INDOCET CONSORTIUM MEETING (VIRTUAL)
Thu. May 16, 2024

South Africa: 14:30-16:30
Moambique, Tanzania, Kenya, Madagascar : 15:30-17:30
Reunion & Mauritius: 16:30-18 :0
East Coast US: 8:30-10:0
France, UK: 13:30- 15:30

Facilitator: Violaine Dulau
Rapporteur: Tim Collins

Attendees:

- Adrian Fajeau, from Gobice, Reunion
- Aina Ramanampamonjy, from Cetamada, Madagascar
- Alex Vogel, from HappyWhale, South Africa
- Angie Gullan, from Dolphin Encountours Research Center, Mozambique
- Anjara Saloma, from Cetamada, Madagascar
- Elisa Seyboth, from MRI whale Unit, Uni. Pretoria, South Africa
- Emmanuelle Leroy, from Globice, Reunion

- Gwen Penry, from Nelson Madela Univ., South Africa
- Ifaliana Andriamananjara, from Cetamada, Madagascar
- Jean Marc Gancille, from Globice, Reunion
- Julie Martin, from Globice, Reunion
- Maeva Terrapon, from St Andrew Univ., UK
- Marine Malen, from Marine Discovery Center, Mauritius
- Mduduzi Seakamela, from Dpt of Environment, Forestry and Fisheries , South Africa
- Michel Vely, from Megaptera, France
- Nina Svensson Dubois, from Marine Discovery Center, Mauritius
- Paul Lallement, from Globice, Reunion
- Sal Cerchio, from AACF, US
- Shanan Atkins, from of Univ. of Witwatersrand, South Africa
- Stephanie Plön, from Bayworld Centre for Research and Education, South Africa
- Svetlana Barteneva, from MMCO, Mauritius
- Ted Cheeseman, from HappyWhale, US
- Tim Collins, from WCS, Kenya
- Vanessa Estrade, from Globice, Reunion
- Violaine Dulau, from Globice, Reunion

Agenda (2-hour timeslot)

1. Feedback on the IWC (IndoCet paper, Indian Ocean Initiative)
2. Humpback whale photo-identification
3. NeMMO initiative
4. WIO synchronised humpback whale counting day
5. New features and improvements on the IndoCet website
6. Call for contributions to Maeva's PhD on killer whales.

Introductions

The meeting opened with introductions from participants. Violaine Dulau provided a brief history of IndoCet and the consortiums objectives. In brief these are to:

- Increase knowledge on cetaceans in the SWIO, promote conservation and mitigate anthropogenic impacts
- Facilitate communication, exchanges and data sharing
- Foster collaboration among regional researchers and conservationists
- Facilitate prioritization and development of future common research projects

Details can be found in the IndoCet Memorandum of Understanding, available on the IndoCet website**.** The Consortium currently comprises 53 Active members and 10 Associate members. The group is quite representative of the people working in the region, and now comprises a relatively large community of researchers that share the same general ambitions.

Since the last meeting, the executive committee (EC) has changed, and currently includes 8 members. The main role of the executive committee is to coordinate IndoCet activities, plan meetings, facilitate communication within the network and with other international organisations (IWC, Naribi Convention, WIOMSA, ect..).

The aim has been to plan in-person meetings on a regular basis, ideally every two years, as it helps with increasing and fostering collaboration in the region. The last meeting was held in October 2022 in Port Elizabeth in South Africa, as a special session of the WIOMSA Scientific Symposium. This regional congress takes place every two years years in different countries of the SWIO and it was decided to try and convene future IndoCet meeting during this event. Grouping these events makes best use of limited travel funds and encourages members to submit and present their work at the WIOMSA Symposium, resulting in a higher representation during the marine mammal session.

The next WIOMSA meeting was meant to be held in 2024 but it has been postponed to 2025, and to date the venue is not yet known. It was therefore decided to organize an online meeting in 2024 to present and discuss the network on-going activities.

Discussion Summary

1. Feedback on the IWC

Tim Collins provided an update on discussion of Indocet at the 2024 meeting of the IWC Scientific Committee, much of it prompted by paper SC69B-SAN-03. The paper was submitted to the Sanctuaries Working Group and was presented by Sal Cerchio in session. The paper provided a non-exhaustive update on activities of the Consortium. The information provided by the network is relevant for reviews of the Indian Ocean Sanctuary[1] as well as other agenda items of other IWC Working Groups. For instance, several IndoCet members have worked extensively with HappyWhale to upload and compare humpback whale photo-identification images across the region and beyond. This section of the IndoCet paper was presented to the Photo-Identification Working Group by Tim Collins, and the consortium was commended for the work and future updates were encouraged.

