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Cetaceans in the southwest Indian Ocean: a review of diversity, distribution and conservation issues

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ABSTRACT

The coastal waters of the southwest Indian Ocean (including Mozambique, Tanzania, Kenya, the Seychelles, Comoros, Mayotte, Madagascar and the Mascarenes and their EEZ) countries are characterized by a high marine biodiversity. This paper review information on the diversity, distribution and conservation issues to cetaceans in this region. To date, up to 33 species of cetaceans have been recorded in the southwest Indian Ocean: 16 delphinids (*Stenella longirostris*, *Stenella attenuata*, *Stenella coeruleoalba*, *Delphinus* spp., *Steno bredanensis*, *Grampus griseus*, *Sousa chinensis*, *Tursiops truncatus*, *Tursiops aduncus*, *Globicephala melas*, *Globicephala macrorhynchus*, *Pseudorca crassidens*, *Orcinus orca*, *Lagenodelphis hosei*, *Feresa attenuata*, *Peponocephala electra*), 8 large toothed whales (*Physeter macrocephalus*, *Kogia sima*, *Kogia breviceps*, *Mesoplodon pacificus*, *Mesoplodon densirostris*, *Mesoplodon mirus*, *Ziphius cavirostris*, *Mesoplodon gingkodens*) and 7 baleen whales (*Megaptera novaeangliae*, *Balaenoptera acutorostrata/ Balaenoptera bonaerensis*, *Balaenoptera physalus*, *Balaenoptera edeni*, *Balaenoptera musculus/ B. m. brevicauda*, *Balaenoptera borealis* and *Eubalaena australis*). However, very little is known on the ecology, spatial distribution, stock identity and abundance of these species. Nonetheless, these data are of particular relevance for management and conservation purposes. Cetaceans are exposed to many anthropogenic threats in the coastal waters of this region. The most significant are bycatch in fishing gears, direct exploitation, habitat degradation, chemical and acoustic pollution and disturbances caused by the whale/dolphin watching activity. Fisheries bycatch have been recorded throughout the region, although the impact on local populations is unknown for most areas. The most commonly bycaught species are Indo-Pacific humpback, bottlenose dolphins and spinner dolphins. Direct exploitation is important in the southwest region of Madagascar, targeting small delphinids. The increasing human population and the development of uncontrolled tourism may also impact negatively on marine mammal populations in the region. Nevertheless, the presence of permanent populations, such as inshore dolphins and migrating humpback whales, may provide opportunities to develop local commercial activities dedicated focusing on observations of cetaceans. Marine mammals may thereby help local communities to develop tourism, and reinforce their economies.

Keywords: cetaceans, Indian Ocean Sanctuary, diversity, distribution, occurrence, conservation issues, threats, southwest Indian Ocean.

INTRODUCTION

The coastal waters of the Southwest Indian Ocean (SWIO: in this study Mozambique, Tanzania, Kenya, Seychelles, Madagascar, Mascarene archipelago, Comoros and Mayotte, i.e. from 0 to 25°S, from eastern Africa to 60°E) countries are characterized by a high marine biodiversity, associated with various geomorphologic and biogeographical environments that provide feeding, nursing and mating grounds for marine organisms. Local climate and biological productivity is controlled by complex oceanographic processes. The western Indian Ocean exhibits greater seasonal variation (temperature, circulation) than the rest of the Indian Ocean, as it is an important region of air-sea interactions (Benny, 2002). In 1979, the Republic of Seychelles presented the International Whaling Commission (IWC) with a proposal to declare the greater Indian Ocean as a whale sanctuary. In that same year, the IWC voted on and accepted the proposal, creating a large sanctuary that comprises the waters of the Northern Hemisphere from the coast of Africa to 100°E, including the Red and Arabian Seas and the Gulf of Oman; and the waters of the Southern Hemisphere in the sector from 20°E to 130°E, with the southern boundary set at 55°S (Leatherwood & Donovan, 1991).

