

Visual Census of the Reef Fishes in the Natural Reserve of the Glorieuses Islands (Western Indian Ocean)

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Abstract—This paper constitutes the first qualitative study of coral reef fish populations in the archipelago of the Glorieuses Islands (northern Mozambique Channel). Sampling by visual census techniques, at depths between 0 and 15 meters, was carried out at 30 stations spread over the whole reef. Three hundred and thirty-two (332) fish species belonging to 57 families were registered in this way. These relatively high numbers show that isolated coral reef formations, even of small size, can be endowed with a great specific richness of reef ichthyofauna. These results may be explained by an oceanic flow that favours recruitment, a diversified habitat, and low anthropogenic impact.

INTRODUCTION

Located in the western Indian Ocean, the Glorieuses Archipelago (11°29'S, 47°23'E) is part of the five islands 'Iles Eparses', including Juan de Nova, Bassas da India, Europa and Tromelin. These French overseas territories, dispersed around Madagascar, have an Exclusive Economic Zone and cover nearly 650,000 km² (Gabrié, 1998). Four of the islands were classified as natural reserves in 1975, the exception being Juan de Nova (Le Corre & Safford, 2001). Oceanographical research in these environments was restarted a few years ago under the direction of the IFRECOR (Initiative Française pour les Récifs Coralliens) after periods of coral bleaching in the region in 1998. One of the main areas of research consists in the evaluation of the specific richness of the coral reef and the drawing up of an index as a means to conceive a management plan and preservation of the environment. Over the last 25 years, only a few

selective missions have enabled observations of some invertebrates and the morphology of the islands (Vergonzanne, 1977; Battistini & Cremers, unpublished data). More recently, research has been conducted on beach dynamics (Troadec, unpublished data) and sea birds (Le Corre & Safford, 2001). To our knowledge, no data have been published on the ichthyological fauna of this reef area. Therefore, the present study was carried out with the objective of establishing a baseline inventory of reef fish species of the Glorieuses Islands, followed by a discussion of the particularities of this archipelago.

MATERIALS AND METHODS

The Glorieuses archipelago is composed of two principal coral islands, the 'Grande Glorieuse', which is 3 km in diameter and characterised by a group of dunes attaining an altitude of 12 m, and the 'Petite Glorieuse' (or Lys Island), with a

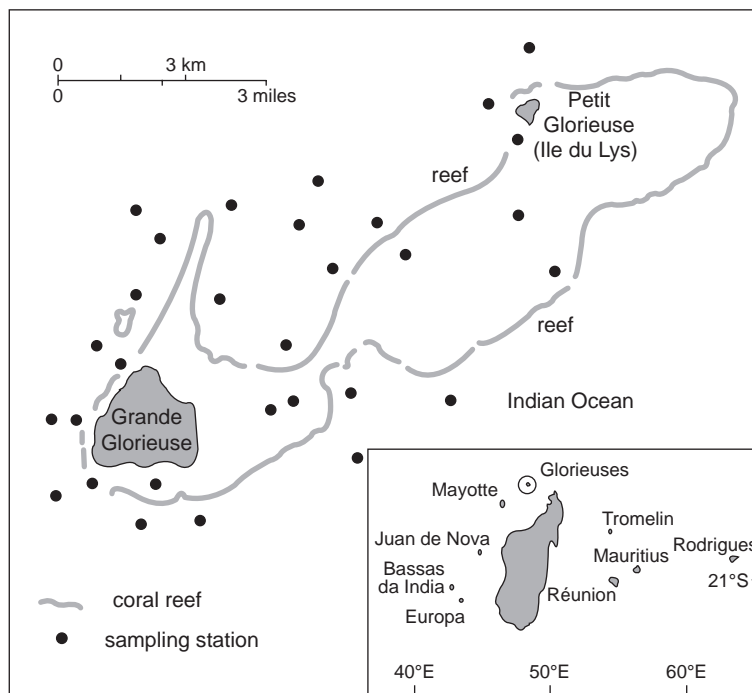


Fig. 1. Geographical location of the Glorieuses Islands and the position of sampling stations

diameter of 0.6 km and a bog formation at its centre. Two rock formations, the 'Roches Vertes' and 'Crabes Island', along with sandbars that more or less emerge at low tide, complete the archipelago. The whole of the coral formation represents an area of about 7 km². It is a coral bank built on a shoal (Vergonzanne, 1977), so there are no distinct geomorphologic areas, apart from a few fringe formations found around the two principal islands (Fig.1).

The oceanographic fieldwork took place over a 10-day period in the beginning of November, 2002 (Austral summer). Sampling of species richness was conducted by underwater visual census techniques, mainly using a slate associated with video recording devices, at a depth of 0 and 15 metres. Using this visual method, qualitative results can be obtained without disturbing the population, though the small and cryptic components of the fish fauna are underestimated (Fowler, 1987). A total of 30 stations distributed along the reef (Fig. 1) were positioned by 1 or 2 divers who moved randomly over the area for 30 minutes, carefully indexing each new species. Finally, a study on the diet feeding habits

(according to Hiatt & Strasburg, 1960; Hobson, 1974; Harmelin-Vivien, 1979; Myers, 1999) was carried out and height trophic categories were considered: herbivores, omnivores, browsers of sessile invertebrates, diurnal carnivores, nocturnal carnivores, piscivores, diurnal planktivores and nocturnal planktivores.

