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Holothurian Distribution in the Lagoon at La Preneuse and Baie du Cap, Mauritius, Indian Ocean

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Abstract : Holothurian (Sea cucumber) study was carried out at two sites along the western and southern coast of Mauritius; namely La Preneuse and Baie du Cap. Visual census was adopted along five belt transect sets; placed at the back reef and shore reef respectively parallel to the reef and the shoreline at each site, to study the abundance and distribution of sea cucumbers. Together with the number of species present, the substrate cover type was noted. Each belt transect set covered 1,000m^2, so that we investigated 20,000m^2 in this study. Although eleven edible species are found in the Southwestern Indian Ocean including Mauritius, little information exists about their abundance and distribution patterns in the waters around the island. In this study, nine species, viz. *Actinopyga echinites, Bohadschia marmorata, Holothuria atra, H. leucospilota, H. pervicax, H. scabra, Stichopus chloronotus, S. variegatus* and *Thenelota ananas* were observed, about which the abundance and distribution patterns were discussed. This study will help in formulating coastal zone management policies.
Keywords : Holothurian, Sea cucumber, Distribution, Abundance, Mauritius

INTRODUCTION

Holothurians, commonly referred to as sea cucumbers or sea slugs, are marine animals belonging to the class Holothuroidea, phylum Echinodermata. Holothurians are conspicuous elements of the shallow water benthos. They commonly inhabit muddy sea floors, thriving on the substratum itself. They ingest and digest organic detritus, and also absorb dissolved organic matter from seawater. Hence, they act as scavengers cleaning the sea of organic materials, thereby contributing to the enhancement of the health of the marine environment.

Holothurians have been used as food in Japan, China, Southeast Asia and many Pacific Islands for centuries. The dried skin of selected species (notably *Actinopyga* spp., *Holothuria* spp., and *Thelenota ananas*) is pickled or added to soup and stews. It has a very high protein content and is highly priced in some areas of Asia, especially in China (Trinidad-Roa, 1987a, b; James, 1994; James and James, 1994). In addition to their value as food item, sea cucumbers are believed to have medicinal properties and are sold as an aphrodisiac in several Asian markets. There are also chemicals of biomedical interest in species of sea cucumbers, notably saponins (*holothurin*) which are toxic to gram-negative bacteria as well as fish (Richmond, 1996). The reddish pigment that is released from the skin of the common pacific reef-flat species *H. atra* is highly toxic to fish. This species is used by artistic fishermen for tide pool fishing to remove octopuses from small caves and crevices.

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Additionally, the collagen found in the body wall and cuvierian tubules of holothurians is of commercial interest in the production of glues and adhesives. For these reasons, the holothurians have been exposed to overexploitation in several countries.

Although about 700 species have been reported from the world (Brumbaugh, 1980), there is little literature about holothurian species in Mauritius. Michel (1974) reviewed 23 species in Order Aspidochirotida, and Arakaki and Fagoonee (1996) reported 28 species or varieties with 14 species not specifically identified and 2 species requiring further taxonomic study in this island. Conand (1998) mentioned 11 edible species in the Southwestern Indian Ocean region including Mauritius. However, little information exists about their abundance and distribution patterns in the water around the island.

The present study was carried out to assess the distribution and abundance of holothurians in the lagoon at La Preneuse (west coast) and Baie du Cap (south coast) before any commercial exploitation is envisaged in this island.

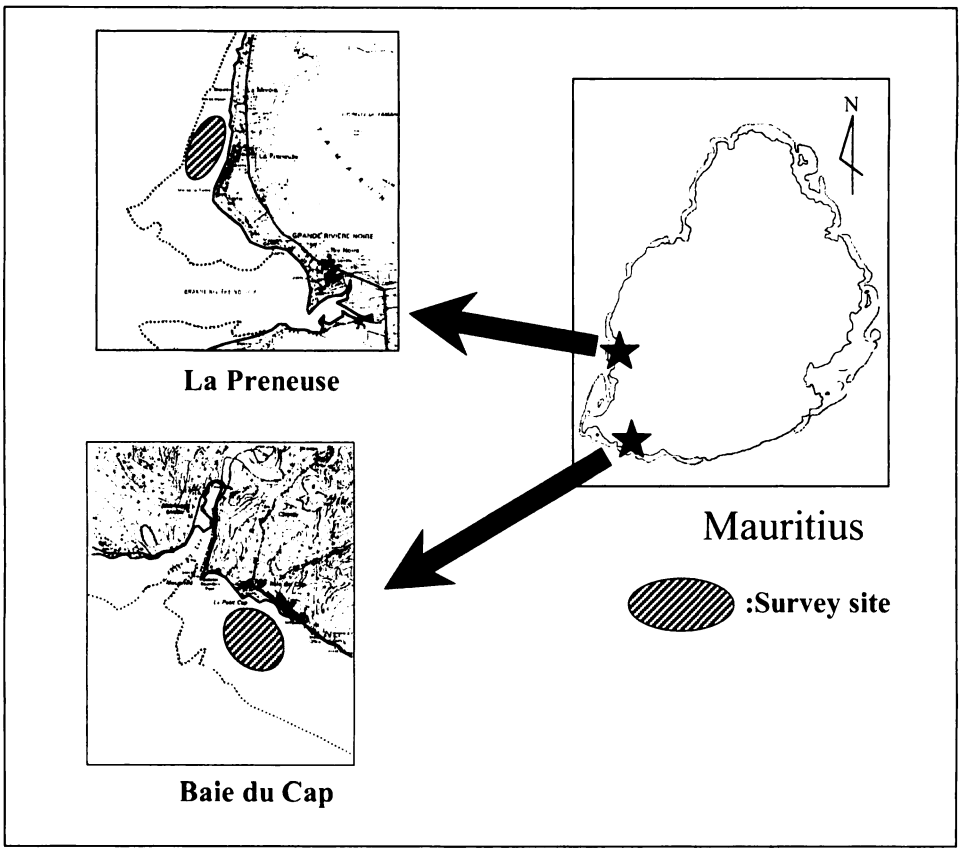


Fig.1 Two survey sites, La Preneuse (west coast) and Baie du Cap (southcoast).

