DISTRIBUTION, SEASONAL MOVEMENTS AND MIGRATION BEHAVIOURS OF HUMPBACK WHALES (*Megaptera novaeangliae*) IN THE PONTA DO OURO PARTIAL MARINE RESERVE (PPMR) – MOZAMBIQUE – 2013 to 2016

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Image Source: DERC

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Abstract

This is the first annual report on distribution, seasonal movements and migration behaviours of humpback whales (*Megaptera novaeangliae*) in the Ponta do Ouro Partial Marine Reserve (PPMR). Humpback whale research has been undertaken in the area for the past 10 years as part of Dolphin Encountours Research Center (DERC) and DolphinCareAfrica's (DCA) opportunistic monitoring work. Data has been previously compiled within the annual DolphinCare Report - Monitoring of Marine Megafauna within the PPMR.

In order to create an environment for gathering and exchanging data that can be used for the enrichment of knowledge on the humpback whale population, a Memorandum of Understanding (MOU) was signed in August 2014 between DERC & DCA, represented by Diana Rocha and Back to Basics Adventures (B2B), represented by Jenny Stromvoll to conduct longterm research on humpback whales in the PPMR.

During the winter months, humpback whales migrate from their Antarctic summer feeding grounds to their sub-tropical winter calving grounds. Habitat considered important for supporting humpback whale populations are those areas utilised for feeding, calving, resting and migratory routes (DEH 2005). The PPMR is known as a migratory route for humpback whales that breed around the Bazaruto Archipelago.

This report compiles data collected from the migratory seasons of 2013 to 2016 from the DERC commercial boat, as well as the 2014 migratory season from B2B

commercial boat. Due to lack of funding B2B did not continue the Humpback Whale Project.

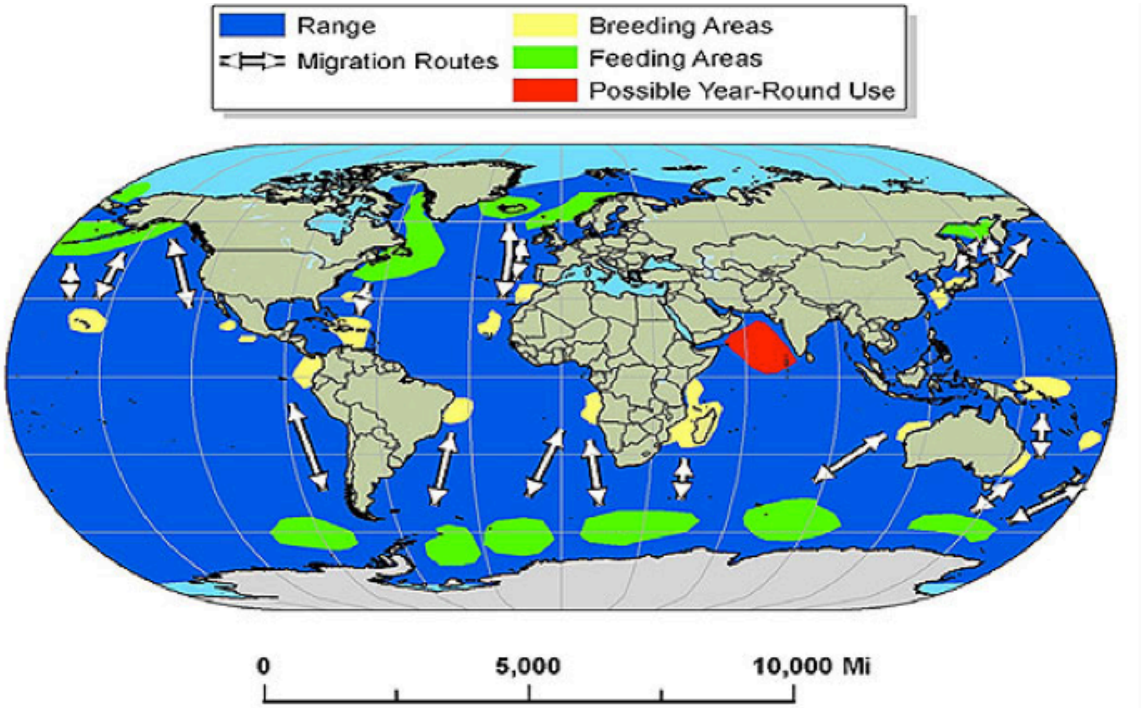
Results indicate that the whales travel these waters from June to December and change from northbound to southbound in August; they presented mostly a travelling behaviour confirming this area as a migratory corridor. The small amount of sightings during northbound suggest the whales travel further offshore, where the commercial dolphin viewing and diving boats don´t travel.

