



Annual Report of Benthos, Reef Fish and Invertebrate Surveys for Reef Slope and Reef Flat Areas in Rodrigues 2007

E. R. Hardman, F.E. I. Blais, M. S. Desiré, J.S.J Raffin, S. Perrine and Taylor, L.

Shoals Rodrigues, Pointe Monier, Rodrigues

February 2008



Annual Report of Benthos, Reef Fish and Invertebrate Surveys for Reef Slope and Reef Flat Areas in Rodrigues 2007

E. R. Hardman, F.E.I. Blais, M.S. Desiré, J.S.J Raffin, S. Perrine, and Taylor, L.

Shoals Rodrigues, Pointe Monier, Rodrigues

Contents

1	Introduction	1
2	Materials and Methods	1
3	Results	3
3.1	Benthos	3
3.2	Fish	8
3.3	Invertebrates	13
3.4	Comparison over 5 years	18
3.41	Benthos	18
3.42	Fish	20
3.43	Invertebrates	21
3.5	Water Quality	23
4	Discussion	25
5	References	26
6	Appendices	28
6.1	Transect Locations	28
6.2	Benthic categories	32
6.3	Data Tables	35

List of Figures

Figure 1.	The location of reef monitoring sites around Rodrigues and the position of the 4 proposed marine reserves	2
Figure 2.	The percentage cover of the different benthic habitats at the 6 reef slope sites during (A) Summer (March) and (B) Winter (October)	4
Figure 3.	The proportion of coral cover consisting of each of the 9 growth form categories	5
Figure 4.	The percentage cover of the different benthic habitats at the 7 reef flat sites during (A) Summer (March) and (B) Winter (October)	6
Figure 5.	The proportion of coral cover consisting of each of the 9 growth form categories	7
Figure 6.	The distribution of fish families at the 6 reef slope survey sites during the summer survey (March-April)	9
Figure 7.	The distribution of fish families at the 7 reef flat survey sites during (A) Summer (March) and (B) Winter (October)	12
Figure 8.	The distribution of invertebrates at the 6 reef slope survey sites during (A) Summer (March) and (B) Winter (October)	15
Figure 9.	The distribution of invertebrates at the 7 reef flat survey sites during (A) Summer (March) and (B) Winter (October)	17

Figure 10. Multi-dimensional scaling plot of benthic composition on the reef slope at (A) Rivière Banane, (B) Passe Armand, (C) Grand Bassin and (D) Passe Demi between March 2002 and October 2007. The circles highlight dates with a similar benthic composition.....	18
Figure 11. Multi-dimensional scaling plot of benthic composition on the reef flat at (A) Rivière Banane, (B) Passe Armand, (C) Grand Bassin (D) Trou Blanc, (E) Passe Cabris and (F) Ile aux Fous between March 2002 and October 2007. The circles highlight dates with a similar benthic composition.....	19
Figure 12. Multi-dimensional scaling plot of fish community composition on the reef slope at (A) Rivière Banane, (B) Passe Armand, (C) Grand Bassin and (D) Passe Demi between March 2002 and October 2007. The circles highlight dates with a similar fish community composition.....	20
Figure 13. Multi-dimensional scaling plot of fish community composition on the reef flat at (A) Rivière Banane, (B) Passe Armand, (C) Grand Bassin (D) Trou Blanc, (E) Passe L'Ancre and (F) Passe Cabris between March 2002 and October 2007. The circles highlight dates with a similar fish community composition.....	21
Figure 14. Multi-dimensional scaling plot of invertebrate community composition on the reef slope at (A) Rivière Banane, (B) Passe Armand, (C) Grand Bassin (D) Passe Demi and (E) North Ile aux Sables between March 2002 and October 2007. The circles highlight dates with a similar invertebrate community composition.....	22
Figure 15. Multi-dimensional scaling plot of invertebrate community composition on the reef flat at (A) Rivière Banane, (B) Passe Armand, (C) Grand Bassin (D) Trou Blanc and (E) Passe L'Ancre between March 2002 and October 2007. The circles highlight dates with a similar invertebrate community composition.....	23
Figure 16. The mean nitrate concentration (mg l ⁻¹) (±SE) at the 13 survey sites during March/April 2007.....	24
Figure 17. The mean sea temperature based on continuous temperature loggers at the reef flat sites at Ile aux Fous, Grand Bassin and Passe Cabris between March 2006 and December 2007.....	24

List of Tables

Table 1. The location of the monitoring sites at which surveys were carried out.....	1
Table 2. The mean number of coral recruits per settlement tile at each of the 3 surveys sites during summer (October-March) and winter (March-October).....	8
Table 3. The mean number of individuals, species, genera and families and species diversity indices for the fish communities at each of the 6 reef slope sites during summer (March)	8
Table 4. The percentage of the 12 key fish species observed, which were below the published length of maturity (FishBase, 2006) at the 6 reef slope sites (RB = Riviere Banane, PA = Passe Armand, GB = Grand Bassin, PD = Passe Demi, IS = North Ile aux Sables, IF = Ile aux Fous) during Summer (March) and Winter (October).....	10
Table 5. The mean number of individuals, species, genera and families and species diversity indices for the fish communities at each of the 7 reef flat sites during summer (March)	11
Table 6. The percentage of the 12 key fish species observed, which were below the published length of maturity (FishBase, 2006) at the 7 reef flat sites (RB = Riviere Banane, PA = Passe Armand, GB = Grand Bassin, TB = Trou Blanc, PIA = Passe L'Ancre, IF = Ile aux Fous, PC = Passe Cabris) during Summer (March) and Winter (October).....	13

Table 7. The mean number of individuals and species and species diversity indices for the invertebrate communities at each of the 6 reef slope sites during summer (March) and winter (October).....	14
Table 8. The mean number of individuals and species and species diversity indices for the invertebrate communities at each of the 7 reef flat sites during summer (March) and winter (October).....	16

Acknowledgements

This work was funded by the U.K. Department for Environment, Food and Rural Affairs (DEFRA) Darwin Initiative, the North of England Zoological Society (Chester Zoo), WWF and the Fonds Français pour l'Environnement Mondial. Thank you to Dr Alasdair Edwards from the University of Newcastle upon Tyne, UK and Dr Charles Anderson from Manta Marine Ltd., Maldives for advice on survey methodology. *Shoals Rodrigues* would also like to acknowledge the co-operation of the Rodrigues Regional Assembly and the Mauritius Oceanography Institute in the undertaking of this work.

Abstract

Surveys of reef composition and fish and invertebrate populations were undertaken using the Global Coral Reef Monitoring Network methodology during March/April 2007 and October/November 2007, to continue a monitoring programme that began in 1999. Nine sites around the fringing reef were included: Rivière Banane, Passe Armand, Grand Bassin and Ile aux Fous (reef flat and reef slope stations), Passe Cabris, Trou Blanc and Passe L'Ancre (reef flat stations only) and Passe Demi and North Ile aux Sables (reef slope only). The surveys show that coral cover is high on the reef slopes at Rivière Banane, Grand Bassin and Ile aux Fous (>45%), but is low at Passe Demi, North Ile aux Sables and Passe Armand (<30%). In contrast, coral cover was low on all reef flat sites (<30%) indicating that these reefs are being subjected to human and natural impacts. Coral settlement was low, suggesting that these reefs have a limited ability to recover from impacts such as coral bleaching. The fish community at all sites tended to be dominated by Damselfish. Emperors, Snappe, Trevally and Grouper were rare or absent and no Triggerfish, were observed at any site during the surveys. This lack of large piscivorous predators suggests that the fish population may be unbalanced due to overfishing. Fish communities are also dominated by small, under-sized individuals, further indications of overfishing. Invertebrates were low on the reef slope sites and most sites were dominated by the bio-eroding urchin, *Echinometra mathaei*; this species also dominated the reef flat sites. At all sites, molluscs and crustaceans were either rare or absent; in particular *Tridacna* clams were in low abundance and large gastropods such as *Pleuroploca trapezium* were not observed. This may be an indication that local consumption is resulting in over-harvesting. It is suggested that the development of marine reserves will protect the healthy reef slopes from future impacts and aim to facilitate recovery of the degraded reef flat areas.

1 Introduction

Rodrigues is surrounded by a fringing reef, which forms an almost continuous band measuring approximately 90km in length. The reef encloses a shallow lagoon, which, at 240km², is twice the area of the island itself. The maximum tidal range is approximately 1.5m, and since the average water depth in the lagoon is less than 2m, many areas are exposed at low spring tides. The water depth immediately beyond the reef slopes is usually within the range of 10m to 30m. The island has three major channels, one dredged channel for the main harbour at Port Mathurin in the north, and natural channels in the south near Port Sud Est and in the East at St Francois. Several small passes are also found at intervals around the reef.

The reefs of the island consist mainly of scleractinian corals, with *Acropora* spp. dominant on both the reef flat and reef slope. 140 species of coral were recorded in Rodrigues during the first Marine Biodiversity Workshop held in September 2001, of which 25 were *Acropora* spp. (*Shoals of Capricorn Programme*, 2002). The coral cover on the reef slopes around Rodrigues is relatively healthy, while reef flat areas are more heavily impacted, both by fishing (particularly trampling by octopus fishers (Clark, 2001)) and by bleaching events (Hardman *et al.*, 2004).

In order to evaluate temporal changes in the health of the coral reef and the populations of fish and invertebrates that it supports, monitoring activities have been carried out since 1999. The data is also made available to the Global Coral Reef Monitoring Network (GCRMN), being submitted via the regional network administered by the Indian Ocean Commission. This report details findings of the GCRMN monitoring activities that took place in 2005, and contains some comparisons with data from 2002 - 2006 (Hardman *et al.*, 2007; Hardman *et al.*, 2006; Lynch *et al.*, 2004a; Lynch *et al.*, 2004b).

2 Materials and Methods

Surveys were carried out at six reef slope and seven reef flat stations around the island by *Shoals Rodrigues* staff in March/April and October/November 2007. Of these, the stations at Rivière Banane, Grand Bassin, Passe Demi and Passe Cabris were within the 4 proposed marine reserves, whilst the remaining stations were outside of the proposed reserves. The site locations are listed in Table 1 and shown in Figure 1.

Table 1. The location of the monitoring sites at which surveys were carried out

Site Name	Reef flat GPS Position	Reef slope GPS Position
Rivière Banane	19° 40.224' S; 63° 28.224' E	19° 40.154' S; 63° 28.484' E
Passe Armand	19° 40.272' S; 63° 24.982' E	19° 40.084' S; 63° 24.677' E
Grand Bassin	19° 39.408' S; 63° 21.447' E	19° 39.381' S; 63° 21.366' E
Trou Blanc	19° 45.401' S; 63° 28.443' E	
Passe L'Ancre	19° 48.825' S; 63° 25.613' E	
Passe Demi		19° 42.515' S; 63° 17.562' E
N Ile aux Sables		19° 40.770' S; 63° 17.984' E
Passe Cabris	19° 39.587' S; 63° 26.406' E	
Ile aux Fous	19° 39.313' S; 63° 23.593' E	19° 39.218' E; 63° 23.977' E

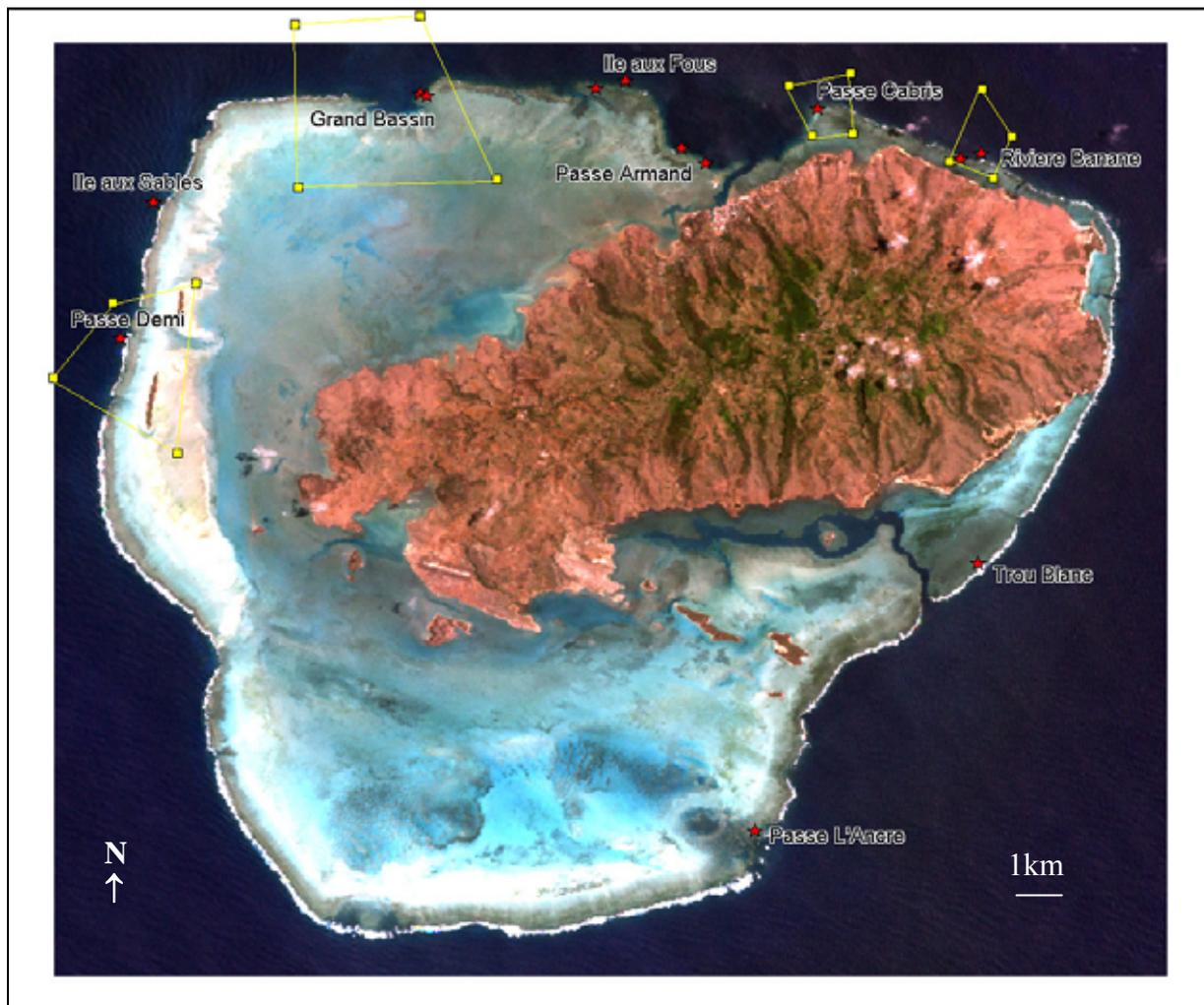


Figure 2. The location of reef monitoring sites around Rodrigues and the position of the 4 proposed marine reserves.

The depth on the reef flat was approximately 1m, while surveys on the reef slope took place at between 6m and 12m depth. Reef flat monitoring was carried out by snorkelling, with SCUBA used for reef slope surveys. The location of the site was recorded on a GPS and transects marked by metal bars and buoys. The methodology used was that of the Indian Ocean Commission regional reef monitoring network as described in their manual (Conand *et al.*, 1997), for which three transects were laid at each station. To facilitate replication of the surveys, the transects were permanently marked at 0m, 5m, 10m, 15m and 20m, using 1m lengths of concrete re-enforcing bar hammered into the reef. Settlement tiles were placed at the reef slope sites at Passe Armand, Rivière Banane and Grand Bassin. Tiles were collected and replaced every 6 months to identify seasonal changes in coral settlement.

Counts of all fish encountered were carried out for a belt of 50 x 5m along each transect, by 2 observers while coverage of benthic species and abiotic features was determined by line intercept along the first 20m of each transect. Surveys of invertebrates were carried out by determining abundance of species over a belt 20 x 5m wide for each transect. The lengths of 12 key fish species were also estimated at each site (Anderson, 2006).

Permanent temperature loggers were placed at 5 sites to record temperature every hour over a 21-month period (March 2006 – December 2007) and nutrient concentration (nitrates, nitrites and phosphates) were determined using the Palintest system.

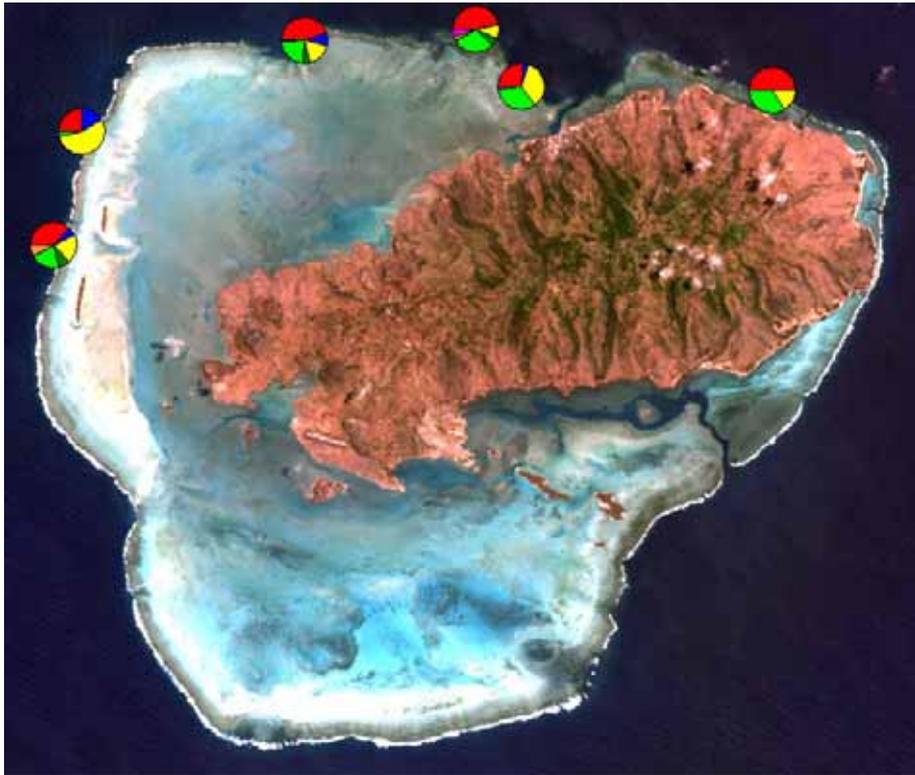
3 Results

3.1 Benthos

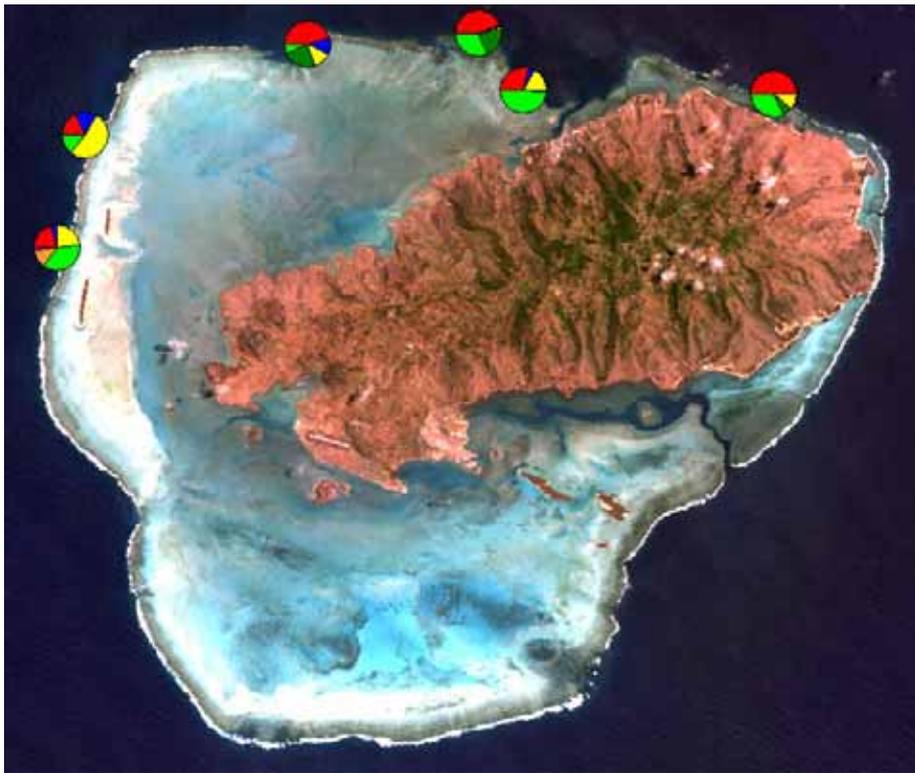
During the summer surveys, live hard coral cover on the reef slope was >45% at Grand Bassin, Rivière Banane and Ile aux Fous, but <40% at Passe Demi, North Ile aux Sables and Passe Armand (Figure 2). North Ile aux Sables had a high cover of the soft coral, *Sinularia* sp. (16%). The site at North of Ile aux Sables was dominated by coralline algae (54%), whilst Passe Armand and Passe Demi had a high cover of both coralline and turf algae (>20%). All sites had a low percentage of recently dead coral (<2%), rubble (<10%) and macro-algae (<10%).

