CHAPTER III
ENVIRONMENTAL PARAMETERS

"An estuary is a semienclosed coastal body of water which has a free connection with the open sea and within which seawater is measurably diluted with fresh water derived from the land drainage" (Pritchard, 1967).

Naturally, this complex system is prone to seasonal changes, affecting both the biotic and abiotic factors. Because of this nature, any study in an estuary without the background informations of environmental parameters will remain incomplete (Qasim, 1972). On the contrary, an open sea shore which is not apparently affected by the direct river drainage represents a comparatively stable environment. So, it was thought that, a comparative study of these two environments, with sedentary fouling organisms as experimental species will be of much interest.

The literature survey shows only very little information available on the studies of bioenergetics of barnacles with respect to various hydrographic parameters. The physico-chemical features of the environment have a direct impact on the physiological state of marine organisms. Therefore, the important hydrographic
parameters such as temperature, salinity, total suspended matter, chlorophyll a, phaeopigments, particulate organic carbon (POC) and pH were monitored during the entire period of study from all the three stations.

In an estuary, the major environmental factor that controls the nature of the community is salinity (Anil, 1986; Meenakumari & Nair, 1984). Many workers from different parts of India have reported the impact of monsoon on the fluctuation of salinity (Panikkar and Aiyar, 1939 from Madras; Ganapati et al, 1958 from Visakhapatnam; Meenakumari & Nair, 1984 from Cochin Harbour; Anil, 1986 from Goa waters).

In the aquatic environment temperature is the other important hydrographic parameter, which controls the growth of marine organisms (Sverdrup, et al, 1942; Kinne, 1970). Slight increase or decrease in temperature can influence the marine life through the alterations in growth, metabolism, distribution, reproduction etc. Indirectly it can alter the chemistry of seawater which in turn affect the marine life. Temperature is an important factor for determining the abundance and distribution of organisms in the higher latitude but may not necessarily act as a controlling factor in tropical environment since
the fluctuation of temperature in these waters is marginal (Devassy, 1983). Literature shows large amount of work that has been carried out on the effects of temperature on marine organisms (Southward, 1955, 1958; Patel & Crisp, 1960; Barnes, 1963; Kinne, 1970; Stickle & Bayne, 1982).

The amount of dissolved oxygen in seawater is important as the sole source of oxygen for the marine organisms. The requirement of the same in turn depends on the temperature of the surrounding environment (Sverdrup et al, 1942).

Suspended matter is important as one of the major sources of food for the filter feeding sedentary organisms like foulers. Works on the food value of suspended matter was carried out by many workers throughout the world (Riley, 1970; Qasim & Sankaranarayanan, 1972; Qasim, 1972; Krishnakumari et al, 1978).

POC deserves special mention in this study as it gives the total carbon content of the suspended matter present in the seawater which is available as the source of energy for the filter feeding organisms (Nandakumar et al, 1987). The concentration of POC has been studied by many workers all over the world. Some of them are Menzel

Measurement of the most important plant pigment, Chl a gives an indirect estimation of the primary production at the area studied (Devassy, 1983). This forms the major energy source for the filter feeding organisms especially foulers. Phaeopigments are the degraded products of Chl a present in the seawater. Measurement of this parameter is also important in the calculation of the primary production of a certain locality.

The present study period covered monsoon, postmonsoon and premonsoon seasons, as the observations commenced from April, 1986 and extended up to July, 1987. The data so collected are presented with the help of 16 figures and 8 tables.

MARMAGAO HARBOUR

Salinity (Table 1, Fig. 2):

During the period of study at this station, salinity varied from 12% to 35.68%. During the premonsoon months of 1986, salinity did not show much fluctuation. In the
early period of monsoon season (June, 1986) the salinity was recorded as 32.57%. but the value dropped down to 12.00% in July, 1986. A rise in salinity values was observed in the latter part of monsoon, 1986. During the post monsoon period 1986 (October, 1986 to January, 1987) and premonsoon period 1987 (February, 1987 to May, 1987) more or less uniform salinity was observed. A similar set of values of salinity could be observed during the monsoon season, of 1987 as that of 1986.

