

Marine Mammal Bycatch in the Southwest Indian Ocean: Review and Need for a Comprehensive Status Assessment

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Abstract—Incidental catch in fishing gears is a serious, worldwide threat to marine megafauna (particularly sea turtles, sharks and marine mammals). In order to inform the implementation of effective bycatch management strategies, an important first step is to conduct an assessment of the extent of this threat. In the southwest Indian Ocean (SWIO) (from 0 to 25°S, from eastern Africa to 60°E), there is a paucity of published data describing marine mammal bycatch. This review collates available information from a range of sources relating to marine mammal bycatch for nine SWIO countries: Mozambique, Tanzania (including Zanzibar), Kenya, the Seychelles, the Comoros, Mayotte, Madagascar, Reunion Island and Mauritius. An overview of the bycatch issue within each country is provided by considering the following key points: status of marine mammals, fishing effort, bycatch information and mitigation measures. Quantitative information, especially with respect to number of bycaught animals and impact on local populations, was found to be limited (except for Zanzibar). However, it is clear that several fisheries do incidentally catch marine mammals in the region, those of greatest concern being gillnets catching dugong (*Dugong dugon*) and coastal dolphins (*Tursiops aduncus* and *Sousa chinensis*) in Zanzibar and southwest Madagascar. To date, mitigation measures, particularly efforts to reduce the use of these gears, have not been employed effectively. From the information provided in this review, it is evident that it is critical to initiate the collection of quantitative data for marine mammal bycatch (particularly in gillnets) and its impact on local marine mammal populations and to implement relevant and effective mitigation measures.

INTRODUCTION

Interactions between marine mammals and fisheries have occurred for centuries and have increased in

frequency and intensity during the last decades (DeMaster *et al.*, 2001). Major adverse ecological impacts of fisheries are closely related to the bycatch issue (Lewison *et al.*, 2004). Globally, between

1990 and 1994, 653,365 marine mammals were taken accidentally in fishing gears. The incidental mortality of marine mammals in fishing gear is probably the most direct threat to these species on the worldwide scale (Read *et al.* 2006).

One of the most important requirements of the United Nations Convention on the Law of the Sea of 1982, which determines strategies of exploitation of marine living resources (Article 119, b), is to take into account the impact of fisheries on “species associated with, or dependent upon, harvested species with a view to maintaining or restoring populations of such associated or dependent species above levels at which their reproduction may become seriously threatened” (United Nations, 1983). Bycatch is defined by the FAO (Food and Agriculture Organization) as “part of a fishing unit taken incidentally, in addition to the targeted species towards which fishing effort is directed.” The FAO Code of Conduct for Responsible Fisheries (CCRF) calls for the catch of non-targeted species to be minimized and promotes the conservation of biodiversity by minimizing fisheries impacts on non-targeted species and ecosystems in general.

In 1996 the World Conservation Union (IUCN) formulated several recommendations for the global management of fisheries bycatch; in particular, there was a call on the parties to the Convention on Biological Diversity (CBD) to investigate the potential for promoting the development of mechanisms, including legal instruments, to minimize the negative impacts of fisheries practices on marine biodiversity. More recently, at the 14th Meeting of the CMS (Convention on Migratory Species of Wild Animals) Scientific Council, detailed requirements to assess bycatch in global fisheries were put forward. These included assessments of the level of knowledge regarding bycatch of non targeted species, including marine mammals; an indication of any trends in bycatch; and collating information relating to the use of mitigation strategies to reduce the impacts of incidental take on non-target species (CMS, 2007).

The incidental mortality of marine mammals in fishing gear, as well as other marine megafauna (e.g. seabirds, sea turtles and sharks) is probably the most direct threat to these species within the southwest

Indian Ocean (SWIO) and globally (Amir *et al.*, 2002) and mortality due to bycatch is one of the major adverse ecological impacts of fisheries on marine ecosystems (Lewison *et al.*, 2004). Bycatch is known to occur throughout the SWIO region (Figure 1), both in coastal (Amir *et al.*, 2002) and pelagic ecosystems (Romanov, 2001). However, few studies have been conducted on bycatch in any of the major SWIO fisheries, including long-line, purse seine, prawn trawl and gillnet fisheries and currently, sparse quantitative information is available for the SWIO region. Furthermore, few mitigation measures have been implemented in the region (e.g. IOTC, 2007).

Some notable studies assessing bycatch within the region include a dedicated study in Zanzibar to determine the level of dolphin mortality in the gillnet fishery (Amir *et al.*, 2002). and interview surveys to assess the extent of cetacean bycatch in south west Madagascar (Razafindrakoto *et al.*, 2007). However, no additional investigations have been undertaken to assess the impact of fisheries on the survival of non-targeted species such as cetaceans and the threatened dugong (*Dugong dugon*) (Cockcroft & Krohn; 1994; Romanov, 2001; WWF EAME, 2004). The limited data available, coupled with the fact that most coastal states and territories in the WIO region are presently underdeveloped with poor infrastructure and limited facilities, creates a major challenge for research and management.

During the Western Indian Ocean Marine Science Association (WIOMSA) Scientific Symposium held in Mauritius in August 2005, scientists working on marine mammals and sea turtles in the region held a meeting to discuss the issue of fisheries bycatch of these taxonomic groups and ways to mitigate this threat. This was followed by the establishment of a SWIO discussion group and a regional workshop to further address the issues identified. The workshop provided a forum for the discussion of common issues and data related to bycatch within the SWIO region and a review of the potential threat from coastal and pelagic fisheries to marine megafauna (Kiszka & Muir, 2007). The objective of the current paper is to present an overview of marine mammal status, fisheries, marine mammal bycatch and mitigation

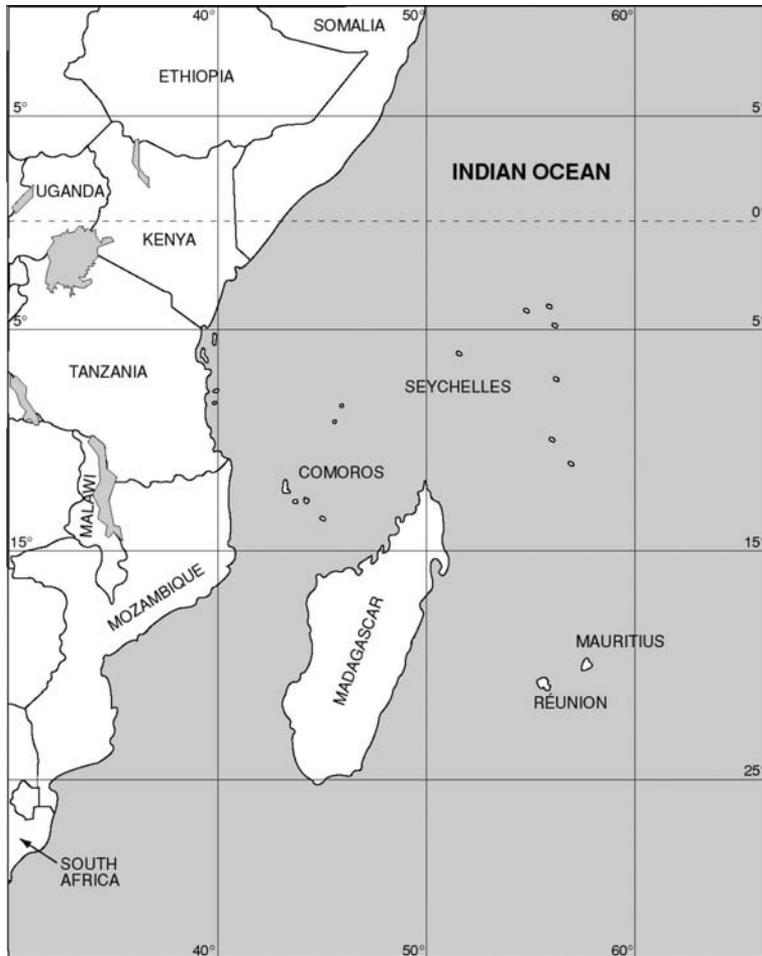


Fig. 1. Map of the southwest Indian Ocean region

measures in the SWIO region, based on the data provided by participants during the workshop (unpublished data) and the available literature (grey and published). It is intended that researchers and managers may utilize the information provided here to prioritize and inform research, management, and mitigation of marine mammal bycatch in the SWIO region.