[1] https://iwc.int/management-and-conservation/sanctuaries

Tim also provided an update on a project called the "Indian Ocean Sanctuary Initiative" lead by IWC with a view to improving the availability of cetacean abundance and distribution data for the Indian Ocean. The project was motivated by major concerns about bycatch rates of small cetaceans in the Indian Ocean. The IWC has convened several online meetings to discuss the initiative since it was first proposed in 2020 but it has not yet made any progress.

It is clear that many researchers in the region are largely supportive of the need for such an initiative, but it was generally agreed that its leadership must be regional, should be considerate of the existing objectives of various networks (e.g. Arabian Sea Whale Network, IndoCet, HudoNet, etc) and should be constructed in such a way that it does not work at cross purposes to them, which it risks to do given limited opportunities for funding and stakeholder engagement.

[*An online meeting to discuss the initiative was convened by the IWC on 2024-05-21, and it was agreed that a smaller working group would work to refine the objectives and identify a steering group from across the broader region*.]

2. Humpback whale photo-identification

- **Update on HappyWhale**

Ted Cheeseman provided background on HappyWhale[2], including a summary of humpback whale fluke catalogues and matches from the region.

The platform uses an algorithm that can consistently find 97% - 99% of potential matches among images of humpback flukes. Image quality is still a limiting factor, but the platform performs better that expected with images of more limited quality. Most of the data is publicly visible, but there are various privacy restrictions, such as, for example, pending data from WCS. Some data are not publicly visible, but may be visible within a group of collaborators, and perhaps subsequent to publication they then become publicly visible. Later in discussion Ted pointed out that there is a lot of value to data being publicly visible for encouraging public engagement. Most of the Indian Ocean data is currently publicly visible and this has helped with contributions of researchers from the region and of less traditional sources of data, such as whale watch operators and others who would otherwise, either leave photos on a hard drive, or perhaps might not think to take a photo at all. Ted acknowledged the efforts of Alex Vogel, who has voluntarily uploaded many regional datasets from a variety of contributors, including whale watch operations.

Regional data on the platform have grown substantially since 2018, growing rapidly from a few individuals to over 8,000 individuals and more than 14,000 encounters in early 2024. The regional

[2] https://happywhale.com/

resighting rate is still relatively low, however. For instance, in South Africa the resight rate lies between 10% - 20% which is still pleasing given that for the first few years of HappyWhale's implementation in the region it was ~1%.

The HappyWhale platform is also able to identify individuals from other body features, in particular dorsal fins. The technology is still in development but the collection of a broad suite of data is encouraged, including date, location, fluke (and fin) photos, and any attribute and observation data (for example behavioural state, sex, class, age, class, and similar), to be able to support population studies, individual studies.

Much of Teds interest lies in the Southern Ocean, because of the data deficiency and also personal experience of working in Antarctica as an expedition guide and tour leader for 30 years. The recovery of whales there has been remarkable including the various rates of recovery for different species. The Indian Ocean/sub-Saharan African humpback whales are among the most difficult to study, especially in the feeding regions (South Africa excepted), largely because there are such big spaces that lacks vessels of opportunity and research efforts.

The data sets provided by different contributors so far, include those of the Globice, Whale Unit, WCS and Cetamada. These include matches made over broad time periods (1990s – 2020) and mataches between Madagascar, Mozambique, South Africa, Brazil and both eastern and western Australia. While migratory patterns appear to be broadly consistent, it is clear that many individuals do something completely different. This contrasts with migratory patterns seen in the North Pacific, but it remains unclear if they are categorically different in the Southern Hemisphere and in the Southern Ocean in general, or whether there are individuals that are big exceptions.

Ted also encouraged participants to identify data sets (perhaps from older French voyages) that may have been tucked away on a hard drive somewhere, from old photos that need to be scanned. Particularly needed are pelagic Southern Ocean and Indian Ocean datasets. There are some data, including from South Georgia, the South Sandwich Islands and the Ross Sea. Data from voyages include those of the Polar Stern (German), IWC SOWER voyages and Greenpeace voyages. There are also some citizen science data as well.

The Fluke ID methodology and accuracy is very well established. However, a next-generation algorithm (or actually a set of algorithms), that also work with dorsal fins of a variety of species is currently being developed. They essentially work on any cetacean that has persistent features that are visible and photographable, and which provide photo-ID characteristics. These can be used to extract all available signal that can be used for image recognition/computer vision. There are many caveats when compared to images of humpback whale flukes. For instance, it takes a much higher quality image and more work to curate the reference set, but it is a functionality that exists in Happy Whale. Ted expressed a personal goal that is to be supportive of local and regional

research initiatives and to provide technology that wouldn't be available unless built collectively and collaboratively.