LOCATION AND METHODS

Two sites were earmarked for the present survey, namely La Preneuse and Baie du Cap (Fig.1). Both sites are known to have different holothurian species as observed by local fishermen of the areas. At each site, two stations were selected, namely the backreef and the shorereef. Site selection was mainly based on the substrate cover type at each station, as sea cucumbers occur mainly on sand - gravel bottoms near seagrass beds and mix mud - sand bottoms, common to coastal seas of tropical area.

Field surveys were undertaken during 6 days in September 1998 at the La Preneuse (3rd, 15th and 16th) and Baie du Cap (8th, 17th and 18th). The holothurian distribution was recorded by using a belt transect method mentioned below. Five replicates (belt transect sets) were laid parallel to each of the backreef or shorereef to cover a large area (Fig.2). Each belt transect set consisted of one main line and five side transects, laid in such a way as to avoid overlapping, as shown in Fig.3. A 100m main line was laid first, followed by 40m side transects placed at 25m intervals alternately on both sides of the main line.

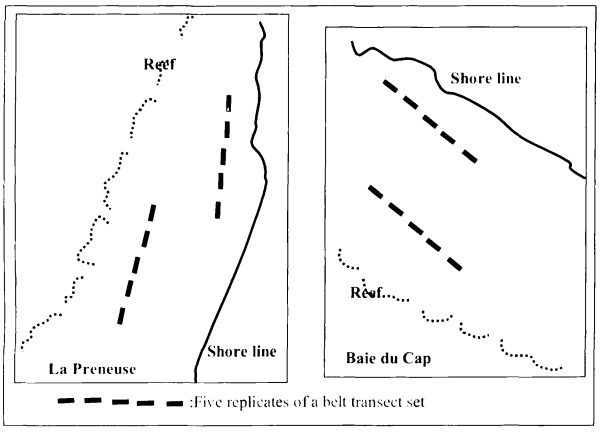


Fig.2 Five replicates of belt transect set at both backreef and shorereef.

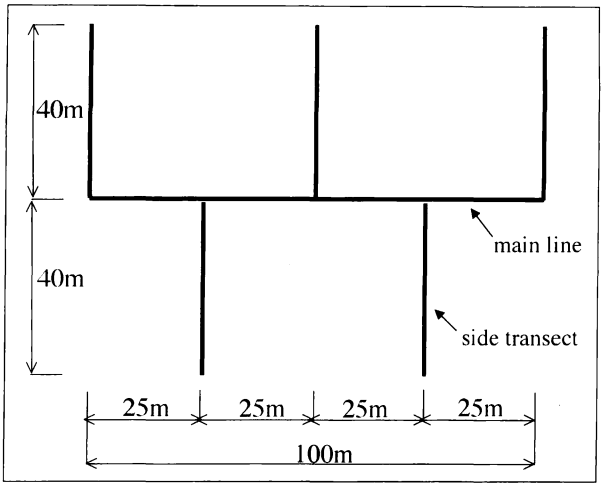


Fig.3 Schematic representation showing transect method used to carry out the visual census.

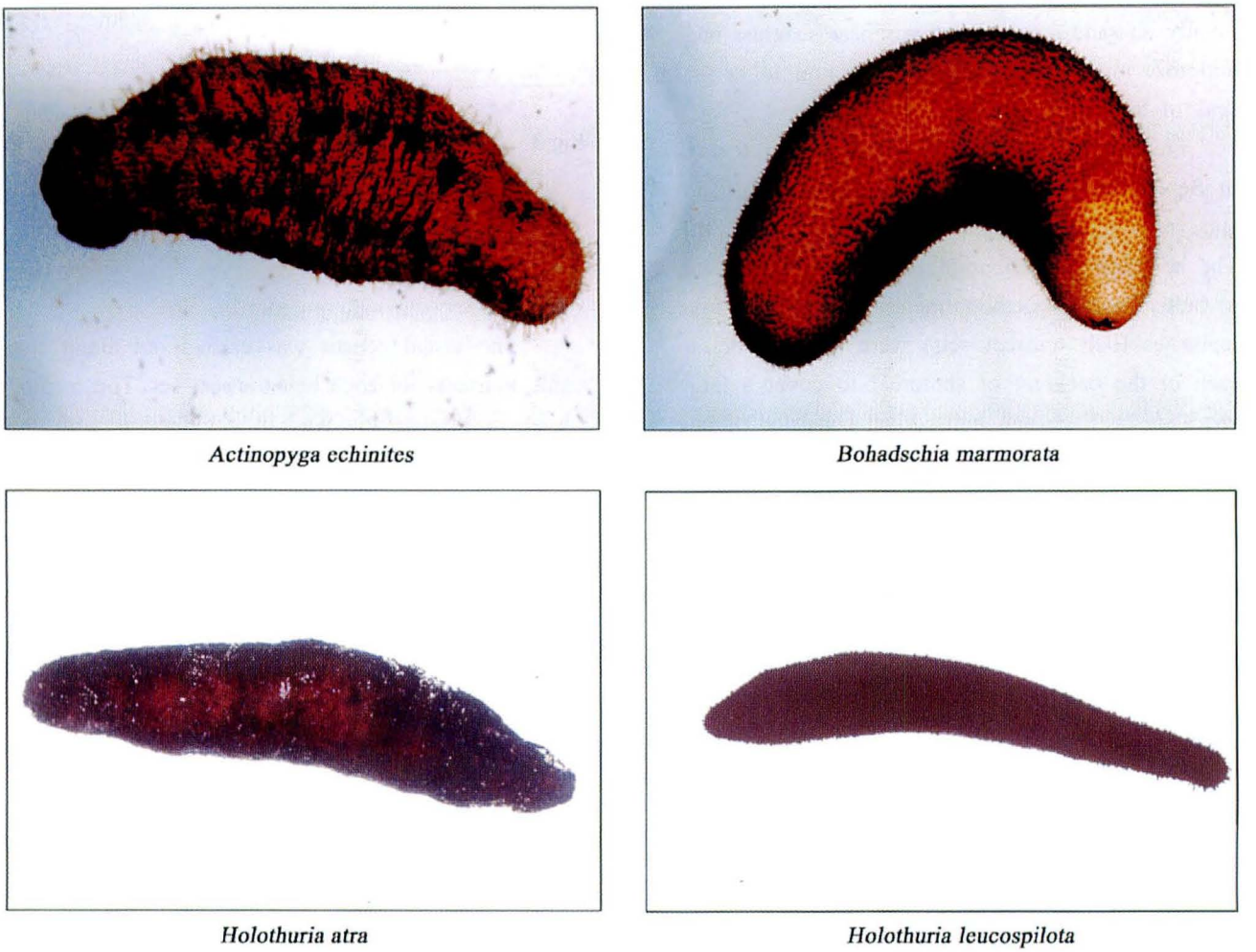
The visual census was carried out along five side transects for each belt transect set. The method used in this census was in conjunction with the Line Intercept Transect (LIT) method as developed by Loya (1978) and English *et al.* (1997). The observer swam using SCUBA along the transect, and estimated the number of specimens for each species within a width of 5m, i.e. 2.5m on each side of the side transect. The holothurians classification was based on Cannon and Silver (1984, 1994). Each of belt transect sets thus covered a total area of 1,000m^2 (i.e. 40m long x 5m wide x 5transects). The substrate cover type for each specimen was also noted to show the habitat of the holothurians. The category of substrate cover was according to English *et al.* (1997).