**Temperature (Table 2, Fig. 3):**

During the study the temperature at this station ranged between 24.5°C to 32.0°C. During the premonsoon months of 1986, the temperature varied between 30.0°C to 31.4°C and in the monsoon season, it varied from 24.5°C to 28.5°C. More or less uniform temperature was recorded in postmonsoon season but the premonsoon period 1987 showed an increase in temperature. A marked variation could not be recorded during the months of June and July, 1987.

**Dissolved Oxygen (Table 3, Fig. 4):**

During the study period at this station the values for this parameter varied from 1.69 ml/lit. to 5.55
ml/lit. During the premonsoon months 1986, it varied between 4.15 to 5.55 ml/lit and in monsoon, the variation was between 2.99 ml/lit to 4.78 ml/lit. In the postmonsoon period it ranged between 2.37 ml/lit and 4.10 ml/lit and in premonsoon period 1987, it varied between 2.17 to 4.63 ml/lit. The concentration touched the lowest value of 1.69 ml/lit. in the monsoon period and it could be due to the consumption of oxygen by bacteria degrading the enriched organic matter brought in by the fresh water influx.

**pH** (Table 4, Fig. 5):

As opined by Sverdrup *et al.* (1942) under normal circumstances pH will not act as a controlling factor, as far as the marine life is concerned. During the present study the pH at this station varied between 7.55 to 8.04. The values remained uniform during the entire course of study, except in August, September, November, 1986 and February, 1987 where it crossed 8. Variation of pH with season was not specifically evident.

**Total Suspended Matter** (Table 5, Fig. 6):

At this station concentration of suspended matter
varied from 3.3 to 120.4 mg/lit. thereby showing wide fluctuation during the study. However, a seasonal pattern could not be ascertained from the collected data. During April and May, 1986, it varied from 59.87 to 120.4 mg/lit. and during monsoon months from 3.87 to 61.9 mg/lit. Postmonsoon months recorded the values of 3.3 to 71.6 mg/lit. and in premonsoon 1987, 15.3 to 45.2 mg/lit. During the monsoon months of 1987, the variation was negligible ie. from 13.2 to 13.4 mg/lit.

**Particulate Organic Carbon (POC) (Table 6, Fig. 7):**

The POC concentration at this station varied between 386.94 to 6022.86 µgC/lit. It varied from 1310.03 to 1337.48 µgC/lit during the premonsoon months of 1986 and 386.94 to 1744.05 µgC/lit during monsoon 1986. During the postmonsoon, it varied between 1020.64 to 2719.82 µgC/lit and in premonsoon 1987 it varied between 2349.70 to 6022.86 µgC/lit. During the months of June and July, 1987, the concentration varied between 1076.70 to 1693.58 µgC/lit.

**Chlorophyll a (Chl a) (Table 7, Fig. 8):**

The concentration of Chl a varied between 1.47 to
43.55 µg/lit during the study at this station. During April and May, 1986, the concentration varied between 4.05 to 4.85 µg/lit and during monsoon 1986 it varied between 1.47 to 4.08 µg/lit. An increase in concentration was recorded in postmonsoon period (5.61 to 18.95 µg/lit) and the maximum concentration was recorded in premonsoon 1987 (43.55 µg/lit). During the monsoon months of 1987 the concentration varied between 2.21 to 9.43 µg/lit.

Phaeopigments (Table 8, Fig. 9):

In this study, the concentration of phaeopigments varied between 0.34 to 48.9 µg/lit in July, 1986 and February, 1987 respectively. In the rest of the months, except in August, 1986, it ranged between 2.39 to 5.05 µg/lit., whilst, the concentration in August, 1986 was 0.45 µg/lit.

