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Inventory of echinoderms in the Iles Eparses (Europa, Glorieuses, Juan de Nova), Mozambique Channel, France

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A B S T R A C T

The multidisciplinary programme BioReCIE (Biodiversity, Resources and Conservation of coral reefs at Eparses Is.) inventoried multiple marine animal groups in order to provide information on the coral reef health of the Iles Eparses. All five classes of echinoderms were observed by visual census, photographed and later identified. About 100 species are reported, including a few unidentified ones which require further studies. The Holothuroidea and Ophiuroidea are the most diverse. One new species, the asterinid *Aquilonastra chantalae* O'Loughlin and McKenzie (2013), was discovered in addition to several new records of echinoderms. The illegal fishery targeting holothurians, which are presently highly valuable resources in this zone, is discussed.

1. Introduction

The Iles Eparses (Scattered Islands) are isolated uninhabited French islands, in the South West Indian Ocean. These islands provide ideal conditions for evaluating marine biodiversity that has not been affected by anthropogenic influences. The multidisciplinary programme BioReCIE (Biodiversity, Resources and Conservation of coral reefs at Eparses Is.) undertook an inventory of several marine groups in order to provide information on the health of coral reefs on these islands (Chabanet et al., 2013, 2014a, 2014b, submitted for publication).

Few studies have been conducted on echinoderms from Iles Eparses (Vergonzannes, 1977; Quod et al., 2007; Mulochau and Conand, 2008). The BioReCIE programme has recently provided data on Europa echinoderms (Conand et al., 2013) and on Glorieuses holothurians (Conand et al., 2014). Other studies on echinoderms have been conducted in several countries of the SW Indian Ocean region, on one class, or the whole phylum (Conand and Muthiga, 2007 and Muthiga and Conand, 2014); as for example on the holothurians of Kenya, Madagascar, Reunion, Seychelles and Tanzania; Conand, 2008; Conand et al., 2010; Eriksson et al., 2015; Samyn et al., 2006; Samyn and Tallon, 2005; FAO, 2013; Hoareau et al., 2013; O'Loughlin and McKenzie, 2013; Rowe and Richmond, 2011).

Although the Iles Eparses are generally described as pristine environments, some illegal fisheries for holothurians have developed in recent years (Conand et al., 2014). Illegal, Unreported and Unregulated Fishing (IUU) has recently caught international attention (FAO, 2001; Le Gallic, 2007). As the socioeconomic importance of holothurians has now been recognized (Purcell et al., 2013), threats to the resources will be discussed.

The objective of this paper is to report new data and synthesize our knowledge on the echinoderms in the Iles Eparses.

Abbreviations: ASFMA, Australian Fisheries Management Authority; IUU, illegal, unreported and unregulated fishing; MNHN, Muséum national d'Histoire naturelle, Paris; O, occurrence; rf, reef flat; rs, reef slope; sp., species; TAAF, Terres Australes et Antarctiques Françaises; WIO, Western Indian Ocean.

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2. Material and methods

The study areas of each archipelago and the general survey methods have already been presented in other contributions of this issue (Chabanet et al. 2014b submitted for publication; Poupin,in this issue) or in the other papers already published on echinoderms from the programme BioReCIE (Conand et al., 2013, 2014) and will not be detailed here. The list of the stations visited in Europa, Glorieuses and Juan de Nova is given in Appendix A (Tables A.1, A.2 and A.3), with the date, GPS position, depth and habitat, as presented by Poupin (in this issue) for the Crustacea of the programme.

Representatives of all five echinoderm classes were observed by visual census at low tide on reef flats or by SCUBA diving down to 20 m, on the reef slopes. Some individuals were sampled and photographed for identification. Several taxonomists have assisted with specimen identification (see Acknowledgements). The taxonomy follows the World Register of Marine Species (Boxshall et al., 2014).

Despite various geomorphologic descriptors used on the field (see Appendices), the habitats have been brought together as two main categories: reef flat (RF) and outer reef slope (OR) to allow a first general comparison in these islands. To show the relative presence of each echinoderm species at each island, its occurrence has been calculated, defined as the number of stations (n) where it was present in a specific habitat (RF or OR), divided by the total number of stations (N) studied for this habitat.

When available, the populations of some species have also been categorized from the field observations, as dense or sparse.

Information on illegal fisheries for sea cucumbers in the Iles Eparses have been obtained from TAAF and ASFMA (see Abbreviations).

3. Results

A synthetic view of the general diversity of echinoderms in the Iles Eparses is presented in Table 1.

