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DAVID NICHOLS	Exeter University, Exeter, Devon, England.
DAVID L. PAWSON	Smithsonian Institution, Washington, D.C. 20560, U.S.A.
FRANCIS W. E. ROWE	The Australian Museum, Sydney, New South Wales, Australia.

CONTRIBUTIONS

BIRKELAND, Charles, University of Guam, U.S.A. 96910. (p. 175).

BRUCE, A. J., Heron Island Research Station, Queensland, Australia. (p. 191).

CAMARGO, Tania Maria de, Institute of Oceanography, University of São Paulo, Brazil, (p. 165).

CLARK, Ailsa, M., British Museum (Natural History), London, England, (p. 121).

DAYTON, Paul, K., Scripps Institute of Oceanography, La Jolla, California, U.S.A. 93093. (p. 175).

ENGSTROM, Norman, A., Department of Biological Sciences, Northern Illinois University, DeKalb, Illinois, U.S.A. 60115. (p. 175).

GUILLE, Alain, Muséum National d'Histoire Naturelle, Paris, France. (p. 67).

HARRIOTT, Vicki, Zoology Department, University of Queensland, St. Lucia 4067, Queensland, Australia (p. 53).

JANGOUX, Michel, Zoology Department, Université Libre de Bruxelles, Bruxelles, Belgium. (p. 17).

MARSH, Loisette, M., Western Australian Museum, Perth, Western Australia. (p. 89).

MITROVIC-PETROVIC, Jovanka, Faculty of Mining and Geology, University of Beograd, Beograd, Kamenička 6, Yugoslavia. (p. 9).

NICHOLS, David, Department of Biological Sciences, Exeter University, Devon, England. (p. 147).

PAWSON, David L., Smithsonian Institution, Washington, D.C., U.S.A. 20560. (p. 129).

ROWE, Francis W. E., The Australian Museum, Sydney, New South Wales, Australia. (p. 89).

SIMPSON, R. D., The University of New England, Armidale, New South Wales, Australia. (p. 39).

FOREWORD

Since the first major Symposium on Echinoderm Biology was held in London in 1966, sponsored by the Royal Zoological Society, at least six subsequent meetings have been organised by echinodermologists. These have been held in Washington D.C., U.S.A. (2), Rovinj, Yugoslavia (1), Sydney, Australia (1), London (1); the last two meetings (Sydney and London), within the same year (1978), and Brussels, Belgium. Also, at least four meetings are known to have been held in U.S.S.R. Such has been the surge of interest in the study of echinoderms over the past decade, that there is now a demand for the organisation of regular, and more frequent, meetings. The international representation at these meetings indicates the enormous involvement and co-operation which now exists between colleagues working in this exciting field, the world over.

It is more than evident that the satisfaction and pleasure expressed by Professor Norman Millott, in his foreword to the first Symposium volume (1967), at the resurgence of interest in Echinoderm Biology has been clearly justified and can continue so to be.

This volume presents twelve of the forty-one contributions offered at the Echinoderm Conference, Sydney, 1978. The papers are representative of the wide coverage of topics dealt with during the Conference, including echinoderm palaeontology, physiology, reproduction, ecology, behaviour and taxonomy.

To the speakers and chairmen, and to all those who attended the Sydney Conference, I convey my thanks. I must also thank my Technical Officer, Ms Jan Marshall, and Dr Susan Oldfield (Queen's Fellow at The Australian Museum, February, 1977-1979) for their unstinting assistance in the organisation of the Conference. Thanks are also due to the Department of State Fisheries (N.S.W.), Taronga Park Zoo, McWilliams Wines Pty, Leo Buring Wines Pty, Qantas Airways Ltd, and Trans-Australia Airlines (T.A.A.). To The Australian Museum Society (TAMS) I extend a special thanks for assistance.

This Conference could not have been held without the tremendous support and encouragement afforded to the organiser by Dr D. J. G. Griffin, Director, The Australian Museum, and the very generous financial support of the Trustees of the Museum, to both of whom I offer my very sincere thanks.

