A Nationwide Survey of Cetaceans in Tanzania

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Executive Summary

1. Cetaceans are important and charismatic components of ocean biodiversity, however many populations and species are undergoing substantial declines. In many parts of the world cetaceans remain very poorly known, and this is a major challenge to effective conservation and to informed management. This is the case in Tanzania, where although there have been extensive cetacean studies conducted on Unguja, and ad recording of humpback whales by volunteers, there is very little information on cetaceans from the rest of the country, including the 800km coast and the islands of Mafia and Pemba. The lack of basic information on cetaceans presents a challenge to those tasked with protecting the marine environment or identifying and managing the impact of new developments.

2. Here we report on a national cetacean assessment, the objective of which was to provide broad-scale baseline information on cetacean species occurrence, distribution and abundance for the entire coast of Tanzania.

3. A vessel based visual and acoustic cetacean survey was conducted between March and April 2015 along approximately 2600km of transect lines systematically arranged to evenly cover waters out to 50km from shore. A total of 91 groups of 11 species were recorded. The most commonly encountered species were spinner dolphins (*Stenella longirostris*), Risso's dolphins (*Grampus griseus*), Indo-pacific bottlenose dolphins (*Tursiops aduncus*) and common bottlenose dolphins (*Tursiops truncatus*). As the survey was conducted at the end of the austral summer, migratory baleen whales were absent. The number of cetacean species confirmed to occur in Tanzania is now 19.

4. The survey documented considerable cetacean biodiversity and considerable variation in relative abundance and diversity along the coast. Evidence suggests that the Pemba Channel is the most important area for cetaceans along the Tanzanian coast, as by far the highest number of cetacean species and relative species diversity, as well as high relative abundance were recorded in that location. By contrast, Zone 5 – Mtwara/Lindi had the highest cetacean relative abundance but quite low diversity indices. Near-shore waters are the most heavily fished and impacted by humans therefore the dolphin species that are specifically found only in the coastal zone; Indian Ocean humpback and Indo-pacific bottlenose dolphins, are likely to suffer the greatest mortality in fishing gear and be the most locally threatened. These two species, as well as migratory Humpback whales are priority for more focussed study and conservation.

5. This study demonstrates that there is considerable marine mammal biodiversity in Tanzania. However, our level of knowledge about these mammals, especially with regards to their life history, the impact of threats, and what is required to conserve them lags way behind their terrestrial cousins. This is an important national natural resource that it is important to further understand, manage and protect.

1. Introduction

Cetaceans are important and charismatic components of ocean biodiversity. They can be keystone species that increase productivity of the oceans, and they can be critical to maintain the structure and function of marine ecosystems (e.g. Bowen 1997, Roman et al. 2014, Kiszka et al. 2015). Despite being some of the more iconic animals in the sea, cetaceans as well as many other marine megafauna, including sharks and sea turtles, are undergoing large and unprecedented declines (Heithaus et al. 2008; Lewison et al. 2004). However, in many parts of the world, including in Tanzania, their distribution, abundance and the magnitude of human impact remain very poorly understood which is a major hurdle to their effective conservation and informed management.

Prior to this study, 16 cetacean species had been recorded in Tanzanian waters; the majority odontocetes, as is typical in the tropics (Amir et al. 2012). Most species documented or expected to occur do not undertake large migrations, although there may be seasonal distribution shifts. The exception to this are humpback whales (*Megaptera novaeangliae*) which are present in Tanzanian waters mainly from June to November (Berggren 2009). The cetaceans of Unguja Island are relatively well known as they have been studied during long-term work, which has included documentation of strandings, evaluation of bycatch, and estimation of distribution and abundance of resident coastal dolphins in Menai Bay (e.g.Amir et al. 2002; Christiansen et al. 2010; Stensland and Berggren 2007; Temple et al. 2016). Outside of Unguja there have been very few systematic cetacean surveys and consequently there is very little information on cetaceans from anywhere in the rest of the country, which includes the 800km long coast of the Tanzanian mainland, and Pemba and Mafia Islands (Amir et al. 2012). However, a network of volunteers observers scattered along the entire coastline of Tanzania documented the seasonal visits of humpback whales from 2008 to the present, reporting a large variation on numbers seen, with a maximum for a single day exceeding 300 individuals (Samaki Consultants Ltd. 2010).

The lack of basic information on cetaceans presents a challenge to those tasked with protecting the marine environment or identifying and managing the impact of new developments. In the absence of information, and given the difficulty and expense of collecting field data on cetaceans, this important part of the ecosystem is often omitted, or are given only cursory attention in environmental impact assessments, national marine conservation planning, coastal zone management activities, or during identification of global or regional sensitive, priority or marine protected areas.

In response to this challenge, the objective of this work was to conduct a national assessment of cetaceans that would provide a quantitative overview of cetacean species diversity, abundance and distribution for Tanzania.

2. **Methods**

2.1. Study Area

The Tanzanian coastline is dominated by the warm, nutrient-poor, north East African Coastal Current and is subject to two seasonal monsoons, the NE from December to February and the SE from June to September, interspersed with calm, rainy periods. The study area encompassed the entire coast of Tanzania (approximately 4-10^{o}S) to approximately 50km from shore, irrespective of depth (Figure 1). It includes the Rufiji delta which is one of the largest estuaries in eastern Africa, the islands of Pemba, Unguja, Mafia and Latham which have considerable fringing reefs and seagrass habitat, and oceanic waters more than 1000 m deep in the Pemba Channel and south of Kilwa (Figure 1).

The study area was split into five 'Zones' defined as "*an area with a definable boundary within which the character of habitats, biological communities, and/or management issues have more in common with each other than they do with those in adjacent areas*" (Alliance for Zero Extinction 2003). The zones, which align approximately with the Tanzanian coastal provinces, are from north to south (Figure 1):

- Zone 1 – Pemba Channel,
- Zone 2 – Zanzibar Channel,
- Zone 3 - Dar es Salaam,
- Zone 4 – Rufiji Delta
- Zone 5 – Mtwara/Lindi

2.2. Vessel-based cetacean survey

A visual cetacean survey was conducted from a 50-foot catamaran using standard line transect survey methods (Buckland et al. 2001). Transect lines that ran east-west across depth contours were laid out using the programme DISTANCE (Thomas et al. 2010) giving 36 transect lines, spaced 21 km apart, and 2500 km of on effort survey track (Figure 1).