The taxonomic diversity differs between classes. Based on our sampling programme, the Holothuroidea and Ophiuroidea were the most diverse, with 31 species each (including 4 and 6 unidentified species respectively). The Crinoidea were the least diverse, with only 9 species (including 3 species not identified). The Asteroidea with 11 species (1 not identified) and the Echinoidea with 16 species (2 not identified) showed an intermediate diversity, from the results of this programme. In total, about 100 species were found (including 12 unidentified species, whose specimens were often juveniles). One new species, the asteroid *Aquilonastra chantalae* O'Loughlin and McKenzie (2013), has been discovered (O'Loughlin and McKenzie, 2013) and has been deposited and registered as MNHN IE–2013–617 at the Muséum national d'Histoire naturelle, Paris (MNHN).

All echinoderms from Europa collected during the BioReCIE expedition will be catalogued and housed at the Museum national d'Histoire naturelle, Paris; most of the brittle stars collected from Glorieuses and Juan are housed at the Swedish Museum of Natural History, Stockholm.

The echinoderm species are presented by class and by family, in the Tables 2–6 (including new records), with the occurrence of each species calculated for the main habitats (RF and OR) for each island, and then in total for the results from this programme, allowing comparisons with other sites in the WIO.

The **Holothuroidea** sampled were represented by five families (Table 2). The family Holothuriidae was the most diverse with 19 species identified +3 unidentified including 1 juvenile *Holothuria*. The diversity on the reef flats, with 17 species, is nearly twice as high as on the slopes, with 9 species. The species with total occurrence over, or near 0.20 will be presented here. Ranked by decreasing occurrences, *Bohadschia atra* shows the highest value (0.38), followed by *Holothuria nobilis* (0.25), *Holothuria atra* (0.23) and *Bohadschia subrubra* (0.21).

Four species belong to the family Stichopodidae. *Stichopus chloronotus*, with dense populations on reef flats, had an occurrence of 0.23 and *Thelenota ananas,* mostly found on slopes, has 0.180.

The other families have a low diversity, with 1 Sclerodactilidae *Afrocucumis africana,* 2 Synaptidae +1 *Patinapta* sp. and 1 Chiridotidae.

Fourteen species are considered as new records, from the results of BioReCIE (including the species presented in Conand et al., 2013 for Europa and Conand et al., 2014 for Glorieuses); several species had been reported in Cherbonnier's study of Madagascar (1988); 11 species are from the family Holothuriidae.

The **Ophiuroidea** were represented by 8 families, all from the order Ophiurida (Table 3). As the systematics of this class is rapidly changing (O'Hara et al., 2014), the families are presented in the following order. The Ophiuridae was represented by 1 species, *Ophiura kinbergi*, found at 2 sites. The Ophiodermatidae were represented by 2 species, *Ophiarachnella gorgonia* and *Ophiopeza fallax*. The Ophiocomidae was the most diverse family and was represented by 13 species, including *Ophiocoma erinaceus* which showed the highest occurrence (0.24), followed by *Ophiocoma (Breviturma) brevipes* and *Ophiocoma cynthiae* (0.23). The Ophiotrichidae were represented by 4 identified species and 1 *Ophiothela* sp. The species in the other families had a low diversity and occurrence: the Ophiolepididae with 1 species and 1 juvenile of the same genus *Ophiolepis*, the Ophiactidae with 2 species of *Ophiactis,* with *Ophiactis savignyi* at Europa and Juan de Nova and 1 unidentified of the same genus, the Ophionereididae with 3 species of the genus *Ophionereis* only found at Juan, and finally the Amphiuridae, with the only species *Amphipholis squamata* found at Europa. A cryptic black species, common in coral patches, was not collected (Conand et al., 2013).

Assessing the number of new records of ophiuroids is difficult, since several of the morphologically identified species have been found to comprise several genetic lineages that may have to be treated as separate species (Hoareau et al., 2013), which may revert to currently synonymized names. Since the morphological differences of these genetic lineages have not been worked out, we treat the species found by this study as operational units under the currently valid species names, bearing in mind that some may actually be species complexes. This allows comparison with previous studies. Twelve species are regarded as new for the Eparses Islands (including those reported by Conand et al., 2013 for Europa), but most of them have previously been recorded from the Mozambique Channel at Inhaca (Clark, 1980) and/or at Madagascar (Cherbonnier and Guille, 1978). *Ophiocoma doederleini* appears to be a new record for the area, possibly also *Ophiocoma dentata* if its identity is confirmed (although it may previously have been

Table 1
Diversity in number of species of Echinoderms, by class and total, in the Eparses Islands (Europa, Juan de Nova and Glorieuses), from the BioReCIE programme.