During the winter surveys, live coral cover on the reef slopes was also >45% at Grand Bassin, Rivière Banane and Ile aux Fous and <30% at Passe Demi, North Ile aux Sables and Passe Armand. North Ile aux Sables had a high cover of the soft coral, *Sinularia* sp. (15%). The site at North of Ile aux Sables was dominated by coralline algae (54%), whilst Passe Armand and Passe Demi were dominated by turf algae (>35%). Macro-algae was high at Grand Bassin and Ile aux Fous (>20%), however rubble was low (<5%) and no dead coral was recorded.

In both summer and winter surveys, the coral cover on all reef slope sites was dominated by branching *Acropora* spp., in particular *A. austera*, *A. abrotanoides* and *A. nobilis* (Figure 3). At Grand Bassin, Rivière Banane, Passe Armand and Passe Demi, the corals were dominated by branching *Acropora* spp. (>50%) with other growth forms forming only a low percentage cover. At Ile aux Fous and North Ile aux Sables, branching *Acropora* spp. constituted over 40% of coral cover and the massive corals *Platygyra daedalea* and *Leptoria phrygia* were also common (>25%).



(A) Summer



(B) Winter

Key

 Living Hard Coral	 Coralline Algae	 Zoanthids
 Soft Coral	 Macro-Algae	 Sand
 Dead Coral	 Turf Algae	 Rubble

Figure 2. The percentage cover of the different benthic habitats at the 6 reef slope sites during (A) Summer (March) and (B) Winter (October).



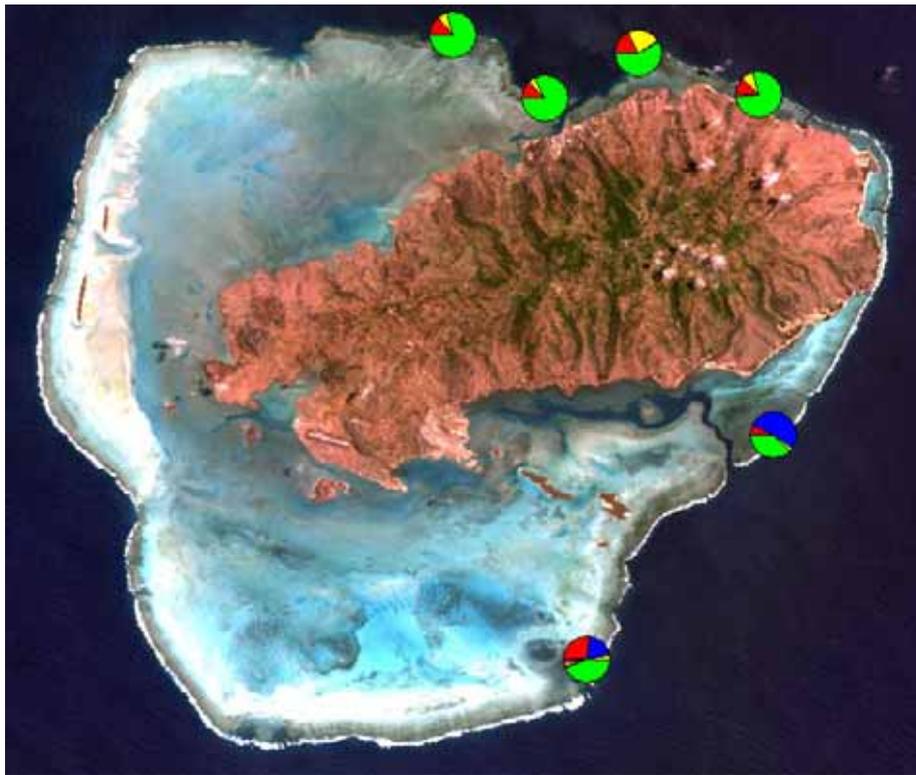
Key

■ Digitate Acropora	■ Encrusting Acropora	■ Massive Coral
■ Branching Acropora	■ Sub-massive Coral	■ Mushroom Coral
■ Tabular Acropora	■ Encrusting Coral	■ Fire Coral

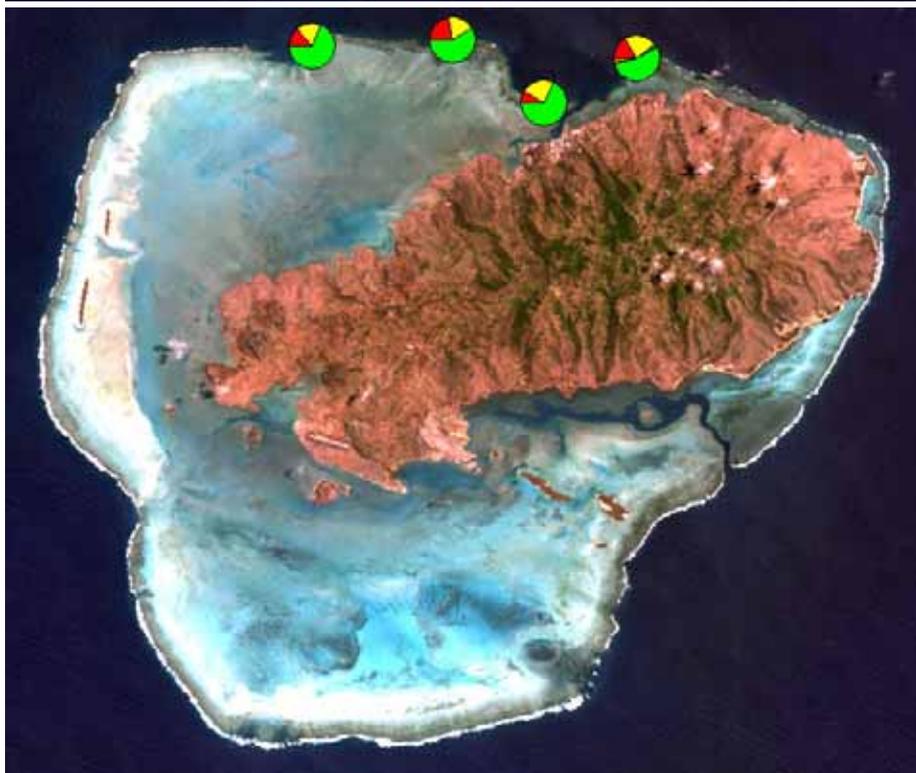
Figure 3. The proportion of coral cover consisting of each of the 9 growth form categories.

During the summer surveys, coral cover on the reef flat was 6-14% at Rivière Banane, Passe Armand, Trou Blanc and Ile aux Fous, 18% at Passe Cabris and 27% at Passe L'Ancre (Figure 4). The sites at Rivière Banane, Passe Armand and Ile aux Fous were dominated by turf algae (>75%), whereas Passe Cabris was dominated by a mixture of turf and coralline algae and the site at Trou Blanc was dominated by the soft corals *Xenia* sp. and *Efflatounaria* sp. (54%). Dead coral was only observed at Passe L'Ancre (<1%) and rubble was low (<5%) at all sites. No coral bleaching was observed.

During the winter surveys, coral cover was 8 – 14% at Passe Armand and Grand Bassin, 17% at Passe Cabris and 23% at Ile aux Fous; the remaining 2 sites could not be surveyed due to weather constraints. All 4 sites were dominated by turf algae (>50% cover). Dead coral was not observed during the survey and rubble was low (<1%) at all sites.



(A) Summer



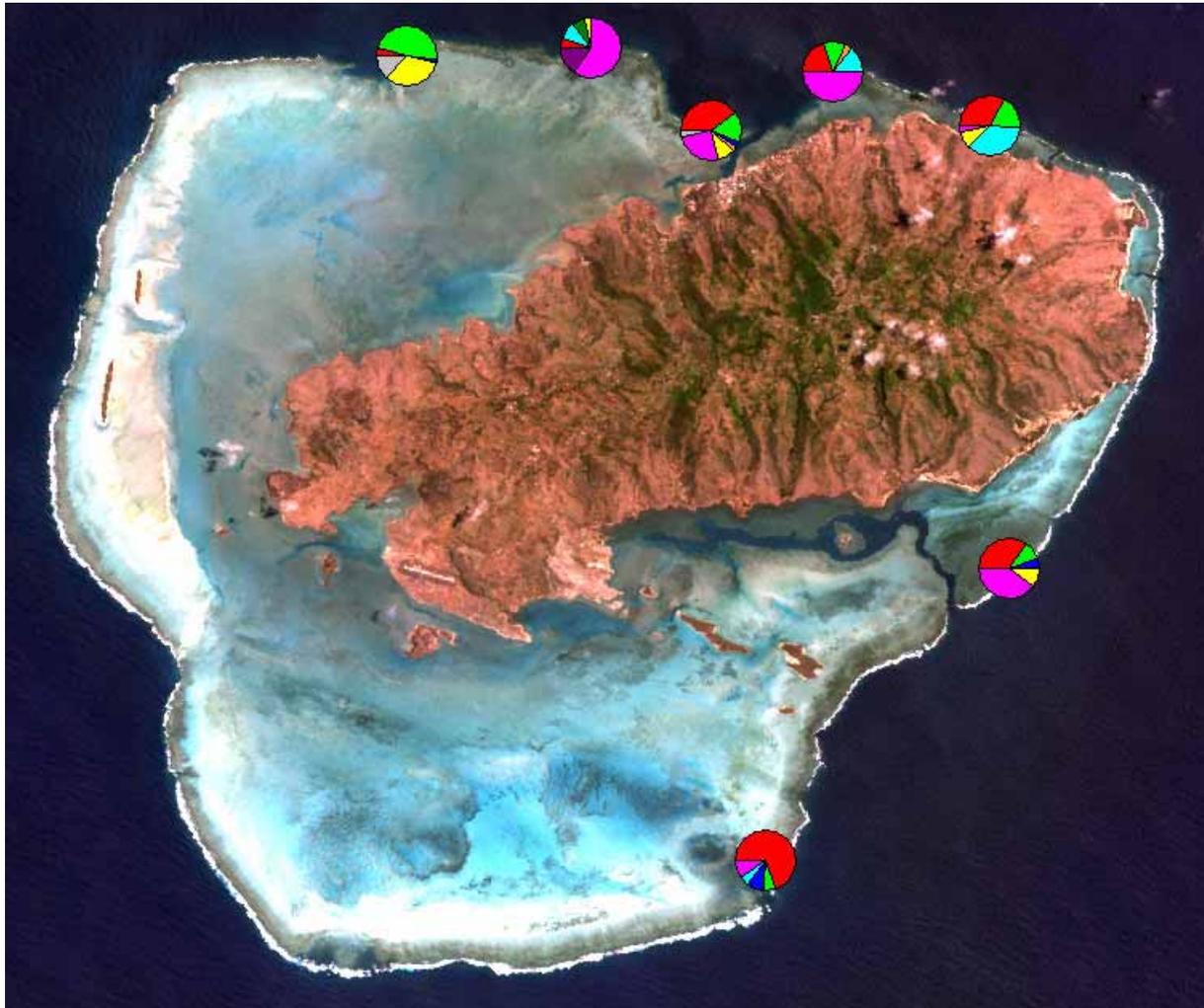
(B) Winter

Key

■ Living Hard Coral	■ Coralline Algae	■ Zoanthids
■ Soft Coral	■ Macro-Algae	■ Sand
■ Dead Coral	■ Turf Algae	■ Rubble

Figure 4. The percentage cover of the different benthic habitats at the 7 reef flat sites during (A) Summer (March) and (B) Winter (October).

The dominant coral growth forms were more variable on the reef flats than on the reef slope with sub-massive and encrusting growth forms more common (Figure 5). Live hard coral was however dominated by branching *Acropora* spp. at Passe Armand (*A. nobilis* and *A. abrotanoides*), Rivière Banane (*A. abrotanoides*), Trou Blanc (*A. formosa*) and Passe L'Ancre (*A. formosa*). Digitate *Acropora* sp. dominated Grand Bassin (*A. digitifera*) whereas at Ile aux Fous and Passe Cabris sub-massive species were dominant (*Porites rus* and *Montipora spumosa*).



Key

- | | | |
|--|--|--|
| ■ Digitate Acropora | ■ Foliose Coral | ■ Massive Coral |
| ■ Branching Acropora | ■ Sub-massive Coral | ■ Mushroom Coral |
| ■ Tabular Acropora | ■ Encrusting Coral | ■ Fire Coral |

Figure 5. The proportion of coral cover consisting of each of the 9 growth form categories.

Coral settlement was low at all sites, and it did not suggest a seasonal recruitment pattern; geographical variations were also difficult to determine. During the period October to March (summer), coral settlement varied from 0 recruits at Rivière Banane to 1.6 recruits per tile at Passe Armand (Table 2). During March to October (winter), coral settlement varied from 0 recruits at Grand Bassin to 1.3 recruits per tile at Rivière Banane. During the winter surveys,

recruits were from the family Pocilloporidae and were all approximately 2mm in diameter, suggesting that they had settled approximately 3 months ago.

Table 2. The mean number of coral recruits per settlement tile at each of the 3 surveys sites during summer (October-March) and winter (March-October).

	Rivière Banane	Grand Bassin	Passe Armand
Summer	0.0	0.2	1.6
Winter	1.3	0.0	0.2

3.2 Fish

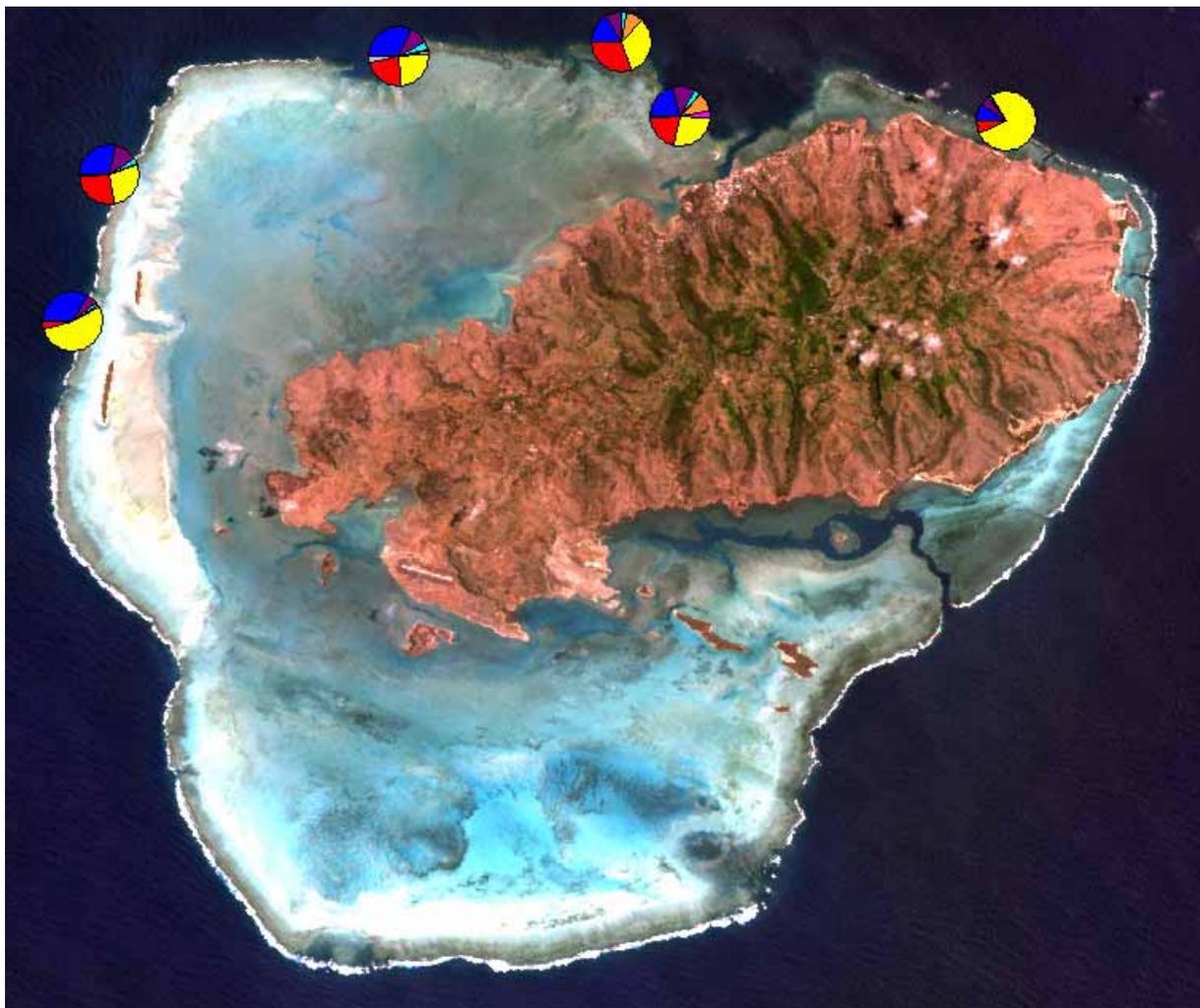
Fish abundance was only recorded during the summer surveys due to logistical reasons. On the reef slopes the highest number of individuals was recorded at Ile aux Fous (mean of 232 individuals) and Rivière Banane (mean of 229 individuals) and the lowest number at North Ile aux Sables (79 individuals) (Table 3). The highest number of species was observed at Passe Armand (38 species) and the highest number of genera at Rivière Banane (26 genera). The lowest numbers of species, genera and families were recorded at North Ile aux Sables (23 species, 20 genera and 8 families) and Ile aux Fous (32 species, 19 genera and 8 families). Species Diversity calculated using the Shannon-Weiner Diversity Index was highest at North Passe Armand ($H' = 2.473$) and lowest at Rivière Banane and Passe Demi ($H' = 1.878$ and $H' = 1.877$ respectively). Similarly, Pielou's Index of Evenness was highest at Passe Armand ($J = 0.789$) and lowest at Rivière Banane and Passe Demi ($J = 0.576$ and $J = 0.599$, respectively).

