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Coastal and marine biodiversity of La Réunion

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Réunion Island marine biota comprise 4374 taxon records. Algae, scleractinians, hydrozoans, molluscs (except nudibranchs and cephalopods) and vertebrates are the better known taxa. Sponges, cnidarians (except hard corals and hydroids), crustaceans and echinoderms are zoological groups that need more investigations. Species diversity of ctenophores, platyhelminthes and others worms, lophophorates and tunicates is completely unknown. In order to increase accessibility to these records, taxa and species distribution data have been recorded in a new online interoperable database, developed by software engineers of Réunion University, and integrated in the information system of the coastal zone network project (Système d'information du Littoral, SIL). Rocky coasts constitute the largest coastal marine habitat of Réunion Island, but coral reefs have been more investigated. Among them, the Saint-Gilles/La Saline coral reef complex is the most studied area and the other reefs and platforms have been neglected so far. Further, hardly any studies exist for the rocky coast and the deep-water ecosystems. Although Réunion coral reefs shelter 191 species registered either in IUCN red list (2003), CITES, CMS and regional Nairobi conventions, the marine biodiversity and the coastal habitats are under increasing anthropogenic threats. In spite of the high species richness, the high number of threatened species and the numerous economic activities that depend of the health of coral reefs, no marine protected areas exist as yet in Réunion, mainly because of disagreements between stakeholders.

[**Key words**: Marine biodiversity, biota, coral reef, human impact, database, GIS, Réunion Island]

Introduction

Consistent with the goals of Census of Marine Life (CoML), a research program that envisages assessing and explaining the abundance of and the changes in the biodiversity in the world oceans, and presented during the first Indian Ocean workshop on marine biodiversity at Goa (India) December 2003, this article focuses on a better understanding of the current state of coastal marine habitats and their biodiversity in Réunion, an island in the south-west Indian Ocean region. By compiling and synthesizing our current knowledge of the coastal and marine biodiversity of the Indian Ocean, the aim of the workshop was to identify the gaps in order to set regional priorities for biodiversity studies and to develop strategies for a research program.

Réunion Island (Fig. 1), a French overseas colony in the Mascarene archipelago, is located between 21°07' S and 55°32' E, about 800 km east of Madagascar. It is a volcanic island of 2.1 millions years old[1], with its highest point the dormant volcano *Piton des Neiges*, towering 3069 m above sea level. The presently active volcano is the *Piton de la Fournaise*, reaching 2631 m altitude. The surface area of the island is about 2512 km^2 and the diameter is 70 km. The total shoreline of the island is 215 km long. The first reef growth on this volcanic basement started as a reef bank dated at 8500 BP, when the sea level was 20 m lower[2]. The present-day fringing coral reefs are relatively narrow (maximum width 520 m), form a discontinuous belt along a 25 km stretch of the island's west side and cover an area of ca. 12 km^2. The reef flats are partially

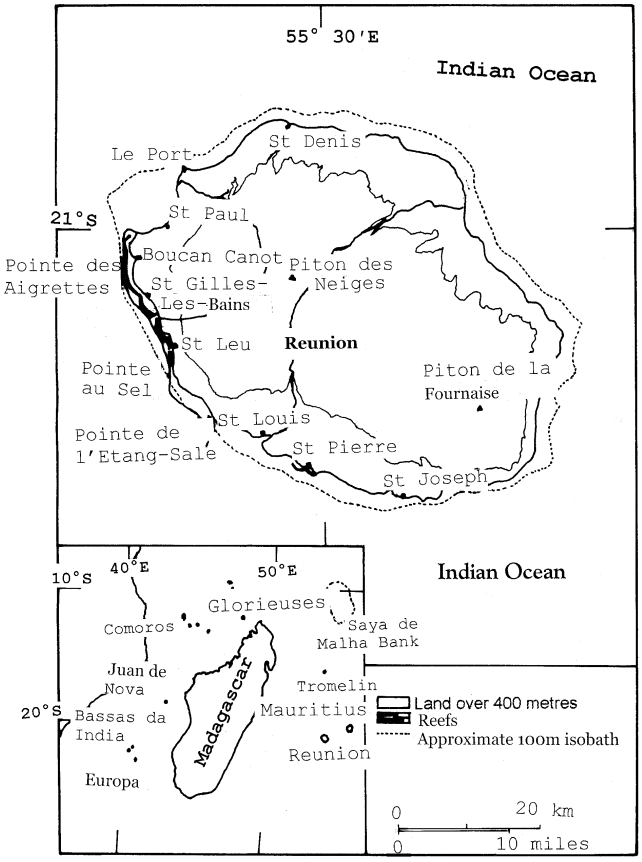

Fig. 1—Map of Reunion Island

exposed during low water springs. From the open ocean towards land, the reef profile includes an outer slope, outer and inner reef flats and a back reef zone[2]. The 9 km long Saint-Gilles/La Saline reef complex is the most developed reef of the island. Besides coral reefs with sandy beaches, the other major coastal biotopes are basaltic rocky coast with volcanic rubbles and steep cliffs, formed by recent volcanic activity in the south and south-east side of the island, representing approximately 100 km of coastline, and sandy basaltic coast mixed with small basaltic blocks and pebbles, which is 90 km in length (north and north-east of the island).