Questions were invited from the floor. Tim Collins commented that it might be worth exploring whether Norwegian scientists ever work around Bouvet Island (a Norwegian territory). This might be of interest given that two animals tagged in Gabon and one in Tanzania swam past Bouvet on their southbound migration. Ted suggested that Frederick Brahms was someone to speak to with regards to Norwegian humpback photo-ID, but it is unclear whether he has any interest in the southern hemisphere. Also considered was the Norwegian Polar Institute.

Tim also asked Ted about the matching process was managed in the North Pacific, a place with hundreds of contributors, and whether he had a personal philosophy about how to handle inter-site matches and publication. This has a bearing on how matches are handled in the Indian Ocean, because as data are added to Happy Whale matches are being discovered among datasets from different sites. There is of course a compulsion to communicate these matches. For instance, animals photographed in Gabon that match to Brazil, Madagascar and Réunion and vice versa. Tim suggested that there would be more value in regional digests of matches than one-to-one or one-to-two matches. Ted provided thoughts on this issue. For instance, with a long-distance match, which may not say very much biologically nonetheless provide a good hook for a story and are often shared relatively quickly via various media. This shouldn't affect publication of a peer-reviewed paper, but it is very important that all parties involved be consulted prior to broadcast. These kinds of stories are often more popular than say descriptions of migratory patterns of a region. Collaboration and discussion are critical, particularly as different organizations in different regions often have different objectives (e.g. population abundance estimation vs migratory patterns). For that purpose, a concept note (Annex 1) was drafted to provide a common vision to the IndoCet contributors with some perspective as regard analysis and scientific publication. This document has been circulated among IndoCet members and can be revised based on member's feedback.

Sal Cerchio asked whether Ted had ever considered packaging the matching capacity of HappyWhale as an application that people can use without having to contribute data into the 'multi-user universe of hundreds of contributors and thousands and thousands of flukes?' This could then be implemented by groups working on their own datasets or among a few collaborators. This does not detract from HappyWhale being incredibly useful but is a little frustrating that matching capacity cannot be used as a tool. Ted explained that there is a tool, called Whale-ID, which is a mobile, desktop or web-based app where users can input photos and find matches. However, it matches solely to the HappyWhale reference set, which need to be updated on a regular basis by HappWhale team, and is cloud-based, which limits the ability to download it and run it on a computer as a separate instance.

Sal replied that the cloud-based aspect of HappyWhale is incredible but is also a limitation as it relies upon a good internet connection, which can be difficult for some people to access. Is developing a standalone application simply a matter of finding the funds to develop an app that can apply the same algorithms to any given dataset. It would be great to have both options; access to the large collaborative open database, as well as access to an app that can be used on a personal computer so that researchers can create and manage their own catalogue before importing it to HappyWhale.

Ted conceded that it would be fantastic to develop an app and make it especially usable in low connectivity environments, but development is a matter of finding resources. However, there are also issues with reducing the platform to an app, including providing updates. The real power of HappyWhale lies in its ability to match data to thousands of flukes with a high degree of accuracy.

Violaine also asked whether there were any plans afoot to make use of the platform less reliant on the HappyWhale team. This is particularly true for generating exports of matching results, which would be particularly useful for some users. Ted agreed that removing reliance on the core team was part of their plan, but challenges included training people to truly understand how the system works. A particular concern is where data includes matches to other users.

- **Regional Matching Paper Concept Note**

Salvatore Cerchio provided a summary on nascent plans to generate regional papers that explored matches between regions and were formalised into an IndoCet concept note, which was sent to the IndoCet members in September 2023 (Annex 1). This originated in the varied efforts to match data from specific regions, and recognition that the data have more value when combined. The idea would be to include all of the existing data sets that have been already committed or in the process of being uploaded to HappyWhale and to look at a range of characteristics in the movements of humpback whales in the South Atlantic, the Southwest Indian Ocean and even into the Southeast Indian Ocean. In its first iteration the plan would be to broadly summarise the matches. This would be a very descriptive analysis that assessed connectivity and described the data set (connections between regions, how many matches etc.). The group has agreed that it would be appropriate for Alex Vogel to lead this work given all of his effort to incorporate catalogues into HappyWhale, but he would receive significant support from co-authors. This could then lead into a more sophisticated statistical treatment that assesses migratory patterns, exchange rates and ultimately population abundance. This would need the support of sophisticated statisticians and modelers, and potential draw on members of the IWC Scientific Committee. Ideally the work would be completed within the next two years, and would thus be available for reviews of the IWC Indian Ocean Sanctuary.

