Monitoring commercially important sea cucumber populations in the reefs of Mayotte (Indian Ocean)

Thierry Mulochau[1]

Abstract

One of the Mayotte Marine Nature Park's major challenges is protecting marine resources, including commercially important sea cucumber species. In December 2016, eight stations were set up to study commercially important sea cucumber species in the reefs of Mayotte. Park agents were given training in sampling methods and in how to identify the main species so that they could carry out regular monitoring. A total of 15 commercially important sea cucumber species were observed during this study, with *Holothuria atra* and *Bohadschia atra* observed most frequently. A total of 258 specimens were recorded, with the most abundant species being *Stichopus chloronotus* and *B. atra*. The observations made seemed to show that certain high-market-value species, such as *Holothuria nobilis* and *Thelenota ananas*, were observed less frequently than in previous studies, particularly on the outer slopes of the barrier reefs. In 2016, illegal harvests seem to have developed in certain areas of the reef. Since the sea cucumber's various environmental roles are vital to the reef ecosystem, urgent measures should be taken to prevent illegal fisheries.

Introduction

Mayotte is located north of the Mozambique Canal between the East African Coast and the coasts of Madagascar (Figure 1). This eight-million-year-old volcanic island (Marty 1993) is part of the Comoros Archipelago, which has four big islands (Grande Comore, Moheli, Anjouan and Mayotte). Mayotte has two main islands, i.e. Petite Terre (Pamanzi) and Grande Terre (Maore), with a 984.91 km^2 lagoon and a 342.4 km^2 reef (Andréfouët 2009).

Commercially important sea cucumber populations have already been studied in Mayotte (Pouget 2004, 2005; Pouget and Wickel 2003; Conand et al. 2005; Eriksson et al. 2012) and an inventory of the various species was recently carried during the ZNIEFF (natural marine areas of ecological interest due to their flora and fauna) survey (Pareto and Arvam 2015). It seems that Mayotte's reefs were protected from harvesting up till the early 2000s. Due to the overexploitation already underway in nearby countries such as Madagascar and the Comoros, harvesting developed in certain zones in Mayotte (Pouget and Wickel 2003). About 6000 kg of sea cucumbers were harvested in Mayotte in this way and exported to countries in the region (e.g. Tanzania, Madagascar, Mauritius Island) between 2002 and 2003, without taking into account clandestine exports. This fishery appears to have disappeared after 2004 following the ban on harvesting, transporting, sales or purchase of sea cucumbers throughout Mayotte (Prefectural Order no. 32/SG/DAF/2004). However illegal harvests seem to have developed in 2016 in certain reef areas (pers. obs.).

In order to try to better quantify this illegal fishery and its impact on sea cucumber populations, a study and a training session for Mayotte Marine Nature Park agents[2] were carried out in December 2016 with a view to setting up monitoring stations on Mayotte's reefs. The Mayotte Marine Nature Park is specifically designed to protect, restore and study coral reefs and related fauna, including various sea cucumber species. Due the overharvesting underway regionally, it is vital that such protection and study objectives continue over the long-term.

Materials and method

Stations

The study took place from 28 November to 2 December 2016 on all the reefs in Mayotte, both barrier and fringing reefs, and involved their outer slopes, inner slopes, reef flats and grass beds. A large number of sites and habitats were prospected and eight monitoring stations for commercially important sea cucumber populations were set up around Mayotte (Figure 1 and Table 1). Each station was uniform in terms of habitat and the various hydrodynamics-related parameters. Different data concerning the biotopes and biocenoses were recorded during the study in order to characterise each station: GPS points, geomorphologic unit, substrate in %, coral cover, seaweed, etc., through to depth in metres (Table1).