Table 3. The mean number of individuals, species, genera and families and species diversity indices for the fish communities at each of the 6 reef slope sites during summer (March).

	Rivière Banane	Passe Armand	Grand Bassin	Passe Demi	Ile aux Fous	Ile aux Sables
No. Individuals	229.0	130.7	114.3	189.7	232.3	79.0
No. Species	31.0	38.0	32.0	31.0	32.0	23.0
No. Genera	26.0	23.0	21.0	23.0	19.0	20.0
No. Families	11.0	11.0	11.0	9.0	8.0	8.0
H'	1.878	2.473	2.173	1.877	2.134	2.153
J'	0.576	0.789	0.714	0.599	0.725	0.719

The most commonly observed families were damselfish (Pomacentridae), parrotfish (Scaridae) and surgeonfish (Acanthuridae). Damselfish dominated the reef slopes at all sites except for Grand Bassin and North Ile aux Sables and were particularly abundant at Rivière Banane (Figure 6). Pomacentridae were dominated by *Chromis* spp. at Rivière Banane and Passe Demi, *Pomacentrus* spp. at Passe Armand and Ile aux Fous and *Abudefduf* spp. at Grand Bassin and North Ile aux Sables. Surgeonfish (Acanthuridae) dominated the fish community at Grand Bassin and North Ile aux Sables and were also common at Passe Armand and Passe Demi. Parrotfish were common at Passe Armand, Grand Bassin, Ile aux Fous and North Ile aux Sables. The number of Butterflyfish (Chaetodontidae) per site ranged from a mean of 1 to 5 individuals. Emperors (Lethrinidae) were only represented by 1 species (*Gnathodentex aurolineatus*) and were absent at Passe Demi and North Ile aux Sables. Lutjanidae were only present at Passe Armand and Grand Bassin and Carangidae at Rivière Banane and Passe Demi, where both families were rare. Groupers (Serranidae) were also rare and no Triggerfish (Balistidae) were recorded at any site.

During the summer surveys, the majority of individuals of the 12 key fish species observed were juveniles (Table 4). At Grand Bassin however 100% of *Lutjanus fulvus* were above the length of maturity; all *Mulloidichthys vanicolensis* at Ile aux Fous and all *Mulloidichthys flavolineatus* at Rivière Banane were adults and all *Chaetodon trifasciatus* at North Ile aux Sables were also above the published length of maturity (FishBase, 2006). During the winter surveys, all individuals of *Mulloidichthys vanicolensis* observed at Rivière Banane were above the published length of maturity, as were the majority of *C. trifasciatus*, however the majority of *Epinephelus spilotoceps* individuals were juveniles.



Key

- | | | |
|--|---|---|
| ■ Acanthuridae | ■ Serranidae | ■ Pomacentridae |
| ■ Labridae | ■ Lethrinidae | ■ Scaridae |
| ■ Chaetodontidae | ■ Mullidae | ■ Other |

Figure 6. The distribution of fish families at the 6 reef slope survey sites during the summer survey (March-April).

Table 4. The percentage of the 12 key fish species observed, which were below the published length of maturity (FishBase, 2006) at the 6 reef slope sites (RB = Riviere Banane, PA = Passe Armand, GB = Grand Bassin, PD = Passe Demi, IS = North Ile aux Sables, IF = Ile aux Fous) during Summer (March) and Winter (October).

(A) Summer

Species	Length at maturity (cm)	% Juveniles					
		RB	PA	GB	PD	IS	IF
<i>Epinephelus spilotoceps</i>	21.2	-	0	100	-	-	100
<i>Plectropomus laevis</i>	65.2	-	-	-	-	-	-
<i>Lutjanus fulvus</i>	23.8	-	-	0	-	-	-
<i>Lethrinus nebulosus</i>	37.4	-	-	-	-	-	-
<i>Mulloidichthys flavolineatus</i>	24.0	0	80	100	-	-	-
<i>Mulloidichthys vanicolensis</i>	24.0	-	-	-	-	-	0
<i>Caranx melampygus</i>	51.3	100	-	-	100	-	100
<i>Chaetodon trifasciatus</i>	11.8	33	33	80	33	0	100
<i>Abudefduf sparoides</i>	10.6	-	-	-	-	-	100
<i>Scarus ghobban</i>	48.8	-	100	-	-	-	-
<i>Rhinecanthus aculeatus</i>	16.8	-	-	-	-	-	-
<i>Naso unicornis</i>	36.1	100	-	-	-	-	-

(B) Winter

Species	Length at maturity (cm)	% Juveniles					
		RB	PA	GB	PD	IS	IF
<i>Epinephelus spilotoceps</i>	21.2	-	100	67	-	-	80
<i>Plectropomus laevis</i>	65.2	-	-	-	-	-	-
<i>Lutjanus fulvus</i>	23.8	-	-	-	-	-	-
<i>Lethrinus nebulosus</i>	37.4	-	-	-	-	-	-
<i>Mulloidichthys flavolineatus</i>	24.0	-	100	-	-	-	-
<i>Mulloidichthys vanicolensis</i>	24.0	0	-	-	-	-	-
<i>Caranx melampygus</i>	51.3	-	-	-	-	-	100
<i>Chaetodon trifasciatus</i>	11.8	0	77	0	0	0	33
<i>Abudefduf sparoides</i>	10.6	-	0	-	-	-	-
<i>Scarus ghobban</i>	48.8	-	-	-	-	-	-
<i>Rhinecanthus aculeatus</i>	16.8	-	-	-	0	-	-
<i>Naso unicornis</i>	36.1	-	-	-	-	100	-

On the reef flat, the highest number of individuals was recorded at Passe L'Ancre (mean of 321 individuals) and the lowest number at Riviere Banane (mean of 88 individuals) (Table 5). The highest number of species and families were observed at Ile aux Fous (26 species, 18 genera and 7 families) and the lowest number of species and families were recorded at Passe Cabris (15 species, 12 genera and 5 families). Species Diversity calculated using the Shannon-Weiner Diversity Index was highest at Passe L'Ancre ($H' = 2.223$) and lowest at Trou Blanc ($H' = 1.288$). Pielou's Index of Evenness was highest at Passe Cabris and Pass L'Ancre ($J = 0.776$ and $J = 0.769$ respectively) and was lowest at Trou Blanc ($J = 0.488$).

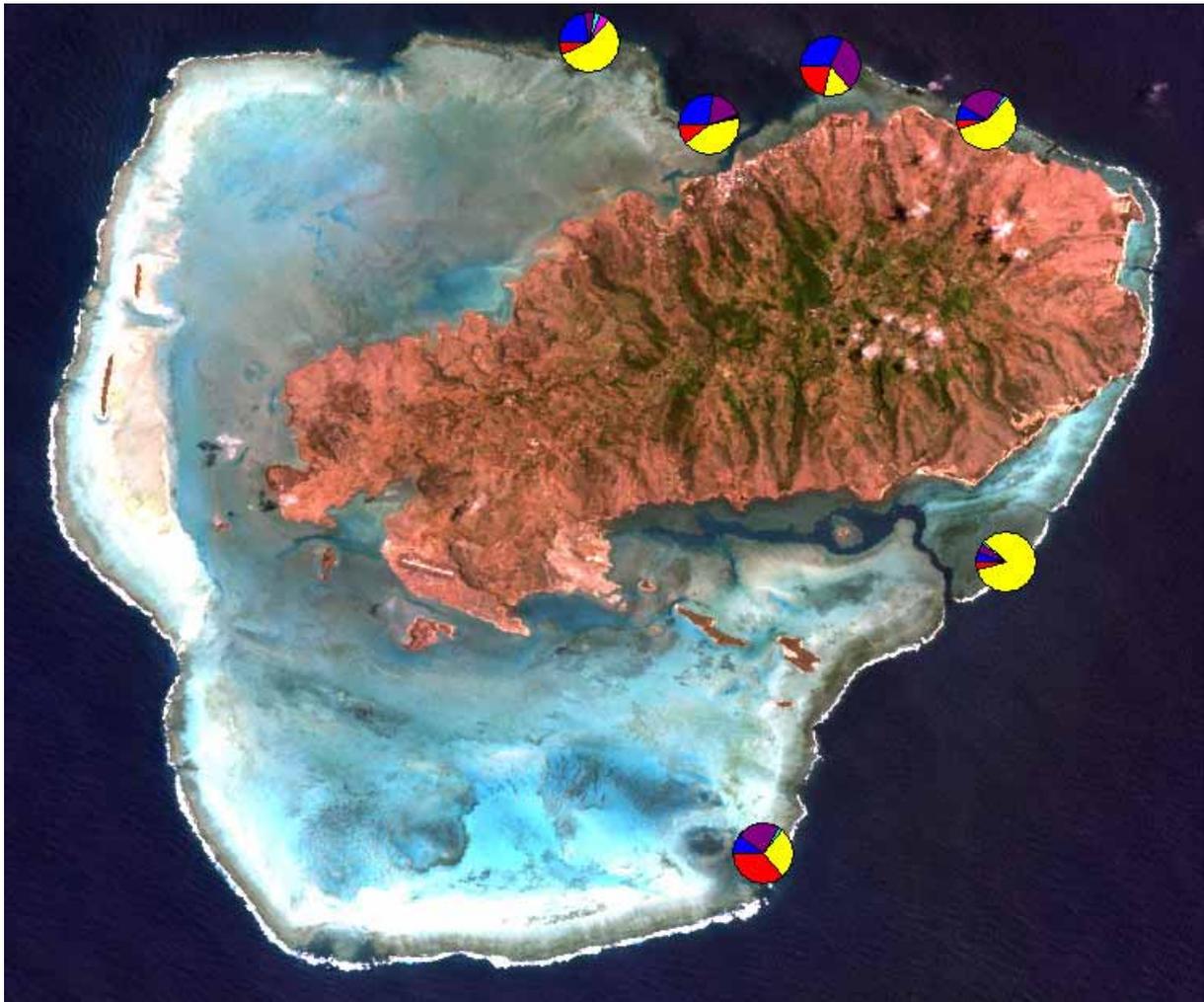
Table 5. The mean number of individuals, species, genera and families and species diversity indices for the fish communities at each of the 7 reef flat sites during summer (March) and winter (October).

(A) Summer

	Rivière Banane	Passe Armand	Trou Blanc	Passe L'Ancre	Passe Cabris	Ile aux Fous
No. Individuals	88.0	213.0	296.3	320.7	112.0	254.0
No. Species	20.0	21.0	14.0	26.0	15.0	26.0
No. Genera	15.0	16.0	14.0	18.0	12.0	18.0
No. Families	5.0	6.0	5.0	6.0	5.0	7.0
H'	1.731	1.815	1.288	2.223	1.927	1.978
J'	0.639	0.655	0.488	0.769	0.776	0.685

Damselfish (Pomacentridae) dominated the reef flat sites at all sites except for Passe Cabris and Passe L'Ancre (Figure 7). Pomacentridae were dominated by *Stegastes spp.* at Rivière Banane, Passe Armand, Rivière Banane and Trou Blanc and by *Dascyllus aruanus* at Passe L'Ancre. The fish community at Passe L'Ancre was dominated by parrotfish (small immature parrotfish) whereas surgeonfish (Acanthuridae) and wrasse (Labridae) dominated the fish community at Passe Cabris. A mean of between 0 and 9 butterflyfish were observed at the reef flat sites and no individuals were recorded at Passe Cabris during the summer. Groupers (Serranidae) were only present at Ile aux Fous and Passe Armand. No Snapper (Lutjanidae), Triggerfish (Balistidae), Trevally (Carangidae) or Fusiliers (Caesionidae) were recorded at any site.

During the summer surveys, the majority of individuals of the 12 key fish species observed were juveniles, in particular all *Epinephelus spilotoceps* individuals observed at all sites were below the published length of maturity (FishBase, 2006) (Table 6). In contrast, Sixty-one percent of *Mulloidichthys flavolineatus* at Ile aux Fous and 67% of the same species at Trou Blanc were adults and all *Naso unicornis* observed at Trou Blanc were adults. Furthermore, over 50% of *Chaetodon trifasciatus* individuals were adults at Ile aux Fous, Passe Cabris, Passe L'Ancre and Trou Blanc. During winter, all individuals of *E. spilotoceps* at Ile aux Fous, Passe Armand and Passe Cabris were juveniles as were all individuals of *N. unicornis* at Grand Bassin, Ile aux Fous and Passe Armand.



Key

■ Acanthuridae	■ Serranidae	■ Pomacentridae
■ Labridae	■ Lethrinidae	■ Scaridae
■ Chaetodontidae	■ Mullidae	■ Other

Figure 7. The distribution of fish families at the 7 reef flat survey sites during (A) Summer (March) and (B) Winter (October).

Table 6. The percentage of the 12 key fish species observed, which were below the published length of maturity (FishBase, 2006) at the 7 reef flat sites (RB = Riviere Banane, PA = Passe Armand, GB = Grand Bassin, TB = Trou Blanc, PIA = Passe L’Ancre, IF = Ile aux Fous, PC = Passe Cabris) during Summer (March) and Winter (October).

(A) Summer

Species	Length at maturity (cm)	% Juveniles					
		RB	PA	TB	PIA	IF	PC
<i>Epinephelus spilotoceps</i>	21.2	-	100	100	100	100	100
<i>Plectropomus laevis</i>	65.2	-	-	-	-	-	-
<i>Lutjanus fulvus</i>	23.8	-	-	-	-	-	-
<i>Lethrinus nebulosus</i>	37.4	-	-	-	-	-	-
<i>Mulloidichthys flavolineatus</i>	24.0	-	-	33	-	39	-
<i>Mulloidichthys vanicolensis</i>	24.0	-	-	-	-	-	-
<i>Caranx melampygus</i>	51.3	-	-	-	-	-	-
<i>Chaetodon trifasciatus</i>	11.8	-	100	0	33	47	17
<i>Abudefduf sparoides</i>	10.6	-	-	-	-	0	-
<i>Scarus ghobban</i>	48.8	-	100	-	-	-	-
<i>Rhinecanthus aculeatus</i>	16.8	-	-	-	-	-	-
<i>Naso unicornis</i>	36.1	-	59	0	-	-	-

(B) Winter

Species	Length at maturity (cm)	% Juveniles			
		GB	IF	PA	PC
<i>Epinephelus spilotoceps</i>	21.2	-	100	100	100
<i>Plectropomus laevis</i>	65.2	-	-	-	-
<i>Lutjanus fulvus</i>	23.8	-	-	-	-
<i>Lethrinus nebulosus</i>	37.4	-	-	-	-
<i>Mulloidichthys flavolineatus</i>	24.0	-	100	-	-
<i>Mulloidichthys vanicolensis</i>	24.0	-	-	-	-
<i>Caranx melampygus</i>	51.3	-	-	-	-
<i>Chaetodon trifasciatus</i>	11.8	-	0	50	0
<i>Abudefduf sparoides</i>	10.6	-	-	-	-
<i>Scarus ghobban</i>	48.8	-	-	-	100
<i>Rhinecanthus aculeatus</i>	16.8	-	-	-	-
<i>Naso unicornis</i>	36.1	100	100	100	-

3.3 Invertebrates

The abundance of invertebrates tended to be low on the reef slopes and a total of only 21 species were recorded during all surveys. In both the summer and winter surveys, the highest number of individuals was recorded at North Ile aux Sables (>600 individuals) and the lowest number of individuals was recorded at Grand Bassin (mean of <10 individuals) (Table 7). The highest number of species was observed at Passe Armand (mean of 10 species in both summer and winter) and the lowest number of species was recorded at North Ile aux Sables during summer (4 species) and Grand Bassin during winter (3 species). Species Diversity calculated using the Shannon-Weiner Diversity Index was highest at Passe Demi ($H' = 1.514$ in summer and $H' = 1.615$ in winter) and lowest at North Ile aux Sables ($H' = 0.033$ in summer and $H' = 0.082$ in winter). Pielou’s Index of Evenness was highest at Passe Demi in summer ($J = 0.728$) and at Grand Bassin in summer ($J = 0.919$) and was lowest at North Ile aux Sables ($J = 0.024$ in summer and $J = 0.046$ in winter).

Table 7. The mean number of individuals and species and species diversity indices for the invertebrate communities at each of the 6 reef slope sites during summer (March) and winter (October)

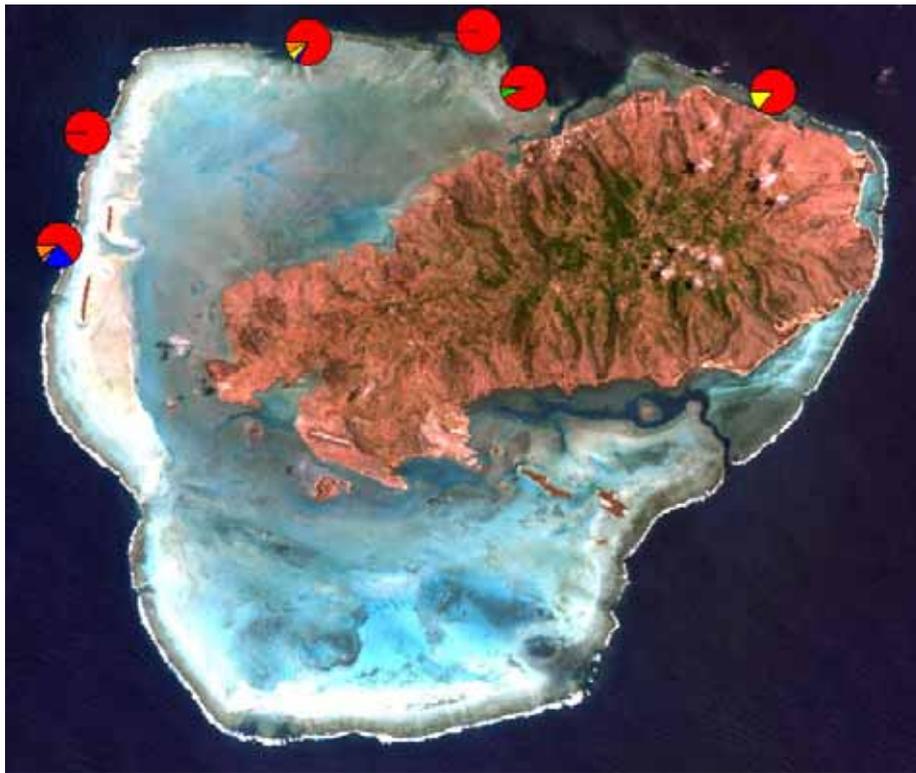
(A) Summer

	Rivière Banane	Passe Armand	Grand Bassin	Passe Demi	Ile aux Fous	Ile aux Sables
No. Individuals	26.3	137.0	8.6	21.6	183.9	691.1
No. Species	7.0	10.0	7.0	8.0	5.0	4.0
H'	1.119	0.452	1.342	1.514	0.147	0.033
J'	0.575	0.196	0.690	0.728	0.091	0.024