Image: Humpback whales
Photo: DERC

Introduction

The Humpback Whale is a cosmopolitan species found in all the major ocean (Clapham and Mead 1999) and only one of the subpopulations (that of the Arabian Sea) does not migrate between mating and calving grounds in tropical waters, usually near continental coastlines or island groups, and productive colder waters in temperate and high latitudes (Fig.1)

Fig.1 – Map of humpback whale migration (https://nature.nps.gov)



Seven Southern Hemisphere humpback whale breeding populations (termed by the International Whaling Commission (IWC) as Breeding Stocks A-G) migrate between seven winter breeding grounds in tropical or sub-tropical coastal waters of Southern Hemisphere continents or island archipelagos, and polar summer feeding grounds to the south (Best et al. 1998) (Fig.2)

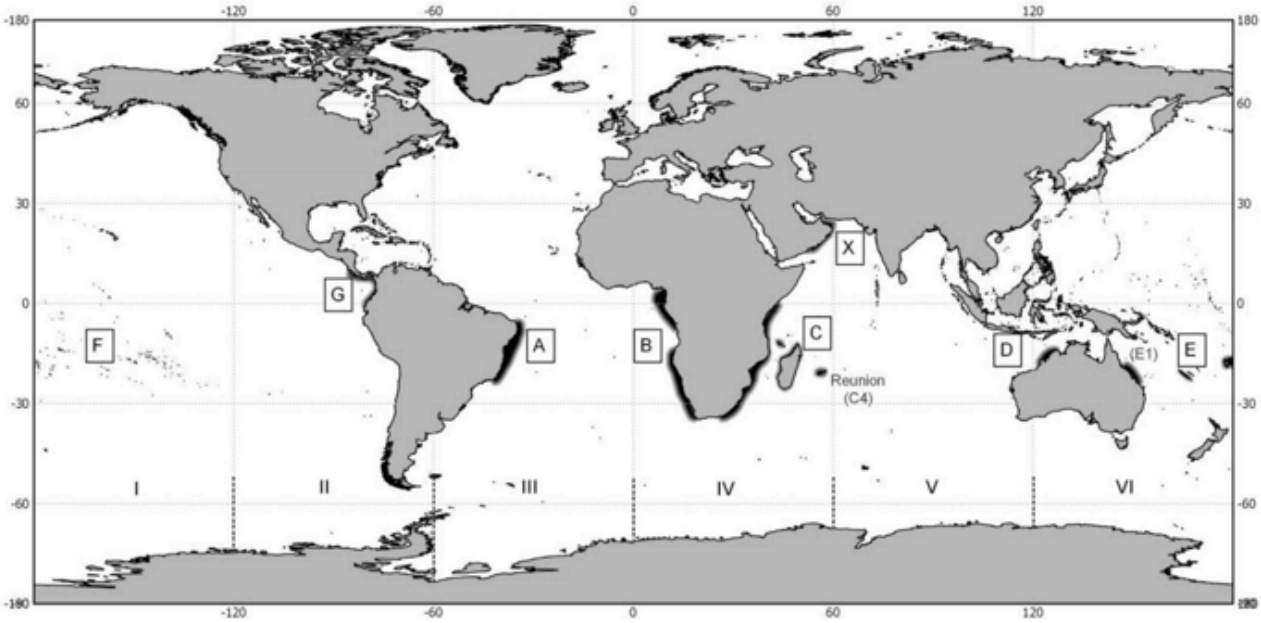


Fig.2 – Distribution of the southern hemisphere breeding stocks (Das et al. 2016).

Some of these populations utilise the continental coastal waters as migratory corridors. The east coast of South Africa conveys whales along the coast of Kwazulu-Natal, South Africa between the breeding grounds in Mozambican waters and the Antarctic feeding grounds (Best et al. 1998, Findlay et al. 2011a and b). Four sub-stocks are recognised within Breeding stock C, namely C1S wintering off the northeast coast of South Africa to Mozambique and a relatively small C1N component ranging in Tanzanian and Kenyan waters; C2, a group that potentially migrates up the Mozambique channel to winter grounds in the Comoros Archipelago and Aldabra; C3 overwintering in the coastal waters of Madagascar and C4 overwintering in the coastal waters of the Mascarene archipelago (Best et al. 1998; IWC 2011).

Populations of Southern Hemisphere humpback whales declined markedly during the 20th century as a result of severe modern whaling on both the Antarctic feeding and tropical breeding grounds (Findlay, 2001). Modern whaling started off

the east African coast in 1908 and coastal migrating humpback whales were the first species to be targeted. By 1915 it is estimated that over 25,000 humpback whales were taken off the African coast from Congo to Madagascar (Findlay, 2001). Modern whaling occurred in Mozambican waters between 1910 and 1923, with land stations and floating factories between Angoche and Delagoa Bay; with humpback whales dominating the catch (Tonnessen and Johnsen, 1982). Certain Southern Hemisphere populations of humpback whales appear to be undergoing considerable recovery from whaling in some wintering grounds including the C1 stock where Findlay et al. (2011a) have estimated the annual increase rate at some 10% per annum over the period 1988 to 2002, and the abundance of this stock has been modelled to now be at some 65-98% of its pre-exploitation abundance (IWC, 2011).