DONA PAULA

Salinity (Table 1, Fig. 2):

Salinity at this station during the study varied between 12.48% to 36.49%. During the premonsoon months of 1986, it varied between 34.05 to 36.49%. and during
monsoon 1986 it varied between 12.48 to 31.42%. The salinity during postmonsoon varied between 31.31 to 34.73%. Almost a similar range of salinity was observed during the rest of the period with an exception during the monsoon months of 1987 when, the values recorded were 12.60% and 20.33% respectively.

**Temperature** (Table 2, Fig. 3):

Temperature was found to be more or less uniform throughout the period of study at this station. It showed the variation between 24.5°C to 32.5°C. The minimum temperature observed was in the month of August, 1986. The maximum temperature recorded was in the month of April, 1987, a premonsoon period. Except this, the temperature was found to be more or less stable throughout the study period.

**Dissolved Oxygen** (Table 3, Fig. 4):

The values of dissolved oxygen varied between 1.74 to 4.25 ml/lit. during the study. The premonsoon months of 1986 recorded a value of 4.01 to 4.10 ml/lit, whereas, during monsoon 1986 it varied between 2.85 to 4.25 ml/lit. More or less uniform values were observed (3.09 to 3.72
ml/lit) during the postmonsoon season and it varied between 1.74 to 3.09 ml/lit during the premonsoon 1987. During the monsoon months of 1987, the values read more or less same as that for premonsoon season of 1987.

**pH** (Table 4, Fig. 5):

The pH of seawater did not show much variation as expected during the entire study period. The minimum value recorded was 7.58 and the maximum 8.02. The effect of season on pH distribution was negligible.

**Total Suspended Matter** (Table 5, Fig. 10):

The concentration of suspended matter at this station varied between 10.33 to 60.00 mg/lit (dry weight). A marginal increase in suspended matter concentration was observed during both the monsoon months. Except this the values remained more or less same during the study.

**Particulate Organic Carbon** (Table 6, Fig. 11):

The concentration of POC varied between 487.89 to
3258.18 µgC/lit. during the period of study. In the premonsoon months of 1986 the values varied between 681.36 to 995.40 µgC/lit. and during monsoon 1986 they varied from 487.89 to 1979.58 µgC/lit. The postmonsoon period showed a variation between 813.14 to 1797.32 µgC/lit and an increase in the POC concentration could be recorded during the premonsoon period 1987 with the values ranging between 1934.72 to 3258.18 µgC/lit. The monsoon months of 1987 showed a concentration of 1357.10 to 2781.52 µgC/lit, which was slightly higher than the values recorded during the months of monsoon 1986.

Chlorophyll a (Table 7, Fig. 12):

As with the Harbour station, at this station too Chl a concentration showed wide fluctuations ranging between 0.70 to 24.5 µg/lit. During the months of April and May, 1986 the values showed a variation of 1.83 to 2.72 µg/lit and the monsoon months recorded the values of 0.7 to 4.06 µg/lit. During the postmonsoon period the Chl a varied between 1.79 and 5.17 µg/lit and in the premonsoon 1987 it ranged between 3.93 to 24.5 µg/lit. The monsoon months of 1987 showed a higher concentration of Chl a than the previous one with the values ranging between 4.09 to 7.82 µg/lit.
Phaeopigments (Table 8, Fig. 13):

The concentration of phaeopigments at this station showed a range of 0.02 to 19.29 μg/lit. With the exception of the high values of phaeopigments for the month of June, 1987 (19.29 μg/lit), they remained below 4.45 μg/lit. (July, 1987). The higher values recorded were only in the monsoon months of 1987.

ARAMBOL

Salinity (Table 1, Fig. 2):

Arambol rocky shore represents an open seashore where the seawater is not directly affected by the river drainage. In contrast to the above two stations, the salinity values were more or less uniform with a little effect of monsoon. Here, during the study period, the salinity ranged between 25.54% to 36.97%. In the months of April and May, 1986 the salinity ranged between 26.80 to 36.97%. and in 1987 monsoon months it ranged between 25.54 to 26.95%.

