Humpback whale (*Megaptera novaeangliae*) post breeding dispersal and southward migration in the western Indian Ocean Whale Sanctuary

Sabrina Fossette[1,2]*, Mads-Peter Heide-Jørgensen[3], Mikkel Villum Jensen[4], Jeremy Kiszka[5], Martine Bérubé[6], Nils Bertrand[7], Michel Vély[8]

[1]Department of Biosciences, College of Science, Swansea University, Singleton Park, SA2 8PP, Swansea, UK
[2]Present address: NOAA Southwest Fisheries Science Center, Environmental Research Division, Pacific Grove, California 93950, USA.
[3]Greenland Institute of Natural Resources, Bok 570, 3900 Nuuk, Greenland
[4]Mikkels Vaerksted, Gislingevej 2, DK-4571 Grevinge, Denmark
[5]Marine Sciences Program, Department of Biological Sciences, Florida International University, 3000 NE 151 St, FL 33181, North Miami, USA
[6]Marine Evolution and Conservation, Centre for Ecological and Evolutionary Studies, University of Groningen, Linnaeusborg, 9747 AG Groningen, The Netherlands
[7] Sea Blue Safari, BP 629 Kawéni 97600 Mamoudzou, Mayotte, France
[8]MEGAPTERA, 23 rue Alexandre Dumas, 75011 Paris, France

*Corresponding author: Sabrina.fossette@googlemail.com
Phone : (001) 831 717 7361

Abstract

Little is known about humpback whale (*Megaptera novaeangliae*) dispersal within the Indian Ocean Whale Sanctuary (IOWS). Such information is however critical for conservation and management of this species in the sanctuary as it will help understanding connections among breeding grounds and between breeding and foraging grounds. In October 2011 and 2012, eleven satellite transmitters were deployed on wintering humpback whales in the Comoros islands (Mohéli, n = 6 and Mayotte, n = 5), in the south-western tropical IOWS. Eight individuals were successfully tracked for 24.3 ± 12.4 days (range = 8-49 days) and travelled between 146 km and 5804 km in total. Three main dispersal behaviours were identified in both years. Whales either remained at their breeding site for several weeks after tagging (n = 3) or disperse to the northwest (n = 2) or to southwest (n = 3) coast of Madagascar. Whales used the same two sites along the coast of Madagascar in both years suggesting these might be regular stop-overs during migration. One whale then followed the coast up north before going back south along the east coast. Its tag stopped while it was 70 km from the breeding site of Sainte Marie Island. It is the first report of whales visiting the Comoros archipelago (breeding sub-region C2) and both the western and eastern coasts of Madagascar (breeding sub-region C3) during the same breeding season. Finally, two whales were tracked further south towards their Antarctic foraging grounds. One whale followed a south-eastward direction towards the French Sub-Antarctic Islands while the other one travelled to IWC foraging area III, one of the supposed Antarctic foraging areas for humpback whales of breeding stock C. This is the first time movements of humpback whales from this breeding stock are being described and their potential foraging areas in the Southern Ocean identified.

Keywords: marine mammals, migration, satellite telemetry, connectivity, Antarctica, International Whaling Commission

1. Introduction

In a context of rapid global environmental changes, investigating dispersal movements of individuals among and within populations has been stressed as a pressing research question (e.g. Grémillet and Boulinier 2009, Ponchon et al., 2012). Individual dispersal between breeding sites is one of the key mechanisms behind the dynamics of the spatial distribution of populations and species ranges, as well as in gene flows within meta-populations (Clobert et al., 2001). This ultimately has important consequences for the management of protected species. Such dispersal behaviour has been mainly described in birds (e.g. Dall et al., 2005) but also in some mammals (e.g. Selonen and Hanski 2010) including humpback whales (*Megaptera novaengliae*). In this species for instance, capture-mark-recapture, genetic and tracking studies have suggested some degree of individual dispersal within a same breeding region (e.g. Cerchio et al., 1998, Lagerquist et al., 2008, Rosenbaum et al., 2009, Garrigue et al., 2011) and among breeding regions (e.g. Stevick et al., 2011).