FISHERIES AND MARINE MAMMAL BYCATCH IN THE SOUTHWEST INDIAN OCEAN

Union of the Comoros

Marine mammal diversity and status

The status of marine mammals is poorly understood

in the Union of the Comoros. Fourteen species have been recorded around the three islands (Anjouan, Mohéli and Grande Comore), including migrating humpback whales (*Megaptera novaeangliae*) during austral winter (July-October) and the dugong (WWF EAME, 2004; Kiszka *et al.*, 2006). The most common species around the archipelago are spinner (*Stenella longirostris*), pantropical spotted (*Stenella attenuata*) and Indo-Pacific bottlenose dolphins (*Tursiops aduncus*). Other oceanic species also occur, such as a Longman's beaked whale (*Mesoplodon pacificus*) and short-finned pilot whale (*Globicephala macrorhynchus*) (Anderson *et al.*, 2006; Kiszka *et al.*, 2006). The dugong predominantly occurs south of the island of Mohéli (Marine Park; Davis & Poonian, 2007). Sperm whales (*Physeter macrocephalus*) also regularly occur, especially during late austral summer and

were caught by American whalers in the vicinity of the Comoros during the 19th Century (Wray & Martin, 1983).

Fisheries

Fishing in the Comoros is entirely artisanal and catches are generally consumed locally. Fishing licences, however, are also given to commercial Asian and European longline and purse-seine fishing vessels. Coastal fishing gears include beach seines, fish traps, gillnets, and lines (including trolling and droplines, Table 1) with lines targeting pelagic fish being the most commonly utilised (Poonian *et al.*, 2009). Gillnets targeting sharks have been reported (up to 270 m long, 2 m wide with a mesh size of 30 cm) (*Ministère de l'Agriculture et de la Pêche*, 1995). Two types of boat are commonly used: *galawa* (traditional canoe) and *vedette* (motorized boat) (UNEP, 2002), with the most recent surveys indicating that in 2005 there were approximately 8,500 artisanal fishers using 3,403 *galawas* and 924 *vedettes* (Abdoulhalik, 1998; *Union des Comores*, 2005). Fishing activity in the Comoros is seasonal and the most productive seasons for fishing vary for each island. For example, on Grande Comore, peak production occurs during the Kashkazi season (November-March) and on Mohéli it is at the beginning of the Kashkazi. Seasonality is more complex on Anjouan because of the island's shape with production poor on the east coast and peaking on the north-west coast during the Kusi season (May-August), but this pattern is reversed during Kashkazi (Abdoulhalik, 1998).

Marine mammal bycatch

Cetacean species reported as bycatch in the Union of the Comoros include (from most frequent to least common): spinner dolphin, Indian Ocean bottlenose dolphin, humpback dolphin (*Sousa chinensis*) and Risso's dolphin (*Grampus griseus*) (Table 1). Dolphins caught accidentally are generally released, since they have no value as food; however, some fishers kill them because they perceive them as a threat to fish stocks (mortality of cetaceans caught accidentally was estimated at 11% on Grande Comore and 25% on Mohéli; Poonian *et al.*, 2009). Bycatch of dugong has been recorded in gillnets around the island of Mohéli, including within

Mohéli Marine Park. Dugong captures occurred most frequently in the 1970s and 80s, suggesting that the species has declined significantly in the recent years, a trend which is also evident in other areas of eastern Africa (Davis & Poonian, 2007; WWF EAME, 2004).

Mitigation measures

A number of legal restrictions to reduce marine mammal bycatch have been put in place, including prohibition of destructive fishing techniques (dynamite, poison) and capture of endangered species, but these sanctions are yet to be effectively enforced (UNEP, 2002). There has been an official ban on gillnets in Mohéli Marine Park since 2001 (Gabrié, 2003) which has been poorly received by local fishing communities because of a lack of provision for alternative livelihoods and logistical difficulties with enforcement in the absence of sustainable funding mechanisms for the Marine Park (Hauzer *et al.*, 2008). Additionally, informal bans by some communities in certain areas, have however been enforced by local village associations and fishing syndicates since at least 1995, although there is currently no evidence of their success in mitigating marine mammal bycatch (*Ministère de l'Agriculture et de la Pêche*, 1995).

Mayotte (France)

Marine mammal diversity and status

The island of Mayotte is characterized by the presence of a large closed lagoon (around 1,100 km²), and a very steep slope close to the barrier reef. More than twenty species of marine mammal have been recorded around Mayotte, including humpback whales during austral summer, the blue whale (*Balaenoptera musculus*), the dugong, at least 12 species of dolphin (including *S. chinensis*, *S. longirostris*, *S. attenuata*, *Lagenodelphis hosei*, *T. aduncus*, *T. truncatus*, *Peponocephala electra*, *Feresa attenuata*, *Pseudorca crassidens*, *G. griseus*, *Orcinus orca*, *G. macrorhynchus*), beaked whales (including *Mesoplodon densirostris*, *M. pacificus* and possibly *Mesoplodon ginkgodens*) and sperm whales (*P. macrocephalus*, *Kogia sima*, *Kogia breviceps*) (Kiszka *et al.*, 2007a). The most common species are the spinner dolphin, the pantropical

Table 1: Marine mammal bycatch matrix for the southwest Indian Ocean region. DU = Dugongs; SC = Small cetaceans; LC = Large cetaceans; OBS = Observers; INT = Interviews; LAN = Landings

Country	Fishery	Tarteted sp.	Fishing effort		Bycatch			Data			Data source
			N.	Season	DU	SC	LC	INT	INT	LAN	
Comoros	Fish trap	Reef fishes	900 gears	Year							Community-Centred Conservation (C3, unpublished data). Poonian <i>et al.</i> (2009).
	Gillnet	Sharks, others	?	Nov-March	X	X			X		
	Handline	Reef fishes	3 300 gears		X	X					
	Artisanal longline	Tuna	?	?							
	Beach seine	Fry	?				X				
	Purse seine	Tuna	?	?							
	Spear gun	Reef fishes	?	?							
Mayotte (FR)	Reef seine	Reef fishes	~20 gears			X			X	Pusineri & Quillard (2009); Kiszka & Muir (2007); Direction des Affaires Maritimes (unpublished data)	
	Spear gun	Reef fishes	?								
	Handline	Reef fishes	1 092 gears			X			X		
	Longline	Tuna & sword.	3 gears			X			X		
	Purse seine	Tuna	0-3 boats	March-April							
Kenya	Trawling	Prawns	20 gears	Year						Kenya Marine and Fisheries Research Institute (2006 data, unpublished).	
	Gillnet	Sharks	5 916 gears	Year			X		X		
	Handline	Reef fishes	6 540 gears	Year							
	Beach seine	Reef fishes	970 gears	Year							
	Cast nets	Various	812 gears	Year							
	Basket trap	Various	5 224 gears	Year							
	Monofilament	Various	1 050 gears	Year							
	Scoop net	Various	764 gears	Year							
	Trammel net	Various	23 gears	Year							
	Trolling net	Various	640 gears	Year							
	Spear gun	Octopus	624 gears	Year							
	Others	Reef fishes	9 137 gears	?							