RESULTS

Species richness

In total, 332 species belonging to 57 families were observed (Table 1). Only 5 species were cartilaginous fishes (Chondrichthyes), the 327 others being bony fishes (Osteichthyes). It was noted that 48% of the species belong to 6 principal families: the Labridae with the highest representation (45 species), the Pomacentridae (34 species), the Serranidae (27 species), the Acanthuridae (24 species), the Chaetodontidae (17 species), and finally the Scaridae (14 species). The remaining 52% included 51 families, where 23 (e.g. Carcharhinidae, Haemulidae) were represented only by a single species each.

Table 1. Inventory of the reef fishes of the Glorieuses Islands (from depths of 0–15 m)

Families - Species	Feeding habits
CARCHARHINIDAE	
<i>Carcharhinus amblyrhynchos</i> (Bleeker, 1856)	6
TORPEDINIDAE	
<i>Torpedo sinuspersici</i> (Olfers, 1831)	5
DASYATIDAE	
<i>Urogymnus asperrimus</i> (Bloch & Schneider, 1801)	5
cf. <i>Dasyatis kuhlii</i> (Müller & Henle, 1841)	5
MYLIOBATIDAE	
<i>Aetobatus narinari</i> (Euphrasen, 1790)	4
MURAENIDAE	
<i>Echidna nebulosa</i> (Ahl, 1789)	5
<i>Gymnothorax flavimarginatus</i> (Rüppell, 1830)	5
<i>Gymnothorax javanicus</i> (Bleeker, 1859)	5
<i>Gymnothorax meleagris</i> (Shaw & Nodder, 1795)	5
<i>Rhinomuraena quaesita</i> Garman, 1888	5
<i>Siderea picta</i> (Ahl, 1789)	5
OPHICHTHIDAE	
Ophichthidae sp.	5
CONGRIDAE	
Congridae sp.	5
<i>Heteroconger hassi</i> (Klausewitz & Eibl-Eibesfeldt, 1959)	7
SYNODONTIDAE	
<i>Saurida gracilis</i> (Quoy & Gaimard, 1824)	6
<i>Synodus variegatus</i> (Lacepède, 1803)	6
<i>Synodus</i> sp.	6
CLUPEIDAE	
Clupeidae sp.	7
<i>Spratelloides</i> sp.	7
ENGRAULIDAE	
Engraulidae sp.	7
BELONIDAE	
Belonidae sp.	6
HEMIRAMPHIDAE	
<i>Hemiramphus</i> sp.	2
ANTENNARIIDAE	
<i>Antennarius</i> sp.	6
HOLOCENTRIDAE	
<i>Myripristis adusta</i> Bleeker, 1853	8
<i>Myripristis berndti</i> (Jordan & Evermann, 1903)	8
<i>Myripristis murdjan</i> (Forsskål, 1775)	8

Table 1. continued

Families - Species	Feeding habits
<i>Neoniphon opercularis</i> (Valenciennes in Cuvier & Valenciennes, 1831)	5
<i>Neoniphon sammara</i> (Forsskål, 1775)	5
<i>Sargocentron caudimaculatum</i> (Rüppell, 1838)	5
<i>Sargocentron diadema</i> (Lacepède, 1802)	5
<i>Sargocentron inaequalis</i> Randall & Heemstra, 1985	5
<i>Sargocentron spiniferum</i> (Forsskål, 1775)	5
AULOSTOMIDAE	
<i>Aulostomus chinensis</i> (Linné, 1766)	6
FISTULARIIDAE	
<i>Fistularia commersonii</i> Rüppell, 1838	6
SCORPAENIDAE	
<i>Pterois miles</i> (Bennett, 1828)	6
<i>Scorpenopsis</i> sp.	6
<i>Scorpenopsis</i> cf. <i>oxycephala</i>	6
CARACANTHIDAE	
<i>Caracanthus madagascariensis</i> (Guichenot, 1869)	5
SERRANIDAE	
<i>Aethaloperca rogae</i> (Forsskål, 1775)	5
<i>Cephalopolis argus</i> Bloch & Schneider, 1801	6
<i>Cephalopolis miniata</i> (Forsskål, 1775)	5
<i>Cephalopolis nigripinnis</i> (Valenciennes, 1828)	5
<i>Cephalopolis sexmaculata</i> (Rüppell, 1830)	5
<i>Cephalopolis urodeta</i> (Bloch & Schneider, 1801)	5
<i>Epinephelus fasciatus</i> (Forsskål, 1775)	5
<i>Epinephelus flavocaeruleus</i> (Lacepède, 1801)	6
<i>Epinephelus fuscoguttatus</i> (Forsskål, 1775)	6
<i>Epinephelus hexagonatus</i> (Forster in Bloch & Schneider, 1801)	5
<i>Epinephelus lanceolatus</i> (Bloch, 1790)	6
<i>Epinephelus longispinis</i> (Kner, 1864)	5
<i>Epinephelus malabaricus</i> (Bloch & Schneider, 1801)	6
<i>Epinephelus merra</i> Bloch, 1793	5
<i>Epinephelus polyphkadion</i> (Bleeker, 1849)	6
<i>Epinephelus spilotoceps</i> Schultz, 1953	5
<i>Epinephelus tauvina</i> (Forsskål, 1775)	6
<i>Epinephelus tukula</i> Morgans, 1959	6
<i>Nemanthias carberryi</i> Smith, 1954	7
<i>Plectropomus laevis</i> (Lacepède, 1801)	6
<i>Plectropomus pessuliferus</i> Fowler, 1904	6
<i>Plectropomus punctatus</i> (Quoy & Gaimard, 1824)	6
<i>Pseudanthias cooperi</i> (Regan, 1902)	7
<i>Pseudanthias evansi</i> (Smith, 1954)	7

