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Progress report on Southern Hemisphere Blue Whale Catalogue: Period May 2020-March 2021

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ABSTRACT

The Southern Hemisphere Blue Whale Catalogue has a total of 2189 individual blue whale photo-identifications (photo-IDs) that include regions off Antarctica, Chile, Peru, Ecuador-Galapagos, Eastern Tropical Pacific (ETP), Australia, Timor-Leste, New Zealand, southern Africa, Madagascar and Sri Lanka. From May 2020 to March 2021, new collections of photo-identifications (+416 IDs) have been received from areas off Chile, New Zealand, Timor Leste, Sri Lanka and the Southern Ocean. There are considerable reflecting the continual contributions of blue whale identifications over the years. Photo comparisons from within the Southeast Pacific and ETP with collection received up to March 2020 have also been completed. One match between southern Chile and ETP provides evidence of migratory movements and matches only within southern Chile and within northern Chile, revealing strong site fidelity to feeding areas. Datasets from Australia and Chile are being prepared to be used for regional blue whale assessments.

INTRODUCTION

In the Southern Hemisphere, the pygmy blue whale (*Balaenoptera musculus brevicauda*) in the Indian Ocean and western Pacific Ocean and the Antarctic blue whale (*B. m. intermedia*) in the Southern Ocean are currently recognized as two subspecies by the Taxonomy Committee of the Society for Marine Mammalogy¹. In addition, the yet unnamed subspecies or Chilean blue whale has been proposed as a separate subspecies (*B.m. spp.*) because it is morphologically (Branch *et al.* 2007; Leslie *et al.* 2020; Pastene *et al.* 2020), genetically (LeDuc *et al.* 2007; LeDuc *et al.* 2017), and acoustically (McDonald *et al.* 2006) distinct.

Since 2008, the International Whaling Commission has been supporting the project “Southern Hemisphere Blue Whale Catalogue (SHBWC)” as an international collaborative effort to facilitate cross-regional comparisons of individual blue whale photo-identification catalogues and contribute to Southern Hemisphere blue whale assessments (IWC, 2009).

The SHBWC uses specially designed online software that allows for simultaneous upload and comparisons between catalogues from regions off Antarctica, Chile, Peru, Ecuador-Galapagos, in the Eastern Tropical Pacific, Australia, Timor-Leste, New Zealand, Madagascar and Sri Lanka. Therefore the SHBWC has become the largest repository of Southern Hemisphere blue whale photo-identifications (Galletti Vernazzani *et al.*, 2019a).

Comparisons among different regions will improve the understanding of basic questions relating to blue whale populations in the Southern Hemisphere. The IWC Scientific Committee is currently conducting blue whale assessments on non-Antarctic blue whales and the work of the SHBWC has focus over the past years in comparing photo-IDs from these regions in order to provide useful data to produce abundance estimates.

This report summarizes the progress made between May 2020 to March 2021 on the work of the SHBWC.

¹ <https://www.marinemammalscience.org/species-information/list-marine-mammal-species-subspecies/>

USERS & UPLOADING OF CATALOGUES

Catalogues currently maintained in the SHBWC include those from waters off Antarctica, Chile, Peru, Ecuador-Galapagos, in the Eastern Tropical Pacific (ETP), off southeastern Australia, Western Australia, Timor-Leste, New Zealand, Southern Africa, Madagascar, Indonesia and Sri Lanka. A total of 2,189 blue whales are currently in the SHBWC; totaling 1,572 right side photo-IDs, 1,616 left side and 91 flukes (Table 1).

Overall, 24 blue whale research groups from all regions are contributing to the SHBWC. A considerable number of new photo-identifications (+416 IDs) have been received representing a 23% increase in blue whale photo-IDs over the last year.

New blue whale photo-ID entries from Centro de Conservacion Cetacea (CCC- up to 2015, Chile), Eutropia (Chile), Oregon State University (OSU-New Zealand), Universidade Nacional Timor Lorosa'e (UNTL-Timor-Leste) and opportunistic sightings off New Zealand and Southern Ocean have been received and uploaded.

