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VERTICAL DISTRIBUTION OF BENTHIC MARINE ORGANISMS ON ROCKY COASTS OF THE FERNANDO DE NORONHA ARCHIPELAGO (BRAZIL)

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Synopsis

Qualitative samples of flora and fauna were collected in several points, from the supralittoral fringe down to 30 m, using mainly aqualungs. Species distribution and abundance were determined along four transects, up to 200 m long, in selected places. Samples were taken from 25 x 25 cm quadrats positioned at fixed intervals along the transects down to a variable depth, depending on algal percentage cover and their substrate. The intertidal zone was populated essentially by molluscs. The subtidal was covered predominantly by macroalgae. Montastrea cavernosa, Siderastrea stellata and Mussismillia hispida were the only animal species with a significant percentage cover within the quadrats. Dictyopteris justii, D. plagiograma, Dictyota cervicornis, D. linearis, D. mertensii, Sargassum platycarpum, Sargassum sp, and Stypopodium zonale were the plants with the highest biomass and/or percentage cover, along with Amphiroa fragilissima, Caulerpa verticillata, and crustose corallines. The scarcity of sea urchins, along with the dominance of algae known to produce chemical feeding deterrents or to have a calcareous nature, points towards a strong pressure by predators, with fishes probably playing a key role in the maintenance of the structure of this subtidal community.

Descriptors: Benthic environment, Community composition; Check lists, Quantitative distribution, Vertical distribution, Oceanic archipelago, Nekton, Fernando de Noronha Archipelago: Brazil.
Descritores: Meio ambiente bentônico, Composição da comunidade, Lista das espécies, Distribuição quantitativa, Distribuição vertical, Arquipélago oceânico, Necton, Arquipélago de Fernando de Noronha: Brasil.

Introduction

The Archipelago of Fernando de Noronha is located 360 km off the northeastern coast of Brazil. The main island is the site of a military base, and is inhabited by ca. 1200 people working as government employees or in touristic activities.

Its benthic marine organisms were first collected by the Challenger expedition, from 1873 to 1876 (see Fausto Filho, 1974, Oliveira Filho, 1974). Ridley (1890) published the first taxonomic survey on the crustaceans, molluscs, echinoids, briozoans, and fishes of the Archipelago. Since that time, only taxonomic studies of the fauna have been undertaken, with the exception of the works of Laborel (1969), Matthews & Kempf (1970), and of Fausto Filho (1974), which give the bathymetric distribution of corals, molluscs, and crustaceans, respectively. The only work dealing with the marine flora of the region was done by Dickie (1874). After that, Pereira *et al.* (in press) listed the flora mainly of the intertidal zone. However, there is no quantitative data nor distribution

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profiles of the flora of the region.

As there is interest in increasing touristic activities in the archipelago, on one hand, and a popular movement to preserve its marine flora and fauna, on the other, the knowledge of the biota is a must. This motivated us to make a survey of the region to get preliminary information on the quali-quantitative composition of the flora and fauna of its rocky coasts, especially of the sublittoral. This paper deals with the general characteristics and vertical distribution of these benthic marine organisms.

Study site

The Archipelago of Fernando de Noronha belongs to a branch of the mid-Atlantic Ridge (Almeida, 1955), and is composed of six small volcanic islands and 14 islets. The main island is about 9 x 6 km, oriented in a NE - SW direction (Fig. 1). It emerges at 03°51'S and 32°25'W, receiving the clear, warm (26-27°C), and quite saline waters (36°/oo) of the South Equatorial Current (see Düing *et al.*, 1980). The Archipelago is probably under the effect of the Atlantic Equatorial Undercurrent, which originates off the northeastern Brazilian coast and flows below and in the opposite direction of the South Equatorial Current, along the Equator between 5°S and 5°N, at a depth of 60-90 m (Philander, 1973; Molinari *et al.*, 1981).

During most of the year, southeast trade winds reach the southeastern side of the archipelago, which is, therefore, subject to strong waves. The climate is tropical, with a dry season from August to January, and a wet period in the other months. Annual rainfall indexes reach 1083 mm, and mean air temperature is 25.3°C (Walter & Leith, 1960). There are few fresh-water streams in the archipelago, which remain dry during most of the year (Almeida, 1955).

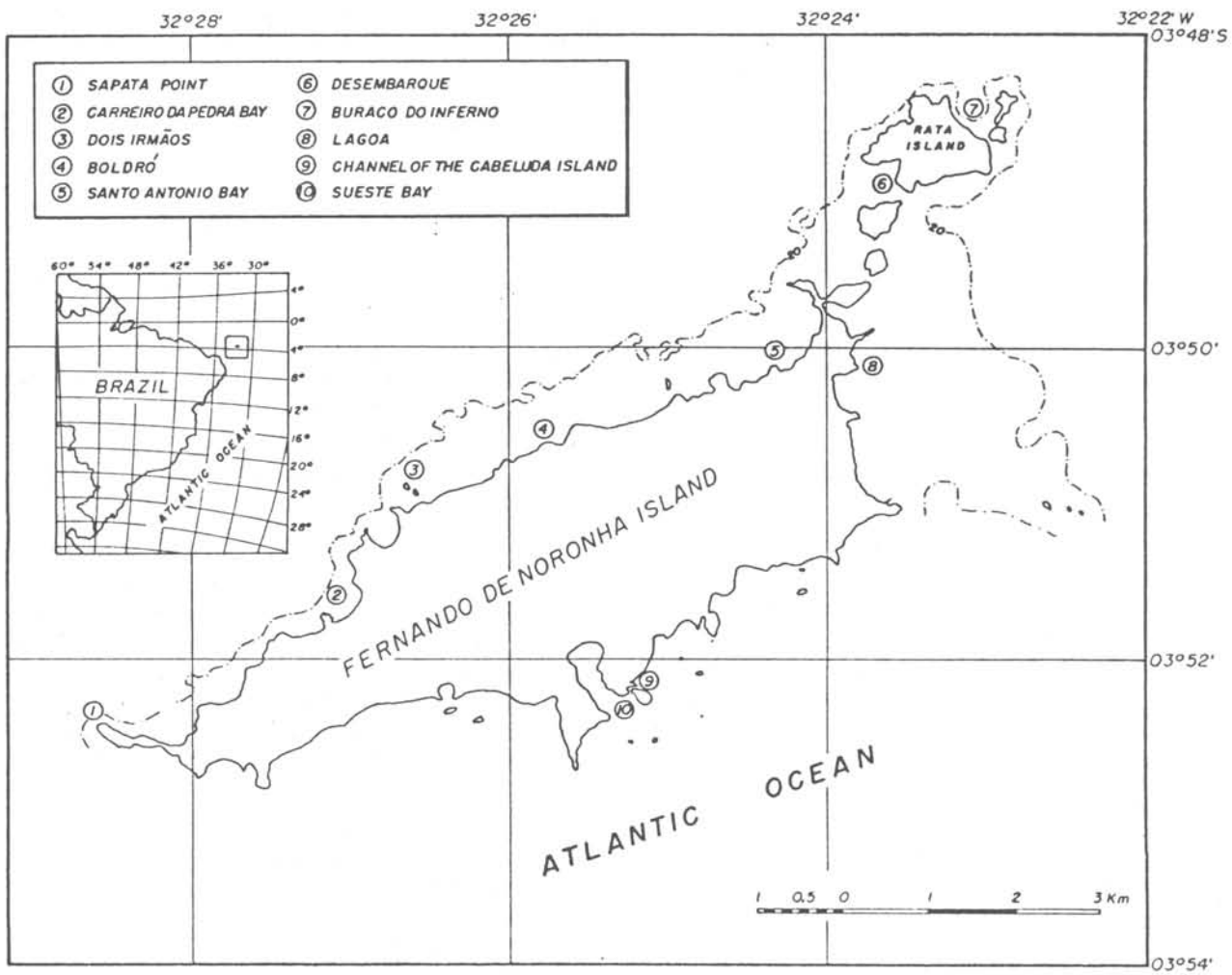

Fig. 1. Sampling stations in the Fernando de Noronha Archipelago.