Understanding the temporal patterns of humpback whales during migration and on winter grounds can reveal aspects of population structure such as age, class and reproductive status (Brown & Corkeron, 1995; Craig et al., 2003; Dawbin, 1997). This data is important in the management of stock recovery. Information relating to humpback whale temporal usage patterns in sub region C1-S as its

Image: Humpback whales traveling. Unique dorsal fin
Photo: DERC

migration route is limited to a small number of shore and boat-based surveys (Banks, 2013) and Findlay et al (1994, 2011) have done two surveys 1991 and 2003.

Establishing effective and representative systems of marine protected areas (MPAs) is part of a global strategy to conserve biodiversity (Convention on Biological Diversity – CBD, 2014) In the face of increasing threats, the establishment of MPAs is rising globally because these areas are viewed as an important management tool to prevent, reduce, or even reverse ongoing loss in marine biodiversity (Agardy, 1994; Agardy et al., 2003; Gormley et al., 2012; Hoyt, 2005; Spalding et al., 2008; Wood et al., 2008). Because of their broad seasonal habitat, highly-mobile and migratory species typically offer a major challenge for spatial management (Game et al., 2009; Hyrenbach et al., 2000). Even though the usefulness of MPAs to protect these species is debatable (Notarbartolo di Sciara, 2007) because MPAs may only include a small portion of a species range, they may represent an effective measure for protecting part of their habitats (Game et al., 2009; Hoyt, 2005).

Methodology

Study area

The area of study falls within the Ponta do Ouro Partial Marine Reserve (PPMR) that extends from Inhaca Island, in the north, to Ponta do Ouro, in the south of Mozambique; bordering South Africa's iSimangaliso World Heritage Site. The reserve has an extension of 3 nautical miles (nmi) out into the Indian Ocean from the coast line and includes a sanctuary and multiple use areas; our focus is within the multiple use areas of Ponta do Ouro and Ponta Malongane (Fig.3).

Fig.3 – PPMR map with boundaries.

Boat based surveys

Two semi-rigid inflatable boats were used from 2 commercial operators (diving and dolphin & whale viewing). Sightings made while vessels were at full searching effort during dedicated surveys were recorded as primary, while those made opportunistically (during commercial activities of vessel, such as diving and travelling) were recorded as secondary.

Boat based data analysis: The total boat time from launching to beaching has two components; “search time” or effort and “observation time”. Trip time starts and ends with the launch and beach times recorded for each trip. These were analysed monthly.

Mean group size was calculated by month, and frequency of each group size calculated for each season. Group size data from each season was stratified into the northbound and southbound migration. By dividing them into these 2 groups we can ascertain when the turnover occurs, i.e. when breeding season is over and they start heading back to their feeding grounds. This division was based on changes in encounter rates, travel direction and group composition data.

GIS plotting was done with GPS coordinates collected on both hand held and mounted systems and the Lowrance Elite 4 HDI GPS set to collect in degrees, decimal & minutes. This was then entered as decimal degrees into an excel spread sheet. Coordinates were collected on sighting of and in close proximity to the whale/s. Data was entered per year to assess the humpback whale distribution within the the PPMR’s borders. GIS staff from the Peace Parks Foundation worked on the data and produced the distribution map.

Behavior analyses: was made based on three behavioral categories: **travelling** – constant move in one direction; **social** - tail displays, twirling, breaching etc and; **logging** - whales are seen resting by standing still on the surface.

Photographic catalogue: On each sighting, an attempt was made to allocate an ‘individual number’ to each individual based on distinguishing marks, scars, or skin pigmentation observed on the body, dorsal fin or tail fluke; this aids on the assignment of dorsal fin images to tail flukes in order to produce a complete photographic record for an individual. Each image was assigned a ‘Fluke Type’ number based on fluke pigmentation patterns, on a 1-5, all- white to all-black scale.

Monitoring Results

a) Effort demonstration

The below table (Table 1) shows the amount of effort hours per month and per year. Considering that the trips are not of a dedicated nature, they are tourism and weather dependent; these values fluctuate throughout the months, but show consistency between the years.

Table 1 – Effort time in hours, per month and per year, from 2013 to 2016.

	Effort (hr)			
month/year	2013	2014	2015	2016
jun	19.7	15.0	19.8	31.5
jul	38.3	23.0	33.8	26.8
aug	26.7	15.0	21.0	33.8
set	20.9	16.0	19.8	24.5
oct	19.7	25.0	18.7	10.5
nov	11.6	11.0	12.8	11.7
TOTAL	136.9	105.0	125.9	138.8

Image: Male humpback whale tail display. Photo: DERC

b) Movement patterns

The following tables (tables 2 to 5) show preliminary results from the data collected on the DERC commercial/research vessel, from the years of 2013 to 2016. Table 6 displays the results from B2B boat during dedicated research trips in 2014.

Only the months from June to December are displayed as these are the months in which humpback whales are observed migrating through the PPMR.

