MACRO-INVERTEBRATE COMMUNITIES OF BAA ATOLL, REPUBLIC OF MALDIVES

BY

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ABSTRACT

In order to guide conservation efforts in Baa Atoll in the Republic of Maldives, macro-invertebrate species (principally sponges, sea stars, urchins, holothurians, crinoids, ophiuroids, ascidians, bivalves, gastropods, anemones, zooanthids, anthipatharian, gorgonians, alcyonaceans, and flatworms) were inventoried on 21 sites to provide an index of benthic species richness (number of species). A total of 182 species were recorded and identified. Richness ranged between 6 to 40 species per sampling sites. The richest sites were hard-bottom submerged lagoonal patch reefs experiencing high currents. Ecological rarity dominates the macro-invertebrate community pattern with 95 species found in only one sampling site. This new data set brings fresh knowledge on Baa Atoll and Maldives in order to identify biodiversity hot-spots. Further work will investigate the sensitivity of biodiversity conservation planning and sitting algorithms to this data set.

INTRODUCTION

Invertebrates include an extremely wide range of organisms with 8 major phyla (Porifera, Cnidaria, Annelida, Sipuncula, Arthropoda, Mollusca, Echinodermata, Chordata), and 24 minor phyla (see Glynn and Enochs, (2011) for a complete list). Coral reefs offer the richest biodiversity on Earth, along with tropical rainforest (Reaka-Kudla, 1997), and the greatest part of this diversity lies in the invertebrate communities. Glynn and Enochs (2011) recently reviewed the taxonomy and functional roles of invertebrates in coral reefs. They offer a synoptic view of the complexity of the invertebrate world. Here, we will consider more particularly the macro-invertebrates. The definition of the macro-invertebrate community is fuzzy, and context-dependant. For instance, Glynn and Enochs (2011) distinguished for cryptic species the macrofauna from the meiofauna, depending if the specimen body size is larger than 1 mm or not. Thus, body sizes, associated with investigation means and habitats define in a relative way the community of macro-invertebrates. Here, the macro-invertebrate benthic community includes all species that can be detected by eye while diving or snorkeling, on soft to hard-bottoms, on both biotic and abiotic substrates.

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Trying to measure invertebrate biodiversity for any given reef complex such as a Maldivian atoll is a daunting challenge that requires enormous field work efforts (Bouchet et al., 2011), rare taxonomic expertise, and genetic analyses. Thus, coral reef sites compendium providing within an accepted taxonomic reference the full range of existing species for most of the 32 phyla are extremely rare (e.g., New-Caledonia in Payri and Richer de Forges, 2006; Guam in Paulay 2003, Santo Island, Vanuatu in Bouchet et al. 2011).

Among valuable resources, a number of specialized taxonomic publications list macro-invertebrate species for selected phyla and locations (e.g., for New Caledonia: echinoderms, ascidians, sponges, gorgonians, are described respectively in Guille et al. 1986, Moniot et al., 1991; Levi et al. 1998; Grasshoff and Bargibant, 2001) but no recent taxonomic compilation exists for Maldives macro-invertebrates to our knowledge. The previous reference was Clarke and Rowe (1971) which is now outdated for several species.

Several well illustrated field guide books list invertebrates species for a given region (e.g., Colin and Arneson, 1995; Coleman, 2001; Laboute and Richer de Forges, 2004; Hervé, 2010; Poupin and Juncker, 2010). Web-based databases and information systems are also increasingly set to catalogue and identify species, and infer distribution maps (e.g., the integrated Taxonomic Information System, http://www.itis.gov, the World Register of Marine Species http://www.marinespecies.org/index.php, the Ocean Biogeographic Information System, http://v2.iobis.org/ and its Indian Ocean node http://www.indobis.org/). Nevertheless, to measure and characterize the biodiversity of a particular previously undocumented coral reef site, often, only a limited number of phyla (e.g., Cnidaria), classes (e.g., Anthozoa), orders (e.g;, Scleractinia) are targeted for new collections. Even more often, in a conservation or monitoring context, census and characterization focus only on few indicator species from various phyla, typically commercial and functionally prominent species of mollusk, crustaceans and echinoderms. This limited approach, taxonomically speaking, corresponds to rapid assessments as performed for instance by NGOs (e.g., Conservation International, McKenna et al., 2009; The Nature Conservancy, Ramohia, 2006), although some taxa have been more thoroughly investigated (e.g., mollusks in McKenna et al., 2002, Appendix 3).

To provide a measurement of Baa Atoll invertebrate biodiversity as completed as possible given the logistic and expertise constraints, it was decided to provide for the most dominant atoll habitats a list of conspicuous macro benthic invertebrates found during day time only. The rationale is that this macro-fauna assessment would provide an index of biodiversity to characterize reef habitat benthic richness and to guide the identification of biodiversity hot-spots for conservation planning (Hamel and Andréfouët, this issue). We report here on the variation of this richness in Baa Atoll. Therefore, the invertebrate sampling effort performed in Baa Atoll can not be compared to huge efforts such as those conducted recently in Santo Island for instance (Bouchet et al., 2011), but it provides an enhanced view of Baa Atoll communities richer than most typical rapid assessment programs that focussed on commercial species only (Le Berre et al., 2009). The Baa census included scleractinian (hard corals) and hydrozoans. These taxa are treated elsewhere (Bigot and Hamir, this issue; Gravier-Bonnet and Bourmaud, this issue). The present census did not consider crustaceans for time and logistical reasons.

METHODOLOGY

Macro-invertebrates communities were sampled during day dives conducted between 26 May to 4 June 2009. During each dive, specimen were inventoried from the deeper areas (typically around 40 m) to the shallows following a random path. This technique is generally more rewarding for biodiversity census than working through transects and quadrats that limit the searching spatial domain. Specimens were photographed in situ, and brought on board the diving vessel for further examination and identification when needed. Specimen were identified at the highest possible taxonomic level (species or genera). No museum collections were created.

Sampling sites were selected to cover the dominant reef types and exposure in Baa Atoll. This included outer oceanic slope and flats, submerged lagoon patch reefs, and sheltered central lagoonal slopes and reef flats. A total of 21 sites were sampled across Baa Atoll (Fig. 1).

Richness per station was simply defined as the number of species, all phyla included, found during the survey.