Feeding habits- 1: herbivores; 2: omnivores; 3: browsers of sessile invertebrates; 4: diurnal carnivores; 5: nocturnal carnivores; 6: piscivores; 7: diurnal planktivores; 8: nocturnal planktivores.

Table 1. continued

Families - Species	Feeding habits
<i>Pseudanthias squamipinnis</i> (Peters, 1855)	7
<i>Variola albimarginata</i> Baissac, 1953	6
<i>Variola louti</i> (Forsskål, 1775)	6
GRAMMISTIDAE	
<i>Grammistes sexlineatus</i> (Thunberg, 1793)	5
APOGONIDAE	
<i>Apogon apogonoides</i> (Bleeker, 1856)	8
<i>Apogon cf. chrysotenia</i>	8
<i>Apogon kallopterus</i> Bleeker, 1856	8
<i>Apogon taeniophorus</i> Regan, 1908	8
<i>Cheilodipterus lineatus</i> Lacepède, 1801	8
<i>Cheilodipterus quinquelineatus</i> Cuvier in Cuvier & Valenciennes, 1828	8
KUHLIIDAE	
<i>Kuhlia mugil</i> (Forster in Bloch & Schneider, 1801)	7
GERREIDAE	
<i>Gerres oeyena</i> (Forsskål, 1775)	4
<i>Gerres</i> sp.	4
HAEMULIDAE	
<i>Plectorhinchus vittatus</i> (Linnaeus, 1758)	5
LUTJANIDAE	
<i>Aphareus furca</i> (Lacepède, 1801)	6
<i>Aprion virescens</i> Valenciennes in Cuvier & Valenciennes, 1830	6
<i>Lutjanus bohar</i> (Forsskål, 1775)	5
<i>Lutjanus fulvus</i> (Forster in Bloch & Schneider, 1801)	5
<i>Lutjanus gibbus</i> (Forsskål, 1775)	5
<i>Lutjanus kasmira</i> (Forsskål, 1775)	5
<i>Lutjanus monostigma</i> (Cuvier in Cuvier & Valenciennes, 1828)	5
<i>Lutjanus rivulatus</i> (Cuvier in Cuvier & Valenciennes, 1828)	5
<i>Macolor niger</i> (Forsskål, 1775)	5
CAESIONIDAE	
<i>Caesio caerulea</i> Lacepède, 1801	7
<i>Caesio lunaris</i> Cuvier in Cuvier & Valenciennes, 1828	7
<i>Caesio striata</i> Rüppell, 1830	7
<i>Caesio teres</i> Seale, 1906	7
<i>Caesio xanthonota</i> Bleeker, 1853	7
<i>Pterocaesio marri</i> Schultz, 1953	7
<i>Pterocaesio tile</i> (Cuvier in Cuvier & Valenciennes, 1828)	7
LETHRINIDAE	
<i>Gnathodentex aureolineatus</i> (Lacepède, 1802)	5
<i>Gymnocranius grandoculis</i> (Valenciennes in	