Humpback whales undertake extensive seasonal migrations from high latitude foraging habitats to low latitude, coastal waters for calving and mating (Dawbin 1966). In the western Indian Ocean Whale Sanctuary (IOWS), three main breeding sub-regions within the breeding stock C have been described based on historical whaling data and contemporary surveys (e.g. Wray and Martin 1983, Best et al., 1998), photo-identification (Dulau-Drouot et al., 2011, Ersts et al., 2011b), and genetic studies (Rosenbaum et al., 2009). The coastal waters of south-eastern Africa, i.e. from Mozambique to Tanzania constitute the breeding sub-region C1 (Findlay et al., 1994, Fleming and Jackson 2011, IWC 2011), the coastal waters of the northern Mozambique Channel Islands (i.e. Comoros archipelago), the west coast of Madagascar and the southern Seychelles the breeding sub-region C2 and the coastal waters of southern and eastern Madagascar, i.e. Antongil Bay and Sainte-Marie island the breeding sub-region C3 (Rosenbaum et al., 1997, Fleming and Jackson 2011, IWC 2011). A breeding sub-region C4 including the Mascarene Islands has been recently proposed (Dulau-Drouot et al., 2011, Fleming and Jackson 2011, IWC 2011). DNA analyses and recaptures of individuals have suggested connectivity between Mayotte (Comoros Archipelago, C2) and Antongil Bay (Madagascar, C3, Ersts et al., 2011b) but a genetic differentiation between Mayotte and East South Africa/Southern Mozambique (C1) has been detected (Rosenbaum et al., 2009, IWC 2011). The connectivity and dispersal movements of humpback whales within and among these breeding sub-regions are, however, far from being fully understood (Pomilla 2006, Pomilla et al., 2006, Cerchio et al., 2009, Ersts et al., 2011b, Fleming and Jackson 2011, IWC 2011). Such information is critical for the sustainable management of this species in the IOWS but also for our understanding of breeding habitat selection, migratory fidelity and ultimately individual responses to global environmental changes in large migrating whales.

It is only recently that tracking studies of humpback whales have started to give a better and deeper understanding of dispersal movements in wintering and summering areas in both hemispheres: i.e. North Pacific Ocean, (Mate et al., 1998, Lagerquist et al., 2008), Southern Ocean (Dalla Rosa et al., 2008), South Atlantic Ocean (Zerbini et al., 2006) and North Atlantic Ocean (Heide-Jørgensen and Laidre 2007). Yet to date, tracking studies of humpback whales have never been performed in the IOWS. Here, we aimed at investigating the dispersal of adult humpback whales equipped with Argos satellite transmitters during part of their breeding season in the western IOWS and during their post-breeding migration. This study specifically aimed at (1) investigating how individual whales disperse within and among breeding sub-regions within the same breeding season, (2) assessing if individuals

from the same breeding sub-region use similar migratory routes and stop-over sites along these routes, (3) identifying the main foraging area(s) of these whales. This study focused on the breeding sub-region C2, i.e. the Comoros archipelago, where male and female humpback whales come to breed from July to October each year (Kiszka et al., 2010, Ersts et al., 2011a) and for which additional data on population structure and dispersal are critically needed (Fleming and Jackson 2011, IWC 2011).

2. Material and methods

2.1 Study area and tag deployment

The study was conducted in the Comoros archipelago: off Mohéli Island (12°24' S, 43°45' E) between 11 and 14 October 2011 and off Mayotte Island (12°49' S, 45°09' E) between 2 and 20 October 2012. Eleven satellite transmitters were deployed on adult humpback whales (Table 1). Daily searches for whales were conducted from a rigid inflatable boat. When a whale was sighted, it was initially photographed to enable identification using dorsal fin and/or fluke markings prior to instrumentation (Katona and Whitehead 1981). This avoided double-tagging of the same individual and allowed comparison of the whale's markings with existing individual identifications. A satellite tag was then deployed into the left or right flank of the whale about 0.5 - 1 m ahead of the dorsal fin and usually within 0.7 m from the midline of the whale's body. Two configurations of satellite transmitters were used : nine transmitters were "implantable" tags (SPOT5, Wildlife Computers, USA, 10 cm long by 2 cm diameter cylinder) while two transmitters were "mini-swing" tags (SPLASH, Wildlife Computers, USA, 53x35x25 mm). Both types of transmitters were attached to a stainless steel anchoring system equipped with foldable barbs and a triangular sharp tip. The SPOT5 tags were deployed with the 'ARTS' (Air Rocket Transmitter System), i.e. a modified pneumatic air gun, at about 8 to 10 m from the whale set at pressure of 11 bars (Heide-Jørgensen et al., 2001). The SPLASH tags were deployed using an 8 m long fibreglass pole at about 4 to 5 m from the whale (Heide-Jørgensen et al., 2003). In 2011, transmitters were configured to transmit every day from 3am to 6pm (GMT), as long as the saltwater switch (SWS) was out of the water while in 2012 transmitters were configured to transmit between 8am to 8pm every day. The sex of eight satellite-tracked humpback whales was determined by molecular analysis (Bérubé & Palsbøll 1996) of genomic DNA extracted using the Qiagen_DNeasy Blood and Tissue kit DNA from skin samples obtained by biopsy sampling (Palsbøll et al. 1992). No skin samples could be collected for three individuals but for two of them, we assumed they were female because they were the adult individual in a cow-calf pair.