DECEMBER 1979 FRANCIS W. E. ROWE

CONTENTS

10. CHANGES IN THE ECHINODERM FAUNA IN A POLLUTED AREA ON THE COAST OF BRAZIL

TANIA MARIA DE CAMARGO

Institute of Oceanography, University of São Paulo, Brazil

SUMMARY

The purpose of this research was to compare the changes in echinoderm fauna in a region under increasing eutrophication.

A preliminary survey of the fauna was conducted by Tommasi in 1964; such results here served as a baseline for comparison with the data obtained during a more thorough investigation made from 1974 to 1976 by a team from the Institute of Oceanography.

The animals were identified to species and their distributions correlated to environmental parameters like type of sediment, water temperature, salinity, depth and dissolved oxygen, as well as parameters indicative of pollution, mostly nutrients and turbidity.

The results for 1974 to 1976 period indicate a lower diversity as well as the disappearance of a number of species when compared to the 1964 period.

INTRODUCTION

The echinoderm fauna of the coast of the State of São Paulo, Brazil, has been studied by Bernasconi (1956) and by Tommasi (1957, 1958, 1965 and 1966). In 1964 Tommasi studied the distribution of these animals as part of a more thorough investigation of the benthic assemblages of the Bay of Santos (24°00'S, 46°20'W), his results were published in 1967, at which time considerable concern had already been aroused by drastic changes which had occurred as the result of sewage, dredgings as well as the installation of smelters and other industrial plants.

As pointed out by Isaacs (1973) the discharge of sewage as well as of industrial effluents in estuarine regions can affect the communities of benthonic invertebrates in two ways: (a) a great influx of organic matter tends to have a deleterious effect on filter feeders, detritus feeders and also on their predators; (b) the change in consistency of sediments, the increase in the level of heavy metals and toxic organic compounds, the reduction in dissolved oxygen as well as the increase in sulphides as a result of the deposition and decomposition of organic matter, may inhibit larval attachment or may have toxic effects directly on already attached larvae or on adults which may be sensitive to such pollutants.

From 1964 onwards the Santos region has suffered a considerable increase in eutrophication levels as a result of its development as a summer resort, accommodating during the summer months more than one million people, as well as the increase of its docking facilities and installation of new industrial plants.

In 1974 a joint programme was established between the Institute of Oceanography of the University of São Paulo and the State Centre for Basic Monitoring of Environment (CETESB) in order to investigate the present status of the animal assemblages and environmental conditions in the region. As part of this programme, a study was carried out on the distribution of the echinoderm fauna, similar to that carried out by Tommasi (1967). As much as possible, the echinoderm distribution and abundance has been considered in relation to environmental parameters such as nutrient content, temperature, salinity, type of sediment, dissolved oxygen and depth.

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DESCRIPTION OF AREA STUDIED

The bay and the estuary of Santos (24°00'S, 46°20'W) on the coast of the State of São Paulo (fig. 1) receive a very heavy load of organic pollutants as a result of the outflow of sewage effluents of the city of Santos and nearby villages. Aside from the several kinds of detritus and substances originating from mangroves and nearby rivers, a number of industrial wastes, sewage and oil residues are introduced in the Santos region. The final picture in the estuary and bay area is one of high water turbidity, high level of suspended material and considerable eutrophication of marine environment.

The area under study can be divided into two distinct regions, namely one in the west side and one in the east side of the bay of Santos. The more saline water which comes from the south penetrates under the more diluted water which leaves the estuarine area and the bay. This high salinity wedge which penetrates the east side of the bay is more pronounced than the one on the west side where there is a much greater mixture of deep and surface water.

Previous studies (Emilson, 1955) have shown that the west side of the bay is under heavier influence of the tidal currents, while the east side is characterized by waters originating from the estuarine area. Such a pattern of water circulation produces two distinct areas, one on the west side where there is a predominance of waters from the continental platform and the other on the east side where waters are mostly of low salinity, originating from the estuary of Cubatao River.