Table 1. continued

Families - Species	Feeding habits
Cuvier & Valenciennes, 1830)	5
<i>Lethrinus cf. atkinsoni</i> (Seale, 1909)	5
<i>Lethrinus erythracanthus</i> Valenciennes in Cuvier & Valenciennes, 1830	5
<i>Lethrinus mahsena</i> (Forsskål, 1775)	5
<i>Lethrinus rubrioperculatus</i> Sato, 1978	5
<i>Lethrinus xanthochilus</i> Klunzinger, 1870	5
<i>Lethrinus</i> sp.	5
<i>Monotaxis grandoculis</i> (Forsskål, 1775)	5
MULLIDAE	
<i>Mulloidichthys flavolineatus</i> (Lacepède, 1801)	5
<i>Mulloidichthys vanicolensis</i> (Valenciennes in Cuvier & Valenciennes, 1831)	5
<i>Parupeneus barberinus</i> (Lacepède, 1801)	4
<i>Parupeneus cyclostomus</i> (Lacepède, 1801)	6
<i>Parupeneus indicus</i> (Russell & Shaw, 1803)	4
<i>Parupeneus macronemus</i> (Lacepède, 1801)	4
<i>Parupeneus pleurostigma</i> (Bennett, 1832)	4
<i>Parupeneus porphyreus</i> (Jenkins, 1902)	4
<i>Parupeneus trifasciatus</i> (Lacepède, 1801)	4
KYPHOSIDAE	
<i>Kyphosus cinerascens</i> (Forsskål, 1775)	1
EPHIPPIDAE	
<i>Platax</i> sp.	2
POMACANTHIDAE	
<i>Apolemichthys trimaculatus</i> (Lacepède in Cuvier & Valenciennes, 1831)	2
<i>Centropyge acanthops</i> (Norman, 1922)	2
<i>Centropyge bispinosus</i> (Günther, 1860)	2
<i>Centropyge multispinis</i> (Playfair, 1867)	2
<i>Pomacanthus imperator</i> (Bloch, 1787)	3
<i>Pomacanthus semicirculatus</i> (Cuvier in Cuvier & Valenciennes, 1831)	3
<i>Pygoplites diacanthus</i> (Boddaert, 1772)	3
CHAETODONTIDAE	
<i>Chaetodon auriga</i> Forsskål, 1775	3
<i>Chaetodon falcula</i> Bloch, 1793	3
<i>Chaetodon guttatissimus</i> Bennett, 1832	3
<i>Chaetodon kleinii</i> Bloch, 1790	3
<i>Chaetodon lineolatus</i> (Quoy & Gaimard in Cuvier & Valenciennes, 1831)	3
<i>Chaetodon lunula</i> (Lacepède, 1802)	3
<i>Chaetodon madagaskariensis</i> Ahl, 1923	3
<i>Chaetodon meyeri</i> Bloch & Schneider, 1801	3
<i>Chaetodon trifascialis</i> Quoy & Gaimard, 1825	3

Feeding habits- 1: herbivores; 2: omnivores; 3: browsers of sessile invertebrates; 4: diurnal carnivores; 5: nocturnal carnivores; 6: piscivores; 7: diurnal planktivores; 8: nocturnal planktivores.

Table 1. continued

Families - Species	Feeding habits
<i>Chaetodon trifasciatus trifasciatus</i> Mungo Park, 1797	3
<i>Chaetodon unimaculatus interruptus</i> Ahl, 1923	3
<i>Chaetodon vagabundus</i> Linnaeus, 1758	3
<i>Chaetodon xanthocephalus</i> Bennett, 1832	3
<i>Chaetodon zanzibariensis</i> Playfair in Playfair & Günther, 1867	3
<i>Forcipiger longirostris</i> (Broussonet, 1782)	2
<i>Hemitaurichthys zoster</i> (Bennett, 1831)	7
<i>Heniochus monoceros</i> Cuvier in Cuvier & Valenciennes, 1831	3
MALACANTHIDAE	
<i>Malacanthus brevirostris</i> Guichenot, 1848	4
<i>Malacanthus latovittatus</i> (Lacepède, 1801)	4
ECHENEIDAE	
<i>Echeneis naucrates</i> Linnaeus, 1758	5
CARANGIDAE	
<i>Carangoides orthogrammus</i> Jordan & Gilbert, 1882	6
<i>Caranx ignobilis</i> (Forsskål, 1775)	6
<i>Caranx melampygus</i> Valenciennes in Cuvier & Valenciennes, 1833	6
<i>Caranx sexfasciatus</i> Quoy & Gaimard, 1825	6
<i>Elagatis bipinnulata</i> (Quoy & Gaimard, 1825)	6
<i>Scomberoides lysan</i> (Forsskål, 1775)	6
<i>Trachinotus baillonii</i> (Commerson & Lacepède in Lacepède, 1801)	6
<i>Trachinotus blochii</i> (Commerson & Lacepède in Lacepède, 1801)	6
CIRRHITIDAE	
<i>Cirrhitichthys oxycephalus</i> (Bleeker, 1855)	5
<i>Paracirrhites arcatus</i> (Parkinson in Cuvier & Valenciennes, 1829)	5
<i>Paracirrhites forsteri</i> (Bloch & Schneider, 1801)	5
PEMPHERIDAE	
<i>Parapriacanthus ransonneti</i> Steindachner, 1870	8
<i>Pempheris schwenkii</i> Bleeker, 1855	8
<i>Pempheris vanicolensis</i> Cuvier in Cuvier & Valenciennes, 1831	8
POMACENTRIDAE	
<i>Abudefduf notatus</i> (Day, 1870)	2
<i>Abudefduf sexfasciatus</i> (Commerson & Lacepède in Lacepède, 1801)	2
<i>Abudefduf sparoides</i> (Quoy & Gaimard, 1825)	2
<i>Abudefduf vaigiensis</i> (Quoy & Gaimard, 1825)	2
<i>Amblyglyphidodon leucogaster</i> (Bleeker, 1847)	2
<i>Amphiprion akallopisos</i> Bleeker, 1853	2
<i>Amphiprion allardi</i> Klauswitz, 1970	2
<i>Chromis atripectoralis</i> Welander & Schultz, 1951	7
<i>Chromis dimidiata</i> (Klunzinger, 1871)	7