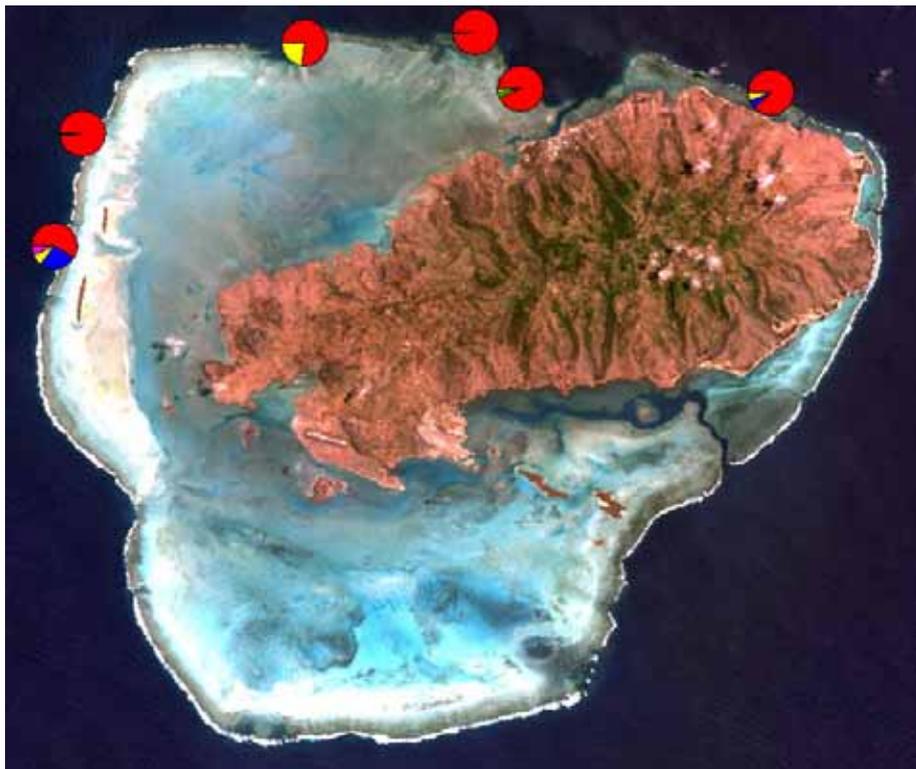
(B) Winter

	Rivière Banane	Passe Armand	Grand Bassin	Passe Demi	Ile aux Fous	Ile aux Sables
No. Individuals	16.0	252.0	1.3	3.9	134.4	820.5
No. Species	4.0	10.0	3.0	6.0	6.0	6.0
H'	1.070	0.408	1.010	1.615	1.572	0.082
J'	0.772	0.177	0.919	0.902	0.088	0.046

All sites were dominated by sea urchins (Echinoidea), especially *Echinometra mathaei*, which was particularly abundant at North Ile aux Sables, where >650 individuals were recorded (Figure 8). The sea cucumber (Holothuroidea) *Stichopus chloronatus* was relatively abundant at Passe Armand (mean of 6 individuals), however holothurians were very rare at the other sites. Gastropods were completely absent from Ile aux Fous in the summer survey and were only found in low numbers at the other sites and the bivalve, *Tridacna maxima* was only observed at Passe Demi, Passe Armand and Ile aux Fous (mean of 1 individual at each site). Crustaceans were only represented by hermit crabs (*Dardanus* sp.) which were observed at Passe Demi, Ile aux Fous and North Ile aux Sables.



(A) Summer



(B) Winter

Key

- | | | |
|---|---|---|
| ■ Sea Urchins | ■ Bivalves | ■ Gastropods |
| ■ Sea Cucumbers | ■ Octopus | ■ Crustaceans |
| ■ Other Echinoderms | | |

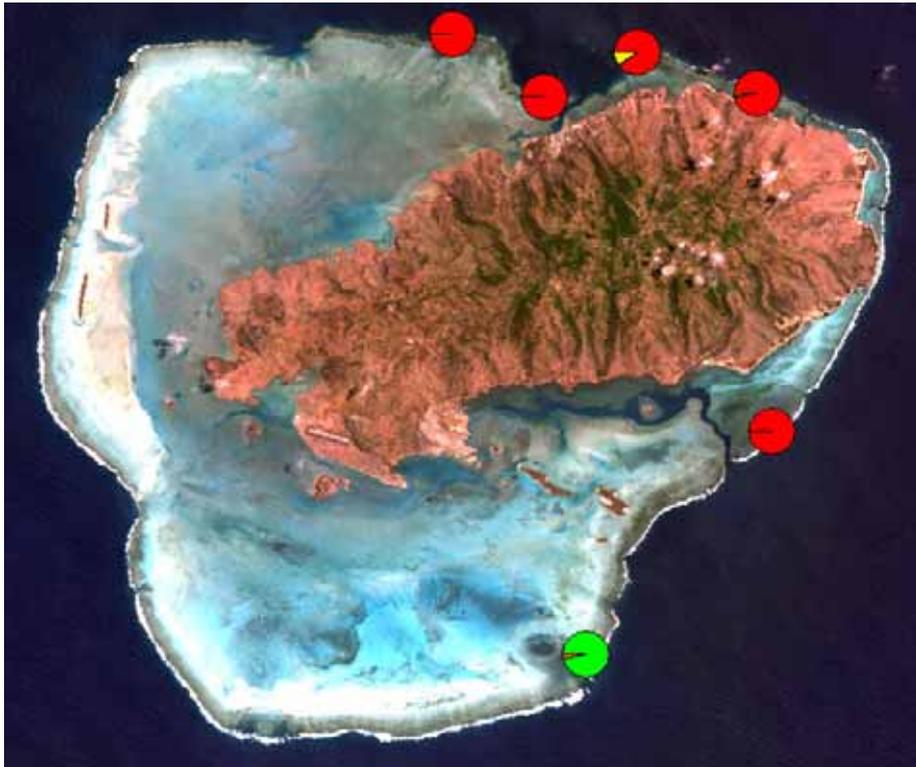
Figure 8. The distribution of invertebrates at the 6 reef slope survey sites during (A) Summer (March) and (B) Winter (October).

Only seventeen invertebrate species were recorded on the 7 reef flat sites during all surveys. The highest number of individuals was recorded at Passe Armand during both the summer and winter surveys (>600 individuals) and the lowest number of individuals was observed at Passe L'Ancre in summer (8 individuals) and at Ile aux Fous during winter (22 individuals) (Table 8). The highest number of species was recorded at Passe Armand and Passe Cabris during summer (10 species) and at Grand Bassin in winter (9 species). The lowest number of species was observed at Ile aux Fous during both summer and winter (1 species in summer and 3 species in winter). Species Diversity calculated using the Shannon-Weiner Diversity Index was highest at Passe Cabris ($H' = 0.493$ in summer and $H' = 0.477$ in winter) and was lowest at Ile aux Fous in summer ($H' = 0.000$) and at Passe Armand in winter ($H' = 0.055$). Pielou's Index of Evenness was highest at Passe L'Ancre in summer ($J = 0.240$) and at Ile aux Fous in winter ($J = 0.291$) and was lowest at Trou Blanc in summer ($J = 0.032$) and at Passe Armand in winter ($J = 0.031$).

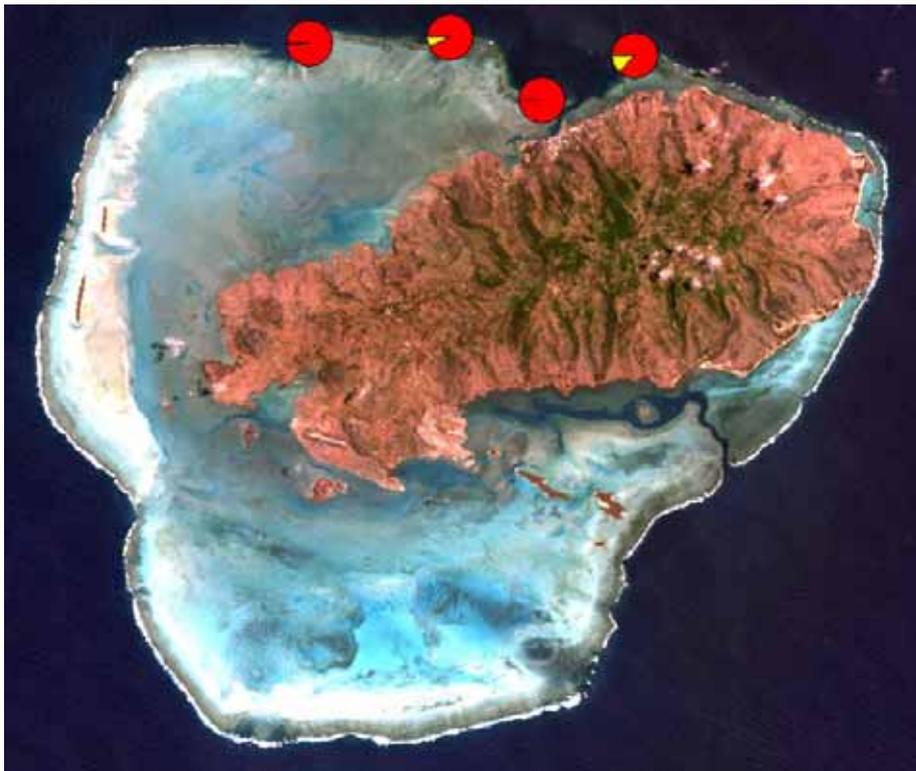
Table 8. The mean number of individuals and species and species diversity indices for the invertebrate communities at each of the 7 reef flat sites during (A) Summer (March) and (B) Winter (October).

(A) Summer						
	Rivière Banane	Passe Armand	Ile aux Fous	Passe Cabris	Passe L'Ancre	Trou Blanc
No. Individuals	533.0	716.7	22.0	169.3	7.6	545.6
No. Species	8.0	10.0	1.0	10.0	2.0	8.0
H'	0.330	0.097	0.000	0.493	0.166	0.066
J'	0.159	0.042	-	0.214	0.240	0.032
(B) Winter						
	Grand Bassin	Passe Armand	Ile aux Fous	Passe Cabris		
No. Individuals	295.5	608.0	22.4	197.6		
No. Species	9.0	6.0	3.0	7.0		
H'	0.199	0.055	0.320	0.477		
J'	0.090	0.031	0.291	0.245		

All sites except for Passe L'Ancre were dominated by Sea Urchins (Echinoidea), especially *Echinometra mathaei*, which was particularly abundant at Passe Armand, Riviere Banane and Trou Blanc (mean of >500 individuals) (Figure 9). Holothurians were observed at 5 of the sites during the summer surveys (mean of 1-7 individuals per site); however during the winter surveys just 1 individual of *Holothuria atra* was recorded at Grand Bassin only. The gastropod, *Trochus maculatus* was relatively abundant at Passe Cabris (mean of 14 individuals in summer and 24 in winter), however molluscs were rare at other sites and completely absent from Ile aux Fous and Pass L'Ancre in the summer surveys. The Bivalve, *Tridacna maxima* was only observed at Passe Armand, Trou Blanc and Grand Bassin (≤ 2 individuals). Crustaceans were only represented by hermit crabs (*Dardanus* sp.) which were present in low numbers (mean of 1 individual per site).



(A) Summer



(B) Winter

Key

- | | | |
|---|---|---|
| ■ Sea Urchins | ■ Bivalves | ■ Gastropods |
| ■ Sea Cucumbers | ■ Octopus | ■ Crustaceans |
| ■ Other Echinoderms | | |

Figure 9. The distribution of invertebrates at the 7 reef flat survey sites during (A) Summer (March) and (B) Winter (October).

3.4 Comparison over 5 years

3.4.1 Benthos

Analysis of Similarity (ANOSIM) indicates that on the reef slope, there were significant differences in benthic composition over time at Rivière Banane ($R = 0.689$, $p < 0.05$), Passe Armand ($R = 0.638$, $p < 0.05$), Grand Bassin ($R = 0.384$, $p < 0.05$) and Passe Demi ($R = 0.403$, $p < 0.05$), however there was no significant difference at Ile aux Fous or North Ile aux Sables. At Rivière Banane, SIMPER analysis shows that this was due to very high macro-algae cover in October 2004 (40%) and increased turf algal cover from March 2006 onwards (>20%). These differences are also highlighted by multi-dimensional scaling (MDS) which groups together surveys based on the similarity of their benthic composition (Figure 10). At Passe Armand, March and October 2002 were distinct due to high coral cover (>40%) and there was increased turf algae cover from March 2006 onwards (>15%). Variations in benthic composition at Grand Bassin were less obvious and more governed by variations in coralline algae, with coralline algae low (<20%) in March and October 2002 and high (>25%) in March and October 2003, March 2004 and October 2006; October 2004 was distinct due to high macro-algal cover (36%). There were also no obvious temporal trends at Passe Demi; however October 2004 was distinct due to high macro-algae cover (34%) and there was an increase in turf algae after March 2006 (>25%).

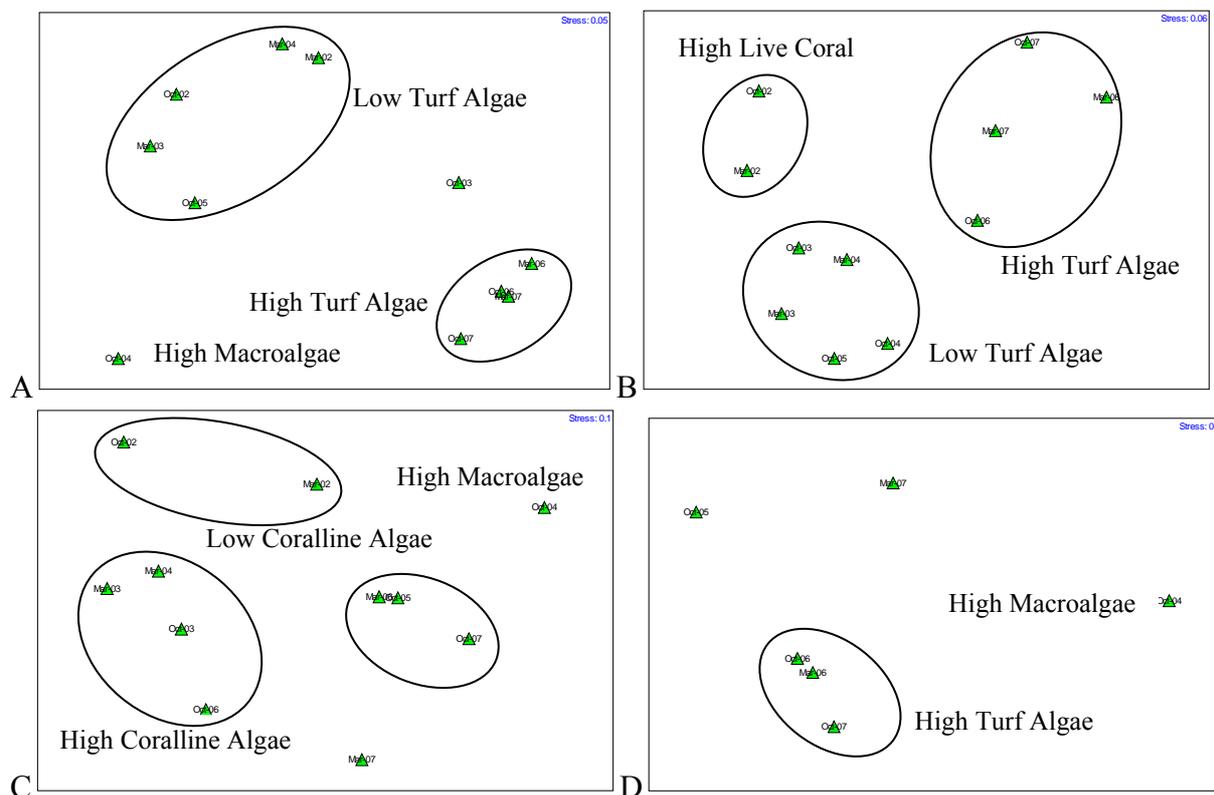


Figure 10. Multi-dimensional scaling plot of benthic composition on the reef slope at (A) Rivière Banane, (B) Passe Armand, (C) Grand Bassin and (D) Passe Demi between March 2002 and October 2007. The circles highlight dates with a similar benthic composition.

On the reef flat, ANOSIM indicates that there were significant difference in benthic composition over time at all 7 sites ($p < 0.05$). At Rivière Banane, SIMPER analysis shows that this was due to high macro-algae (17%) in March 2003 and high turf algae (>70%) in October 2003, March 2006 and March 2007. These differences are also highlighted by multi-

dimensional scaling (MDS) which groups together surveys based on the similarity of their benthic composition (Figure 11). At Passe Armand, March 2002 and October 2005 were distinct due to high dead coral (>30%) and turf algae was high (>70%) from March 2006 onwards. Similarly, at Grand Bassin, March 2002 was distinct due to high dead coral (26%) and turf algae was high (>25%) from March 2006 onwards. At Trou Blanc, October 2002 was distinct due to high macro-algae (37%) and October 2005 was distinct due to high dead coral (32%) and turf algal cover was high from March 2006 onwards. At the remaining sites, there were no obvious temporal trends and variations tended to be due to changes in turf and coralline algal cover, however October 2005 was distinct at Ile aux Fous due to high dead coral (38%).

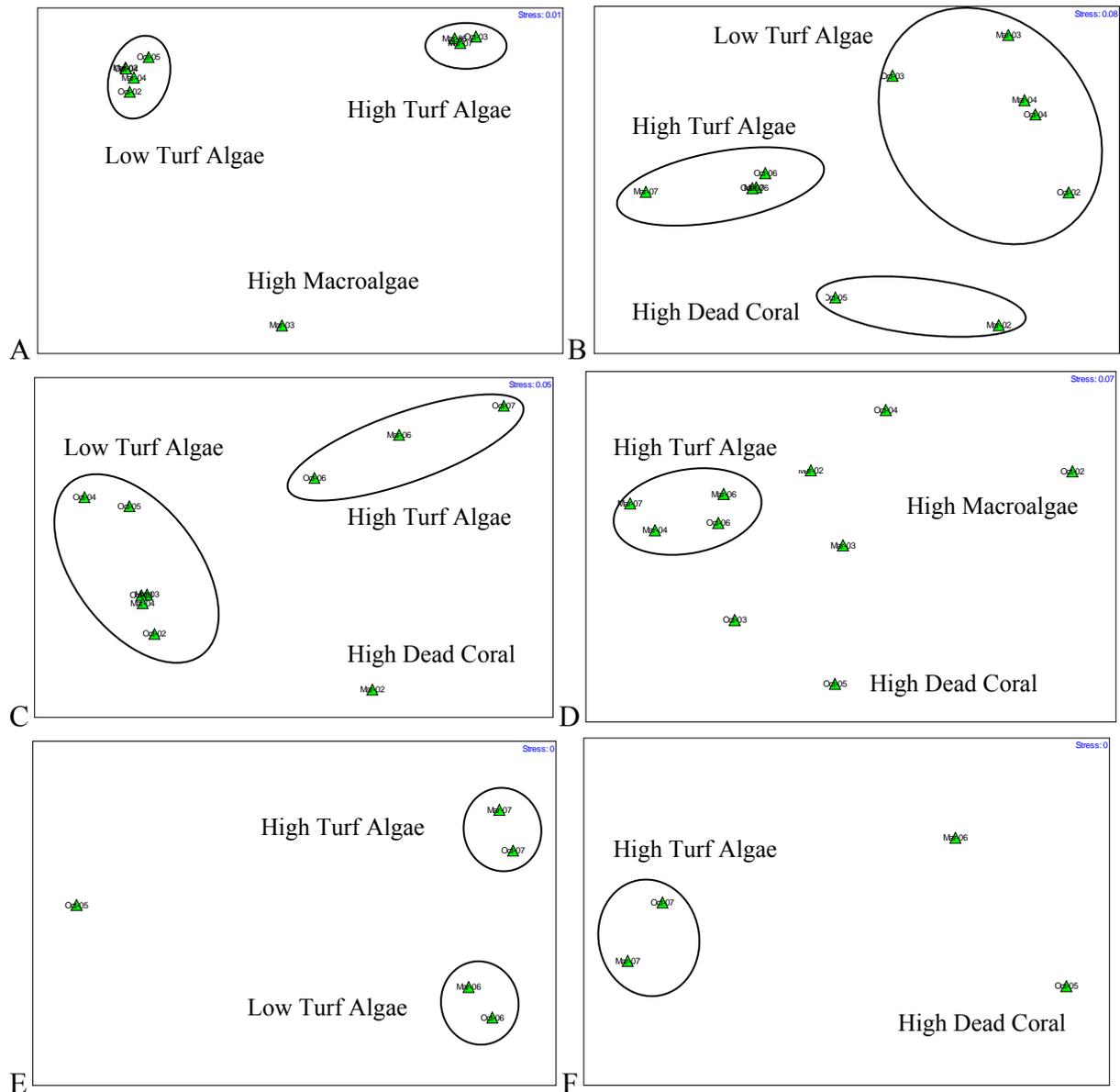


Figure 11. Multi-dimensional scaling plot of benthic composition on the reef flat at (A) Rivière Banane, (B) Passe Armand, (C) Grand Bassin (D) Trou Blanc, (E) Passe Cabris and (F) Ile aux Fous between March 2002 and October 2007. The circles highlight dates with a similar benthic composition.

