

# The endangered status of dugongs *Dugong dugon* around Mayotte (East Africa, Mozambique Channel) assessed through interview surveys

C Pusineri<sup>1\*</sup>, J Kiszka<sup>2</sup>, M Quillard<sup>3</sup> and S Caceres<sup>1</sup>

<sup>1</sup> Office National de la Chasse et de la Faune Sauvage, 12 allée de la Forêt/Parc de la Providence - 97400 Saint-Denis, France

<sup>2</sup> Université de La Rochelle, Littoral, Environnement et Sociétés, UMR 6250, CNRS-Université de La Rochelle, Institut du Littoral et de l'Environnement, 2 rue Olympe de Gouge, 17000, La Rochelle, France; current address: Marine Sciences Program, Department of Biological Sciences, Florida International University, 3000 NE 151 Street, North Miami, FL-33181, USA

<sup>3</sup> Direction de l'Environnement et du Développement Durable, Conseil Général de Mayotte, 97600, Mamoudzou, Mayotte, France

\* Corresponding author, e-mail: [claire.pusineri@gmail.com](mailto:claire.pusineri@gmail.com)

The status of dugongs *Dugong dugon* around Mayotte in the Mozambique Channel was assessed from interviews with artisanal fishers conducted in 2007, along with the collation of opportunistic sighting information from tour operators between 2002 and 2011. In all, 106 of the 406 fishers interviewed (26%) had observed a live dugong at least once during their lifetime, and among these sightings 18 were made in 2007. Nine fishers stated that they observed on one occasion people selling dugong meat on the beach of their village, six fishers admitted that they caught a dugong themselves and three had caught more than one dugong during their lifetime. Tour operators reported 78 dugong sightings between 2002 and 2011, and among these 15 were cow-calf pairs. Since the late 1990s, no deliberate hunting was reported but four bycatch deaths due to entanglement in artisanal fishing nets were reported. We concluded that the current dugong population size is likely to be small but reproduction still occurs and that entanglement in artisanal fishing nets remains the major threat to the species in Mayotte.

**Keywords:** bycatch, conservation, sirenians, South-West Indian Ocean

## Introduction

Over the past 10 years, interview surveys have allowed important questions to be answered regarding the status of endangered and elusive marine species, including the whale shark *Rhincodon typus* (Rowat 2007), a number of marine mammal species (Dolar et al. 1997), as well as the dugong *Dugong dugon* (e.g. Hines et al. 2005, 2008, WWF EAME 2004). Whereas aerial surveys are usually recommended for formal population estimates, they can be prohibitively expensive, ineffective or dangerous in some conditions (Reynolds et al. 2012). In such cases, interview surveys have been recognised as an important alternative source of information, especially in developing countries where funding opportunities are often lacking. Moore et al. (2010) showed that interview surveys could provide semi-quantitative information on the extent of anthropogenic impacts on endangered long-lived species, such as marine mammal and sea turtle bycatch in coastal artisanal fisheries. Also, interview surveys provide information to set up efficient and integrated conservation plans, such as the social and cultural role of a species as well as the perception people have of its status (Ortega-Argueta et al. 2012).

Dugongs occur in tropical and subtropical Indo-Pacific waters from the East African coast to Vanuatu, between the 26° north and south parallels (Marsh et al. 2002). The species reaches sexual maturity between 6 and 17 years of age and the mean inter-birth interval ranges from 3 to 7 years (Marsh 1995, Kwan 2002). Due to this slow reproductive cycle, a

dugong population is unlikely to increase by more than 5% per year, even in optimal conditions (low natural or anthropogenic mortalities; Marsh 1995, Boyd et al. 1999). Dugongs feed primarily on seagrass but may also consume seaweeds (Spain and Heinsohn 1973, Marsh et al. 1982, Whiting 2002). The species is generally resident; however, daily, seasonal and random movements of individuals have been observed, ranging from a few kilometres to several hundred kilometres, in coastal and oceanic habitats (Anderson 1982, Marsh et al. 1994, 2002, Sheppard et al. 2006, Hobbs et al. 2007).

Dugongs are particularly vulnerable to anthropogenic impacts because of their dependence on coastal habitats, as well their low population growth rate. The species is classified as Vulnerable by the IUCN (IUCN 2012) and is found in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Historical data indicate that the species has declined in most of the south-western Indian Ocean (SWIO) countries since the 1960s, on account of overexploitation and bycatch in gillnets (WWF EAME 2004, Muir and Kiszka 2012). Currently, dugong sightings are anecdotal in most SWIO countries (WWF EAME 2004). The largest known population is found in the Bazaruto archipelago, Mozambique, at around 250 individuals (Findlay et al. 2011). The main current threat to dugongs is entanglement in inshore artisanal gillnets (especially bottom-set gillnets), whereas deliberate capture rates have declined (WWF EAME 2004).