[1] BIORECIF, 3 ter rue de l'Albatros 97434 La Réunion, France – biorecif@gmail.com
[2] http://www.aires-marines.fr/L-Agence/Organisation/Parcs-naturels-marins/mayotte

Figure 1. Mayotte's location in Mozambique Channel and the location of the eight sampling stations set up in December 2016 to monitor commercially important sea cucumbers. Geomorphology (green thumbtacks: seagrass bed; red thumbtacks: reef flats; yellow thumbtacks: outer slopes; black thumbtacks: inner slopes) (H MTZA: Mtzamboro Island seagrass bed; P CHOI: Choizil Island reef flat; P RANI: Rani inner reef flat; PE BAND: Bandrélé outer slope; PERF Kolo: MtsangaKolo fringing reef outer slope; PI GRNE: Great north-eastern reef inner slope; PIRF PAM: Pamandzi fringing reef inner slope) (DigitalGlobe 2012;[3] Google Earth[4]).

Table 1. Monitoring stations for commercially important sea cucumber populations set up in Mayotte in December 2016, Sites, GPS Points (GPS Pts) in WGS84 with longitude/latitude (in decimal degrees), depth in meters (Depth (m)), Geomorphology.

Stations	Sites	GPS Pts	Depth (m)	Geomorphology
H MTZA	Mtzamboro Island North-west	-12.649260 N 45.024623 E	2	Sparse multispecies seagrass bed whose dominant species was Halodule universis – sandy zones
P CHOI	Choizil Island West	-12.677271 N 45.050248 E	1.5–2	Below-surface flat at the island's fringing reef with sparse coral cover, sandy and rubble zones
P RANI	Rani Inner reef South-east	-12.941800 N 45.056871 E	4–8	External flat of inner reef with sparse coral cover – algal communities - sandy and rubble zones
PI GRNE	Great Reef North-east	-12.748483 N 45.279667 E	3	Inner slope of barrier reef with coral formations spread out over a sandy zone
PI SADS	Sada Pass South	-12.909540 N 44.969501 E	5–10	Inner slope of barrier reef open to the sea with coral heads and spans and sparse coral cover - sandy and rubble zones
PE BAND	Bandrélé	-12.906945 N 45.251620 E	4	Outer slope of barrier reef with average coral cover - sandy and rubble zones
PERF KOLO	Mtsanga Kolo Sazilé	-12.984490 N 45.197810 E	6	Outer slope of fringing reef with extensive coral cover – soft coral – sandy zones
PIRF PAM	Pamandzi	-12.812663 N 45.276269 E	3	Inner slope of fringing reef with coral formations spread out over a sandy zone

[3] https://www.digitalglobe.com/
[4] http://www.earth.google.com

Method

The stations were surveyed using the Manta Tow method (Friedmann et al. 2008) in order to count the number of commercially important sea cucumbers on beds at between 1.5 and 6 to 8 m depending on visibility. The observer was towed by a boat and the stations divided into six 300 m x 2 m transects, i.e. 600 m^2 each. The speed was very slow and the position and distance were monitored by an above-water observer on the boat using a portable GPS. The surface area sampled at each station was 3600 m^2 and observers noted the number of specimens for each species. All six transects of the station were recorded with GPS points at the beginning and at the end of each transect, which makes it possible to know the exact zone sampled for future monitoring.

Results

Species richness

A total of 15 species of commercially important sea cucumber species were observed during this study (Table 2).

Holothuria atra (75%) and *Bohadschia atra* (62.5%) were the species most frequently observed at the eight stations (Figure 2). Several species were only observed at a single station: *Actinopyga* cf. *obesa*, *Bohadschia subrubra*, *B. vitiensis*, *Holothuria fuscogilva*, *H. fuscopunctata*, *Pearsonothuria graeffei* and *Thelenota anax*.

The average number of species observed by station for the eight stations in this study was 4.25 species (± 1.5). The H MTZA station, located north of Mayotte (Figure 1 and Table 1), was the station that had the greatest diversity in this study with seven sea cucumber species recorded there (Figure 4). The PIRF PAM station (Figure 1 and Table 1) was the station with the lowest diversity with only two species recorded there (Figure 4).

Abundances

Some 258 specimens of commercially important sea cucumbers were recorded at the eight stations (Figure 3).

