Field observations of sea cucumbers at North Male Atoll in the Maldives

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Introduction

The commercial exploitation of sea cucumbers began recently in the Republic of the Maldives, starting in the mid-1980s and dramatically increasing to 745 t in 1990 (Conand and Bryne 1993). Management measures — including a ban on using scuba — were introduced in 1993 because of dramatic declines in sea cucumber catches (Ahmed et al. 1996). Very little information is available on sea cucumber resources in the Maldives. Joseph (1992), in a review of the sea cucumber fishery for the Bay of Bengal Programme, reported that eight species had been identified from Baa, Haa Alifu and Haa Dhaalu atolls during investigations carried out in 1988 under a UNDP/ESCAP-sponsored Maldives/China pilot study in the Male atolls. Joseph (1992) provides the relative abundance of species that are collected for commercial purposes. The relative abundance is based on information provided by fishers during a study of the ecology and reproductive biology of *Holothuria fuscogilva* (Reichenbach 1999).

The present study describes the findings of a sea cucumber survey that was conducted on the coral reefs of the islands of North Male Atoll. The study was part of a larger survey (McClanahan 2005) that assessed the coral reef recovery after the 1998 bleaching event, which caused widespread mortality of corals (McClanahan 2000).

Materials and methods

The survey of the abundance and distribution of sea cucumbers was carried out at eight islands around the center of North Male Atoll (Table 1). At each location, 40-minute searches were made along a visual transect parallel to the reef crest, using scuba, snorkel or walking, depending on depth. Surveys were carried out by examining the benthos and searching under crevices and rocks in the lagoon, reef crest and reef edge, and identifying and recording all sea cucumbers that were encountered.

In addition, the abundance of sea cucumbers was estimated in 50 m x 2 m belt transects, laid parallel to the shoreline in the reef lagoon, reef crest and reef edge at Vabbinfaru, a site adjacent to the Banyan Tree Resort and Spa. Although the reefs of Vabbinfaru were not officially designated as protected, conservation activities by the Banyan Tree Resort and Spa resulted in no fishing occurring on these reefs; hence, the area effectively functioned as a protected area. The characteristics of the reef, including the benthic cover of the main ecological components of the substrate, were derived from data collected using line transects during the larger coral reef surveys (Table 1).

Results

Turf algae dominated the benthic cover, followed by hard coral and coralline algae (Table 1). There was a very low percentage (> 6%) of sand, soft coral, sponge and fleshy algae in the substratum (McClanahan 2005). The average hard coral cover at all sites was 20% of the substratum. The sites at Angsana and Vabbinfaru had the highest hard coral cover, and the Furana site had the lowest hard coral cover. This is significantly higher than the 8% reported by McClanahan in 2000, indicating that there has been some recovery since the 1998 bleaching.

Fourteen species of sea cucumber were encountered during the survey (Table 2). Of these, two (*Holothuria nobilis* and *Thelenota ananas*) were of high and medium commercial value (respectively), while the rest were of low commercial value. Six species were recorded at Lohi Fushi, Vabbinfaru and Angsana, five at Thulgaari, and one each at Furana and Kalhuga. No sea cucumbers were encountered during searches at Rasfari and Magaari. The number of additional species that were encountered during each 40-minute search (Fig. 1) showed an increasing trend and did not approach a plateau.

The total number of individual sea cucumbers encountered at all the sites was 233 within a search period of 8.7 hours. The overall density was 17.93 ± 16.09 ind per 40-min search. The density of sea cucumbers was highest at the Vabbinfaru where 92% of all individuals counted occurred.

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Table 1. Survey site locations and habitat characteristics. The benthic substrate of the main ecologically important benthic components are reported as the average per cent cover (SEM) of three 10 m line transects measured at each site (modified from McClanahan 2005).

Location	Hard coral (%)	Turf algae (%)	Fleshy algae (%)	Coralline algae (%)	Sand (%)
Lohi Fushi	10 (2.4)	80.7 (1.3)	0	7.0 (1.1)	1.5 (0.7)
Vabbinfaru (E)	14.5 (2.9)	67 (3.4)	0	17.6 (0.6)	0
Vabbinfaru (W)	39.6 (4.1)	41.5 (2.2)	0.1 (0.1)	18.4 (3.9)	0
Rasfari	20.7 (8.3)	64.3 (10.6)	0	5.3 (1.8)	6.8 (3.5)
Furana	4.9 (1.7)	70.1 (6.6)	0	23.8 (5.1)	0.4 (0.4)
Angsana (E)	29.2 (7.7)	64.8 (11)	0	5 (3.6)	0.8 (0.8)
Angsana (W)	43.2 (2.0)	35.3 (2.7)	0	20.8 (3.8)	0.5 (0.5)
Thulgaari	12.2 (3.4)	56.7 (4.8)	0	29.0 (1.6)	0
Kalhuga	20.7 (3.7)	46.4 (6.4)	0	23.0 (4.9)	4.1 (4.1)
All sites	20 (2.4)	60.5 (2.8)	0	15.7 (1.6)	2.5 (0.9)

Table 2. Sea cucumber species recorded during the survey of North Male and species reported by Joseph (1992) and Reichenbach (1999).