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Country	Fishery	Tarteted sp.	Fishing effort		Bycatch				Data		Data source
			N.	Season	DU	SC	LC	INT	INT	LAN	
Madagascar	Trawling	<i>Prawns & Tuna</i>	?	March-Dec.							Razafindrakoto <i>et al.</i> (2009); Direction de la Pêche et des Ressources Halieutiques (2006 data, unpublished)
	Longline industrial	<i>Sharks</i>	?	Year							
	Longline artisanal	<i>Sharks</i>	?	Year	X	X	X		X		
	Gillnet industrial	<i>Shark & others</i>	?	Year							
	Gillnet artisanal	<i>Shark & others</i>	?	Year	X	X	X		X		
	Handline	<i>Fishes</i>	?	Year							
	Beach seine	<i>All resources</i>	?	Year							
	Spear gun	<i>Reef fishes</i>	?	Year							
	Trawling	<i>Prawns</i>	10 gears	Year							
	Shark net	<i>Sharks & rays</i>	8 820 gears	Year	X	X	X		X		
Tanzania (mainland)	Gillnet	<i>Kingsfish, grouper</i>	18 808 gears	Year	X	X			X		
	Longline	<i>Tuna & sword.</i>	53 549 gears	Year							
	Handline	<i>Reef fishes</i>	14 908 gears	Year							
	Beach seine	<i>Reef fishes</i>	453 gears	Year							
	Basket trap	<i>Various</i>	5 907 gears	Year							
	Cast net	<i>Various</i>	73 gears	Year							
	Scoop net	<i>Various</i>	710 gears	Year							
	Weir	<i>Various</i>	14 gears	Year							
	Lift net	<i>Various</i>	150 gears	Year							
	Spear gun	<i>Various</i>	350 gears	Year							
Zanzibar	Sharknet	<i>Sharks, others</i>	1 647 gears	Year	X	X	X		X		Amir <i>et al.</i> (2002; 2005) Jiddawi & Khatib (2007)
	Gillnet	<i>Various</i>	5 328 gears	Year							
	Traps	<i>Various</i>	10 599 gears	Year							
	Handline	<i>Reef fishes</i>	18 865 gears	Year							
	Longline	<i>Tuna & sword.</i>	706 gears	Year							
	Beach seine	<i>Various</i>	938 gears	Year							
	Purse seine	<i>Small pelagics</i>	215 gears	Year							
	Cast nets	<i>Various</i>	1 046 gears	Year							
	Ring nets	<i>Various</i>	180 gears	Year							
	Spear gun	<i>Various</i>	2 349 gears	Year							
Scoop nets	<i>Various</i>	265 gears	Year								
Weir	<i>Various</i>	13 gears	Year								

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spotted dolphin, the Indo-Pacific bottlenose dolphin and the melon-headed whale, which are resident throughout the year (Kiszka *et al.*, 2007a).

Fisheries

The fisheries around Mayotte are artisanal and poorly developed (Table 1). The most important fishery is the hand line, targeting reef fishes, especially predatory demersal species such as grouper and snapper. Other fishing techniques include small seines deployed on barrier and fringing reefs (less than 20 small, open boats or 'barks'). Three long liners are based in Mayotte and fish in the territorial waters, targeting swordfish (*Xiphias gladius*) and tunas, and deploying between 400 and 700 hooks each. In 2006, 1,092 small boats (including pirogues and small barks less than 7 m long) were recorded by the local fishing service (*Direction des Affaires Maritimes de Mayotte*, unpublished data).

Marine mammal bycatch

Dugong bycatch and deliberate hunting has been recorded around Mayotte, but has declined in recent decades due to the reduction in numbers of this species (Kiszka *et al.*, 2007b). Incidental catches in seine nets are likely very rare. During a recent interview survey in 2007 (n=406), only 10 fishers declared that they had caught a cetacean (all were dolphins) and eight of the animals were released alive. Of these ten dolphins, four were caught by net, three by hand line and three by longline (Pusineri & Quillard, 2009; Table 1) and species involved were thought to be Indo-Pacific bottlenose, spinner and spotted dolphin.. There is evidence for interactions between Indo-Pacific bottlenose dolphins and hand line fisheries and short-finned pilot whales and longlines around Mayotte (Kiszka *et al.*, 2009). In addition, short-finned pilot whales, melon-headed whales and spinner dolphins have been bycaught in the longline fishery, but in very limited numbers (less than 1 individual every 5 years; F. Fredericci & G. Wunderlee, pers. comm.). Spinner dolphin bycatch is probably linked to bait attraction (squid, saury). Remains of gillnets have also been observed on humpback whales migrating to Mayotte on several occasions although no mortalities have been observed to date. Consequently, based on the small

numbers reported it is considered that the current bycatch of cetaceans in Mayotte is likely to have a negligible impact on these species.

Mitigation measures

The use of seine nets is controlled as it is not permitted on seagrasses (important habitat for dugong) and live reefs. In addition, three marine protected areas around the island (two of them are located in the eastern part of the lagoon) limit the extent of fisheries, although these areas are relatively small (less than 2% of the lagoon waters). Nets are not allowed in any of the existing marine protected areas, and hand lining is prohibited in one of them. There are no mitigation measures in force for the longline fishery.

Kenya

Marine mammal diversity and status

There is limited information on the status of marine mammals off Kenya, however, the sperm whale, humpback whale, Bryde's whale (*Balaenoptera edeni*), minke whale (*B. acutorostrata*), killer whale (*Orcinus orca*), melon-headed whale, bottlenose dolphin (*Tursiops* sp.), common dolphin (*Delphinus* sp.), humpback dolphin (*Sousa chinensis*), spinner dolphin, spotted dolphin, Fraser's dolphin, Risso's dolphin and the striped dolphin (*Stenella coeruleoalba*) have all been recorded (Wamukoya *et al.*, 1996). Indo-Pacific bottlenose and humpback dolphins seem to be resident in a number of coastal areas. The dugong occurred in large numbers off Kenya before the 1960s, and a large group of 500 were seen in the south of the country in 1967, although this species has declined significantly in recent decades due to incidental captures in gillnets and hunting. Currently, dugongs are still present in small numbers, especially off the Tana delta area, in the Lamu archipelago and in Kiunga (WWF EAME, 2004).