RESULTS AND DISCUSSION

The survey of the 21 stations provided a total of 182 identified species (Table 1 in Appendix), plus 5 specimen of sponges and 2 Crinoidea species left unidentified. Records were distributed among the phylum Cnidaria (class Anthozoa, n=34), Echinodermata (class Asteroida n=10, Crinoidea n=9, Echinoidea n=7, Holothuroidea n=12, Ophiuroidea n=11), Mollusca (class Bivalvia n=14, Cephalopoda n=1 and Gastropoda n=48), Porifera (class Calcarea n=3, Demospongiae n=26) ,Chordata (class Ascidiacea,n=7), Annelida (class Polychaeta, n=1) and Platyhelminthes (class Turbellaria, n=1). Selected specimen are illustrated Plates 1 to 5.

Richness per station ranged between 6 (station 23: deep lagoon, and station 2: seagrass bed) to 40 species (station 1, lagoon slope and reef flat). Figure 2 and Figure 3 provide the continuum of richness found for all stations. In terms of richness per habitat, the submerged lagoon patch reef frequently provided high richness (N>29) with stations 10, 11, 17, 25. These stations were characterized by high currents, hard-bottom and numerous hang-outs and small caves. Station 19, one of the poorest stations with 12 species, was also a patch reef characterized by high current but also by soft bottom, in contrast with the richer patch reef sites.

Average richness per geomorphological habitat type varied (Fig. 4), but the poorest habitats (deep lagoon, oceanic reef flat, and seagrass beds) where also the less sampled (n=1 for each of them). For the well sampled habitats (n>5), richness appeared homogeneous without significant difference (Fig. 4). The survey that occurred only on lagoon reef flats (thus without adjacent deep slopes) yielded a similar richness (N=26, n=1, station 3) than the dives that occurred on both lagoon slopes and flats (N=23.5, n=7), even if they have been visited only once. Thus, a sampling effort bias on lagoon reef flats was likely less an issue to estimate richness, compared to deep lagoons and outer reef flats.

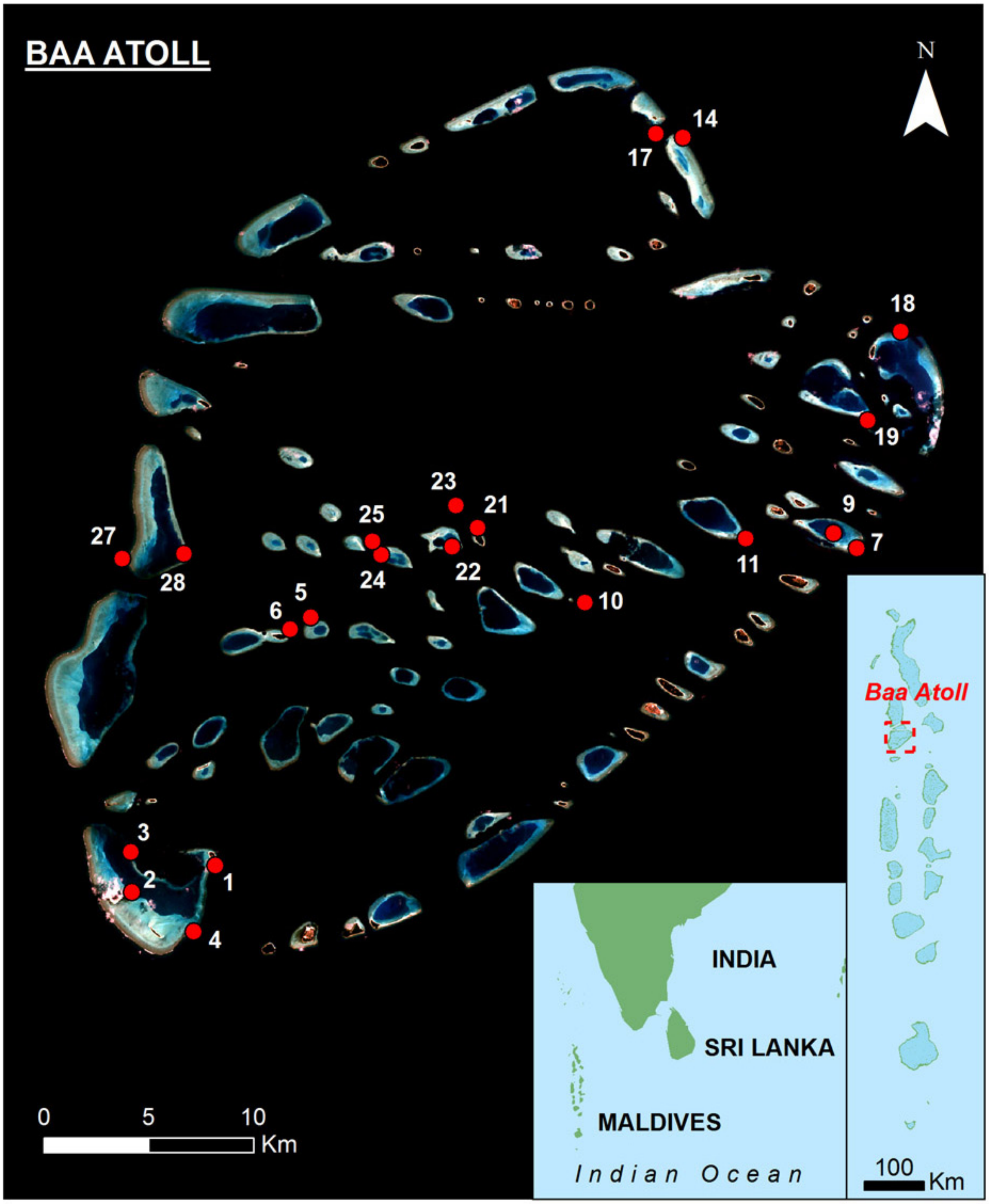

Figure 1. Location of Baa Atoll and macro-invertebrates sampling stations.

The converging richness values for different strata suggest that around 35 species per habitat is the richness limit that can be reached given the sampling method (Fig. 3 and Fig. 4). Obviously, additional species will appear by searching in cryptic spaces, by night, during longer dives, and for more sampling sites per strata.

The turn over of species per station was high, highlighting ecological rarity in Baa Atoll macro-invertebrates community. More than half of the species (n=95) were found in only one station, suggesting that macro-invertebrates beta-diversity as it was sampled here in Baa Atoll reefs is high (Fig. 4). The most frequently encountered species were the starfish *Linckia multifora* (found on 17 stations), the pin-cushion seastar *Culcita schmedeliana* (15 stations) and the holothurian *Pearsonothuria graeffei* (15 stations). Two specimen of *Acanthaster plancii* were found in station 25 only during the macro-invertebrate surveys, although others have been seen during the habitat survey in station 23.

