

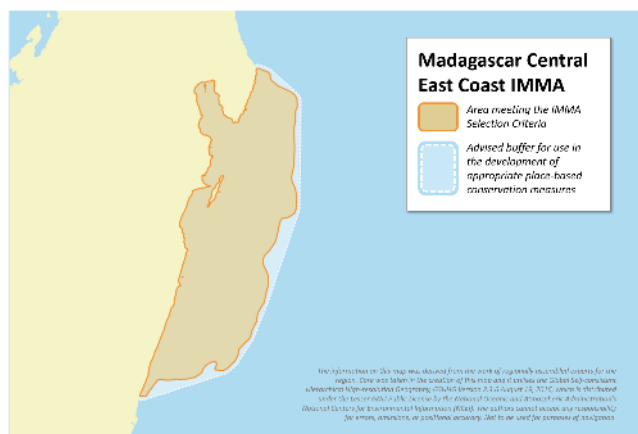
# Madagascar Central East Coast IMMA

## Description

The east coast of Madagascar is characterized by a very narrow continental shelf with a steep slope down to abyssal plain waters. In the central eastern portion, the continental shelf extends out to its widest point at approximately 5–60 km. The Masoala Peninsula in the northern part of this range defines Antongil Bay (16°00'S, 49°55'E), the largest bay in Madagascar, at approximately 60 km long and 30 km wide covering 2800 km<sup>2</sup>. It is an expansive relatively shallow habitat with half being less than 50 m deep, and with 270 km of coastline. Île Sainte-Marie (16°55'S, 49°54'E), also known as Nosy Boraha, is an island off the east coast of Madagascar within the Analanjirofo administrative region. The island is 60 km long and less than 10 km wide and covers an area of 222 km<sup>2</sup>. It is surrounded by a barrier reef that encloses a narrow, shallow-water lagoon (≤10 m depth). The Sainte Marie Channel (49°50' E–50°10' E, 16°60' S–17°55' S) lies between Île Sainte-Marie and the mainland of eastern Madagascar and is approximately 7 km wide with relatively shallow water depths (up to ~60 m).

The boundaries of the IMMA start in the north at the Masoala Peninsula (~15°S) and extend south to approximately 19.6°S, encompassing Antongil Bay, the waters off Île Sainte-Marie, the Sainte Marie Channel, and the narrow continental shelf past the port city of Toamasina (also known as Tamatave) to the mouth of the Mongoro River. The mouth of the Mongoro River (approx. 18°58' S, 49°50' E) demarcates the southern boundary of the IMMA. This area represents a bathymetric transition from a relatively shallow portion of the shelf that extends north to the Masoala Peninsula. The IMMA extends seaward approximately 50 nm, past the continental shelf edge.

Humpback whales are known to aggregate in the coastal waters of central eastern Madagascar during the winter, including in Antongil Bay, Île Sainte-Marie, and the waters south to the Mongoro River mouth (Rosenbaum et al., 1997; Best et al., 1998; Ersts and



## Area Size

55,524 km<sup>2</sup>

## Qualifying Species and Criteria

Humpback whale – *Megaptera novaeangliae*

Criteria B2, C1, C3b

## Other Marine Mammal Species Documented

*Feresa attenuata*, *Indopacetus pacificus*,  
*Megaptera novaeangliae*, *Peponocephala electra*,  
*Physeter macrocephalus*, *Pseudorca crassidens*,  
*Tursiops aduncus*, *Tursiops truncatus*, *Ziphius cavirostris*

## Summary

The Madagascar Central East Coast IMMA encompasses Antongil Bay, the waters off Île Sainte-Marie, the narrow continental shelf past the port city of Toamasina (Tamatave) and waters beyond the continental shelf edge up to ~50km offshore. The area comprises important habitat for breeding aggregations of humpback whales (*Megaptera novaeangliae*), with mother–calf pairs showing a strong preference for shallow waters within Antongil Bay. The IMMA also hosts migrating humpback whales, with demonstrated connectivity to several other breeding grounds and migration routes, including those in the Mascarenes, northwest Madagascar, southern Madagascar, the Comoros Archipelago, and eastern Africa. Diversity and densities of other species within the area are observed to be relatively moderate for the region; however, Vulnerable sperm whales (*Physeter macrocephalus*) and beaked whale species have been observed in association with the 2000 m isobath.