Fisheries

Fishing has considerable socio-economic importance in Kenya and the marine fishery can be classified into two broad categories: artisanal and semi- industrial. Artisanal fishing is confined

to the shallow waters along the entire coastline and accounts for about 90% of the annual total marine fish landed (approximately 10,000 metric tons). The coastal waters are a major source of livelihood for 9,017 fishers (Frame survey report, 2004) with over 250,000 persons depending on coastal and marine fish production and the marine catch is estimated to represent approximately 5.0% of the total fish catch in Kenya (Fisheries statistical bulletin, 2004). Kenyan fisheries employ a wide range of gears, including gillnets (2006: n=5,916 gears), beach/prawn/reef seines (2006: n=970), prawn trawls (2006: n=20), long line hooks (2006: n=8,224), monofilament nets, baskets, hand lines, scoop nets and trolling lines. In 2006, a total of 28 landing sites were recorded along the Kenyan coast (Marine Waters Frame Survey 2006 Report, Kenya Marine & Fisheries Research Institute, unpublished data; Table 1).

Marine mammal bycatch

Little is known about marine mammal bycatch along the coast of Kenya. Incidental catches of dugongs in gillnets and trawls were reported during interview surveys conducted in 2003 in 14 villages (WWF EAME, 2004). Cetacean bycatch is currently undocumented, but is expected to occur in areas where gillnets are used (for example: Bofa, Tenewi Ziwayuu and Manda regions; Kenya Marine & Fisheries Research Institute, unpublished data). Cetacean species caught incidentally, however, are known to include Indo-Pacific humpback and bottlenose dolphins (Table 1). Although the extent of marine mammal bycatch in Kenya is unknown, it could potentially be considerable due to the extensive use of gillnets.

Mitigation measures

No mitigation measures have been implemented in Kenya to reduce marine mammal bycatch in fishing gears. Actions have been taken, however, by various stakeholders, to raise fisher awareness of this issue.

Madagascar

Marine mammal diversity and status

A review of the diversity and status of marine mammals around Madagascar indicated the

presence of 27 species (Rosenbaum, 2003). Large cetaceans recorded include the humpback whale, the blue whale, the fin whale (*Balaenoptera physalus*), the southern right whale (*Eubalaena australis*), the pygmy right whale (*Caperea marginata*) and the sperm whale. During austral winters, a large number of humpback whales annually visit the known breeding grounds along the eastern coast, especially between Cap Sainte Marie south of Tolagnaro and Baie d'Antongil and in the south-western region (Rosenbaum *et al.*, 1997; Rosenbaum, 2003; Cerchio *et al.*, 2006). Bottlenose and humpback dolphins are the most common species of the 20 odontocetes present and are predominantly distributed along the west and north-east coasts (Cockcroft & Young, 1998; Rosenbaum, 2003; Razafindrakoto *et al.*, 2004). Other species recorded include four beaked whale species, the pygmy and dwarf sperm whales and 10 delphinid species (Rosenbaum, 2003). The dugong is known to occur in Madagascar but its status remains unclear (WWF EAME, 2004). In addition, two species of pinniped: the crabeater seal (*Lobodon carcinophagus*) and the subantarctic fur seal (*Arctocephalus tropicalis*) have been found stranded on Malagasy shores (Rosenbaum, 2003; Garrigue & Ross, 1996).

Fisheries

Fisheries constitute the main source of income for coastal communities and foreign revenue for the national economy. Three types of fisheries exist in Madagascar's waters which are classified according to the power of the vessels' engines, these are commercial (>50HP), artisanal (<50HP) and traditional (non-motorized). A total of 80 commercial longline and trawling fishery vessels exploiting tunas, swordfish, shark, and shrimps in EEZ of Madagascar were recorded in 2006 (Fisheries Department, Ministry of Agriculture, Fisheries and Livestock). The artisanal fishery principally utilizes gillnets to target elasmobranchs, fishes, gastropods and crustaceans within 12 miles offshore (Table 1) and 26 artisanal fishing companies were listed in Madagascar in 2006 (DPRH, unpublished data). Traditional fisheries target a full range of exploitable resources (e.g. elasmobranchs, cephalopods, gastropods, echinoderms, turtles, marine mammals) in shallow and pelagic waters

within Madagascar's EEZ with a total of 26,000 traditional fishers were recorded by the Fisheries Department in 2006.

Marine mammal bycatch

Marine mammal bycatch has been reported to occur in commercial, artisanal and traditional fisheries in Madagascar (*Direction des Pêches et des Ressources Halieutiques*, unpublished data), although accurate quantitative data are lacking (Table 1). A project was initiated in 2005 to evaluate the extent of bycatch in artisanal fisheries in the south-western region of Madagascar in which incidental capture of Indo-Pacific humpback, bottlenose, and Fraser's dolphins had been reported and gillnet capture of humpback whales, Indo-Pacific humpback dolphins, spinner dolphins and bottlenose dolphins (Andrianarivelo, 2001; Razafindrakoto *et al.*, 2004). Furthermore, a total of 111 interviews were analyzed which indicated 56 events of by-catch in four villages between 2000 and 2005. Humpback whales and three species of dolphin species were reported incidentally caught in fishing gear targeting sharks. Longlines were only reported to catch humpback whales whereas dolphins were mostly entangled in gillnets. Bottlenose and spinner dolphins represented around 48% and 32%, respectively, of the total cetacean bycatch between 2000 and 2005 (Razafindrakoto *et al.*, 2009).

Mitigation measures

Regulatory measures to mitigate marine mammal bycatch in any type of fishery have not been implemented in Madagascar. The Cetacean Conservation and Research Project of the Wildlife Conservation Society, however, has attempted to involve local communities in the implementation of management actions to reduce threats to marine mammals, in particular hunting and bycatch in artisanal and traditional fisheries. Various suggestions from fishers (e.g. incentive programmes for the release of animals, legislative frameworks and promotion of whale and dolphin watching) were discussed during a two day workshop in 2007 and a follow-up meeting was held recently to form a local association to protect whales and dolphins in the south-western region of Madagascar (H.C. Rosenbaum, pers. comm.).

Mozambique

Marine mammal diversity and status

There is sparse published information regarding the status of marine mammals along the Mozambican coast. Humpback whales, however, are known to occur in coastal waters during the austral winter (Findlay *et al.*, 1994) and the most common cetacean species in inshore waters are Indo-Pacific bottlenose and humpback dolphins, especially in Maputo Bay and the Bazaruto archipelago with an estimated at 105 humpback dolphins in Maputo (Guissamulo & Cockcroft, 2004). Dugongs occur in Maputo and Inhambane Bays, and the largest population, is located in the Bazaruto Bay. The most recent estimate of dugong population size in the Bazaruto bay is 130 individuals (Guissamulo & Cockcroft, 1997). This population is considered to be the only viable population in eastern Africa (WWF EAME, 2004).

Fisheries

Sixty percent of the Mozambican population is dependant on marine resources. A wide variety of fisheries are present including a significant prawn trawl fishery, hand lining, and gillnetting (for sharks and other large pelagic fishes).

Marine mammal bycatch

Little is known regarding the extent of marine mammal bycatch off the coast of Mozambique. Entanglement in gillnets appears to be a major cause of dugong mortality along the entire coast and the level of this threat has augmented since the early 1990's as gillnet use has increased (WWF EAME, 2004). Interview surveys with fishers have confirmed that humpback dolphins are also bycaught in the drift gillnet fishery (Guissamulo & Cockcroft, 1997). Gillnets also appear to have an impact on small coastal cetaceans, particularly bottlenose and humpback dolphins and a marked decline in coastal dolphin populations was observed in the early 1990's (Cockcroft & Krohn, 1994). It is important to note, however, that intentional captures have also contributed to the decline of humpback dolphins (Guissamulo & Cockcroft, 1997).