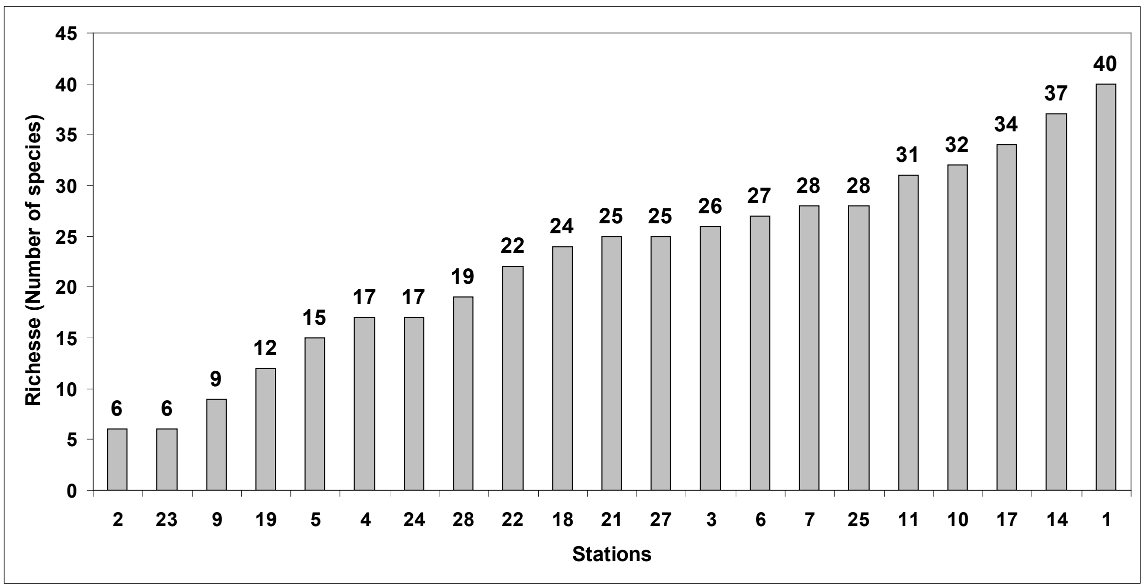

Figure 2. Variation of species richness per sampled station.

Similar high turnover of species was noted for macromollusc species in Tuamotu atolls in the Central Pacific Ocean (Pante et al., 2006), with 70% of 27 species encountered in only one or two habitats. A systematic comparison with the study by Adjeroud et al. (2000) and Pante et al. (2006) is not possible since they focused on lagoon habitats only and considered different type of habitats and geomorphological strata than the present study, and not all the phylum considered here. However, as seen in Figure 4, lagoon habitats sheltered an average of about 25 species in Baa Atoll. All lagoon habitats yielded a total of 94 species mollusks and echinoderms species. In average, lagoon stations provided 15.0 ± 3.9 species (mean ± stdev, n=13). In contrast, Adjeroud et al. (2000) listed a grand total of 36 species in 9 atolls, thus nearly 1/3 less than in Baa alone. They also reported a range of lagoon-scale richness between 2 and 22 for 9 atoll lagoons, with 10.4 ± 7.1 species (mean ± stdev, n=9).

Pearse (2009) reported for shallow water asteroids, echinoids and holothuroids in 6 Pacific Ocean sites that 56% of the 113 species were found in only one site. Thus, we found a similar ratio of single species in Baa Atoll than in a Pacific wide search suggesting that rarity could obey pattern across multiple spatial and biogeographical scales but this warrants larger tropical investigations on invertebrates community structure (Iken et al., 2010).

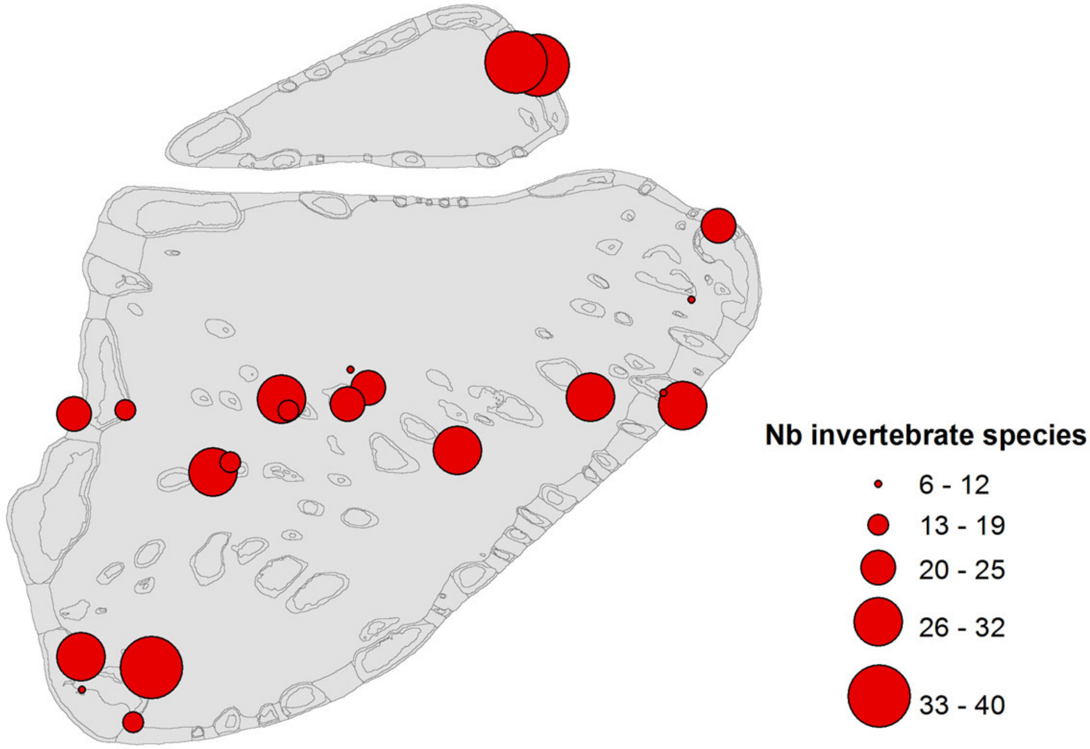

Figure 3. Mapped species richness for the 21 stations (Fig. 1).