The number of sightings have been divided into 2 groups, northbound (= when the whales are travelling north, from Antarctica to their breeding grounds in Mozambique) and the southbound (= when the whales are travelling south, from their breeding grounds in Mozambique to their feeding grounds in Antarctica).

The results indicate that August is the turnover month for both migratory seasons. It also shows that there are more sightings during the southbound, especially of mother and calf pairs (Fig. 3)

The data shows a decrease of sightings on the northbound in the last two years (2015 & 2016) (Tables 4 and 5).

Table 2 - Variables observed during migratory season of 2013, data collected on board of dolphin commercial boat.

Month	#Dyads	# Sightings S	# Sightings N	Length obs (min)	Effort (hr)
13-Jun	3	0	4	99	20
13-Jul	4	1	7	155	39
13-Aug	7	8	10	228	27
13-Sep	6	11	3	226	21
13-Oct	12	10	2	214	20
13-Nov	2	4	0	34	12
13-Dec	1	1	0	21	36
TOTAL	35	35	26	977	175

Table 3 - Variables observed during migratory season of 2014, data collected on board of dolphin commercial boat.

Month	#Dyads	# Sightings S	# Sightings N	Length obs (min)	Effort (hr)
14-Jun	0	0	0	0	15
14-Jul	6	1	10	149	23
14-Aug	10	5	8	249	15
14-Sep	13	19	7	279	16
14-Oct	20	16	7	248	25
14-Nov	2	14	8	15	11
14-Dec	2	3	0	19	26
TOTAL	53	58	40	959	131

Table 4 - Variables observed during migratory season of 2015, data collected on board of dolphin commercial boat.

Month	#Dyads	# Sightings S	# Sightings N	Length obs (min)	Effort (hr)
15-Jun	0	0	1	24	26
15-Jul	1	2	5	115	44
15-Aug	6	20	5	200	27
15-Sep	13	28	4	224	26
15-Oct	4	13	0	161	24
15-Nov	3	3	0	53	17
15-Dec	0	0	0	0	47
TOTAL	27	66	15	777	209

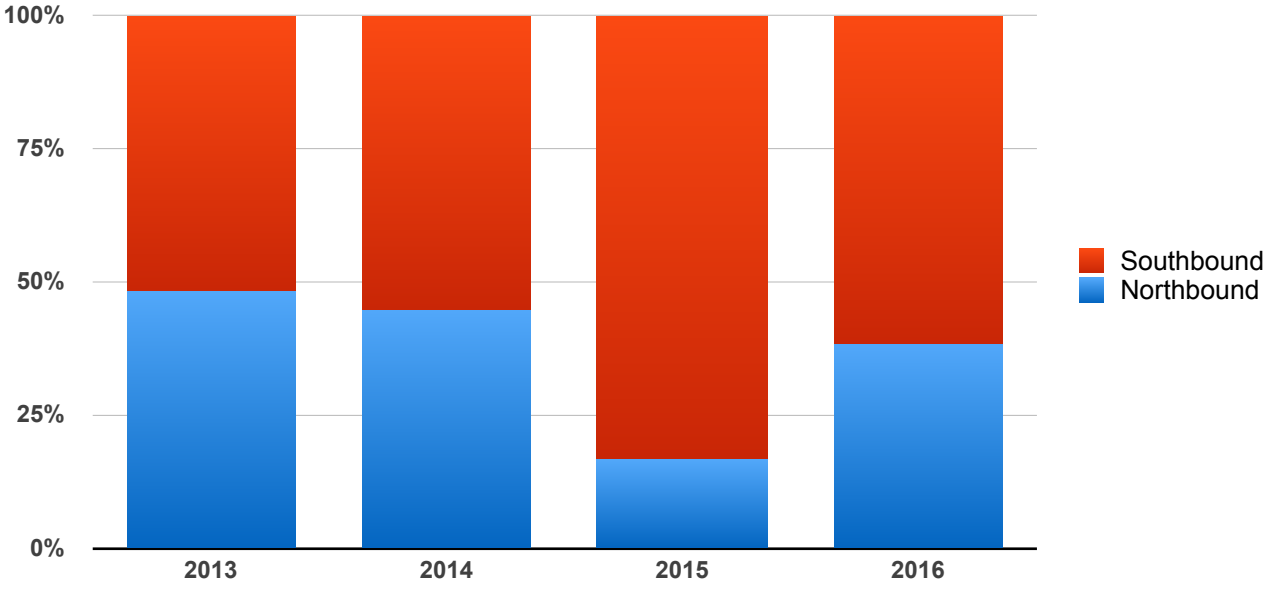
Table 5 - Variables observed during migratory season of 2016, data collected on board of dolphin commercial boat.

Month	#Dyads	# Sightings S	# Sightings N	Length obs (min)	Effort (hr)
16-Jun	0	0	0	0	41
16-Jul	3	4	4	107	35
16-Aug	6	25	6	233	44
16-Sep	7	20	5	164	32
16-Oct	6	7	1	112	29
16-Nov	0	0	0	0	15
16-Dec	0	0	0	0	56
TOTAL	22	56	16	616	252

Table 6 - Movement patterns collected by Back to Basics boat during both, dedicated (research trips) and opportunistic observations (dives), during 2014 migratory season.