Three observers scanned continuously for cetaceans from the roof of the catamaran using 7 x 50 marine binoculars. A central observer scanned 45 degrees either side of the trackline, and two observers scanned from the beam to the track. Observers took 1 hour of rest for every 1.5 hrs of

observations to maintain concentration. Survey effort and sea conditions measured by the Beaufort scale (see Annex A for details) were logged at thirty minute intervals throughout the day, and when conditions changed, and surveying was suspended when sea conditions rose above Beaufort 4. When cetaceans were first sighted, the vessel's location was recorded using GPS, cetaceans were approached and photographed, the species identified, and group size recorded with a best, high and low estimate of numbers. After each sighting the vessel returned to the transect line.

Figure 1 - Team of visual observers searching for cetaceans

At the same time as the visual survey, during daylight hours, passive acoustic monitoring (PAM) using a towed hydrophone array was conducted to detect the echolocation clicks, whistles, and other vocalizations of cetaceans. This was especially useful to detect species such as beaked whales (Ziphiidae) and other cetaceans that dive to great depths and have a very short-surface interval meaning they were likely to be missed by the visual survey. A stereo towed hydrophone array was deployed on 100 m of Kevlar strengthened cable. A TASCAM DR680 recorder was used to make continuous 2 channel, 192kHz, 24 bit recordings. A custom SoundTrap 202 High Frequency self-contained archival acoustic recorder (http://www.oceaninstruments.co.nz/) was towed simultaneously from the end of the array. The device had a frequency range of 20Hz to 238kHz and sampled at 576 kHz so that the data could be used to detect the high frequency clicks produced by *Kogia* spp (dwarf and pygmy sperm whales), which would be missed by the lower sample rate on the array. PAMGuard was the software used to analyse the PAM data (Gillespie et al. 2008).

Detections of potential echolocation clicks of sperm whales (*Physeter macrocephalus*), beaked whales and *Kogia* spp. were extracted using PAMGuard and were manually checked and identified to species group based on click length, frequency modulation, frequency range, and (where possible) directionality of the click train. Computer machine learning algorithms are being developed to automatically identify and classify cetacean whistles to species (Gillespie et al. 2013; Roch et al. 2011). As development of whistle classifiers in the western Indian Ocean is still in its infancy (Gruden et al. 2016), we began the process of developing our own classifier. Details of the methods used to develop the whistle classifier and the classifier results are presented in Annex B.

Figure 2- Deploying the Acoustic Array

For the entire study area and for each zone we used all on-effort visual and acoustic detections to determine:

- Cetacean relative abundance (cetacean sightings / km of survey effort in sea conditions of Beaufort 4 or less, termed 'good' conditions), and
- Relative cetacean species diversity (cetacean species / km of survey effort in good survey conditions).

All acoustic detections were included in the calculation of relative abundance, but as only acoustically detected beaked whales were identified to species with confidence only these were included in the calculation of relative species diversity.

2.3. Existing information and opportunistic data on cetaceans

Existing information on cetaceans was collated by examining museum collections; identifying cetacean skeletal remains displayed in hotels, scuba-diving centres, and in coastal communities; searching libraries for published and unpublished information; gathering cetacean sightings from dive centres, sport fishers, tourists, sailors, etc.; collating sightings from Marine Mammal Observers (MMOs) on seismic survey ships and from unpublished coastal dolphin ad humpback whale surveys.

Records were entered into a database provided there were good quality supporting photographs to allow verification of the species. Bottlenose dolphin sightings that could not be identified to species were retained as *Tursiops* spp. All other records that could not be identified, that did not have a location of origin or that were outside the study area were excluded. The number of species present, and the number of records of each species were determined for each zone.

3. Results

3.1. Vessel-based cetacean survey

Over 34 days in March and April 2015, 2616 km of visual boat-based survey effort were conducted along the Tanzanian coast, from the Mozambique border to the Kenya border. Weather was acceptable for the majority of the survey; 90.5% (2368 km) was in Beaufort sea state 4 or less, and 75.5% (1974km) in good conditions of Beaufort sea state 3 or less. The towed acoustic array was deployed during 32 survey days collecting 216h of recordings, and the SoundTrap data totalled 237h of recordings.

A total of 75 marine mammal groups of 11 species were sighted (Table 1). The majority of acoustic cetacean detections coincided with visual cetacean encounters (i.e. cetacean groups sighted at the surface were also simultaneously heard underwater), however for 11 groups of dolphins (family Delphinidae) and five groups of beaked whales (family Ziphiidae) there was no visual sighting only an acoustic detection. This takes the total combined number of cetacean groups detected during the entire survey using both visual and acoustic methods to 91 (Table 1; Figure 1).

The cetacean community recorded was mostly composed of marine dolphins (family Delphinidae), and also included several large odontocetes (e.g. beaked whales (Ziphiidae) and the short-finned pilot whale (*Globicephala macrorhynchus*). The most frequently encountered species was the spinner dolphin, followed by Risso's dolphin, Indo-Pacific bottlenose and common bottlenose dolphins. A single sighting of two dugongs (*Dugong dugon*) was made north of Mafia Island. Indian Ocean humpback dolphins were sighted in shallow near-shore waters less than 30m deep close to Kilwa and along the mainland coast of the Zanzibar Channel. One mixed species group of short-finned pilot whales with Fraser's dolphins (*Lagenodelphis hosei*), and several of Indo-Pacific bottlenose dolphins with Indian Ocean humpback dolphins were observed (Table 1).