The rainfall regime of the island is controlled primarily by the southeast trade winds. The east coast receives heavy rainfall (5000 mm per year) and, because of the steep topography, the leeward west coast contrasts starkly with only 1300 mm of rain per year. During the cool season (from June to October), strong trade winds produce swells of 1-2 m amplitude, while during the hot season (from November to May) weak winds generate swells of only 0.5 m amplitude. Occasional hurricanes and storms generate very rough conditions. The tidal range varies from 0.9 m (springs) to 0.1 m (neaps).

The first human settlers arrived around AD 1650. Today, with an average population of 284 inhabitants par km^2, Réunion Island is densely populated. The current population of 753,600 sharp increase in population size and entails rapid extensions in urbanised areas and infrastructure (roads, buildings …), Due to the steep topography, 82% of the population is concentrated close to the north and west coast. The west coast is particularly attractive for settlement because of the dryer climate and the coral reef beaches.

Being a young volcano, Réunion Island has a narrow continental shelf and water depth increases very rapidly from the shore. The Exclusive Economic Zone (EEZ) surrounding Réunion covers about 320 000 km^2. With exception of a few seamounts, the ocean is always very deep and offers few possibilities for bottom fishing. The region is located at the southern limit of the South Equatorial Current; sea surface temperatures vary between 22 and 28° C. At a depth of 200 m, the temperature is 20°C throughout the year.

This paper presents an overview of the marine biodiversity of Réunion Island. First, we will expand on present knowledge of the marine species richness of Réunion Island, mainly from coral reefs, after which we will proceed by identifying specific shortcomings in the present state of knowledge of marine biota and analyse the current threats to marine biodiversity.

Marine Biota—Known

A comprehensive bibliographic study was carried out to give the state of knowledge of the marine biota at Réunion Island. Data mainly provided from references including results from Ph.D. theses[3-9], biodiversity and ecological studies[10-16] and technical reports on environmental impact assessment or on coral reef monitoring (French documents of limited distribution)[17-20]. We also recorded unpublished data provided by local taxonomists (unpublished data of Odile Naïm and Nicole Gravier-Bonnet, on hard corals and hydrozoans respectively) and issued from the Natural History Museum of La Réunion (kindly provided by Dr. Sonia Ribes).

About 4374 marine species have been recorded in

Table 1—The state of knowledge of the marine biota.

Taxa	Number of marine taxa recorded in Réunion Island	Number of taxa reported in MASDEA[23]	State of marine knowledge in Reunion sea
Seagrasses [6,16]	2		Good
Algae [8,15]	179	215	Good
Porifera	19	44	Sketchy
Cnidaria[3,6,17,19,20,21]	459	789	Sketchy
Hard Corals	148	714 (Anthozoa)	Very Good
Hydroids	256	61	Good
Soft corals	43		Sketchy
Sea fans	7		Bad
Black corals	8		Bad
Others	3		Bad
Ctenophora	-		Unknown
Platyhelminthes	-	37	Unknown
Other worms	-	22	Unknown
Polychaeta[9]	75	646	Sketchy
Mollusca [12,20]	2500	2559	Good
Crustacea[9]	192	2306	Sketchy
Bryozoa	-	120	Unknown
Echinodermata[11]	61	538	Sketchy
Sea Cucumbers	17	249	Good
Brittlestars	20	107	Good
Starfish	5	81	Sketchy
Sea urchins	19	76	Sketchy
Feather Stars	-	25	Unknown
Ascidiacea	-	1	Unknown
Fishes[4,5,7,13,14,17,18]	858	1870	Very good
Reptilia[20]	4	6	Very good
Mammalia[20]	3	28	Good
TOTAL	4374		

