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# Settlement and Community Interrelations of Fouling Organisms in Cochin Harbour, India

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A qualitative and quantitative assessment of the fouling community on a sequential, progressive and cumulative basis carried out at the Cochin Harbour is presented in this paper. A total of 67 species were recorded in this study. The index of dominance of various animals was found. Mud-tube worms dominated during the pre-monsoon, cirripedes during monsoon and post-monsoon period. A comparison is attempted on the number of micro and macro foulers recorded from various Indian and world harbours. In India, Cochin ranks second in so far as the occurrence of macrofoulers are concerned. The correlation coefficient of the settled organisms was found and the modulus values are presented in the form of a matrix diagram. To separate out the groups of foulers with higher correlation coefficient, a dendrogram was constructed using correlation matrices and based on the clustering of animal groups.

The organisms that constitute the fouling community comprise a large assemblage of animals and plants. There is a growing awareness that improved anti-fouling systems can be developed only on the basis of a thorough understanding of the biology of fouling organisms. Several studies have been reported on the fouling communities inhabiting different harbours of the world (Mistakidis, 1951; Skerman, 1958, 1959; Mawateri & Kobayashi, 1954; Nair, 1962; Bastida, 1968; Haderlie, 1968, 1976; Ghobashi, 1976; Matricardi *et al.*, 1980; Viviyani & Disalvo, 1980; Huang, 1984).

Important works in Indian harbours include those of Paul (1942), David (1954), Ganapati *et al.* (1958), Karande (1968). Menon *et al.* (1977) Dharmaraj & Nair (1981), Meenakumari & Nair (1984) and Nair (1984). The purpose of the present study was to collect more detailed information on several aspects of the ecology of common micro and macro fouling organisms inhabiting the Cochin harbour.

## Materials and Methods

Glass panels of size 150 x 100 mm were used to collect foulers for qualitative and quantitative assessment of fouling community on a sequential, progressive and cumulative basis. Observations were conducted during 1981-82 at North Oil Tanker Berth of Cochin Harbour. The panels were put in a grooved wooden rack suspended 1 m below the lowest tide mark and one panel each was removed at an interval of one month to give an idea of the foulers for 1 year period. Salinity and oxygen content of the water were determined following Strickland & Parsons (1968). Air temperature and surface water temperature were measured with a mercury thermometer correct to 0.1°C. For finding the index of dominance, the method employed by Simpson (1949) was used. The index of dominance, $c = \Sigma\,(ni/Ni)^2$, where ni is the importance value for each species and Ni is the total importance value. For estimating the number of sessile as well as free living epifauna on the panels, random points sampling system was employed. The glass panel was divided into 10 $mm^2$ squares by placing a modular grid over it and the organisms present in 30 random squares were counted. The data were then scaled up to read the number per square metre. Matrix diagram and dendrograms were prepared by finding the correlation coefficient (Snedecor &

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Cochran, 1968) of the animal fouling groups.

**Results and Discussion**

The fouling community at the Cochin harbour consisted chiefly of sponges, hydroids, sea anemones, bryozoans, mud-tube dwelling polychaetes, calcareous-tube dwelling polychaetes, barnacles and bivalves. The settlement pattern of the most important groups of foulers are shown in Fig. 1. Bryozoans and barnacles were present on

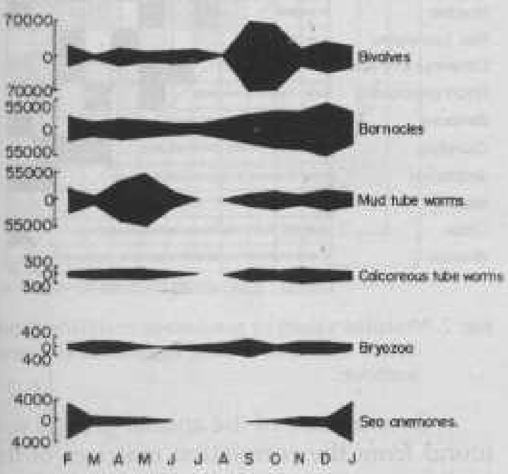


Fig.1 The pattern of settlement of sessile fouling organisms on glass panels at Cochin harbour.

the panels throughout the year. There was no settlement of mud-tube worms, calcareous-tube worms and sea anemones during the monsoon. Settlement of bivalves was also restricted during the low salinity period. Salinity of the surface water fluctuated between 0.8‰ and 32.6‰ (Table 1). During the monsoon period (June - Sept) the salinity was very low due to precipitation and land drainage into the estuary. This low saline condition consequent on the monsoon imposes restrictions on the otherwise continuous settlement of fouling organisms in Cochin harbour (Meenakumari & Nair, 1984).