Tides are semi-diurnal, with an amplitude of 3.2 m during the spring tides and 2.0 m in neap tides (Almeida, 1955). Smooth descending slopes, with boulders large enough not to be dislodged by the waves, compose most of the subtidal seascape where samples were collected (Fig. 1). Sapata Point was an exception, with its steep slope down to 27 m.

Methods

Qualitative samples of flora and fauna were collected in several points, from the supralittoral fringe down to 30 m, using mainly aqualungs, during late October-early November of 1985, to get an overview of the biota around the archipelago (Fig. 1).

In order to assess the vertical distribution and abundance of the species on the rocky coasts four transects, up to 200 m long, were laid perpendicularly to the shore in selected places: Sapata Point, Carreiro da Pedra Bay (Golfinhos Bay), Desembarque, and Buraco do Inferno. Samples were taken from 25 x 25 cm quadrats positioned at fixed places (5,10, or 20 m) interval along the transects down to a variable depth depending of algal abundance and their substrate. After being photographed and having its percent cover estimated visually, the flora was collected and sorted out in the laboratory. Four smaller quadrats (12.5 x 12.5 cm), placed within the standard one, were used to increase the precision of the cover data. The biomass of the most common fleshy species was measured (wet weight). The collected material was deposited in the herbarium of the Instituto de Biociências, Universidade de São Paulo, Brazil (SPF).

Percent cover data of the dominant algae (> 25% cover within each quadrat) was used to picture their distribution along the transects. Algae present with 25 ⊢ 50%, 50 ⊢ 75% and 75 ⊢⊣ 100% cover within the quadrats were drawn as 1,2, or 3 individuals, respectively, in Figures 2 to 5, which represent the transects. Because fauna was usually not abundant within the quadrats, its quantitative data was based on the observation of its occurrence along the entire transect. Identification of the fishes was based on photographs.

Results

Most of the observations described below concern the northwestern side of the Archipelago, once the strong waves did not permit satisfactory work on the other side. The vertical distribution of the benthic marine organisms along the four transects studied is illustrated in Figures 2-5.

The intertidal zone was essentially populated by the gastropods *Nodilittorina vermeiji*, *Collisella noronhensis*, *Nerita ascensionis deturpensis*, and *Siphonaria hispida*, and by the crab *Grapsus grapsus* (Table 1). *N. vermeiji* and *N. ascensionis* reached the highest position in the shore, present from the supralittoral fringe to the lower level of the midlittoral; together with *C. noronhensis* and *S. hispida*, these snails formed dense populations in the midlittoral zone. *C. noronhensis* and *N. ascensionis* were specially abundant in the exposed sites. Large portions of the intertidal substrate were often devoid of macroorganisms, being apparently naked. Algae, such as blue-greens, calcareous crusts, and *Bostrychia binderi* (Table 2) were occasionally present in the intertidal zone. The molluscs *Thais rustica* and *Leucozonia nassa* were observed mainly between the lower intertidal and the infralittoral fringe, a region usually characterized by red Melobesioidae algae, vermetids (*Dendropoma irregulare* and *Petaloconchus varians*) and *Brachidontes exustus*. The vermetids were isolated or forming small concretions, rarely constituting reefs. Boldró Beach was an exception, where there was a Vermetidae/Melobesioidae reef platform on the infralittoral fringe. This reef formation sheltered in crevices and pools a more varied fauna, composed, for instance, of *Leucozonia ocellata*, *Columbella mercatoria*, *Astraea tecta*, *Conus regius*, *Eucidaris tribuloides*, *Fissurella* spp, zoanthids, and pagurids.

The subtidal was covered predominantly by macroalgae, specially in Carreiro da Pedra Bay, Desembarque, and Buraco do Inferno (Figs 3-5), where their percentage cover was 100% within almost all quadrats (Tables 3-5). Corals and several species of sponges were observed, not covering, however, great extensions of the coasts. *Montastrea*

cavernosa, *Siderastrea stellata* and *Mussismillia hispida* were the only animal species with a significant percentage cover within the sampling quadrats. Sapata Point (Fig. 2) was a contrast to this rule, being dominated by sessile fauna. A list of the fauna collected within the quadrats and in the other sampling sites is presented in Table 1.

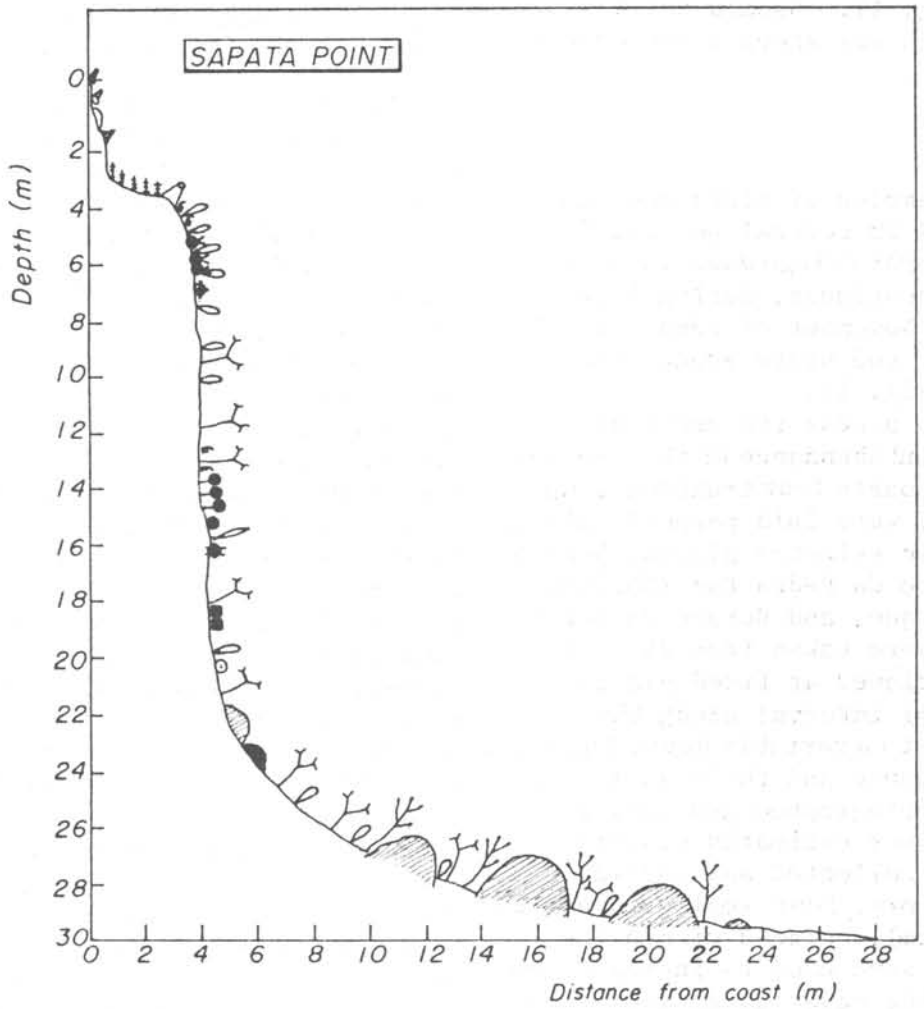

Fig. 2. Vertical distribution of the sessile animals and of the main algae present along the Sapata Point transect

