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SPECIES COMPOSITION AND DIVERSITY IN SHALLOW WATER FOULING COMMUNITIES OF MADRAS HARBOUR*

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ABSTRACT

Quantitative assessment of community structure was carried out at eight stations in the Madras Harbour. Population density and trophic relationships of the biotic samples from an area of 0.1 m^2 were assessed and were subjected to certain useful indices of species structure and species abundance curves. Rigorous stress and pollution in one station reduces species diversity, while certain other stations show the nature of established communities in a stable environment. Detritus circuit of energy transfer is evident in the communities analysed.

INTRODUCTION

REVIEWING the literature (Aiyar and Panikkar, 1936; Paul, 1937, 1942; Nair, 1944, 1946; Tampi, 1946; Sebastian, 1953; Ali, 1954, 1956; Daniel, 1954, 1956; Daniel and Srinivasan, 1956; Krishnaswamy, 1957; Thampy, 1958; Anthony Raja, 1959 : Srinivasan, 1959; Forest Research Institute, 1970) on the marine ecology of the Madras Harbour (13°4'N, 80°17'E), it is evident that little attention has been paid to the study of species composition of the harbour waters. Recent studies have shown the occurrence of pollution due to oil spillage (Fernandez et al., 1977) and paint scrappings of ships and boats. Therefore it was felt necessary to investigate the structure of species composition in a community under stress applying the principles of quantitative ecology in eight selected Stations as indicated in Fig. 1.

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MATERIAL AND METHODS

At each of the Stations, collections were made at a region one foot below the water level using a specially designed collecting apparatus.

Fig. 1. Location of eight stations selected in the Madras Harbour for the present study.

* Extracted from M. Phil. Dissertation 'Biocoenosis of the Madras Harbour' of the Madras University by Sultan A. Ismail.

Description of the collecting apparatus

The collection apparatus consists of a metal frame of 0.1 m^2. A nylon bag to collect the epifauna was firmly bolted to the metal frame, with cloth binding. On one side of the bag a small opening was made so as to facilitate hand movement for scraping, but small enough to prevent the escape of animals. The frame was fixed at a decided depth at each station and the flora and fauna falling within the frame were scraped completely. On hauling the bag, the contents were transferred to a polyethylene bag with sea water and transported to the laboratory for further studies.

In the laboratory, samples were sorted out and identified. In order to study the species composition, the methods used in the study of the trophic structure of the ecosystem was adopted which consists of measurement and description of the species per unit area. Quantitative estimation of the bryozoans was determined by their volume and their population density was calculated by multiplying this number by the number of bryozoans displacing one ml of water. For the sake of convenience five thousand bryozoans were designated as one unit on an arbitrary basis. (It must be noted that this arbitrary unit measure of bryozoan populations has the effect of making the statistics of this study unique and not comparable to other studies. Still the application of similar measures and derived statistics from one Station to another is appropriate.)

Index of dominance (Simpson, 1949) was assessed using the formula $c = \Sigma\,(ni/N)^2$ where ni = number of individuals for the species N = total number of individuals in a Station.

Index of similarity between two samples (Sorenson, 1948 ; Odum, 1971) was assessed using the formula

$S = \frac{2C}{A+B}$, where A = number of species in sample A ; B = number of species in sample B and C = number of species common to both samples.

Index of dissimilarity was derived from the index of similarity by $1 - S$.

Species diversity was assessed using the following indices

(A) Two species richness or variety indices [d_1 Margalef, 1958 and d_2 Menhinick, 1964 (Odum, 1971)]

$$\left[d_1 = \frac{S-1}{\log N} \qquad d_2 = \frac{S}{\sqrt{N}} \right]$$

where S = number of species

N = number of individuals

(B) Shannon index of general diversity '$\bar{H}$' (Shannon and Weaver, 1949 ; Odum, 1971) was assessed by the formula

$$[\bar{H} = -\Sigma\, ni/N \log_e ni/N$$
$$= -\Sigma\, Pi \log_e Pi]$$

where ni = importance value for each species

N = total of importance values

Pi = importance probability for each species (ni/N)

(C) Evenness component 'e' was assessed by the formula

$$e = \frac{\bar{H}}{\log_e S} \quad \text{where } \bar{H} = \text{Shannon index}$$

S = number of species

In some ecological studies, analysis of species diversity is made by comparison based on the shapes, patterns or equations of species abundance curves and by comparison based on diversity indices which are the ratios of species importance relationships. An attempt was made here to study the species richness (variety component) and the evenness or equitability in the apportionment of individuals among the species. In each study the general relationship between species rank (S) and the number of individuals per species (N/S) is exposed graphically.