Also such a pattern exerts influence on the types of sediments of the bay; on the west side predominate medium and fine sand, while on the east side, finer sediments (silt) are to be found.

The granulometric analysis carried out by Tommasi (1967) indicated a predominance of very fine sediments in several stations of the area under study. On the southern part of the bay as well as along the shores predominated sandy bottoms while on the eastern side some of the stations provided samples with a number of dead shells, coarse sediments and detritic material.

The sample obtained in the last years showed only the presence of sediments ranging from 0.063 to 0.250 mm in diameter, namely from clay and silt to fine sand; silt and clay were found mostly near the estuary, very fine sand on the east side and fine sand along the beaches and west side of the bay.

Prevailing winds are from the coast during spring and summer, southerly winds predominating during fall and winter (Oliveira-Santos, 1965). Annual precipitation in the area reaches values of 2000 mm or more; highest levels are measured from January to March and the lowest ones in July and August (Camargo, 1960).

Mean values for salinity increase from 29°/00 in December (rainy season) to July 34°/00 (dry season). The curves for salinity and temperature (fig. 2) show an inverse relationship.

Values for dissolved oxygen and salinity are extremely variable in the channel, and estuarine region; salinity values as low as 5.5°/00 have been found in surface waters on some occasions, while that at the bottom remains fairly constant (27 to 32°/00). Temperature fluctuates from values as low as 16.6°C in the winter to 29°C in the summer, mean values ranging 17 to 27°C.

METHODS

The bottom samples were obtained with a Van-Veen bottom grab, which sampled an area of 0.10 m^2 and had a capacity of 10-12 litres. Periodic collections were made every season during the period December 1974 to November 1976 in 31 stations ecompassing all the estuary and Bay of Santos (fig. 3) to a maximum depth of 15 metres.

