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Coral reef monitoring in the Iles Eparses, Mozambique Channel (2011–2013)

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ABSTRACT

Monitoring of coral reefs has become a major tool for understanding how they are changing, and for managing them in a context of increasing degradation of coastal ecosystems. The Global Coral Reef Monitoring Network (GCRMN) has near-global coverage, but there are few remote sites free of direct human impact that can serve as reference sites. This study provides baseline data for the French Iles Eparses in the Mozambique Channel, Western Indian Ocean (WIO), whose coral reefs are little known owing to their limited accessibility, and have been free from fishing pressure for over 20 years. Surveys of coral reef health and fish community structure were undertaken at four of the islands (Europa, Bassas da India, Juan de Nova and Glorieuses) in 2011–2013. Monitoring was conducted using standardized GCRMN methods for benthos and fish communities, at the highest taxonomic level. Benthic cover showed a latitudinal gradient, with higher coral cover and conversely lower algae cover (60% and 14% respectively) in the south of the Mozambique Channel. This could be due to the geomorphology of the islands, the latitudinal temperature gradient, and/or the history of chronic stress and bleaching events during the last decades. Fish also showed a latitudinal gradient with higher diversity in the north, in a center of diversity for the western Indian Ocean already recognized for corals. An exceptional biomass fish was recorded (approximately 3500 kg/ha excluding sharks, compared to a maximum of 1400 kg/ha elsewhere in the WIO). The presence of large predators and sharks in all the islands as well as the absence of fleshy benthic algae were indicators of the good health of the reef systems. Nevertheless, these islands are beginning to experience illegal fishing, particularly in the north of the Mozambique Channel, demonstrating their vulnerability to exploitation and the need to protect them as reference sites for coral reef studies, including of climate change impacts, for the region and globally.

1. Introduction

Coral reefs are the most diverse marine ecosystem on Earth (Veron, 1995; Paulay, 1997; Bellwood and Hughes, 2001) and their biological, aesthetic, cultural and economic benefits are widely recognized (Munro and Williams, 1985; Done et al., 1996). But they are also among the most threatened ecosystems. A root cause of coral reef degradation is demographic growth worldwide, through disturbance to coastal zones associated with coral environments, in particular in areas with large human populations (Salvat, 1990) and overexploitation of fish resources (Newton et al., 2007; Mora et al., 2011; Johnson et al., 2013). As a result coral reefs become more susceptible to current and future climate change (Hughes et al., 2003). These changes have a significant impact on the welfare and livelihoods of over 500 million people worldwide, who depend directly on these ecosystems and the goods and services they

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provide (Moberg and Folke, 1999). The management of coral reef ecosystems is therefore critical for, both social and ecological reasons. With the establishment of the Global Coral Reef Monitoring Network (GCRMN) in 1996, monitoring of coral reefs worldwide has become a major tool for understanding these changes to reefs, and managing them. A wealth of small-scale, quantitative studies now exist that describe changes such as reduced coral cover, reduced physical and biological diversity, and increases in the spatial and temporal extent of macroalgae on individual reefs (Wilkinson, 1998, 2000, 2004, 2008).

Currently, there are very few coral ecosystems isolated and free from direct anthropogenic pressure (eg. Cocos Islands, Rowley Shoals, Line Islands), and many of these are located islands with very small human populations and/or are difficult to access. This is the case of the French Iles Eparses in the SW Indian Ocean where there are no permanent inhabitants, with the exception of a small military base. These islands support 534 km^2 of coral reefs, over ten times the land area, and are managed as ecological sanctuaries of marine and terrestrial biodiversity.

To date, little is known about the remote coral reefs of the Iles Eparses because of their limited accessibility. The fauna and flora of the coral reefs were little studied before 2002 (Dautzenberg, 1895; Fourmanoir, 1952; Derijard, 1966; Vergonzannes, 1977; Gabrié, 1982). Between 2002 and 2006, studies were conducted within the framework of IFRECOR (Initiative Française pour les Récifs Coralliens) actions through the CoSuReCo programme (Knowledge and Monitoring of Coral Reefs of the French islands of the Indian Ocean). This programme has helped to advance knowledge, including on the diversity of reef organisms such as hydroids (Gravier-Bonnet and Bourmaud, 2006a, b), echinoderms (Mulochau and Conand, 2008) and fish (Durville et al., 2003; Chabanet and Durville, 2006; Durville and Chabanet, 2009), but unevenly among the islands. At the same time, a few reference GCRMN stations for monitoring coral reefs were set up in the Iles Glorieuses and Juan de Nova. In 2009, on the initiative of the authorities of the Terres Australes et Antarctiques Françaises (TAAF: French Southern and Antarctic Lands), the symposium “Les Iles Eparses, terres d'avenir” (the Iles Eparses, lands of the future) enabled the genesis of a collaborative research programme on the environment and ecology of the Iles Eparses and multi-disciplinary research was run between 2011 and 2013. Of the 18 research projects selected, BioReCIE (Biodiversity, Resources and Conservation of coral reefs in the Iles Eparses) dealt specifically with the biodiversity and conservation of the coral reefs of the Iles Eparses. Amongst other achievements, this programme completed inventories of algae, cnidarians, crustaceans, echinoderms and fish (Mattio et al., 2012; O'Loughlin and McKenzie, 2012; Poupin and Komai, 2012; Poupin et al., 2012, 2013; Fricke et al., 2013; Conand et al., 2013, 2014). In addition, habitats were mapped in Europa and Juan de Nova and a more comprehensive network of GCRMN stations was set up on all of the islands. In this article we use the results of this monitoring in order to describe the health of the coral reefs of the Iles Eparses and the state of its fishery resources in 2011–2013, our work being a baseline study of the situation at a specific point in time.