Table 1. *Hydrographical parameters of test site*

| 1981-82 Month | Air Temp. °C | Surface Water Temp. °C | Salinity ‰ | Dissolved $O_2$ ml l$^{-1}$ |
|---|---|---|---|---|
| January | 27.0 | 29.0 | 26.2 | 3.8 |
| February | 30.0 | 28.0 | 26.0 | 3.4 |
| March | 28.9 | 30.3 | 28.5 | 4.2 |
| April | 31.3 | 31.1 | 25.8 | 3.7 |
| May | 31.2 | 30.6 | 19.9 | 3.6 |
| June | 29.2 | 29.7 | 2.7 | 4.2 |
| July | 29.7 | 28.0 | 1.1 | 4.1 |
| August | 28.4 | 29.5 | 0.8 | 3.7 |
| September | 29.0 | 29.7 | 16.7 | 3.9 |
| October | 30.6 | 29.8 | 17.5 | 3.8 |
| November | 28.6 | 29.9 | 14.5 | 4.0 |
| December | 28.0 | 29.3 | 29.0 | 3.7 |
| January | 31.2 | 29.7 | 32.6 | 3.8 |
| February | 30.7 | 29.1 | 31.5 | 3.4 |

Table 2. *Prevalence and dominance of fouling groups at Cochin harbour*[1]

| Animal group | Period | | | |
|---|---|---|---|---|
| | Pre-Monsoon | Monsoon | Post-Monsoon | For the year |
| Sea-anemones | 153(7) | 0.801(12) | 1110(6) | 2650(6) |
| Planarians (Flat worms) | 68.2 | 2.07(11) | 55.6(8) | 110(10) |
| Bryozoa | 24.9(9) | 178(6) | 12.5(11) | 212(8) |
| Mud-tube worms | 440000(1) | 71000(4) | 65900(5) | 577000(2) |
| Calcareous tube-worms | 14.7 | 5.55(10) | 17.5(10) | 37.70(12) |
| Errant polychaetes | 21.9(9) | 126(8) | 25.40(9) | 202(9) |
| Cirripedes | 165000(3) | 908000(1) | 617000(1) | 1530000(1) |
| Caprellids | 360000(2) | 219(7) | 81500(4) | 442000(5) |
| Amphipods | 31100(5) | 259000(3) | 183000(3) | 473000(4) |
| Isopods | 709(6) | 263(5) | 505(7) | 148(7) |
| Crabs | 1.26(11) | 62(9) | 8.10(12) | 71.30(11) |
| Bivalves | 66600(4) | 488000(2) | 219000(2) | 774000(2) |

1. Numbers are in millions m$^{-2}$. Numbers in parenthesis indicate the order of dominance among foulers.

A total of 67 species were recorded in this study (Table 3). Not all the organisms in the community are equally important in determining the nature and function of the whole community. The index of dominance of various animals during the pre-monsoon, monsoon and post-monsoon shows that mud-tube worms were dominant during the pre-monsoon and cirripedes during the monsoon and post-monsoon periods. The dominance for the whole year was exhibited by cirripedes (Table 2). In a community, a relatively few species or species groups generally exert the major controlling influence by virtue of their number, size, reproduction or other activities. Species or species groups which largely control the energy flow and strongly affect the environment of all the species are known as 'Ecological dominants' and the degree to which dominance is concentrated in one, several or many species can be expressed by an approximate index of dominance that sums up the importance of each species in relation to the community as a whole.

Table 3. *The number of micro and macro fouling animals recorded from different Indian harbours*

| Locality | Micro foulers | Macro foulers | Reference |
|---|---|---|---|
| Visakhapatnam | 11 | 43 | Ganapati *et al.*, 1953 |
| Madras | 15 | 41 | Daniel, 1954 |
| Madras | 48 | - | Daniel, 1955 |
| Bombay | 30 | 54 | Karande, 1968 |
| Krusadi | 7 | 40 | Kuriyan, 1950 |
| Andamans | - | 30 | Karande, 1978 |
| Neendakara | - | 40 | Dharmaraj & Nair, 1981 |
| Mangalore | - | 10 (major fouling groups) | Menon *et al.*, 1977 |
| Tuticorin | - | 18 (major fouling groups) | Renganathan *et al.*, 1982 |
| Cochin | 15 | 37 | Meenakumari & Nair, 1984 |
| Cochin | 7 | 30 | Nair, 1984 |
| Cochin | 19 | 48 | Present study |