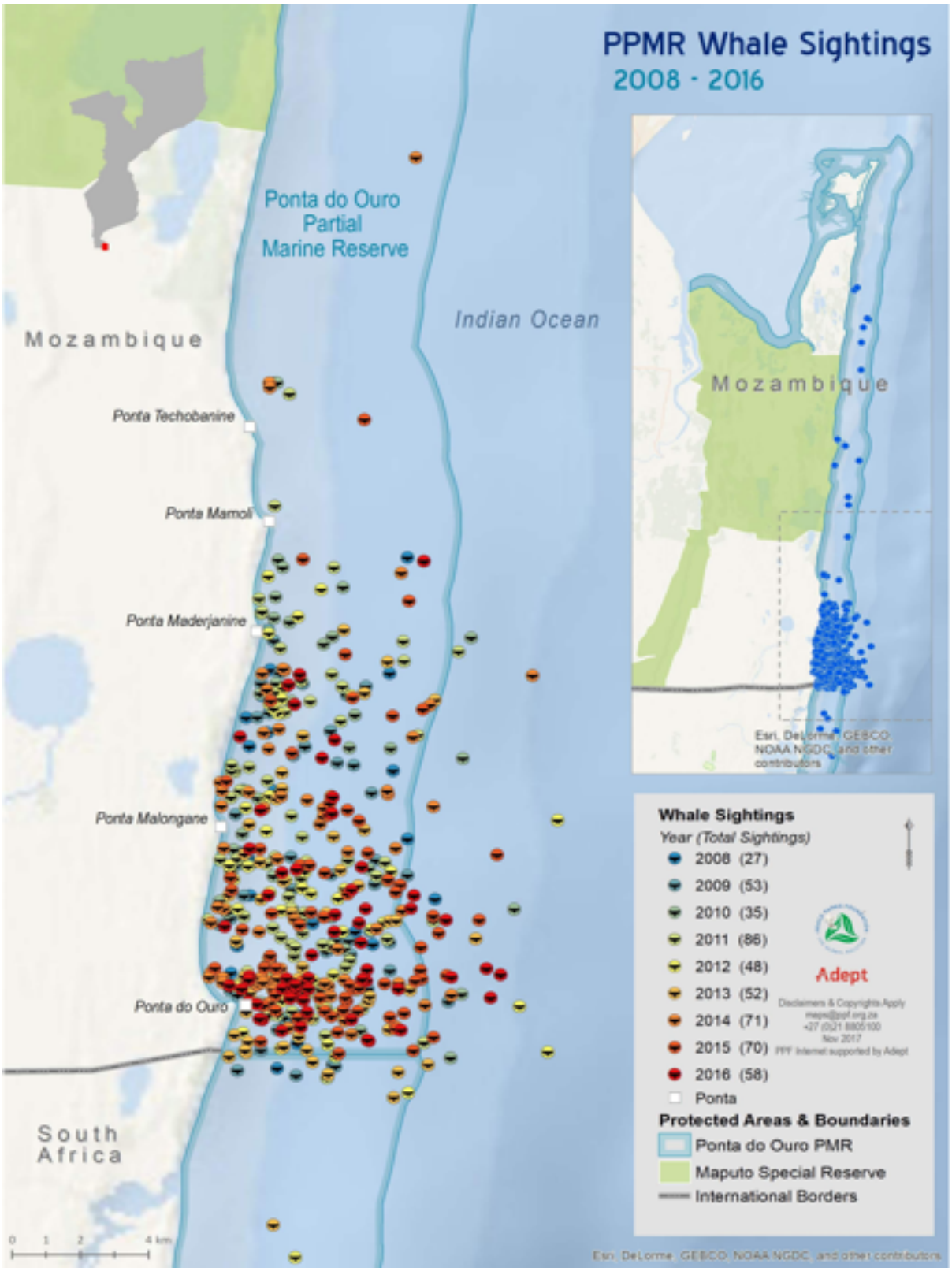
Month	#Dyads	# Sightings S	# Sightings N	# Sightings/ month
14-Jun	0	0	0	0
14-Jul	0	0	0	0
14-Aug	3	5	4	18
14-Sep	7	16	5	24
14-Oct	1	2	1	5
14-Nov	0	0	0	0
14-Dec	0	0	0	0
TOTAL	11	23	10	47

Fig.4 – Percentage of groups with dyads sighted per bound (north and south), per year (2013 to 2016).



A total of 499 sighting were considered for the GIS plotting that spread over 9 years. The 2008 season saw the least amount of sightings recorded while 2011 the most. Sighting aggregations can be seen between the bays of Ponta do Ouro and Ponta Madajanine as this is the search area from commercial marine mammal tours.

