

Shelf Waters of Southern Madagascar IMMA

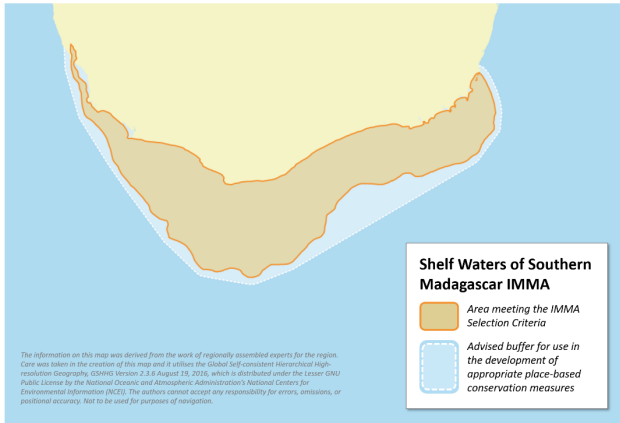
Description

The IMMA encompasses a wide portion of the continental shelf and slope off Southern Madagascar. The western edge lies near the town of Androka in southwest Madagascar (25°01' S, 44°04' E) and extends eastwards to Tôlanaro (alternatively Fort Dauphin, as referred to in the description below) (25°01'S, 47°14'E). The IMMA extends seaward to encompass the upper half of the continental slope, where it meets the northern boundary of the Madagascar Ridge IMMA.

The continental shelf is relatively wide off south Madagascar and it is likely that the western portion of the shelf also represents important breeding habitat for humpback whales (Cerchio et al., 2016; Trudelle et al. 2016). While the sample size of satellite-tagged animals is relatively small compared to the size of the population (although comparable to other satellite telemetry studies for this species), research suggests that humpback whales aggregate for mating (Clapham et al. 2015). As such, a breeding 'hotspot' indicated by only a few animals through satellite telemetry data may represent a more significant aggregation area as other animals are attracted to the site.

Criterion B: Distribution and Abundance Sub-criterion B2: Aggregations

The area represents an important aggregation area for breeding humpback whales. Aggregation hotspots were determined from kernel density models of satellite telemetry data from southern Madagascar, including south of Fort Dauphin extending seaward to the Madagascar Plateau (Dulau et al., 2017). The area is also used by whales tagged in southwest Madagascar (Anakao) and in the central east of Madagascar (Sainte Marie) (Cerchio et al., 2016).



Area Size

18,575 km²

Qualifying Species and Criteria

Humpback whale – *Megaptera novaeangliae*

Criteria B2, C1, C3

Summary

The IMMA encompasses a wide portion of the continental shelf waters and slope off southern Madagascar. The western edge approximates the location of the town of Androka in southwest Madagascar and extends eastwards to Tôlanaro/ Fort Dauphin, and extends seaward to encompass the upper half of the continental slope. This area contains important habitat for aggregations of breeding humpback whales and also represents an important portion of the migration route for this species in the region. Kernel density models demonstrate a breeding 'hotspot' in the waters off southern Madagascar for humpback whales satellite tagged off Reunion Island for both males and females with calf, although relatively more so for males, as well as for whales satellite tagged in the southwest of Madagascar off Toliara / Anakao. These hotspots are observed to span the waters from the coastline out to the continental shelf edge on the eastern portion of the shelf and were used to delineate the eastern boundary of the IMMA.

Criterion C: Key Life Cycle Activities

Sub-criterion C1: Reproductive Areas

Satellite tracking data revealed new inferences on habitat utilization in Madagascar, with the central eastern and southern coast identified as areas with high concentrations of localized movements, and therefore main breeding habitats of humpback whales (Dulau et al., 2017; Cerchio et al., 2016). When reaching Southern Madagascar, several tagged individuals switched to localized movement behaviour and remained in the area for up to 15 days (Dulau et al., 2017). Kernel density models derived from satellite telemetry data highlight breeding 'hotspots' on the eastern portion of the shelf, off Fort Dauphin (Figure 1b, Dulau et al. 2017). The similarly wide continental shelf area to the west also represents important breeding habitat for the species (Cerchio et al., 2016; Trudelle et al. 2016).

Criterion C: Key Life Cycle Activities

Sub-criterion C3: Migration Routes

There are multiple sources of evidence of extensive humpback whale movements and genetic connectivity between the area of southern Madagascar, other areas surrounding Madagascar, as

well as areas off east Africa and the Mascarenes (Rosenbaum et al. 2009; Ersts et al. 2011; Fossette et al. 2014; Cerchio et al. 2016; Trudelle et al. 2016; Dulau et al. 2017; Kershaw et al. 2017). More broadly, the area falls within the migratory stream of IWC Breeding Stock C whales as they commute annually between productive feeding areas in the Southern Ocean and warmer wintering grounds off East Africa, the Comoros Archipelago, Madagascar, and the Mascarenes.

Supporting Information

Cerchio, S., Trudelle, L., Zerbini A.N., Charrassin, J.B., Geyer, Y., Mayer, F.X. et al. 2016. 'Satellite telemetry of humpback whales off Madagascar reveals insights on breeding behavior and long-range movements within the southwest Indian Ocean'. *Marine Ecology Progress Series*, 562: 193–209.