3.42 Fish

On the reef slope, ANOSIM indicates that there were significant differences in fish community composition over time at all sites ($p < 0.05$). SIMPER analysis however does not highlight any temporal trends, but indicates that these differences are due to the occasional occurrence of large shoals of fish such as *Pterocaesio tile* (Caesionidae) in March 2003 and 2006 (Rivière Banane, Grand Bassin and Passe Demi), *Gnathodentex aureolineatus* (Lethrinidae) in March and October 2002 and *Acanthurus* sp. in October 2002 (Passe Armand), October 2003 (Grand Bassin) and March 2007 (Passe Demi). These variations are also highlighted by multi-dimensional scaling (MDS) which groups together surveys based on the similarity of their fish community composition (Figure 12).

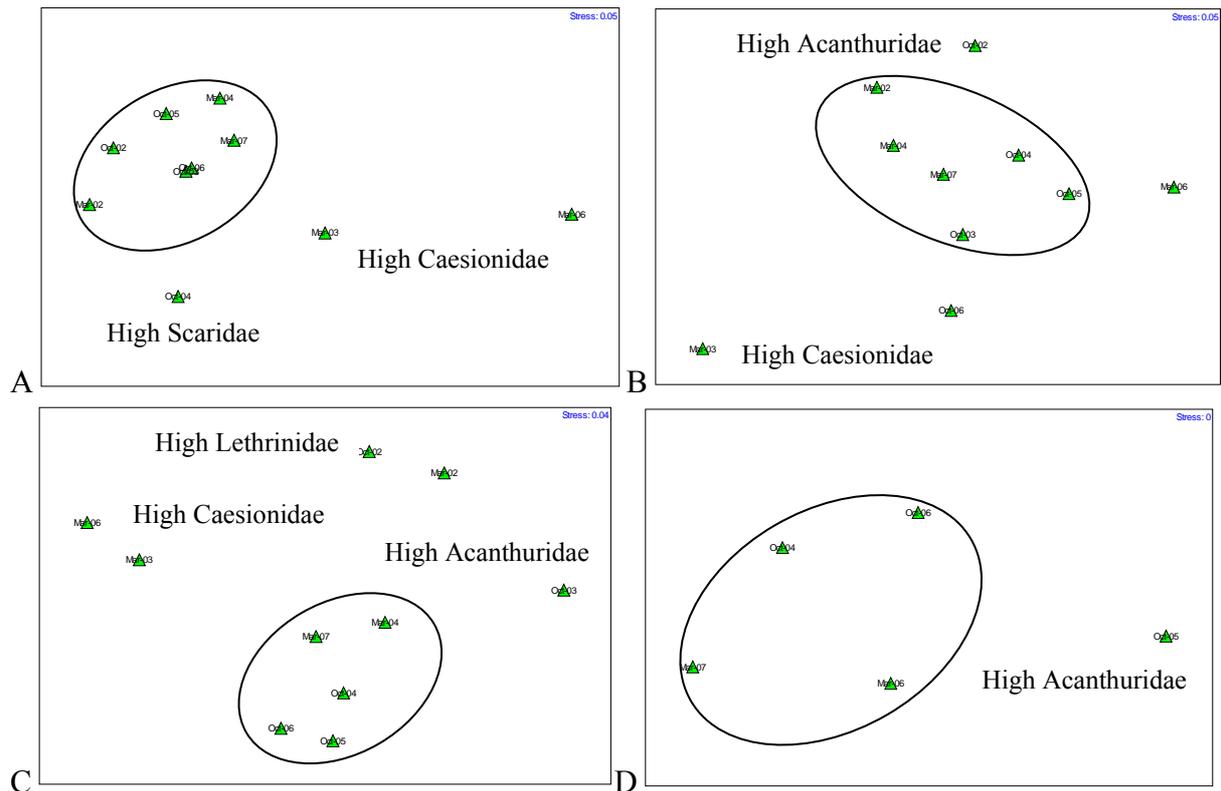


Figure 12. Multi-dimensional scaling plot of fish community composition on the reef slope at (A) Rivière Banane, (B) Passe Armand, (C) Grand Bassin and (D) Passe Demi between March 2002 and October 2007. The circles highlight dates with a similar fish community composition.

On the reef flat, ANOSIM indicates that there were significant differences in fish community composition over time at all 7 sites ($p < 0.05$). SIMPER analysis however does not highlight any temporal trends, but indicates that these differences are due to variations in Acanthuridae (Rivière Banane, Trou Blanc and Passe L'Ancre) and shoals of Mullidae during March 2002 (Passe Armand) and Lethrinidae (Grand Bassin). These variations are also highlighted by multi-dimensional scaling (MDS) which groups together surveys based on the similarity of their fish community composition (Figure 13).

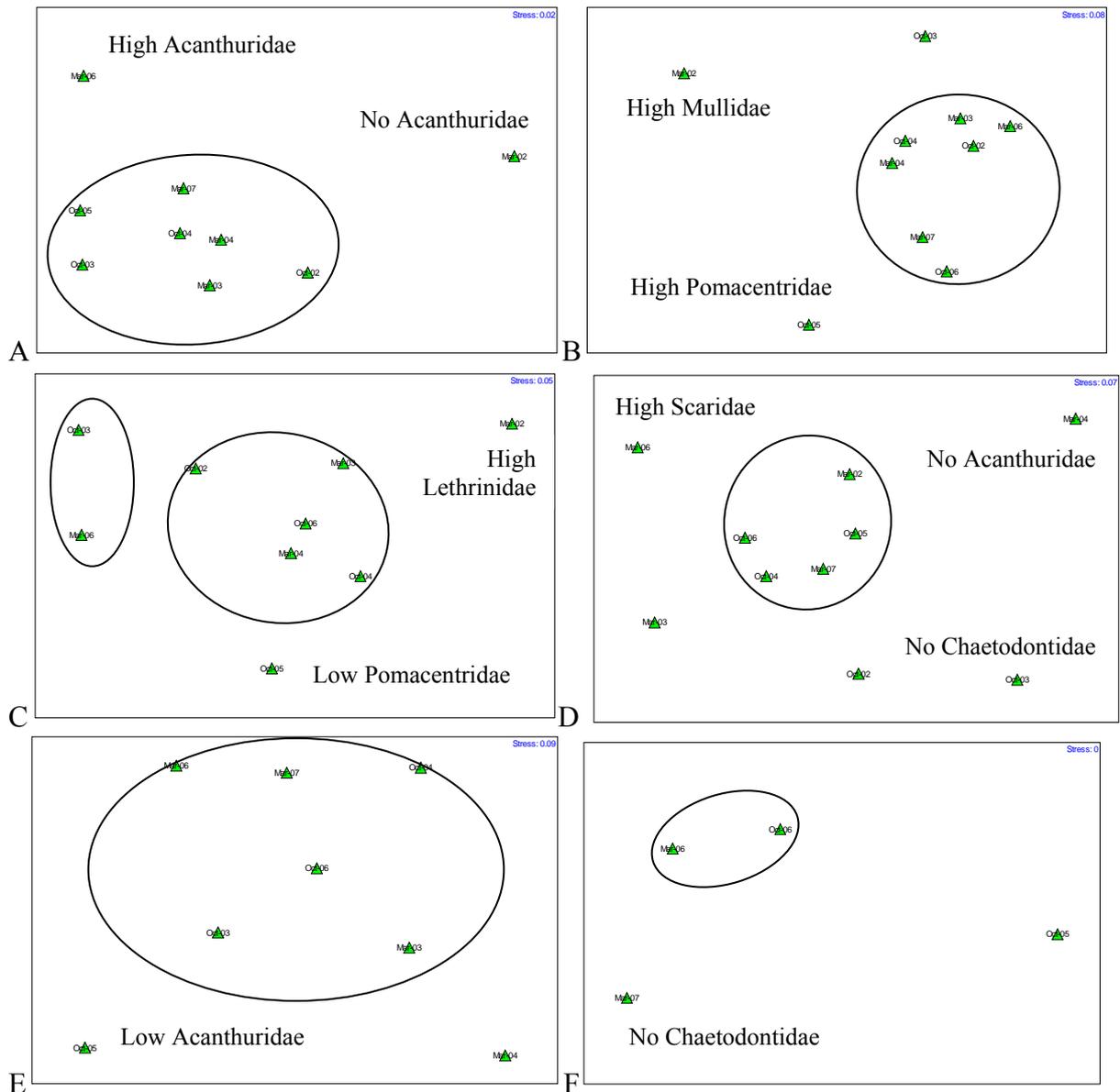


Figure 13. Multi-dimensional scaling plot of fish community composition on the reef flat at (A) Rivière Banane, (B) Passe Armand, (C) Grand Bassin (D) Trou Blanc, (E) Passe L’Ancre and (F) Passe Cabris between March 2002 and October 2007. The circles highlight dates with a similar fish community composition.

3.43 Invertebrates

On the reef slope, ANOSIM indicates that there were significant differences in invertebrate community composition over time at all sites except for Ile aux Fous ($p < 0.05$). SIMPER analysis indicates that at Rivière Banane and Grand Bassin this is due to the absence of *Diadema* sp. from March 2005 onwards. At Passe Armand the difference is due to an increase in the urchin, *Echinometra mathaei* from October 2005 onwards, whereas at Passe Demi it is due to the absence of Featherstars in October 2004, 2005 and 2007 and at North Ile aux Sables the difference is due to lower numbers of *E. mathaei* in March and October 2006. These variations are also highlighted by multi-dimensional scaling (MDS) which groups together surveys based on the similarity of their invertebrate community composition (Figure 14).

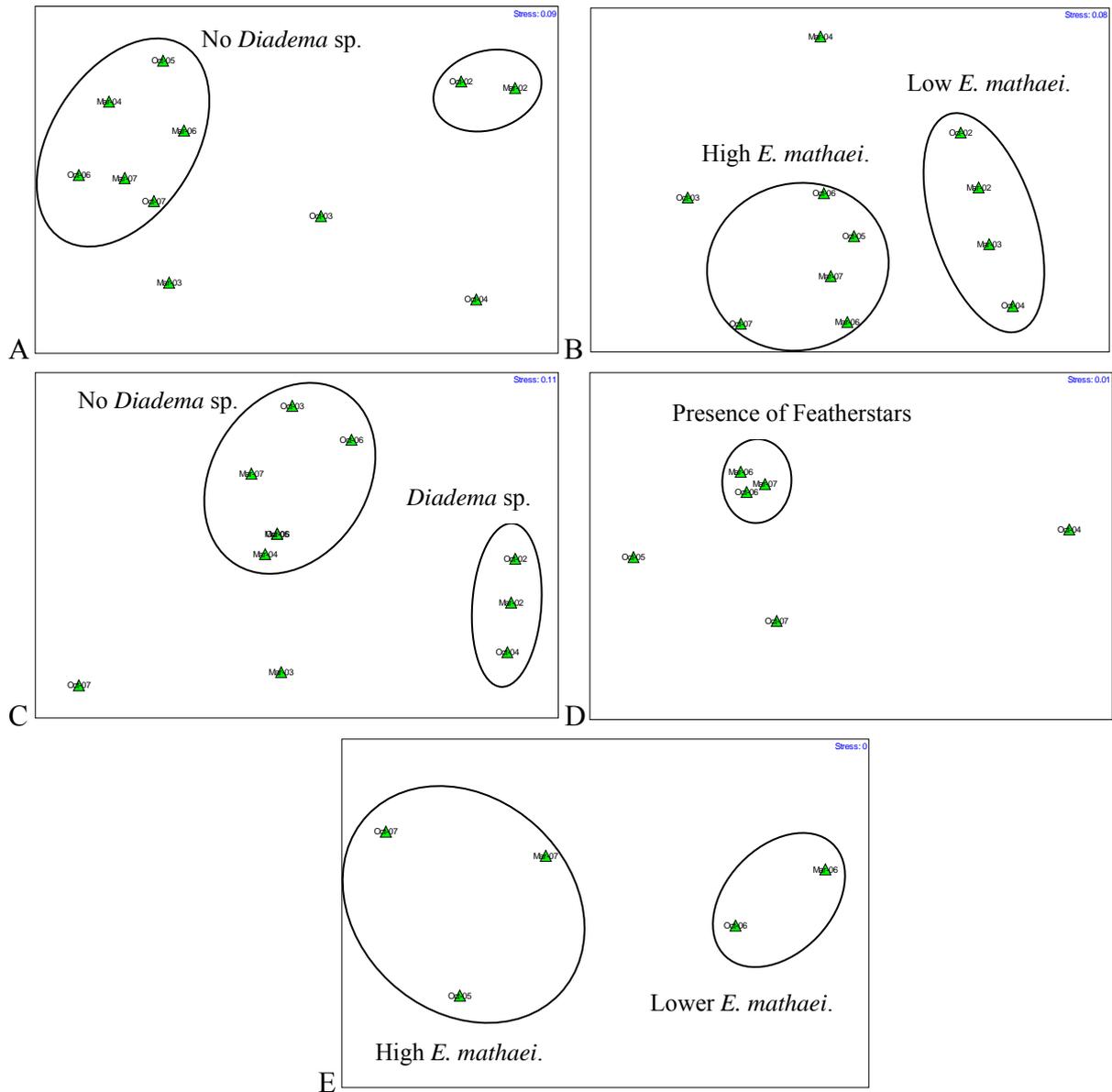


Figure 14. Multi-dimensional scaling plot of invertebrate community composition on the reef slope at (A) Rivière Banane, (B) Passe Armand, (C) Grand Bassin (D) Passe Demi and (E) North Ile aux Sables between March 2002 and October 2007. The circles highlight dates with a similar invertebrate community composition.

On the reef flat, ANOSIM indicates that there were significant differences in invertebrate community composition over time at 5 of the sites ($p < 0.05$). SIMPER analysis indicates that at Rivière Banane, Passe Armand, Grand Bassin and Trou Blanc this is due to an increase in the abundance of *Echinometra mathaei* from October 2005 onwards. At Passe L’Ancre, the difference is due to a seasonal variation in invertebrate abundance, with a low abundance of all invertebrates observed during the summer surveys (March). These variations are also highlighted by multi-dimensional scaling (MDS) which groups together surveys based on the similarity of their invertebrate community composition (Figure 15).

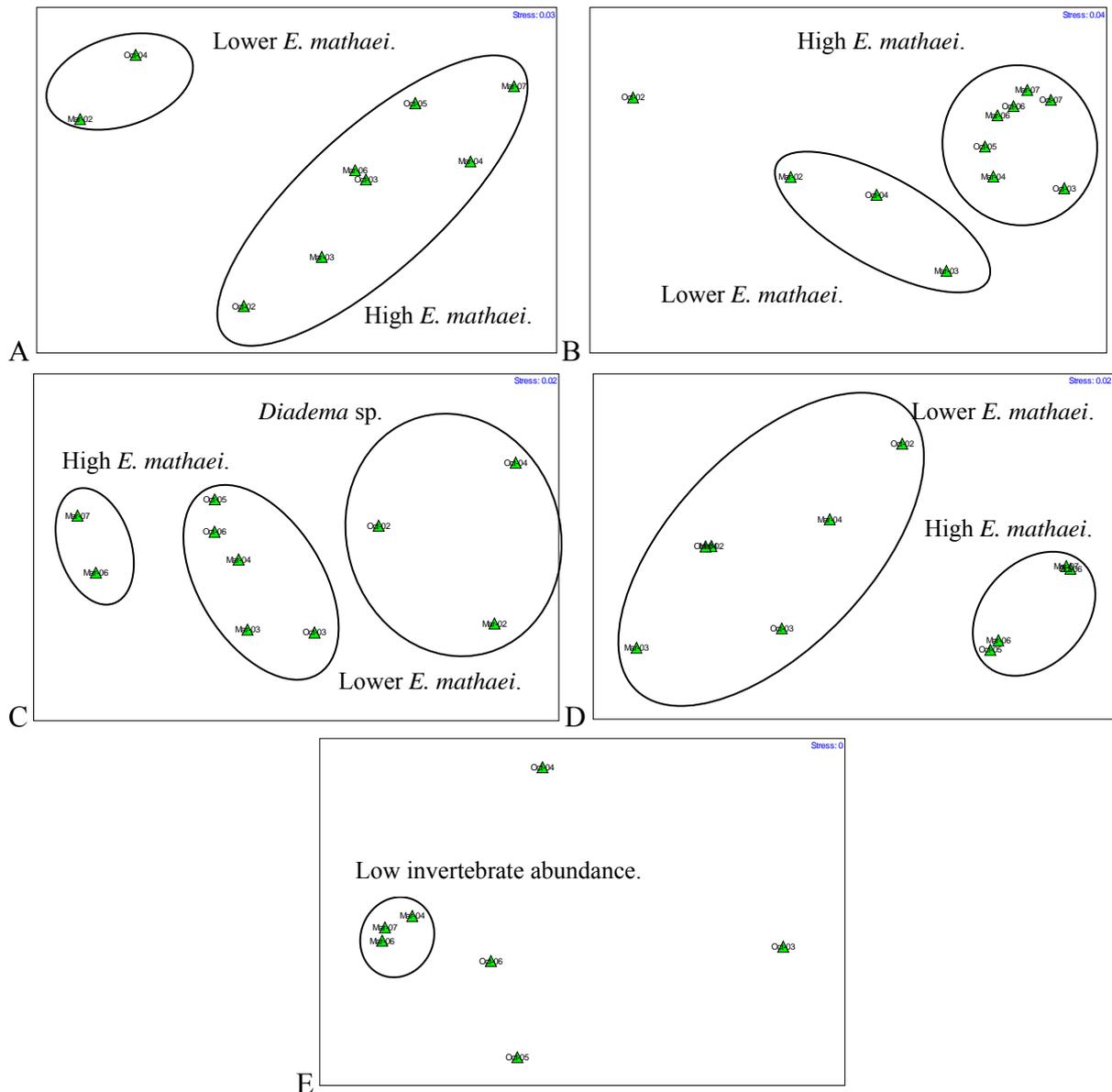


Figure 15. Multi-dimensional scaling plot of invertebrate community composition on the reef flat at (A) Rivière Banane, (B) Passe Armand, (C) Grand Bassin (D) Trou Blanc and (E) Passe L'Ancre between March 2002 and October 2007. The circles highlight dates with a similar invertebrate community composition.