RESULTS

Table 1 provides information on the species composition at the eight stations studied during January-February 1978. It is seen that the species array at no two stations is exactly the same. For example at Station 1 a total number of fourteen species are recorded whereas at station 7, only five species are recorded. Further, there is also quantitative difference at each of the stations.

TABLE 1. *List of species/groups and their numerical abundance in eight stations of the harbour area (January-February 1978)*

Species Groups	Stations 1	2	3	4	5	6	7	8
Obelia	0	0	+	+	0	0	0	0
Adamsia (?)	0	0	0	1	3	1	0	25
Dasychone	0	2	0	22	32	17	0	27
Hydroides	2025	7200	64	470	906	238	0	20
Nereids	30	14	4	4	0	2	0	11
Terebellids	0	0	1	2	0	10	0	0
Elasmopus	58	28	18	8	2	12	0	0
Stenothoe	103	36	18	28	21	6	1	9
Microdeutopus	0	0	2	11	2	0	0	2
Caprella	0	0	0	1	0	0	0	0
Sphaeroma	3	60	79	2	33	4	0	0
Cirolana	761	1942	1072	17	54	143	0	0
Portunus	0	1	0	1	2	0	0	0
Penaeus	0	0	0	0	0	4	0	0
Alphaeus	0	0	0	0	1	0	0	0
Balanus	45	69	1014	1023	3026	206	1372	233
Amphitoe	50	0	0	0	0	0	0	0
Ligia	0	2	0	0	0	0	0	0
Endeis	1	5	0	0	0	0	0	0
Tanystylum (?)	0	9	0	0	0	0	0	0
Modiolus	12	2	9	4	10	5	47	2043
Perna	0	0	2	0	0	0	0	0
Thais	0	10	0	0	0	0	5	0
Amathia	229.4*	279.0*	855.6*	446.4*	465.0*	985.8*	0	0
Crisia	1.31*	86.7*	0	9.23*	14.26*	15.4*	0	0
Bowerbankia	124.0*	0	44.6*	0	0	0	0	0
Bugula	0	0	0	8.5*	0	4.07*	0.74*	18.5*
Loxosoma (?)	30	0	0	0	0	0	0	0
Ophiactis (?)	0	1	0	0	0	0	0	0
Styela	0	0	0	1	2	1	0	0
Egg mass	0	+	0	0	0	+	0	0
Algae	0	0	+	0	+	+	0	0

* Units — 5,000 Zooids.

Index of dominance '*c*'

The analysis of the index of dominance is given in Table 2 for the eight stations under study. The zooids index of dominance is that obtained when the number of individual zooids in a colony is taken as such for analysis. The units index is the value obtained when units (5000 zooids as one unit) are taken into consideration. It can be seen by comparison that the concentration of dominance changes in each of the representation. At stations 3, 4, 5, 6 and 8 the difference in the derived measures is marked. In studies of dominance lower values indicate that dominance is shared by several species whereas higher values indicate dominance by one or two species. At stations 1, 2 and 7 the dominance is shared by four, four and two species respectively, while in the other Stations there is essential dominance by one species. It is interesting to note that station 7 which ranked the second position in zooid dominance due to its sharing of dominance with many species has assumed the eighth position in unit dominance with the highest value of dominance being 0.96 which reflects the total dominance by one species namely *Modiolus striatulus*.

Index of dissimilarity (1-S)

Figure 2 indicates that stations 5 and 7 show maximum degree of dissimilarity. It is also interesting to point out, when comparison of one station is made with stations 7 or 8 the resulting value of dissimilarity is always high, *i.e.* 0.4.