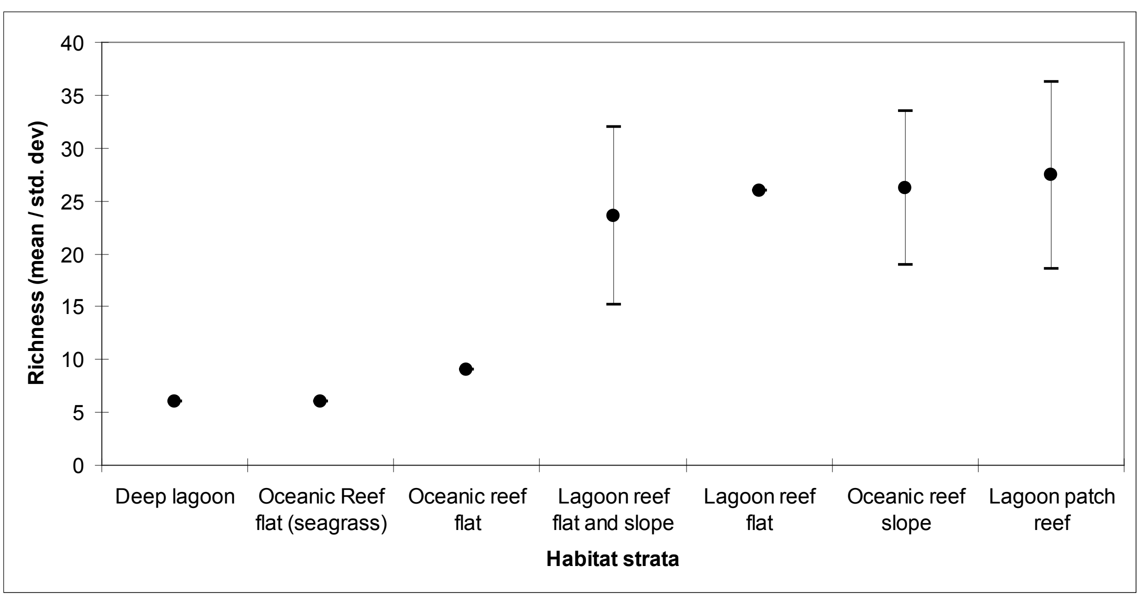

Figure 4. Variation of richness per habitat.

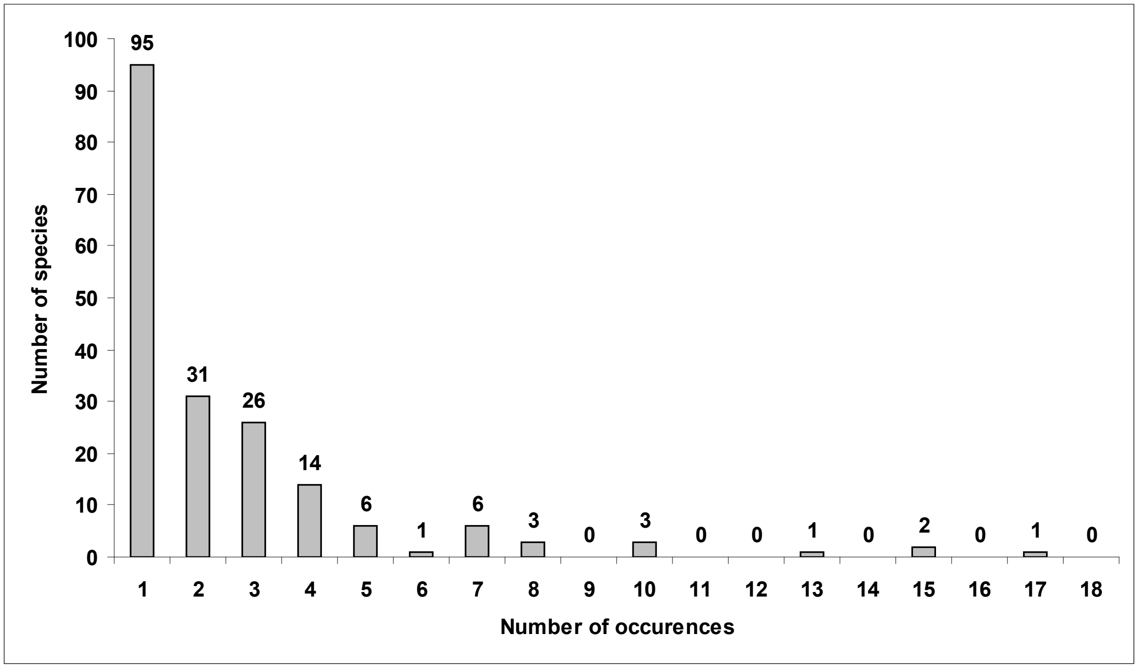

Figure 5. Histogram of species occurrences for the 21 sites.

Similar observations on high beta-diversity can be made at the genera level. 127 genera were identified and recorded, and 50 were found only once. Half of the genera were found only once or twice. The most frequently found genera were the echinoderms *Linckia, Culcita, Pearsonothuria and Choriaster* found in 18, 17, 15, and 13 stations respectively. Next was the mollusk genera *Tridacna* with 11 stations.

Few recent (in the past 20 years) publications have updated taxonomic check-lists for macro-invertebrates in the Maldives (e.g. for 47 species of brachyuran crabs in Laamu Atoll, see Kumar and Wesley, 2010) and none to our knowledge which would be Baa-specific. Commercial macro-invertebrate resources were the object of national-scale fishery reports, specifically for clams (Basker, 1991) and sea cucumbers (Joseph, 1992). Both authors reported that these fisheries were already unsustainable with quickly depleting resources. Clams (both *Tridacna maxima* and *T. squamosa*) were actually more present in Baa than what Table 1 suggests. Indeed, they were seen on virtually all stations of the survey completed for habitat mapping (Andréfouët et al., this issue). They may have been missed during the macro-invertebrate survey given the longer time spent at depth than in the shallows (between 0 and 5 meters) where they are more abundant. For sea cucumbers, Joseph (1992) listed 9 species commonly fished throughout Maldives, and refer to an 1988 expedition by a Maldives/China UNDP/ESCAP pilot study that listed 8 species identified from Baa, Haa Alifu and Haa Dhaalu Atolls, namely *Bohadschia marmorata, Actinopyga lecanora, A. mauritiana, Holothuria (Halodeima) atra, H. leucospilota, H. (Microthele) nobilis, Stichopus chloronotus,* and *Synapta maculata*. The last four of these 8 species were not found in the 2009 Baa survey which yielded a total of 12 species (Table 1).

In Diego Garcia, an atoll of the Chagos Archipelago in the south of Maldives, Clark and Taylor (1971) reported for the Echinodermata phyla, 9, 11, 1 and 14 species for respectively the Echinoidea, Ophiuroidea, Asteroida and Holothuroidea classes. In Baa, we report here respectively 7, 11, 10 and 12 species for the same classes, thus similar values, except for the Asteroida. Conversely, Taylor (1971) reported for Diego Garcia 179 species of mollusks alone, *vs* 63 species here (class Bivalvia n=14, Cephalopoda n=1 and Gastropoda n=48). Overall, the Mollusca phylum appears undersampled in Baa compared to other check-lists published for the region in the past (e.g. Kohn and Robertson (1968) for conidae).