3. NeMMO Initiative

Adrian Fajeau provided a summary of the NeMMO Initiative (the Network of Marine Mammal Observers). The initiative was established to improve the availability of cetacean (and other megafauna) species data from pelagic waters, remote islands and seamounts. Prior data collection efforts include REMMOA (2010) which covered extensive pelagic areas during dedicated aerial surveys but was limited to the Austral Summer. Boat-based marine surveys have also been completed, but they are exceptions. Acoustic work and telemetry can help although they are limited, and additional visual survey data is needed.

NeMMO has several objectives:

- To gather and enhance the collection of data in oceanic waters from platforms of opportunity
- To standardise observation protocols
- To increase effort and the number of opportunistic surveys in the region
- To use surveys to train new marine mammal observers
- To increase exchanges between regional researchers and organisations.
- To compile collected data in a regional database.

The data collection protocol is simple and replicable and does not interfere with the main mission of the boat. A concept note for the initiative is available and has been distributed by email to all members in November 2023 and can be downloaded from the IndoCet website.

Observers spend daylight hours searching for animals and other features from the highest practicable platform, and data collection includes positional information and the angle and estimated distance of detections. All cetaceans are recorded, but also marine birds, sharks, and sea turtles. This helps MMOs to focus as cetaceans may not be sighted for several days. It also provides opportunities to collect data on other taxa, and thus opens new opportunities for collaboration.

Surveys are typically conducted using opportunistic platforms given the difficulty of paying for offshore survey work. Opportunistic platforms include vessels engaged in other scientific survey work, fishing patrols and tourism cruises. Organisations from the region are encouraged to develop partnership to increase the effort. If IndoCet members hear of opportunities they are encouraged to contact Adrian who can then help, particularly with providing a protocol, an online training if necessary, with data verification post-survey and then data storage.

The aim is that collected data are stored in the same database and accessible online, and in turn can help to foster communication and collaboration. This includes all members of IndoCet, but also other scientists. The database will be visible on the IndoCet website shortly, as an interactive

map to help navigate between all the families, species and the surveys. Data can only be viewed and not downloaded as this needs to respect rules for data-sharing established by different programs. Collaborations need to be established independently.

Beginning in 2021, 17 surveys in the region have been completed so far. The majority have been completed by Globice (which then led to the idea to form NeMMO) and the majority of these with the Osiris II, a French vessel patrol that mostly surveys the Mozambique channel. These surveys have provided opportunities to bring onboard other partners. Other platforms have included Greenpeace cruises to the Saya de Malha Bank and work with Exploration de Monaco.

The dataset currently comprises more than 1,200 sightings, including 24 cetacean species (of the ~32 described from the region). Most of these are from the Mozambique Channel and especially within French waters. This return for relatively few missions is a major success of the program. Although humpback whales dominate the list of sightings (more than 800), sightings also include the Kojidae as well as some shy and rarely seen dolphin and beaked whale species.

The results for humpback whales are also notable for the addition of 100 photo IDs, many of them from places with no other data. An area of particular interest is the south of Madagascar where hundreds of individuals have been recorded. Other interesting results include those for sperm whales and killer whales.

The hope is that the network of MMO will expand, and results so far are just a start. Several surveys are planned for 2024, including the mission MASC, around La Perouse seamount and Tromelin in July on the Marion Dufresne, and another through the Mozambique Channel using the Osiris II. Other opportunities include those in partnership with Ponant as part of the WCS led QWIO project.

In response to the presentation Sal Cerchio offered his congratulations to Adrian and others for the presentation and accomplishments so far.

Violaine added that NeMMO was created within the IndoCet network (which is reflected in the logo) very deliberately as NeMMO is meant to be collaborative. All members are encouraged to join the effort either by taking part of surveys as MMO or establishing partnership with commercial compagnies or largescale research surveys. Currently MMOs have included staff and volunteers from Globice, Cetamada, CetaMaore, MMCO, Attitude, KMMREC, University of Nelson Mandela etc), based on availabilities and funding. The NeMMO initiative in itself is not funded, but funding so far has been provided through research programs led by regional organisations (COMBAVA, PRIM projets led by Globice, QWIO project led by WCS). It was suggested to make a list of MMOs who are willing to take part of this surveys when the opportunities arise.