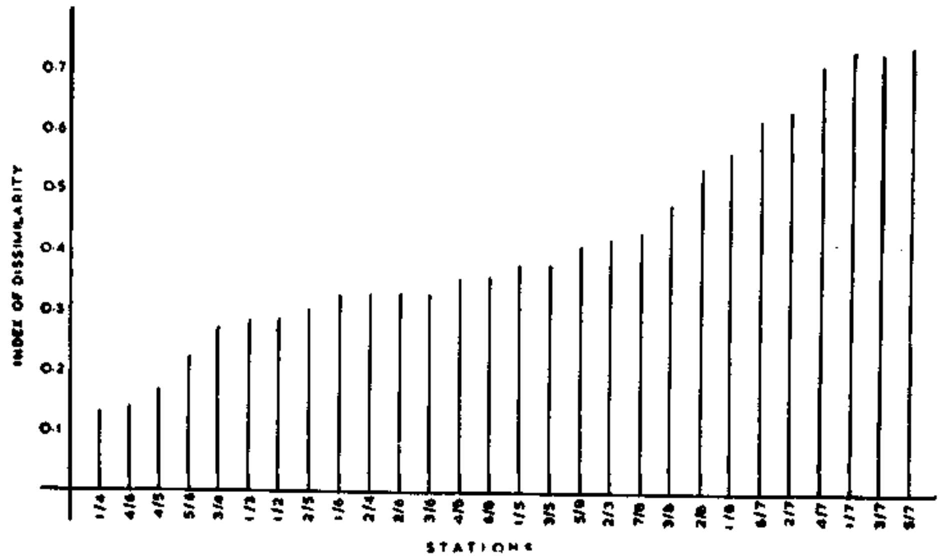

Fig. 2. Index of dissimilarity (Arranged in the ascending order of dissimilarity).

Indices of species diversity

(A) *Two species richness or variety indices* '*d*' The results are shown in Table 2. It is seen that at stations 4 and 6 the species richness registers a high value whereas at station 7 it falls considerably. It is of interest to note that at station 2, although the number of species is almost equal to that at stations 4 and 6; the species richness index is considerably reduced due to the disproportionate increase in the number of individuals of *Hydroides norvegica*.

TABLE 2. *Density, dominance and diversity of the Harbour fauna for the period January-February* 1978

Indices	Stations 1	2	3	4	5	6	7	8
Density No./0.1 m^2 :								
Units	3442	9744	3183	2059	4573	1654	1426	2389
Zooids	1771638	1822881	4503283	2322245	2400394	5026999	5175	94870
Biomass Kg/0.1 m^2	0.48	0.60	0.68	1.14	1.31	1.15	0.64	0.85
Index of Dominance (c)								
Units	0.40	0.59	0.29	0.35	0.49	0.40	0.93	0.74
Zooids	0.54	0.64	0.90	0.92	0.94	0.96	0.60	0.95
Variety index (d_1)	1.60	1.74	1.61	2.36	1.66	2.02	0.55	1.03
(d_2)	0.24	0.17	0.25	0.42	0.22	0.39	0.13	0.18
Shannon index ($\bar{H}$)	1.31	0.82	1.40	1.41	1.03	1.31	0.18	0.59
Evenness index (e)	0.51	0.29	0.55	0.49	0.38	0.47	0.11	0.27

Supportive evidence is given in the earlier section in that the index of dominance is high in station 2 indicating dominance by one species.

(B) *Shannon index of general diversity* '$\bar{H}$'

Shannon function or $\bar{H}$ index combines the variety and evenness component as one comprehensive index of diversity. In this index it is customary to analyse both e and $\bar{H}$ indices. The data obtained are summarised in Table 2.

(C) *Evenness index* '*e*'

Evenness index is another way of expressing species diversity. The results of the analysis are given in Table 2. The pattern of evenness in all the stations recalls similar variations as that of $\bar{H}$ index suggesting thereby that high values indicate a low concentration of dominance. The present results agree with other reports on species diversity in that both e and $\bar{H}$ show an inverse relationship with the index of dominance (Fig. 3). It may be worthwhile to point out that at stations 1, 3, 4 and 6 the evenness index ranged over 0.5. Correspondingly the index of dominance in each of these stations was less the 0.4.