Table 1. continued

Families - Species	Feeding habits
<i>Chromis nigrura</i> Smith, 1960	7
<i>Chromis opercularis</i> (Günther, 1867)	7
<i>Chromis ternatensis</i> (Bleeker, 1856)	7
<i>Chromis weberi</i> Fowler & Bean, 1928	7
<i>Chrysiptera biocellata</i> (Quoy & Gaimard, 1825)	2
<i>Chrysiptera glauca</i> (Cuvier in Cuvier & Valenciennes, 1830)	2
<i>Chrysiptera leucopoma</i> (Lesson in Cuvier & Valenciennes, 1830)	2
<i>Chrysiptera unimaculata</i> (Cuvier, 1830)	2
<i>Dascyllus aruanus</i> (Linnaeus, 1758)	7
<i>Dascyllus carneus</i> Fischer, 1885	7
<i>Dascyllus trimaculatus</i> (Rüppell, 1829)	7
<i>Lepidozygus tapeinosoma</i> (Bleeker, 1856)	7
<i>Neoglyphidodon melas</i> (Cuvier, 1830)	4
<i>Plectroglyphidodon dickii</i> (Liénard, 1839)	2
<i>Plectroglyphidodon johnstonianus</i> Fowler & Ball, 1924	2
<i>Pomacentrus caeruleus</i> Quoy & Gaimard, 1825	2
<i>Pomacentrus pavo</i> (Bloch, 1787)	2
<i>Pomacentrus sulfureus</i> Klunzinger, 1871	2
<i>Pomacentrus trichrourus</i> Günther, 1877	2
<i>Pomacentrus</i> sp.1	2
<i>Pomacentrus</i> sp. 2 <i>cf. coelestis</i>	2
<i>Stegastes albifasciatus</i> (Schlegel & Müller, 1839)	1
<i>Stegastes fasciolatus</i> (Ogilby, 1889)	1
<i>Stegastes nigricans</i> (Lacepède, 1802)	1
<i>Stegastes pelicierii</i> Allen & Emery, 1985	1
LABRIDAE	
<i>Anampses caeruleopunctatus</i> Rüppell, 1829	4
<i>Anampses lineatus</i> Randall, 1972	4
<i>Anampses meleagrides</i> Valenciennes in Cuvier & Valenciennes, 1840	4
<i>Anampses twistii</i> Bleeker, 1856	4
<i>Bodianus anthioides</i> (Bennett, 1832)	4
<i>Bodianus axillaris</i> (Bennett, 1832)	4
<i>Bodianus bilunulatus bilunulatus</i> (Lacepède, 1801)	4
<i>Bodianus diana</i> (Lacepède, 1801)	4
<i>Cheilinus fasciatus fasciatus</i> (Bloch, 1791)	4
<i>Cheilinus oxycephalus</i> Bleeker, 1853	4
<i>Cheilinus trilobatus</i> Commerson & Lacepède in Lacepède, 1801	4
<i>Cheilinus undulatus</i> Rüppell, 1835	4
<i>Cirrhilabrus exquisitus</i> Smith, 1957	4
<i>Coris africana</i> Smith, 1957	4
<i>Coris aygula</i> Lacepède, 1801	4
<i>Coris caudimacula</i> (Quoy & Gaimard, 1834)	4
<i>Cymolutes</i> sp.	4
<i>Epibulus insidiator</i> (Pallas, 1770)	4

Feeding habits- 1: herbivores; 2: omnivores; 3: browsers of sessile invertebrates; 4: diurnal carnivores; 5: nocturnal carnivores; 6: piscivores; 7: diurnal planktivores; 8: nocturnal planktivores.

Table 1. continued

Families - Species	Feeding habits
<i>Gomphosus caeruleus caeruleus</i> Lacepède, 1801	4
<i>Halichoeres cosmetus</i> Randall & Smith, 1982	4
<i>Halichoeres hortulanus</i> (Lacepède, 1801)	4
<i>Halichoeres iridis</i> Randall & Smith, 1982	4
<i>Halichoeres marginatus</i> Rüppell, 1835	4
<i>Halichoeres nebulosus</i> (Valenciennes in Cuvier & Valenciennes, 1839)	4
<i>Halichoeres scapularis</i> (Bennett, 1832)	4
<i>Hemigymnus fasciatus</i> (Bloch, 1792)	4
<i>Hemigymnus melapterus</i> (Bloch, 1791)	4
<i>Hologymnosus doliatus</i> (Lacepède, 1801)	4
<i>Labroides bicolor</i> Fowler & Bean, 1928	4
<i>Labroides dimidiatus</i> (Valenciennes in Cuvier & Valenciennes, 1839)	4
<i>Labropsis xanthonota</i> Randall, 1981	4
<i>Macropharyngodon bipartitus bipartitus</i> Smith, 1957	4
<i>Novaculichthys taeniourus</i> (Lacepède, 1801)	4
<i>Oxycheilinus digrammus</i> (Lacepède, 1801)	4
<i>Pseudocheilinus evanidus</i> Jenkins, 1901	4
<i>Pseudocheilinus hexataenia</i> (Bleeker, 1857)	4
<i>Pseudocheilinus octotaenia</i> Jenkins, 1901	4
<i>Pteragogus flagellifer</i> (Valenciennes in Cuvier & Valenciennes, 1839)	4
<i>Stethojulis albovittata</i> (Bonnaterre, 1788)	4
<i>Thalassoma amblycephalum</i> (Bleeker, 1856)	4
<i>Thalassoma hardwicke</i> (Bennett, 1830)	4
<i>Thalassoma hebraicum</i> (Lacepède, 1801)	4
<i>Thalassoma lunare</i> (Linnaeus, 1758)	4
<i>Thalassoma</i> sp.	4
<i>Xyrichtys pavo</i> Valenciennes in Cuvier & Valenciennes, 1840	4
SCARIDAE	
<i>Bolbometopon muricatum</i> (Valenciennes in Cuvier & Valenciennes, 1840)	4
<i>Cetoscarus bicolor</i> (Rüppell, 1829)	1
<i>Chlorurus sordidus</i> (Forsskål, 1775)	1
<i>Chlorurus strongylocephalus</i> (Bleeker, 1847)	1
<i>Hipposcarus harid</i> (Forsskål, 1775)	1
<i>Scarus caudofasciatus</i> (Günther, 1862)	1
<i>Scarus frenatus</i> Lacepède, 1802	1
<i>Scarus niger</i> Forsskål, 1775	1
<i>Scarus rubroviolaceus</i> Bleeker, 1847	1
<i>Scarus russellii</i> Valenciennes in Cuvier & Valenciennes, 1840	1
<i>Scarus scaber</i> Valenciennes in Cuvier & Valenciennes, 1840	1
<i>Scarus</i> sp.1	1
<i>Scarus</i> sp.2	1
<i>Scarus</i> sp.3	1
SPHYRAENIDAE	
<i>Sphyræna barracuda</i> (Walbaum, 1792)	6

