (Castro *et al.*, 2012). BF: Photo-identifications connect Panama with West Antarctic Peninsula (WAP), (*n*=8) and also (*n*=1) Chilean waters (Guzman *et al.*, 2014). BF: Photo-ID connect Costa Rica with West Antarctic Peninsula (*n*=7), no Magellan comparison (Rasmussen *et al.*, 2007). BF: Photo-ID analysis across BSG and Magellanic Strait/WAP suggests higher than expected connectivity between Central America and Magellanic Strait, possible breeding/feeding ground substructure (Acevedo *et al.*, 2008a). BF: Photo-ID match between Ecuador and South Orkney Islands (46°W), western South Atlantic, whale also sighted in WAP, suggesting eastern presence of BSG in Orkneys/western Weddell Sea (Dalla Rosa *et al.*, 2012). BF: Photo-ID comparison between Ecuador, and islands in the South Atlantic (catalogue for the latter area, *n*=23) in the western South Atlantic. One match between Ecuador and 56°16'S, 27°32'W, suggesting eastern extension of BSG or migratory movement between BSG/BSA (Castro *et al.*, 2011a). BF: Satellite tracking of humpbacks from Ecuador suggests solo adults travel south offshore, mothers with calves travel close to coast. One direct connection with WAP (Félix and Guzmán, 2014). BF: Mixed stock analysis of mtDNA haplotypes from Colombia, Brazil, the WAP, French Polynesia, New Caledonia and Tonga revealed 97.5% apportionment of WAP to Colombia and 1.5% to French Polynesia, confirming the strong connection between Colombia and the WAP (SC/66a/SH13). FF: Photo-IDs (*n*=17) from Chilean Corcovado Gulf compared with Magellan Straits and Antarctic Peninsula catalogue, no matches (Acevedo *et al.*, 2008b). One match between Isla de Chiloe (*n*=22 flukes) and Magellan Strait (Vernazzani *et al.*, 2008).		

Verdict: *Good potential for an updated assessment of this area. Abundance has been estimated for Magellan Strait feeding ground, and multiple comparisons of breeding ground/feeding ground photo-ID catalogues qualitatively indicate connectivity between Ecuador/Colombia and the Antarctic Peninsula, and possibly connectivity between Central America and Magellan Strait feeding grounds, although data are sparse and application of a quantitative framework for evaluating connectivity/exchange would be extremely useful. Satellite tracks from Ecuador suggest possible differences in migratory route depending on reproductive status, with mothers/calves travelling along the South American coast/ adults offshore; is it possible that coastal catches may have therefore predominantly been mothers/calves? Core catch allocation 50-100°W used in 2011 assessment (Johnston et al., 2011) is consistent with observations of whales in western Weddell Sea, so core BSG catch boundaries not updated by recent data.*

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Appendix 3

ARABIAN SEA HUMPBACK WHALE WORKSHOP: RECOMMENDATIONS FOR FOLLOW-UP ACTION[3]

(1) Form an Arabian Sea Humpback Whale Research Network: To include development of a mission statement and objectives and a clear set of conservation- and research-related roles for the members.
(2) Identify a focal point in each ASHW range state responsible for liaising with the network coordination team and for: (i) verification and documentation of all ASHW stranding and sighting reports; (ii) working with local communities, coastguards and others to collect data opportunistically; and (iii) assistance in drafting funding proposals and research plans for country-based or cross-border priority areas (in the most likely suspected current range of ASHW).
(3) Develop a common (web-based) platform for sharing documents, data and research protocols among network members. To include, if possible, a regional photo-identification matching platform.
(4) Establish data-sharing agreements for any web-based/group-wide data repositories, and memoranda of understanding between partners who embark on shared analyses to ensure proper data ownership and publication rights.
(5) Produce a 'glossy' presentation of ASHW background and conservation concerns that network partners can use to raise awareness and attract funding.
(6) Engage in dedicated fund-raising efforts to support network coordination and research activities at both national and regional scales.
(7) Implement regional research activities that include passive acoustic monitoring at strategic locations, dedicated boat surveys for genetic sampling, photo-identification and collecting data on distribution and numbers, and further analyses of acoustic and genetic data already obtained from Oman and other locations.
(8) Create a common pool of equipment and other resources that can be used for research and analysis in different range states as required.
(9) Encourage Master's and PhD candidates from range states to conduct research and conservation work on ASHWs.
(10) Execute a large-scale GIS exercise - mapping all known/confirmed ASHW sightings (with effort indices when available) and strandings for analysis of spatial/temporal trends, as well as overlap with known threats (e.g. shipping lanes, high-density fisheries that use gillnets or vertical lines, oil and gas exploration and development sites).
(11) Maintain liaisons with international and inter-governmental organisations that can support the network's aims and objectives and ensure that network findings/results are applied toward regional and international management and conservation frameworks.