Classes	Europa	Juan de Nova	Glorieuses	Total
Asteroidea	5	7	8	13
Ophiuroidea	13	16	17	31
Echinoidea	8	10	11	16
Holothuroidea	8	21	20	31
Crinoidea	4	6	3	9
Total	**38**	**60**	**59**	**100**

Table 2
Holothuroidea from the BioReCIE programme. Occurrences are presented first by habitat for each island (RF: reef flat; OR: outer reef slope), then for the total of the reef flats (RF) and slopes (OR) and the Eparses total (Σ). The number of stations by habitat, by island and for the total, are recorded as N and the number of stations where a species occurs as n. New records for Iles Eparses are marked by*.

	Europa				Juan de Nova				Glorieuses				Eparses (total)		
	RF N = 14	n	OR N = 10	n	RF N = 21	n	OR N = 4	n	RF N = 12	n	OR N = 10	n	RF N = 47	OR N = 24	Σ N = 71
Family Holothuriidae															
*Actinopyga echinites**					0.05	1							0.021		0.014
Actinopyga mauritiana					0.19	4			0.25	3			0.149		0.099
*Actinopyga miliaris**					0.14	3							0.064		0.042
*Actinopyga obesa**					0.10	2	0.75	3					0.043	0.125	0.070
Bohadschia atra	0.21	3	0.1	1	0.38	8	0.25	1	0.42	5	0.90	9	0.340	0.458	0.380
*Bohadschia koellikeri**									0.08	1			0.021		0.014
Bohadschia subrubra	0.07	1			0.43	9	0.25	1	0.33	4			0.298	0.042	0.211
*Bohadschia vitiensis**	0.07	1											0.021		0.014
*Holothuria arenicola**									0.08	1	0.1	1	0.021	0.042	0.028
Holothuria atra	0.14	2			0.48	10	0.5	2			0.2	2	0.255	0.167	0.225
*Holothuria difficilis**					0.05	1			0.08	1			0.043		0.028
*Holothuria fuscocinerea**					0.05	1			0.33	4			0.106		0.070
Holothuria fuscogilva					0.1	2							0.043		0.028
*Holothuria impatiens**	0.07	1			0.1	2							0.064		0.042
*Holothuria hilla**					0.1	2			0.17	2	0.1	1	0.085	0.042	0.070
Holothuria lineata									0.08	1			0.021		0.014
Holothuria nobilis					0.33	7			0.58	8	0.3	3	0.319	0.125	0.254
*Holothuria pardalis**					0.05	1			0.25	3	0.2	2	0.085	0.083	0.085
Holothuria sp1					0.05	1							0.021		0.014
Holothuria sp2							0.25	1						0.042	0.014
Holothuria sp juvenile											0.1	1		0.042	0.014
Pearsonothuria graeffei					0.14	3	0.5	2			0.2	1	0.064	0.125	0.085
Family Stichopodidae															
Stichopus chloronotus	0.29	4	0.1	1	0.38	8	0.5	2	0.08	1			0.277	0.125	0.225
*Stichopus herrmanni**					0.05	1							0.021		0.014
Thelenota ananas			0.1	1	0.33	7	0.75	3			0.2	2	0.149	0.250	0.183
Thelenota anax					0.05	1							0.021		0.014
Family Sclerodactylidae															
*Afrocucumis africana**									0.08	1			0.021		0.014
Family Synaptidae															
Euapta godeffroyi									0.08	1			0.021		0.014
Synapta maculata									0.17	4			0.085		0.056
Patinapta sp.	0.08	1											0.021		0.014
Family Chiridotidae															
*Chiridota stuhlmani**											0.1	1		0.042	0.014

confused with *Ophiocoma brevipes*).

The **Asteroidea** were represented by 6 families (Table 4). The Acanthasteridae were only represented by *Acanthaster planci* which ranked 3rd in occurrence; it was not found during BioReCIE at Europa where it had been seen previously (Quod et al., 2007), but outbreaks and disappearance of its populations are common; its occurrence was the greatest at Juan de Nova where it was recorded at 3 reef flat sites. The Asterinidae were only found at Europa and a new species *Aquilonastra chantalae* has been discovered (O'Loughlin and McKenzie, 2013; Conand et al., 2013). It is the only new echinoderm species from this programme, but some of the ophiuroid species may turn out to be currently unrecognized species (Hoareau et al., 2013). The Ophidiasteridae presented 3 species, including *Linckia laevigata*, with an occurrence of 0.17, the highest for this class. The Goniasteridae was only represented by the infrequent species *Neoferdina offreti*. The Oreasteridae were represented by 2 species, *Culcita schmiedeliana* with an occurrence of 0.13 on the reef flats, and *Choriaster granulatus* found on 1 reef slope at the Glorieuses and 1 unidentified juvenile. The last family, Asteropseidae, was only represented on a reef flat at Juan de Nova (Mulochau et al. submitted for publication).