Mitigation measures

No mitigation measures have been implemented in Mozambique to reduce marine mammal bycatch.

Tanzania (including Zanzibar)

Marine mammal diversity and status

At least seven species of dolphin, three species of whales and the dugong have been recorded in Tanzania, including Zanzibar (Unguja Islands) where the majority of cetacean surveys have been conducted in the coastal waters. Dolphin species present include Indo-Pacific bottlenose dolphins, spinner dolphins, Risso's dolphins, Indo-Pacific humpback dolphins, pantropical spotted dolphins, and common bottlenose dolphins (*T. truncatus*) (Amir *et al.*, 2002, 2005). In addition, Berggren *et al.* (2001) recorded the rough-toothed dolphin in Tanzania, off Zanzibar (*Steno bredanensis*). The most common of these species are Indo-Pacific bottlenose, spinner and humpback dolphins (Ortland, 1997; Stensland *et al.*, 1998; Amir *et al.*, 2002, 2005). Dolphins (not identified to species level, but probably *T. aduncus* and/or *S. chinensis*, as these are the most coastal species) have also been recorded in the Rufiji Delta, Saadani, around Latham Island, Tanga (northern Tanzania) and Mtwara (south Tanzania) (Linden & Lundin, 1995 and Chande *et al.*, (1994) noted three dolphin (*T. truncatus*, *S. longirostris* and *S. bredanensis*) during a survey conducted in Mtwara, Dar es Salaam, Bagamoyo and Tanga. Sperm whales and humpback whales are the most commonly-observed species of whale Amir & Berggren (unpublished). Population estimates exist for Indo-Pacific bottlenose and humpback dolphins off the south coast of Zanzibar, *i.e.* 136-179 bottlenose and 58-65 humpback dolphins (Stensland *et al.*, 2006).

Dugongs have been recorded as bycatch both on the Tanzanian mainland and Zanzibar, indicating they are present, but their numbers are unknown (WWF EAME, 2004).

Fisheries

The marine fisheries in Tanzania are artisanal. Fishing gears used include handlines, gillnets, shark nets, scoop nets, long lines, troll lines, cast nets, ring nets, purse seines, movable traps, fixed fences and spears. The number of fishing vessels

recorded in Zanzibar was 7,342 and 7,155 in the Tanzanian mainland (MLFD / MALE, 2008). The most threatening fishing gears are drift gillnets for large pelagic fish and bottom set nets for demersal species. Drift nets, targeting large pelagic fish such as kingfish, swordfish, sailfish, skipjack tuna and marlin, are approximately 500–900 m in length with variable mesh sizes from 7–20 cm, while bottom-set nets, targeting sharks and rays, vary in length up to 450 m, with mesh sizes ranging from 20–40 cm. These bottom nets are typically set very close to the shore.

Marine mammal bycatch

Dolphins and whales have been recorded as bycaught in gillnets at sites around Unguja Island, in the Zanzibar Channel and along the coast of northern Tanzania (Amir *et al.*, 2002). The level of dolphin bycatch in the artisanal gillnet fishery has been investigated in a questionnaire survey of 101 gillnet vessel operators from 10 villages around Zanzibar (Amir *et al.*, 2002). A total of 96 dolphins were reported to have been incidentally caught between 1995 and 1999: 43 *T. aduncus*, 29 *S. longirostris*, 5 *S. chinensis* and 19 unidentified dolphins. This study suggests that incidental capture of delphinids in the Zanzibar gillnet fishery may be high enough to negatively impact local populations (Amir *et al.*, 2002).

During questionnaire surveys conducted in April 2007 and February 2008 in Mtwara, where 64 fishers were interviewed, 15 (23%) of the fishers had personally caught a dolphin (Indo-Pacific bottlenose, spinner, humpback and Risso's dolphins) in gillnets. However, even respondents who had not personally caught a dolphin still cited gillnets as a major threat. Indo-Pacific bottlenose dolphins were most frequently identified as the species caught, although spinner dolphins were also cited as being caught, particularly in offshore gillnets (Institute of Marine Science, unpublished data). Dolphins have also been recorded as bycatch in Pangani, Temeke, Rufiji and Kilwa (SeaSense, unpublished data).

Dugong bycatch are still very frequent in Tanzania. From 2000 to 2004, 26 individuals (adults, juveniles and cow-calf pairs) were reported as bycatch. These incidental captures mostly occurred in the Rufiji Delta and off Kilwa (WWF

EAME, 2004). Fishers also report incidental capture of humpback whales in gillnets every year, although these are generally cut free. Dead humpback whales have been found stranded on beaches, still entangled in gillnets (Institute of Marine Science, unpublished data).

Mitigation measures

An experiment using acoustic devices (pingers) as a means of reducing incidentally catch of dolphins in gillnet fisheries is currently being conducted in Menai Bay Conservation Area, Zanzibar. No other mitigation measures are in place.

Seychelles

Marine mammal diversity and status

The Seychelles archipelago, including the Amirantes and Aldabra, was an important whaling ground for American whalers during the 19th Century (Wray & Martin, 1983). Leatherwood *et al.* (1984) reported the presence of sperm whales (including over the Seychelles Bank, east of Bird Island), spinner dolphins and bottlenose dolphins in Seychelles waters. 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, including the Seychelles oceanic waters (Ballance & Pitman, 1998). The most common species observed in this area were, in order of occurrence: sperm whale, spinner dolphin, striped dolphin, bottlenose dolphin and pilot whales (unspecified species, but likely *G. macrorhynchus*). Other species have been observed, including rough-toothed dolphins, dwarf sperm whale, pygmy sperm whale, melon-headed whale, pygmy killer whale and beaked whales (*Mesoplodon* sp.). Longman's beaked whales have been recorded on several occasions (Anderson *et al.*, 2006). Robineau (1991) recorded Bryde's whales offshore, west of the Seychelles, as well as blue and fin whales (species identification still unclear). The dugong occurs in small numbers (at least 3 individuals) at Aldabra atoll (WWF EAME, 2004).

Fisheries

Various fishing techniques are used in the Seychelles: drift longline (8 boats in 2006) targeting swordfish

and sharks; handline targeting groupers and snappers; beach seine targeting small pelagic fishes; and traps targeting reef fishes. The use of gillnets (formerly targeting reef sharks) has been recently prohibited in Seychelles territorial waters (Seychelles Fishing Authority, pers. comm.). Seychelles host the major oceanic purse seine fishery of the Indian Ocean. This fishery, composed of large boats (up to 100m long), operates all year long and only targets tuna-like species.

Marine mammal bycatch

No marine mammal bycatch has been recorded in the Seychelles. According to the Indian Ocean Tuna Commission, this problem is not significant in the oceanic purse seine fisheries (IOTC, 2007).

Mitigation measures

As bycatch extent is limited around the Seychelles, no mitigation measures are planned.