RESULTS

A total of 1,129 specimens comprising 9 species, viz. *Actinopyga echinites, Bohadschia marmorata, Holothuria atra, H. leucospilota, H. pervicax, H. scabra, Stichopus chloronotus, S. variegatus*, and *Thenelota ananas* were observed from the survey sites of La Preneuse and Baie du Cap (Fig.4). Although Arakaki and Fagoonee (1996) and Conand (1998) listed *B. vitiensis* from Mauritius in their papers, Cannon and Silver (1984)

and Cannon *et al.* (1994) mentioned *B. vitiensis* as being a synonym of *B. marmorata. B. marmorata* is being used in this paper instead of *B. vitiensis*.

The number of holothurians recorded on each replicate at both sites of La Preneuse and Baie du Cap are shown in Table 1 and Fig.5. The depth at which these sea cucumbers were found ranged from 0.5m to 3 metres.



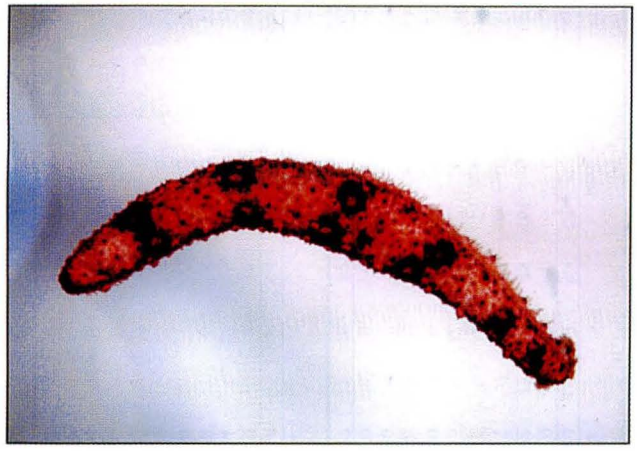
Actinopyga echinites

Bohadschia marmorata

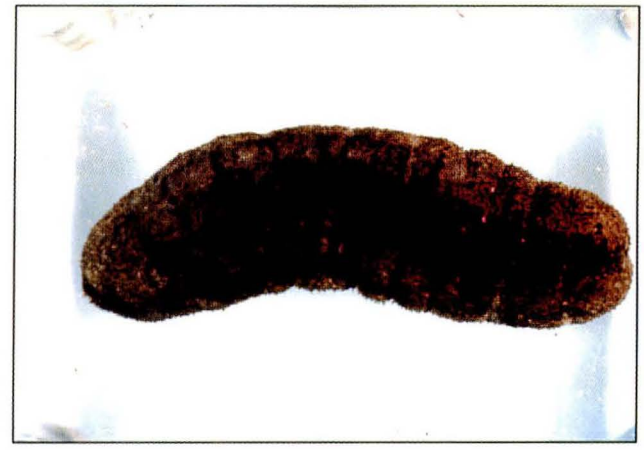
Holothuria atra

Holothuria leucospilota

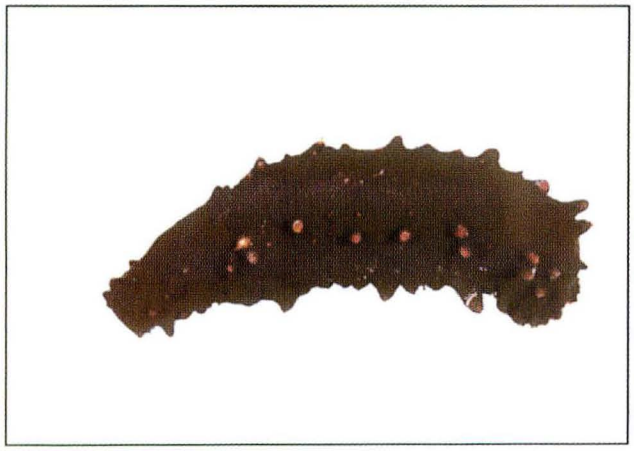
Fig.4-1 Holothurian species observed at survey sites (1).



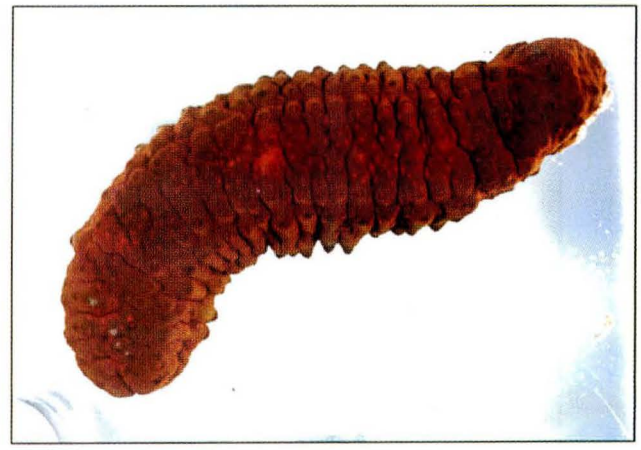
Holothuria pervicax



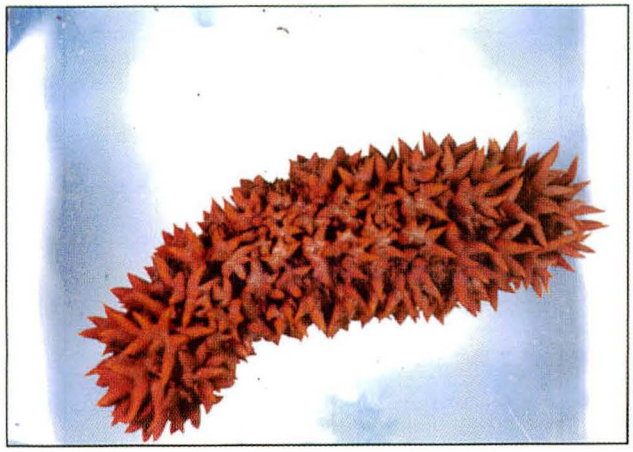
Holothuria scabra



Stichopus chloronotus



Stichopus variegatus



Thenelota ananas

Fig.4-2 Holothurian species observed at survey sites (2).