Cetacean research has been conducted throughout the Indian Ocean Sanctuary although most studies, to date, have focused on continental coastal waters (e.g. Cockcroft *et al.*, 1990, 1991, 1992; Findlay *et al.*, 1994; Findlay & Best, 1996; Karczmarski, 1996; Karczmarski & Cockcroft, 1999). Some studies have been undertaken around the islands of the western reaches of the Indian Ocean Sanctuary (e.g., Keller *et al.*, 1982 for the Seychelles; Corbett, 1994 for Mauritius; Rosenbaum *et al.*, 1997 and 2003, Cerchio *et al.*, 2009a for Madagascar, Amir *et al.*, 2002, 2005a, b; Berggren *et al.* 2007; Stensland *et al.*, 2006 for Zanzibar, and Kiszka *et al.*, 2006, 2007, 2009 for the Union of the Comoros and Mayotte). In oceanic waters, in-depth and long-term studies on the status, abundance and distribution of cetaceans are scarce (for review see Leatherwood & Donovan, 1991; De Boer *et al.*, 2002). Cetacean sightings and related environmental features were recorded during a NOAA survey (not targeting cetaceans) in 1995 covering a wide area of the western Indian Ocean (Ballance & Pitman, 1998). Cetaceans are exposed to a variety of threats that have been identified in the region e.g. direct exploitation for meat, incidental catch in fishing gear (gillnets) and disturbances from whale/dolphin watching activities (Amir *et al.*, 2002, 2005; Berggren *et al.* 2007; Razafindrakoto *et al.*, 2004; Stensland & Berggren, 2007; Kiszka *et al.*, 2009; Razafindrakoto *et al.*, 2009). Acoustic and chemical pollution, habitat degradation and climate change are potential threats to marine mammals in this region.

The objective of this paper is to review the diversity, occurrence, distribution and conservation issues to cetaceans in the southwest tropical Indian Ocean using available information from published articles, reports and unpublished reports and data.

CETACEAN DIVERSITY IN THE SOUTHWEST INDIAN OCEAN

To date, 31-33 species of cetaceans (Table 1) and 1 species of sirenian have been recorded in the SWIO, including coastal and oceanic waters (all reference listed in Table 1). In total, 16 delphinids, 8 large toothed whales (*Ziphiidae*, *Kogiidae*, *Physeteridae*) and 7-9 baleen whales (*Balaenopteridae*, *Balaenidae*) have been recorded in the SWIO.

Delphinids

Delphinids represent the majority of cetacean diversity in the SWIO. Most of the detailed information on delphinids has been collected in coastal waters in the region, especially off Mayotte, Mozambique, Zanzibar, La Reunion and Madagascar. In oceanic waters, no dedicated surveys have been undertaken but several studies using platforms of opportunities have been conducted (Ballance & Pitman, 1998).

The most common species encountered along the continental coasts of eastern Africa (Mozambique, Tanzania and Kenya) are Indo-Pacific bottlenose, *Tursiops aduncus*, humpback dolphins *Sousa chinensis* and spinner dolphins (*Stenella longirostris*), (see e.g. Karczmarski, 1996; Karczmarski, 1999; Karczmarski & Cockcroft, 1999; Amir *et al.*, 2002, 2005a, b; Guissamulo & Cockcroft, 2004; Stensland *et al.*, 1998, 2006). Several resident populations have been studied in the recent years, such as in Maputo Bay (Guissamulo & Cockcroft, 2004), Algoa Bay (Karczmarski, 1996; Karczmarski, 1999) and off southern Zanzibar (Amir *et al.*, 2002, 2005a, b; Stensland & Berggren 2007; Stensland *et al.*, 2006). These studies suggest variable degrees of site fidelity for Indo-Pacific bottlenose and humpback dolphins. Available data recorded in Madagascar showed that observations of humpback dolphins were only made along the western coast (Cockcroft & Young, 1998; Rosenbaum, 2003; Razafindrakoto *et al.*, 2004; Cerchio *et al.*, 2009a). Humpback dolphins have been also