2.2 Data analysis

Locations were collected via the ARGOS system (https://argos-system.cls.fr). A Location Class (LC) is associated with each location and ranges from A, B, 0, 1, 2, to 3 in increasing order of position accuracy. Argos locations of all qualities but LC 0 were included in route reconstruction (Hays et al., 2001, Witt et al., 2010). The data were then filtered in STAT (http://www.seaturtle.org/stat/) using a maximum rate of travel of 12 km/h (maximum swimming speed reported for humpback whales, Mate et al., 1998) and a maximum azimuth of 35° between successive locations. Filtered positions were then mapped and tracks were reconstructed for individual whales. For calculating distance and rate of travel for each whale and limiting auto-correlation in the dataset, the location with the greatest spatial accuracy (highest LC) received in each 24 h period (00.00–23.59 UTC) was selected. When more than one location of equal accuracy was received per day, the first location was selected. Distance

148 from shoreline and bottom depth were sampled for all daily locations in the STAT database
149 using GEBCO product with 1’ spatial resolution (www.ngdc.noaa.gov/mgg/gebco/).

Table 1. Transmitters deployed on humpback whales *Megaptera novaeangliae* wintering off Mohéli and Mayotte Islands, Comoros archipelago in 2011 and 2012.

Whale ID no.	Sex	Tag type	Tagging date	Tagging location	Tag longevity (days)	No. of locations received	No. of locations used	Distance travelled (km)
22851	M[1]	SPOT5	11 Oct 2011	12°24´29,4"S 43°36´38,7"E	28	60	11	749
33000	F[2]	SPOT5	12 Oct 2011	12°24´43,3"S 43°37´15,9"E	18	98	79	146
37236	F[2]	SPOT5	11 Oct 2011	12°24´43,3"S 43°37´15,9"E	0	0	0	0
20157	F[1]	SPLASH	13 Oct 2011	12°26´33,7"S 43°19´44,3"E	0	0	0	0
20690	F[1]	SPLASH	14 Oct 2011	12°27´45,0"S 43°43´23,2"E	8	51	23	506
27261	F[1]	SPOT5	11 Oct 2012	12°57'20,3"S 44°55'41,0"E	18	165	107	471
27262	M[1]	SPOT5	11 Oct 2012	12°59'43,9"S 44°54'29,6"E	20	181	139	460
37227	F[1]	SPOT5	12 Oct 2012	12°59'00,0"S 44°14'00,0"E	20	145	84	1155
37228	F[1]	SPOT5	18 Oct 2012	12°26'05,1"S 43-37'24,4"E	0	0	-	-
37235	unidentified	SPOT5	21 Oct 2012	12°49'16,4"S 44°56'21,6"E	49	236	127	5804
37278	M[1]	SPOT5	21 Oct 2012	12°49'16,4"S 44°56'21,6"E	33	150	93	3715

[1] Determined by molecular analysis (see methods)

[2] Assumed to be a female because it was the adult individual in a cow-calf pair

Chlorophyll a surface concentration was extracted from the STAT database for November 2012 using monthly grids obtained from NASA's Ocean Color project MODIS satellite-based sensor (4 km spatial resolution, http://oceancolor.gsfc.nasa.gov).

3. Results

Eleven satellite transmitters were deployed on individual whales but only eight transmitted locations. Three transmitters probably failed due to a bad position on the whale preventing them from transmitting (i.e. too low on the back of the whale) or due to potential damage to the tag during deployment. Data on deployments of the tags are summarized in Table 1. No strong behavioural reaction to tag implantation other than an apparent short-term increase in swimming speed was noted. The total distance travelled ranged from 146 km (Whale #33000) to 5804 km (Whale #37235).

3.1 No immediate dispersal

One individual in 2011 and two in 2012 remained around their respective breeding site for the entire duration of the deployment. Whale #33000, a mother accompanied by a calf, stayed south of Mohéli Island for almost three weeks (Figs 1, 2). It spent most of its time on the continental shelf (i.e. depth < 200 m) moving on average 8.1 ± 7.9 km.day^{-1} (mean ± SD) and was still in Mohéli's coastal waters when its tag stopped transmitting on 30 October 2011. Whales #27261 and #27262 were travelling together when they were tagged. Whale #27261 was a mother accompanied by a calf and whale #27262 its escort. The trio remained together around Mayotte for most of the tracking period, alternating between the lagoon's shallow waters and the deeper waters (up to 3300m) outside the barrier reef (mean distance from shore ± SD = 8.4 ± 8.8 km, Figs 1, 2). Their mean travel rates were similar: 26.7 ± 18.6 km.day^{-1} and 26.2 ± 21.0 km.day^{-1} (mean ± SD) for #27261 and #27262, respectively.