CONCLUSION

The image of the benthic fauna made from the distribution of sponges, sea stars, urchins, holothurians, crinoids, ophiuroids, ascidians, bivalves, gastropods, anemones, zooanthids, anthipatharian, gorgonians, alcyonaceans, and flatworms provided a fresh view of the Baa Atoll benthic macro-invertebrate richness. This assessment is obviously dependent on the sampling strategy applied in May-June 2009, and for the sake of knowledge more detailed census with larger resources remain worth investigating for Baa, and for the Maldives in general. Nevertheless, the results presented here update the level of knowledge of Baa atoll and Maldives biodiversity.

The taxonomic inventory performed here brings a different biodiversity layer to guide conservation planning than what was usually done for coral reef ecosystems. Conservation planning is dependent on optimization algorithms, and these algorithms often use richness and rarity, and complementarity between sites to converge towards a solution able to fill the conservation targets. Given the beta-diversity patterns observed here, further work will investigate the sensitivity of conservation planning and siting algorithms to the macro-invertebrate layer.

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Table 1. Check list of macro-invertebrates species for the 21 sampled stations (1=presence).

					Stations																				
Phylum	**Class**	**Order**	***Genera***	***Species***	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**9**	**10**	**11**	**14**	**17**	**18**	**19**	**21**	**22**	**23**	**24**	**25**	**27**	**28**
Annelida	Polychaeta	Sabellida	*Sabellastarte*	*indica*																1					
Chordata	Ascidiacea	Aplousobranchia	*Didemnum*	*molle*	1		1								1	1	1	1					1	1	1
Chordata	Ascidiacea	Aplousobranchia	*Diplosoma*	*versicolor*															1						
Chordata	Ascidiacea	Aplousobranchia	*Eudistoma*	*sp.*																				1	
Chordata	Ascidiacea	Aplousobranchia	*Polysynchraton*	*sp.*												1									
Chordata	Ascidiacea	Phlebobranchia	*Ascidia*	*glabra*			1								1	1	1								
Chordata	Ascidiacea	Stolidobranchia	*Botrylloides*	*sp.*										1											
Chordata	Ascidiacea	Stolidobranchia	*Pyura*	*gangelion*			1								1										
Cnidaria	Anthozoa	Actiniaria	*Actinodendron*	*arborum*	1																				
Cnidaria	Anthozoa	Actiniaria	*Heteractis*	*magnifica*						1			1									1	1		
Cnidaria	Anthozoa	Actiniaria	*Stichodactyla*	*cf mertensii*					1				1												
Cnidaria	Anthozoa	Actiniaria	*Dofleina*	*sp.*									1					1							
Cnidaria	Anthozoa	Actiniaria	*Heteractis*	*aurora*									1												
Cnidaria	Anthozoa	Actiniaria	*Actinodendron*	*cf. plumosum*																1					
Cnidaria	Anthozoa	Actiniaria	*Discosoma*	*sp.*																1		1			
Cnidaria	Anthozoa	Actiniaria	*Entacmea*	*quadricolor*																		1	1		
Cnidaria	Anthozoa	Alcyonacea	*Dendronephthya*	*sp.1*						1	1			1		1									
Cnidaria	Anthozoa	Alcyonacea	*Chironephthya*	*sp.1*										1		1									
Cnidaria	Anthozoa	Alcyonacea	*Chironephthya*	*sp.2*												1									
Cnidaria	Anthozoa	Alcyonacea	*Dendronephthya*	*sp.2*									1												
Cnidaria	Anthozoa	Alcyonacea	*Dendronephthya*	*sp.3*										1											
Cnidaria	Anthozoa	Alcyonacea	*Subergorgia*	*sp.*						1															
Cnidaria	Anthozoa	Alcyonacea	*Acanthogorgia*	*sp.1*						1															
Cnidaria	Anthozoa	Alcyonacea	*Acabaria*	*sp.1*					1							1									
Cnidaria	Anthozoa	Alcyonacea	*Acabaria*	*sp.2*								1	1	1											
Cnidaria	Anthozoa	Alcyonacea	*Acabaria*	*sp.3*										1		1									
Cnidaria	Anthozoa	Alcyonacea	*Annella*	*mollis*											1										
Cnidaria	Anthozoa	Alcyonacea	*Acanthogorgia*	*sp.2*											1										
Cnidaria	Anthozoa	Alcyonacea	*Acanthogorgia*	*sp.3*											1										
Cnidaria	Anthozoa	Antipatharia	*Stichopathes*	*sp.*	1					1	1		1	1	1	1									
Cnidaria	Anthozoa	Antipatharia	*Cirrhipathes*	*sp. cf. anguineus*	1								1		1										
Cnidaria	Anthozoa	Antipatharia	*Antipathes*	*sp.1*						1	1			1											
Cnidaria	Anthozoa	Antipatharia	*Antipathes*	*sp.3*				1		1						1	1								
Cnidaria	Anthozoa	Antipatharia	*Antipathes*	*sp.4*												1									
Cnidaria	Anthozoa	Antipatharia	*Antipathes*	*sp.5*									1		1	1									
Cnidaria	Anthozoa	Antipatharia	*Antipathes*	*sp.6*												1									
Cnidaria	Anthozoa	Zoanthidea	*Palythoa*	*caesia*	1		1	1	1				1		1									1	
Cnidaria	Anthozoa	Zoanthidea	*Zoanthus*	*mantoni*																		1			
Cnidaria	Anthozoa	Zoanthidea	*Protopalythoa*	*sp.*																			1		1
Cnidaria	Anthozoa	Zoanthidea	*Zoanthus*	*sp.*						1															
Cnidaria	Anthozoa	Zoanthidea	*Parazoanthus*	*sp.*												1							1		
Cnidaria	Anthozoa	Zoanthidea	*Palythoa*	*caesia cf.tuberculosa*											1										
Echinodermata	Asteroidea	Spinulosida	*Acanthaster*	*planci*																			1		
Echinodermata	Asteroidea	Valvatida	*Choriaster*	*granulatus*	1	1	1	1		1			1	1	1	1			1		1		1	1	
Echinodermata	Asteroidea	Valvatida	*Culcita*	*schmedeliana*	1	1	1	1		1		1	1		1	1	1		1			1	1	1	1
Echinodermata	Asteroidea	Valvatida	*Linckia*	*guildingi*	1					1	1													1	1
Echinodermata	Asteroidea	Valvatida	*Culcita*	*cf. novaeguineae*					1												1				
Echinodermata	Asteroidea	Valvatida	*Linckia*	*multifora*	1		1	1		1		1	1		1	1	1	1	1		1	1	1	1	1
Echinodermata	Asteroidea	Valvatida	*Fromia*	*indica*			1			1									1						
Echinodermata	Asteroidea	Valvatida	*Gomophia*	*sp.*																1					
Echinodermata	Asteroidea	Valvatida	*Fromia*	*milleporella*						1					1										
Echinodermata	Asteroidea	Valvatida	*Fromia*	*nodosa*					1				1						1	1	1		1		
Echinodermata	Crinoidea	Comatulida	*Comanthus*	*parvicirrus*			1								1	1	1								
Echinodermata	Crinoidea	Comatulida	*Comanthina*	*schlegeli*									1	1			1								