sighted along the coasts of Kenya (Wamukoya *et al.*, 1996) and in Mayotte (Kiszka *et al*., 2007). No humpback dolphin records have been collected from other islands of the SWIO despite sighting surveys and sightings networks around Reunion (Globice, pers. comm.) and in the waters of the Union of the Comoros (Kiszka *et al.*, 2006). Indo-Pacific bottlenose dolphins have been recorded around Mayotte (Kiszka *et al.*, 2007), Madagascar (Cockcroft & Young, 1998; Rosenbaum, 2003; Cerchio *et al.* 2009a, b, Kiszka & WCS, unpublished data) and the Union of the Comoros (Kiszka *et al.*, 2006), La Réunion (Dulau *et al.*, 2007; Dulau-Drouot *et al.*, 2008), off the Seychelles (Marine Conservation Society Seychelles, unpublished data) and Mauritius (MMCS, pers. comm.). Abundance estimates have been provided for some of these areas, suggesting relatively small resident populations. In the lagoon of Mayotte, around 100 Indo-Pacific bottlenose dolphins and 3 humpback dolphins occur (Kiszka & Pusineri, unpublished data). In Maputo bay (Mozambique), the abundance of humpback dolphin is of 105 (Guissamulo & Cockcroft, 2004). Off the south coast of Zanzibar, the abundance of humpback dolphin is 58-65 and 136-179 for Indo-Pacific bottlenose dolphins (Stensland *et al.*, 2006).

The scientific community and management authorities (e.g. the International Whaling Commission), currently recognize two species of *Tursiops*: the Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) and the common bottlenose dolphin (*Tursiops truncatus*) (IWC, 2000). The Indo-Pacific bottlenose dolphin is smaller than the common bottlenose dolphin, has a longer rostrum, and develops ventral spotting at about the time of sexual maturity (Ross & Cockcroft, 1990). At sea, it is relatively easy to distinguish common and Indo-Pacific bottlenose dolphins using visual criteria. The common bottlenose dolphin has been reported as by-caught off Zanzibar (Amir *et al.*, 2005a), observed at sea around Mayotte and the Comoros (Kiszka *et al.*, 2006, 2007), off the south coast of La Réunion (Dulau-Drouot *et al.*, 2008) and off the southwest and northwest coasts of Madagascar (Cerchio *et al.*, 2009a).

In oceanic waters of the SWIO, three species of *Stenella*, particularly the pantropical spotted dolphin, *Stenella attenuata*, the spinner dolphin, *Stenella longirostris* and the striped dolphin, *Stenella coeruleoalba* are the most common species encountered (Ballance & Pitman, 1998). Spinner dolphins and spotted dolphins have been recorded throughout the SWIO, both close to oceanic islands and reef complexes, as well as in deep oceanic waters. In areas where the continental shelf is wide, these species tend to occur further offshore, in the vicinity of deeper waters (see for example Rosenbaum, 2003). Spinner and pantropical spotted dolphins have been recorded around Madagascar (Andrianarivelo, 2001; Rosenbaum, 2003,; Razafindrakoto *et al*., 2004; Cerchio *et al.*, 2009a), Mayotte and the Comoros (Kiszka *et al.*, 2006, 2007), the Seychelles (Ballance & Pitman, 1998), Mauritius (Corbett, 1994), La Réunion (Dulau-Drouot *et al.*, 2008), Zanzibar (Amir *et al.*, 2002, 2005b), Kenya (Wamukoya *et al.*, 1996) and Mozambique (Peddemors *et al.*, 1997). Off the southwest of Madagascar, pantropical spotted dolphins have a distinctly offshore distribution compared to the more inshore distribution of spinner dolphins (Cerchio *et al.*, 2009a). Cockcroft and Young (1998) make reference to a potentially undescribed fourth species of *Stenella*, calling it a dwarf spinner; observations of Cerchio and Andrianarivelo (pers. comm.) support this possibility.