Finally nine species are considered as new records, from the results of BioReCIE (including the species presented in Conand et al., 2013 for Europa).

The **Echinoidea** were represented by 5 families of Regularia and 2 families of Irregularia (Table 5). The Cidaridae were represented by 3 species, with *Eucidaris metularia* found on reef flats and more frequently on slopes with a general occurrence of 0.14. The Diadematidae, with 5 species, comprised a few juveniles that could not be identified at species level; *Echinothrix calamaris* was present on the 3 islands, on both reef habitats, with a general occurrence of 0.32. The Echinometridae were represented by 2 frequent and abundant species, *Echinometra mathaei*, mostly on reef flats, with a total occurrence of 0.23 and *Echinostrephus molaris* as the most frequent echinoid (0.42). *Heterocentrotus mammillatus* was found at Juan and Glorieuses. The Stomopneustidae and the Toxopneustidae were not observed at Europa and remain unfrequent on the whole. Only a few Irregularia from the Brissidae and Maretiidae families were observed.

Finally nine species are considered as new records, from the results of BioReCIE.

The **Crinoidea** were represented by 5 families (Table 6). They are usually more frequent on the reef slope habitats. The Mariametridae, with Stephanometra indica, a species found at the 3 islands, has the highest (but still rather low <0.2) occurrence. The other species still need a precise identification.

The five species are considered as new records, from the results of BioReCIE.

Table 3
Ophiuroidea from the BioReCIE programme. Occurrences are presented first by habitat for each island (RF: reef flat; OR: outer reef slope), then for the total of the reef flats (RF) and slopes (OR) and the Eparses total (Σ). The number of stations by habitat, by island and for the total, are recorded as N and the number of stations where a species occurs as n. New records for Iles Eparses are marked by*.

	Europa				Juan de Nova				Glorieuses				Eparses (total)		
	RF N = 14	n	OR N = 10	n	RF N = 21	n	OR N = 4	n	RF N = 12	n	OR N = 10	n	RF N = 47	OR N = 24	Σ N = 71
Family Ophiuridae															
*Ophiura kinbergi**			0.1	1	0.04	1							0.021	0.042	0.028
Family Ophiodermatidae															
Ophiarachnella gorgonia					0.04	1			0.17	2			0.064		0.042
*Ophiopeza fallax**							0.25	1			0.1	1		0.083	0.028
Family Ophiocomidae															
Ophiocoma brevipes					0.24	6			0.75	9	0.1	1	0.319	0.042	0.225
Ophiocoma cynthiae					0.12	3			0.92	11	0.2	2	0.298	0.083	0.225
Ophiocoma pica									0.33	4	0.2	2	0.085	0.083	0.085
Ophiocoma cf. *dentata**									0.08	1	0.1	1	0.021	0.042	0.028
Ophiocoma cf. *pusilla**					0.04	1					0.1	1	0.021	0.042	0.028
Ophiocoma erinaceus			0.2	2	0.12	3			0.33	4	0.8	8	0.149	0.417	0.239
*Ophiocoma doederleini**									0.08	1	0.1	1	0.021	0.042	0.028
Ophiocoma scolopendrina	0.28	4							0.25	3			0.149	0.000	0.099
Ophiocoma valenciae	0.08	1							0.08	1	0.1	1	0.043	0.042	0.042
Ophiomastix venosa					0.04	1			0.42	5			0.128		0.085
*Ophiarthrum elegans**									0.08	1	0.2	2	0.021	0.083	0.042
Ophiarthrum pictum									0.17	2			0.043		0.028
*Ophiocomella sexradia**	0.08	1											0.021		0.014
Family Ophiotrichidae															
Macrophiothrix longipeda					0.2	5			0.17	2	0.6	6	0.149	0.250	0.183
Ophiothrix trilineata			0.1	1							0.1	1		0.083	0.028
*Ophiothrix purpurea**			0.5	5										0.208	0.070
*Ophiothela danae**			0.6	6										0.250	0.085
Ophiothela sp.					0.04	1							0.021		0.014
Family Ophiactidae															
*Ophiactis macrolepidota**			0.2	2										0.083	0.028
Ophiactis sp.			0.1	1	0.04	1							0.021	0.042	0.028
*Ophiactis savignyi**	0.21	3			0.04	1							0.085		0.056
Family Ophionereididae															
Ophionereis dubia							0.25	1						0.042	0.014
Ophionereis sp.					0.04	1							0.021		0.014
Ophionereis porrecta					0.08	2	0.25	1					0.043	0.042	0.042
Family Ophiolepididae															
Ophiolepis cincta									0.08	1			0.021		0.014
Ophiolepis juv.					0.04	1							0.021		0.014
Family Amphiuridae															
*Amphipholis squamata**	0.08	1											0.021		0.014
Indet. black sp (cryptic)			0.5	5										0.208	0.070

Table 4
Asteroidea from the BioReCIE programme. Occurrences are presented first by habitat for each island (RF: reef flat; OR: outer reef slope), then for the total of the reef flats (RF) and slopes (OR) and the Eparses total (Σ). The number of stations by habitat, by island and for the total, are recorded as N and the number of stations where a species occurs as n. New records for Iles Eparses are marked by*.