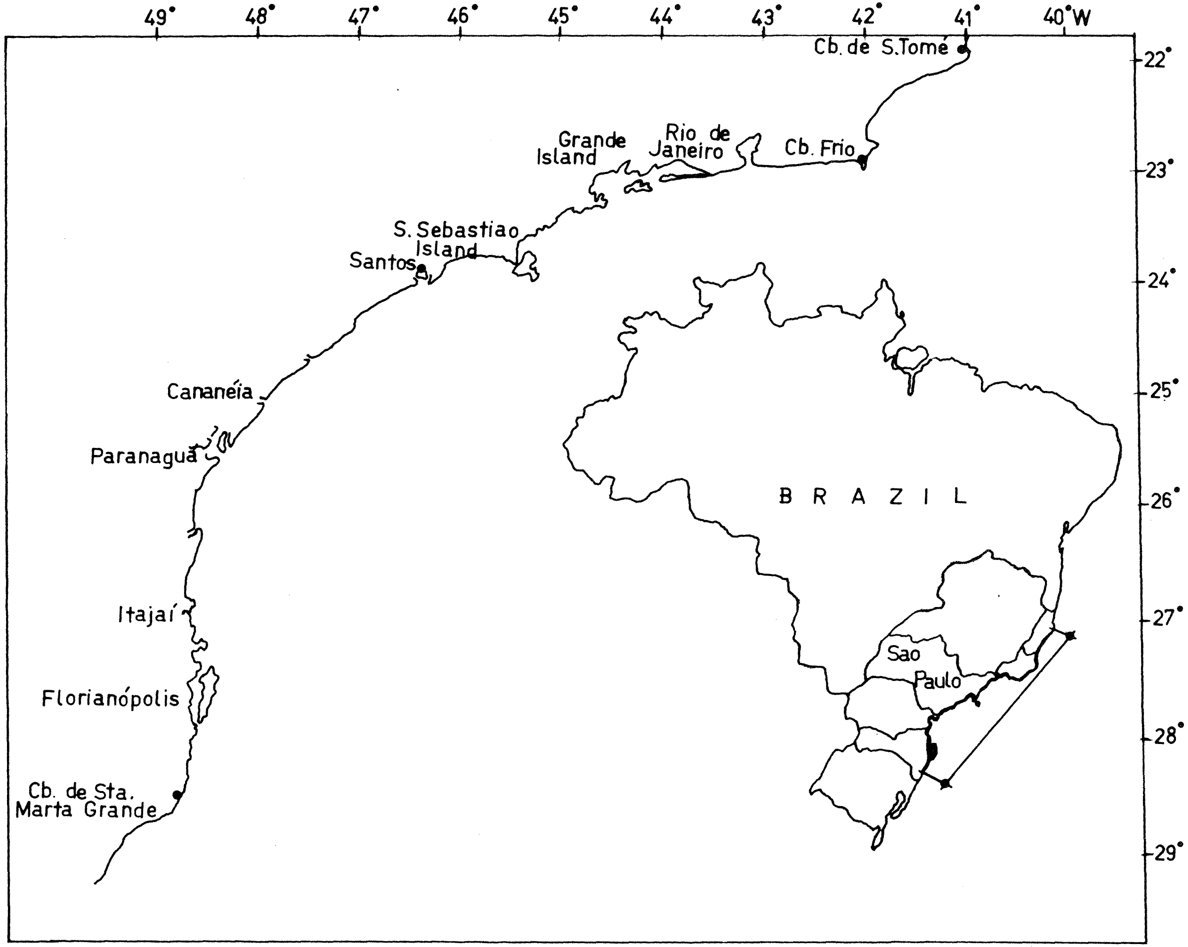

Fig. 1. City of Santos on the coast of Brazil.