Risso's dolphin (*Grampus griseus*), has been recorded once off the east coast of Madagascar (Kruse *et al.*, 1991; Peddemors *et al.* 1997) and regularly off the southwest coast of Madagascar (Cerchio *et al.*, 2009a; WCS, unpublished data). Observations of Risso's have also been made around the Seychelles (Kruse *et al.*, 1991), off Mozambique, around Mayotte, the Union of the Comoros (Kiszka *et al.*, 2006) and around Zanzibar (Amir *et al.*, 2002). Several species of the "Blackfish" (common name used in the region for killer whale (*Orcinus orca*), the false killer whale (*Pseudorca crassidens*), the pygmy killer whale (*Feresa attenuata*), the melon-headed whale (*Peponocephala electra*), the short-finned pilot whale (*Globicephala macrorhyncus*), and the long finned pilot whale (*Globicephala melas*) have been recorded throughout the SWIO region. A review of records of these species was provided for the entire Indian Ocean Sanctuary by Leatherwood *et al.* (1991). Killer whales have been sighted off the Seychelles, in the north-western Mozambique Channel (Leatherwood *et al.*, 1991) and around the Southern Islands of the Seychelles (Aldabra, Cosmoledo and Astove) (D. Rowat, personal observation). Killer whales have also been observed off Kenya (Wamukoya *et al.*, 1996), around Mayotte on several occasions (J. Kiszka, unpublished data), off La Réunion (Dulau-Drouot *et al.*, 2008) and off the Seychelles (D. Rowat, personal observation). Data on strandings and catches revealed the presence of killer whales off the southern coast of Madagascar (Andrianarivelo, 2001). Moreover, anecdotal accounts of cooperative fishing between artisanal fishermen and killer whales in the Toamasina region, Madagascar, have also been reported (reviewed in Rosenbaum, 2003). The false killer whale has been recorded around the Seychelles, in the northern Mozambique Channel and off Tanzania (Leatherwood *et al.*, 1991). This species has also been sighted off Toliara, south-west Madagascar (Cockcroft & Young, 1998), around Mayotte (Kiszka *et al.*, 2007) and off La Réunion where, with Risso's dolphins and short-finned pilot whales, interacting with longline fisheries (Poisson *et al.*, 2001). Short-finned pilot whales has been reported off the north-east and southwest coasts of Madagascar and around the Seychelles (Leatherwood *et al.*, 1991; Cerchio *et al.*, 2009a), off

Mauritius (Corbett, 1994), La Réunion (Dulau-Drouot *et al.*, 2008), Mayotte and around the Union of the Comoros (Kiszka *et al.*, 2006, 2007). Pygmy killer whales were recorded west of the Seychelles Bank and in the southern Mozambique Channel (gillnet bycatch; Leatherwood *et al.*, 1991), around Mayotte and the Comoros (Kiszka *et al.*, 2006, 2007) and off Mauritius (Corbett, 1994). This species has been observed stranded alive at La Réunion (GLOBICE, unpublished data). Melon-headed whales have been reported stranded on the atoll of Aldabra (Seychelles) (Keller *et al.*, 1982; Leatherwood *et al.*, 1991) and the northwest coast of Madagascar (WCS, unpublished data), sightings have also been documented off the southwest coast of Madagascar (Cerchio *et al.*, 2009a), around Mayotte and the Comoros (Kiszka *et al.*, 2006, 2007), off Mozambique (Peddemors *et al.*, 1997), La Réunion (Dulau-Drouot *et al.*, 2008), Mauritius (Corbett, 1994) and Kenya (Wamukoya *et al.*, 1996). The remaining delphinid species previously recorded are, Fraser's dolphin (*Lagenodelphis hosei*), long and short-beaked common dolphins (*Delphinus* spp.) and rough-toothed dolphin (*Steno bredanensis*) (see table 1 for detailed references). While striped dolphin has been commonly recorded in pelagic waters, few observations have been made close to shores of the SWIO region. Rough-toothed dolphin appears rare in the region, with single records off Tanzania (Chande *et al.*, 1994), and Zanzibar (Berggren 2000) and several records off Aldabra atoll and off Denis Island (M. Vely, personal observation). The common dolphin has been reported in the SWIO, such as off Madagascar and Mozambique (Peddemors *et al.*, 1997; Rosenbaum, 2003). Common dolphins have also been recorded off Europa, in the southern Mozambique Channel. However, no information has been provided to allow distinction between long-beaked and short-beaked species. Fraser's dolphin has recently been reported around Mayotte and the Comoros (Kiszka *et al.*, 2006, 2007), off the north-eastern Madagascar (WCS, unpublished data), La Réunion (Dulau-Drouot *et al.*, 2008) and from Zanzibar (O. Amir, pers. comm.).

Sperm and beaked whales

Pygmy sperm whales (*Kogia breviceps*) have been recorded at sea near Tromelin Island, as well as stranded on the coast of La Réunion (Chantrapornsyl *et al.*, 1991; S. Ribes-Beaudemoulin, pers. comm.) and as a stranded specimen on Zanzibar (O. Amir, pers. comm.). A sighting of a group of six individuals has been reported off Mayotte (J. Kiszka, personal observation). Dwarf sperm whales (*Kogia sima*) have been recorded once near Tromelin Island, once in La Reunion (GLOBICE, unpublished data), twice in Madagascar. It is a regularly sighted species off Mayotte (Chantrapornsyl *et al.*, 1991; Rosenbaum, 2003; Kiszka *et al.*, 2007). This species has also been recorded off Mahe, Seychelles, in May 2007 (M. Vely & D. Rowat, personal observation).