3.5 Water Quality

Nitrite and phosphate levels at all 13 sites were negligible. Nitrate concentration was however significantly higher at the reef flat sites at Passe Armand and Passe Cabris than at the remaining sites (1-way ANOVA, $p < 0.001$) (Figure 16). Sea surface temperature measured at the 3 reef flat sites, varied between 19.82°C in August 2007 and 31.59°C at Grand Bassin. Mean temperature was significantly higher at Passe Cabris than at Grand Bassin and Ile aux Fous (1-way ANOVA, $p < 0.001$) (Figure 17).

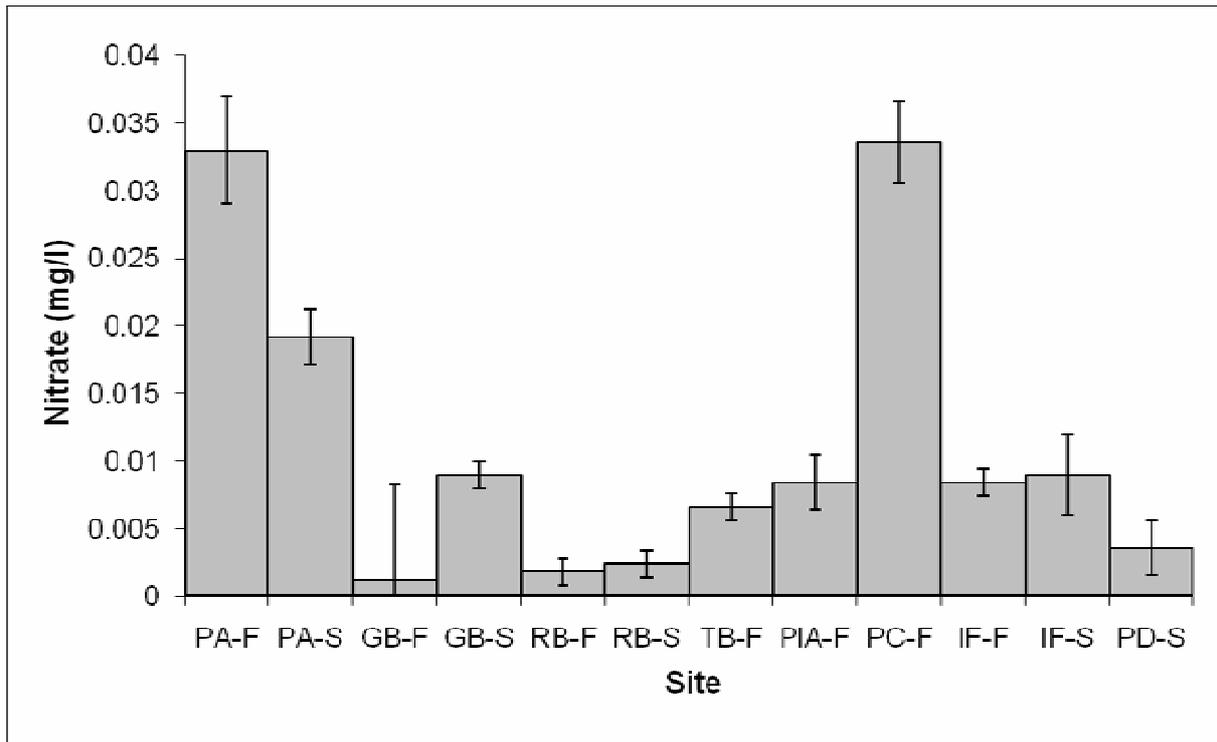


Figure 16. The mean nitrate concentration (mg l⁻¹) (\pm SE) at the 13 survey sites during March/April 2007.

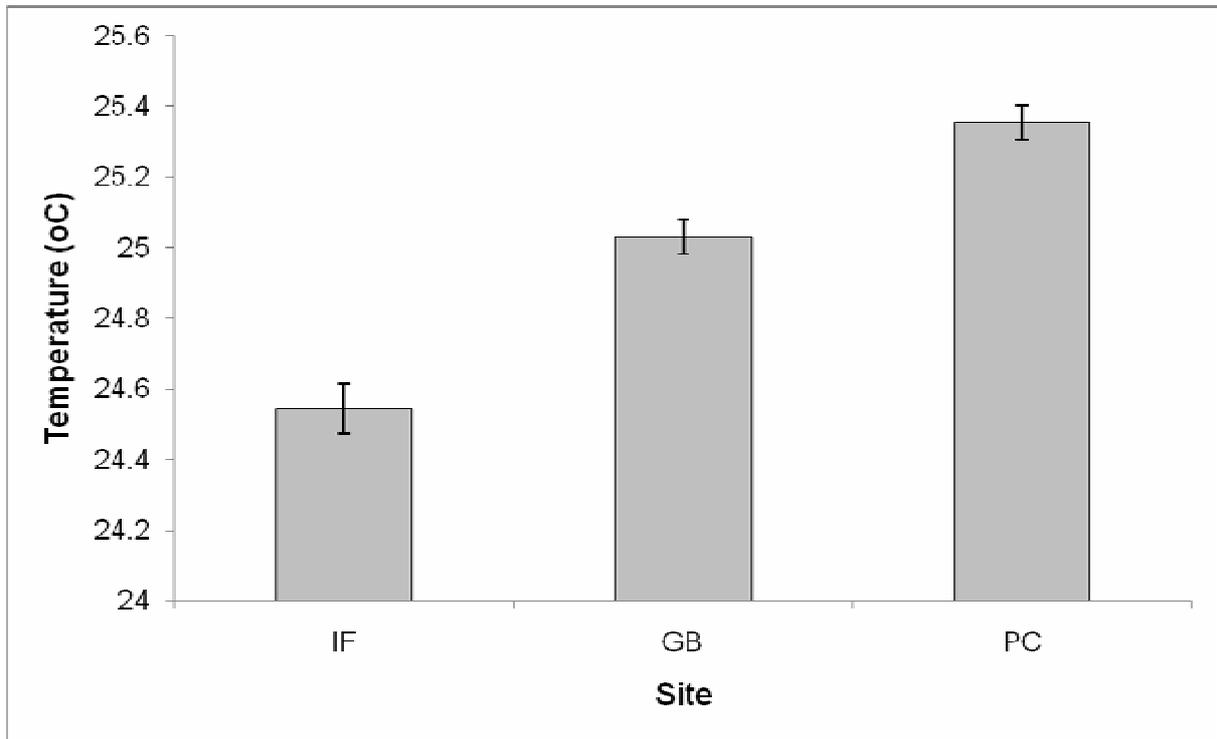


Figure 17. The mean sea temperature based on continuous temperature loggers at the reef flat sites at Ile aux Fous, Grand Bassin and Passe Cabris between March 2006 and December 2007.

4 Discussion

Hard coral cover was high on the reef slope at Rivière Banane, Grand Bassin and Ile aux Fous (>45%), but was low at Passe Demi, North Ile aux Sables and Passe Armand, which were dominated by coralline and turf algae. There was however low dead coral cover at all sites, suggesting that the sites are generally healthy. Faure (1982) also notes that coral cover on the reef slopes was 50-60%, suggesting that there has been little change over time. There were increases in the red macro-algae, *Asparagopsis taxiformis*, at some sites during October 2004, however macro-algae returned to low levels in the following summer surveys, suggesting this may be natural. Indeed, Faure (1982) also comments that this species was common on sheltered reefs in the north of the island.

In contrast, coral cover was low on the reef flat sites (<30%). Faure (1982) and Faure and Montaggioni (1974) observed that live coral cover was 2-30% on the reef flats, suggesting that there has been some decline in coral cover over time, particular at the northern sites. There were also temporal increases in dead coral cover, with high values recorded during March 2002 at Passe Armand and Grand Bassin and during October 2005 at Passe Armand, Trou Blanc and Ile aux Fous. Coral bleaching affected corals on the reef flats during 2002 (Hardman *et al.*, 2004) and 2005 (Hardman *et al.*, in press), causing 90% bleaching of the dominant branching *Acropora* species and this is likely to have resulted in the increase in dead coral observed at these reef flat sites. Sea temperature was highest at the sheltered inshore site of Passe Cabris, suggesting that corals at this site are very vulnerable to future bleaching events. Coral settlement was also low, with <2 recruits observed per tile and no recruits observed at Rivière Banane during summer or Grand Bassin during winter, suggesting that these reefs have a limited ability to recover from impacts such as coral bleaching.

On the reef slope all sites except Grand Basin and North Ile aux Sables were dominated by Damselfish, with very high numbers being recorded at Rivière Banane. Damselfish were also dominant at 5 of the reef flat sites. At all sites, Emperors, Snapper, Trevally and Grouper were rare or absent. This lack of large piscivorous predators suggests that the fish population may be unbalanced due to overfishing. Sites showed no obvious temporal variations in community composition and differences tended to be due to the presence of occasional large shoals of surgeonfish and fusiliers. At both the reef slope and reef flat sites, the majority of key fish species observed were below the published length of maturity. This suggests that either these areas are important grounds for juveniles or that the population is dominated by small under-sized individuals due to intense fishing of the adult individuals. Studies of the lagoon fishery in Rodrigues also indicate overfishing due to a decline in fish catches over time (Hardman *et al.*, 2007) and a decline in the catch of predatory species such as *Lethrinus harak* (Pearson, 1988).

Invertebrates were low on the reef slope sites and all sites, were dominated by the urchin, *Echinometra mathaei*. This species also dominated all of the reef flat sites, except for Passe L'Ancre. There were temporal variations in the abundance of *E. mathaei* on the reef slope at Passe Armand and North Ile aux sables and there has been a general increase in numbers from October 2005 onwards on the reef flat at Rivière Banane, Passe Armand, Grand Bassin and Trou Blanc. The high number of this species may be as a result of intense fishing pressure and the removal of predator fish species. *E. mathaei* is a bio-eroder and so their high density is cause for concern, especially with possible increase in the incidences of coral bleaching resulting in higher coral mortality. At all sites molluscs and crustaceans were either rare or absent; in particular *Tridacna* clams were in low abundance and large gastropods such as

Pleuroploca trapezium were not observed. This may be an indication that local consumption is resulting in over-harvesting.

Nutrient values were low, however nitrate values were significantly higher at Passe Armand and Passe Cabris. These sites are the two closest sites to Port Mathurin and this suggests that the lagoon is starting to become polluted through domestic and industrial run-off from the main town. Further surveys carried out at different times of the year are however needed to confirm whether this is indeed the case.

Considering the sites within the proposed marine reserves, it can be seen that the reef slopes are generally healthy with high coral cover (>45%) at Grand Bassin and Rivière Banane and a low percentage cover of dead coral and rubble. Fish communities are dominated by Damsel fish, with Surgeonfish dominant at Grand Bassin and the endemic Damsel fish, *Pomacentrus rodriguesensis*, was observed at Rivière Banane. At present, the majority of fish species are undersized, however adult individuals of the commercially important species, *Caranx melampygus*, *Naso unicornis* and *Mulloidichthys flavolineatus* were observed. Invertebrates tend to be low at all sites. The reef flat sites within the proposed marine reserves are more degraded with low coral cover (<20%). The abundance of fish was low at Rivière Banane and at Passe Cabris and the majority of individuals were juveniles. The invertebrate community at these sites was dominated by very high numbers of the urchin *Echinometra mathaei*, suggesting that erosion of the reef structure may be occurring. The presence of marine reserves in these areas will protect the healthy reef slopes from future impacts and aim to facilitate recovery of the degraded reef flat areas.

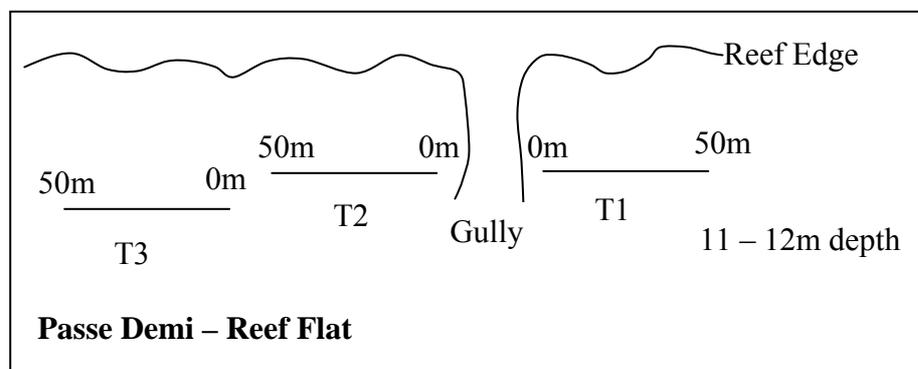
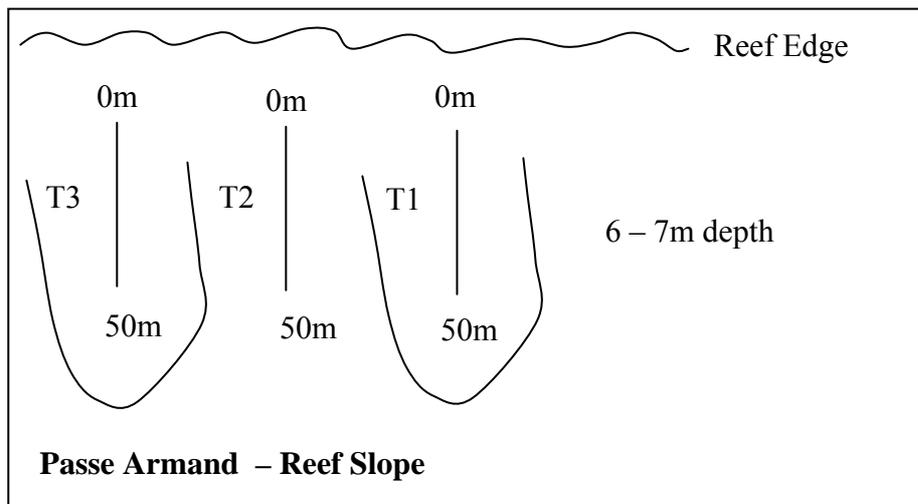
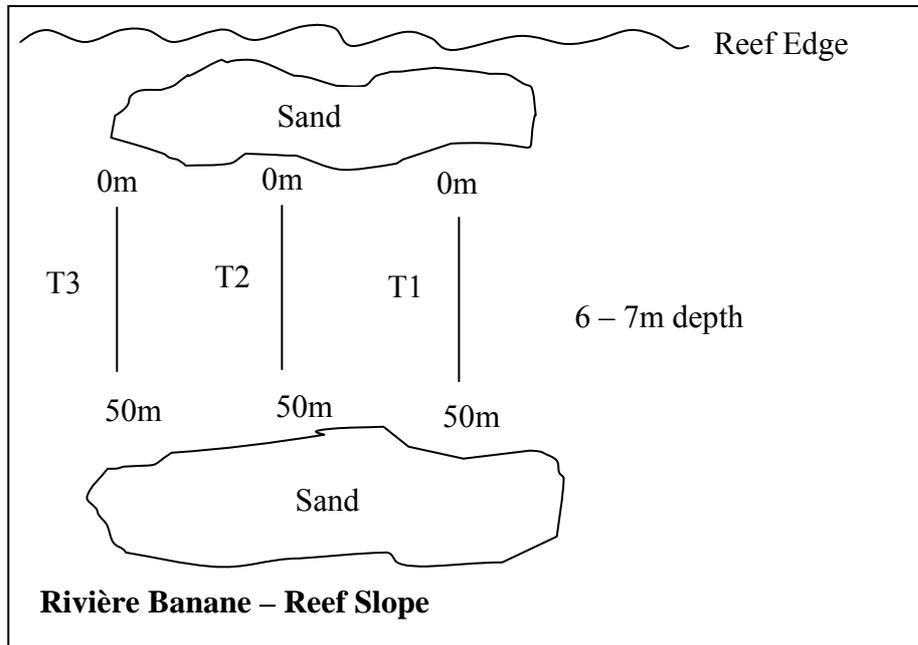
5 References