The Comoros archipelago is situated in the northern Mozambique Channel, between Madagascar and the east coast of Africa. Mayotte (12°50' S, 45°10' E, Figure 1), the easternmost and oldest island of the archipelago, is surrounded by one of the largest inner lagoons in the Indian Ocean (1 500 km<sup>2</sup>). The island is under French administration and has undergone a rapid economic development over the past few decades. The combination of economic development and the associated high population density (more than 500 inhabitants km<sup>-2</sup>) has resulted in compounded anthropogenic threats to the marine environment, such as water pollution, habitat degradation, overfishing, poaching and bycatch (Loricourt 2005, Herfaut 2006, Pusineri and Quillard 2008, Turquet et al. 2010).

Kiszka et al. (2007) conducted a preliminary dugong status assessment in Mayotte from 2002 to 2005, using a combination of a limited interview survey of 35 fishers, a collection of opportunistic dugong sighting information from tour operators and an exploratory aerial survey (21 h at an altitude of 350 m). The main conclusions of this study were

that dugongs inhabit the Mayotte Lagoon where calving still occurs, and that current threats are incidental catches in coastal fishing gillnets, habitat destruction, pollution, disturbance and boat strikes. The aim of the present study was to assess and build upon the results of this preliminary work by Kiszka et al. (2007).

## Materials and methods

### Study area

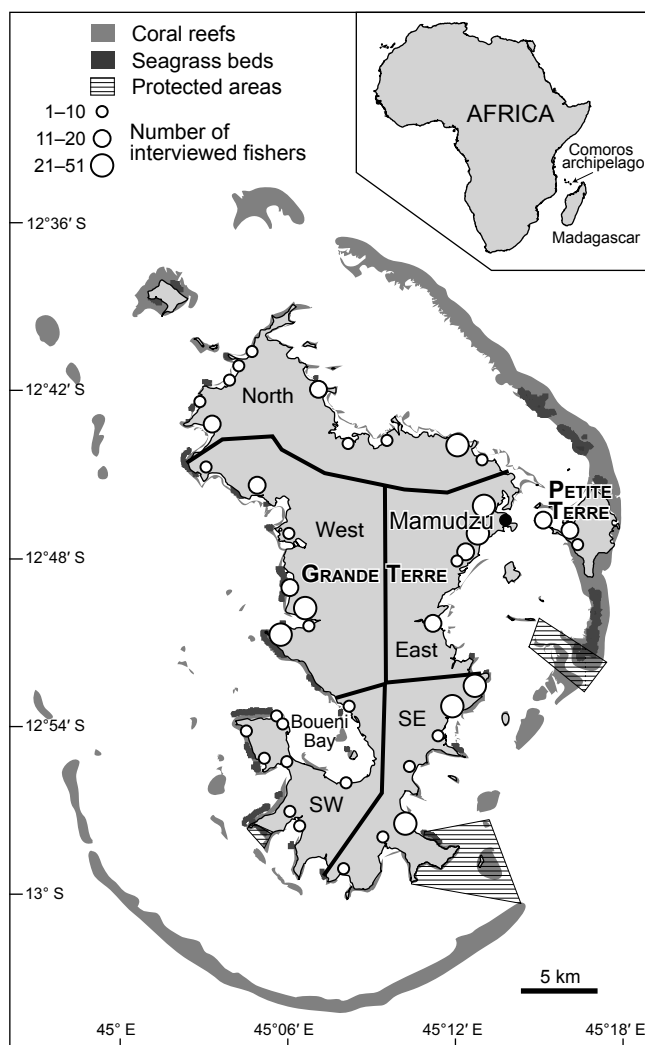
Mayotte Island (consisting of one main island and a smaller island) is almost entirely surrounded by a 197 km barrier reef, with deep passes through the reefs (Quod et al. 2000, Figure 1). The average depth of the lagoon is 20 m, being deepest (80 m) in the older, western region. There are some 20 small islets surrounded by fringing reefs. Using satellite imagery and aerial photographs, Loricourt (2005) estimated that seagrass beds covered 7.6 km<sup>2</sup>, which were mostly situated on the eastern barrier reef and along the western shore of the larger Grande Terre Island.