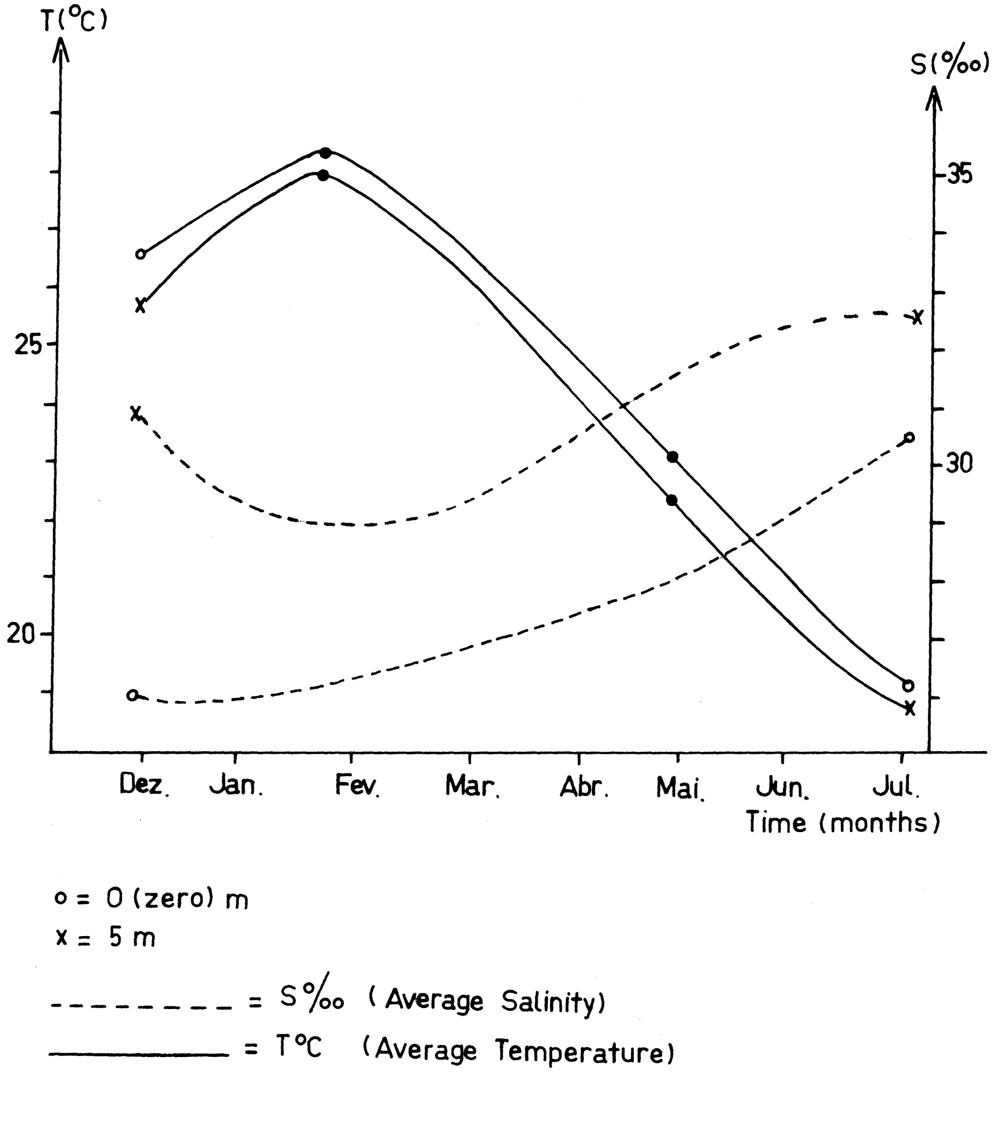

Fig. 2. Curves of salinity and temperature from the region studied.