Appendix 4

BALEEN PLATES FROM THE *HASHIDATE-MARU* AND *NISSHIN-MARU* DURING THE 1946-47 SEASON: THEIR COLLECTION, 'DISAPPEARANCE' AND REDISCOVERY

C.W. Potter[4], J.J. Ososky[4], J.G. Mead[4] and R.L. Brownell, Jr.[5]

INTRODUCTION

After the end of World War II (WWII), General Douglas MacArthur was the Supreme Commander of Allied Powers (SCAP) in Japan. MacArthur authorised Japan to resume whaling in the Antarctic and operations resumed in the 1946/47 season. Japanese Antarctic whaling operations were authorised to resuming hunting by the General Headquarters (GHQ), SCAP. Two factory ships operated during the 1946/47 Antarctic season, the *Nisshin-Maru* (*NM*) and the *Hashidate-Maru* (*HM*).

Under SCAP there was a Natural Resources Section and under that was a Fisheries Division (FD). The FD and the Australian government provided personnel to oversee the SCAP whaling operations in the Antarctic conducted by Japan, as they were not a member yet of IWC. During the 1946/47 season Lieutenant David R. McCracken, US Navy and Kenneth Coonan retired Petty Officer Royal Australian Navy were on board the *Hashidate-Maru* (McCracken, 1948). We have not been able to determine the non-Japanese observers on the *Nisshin-Maru*. The total catch for the 1946/47 season was 797 blue whales and 269 fin whales.

Here we report on the details surrounding the mystery of baleen plates collected during the 1946/47 and shipped to the USA where they were 'lost' and then rediscovered. We also propose a pilot project to study these materials.

Collection

Researchers in the 1940s were trying to find a way to age baleen whales and using baleen plates appeared to be a promising method. Therefore, sometime before the 1946/47 season, Dr. A. Remington Kellogg (ARK) of the Smithsonian Institution (SI) wrote to William C. Herrington

[3]Summarised in Minton, G., Reeves, R., Collins, T. and Willson, A. 2015. Report on the Arabian Sea Humpback Whale Workshop: developing a collaborative research and conservation strategy, Dubai, 27-29 January 2015. 50pp.

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(Chief of the Fisheries Division under the National Resources Section of SCAP) requesting that the largest baleen plates be collected and preserved from each rorqual processed during the 1946/47 SCAP Expeditions. Kellogg was a marine mammal paleontologist with no experience working on modern whales, but ARK was also the link with IWC. Therefore, ARK was in a key position to request the baleen plate samples from SCAP. Kellogg and Raymond M. Gilmore (RMG) of the US Fish and Wildlife Service wanted to attempt to age whales using their baleen. The specimens were collected on board the factory ships, and after they returned to Tokyo the baleen was shipped to the USFWS office in San Francisco and then to the SI. This collection of baleen was recently rediscovered in the Mammal Division collection in the National Museum of Natural History, SI.

Nishiwaki (1950) reported that during the first three Japanese Antarctic whaling seasons (1946/47-1948/49) after WWII a few of the largest baleen plates were collected from each rorqual processed on board the factory ships. However, Nishiwaki noted that he had access to only the baleen plates from the 1948/49 season for his study. Nishiwaki also explained that the baleen plates from ‘the first and second expeditions (1946-47 and 1947-48 season) were sent to the United States’. Until recently it was a mystery as to where the baleen plates from the first two seasons were shipped to in the United States. Nishiwaki (1951) also noted that ‘on board the factory ships the largest left and right baleen plates were collected as the sample from each whale’.

Nishiwaki (1952) reported that during the 1946/47 season the total catches for blue and fin whales were 690 (*NM* 396 and *HM* 294) and 474 (*NM* 289 and *HM* 185), respectively. In 1947/48, the totals for blue whales and fin whales were 710 (*NM* 436 and *HM* 274) and 397 (*NM* 397 and *HM* 211), respectively. Kasuya (2011) reported that the catch of the two factory ships during the 1946/47 was 932 blue whale units (BWUs). Humpback whales were taken for the first time after WWII by Japan during the 1949/50 Antarctic season [see WRI #6:75]. During the 1947/48 season the two government biologists on the factory ships were K. Mizue and T. Murata. The first non-Japanese expedition after WWII was the *Balaena* in the 1947/48 season. Humpback whales were not taken until the 1949/50 Antarctic season [see WRI #6:75]. Japan’s adherence to the Convention was on 21 April 1951, in time for the 1951/52 Antarctic season or their 6th post WWII season.