CCC is finalizing their internal catalogue consolidation with new photo-ID encountered between 2016-2019 off southern Chile that consists of additional 155 blue whales. This large new dataset is not included yet on the summary table (Table 1). Photos and data are expected to be fully available before end of June 2021 to be compared with the other southeast Pacific catalogues during the next matching process.

Currently, the Antarctic sub-catalogue uploaded to the SHBWC includes photographs of 369 individuals contributed by IWC IDCR/SOWER surveys from 1987/1988 to 2008/2009, by the Australian Antarctic Division (AAD) from 2013, 2015, and 2019, by the Mammal Research Institute Whale Unit, University of Pretoria from 2014, by the British Antarctic Survey from 2020, and opportunistic sightings from 2005, 2016 and 2020. The photographs cover all six IWC Management Areas.

The Gulf of California/ETP/South America sub-catalogue includes photographs of a total of 872 individuals contributed by the SWFSC/NOAA during various years between 1992 to 2006 off the Galápagos Islands, Peruvian waters and the Costa Rica Dome, 1997/98 IWC/SOWER survey off Chile, Centro de Conservacion Cetacea off Chile between 2004 and 2015, MERI Foundation off southern Chile between 2014 and 2017, Panthalassa off Isla de Chañaral, northern Chile between 2010 and 2019, Eutropia off Isla de Chañaral, northern Chile from 2006, 2008 and between 2015-2019, and opportunistic sightings off Peru, northern Chile and southern Chile from 2010-2018.

The Australia sub-catalogue includes photographs of 502 individuals that were contributed by Blue Whale Study Inc. (BWS) from 1998 to 2009, AAD from 2012 and Flinders University from 2015 off Bonney Upwelling, Western Whale Research (WWR) from 1999 to 2003 off Geographe Bay, Center for Whale Research (CWR)² in Perth Canyon and Oceans Blueprint from 2017 and 2018 off Timor-Leste.

The New Zealand sub-catalogue includes photographs of 164 individuals that were contributed by AAD from 2013 and 2015, OSU with photo-IDs from surveys as well as opportunistic sightings between 2009-2018, NIWA from 2018 and other opportunistic sightings off New Zealand between 2004-2018.

The Timor-Leste sub-catalogue includes photographs of 131 individuals that were contributed by UNTL from 2014 to 2020.

Cascadia Research Collective, Olympia, WA, USA, has a Costa Rica Dome catalogue from the eastern Pacific and they have already agreed to join and upload photos to SHBWC. These data would be useful since we now know there is some movement of whales between Southern Hemisphere and Costa Rica Dome (Douglas *et al.*, 2015).

² Data on sightings dates and location have not been received yet.

Sri Lanka Datasets

The Sri Lanka sub-catalogue includes photographs of 151 individuals that were contributed by Asha de Vos.

In 2019, Biosphere Foundation (BF) provided an external hard drive with 510Gb of photo-IDs and data from Sri Lanka, obtained between 1983-1984 and 2010-2015 surveys. However, their catalogue was not yet reconciled. In 2020, the Scientific Committee agreed to reconcile and upload catalogue collections of blue whales off Sri Lanka from 1983-1984 and 2010-2015 contributed by BF. It also decided to undertake matching between newly contributed photo-IDs from BF off Sri Lanka (estimated approx. 20-30 IDs) with regional catalogues.

The dataset from BF was larger than expected:

- 1983-84 surveys reported 189 blue whale sightings with 136 photo-IDs that are still in the process of internal reconciliation.
- 2010 surveys recorded 61 sightings with no blue whale sightings.
- 2013 surveys recorded 40 sightings of which 22 were sightings of blue whales. 37 blue whale photo-IDs were identified by the research team but no related photographs are available. Instead, photos from the entire field surveys photos were provided.
- 2014 surveys recorded 196 sightings of which 115 were sightings of blue whales. No photo-ID are available for this period; instead photo from the entire field surveys were provided and need to be managed to get photo-ID numbers and associate data.
- 2015 surveys reported 75 sightings of which 23 were blue whale sightings. No photo-ID are available for this period; instead photos from the entire field surveys were provided and need to be managed to get photo-ID numbers and associate data.