### Fisheries characteristics

There are about 2 000 fishers in Mayotte, including both professional and subsistence fishers (Busson 2011). Fishing is mainly coastal and artisanal and the largest proportion of fishing vessels (73%) are non-motorised outrigger canoes made from a single log (Herfaut 2006), which are mainly used for subsistence fishing. The other fishing vessels are small motorised boats that enable fishing in the oceanic waters adjacent to the lagoon. The most common traditional fishing gear are handlines, which are used in 71% of fishing trips (Herfaut 2006). These and small set-nets are used to target small coral reef fish. Larger pelagic fish species are targeted by seine-nets or longlines (Fouquet 2001). Local regulation prohibits the use of nets on coral reefs, seagrass beds and in mangrove areas. Mesh size larger than 6 cm is forbidden and nets must not be longer than 300 m. The use of dynamite and spearguns inside the lagoon is prohibited. Three small protected areas have been established where fishing activity is even more restricted (e.g. nets forbidden, Figure 1). However, legislation is currently poorly adhered to. The dugong has been protected in Mayotte since 1995, and in 2007 France signed a Memorandum of Understanding on the Conservation and Management of Dugongs and their Habitats throughout their Range (<http://www.cms.int/species/dugong/index.htm>).

### Data collection

Interviews with fishers were conducted in July 2007. Assessing the conservation status of dugongs around Mayotte was included in the objectives of the survey; other objectives were to assess the extent of marine mammal and marine turtle bycatch around Mayotte (Pusineri and Quillard 2008). The interviewers consisted of four young (18–20 years old) biology students who were fluent in the local languages (Maore, Malagasy and French). The questionnaire was translated accordingly. The interviews were conducted in all the fishing villages of the island, except for the smallest villages (where the number of fishing vessels was less than 10). In total, 41 villages of the 57 inventoried by the Fisheries Service were selected: 10 were situated in



**Figure 1:** Mayotte Island, of the Comoros archipelago, showing the two main islands, Grande Terre and Petite Terre, and islets

the north of Grande Terre (the main island), five in the east, seven in the south-east, nine in the south-west, seven in the west and three were located in Petite Terre (Figure 1). We conducted structured interviews at the fishing landing sites, in the early mornings when the fishers returned from night trips, and also in the afternoons when fishers returned from day trips. First, the group of interviewers would explain the project to all the fishers present at the landing site. Then they showed a picture of the species to all the willing fishers and interviewed them on a one-to-one basis. The questionnaire was mainly based on closed-ended questions (available as online supplementary material at <http://dx.doi.org/10.2989/1814232X.2013.783234>). We first focused on general information about the fisher: age, fishing effort, preferred fishing gear and preferred fishing environment. We then asked fishers to date their latest dugong observation and locate it on a map. A third set of questions focused on dugong catches, inquiring whether the fisher had caught dugongs or had observed captured dugongs during his/her lifetime. If they answered positively, details of the most recent capture were requested: the approximate date, whether capture was deliberate or accidental, the type of fishing gear used, the catch location and the subsequent use of the animal (for example: was the animal killed or released if found alive, and if the meat was sold?). Finally, open-ended questions focused on the species' conservation status, in order to determine whether the fishers were aware of the legal status of the species, and how they perceived it.

A network of opportunistic observers has been implemented since 2002, when dugongs were first studied in Mayotte (Kiszka et al. 2007). This network consists of eight tour operators: one aircraft operator from Petite Terre and one from the south of Grande Terre, as well as two whale/dolphin watching operators and three recreational diving operators from Mamudzu, the main marina of Mayotte (Figure 1). These operators work every day and all-year-round; they frequently navigate in the north, east and south regions of the lagoon but less frequently in the west. The observers generally provide the location of the sighting and the number of individuals, and specify whether a calf was seen. These data are gathered into a database by the local wildlife agency and were analysed in the present study.

**Results**

**General**

In all, 406 fishers from the 41 selected fishing villages were interviewed. One-quarter of the interviews was conducted in villages located in the east of Grande Terre Island, 19% in the north, 19% in the west, 19% in the south-east, 12% in the south-west and 6% in Petite Terre Island (Figure 1). The fishers interviewed were all males, mainly from 18 to 55 years old (81%; Table 1). Most of them (66%), fished several times per week and inside the lagoon (46%); 33% fished mostly outside the lagoon and 20% fished mainly on the barrier reef. The preferred fishing gear were handlines (91%). Other gear used included nets, longlines and spearguns.