Several beaked whale species have been recorded in the SWIO. Cuvier's beaked whale (*Ziphius cavirostris*) has been confirmed in *Grande Comore* (Robineau, 1975), sighted off Zanzibar (P. Berggren, personal observation) and probably once off the island of Europa (*Observatoire des Mammifères Marins de Mayotte*, unpublished data). Blainville's beaked whale (*Mesoplodon densirostris*) may be the most common *ziphiidae* in this region. This species has been recorded off Mauritius (Michel & van Bree, 1976; Corbett, 1994), Mayotte (Kiszka *et al.*, 2007), the Union of the Comoros (Kiszka *et al.*, 2006) and the Seychelles (Marine Conservation Society Seychelles, unpublished data). Longman's beaked whale (*Mesoplodon pacificus*) is probably the second most common beaked whale species in the SWIO, with records around Mayotte, Mohéli (Comoros), the Seychelles and a stranded specimen in Kenya (Anderson *et al.*, 2006). A Ginkgo-toothed beaked whale has been sighted off the east coast of Mayotte (Kiszka *et al.*, 2007). However, no pictures supported identification of this species. This species has been formerly identified further north around the Maldives (Anderson, 2005). The True's beaked whale has been recorded stranded in La Réunion (GLOBICE, unpublished data).

Historical records show large concentrations of sperm whales (*Physeter macrocephalus*) around Madagascar (Townsend, 1935). More recently, sperm whales have been recorded in the Comoros and around Mayotte (Kiszka *et al.*, 2006, 2007), around the Seychelles (Kahn, 1991), off La Réunion (Dulau-Drouot *et al.*, 2008), Madagascar (Andrianarivelo, 2001; Rosenbaum, 2003), Zanzibar (Berggren, 2000) and a population probably occur off the west coast of Mauritius (Corbett, 1994). Very little information is available on the status, distribution and abundance of this species in the region. Large aggregations have been reported by Kasuya & Wada (1991) during summer, especially off the north and east coast of Madagascar.

Baleen whales

Several projects have been dedicated to large baleen whales in the SWIO. In coastal waters, studies have been primarily dedicated to humpback whales, such as off Mozambique (Findlay & Best, 1996a, b; Findlay *et al.*, 1994), Madagascar (Rosenbaum *et al.*, 1997; Rosenbaum 2003; Ersts & Rosenbaum, 2003), the Comoros, Mayotte and adjacent reef complexes (Kiszka *et al.*, 2006), Zanzibar (Berggren, unpublished data). During the austral winter, humpback whales undertake an annual migration from the cold waters of Antarctic feeding grounds to the warm, tropical waters of low-latitude wintering regions where breeding and calving take place. The IWC recognizes seven major low-latitude wintering regions [A – G] for management of Southern

Hemisphere humpback whale populations (IWC, 2000; IWC, 2004). The SWIO has been designated Wintering Region C and is currently further partitioned into three smaller units; Wintering sub-Region C1, C2, and C3. These sub-regions largely correspond to the termini of three migratory streams postulated to exist within the SWIO (Best *et al.*, 1998). From July to October, humpback whales are common along the east African coast, from South Africa to Kenya, around the Mozambique Channel islands (Comoros, Mayotte and adjacent banks), off Madagascar and off Zanzibar (Findlay *et al.*, 1994; Best *et al.*, 1996; Wamukoya *et al.*, 1996; Rosenbaum *et al.*, 1997). During this period humpback whales are also sighted off the northern islands of Seychelles migrating in a south westerly direction (Seychelles Island Foundation, unpublished data; Hermans & Pistorius, 2008) and regularly reported off La Réunion, Mauritius and in the southern islands of the Seychelles (Corbett, 1994; Dulau *et al.*, 2007; Drouot-Dulau *et al.*, 2008; Marine Conservation Society Seychelles, unpublished data).