Table 1 Number of holothurians observed at La Preneuse and Baie du Cap

(La Preneuse : Shorereef)	Date: 15-Sep-98)																											
Replicate No.	Replicate 1						Replicate 2						Replicate 3						Replicate 4						Replicate 5					
Species \ Belt transect No.	1-1	1-2	1-3	1-4	1-5	Total	2-1	2-2	2-3	2-4	2-5	Total	3-1	3-2	3-3	3-4	3-5	Total	4-1	4-2	4-3	4-4	4-5	Total	5-1	5-2	5-3	5-4	5-5	Total
Actinopyga echinites	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	2	0	1	3	0	0	2	0	0	2
Bohadschia marmorata	0	1	0	0	0	1	0	12	0	0	1	13	8	0	0	0	0	8	3	4	1	2	2	12	0	4	1	0	1	6
Holothuria atra	2	0	1	2	1	6	4	2	5	1	4	16	6	3	5	3	4	21	13	8	1	6	1	29	4	8	1	0	4	17
Holothuria leucospilota	0	1	0	0	0	1	1	0	0	0	1	2	2	0	1	6	5	14	0	0	0	4	0	4	1	0	0	0	0	1
Holothuria pervicax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0	2	0	0	2
Holothuria scabra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stichopus chloronotus	1	0	1	0	0	2	0	0	0	2	1	3	4	1	1	6	5	17	0	0	1	1	4	6	0	0	1	1	0	2
Stichopus variegatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thenelota ananas	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Total	3	2	2	2	2	11	5	14	5	3	7	34	21	5	7	15	14	62	16	12	7	13	8	56	5	12	7	1	5	30
(La Preneuse : Backreef)	Date: 15-Sep-98)																											
Replicate No.	Replicate 1						Replicate 2						Replicate 3						Replicate 4						Replicate 5					
Species \ Belt transect No.	1-1	1-2	1-3	1-4	1-5	Total	2-1	2-2	2-3	2-4	2-5	Total	3-1	3-2	3-3	3-4	3-5	Total	4-1	4-2	4-3	4-4	4-5	Total	5-1	5-2	5-3	5-4	5-5	Total
Actinopyga echinites	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bohadschia marmorata	0	0	0	0	0	0	0	0	0	0	0	0	9	12	19	27	14	81	0	1	1	0	0	2	0	0	0	0	0	0
Holothuria atra	1	0	1	1	1	4	1	0	2	1	1	5	1	2	1	1	3	8	2	5	5	3	0	15	3	0	4	1	2	10
Holothuria leucospilota	1	1	0	0	0	2	2	1	1	0	0	4	1	0	0	1	0	2	1	0	0	0	0	1	2	2	1	0	1	6
Holothuria pervicax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	2	0	0	1	0	0	1
Holothuria scabra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stichopus chloronotus	0	0	0	1	0	1	0	0	0	1	1	2	0	0	0	4	2	6	5	7	10	7	0	29	15	1	1	3	4	24
Stichopus variegatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Thenelota ananas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	2	1	1	2	1	7	3	1	3	2	2	11	11	14	21	33	19	98	9	13	17	10	0	49	20	3	7	4	7	41
(Baie du Cap : Shorereef)	Date: 18-Sep-98)																											
Replicate No.	Replicate 1						Replicate 2						Replicate 3						Replicate 4						Replicate 5					
Species \ Belt transect No.	1-1	1-2	1-3	1-4	1-5	Total	2-1	2-2	2-3	2-4	2-5	Total	3-1	3-2	3-3	3-4	3-5	Total	4-1	4-2	4-3	4-4	4-5	Total	5-1	5-2	5-3	5-4	5-5	Total
Actinopyga echinites	0	0	0	1	1	2	4	7	0	1	0	12	2	0	0	0	0	2	1	1	0	0	0	2	0	0	0	1	0	1
Bohadschia marmorata	4	5	8	10	4	31	12	2	7	12	8	41	3	4	0	0	0	7	8	1	2	22	12	45	48	16	0	59	7	130
Holothuria atra	2	0	15	1	4	22	2	4	2	2	1	11	3	9	0	3	3	18	6	2	6	1	0	15	1	6	0	1	2	10
Holothuria leucospilota	2	0	2	1	1	6	3	1	0	0	2	6	6	6	2	0	0	14	0	0	1	1	0	2	1	2	6	0	0	9
Holothuria pervicax	6	5	0	0	1	12	8	4	0	0	0	12	4	2	4	2	1	13	4	1	4	3	0	12	2	2	0	2	3	9
Holothuria scabra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Stichopus chloronotus	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stichopus variegatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thenelota ananas	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2
Total	14	12	25	13	11	75	29	18	9	15	11	82	18	21	6	5	4	54	19	5	13	27	12	76	52	28	7	63	12	162
(Baie du Cap : Backreef)	Date: 18-Sep-98)																											
Replicate No.	Replicate 1						Replicate 2						Replicate 3						Replicate 4						Replicate 5					
Species \ Belt transect No.	1-1	1-2	1-3	1-4	1-5	Total	2-1	2-2	2-3	2-4	2-5	Total	3-1	3-2	3-3	3-4	3-5	Total	4-1	4-2	4-3	4-4	4-5	Total	5-1	5-2	5-3	5-4	5-5	Total
Actinopyga echinites	0	0	0	0	2	2	0	0	0	1	0	1	0	0	0	1	1	2	0	0	0	0	0	0	6	0	0	2	0	8
Bohadschia marmorata	0	1	0	0	1	2	1	0	1	0	0	2	0	0	1	0	0	1	2	0	0	14	1	17	9	3	0	1	0	13
Holothuria atra	9	11	0	6	3	29	2	2	2	3	4	13	2	3	2	3	3	13	1	1	3	0	1	6	6	4	0	2	1	13
Holothuria leucospilota	3	0	6	11	4	24	3	11	10	13	3	40	21	16	10	13	13	73	1	0	0	0	0	1	0	0	6	0	0	6
Holothuria pervicax	0	0	0	5	0	5	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	1	5	0	0	0	1	0	1
Holothuria scabra	2	0	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Stichopus chloronotus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stichopus variegatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thenelota ananas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	14	12	7	22	10	65	6	13	13	17	7	56	23	19	13	17	17	89	6	1	5	14	3	29	21	7	7	6	1	42