1.1 Dispersal towards northwest and east Madagascar

In both years, an individual travelled to the northwest coast of Madagascar only a few days after being tagged at either Mayotte or Mohéli, and then stopped along the coast between Mahajamba Bay and Moramba Bay for a few days (Figs 1, 3). In 2011, the whale #20690, a mother accompanied by a calf, spent three days around Mohéli after tagging before reaching Anjouan on the fourth day. Between both islands, the whale travelled on average 25.6 ± 5.5 km.day^{-1} (mean ± SD). The tag then stopped transmitting for three days. During that time the whale seemed to have crossed from Anjouan towards the north-western coast of Madagascar where it remained for at least 24 hours before transmissions ceased. In 2012, whale #37227, also a mother-calf pair, spent two days in the waters surrounding Mayotte after tagging before moving towards the northwest coast of Madagascar that was reached two days later on 14 October (Figs 1, 3). During the crossing, its travel rate was 134.7 ± 17.1 km.day^{-1} (mean ± SD). It first spent two days in the area where #20690 was last located the year before and then closely followed the coast of Madagascar to the north (mean distance from shore ± SD = 14.3 ± 13.9 km). It briefly stopped near Nosy Be, and reached Cape Amber on 23 October before travelling southward along the east coast. During that time, its mean travel rate was 54.3 ± 51.2 km.day^{-1} (mean ± SD). The day transmissions stopped, #37227 was about 90 km south-east of Antongil Bay and 70 km east of Sainte-Marie Island in oceanic waters (~3300m).

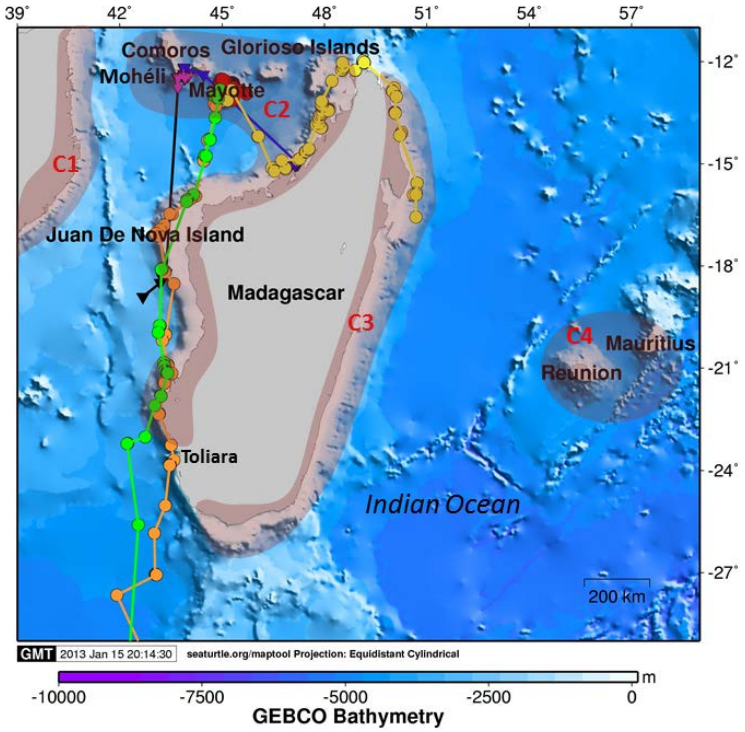

Figure 1: Movement patterns of eight satellite-tracked humpback whales *Megaptera novaeangliae* wintering off Mohéli (#33000: purple triangles, #20690: blue triangles, #22851: black triangles), and Mayotte (#37235: green circles, #37278: orange circles, #37227: yellow circles, #27261: blue circles, #27262: red circles) Islands, Comoros archipelago in 2011 and 2012, respectively. The red-shaded areas represent the breeding sub-regions: C1, C2, C3 and C4 (Fleming and Jackson 2011, IWC, 2011).

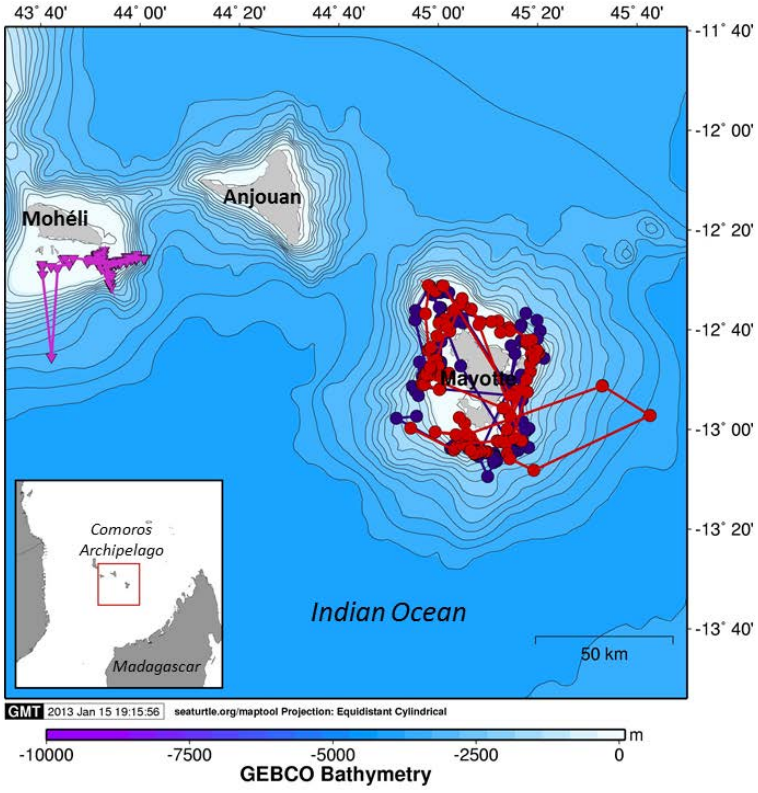

Figure 2: Movement patterns of three satellite-tracked humpback whales *Megaptera novaeangliae*, wintering off Mohéli (#33000: purple triangles) and Mayotte (#27261: blue circles, #27262: red circles) Islands, Comoros archipelago in 2011 and 2012. The whales #27261 and #27262 were part of the same group when they were tagged.