**Live sightings collected from the interview survey**

Of the 406 fishers interviewed, 106 (26%) had observed a live dugong at least once during their lifetime. Among

these, 54 (51%) reported that their last dugong observation was prior to 1997; 34 (32%) saw a dugong for the last time between 1997 and 2007, and 18 (17%) saw a dugong in 2007. In all, 93 fishers were able to locate their observations on the map provided; 46 came from the pre-1997 sightings (Table 2) and 47 were made between 1997 and 2007. For both periods, dugongs were observed all around the lagoon. However, before 1997, the two areas of highest densities were the south-west ( $n = 13$ ) and the north ( $n = 16$ ), whereas from 1997 to 2007, most of the sightings were located in the east ( $n = 16$ , Petite Terre included) and in the south-east ( $n = 17$ , Table 2).

**Live sightings collected from the network of opportunistic observers**

From 2002 to 2011, 78 dugong sightings records were taken from the network (1.1 sightings  $y^{-1}$  observer $^{-1}$ ). Most of these sightings were from the east ( $n = 45$ , Petite Terre included), south-east ( $n = 20$ ) and south-west ( $n = 8$ ) of

**Table 1:** Summary of the profile and fishing activities of fishers that were interviewed for this study. For preferred fishing gear, fishers could give several answers

Parameter	Number of individuals	
	<i>n</i>	%
<i>Age (y)</i>		
<18	2	1
18–35	139	34
35–55	190	47
>55	73	18
No answer	2	1
<i>Fishing effort</i>		
Every day	58	14
Several times per week	269	66
Once per week	77	19
No answer	2	1
<i>Preferred environment</i>		
Inside lagoon	188	46
Outside lagoon	134	33
On barrier reef	79	20
Other	5	1
<i>Preferred fishing gear</i>		
Handline	369	91
Net	29	7
Longline	21	5
Speargun	5	1
Other	3	1

**Table 2:** Locations of the last dugong sighting during the periods 1997–2007 and before 1997, by individual fishers interviewed

Location	Sightings made before 1997		Sightings made from 1997 to 2007	
	<i>n</i>	%	<i>n</i>	%
North	16	35	5	11
East	7	15	16	34
South-east	5	11	17	6
South-west	13	28	2	4
West	5	11	7	15
Total number	46		47	

the lagoon (Figure 2). The majority of sightings ( $n = 57$ ) consisted of a solitary individual; 14 observations were of paired animals and seven observations consisted of a group of three animals. Between one and two sightings of a cow–calf pair were reported each year from 2002 to 2011, which represents, in total, 15 sightings of cow–calf pairs. These cow–calf pairs were mainly observed over the east and south-east barrier reef, as well as along the south coast of Grande Terre Island (Figure 2).

#### **Dugong catches reported by fishers**

In all, 18 of the 406 fishers interviewed reported dugong captures, of which nine did not catch a dugong themselves but had observed on one occasion people selling dugong meat on the beach of their village. Six fishers stated that they caught one dugong in their lifetime and three fishers said that they caught more than one dugong in their lifetime (in this case, they were asked to give information on their last catch only). Thirteen dugong captures occurred before 1997, four occurred from 1997 to 2007, and one fisher could not provide an approximate date. Five catches occurred in the north of Grande Terre Island, five in Boueni Bay (south-west), two in the south-east, three in Petite Terre Island and three catches could not be located. Of the nine fishers who caught a dugong, the animal was captured with a net; seven

fishers stated that the capture was accidental, one admitted it was deliberate (about 10 years previously) and one did not answer this question. Five dugongs were found dead by the fishers and four were found alive, but all were retained for meat consumption or sale. Of these nine fishers, six were older than 55 and three were between 35 and 55 years old.