Southern right whales are common during the winter months along the western coast of South Africa (Best, 1990). Conversely, this species is rarely observed elsewhere in the SWIO (Townsend, 1935; Rosenbaum *et al.*, 2001). Sightings have been made in two sites along the eastern coast of Madagascar, particularly in the northeast and southeast (Rosenbaum *et al.*, 2001). Other observations were made recently off the southwestern region (WCS, unpublished data) and off the north-east coast (NGO Megaptera, unpublished data.). Right whales have also been documented off Mauritius and twice off La Réunion (Rosenbaum *et al.*, 2001; S. Ribes-Beaudemoulin, personal observation).

The other baleen whales recorded in the SWIO are blue whale (*Balaenoptera musculus*), fin whale (*Balaenoptera physalus*), sei whale (*Balaenoptera borealis*), Bryde's whale (*Balaenoptera brydei*) and Minke whale (*Balaenoptera bonaerensis*). Two subspecies of blue whales are known to occur in the region: *B. m. musculus*, the Antarctic blue whale and *B. m. brevicauda*, the pygmy blue whale (Branch *et al.*, 2007). These species are difficult to distinguish at sea, even if Antarctic blue whales are larger than pygmies and have a slightly different morphology. Blue whales are abundant off southern Madagascar (south of 25°S) during summer (Best *et al.*, 2003), while elsewhere in the SWIO, sightings are rare but have been reported off Mauritius (Corbett, 1994) and Mayotte year-round (J. Kiszka, personal observations). The presence of blue whales around the Seychelles has also been suspected by Robineau (1991). Further north around the Maldives, pygmy blue whales are year-round resident (Anderson, 2005). Fin whales have been reported off Mauritius (Corbett, 1994), south of the Mascarene (Kasuya & Wada, 1991), and possibly around the Seychelles (Robineau, 1991). Bryde's whales have been recorded offshore the Mascarene archipelago (Corbett, 1994), in the southern Mozambique Channel, west of the Seychelles (Robineau, 1991) and off Kenya (Wamukoya *et al.*, 1996). Minke whales have been recorded in the southern Mozambique Channel (Kasuya & Wada, 1991), La Réunion (Dulau-Drouot *et al.*, 2008) and off the coast of Kenya (Wamukoya *et al.*, 1996).

CONSERVATION ISSUES

Various threats have been identified for cetaceans in the SWIO. They are incidental catches in fishing gears (mainly gillnets, see for review Kiszka & Muir, 2007 and Kiszka *et al.*, 2009), direct catches (Andrianarivelo, 2001; Razafindrakoto *et al.*, 2004; Cerchio *et al.*, 2009a,b), and disturbance from whale/dolphin watching activities (Stensland & Berggren, 2007; Berggren *et al.*, 2007). Many other threats are suspected in the region, such as habitat degradation, climate change, pollution, overfishing, oil and gas exploration (use of low frequency active sonars) as well as the resumption of commercial whaling. We will only review identified threats that have been previously documented in the region. Countries of the SWIO are mostly under-developed. The region has a coastal population of over 35 million people who are among some of the poorest in the world and whose livelihoods are largely dependent on marine and coastal resources such as inshore fisheries and mangroves (Sosovele, 2000).

Bycatch in fishing gears

Pelagic fisheries, purse-seining and longlining, are practiced by a number of countries in the region, although the impact these may have on marine mammals are largely unknown. Romanov (2001) reported a single sei whale bycatch in Soviet purse-seines, as this species associate with tuna schools. However, it is still difficult to assess the frequency and probability of whale mortality by the purse-seine fishery in the western Indian Ocean (Romanov, 2001). No dolphin bycatch have been reported in the region in the purse-seine fishery in the SWIO. However, it is possible that bycatches occur in these fisheries, as dolphins and tunas are known to associate in the region. To date, the known threats facing cetaceans in the SWIO are essentially concentrated in the coastal waters. Bycatch in fishing gears, especially gillnets, likely poses the greatest direct threat to marine mammals in most of the SWIO countries (Kiszka *et al.*, 2009). Off Zanzibar, bycatch primarily affect Indo-Pacific bottlenose, humpback dolphins and spinner dolphins, but also pantropical spotted dolphins, common bottlenose