Table 1 (Con'td)

Phylum	Class	Order	Genera	Species	Stations 1	2	3	4	5	6	7	9	10	11	14	17	18	19	21	22	23	24	25	27	28
Echinodermata	Crinoidea	Comatulida	*Capillaster*	*sp.*				1				1	1							1			1		
Echinodermata	Crinoidea	Comatulida	*Comanthus*	*sp.2*										1			1		1						
Echinodermata	Crinoidea	Comatulida	*Comaster*	*sp.*																1					
Echinodermata	Crinoidea	Comatulida	*Comanthus*	*cf. parvicirrus*											1	1							1		
Echinodermata	Crinoidea	Comatulida	*Stephanometra*	*sp.*																1					
Echinodermata	Echinoidea	Diadematoida	*Echinothrix*	*calamaris*							1														
Echinodermata	Echinoidea	Diadematoida	*Diadema*	*savignyi*	1																				
Echinodermata	Echinoidea	Echinoida	*Echinostrephus*	*molaris*	1			1							1	1	1							1	1
Echinodermata	Echinoidea	Echinoida	*Heterocentrotus*	*mammillatus*	1		1																		
Echinodermata	Echinoidea	Echinoida	*Echinometra*	*mathaei*	1		1																		
Echinodermata	Echinoidea	Spatangoida	*Metalia*	*sp1-cf sternalis*	1							1			1					1	1				
Echinodermata	Echinoidea	Spatangoida	*Schizaster*	*sp.*														1							
Echinodermata	Holothuroidea	Apodida	*Synaptula*	*sp.*																		1			
Echinodermata	Holothuroidea	Aspidochirotida	*Pearsonothuria*	*graeffei*	1		1	1	1	1	1		1	1	1	1	1		1			1		1	1
Echinodermata	Holothuroidea	Aspidochirotida	*Holothuria*	*fuscogilva*						1															
Echinodermata	Holothuroidea	Aspidochirotida	*Actinopyga*	*lecanora*							1														
Echinodermata	Holothuroidea	Aspidochirotida	*Bohadschia*	*argus*																		1	1		
Echinodermata	Holothuroidea	Aspidochirotida	*Bohadschia*	*marmorata sp1*		1							1												
Echinodermata	Holothuroidea	Aspidochirotida	*Bohadschia*	*marmorata sp2*										1											
Echinodermata	Holothuroidea	Aspidochirotida	*Actinopyga*	*mauritiana*			1																		
Echinodermata	Holothuroidea	Aspidochirotida	*Thelenota*	*ananas*																				1	
Echinodermata	Holothuroidea	Aspidochirotida	*Thelenota*	*anax*									1	1					1					1	
Echinodermata	Holothuroidea	Aspidochirotida	*Holothuria (Halodeima)*	*edulis*																			1		
Echinodermata	Holothuroidea	Aspidochirotida	*Holothuria (Halodeima)*	*atra*															1	1		1			
Echinodermata	Ophiuroidea	Ophiurida	*Ophiothrix (Acanthophiothrix)*	*sp1*					1								1							1	
Echinodermata	Ophiuroidea	Ophiurida	*Ophiothela*	*danae*					1																
Echinodermata	Ophiuroidea	Ophiurida	*Ophiocoma*	*erinaceus*	1		1	1			1		1	1	1	1			1					1	
Echinodermata	Ophiuroidea	Ophiurida	*Ophiolepis*	*cf. cincta*																				1	
Echinodermata	Ophiuroidea	Ophiurida	*Ophiarthrum*	*elegans*											1	1								1	
Echinodermata	Ophiuroidea	Ophiurida	*Ophiothrix*	*sp.2*														1							
Echinodermata	Ophiuroidea	Ophiurida	*Ophiothrix*	*sp.3*																			1		
Echinodermata	Ophiuroidea	Ophiurida	*Ophionereis*	*sp.1*											1										
Echinodermata	Ophiuroidea	Ophiurida	*Ophiarachnella*	*cf. gorgonia*																				1	
Echinodermata	Ophiuroidea	Ophiurida	*Ophiothrix (Acanthophiothrix)*	*purpurea*						1														1	
Echinodermata	Ophiuroidea	Ophiurida	*Ophionereis*	*sp.2*																1					
Mollusca	Bivalvia	Arcoida	*Arca*	*ventricosa*					1			1												1	
Mollusca	Bivalvia	Ostreoida	*Hyotissa*	*hyotis*	1		1		1	1							1		1				1	1	
Mollusca	Bivalvia	Ostreoida	*Lopha*	*cristagalli*									1	1										1	
Mollusca	Bivalvia	Pectinoida	*Spondylus*	*varians*				1						1	1	1								1	
Mollusca	Bivalvia	Pectinoida	*Spondylus*	*sp.*																1					
Mollusca	Bivalvia	Pterioidea	*Pinctada*	*margaritifera*											1	1						1			
Mollusca	Bivalvia	Pterioidea	*Pinna*	*sp.*																		1			
Mollusca	Bivalvia	Pterioidea	*Pteria*	*penguin*									1	1										1	
Mollusca	Bivalvia	Veneroida	*Cardiidae*	*indéterminé*	1																				1
Mollusca	Bivalvia	Veneroida	*Cardium*	*sp.*														1							
Mollusca	Bivalvia	Veneroida	*Globivenus*	*toreuma*												1									
Mollusca	Bivalvia	Veneroida	*Tapes*	*literatus*																			1		
Mollusca	Bivalvia	Veneroida	*Tridacna*	*maxima*	1	1	1			1	1		1				1	1	1	1					
Mollusca	Bivalvia	Veneroida	*Tridacna*	*squamosa*						1										1		1			
Mollusca	Cephalopoda	Octopoda	*Octopus*	*cyanea*	1																				
Mollusca	Gastropoda	Caenogastropoda	*Cerithium*	*nodulosum*											1					1					
Mollusca	Gastropoda	Caenogastropoda	*Rhinoclavis*	*vertagus cf.*														1							
Mollusca	Gastropoda	Caenogastropoda	*Rhinoclavis*	*aspera*												1									1
Mollusca	Gastropoda	Littorinimorpha	*Cypraea*	*tigris*	1		1																		