Table 1. continued

Families - Species	Feeding habits
MUGILIDAE	
Mugilidae sp.	2
PINGUIPEDIDAE	
<i>Parapercis hexophtalma</i> (Ehrenberg in Cuvier & Valenciennes, 1829)	4
<i>Parapercis punctulata</i> (Cuvier in Cuvier & Valenciennes, 1829)	4
<i>Parapercis</i> sp.	4
CALLIONYMIDAE	
<i>Synchiropus stellatus</i> Smith, 1963	4
<i>Diplogrammus infulatus</i> Smith, 1963	4
BLENNIDAE	
<i>Aspidontus dussumieri</i> (Valenciennes in Cuvier & Valenciennes, 1836)	4
<i>Cirripectes</i> sp.	1
<i>Ecsenius midas</i> Starck, 1969	1
<i>Ecsenius</i> sp.	1
<i>Exallias brevis</i> (Kner, 1868)	1
<i>Istiblennius</i> sp.	1
<i>Meiacanthus mossambicus</i> Smith, 1954	1
<i>Plagiotremus rhinorhynchus</i> (Bleeker, 1852)	4
<i>Plagiotremus tapeinosoma</i> (Bleeker, 1857)	4
Blenniidae sp.	1
MICRODESMIDAE	
<i>Gunnellichthys</i> sp.	7
<i>Nemateleotris magnifica</i> Fowler, 1938	7
<i>Ptereleotris evides</i> (Jordan & Hubbs, 1925)	7
<i>Ptereleotris heteroperca</i> (Bleeker, 1855)	7
<i>Ptereleotris zebra</i> Fowler, 1938	7
GOBIIDAE	
<i>Amblyeleotris sungami</i> (Klausewitz, 1969)	2
<i>Eviota</i> sp.	2
<i>Fusigobius</i> sp.	2
<i>Gnatholepis</i> sp.	2
<i>Lotilia graciliosa</i> Klausewitz, 1960	2
<i>Valenciennea helsdingenii</i> (Bleeker, 1858)	4
<i>Valenciennea strigata</i> (Broussonet, 1782)	4
Gobiidae sp.1	2
Gobiidae sp.2	2
ACANTHURIDAE	
<i>Acanthurus bariene</i> Lesson, 1830	1
<i>Acanthurus dussumieri</i> Valenciennes in Cuvier & Valenciennes, 1835	1
<i>Acanthurus leucosternon</i> Bennett, 1833	1

Feeding habits- 1: herbivores; 2: omnivores; 3: browsers of sessile invertebrates; 4: diurnal carnivores; 5: nocturnal carnivores; 6: piscivores; 7: diurnal planktivores; 8: nocturnal planktivores.