To date, only 1983-84 photo-ID datasets have been reviewed. Of the 136 photo-IDs, 80 corresponded to fluke IDs, 26 to left side IDs and 39 right side IDs. Matching to check for duplicate individuals is still underway.

Data for 2013, 2014 and 2015 are still not yet analyzed. It is anticipated that there will be many additional photo-IDs from these datasets.

The large quantity of blue whale photographs and datasets to process indicates that the budget considered during the 2020 Scientific Committee meeting to conduct the work to reconcile photo-IDs from BF off Sri Lanka, upload them into the SHBWC, conduct photo-quality coding and the matching process within Sri Lanka catalogues have been considerably underestimated (based on the expected 20-30 IDs).

Another consideration is that most of the 1983-1984 photo-IDs are from fluke IDs and Asha de Vos's catalogue doesn't have fluke photo-ID so it would only be possible to conduct left and right comparisons between those two catalogues. It is still unknown how many left and right side photo-IDs will be obtained from 2013-2015 surveys, however it seems that BF and their associated research group focus are placing greater focus on obtaining more fluke photo-IDs.

MATCHING PROGRESS

Individual blue whales are identifiable from unique patterns of mottling on both sides of the body near the dorsal fin (Sears *et al.*, 1990) and from the highly variable dorsal fin shape (Gendron and Ugalde de la Cruz 2012). In some cases, permanent scars can be used to identify or confirm individuals. The SHBWC holds photo-IDs from left and right side of blue whales as well as the fluke, if available.

Initially, the SHBWC focused on regional comparisons within the southeast Pacific (the ETP and South America). Comparison between catalogues uploaded up to 2009 have been completed in 2011. One match was found over a ten-year period in southern Chile (Galletti and Cabrera, 2011). Also, comparisons were conducted between the regions of Antarctica, ETP and Chile uploaded through to 2009; no matches were

found for left and right sides (Galletti Vernazzani and Olson, 2013). Recently a major matching process has been completed with 838 individuals photographed from various research groups in southern and northern Chile and the ETP between 1998 to 2019, in addition to opportunistic sightings, which provided 25 re-sightings. One match reveals information on the connectivity and migration of blue whales from southern Chile to the ETP. Other matches were found only within southern Chile and within northern Chile, providing further evidence for strong site fidelity to feeding areas (Galletti Vernazzani *et al.*, 2021).

In 2015, major datasets from Australia/New Zealand/Sri Lanka were received and comparisons found five whales were re-sighted within Australia, but no matches were found between Australia and New Zealand (Galletti Vernazzani *et al.*, 2016). With new photo-IDs contributed to the SHBWC to January 2018, a new matching process began. 698 photo-identified blue whales from seven different research groups working in the Perth Canyon (southwestern Australia), Geographe Bay (southwestern Australia), Bonney Upwelling (southern Australia), around New Zealand, and Sri Lanka provided eighteen whales resighted between different areas. Matches were found between Australian catalogues and between New Zealand catalogues, but no matches were found between those two regions or with Sri Lanka (Galletti Vernazzani *et al.*, 2019b).

Regional comparisons within Southern Ocean have been systematically conducted by Olson (Olson *et al.*, 2020), under the IWC Antarctic Blue Whale Catalogue project, that also include photo-ID data from the Institute of Cetacean Research's expeditions (JARPA, JARPAII, and NEWREP A), and from photographs contributed by citizen scientists. Sixteen whales from the Southern Ocean were re-sighted in multiple years; six of the whales were re-sighted within 19 to 753 km of their original location and two whales had a 12-year sighting interval (Olson *et al.*, 2020).

New data have been uploaded from whales found in the Oceania region (n=16) that have not yet been matched. New data received from New Zealand and Chile before March 2020 is in process of being compared with the rest of their regional catalogues. Additional data from CCC between 2016-2019 are expected to be received before end of June 2019 and comparisons are scheduled immediately afterwards with other catalogues from Southern American/ETP catalogues.