Species	Location							
	Lohi Fushi	Vabbinfaru	Furana	Angsana	Thulgaari	Kalhuga	James (1992)	Reichenbach (1999)
Actinopyga echinites (Jaeger 1833)								•
Actinopyga lecanora (Jaeger 1833)					•		•*	
Actinopyga mauritiana (Quoy & Gaimard 1833)	•		•		•		•*	•
Actinopyga miliaris (Quoy & Gaimard 1833)				•				•
Actinopyga sp.							•	
Bohadschia argus Jaeger 1833							•	
Bohadschia atra Massin et al. 1999		•		•				
Bohadschia graeffei (Semper 1868)		•					•	
Bohadschia marmorata (Jaeger 1833)							•*	
Bohadschia vitiensis (Semper 1868)		•						
Holothuria atra Jaeger 1833	•	•		•			•*	
Holothuria edulis Lesson 1830					•		•	
Holothuria hilla Lesson 1830		•						
Holothuria leucospilota Brandt 1835	•	•					•*	
Holothuria fuscogilva Selenka 1867								•
Holothuria (Microthele) fuscopunctata Jaeger 1833							•	•
Holothuria nobilis (Selenka 1867)	•						•*	
Pearsonothuria graeffei (Semper 1868)	•	•		•	•		•	
Stichopus chloronotus Brandt 1835	•	•		•			•*	
Stichopus herrmanni Semper 1868							•	•
Thelenota ananas (Jaeger 1833)				•			•	•
Thelenota anax H.L. Clark 1921					•	•	•	•
Synapta maculata							•*	

* indicates species recorded in 1988 during a UNDP project

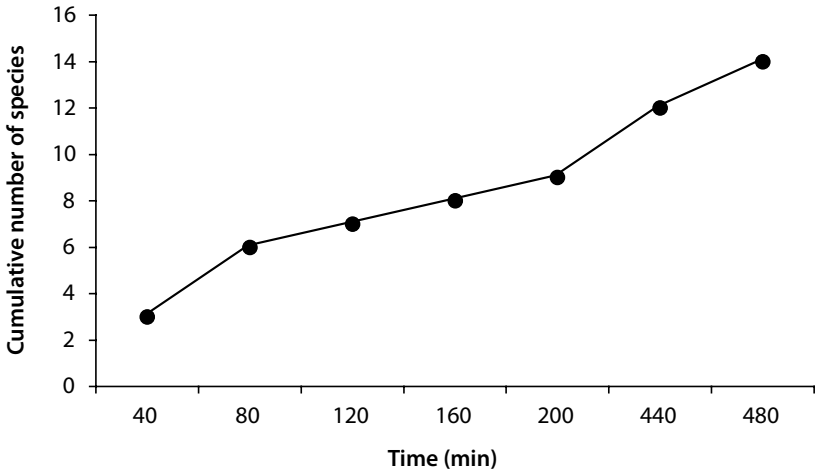

Figure 1. Species cumulative curve for sea cucumbers recorded at all sites during 40-minute searches.

Table 3. Sea cucumber abundance in the survey. Relative abundance is reported as the per cent occurrence of each species relative to the total number of individuals encountered at all sites.

Species	Location						Relative abundance (%)
	Lohi fushi	Vabbinfaru	Furana	Angsana	Thulgaari	Kalhuga	
Actinopyga lecanora	1				1		0.43
A. mauritiana			1		1		1.29
A. miliaris				1			0.43
Bohadschia atra		1		1			0.86
B. vitiensis		1					0.43
Holothuria atra	1	100		1			43.78
H. edulis					1		0.43
H. hilla		1					0.43
H. leucospilota	1	1					0.86
H. nobilis	1						0.43
Pearsonothuria graeffei	1	10		1	1		5.58
Stichopus chloronotus	1	100		1			43.78
Thelenota. ananas				1			0.43
T. anax					1	1	0.86

The abundance of individual species was very variable (Table 3), ranging from 0–100 ind per 40-min search. *Holothuria atra* and *Stichopus chloronotus* were the most abundant species, with a relative abundance of 43.78% each, followed by *Pearsonothuria graeffei* (5.58%) and *Actinopyga mauritiana* (1.29%). *H. atra* and *S. chloronotus* were also among the most frequently observed species along with *P. graeffei* and *A. mauritiana* (Table 3). There was no clear relationship between any of the benthic substrate components and the number of species or, the density of sea cucumbers. High numbers of species were found in sites of both high hard coral cover (Vabbinfaru and Angsana) and low hard coral cover (Lohi Fushi and Thulgaari).