Table 1 (Con'td)

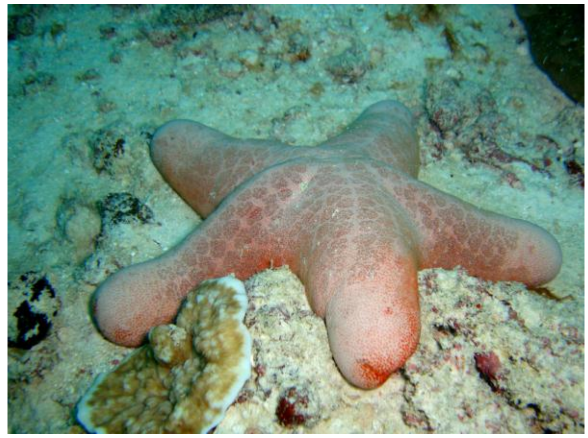
Phylum	Class	Order	Genera	Species	Stations 1	2	3	4	5	6	7	9	10	11	14	17	18	19	21	22	23	24	25	27	28
Mollusca	Gastropoda	Littorinimorpha	*Cypraea*	*caputserpentis*							1														
Mollusca	Gastropoda	Littorinimorpha	*Cypraea*	*tigris*	1																				
Mollusca	Gastropoda	Littorinimorpha	*Cypraea*	*linx*																					1
Mollusca	Gastropoda	Littorinimorpha	*Dendropoma*	*maximum*			1		1		1			1											
Mollusca	Gastropoda	Littorinimorpha	*Lambis*	*lambis*			1																		
Mollusca	Gastropoda	Littorinimorpha	*Lambis*	*chiragra arthritica*			1						1		1										1
Mollusca	Gastropoda	Littorinimorpha	*Lambis*	*truncata truncata*						1	1												1		
Mollusca	Gastropoda	Littorinimorpha	*Monoplex*	*aquatilis*																					1
Mollusca	Gastropoda	Littorinimorpha	*Septa*	*rubecula*							1														
Mollusca	Gastropoda	Littorinimorpha	*Serpulorbis*	*grandis*	1		1		1		1		1				1			1		1			
Mollusca	Gastropoda	Littorinimorpha	*Strombus (canarium)*	*sp.cf. dentatum*													1								
Mollusca	Gastropoda	Neogastropoda	*Acus*	*crenulatus*	1																				
Mollusca	Gastropoda	Neogastropoda	*Benimakia*	*nodata*																		1			
Mollusca	Gastropoda	Neogastropoda	*Chicoreus*	*microphyllus*	1												1								
Mollusca	Gastropoda	Neogastropoda	*Chicoreus*	*sp2*					1					1			1								
Mollusca	Gastropoda	Neogastropoda	*Chicoreus*	*palmarosae*	1						1														
Mollusca	Gastropoda	Neogastropoda	*Chicoreus*	*ramosus*																				1	
Mollusca	Gastropoda	Neogastropoda	*Conus*	*eburneus*				1																	
Mollusca	Gastropoda	Neogastropoda	*Conus*	*lithoglyphus*													1								
Mollusca	Gastropoda	Neogastropoda	*Conus*	*virgo*	1																				
Mollusca	Gastropoda	Neogastropoda	*Conus*	*miliaris*			1																		
Mollusca	Gastropoda	Neogastropoda	*Conus*	*miles cf.*															1						
Mollusca	Gastropoda	Neogastropoda	*Conus*	*arenatus cf.*																					1
Mollusca	Gastropoda	Neogastropoda	*Conus*	*emaciatus cf.*										1											1
Mollusca	Gastropoda	Neogastropoda	*Conus*	*bandanus*														1							
Mollusca	Gastropoda	Neogastropoda	*Conus*	*distans*							1														
Mollusca	Gastropoda	Neogastropoda	*Drupa*	*sp.*																					1
Mollusca	Gastropoda	Neogastropoda	*Drupa*	*ricina arachnoides*	1						1														
Mollusca	Gastropoda	Neogastropoda	*Harpa*	*amouretta*															1						
Mollusca	Gastropoda	Neogastropoda	*Latirolagena*	*smaragdula*																			1		
Mollusca	Gastropoda	Neogastropoda	*Latirus*	*sp1*							1														
Mollusca	Gastropoda	Neogastropoda	*Mitra*	*mitra*		1																			
Mollusca	Gastropoda	Neogastropoda	*Mitra*	*cf. contracta*											1										
Mollusca	Gastropoda	Neogastropoda	*Myurella*	*affinis*									1												
Mollusca	Gastropoda	Neogastropoda	*Pleuroploca*	*glabra cf.*												1									
Mollusca	Gastropoda	Neogastropoda	*Thais*	*mancinella*																		1			1
Mollusca	Gastropoda	Neogastropoda	*Turrilatirus*	*turritus*												1									
Mollusca	Gastropoda	Neogastropoda	*Vasum*	*ceramicum cf.*							1														
Mollusca	Gastropoda	Nudibranchia	*Nembrotha*	*megalocera*																			1		
Mollusca	Gastropoda	Nudibranchia	*Phyllidia*	*varicosa*													1	1					1		1
Mollusca	Gastropoda	Nudibranchia	*Phyllidiella*	*rudmani*	1		1																		
Mollusca	Gastropoda	Nudibranchia	*Phyllidiella*	*rosans*										1											
Mollusca	Gastropoda	Trochoidea (super family)	*Tectus*	*maculatus*						1				1											1
Mollusca	Gastropoda	Trochoidea (super family)	*Tectus*	*pyramis*													1								
Platyhelminthes	Turbellaria	Polycladida	*Maiazoon*	*orsaki*													1								
Porifera	Calcarea	Clathrinida	*Clathrina*	*sp.*																			1		
Porifera	Calcarea	Clathrinida	*Leucetta*	*chagosensis*			1							1	1									1	
Porifera	Calcarea	Clathrinida	*Pericarax*	*sp.*																1					
Porifera	Demospongiae	Astrophorida	*Stelletta*	*clavosa*															1						
Porifera	Demospongiae	Dendroceratida	*Dendrylla*	*sp.*															1						
Porifera	Demospongiae	Dictyoceratida	*Carteriospongia*	*foliascens*		1																			
Porifera	Demospongiae	Dictyoceratida	*Dactylospongia*	*metachromia*											1	1			1						