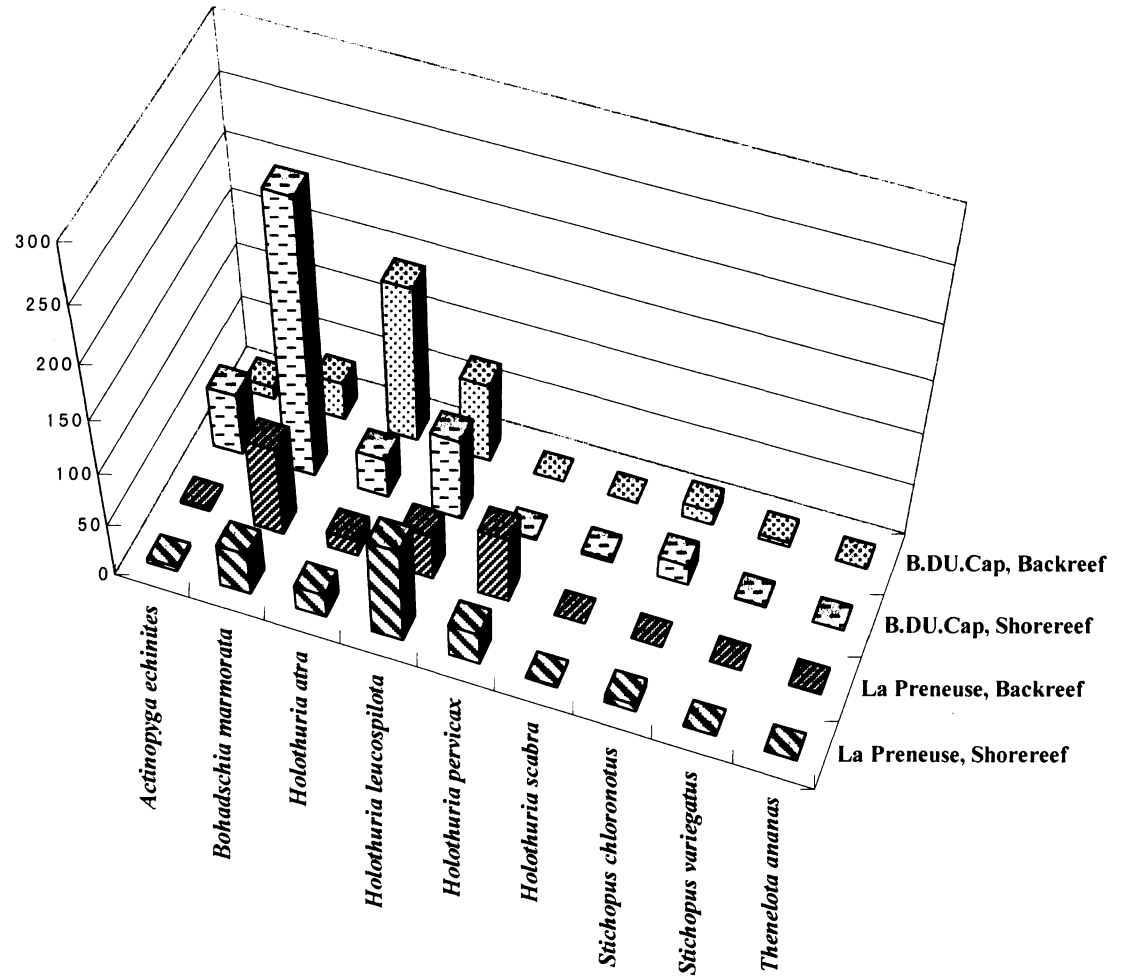


Fig.5 Number of holothurians observed at La Preneuse and Baie du Cap.

La Preneuse A total of 399 specimens of 8 species were found at La Preneuse. On the shorereef , 193 specimens of 7 species, viz. *A. echinites, B. marmorata, H. atra, H. leucospilota, H. pervicax, S. chloronotus*, and *T. ananas*, were observed, while 206 specimens of 6 species, viz. *B. marmorata, H. atra, H. leucospilota, H. pervicax, S. chloronotus*, and *S. variegatus*, were observed on the backreef. Among these species, *A. echinites* and *T. ananas* were observed on the shorereef but not on the backreef. *S. chloronotus*, which was not observed on the backreef, was present on the shorereef.

Number and percentage of specimens for each species observed on each area of 5,000m^2 are shown in Table 2. The dominant species *H. atra* occupied 46.11% of the total number observed, followed by *B. marmorata* (20.73%), *S. chloronotus* (15.54%), and *H. leucospilota* (11.40%) on the shorereef. However, *B. marmorata* was dominant on the backreef and occupied 40.29% of the total amount, followed by *S. chloronotus* (30.10%), *H. atra* (20.39), and *H. leucospilota* (7.28%). Consequently, the total percentages of these 4 species on both shorereef and backreef were 93.78% and 98.06%, respectively. These 4 species were dominant at La Preneuse.

On 10,000m^2 of sea floor area as a total of the shorereef and backreef at La Preneuse, We observed 399 holothurians, which consisted of *A.*

Table 2 Number and percentage of specimens for each species observed at La Preneuse

(La Preneuse)	Shorereef		Backreef	
	No. of specimens	%	No. of specimens	%
Actinopyga echinites	7	3.63	0	0.00
Bohadschia marmorata	40	20.73	83	40.29
Holothuria atra	89	46.11	42	20.39
Holothuria leucospilota	22	11.40	15	7.28
Holothuria pervicax	4	2.07	3	1.46
Stichopus chloronotus	30	15.54	62	30.10
Stichopus variegatus	0	0.00	1	0.49
Thenelota ananas	1	0.52	0	0.00
Total	193	100.00	206	100.01

echinites (1.75%), *B. marmorata* (30.83%), *H. atra* (32.83%), *H. leucospilota* (9.27%), *H. pervicax* (1.75%), *S. chloronotus* (23.06%), *S. variegatus* (0.25%), and *T. ananas* (0.25%). Therefore, the abundance of holothurians was simply estimated at 1 specimen per 25m^2 of sea floor area (0.04 individuals per 1m^2).