New data from Timor Leste has also been received but no comparisons has been conducted yet for this region. In addition, new data from Southern Ocean have been received and comparisons have already been completed.

During all matching processes, it has been found that several catalogues included duplicate individuals; these have been corrected, and the contributors notified. It is not an unusual situation, particularly with large catalogues, and may affect abundance estimates. Photo-quality control can play an important role in reducing this risk, but sometimes duplicate photo-IDs may all be of good quality and inadvertently included. The effect of duplicated animals on abundance estimates produced by models used may need to be considered.

PROGRESS TOWARD POPULATION ASSESSMENTS

An enormous number of photo-IDs from multiple blue whale researchers from around the Southern Hemisphere have been received by the SHBWC and many of the photo-IDs have already been compared or are in the process of comparison.

Priorities for the Sub-committee on other Southern Hemisphere Whale Stocks currently include blue whales off Australia and Chile (IWC, 2017). All matching processes for these regions with photographs uploaded before January 2018 and March 2020 respectively have been completed (Galletti Vernazzani *et al.* 2019b, 2021).

Two important aspects need to be addressed to prepare the database for a capture-recapture analysis. These include photo quality control and data management. Afterwards, the encounter histories of the animals may be used in mark-recapture abundance estimate models.

Photo-quality control

A photo quality control guide has been already developed (Olson *et al.*, 2021). Photo-quality control has started for Australian catalogues but no results are yet available. Photo-quality control of South America/ETP as well as New Zealand and Sri Lanka catalogues will follow.

In the past, it has not been possible to fully implemented the photo-quality control tool on the website. Therefore, photo-quality control for Australian photos is being undertaken manually and quality coding data entered directly into the database.

Fortunately, a new IT team is working on the improvements to the software and it is expected that a new quality control tool will be implemented soon for use in future photo quality coding work planned with photographs from South America/ETP, New Zealand and Sri Lanka.

Data management

Most groups that joined the SHBWC at the beginning of its development were not requested to upload their associated data, which includes dates and locations. Data on dates are key for mark-recapture abundance estimate models. Over the past year, most of the groups have already contributed their photo-ID associated data.

Some data that have already been contributed, however, seem to have some typographical errors, particularly regarding sighting dates. Data will need to be checked before any abundance estimates are produced.

Instructions to upload missing data were developed and a special report containing all IDs and data have been compiled for each group. These data are confidential under the data sharing agreement. Regional coordinators have approached each research group to complete missing data in the SHBWC, and some groups have done but others are still pending.

A summary of the status of different catalogues, including uploading of photo-ID, matching and data management is shown in Table 2.

Groups from Australia that have already been matched have not uploaded any new photos. Only one group is still pending to upload their data. Almost all groups from Chile/ETP have their data already contributed to the SHBWC. When the matching of newly contributed Chile photos and photo quality coding is completed, both datasets (Australia and Chile) will be available for use to produce abundance estimates.

All data from New Zealand catalogues are currently available. When the matching of newly contributed NZ photos and photo quality coding is completed, its dataset will also be available for use in abundance models.

Sri Lanka datasets have not all been contributed, and internal reconciliation of photo-ID from one group is ongoing.

The SHBWC software includes a special report function that produces encounter histories of selected groups to be used for abundance estimates purposes.

In Table 3, details on numbers of whale photo-IDs per season for each group from Australia and Chile are provided. According to data uploaded into SHBWC, blue whale sightings are recorded mostly during summer/autumn (December-April) however there are some sightings recorded since September. In this sense, a “year/season” will be considered grouping sightings from September until August of next year, not as a calendar year from January to December. This information provides insight on the season-span and numbers available for mark-recapture analysis and can assist in identifying the datasets to be used in future populations assessments.

SOFTWARE IMPROVEMENTS

Over the years, improvements to the software have been continually identified and additional information integrated in order to fulfill the new IWC photo-ID catalogue guideline requirements (Olson *et al.* 2017) and the requirements of the Scientific Committee. Several improvements have already been implemented and others have been postponed in order to give priority to those needed for assessment purpose. Recent priority issues included migration to IWC server and integration of photo-quality control option.