2. Materials and methods

2.1. Study site and geomorphology of coral reefs

The Iles Eparses (Europa, Bassas da India, Juan de Nova, Glorieuses, Tromelin) are spread out around Madagascar in the Southwest Indian Ocean. These are French territories administered by the TAAF, and represent an Exclusive Economic Zone of nearly 650,000 km^2 (Quod et al., 2007). These islands have been classified as natural reserves since 1975, with the exception of Juan de Nova (Le Corre and Safford, 2001). The Natural Marine Park of the Glorieuses was recently created in 2012 (surface area >43,000 km^2). Apart from Tromelin, excluded from this study, the others are located along a north-south gradient in the Mozambique Channel (Fig. 1).

Europa, Bassas da India, Juan de Nova and the Glorieuses include 2% of the diversity of reef structures worldwide and 7% of the western and central Indian Ocean islands (Andréfouët et al., 2009). The total area of coral reef in the four islands is 517 km^2, less than 1% of the total area of coral reefs of western and central Indian Ocean islands. These islands present two major types of reef structure: banks (Juan de Nova and the Glorieuses) and atolls (Bassas da India and Europa). Both atolls and banks can be subdivided into three habitats: forereef, reef flat (adjacent to the main reef rim), and inner terrace with development of a lagoon in atolls (shallow or deep with or without coral construction). Because of the large area of lagoon/terrace habitats, most of the banks and atolls are dominated by non-reefal (sedimentary) structures (73% of total area). Thus, though Glorieuses is the largest island (207 km^2), followed by Juan de Nova with 197 km^2, Bassas da India and Juan de Nova have the biggest area of reef construction with 47 km^2 and 43 km^2 respectively.

Europa (22°22′S, 40°22′E) is located approximately 355 km west-northwest of Madagascar and 529 km east-northeast of Mozambique (Fig. 1-E). The island measures 7 km by 6 km. It is a former atoll, uplifted to a maximum altitude of 7 m, leaving the fossil coral reefs dry. The emergent land is about 35 km^2 while the overall coral reef structure has a total area of 18 km^2. It is surrounded by a fringing reef with a narrow shallow lagoon, which only widens towards the north of the island, where there is also the entrance of an extensive inland lagoon system ringed by mangroves.

Bassas da India (21°28′S, 39°42′E) is a sub-circular atoll rim emerging in the southern Mozambique Channel 450 km from Mozambique and 350 km from Madagascar (Fig. 1-D). Almost entirely covered by the sea at high tide, the reef reaches a width of 12 km at low tide. It includes a coral crown uncovering to up to 1.20 m at low tide, and several rocks on the north to 2–3 m above the high tide level. The total coral reef area is 54 km^2 with an atoll lagoon area of 47 km^2.

Juan de Nova (17°03′S, 42°45′E) is located 175 km from Madagascar and 285 km from Mozambique, in the narrowest portion of the Mozambique Channel (Fig. 1-C). As the result of the dominant S–SE trade winds, the contour of the island is that of an arc whose convex side faces the wind, with east and west ends prolonged by sand banks. The length of the island between these two points is 6 km, and the maximum width is 1700 m. The emergent land is about 5 km^2 while the overall coral reef structure covers 207 km^2. The whole annular coral reef structure extends offshore to 12 km from the northern part of the island and 1–2 km from its southern part (Fig. 1). The island has a well-defined inner reef flat (1–2 km, 0–3 m depth) on its south side, while a slope descends gently to a depth of 20 m on the northern side of the island. Tides are semidiurnal with a range of up to 3 m.

The archipelago of the Glorieuses (11°33′S, 47°20′E) is located 220 km off Cap Ambre (Madagascar) and 260 km from Mayotte (France). It is composed of two main coral islands, Grande Glorieuse (2.3 km in diameter, maximum altitude 14 m) and Lys Island or Petite Glorieuse (0.6 km in diameter, maximum altitude 12 m). Between Grande Glorieuse and Ile du Lys lie the islets of Roches Vertes and Ile aux Crabes, and a sand bank which is uncovered at low tide. The emerged land area is about 9 km^2 while the overall coral reef structure covers a total area of 201 km^2. Grande Glorieuse is surrounded by a fringing reef that is covered during high tides (Fig. 1-B).