#### **Conservation status of the dugong**

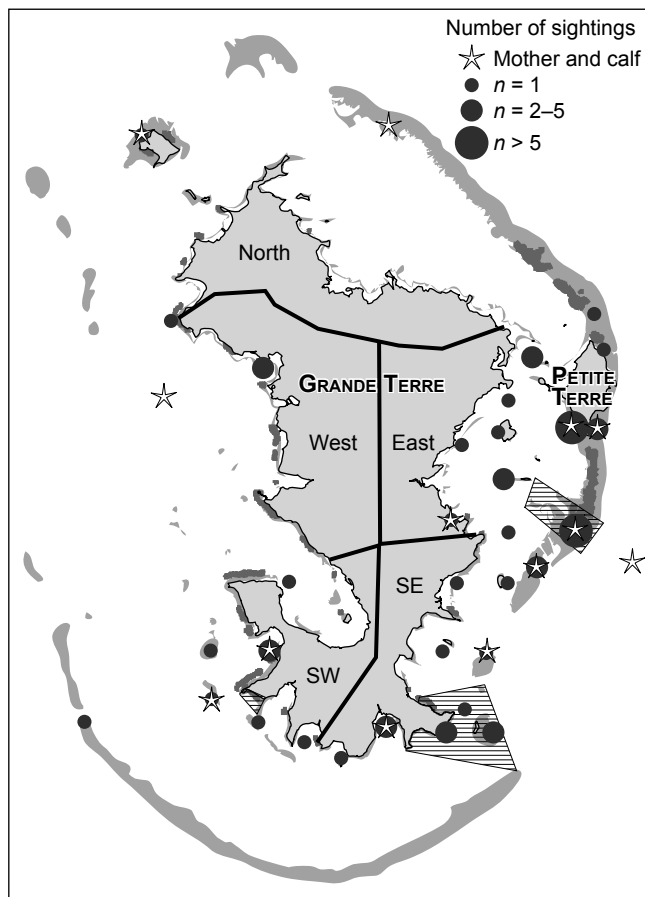
The majority of the fishers (71%) knew that dugongs are threatened with extinction; 25% did not know and 4% did not answer the relevant question. Most fishers (85%) knew dugongs are protected by law, 14% did not know and 1% did not answer the question. Most fishers (92%) declared their interest in protecting the dugong. The answers to the open questions regarding dugong status were grouped into common themes, namely: to protect the environment/biodiversity (32%); because it is a rare animal (14%); important for future generations (13%); it is not edible (8%); for tourism (8%); it is human-like (4%); it is protected by law (2%).

#### **Discussion**

##### **The use of interview surveys**

A major drawback of interview surveys is the problem of judging the reliability of responses (Broadfoot 2000). Ortega-Argueta et al. (2012) stated that biases from responses to questionnaires are usually on account of three main reasons: (1) the respondents' behaviour: the respondents may deliberately try to please the interviewer, or prevent him or her from learning some undesirable, controversial or possibly illegal information; (2) the questionnaire administration: misunderstandings due to the wording sequence or mistranslations; (3) the interviewer, whose possible lack of knowledge of local culture or questioning techniques, can impede communication. We took several precautionary measures to minimise these biases while compiling the interview protocol. As for the biases due to respondents' behaviour, we anticipated that most of the fishers would fear repression. Indeed, dugongs are protected in Mayotte and use of nets is restricted. Furthermore, in 2003, local authorities confiscated the fishing boat and the net of a fisher who was caught selling dugong meat. As a consequence, we endeavoured to secure a safe and confidential interview environment: the interviews took place in an informal setting (at the landing sites), we chose as interviewers four young (18–20 years old) local biology students instead of scientists or agents from the local wildlife agency, and the interviews were conducted in the local languages. In order to minimise bias due to mistranslations or misinterpretations, we chose a structured approach with closed-ended questions, the questionnaire was translated in the three local languages and questions were made as simple and clear as possible. Also, we minimised the cultural differences between interviewer and respondent by choosing people from local communities to carry out the interviews.

Sampling protocol such as sampling sites, interviewee selection or sampling size can be another source of errors. Regarding sampling site selection, the interviews were conducted in all the fishing villages of the island, except for the smallest villages. These villages selected represented 72% (41 of 57) of the fishing sites inventoried



**Figure 2:** Distribution and numbers of sightings provided by tour operators in Mayotte Island from 2002 to 2011

by the Fisheries Service and they were distributed around the island. Regarding interviewee selection, willing fishers may have been particularly involved/sensitive to the lagoon conservation. Thus, there may be some biases in our results, such as an underestimation of the number of intentional catches and an overestimation of the fishers' legislation knowledge. Concerning sampling size, our survey covered 40% of the fishers' population.

Finally, our main findings were supported by related studies or observations, including the aerial surveys conducted in 2005 by Kiszka et al. (2007), opportunistic observations and the past research conducted in the SWIO region (WWF EAME 2004).