Reunion Island (France)

Marine mammal diversity and status

Ten species of cetacean have been recorded around Reunion Island; including migrating humpback whales during austral summer (Dulau-Drouot *et al.*, 2008). The most common species are the Indo-Pacific bottlenose dolphin, spinner dolphin, common bottlenose dolphin and pantropical spotted dolphin. Other species, such as the melon-headed whale, the Fraser's dolphin and the short-finned pilot whale, occur but are relatively rare (Dulau-Drouot *et al.*, 2008). Two other species have been recorded by the *Muséum d'Histoire Naturelle* of St Denis: the Bryde's whale (observed stranded once) and the southern right whale, that has been sighted twice (S. Ribes-Beaudemoulin & P. Durville, pers. comm.).

Fisheries

Two types of fisheries are active around Reunion: the longline (offshore and pelagic) and the hand line fishery (coastal). Longlining is conducted throughout the year by a fleet of approximately 30 boats; the primary target species are swordfish and tunas. Hand lines target reef fishes, especially groupers and snappers. Around 300 fishing boats

have been registered around the island (SIH-IFREMER, unpublished data). Game fishing, targeting large pelagic fishes, has a high socio-economic value in Reunion and its extent is currently unknown.

Marine mammal bycatch

There is a minimal amount of bycatch reported around Reunion. Bycatch has been mainly recorded in the game fishery that uses troll-line (Dulau/Globice personal communication.). Predation in the Réunion longline fishery is known to occur with Risso's dolphins (on bate) and short-finned pilot whales (on catches), but very few cases of by-catch of this species over the last six years were reported in this fishery (SIH-IFREMER, unpublished data). Two spinner dolphins were reported entangled in game fishing line, but such events may be considered as anecdotal. Capture of Indo-Pacific bottlenose dolphin in beach-seine nets is also reported, although this appears to be a rare event. Hook injuries and dorsal fin disfigurements due to fishing lines have been recorded in spinner, Indo-Pacific bottlenose and common bottlenose dolphins; however, no mortalities have been documented to date (Dulau *et al.*, 2007).

Mitigation measures

As the extent of bycatch is minor around Reunion Island, no mitigation measures are planned.

Mauritius

Marine mammal diversity and status

Very little is known about the diversity and status of marine mammals around Mauritius. Other than a cataloguing of some species seen in the waters of the island, little research has been conducted to determine population, diversity, and status. Strandings of Blainville's beaked whales were reported by Michel & van Bree (1976). Corbett (1994), during a year-long study, observed that spinner dolphins and sperm whales were the most common cetacean species around the island. In addition, baleen whales, including blue, humpbacks, and fin whales, have been recorded. A variety of odontocetes also occur: pantropical spotted dolphin, bottlenose dolphin (Indo-pacific and common), Risso's dolphin, striped dolphin, melon-headed

whale, pygmy killer whale, and Blainville's beaked whale (Corbett, 1994). The spinner dolphin is particularly common in the Bay of Tamarin, where they rest during the day (Mauritius Marine Conservation Society, pers. comm.). The dugong occurred around Mauritius and Rodrigues, and was considered as very abundant in this area in the 17th Century (Haskins & Davis, 2008). This species is now suspected to have become extinct from the Mascarenes.

Fisheries

The following fisheries have been recorded around Mauritius: longline (183 boats) and drift longline (for tunas and swordfish, mainly on FADs, 170 boats), purse seine (43), and midwater trawling (2). Artisanal fisheries using basket traps, line, harpoon, large nets and gillnets, totalize 2312 fishers and 1852 boats (Ministry of Agro Industry & Fisheries - Fisheries Division, 2006).

Marine mammal bycatch

No cetacean bycatch has been recorded around Mauritius.

Mitigation measures

The bycatch issue has been not studied around Mauritius, and no mitigation measures are undertaken or planned. Mauritius has a relatively large EEZ, thus a substantial bycatch is likely to occur. In addition, there are an unknown number of illegal vessels that do not report their catches and may be experiencing bycatch.

DISCUSSION AND CONCLUSION

Marine mammal bycatch has a highly variable extent within the southwest Indian Ocean region. Along continental coastlines such as in Kenya, Tanzania and Madagascar, gillnets are extensively used to catch sharks and other large fishes. The species most affected through bycatch in this gear are Indo-pacific humpback and bottlenose dolphins, as well as the dugong, which is probably the most endangered marine mammal in eastern Africa (WWF EAME, 2004). Where gillnets are not a major fishery, localized and unquantified bycatch still occurs and warrants further investigation. Around oceanic islands, such as in the Mascarene,

the Comoros, Mayotte and the Seychelles, marine mammal bycatch has a particularly limited extent. Gillnets are rarely deployed around these oceanic islands where the presence of coral reefs and a steep insular slope make effective deployment of large gillnets difficult. In the Comoros, overfishing of coral reef fisheries has forced fishers to move offshore where line fishing for pelagic fishes is now the preferred gear (C-3, unpublished data).

Interactions with the handline fishery occur and cause injuries to inshore dolphins in the lagoon of Mayotte (Kiszka *et al.*, 2009). Incidental catches in longline fisheries (targeting swordfish and tuna) is limited to oceanic species in the region, mostly pilot whales. The extent of interactions seems limited. However, these interactions need to be assessed spatially and quantitatively, as such interactions may induce mortalities and demographic impacts on populations. Incidental catches in the purse-seine fishery appear rare in the southwest Indian Ocean, with only a single baleen whale species reported caught in the Soviet purse-seine fishery (Romanov, 2001). It may be related to the rare occurrence of associations between cetaceans and tuna in this region.

Interactions, causing mortalities or injuries, with handlines need to be considered, as they appear to impact regularly on small coastal species of delphinids such as around Mayotte and Reunion. Even though data on bycatch within the region remains very poor and heterogeneous, particularly in countries with important artisanal inshore fisheries (particularly gillnetting), coastal marine mammals are clearly at risk from bycatch along the continental coasts and Madagascar. Surveys to quantify the extent of marine mammal bycatch are urgently needed, and the *Rapid Bycatch Assessment* through interview surveys (see GLOBAL project, Global Bycatch Assessment of Long-lived Species, <http://bycatch.env.duke.edu/>) provides a useful tool. However, such surveys could underestimate the extent of bycatch in sampled areas, as fishermen could avoid reporting bycatch. Nevertheless, other types of surveys, such as observer programs and coastal marine mammal abundance estimates/demographic studies, are also clearly needed where bycatch is known to occur (especially at a relatively high level). This work will help to better understand the level of threat and allow appropriate

and effective mitigation measures to be developed in collaboration with local stakeholders. Examples of mitigation measures include: the establishment of MPAs (Marine Protected Areas) for species of limited home range and/or for particular critical breeding/feeding grounds (seagrass beds for dugongs and sea turtles) or the use of deterrent devices such as pingers for small cetaceans. However, these mitigation measures appear difficult to implement in the absence of quantitative data on the extent of marine mammal bycatch, both at the local and regional levels. In addition, they appear to be expansive and difficult to implement in such developing countries (e.g. maintenance of the deterrent devices). The use of marine mammals (especially whales and dolphins) as ecotourism targets for some countries appears to be an alternative method for fishermen. The assessment of potential sites for whale/dolphin activities could be undertaken in some regions. Several potential sites have been identified, such as in the Comoros or along the northwest coast of Madagascar (Kiszka *et al.*, 2006; Wildlife Conservation Society, unpublished data). If well managed, whale/dolphin watching activities could indirectly contribute to the conservation of coastal marine mammals in the southwest region of the Indian Ocean.