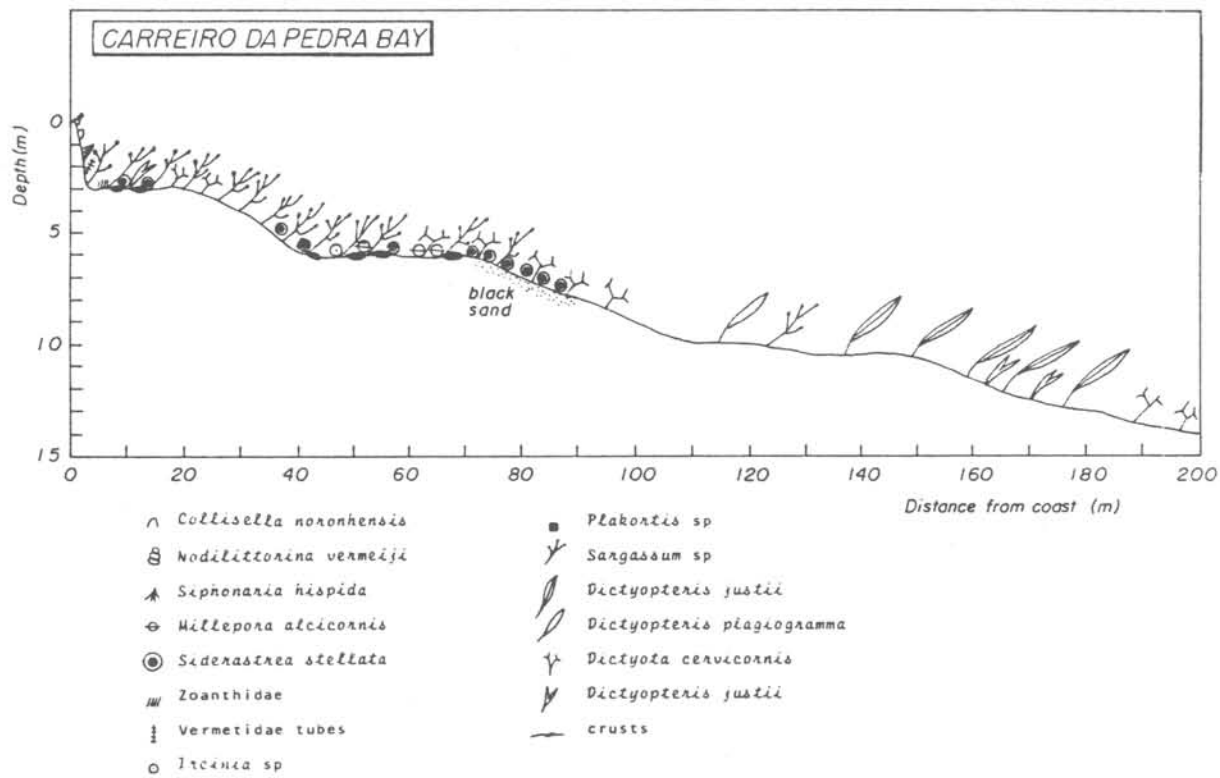

Fig. 3. Vertical distribution of the sessile animals and of the main algae present along the Carreiro da Pedra Bay transect. Data of flora beyond 100 m were estimated without the quadrats.

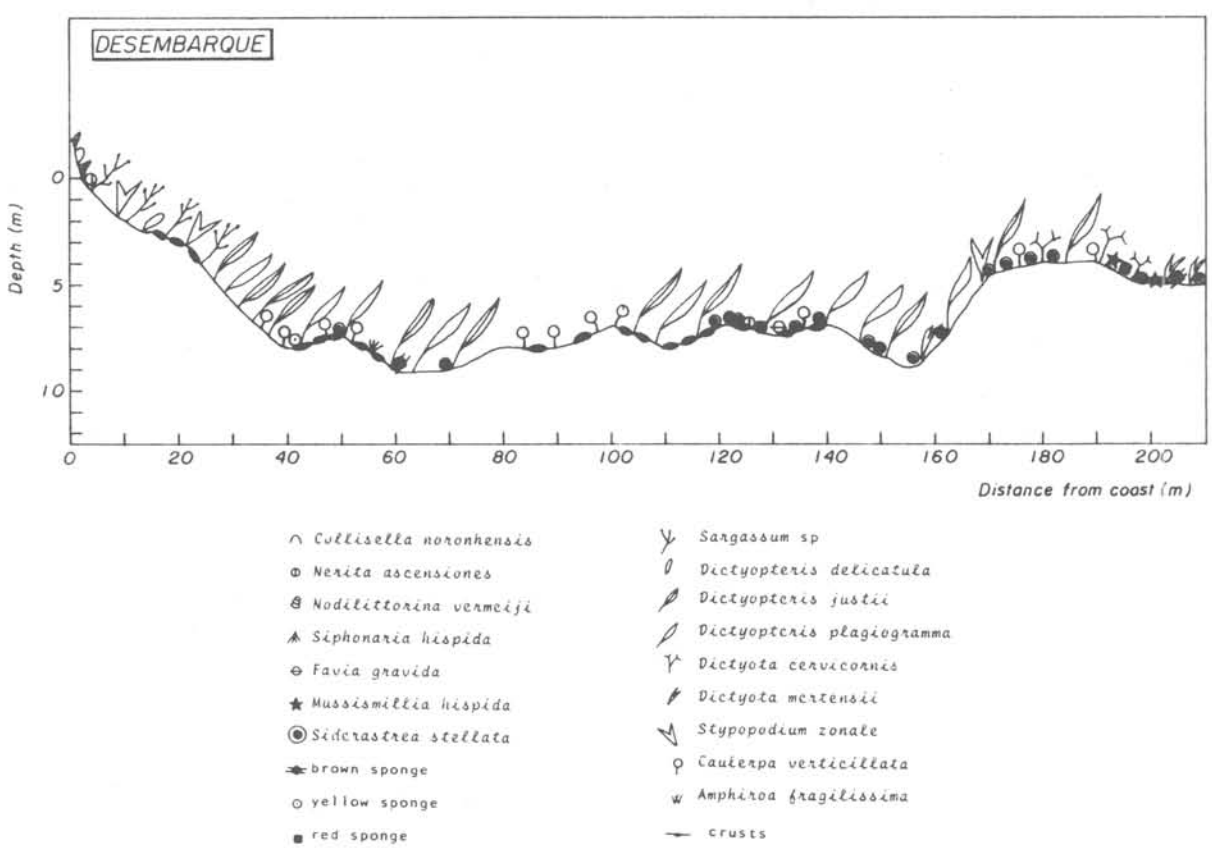

Fig. 4. Vertical distribution of the sessile animals and of the main algae present along the Desembarque transect.