	Europa				Juan de Nova				Glorieuses				Eparses (total)		
	RF N = 14	n	OR N = 10	n	RF N = 21	n	OR N = 4	n	RF N = 12	n	OR N = 10	n	RF N = 47	OR N = 24	Σ N = 71
Family Acanthasteridae															
Acanthaster planci					0.14	3	0.25	1	0.08	1			0.85	0.04	0.070
Family Asterinidae															
*Aquilonastra richmondi**	0.08	1											0.021		0.014
Aquilonastra chantalae new sp.*	0.08	1											0.021		0.014
Family Goniasteridae															
*Dactylosaster cylindricus**					0.05	1			0.08	1			0.043		0.028
*Linckia laevigata**	0.08	1			0.24	5			0.17	2	0.40	4	0.170	0.17	0.169
*Linckia multifora**					0.05	1			0.08	1			0.043		0.028
Family Ophidiasteridae															
*Neoferdina offreti**					0.05	1	0.5	2			0.10	1	0.021	0.13	0.056
Family Oreasteridae.															
*Culcita schmideliana**					0.24	5			0.08	1			0.128		0.085
*Choriaster granulatus**											0.10	1		0.04	0.014
Oreasterid juv.	0.08	1											0.021		0.014
Family Asteropseidae															
*Asteropsis carinifera**					0.05	1							0.021		0.014

Table 5
Echinoidea from the BioReCIE programme. Occurrences are presented first by habitat for each island (RF: reef flat; OR: outer reef slope), then for the total of the reef flats (RF) and slopes (OR) and the Eparses total (Σ). The number of stations by habitat, by island and for the total, are recorded as N and the number of stations where a species occurs as n. New records for Iles Eparses are marked by*.

	Europa				Juan de Nova				Glorieuses				Eparses (total)		
	RF N = 14	n	OR N = 10	n	RF N = 21	n	OR N = 4	n	RF N = 12	n	OR N = 10	n	RF N = 47	OR N = 24	Σ N = 71
Family Cidaridae															
*Plococidaris verticillata**					0.05	1							0.021		0.014
*Prionocidaris pistillaris**							0.25	1						0.042	0.014
Eucidaris metularia	0.16	2	0.1	1	0.1	2	0.25	1			0.4	4	0.085	0.250	0.141
Family Diadematidae															
*Diadema savignyi**	0.08	1	0.1	1									0.021	0.042	0.028
Diadema sp.	0.25	3	0.1	1									0.064	0.042	0.056
*Echinothrix calamaris**			0.1	1	0.38	8	0.25	1	0.67	8	0.5	5	0.340	0.292	0.324
*Echinothrix diadema**	0.25	3			0.1	2							0.106		0.070
Echinothrix sp.			0.3	3										0.125	0.042
Family Echinometridae															
Echinometra mathaei	0.58	8	0.2	2	0.05	1			0.42	5			0.298	0.083	0.225
Echinostrephus molaris	0.33	3	0.5	5	0.48	10	1	4	0.33	4	0.9	4	0.362	0.542	0.423
*Heterocentrotus mammillatus**							0.25	1			0.4	4		0.208	0.070
Family Stomopneustidae															
*Stomopneustes variolaris**					0.1	2			0.17	2			0.085		0.056
Family Toxopneustidae															
Toxopneustes pileolus											0.1	1		0.042	0.014
Family Brissidae															
*Brissus latecarinatus**									0.08	1	0.1	1	0.021	0.042	0.028
*Metalia spatangus**					0.05	1							0.021		0.014
Maretiidae															
*Maretia planulata**											0.2	2		0.083	0.028

4. Discussion

The programme BioReCIE has allowed the first synthesis on the diversity of the five classes of the phylum Echinodermata, in the Iles Eparses of the Mozambique Channel (Europa, Juan de Nova and Glorieuses, from South to North). In total, about 100 species are present, with 31 Holothuroidea, 31 Ophiuroidea, 13 Asteroidea, 16 Echinoidea and 9 Crinoidea, with several not yet identified at the species level. A more precise identification will be needed in the future. One new species, *Aquilonastra chantalae*, has been described so far (O'Loughlin and McKenzie, 2013) and several new records are reported for each class, as these islands had previously received little attention.