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REFERENCES CITED

- Abdoulhalik, F.M. (1998). Marine Science Country Profiles, Comores. Intergovernmental Oceanographic Commission, *Western Indian Ocean Marine Science Association*. 35p.
- Amir, O.A., Berggren, P. & Jiddawi, N.S. (2002). The incidental catch of dolphins in gillnets fisheries in Zanzibar, Tanzania. *Western Indian Ocean J. Mar. Sci.*, **1**: 155-62.
- Amir, O.A., Jiddawi, N.S. & Berggren, P. (2005). The occurrence and distribution of dolphins in Zanzibar, Tanzania with comments on the differences between two species of *Tursiops*. *Western Indian Ocean J. Mar. Sci.*, **4**: 85-93.
- Anderson, R.C., Clark, R., Madsen, P.T., Johnson, C., Kiszka, J. & Breysse, O. (2006). Observations of Longman's beaked whales (*Indopacetus pacificus*) in the western Indian Ocean. *Aquat. Mamm.*, **32**(2): 223-231.
- Andrianarivelo, N. (2001). Inventaire et essai d'évaluation de l'importance de la pêche aux dauphins d'Anakao, région sud – ouest de Madagascar. Mémoire de DEA, Institut Halieutique et des Sciences Marines, Université de Toliara.
- Ballance, L.T. & Pitman, R.L. (1998). Cetaceans of the western tropical Indian Ocean: distribution, relative abundance and comparison with cetacean communities of two other tropical ecosystems. *Mar. Mammal Sci.*, **14**: 429-459.
- Berggren, P., Amir, O. A., Stensland, E., Jiddawi, N. S. (2001). Marine Mammals in Zanzibar: A Resource in Need of Conservation and Management. Paper Presented at the Wiomsa Second Scientific Symposium, 22nd – 25th October 2001, Karimjee Hall, Dar es Salaam, Tanzania.
- Bourjea, J. & Evano, H. (2008). Current status of French longline fishery in the Indian Ocean: focus on billfish data. IOTC Billfish Working Group, Seychelles 7 - 10 juillet 2008.
- Cerchio S., Pomilla, C. Ersts, P., Razafindrakoto, Y., Leslie, M., Andrianarivelo, N., Collins, T., Dushane, J. Murray, A., Weber, D. & Rosenbaum, H. (2006). Estimation of abundance of breeding stock C3 of humpback whales assessed through photographic and genotypic mark-recapture data from Antongil Bay, Madagascar. Report SC/A06/HW9 submitted to the Scientific Committee of the International Whaling Commission. 12p.
- Chande, A.I., Mtoka, G.F. & Mhitu, H.A. (1994). Marine mammals and fisheries interactions in Tanzania. Tanzanian Fisheries Research Institute. Unpublished report to UNEP. 39p.
- CMS (Convention on the Conservation of Migratory Species of Wild Animals) (2007). 14th Meeting of the CMS Scientific Council. Bonn, Germany, 14-17 March 2007. CMS/ScC14/Doc.19. 5p.
- Cockcroft, V.G. & Krohn, R. (1994). Passive gear fisheries of the south-western Indian and southeastern Atlantic oceans: an assessment of their possible impact on cetaceans. *Rep. Int. Whal. Comm.*, **15** (Special Issue): 317-328.
- Cockcroft, V.G. & Young, D.D. (1998). An investigation of the status of coastal marine resources along the west coast of Madagascar. Report mission, Center for Dolphin Studies, Port Elisabeth, South Africa. 58 pp.
- Corbett, H.D. (1994). The occurrence of cetaceans of Mauritius and adjacent waters. *Rep. Int. Whal. Comm.*, **44**: 393-97.
- Davis, P.Z.R. & Poonian, C.N.S. (2007). Incidental capture of the dugong, *Dugong dugon*, in gillnets, Mohéli, Union of the Comoros. In: J. Kiszka & C. Muir (Eds.). Incidental catch on non-targeted marine species in the western Indian Ocean problems and mitigation measures. Workshop proceeding. 13-15th November 2006, Mayotte, France. Pp. 58-61.
- DeMaster, D.J., Fowler, C.W., Perry, S.L. & Richlen, M.E. (2001). Predation and competition: the impact of fisheries on marine mammal populations over the next one hundred years. *J. Mammal.*, **82**: 641-651.
- Dulau, V., Boucaud, V. & Rota, B. (2007). Cetacean diversity off La Réunion Island and interactions with human activities. In J. Kiszka & C. Muir (Eds.). Incidental catches of non-targeted marine species in the western Indian Ocean: problems and mitigation measures. Workshop proceeding. 13-15th November 2006, Mayotte, France. Pp. 100-103.
- Dulau-Drouot, V., Boucaud, V. & Rota, B. (2008). Cetacean diversity off La Réunion Island. *Journal of the Marine Biological Association, UK.*, **88**: 1263-1272.
- Findlay, K.P., Best, P.B., Peddemors, V.M. & Gove, D. (1994). The distribution and abundance of humpback whales on their southern and central