### **Current status of the dugong around Mayotte**

There were three important findings from our study. First, the population size in the lagoon is small, considering that only 4% of the fishers interviewed observed a dugong in 2007 and the mean annual number of sightings reported by tour operators over the period 2002–2011 was only 1.1 per observer. This concurs with the low number of dugongs previously observed by Kiszka et al. (2007) during their aerial survey around Mayotte in 2005 (i.e. four sightings — three single animals and a cow–calf pair) over 21 flight hours. Second, reproduction of the species still occurs in Mayotte, because mother and calf pairs have been regularly sighted from 2002 to 2011. Unfortunately, it is not possible to assess reproductive rates as multiple sightings may include common mother–calf pairs. Third, the locations of sightings made by the fishers since 1997 and the tour operators since 2002 indicate that the dugong is now mainly distributed in the east and south of the lagoon, where the protected areas are found. However, this theory should be viewed with caution since these areas also support the main marinas of the lagoon and the higher number of sightings in these locations may therefore be linked to the high human presence there.

### **Current threats**

Dugongs have not been hunted since the late 1990s. Most of the fishers interviewed were younger than 55 (81%) but two-thirds of the fishers that had caught a dugong were older than 55. This suggests that dugong fishing is no more a cultural habit of the new generation of fishers. The majority of the fishers were aware that the dugong is threatened with extinction and protected by law, with most of the fishers declaring their interest in protecting the species. The end of dugong hunting is certainly partly due to the current rarity of the species. However, as most of the fishers interviewed were aware of the legal protection of the species (since 1995) and seemed to support this legislation, we believe the end of dugong hunting is a result of the success of the various education campaigns.

Bycatch in fishing nets remains a major threat for the dugong in Mayotte. Indeed, four such captures from different areas were reported from 1997 to 2007 during our interview survey: two fishers accidentally captured a dugong and two observed on one occasion dugong meat being sold on the beach of their village, which likely was an animal that was part of a bycatch. Dugongs are large animals and the price of their meat is similar to the most

expensive fish caught locally (US\$8–12 kg<sup>-1</sup>, equivalent to ZAR70–100 kg<sup>-1</sup>; Wildlife Agency pers. comm.).

In other regions of the Indo-Pacific Ocean, other anthropogenic threats have increased, such as acoustic pollution (Hodgson and Marsh 2007), boat strikes (Chilvers et al. 2005) and the degradation of seagrass beds (Lanyon 2003, Hines et al. 2008). Loricourt (2005) showed deterioration of seagrass beds in the north-eastern Mayotte Lagoon area as a result of urban development. So far, no impact of acoustic pollution and boat strike on dugongs have been reported for Mayotte but the increase in motorised boats (up to 2 000 in 2007) has been considerable and these threats should be closely monitored.

### **Conservation**

Our study supports the main conclusions of Kiszka et al. (2007) and provided us with further details on dugongs' status in Mayotte: (1) the current population size can be assumed to be small but reproduction still occurs; (2) entanglement in artisanal fishing nets constitutes the main current direct threat to Mayotte dugongs.

In an effort to protect the reduced Mayotte dugong population, a dugong action plan was written in 2011 by the French Wildlife Agency (Pusineri and Caceres 2012). This plan is currently being implemented. The objectives are to (1) reduce bycatch mortality to zero, and review net fishing legislation in close collaboration with fishers; (2) set up a dugong monitoring programme through regular interview surveys and the establishment of a stranding network; (3) improve seagrass mapping and protection; and (4) develop collaborative efforts with nearest islands where dugongs are still observed, e.g. Moheli, Union of the Comoros, and Madagascar (Beudard and Ciccone 2008, C3 Madagascar and Indian Ocean Islands Programme 2010, Davis and Poonian 2007).

*Acknowledgements* — We thank the Conseil Général de Mayotte, the Office National de la Chasse et de la Faune Sauvage and the Direction de l'Environnement, de l'Aménagement et du Logement for funding this study. We are grateful to all the tour operators who reported dugong observations and the fishers who were willing to be interviewed. We also thank the students (Omar Hamada, Soulaïmana Nawalidine, Daniel Oiziri and Stephanie Randrianatoanina) who carried out the interviews and the technicians of the Marine Turtle Observatory (Soula Assani and Samion Soumaïla) and the Brigade Nature de Mayotte for their involvement and support. Particular thanks are due to Ellen Hines, Jennifer McGowan and Caroline Vignard for their valuable comments on earlier versions of this manuscript.