Temperature (Table 2, Fig. 3):

In contrast to the salinity, the seawater temperature
at this station showed the effect of monsoon. During the entire study span the temperature ranged between 22.5°C and 32.4°C. While in the premonsoon months of 1986 temperature ranged between 31.5°C to 32.4°C, the monsoon period showed a reduced temperature of 22.5°C to 28.5°C. The postmonsoon period showed the temperature range of 27.0°C to 29.6°C and the premonsoon 1987 27.8°C to 31.7°C. Again during the months of monsoon 1987, the temperature dropped down to 24.8°C.

**Dissolved Oxygen** (Table 3, Fig. 4):

The values for dissolved oxygen ranged between 1.93 to 4.78 ml/lit during the entire study period. The concentration remained above 3.04 ml/lit till May, 1987 from the beginning of the study and then it dropped down and ranged between 1.93 to 2.22 ml/lit during the rest of the months.

**pH** (Table 4, Fig. 5):

The pH of seawater during the study period at this station varied between 7.44 to 8.23. The pH remained more or less uniform throughout the study except on two occasions when it crossed the value of 8 which was
recorded in the months of May, 1986 and June, 1987.

**Total Suspended Matter** (Table 5, Fig. 14):

The suspended load in the seawater at this station varied between 14.2 to 181.5 mg/lit during the study. The maximum value was observed in July, 1986 and the minimum in February, 1987. Generally, the content of suspended matter during the monsoon 1986 and '87 showed a slightly higher value than the rest of the period.

**Particulate Organic Carbon** (Table 6, Fig. 15):

The abundance of POC during the study at this station ranged between 956.15 to 4133.0 μgC/lit. Comparatively higher concentrations of POC were observed during the monsoon months of 1986 and 1987. During the rest of the period, the concentrations ranged between 956.15 to 2669.34 μgC/lit.

**Chlorophyll a** (Table 7, Fig. 16):

The Chl a values varied between 1.45 to 13.42 μg/lit during this study. The higher values of Chl a was observed during the earlier half of the study period i.e., from
April, 1986 to November, 1986 than the latter part.

**Phaeopigments** (Table 8, Fig. 17):

The concentration of phaeopigments ranged between 1.06 to 16.34 μg/lit during the study period. A high content of phaeopigments could be traced during both the monsoon seasons, otherwise the concentration remained more or less the same during the study. The maximum value was observed in the month of August, 1986 and the minimum in April, 1986.

Generally, in tropical area salinity acts as the master factor which may decide the nature of the development of animal and plant communities such as fouling community, intertidal organisms etc. At the same time, the temperature is the master factor deciding the nature of community in the temperate areas. This was reported earlier by many workers (Paul, 1942; WHOI, 1952; Daniel, 1954; Sverdrup et al, 1942; Kinne, 1970).

The major fouling barnacle species of these localities are Balanus amphitrite, B. tintinnabulum, B. amaryllis and Chthamalus sp. The wide salinity fluctuations during the south west monsoon may act as major stress on
these organisms, which in turn will have to spend more energy to overcome this impact. The wide fluctuation of various hydrographic parameters during the monsoon may even result in the death of these organisms. This was well illustrated by the mass mortality of barnacles that occurred during the monsoon seasons. During the present study at Arambol, mortality of > 50% (in 1986 monsoon) and > 95% (in 1987 monsoon months) of B. tintinnabulum was recorded. At the Harbour station the mortality rate of B. amphitrite during the monsoon period was > 80%. Similar rate of mortality (80 - 85%) in the case of B. amphitrite was reported earlier from the Harbour station by Anil (1986). Effect of salinity on barnalces and their larvae has been worked out for different species of barnacles by Bhatnagar & Crisp (1965); Barnes & Barnes (1974); Cawthrone & Davenport (1980).

