

3. FLORA AND FAUNA

3.1 Bacteria

Data of bacterial population in water and sediment are available for some segments along the Gulf. Population counts are enumerated through plate as well as Membrane filter and the following assessment is based only on the former. Total Viable Counts (TVC) and Total Coliforms (TC) are important in making comparisons between zones as the former indicates the fertility while the latter the health of the water. *Escherichia coli* like organisms count on M-Fc media for coliforms (M-Fc ECLO) and *Streptococcus faecalis* like organisms (SFLO) are indicators of unhealthy water quality. Among the pathogens *Salmonella* like organisms (SLO) and *Vibrio cholerae* like organisms (VCLO) are important in evaluating possible level of contamination. Occurrence of any potential pathogen at a concentration of 3 or more cells per ml implies risk to human health. At such concentrations their chances of associations with plankton and fish are high. These associations are conducive to their rapid multiplication and longer survival in the marine environment. The bacterial load / density in water and sediment are expressed as counts/ml and no./10²g dry wt respectively.

Okha: It is evident from Table 3.1.1 that TVC varied between 9.0-6.3 x 10³ with an average value of 1.6 x 10³/ml. Variation in TC is at a low rate of ND-61 with an average value of 12.5/ml. Counts of M-Fc ECLO and SFLO are generally low. Harmful pathogens like SLO and VCLO also are either nondetectable or at very low levels except during the high values observed in February 1996. In sediment the TVC count (1.4 x 10² –1.68 x 10³, with an average value of 1026.7 x 10²/g dry wt. and TC 0-50.1, with an average value of 7.3 x 10²/g dry wt. show high levels as compared to water as expected because the organic detritus that settles on the bed favours proliferation of microorganisms. Faecal coliforms and pathogens are also at very low level.

The levels of various bacterial counts in water and sediment are of the order expected for coastal waters, under moderate human influence.

Vadinar: TVC in water ranged from 17-1100 with an average value of 160/ml while TC fluctuated between ND-59 with an average value of 14/ml (Table 3.1.2) suggesting normal values. Faecal coliforms and pathogens are either absent or present in fairly high numbers. TVC and TC in sediment vary respectively from 260-3600 with an average value of 1521 x 10²/g dry wt and ND - 180 with an average value of 33 x 10²/g dry wt. Like the observed value in water, sediment also shows fairly higher counts of harmful pathogens. The study indicates the influence of contaminants off Vadinar

Sikka: TVC and TC in water show a variation of 49-500 with an average value of 278/ml and ND-39 with an average value of 22/ml (Table 3.1.3). ECLO, SFLO and VCLO are in fairly high number. In sediment TVC values 130-2820, with an average value of 1030 x 10²/g are high, TC level varies from ND to 0.4 with an average value of 0.2 x 10²/g. Pathogens and coliforms except ECLO are in relatively higher numbers indicating the presence of contaminants.

Bedi: In water population of TVC 27-600, with an average value of 160/ml and TC ND-121 with an average value of 17/ml are comparable to that observed in a marine environment (Table 3.1.4). In sediment TVC and TC ranges are respectively 530-3500 with an average value of 1748 x 10²/g dry wt and ND-7.3 with an average value of 5.2 x 10²/g dry wt. ECLO and SFLO show normal levels while pathogens like VCLO often indicates high levels suggesting possible low level contamination.

Kandla: It is seen from Table 3.1.5 that TVC with an average value of $14.1 \times 10^3/\text{ml}$ and TC with an average value of 44/ml are fairly high. Population of SFLO, SLO and VCLO are often high. In sediment the TVC values with an average value of $126.4 \times 10^2/\text{g}$ are lower than to that of water. Also, the sediment associated pathogen like bacteria are restricted to a few types. At these concentration the chances of pathogenic bacterial contamination of seafood is low though their presence suggests possible low level contamination by sewage.

Luni: Population TVC varies from 62-500 (av. 194)/ml while TC fluctuated between ND-12 with an average value of 7/ml (Table 3.1.6). TVC in sediment 1620-4790, with an average value of $3170 \times 10^2/\text{g}$ is much higher than that in water while enhancement of population of TC 2.9-5.1, with an average value of $7.1 \times 10^2/\text{g}$ in sediment is at a lesser extent. Faecal coliforms and pathogens like VCLO in water and sediment are moderately high indicating low-level contamination.

Mundra: It is clear from Table 3.1.7 that TVC with an average value of $7.2 \times 10^3/\text{ml}$ and TC with an average value of $3.3 \times 10^2/\text{ml}$ are high in the water. Populations of TC, SHLO, PKLO, VPLO and VLO are common in the area while ECLO, SLO, PALO and SFLO are absent or present in very low numbers and hence restricted in their distribution. At these concentrations, the chances of pathogenic bacterial contamination of seafood is low though their presence suggests possible low to moderate level contamination by sewage and other organic wastes.

TVC in sediment are higher only by an order of magnitude as compared with populations in water perhaps because of low organic matter in sediment. TVC and TC in sediment ranged from 50 to $4800 \times 10^2/\text{g}$ with an average value of $2560 \times 10^2/\text{g}$ dry wt and $2-1500 \times 10^2$ with an average value of $39.4 \times 10^2/\text{g}$ dry wt. The sediment-associated populations of pathogen like bacteria are however consistently high as normally observed for coastal areas.