4. Humpback whale synchronised counting day

The initiative of sharing feedback about the humpback whale season among breeding sites started in 2020 (#WhereAreTheWhales). A form was sent to IndoCet members to report on the levels of occurrence of whales. However, this was not quantified, no specific metrics were collected, and was more of a temperature check for how productive the season was at each site. In 2023 we thus developed the idea of having observers across the region count whales on specific days so that occurrence and relative abundance at different sites within the region could be compared.

The response to the idea of a coordinated effort was very positive, particularly among the IndoCet membership, and although quite late in the season, a concerted effort was made to develop some metrics that could be comparable between sites. At the same time, links were made to an existing 15-year effort on the East African coast led by Matt Richmond, known as the Synchronised Whale Watching Day (SWWD). Over four days, nine sites in five countries were sampled. Cetamada and Megaptera surveyed in Madagascar, MMCO surveyed in Mauritius, Globice surveyed three sites in Reunion and other groups participated in South Africa and Mozambique. Initial data remain limited but allows for estimation of the number of individuals sighted per hour at each site. The highest occurrences were recorded in Reunion followed by Madagascar and other sites were considerably lower.

Violaine explained that the hope is to establish an initiative, but it needs discussion among the IndoCet membership, including development of a practical observation protocol. Currently the initiative uses the same data sheet developed by Matt Richmond, so that the data is standardized across all sites. But there are important caveats, including differences in survey height, with some surveying at sea level and others much higher and differences in effort; some sites were surveyed for a full day, but others only for a few hours. It might be worth agreeing on observing for a shorter period of time but perhaps completing observations several time in the season.

Violaine invited the meeting participants to think about whether the effort should be repeated in 2024, and to agree on the sampling scheme. Angie clarified that her group have been participating in the Synchronised Whale Watching day (one per season) for many years, and agreed that it would be great if a date could be set in order to allow people to prepare. Angie suggested that the respective efforts be combined, to ensure that maximum coordination is reached.

Violaine clarified that Globice worked to collect and centralize the data for 2023 but it would be great if someone could volunteer to lead the initiative within IndoCet and link with Matt Richmond to combine efforts and produce common outputs. For the moment it is not clear if the Synchronised Counting Day led by Matt is only shore-based, and how the results are presented.

A small working group will be created to further discuss these points and best plan the coming season.

Tim Collins agreed that settling on a date would be a good idea, and to settle on participation and sites. It would for instance be good to identify someone in Somalia given recent tag data. And as part of the process someone should be identified who can process datasheets, perhaps an Honours student or similar, particularly if there are 15 or more years of data available.

Having multiple days within a season was also discussed, and Violaine asked about the participants whether completing more than one day was feasible. Sal agreed that this was a great initiative, was amazing to see the participation and the range of contributing sites. Sal also suggested that multiple surveys be conducted, perhaps keeping it simple, with sites observing on the 1st day of each month (for example) for as many months as they could manage, and perhaps not the whole day. Violaine agreed but suggested extending it to a broader period, perhaps the first week of each month to allow for flexibility and to accommodate things like weather. At least one day should be completed at the peak of the season, (August in Réunion, maybe September or October in Mayotte etc etc). Maeva added that it would be worth talking to groups who were not focused on humpback whales, especially if there is emphasis on completing at least one day per season.

5. IndoCet Website

Violaine presented briefly on the latest revisions to the IndoCet website. She also reminded members that there is a table available for members with relatively records to report their stranding data. This table was meant to provide a mean to collate stranding data for the organisations that do not have a stranding data base, to make sure data are archived and cetnralised. Since stranding data are usually few, especially in small islands, this gives their data added resonance as they can then bolster a regional dataset. This was exemplified in the regional paper reporting on 2000-2020 strandings from the region (Ploen et al., 2023) and in the IWC paper presented previously with IndoCet Strandings results. Members were also reminded to record the localities of their strandings.

Currently the stranding data can be visualised on a Google map on the IndoCet website. The plan is to move to a more practical platform that allows filtering with more than 10 different categories (by species).

Plans are also afoot to try and set up a page to record data on entanglements in the region – an idea that developed following an entanglement workshop in partnership with the International Wedding Commission. Gwen Penry suggested that it would be very important to record the gear type as part of the effort. Gwen clarified that all entanglements records in South Africa are

centralized through the South African Whale disentanglement network. A similar process exists for stranding data. Violaine clarified that the intent was to provide people or groups in different regions that did not have a means to report locally with a way to record their observations and/or events and the online table is not meant to include large dataset in countries where stranding and entanglement data are already well-structured into a large database. This should be clarified on the website.