Table 1 (Con’td)

					Stations																				
Phylum	**Class**	**Order**	***Genera***	***Species***	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**9**	**10**	**11**	**14**	**17**	**18**	**19**	**21**	**22**	**23**	**24**	**25**	**27**	**28**
Porifera	Demospongiae	Dictyoceratida	*Hyrtios*	*erectus*					1					1											
Porifera	Demospongiae	Dictyoceratida	*Lamellodysidea*	*chlorea*	1																			1	1
Porifera	Demospongiae	Halicondrida	*Auletta*	*sp.*																1					
Porifera	Demospongiae	Halicondrida	*Axinella*	*labyrinthica*							1														
Porifera	Demospongiae	Halicondrida	*Dragmacidon*	*australe*				1		1	1	1	1	1	1	1									
Porifera	Demospongiae	Halicondrida	*Liosina*	*paradoxa*																			1		
Porifera	Demospongiae	Halicondrida	*Phakellia*	*carteri*	1			1				1	1	1	1								1		
Porifera	Demospongiae	Halicondrida	*Phakellia*	*cf. cavernosa*				1		1	1				1										
Porifera	Demospongiae	Halicondrida	*Stylissa*	*flabelliformis*				1			1		1						1				1		
Porifera	Demospongiae	Haplosclerida	*Amphimedon*	*sp.*	1									1			1								
Porifera	Demospongiae	Haplosclerida	*Amphimedon*	*cf.viridis*	1		1				1					1				1		1	1		
Porifera	Demospongiae	Haplosclerida	*Haliclona*	*nematifera*									1												
Porifera	Demospongiae	Haplosclerida	*Haliclona*	*ostros*	1														1						
Porifera	Demospongiae	Haplosclerida	*Microxina*	*sp.*							1				1		1				1				
Porifera	Demospongiae	Haplosclerida	*Niphates*	*sp.*																			1		
Porifera	Demospongiae	Homoscleromorpha	*Plakortis*	*sp.*	1													1	1						
Porifera	Demospongiae	Poecilosclerida	*Acarnus*	*sp.*	1				1		1			1											
Porifera	Demospongiae	Poecilosclerida	*Clathria (Microciona)*	*plinthina*	1					1						1		1							
Porifera	Demospongiae	Poecilosclerida	*Monanchora*	*unguiculata*						1						1									
Porifera	Demospongiae	Spirophorida	*Craniella*	*abracadabra*																1					
Porifera	Demospongiae	Spirophorida	*Paratetilla*	*bacca*	1		1			1		1	1						1				1		
Porifera	Demospongiae	Verongida	*Pseudoceratina*	*verrucosa*															1						

Plate 1: Specimen of the Echinodermata phylum photographed in situ
(photos: Jean-Louis Menou).

Linckia multifora



Choriaster granulatus.

Comanthina schlegeli

Fromia indica

Bohadschia marmorata

Holothuria fuscogilva

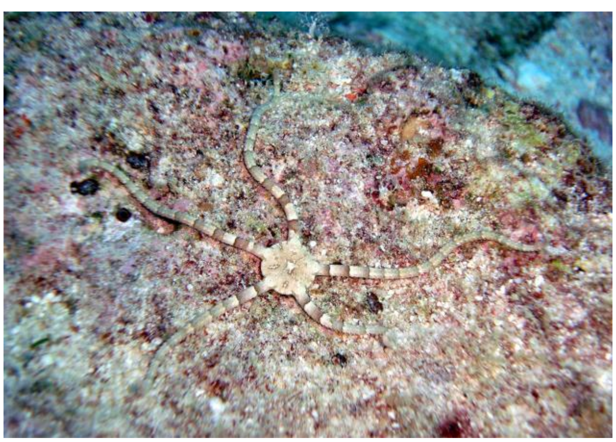
Plate 2: Specimen of the Echinodermata phylum photographed in situ
(photos: Jean-Louis Menou).

Culcita cf novaeguineae

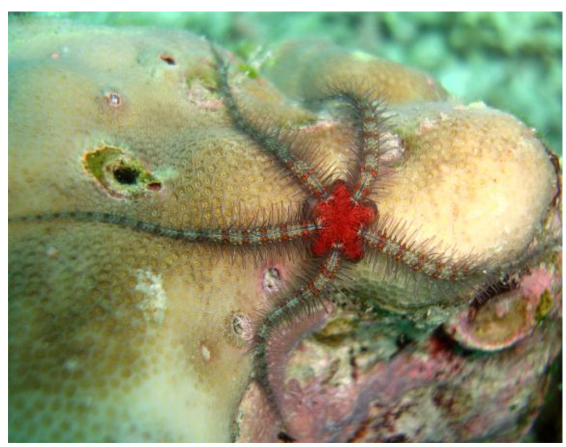
Culcita schmedeliana.

Echinostrephus molaris

Echinometra mathaei



Ophiarachnella cf. gorgonia



Ophiothrix sp.

Plate 3: Specimen of the Cnidaria phylum photographed in situ
(photos: Jean-Louis Menou).

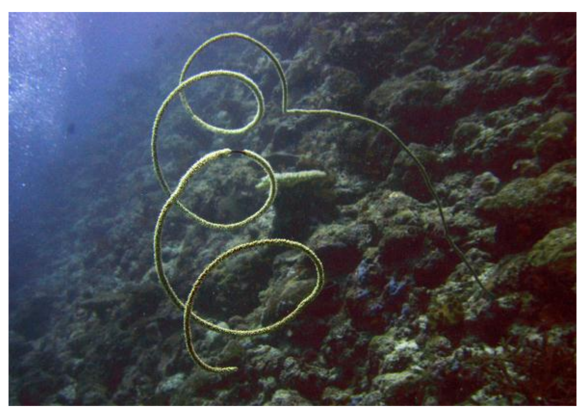
Heteractis aurora

Entacmea quadricolor

Chironephthya sp.

Dendronephthya sp.

Acanthogorgia sp.



Cirrhipathes cf. anguineus.

Plate 4: Specimen of the Porifera phylum photographed in situ
(photos: Jean-Louis Menou).

Phakellia carterii

Paratetilla bacca

Carteriospongia foliascens.

Clathria (Microciona) plinthina

Haliclona nematifera

Haliclona ostros