Stichopus chloronotus (31%) and *B. atra* (30.6%) were the most abundant species at the eight stations with

Table 2. Commercially important sea cucumbers (Purcell 2014; Purcell et al. 2012 and 2013) observed in Mayotte in 2005a (Pouget), 2005b (Conand et al.), 2012 (Eriksson et al.), 2015 (Pareto et al.) and 2016 ('this study'), market value and International Union for Conservation of Nature (IUCN 2016) status. x = observed.

	2005a	2005b	2012	2015	'This study'	Market value	IUCN status
Actinopyga echinites		x	x			Average	Vulnerable
Actinopyga caerulea			x	x		Low	Data Deficient
Actinopyga mauritiana	x	x	x	x	x	Average	Vulnerable
Actinopyga miliaris		x	x	x	x	Average	Vulnerable
Actinopyga obesa		x	x	x	x	Average	Data Deficient
Bohadschia atra	x	x	x	x	x	Average	Data Deficient
Bohadschia marmorata		x				Low	Data Deficient
Bohadschia vitiensis	x	x	x	x	x	Low	Data Deficient
Bohadschia subrubra	x	x	x	x	x	Average	Data Deficient
Holothuria atra	x	x	x	x	x	Low	Least concern
Holothuria fuscogilva		x	x	x	x	High	Vulnerable
Holothuria fuscopunctata		x	x		x	Average	Least concern
Holothuria nobilis	x	x	x	x	x	High	Endangered
Holothuria scabra	x	x	x			High	Endangered
Holothuria lessoni		x				High	Endangered
Pearsonothuria graeffei		x	x	x	x	Low	Least Concern
Stichopus chloronotus	x	x	x	x	x	Low	Least Concern
Stichopus herrmanni		x	x	x	x	Average	Vulnerable
Thelenota ananas	x	x	x	x	x	High	Endangered
Thelenota anax		x	x	x	x	Average	Data Deficient
Total	9	19	18	15	15		

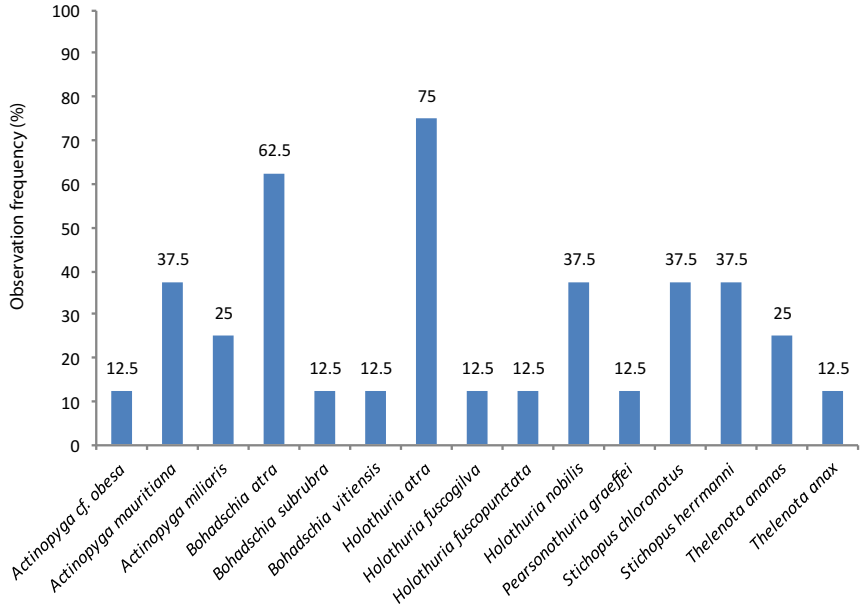

Figure 2. Observation frequency in % of total (ratio of the number of stations where the species was observed to the total number of stations) for commercially important sea cucumbers at the eight stations monitored.