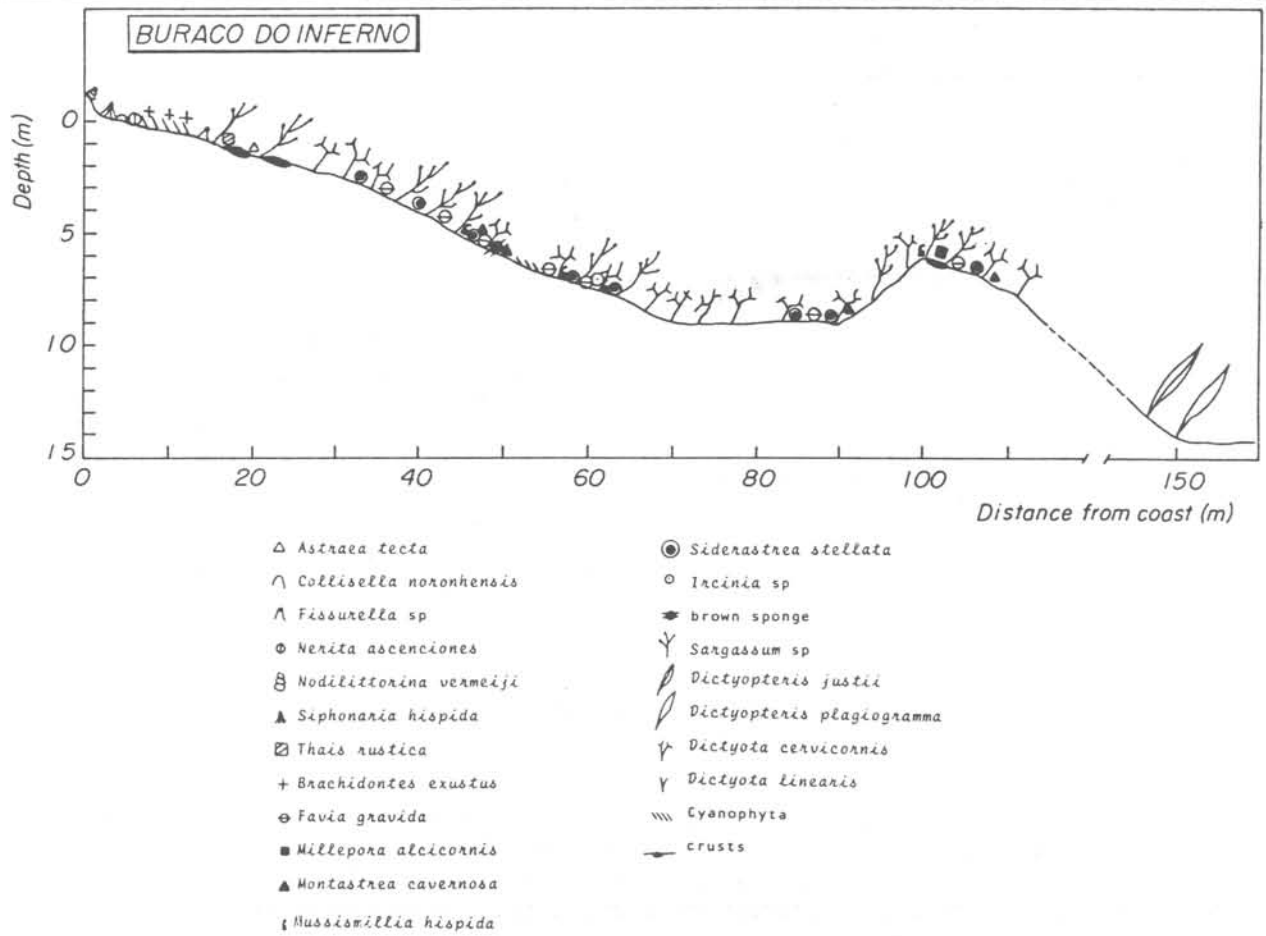

Fig. 5. Vertical distribution of the sessile animals and of the main algae present along the Buraco do Inferno transect. Data of flora beyond 110 m were estimated without the quadrats.

The most common species of macroalgae around the archipelago are listed in Table 2, which does not include small filaments, tiny epiphytes, and many of the blue-greens. Brown algae of the families Dictyotaceae (*Dictyopteris justii*, *D. plagiogramma*, *Dictyota cervicornis*, *D. linearis*, *D. mertensii*, *Stypopodium zonale*) and Sargassaceae (*Sargassum platycarpum* and *Sargassum* sp) were dominant in terms of biomass and/or percent cover, along with *Caulerpa verticillata* (Caulerpaceae), *Amphiroa fragilissima* (Corallinaceae), and crustose corallines (Table 3-6, Figs 2-5). Desembarque (Fig. 4, Table 4) presented the highest algal diversity among the transects studied. *Dictyopteris* spp. normally occurred deeper than *Sargassum* spp. *Halodule wrightii* was the only species of Magnoliophyta found, observed at Sueste Bay.

Sea urchins were scarce. Only one specimen of *Tripneustes ventricosus*, and a few *Eucidaris tribuloides* and *Diadema antillarum ascensionis* were seen. Fishes, on the other hand, were abundant; the most common species observed during the dives are listed in Table 7. Large pelagic carnivores, such as sharks, barracudas, and dolphins were also present. A large population of dolphins (*Stenella longirostris*), that remained for long periods at Carreiro da Pedra Bay, was remarkable. Only one specimen of *Chelonia mydas*, a herbivorous sea turtle, was seen at Desembarque.

Discussion

A striking feature of the Fernando de Noronha northwestern shores was the simplicity of the littoral zone, in terms of species diversity and zonation.

The supralittoral fringe and the midlittoral zone were dominated by gastropods that showed wide vertical ranges when compared to their mainland equivalents. *Nodilittorina lineolata* (= *Littorina ziczac brasiliensis*) (see Bandel & Kaldosky, 1982), for instance,

Table 1. Macrofauna species collected in the Fernando de Noronha Archipelago, arranged according to the sampling stations: (1) Sapata Point; (2) Carreiro da Pedra Bay; (3) Dois Irmãos; (4) Boldró; (5) Santo Antonio Bay; (6) Desembarque; (7) Buraco do Inferno; (8) Lagoa; (9) Channel of the Cabeluda Island and (10) Sueste Bay. Obs: C = common; U = uncommon; * = mainly intertidal; + intertidal and subtidal; without any mark = mainly subtidal

CLASSES AND SPECIES	COLLECTING LOCALITIES 1	2	3	4	5	6	7	8	9	10
DEMOSPONGIAE										
Callyspongia sp	C		C	C				C		
Chelonaphysilla sp								U		
Plakortis sp	C	C						C		
Ircinia sp		C		C		C		C		
Spongia sp			C							
Irgernella sp				U						
HYDROZOA										
Eudendrium sp				U						
Halocordyle disticha			C	C						C
Millepora alcicornis		C					C			
ANTHOZOA										
Zoanthus sp +		U								
Palythoa sp +	C			C						
Agaricia agaricites		U								
Favia gravida						U	U			
Montrastea cavernosa	C						C			
Mussismillia hispida	C	C	C			C	C			
Porites asteroides		U					U			
Siderastrea stellata		C		C		C	C			
GASTROPODA										
Fissurella spp *	U	U		U	U	U	U	U		
*Collisella noronhensis**	C	C	C	C	C	C	C	C		C
Astraea tecta+		C		C		C	C			
*Nerita ascensionis deturpensis**	C	C	C	C	C	C	C	C		C
*Nodilittorina vermeiji**	C	C	C	C	C	C	C	C		C
Dendropoma irregulare+	C	C		C			C			
*Petaloconchus varians**				U						
Trivia pediculus	U									
Cypraea cinerea		U								
*Thais haemastoma**				U						
Thais rustica+	U		C				C			
Thais nodosa meretricula										
*Columbella mercatoria**				C		C	C			
Engina turbinella								U		
*Leucozonia nassa**	C		C	C				C	C	
*Leucozonia ocellata**				C				C		
Latirus angulatus			U							
Conus regius+						C	C	C	C	
*Siphonaria hispida**	C	C		C	C	C	C	C	C	