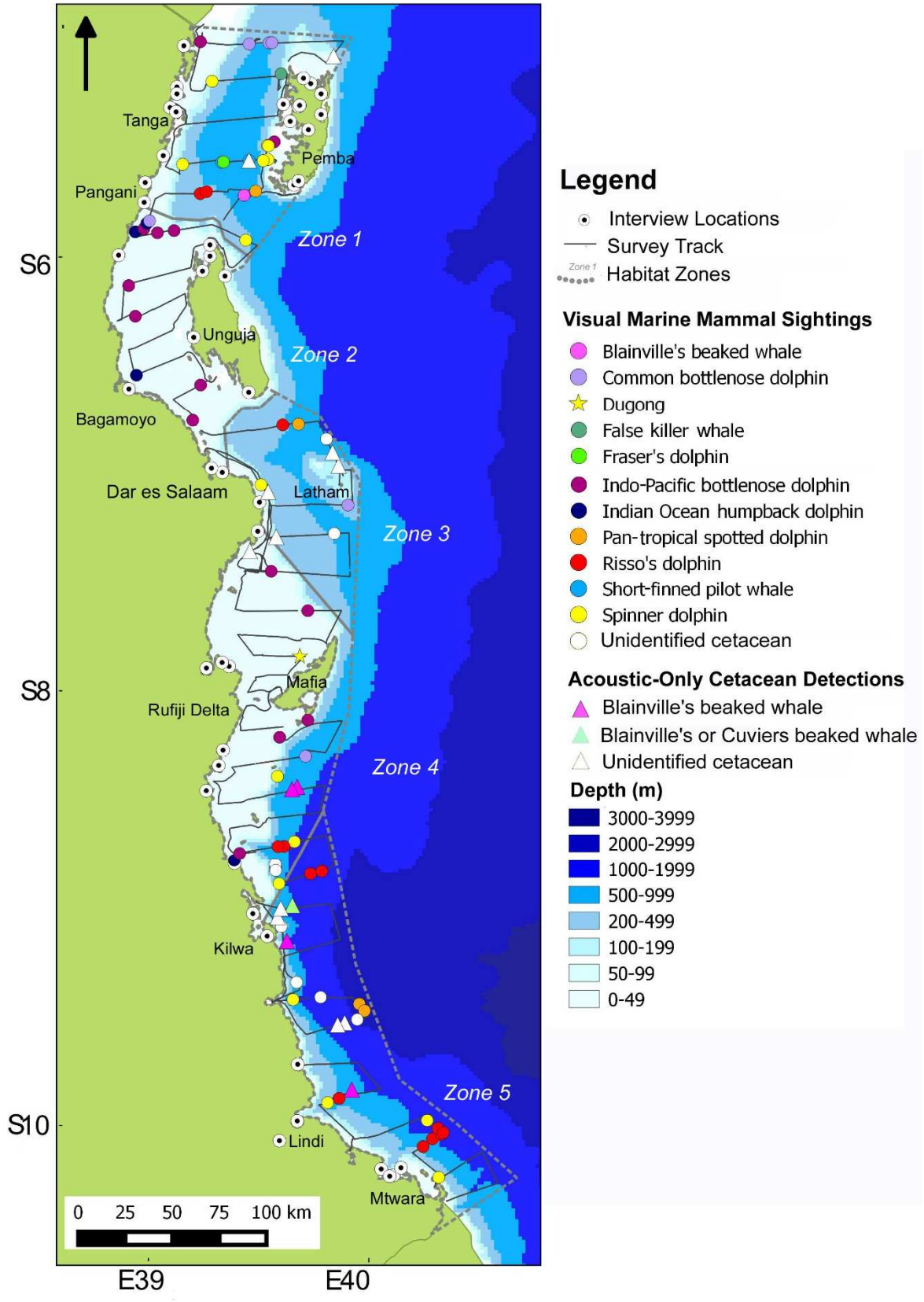

Figure 3 – Boat survey track and the location of visual and acoustic marine mammal group detections made during the vessel-based cetacean survey of the entire coast of Tanzania conducted between March 4th and April 6th 2015.

Table 1 - Species and number of groups of marine mammals detected visually and acoustically during a March-April 2015 survey of Tanzania

Rank	Species	No. of Groups detected (Visual + only Acoustic)	Red List Status (IUCN 2015)	Average Depth m (min-max)
1	Spinner dolphin (*Stenella longirostris*)	17	DD	457 (71-1100)
2	Rissos dolphin (*Grampus griseus*)	14	LC	955 (370-2600)
3	Indo-Pacific bottlenose dolphin (*Tursiops aduncus*)	14	DD	37 (10-73)
4	Blainville's beaked whale (*Mesoplodon densirostris*)	1+5[a]	DD	597 (400-1050
5	Common bottlenose (*Tursiops truncatus*)	5	LC	464 (318-439)
6	Pantropical spotted dolphin (*Stenella attenuata*)	4	LC	1650 (700-2600)
7	Indian Ocean humpback dolphin (*Sousa plumbea*)	4	EN	18 (5-40)
8	Short-finned pilot whale (*Globicephala macrorhynchus*)	2	DD	700
9	Fraser's dolphin (*Lagenodelphis hosei*)	1	LC	700
10	False killer whale (*Pseudorca crassidens*)	1	DD	400
11	Dugong (*Dugong dugon*)	1	VU	4
	Unidentified	11+11[b]		-
	Total	**91**		

[a] One acoustic beaked whale detection that may have been Blainville's or Cuvier's beaked whale included here

[b] Eight of the acoustic detections included here as unidentified were assigned to spinner dolphins by the whistle classifier which has a ~70% likelihood of being the correct identification.

The sighting of a group of Blainville's beaked whales (*Mesoplodon densirostris*) was made in the channel between Pemba and Unguja Islands (Figure 1). There were also five acoustic detections of beaked whales, all in the south in deep water ranging from 459 to 1050m (Figure 1) and none of them had an associated visual sighting. The peak click frequency for each beaked whale acoustic detection was between 31 and 35 kHz which is consistent with identification as Blainville's beaked whale (Johnson et al. 2006). One detection, located 20km east of Kilwa Masoko had a peak frequency of

34kHz in the same frequency range as for Blainville's beaked whale but also a secondary peak at 40kHz which would align with Cuvier's beaked whale (*Ziphius cavirostris*) (Baumann-Pickering et al. 2013). Both species occur in tropical waters of the western Indian Ocean and the 10% and 90% percentiles of their click peak frequencies overlap making it difficult to make a species determination in this case. We have identified this as probable Blainville's beaked whale but it is possible it was a Cuvier's beaked whale or another species whose vocalisations have yet to be characterised (Table 1).