However, the appearance rates of the 8 species observed on each belt transect set were quite different. Fig. 6 shows the average and standard deviation of the number of specimens observed in 1,000 m^2 of each belt transect set. Almost all of standard deviations showed approximately the same value as the average. These relatively large standard deviations indicated a large variation in the population of holothurian on each belt transect set. On each of the shorereef and backreef at this survey site, holothurians were not evenly distributed.

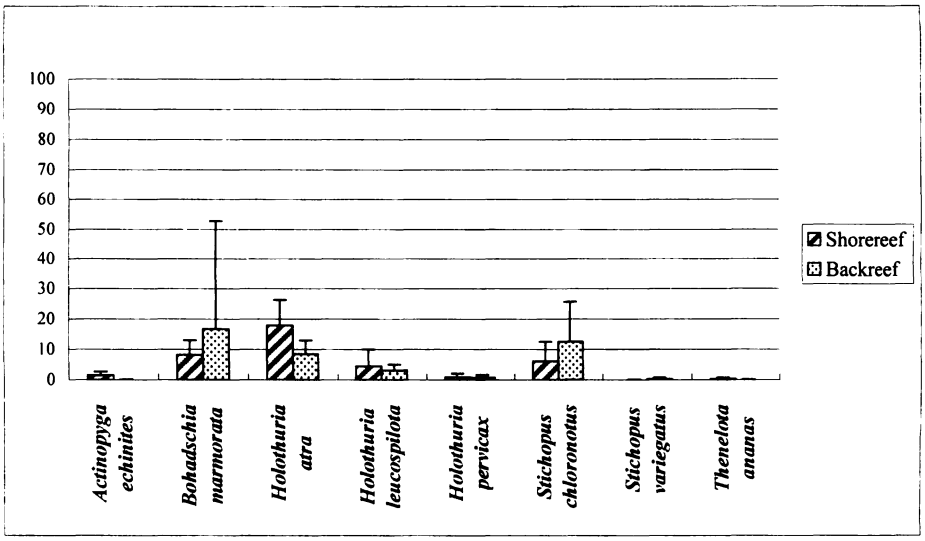


Fig.6 Average and standard deviation of the number of specimens for each species observed in 1,000m^2 at La Preneuse.

Baie du Cap A total of 730 specimens from 8 species, viz. *A. echinites, B. marmorata, H. atra, H. leucospilota, H. pervicax, H. scabra, S. chloronotus*, and *T. ananas*, were found at Baie du Cap. On the shorereef, 449 specimens from the 8 species were observed, while 281 specimens from 6 species were observed on the backreef. The two species, *S. chloronotus* and *T. analas*, were recorded on the shorereef, but not on the backreef.

The number and percentage of specimens for each species observed on each area of 5,000m^2 are shown in Table 3. The dominant species, *B. marmorata*, occupied 56.57% of the total number of specimens on the shorereef, followed by *H. atra* (16.93%), *H. pervicax* (12.92%), *H. leucospilota* (8.24%), and *A. echinites* (4.23%), whereas *H. leucospilota* dominated and occupied 51.25% of the total amount on the backreef, followed by *H. atra*

(26.33%), *B. marmorata* (12.46%), *A. echinites* (4.63%), and *H. pervicax* (3.91%). The total percentages of these 5 species on both shorereef and backreef were 98.89% and 98.58%, respectively.

On 10,000m^2 of sea floor area combining the shorereef and backreef at Baie du Cap, We observed 730 holothurians, which consisted of *A. echinites* (4.38%), *B. marmorata* (39.59%), *H. atra* (20.55%), *H. leucospilota* (24.79%), *H. pervicax* (9.45%), *H. scraba* (0.68%), and *T. ananas* (0.41%). Therefore, the abundance of holothurian was simply estimated at 1 specimen per 13.7m^2 of sea floor area (0.07 individuals per 1m^2).

However, similar to the situation at La Preneuse, the appearance rates of the 7 observed species on each belt transect set were quite different. The averages and standard deviations of the number of specimens in 1,000m^2 of each belt transect set are shown in Fig.7. Almost all of standard deviations showed approximately the same value as the average. These relatively large deviations indicated a large variation in occurrence of holothurian among belt transect sets. Therefore, holothurians were unevenly distributed in each of the shorereef and backreef in this survey site.

Table 3 Number and percentage of specimens for each species observed at Baie du Cap

(Baie du Cap)	Shorereef		Backreef	
	No. of specimens	%	No. of specimens	%
Actinopyga echinites	19	4.23	13	4.63
Bohadschia marmorata	254	56.57	35	12.46
Holothuria atra	76	16.93	74	26.33
Holothuria leucospilota	37	8.24	144	51.25
Holothuria pervicax	58	12.92	11	3.91
Holothuria scabra	1	0.22	4	1.42
Stichopus chloronotus	1	0.22	0	0.00
Stichopus variegatus	0	0.00	0	0.00
Thenelota ananas	3	0.67	0	0.00
Total	449	100.00	281	100.00

Substrate cover type A total of 1,129 specimens were observed at all survey sites during the survey. Specific compositions on each of the substrate cover types, which were categorised into sand, rubble, seagrass, algal assemblage, macroalgae, rock, live coral, and dead coral, are shown in Table 4. Among all 9 species observed, 578 specimens occurred on sandy bottom, whereas 363 specimens and 130 specimens occurred on