CLASSES AND SPECIES	COLLECTING LOCALITIES 1	2	3	4	5	6	7	8	9	10
BIVALVIA										
*Brachidontes exustus**		C		C			C			
Pinna carnea			U							
CIRRIPEDIA										
*Megabalanus coccopoma**	U									
MALACOSTRACA										
*Grapsus grapsus**	C	C	C	C	C	C	C	C		C
Leptodius parvulus				U						
Macrocoeloma trispinosum				U						
Microphrys antillensis										
Microphrys bicornutus										
Mithrax forceps			U							
Panibacus antarticus							U			
Peronon gibbesi							U			
Pitho lherminieri		U								
Plagusia depressa				U						
ECHINOIDEA										
Diadema ascencionis							U			
Eucidaris tribuloides				U						
Tripneustes ventricosus										U
POLYCHAETA										
Hermodice carunculata				C				C		
*Eurithoe complanata**							C			
Marphysa regalis						C				
Glycera sp										C
? *Nereis* sp						C				
ASCIDIACEA										
Eudistoma sp	C									
Distaplia bermudensis	C									
Cystodytes dellechiajei						U				
Didemnun speciosum	C									
Polysyncraton sp						C				

occurs only on the high shore of the mainland coast of Brazil (Vermeij & Porter, 1971; Vermeij, 1973). Bands of barnacles and dense covers of macroalgae, characteristic of the intertidal zone around the world (see Lewis, 1964), were absent. The only barnacle observed, *Megabalanus coccopona*, was at Sapata Point. With the exception of *Brachidontes exustus*, this zone was also devoid of other filter-feeding animals. Vermeij (1972) and several other authors have already pointed out that intertidal suspension-feeders (mussels and barnacles) tend to be absent on temperate and tropical oceanic islands. The intertidal zone of Fernando de Noronha was similar to that of Ascension Island due to the presence of the snails *Nodilittorina miliaris* and *Nerita ascensionis ascensionis* on its supralittoral fringe and the absence of barnacles in the midlittoral zone. The great difference between the intertidal zones

Table 2. Common macroalgal species around the Fernado de Noronha Archipelago, sorted out according to functional-form groups (see Littler & Litter, 1980). Chemical grazing deterrents are indicated (*TO* when toxins are known for the species, and (*TO*) when they are known for the genus - see Norris & Fenical, 1982; Hay, 1984). Small filaments and epiphytes, and most of the blue-greens were not included

FILAMENTOUS GREENS

Bryopsis spp (10)
(TO) *Caulerpa fastigiata** (2)
(TO) *Caulerpa verticillata* (1,2,3,4,6, 7,9,10)
Chaetomorpha antennina (4&7: intertidal)
*Chaetomorpha spiralis** (5:drift, 7:intertidal,8,10)
Cladophora sp (4)
Cladophoropsis membranacea (4)
Enteromorpha sp (8)
Microdictyon sp* (2,7)
Siphonocladus sp* (6:uppertidal,8)

FILAMENTOUS REDS

Bostrychia binderi (5:uppertidal,6,7)
(TO) *Centroceras clavulatum* (1:intertidal, 4,7)
Champia sp* (2,4,7)
(TO) "Falkenbergia" phase of *A. taxiformis* (6,9,10)
Gelidiella acerosa (2,2:intertidal,4, 4:intertidal,6,7:intertidal,10)
*Gelidiopsis gracilis** (4)
Gelidiopsis planicaulis (2)
Gelidium pusillum (2)
Gelidium sp (1,2,2:intertidal,4,8)
Griffithsia sp (1,2:intertidal,4,9)
Wrangelia argus (1,3,4,5,6,7,7: intertidal,9,10)

FILAMENTOUS BROWNS

Ectocarpus breviarticulatus (1:intertidal,4,7:intertidal)
Sphacelaria sp (2)

FILAMENTOUS BLUE-GREENS

*Aphanocapsa littoralis**(1:intertidal)
*Arthrospira miniata** (3,4)
*Calothrix confervicola** (1:intertidal,4)
*Hydrocoleum lyngbyaceus**(1:intertidal,4)
*Lyngbya aestuarii**(1:intertidal,3)
*Lyngbya majuscula** (3,5,6)
Lyngbya sp* (3,5,6,7)
*Oscillatoria vizagapatensis** (4,6)
*Phormidium linneticum** (4, 6,7,8)
*Spirulina major** (3,4)

FOLIOSE GREENS

Ulva fasciata (9,10)
Ulva lactuca (9,10)

FOLIOSE REDS

Amansia multifida (9,10)
Cryptonemia sp (4,4:intertidal)

FOLIOSE BROWNS

Chnoospora sp (4)
Dictyopteris delicatula (1, 2,2:intertidal, 3,4,5:drift 6,7,7:intertidal,8,9,10)
Dictyopteris plagiogramma (2,2:intertidal,3,5,5: drift,6,7,7:intertidal, 8,9,10)
TO *Dictyota bartayresii* (3)
(TO) *Dictyota cervicornis* (2: intertidal,3,4,6,7,8)
(TO) *Dictyota ciliolata* (2,3)
(TO) *Dictyota dichotoma* (1,2,2: intertidal,3,6,7,7: intertidal,10)
(TO) *Dictyota linearis** (1,2,2: intertidal,3,5,6,7,8,10)
(TO) *Dictyota mertensii* (2,2: intertidal,4,6,7)
(TO) *Dictyota* sp (1,4,6,8,9,10)

FLESHY-WIRY GREENS (vesicular forms included)

TO *Caulerpa* ***cupressoides*** (8,9,10)
TO *Caulerpa mexicana* (10)
TO *Caulerpa prolifera* (7,10)
(TO) *Caulerpa racemosa* (10)
TO *Caulerpa sertularioides* (5,6,7,10)
*Codium intertextum** (4)
Codium isthmocladus (4)
Dictyosphaeria sp (4,4:intertidal, 6,7,7:intertidal,9,10)
Halycistis sp* (6,7:intertidal,8)
Valonia macrophysa (6,8)

FLESHY-WIRY REDS (vesicular forms included)

(TO) *Asparagopsis taxiformis* (10)
*Botryocladia occidentalis**(5,6,8)
*Botryocladia pyriformis** (2,6)
Bryothamnion triquetum(4,5,5:drift, 6,8,9,10)
(TO) *Chondria* sp* (2,4,7)
Chrysymenia sp (1,2)
Dictyurus occidentalis (10)
TO ***Digenia*** *simplex* (1,2,5,5:drift)
Enantiocladia sp (6,9)
Hypnea spinella (1:intertidal,7: intertidal,8)

FLESHY-WIRY BROWNS (vesicular forms included)

Colpomenia sinuosa (4,5: drift,6,8,9,10)

LEATHERY-RUBBERY BROWNS

Dictyopteris justii (2,2: intertidal,5:drift,6,7,8, 9,10)
Lobophora variegata (2,5,6, 7,8,9,10)
Padina spp (2,3,4,5,7,8,9,10)
(TO) *Sargassum filipendula** (10)

(Cont.)