Table 1. continued

Families - Species	Feeding habits
<i>Acanthurus lineatus</i> (Linnaeus, 1758)	1
<i>Acanthurus mata</i> Russell in Cuvier, 1829	7
<i>Acanthurus nigricauda</i> Duncker & Mohr, 1929	1
<i>Acanthurus nigrofuscus</i> (Forsskål, 1775)	1
<i>Acanthurus tennentii</i> Günther, 1861	1
<i>Acanthurus thompsoni</i> (Fowler, 1923)	1
<i>Acanthurus triostegus triostegus</i> (Linnaeus, 1758)	1
<i>Acanthurus xanthopterus</i> (Valenciennes in Cuvier & Valenciennes, 1835)	1
<i>Ctenochaetus binotatus</i> Randall, 1955	1
<i>Ctenochaetus striatus</i> (Quoy & Gaimard, 1825)	1
<i>Ctenochaetus strigosus</i> (Bennett, 1828)	1
<i>Naso brachycentron</i> (Valenciennes in Cuvier & Valenciennes, 1835)	1
<i>Naso brevirostris</i> (Cuvier, 1829)	1
<i>Naso hexacanthus</i> (Bleeker, 1855)	1
<i>Naso lituratus</i> (Forster in Bloch & Schneider, 1801)	1
<i>Naso thynnoides</i> (Valenciennes in Cuvier & Valenciennes, 1835)	7
<i>Naso tuberosus</i> Lacepède, 1801	1
<i>Naso unicornis</i> (Forsskål, 1775)	1
<i>Paracanthurus hepatus</i> (Linné, 1766)	1
<i>Zebrasoma scopas</i> (Cuvier, 1829)	1
<i>Zebrasoma velifer</i> (Bloch, 1795)	1
ZANCLIDAE	
<i>Zanclus canescens</i> (Linnaeus, 1758)	3
SIGANIDAE	
<i>Siganus laqueus</i> (Bonde, 1934)	1
<i>Siganus sutor</i> (Valenciennes in Cuvier & Valenciennes, 1835)	1
<i>Siganus</i> sp.	1
BOTHIDAE	
<i>Bothus mancus</i> (Broussonet, 1782)	4
SCOMBRIDAE	
<i>Gymnosarda unicolor</i> (Rüppell, 1836)	6
BALISTIDAE	
<i>Balistapus undulatus</i> (Mungo Park, 1797)	4
<i>Balistoides conspicillum</i> (Bloch & Schneider, 1801)	4
<i>Balistoides viridescens</i> (Bloch & Schneider, 1801)	4
<i>Melichthys niger</i> (Bloch, 1786)	7
<i>Pseudobalistes flavimarginatus</i> (Rüppell, 1829)	4
<i>Rhinecanthus aculeatus</i> (Linnaeus, 1758)	4
<i>Rhinecanthus rectangulus</i> (Bloch & Schneider, 1801)	2
<i>Sufflamen bursa</i> (Bloch & Schneider, 1801)	4
<i>Sufflamen chrysopterus</i> (Bloch & Schneider, 1801)	4
<i>Sufflamen fraenatus</i> (Latreille, 1804)	4

Table 1. continued

Families - Species	Feeding habits
MONACANTHIDAE	
<i>Amanses scopas</i> (Cuvier, 1829)	3
<i>Cantherhines dumerilii</i> (Hollard, 1854)	3
<i>Cantherhines pardalis</i> (Rüppell, 1837)	3
OSTRACIIDAE	
<i>Lactoria cornuta</i> (Linnaeus, 1758)	3
<i>Ostracion cubicus</i> Linnaeus, 1758	3
<i>Ostracion meleagris</i> Shaw in Shaw & Nodder, 1796	3
TETRAODONTIDAE	
<i>Arothron hispidus</i> (Linné, 1758)	5
<i>Arothron meleagris</i> (Commerson & Lacepède in Anonymus, 1798)	5
<i>Arothron nigropunctatus</i> (Bloch & Schneider, 1801)	5
<i>Arothron stellatus</i> (Commerson & Lacepède in Anonymus, 1798)	5
<i>Canthigaster bennetti</i> (Bleeker, 1854)	2
<i>Canthigaster janthinoptera</i> (Bleeker, 1855)	2
<i>Canthigaster solandri</i> (Richardson, 1844)	2
<i>Canthigaster valentini</i> (Bleeker, 1853)	2
DIODONTIDAE	
<i>Diodon hystrix</i> Linnaeus, 1758	5

Feedings habits- 1: herbivores; 2: omnivores; 3: browsers of sessile invertebrates; 4: diurnal carnivores; 5: nocturnal carnivores; 6: piscivores; 7: diurnal planktivores; 8: nocturnal planktivores.

Trophic structure

Among the species sampled, 73% were carnivores, feeding on zooplankton, fish, and/or invertebrates (Fig. 2). Among those, the small diurnal (Labridae) and nocturnal (Lutjanidae, Lethrinidae) carnivores were the most highly represented species, composing 23 and 17%, respectively of those species observed, followed by piscivores or high-ranking predators (Carangidae, Serranidae) composing 10%, then by diurnal (Caesionidae) and nocturnal (Apogonidae, Pempheridae) planktivores, 15%. Within the planktivores, the browsers of sessile invertebrate (Chaetodontidae) represented 8% of the species observed. For the other trophic categories, the herbivores (Acanthuridae, Scaridae) represented 15% of the total indexed species, while the omnivores (mainly Pomacentridae) represented 12%.