dolphins, Risso's dolphins and humpback whales (Amir *et al.*, 2002, 2005b; O. Amir, personal observation). The recorded large number of dolphin bycaught in gillnets off Zanzibar is a serious cause of concern, e.g. unsustainable bycatch levels (>5% per year of population size estimates) of *T. aduncus* and *S. chinensis* have been documented in drift-and bottom set gillnets off the South coast of Zanzibar (Berggren *et al.* 2007) Currently studies are on-going to determine the magnitude and to mitigate small cetacean bycatch off Zanzibar. Off the mainland of Tanzania, evidence of both direct and indirect catches have been reported from Tanga, Dar es Salaam and Mtwara, involving *Stenella* spp., *Steno bredanensis* and *Tursiops* (probably *T. aduncus* rather than *T. truncatus*) (Chande *et al.*, 1994). Dolphins used to be caught intentionally for use as baits in the longline shark fishery although activity has been replaced by dolphin tourism off Zanzibar (Borobia, 1997, Berggren *et al.* 2007). Along the coast of Mozambique, the use of gillnets (both commercial and artisanal) is extensive and increasing, and there have been a corresponding decline in coastal dolphin numbers (Cockcroft & Krohn, 1994). Interview surveys conducted by Guissamulo & Cockcroft (1997) confirmed that humpback dolphins are taken in drift gillnets. Around Madagascar, gill and shark nets are extensively used, and dolphin bycatch probably occur but no assessment has been undertaken. Around Mayotte, the Seychelles and the Comoros, gillnets are not used except off Mohéli where bycatch could occur. Humpback whale bycatch has been reported in the southwest region of Madagascar (Razafindrakoto *et al.*, 2009). Off the island of Mayotte, a juvenile humpback whale was observed at the surface in September 2005, entangled in a gillnet, but the animal was successfully released (J. Kiszka, personal observation).

Direct catches

Direct takes of dolphins have also been reported around the Seychelles (despite cetaceans being fully protected by a national legislation); over the Mahe Plateau and the outlining islands of the Seychelles group (de Lestang, 1993). The targeted species would be the bottlenose dolphin (*Tursiops* spp.), and probably other species such as spinner dolphins. Direct exploitation of small cetaceans is commonly reported along the western coast of Madagascar, mostly targeting humpback dolphins, bottlenose dolphins and spinner dolphins (Andrianarivelo, 2001; Razafindrakoto *et al.*, 2004; Cerchio *et al.*, 2009a, b). Recent evidence indicates a six-fold difference in encounter rate of humpback dolphins between the northwest, where there is allegedly little or no hunting, and the southwest (Cerchio *et al.*, 2009b), suggesting depletion of the southwest population. Throughout the region, dugongs are also targeted for their meat and other body parts, which induced a significant decline of the species (WWF EAME, 2004).

Disturbances from whale/dolphin watching activities

The other important and clearly identified threat to marine mammals (especially cetaceans) in the region is disturbances from unregulated whale and dolphin watching activities. This problem has been clearly identified off the island of Zanzibar, with Indo-Pacific bottlenose dolphins, where dolphin watching activities lead to changes in behaviour that may have negative effects on both individual and population level (Stensland & Berggren, 2007; Berggren *et. al.* 2007; Christiansen *et al.*, submitted). Elsewhere, no clear evidences have been published. However, we can suspect similar patterns where dolphin/whale tourism operates on a regular basis. Such is the case off the west coast of La Réunion where the dolphin watching activity (mainly focussed on Indo-Pacific bottlenose dolphins) operates on a daily basis, as well as in the lagoon of Mayotte. Dolphin watching activities are also important off Mozambique and Mauritius. Whale watching (humpback whales) activities are increasing in many areas, such as in the Sainte Marine Channel (north-east Madagascar), La Réunion and Mayotte.

Other potential threats

There are several other human activities that may have a negative impact on whales and dolphins in the SWIO region but there is little information available. For example, oil and gas exploration is ongoing in the region using seismic survey methods to explore the sea floor. Further, the use of military underwater sonar has been linked to strandings and deaths of several whale species in other parts of the world may and also pose of threat in the SWIO. Pollution originating from oil exploration or other sources of human activities at sea, or on land which reach the coastal areas as rainwater or drainage may also have negative health effects on whales and dolphins in the SWIO region.