The effect of temperature on the development of barnacle larvae has been studied by various workers (Southward, 1964; Crisp & Ritz, 1967; Ritz & Foster, 1968; Cawthrone & Davenport, 1980; Harms, 1984, 1986). The range of temperatures in the present environment is not large enough to act as a controlling factor. Nevertheless, the reason for the high mortality occurred at Arambol station may be the combined effects of low
temperature and salinity and high turbidity (high content of suspended matter).

The dissolved oxygen at these stations, except during the monsoon period was uniform. The low values for dissolved oxygen in the water can make the organism anoxic and hence it may undergo heavy stress resulting in the increased expenditure of energy for survival (WHOI, 1952). Indirectly, it is likely to affect the rate of respiration, growth, reproduction, survival etc. In the experiment conducted by Achituv et al (1980), on nauplii stage I and II of B. balanoides, it was revealed that under anoxic conditions, the nauplii stage I could only survive 4 hrs. and within that time they became inactive. There was a lot of difference in the biochemical constituents of anoxic and oxic nauplii stage I (Achituv et al, 1980).

In the present study, the chlorophyll a content was important so as to assess the rate of primary production which acts as the elementary source of energy available for the marine ecosystem. It can be mainly in the form of unicellular algae, diatoms and bacteria. These organisms constitute the major food for the filter feeding organisms like sedentary fouling barnacles. As reported by Devassy
(1983) the primary production of Goa waters is $20.430 \text{ mgC/m}^2$. The measurements of phaeopigments are also important in the primary production calculation, since they form the degraded product of chlorophyll $a$. The reason for the unusually high concentrations of Chl $a$ and phaeopigments in the months of February & March, 1987 could be due to the phytoplankton bloom that occurred in the Zuari estuary mouth during that particular period (February & March, 1987).

The quantity of suspended matter was the other important factor in this study, since, it contributes a major share of food for the filter feeding organisms including barnacles. The composition of suspended matter include the detrital organic residues bacteria, parts of diatom cells, algae, larvae of various organisms etc. (Qasim 1972). The particulate organic carbon estimation gives the energy potential of the suspended matter. So, the data on suspended matter supported by the POC content could give a fairly clear picture of the food value of this detrital material in seawater.

In light of these considerations data on physico-chemical parameters have been collected so that the dynamics of energy transfer could be properly understood and explained.
Table 1

Monthly variations in Salinity (ppt) at three stations during the study period.

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Table 2

Monthly variations in temperature (°C) at three stations during the study period.

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Table 3

Monthly variations in Dissolved oxygen (ml/l) at three stations during the study period.

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<td>7.79</td>
<td>7.84</td>
</tr>
<tr>
<td>Jan'87</td>
<td>7.90</td>
<td>7.92</td>
<td>7.97</td>
</tr>
<tr>
<td>Feb</td>
<td>8.02</td>
<td>7.81</td>
<td>7.96</td>
</tr>
<tr>
<td>Mar</td>
<td>7.55</td>
<td>7.58</td>
<td>7.73</td>
</tr>
<tr>
<td>Apr</td>
<td>7.56</td>
<td>7.84</td>
<td>7.44</td>
</tr>
<tr>
<td>May</td>
<td>7.80</td>
<td>7.85</td>
<td>7.89</td>
</tr>
<tr>
<td>Jun</td>
<td>7.73</td>
<td>7.78</td>
<td>8.23</td>
</tr>
<tr>
<td>Jul</td>
<td>7.64</td>
<td>7.77</td>
<td>7.56</td>
</tr>
</tbody>
</table>
### Table 5

Monthly variations in suspended matter (mg/l) at three stations during the study period