Rosenbaum, 2003; Cerchio et al., 2009; Best and Brandão, 2009; Cerchio et al., 2016; Trudelle et al. 2016; Dulau et al., 2017; Trudelle et al., 2018; Fig. 1). In addition to humpback whales, at least eight other species were sighted during the REMMOA aerial survey in northeast Madagascar (January 2010). Of note, a number of deep-diving species were observed to associate with the 2000 m depth contour, including vulnerable sperm whales, near-threatened false killer whales, Cuvier's beaked whales, Longman's beaked whales, and other Mesoplodon spp. (Van Canneyt et al., 2010). Sperm whale relative density (not corrected for availability bias) was calculated as  $0.20 \times 10^{-2}$  individuals per  $\text{km}^2$ , and uncorrected beaked whale relative density was calculated as  $0.25 \times 10^{-2}$  individuals per  $\text{km}^2$  (Laran et al., 2012, 2017).

## Criterion B: Distribution and Abundance

### Sub-criterion B2: Aggregations

The area represents an important aggregation area for breeding humpback whales. Kernel density models of satellite telemetry data from whales initially tagged off Reunion Island indicate breeding hotspots off Île St. Marie, including the Saint Marie Channel and the waters of the continental shelf south of Île Sainte Marie to the Mongoro River mouth (Dulau et al., 2017).

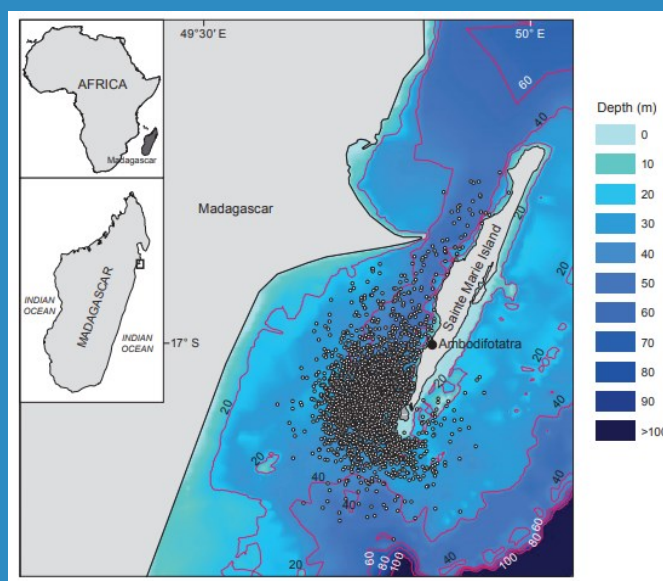


Figure 1: Distribution of the humpback whale sightings made in the Sainte Marie Channel during the breeding season (June-September) across the five-year study period (2009-2013). Each dot represents a sighting. Adapted from Trudelle et al., 2018, Fig. 1.

Similarly, Cerchio et al. (2016) identified the same general area as an area of "localized" movement behaviour for whales tagged off Île Sainte-Marie in 2012. These 'hotspots' coincide with a relatively shallow area of the continental shelf, which may provide a higher suitability of breeding habitat for this species (Trudelle et al., 2016). While the sample size of satellite tagged animals is relatively small compared to the size of the population (although comparative with other satellite telemetry studies for this species), research suggests that humpback whales have a strong tendency to aggregate when conspecifics are detected (e.g., by song), especially now populations have been diminished by whaling (Clapham and Zerbini, 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 C: Key Life Cycle Activities

### Sub-Criterion C1: Reproductive Areas

The southwest Indian Ocean represents breeding and migratory habitat for humpback whale "Breeding Stock C," as defined by the International Whaling Commission. Breeding Stock C is further divided into four "breeding substocks" (i.e., "BSC1-C4"). Breeding Substocks C3 and C4 are known to aggregate in the coastal waters of central eastern Madagascar, including Antongil Bay, Île Sainte-Marie, and the waters south to the Mongoro River mouth during the winter (Rosenbaum et al., 1997; Best et al., 1998; Ersts and Rosenbaum, 2003; Cerchio et al. 2009; Best and Brandão, 2009; Cerchio et al., 2016; Trudelle et al., 2016; Dulau et al., 2017; Trudelle et al., 2018). Following preliminary surveys in 1996, Rosenbaum et al. (1997) described Antongil Bay as a breeding area for humpback whales in the southwestern Indian Ocean. Behaviours widely accepted to indicate breeding activity were regularly sighted, including males singing and exhibiting competitive behaviour, and females with young calves (Pomilla and Rosenbaum, 2006). Humpback whales have generally been observed in Antongil Bay from June to October, with the highest concentrations occurring in July through early September (Rosenbaum et al.,