1.2 Dispersal towards southwest Madagascar and the Southern Ocean

The last three individuals all travelled to the southwest coast of Madagascar after being tagged at either Mayotte or Mohéli. Whale #22851 was travelling together with another adult individual when it was tagged. Its tag however did not transmit any positions for the next six days. When the tag started transmitting, the whale was already along the southwest coast of Madagascar, 641 km south of where the tag was deployed off Mohéli (Figs 1, 3). The whale remained in Madagascar's coastal waters for 14 days moving on average 4.1 ± 4.5 km.day^{-1} (mean ± SD) before it started moving again

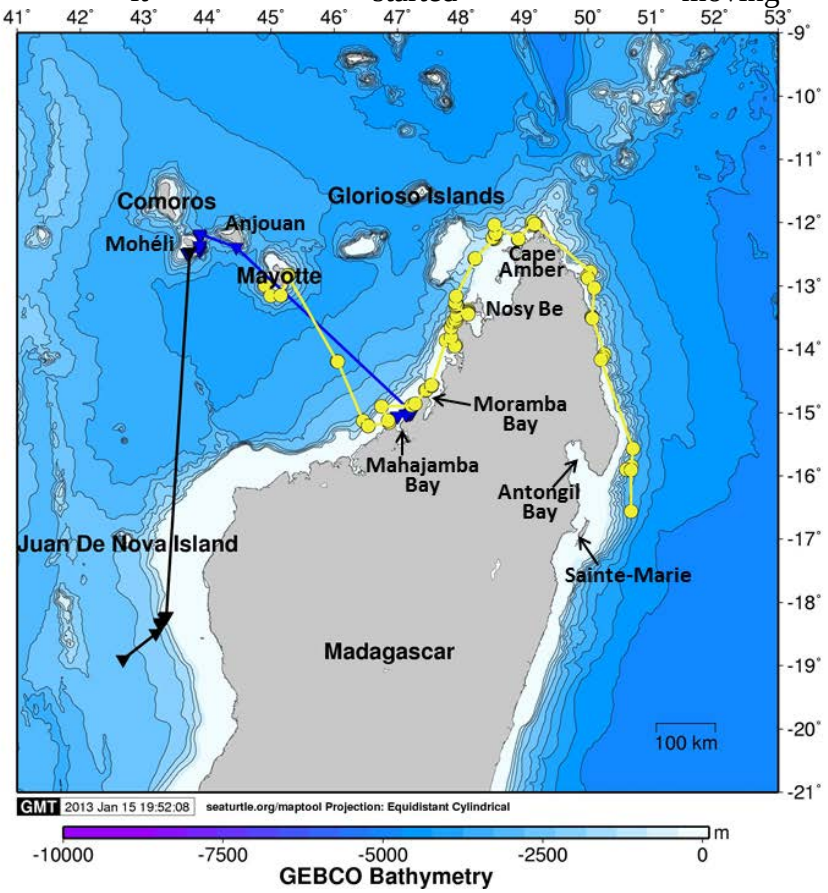

Figure 3: Migration paths of three satellite-tracked humpback whales *Megaptera novaeangliae*, wintering off Mohéli (#20690: blue triangles, #22851: black triangles) and Mayotte (#37227: yellow circles) Islands, Comoros archipelago in 2011 and 2012.

southwestward into the Mozambique Channel. The last position before the tag stopped transmitting was about 170 km west from the coast of Madagascar.

Whale #37235 and #37278 were part of a group of four adult individuals travelling together when they were tagged off Mayotte on 21 October. Both whales resumed their southward

migration after tagging (Figs 1, 4, 5). They reached the coastal waters of southwest Madagascar after two days apparently travelling together at a similar rate (#37278: 172.5 ± 22.1 km.day^{-1} and #37235, 167.2 ± 37.1 km.day^{-1}, mean ± SD). They then followed the edge of the continental shelf (mean distance from shore ± SD = 66.7 ± 43.1 km) at a slightly slower travel rate until they reached ~21°S on 27 October. On their way south, they stopped for a day in the area where #22851 stopped for two weeks the year before. The whales then followed two different routes.