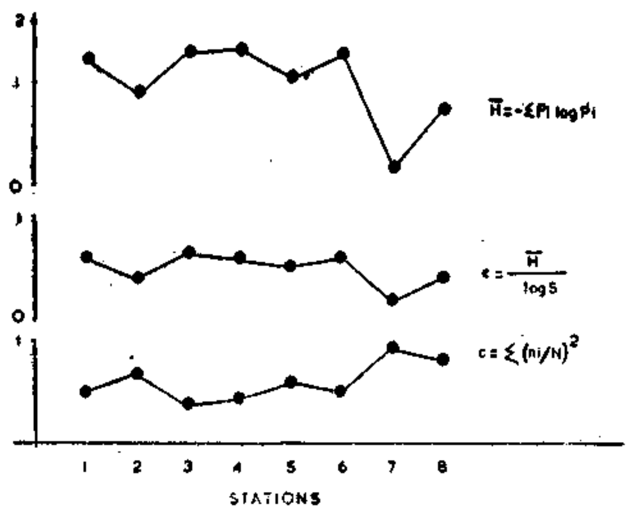

Fig. 3. Shannon index of general diversity ($\bar{H}$) and evenness index (e), compared with the index of dominance (c).

Species diversity by Abundance Curve Method

Species diversity can also be analysed by comparison of shapes of species abundance curves. The general relationship between numbers per sample of the various species is generally plotted on a graph ordered from the least to the most numerous. The nature of the resulting curve reflects the relationship between species numbers (S) and number of individuals per species (N/S) under a given environmental condition. The form of the curve is the result of the apportionment of individuals in a given sample to the various species. On this basis the data were analysed. Figures 4 a and 4 b illustrate the general relationship between S and N/S. It is interesting to note that in stations 1, 2, 3 and 5 the curve is less concave than in stations 4, 6 and 8. However the curve for station 7 is flattened to a greater extent which is indicative of rigorous physical environment or pollution or other stress, in that there are relatively few species.

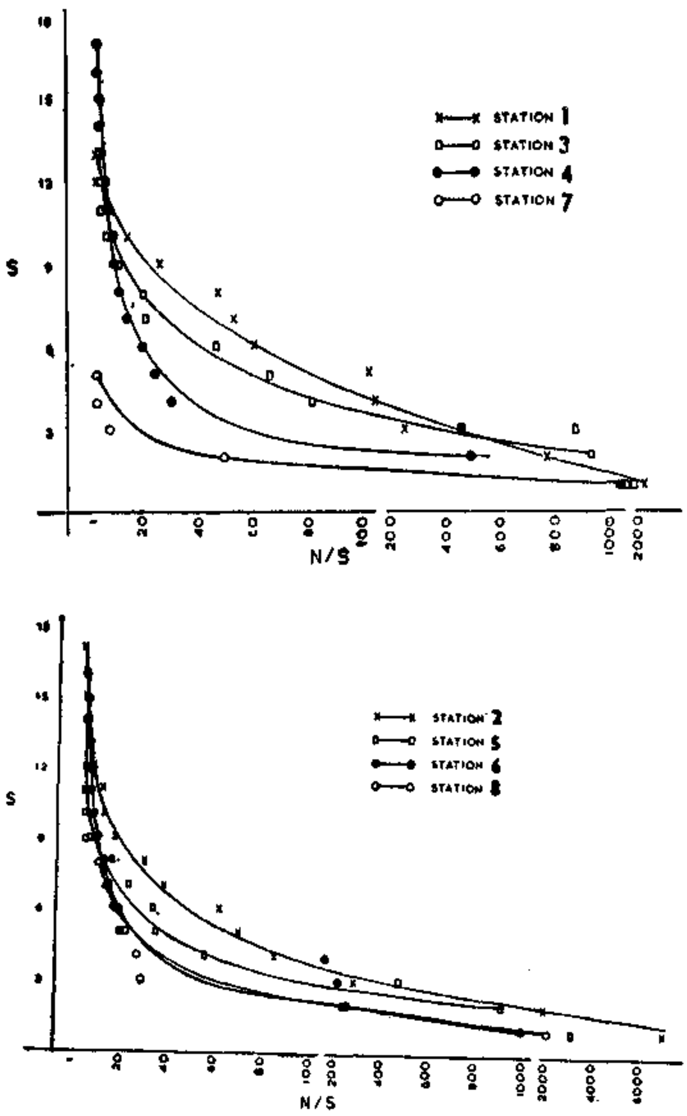

Fig. 4. Species abundance curves: S/(N/S).