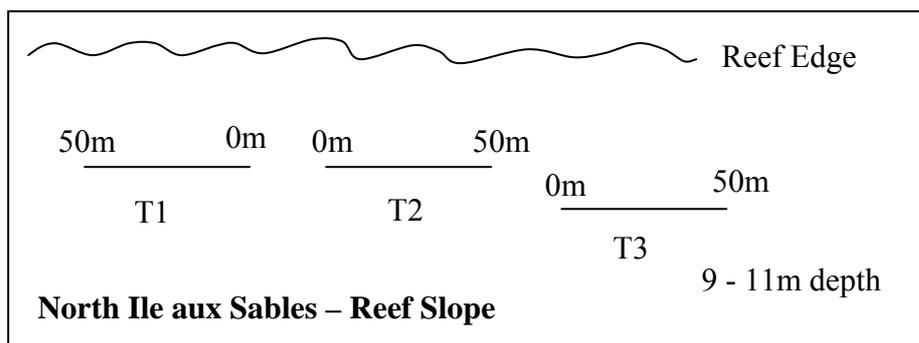
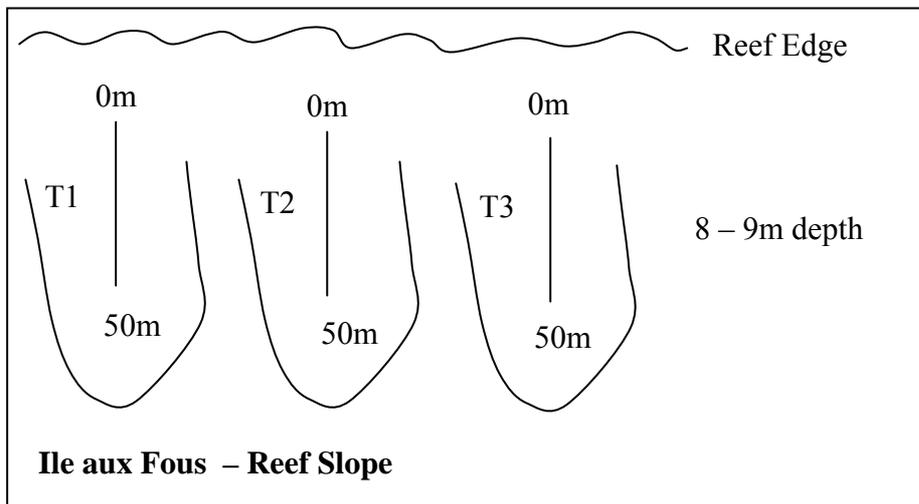
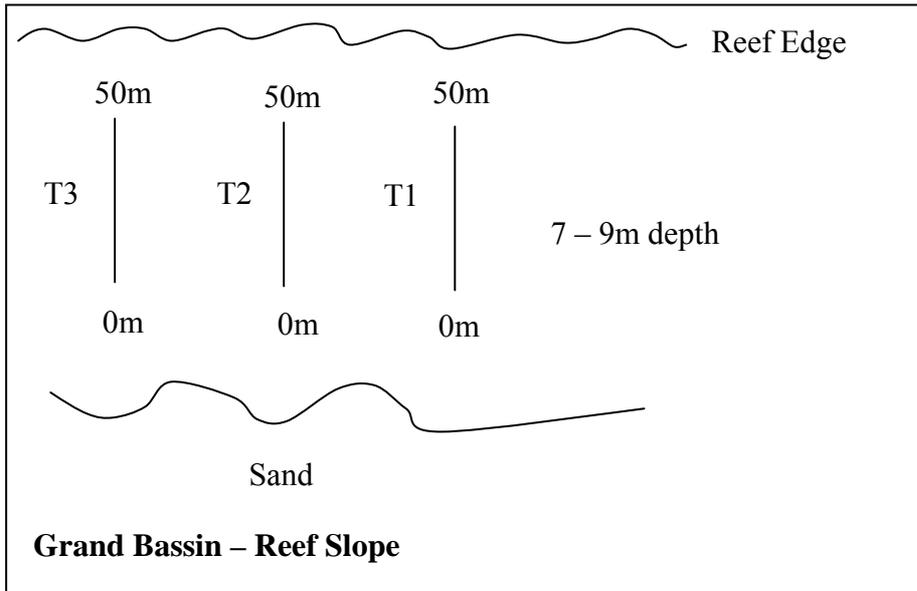
- Anderson, R. C. (2006). Impacts of marine reserves in Rodrigues; report of a training visit to Shoals Rodrigues, March 2006. Unpublished report 21pp.
- Clark T.H. (2001). The Status of the Coral Reefs in Rodrigues. Shoals of Capricorn Programme unpublished report.
- Conand C., Chabanet P., Quod J.P and Bigot L. (1997). Guidelines for coral reef monitoring in the south-west region of the Indian Ocean. Indian Ocean Commission.
- Faure, G. (1982). Recherche sur les peuplements de Scléractiniaires des récifs coralliens de l'Archipel des Mascareignes. PhD Thesis, Université d'Aix-Marseille, France.
- Faure, G. and Montaggioni, L. (1974). Le récif corallien de l'île Rodrigue (Archipel des Mascareignes, Océan Indien). Géomorphologie et répartition des peuplements. *Journal of the Marine Biological Association of India* **16**: 1-30.
- Hardman, E. R., Meunier, M. S., Turner, J. R., Lynch, T. L., Taylor, M and Klaus, R. (2004). The extent of coral bleaching in Rodrigues, 2002. *Journal of Natural History* **38**: 3077-3089.
- Hardman, E. R., Blais, F. E. I., Desiré, S. M., Raffin, J. S. J., Perrine, S., Raffaut, R. and Chinien-Chetty, M. (2006). Annual report of benthos, reef fish and invertebrate surveys for reef slope and reef flat areas in Rodrigues 2005. Shoals Rodrigues report, 43pp.
- Hardman, E. R., Blais, F. E. I., Desiré, S. M., Raffin, J. S. J., Perrine, S., Chinien-Chetty, M. and Towill, J. (2007). Annual report of benthos, reef fish and invertebrate surveys for reef slope and reef flat areas in Rodrigues 2006. Shoals Rodrigues report, 51pp.
- Hardman, E. R., Stampfli, N. S., Hunt, L., Perrine, S., Perry, A. and Raffin, J. S. J. (in press). The impacts of coral bleaching in Rodrigues, western Indian Ocean. *Atoll Research Bulletin*.

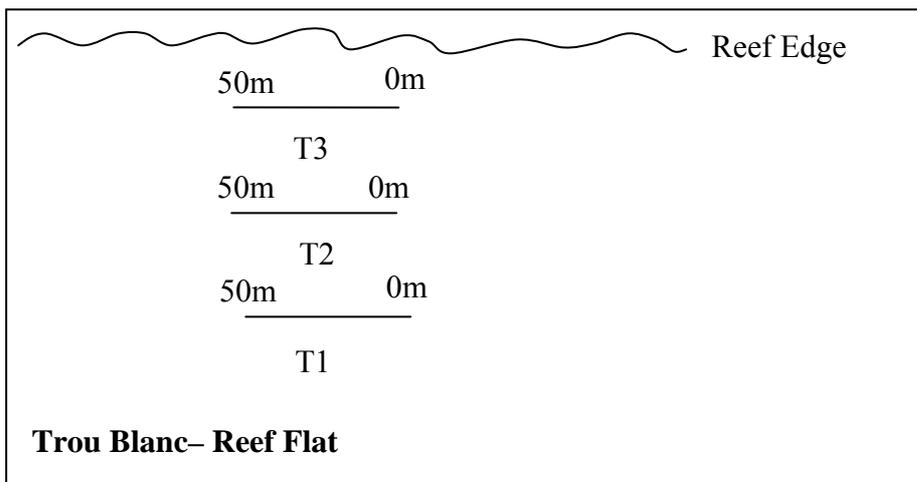
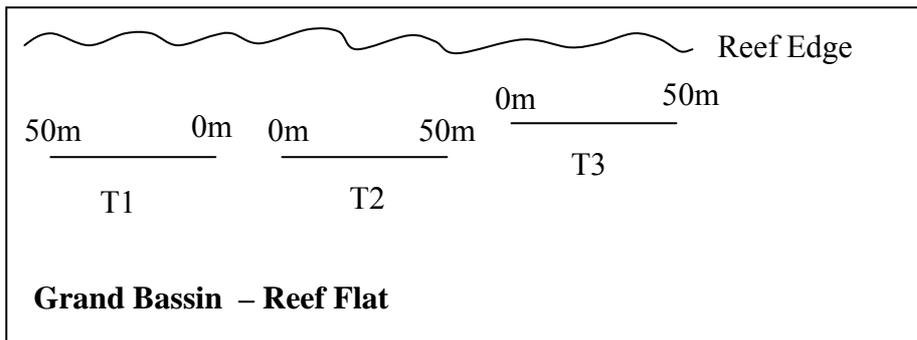
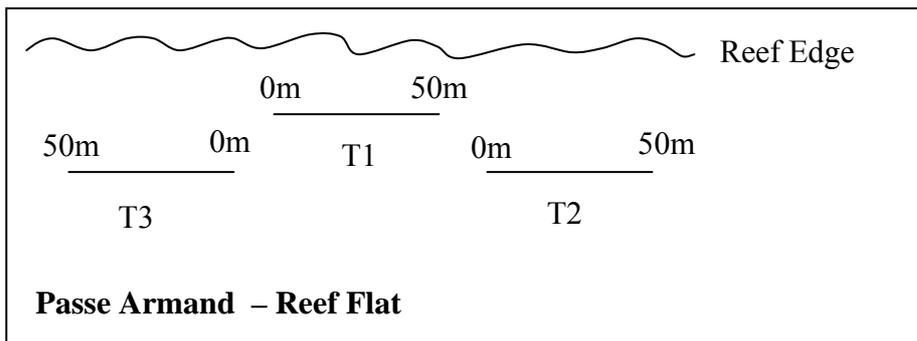
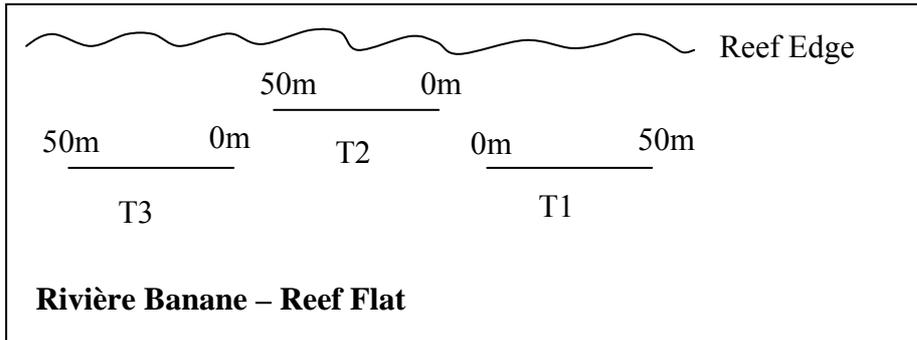
- Lynch T.L., Meunier M.S., Hooper T.E.J., Blais F.E.I., Raffin J.S.J, Perrine S., Félicité N., Lisette J., Grandcourt J.W. (2002). Annual report of benthos, reef fish and invertebrate surveys for Rodrigues 2002. Shoals Rodrigues report, 30pp.
- Lynch, T. L., Meunier, M. S., Hooper, T. E. J., Blais, F. E. I., Raffin, J. S. J., Perrine, S., and Raffaut, R. (2004a). Annual report of benthos, reef fish and invertebrate surveys for reef slope and reef flat areas in Rodrigues 2003. Shoals Rodrigues report, 52pp.
- Lynch, T. L., Meunier, M. S., Blais, F. E. I., Raffin, J. S. J., Perrine, S., Raffaut, R. and Perry, A. C. (2004b). Annual report of benthos, reef fish and invertebrate surveys for reef slope and reef flat areas in Rodrigues 2004. Shoals Rodrigues report, 48pp.
- Pearson, M. P. (1988). Rodrigues. Rapid survey of the status of the exploitation and environmental damage of the lagoon and coral reefs of Rodrigues. Report prepared for the project 'Assistance to artisanal fishermen and development of outer reef fishery'. FAO, Rome.
- Shoals of Capricorn Programme (2002). Rodrigues Marine Biodiversity Workshop 10 September to 05 October 2001 Final Report.

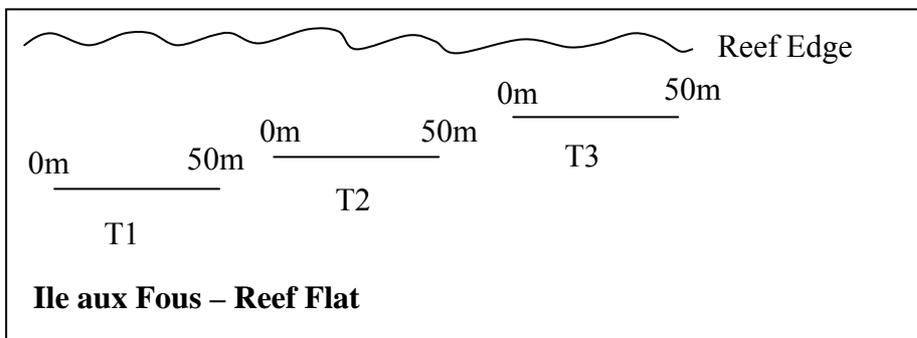
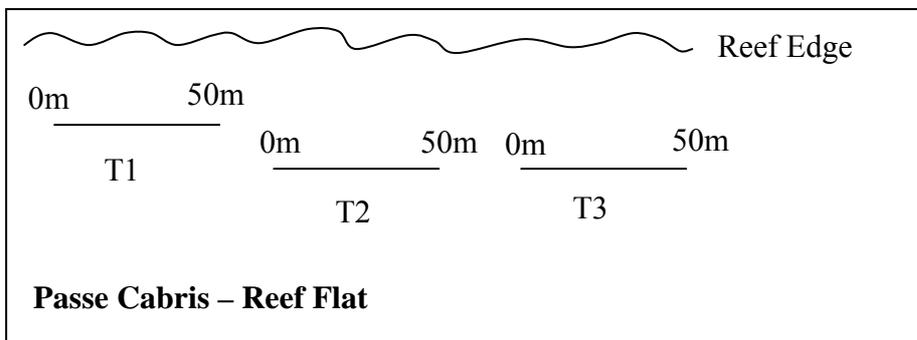
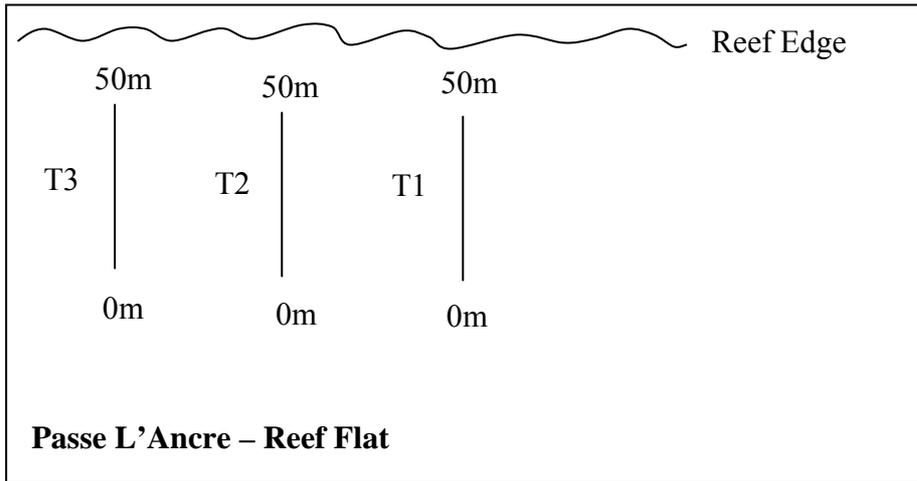
6 Appendices

6.1 Transect Locations









6.2 Benthic categories

Acropora branching (ACB)



Acropora digitate (ACD)



Acropora encrusting (ACE)



Acropora tabular (ACT)



Coral branching (CB)



Coral encrusting (CE)



Coral foliose (CF)



Coral mushroom (CL)



Coral massive (CS)



Coral sub-massive (CS)



Millepora (MI)



Soft coral (SC)



Zoanthids (ZO)



Dead coral (DC)



Rubble (RB)



Macroalgae (MA)



Turf algae (TA)



Coralline algae (CA)



6.3 Data Tables

Table A1. The mean percentage cover of the different benthic habitats at the 6 reef slope sites during (a) summer (March) and (b) winter (October).

(a) Summer

	Rivière Banane	Passe Armand	Grand Bassin	Passe Demi	Ile aux Fous	North Ile aux Sables
Branching <i>Acropora</i>	70.6	45.4	54.6	46.4	45.6	39.8
Digitate <i>Acropora</i>	2.7	0.0	5.0	4.1	0.3	2.4
Tabular <i>Acropora</i>	12.1	3.6	18.8	11.0	3.3	0.0
Encrusting <i>Acropora</i>	1.8	0.0	0.0	0.0	0.0	0.0
Branching Coral	0.0	0.0	7.8	1.2	0.0	0.0
Foliose Coral	0.0	0.0	0.0	0.0	0.0	0.0
Encrusting Coral	1.8	21.3	6.7	12.8	4.8	12.7
Massive Coral	8.6	25.6	4.7	15.0	41.0	29.1
Sub-massive Coral	2.1	4.1	0.4	7.5	4.0	12.7
Mushroom Coral	0.0	0.0	0.4	0.4	0.0	0.3
<i>Millepora</i> sp.	0.2	0.0	1.6	1.5	0.9	2.9
Soft Coral	0.4	3.9	8.6	6.2	1.3	16.2
Coralline Algae	15.3	33.8	17.2	19.3	9.0	54.1
Macro-Algae	0.0	0.0	5.0	7.7	6.1	0.0
Turf Algae	33.5	33.3	22.4	20.0	28.2	3.9
Zoanthids	0.3	0.0	0.0	1.1	0.5	0.0
Dead Coral	0.2	0.0	1.7	0.0	0.0	0.0
Sand	0.0	0.0	0.0	8.2	2.4	0.0
Rubble	0.0	2.3	0.0	0.0	6.0	0.0

(b) Winter

	Rivière Banane	Passe Armand	Grand Bassin	Passe Demi	Ile aux Fous	North Ile aux Sables
Branching <i>Acropora</i>	88.9	62.2	61.5	82.3	38.0	45.0
Digitate <i>Acropora</i>	2.7	1.5	4.3	1.7	2.3	2.3
Tabular <i>Acropora</i>	0.0	3.3	18.0	0.8	6.3	0.0
Encrusting <i>Acropora</i>	1.4	0.0	0.0	0.0	0.0	0.0
Branching Coral	0.0	0.4	0.0	0.0	0.0	0.0
Foliose Coral	0.0	0.0	0.0	0.0	0.0	0.0
Encrusting Coral	0.3	17.8	4.0	0.0	7.9	2.6
Massive Coral	5.2	9.3	0.8	13.0	38.2	22.4
Sub-massive Coral	1.5	2.2	5.3	2.1	5.4	18.6
Mushroom Coral	0.0	0.0	0.0	0.0	0.0	0.0
<i>Millepora</i> sp.	0.0	3.3	6.1	0.0	2.0	9.2
Soft Coral	0.3	4.0	11.8	4.2	1.3	14.8
Coralline Algae	10.8	16.8	11.3	23.1	1.7	51.7
Macro-Algae	6.7	1.5	23.4	0.0	21.3	0.0
Turf Algae	31.8	48.6	7.6	36.7	31.4	15.0
Zoanthids	0.4	0.0	0.0	0.0	0.0	0.0
Dead Coral	0.0	0.0	0.0	0.0	0.0	0.0
Sand	0.0	0.0	0.0	13.0	0.0	0.0
Rubble	0.0	0.0	0.0	2.3	0.0	0.0

Table A2. The mean number of fish species present at the 6 reef slope sites during summer (March)