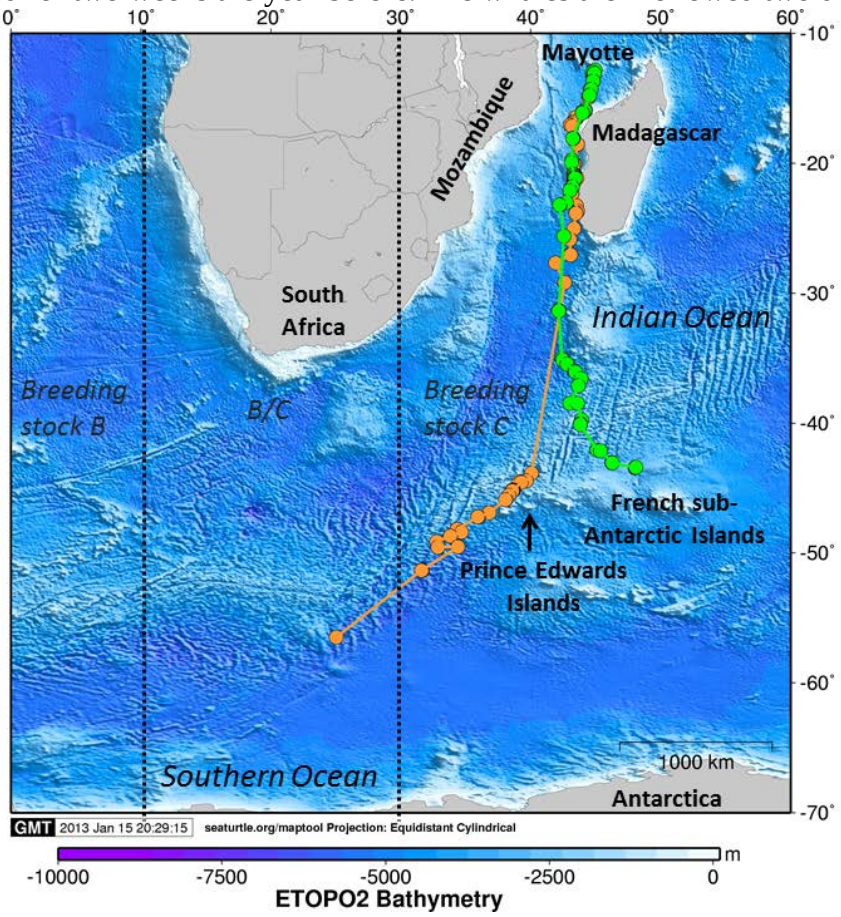

Figure 4: Migration paths of two satellite-tracked humpback whales *Megaptera novaeangliae*, wintering off Mayotte Island (#37235: green circles, #37278: orange circles), Comoros archipelago in 2012. These two whales were travelling together when they were tagged. The black dotted line represents the border between the breeding stock B and breeding stock C (Fleming and Jackson 2011, IWC 2011).

Whale #37278 first spent three days at about 100 km offshore the bay of Toliara in the southwest moving 38.2 ± 49.2 km.day^{-1} (Figs 1, 4, 5). On 31 October the whale started migrating south at a mean travel rate of 116.8 ± 95.4 km.day^{-1} (mean ± SD). On 11 November, it changed its main direction and started travelling south-eastward (150°) towards the French Sub-Antarctic islands alternating between fast (132.7 ± 36.8 km.day^{-1}) and slow (36.2 ± 38.7 km.day^{-1}) moving periods. The tag stopped transmitting on 23 November while the whale was 340 km northwest of the Crozet Plateau in deep (~3000m) and productive waters ([Chla] = 1 to 2 mg.m^{3}, Fig 5).

Whale #37235 remained close to the west coast of Madagascar (~20 km) from 27 to 29 October, until it reached the bay of Toliara in the southwest. It then left Madagascar's coastal waters and started travelling offshore in a southward direction at a mean travel rate of 128.6 ± 72.5 km.day^{-1} (Figs 1, 4). On 3 November, the tag stopped transmitting for 12 days. When transmissions

resumed, #37235 was at ~43°S moving south-westward towards Prince Edward Islands (South Africa). Between 16 and 22 November, the whale's travel rate decreased to an average of 46.8 ± 30.9 km.day^{-1} (mean ± SD) and on 23 November, #37235 was 60km west of Marion Island. It then resumed travelling south-westward (222°) at a faster travel rate of 122.6 ± 77.3 km.day^{-1}. On 7 December, the whale reached 57°22′S, 27°59′E and slowed down to 26 km.day^{-1}. Contact was lost on 9 December.