The website also provides a table for the accession of metadata (telemetry, photo-id, acoustics, biopsies etc). However, the table is under used and one reason may be that too much detail was being requested. The idea is to try and simplify it in order to encourage participation, including addition of a mapping facility. The idea is to ensure that members have an idea of who is doing what in the region.

The website also has a publication page, and members were encouraged to add their recent publications, which now stands at over 130 for the region.

Violaine also thanked members for their contribution to the newsletter. One to two editions per year are currently being produced and all articles are also reported in the "News" page of the IndoCet website.

6. Killer whales PhD

Maeva Terrapon presented briefly on her PhD project focusing on killer whales. She wanted to remind everyone that she is still looking for data. Her PhD is dependent on incidental records given the rarity of sightings. Currently she has access to 90 reported sightings over the previous 30 years, including 12 from 2023 and already three in 2024. Photo-identification data is particularly welcome, in order to match individuals from one location to another. For example, an animal seen in Mayotte 2015 was recited in Aldabara in 2020, and then again in Mayotte in 2021, highlighting long-term site fidelity to the region.

Another aspect of the PhD is an assessment of killer whale feeding ecology, including assessing the impact that killer whales can have on their prey, such as humpback whale calves. Predation on whales is described from the region, but observations remain rare. One way to estimate the impact of that predation on the humpback whale population is to look at surviving individuals that bare scars from unsuccessful attacks. Happywhale is one source of information for this, and Maeva is seeking additional permissions to use study regional HappyWhale datasets in order to search for rake scars. This also ensures that duplicates from multiple sites can also be accounted for. Finally, as part of another project in the PhD, Maeva is looking at killer whale stable isotopes and needs additional samples that can inform the work.

Following a question from Tim Collins, Maeva clarified that she has been working with Charles Anderson from the Maldives to get a photo ID and publication on killer whales sighted in the Maldives, as well as Georgina Gemmell from from the Northern Indian Ocean Killer Whale Alliance. Once the SWIO catalogue is compiled Maeva will compare catalogues, including those in the NIO and those from South Africa and Marion Islands.

ANNEX 1.

CONCEPT NOTE (working document)

Assessment of humpback whale connectivity among African sub-stocks and movements among adjacent ocean basins

Introduction

Southern Hemisphere humpback whales (*Megaptera novaeangliae*) undertake annual migrations from the Southern Ocean summer feeding grounds to the warm tropical or sub-tropical winter breeding grounds (Chittleborough, 1965; Dawbin, 1956, 1966; Rasmussen *et al*., 2007). Within the region, seven Breeding Stocks (BSs) of the species are recognized by the International Whaling Commission (IWC) referred to as BSA to BSG, each associated with a specific breeding area (IWC, 1998). Based on genetic, mark-recapture or whaling data (Rosenbaum *et al*., 2009; Findlay, 2000; Fleming and Jackson, 2011), some BSs have been subdivided into sub-stocks. The breeding and feeding grounds used by each BS and sub-stock are as follows (see Figure 1):

- BSA: East coast of South America the south-western Atlantic Ocean; Antarctic: 50°W–20°W;
- BSB: West coast of Africa, being divided into B1 (Gabon) and B2 (western Namibia and South Africa); Antarctic: 20°W–10°E;
- BSC: East coast of Africa and the western Indian Ocean, divided into C1 (Mozambique), C2 (Comoros Archipelago), C3 (Madagascar), and C4 (Mascarene Islands); Antarctic: 10°E–60°E;
- BSD: West coast of Australia; Antarctic: 60°E–120°E;
- BSE: East coast of Australia and the western Pacific Ocean, split in E1 (Australia), E2 (New Caledonia), E3 (Tonga); Antarctic: 120°E–170°W;
- BSF: South-central Pacific Ocean, divided in F1 (Cook Islands) and F2 (French Polynesia); Antarctic: 170°W–110°W; and
- BSG: East coast of South America from northern Peru to Costa Rica; Antarctic: 110°W–50°W (IWC, 2007; Branch, 2011).