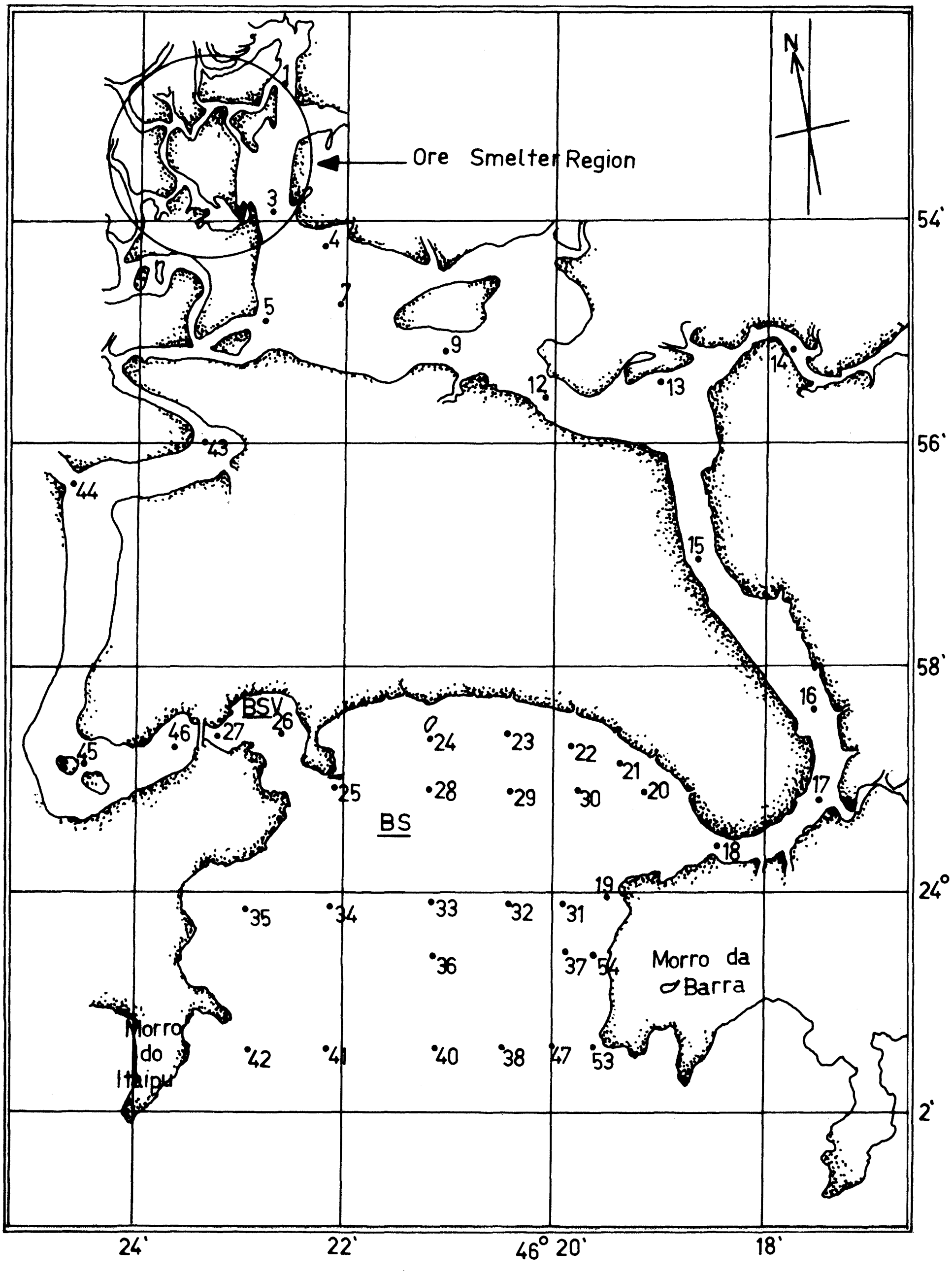

Fig. 3. Sampling positions in region studied.

In each station two bottom samples were obtained; on board the ship all the macrofauna was immediately separated by sieving the sample through 2 mm and 1 mm mesh. The animals were preserved for further examination under a stereoscopic microscope. The echinoderm specimens were then separated and identified down to species level.

Samples of water were also taken near the bottom for analysis of salinity, dissolved oxygen and nutrients (phosphate and nitrate); such analyses were conducted according to the methods recommended by Environmental Protection Agency (EPA) 1972 and Standard Methods for the Examination of Water (1971).

Also, a part of the bottom sample was separated to be used in the granulometric analysis.

RESULTS

Before presenting the results obtained in the present survey, it seems advisable to list those found by Tommasi in 1964. At that time 14 species of echinoderms were found, the ophiuroids being the most abundant group. The species included *Amphipholis januarii* Ljungman, *Hemipholis elongata* (Say), *Micropholis atra* (Stimpson), *Micropholis gracillima* (Stimpson), *Ophiactis lymani* Ljungman, *Ophioderma januarii* Lütken and *Ophiothrix angulata* (Say).

The asteroids were represented by *Astropecten brasiliensis* Müller and Troschel, *Astropecten marginatus* Müller and Troschel, *Echinaster brasiliensis* Müller and Troschel, *Coscinasterias tenuispina* (Lamarck) and *Luidia senegalensis* (Lamarck). The occurrence of both crinoids and echinoids was restricted to *Tropiometra carinata* (Lamarck) and *Mellita quinquiesperforata* (Leske) respectively.

In the more recent samples (1974 to 1976), the animals collected included the ophiuroids *A. januarii*, *H. elongata*, *M. atra*, *M. subtilis* (Ljungman), *O. lymani* and *Ophiophragmus lütkeni* (Ljungman), the asteroids *A. marginatus* and *L. senegalensis;* the only echinoid found was *M. quinquiesperforata*, which occurred in fairly dense populations. The quantitative aspects of the samples are presented in Table 1, which shows that the more abundant species were the ophiurans *H. elongata* and *M. atra*.

The crinoid species *T. carinata*, the asteroids *A. brasiliensis*, *E. brasiliensis*, *C. tenuispina*, and the ophiuroids *M. gracillima*, *O. januarii* and *O. angulata* were not found in any of the samples.

In the eastern position of the bay, next to the Morro da Barra, mostly in station 19 and 31, high densities of the ophiuroids *M. atra* and *H. elongata* were found. Tommasi (1967) had already pointed out that this region presented a much higher number of echinoderms as compared to other areas of the Bay. It is to be noticed that in station 19 and 31 the bottom deposits are constituted mostly of silt and fine sand.

In the region next to the beaches there was a predominance of sandy bottoms, the asteroid *A. marginatus* being the dominant species; on the west side of the bay the echinoid *M. quinquiesperforata* presented densities higher than any other species. Such a general pattern of distribution had already been observed in the 1964 samples.