Discussion

Biotic—abiotic components of the environment are inseperably interrelated and interact upon each other, which lead to the concept of the ecosystem. Results presented in this work cover some aspects of the components and processes of the ecosystem. At stations 3, 5 and 6 algae like *Ulva* and *Chaetomorpha* are the chief primary producers attached to the substratum. Planktonic diatoms found in this area may also contribute to the primary production of this area. At other stations in the absence of sessile autotrophs, the base of the trophic cycle may consist of diatoms and imported detrital material. That the community is suited to harvest energy through organic detritus circuit rather than by a grazing circuit is indicated by the abundance of sessile organisms that are predominantly detritus feeders such as *Adamsia* (?) (*Coelenterata*), *Dasychone cingulata* and *Hydroides norvegica* (Annelida), *Balanus* (Arthropoda), *Modiolus striatulus* and *Perna viridis* (Mollusca) and *Styela* (Urochordata). Prawns may represent macroconsumers and crabs may also come under the category of macroconsumers but as a special group, scavengers. It is highly significant that filter-feeders like *Balanus* and *Modiolus* occur at all the eight stations whereas species like *Caprella*, *Penaeus*, *Alphaeus*, *Endeis* and *Tanystylum* (?) (Arthropoda), *Perna* (Mollusca) and *Ophiactis* (?) (Echinodermata) occur only at stations 4, 6, 5, 2, 3 and 2 respectively.

Further, species of *Hydroides* (Annelida), *Elasmopus* and *Stenothoe* (Amphipoda, Arthropoda), *Sphaeroma* and *Cirolana* (Isopoda, Arthropoda) *Balanus* (Cirripedia, Arthropoda), *Modiolus* (Mollusca) and *Amathia* (Ectoprocta) are always found living together. As recorded at station 7, in the absence of *Amathia*, filter feeders like *Balanus* and *Modiolus* thrive well. Although absence of one specimen and abundance of the other may suggest antigonistic relationship with each other, it is quite possible that ambient physicochemical conditions may play and equal role in favouring one species over the other.

In order to assess the trophic relationship, four major levels were recognised. They are algal feeders, filter feeders, macroconsumers and scavengers. Figures 5A, 5B and 5C summarise such relationships in the Quay, the Boat Basin and the Timber Pond. It is seen that in the Quay the distribution of animals in reference to trophic levels appears to be well balanced in that the number of organisms show equitable distribution among the trophic levels. In the Boat Basin, Isopods dominate in the algal feeders group and at the level of the filter feeders *Hydroides* and *Balanus* dominate. In the Timber Pond algal feeders are completely reduced while filter feeders are represented in sizable numbers. Prawns like *Penaeus* and *Alphaeus* show various ecological niches, being classified as algal feeders, filter feeders and macroconsumers.

Table 3 summarises the general pattern obtained by calculating the averages of various indices of species structure in the three areas namely A (Quay), B (Boat Basin) and C (Timber Pond). In such analysis it is found that species dominance is lowest in area B (When represented as units) indicating the dominance being shared by many species. Similarly e and $\bar{H}$ indices for area B are high, which is indicative of complex communities adapted for a stable environment (Odum, 1971). Suggestive evidence that the community in area B may be an old community in a stable environment is provided by the high values of d_1 and d_2 indices which give a picture of general variety of species richness. In area C, not only is one species dominant (*Balanus* in station 7 and *Modiolus* in station 8) but also e and $\bar{H}$ are very low which is consistent with seasonal or periodic pertuberations by man or nature. A causal visit to the habitat indicated the occurrence of high levels of pollution in the Timber Pond,