At Vabbinfaru, 10 belt transects were laid in the reef lagoon, reef crest and reef edge. Four species of sea cucumbers were counted in these transects (Table 4). Of the four species encountered, there were significantly more *H. atra* (8.4 ± 3.6 ind 100 m^{-2}) than the other three species observed. There were also more individual sea cucumbers counted in the reef lagoon (7.38 ± 4.51 ind 100 m^{-2}) than on the reef crest and reef edge, although this difference was not significant between reef habitats (Table 4). Approximately 70% of the *H. atra* recorded were observed in the lagoon, while all *P. graeffei* encountered were on the reef edge.

Discussion

The sea cucumber resources of the Maldives are poorly studied and the available information consists of publications and reports mainly concentrating on the sea cucumber fishery and a study on the ecology and reproduction of *H. fuscogilva* (Joseph 1992; Conand and Bryne 1993; Ahmed et al. 1996; Reichenbach 1999). The present study adds to data on sea cucumber diversity and distribution in the Maldives. The survey recorded eight species that were reported in Joseph (1992) and four species that have not previously been recorded in the Maldives: *Actinopyga miliaris, Bohadschia atra, B. vitiensis* and *Holothuria hilla*. Two species previously reported by Joseph (1992), *Bohadschia marmorata* and *Stichopus maculata,* were not encountered in the current survey; the former is probably *B. atra* but it is difficult to verify this identification because no samples were collected. The diversity of sea cucumbers in the present study is lower than the 75 species reported by James (1989) in the shallow waters of the seas around India. The cumulative species curve of the individuals encountered is an upward trajectory, which indicates that additional surveys need to be carried out to get a more complete species list for the Maldives. In general, most of the species encountered on the reefs of North Male Atoll during the present survey are also common elsewhere throughout their range (Clark and Rowe 1971).

Joseph (1992) reported that the most abundant species were *Holothuria atra, H. leucospilota* and *Actinopyga Lecanora*, while *H. atra* and *Stichopus chloronotus* were the most common and most abundant sea cucumbers in the current survey. These species are also the most common sea cucumber species in the western Indian Ocean (Conand and Muthiga 2007). Reichenbach (1999) reported that *H. fuscogilva* was the dominant species on the lagoon floor between islands, with a relative density ranging between 70% and 94.9%. *H. fuscogilva* was not encountered in this study, possibly due to the focus on shallow reef habitats. According to Reichenbach (1999), *H. fuscogilva* recruits onto shallow seagrass beds and moves to the lagoon floor in deeper waters prior to sexual maturity. Reichenbach (1999) also noted much lower abundances of *H. fuscogilva* at North Male Atoll than at Laamu Atoll, and attributed this to fishing pressure. Because *H. fuscogilva* occurs in deeper waters, scuba is the main method of collection; however, according to Ahmed et al. 1996, the ban on using scuba for collecting sea cucumbers in the Maldives was not effective. Fishing could therefore potentially have been one of the factors affecting the lack of *H. fuscogilva* in the present survey.

Species distribution was patchy and showed no geographic pattern across the atoll, although more individuals were found on the western sides of Vabbinfaru reef, which also has higher coral cover. Although the number of species varied between

Table 4. Sea cucumber density in 100 m^2 belt transects in the reef lagoon, reef crest and reef edge at Vabbinfaru.

Habitat	Mean ± SEM	Comparison	P value
Reef lagoon	7.38 ± 4.51	Between habitats	0.044 *
Reef crest	3.06 ± 0.95		
Reef edge	1.64 ± 1.04		
B. atra	0.3 ± 0.15	Between species	0.164 ns
H. atra	8.4 ± 3.60		
P. graeffei	2.7 ± 1.41		
S. chloronotus	2.5 ± 1.03		

* Significant at p = 0.05

sites, there was no significant difference in species richness between sites. Sea cucumber density was generally low, and varied between sites, which is also common in other areas in the Indo-Pacific (Conand and Muthiga 2007). There were, however, significantly more individuals in the reef lagoon than on the reef crest or reef edge, which is also the case in other western Indian Ocean sites (Muthiga et al. 2007). The density of sea cucumbers was significantly higher at Vabbinfaru, where conservation activities have resulted in significant fishing reduction. The low number of commercial species may be an indication that the ban on using scuba is not effective, as reported by Adam (2006). Because there are so few previous studies with which to make comparisons, it is difficult to make reliable recommendations. However, it is suggested that monitoring should be increased and enforcement of the current ban on using scuba should be maintained and improved.

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