### **References**

- Anderson PK. 1982. Studies of dugongs at Shark Bay, Western Australia I. Analysis of population size, composition, dispersion and habitat use on the basis of aerial survey. *Australian Wildlife Research* 9: 69–84.
- Beudard F, Ciccone S. 2008. Survival of dugongs around Moheli Island. *Sirenews* 49: 13–16.
- Boyd I, Lokyer C, Marsh H. 1999. Reproduction in marine mammals. In: Reynolds JE, Rommel SA (eds), *Biology of marine mammals*. Washington, DC: Smithsonian Institution Press. pp 218–286.
- Broadfoot P. 2000. Interviewing in a cross-cultural context: Some issues for comparative research. In: Pole CJ, Burgess RG (eds), *Cross-cultural case study*. New York: Elsevier Science. pp 53–66.
- Busson O. 2011. *La pêche à Mayotte Entre archaïsme et post-modernité*. Mayenne, France: l'Harmandin.

- C3 Madagascar and Indian Ocean Islands Programme. 2010. *Rapid assessment of dugongs and their seagrass habitat in northern Madagascar. A report submitted to the Convention on Migratory Species of Wild Animals (CMS) secretariat, Abu Dhabi*. C3 Technical Report Series No. 6. London: Community Centred Conservation (C3).
- Chilvers BL, Lawler IR, Macknight F, Marsh H, Noad M, Paterson R. 2005. Moreton Bay, Queensland, Australia: an example of the co-existence of significant marine mammal populations and large-scale coastal development. *Biological Conservation* 122: 559–571.
- Davis PZR, Poonian CNS. 2007. Incidental capture of the dugong (*Dugong dugon*) in gillnets, Mohéli, Union of the Comoros. In: Kiska J, Muir C (eds), *Proceedings of the 1st regional workshop on incidental catches of non-targeted marine species in the Western Indian Ocean*, 13–15 November 2006, Mayotte, France. Mayotte: WIOMSA. pp 58–61.
- Dolar MLL, Yaptinchay AA, Jaaman SAB, Santos MD, Muhamad SBS, Perrin WF, Alava MNR. 1997. Preliminary investigation of marine mammal distribution, abundance, and interactions with humans in the southern Sulu Sea. *Asian Marine Biology* 14: 61–81.
- Findlay K, Cockcroft VG, Guissamulo AT. 2011. Dugong abundance and distribution in the Bazaruto Archipelago, Mozambique. *African Journal of Marine Science* 33: 441–452.
- Fouquet P. 2001. Situation de la pêche artisanale à Mayotte en l'an 2000, Analyse statistique du système de suivi de l'activité halieutique (janvier 1997–juin 2000). MSc thesis, University of Caen, France.
- Herfaut J. 2006. Suivi statistique de la pêche artisanale mahoraise: effort de pêche, capture et CPUE en 2005. Mamoudzou, Mayotte: Technical report of Mayotte Direction of Environment.
- Hines E, Adulyanukosol K, Duffus D, Dearden P. 2005. Community perspectives and conservation needs for dugongs (*Dugong dugon*) along the Andaman Coast of Thailand. *Environmental Management* 36: 654–664.
- Hines E, Adulyanukosol K, Somany P, Ath LS, Cox N, Boonyanate P, Hoa NX. 2008. Conservation needs of the dugong *Dugong dugon* in Cambodia and Phu Quoc Island, Vietnam. *Oryx* 42: 113–121.
- Hobbs J-PA, Frisch AJ, Hender J, Gilligan JJ. 2007. Long-distance oceanic movement of a solitary dugong (*Dugong dugon*) to the Cocos (Keeling) Islands. *Aquatic Mammals* 33: 175–178.
- Hodgson AJ, Marsh H. 2007. Response of dugongs to boat traffic: The risk of disturbance and displacement. *Journal of Experimental Marine Biology and Ecology* 340: 50–61.
- IUCN. 2012. *IUCN Red List of Threatened Species*. Version 2012.2. Available at [www.iucnredlist.org](http://www.iucnredlist.org) [accessed 14 February 2013].
- Kiszka J, Muir C, Jamon A. 2007. Status of a marginal dugong (*Dugong dugon*) population in the Lagoon of Mayotte (Mozambique Channel), in the Western Indian Ocean. *Western Indian Ocean Journal of Marine Science* 6: 111–116.
- Kwan D. 2002. Towards a sustainable indigenous fishery for dugongs in Torres Strait: a contribution of empirical data and process. PhD thesis, James Cook University, Townsville, Australia.
- Lanyon JM. 2003. Distribution and abundance of dugongs in Moreton Bay, Queensland, Australia. *Wildlife Research* 30: 397–409.