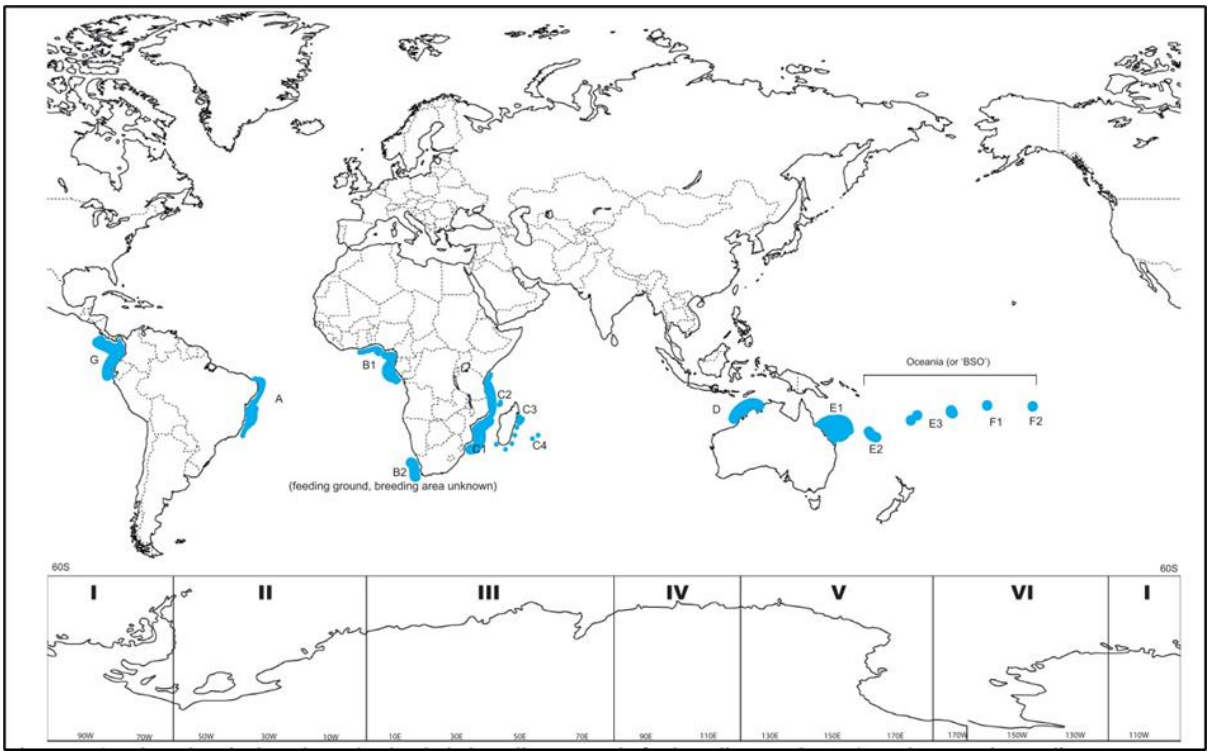

Figure 1.: The Southern Hemisphere humpback whale Breeding Stocks (A-G) and the Management Areas in the Southern Ocean, where their feeding grounds are located (Jackson *et al*., 2015).

The species was severely depleted by modern commercial whaling in the Southern Hemisphere, with about 216,000 individuals killed across the region from 1903 to 1973 (Allison, 2020). As the species recovers from whaling (e.g., Jackson *et al*., 2015), some BSs and sub-stocks are reoccupying areas used prior to whaling and/or expanding historical breeding grounds (e.g., Zerbini *et al*., 2004; Irvine *et al*., 2018; Horswill and Jackson, 2012), possibly affecting connectivity among BSs (e.g., Marcondes *et al*., 2021).

For the southern African region, different levels of interchange have been identified amongst the sub-stocks that utilize the area. For example, there is photographic evidence of interchange between sub-stocks B1 and B2 (Barendse *et al*., 2011), although genetic data have indicated differentiation between them (Pomilla *et al*., 2006; Rosenbaum *et al*., 2009; Carvalho *et al*., 2014). Potential reasons for such genetic differentiation are maternal site fidelity, the use of two migratory routes (one coastal and the other offshore), and spatial or temporal segregation within the Gulf of Guinea breeding ground (Carvalho *et al*., 2014). For BS-C, genetic studies have shown some level of differentiation between C1 and C3, and C1 and C2, but no differentiation between C2 and C3 (IWC, 2006; Pomilla *et al*., 2006; Cerchio *et al*., 2008; Rosenbaum *et al*., 2009; Ersts *et al*., 2011; Kershaw *et al*., 2017). On the other hand, photographic and satellite tracking data suggest a significant mixing between sub-stocks C2 and C3, and between C3 and C4, but little

interchange between sub-stock C1 and the other sub-stocks (Ersts *et al*., 2006; Cerchio *et al*., 2008; Dulau-Drouot *et al*., 2011; Fossette *et al*., 2014; Dulau *et al*., 2017).