	Rivière Banane	Passe Armand	Grand Bassin	Passe Demi	Ile aux Fous	North Ile aux Sables
Large dark surgeons >40cm	0.0	0.7	0.0	0.0	0.0	0.0
Medium dark surgeons 20-40cm	3.0	5.0	6.0	34.3	5.0	2.0
Small dark surgeons <20cm	15.7	20.7	28.7	30.0	20.3	20.3
<i>Acanthurus triostegus</i>	0.0	0.0	0.0	0.0	11.3	0.0
<i>Naso unicornis</i>	0.7	0.0	0.0	0.0	0.0	0.0
<i>Zebrasoma desjardinii</i>	0.0	0.0	0.7	0.0	0.0	0.7
<i>Zebrasoma scopas</i>	2.3	1.3	1.3	0.7	2.0	0.0
<i>Caranx melampygus</i>	1.0	0.0	0.0	0.3	0.0	0.0
<i>Chaetodon auriga</i>	0.0	0.0	1.0	0.0	0.7	0.0
<i>Chaetodon guttatissimus</i>	0.0	1.7	0.7	0.3	0.0	0.0
<i>Chaetodon interruptus</i>	0.0	1.0	0.0	0.0	0.0	0.0
<i>Chaetodon lunula</i>	0.0	0.0	0.3	0.0	0.3	0.0
<i>Chaetodon madagaskariensis</i>	0.0	0.3	0.0	0.0	0.3	0.0
<i>Chaetodon melannotus</i>	0.0	0.3	1.0	0.0	1.0	0.0
<i>Chaetodon trifascialis</i>	0.0	0.3	2.0	0.3	1.3	0.0
<i>Chaetodon trifasciatus</i>	1.0	0.0	0.0	2.0	0.0	2.0
<i>Chaetodon unimaculatus</i>	0.0	0.0	0.3	0.0	0.0	0.3
<i>Chaetodon xanthocephalus</i>	0.0	0.7	0.0	0.0	0.0	0.0
<i>Chaetodon zanzibarensis</i>	0.0	0.0	0.0	0.0	0.7	0.0
<i>Forcipiger flavissimus</i>	0.0	0.0	0.0	0.7	0.0	0.0
<i>Heniochus monoceros</i>	0.0	0.0	0.0	1.3	0.0	0.0
<i>Paracirrhites arcatus</i>	0.3	0.0	0.0	1.7	0.0	0.7
<i>Cheilinus trilobatus</i>	0.0	0.0	0.0	0.3	0.0	0.3
<i>Cheilinus chlororus</i>	0.3	0.0	0.0	0.0	1.0	0.0
<i>Coris aygula</i>	0.0	0.0	0.3	0.0	0.0	0.0
<i>Hemigymnus fasciatus</i>	0.0	0.7	0.0	0.0	1.0	0.0
<i>Anampses caeruleopunctatus</i>	1.0	0.0	0.3	0.0	0.0	0.0
<i>Anampses melagrides</i>	0.0	0.0	0.0	0.0	1.3	1.0
<i>Anampses twistii</i>	0.0	0.0	0.0	0.7	0.7	0.0
<i>Gomphosus caeruleus</i>	0.7	0.3	1.0	1.7	1.7	0.3
<i>Halichoeres hortulanus</i>	0.0	0.0	0.0	0.0	0.7	0.0
<i>Halichoeres marginatus</i>	1.7	0.0	1.0	0.7	0.7	2.0
<i>Labroides bicolor</i>	0.0	0.7	0.0	0.7	0.3	0.3
<i>Labroides dimidiatus</i>	0.3	1.0	0.0	0.0	1.3	0.0
<i>Stethojulis albobittata</i>	0.7	3.3	0.7	1.7	2.3	2.7
<i>Thalassoma genivittatum</i>	6.3	10.3	8.0	4.0	10.7	3.3
<i>Thalassoma hardwicke</i>	0.0	0.0	0.3	0.0	0.0	0.0
<i>Gnathodentex aurolineatus</i>	0.3	13.0	2.3	0.0	21.7	0.0
<i>Lutjanus fulvus</i>	0.0	0.3	0.7	0.0	0.0	0.0
<i>Oxymonacanthus longirostris</i>	1.3	0.0	2.7	0.0	0.0	0.0
<i>Mulloidichthys flavolineatus</i>	0.0	5.0	0.0	0.0	0.0	0.0
<i>Mulloidichthys Vanicolensis</i>	1.7	0.0	0.0	0.0	0.0	0.0
<i>Parupeneus trifasciatus</i>	0.3	0.0	0.0	0.0	0.0	0.0
<i>Abudefduf sexfasciatus</i>	10.0	1.3	20.3	43.7	0.0	8.7
<i>Abudefduf vaigiensis</i>	0.0	1.0	0.0	0.0	0.0	0.0
<i>Chromis dimidiata</i>	0.0	0.0	0.0	18.3	12.3	0.0
<i>Chromis nigrura</i>	110.0	5.7	0.0	25.3	0.0	1.0
<i>Plectroglyphidodon dickii</i>	31.0	1.7	5.0	2.7	23.7	2.7

	Rivière Banane	Passe Armand	Grand Bassin	Passe Demi	Ile aux Fous	North Ile aux Sables
<i>Plectroglyphidodon johnstoniatus</i>	1.3	1.7	0.7	2.0	10.0	0.0
<i>Pomacentrus caeruleus</i>	0.0	5.7	0.0	0.3	0.0	0.0
<i>Pomacentrus indicus</i>	20.0	4.3	0.7	3.3	26.3	6.3
<i>Pomacentrus pikei</i>	0.0	1.3	1.0	4.0	2.7	2.0
<i>Pomacentrus rodriguesii</i>	1.7	9.7	0.0	0.0	0.3	0.0
<i>Stegastes peliceri</i>	0.0	2.0	0.0	0.0	0.0	0.0
<i>Hipposcarus harid</i>	0.3	0.0	1.7	0.0	0.0	0.0
<i>Scarus ghobban</i>	0.0	0.3	0.0	0.0	0.0	0.0
<i>Scarus scaber</i>	2.7	0.3	0.3	0.7	0.0	0.0
<i>Chlorurus sordidus</i>	6.3	12.0	3.7	4.3	1.7	19.7
<i>Chlorurus strongylocephalus</i>	1.7	0.0	0.0	0.0	0.0	0.0
Small immature parrotfish	3.3	14.7	20.3	2.7	67.3	1.7
<i>Plectropomus punctatus</i>	0.3	0.3	0.3	0.0	0.0	0.0
<i>Cephalopholis argus</i>	1.7	0.0	0.0	0.3	0.3	0.3
<i>Variola louti</i>	0.0	0.3	0.0	0.3	0.0	0.3
<i>Epinephelus spilotoceps</i>	0.0	0.3	0.0	0.0	0.0	0.0
<i>Siganus sutor</i>	0.0	0.0	0.7	0.0	0.0	0.0
<i>Canthigaster valentini</i>	0.0	0.3	0.0	0.0	0.0	0.0
<i>Zanclus cornutus</i>	0.0	1.0	0.3	0.3	1.3	0.3

Table A3. The mean number of invertebrate species present at the 6 reef slope sites during (A) summer (March) and (B) winter (October).

(a) Summer

	Rivière Banane	Passe Armand	Grand Bassin	Passe Demi	Ile aux Fous	North Ile aux Sables
<i>Echinothrix diadema</i>	6.7	0.3	2.0	0.7	0.3	0.7
<i>Echinometra mathaei</i>	15.7	125	4.7	2.7	178.7	688.0
<i>Echinostrephus molaris</i>	0.0	1.7	0.0	10.3	4.3	0.0
<i>Heterocentrotus mammillatus</i>	0.0	0	0.3	0.0	0.0	0.0
<i>Holothuria atra</i>	0.0	1.3	0.0	0.0	0.0	0.0
<i>Holothuria edulis</i>	0.0	0	0.0	0.0	0.3	0.0
<i>Stichopus chloronatus</i>	0.0	5.3	0.0	0.0	0.0	0.0
<i>Tropiometra carinata</i>	0.0	0	0.0	4.3	0.0	0.0
<i>Ophicoma erinaceus</i>	0.0	0	0.3	0.7	0.0	0.0
<i>Trochus maculatus</i>	0.0	1	0.3	0.0	0.0	1.7
<i>Turbo argyrostomus</i>	2.3	0	0.3	0.0	0.0	0.7
<i>Conus</i> sp	0.3	0.3	0.0	0.3	0.0	0.0
<i>Drupella</i> sp.	0.7	0	0.0	0.0	0.0	0.0
<i>Morula</i> sp.	0.0	0.7	0.0	0.0	0.0	0.0
<i>Vasum</i> sp	0.3	0	0.0	0.0	0.0	0.0
Nudibranch	0.0	0.7	0.0	0.0	0.0	0.0
<i>Tridacna maxima</i>	0.0	0.7	0.0	0.3	0.0	0.0
<i>Dardanus</i> sp	0.3	0.0	0.7	2.3	0.3	0.0

(b) Winter

	Rivière Banane	Passe Armand	Grand Bassin	Passe Demi	Ile aux Fous	North Ile aux Sables
<i>Echinothrix diadema</i>	7.0	0.0	0.0	0.0	0.7	0.0
<i>Echinometra mathaei</i>	7.0	232.7	0.7	1.3	131.0	810.0
<i>Echinostrephus molaris</i>	0.0	3.3	0.0	1.0	1.0	0.0
<i>Heterocentrotus mammillatus</i>	0.0	0	0.3	0.0	0.0	0.0
<i>Holothuria atra</i>	0.0	1.3	0.0	0.0	0.0	0.0

	Rivière Banane	Passe Armand	Grand Bassin	Passe Demi	Ile aux Fous	North Ile aux Sables
<i>Stichopus chloronatus</i>	0.0	6.3	0.0	0.0	0.0	0.0
<i>Ophicoma erinaceus</i>	1.0	0	0.0	0.7	0.0	0.5
<i>Fromia</i> sp	0.0	0	0.0	0.3	0.0	0.0
<i>Linckia</i> sp.	0.0	0.3	0.0	0.0	0.0	0.0
<i>Trochus maculatus</i>	0.0	4.7	0.0	0.0	0.7	6.5
<i>Turbo argyrostomus</i>	1.0	0	0.0	0.0	0.0	0.5
<i>Cypraea caputserpentis</i>	0.0	0.7	0.0	0.0	0.0	0.5
<i>Conus</i> sp	0.0	0.7	0.0	0.0	0.0	2.5
<i>Morula</i> sp	0.0	1.3	0.0	0.0	0.0	0.0
Nudibranch	0.0	0	0.3	0.3	0.0	0.0
<i>Tridacna maxima</i>	0.0	0.7	0.0	0.3	0.3	0.0
<i>Dardanus</i> sp	0.0	0.0	0.0	0.0	0.7	0.0

Table A4. The mean percentage cover of the different benthic habitats at the 7 reef flat sites during (A) summer (March) and (B) winter (October).

(a) Summer

	Rivière Banane	Passe Armand	Trou Blanc	Passe L'Ancre	Ile aux Fous	Passe Cabris
Branching <i>Acropora</i>	33.1	43.8	35.2	69.4	4.8	21.8
Digitate <i>Acropora</i>	18.1	22.0	9.8	6.1	0.0	10.0
Tabular <i>Acropora</i>	0.0	2.1	4.5	9.1	0.0	0.0
Encrusting <i>Acropora</i>	0.0	4.3	0.0	0.0	0.0	9.5
Branching Coral	0.0	0.0	0.0	10.5	0.0	0.0
Foliose Coral	0.0	0.0	0.0	0.0	0.0	0.0
Encrusting Coral	35.8	0.0	0.0	4.8	15.8	21.1
Massive Coral	9.3	2.8	11.1	0.0	3.2	0.6
Sub-massive Coral	3.7	21.2	39.3	0.0	66.8	36.9
Mushroom Coral	0.0	0.0	0.0	0.0	9.5	0.0
<i>Millepora</i> sp.	0.0	3.8	0.0	0.0	0.0	0.0
Soft Coral	0.0	0.0	54.4	20.5	0.0	0.0
Coralline Algae	8.3	4.8	2.2	3.8	7.2	23.6
Macro-Algae	0.7	0.0	0.0	0.3	0.0	0.8
Turf Algae	76.8	81.4	37.2	41.8	79.3	57.6
Zoanthids	0.0	0.0	0.0	0.0	0.0	0.0
Dead Coral	0.0	0.0	0.0	0.7	0.0	0.0
Sand	0.8	0.0	0.0	3.3	0.0	0.0
Rubble	1.2	1.1	0.0	2.5	0.0	0.0

(b) Winter

	Grand Bassin	Passe Armand	Ile aux Fous	Passe Cabris
Branching <i>Acropora</i>	4.1	37.1	4.7	19.0
Digitate <i>Acropora</i>	48.2	10.9	0.4	13.1
Tabular <i>Acropora</i>	1.4	3.4	0.0	0.0
Encrusting <i>Acropora</i>	0.0	0.0	0.0	0.0
Branching Coral	0.0	0.0	0.0	0.0
Foliose Coral	0.0	0.0	14.3	0.0
Encrusting Coral	0.0	0.0	4.1	6.2
Massive Coral	32.8	15.0	4.8	0.0
Sub-massive Coral	0.0	29.9	48.9	61.6
Mushroom Coral	0.0	0.0	22.8	0.0
<i>Millepora</i> sp.	13.5	3.7	0.0	0.0
Soft Coral	0.0	0.0	0.0	0.0

	Grand Bassin	Passe Armand	Ile aux Fous	Passe Cabris
Coralline Algae	17.5	24.3	18.3	23.1
Macro-Algae	0.0	0.0	0.0	2.5
Turf Algae	68.8	66.8	58.7	52.8
Zoanthids	0.0	0.0	0.0	0.7
Dead Coral	0.0	0.0	0.0	0.0
Sand	0.0	0.0	0.0	4.3
Rubble	0.0	0.7	0.0	0.0

Table A5. The mean number of fish species present at the 7 reef flat sites.

	Ile aux Fous	Passe Armand	Passe Cabris	Passe L'Ancre	Rivière Banane	Trou Blanc
Large dark surgeons >40cm	0.0	16.7	16.0	1.7	0.0	0.0
Medium dark surgeons 20-40cm	0.0	28.7	16.7	29.7	0.0	12.7
Small dark surgeons <20cm	51.7	6.3	3.7	0.0	5.3	0.0
<i>Acanthurus triostegus</i>	5.0	0.0	0.0	0.0	1.7	0.0
<i>Naso lituratus</i>	0.0	5.7	0.0	0.0	0.0	0.0
<i>Zebrasoma desjardini</i>	1.0	1.7	0.0	0.0	0.0	0.0
<i>Zebrasoma scopas</i>	0.3	0.0	0.0	2.0	0.0	0.7
<i>Chaetodon auriga</i>	0.3	0.7	0.0	0.0	0.0	0.0
<i>Chaetodon lunula</i>	0.7	0.0	0.0	0.0	0.7	0.0
<i>Chaetodon madagaskariensis</i>	0.0	0.0	0.0	3.0	0.0	4.3
<i>Chaetodon melannotus</i>	1.7	0.0	0.0	1.3	0.0	0.0
<i>Chaetodon trifasciatus</i>	6.0	1.3	0.0	0.3	0.0	0.0
<i>Chaetodon interruptus</i>	0.0	0.0	0.0	1.0	0.0	0.0
<i>Chaetodon vagabundus</i>	0.0	0.0	0.0	1.0	0.7	0.0
<i>Chaetodon xanthocephalus</i>	0.0	0.0	0.0	0.3	0.7	0.0
<i>Cheilinus chlororus</i>	1.7	0.0	0.0	0.0	0.3	0.0
<i>Coris aygula</i>	0.0	0.0	0.0	1.7	0.3	0.0
<i>Hemigymnus fasciatus</i>	0.0	0.0	1.7	29.7	0.0	0.0
<i>Anampses twistii</i>	0.0	0.3	1.7	2.0	0.0	1.0
<i>Gomphosus caeruleus</i>	2.0	0.0	0.0	0.0	0.3	0.0
<i>Halichoeres hortulanus</i>	0.0	6.0	3.0	2.3	0.0	0.0
<i>Halichoeres marginatus</i>	0.3	0.0	0.0	0.0	1.7	0.0
<i>Halichoeres nebulosus</i>	0.0	0.0	0.0	9.3	0.0	0.7
<i>Labroides dimidiatus</i>	0.3	9.0	21.7	8.0	0.0	3.3
<i>Stethojulis albobittata</i>	0.0	19.7	6.7	13.0	6.0	7.0
<i>Thalassoma genivittatum</i>	5.3	2.7	0.0	11.0	15.7	5.7
<i>Thalassoma hardwicke</i>	3.3	0.0	0.0	0.0	0.0	0.0
<i>Oxymonacanthus longirostris</i>	0.0	0.0	0.7	0.0	0.0	0.0
<i>Mullodichthys flavolineatus</i>	12.7	0.0	0.0	0.3	0.0	0.0
<i>Parupeneus trifasciatus</i>	0.7	0.0	0.0	0.0	0.0	0.0
<i>Abudefduf sexfasciatus</i>	21.0	0.0	0.0	0.0	0.0	0.0
<i>Abudefduf sparoides</i>	1.0	0.0	0.0	0.0	0.0	0.0
<i>Chrysiptera glauca</i>	0.0	0.0	1.0	8.7	0.7	5.3
<i>Dascylus aruanus</i>	36.0	0.0	0.0	53.7	0.0	53.3
<i>Plectroglyphidodon dickii</i>	0.3	0.0	0.0	3.0	0.0	0.0
<i>Plectroglyphidodon johnstoniatus</i>	0.0	0.3	0.0	0.0	0.7	0.0
<i>Pomacentrus caeruleus</i>	0.7	0.0	0.0	0.0	0.0	0.0
<i>Pomacentrus indicus</i>	0.0	3.0	1.0	0.0	5.7	0.0
<i>Stegastes spp</i>	0.0	57.0	13.0	0.0	0.0	0.0
<i>Stegastes limbatus</i>	9.3	30.0	0.0	12.3	10.0	188.3
<i>Stegastes nigricans</i>	73.3	0.0	2.0	8.3	32.3	0.0

	Ile aux Fous	Passe Armand	Passe Cabris	Passe L'Ancre	Rivière Banane	Trou Blanc
<i>Hipposcarus harid</i>	0.0	0.0	0.0	0.0	1.0	0.0
<i>Scarus ghobban</i>	0.0	0.3	10.3	0.0	0.0	0.0
<i>Scarus scaber</i>	0.0	0.0	0.0	2.3	0.0	0.3
<i>Chlorurus sordidus</i>	6.0	7.3	0.0	11.3	3.7	1.0
<i>Chlorurus strongylocephalus</i>	0.0	0.7	0.0	0.0	0.3	0.0
Small immature parrotfish	12.7	15.0	13.0	103.3	0.3	12.7
<i>Epinephelus merra</i>	0.0	0.7	0.0	0.0	0.0	0.0
<i>Epinephelus spilotoceps</i>	0.7	0.0	0.0	0.0	0.0	0.0

Table A6. The mean number of invertebrate species present at the 7 reef flat sites in (A) summer (March) and (B) winter (October).

(a) Summer

	Rivière Banane	Passe Armand	Ile aux Fous	Passe Cabris	Passe L'Ancre	Trou Blanc
<i>Echinothrix diadema</i>	17.0	3.7	0.0	0.7	0.0	0.0
<i>Echinometra mathaei</i>	499.0	707.0	22.0	149.7	0.0	540.7
<i>Holothuria atra</i>	1.3	0.3	0.0	0.3	7.3	0.7
<i>Stichopus chloronatus</i>	2.0	1.7	0.0	1.0	0.0	0.0
<i>Nardoa variolata</i>	2.0	0.0	0.0	0.0	0.0	0.3
<i>Ophicoma erinaceus</i>	0.0	0.0	0.0	0.0	0.0	2.3
<i>Trochus maculatus</i>	0.0	0.7	0.0	13.7	0.0	0.0
<i>Turbo argyrostomus</i>	0.0	0.0	0.0	0.3	0.0	0.0
<i>Cypraea caputserpentis</i>	0.0	0.3	0.0	2.0	0.0	0.3
<i>Cypraea annulus</i>	2.7	0.0	0.0	1.0	0.0	0.0
<i>Conus</i> sp	8.0	1.0	0.0	0.3	0.0	0.0
<i>Morula</i> sp.	1.0	0.0	0.0	0.0	0.0	0.0
<i>Vasum</i> sp	0.0	1.0	0.0	0.0	0.0	0.0
<i>Lithophaga</i> sp	0.0	0.0	0.0	0.0	0.0	0.3
<i>Tridacna maxima</i>	0.0	0.3	0.0	0.0	0.0	0.7
<i>Dardanus</i> sp	0.0	0.7	0.0	0.3	0.3	0.3

(b) Winter

	Grand Bassin	Passe Armand	Ile aux Fous	Passe Cabris
<i>Echinothrix diadema</i>	6.0	2.7	0.0	0.7
<i>Echinometra mathaei</i>	285.3	603.3	20.7	170.3
<i>Echinostrephus molaris</i>	0.0	0.7	0.0	0.0
<i>Holothuria atra</i>	0.3	0.0	0.0	0.0
<i>Trochus maculatus</i>	0.0	0.7	0.7	24.0
<i>Turbo argyrostomus</i>	0.0	0.3	0.0	0.0
<i>Cypraea caputserpentis</i>	1.3	0.0	0.0	0.3
<i>Conus</i> sp	0.7	0.3	1.0	0.3
<i>Morula</i> sp.	1.0	0.0	0.0	1.3
<i>Vasum</i> sp	0.3	0.0	0.0	0.0
<i>Tridacna maxima</i>	0.3	0.0	0.0	0.0
<i>Dardanus</i> sp	0.3	0.0	0.0	0.7