By far the highest number of species (nine), and relative species diversity was recorded in Zone 1 – the Pemba Channel, and this area also had one of the highest indices of relative abundance (Table 2; Figure 2). Low species encounter rates, number of species and relative abundance were documented in Zone 2 – Zanzibar Channel, where only Indo-Pacific bottlenose and Indian Ocean humpback dolphins were recorded. Despite excellent survey conditions (Beaufort ≤2), very few cetaceans were encountered in Zone 4 – Mafia / Rufiji. Zone 5 – Mtwara/Lindi had the highest group encounter rate of any zone, but relatively low diversity indices with sightings dominated by two species: spinner and Risso's dolphins. The two most commonly encountered cetacean species were different in every zone (Table 2).

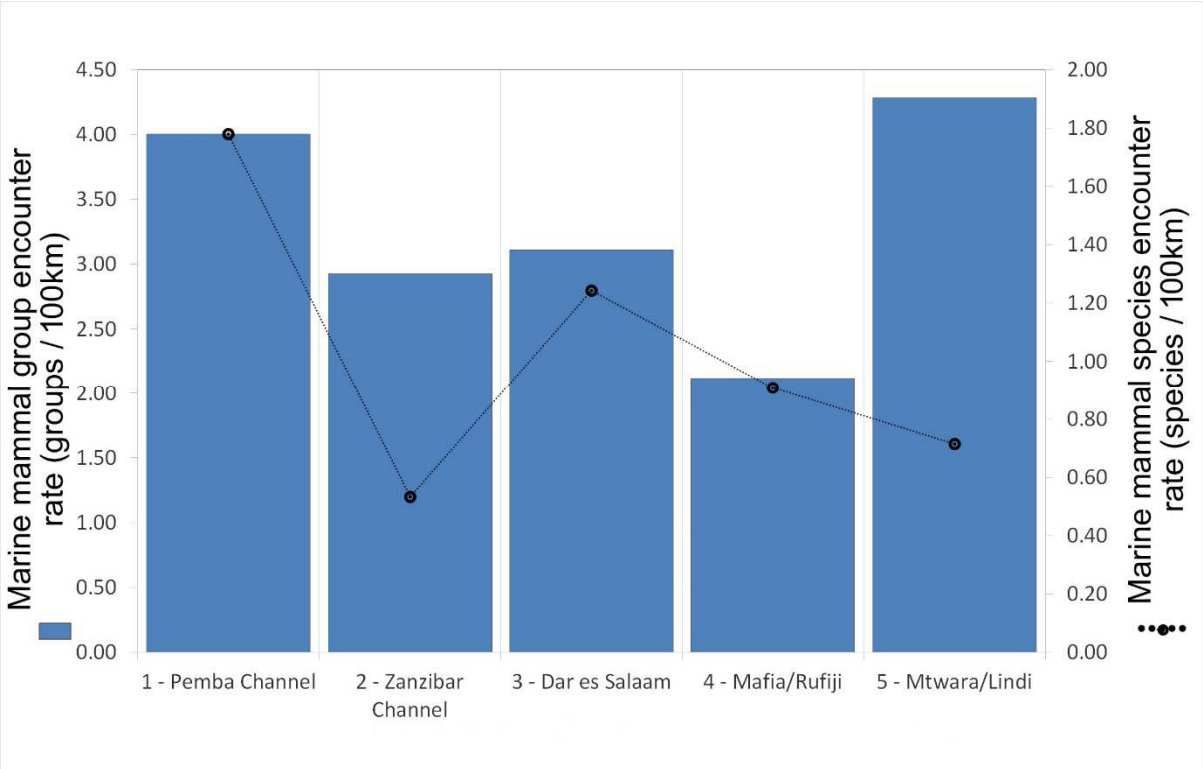

Figure 4- Marine mammal group and species encounter rates along the coast of Tanzania

Table 2 - Summary of Marine Mammals recorded during visual and acoustic survey of the coast of Tanzania

Zone	Number of marine mammal species recorded	Marine Mammal Species Encounter Rate (species / 100km of good[a] survey conditions)	Marine Mammal Group Visual and Acoustic Encounter Rate (groups / 100km of good[a] survey conditions)	Number of Threatened Species Observed	Two most frequently sighted species	Species Visual Encounter Rate (groups / 100km)
1. Greater Pemba Channel	9	1.78	4.01	1	1.Spinner dolphin (*Stenella longirostris*)	1.11
					2.Common bottlenose dolphin (*Tursiops truncatus*)	0.67
2. Zanzibar Channel	2	0.53	2.92	1	1.Indo-Pacific bottlenose dolphin (*Tursiops aduncus*)	2.13
					2.Indian Ocean humpback dolphin (*Sousa plumbea*)	0.53
3. Dar es Salaam	4	1.24	3.11	0	None	None
4.Mafia, Kilwa Rufiji	6	0.91	2.12	**2**	1.Indo-pacific bottlenose dolphin (*Tursiops aduncus*)	0.76
					2.Spinner dolphin (*Stenella longirostris*)	0.30
5. Mtwara & Lindi	4	0.71	4.28	0	1.Risso's dolphin (*Grampus griseus*)	1.61
					2.Spinner dolphin *(Stenella longirostris*)	1.07

a – Good conditions defined as sea state 4 or less

3.1.1.Existing information and opportunistic data on cetaceans

In total, 406 records of marine mammal sightings, strandings, and skeletal material were compiled, comprising 20 stranded animals, 43 skeletal remains and 339 live sightings. Fourteen species were represented in the data, but 80% of the records were of five species:

- Spinner dolphin (n=126; 31% of all records)
- Humpback whale (n=61; 15%)
- Indo-Pacific bottlenose dolphin (n=56; 14%)
- Indian Ocean humpback dolphin (n=41; 10%);
- Risso's dolphin (n=35; 9%).

Three species in the qualitative data had not been seen during the survey. These were common dolphin (*Delphinus delphis*) and dwarf sperm whale (*Kogia sima*) both recorded in the Pemba Channel. Humpback whales were absent from Tanzania at the time of the survey but were documented from every zone in the qualitative data. This takes the total number of documented cetacean species in the entire assessment to twelve. Once humpback whales are removed from the data, the species with the largest number of qualitative records in each zone, is the same as the species most frequently encountered during the boat-based survey (Table 2).