<table>
<thead>
<tr>
<th>Month</th>
<th>Harbour</th>
<th>Dona Paula</th>
<th>Arambol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apr'86</td>
<td>59.87±1.2</td>
<td>12.81±0.0</td>
<td>-</td>
</tr>
<tr>
<td>May</td>
<td>120.40±00</td>
<td>10.33±2.2</td>
<td>35.80±7.4</td>
</tr>
<tr>
<td>Jun</td>
<td>3.87±0.00</td>
<td>46.00±0.0</td>
<td>59.60±0.0</td>
</tr>
<tr>
<td>Jul</td>
<td>42.10±0.5</td>
<td>60.00±0.0</td>
<td>181.50±00</td>
</tr>
<tr>
<td>Aug</td>
<td>61.9±47.3</td>
<td>16.70±1.3</td>
<td>46.10±5.3</td>
</tr>
<tr>
<td>Sep</td>
<td>16.30±3.3</td>
<td>18.37±0.0</td>
<td>18.50±3.3</td>
</tr>
<tr>
<td>Oct</td>
<td>71.600±39</td>
<td>17.50±3.5</td>
<td>38.60±1.4</td>
</tr>
<tr>
<td>Nov</td>
<td>25.50±1.3</td>
<td>19.30±0.7</td>
<td>37.40±0.0</td>
</tr>
<tr>
<td>Dec</td>
<td>-</td>
<td>14.20±0.6</td>
<td>42.6±10.6</td>
</tr>
<tr>
<td>Jan'87</td>
<td>3.30±1.30</td>
<td>26.10±6.7</td>
<td>25.70±4.1</td>
</tr>
<tr>
<td>Feb</td>
<td>45.20±0.2</td>
<td>27.63±0.0</td>
<td>14.20±0.0</td>
</tr>
<tr>
<td>Mar</td>
<td>19.20±3.2</td>
<td>16.50±0.1</td>
<td>20.00±0.8</td>
</tr>
<tr>
<td>Apr</td>
<td>15.30±0.5</td>
<td>18.90±0.5</td>
<td>22.70±0.7</td>
</tr>
<tr>
<td>May</td>
<td>21.20±0.0</td>
<td>28.32±0.0</td>
<td>24.30±0.5</td>
</tr>
<tr>
<td>Jun</td>
<td>13.20±0.4</td>
<td>26.00±1.6</td>
<td>80.1±18.1</td>
</tr>
<tr>
<td>Jul</td>
<td>13.40±0.8</td>
<td>13.50±0.5</td>
<td>21.30±0.3</td>
</tr>
</tbody>
</table>
Table 6

Monthly variations in POC (µgC/l) at three stations during the study period. Values in parenthesis represent standard deviation for the duplicate analysis

<table>
<thead>
<tr>
<th>Month</th>
<th>Harbour</th>
<th>Dona Paula</th>
<th>Arambol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apr '86</td>
<td>1337.48 (+0)</td>
<td>995.40 (+218.71)</td>
<td>956.15 (+2.81)</td>
</tr>
<tr>
<td>May</td>
<td>1310.03 (+89.73)</td>
<td>681.36 (+16.83)</td>
<td>2303.23 (+149.81)</td>
</tr>
<tr>
<td>Jun</td>
<td>1149.67 (+280.43)</td>
<td>992.60 (+229.92)</td>
<td>3715.23 (+448.63)</td>
</tr>
<tr>
<td>Jul</td>
<td>433.68 (+7.48)</td>
<td>1979.58 (+61.70)</td>
<td>4133.00 (+263.56)</td>
</tr>
<tr>
<td>Aug</td>
<td>386.94 (+24.30)</td>
<td>487.89 (+151.41)</td>
<td>1758.08 (+356.10)</td>
</tr>
<tr>
<td>Sep</td>
<td>1744.05 (+128.99)</td>
<td>1968.37 (+16.83)</td>
<td>1993.60 (+316.84)</td>
</tr>
<tr>
<td>Oct</td>
<td>2719.82 (+179.46)</td>
<td>1390.76 (+11.22)</td>
<td>1668.34 (+58.88)</td>
</tr>
<tr>
<td>Nov</td>
<td>1626.29 (+123.37)</td>
<td>1160.83 (+151.41)</td>
<td>1558.74 (+11.46)</td>
</tr>
<tr>
<td>Dec</td>
<td>-</td>
<td>813.14 (+56.08)</td>
<td>1623.48 (+126.18)</td>
</tr>
<tr>
<td>Jan '87</td>
<td>1020.64 (+185.06)</td>
<td>1797.32 (+14.02)</td>
<td>1766.96 (+236.00)</td>
</tr>
<tr>
<td>Feb</td>
<td>6022.86 (+639.30)</td>
<td>2529.14 (+207.50)</td>
<td>2669.34 (+213.10)</td>
</tr>
<tr>
<td>Mar</td>
<td>2820.76 (+207.48)</td>
<td>3258.18 (+858.02)</td>
<td>1643.10 (+185.06)</td>
</tr>
<tr>
<td>Apr</td>
<td>3073.12 (+919.68)</td>
<td>2125.38 (+151.42)</td>
<td>2456.26 (+67.30)</td>
</tr>
<tr>
<td>May</td>
<td>2349.70 (+128.98)</td>
<td>1934.72 (+61.68)</td>
<td>2383.36 (+5.60)</td>
</tr>
<tr>
<td>Jun</td>
<td>1693.58 (+157.02)</td>
<td>2781.52 (+201.88)</td>
<td>2063.70 (+179.46)</td>
</tr>
<tr>
<td>Jul</td>
<td>1076.70 (+302.82)</td>
<td>1357.10 (+11.22)</td>
<td>2137.14 (+127.50)</td>
</tr>
</tbody>
</table>
Table 7

