

Acoustic Monitoring Highlights A Complex Connectivity Among Southwest Indian Ocean Humpback Whales

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Background

The Humpback whale (*Megaptera novaeangliae*) is a migratory species. In the southern hemisphere, they feed around Antarctica over the summer and reach the low latitudes during the austral winter to breed. The South Indian Ocean (SIO) hosts two of the seven breeding stocks of the southern hemisphere defined by the International Whaling Commission. For Breeding stock C, in Southwestern Indian Ocean (SWIO), the lack of data does not allow us to completely understand the migratory movements. Range of Each breeding stock have been documented, but the connection between them and their link with feeding grounds is yet poorly understood. Photographic identification, genetic and satellite tracking data have revealed varying degrees of population connectivity between sub-regions, and Passive Acoustic Monitoring (PAM) is another method than can bring complementary information. Indeed, male humpback whales produce a highly structured and constantly evolving song. Because individuals share songs at the population level, song similarities can be used to inform population structure and connectivity at different spatial and temporal scales.

Method

Autonomous recorders were deployed at several sites in the SIO breeding grounds, including Réunion Island, Madagascar, Tanzania, Mozambique, South Africa and Western Australia during the austral winters 2016 to 2019, to assess temporal distribution of song occurrence and compare song structure across sub-regions and years. The dataset comprised around 50,000 hours of recording. Presence/absence of humpback whale songs were noted during the first 20 minutes of each hour. High quality recordings of song sequences were used to analyze song structure, based on a description of phrase types. Quantitative analyses were computed by describing each song with counts of phrases to compute the proportion of each phrase in a song. Samples were selected to capture inter-individual, intra-population and inter-population variability within and between years.

Results

The dataset provided information on the temporal distribution at each survey site and allowed to detect spatio-temporal variation in humpback whale occurrence. Being

located further away from the feeding grounds, the northernmost sites are logically less frequented and for a shorter period of time and even more so in weak years where low occurrences were detected at the basin scale. Song patterns differed according to the sites and especially according to the years. The analysis of song structure, based on the visual inspection of the spectrograms, allowed to identify 4 different songs and a total of 17 phrases during the 4 years of study. It was noted that 3 of the songs heard in the area spread from west to east, some within the same breeding season and others between seasons. A first one was sung in South Africa in 2016 and then sung to the east in Nosy Be and Reunion in 2017. A second one was sung in SWIO in 2016 and then sung 3 years in a row in Australia (2017 to 2019). A last one was sung in SWIO in 2018, and then reached Australia in 2019. We observed heterogeneity in the distribution and number of songs each year (3 songs in 2016 and 2018, 2 in 2017 and 2019) and on the evolution of songs over several years for each given site (song fidelity or replacement). During the two years allowing a complete SWIO comparison, 2018 shows a complex pattern while in 2019 one same song was recorded all over the basin. In 2018, 3 patterns were observed: one song for Eastern Africa, another one for Reunion and north-east Madagascar and a mix of the two (79% of western song and 21% of eastern song) for Nosy Be. Similarities in song structure between eastern (Australia) and the western part of SWIO were demonstrated (two songs shared but with an annual shift). Phrase counts did not show large differences in the proportion of phrases for the composition of each song.

Conclusion

Songs analysis showed different phrase distributions between years, which might suggest heterogeneous movement patterns between years. SWIO connectivity appears to be complex, due to the number and the geographical distribution of each breeding site, compared to more linear breeding stock (for example western coast of Australia). Madagascar island seems to be a key point with their western and eastern coast respectively link to western and eastern parts of the SWIO basin. The relatively strong connection between SWIO and Australia is an important new result. Regarding the annual shift of the spread of the song, feeding ground seems to play an important role of these two populations connection. Some hypothesis (size of each population, influence of food availability, diversity and layout of the various breeding sites) needs to be explored to explain the different song pattern observed. The eastern diffusion of the song observed from SWIO to Australia was also observed in the same year inside the SWIO, with maybe two different explanations. These analyses highlight the lack of data on feeding grounds, and the importance to record several years in a row in remote sites to have a complete picture of the humpback whale's connectivity.

The collection of additional acoustic data on the feeding grounds, together with other source of data such as satellite tracking and photo identification in the region in the future will provide further insights to better understand the complex migrations that humpback whales undertake each year.