Tables 3 & 4 present the number of micro and macro fouling animals recorded from various Indian and world harbours respectively. With regard to the composition of fouling, some authors have ignored notably the free living and the microscopic forms. Therefore, the numbers cannot be taken as a true indication of the various fouling species, but give an approximate picture of the occurrence of fouling animals in the various localities. A comparison of the present study with those from other harbours of India (Table 3) shows that Cochin harbour is not poor in fouling species even though their settlement and growth are very much restricted during the monsoon period (Fig. 1). Cochin ranks second in so far as the occurrence of macrofoulers are concerned, the first being Bombay.

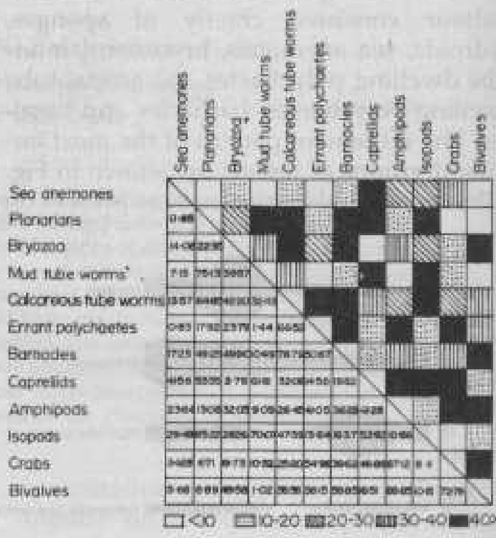


Fig. 2. Modulus values of percentage correlation coefficient matrix of fouling organisms at Cochin harbour.

Co-existence of the animal groups was found from the correlation matrices of the fouling groups over time at Cochin harbour (Fig. 2). Significant positive correlation can be taken as an indication of the animal groups existing together, and the negative correlation as the index of competition between different animal groups in the community for existance. To separate out the groups of foulers with higher correlation coefficient, a dendrogram was constructed using correlation matrices, and based on the clustering of animal groups (Fig. 3). The dotted line in the figure shows significant coefficient of correlation at 5% level.

Studies of Sutherland (1974). Sutherland & Karlson (1977) and Smedes (1984) along the Atlantic coast have furnished information on the changes in the community structure of developing fouling communities. Recruitment of animals was found to be highly seasonal, salinity playing a strong influence on the composition and per-

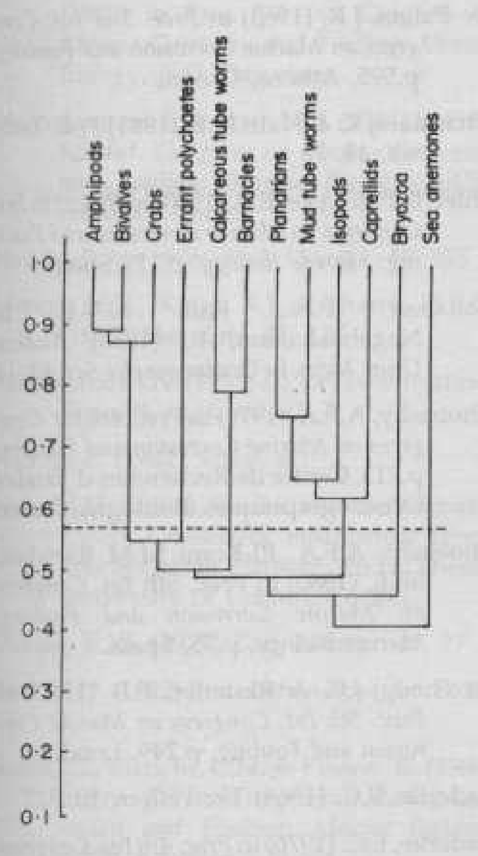


Fig. 3. Dendrogram from affinity indices among the groups of animals present in Cochin harbour. The dotted line represents significant coefficient of correlation at $p < 0.05$

sistence over time in this study. Several species were represented in the community, but no equilibrium number was attained at Cochin harbour. Even though competitive hierarchies were observed, there was no direct order of colonisation and establishment of a climax community as observed in several temperate locations. Osman (1977) also could not observe totally seasonal or totally successional pattern in Cape Cod fouling communities. At the Cochin Harbour there was total extinction of many of the fouling communities particularly at the intertidal zone, even though many of the animals like barnacles and oysters survive at deeper