- Loricourt A. 2005. Etude des herbiers à phanérogames marines à Mayotte. MSc thesis, University of Pau, France.
- Marsh H. 1995. The life history, pattern of breeding, and population dynamics of the dugong. In: O'Shea TJ, Ackerman BB, Percival HF (eds), *Population biology of the Florida manatee*. US National Biological Service, Information & Technology Report 1. Washington, DC: US Department of the Interior. pp 75–83.
- Marsh H, Channells PW, Heinsohn GE, Morissey J. 1982. Analysis of stomach contents of dugongs from Queensland. *Australian Wildlife Research* 9: 55–67.
- Marsh H, Penrose H, Eros C, Hugues J. 2002. Dugong – status report and action plans for countries and territories. UNEP Early Warning Assessment Report Series 1. Townsville, Australia: United Nations Environment Programme.
- Marsh H, Prince RIT, Saalfeld WK, Shepherd R. 1994. The distribution and abundance of dugongs in Shark Bay. *Wildlife Research* 21: 149–161.
- Moore JE, Cox TM, Lewison RL, Read AJ, Bjorkland R, McDonald SL, Crowder LB, Aruna E, Ayissi I, Espeut P, Joynson-Hicks C, Pilcher N, Poonian CNS, Solarin B, Kiszka J. 2010. An interview-based approach to assess marine mammal and sea turtle captures in artisanal fisheries. *Biological Conservation* 143: 795–805.
- Muir CE, Kiszka J. 2012. Eastern African dugongs. In: Hines E, Reynolds JE, Aragones L, Mignucci-Giannoni A, Marmontel M (eds), *Sirenian conservation: issues and strategies in developing countries*. Florida, USA: University Press of Florida. pp 84–90.
- Ortega-Argueta A, Hines E, Calvimontes J. 2012. Using interviews in sirenian research. In Hines E, Reynolds JE, Aragones L, Mignucci-Giannoni A, Marmontel M (eds), *Sirenian conservation: issues and strategies in developing countries*. Florida, USA: University Press of Florida. pp 109–115.
- Pusineri C, Caceres S. 2012. Plan national d'actions en faveur du dugong, *Dugong dugon*, volet Mayotte. Ministère de l'Ecologie, du Développement Durable et de l'Energie, Direction de l'Environnement, de l'Aménagement et du Logement de Mayotte, Office National de la Chasse et de la Faune sauvage. Available at [www.developpement-durable.gouv.fr/-Especes-menacees-les-plans-.html](http://www.developpement-durable.gouv.fr/-Especes-menacees-les-plans-.html) [accessed 14 February 2013].
- Pusineri C, Quillard M. 2008. Bycatch of protected megafauna in the artisanal coastal fishery of Mayotte Island, Mozambique Channel. *Western Indian Ocean Journal of Marine Science* 7: 137–150.
- Quod J-P, Naim O, Abdourazi F. 2000. The Comoros archipelago. In: Sheppard C (ed.), *Seas at the Millennium: an environmental evaluation*. Oxford: Pergamon Press. pp 243–252.
- Reynolds JE, Morales-Vela I, Lawler I, Edwards HH. 2012. Utility and design of aerial surveys for sirenians. In: Hines E, Reynolds JE, Aragones L, Mignucci-Giannoni A, Marmontel M (eds), *Sirenian conservation: issues and strategies in developing countries*. Florida, USA: University Press of Florida. pp 186–195.
- Rowat D. 2007. Occurrence of whale shark (*Rhincodon typus*) in the Indian Ocean: a case for regional conservation. *Fisheries Research* 84: 96–101.
- Sheppard JK, Preen AR, Marsh H, Lawler IR, Whiting SD, Jones RE. 2006. Movement heterogeneity of dugongs, *Dugong dugon* (Müller), over large spatial scales. *Journal of Experimental Marine Biology and Ecology* 334: 64–83.
- Spain AV, Heinsohn GE. 1973. Cyclone associated feeding changes in the dugong (Mammalia: Sirenia). *Mammalia* 37: 678–80.
- Turquet J, Nicet JB, Cambert H, Pareto D, Gonzalez JL, Bigot L, Guyomarch J, Budzinski H, Tapie N, Jamon A, Pribat B. 2010. Définition des réseaux de surveillance DCE de la qualité des masses d'eau côtières de l'île de Mayotte – Tome 1: synthèse et propositions. Technical Report of the French Agency of Mining and Geology Research. Saint Denis, de La Réunion.
- Whiting SD. 2002. Rocky reefs provide foraging habitat for dugongs in the Darwin region of Northern Australia. *Australian Mammalogy* 24: 147–150.
- WWF EAME (Eastern African Marine Ecoregion). 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 Salaam: World Wide Fund.