Monthly variations in Chl.a (μg/l) at three stations during the study period

<table>
<thead>
<tr>
<th>Month</th>
<th>Harbour</th>
<th>Dona Paula</th>
<th>Arambol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apr'86</td>
<td>4.05±0.07</td>
<td>1.83±0.16</td>
<td>1.83±0.09</td>
</tr>
<tr>
<td>May</td>
<td>4.85±0.54</td>
<td>2.72±0.12</td>
<td>8.35±0.60</td>
</tr>
<tr>
<td>Jun</td>
<td>1.66±0.10</td>
<td>1.73±0.17</td>
<td>5.82±0.40</td>
</tr>
<tr>
<td>Jul</td>
<td>1.47±0.11</td>
<td>4.06±0.00</td>
<td>8.06±1.13</td>
</tr>
<tr>
<td>Aug</td>
<td>1.68±0.23</td>
<td>0.70±0.00</td>
<td>13.42±.33</td>
</tr>
<tr>
<td>Sep</td>
<td>4.08±0.16</td>
<td>2.96±0.08</td>
<td>2.07±0.06</td>
</tr>
<tr>
<td>Oct</td>
<td>18.95±3.27</td>
<td>5.17±0.07</td>
<td>7.29±0.65</td>
</tr>
<tr>
<td>Nov</td>
<td>13.93±2.68</td>
<td>3.45±0.92</td>
<td>6.80±0.00</td>
</tr>
<tr>
<td>Dec</td>
<td>-</td>
<td>1.79±0.03</td>
<td>3.23±0.10</td>
</tr>
<tr>
<td>Jan'87</td>
<td>5.61±0.23</td>
<td>2.89±0.16</td>
<td>2.03±0.91</td>
</tr>
<tr>
<td>Feb</td>
<td>43.55±7.32</td>
<td>24.50±4.60</td>
<td>2.56±0.21</td>
</tr>
<tr>
<td>Mar</td>
<td>15.76±1.20</td>
<td>12.91±0.75</td>
<td>2.15±0.01</td>
</tr>
<tr>
<td>Apr</td>
<td>11.87±1.30</td>
<td>15.88±0.62</td>
<td>4.50±0.81</td>
</tr>
<tr>
<td>May</td>
<td>4.82±0.35</td>
<td>3.93±0.13</td>
<td>1.63±0.28</td>
</tr>
<tr>
<td>Jun</td>
<td>9.43±0.00</td>
<td>7.82±0.88</td>
<td>3.32±1.34</td>
</tr>
<tr>
<td>Jul</td>
<td>2.21±0.43</td>
<td>4.09±0.00</td>
<td>1.45±0.47</td>
</tr>
</tbody>
</table>
Table 8