The most frequent group size sighted was of 2 individuals with values between 39 groups for the year of 2013 and 61 groups for the year of 2016, followed by ones and threes. Groups with 4 or more individuals are uncommon for this study area. Sightings recorded out of the PPMR border are likely data collection or entry errors.



c) Group Size analysis:

Group size was divided into 5 categories. Groups with 1 individual, 2 individuals, 3 individuals, 4 individuals or more and analysed per year/season (Fig.5).

The most frequent group size sighted was of 2 individuals with values between 39 groups for the year of 2013 and 61 groups for the year of 2016, followed by ones and threes. Groups with 4 or more individuals are uncommon for this study area.

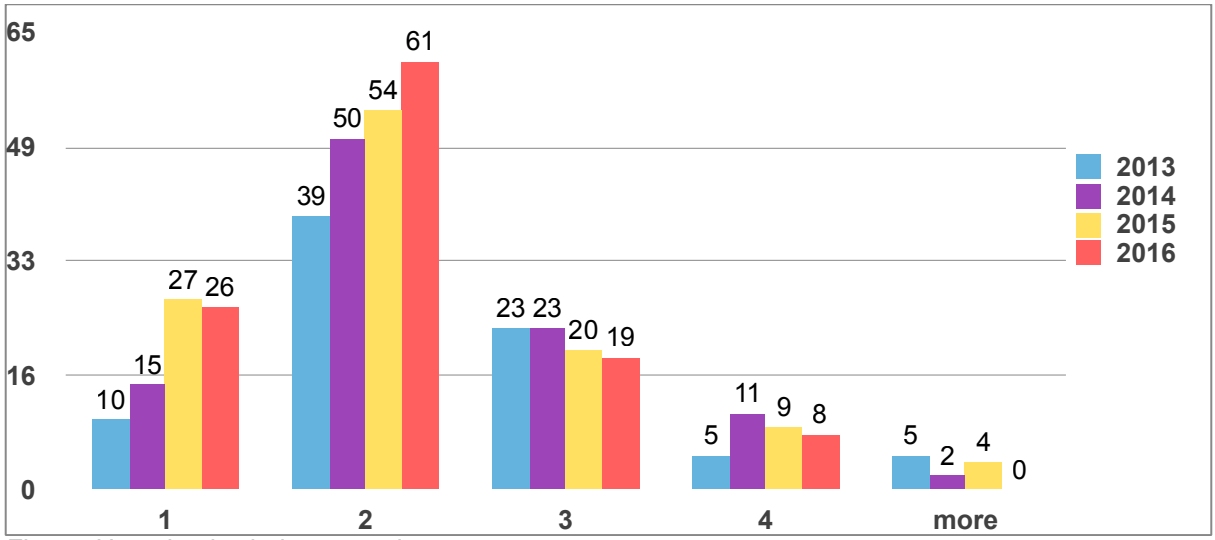


Fig.5 – Humpback whale group size per year.

d) Behavior analysis:

Whale behavior was calculated per month (Table 7) for the years of 2013 to 2016. Travelling was the most observed behavior for all years with percentages between 66% and 74%, followed by social behaviors, with percentages between 17% and 33%; and ending with logging between 0% and 10%. Logging displays an unusual high value of 10% for the year of 2014.

Table 7 – Number of observations per behavior category, per year (season).

Year	Travel	% Travel	Social	% Social	Logging	% Logging	TOTAL
2013	38	66	19	33	1	2	58
2014	53	74	12	17	7	10	72
2015	59	71	24	29	0	0	83
2016	46	67	23	33	0	0	69

e) Photo identification catalogue:

The pictures were taken from DERC boat for years between 2009 and 2016, all the good quality pictures of a full fluke were taken in account and listed per year (Table 8). B2B provided pictures only from 2014.

For future results each image must now be assigned a 'Fluke Type' number based on fluke pigmentation patterns on a 1-5; all- white to all-black scale (Fig.6).

An annual catalogue was created from all the pictures taken per season (Table 9); it is now necessary to merge all years and establish a mark-recapture history for the population.

Table 8 – Number of ID pictures obtained per year.