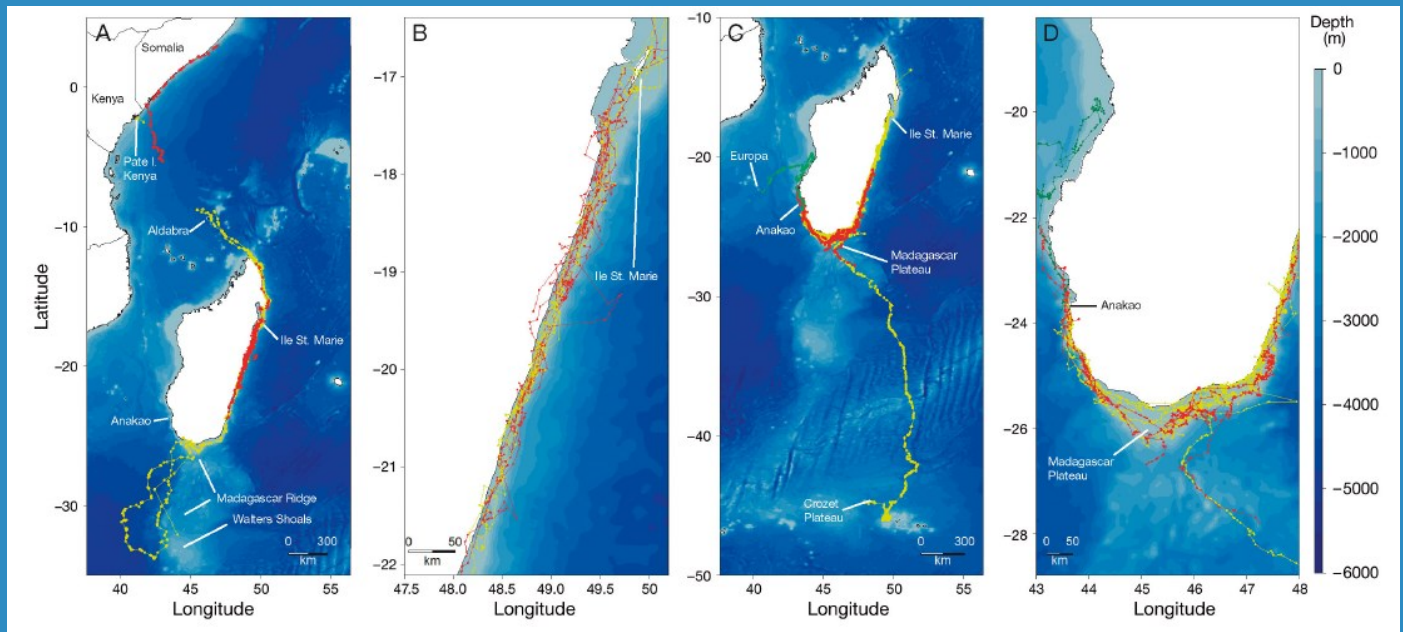


Figure 2: Tracks of all tagged humpback whales (A) from Île Sainte-Marie in the northeast during 2012, with (B) detail of movements off the central east coast, and (C) from Anakao in the southwest during 2013, with (D) detail of movements off the southwest to southeast coasts. Each track is represented 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, including the IMMA, as migratory habitat for humpback whales (Criterion C3). Adapted from Cerchio et al., 2016, Figure 2.

1997; Cerchio et al., 2009). Photographic mark-recapture data indicated that humpback whales utilizing Antongil Bay between 2000 and 2006 had low recapture rates with short residency times; therefore, whales appeared to regularly move through the bay with transient residency as part of a more extensive breeding range for a large population, estimated to be in excess of 6000 animals in 2006 (Cerchio et al., 2009). More recently, satellite telemetry data of humpback whales tagged off Île Sainte-Marie (N=12) in 2012, Anakao in the southwest (N=11), and La Reunion (N=12) in 2013 have highlighted potential breeding 'hotspots' off Île Sainte-Marie and the waters south to the Mongoro River mouth, but no entry or usage of Antongil Bay despite substantial use of the Sainte Marie Channel and areas just east of the Bay mouth (Cerchio et al., 2016; Trudelle et al., 2016; Dulau et al., 2017; Fig. 2). These data and other anecdotal observations suggest a reduced usage of Antongil Bay in recent years, and potential change of condition given extensive documentation of high densities in the bay during peak season in previous years (1996 to 2006) (Rosenbaum et al., 1997, Ersts and Rosenbaum, 2003, Cerchio et al., 2009).

## Criterion C: Key Life Cycle Activities

### Sub-Criterion C3: Migration Routes

#### C3b – Migration / Movement Area

There are multiple sources of evidence of extensive humpback whale movements between the area defined by the Madagascar Central East Coast IMMA and other areas surrounding Madagascar, as well as areas off east Africa and the Mascarenes (e.g., Rosenbaum et al., 2009; Ersts et al., 2011; Fossette et al., 2014; Cerchio et al., 2008, 2016; Trudelle et al., 2016; Dulau et al., 2017; Kershaw et al., 2017) (Fig. 2). More broadly, the area falls within the migratory stream of Breeding Stock C, as animals transit 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

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**MARINE MAMMAL PROTECTED AREAS TASK FORCE**

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