At the scale of the WIO, these results are compared with the number of species recorded by class, presented and illustrated for the most common ones, in the chapter 'Phylum Echinodermata' by Rowe and Richmond (2011) on Eastern Africa and the Western Indian Ocean Islands, as this is a recent synthesis on this phylum presently available: 140 Holothuroidea (45 presented, 30 illustrated), 130 Ophiuroidea (80 presented, 24 illustrated), 60 Asteroidea (52 presented, 30 illustrated), 60 Echinoidea (45 recorded, 30 illustrated) and 20 Crinoidea (17 presented, 6 illustrated). Our results from the BioReCIE programme, limited to 3 coral islands, bring roughly the same proportions for the different classes, showing the dominance of Holothuroidea and Ophiuroidea.

The total diversity of echinoderms is higher in the north of the Mozambique Channel (Glorieuses and Juan de Nova) compared to the south of the channel (Europa). This pattern is also described for scleractinians by Obura (2012) who described the north of the

Table 6
Crinoidea from the BioReCIE programme. Occurrences are presented first by habitat for each island (RF: reef flat; OR: outer reef slope), then for the total of the reef flats (RF) and slopes (OR) and the Eparses total (Σ). The number of stations by habitat, by island and for the total, are recorded as N and the number of stations where a species occurs as n. New records for Iles Eparses are marked by*.

	Europa				Juan de Nova				Glorieuses				Eparses (total)		
	RF N = 14	n	OR N = 10	n	RF N = 21	n	OR N = 4	n	RF N = 12	n	OR N = 10	n	RF N = 47	OR N = 24	Σ N = 71
Family Mariametridae															
*Stephanometra indica**			0.2	2	0.25	1			0.1	1			0.021	0.125	0.056
Family Comatulidae															
*cf Comanthus whalbergii**	0.16	2	0.1	1	0.1	2	0.25	1			0.4	4	0.085	0.250	0.141
Family Tropiometridae															
*Tropiometra cf carinata**	0.08	1	0.1	1									0.021	0.042	0.042
Family Colobometridae															
*Cenometra bella**			0.1	1	0.04	1							0.021	0.04	0.028
Family Antedonidae															
*Dorometra cf aegyptica**			0.1	1										0.04	0.014
Dorometra sp.											0.1	1		0.04	0.014
Antedonidae indet							0.25	1						0.04	0.014
crinoidea indet sp 1					0.4	1							0.21		0.014
crinoidea indet sp 2							0.25	1						0.04	0.014

Mozambique Channel as the “coral triangle of the Indian Ocean”. This pattern could be due to currents, which favour connectivity between coral reef populations in this region. As for other sites, the species richness of Echinodermata is low compared to fishes (Chabanet et al., 2014a) or Decapoda crustaceans which comprise 175 species in Europa, 157 in Glorieuse and 109 in Juan (Poupin, submitted).

Among the five classes, the **Holothuroidea**, given the increasing commercial value of several species (Conand, 2004, 2006, 2008), have received more attention, with several local studies in the Comoros (Samyn et al., 2006), Madagascar (Cherbonnier, 1988), Mayotte (Pouget, 2005; Eriksson et al., 2012), or La Reunion (Conand et al., 2010), and more generally in this region of the WIO (Samyn and Tallon, 2005; Conand and Muthiga, 2007; Conand, 2008; Muthiga and Conand, 2014; Eriksson et al., 2015).

The systematic and classification of the **Ophiuroidea** are presently being reviewed, both with genetics and morphology (Thuy & Stöhr in prep; Hoareau et al., 2013; O'Hara et al., 2014; O'Hara et al. in prep.) and changes at all taxonomic levels are expected. Most of the observed species are common tropical shallow water species previously reported from the Indian Ocean, the Indo-Pacific, and nearby islands such as La Réunion (Clark and Rowe, 1971; Stöhr et al., 2008).

In **Asteroidea**, the populations of *Acanthaster planci* deserve special attention, given the dynamic of their outbreaks. They have for example recently been studied in Mayotte (UICN, 2014) and should be monitored in the Iles Eparses.

The **Echinoidea** present large populations of common species on the reef flats, as generally observed in the tropics, but additional collecting efforts remain necessary to evaluate the diversity of the cryptic and infaunal species.

The **Crinoidea** constitute large populations mostly observed on the exposed reef slopes, a feature that may be linked to current flow requirement for basic physiological functions such as feeding. Their diversity is probably underestimated, as some species, such as *Stephanometra indica* and *Tropiometra carinata* may constitute complexes (*in* Mulochau et al. in revision). The Crinoidea collected during the BioReCIE program are attributed to five families, four of which are closely related, whereas the family Antedonidae is ill-defined. The class Crinoidea is undergoing a complete revision at all levels of the taxonomy.