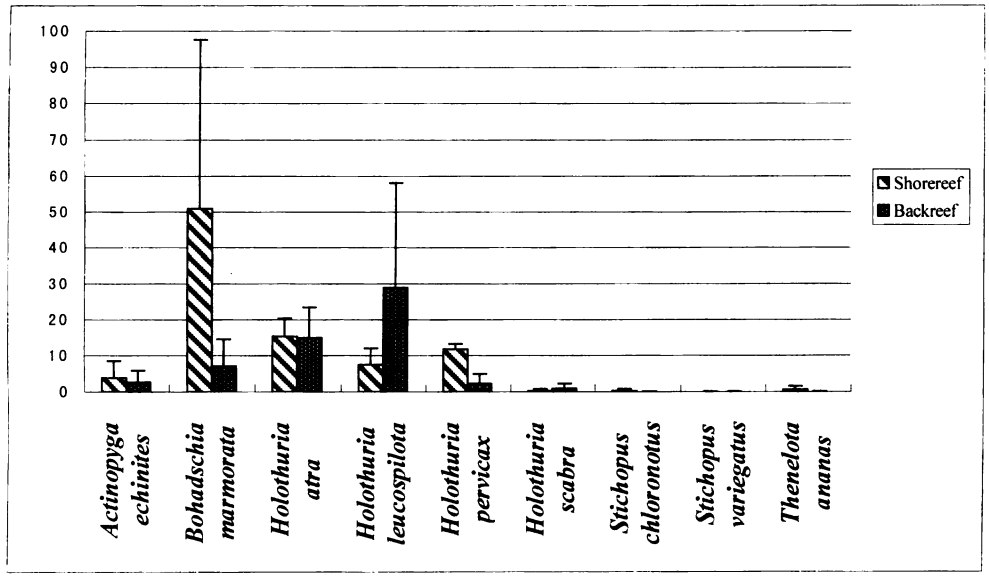


Fig.7 Average and standard deviation of the number of specimens for each species observed in 1,000 m^2 at Baie du Cap.

rubble and seagrass area, respectively.

Appearance rates of each species on categorised substrates are shown in Fig.8. In sand area, 578 specimens of 9 species were observed, among which dominant species was *B. marmorata* (61.1%), followed by *H. atra* (15.4%) and *H. leucospilota* (13.3%). In rubble area, 363 specimens of 7 species were observed, among which dominant species were *H. atra* (35.5%) and *H. leucospilota* (32.8%), followed by *S. chloronotus* (13.2%). In seagrass area, 130 specimens of 8 species were observed, among which dominant species were *H. atra* (36.2%) and *H. pervicax* (26.9%), followed by *B. marmorata* (15.4%) and *H. leucospilota* (10.0%). Only one to 26 specimens of holothrian were observed in other categories of substrate cover type.

DISCUSSION

The number of holothurians in the total area surveyed in this study was estimated at about 1,129 specimens per 20,000m^2, which consisted of 39 specimens of *A. echinites*, 412 specimens of *B. marmorata*, 281 specimens of *H. atra*, 218 specimens of *H. leucospilota*, 76 specimens of *H. pervicax*, 5 specimens of *H. scabra*, 93 specimens

Table 4 Specific composition related to substrate cover

Species \ Substrate	Sand	Rubble	Sea grass	Algal assamblage	Macro algae	Rock	live coral	Dead coral	Total
Actinopyga echinites	13	11	10	0	3	0	2	0	39
Bohadschia marmorata	353	36	20	0	0	1	0	2	412
Holothuria atra	89	129	47	0	0	2	6	8	281
Holothuria leucospilota	77	119	13	0	2	1	4	2	218
Holothuria pervicax	23	18	35	0	0	0	0	0	76
Holothuria scabra	3	2	0	0	0	0	0	0	5
Stichopus chloronotus	17	48	4	0	2	3	5	14	93
Stichopus variegatus	1	0	0	0	0	0	0	0	1
Thenelota ananas	2	0	1	1	0	0	0	0	4
Total	578	363	130	1	7	7	17	26	1,129

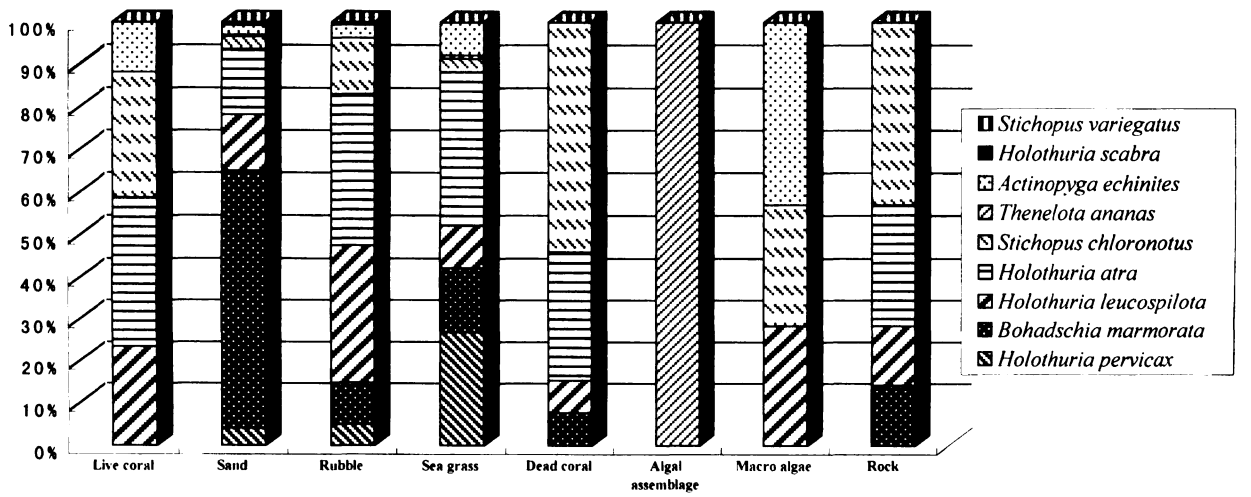


Fig.8 Percentage of occurrence for each species on each category of substrate.

of *S. chloronotus*, 1 specimen of *S. variegatus*, and 4 specimens of *T. ananas*. This result may show that the holothurians are sparsely distributed and are not in abundance enough for industrial exploitation at these sites. James and Baskar (1994) mentioned that 90,000 specimens of *Actinopyga* species were fished for three months at Tuticorin in India in 1992. This indicates that an average of 1,000 specimens of holothurians was collected per day while this number is approximately equal to the holothurians observed in total at our survey site.

These organisms are slowly moving and conspicuous with no defence against human "predator", and can be easily overfished. Their biology is such that population can be extirpated quickly, with little to no chances for recovery. The greatest threat to holothurian resources is overfishing.