4. **Notes on selected cetacean species recorded in Tanzania**

4.1. Spinner dolphin (*Stenella longirostris*)

Spinner dolphins are small (maximum size 2.35m), and slender with a small upright triangular dorsal fin, and a very long thin rostrum. The body is characterised by a tripartite colour pattern, pale beneath, light grey on the side and dark grey above, and there is a dark line from the eye to the flipper.

Spinner dolphins have a pan-tropical distribution and are one of the most common dolphins in tropical oceans worldwide. Our survey indicates that they are also the most abundant cetacean in Tanzania. Spinners are named for their characteristic behaviour, their habit of leaping clear of the water and spinning rapidly on their long axis. They also frequently ride the bow-wave of ships and boats. Group sizes in Tanzania range from 10 to more than 800 seen in the Pemba channel. This species often rests in shallow areas during the day and forages in nearby oceanic waters at night. Spinner dolphin's feed on a large variety of small fishes (Jefferson et al. 2015).

IUCN Red List Status: Data Deficient

4.2. Risso's dolphin (*Grampus griseus*)

Risso's dolphins are distinctive, medium-sized (up to 3.8m long), blunt-headed dolphins with a tall slender dorsal fin. Perhaps their most distinctive feature is the large amount of white scarring on the body so that they often appear very light in colour.

Risso's dolphins are distributed from the tropics to temperate waters principally in steeply shelving deep waters of the continental shelf. Group sizes typically range from 10-100. Risso's dolphins feed principally on squid and octopus. In Tanzania Risso's dolphins are common in deeper waters off Lindi and Mtwara. Risso's dolphins sometimes exhibit 'sailing' behaviour (hanging upside down in the sea with the tail exposed in the air) in Tanzania.

IUCN RedList Status: Least Concern

4.3. Common bottlenose dolphin (*Tursiops truncatus*)

Common bottlenose dolphins are relatively robust, uniform, slate grey dolphins (up to 3.8m long) with a short beak and tall falcate dorsal fin. It is this species that is probably the most familiar type of dolphin to most people as it is seen most frequently on television and in aquariums.

The taxonomy of this group is not fully settled, but in Tanzania common bottlenose dolphins are much larger size, occur in larger groups and further offshore than the similar, related Indo-pacific bottlenose dolphin (described below). Common bottlenose dolphins have been observed in the Pemba Channel, and around Mafia and Latham Islands. Group sizes range from approximately 10 to many hundreds. Behaviour is frequently very acrobatic, animals bow-ride for long periods, and exhibit a variety of high acrobatic leaps. This species consumes a wide variety of fish and squid species (Jefferson et al. 2015).

IUCN RedList Status: Data Deficient

4.4. Indo-pacific bottlenose dolphin (*Tursiops aduncus*)

Indo-pacific bottlenose dolphins look similar to common bottlenose dolphins, but they are smaller in size (max of approximately 2.7m), have a longer beak, and the dorsal fin is less falcate with a broader base. This species occurs throughout coastal waters of the Indo-pacific and is one of the most common dolphin species in shallow coastal waters in Tanzania. They may approach boats but seldom bow-ride. Group sizes are generally less than 50 individuals and they prey on a large variety of schooling demersal and reef fishes and cephalopods (Jefferson et al. 2015). They have been seen herding fish onto shallow banks in the north of the country.

IUCN RedList Status: Data Deficient

4.5. Pan-tropical spotted dolphin (*Stenella attenuata*)

Pan-tropical spotted dolphins are small, slender dolphins (approximately 2.5m maximum length) with a characteristic dark cape that dips forward of the dorsal fin. Spotted dolphins are light grey on the under-side and there are pale spots on the body that become more numerous and visible with age. The lips and beak tip are white.

Pan-tropical spotted dolphins occur primarily in tropical offshore waters of the Indian, Pacific and Atlantic oceans and have been seen in deeper offshore waters in Tanzania. This species occurs in groups up to several hundred in size, they frequently bow-ride and exhibit acrobatic behaviour. They feed on small epi- and meso-pelagic fishes, squid and crustaceans.

IUCN Red List: Least Concern

4.6. Indian Ocean humpback dolphin (*Sousa plumbea*)

Indian Ocean humpback dolphins (max length approximately 2.8m) have long well defined beaks and robust bodies and in Tanzania are a uniform light brownish-grey colour. The main diagnostic feature is a distinctive dorsal hump that is present in young animals and gets progressively larger in older animals, especially males. The dorsal fin is small and sits on top of the dorsal hump (Jefferson et al. 2015).

This species was only formally recognised as distinct in 2014 (Jefferson and Rosenbaum 2014). It occurs from South Africa to India, in very shallow, nearshore waters typically less than 30m deep or 2km from shore. In Tanzania, Indian Ocean humpback dolphins occur in small groups, generally less than 10 individuals; they are very shy and do not approach boats. Humpback dolphins are known to occur in Tanzania west of Pemba and Unguja Islands, in the Rufiji Delta, north of Dar es Salaam and around Pangani. Indian Ocean humpback dolphins sometimes occur in mixed species groups with Indo-pacific bottlenose dolphins.

IUCN Redlist Status: Proposed as Endangered (Braulik et al. 2015a), listing currently in review by IUCN.

4.7. Fraser's dolphin (*Lagenodelphis hosei*)

Fraser's dolphins (max 2.7m) are distinctive stocky dolphins with a very small upright triangular dorsal fin and a very short beak. Young animals are light grey in colour, and there is a dark thick longitudinal stripe that is present in some mature animals.

This is an oceanic species that occurs in deep offshore tropical oceans. They occur in large active and dense groups of several hundred or more. The diet of Fraser's dolphins is comprised of a large variety of mid-water fish, squid and crustaceans (Jefferson et al. 2015). This species is known from sightings and strandings to occur in the Pemba channel.

IUCN Red List Status: Least Concern

4.8. Short-finned pilot whale (*Globicephala macrorhynchus*)

Pilot whales are very large, powerful black toothed whales (males max 7.2m, females 5.5m) with a round bulbous head, and a the large broad-based and rounded dorsal fin positioned very far forward on the body. There is sexual dimorphism in this species, and adult males have an especially large dorsal fin and bulbous head. There is a light anchor shaped patch on the chest.