Illegal fisheries are an important problem which needs new tools to be documented and managed carefully. Among echinoderms, holothurians are of strong concern as a highly priced commodity, overexploited in many countries for export of the dried product Bêche-de-mer (or trepang), consumed by Asiatic populations (Conand, 2004, 2006, 2008; Toral-Granda et al., 2008; Purcell et al., 2013). Illegal, Unreported and Unregulated (IUU) fishing activities have received increasing attention, at both national and international levels, since the first FAO report (FAO, 2001), and the number of recent multidisciplinary (concerning environment and society) publications in the fishery literature is growing, because IUU undermine management efforts and conservation success (Le Gallic, 2007; Osterblom, 2014). The small-scale fisheries of sea cucumbers have a very long history, mostly in tropical regions where poaching has long been reported. In the WIO it is unfortunately also a recurrent practice, as noted for several countries where the regulations and their enforcement are weak (Conand, 2008; Conand et al., 2014; Eriksson et al., 2015). Despite the apparent abundance of commercial species recorded during this project, the question of the illegal fishery must be considered. Seizures within the Exclusive Economic Zone (EEZ) of the Iles Eparses were done in 2013 and again 2014, when foreign vessels with diving gear and one tonne of holothurians preserved in salt were arrested by the French authorities (TAAF, 2014) Other indirect evidence is also coming from this programme, as during the 2012 fieldtrip in Glorieuses, the white teatfish H. fuscogilva, a highly valuable species previously observed, was not found again, which might be attributable to poaching (Conand et al., 2014). The need for better protection of these resources in the Iles Eparses has been stressed. Illegal catches (quantity and species specific records) will be documented by the French authorities and the species abundance in the natural habitat should be monitored. International collaboration will also be very useful to better fight IUU.

Comparison with the synthetic results on the other taxonomic groups, from this programme BioReCIE, and from other studies in the Eparses and the WIO will later allow a more detailed analysis of the general characteristics of the habitats and their flora and fauna.

Additional sampling in the Iles Eparses is needed to properly compare the coral reef fauna between the islands over time, to conserve and protect the biodiversity of these remote and relatively pristine areas.

Disclosure

Chantal Conand has participated in the Europa fieldtrip, identified the holothurians and wrote the draft manuscript. And approves the final text.

Thierry Mulochau has participated in the Glorieuses and Juan fieldtrips, collected and identified some echinoderms. And approves the final text.

Marc Eléaume has identified the Crinoidea. And approves the final text.

Sabine Stöhr has identified the Ophiuroidea and contributed to writing the article. And approves the final text.

Pascale Chabanet has organised the programme, participated in the fieldtrips and contributed to the writing. And approves the final text.

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Appendix A

Table A.1
Station list for Echinodermata observed at Europa during BioReCIE (Conand et al., 2013).

Dates	Stations	Habitat	Latitude (S)	Longitude (E)	Depth (m))
07/11/2011	dive 1 (EU7)	Outer slope	−22.32943	40.36508	9–12 m
08/11/2011	dive 2 (EU6)	Outer slope	−22.34063	40.33716	8–10 m
09/11/2011	dive 3 (EU3)	Outer slope	−22.37300	40.32483	11–13 m
09/11/2011	dive 4 (EU4)	Outer slope	−22.4040	40.3702	12 m
10/11/2011	dive 5 (BIO8)	Outer slope	−22.3853	40.3885	11 m
10/11/2011	dive 6 (EU2)	Outer slope	−22.3529	40.3967	13 m
11/11/2011	dive 7 (BIO14)	Outer slope	−22.3590	40.3296	12 m
11/11/2011	dive 8 (BIO5)	Outer slope	−22.3840	40.375	10 m
12/11/2011	dive 9 (BIO12)	Outer slope	−22.3353	40.3889	10 m
13/11/2011	dive 10 (EU5)	Reef front	−22.3412	40.3376	3 m
07/11/2011	St 1 (Pl1)	Reef flat	−22.3400	40.3461	0.5
07/11/2011	St 3	Reef flat	−22.3395	40.3641	0.5
08/11/2011	St 4 (BIO28)	Reef flat	−22.3596	40.3310	0.5
08/11/2011	St 5	Reef flat	−22.3484	40.3314	0.5
08/11/2011	St 6	Reef flat	−22.3431	40.3819	2
08/11/2011	St 6A	Mangrove	−22.3395	40.3641	0.5
09/11/2011	St 8 (B34)	Reef flat	−22.3448	40.3676	0.5
09/11/2011	St 8A (CC)	Reef flat			0.5
09/11/2011	St 9	Mangrove	−22.3489	40.3708	0.5
10/11/2011	St 10	Mangrove	−22.3431	40.3819	0.5
10/11/2011	St 11 (BIO116)	Lagon-mangrove	−22.3364	40.3837	0.5
10/11/2011	St 11A (CC)	Reef flat			0.5
11/11/2011	St 14	Lagon-mangrove	−22.3565	40.3912	0.5
12/11/2011	St 15 (BIO25)	Reef flat	−22.3953	40.3767	0.5

Table A.2
Station list for Echinodermata observed at Glorieuses during BioReCIE (Conand et al., 2014).