Table 2. (Cont.)

Valonia ventricosa (6,8,10)

(TO) *Laurencia* spp (1:intertidal,2,4,4: intertidal,7,7:intertidal,8,9,10)

(TO) *Sargassum hystrix* (4)
(TO) *Sargassum platycarpum** (2,2: intertidal,4,6,7,9)
(TO) *Sargassum vulgare* (1: intertidal,5,5:drift,7: intertidal)
(TO) *Sargassum* sp (6,7,8)
TO *Stypopodium zonale** (5: drift,6,7,8,10)

UPRIGHT CALCAREOUS GREENS

Chamaedoris peniculum (8)
(TO) *Halimeda* spp (1,2,6,9,10)
Neomeris annulata (1,2,6,9,10)

UPRIGHT CALCAREOUS REDS

*Amphiroa cylindrica** (6,10)
*Amphiroa fragilissima** (6,7,10)
Amphiroa rigida var. *antillana* (6,10)
Amphiroa spp (1,2,2:intertidal,4,6,7, 7:intertidal,8,9,10)
Corallina subulata (2:intertidal)
Galaxaura cylindrica (2,2:intertidal, 4,5,6,8,9,10)
Galaxaura marginata (2)
Galaxaura obtusata (2,2:intertidal, 6,10)
Galaxaura spp (2,2:intertidal,4,4: intertidal,7,7:intertidal,8)
Jania adhaerens (3)
Jania capillacea (4,7,8,9)
Jania pumila (2,2:intertidal,4)
Liagora sp (4)

CRUSTOSE REDS

Hildenbrandia sp (2)
Lithothamnion spp (1,2:intertidal, 6,8,10)
*Peyssonelia boudouresquei** (4)
Peyssonelia sp (2,6,7,8)

CRUSTOSE BROWNS

Ralfsia sp* (4)

Obs: - Numbers between parentheses correspond to sampling sites (see Fig. 1). When tidal level is not mentioned, the algae were collected subtidally;
- Macrophytes for the first time mentioned for the Archipelago are indicated (*).

of these two islands is the presence, in protected places, of a distinctive band of oysters in Ascension, not observed by us in Fernando de Noronha. The infralittoral fringe, on the other hand, was rather different from those of Ascension and other tropical Atlantic shores, specially in the lack of the sea urchin *Echinometra lucunter*, normally found in large numbers in those localities (see Price & John, 1980). Typical of the southeastern side of the archipelago is the existence of a Vermetidae and Melobesioidae reef platform on the infralittoral fringe that requires intense water movement and clear waters, and thus does not develop well on the protected side (Laborel & Kempf, 1965/1966; Kempf & Laborel, 1968).

In the subtidal the macroalgae showed exuberant growth and relatively high biomass when compared to other tropical regions (Oliveira Filho, unpublished). The absence of extensions covered by corals was also remarkable. *Montastrea cavernosa* is the only coral species able to build colonies of respectable size; *Mussismillia*, *Millepora*, and *Siderastrea*, known to build reefs, hardly develop in the archipelago (Laborel, 1969). Sea urchins were also scarce; *Eucidaris tribuloides* and *Diadema antillarum ascensionis* occurred only in shelters, usually in the rare reef formations of the protected side. At Sapata Point this situation was quite different; the incidence of light in the rocky substrate was apparently lower than in the other sites, due to the steep slope of the cliff, what may not favor the development of a dense canopy of algae.

Both for the northern and southern

Table 3. Percent cover data of the dominant sessile organisms (estimated with quadrats) along the Carreiro da Pedra Bay transect in Fernando de Noronha

Distance from coast and (depth)	Canopy		Understory		Primary space	
	species	%cover	species	%cover	species	%cover
5m (3m)	*Sargassum* sp.	75	*Amphiroa* sp	6	Melobesioidae	6
	Dictyota linearis	6	filamentous red	6	*Peyssonelia* sp	6
			Dictyopteris delicatula	< 0.5		
			Gelidium sp	< 0.5		
10m (4.5m)	*Sargassum* sp	60		< 0.5	Melobesioidae	25
	Dictyota mertensii	25	*Dictyopteris delicatula*	< 0.5	*Peyssonelia* sp.	25
			Dictyota linearis	< 0.5		
15m (4.5m)	*Sargassum* sp	25	*Jania* sp	< 0.5	non identified crust	12.5
	Dictyota ciliolata	10	*Microdyction* sp	< 0.5	*Peyssonelia* sp	6
20m (4.5m)	*Dictyota cervicornis*	25	*Jania* sp	12.5	Melobesioidae	4
	Sargassum sp	25	*Dictyopteris delicatula*	< 0.5	*Peyssonelia* sp	2.5
	Dictyota dichotoma	6	*Galaxaura* sp	< 0.5		
			Gelidium sp	< 0.5		
30m (2m)	*Sargassum* sp	95	*Jania* sp	6	Melobesioidae	6
					Peyssonelia sp	6
					non identified crust	6
40m (5m)	*Sargassum platycarpum*	100	*Lobophora variegata*	2.5	*Peyssonelia* sp	25
					Melobesioidae	6
					non identified crust	6
50m (4.5m)	*Sargassum* sp	85	*Caulerpa verticillata*	6	non identified crust	50
			Lobophora variegata	< 0.5	*Peyssonelia* sp	< 0.5
70m (4.5m)	*Dictyota cervicornis*	50	*Jania* sp	6	*Peyssonelia* sp	10
	Sargassum sp	40	*Galaxaura cylindrica*	6	Melobesioidae	25
			Dictyopteris delicatula	2.5		
			Lobophora variegata	< 0.5	non identified crust	5
			Padina sp	< 0.5		
90m (6m)	*Dictyota cervicornis*	40	*Digenia simplex*	2.5		
	Dictyota linearis	12.5	*Jania* sp	2.5		
	Dictyopteris plagiogramma	6	*Sargassum* sp	< 0.5		
	Sargassum platycarpum	4				

Hemispheres it has been demonstrated that low densities of sea urchins favor the existence of abundant flora (for example, see North & Pearse, 1970; Duggins, 1983; Dayton, 1985, and Miller, 1985). On the other hand, many fishes known to feed heavily on marine algae, such as surgeon-fishes, blennies, and parrotfishes, were observed at Fernando de Noronha, although not in the high densities present in Ascension, where they eliminate all erect macroalgae (see Price & John, 1980).