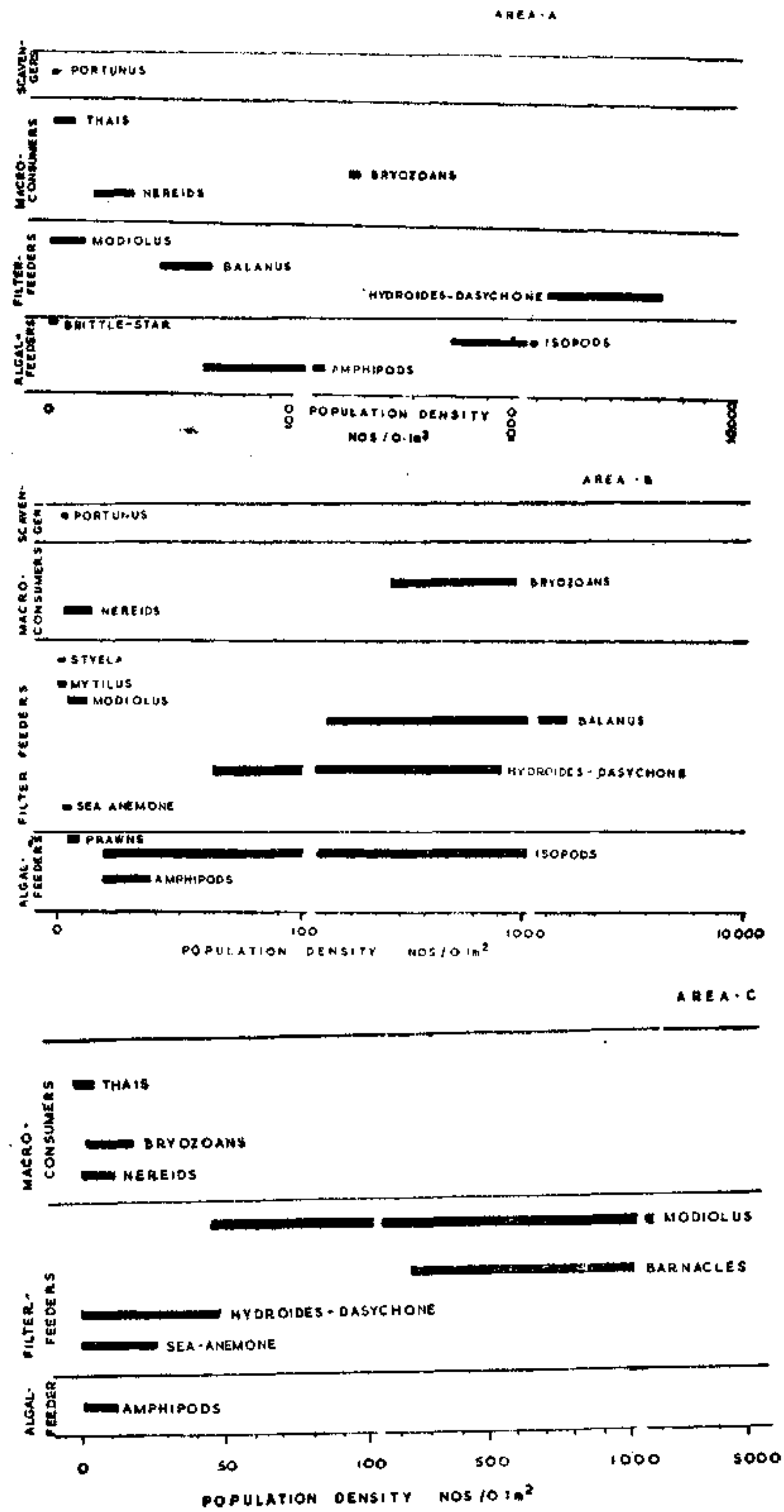

Fig. 5. Trophic relationships. Area A (Quay), Area B (Boat Basin) and Area C (Timber Pond).

TABLE 3. *Mean values of Index of dominance and diversity indices of the quay, boat basin and timber pond areas of the harbour*

Indices	Area A	Area B	Area C
Index of dominance (C)			
Units	0.50±0.13	0.38±0.08	0.84±0.13
Zooids	0.59±0.07	0.93±0.03	0.76±0.25
Variety Index (d)			
d_1 S-1/log N	1.67±0.10	1.91±0.35	0.79±0.34
d_2 $S/\sqrt{N}$	0.21±0.05	0.32±0.10	0.16±0.04
Evenness index (e)	0.40±0.16	0.47±0.07	0.19±0.11
Shannon index ($\bar{H}$)	1.07±0.35	1.29±0.18	0.39±0.29

A. Quays B. Boat Basin C. Timber Pond

which is a body of water enclosed on three sides and which has heavy oil spillage (Fernandez *et al.*, 1977). It is quite likely that communities found there are those that are able to adopt to a polluted environmental condition or the communities might have recently been established after the elimination of a community not suited for withstanding environmental stress. It is hoped that further work, on the physicochemical properties of water as well as the extent of oil pollution may throw more light on inferences drawn above.

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