- Mozambique winter grounds. *Rep. Int. Whal. Comm.*, **44**: 311-20.
- Gabrie, C. (2003). Programme d'aménagement du Parc Marin de Mohéli. Projet Conservation de la Biodiversité et développement durable aux Comores. PNUD/GEF COI/97/G32/A1/1G/99. 80 pp.
- Garrigue, C. & Ross, G. (1996). A record of the subantarctic fur seal, *Arctocephalus tropicalis*, from Madagascar, Indian Ocean. *Mar. Mammal Sci.*, **12**: 624-627.
- Guissamulo, A. & Cockcroft, V.G. (1997). Dolphin and dugong occurrence and distribution and fisheries interactions in Maputo and Bazaruto bays, Mozambique. Paper SC/49/SM24 presented to the Scientific Committee of the International Whaling Commission.
- Guissamulo & Cockcroft, V.G. (2004). Ecology and population estimates of Indo-Pacific humpback dolphins (*Sousa chinensis*) in Maputo bay, Mozambique. *Aquat. Mamm.*, **30**: 94-102.
- Haskins, G. & Davis, P. (2008). Has the dugong gone the way of the dodo? *Sirennews*, 49: 16-17.
- Hauzer, M., Poonian, C., Moussa Ibouira, C. (2008). Mohéli Marine Park, Comoros – Successes and Challenges of the co-management approach. In: Obura, D.O., Tamelander, j, & Linden, O. (Eds.) Ten years after bleaching facing the consequences of climate change in the Indian Ocean. CORDIO Status Report 2008. Coastal Oceans Research and Development in the Indian Ocean/Sida-SAREC. Mombasa. <http://www.cordioea.org>.
- IDPPE (2004). *Censo Nacional da Pesca Artesanal Águas Marítimas* (2002), IDPPE. Maputo. 76 pp.
- IOTC (2007). Report of the Third Session of IOTC. Working party on Ecosystems and Bycatch. Seychelles, 11-13 July 2007. Indian Ocean Tuna Commission. 39 pp.
- Kiszka, J. & Muir, C. (2007). Incidental catches of non-targeted marine species in the Western Indian Ocean: problems and mitigation measures. Workshop proceeding. 13-15th November 2006, Mayotte, France. Western Indian Ocean Marine Science Association (WIOMSA). 111 pp.
- Kiszka, J., Breysse, O., Boinali, K. & Vely, M. (2006a). Marine mammals around the Union of the Comoros (Mozambique Channel): recent records and review of available information. Report SC/58/O6 submitted to the Scientific Committee of the International Whaling Commission. 5 pp.
- Kiszka, J., Ersts, P.J. & Ridoux, V. (2007b). Cetacean diversity around the Mozambique Channel island of Mayotte (Comoros archipelago). *J. Cet. Res. Manage.*, **9**(2): 105-109.
- Kiszka, J., Muir, C. & Jamon, A. (2007a). Status of a marginal dugong (*Dugong dugon*) population in the lagoon of Mayotte (Mozambique Channel), in the western Indian Ocean. *Western Indian Ocean J. Mar. Sci.*, **6**: 111-116.
- Kiszka, J., Pelourdeau, D. & Ridoux, V. (2008). Dorsal fin scars as an indicator of interactions between small cetaceans and fisheries around the Mozambique Channel island of Mayotte. *Western Indian Ocean J. Mar. Sci.*, **7**(2): 185-193.
- Leatherwood, S., Peter, R., Satterre, R., Satterre, H., Clark, J.C. (1984). Observations of cetaceans in the northern Indian Ocean Sanctuary, November 1980 – May 1983. *Rep. Int. Whal. Comm.*, **34**: 509-520.
- Lewison, R.L., Crowder, L.B., Read, A.J. & Freeman, S.A. (2004). Understanding impacts of fisheries bycatch on marine megafauna. *Trends in Ecology and Evolution*, **11**: 598-604.
- Linden, O. & Lundin, C.G. (1995). Proceedings of the national workshop on integrated coastal zone management in Tanzania. World Bank and Sida, Stockholm.
- Michel, C. & van Bree, P.J.H. (1976). On two strandings of the beaked whale *Mesoplodon densirostris* on Mauritius. *Z. Säugetierkunde*, **41**: 194-96.
- Ministère de l'Agriculture et de la Pêche (1995). Etude socio-économique sur la pêche artisanale aux Comores. Rapport Final. Ecole Nationale Supérieure Agronomique de Rennes, DEERN, Unit Halieutique, Centre d'Etudes de Projets, Université de Montpellier 1, Association Thonier, Commission de l'Océan Indien Projet 6. ACP. RPR.458 – Projet Thonier Régional II – Marche ENSAR/CEP/ORSTOM/ATCOI/COM – Octobre 1995.
- Ministry of Livestock & Fisheries Development (Mainland) and Ministry of Agriculture, Livestock & Environment (Zanzibar) (2008). Marine Fisheries Frame Survey Results for 2007.
- Ortland, N. (1997). Species composition, behaviour and movement patterns of dolphins in Nungwi, Zanzibar. SIT, Mar. Res. Rep. Institute of Marine Sciences, Zanzibar, University of Dar es Salaam. (unpublished report available from Institute of Marine Sciences, Zanzibar).
- Poonian, C.N.S., Hauzer, M.D., Ben Allaoui, A., Cox, T.M., Moore, J.E., Read, A.J., Lewison, R.L. & Crowder, L.B. (2009). Rapid assessment of sea turtle and marine mammal bycatch in the Union of the Comoros. *Western Indian Ocean J. Mar. Sci.*, **7**(2): 207-216.
- Pusineri, C. & Quillard, M. (2009). Bycatch and direct captures of protected megafauna by the artisanal

- coastal fishery of Mayotte. *Western Indian Ocean J. Mar. Sci.*, **7**(2): 195-206.
- Razafindrakoto, Y., Andrianarivelo, N. & Rosenbaum, H.C. (2004). Sightings, catches and other records of Indo-Pacific humpback dolphins in the coastal waters of Madagascar. *Aquat. Mamm.*, **130**: 103-110.
- Razafindrakoto, Y., Andrianarivelo, N., Cerchio, S., Rosenbaum, H.C. & Rasoamananto, I. (2007). Assessing the extent of cetacean bycatch in the artisanal gillnet fisheries and direct captures in the south-western region of Madagascar. *In*: J. Kiszka & C. Muir (Eds.). Incidental catch of non-targeted marine species in the western Indian Ocean : problems and mitigation measures. Workshop proceeding. 13-15th November 2006, Mayotte, France. Pp. 45-52.
- Razafindrakoto, Y., Andrianarivelo, N., Cerchio, C. Rasoamananto, I. & Rosenbaum, H. (2009). Preliminary assessment of cetacean incidental mortality in artisanal fisheries in Anakao, southwestern region of Madagascar. *Western Indian Ocean J. Mar. Sci.* **7**(2): 175-184.
- Read, A.J., Drinker, P. & Northridge, S. (2006). Bycatch of marine mammals in U.S. and global fisheries. *Cons. Bio.*, **20**: 163-169.
- Robineau, D. (1991). Balaenopterid sightings in the western tropical Indian Ocean (Seychelles area), 1982-1986. *In*: S. Leatherwood & G.P. Donovan (eds.). Cetaceans and cetacean research in the Indian Ocean Sanctuary. Marine Mammal Technical Report N°3. UNEP, Nairobi, Kenya. Pp. 171-179.
- Romanov, E.V. (2001). Bycatch in the tuna purse-seine fishery in the western Indian Ocean. *Fish. Bull.*, **100**: 90-105.
- Rosenbaum, H.C. (2003). Marine mammals of Madagascar. Pp. 213-216. *In*: S. Goodman & J. Bengston (Eds.). *The Natural History of Madagascar*. University of Chicago Press, Chicago, Illinois.
- Rosenbaum, H.C., Walsh, P.D., Razafindrakoto, Y., Vely, M. & DeSalle, R. (1997). First description of a humpback whale breeding ground in Baie d'Antongil, Madagascar. *Cons. Biol.*, **11**: 312-14.
- Stensland, E., Berggren, P., Johnstone, R. & Jiddawi, N. (1998). Marine mammals in Tanzanian waters: urgent need for status assessment. *Ambio*, **27**: 771-774.
- Stensland, E., Carlén, I., Särnblad, A., Bignert, A. & Berggren, P. (2006). Population size, distribution, and behaviour of Indo-Pacific bottlenose (*Tursiops aduncus*) and humpback (*Sousa chinensis*) dolphins off the south coast of Zanzibar. *Mar. Mamm. Sci.*, **22**: 667-682.
- UNEP (2002). L'Afrique orientale: atlas des ressources côtières. United Nations Environment Programme, Nairobi. 154pp.
- Union des Comores (2005). Document de stratégie de croissance et de réduction de la pauvreté. Document Intérimaire Actualisé. 138pp.
- United Nations (1983). The Law of the Sea. Official text of the United Nation Convention on the Law of the Sea with annexes and index/final act of the third United Nations conference on the Law of the Sea/introductory material on the conservation and the conference. United Nations, New York, NY. 224pp.
- Wamukoya, G.M., Mirangi, J.M. & Ottichillo, W.K. (1996). Report on the marine aerial survey of the marine mammals, turtles, sharks and rays. *Kenya Wildlife Service Technical Report Series N°1*. 22pp.
- Wray, P. & Martin, K.R. (1983). Historical whaling records from the western Indian Ocean. *Rep. int. Whal. Comm.*, **5** (Special issue): 218-242.
- WWF Eastern African Marine Ecoregion (EAME) (2004). Towards a Western Indian Ocean Dugong Conservation Strategy: The Status of Dugongs in the Western Indian Ocean Region and Priority Conservation Actions. Dar es Salam, Tanzania. 68pp.