The Dictyotaceae and Sargassaceae were the predominant groups of brown algae in Fernando de Noronha, a situation similar to that of the Caribbean sea (see Norris & Fenical, 1982). The dominance of these algae suggests that they are not only better succeeded in terms of space, but also less preferable as a food item to fishes

Table 4. Percent cover data of the dominant sessile organisms (estimated with quadrats), along the Desembarque transect in Fernando de Noronha (corals are indicated *)

Distance from coast and (depth)	Canopy species	%cover	Understory species	%cover	Primary space species	%cover
10m (2m)	*Sargassum* sp	75	*Amphiroa* sp	6	brown mat	6
	Stypopodium zonale	40	*Padina* sp	< 0.5		
	Dictyopteris plagiogramma	6				
	Dictyota cervicornis	6				
20m (3m)	*Sargassum platycarpum*	50	*Dictyopteris plagiogramma*	< 0.5	Melobesicidae	50
	Dictyopteris delicatula	30	*Dictyota* sp	< 0.5	*Peyssonelia* sp	6
	Stypopodium zonale	25	*Lobophora variegata*	< 0.5		
30m (6m)	*Dictyopteris justii*	50	*Lobophora variegata*	5		
	Dictyopteris plagiogramma	25	*Dictyosphaeria* sp	< 0.5		
			Sargassum sp	< 0.5		
			Valonia utricularis	< 0.5		
			Valonia ventricosa	< 0.5		
40m (8m)	*Dictyopteris justii*	50	*Caulerpa verticillata*	75		
	Dictyopteris plagiogramma	25	*Lobophora variegata*	4		
			Amphiroa fragilissima	< 0.5		
			Dictyopteris delicatula	< 0.5		
			Dictyota cervivornis	< 0.5		
50m (7.5m)	*Dictyopteris justii*	50	*Caulerpa verticillata*	50	Melobesioidae +	
	Dictyopteris plagiogramma	50	*Amphiroa fragilissima*	25	*Peyssonelia* sp	75
	Dictyota cervicornis	6	*Lobophora variegata*	6	*Siderastrea stellata**	4
	Dictyota linearis	2.5	*Dictyota mertensii*	< 0.5		
70m (9m)	*Dictyopteris justii*	50	*Caulerpa verticillata*	12.5	Melobesioidae	12.5
	Dictyopteris plagiogramma	50	*Dictyopteris delicatula*	< 0.5		
			Galaxaura obtusata	< 0.5		
			Lobophora variegata	< 0.5		
			Neomeris annulata	< 0.5		
90m (8m)	*Dictyota linearis*	6	*Caulerpa verticillata*	50	Melobesioidae	25
	Dictyopteris plagiogramma	2.5	*Lobophora variegata*	7.5		
			Colpomenia sinuosa	6		
			Caulerpa sertularioides	4		
			blue-greens	2.5		
			Valonia utricularis	< 0.5		
110m (8m)	*Dictyopteris justii*	75	*Caulerpa verticillata*	12.5	Melobesioidae	70
	Dictyopteris plagiogramma	50	*Lobophora variegata*	6	*Peyssonelia* sp	6
	Stypopodium zonale	20	*Dictyopteris delicatula*	< 0.5		
			Dictyota mertensii	< 0.5		
			Enantiocladia sp	< 0.5		
			Valonia ventricosa	< 0.5		
130m (7.5m)	*Dictyopteris justii*	25	*Bryothamnion triquetum*	< 0.5	Melobesioidae +	
	Dictyopteris plagiogramma	25	*Dictyopteris delicatula*	< 0.5	*Peyssonelia* sp	25
	Dictyota cervicornis	20	*Dictyota mertensii*	< 0.5		
			Gelidiella acerosa	< 0.5		
			Halimeda spp	< 0.5		
			Valonia ventricosa	< 0.5		

(Cont.)

Table 4. (Cont.)

150m (8m)	*Dictyopteris plagiogramma*	50	*Caulerpa verticillata*	7.5	*Lithothamnium* sp	< 0.5
	Dictyopteris justii	25	*Sargassum* sp.	< 0.5		
	Dictyota mertensii	25	*Stypopodium zonale*	< 0.5		
170m (4.5m)	*Dictyopteris justii*	50	*Caulerpa verticillata*	25	*Peyssonelia* sp	2.5
	Dictyota cervicornis	25	*Amphiroa fragilissima*	< 0.5		
	Stypopodium zonale	25	*Dictyopteris delicatula*	< 0.5		
			Dictyopteris plagiogramma	< 0.5		
			Dictyosphaeria sp	< 0.5		
			Dictyota mertensii	< 0.5		
			Sargassum sp	< 0.5		
190m (4m)	*Dictyota cervicornis*	50	*Caulerpa verticillata*	30	Melobesioidae	6
	Dictyopteris justii	25	*Amphiroa fragilissima*	< 0.5	*Siderastrea stellata*	*4
			Dictyosphaeria sp	< 0.5		
			Dictyota linearis	< 0.5		
			Sargassum sp	< 0.5		
210m (5m)	*Dictyota mertensii*	87.5	*Amphiroa fragilissima*	< 0.5		
	Dictyopteris justii	12.5	*Sargassum* sp	< 0.5		

than most of red and green algae. The Dictyotaceae are known to contain diterpenoids that may be toxic to fishes (Norris & Fenical, *op. cit.*; Hay, 1984). Polyphenols, known to have antibacterial effects, have already been extracted from *Sargassum* spp (Hay, *op. cit.*), algae eaten only by a few herbivorous and omnivorous fishes: kyphosids (not observed by us in the archipelago), pomacanthids as the parú *Pomacanthus paru*, and the balistid *Melichthys niger* (Randall, 1967).

Caulerpaceae, one of the conspicuous families of green algae in the Caribbean sea (Norris & Fenical, 1982) and at Saint Paul's Rocks (Lubbock & Edwards, 1981), was also well represented in Fernando de Noronha. Caulerpaceae produce secondary metabolites, such as caulerpin, caulerpicin, and caulerpenyne, that may intoxicate fishes and deter feeding in sea urchins (Hay, 1984). The other dominant algae observed in the archipelago are also known to deter feeding for their calcareous incrustation, such as *Amphiroa* spp., or for a morphology, such as that of calcareous and non-calcareous crusts, that makes it difficult for several groups of herbivores to feed on them (see Hay, 1981). Also remarkable were the abundance and diversity of blue-green algae and the absence of fleshy reds, such as Gracilariaceae, so common in the mainland littoral. Nevertheless, the existing species of algae are common members of the northeastern coast of Brazil (Oliveira Filho, 1977).

Besides the scarcity of barnacles and of sea urchins, several other animal groups were not well represented or were even quite rare. Starfishes, sea cucumbers, crinoids, solitary ascidians, and oysters, for instance, were not found by us in Fernando de Noronha. Matthews & Kempf (1970) and Fausto Filho (1974), studying molluscs and crabs, respectively, have also noted that many species that occur on the mainland do not occur in the archipelago. Evidence concerning the assumption that the archipelago is relatively isolated from the continent is the incidence of endemic species and subspecies in the intertidal and shallow waters (see Vermeij, 1972; Fausto Filho, 1974). Many of the species that do not have long-lived larval stages would have difficulty in reaching the islands or would be in insufficient numbers to establish a self-maintaining population. Most of the marine species found in Fernando de Noronha, however, are common to the western Atlantic, specially to

Table 5. Percent cover data of the dominant sessile organisms (estimated with quadrats) along the Buraco do Inferno transect in Fernando de Noronha (corals are indicated *)