the sea around Réunion Island (Table 1). Several taxa are well studied: algae, scleractinians, hydrozoans, molluscs (except nudibranchs and cephalopods) and vertebrates. Seagrasses are scarce and only 2 species have been recorded with a sporadic distribution (*Syringodium isoetifolium* in the coral reefs[6] and *Halophila stipulacea* out of the reefs[16]). Studies about algae[8,15] showed 179 species distributed in 39 families and 94 genera, sampled from the reef flat to the outer slope (40 m deep). The Rhodophyta are the most numerous and diversified (55 genera, 90 species) in contrast with the Pheophyta (14 genera, 29 species). The Chlorophyta comprise 25 genera and 51 species i.e. about the 1/3 of species richness. Coral reefs support 148 species of hard corals (hermatypic and ahermatypic Scleractinia)[3,6,17,19,21] and 6 species of hydrocorals (Milleporidae and Stylasteridae)[6]. These cnidarians are distributed in 17 families and 48 genera, that is important compared to the 70 genera reported from the Mollucas-Philippines hot spot region as cited by Naïm[22]. The scleractinian *Acropora formosa* is the dominant species structuring benthic reef flat communities and characterize oligotrophic conditions as they are among the first to disappear when communities become eutrophicated[22]. Hydroids are well distributed: 256 species were recorded with 160 species recorded in the coral reefs. Among the 2500 molluscs recorded, several thousands comprise microfaunal species (< 1 cm)[12,20]. The level of endemism is estimated at 10% (Jay, pers. comm.). However, the concept of endemism should be used carefully, particularly in marine waters, where marine biodiversity has received only a fraction of the attention compared to its terrestrial counterpart. Letourneur *et al*.[14] indicate a total of 858 fish species belonging to 146 families. The composition of this list is biased in favour of the shallow-water species, which were sampled more thoroughly than those in other habitats. The shore species (mainly from coral reefs, but also from rocky coasts and soft-bottom) represented about 81.0% of the species, including about 6.2% that were found only on coral reef flats.

The percentage of pelagic species number is about 7.4%, and deep demersal 11.6%. Nine species are known only from Réunion, suggesting a level of endemism[14] of about 1%. The most speciose families of ichthyofauna are the Labridae, Gobiidae, Serranidae, and Pomacentridae. According to Letourneur *et al.*[14], these families are also among the most speciose at neighbouring Mauritius Island (except the gobiids), and, in general, at other localities/islands in the Indian Ocean (Maldives, Chagos, Madagascar and Chrismas Island). Comparing with MASDEA data-bank[23] (Marine Species Database for Eastern Africa), Réunion Island apparently harbours 46.4% and 58.2% of fishes and cnidarians, respectively. For Algae and Mollusca, this rate is 83.3% and 97.7%, respectively. Therefore, in spite of the island's small size, and the relatively young age of the Réunion island, its marine environment is home to a rich biodiversity.

Management and conservation

According to comparative studies, coral species richness and recovery rate have decreased during the last 20 years. Naïm[24] estimates that 50% of reef flats are disturbed and 28% are strongly degraded. According to the IUCN red list (2003), international and regional conventions (CITES, CMS and Nairobi), 191 species are in need of protection (Table 2). However, tensions and conflicts between the different coral reef users delay the establishment of a marine protected area. The three species of turtles scarcely identified[10] are protected and the Réunion turtle's farm has been closed in 1994 and devoted to turtle's scientific studies. Turtles do not nest on Réunion beaches.

Database and SIL

The study of the marine biodiversity of Réunion island is included in the Information System on Coastal Zone project (Système d'Information du Littoral, SIL), designed to be a web-enabled information system bringing together different aspects of coastal research such as geographic, bibliographic, iconographic and taxonomic databases. The overall objective is the possibility for scientists to share their accumulated and new data within a common reference framework in the fields of biology, geology, geography, socio-economy, law, policy and computer science. The SIL is managed and supported by different laboratories in Réunion University, within the ETIC program and with external partners (Museum, WWF, ARVAM).

Table 2—Threatened species (191) registered in International Conventions

Zoological groups	Order or familia	Number of species	Total
Cnidaria	Scleractinia	148	
	Antipatharia	8	
	Helioporacea	1	
	Hydrozoa Milleporidae	4	
	Stylasteridae	2	163
Mollusca	Tridacnidae	2	
	Pteriidae	4	6
Crustacea	Palinuridae	1	1
Chondrichthyes	Carcharhinidae	6	
	Mobulidae	1	
	Myliobatidae	1	
	Orectobolidae	1	
	Rhinchodontidae	1	10
Osteichthyes	Syngnathidae	2	
	Pegasidae	1	
	Serranidae	2	5
Cetacea	Balaenopteridae	1	
	Delphinidae	2	3
Chelonia	Chelonidae	3	3

In order to achieve the objectives of the SIL, a new conceptual data model was done in order to build a database, gathering all the existing data about marine species at La Réunion, and in order to facilitate the interoperability through the net and the update of marine biota. Such a conceptual data model allows a total freedom concerning the choice of the DataBase Management System (DBMS) and, more importantly, data from other systems are easily manageable.

The Unknown Biodiversity

Marine Biota

An analysis of Table 1 allows rapid identification of specific shortcomings in the current state of knowledge of marine biodiversity at Réunion Island. Some invertebrate groups are completely unknown such as the Ctenophora, Platyhelminthes, Nemertea, Sipunculida, Echiura, Bryozoa and other Lophophorates, Ascidiacea. The phyla Porifera, Cnidaria (because of octocorals such as soft corals, stoloniferans and gorgonians, sea pens, and because of hexacorals such as sea anemones, zoanthids, corallimorpharians, black corals, tube anemones and jellyfish), Polychaeta, Crustacea and Echinodermata need additional investigations.