YEAR	# Ids
2009	10
2010	12
2011	34
2012	13
2013	27
2014	31
2015	26
2016	21

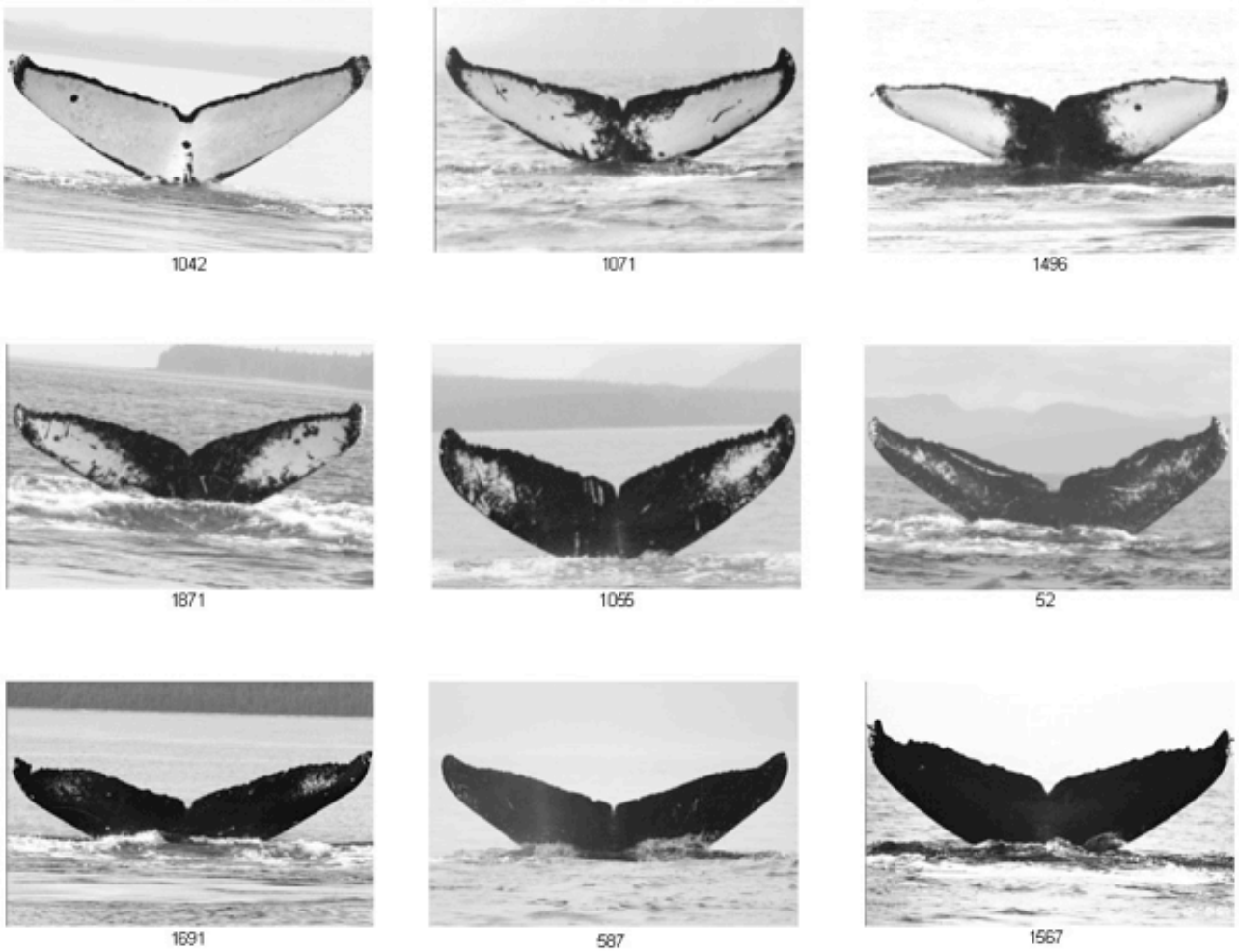


Figure 6 – Fluke type, all white to all black example.

Access: www.alaskahumpbacks.org, 10/10/14.