Table 4. *The number of micro and macro fouling animals recorded from different world harbours*

| Locality | Micro foulers | Macro foulers | Reference |
|---|---|---|---|
| Easter harbour of Alexandria | 7 | 23 | Ghobashi,1976 |
| Montery harbour | 11 | 59 | Haderlie,1969 |
| California | 2 | 132 | Haderlie,1976 |
| Mar Del Plata Argentina | 34 | 33 | Bastida,1968 |
| East coast of China | 207 | 508 | Huang,1984 |
| Strait of Florida, Florida | 13 | 68 | De Palma,1963 |
| Ago Bay, Japan | - | 13 | Mawatari & Kobayashi,1954 |
| Essex, England | 1 | 71 | Mistakidis,1951 |
| Alameda Marina, San Francisco | 8 | 32 | Ehler & Lyke,1980 |
| Western Norway | 35 | 81 | Nair,1962 |
| Auckland, New Zealand | 1 | 23 | Skerman,1959 |
| Port Littleton, New Zealand | 3 | 24 | Skerman,1953 |
| Port of Ingeniero White, Argentina | 1 | 52 | Martines *et al.*, 1984 |
| Puerto Quenquen, Argentina | 52 | 30 | Brankevich *et al* 1980 |
| Po River Delta, Italy | - | 33 | Matricardi *et. al.*,1980 |
| Chilean coastal bay South America | 5 | 22 | Viviyani & Disalvo,1980 |
| Pearl harbour | 5 | 85 | Grovhoug & Rastetter,1980 |
| Tyrrhenian Coast, Rome | - | 72 | Relini *et al.*, 1980 |
| Suez Canal | 11 | 61 | Ghobashy *et al.*, 1980 |

waters owing to stratification of salinity consequent on freshwater run off during the monsoon. A long-term consistency in the development of fouling community as demonstrated by Dean (1977), Smedes (1978) and Dean & Hurd (1980) was not observed at Cochin owing to the restriction imposed by the monsoon. Smedes (1984) also observed a general tendency towards species lower in the competitive ranking to appear earlier in the year. This was true in the case of *Balanus amphitrite* observed settling throughout the year even though with fluctuating intensity (Fig. 1).

During the beginning of the post-monsoon period at Cochin harbour, hydroids settled in large numbers and grew very fast. This may be a survival mechanism to compete successfully with barnacles and bivalves. Thus, a true biotic succession in the settlement of fouling organisms was lacking in Cochin harbour. What exists is only ecological succession brought about by short-term changes in salinity consequent on the monsoon. Biological competitions and death coupled with salinity changes make substrate space available on a fairly predictable basis at Cochin harbour. Timing strategy in reproduction of many poor competitors was observed by Dayton (1971), Menge (1976), Sutherland & Karlson (1977) and Dean & Hurd (1980). The post-monsoon pulse in settlement of hydroids, barnacles and mussels observed in this study is a typical example of this phenomenon. In short, community stability depends on biological and physical properties of the community and type of natural perturbations. The response of the community was also influenced by seasonal short-term factors such as salinity in the Cochin Harbour waters.

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**References**

Bastida, R. (1968) in *Proc. 2nd Int. Congress on Marine Corrosion and Fouling*, p. 557, Athens, Greece

Brankevich, G., Bastida, R. & Martines D. (1984) in *Proc. 6th Int. Congress on Marine corrosion and Fouling: Marine Biology*, p.567, Athens, Greece

Daniel, A. (1954) *J. Madras Univ. B.* **24**, 97

Dayton, P.K. (1971) *Ecol. Monogr.* **41**, 351

Dean, T.A. (1977) *Succession in a marine fouling community - changes in community structure and mechanisms of development.* Ph.D. Dissertation, Univ. of Delaware, USA

Dean, T.A. & Hurd, L.E. (1980) *Oecologia*, **46**, 295

De Palma, J.R. (1968) in *Proc. 2nd Int. Congress on Marine Corrosion and Fouling*, p.595, Athens, Greece.