Short-finned pilot whales are fairly common in deep offshore waters of warm temperate and tropical oceans worldwide. This species is highly social and occurs in large aggregations of several hundred spread out over large areas. Pilot whales often associate with other species, and in Tanzania have been seen with Fraser's dolphins and Common bottlenose dolphins. Pilot whales feed primarily on squid at depths of 200-500m (Jefferson et al. 2015).

IUCN Red List Status: Data Deficient

4.9. False killer whale (*Pseudorca crassidens*)

False killer whales are large in size, adults reach 6m in length, and they have long slender, uniform coloured black or dark grey bodies. There is no beak; the head is rounded, and the dorsal fin is tall and falcate with a rounded tip. One of the diagnostic features is a hump on the leading edge of the flipper, however this is difficult to see in the wild unless animals breach.

False killer whales are distributed in tropical and temperate oceans in deep water, and occasionally range into waters of the continental shelf. Group sizes range from approximately 10-60. False killer whales eat fish and cephalopods, including large species such as tuna, mahi mahi and wahoo (Jefferson et al. 2015). This species has been recorded off the west coast of Pemba in Tanzania.

IUCN Red List Status: Data Deficient

4.10. Blainville's Beaked Whale (*Mesoplodon densirostris*).

This species of beaked whale has a spindle shaped body (maximum size 4.7m), with a small head and small dorsal fin located 2/3rds of the way along the back. The body is brownish grey with varying numbers of white oval scars. The diagnostic feature, visible even in females and calves, but most pronounced in adult males is the highly arched square lower jaw. There is sexual dimorphism in this species, and males have large flattened tusks that protrude from the lower jaw, and which may be covered in tasselled barnacles and their bodies are marked with longitudinal scars from other tusks.

Blainville's beaked whales are widely distributed in tropical and temperate oceans and are one of the more common, and best known of the generally very poorly understood beaked whale family (Ziiphidae). This species has been recorded in most countries in the Western Indian Ocean and although the sighting made in the current survey was the first record for Tanzania, subsequent visual and acoustic detections indicate that it is relatively common in Tanzania slope waters. In other countries, this species prefers depths of 200-1000m of the continental slope. Squid is the primary prey. This species, along with other beaked whales, is sensitive to anthropogenic noise including by mid- or low-frequency sonar.

Status: Data Deficient

4.11. Humpback whale (*Megaptera novaeangliae*)

The humpback whale has a large (11-17m in length) robust body, with extremely long pectoral flippers that can be up to 1/3rd of the body length. Tail flukes have a serrated trailing edge and the flippers

have a series of bumps, called tubercles, on the leading edge. The dorsal fin is low and broad based and sometimes has a prominent hump. The head is also covered in tubercles. The body is black with variable amounts of white (Jefferson et al. 2015).

Humpback whales occur in both the northern and southern hemisphere, in almost all oceans. They migrate from polar feeding areas to tropical breeding areas, and are predominantly found in coastal waters. Humpback whales visit Tanzania seasonally and are present from roughly June to November with the peak in numbers in August and September.

Status: Vulnerable

5. **Discussion**

5.1. Distribution of Cetaceans in Tanzania

This assessment demonstrated considerable cetacean diversity in Tanzania as well as substantial variation in cetacean relative abundance and diversity along the coast. Three new mammal records; Blainville's beaked whale, dwarf sperm whale and common dolphin were documented, taking the total number of cetaceans on the national checklist to 19 (Annex C). Cetacean abundance indices were highest in the two deepest parts of the coast (Zone 1 - Pemba Channel and Zone 5 - Mtwara), almost

double those of the shallower areas (Zone 2 and 4), whilst relative cetacean diversity was two to three times higher in the Pemba Channel than any other area. Higher diversity and abundance of cetaceans in areas with a greater variety of depth and slope habitat is not atypical and may be related to a larger number of habitat niches, and increased mixing of nutrient rich waters which increases productivity and prey availability (Caňadas et al. 2002; Hooker et al. 1999).

With high relative cetacean abundance and diversity, the Pemba Channel (Zone 1) in the north of Tanzania can be considered the most important area in the country for cetaceans. A total of 15 cetacean species, of the 19 known to occur in Tanzania, have been documented from this location, including the endangered Indian Ocean humpback dolphin and Blainville's beaked whales. The channel between the Tanzanian mainland and Pemba island is only 50km wide but it is 1000m deep, and has bathymetric features similar to submarine canyons which are well known as important areas for cetaceans (Moors-Murphy 2014). There is a fast (0.5-3m/s) north-flowing current, and the turbulence and vertical mixing that occurs along the margins of the channel create nutrient-rich conditions (Barlow et al. 2011; Mahongo and Shaghude 2014). This type of mixing, which is common adjacent to tropical islands, has been noted to provide oases of biodiversity in otherwise nutrient-poor tropical oceans (Kiszka et al. 2010). The Pemba Channel was recently identified as an Ecologically and Biologically Significant Area (EBSA) by the Convention on Biological Diversity (2013) and it is renowned for catches of large pelagic fish (Hemphill 1995). This area is a priority for future research and conservation of cetaceans.

The Rufiji delta (Zone 4) is one of the largest estuaries and mangrove stands on the east coast of Africa. For endangered marine megafauna species this location is important as it harbours the only remaining population of dugong (Muir et al. 2003), resident whale sharks (*Rhincodon typus*) (Cagua et al. 2015), large numbers of nesting sea turtles (Bourjea et al. 2008) and also Indian Ocean humpback dolphins. The same issues, principally fisheries bycatch, threaten all these endangered species and conservation actions on behalf of one are likely to benefit all.

Mtwara/Lindi (Zone 5) in southern Tanzania is the least developed part of the Tanzanian coastline and is the area of highest cetacean relative abundance. Cetacean communities were dominated by spinner and Risso's dolphins, both species that preferentially occur on the margins of the continental shelf (Jefferson et al. 2014). This area is the focus of exploration and extraction of oil and gas in Tanzania and, given the high relative abundance of cetaceans and the presence of species that are known to be sensitive to anthropogenic sound, such as beaked whales and humpback whales, it is important that potential impacts of these activities be carefully evaluated and mitigated (Cerchio et al. 2014; Southall et al. 2009).