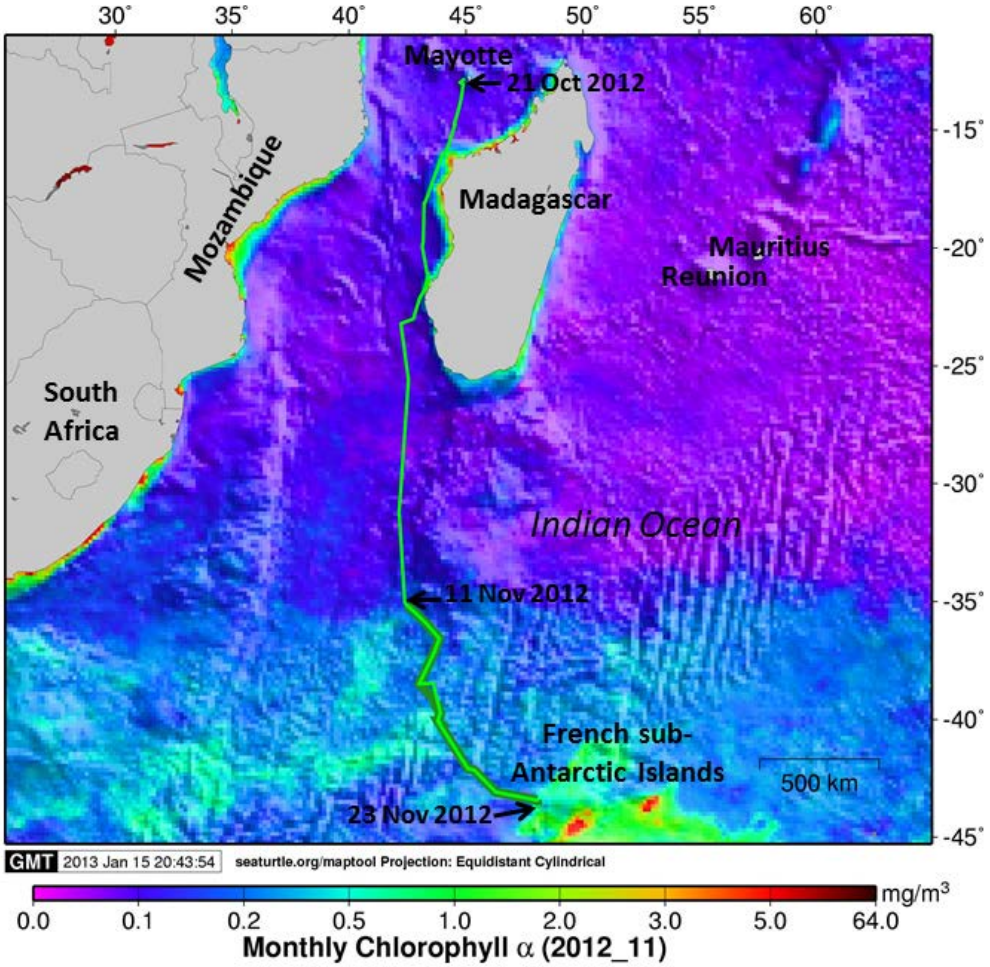

Figure 5: Migration path in relation to monthly chlorophyll a concentration [Chla] of a satellite-tracked humpback whale *Megaptera novaeangliae*, (#37278: green line) wintering off Mayotte Island, Comoros archipelago in 2012. The fine green line represents the whale's track from 21 October 2012 to 23 November 2012 while the bold green line represents the period from 11 November to 23 November 2012 concurrent to [Chla] map.

2. Discussion

This is the first time humpback whales from IWC breeding stock C have been successfully tracked within the Indian Ocean Whale Sanctuary and towards their foraging grounds in the Southern Ocean. A total of 194 days of tracking revealed three main dispersal behaviours

adopted by humpback whales at the end of their breeding season in the Comoros archipelago and two potential migratory destinations. Although our sample size of eight successfully-tracked individuals was relatively small, the similarity of the whales' movements between years suggested that the behaviours observed in this study may be characteristic of this region.

4.1 Late departure from the breeding site

In the Comoros archipelago, the peak of the breeding season for humpback whales is considered to be in August, although whales are occasionally observed as late as November (Best et al., 1998, Kiszka et al., 2010, Ersts et al., 2011a). The whales tagged in this study were instrumented relatively late in the breeding season (i.e. October), yet none of them started their migration towards the Antarctic right after tagging. The whales either remained in their breeding region during the entire tracking period or stopped in the coastal waters of Madagascar for varying periods of time (up to two weeks in the same area). Humpback whales fast during the breeding season and their energy stores are depleted when they leave from their breeding site suggesting that the most direct route to their Antarctic foraging ground should be the most common pattern observed amongst late breeders. Surprisingly this was not the case in this study. In particular, three whales stayed in their respective breeding region for at least three more weeks after tagging. Two of them were females accompanied by calves and therefore were probably resting and waiting for the calf to be ready for migration. This is supported by their slow daily travel rates, i.e. between 8 and 27 km.day^{-1}, similar to the travel rates of humpback whale calves estimated by Cartwright and Sullivan (2009) in Hawaii. The third whale seemed to stay closely associated with the mother and calf for most of the tracking period. This individual was a male which escorted the female potentially seeking for mating opportunities, as regularly observed in humpback whales (Pack et al., 2002, 2009).