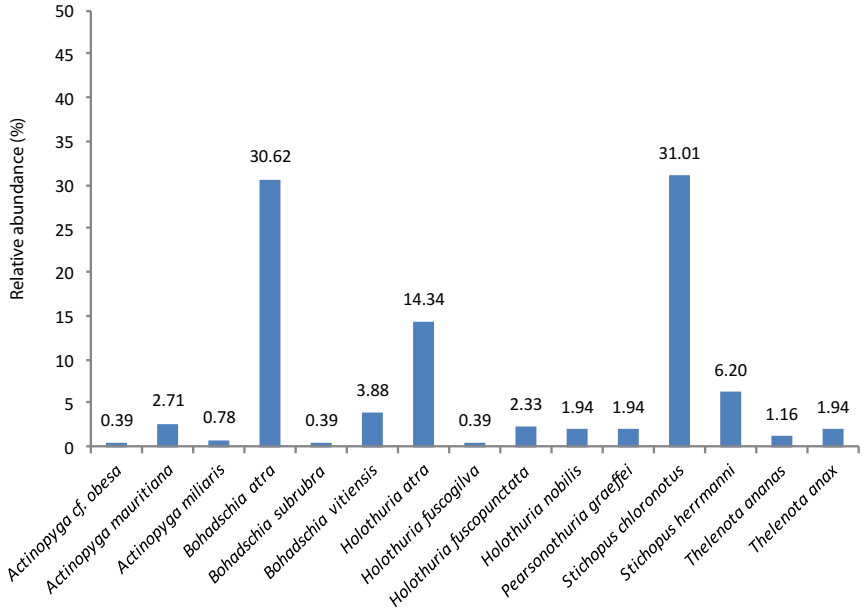

Figure 3. Relative abundances in % (ratio of the number of specimens per species to the total number of sea cucumbers) of the various species of commercially important sea cucumbers sampled in Mayotte at the eight stations monitored.

totals of 80 and 79 specimens recorded, respectively, for those two species. *S. chloronotus* was more abundant at the two reef flat stations (Table 1 and Figure 4), where it accounted for 72% of the relative abundances with a total of 68 specimens observed at those two stations. This species was also found at the seagrass bed station (H MTZA) (Table 1), where it accounted for 22.6% of the relative abundances with 12 specimens recorded, but it was absent from the other stations. *Bohadschia atra* was more abundant at the PERF KOLO station (Table 1 and Figure 4), where it accounted for 83% of the relative abundances with 44 specimens recorded. This species was also dominant at the two inner slope stations, PI SADS and PIRF PAM, with an abundance of 60%. *Holothuria atra* was the most abundant species at the seagrass