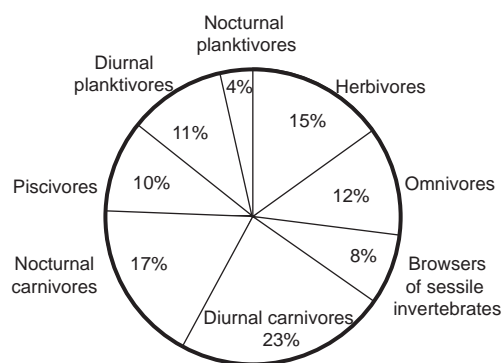


Fig. 2. Trophic structure, expressed in percentages of total number of species

DISCUSSION

Species richness

In total, 332 species were registered during this study. Despite the study's limited duration (10 days) and the use of visual observation, which typically underestimates global populations (Harmelin-Vivien et al., 1985), the fish species richness of the Glorieuses Islands proved to be elevated for isolated reefs of small surface area. Reef fish populations of small oceanic islands such as these, are sometimes considered as poor in species (Hourigan & Reese, 1987; Randall, 1998). However, in the Cocos Islands and Malpego (eastern Pacific), a specific richness higher than 220 species was recorded (Robertson, 2001), all the while remaining inferior to that of regional fauna (on average 1/3 fewer species). In the western Indian Ocean, 294 species were recorded in Geyser and Zélée (Chabanet et al., 2002), 239 in Mayotte (Letourneur, 1996; Chabanet, 2002), 300 in Rodrigues (Heemsta et al., unpublished data), and 257 in Réunion (Chabanet, 1994); all these data were recorded using visual observation, at between 5 and 15 m depth. Furthermore, 305 species were indexed essentially by fishing methods in Bassas da India (Van der Elst & Chater, 2001). Also Fricke (1999) indexed 1123 species of fish in The Mascarene Islands (Réunion, Mauritius, Rodriguez) from working on collections.

The Glorieuses Islands are unique in that

though small and relatively isolated (200 km of Madagascar, 250 km of Mayotte and 250 km of Aldabra), the islands possess a high species richness, even superior to that of other coral reefs in the western Indian Ocean.

Recent studies have shown that auto-recruitment was frequent in isolated coral zones (Galzin et al., 1998; Jones et al., 1999; Cowen et al., 2000; Fowler et al., 2000). It could account for a significant part in the fish recruitment of the Glorieuses Islands. However, given the relatively high species richness of the islands and the similarity of species to those found on neighbouring coral reefs, auto-recruitment may well be associated with a regional recruitment from other coral reefs in the zone (Geyser and Zélée coral banks, Madagascar, Comoros archipelago, The Seychelles). In the central part of northern Mozambique regional recruitment is favoured by oceanic currents (convergence zone) that occur in the central part of the northern Mozambique Channel (Piton, 1989; Benny, 2002). Moreover, no rare or new species were noted in our study.

Some families like the Carcharhinidae or the Haemulidae were represented by a single species; it is probable that others of the same family were present on these reefs. Likewise, no species of either the families Syngathidae or Priacanthidae was observed during the sampling period, although these species are otherwise common in this zone of the Indian Ocean. Further investigations will be necessary in this case, to complete this initial fieldwork. In contrast, some families, like the Serranidae, Carangidae, or Lutjanidae were observed at all sampling stations. Despite the fact that no actual measurements of the fish were taken, these individuals tended to be adult and large-sized, showing almost no sign of fisheries impact and highlighting the beneficial effects of a conservation area for these families.

Trophic structure

The presence of a large number of carnivorous species on coral reefs, habitually varying between 60 and 80% of the observed species according to the geographic area considered, constitutes one characteristic of fish populations in coral reef environments (Harmelin-Vivien, 1979). As a

Table 2. Trophic structure of the fish communities, expressed in percentages of total number of species on different Indo-Pacific coral reefs. Data were recorded on the outer slope (depth between 0 and 15 m)

		Carnivores	Omnivores	Herbivores
Tuléar (Madagascar)	Harmelin-Vivien, 1979	74	13.5	12.5
Réunion	Chabanet, 1994	51	24	25
Mayotte	Chabanet, 2002	69	12.5	18.5
Geyser et Zélée	Chabanet et al., 2002	69	16	15
Glorieuses	This study	73	12	15

general rule, Harmelin-Vivien (1992) notes that the destruction of coral reefs (pollution, overfishing, bleaching) often results in a reduction of the number of these carnivores to the advantage of herbivores; something that does not seem to be the case in the Glorieuses Islands where the percentage of the number of carnivores species (73%) remains one of the highest in the western Indian Ocean (Table 2). It seems that the trophic structure of the fish population has not been affected at all (or only to a minimal extent) by even the slightest anthropomorphic or natural pressure, such as the massive coral bleaching that took place in 1998 (Quod, 1999; Wendling et al., 2000). A comparison of the percentages of the number of species by trophic category with other reefs in the zone shows that the data obtained in the Glorieuses Islands came closest to that of Tuléar coral reefs in Madagascar. This particular reef, studied actively over several years, was considered as a reference in terms of health of coral environments for a long time (Harmelin-Vivien, 1979). The reef of the Glorieuses archipelago represents, as such, a healthy environment that is relatively protected from human impact.

CONCLUSION

This first survey of the fish species richness of the Glorieuses Islands highlights an exceptional patrimonial character. The isolation and the small size of this coral system do not appear to be limiting factors in terms of biodiversity. Despite an underestimation of small cryptic species and those from coastal pools that were not taken into account in this study, 332 species were indexed in just 10 days of observation, a number that is equivalent or even superior to other coral reefs in the western Indian Ocean.

The Glorieuses Islands, shielded from anthropogenic impact not only by their status and their isolation, but also by the permanent presence of a French military detachment, offer one of the rare examples of coral sanctuaries where human intervention is controlled and restricted. They are thus privileged sectors for the scientific observation of underwater fauna and flora and should be used as reference stations for sustained study of reefs on a worldwide scale.

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