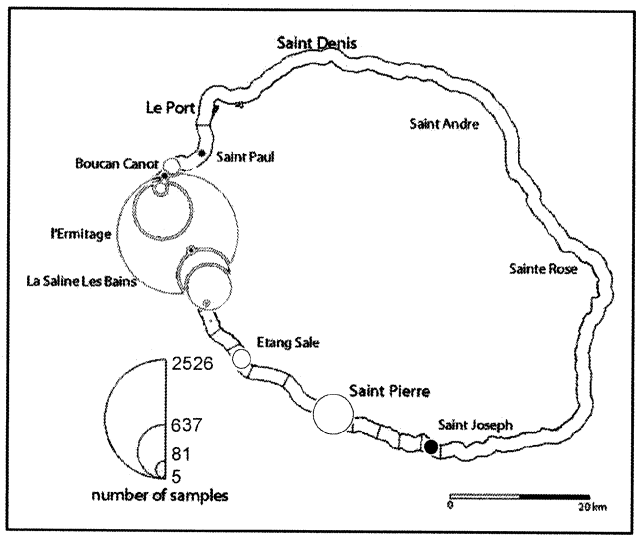

Fig. 2—Number of Observations

Ecosystem/habitats type

Fringing coral reefs in Réunion Island are well-studied since 1967. Most studies have focused on Saint-Gilles/La Saline reef complex (Fig. 2), which is the most important reef area in Reunion (48% of the total surface of reef flats). In contrast, start-up reefs (e.g. at Boucan Canot, Cap La Houssaye, …) and reef banks (e.g. at Manapany, Grand Bois, …) have not been studied. Moreover, shallow soft-bottom areas are poorly known. More recently, a research programme on sediment macrofauna was started in the University of Réunion Island. The cryptic fauna was largely unstudied. Similarly, sampling efforts on deep waters were relatively low. Because of strong wind, big swells and generally rough conditions, the east coast of the island is largely inaccessible and hence the biodiversity of rocky shores remains poorly investigated. However, according to Bigot (pers. comm.), the species richness in this habitat may be quite low, with facies often monospecific and comprising pioneer taxa.

Current Threats

Major changes in the structure of ecological communities coral reefs are attributed to a combination of natural factors, such as cyclones or exceptionally low tides, and anthropogenic factors such as polluted groundwater discharge. River run-off, sedimentation, farming, industrial and domestic wastes and sewage are other well-identified sources of disturbance[16]. These factors are often responsible for transitions for coral-dominated to algae-dominated benthic communities. Coastal urbanization development lead to eutrophication.

Coral bleaching is also a consequence of current threats, such as sedimentation and pollution, in addition with global warming. During 1997-1998, the extent of the bleaching in Réunion was moderate and mostly localized on reef flats, affecting only pre-stressed colonies[25]. During 2001, a localized bleaching event with varied intensities occurred in the lagoon of La Saline, where *A. formosa* dominates the benthic community. Livingstone site in La Saline was the most affected with 50 to 90% of corals bleached. As this time, the coastal waters were 0.5 to 1°C warmer than average (1993-2001 reference period), lagoon waters were subjected to large tidal and diurnal variations (Δ 6°C) and warmer conditions (32°C) were prevalent for a whole week. Monitoring showed that some colonies might remain bleached for 3 months. Spatial and temporal analyses of collected data (field observations, LIT, temperature variations, algal cover) show that as resistance of *A. formosa* colonies vary from place to place, environmental factors (topography, hydrology and currents, nutrient load) may influence the extent of bleaching and subsequent effects[26]. The study of bleaching events contributes to determine resilience and resistance factors for lagoon communities of Réunion reefs. These will be important for effective local issues regarding both Integrated Coastal Management and mitigating impacts of natural threats such as cyclones and/or climate change. Fishing and tourism comprise current threats for biodiversity and are sectors on which a degradation of the ecosystem can have strong socio-economic consequences.

Marine Protected Area

In spite of these current threats on biodiversity, habitats or ecosystem and on socio-economics, there are no marine protected area (MPA) so far in Réunion Island. A project has been on hold since several years. If chemical pollutions combine effects with over-harvesting and recreation activities, coral communities can evolve to a completely degraded state totally dominated by algae, as can be the case in following decades in Réunion[22]. Management, both for conservation of marine organisms and their habitats, and for a sustainable exploitation of marine resources, is therefore needed. One way to allow

efficiency of such management requirements is likely to have the best possible knowledge of marine biodiversity in the various biotopes.

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