Dharmaraj K. & Nair, N.B. (1981) *Fish. Technol.* **18**, 79

Ehler, C.P. & Lyke, E.B. (1980) in *Proc. 5th Int. Congress on Marine Corrosion and Fouling: Marine Biology*, p.175, Spain

Ganapati, P.N., Rao, N.V.L. & Nagabushanam, R. (1958) *Andhra Univ. Mem. in Oceanography Ser.* **62**, 11

Ghobashy, A.F.A. (1976) in *Proc. 4th Int. Congress on Marine Corrosion and Fouling*, p.213, Centre de Recherches d'Etudes Oceanographiques, Boulogne, France

Ghobashy, A.F.A., El-Komi, M.M. Ramdan, Sh.E. (1980) in Proc. 5th *Int. Congress on Marine Corrosion and Fouling: Marine Biology*, p.75, Spain.

Grovhoug, J.G. & Rastetter, E.B. (1980) in *Proc. 5th Int. Congress on Marine Corrosion and Fouling*, p.249, London

Haderlie, E.C. (1968) *The Veliger*, **10**, 327

Haderlie, E.C. (1976) in *Proc. 4th Int. Congress on Marine Corrosion and Fouling*, p. 24, Centre de Recherches et d'Etudes Oceanographiques, Boulogne, France

Huang, Z.C. (1984) in *Proc. 6th Int. Congress on Marine Corrosion and Fouling: Marine Biology*, p.23, Athens, Greece

Karande, A.A. (1968) in *Proc. 2nd Int. Congress on Marine Corrosion and Fouling*, p.563, Athens, Greece.

Kuriyan, G.K. (1950) *Bombay Nat. Hist. Soc.* **49**, 90

Mawatari, S. & Kobayashi, S. (1954) *Misc. Rep. Res. Inst. Nat. Resour. Tokyo*, **35**, 37

Martinez, D., Bastida, R. & Brankevich, G. (1984) in *Proc. 6th Int. Congress on Marine Corrosion and Fouling: Marine Biology*, p.521, Athens, Greece

Matricardi, G., Relini, G. & Diviacco, G. (1980) in *Proc. 5th Int. Congress on Marine Corrosion and Fouling: Marine Biology*, p.45, Barcelona

Meenakumari, B. & Nair, N.B. (1984) in *Proc. 6th Int. Congress on Marine Corrosion and Fouling: Marine Biology*, p.159, Athens, Greece

Menge, B.A. (1976) *Ecol. Monogr.* **46**, 355

Menon, N.R., Katty, R.J. & Shetty, H.P.C. (1977) *Mar. Biol.* **41**, 127

Mistakidis, M.N. (1951) *Fishery Investigations Series II, H.M.S.O.* **17**, 5

Nair, N.B. (1962) *Sarsia*, **8**,1

Nair, N.U. (1984) *Studies on the Backwater Oyster Crassostrea madrasensis (Preston) of Cochin Harbour*. Ph.D. Thesis, University of Cochin, Cochin.

Osman, R.W. (1977) *Ecol. Monogr.* **47**, 37

Paul, M.D. (1942) *Proc. Indian Acad. Sci. B.* **15**, 1

Relini, G., Bianchi, C.N. & Pisano, E. (1980) in *Proc. 5th Int. Congress on Marine Corrosion and Fouling: Marine Biology*, p.279, Barcelona, Spain

Simpson, E.H. (1949) *Nature*, **163**, 688

Skerman, T.M. (1958) *New Zealand. J. Sci.* **1**, 224

Skerman, T.M. (1959) *New Zealand. J. Sci.* **2**, 57

Smedes, G.W. (1978) *Succession and stability in a marine fouling community*. Ph.D. Dissertation, Univ. of Delware, USA

Smedes, G.W. (1984) in *Marine Biodeterioration : An Interdisciplinary Study* (Costlow, J.D. and Tipper R.C., Eds.) p.155, E and F.N.S. Spon., London, UK

Snedecor, G.W. & Cochran, W.G. (1968) *Statistical Methods*, Indian Edition. Oxford and IBH Publishing Co. Ltd., New Delhi

Strickland, J.H. & Parsons. T.R. (1968) *Fish. Res. Bd. Canada* **167**

Sutherland J.P. (1974) *Amer. Nat.* **108**. 859

Sutherland J.P. & Karlson, R.H. (1977) *Ecol. Monogr.* **47**, 425

Viviyani, CA, & Disalvo, L.H. (1980) in *Proc. 5th Int. Congress on Marine Corrosion and Fouling: Marine Biology*, p.69, Barcelona, Spain