Disappearance

Kellogg and Gilmore, as far as we know, never examined the baleen collection during the SCAP expeditions. The study was probably going to be undertaken mainly by RMG, a terrestrial mammalogist who was working with ARK at the SI in the late 1940s. RMG was an associate curator of mammals at the National Museum in Washington; however, in the late 1940s he was transferred to the USFWS office in San Francisco, California to be in charge of a new whale research program for the USFWS, and then to San Diego where in December 1952 he began the work [Scripps Institution of Oceanography in La Jolla] on what he is best known for on gray whales (Gilmore, 1960). ARK moved into administration at Smithsonian in 1948 when he was named director of the National Museum of Natural History; then in 1958 he was appointed assistant secretary of the Smithsonian Institution. Thus, the interest to study these samples was lost.

Rediscovery

Recently we realised that a large collection of baleen (blue and fin whales) held at the Smithsonian Institution were those collected on board the two Japanese factory ships after the end of WWII. The collection of baleen is housed in about 30 museum storage cases (each is about a metre square).

Future

We propose a two-step project for this collection of blue whale baleen. The first step is for Japan (Kato and Kasuya) to attempt to find the original data (for 1946/47 and 1947/48) for these samples and associate it with the baleen. The second step is to confirm that DNA can be extracted from the baleen, as has been successfully achieved with baleen samples from other mysticetes. Funding is currently available for a pilot project to evaluate the feasibility of using next generation sequencing to generate mitogenomic sequences from a subset of the blue whale baleen plates (*n*=10-12). If this pilot project is successful, analyses of additional baleen samples from this collection can be used to assess the loss of genetic diversity and reconstruct the demographic history of Antarctic blue whales between the mid-1940s to the present time.

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Appendix 5

PRELIMINARY RESULTS ON COMPARISONS AMONG BLUE WHALE CATALOGUES OFF AUSTRALIA AND NEW ZEALAND HELD UNDER THE SOUTHERN HEMISPHERE BLUE WHALE CATALOGUE

B. Galletti Vernazzani

This Appendix summarises preliminary results from comparisons between catalogues of blue whales from Australia and New Zealand, conducted under the framework of the Southern Hemisphere Blue Whale Catalogue (SHBWC).

The Indonesia/Australian/New Zealand sub-catalogue of the SHBWC includes photographs of 356 individuals comprising 235 left side identification photos and 230 right side identification photos, and 26 fluke IDs (Table 1). Currently, almost 75% of left side comparisons have been completed. Right side comparisons will begin after the left side comparisons are concluded.

To date there is one match between AAD and BWS of an individual re-sighted three times in the Bonney Upwelling. The individual was first seen on 28 February 2005 (BWS), re-sighted on 12 January 2009 (BWS), and re-sighted on 19 January 2012 (AAD).

Although preliminary, this match highlights the value of collaborative efforts to better understand spatial and temporal patterns and provides evidence of a level of site fidelity to this feeding area. Jenner *et al.* (2008) reported one match from the Bonney Upwelling and the Perth Canyon and three matches from Geographe Bay and the Perth Canyon, showing connectivity between those regions. The fact that no matches have been found during our comparisons between these three areas are likely to be due to: (1) comparisons between Bonney Upwelling and Perth Canyon are not yet completed; and (2) both catalogues from Perth Canyon and Geographe Bay are still not fully uploaded to SHBWC. Matches may yet be found between these areas as comparisons continue.

While genetic analyses have found that New Zealand blue whales are similar to those found in Australia, the photo-identification analyses reported here have not found matches. Furthermore, SC/66a/SH06 also found no matches between 22 blue whales off New Zealand and 174 individual Australian blue whales[6]. The lack of matches between New Zealand and Australia may represent a level of site fidelity to feeding grounds that has been shown for other populations. However the small sample size from New Zealand still prevents a conclusion about a possible isolation from Australian population.

Table 1

Summary of photographic collection of blue whale catalogues under the Indonesia/Australian/ New Zealand sub-catalogue of the SHBWC. The catalogues were contributed by Blue Whale Study Inc. (BWS), Western Whale Research (WWR), Center for Whale Research (CWR), and Australian Antarctic Division (AAD).

Group	Whale ID	Left	Right	Fluke	Area
BWS	148	84	81	3	Australia - Bonney Upwelling
AAD	37	27	27	0	Australia - Bonney Upwelling
CWR[1]	117	83	89	23	Australia – Perth Canyon
WWR[1]	40	30	23	0	Australia – Geographe Bay/Timor Leste
MARVEL[2]	0	0	0	0	Australia
AAD	14	11	10	0	New Zealand
OSU[2]	0	0	0	0	-
Total	356	235	230	26	-

[1]Catalogue in process of uploading. [2]Catalogue not yet uploaded.

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[6]The internal matching process revealed that one of the catalogues used by Torres *et al.* in SC/66a/SH06 had 24 duplicated individuals seen multiple times, therefore their results were compared to less individuals than 174.