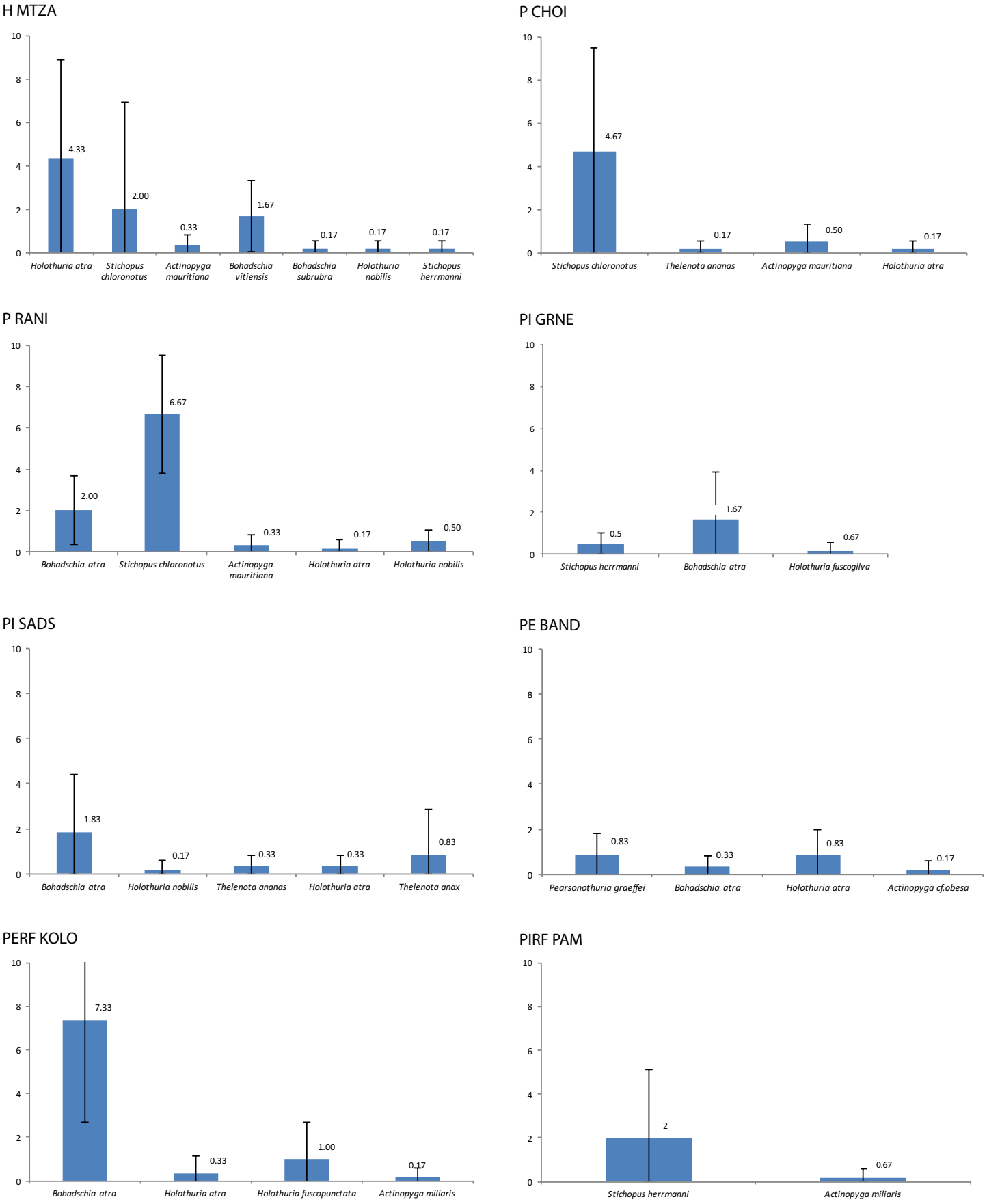

Figure 4. Average abundances (± standard deviation) of the various species of commercially important sea cucumbers in number of specimens per transect (600 m²) for the eight sampling stations (Table 1).

bed station H MTZA with 49.1% and 26 specimens recorded, and found in lower abundance at the five other stations where it was recorded. *Actinopyga* cf. *obesa*, *B. subrubra* and *H. fuscogilva* were found in very low abundances; each with a single specimen recorded for all eight stations.

Discussion

A total of 15 sea cucumber species were observed at the eight stations set up during this study. These species had already been recorded during previous studies (Pouget 2005; Conand et al. 2005; Eriksson et al. 2012; Pareto et al. 2015) and are Mayotte's main commercially important sea cucumber species (Table 2). Eriksson et al. (2012) recorded 18 commercially important species in Mayotte, including *Holothuria scabra*, a species that is especially found in seagrass beds and is listed as 'Endangered' by the IUCN (2016), and *Actinopyga echinites*, a species that is found on reef flats in Mayotte and is listed as 'Vulnerable', but neither species was observed during this study. During the ZNIEFF (natural marine areas of ecological interest due to their flora and fauna) survey in 2014 (Pareto et al. 2015), 15 commercially important sea cucumber species were sampled, including *Actinopyga caerulea*, which was not observed during this study. In the region, Samyn et al. (2006) recorded 20 commercially important species in the Comoros and Mulochau et al. (2007 and pers. obs.) observed 11 species on Geyser Bank located 110 km north-east of Mayotte. Those data do not take into account non-market-value species.