Overfishing has already occurred in a number of islands including the Solomon Islands, the Cook Islands, and Fiji in Micronesia (Richmond, 1996). Overfishing is largely the result of the present fishery and exploitation system, which usually involves foreign buyers offering a low price to indigenous fishermen for valuable species. The goal of foreign buyers is to get into an area, get as much resource as possible, as cheaply as possible, and get out. The goals and interests of the indigenous fishermen appear to be quite different. Buyers focus on the largest profit in the shortest time period, while indigenous fishermen are usually more concerned with sustainable utilisation. There is probably no example of a buyer encouraging sustainable resource utilisation in the historical record of sea cucumber fisheries. Once an area is overfished, buyers look for new sources.

The quality of the product, greatly influenced by size, affects the price paid to the fishermen. The relationship between size and price is not linear, meaning that a 10 - 25% reduction in length can be translated to a 50% reduction in price paid. This relationship, as applied by foreign buyers, encourages overfishing. As an example, once the largest specimens of black teat *H. nobilis* are fished out, smaller size classes are captured in Micronesia (Richmond, 1996). While a fisherman may receive $1 for black teat of 20cm in length, specimen of 15cm may only fetch $0.50, meaning that a fisherman must capture twice as many smaller cucumbers to match the income produced by selling the larger individuals. There are two problems that a larger number of individuals are taken for a lot less money and that pre-reproductive individuals are collected reducing the reproductive stock. Such free-market systems without any controls inevitably lead to resource depletion.

However data are sketchy, there are more reports which document the effects of overfishing, including reduction in number of individuals, a decrease in the population size distribution, and the disappearance of certain species (Trinidad - Roa, 1987a, b; Johnson, 1990; Richmond, 1996). Data from the Micronesia during the Japanese Mandate years 1922 - 36 indicate that approximately 5,124 tons of sea cucumbers were removed from the reefs in 14 years preceding World War II (South Sea Bureau, 1937; Takehisa, 1940). At an average of 6.6 animals per kg, this equalled approximately 30,743,460 individuals of sea cucumber. A survey of eight sites around Chuuk Island performed in 1988 found 16 species but only two individuals of the black teat *H. nobilis* (Richmond, 1996). These data, in the light of the record of the large number of sea cucumber exported from Chuuk Island, suggest that the present population might not have recovered from the heavy exploitation in 1920 - 1940's. Considering the reproductive biology of the commercially valuable species, once population densities are below a certain level, the probability of fertilization of spawned eggs is low to be negligible. If an over-exploited area is beyond the distance that allows for the immigration of larvae from source areas, it is conceivable that populations may never recover unless artificial resource enhancement is performed. Knowledge of larval competency periods and oceanic circulation patterns should be important for making local as well as regional management decisions.

In Madagascar the official exportation of sea cucumbers was approximately 600 tons in 1991 and 1994 showing an important decline in export

(Conand, 1998). Overexploitation had caused poor quality and reduction in the value of the product. There were many fishermen in Madagascar who captured the juvenile sea cucumber, which had a negative impact on the stock. They also damaged corals during their fishing activity, which caused degradation of the marine environment. It was most probable that there might be a transfer of interest to other countries in the region, due to depletion of resource in Madagascar. This was very similar to the occasion which had happened in the tropical region of the Pacific, so as to satisfy the great demand in sea cucumbers (Conand, 1998).

One of the most interesting and unfortunate examples of the negative ecological effects of sea cucumber fisheries occurred within a National Park in the Galapagos Islands where the species *Isostichopus fuscus* was commercially harvested during the year 1991 and 1992. A preliminary assessment funded by IUCN showed a highly significant difference in sea cucumber population among different sites (Richmond, 1996). This was attributed to the level of exploitation, through interviews with fishermen, Park Service officials and Darwin Station scientists who identified the sites where sea cucumbers were commercially collected. The highest density observed was 183 individuals per $100m^2$ (1.83 individuals per $1m^2$) which occurred in a site not fished. Densities ranging from 0-4 individuals per $100m^2$ were encountered in areas, which were reported to have had heavy fishing pressure.

Density of sea cucumbers in Mauritius was 0.04 individuals per $1m^2$ at La Preneuse and 0.07 individuals per $1m^2$ at Baie du Cap, where commercial exploitation has not taken place clearly. The results denote that the density of holothurians in our waters is equivalent to the density (0.04 individuals per $1m^2$) at sites in the Galapagos, where commercial exploitation and overfishing had already taken place.

Ecological problems may also result from overfishing of holothurian. They are important agents of bioturbation and recycling nutrients in coral lagoon and reef flat communities. Recent studies have shown that a coral reef is one of the most productive communities and this productivity is based on the tight recycling of nutrients starting with the animal-algal symbiosis of coral (Richmond, 1996). A high standing stock or biomass occurs on coral reef ecosystems, but high export levels are not sustainable. The export of massive quantities of holoturians leads to rapid depletion of population and may remove an important source of raw materials from a system based on efficient recycling. Sea cucumber larvae and juveniles may also be important links in reef food chains.

Consequently, any exploitation of holothurians should be carefully considered for the conservation of the coastal environment and ecosystem in Mauritius. For a better understanding of their distribution in the water around Mauritius, it is envisaged that further surveys should be carried out at other selected sites. A monitoring program with emphasis on the abundance, species diversity, and others will give an indication of any change in the marine environment. This information will help in formulating coastal zone management policies.

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インド洋モーリシャスのラプレニュースとベドカップにおけるナマコ類の分布

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要約：モーリシャスを含む南西インド洋のナマコ類では11種の食用種が知られているが，モーリシャス沿岸ではこれらの量や分布パターンに関する情報はほとんど無い。このため，沿岸管理方針作成の一助として，モーリシャス西岸のラプレニュースと南岸のベドカップにおいて，ナマコ類の調査を実施した。各調査地点では，バックリーフとショアリーフにそれぞれ5 セットのベルトトランセクトを設定し，目視観察によってナマコ類の量と分布を調査し，底質のタイプをあわせて記録した。各ベルトトランセクトセットの調査範囲は1,000m^2 であり，総調査範囲は20,000m^2 であった。今回の調査では，*Actinopyga echinites*, *Bohadschia marmorata*, *Holothuria atra*, *H. leucospilota*, *H. pervicax*, *H. scabra*, *Stichopus chloronotus*, *S. variegatus*, *Thenelota ananas* の9 種の生息が確認され，その量と分布パターンが検討された。

キーワード：ナマコ，分布，量，モーリシャス