HBW ID Catalogue				HBW ID Catalogue			
2009	2010	2011	2012	2013	2014	2015	2016
HBW2009.001	HBW2010.001	HBW2011.001	HBW2012.001	HBW2013.001	HBW2014.001	HBW2015.001	HBW2016.001
HBW2009.002	HBW2010.002	HBW2011.002	HBW2012.002	HBW2013.002	HBW2014.002	HBW2015.002	HBW2016.002
HBW2009.003	HBW2010.003	HBW2011.003	HBW2012.003	HBW2013.003	HBW2014.003	HBW2015.003	HBW2016.003
HBW2009.004	HBW2010.004	HBW2011.004	HBW2012.004	HBW2013.004	HBW2014.004	HBW2015.004	HBW2016.004
HBW2009.005	HBW2010.005	HBW2011.005	HBW2012.005	HBW2013.005	HBW2014.005	HBW2015.005	HBW2016.005
HBW2009.006	HBW2010.006	HBW2011.006	HBW2012.006	HBW2013.006	HBW2014.006	HBW2015.006	HBW2016.006
HBW2009.007	HBW2010.007	HBW2011.007	HBW2012.007	HBW2013.007	HBW2014.007	HBW2015.007	HBW2016.007
HBW2009.008	HBW2010.008	HBW2011.008	HBW2012.008	HBW2013.008	HBW2014.008	HBW2015.008	HBW2016.008
HBW2009.009	HBW2010.009	HBW2011.009	HBW2012.009	HBW2013.009	HBW2014.009	HBW2015.009	HBW2016.009
HBW2009.010	HBW2010.010	HBW2011.010	HBW2012.010	HBW2013.010	HBW2014.010	HBW2015.010	HBW2016.010
	HBW2010.011	HBW2011.011	HBW2012.011	HBW2013.011	HBW2014.011	HBW2015.011	HBW2016.011
	HBW2010.012	HBW2011.012	HBW2012.012	HBW2013.012	HBW2014.012	HBW2015.012	HBW2016.012
		HBW2011.013	HBW2012.013	HBW2013.013	HBW2014.013	HBW2015.013	HBW2016.013
		HBW2011.014		HBW2013.014	HBW2014.014	HBW2015.014	HBW2016.014
		HBW2011.015		HBW2013.015	HBW2014.015	HBW2015.015	HBW2016.015
		HBW2011.016		HBW2013.016	HBW2014.016	HBW2015.016	HBW2016.016
		HBW2011.017		HBW2013.017	HBW2014.017	HBW2015.017	HBW2016.017
		HBW2011.018		HBW2013.018	HBW2014.018	HBW2015.018	HBW2016.018
		HBW2011.019		HBW2013.019	HBW2014.019	HBW2015.019	HBW2016.019
		HBW2011.020		HBW2013.020	HBW2014.020	HBW2015.020	HBW2016.020
		HBW2011.021		HBW2013.021	HBW2014.021	HBW2015.021	HBW2016.021
		HBW2011.022		HBW2013.022	HBW2014.022	HBW2015.022	
		HBW2011.023		HBW2013.023	HBW2014.023	HBW2015.023	
		HBW2011.024		HBW2013.024	HBW2014.024	HBW2015.024	
		HBW2011.025		HBW2013.025	HBW2014.025	HBW2015.025	
		HBW2011.026		HBW2013.026	HBW2014.026	HBW2015.026	
		HBW2011.027		HBW2013.027	HBW2014.027		
		HBW2011.028			HBW2014.028		
		HBW2011.029			HBW2014.029		
		HBW2011.030			HBW2014.030		
		HBW2011.031			HBW2014.031		
		HBW2011.032					
		HBW2011.033					
		HBW2011.034					

Table 9 – List if ID´s for Humpback Whales from the migratory season of 2009 to 2016.

Ongoing studies & projects:

1. Mozambican Fluke ID Catalogue: An annual catalogue was created from all the pictures taken per season, it is now necessary to merge all years and establish a mark-recapture history for the population. This main ID Catalogue can, in the future be used to compare C1-S with C1-N populations, as well as all C populations.

   Once all back data has been introduced into the mark recapture software and a main catalogue has been established, we will reach out to other researchers in Mozambique that have fluke pictures to collaborate with in creating a national humpback whale catalogue.

2. Matching Catalogue with CetaMada's catalogue (humpback whale research team in Madagascar).

3. Collaboration with an American start up, Happy Whale, a computer algorithm based fluke catalog which allows citizen scientists and active research groups around the world to share their fluke photographs and match them against each other in real time.

4. Longterm monitoring of the Humpback whale population that travels through the PPMR. Land based observation, opportunistic sightings during diving activities, boat based sightings during commercial dolphin and whale trips and dedicated research trips will be used to gather information.

Conclusion

Due to lack of funding, no dedicated trips occurred.

The results indicate that humpback whales navigate these waters from June to December every year on their way to the breeding grounds, giving the Ponta do Ouro Partial Marine Reserve great importance for the protection of this species.

The even distribution along the 3 nautical mile width of PPMR suggests that monitoring should be extended beyond the borders to asses full distribution of humpback whales within this area and to establish if 3 nautical miles is enough to protect the migratory corridor of this animals or if further widening should be considered.

Results show that most whales presented a travelling behavior, confirming that this is a migratory corridor, and not yet part of their northern breeding grounds.

The small amount of sightings during the northbound suggest that the whales navigate further out to sea, where the commercial dolphin viewing and diving boats don´t often venture.

The change from northbound to southbound occurs predominantly over the month of August.

August, September and October have proven to be the months with more sightings closer inshore where all commercial boats navigate; these are mostly whales moving south.

Recommendations

It is important to do dedicated monitoring trips especially in deeper waters to obtain more data on the southbound and produce more reliable results.

An increase in patrolling on the shallower, multi use waters is suggested during the whale peak sighting months of August, September and October to ensure no proximity (300m distance) of unauthorised private and commercial boats, as well as overcrowding and misbehaviour of licensed boats.

It is also suggested that more information be supplied to reserve users (residents and visitors) in the form of posters, brochures, educational events & briefings by boat operators and informational briefings by government officials issuing boat and fishing permits.

Although there is a code of conduct for marine mammals enforced by the PPMR Management Plan we recommend the inclusion of an exclusive Humpback Whale Code of Conduct. The marine mammal code of conduct as the name implies, applies to all marine mammals, however it was designed based on the resident bottlenose dolphin population in the reserve which is the most common marine mammal to be encountered by tourism operators and tourists. Humpback whales are a migratory species using this area only as a migratory corridor therefore their behavior and reaction to human approach will be different and a dedicated code of conduct should be designed. More monitoring is necessary to ascertain the need of a longer distance of observation, observation periods and resting intervals for the individuals between each operators approach.

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