In addition, last year Python Software Foundation stopped supporting Python version 2.7 used in the SHWBC and the Scientific Committee decided to support a software upgraded in Python or, if possible, a re-writing of the code into PHP language. As languages versions are always changing, upgrading the versions will always be required and considered as part of the ongoing maintenance of the website.

During 2020, the SHBWC software and database have been entirely and successfully moved to IWC servers. A new IT team has been engaged and they are working to solve some errors recently found in the software that appeared after new updates were made on the code. Following the resolution of these errors, the team will implement the photo-quality control option for users and if successfully achieved they will be appointed to upgrade/re-write the software language.

As pointed out in previous years, because large number of new improvements to the SHBWC software have been implemented, the 2016 user manual will need to be updated. Because the software language will be changed and new tools implemented, placing the manual updates on hold until these changes are finalised is proposed, so they can also be reflected in the user manual.

CONCLUSIONS AND NEXT STEPS

The matching process is completed for Australia-New Zealand-Sri Lanka with data received prior to 2018 and for South America-ETP catalogues received prior to March 2020.

Photo-quality coding for Australian datasets is ongoing and will follow for the South America-ETP datasets.

There are still some data missing for a few groups and some other groups have still not uploaded their catalogues.

The dataset from BF off Sri Lanka has been larger than expected and more funding will be needed to finish the catalogue reconciliation and matching process with other catalogues from the region.

The Timor-Leste catalogue from UNTL also has important information that has not yet been compared to any group.

The question on potential duplicates individuals should be discussed, and, if there is value into measuring its impact on abundance estimates, data should be collected when the matching process is undertaken.

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Table 1 – Summary of blue whale photographic collections and catalogues in the SHBWC as of March 2021, in (.) new collections received from May 2020-March 2021

Region	Group	Fluke (New)	Left Side (New)	Right Side (New)	Area
ETP-South America	SWFSC	0	60	53	Peru, Ecuador, ETP
	CCC	0	469 (180)	484 (184)	Chile
	IWC Chile	0	14	9	Chile
	MERI	9	48	45	Chile
	CBA-UACH	0	0	0	Chile
	Eutropia	0	(16)	(25)	Chile
	Phantalassa	2	16	28	Chile
	Opportunistic Southeast Pacific	0	12	6	All
	Sub-total	11	635 (196)	650 (209)	
Sri Lanka-Australia-New Zealand-Coral Triangle	BWS	5	85	84	Australia
	WWR	0	30	23	Australia
	CWR	50	204	212	Australia
	FLINDERS	0	15	12	Australia
	AAD-Australia	0	35	36	Australia
	KWA	1	6	10	Australia
	Oceans Blueprint	0	4	4	Australia
	OSU	14 (9)	98 (58)	89 (53)	New Zealand
	AAD-NewZealand	0	12	11	New Zealand
	NIWA	1	7	2	New Zealand
	Opportunistic New Zealand	0	(19)	(12)	New Zealand
	UNTL	9 (6)	97 (35)	64 (9)	Timor-Leste
	APEX/Oceans Blueprint	0	0	0	Timor-Leste
	APEX	0	0	0	Indonesia
	Asha de Vos	0	89	79	Sri Lanka
	BF	0	0	0	Sri Lanka
	NARA	0	0	0	Sri Lanka
Sub-total	80 (15)	701 (112)	638 (74)		
Southern Ocean	IWC SOWER	0	158	157	Antarctica
	MRI-SO	0	19	13	Antarctica
	AAD-Antarctica	0	83	94	Antarctica
	Opportunistic Southern Ocean	0	(20)	(20)	All
	KWA SO	0	0	0	Antarctica
	Sub-total	0	280 (20)	284 (20)	
West and Central Indian Ocean	MRI-SA	0	0	0	South Africa, Madagascar
	Gardline	0	0	0	South Africa, Madagascar
	Sub-total	0	0	0	
TOTAL	91 (15)	1616 (328)	1572 (303)		