Monthly variations in Phaeopigments (µg/l) at three stations during the study period

<table>
<thead>
<tr>
<th>Month</th>
<th>Harbour</th>
<th>Dona Paula</th>
<th>Arambol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apr '86</td>
<td>-</td>
<td>1.10±0.26</td>
<td>1.09±0.26</td>
</tr>
<tr>
<td>May</td>
<td>2.80±0.11</td>
<td>0.82±0.10</td>
<td>4.15±1.01</td>
</tr>
<tr>
<td>Jun</td>
<td>3.12±0.00</td>
<td>1.11±0.12</td>
<td>6.31±0.79</td>
</tr>
<tr>
<td>Jul</td>
<td>0.34±0.00</td>
<td>0.02±0.00</td>
<td>6.33±0.36</td>
</tr>
<tr>
<td>Aug</td>
<td>0.45±0.00</td>
<td>1.67±0.22</td>
<td>16.34±3.96</td>
</tr>
<tr>
<td>Sep</td>
<td>2.81±0.34</td>
<td>0.02±0.00</td>
<td>1.06±0.28</td>
</tr>
<tr>
<td>Oct</td>
<td>5.05±2.28</td>
<td>0.13±0.00</td>
<td>7.21±0.74</td>
</tr>
<tr>
<td>Nov</td>
<td>2.28±0.04</td>
<td>1.33±0.29</td>
<td>7.28±0.20</td>
</tr>
<tr>
<td>Dec</td>
<td>-</td>
<td>2.48±0.00</td>
<td>5.48±1.81</td>
</tr>
<tr>
<td>Jan '87</td>
<td>3.02±0.00</td>
<td>2.98±0.38</td>
<td>4.63±1.11</td>
</tr>
<tr>
<td>Feb</td>
<td>48.9±2.06</td>
<td>3.69±0.87</td>
<td>2.74±0.18</td>
</tr>
<tr>
<td>Mar</td>
<td>2.76±1.09</td>
<td>2.87±2.58</td>
<td>3.32±0.28</td>
</tr>
<tr>
<td>Apr</td>
<td>3.01±0.00</td>
<td>3.14±1.09</td>
<td>6.81±1.62</td>
</tr>
<tr>
<td>May</td>
<td>3.02±0.26</td>
<td>3.56±0.00</td>
<td>3.51±0.18</td>
</tr>
<tr>
<td>Jun</td>
<td>2.41±0.55</td>
<td>19.29±0.46</td>
<td>13.50±6.74</td>
</tr>
<tr>
<td>Jul</td>
<td>2.39±0.02</td>
<td>4.45±0.03</td>
<td>4.43±0.42</td>
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</tbody>
</table>
Fig. 2. Monthly variations of Salinity values at three study stations.
Fig. 3. Monthly variations of Temperature values at three study stations
Fig. 4. Monthly variations of Dissolved oxygen concentration at three study stations
Fig. 5. Monthly variations of pH values at three study stations
Fig. 6. Monthly variations of suspended matter concentration at Harbour.
Fig. 7. Monthly variations of POC at Harbour.
Fig. 8. Monthly variations of Chl-a concentration at Harbour.
Fig. 9. Monthly variations of Phaeopigment concentration at Harbour.
Fig. 10. Monthly variations of suspended matter concentration at Dona Paula.

Bar lines indicate S.D.
Fig. II. Monthly variations of POC concentration at Dona Paula.

Bar lines indicate S.D.
Fig. 12. Monthly variations of Chl-a concentration at Dona Paula.
Fig. 13. Monthly variations of Phaeopigment concentration at Dona Paula.
Fig. 14. Monthly variations of suspended matter concentration at Arambol.
Fig. 15. Monthly variations of POC concentration at Arambol.
Fig. 16 Monthly variations of Chl-a concentration at Arambol.
Fig. 17. Monthly variations of Phaeopigment concentration at Arambol.

Bar lines indicate S. D.