CONCLUSIONS

A vast diversity of marine mammals occurs in the SWIO region. Few in-depth investigations have been undertaken to assess the status, distribution and ecology of marine mammals in this area, even though these organisms are highly exposed to many human-induced threats such as bycatch and disturbances from whale/dolphin watching activities. The dugong, likely the most endangered species in the region, is probably

still in decline and many coastal populations of dolphins; especially Indo-Pacific humpback and bottlenose dolphins are facing detrimental interactions with fisheries and other human disturbance. A regional assessment of dugong populations needs to be conducted, especially to look at absolute abundance, distribution and movements of dugongs in the region.

For oceanic cetaceans, the use of platforms of opportunity, such as fishing vessels operating throughout the region, would provide more information on the spatial, temporal distribution, relative abundance and habitat preference of cetaceans in the SWIO. While local strategies to mitigate and limit disturbance from dolphin/whale watching activities are clearly needed, a regional strategy to assess, regulate, and mitigate bycatch in the gillnet fisheries is an urgent priority.

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Country	**Mozambique**	**Tanzania**	**Kenya**	**Comoros/Mayotte**	**Seychelles**	**Madagascar**	**Réunion/Mauritius**
Species							
Delphinidae							
Stenella longirostris	X	X	X	X	X	X	X
Stenella attenuata	X	X	X	X	X	X	X
Stenella coeruleoalba			X		X		X
Tursiops aduncus	X	X	X	X	X	X	X
Tursiops truncatus	X	X		X	X	X	X
Globicephala macrorhynchus	X			X	X	X	X
Pepopocephala electra	X		X	X	X	X	X
Feresa attenuata				X	X		X
Grampus griseus	X	X	X	X	X	X	
Sousa chinensis	X	X	X	X		X	
Steno bredanensis		X			X		
Lagenodelphis hosei		X	X	X	X	X	X
Delphinus spp.			X		X		
Orcinus orca			X	X	X	X	X
Pseudorca crassidens	X	X		X	X	X	
Ziphiidae							
Mesoplodon densirostris		X		X	X		X
Mesoplodon pacificus		X?		X	X		
Mesoplodon mirus	X			X			X
Ziphius cavirostris				X	X		X
Mesoplodon gingkodens				?	X		
Kogidae							
Kogia sima				X	X	X	X
Kogia breviceps		X		X			X
Physeteridae							
Physeter macrocephalus	X	X	X	X	X	X	X

Balaenopteridae							
Megaptera novaeangliae	X	X	X	X	X	X	X
Balaenoptera musculus				X	X	X	
Balaenoptera bonaerensis	X		X	X	X		X
Balaenoptera physalus					X	X?	X
Balaenoptera borealis					X	X?	
Balaenoptera edeni			X		X		
Balaenidae							
Eubalaena australis						X	X
Source	Way & Martin (1983); Rørvik (1980); Saetre & Paula e Silva (1979); Best *et al.* (1998);Cockcroft & Guissamulo (1998; 2007), Guissamulo et al (2007); Guissamulo (2009); Peddemors *et al*. (1997); Findlay *et al.* (1994) Guissamulo, unpublished data; von Lüders *et al*. (2008)	Amir *et al*. (2002, 2005); Berggren *et al.* (2000, 2007)	Wamukoya *et al.*, 1996; N. Wambiji, personal observations	Kiszka *et al.* (2006, 2007); M. Vely, pers. Obs.; J. Kiszka, Unpub. Data	Anon, 1997; Ballance & Pitman, 1998; Leatherwood *et al*., 1984; True, 1894 as cited in Racey and Nicoll, 1984; Keller *et al*., 1982; M. Vely, pers. obs.; Payne *et al*., 2002; D. Rowat, pers. obs.; Leatherwood *et al*., 1991; SIF, 2001; Eyre, 1995; Robineau, 1991; Hermans & Pistorius, 2008	Andrianarivelo, 2001; Best *et al*., 1994; Cerchio *et al*. 2009; Ersts & Rosenbaum, 2003; Razafindrakoto *et al*., 2004; Rosenbaum, 2003; Rosenbaum *et al*., 2001; WCS, Unpub. data	Corbett, 1994; Dulau-Drouot *et al*, 2008; Ribes & Durville, pers. Obs; GLOBICE, unpublished data

Table 1: Cetacean diversity in the southwest Indian Ocean.