Table 2 – Status of catalogue management and matching process, March 2021

Group	Area	Years	Uploaded Photo-ID	Uploaded Data	Checked Data	Matching Status
SWFSC	Peru, Ecuador, ETP	1992-2009	Yes	No	No	Completed
CCC	Chile	2004-2015	Yes	Yes	No	Completed/In progress ³
IWC Chile	Chile	1997-1998	Yes	Yes	Yes	Completed
MERI	Chile	2014-2017	Yes	Yes	Yes	Completed
CBA-UACH	Chile	NA	No	No	No	No
Eutropia	Chile	2006-2019	Yes	Yes	No	In progress
Phantalassa	Chile	2010-2019	Yes	Yes	No	Completed
Opportunistic Southeast Pacific	All	2010-2018	Yes	Yes	Yes	Completed
BWS	Australia	1998-2011	Yes	Yes	Yes	Completed
WWR	Australia	1999-2003	Yes	Yes	Yes	Completed
CWR	Australia	NA	Yes	No	No	Completed
FLINDERS	Australia	2015	Yes	Yes	No	Completed
AAD-Australia	Australia	2012	Yes	Partially	No	Completed
KWA	Australia	2007-2018	Yes	Yes	No	No
Oceans Blueprint	Australia	2017-2018	Yes	Yes	No	No
OSU	New Zealand	2009-2017	Yes	Yes	No	In progress
AAD-NewZealand	New Zealand	2013, 2015	Yes	Partially	No	In progress
NIWA	New Zealand	2018	Yes	Yes	No	In progress
Opportunistic New Zealand	New Zealand	2004-2018	Yes	Yes	No	In progress
UNTL	Timor-Leste	2014-2020	Yes	Yes	No	No
APEX/Oceans Blueprint	Timor-Leste	2018-2020	No	No	No	No
APEX	Indonesia	1999-2019	No	No	No	No
Asha de Vos	Sri Lanka	NA	Yes	No	No	Completed
BF	Sri Lanka	1983-1984 and 2010-2015	No	No	No	No
NARA	Sri Lanka	NA	No	No	No	No
IWC SOWER	Antarctica	1987-2009	Yes	No	No	Completed
MRI-SO	Antarctica	NA	Yes	No	No	Completed
AAD-Antarctica	Antarctica	2013 - 2019	Yes	Partially	No	Completed
Opportunistic Southern Ocean	Antarctica	2005 - 2020	Yes	Yes	No	No
KWA SO	Antarctica	NA	No	No	No	No
MRI-SA	South Africa, Madagascar	NA	No	No	No	No
Gardline	South Africa, Madagascar	NA	No	No	No	No

³ Data from 2016-2019 will start matching process in 2021

Table 3 – Summary of blue whales IDs per season for Australian and Chilean catalogues as of March 2021

	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	Total*
CHILE																							
IWC-Chile	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21
CCC	0	0	0	0	0	0	5	17	82	122	147	85	110	70	28	77	29	59	0	0	0	0	831
MERI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	16	37	6	0	0	64
Phantalassa	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0	0	11	14	6	4	38
Eutropia	0	0	0	0	0	0	0	0	5	3	1	0	0	0	0	0	0	1	11	7	1	5	34
Opportunistic SEP	0	0	0	0	0	0	0	0	0	0	0	0	5	1	0	1	0	3	1	3	1	1	16
TOTAL	21	0	0	0	0	0	5	17	87	125	148	85	116	71	28	80	34	79	60	30	8	10	1004
AUSTRALIA																							
BWS	1	2	4	0	0	8	0	29	9	19	3	35	23	6	0	0	0	0	0	0	0	0	139
WWR	0	0	2	2	3	1	32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40
AAD-Australia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	46	0	0	0	0	0	0	0	46
Flinders	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1**	17	0	0	0	0	18
Ocean Blueprint***	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	4
KWA***	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	2	0	0	7	12
TOTAL	1	2	6	2	3	9	32	29	9	19	4	36	23	6	46	1	1	17	2	0	3	8	259

* It includes re-sightings within same group

**It seems a typographical error and should corresponded to 2015

*** Not yet compared with other Australian catalogues