Indian Ocean humpback and Indo-pacific bottlenose dolphins are two cetacean species recorded in Tanzania that occur predominantly in shallow coastal areas. This near-shore distribution places them in the marine waters most heavily utilised by humans (Keith et al. 2013; Stensland et al. 2006). Throughout their range both species are threatened by bycatch in fishing gear, coastal development and pollution, and in Tanzania they are also exposed to the noise and physical threat of dynamite fishing. The Indian Ocean humpback dolphin which has the most near-shore distribution of the two, is probably the most threatened cetacean in the region, including in Tanzania (Braulik et al. 2015a). Indian Ocean humpback dolphins appear to have a discontinuous distribution along the Tanzanian coast with concentrations in large shallow areas, including on both sides of the Zanzibar and Pemba channels, and in the Rufiji Delta. Although they may occur along the 200km stretch of coast between Kilwa and Mtwara we found no evidence of their presence during surveys and the available shallow habitat along that exposed coastline is extremely limited. As one of the most threatened marine megafauna species regionally, conservation of Indian Ocean humpback dolphins is a national priority. Humpback whales are present in Tanzania in considerable numbers in the calving and breeding seasons, but they are also one of the more frequently entangled and stranded cetacean species nationally. All three of these cetacean species are potentially under pressure from fisheries bycatch and habitat degradation, and it is important to generate information on areas of concentration, residency, movement and connectivity, as well as abundance, in order that key areas may be identified and protected.

5.2. Threats to Cetaceans in Tanzania

Fishing is the single largest threat to cetaceans worldwide, with an estimation of 300,000 cetacean mortalities per year in fishing nets (Read 2008). Fishing interactions are also the largest threat to cetaceans in Tanzania (Amir et al. 2002). Marine fisheries operating in the study area in Tanzania are artisanal and near-shore, they use a variety of gears to target multiple species and the distinction between target and bycatch species is vague, especially as captured dolphins can be utilised in many ways including as food, bait and oil. Often the issue of dolphin bycatch is masked, because bycatch rates per boat are quite low, however there are tens of thousands of boats operating and the total numbers of dolphins killed can still be high. As dolphins reproduce slowly, mature late and are long-lived, populations generally cannot sustain mortality rates greater than a few percentage of population size. Therefore for small, coastal cetacean populations (such as Indian Ocean humpback and Indo-Pacific bottlenose dolphins in Tanzania), in heavily fished areas, mortality rates are very frequently unsustainable (Read 2008). This was demonstrated during onboard observer programmes

in Zanzibar which estimated that 9.6% of the estimated population of Indo-Pacific bottlenose dolphins and 6.3% of Indian Ocean humpback dolphins were taken as bycatch annually, rates which were almost certainly unsustainable (Amir 2010). Further investigation and quantification of cetacean bycatch is a priority, focussing on understanding the gear type and fishing grounds, placing bycatch rates in context by estimating abundance of the most frequently caught cetacean species and ultimately testing, implementing and monitoring mitigation strategies. This type of information is increasingly required if fish are to exported and sold internationally, especially to the USA (US Department of Commerce August 15, 2016).

Tanzania is the only country in the Western Indian Ocean where fishing with explosives has been widely practiced for more than 50 years (Wells 2009). The sound from a single blast can travel up to 50km from the source. With more than 70 blasts/day in some areas, this represents considerable additional noise in the ocean (Braulik et al. 2015b). As whales and dolphins use sound, or echolocation to navigate, search for food and communicate with each other, they are vulnerable to increases in underwater noise, especially from explosions, which may disturb, displace, injure or kill individuals (McGregor et al. 2013). Most blast fishing occurs in coastal waters in the habitat of Indian Ocean humpback and Indo-pacific bottlenose dolphins and these species will be impacted to the greatest extent, with effects ranging from abandoning heavily dynamited habitats, lost feeding, socialising, or resting opportunities, as well as the potential for physical injury (including impaired hearing) and death at short range. Blast fishing negatively impacts many aspects of the marine environment and coastal communities and is also a national security issue that it is complex to combat, but a high priority to prevent.

In addition to fishing, other additional significant threats to cetaceans that also apply to Tanzania include ship strikes, hunting, pollution (especially floating solid waste and debris like plastics), disease, oil spills, anthropogenic noise, the short- and long-term effects of climate change and ocean acidification all of which vary in intensity based on location and species (Thomas et al. 2015).

Dolphin watching eco-tourism is gaining popularity worldwide, can provide important economic benefits to local communities and is also a good way to educate people who might never go out on the sea about the importance of healthy oceans. In the early 1990s in Zanzibar, there was a shift from dolphin hunting, to dolphin tourism, which both provides important income to local villages, with the added benefit of reducing an immediate threat to the local dolphin population (Berggren et al. 2007). There is potential for dolphin watching in other parts of Tanzania, however it is extremely important that these are well planned and well-regulated and that operators adhere to a code of conduct to minimize disturbance and negative impacts on the dolphins. The example of the Kizimkazi swim-with-the-dolphin tours is to be avoided. As the tours have gained in popularity, a very large number of small boats (up to 70) powered with outboard motors have become involved, each able to take a small number of tourists onto the water. Due to competition to access to the dolphins, boats often chase and harass the animals, and many boats may be present with the dolphins at the same time. Accepted international codes of conduct for operating safe, responsible and sustainable dolphin eco-tourism are seldom followed (see https://iwc.int/whalewatching). Several studies have shown that the dolphins change their behaviour in the presence of many boats, resting less often and travelling more frequently, and this can have negative impacts especially on females and calves (Christiansen et al. 2010; Stensland and Berggren 2007).

If dolphin watching eco-tourism is considered in other places in Tanzania relatively simple planning could ensure that this activity follows a minimally intrusive and more sustainable model. For example: 1) a single large boat could be used for daily tours rather than numerous small vessels; 2) the presence of a trained guide on the boat would provide tourists with information on the dolphins and their ecology; 3) boat operators strictly adhere to an agreed Code of Conduct that follows international standards; 4) establishment of a community cooperative to share profits equitably should be considered. In this scenario dolphin watching, or swim-with-the-dolphin tours would not heavily impact the dolphins, could provide a safe, satisfying and high quality product for tourists and would provide equitable benefits to the members of the community.