During all the sampling period no echinoderms were found in the estuarine region; the only records are those for station 18, near the entrance to the channel.

The nutrient levels in station 1, fairly close to the iron smelter plant, were about 10 times higher than those generally found in the Bay. In station 1, the levels for PO_4 and NO_3 were respectively 0.44 mg/l and 0.21 mg/l, dissolved oxygen being of order of 1.8 mg/l; transparency of water is reduced to about 0.85 m, the bottom being constituted mostly of silt and clay.

In station 16, typical for most of the channel, values for nutrients were around 0.17 mg/l for PO_4, 0.16 mg/l for NO_3 and 4.9 mg/l dissolved oxygen; transparency of the water was usually close to 1.75 m.

Station 19, which presented the greatest concentration of echinoderms, is located on the east side of the bay; levels for nutrients were of the order of 0.01 mg/l PO_4 and NO_3, 6.4 mg/l dissolved oxygen and transparency of the water around 1.10 m. The bottom is constituted mostly of very fine sand and silt, similarly to station 31.

In the western part of the Bay, the bottoms are mostly of fine sand; stations 26 and 27 presented fairly large population of *Mellita quinquiesperforata*. Measurements of PO_4 and NO_3 showed values of 0.07 mg/l and 0.15 mg/l respectively, dissolved oxygen being around 6.7 mg/l.

DISCUSSION

The analysis of the results obtained for the two different sampling periods shows a fairly definite change in the echinoderm fauna in the area under consideration, suggesting different tolerance limits for different echinoderm species in relation to the environmental parameters under consideration.

Due to the lack of information in relation to some of the environmental parameters (like nutrients) for the 1964 sampling, it is not possible to carry out a more detailed comparison with the more recent information.

It would seem that the disappearance of some of the species is to be correlated with change in the nature of the bottom sediments, due to continued dredging operations near the docking facilities in the channel and the removal of the new material to the vicinity of Itaipu Point. The construction of new roads in the same general area has also helped produce the present picture of a substrate consisting mostly of very fine material. The importance of the type of sediments in the distribution of benthic species has already been discussed by Beanland (1940), Holme (1949) and Sanders (1958).

As already mentioned, *Tropiometra carinata*, *Coscinasterias tenuispina*, *Echinaster brasiliensis* and *Ophiothrix angulata*, all characteristic of hard bottoms, were collected in 1964, but were not found again during the 1974-1976 period. They had been found associated with bottoms constituted of "detritic" material and dead shells, in areas which are now covered by sediments in the range 0.062 mm to 0.088 mm.

Special reference should be made to *Hemipholis elongata* and *Micropholis atra*, the two ophiuroid species which have predominated in soft bottoms on different occasions and which can occur in fairly high concentrations at some stations. The changing environmental conditions seem to have had little or no effect on the number and distribution of these two species.

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Table 1. Quantitative aspects of the samples. List of species, total specimens from each station, total specimens collected (n) and percentage of occurrence (%).

Sp. \ St.	18	19	20	21	22	23	24	25	26	27	29	31	32	33	34	35	37	40	41	42	47	54	n	%
Astropecten marginatus	—	—	—	—	2	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	3	0.46
Luidia senegalensis	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	0.15
Mellita quinquiesperforata	—	—	9	1	—	—	—	3	19	—	—	—	—	—	—	5	—	—	1	71	—	—	109	16.72
Amphipholis januarii	—	6	2	2	—	—	4	—	—	—	—	—	—	14	—	—	—	11	—	—	—	—	39	5.98
Hemipholis elongata	4	1	1	—	12	1	—	4	2	—	6	144	61	63	19	10	6	66	—	12	1	—	413	63.34
Micropholis atra	3	35	1	2	6	—	1	—	6	1	2	—	—	3	—	1	—	—	—	—	—	16	77	11.81
Micropholis subtilis	—	2	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	1	—	—	6	0.92
Ophiactis lymani	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	0.31
Ophiophragmus lutkeni	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	2	0.31

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