4.2 Indirect migratory routes and use of stop-over sites

The other five whales started travelling south, either directly or only a few days, after tagging but all of them stopped in the coastal waters of western Madagascar. Their average travel rates during the crossing to Madagascar varied between ~103 km.day^{-1} and 172 km.day^{-1} which are comparable to migrating humpback whales in the North Pacific and Southwest Atlantic (Mate et al., 1998, Zerbini et al., 2006, Lagerquist et al., 2008). In both years, a female with her calf reached the northwest coast of Madagascar, suggesting this might be a regular stop-over site for migrating humpbacks from sub-region C2. Before reaching Madagascar, whale #20690 also visited the waters of Mohéli's neighbouring island of Anjouan and most likely the waters of Mayotte. Its tag stopped after one day in Madagascar waters. The other whale (#37227) remained in western Madagascar's coastal waters for nine days. Even though this was not the most direct route to their supposed Antarctic foraging grounds, both whales may have tried to maximize the time spent with their calves in shallow waters (Ford and Reeves 2008). This strategy has been documented in grey whales along the coast of California where migrating mother–calf pairs follow the contour of the shoreline presumably to limit encounters with predators, especially killer whales (*Orcinus orca*) (Ford and Reeves 2008). The last three whales (#22851, #37235, #37278) reached the west coast of Madagascar several hundreds of kilometres south. The two whales travelling together (#37235, #37278) first reached the continental shelf at about 15°S and then followed its edge down to 18°S, i.e. to the area where #22851 spent two weeks the year before. It is well known in other marine species that males may visit multiple rookeries within a single breeding season (Wright et al., 2012). These whales might therefore stopped, after visiting

the Comoros archipelago, to mate at another breeding site on their way to the foraging grounds. The slow travelling rate of one individual (~ 4 km.day^{-1}, #22851) in this area may also suggest that this whale stopped there for foraging before resuming its migration to the south. Shrimp trawlers and other fisheries operating in this area (Razafindrainibe 2010, Le Manacha et al., 2011) suggest that these are productive waters. Similarly, the two whales which were tracked further south slowed down regularly during their journey suggesting that they might have foraged en route. Opportunistic feeding behaviour during stopovers along the migratory route has previously been reported in humpback whales (Mate et al., 2007, Lagerquist et al., 2008).

4.3 Migratory destinations

The Walters Shoal, a shallow bank south of Madagascar, has been previously identified as an important stop-over site for humpback whales during their migration, however, the only whale (#37378) in our study which travelled relatively close to Walters Shoal did not seem to stop there. Instead, this whale travelled south-eastward towards the French sub-Antarctic islands and was moving slowly northwest of the Crozet plateau when contact was lost. A phytoplankton bloom occurs north of the Crozet plateau annually from September to January (Venables et al., 2007) probably creating favourable foraging conditions for migrating humpback whales in that area. It is not clear, however, if the Crozet plateau was the whale's final migratory destination or if it travelled further east after the tag stopped. The whale (#37235) followed a different migratory route. This individual migrated south-westwards along the South-West Indian Ridge and first slowed down in an area northwest of the Prince Edward Islands where other large top predators including marine mammals and seabirds have previously been reported foraging (Jonker and Bester 1998, Nel et al., 2001, de Bruyn et al., 2009). It then resumed travelling south-westward and 49 days after it was tagged near Mayotte contact was lost at about 57°S, 27°E, i.e. in IWC feeding ground III previously defined as the main feeding ground of humpbacks whales from breeding stock C (Fleming and Jackson 2011, IWC 2011). This is the first description of the migratory route of a humpback whale from breeding stock C towards the IWC feeding ground III.

4.4 Movements between breeding sub-regions within the same breeding season

Five out of the eight tagged whales visited Madagascar's coastal waters on their way to their foraging grounds. Four remained on the west coast travelling through or stopping at areas where high sighting rates of humpback whales (including competitive groups) have previously been reported in late October/early November, in particular off Toliara in the southwest but also further north off Nosy Be (Cerchio et al., 2009, Best et al., 1998). The relationship of these whales breeding on the west coast of Madagascar to those breeding on the east coast or in the Comoros archipelago is however unknown. Our results are the first to suggest a connection between these sites within the same breeding season and to show that whales from the breeding sub-region C2 stop over along the west coast of Madagascar during their southward migration.

In this study, one female humpback after travelling northward along the west coast of Madagascar crossed the Cape Amber and travelled southward along the east coast. Photo-identification comparisons and genetic analysis have previously suggested a strong between-year connection between the Comoros archipelago and eastern Madagascar (Pomilla et al., 2006, Ersts et al., 2011b) but this is the first report of whales visiting the Comoros archipelago and both the western and eastern coasts of Madagascar during the same breeding season. In other words, humpback whales might use breeding sub-regions C2 and C3 during the same breeding season

which may have important implications for population estimates and to revise the definition of IWC breeding sub-regions. These results indeed suggest that these two sub-regions may be considered as one single region.

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