5.3. Concluding Remarks

The current report provides broad-scale information on relative occurrence of more common cetacean species across a large swath of the Tanzanian coastline. However, it is important to note that there limits to what should be concluded based on this single survey. Temporal shifts in the distribution of some species were not captured. Migratory species not present during the survey (March-April), in this case humpback whales, were not detected. Some rare and uncommon species,

arguably the most important from a conservation perspective, will also probably not have been documented. Despite this, the information generated is valuable to guide future management and target research into key areas. It can be viewed as a preliminary assessment, with more detailed studies, to determine absolute abundance, residency patterns, home ranges and site fidelity for cetaceans within key sites essential.

Tanzania is a country blessed with considerable natural resources, and it is one of the most biodiverse in all of Africa. The vast number of large mammals on land are famed worldwide and attract thousands of visitors to the country each year bringing millions of dollars in revenue. Meanwhile, this study demonstrates that there is also considerable mammal biodiversity in Tanzania's oceans. Our level of knowledge about these mammals, especially with regards to their life history, the impact of threats, and what is required to conserve them lags way behind their terrestrial mammal cousins, but this is also an important national natural resource that it is important to understand, manage and protect.

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Annex A – Beaufort Scale

Beaufort Force	Wind speed Knots	Description	Sea Condition
0	0	Calm	Sea like a mirror
1	1-3	Light air	Ripples but without foam crests
2	4-6	Light breeze	Small wavelets. Crests do not break.
3	7-10	Gentle breeze	Large wavelets. Perhaps scattered white horses
4	11-16	Moderate breeze	Small waves. Fairly frequent white horses
5	17-21	Fresh breeze	Moderate waves, many white horses
6	22-27	Strong breeze	Large waves begin to form. White foam crests, probably spray

Annex B – Tanzanian cetacean whistle detection and classification

Whistles were detected using the PAMGuard Whistle and Moan detector (Gillespie et. al, 2013). Acoustic whistle detections recorded during a visual sighting with a positive species identification were used to train the whistle classifier. Six species were included in the classifier: short-finned pilot whale (*Globicephala macrorhynchus*), Fraser's dolphin (*Lagenodelphis hosei*), false killer whale (*Pseudorca crassidens*), pantropical spotted dolphin (*Stenella attenuata*), spinner dolphin (*Stenella longirostris*) and common bottlenose dolphin (*Tursiops truncatus*). Indo-pacific bottlenose (*Tursiops aduncus*) and Indian Ocean humpback dolphins (*Sousa plumbea*) could not be included, even though they were encountered many times, because they had low whistle rates in recordings and there were insufficient data to train the classifier. Once the classifier had been trained it was then applied to whistles that were recorded where there was no visual sighting, or a visual sighting with no confirmed species identification, in an effort to classify the species acoustically.

The performance of the whistle classifier is summarised in a confusion matrix (Table A) which demonstrates how a group of whistles from a given species were correctly classified or mistakenly identified as a different species. The whistle classifier performed reasonably well given the fairly small dataset; the overall mean correction rate was 60%. Classification accuracy was highest for false killer whales (87.5%) and for spinner dolphins (69.2%). It performed poorly for pilot whales and pantropical spotted dolphins.

Table A – The confusion matrix resulting from the six species delphinid whistle classifier - Numbers in each column represent the % likelihood that whistles classified as the species in header are that species, or alternatively that they are the species listed on the left column.

	Pilot whales	Fraser's dolphin	False Killer Whale	Pan-tropical Spotted dolphin	Spinner dolphin	Common bottlenose
Short-finned Pilot Whale	**38.0**	14.5	10.8	9.6	13.7	15.5
Fraser's dolphin	16.2	**51.7**	0.0	23.3	5.8	2.8
False Killer whale	2.4	0.1	**87.5**	0.0	0.0	0.0

Pan-tropical spotted dolphin	19.9	22.2	0.0	**36.8**	7.9	24.1
Spinner dolphin	5.0	5.2	0.0	10.5	**69.2**	2.2
Common bottlenose	18.5	6.3	1.7	19.6	3.5	**55.4**

Insufficient whistles were recorded from any of the unidentified visual sightings to enable their input into the whistle classifier. There were 11 acoustic detections that had no accompanying visual sighting. From these 11 events, eight were classified as spinner dolphins. The remaining three classifications were uncertain (either of 2 species, or of one of the species for which we have low confidence in the classification), and these are therefore considered as unidentified delphinids.

As more data becomes available it will be possible to improve the classifier accuracy, and add more species, with the result that acoustics will be able to play a bigger and bigger role in cetacean monitoring.

Annex C - Checklist of Marine Mammals Confirmed to Occur in Tanzania

	Common Name	Scientific Name	Reference From
1	Humpback whale	*Megaptera novaengliae*	Berggren et al 2009
2	Sperm whale	*Physeter macrocephalus*	Berggren et al 2009
3	Pygmy Sperm whale	*Kogia breviceps*	Amir et al 2012
4	Blainville's beaked whale	*Mesoplodon densirostris*	This survey
5	Cuviers beaked whale	*Ziphius cavirostris*	Amir et al 2012
6	Longman's beaked whale	*Indopacetus pacificus*	Amir et al 2012
7	Risso's dolphin	*Grampus griseus*	Berggren et al 2009
8	Rough-toothed dolphin	*Steno bredanensis*	Amir et al 2012
9	Indian ocean humpback dolphin	*Sousa plumbea*	Berggren et al 2009
10	Common bottlenose dolphin	*Tursiops truncatus*	Berggren et al 2009
11	Indo-pacific bottlenose dolphin	*Tursiops aduncus*	Berggren et al 2009
12	Pan-tropical spotted dolphin	*Stenella attenuata*	Berggren et al 2009
13	Spinner dolphin	*Stenella longirostris*	Berggren et al 2009
14	Fraser's dolphin	*Lagenodelphis hosei*	Amir et al 2012
15	Killer whale	*Orcinus orca*	Amir et al 2012
16	False killer whale	*Pseudorca crassidens*	Berggren et al 2009
17	Short-finned pilot whale	*Globicephala macrorhynchus*	Amir et al 2012
18	Dugong	*Dugong dugon*	Berggren et al2009
19	Dwarf Sperm Whale	*Kogia sima*	WCS unpublished surveys
20	Common dolphin	*Delphinus delphis*	WCS unpublished surveys
21	Subantarctic fur seal (vagrant)	*Arctocephalus tropicalis*	Berggren et al 2009