In general, photo-identification methods have been increasingly used over the past few decades to study whale population aspects such as abundance and movements between areas (e.g., Adams *et al*., 2006). Especially the use of algorithms for automated photo-identification of individual humpback whales, such as the one used in Happywhale (Cheeseman *et al*., 2022) has substantially increased the ability to track individual humpback whale movements across the globe. This is not only through the rapid and automated identification of individual whales, but also due to the enhanced potential for contribution of opportunistic data through e.g., citizen science. As such, the considerable influx of new data into Happywhale has already shown evidence of substantial movement and mixing of individuals between the pre-defined BSs (Marcondes *et al*., 2021; Acevedo *et al*., 2022; Ramos *et al*., 2023) and revealed previously unknown movement patterns of individual humpback whales, indicating they may not be as segregated as previously thought, with substantial geographical overlap along the southern tip of Africa.

Aim

To gain a better understanding of the interchange between humpback whale BSs and sub-stocks, it is proposed to come together in a wide-ranging collaborative effort in which the use of automated photo-identification (through Happywhale) is optimised with the goal to progress towards the assessment of movement patterns and connectivity between, humpback whale BSs, with a special focus on BSB and BSC. Ultimately, the data would be used to produce estimates of population abundance and exchange rates, which will be relevant to the next IWC Southern hemisphere humpback whale in-depth assessment.

Proposed methods

To achieve this aim, we would like to invite individuals and organisations working in African sub stocks to contribute to this initiative by **uploading humpback whale photo-identification (fluke) images to the HappyWhale platform** with the goal to increase data availability for BS B and C.

On a broader scale, collaborations with researchers from BS A and BS D will also be developed to assess connectivity with adjacent breeding stocks.

Images submissions can be completed by individuals and organisations by creating an account and submitting data on the platform (https://happywhale.com), to ensure maintaining associated IP rights. New submitted images are automatically matched against all images available in HappyWhale and all possible matches are validated internally by the HappyWHale team before being included into the global catalogue (reference set). Each submitted image is scored by photo quality and distinctiveness. When a match is found, data contributors are

informed via an automated e-mail. The results of the matches are visualised on a map on the HappyWhale platform and data can be exported for further mark-recaptures analysis.

Outcome

It is proposed the resulting matches will be assessed scientifically and written up in peer-reviewed publications. In this regard, we foresee this collaborative effort to be inclusive, and written MoUs can be established according to individual/institutional preferences if so required. It is envisioned that all data contributors would be joint co-authors in any publication arising from this collaborative effort.

Currently, 3 levels/type of analysis have been identified:

1. *Description of matches- Individual movements*

After the initial collation of photo-identification images in HappyWhale, the first outcome is envisioned to be a multi-coauthored manuscript, under the lead authorship of Alex Vogel (all other co-authors to be listed according to contribution and/or in alphabetical order) which describes the long-distance movements of individually identified humpback whales from BSB and BSC with other BS.

The ambition is to have the manuscript ready for presentation at the next meeting of the IWC SC and that can be used to support a proposal for further mark-recapture analysis at the population level.

2. *Mark-recapture analysis - Population estimates*

Ultimately, multi-state mark-recapture analyses will be used to assess the rates of exchange among sub-stocks within BSB and BSC and between adjacent breeding stocks (BSs A-B-C-D) and obtain population size estimates for both stocks.

The timeframe for this analysis will be aligned with the agenda of the IWC Scientific committed, so that it is relevant to the next Southern Hemisphere humpback whale in-depth assessment.

3. *Movement between breeding and feeding grounds*.

The dataset will also be used to assess movement between breeding stock C and feeding grounds in Antarctica, provided enough data is available.

Current contributors

To date, several researchers or organisations from the region have been submitting their fluke images to HappyWhale, with multiple recaptures found between sub-stocks (Figure 1).

Breeding Stock B

- Gabon: WCS - Ocean Giants (Tim Collins)

Breeding Stock C

South Africa

- Seafari App, Cape Town, South Africa (Alexander Vogel)
- Mammal Research Institute Whale Unit, Department of Zoology and Entomology, University of Pretoria, Pretoria, South Africa (Elisa Seyboth, Ken Findlay, Els Vermeulen)

Tanzania

- Ekatarina Kalashikova
- WCS (Tim Collins)

Kenya

- Watamu MArine Association (Michael Mwango'mbe)
- WCS (Tim Collins)

Madagascar

- Cetamada (metadata to be updated) (Anjara Saloma)
- WCS (Antongil Bay)

La Reunion

- Globice (Vanessa Estrade, Violaine Dulau)

Other partners are collecting photo-identification data and might be willing to contribute.

Contributors to happyWhales from other BS and foraging grounds

BSA

- ***Brazil***

BSD

- **Western Australia**

Feeding ground/Antarctica

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