Dulau, V., Pinet, P., Geyer, Y., Fayan, J., Mongin, P., Cottarel, G. Zerbini, A.N., and Cerchio, S. 2017. 'Continuous movement behavior of humpback whales during the breeding season in the southwest Indian Ocean: On the road again!' *Movement Ecology* 5: 11 [online]. Available at: DOI 10.1186/s40462-017-0101-5

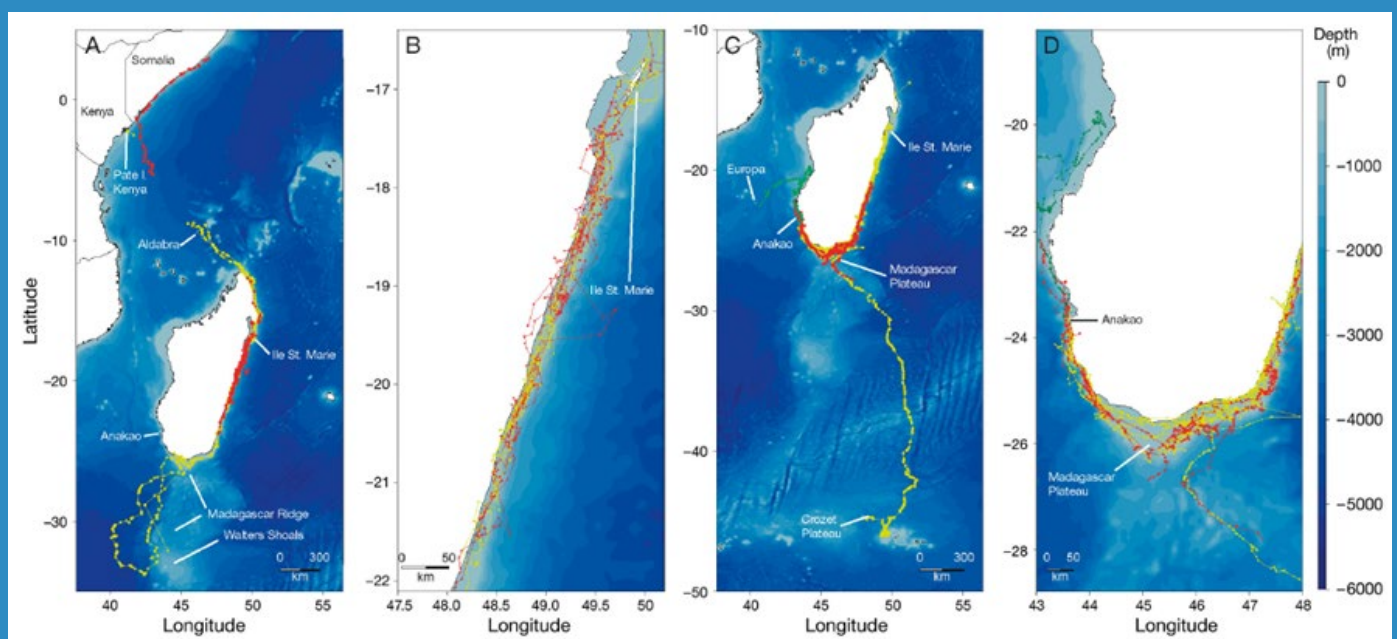


Figure 1: Tracks of all tagged whales (A) from Ile Ste. Marie in the northeast during 2012, with (B) detail of movements off the central east coast, and (C) from Anakao in the southwest during 2013, with (D) detail of movements off the southwest to southeast coasts. Each track is represented by dots for speed-filtered locations and a line connecting temporally consecutive locations. Females are represented in yellow, males in red, and a single whale of unknown sex in green. The satellite tracks clearly demonstrate the importance of this region as migratory habitat for humpback whales. Adapted from Cerchio et al. 2016, Figure 2.

Ersts, P.J., Pomilla, C., Kiszka, J., Cerchio, S., Rosenbaum, H.C., Vély, M. et al. 2011. 'Observations of individual humpback whales utilizing multiple migratory destinations in the south-western Indian Ocean'. *African Journal of Marine Science*, 33: 333–338.

Fossette, S, Heide-Jørgensen, M.P., Jensen, M.V., Kiszka, J., Bérubé, M., Bertrand, N., and Vély, M. 2014. 'Humpback whale (*Megaptera novaeangliae*) post-breeding dispersal and southward migration in the western Indian Ocean'. *Journal of Experimental Marine Biology and Ecology*, 450: 6–14.

Kershaw, F., Carvalho, I., Loo, J., Pomilla, C., Best, P.B., Findlay, K.P., et al. 2017. 'Multiple processes drive genetic structure of humpback whale (*Megaptera novaeangliae*) populations across spatial scales'. *Molecular ecology*, 26: 977–94.


Rosenbaum, H.C., Pomilla, C., Mendez, M., Leslie, M.S., Best, P.B., Findlay, K.P., Minton, G., Ersts, P.J., Collins, T., Engel, M.H. and Bonatto, S.L. 2009. 'Population structure of humpback whales from their breeding grounds in the South Atlantic and Indian Oceans'. *PLoS One*, 4(10) [online]. Available at doi:10.1371/journal.pone.0007318 (Accessed: 1 February 2010)

Acknowledgements

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