Distance from coast and (depth)	species	%cover	Understory species	%cover	Primary space species	%cover
10m (0.5m)					blue-greens	75
20m (1.5m)	*Sargassum* sp	50			Melobesioidae	37.5
	Dictyota sp	6				
30m (3m)	*Dictyota cervicornis*		filamentous red	12.5	*Peyssonelia* sp	6
	+ *D.linearis*	75	*Padina* sp	6		
	Sargassum sp	12.5				
40m (4m)	*Sargassum* sp	75	*Padina* sp	< 0.5	*Peyssonelia* sp	
	Dictyota sp	20				
50m (6m)	*Dictyota cervicornis*	25	*Padina* sp	12.5	blue-greens	25
			Sargassum sp	< 0.5	*Siderastrea stellata**	5
60m (8m)	*Dictyota cervicornis*	75			*Siderastrea stellata**	2.5
	Sargassum platycarpum	50				
70m (9m)	*Dictyota cervicornis*				Melobesioidae	20
	+ *Dictyota* spp	95			*Siderastrea stellata**	10
					Peyssonelia sp	6
					*Mussismillia hispida**	2.5
80m (9m)	*Dictyota cervicornis*	25			Melobesioidae	6
					*Siderastrea stellata**	6
90m (9m)	*Dictyota cervicornis*		*Padina* sp	4	*Siderastrea stellata**	6
	+ *D.linearis*	25	*Valonia* sp	< 0.5		
100m (6m)	*Sargassum platycarpum*	75	*Dictyopteris justii*	< 0.5	*Peyssonelia* sp	25
	Dictyota linearis	25			Melobesioidae	6
110m (8m)	*Dictyota cervicornis*	50			*Siderastrea stellata*	6
	Sargassum platycarpum	6				
	Stypopodium zonale	6				

the Caribbean region and northeastern coast of Brazil (Lopes & Alvarenga, 1955; Matthews & Kempf, 1970; Fauto Filho, 1974). Scheltema (1968) has suggested that the Atlantic Equatorial Undercurrent is an important dispersal agent for pelagic larvae across the Atlantic. The influence of this current could explain why, in Fernando de Noronha, (and also in St. Paul's Rocks, see Lubbock & Edwards, 1981) the predominant marine fauna is more similar to the one of the western Atlantic than to that of the eastern.

The reduced habitat diversity of Fernando de Noronha's rocky coasts is probably responsible for the scarcity of some other species. The lack of estuarine and euryhaline forms, for example, are due to the absence of significant fresh water suplies (Matthews & Kempf, 1970; Fausto Filho, 1974). The only spot of mangal, present in Sueste Bay, was very reduced in area,

Table 6. Mean biomass (kg m^{-2} of wet weight) of the most abundant fleshy algal species of the Fernando de Noronha Archipelago collected within sampling quadrats

taxa \ sites	SAPATA POINT $\bar{X} \pm$ S.E. (N)	CARREIRO DA PEDRA BAY $\bar{X} \pm$ S.E. (N)	DESEMBARQUE $\bar{X} \pm$ S.E. (N)	BURACO DO INFERNO $\bar{X} \pm$ S.E. (N)
Dictyopteris justii	-	-	0.52 ± 0.12 (13)	-
D. plagiogramma	-	-	0.32 ± 0.08 (13)	-
Dityota spp	0.49 ± 0.21 (5)	0.13 ± 0.05 (9)	0.28 ± 0.19 (13)	0.61 ± 0.20 (11)
Sargassum spp	-	1.63 ± 0.36 (9)	0.23 ± 0.11 (13)	0.48 ± 0.20 (11)
Stypopodium zonale	-	-	0.10 ± 0.06 (13)	0.045 ± 0.045 (11)
mixture	-	0.01 ± 0.01 (9)	0.08 ± 0.03 (13)	-
Total biomass	0.49 ± 0.21 (5)	1.77 ± 0.34 (9)	1.53 ± 0.23 (13)	1.135 ± 0.23 (11)

Obs. 1) *Dictyota* spp in Buraco do Inferno were represented by *D.cervicornis* and *D.linearis*, and in Carreiro da Pedra Bay and Desembarque were represented by this two species, and *D.mertensii* as well;

2) *Sargassum* spp were represented by *S.platycarpum* and an unidentified species.

3) The mixture of algae was formed by *Dictyopteris delicatula*, *Galaxaura cylindrica*, *Jania* sp, *Lobophora variegata*, and *Padina* sp in Carrero da Pedra Bay, and by *Amphiroa fragilissima*, *Caulerpa sertularioides*, *C.verticillata*, *Dictyopteris delicatula*, and *Lobophora variegata* in Desembarque.

4) S.E.: standard error; N: number of quadrats sampled.

Table 7. Common species of fishes observed around the Archipelago of the Fernando de Noronha, separated according to food preferences (see Randall, 1967; Lobel, 1981; Lobel & Ogden, 1981; Sazima & Sazima, 1983)

Exclusively or predominantly herbivorous			Exclusively or predominantly carnivorous		
Acanthuridae	-	*Acanthurus coeruleus*	Balistidae	-	*Balistes vetula*
		Acanthurus sp	Bothidae	-	*Bothus lunatus*
Balistidae	-	*Melichthys niger*	Chaetodontidae	-	*Chaetodon* sp
Blennidae	-	several species of blennies	Gobiidae	-	*Gobiosoma* sp
Pomacanthidae	-	*Pomacanthus paru*	Haemulidae	-	*Haemulon bonairense*
Pomacentridae	-	*Stegastes variabilis*			*Haemulon chrysargyreum*
Scaridae	-	*Scarus* spp	Holocentridae	-	*Holocentrus* sp
		Sparisoma rubripinne	Labridae	-	*Halichoeres* sp
		Sparisoma sp	Myrichtidae	-	*Myrichthys ocullatus*
			Ostraciidae	-	*Lactophrys trigonus*
			Pomacentridae	-	*Abudefduf saxatilis*
			Pomadasyidae	-	*Anisotremus virginicus*
			Serranidae	-	*Epinephelus* sp

represented only by *Laguncularia racemosa*. Indeed, where the environments were more diverse, such as in the reef formations of Fernando de Noronha, there was a richer fauna. Fausto Filho (1974), for instance, found that most species of crabs inhabited the windward side of the archipelago. He considered that these reefs, with an uncountable number of microhabitats, provide abundant food and substrate for a more diversified fauna.

The absence of bands of barnacles and of dense covers of macroalgae on the intertidal zone is due, perhaps, to the activities of the dense population of grazers, such as *Collisella* and *Siphonaria*, known, in

other parts of the world, to be able to dislodge newly-settled larva of sessile animals, as they scrape the substrate (see Steneck & Watling, 1982). This, along with the presence of several species of predators (*Thais* spp and *Leucozonia* spp), could contribute to these absences. Predation may be also responsible for the scarcity of sea urchins. The fishes *Balistes veluta*, *Halichoeres* sp, and *Lactophrys trigonus*, predators of sea urchins (see Randall, 1967), are probably limiting the size of their populations. The scarcity of sea urchins, along with the dominance of algae known to produce chemical feeding deterrents or to have a calcareous nature, points towards a strong pressure by predators, with fishes probably playing a key role in the maintenance of the structure of this subtidal community. All these considerations need to be experimentally checked.

Recommendation: the protection of the archipelago

Being an oceanic archipelago, Fernando de Noronha has great scientific importance. The ecological interactions of its marine flora and fauna (with several endemic species), for instance, remain almost completely unstudied. Moreover, the existence of clear and warm waters most of the year makes the archipelago excelent for diving. For this reason, specially, the region has arisen a growing interest in tourism. However, it is obvious that this activity should be carefully planned in order to protect the marine life and scenery of this, so far, tropical paradise. Otherwise, as has already occurred on land, the original fauna and flora could be completely changed or destroyed.

We believe that a wisely planned touristic business, with a significant part of its profits invested in the conservation and study of the area, is the most feasible alternative for protecting the region from further degradation. Therefore, we strongly recommend the establishment of a National Park in the Fernando de Noronha Archipelago.

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