Bohadschia atra, a recently described species (Massin et al. 1999), was one of the most abundant (with *S. chloronotus*) and most frequently encountered (with *H. atra*) species in this study, which was also the case in the Glorioso Islands (Mulochau and Guigou 2017). *Holothuria nobilis* and *T. ananas*, classified as 'Endangered' on the IUCN red list (Conand et al. 2014) and facing a very high risk of extinction, especially due to overharvesting in this part of the Indian Ocean, were observed at a few stations (Figure 4) but in very low abundances. *Actinopyga mauritiana*, *A. miliaris* and *H. fuscogilva*, also recorded during this study and classified as 'Vulnerable' by IUCN, also had very low abundances. During the Mayotte sea cucumber-population distribution and habitat study carried out in 2012 by Eriksson et al., the most frequently encountered and most abundant species were *B. atra, H. nobilis, T. ananas, H. atra, S. chloronotus* and *H. fuscopunctata.* Sampling was carried out at a larger scale in 2012, so it appears difficult to compare to monitoring done as part of this study due to the lower number of stations used. A more in-depth study would be needed to be able to compare changes in commercially important sea cucumber-population trends in Mayotte since 2012 and better measure the impacts they are subjected to. Nevertheless, the observations made this year seem to show that certain high-market-value species, such as *H. nobilis* and *T. ananas*, were less frequently observed and appear to be less abundant than during the 2012 study. Some sites, tentatively chosen for future monitoring and then sampled during this study, were not selected for regular monitoring due to their very low sea cucumber abundance and richness. The very low values at the two seagrass bed stations, which were not selected, each covering a surface area of 3600 m^2, were remarkable since seagrass beds are, in fact, known to be the preferred habitat for certain sea cucumber species and their juveniles (Muthiga and Conand 2014). The eight stations set up will make it possible to monitor abundance and stock status over time beginning with the 2016 estimate, thereby provided a solid foundation on which the Mayotte Marine Nature Park can base its management measures. Regular monitoring of all these stations is vital to understanding changes in commercially important sea cucumber populations on Mayotte's coral reefs and this study should be extended by setting up other stations, particularly on the outer slopes.

Illegal sea cucumber harvests appeared to exist in Mayotte in 2016 (pers. obs.) in spite of the prefectural order prohibiting collection of these animals. Such harvests may, in particular, take place during traditional fishing on foot in fringing-reef flats (Aboutoihi et al. 2010), but also by boat on most distant barrier reefs, as in the early 2000s. Since such harvests are illegal, park agents have difficulties determining the quantities and species involved. Such harvests do not seem to be destined for local consumption – while one part may be processed and packaged on land before export (pers. obs.), another may be shipped directly after harvest to nearby countries (Madagascar, Comoros).

The Mayotte Marine Nature Park's main goal is to protect all its ecosystems from the shore to the open ocean, e.g. seagrass bed, mangroves, coral reefs. Given the vital environmental role that sea cucumbers play in the reef ecosystem (Purcell et al. 2016), it seems that urgent action must be taken by all the necessary means to put a halt to the illegal harvest, transport, packaging and sales of sea cucumbers from Mayotte's reefs.[5] In addition, in many regions affected by such harvests, the depletion of high-market-value sea cucumber species leads to increased harvests of species of lower market value and of those with no market value at all (Conand 2004; Purcell et al. 2012; Eriksson and Byrne 2013).

5 http://www.dm.sud-ocean-indien.developpement-durable.gouv.fr/IMG/pdf/AP_32-Holoturies_cle146c36.pdf

The Mayotte Marine Nature Park has a vital role to play in the south-western Indian Ocean in terms of restoring commercially important sea cucumber populations. Stocks have collapsed in all the countries in this zone and Mayotte's reefs form a coral biodiversity hotspot, with a remarkable diversity of habitats y and a high – most likely underestimated – number of sea cucumber species. Mayotte's sea cucumber populations must be preserved so that, through connections between populations and larvae dispersal, stocks can be reformed as part of both protection programmes and the creation of marine protected areas within the countries in this region. The Mayotte Marine Nature Park needs to protect these sea cucumber populations and inform the public and fishers of the major environmental role they play in the reef ecosystem.

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