Dates	Stations	Habitat	Latitude (S)	Longitude (E)	Depth (m))
07/12/2012	27	Reef flat	−1134134	47.17384	2.5
07/12/2012	28	Reef flat	−1134.128	47.17560	2
07/12/2012	31	Reef flat	−11.34981	47.17111	0.5
07/12/2012	32	Reef flat	−11.35129	47.17346	0.5
07/12/2012	33	Reef flat	−11.34851	47.17126	0.5
08/12/2012	29	Reef flat	−11.35417′	47.18191	0.5
08/12/2012	30	Reef flat	−11.35217′	47.18406	0.5
09/12/2012	GLO 6	Reef slope	−11.32973	47.17755	13
09/12/2012	GLO 2	Reef slope	−11.34880	47.16862	10
10/12/2012	16	Reef slope	−11.35122	47.20091	12
10/12/2012	17	Reef slope	−11.35804	47.18524	9
11/12/2012	18	Reef slope	−11.32067	47.24273	10
11/12/2012	GLO 3	Reef slope	−11.33625	47.22447	13
12/12/2012	19	Reef flat	−11.30505	47.22560	4
12/12/2012	20	Reef slope	−11.30785	47.21712	11
12/12/2012	GLO 7	Inner slope	−11.32227	47.22402	4
13/12/2012	36	Reef flat	−11.30869	47.22759	0.5
13/12/2012	37	Reef flat	−11.30899	47.22512	0.5
14/12/2012	GLO 5	Inner slope	−11.32388	47.20458	6
14/12/2012	GLO 1	Reef slope	−11.33673	47.17474	11
15/12/2012	22	Reef flat	−11.34214	47.19833	0.5
15/12/2012	23	Reef flat	−11.34334	47.20003	0.5

Table A.3
Station list for Echinodermata observed at Juan during BioReCIE (Mulochau et al. in revision).

Dates	Stations	Habitat	Latitude (S)	Longitude (E)	Depth (m)
07/12/2013	St 20	Lagoon reef patch	−17.03259	42.73574	1
07/12/2013	St 52	Lagoon reef patch	−17.03712	42.72429	1
08/12/2013	St 2	Reef flat	−17.06136	42.71416	0.5
09/12/2013	St 3	Reef flat	−17.07019	42.71046	0.5
09/12/2013	St 86	Lagoon reef patch	−17.01781	42.71705	1
10/12/2013	St 25	Lagoon reef patch	−16.95350	42.75982	1
11/12/2013	St 117	Lagoon reef patch	−17.02772	42.72481	1
11/12/2013	St 27	Outer slope	−17.08177	42.72536	5.0
12/12/2013	St 8	Reef flat	−17.05806	42.69461	0.5
12/12/2013	St 28	Lagoon reef patch	−17.01960	42.68127	1
12/12/2013	St 29	Outer slope	−17.05418	42.67435	5.0
13/12/2013	St 10	Reef flat	−17.04569	42.68039	0.5
13/12/2013	St 30	Lagoon reef patch	−16.96562	42.69472	1
13/12/2013	St 31	Lagoon reef patch	−16.94298	42.70940	1
14/12/2013	St 11	Reef flat	−17.04231	42.69587	0.5
14/12/2013	St 33	Outer slope	−17.01507	42.65688	5
14/12/2013	St 140	Outer slope	−17.01493	42.65645	5
14/12/2013	St 144	Reef flat	−17.02939	42.68913	0.5
15/12/2013	St 14	Reef flat	−17.03932	42.73068	0.5
15/12/2013	St 15	Reef flat	−17.04192	42.71683	0.5
15/12/2013	St 34	Outer slope	−17.01076	42.80413	5
15/12/2013	St 35	Outer slope	−17.07472	42.76651	5
15/12/2013	St 165	Reef flat	−17.05728	42.77669	0.5
16/12/2013	St 16	Reef flat	−17.05087	42.68053	0.5
16/12/2013	St 17	Reef flat	−17.04783	42.68040	0.5
16/12/2013	St 37	Reef flat	−17.03573	42.68453	0.5
17/12/2013	St 38	Lagoon reef patch	−17.03507	42.77117	2
17/12/2013	St 196	Lagoon reef patch	−17.03056	42.75651	2

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