3.2 Phytoplankton

Okha: Extensive data for phytoplankton of this segment are available covering a period of 1981 to 1999 (Table 3.2.1). However, rate of primary production is available only for 1989 with an average value of $11 \text{ mg C}/\text{m}^3/\text{h}$ and 1997 with an average value of $3.1 \text{ mg C}/\text{m}^3/\text{h}$ indicating 3.5 fold decrease in production.

Chlorophyll *a* varies from 0.1 to 19.1 with an average value of $1.6 \text{ mg}/\text{m}^3$ at surface and 0.5 to 5.3 with an average value of $1.4 \text{ mg}/\text{m}^3$ in the bottom suggesting low production potential of the area. Over the years there is only marginal variation in pigment values. Phaeophyton values are relatively lower than chlorophyll *a* at the surface 0.1 to 15.8, with an average value of $0.8 \text{ mg}/\text{m}^3$ as well as bottom 0.1 to 6.8, with an average value of $0.8 \text{ mg}/\text{m}^3$.

Cell count shows higher numbers at the bottom with an average value of $714 \times 10^3/\text{l}$ than surface with an average value of $595 \times 10^3/\text{l}$. Total number of genera represented in the area varies from 3-22 with an average value of 10 in the surface and 3-17 with an average value of 9 at the bottom. A total of 40 genera are recorded from Okha and surrounding area (Table 3.2.2). The most common genera represented in the Okha are *Nitzschia*, *Skeletonema*, *Thalassiothrix*, *Coscinodiscus*, *Gyrosigma*, *Chaetoceros*, *Peridinium*, *Synedra* and *Navicula*.

Salaya: There is a single series of observation made during March 1985 for this area and the variation in pigment along with average in parenthesis are given below.

Phytoplankton pigments	Level	March 1985
Chlorophyll <i>a</i> (mg/m ³)	S	0.5-3.2 (1.6)
	B	0.5-2.7 (1.2)
Phaeophytin (mg/m ³)	S	0.1-2.9 (0.9)
	B	0.1-2.4 (0.9)

Levels of chlorophyll-*a* indicate the low level of primary productivity. The relative concentrations of phytoplankton pigments suggest a delicate balance between growth and mortality.

Vadinar: Data available for this region is spread over from 1994 to 2000 (Table 3.2.3). Chlorophyll *a* varies between 0.5 – 2.7 with an average value of 0.9 mg/m³ at the surface and 0.5-2.7 with an average value of 0.8 mg/m³ at the bottom. The corresponding values for phaeophytin are 0.1 – 3.8 with an average value of 0.6 mg/m³ and 0.1 – 2.8 with an average value of 0.7 mg/m³ respectively. There is marginal variation between years with relatively higher levels during January 2000. Cell count is moderately high with higher values for bottom with an average value of 43.6 x 10³/l as compared to surface with an average value of 39.5 x 10³/l. However total number of genera represented shows a reverse trend with respective average values of 13 and 9 for the surface and bottom. Though generic diversity is high in April 1994 (37) during the remaining period values are comparable. 43 genera are represented off Vadinar (Table 3.2.2). The most common genera are *Asterionella*, *Bacillaria*, *Nitzschia*, *Navicula*, *Skeletonema*, *Rhizosolenia* and *Thalassiosira*.

Sikka: Chlorophyll-*a* values indicate variations between 1985 and 2000 with relatively higher levels for October 1989 and November – December 1993 (Table 3.2.4). However, overall variation for surface (0.5– 6.4, av. 1.4 mg/m³) and bottom (0.5-2.7, av. 1.2 mg/m³) shows only low productivity at primary level. Phaeophytin values are also low, the respective average concentration for surface and bottom being 0.8 and 0.6 mg/m³. Cell count is quite high in the surface (4-1702, av. 96.4 x 10³/l) as compared to bottom (8.5-190.9, av. 47.0 x 10³/l). The total genera recorded indicate fluctuations over the years with maximum diversity in 1994. However, overall average for surface (10) and bottom (9) shows comparable values. A total of 38 genera are recorded at Sikka (Table 3.2.2). The most common genera are *Biddulphia*, *Chaetoceros*, *Skeletonema*, *Rhizosolenia* and *Thalassiosira*.

Bedi: There are only two sets of observations covering premonsoon and postmonsoon periods of 1997 for Bedi (Table 3.2.5). Primary productivity during 1977 is relatively higher during premonsoon period with an average value of 42.3 mgC/m³/h as compared to postmonsoon period with an average value of 27.2 mgC/m³/h. Seasonal difference in pigment values is not discernible. Chlorophyll *a* in the surface with an average value of 1.6 mg/m³ and bottom with an average value of 1.4 mg/m³ show moderate production. Average concentration of phaeophytin for surface and bottom are 1.5 and 1.4 mg/m³ respectively. Cell count ranged from 16-440 with an average value of 101 x 10³/l for surface and 14-936 with an average value of 135 x 10³/l for bottom. Generic diversity is more for the premonsoon as compared to the postmonsoon season. 32 genera have been identified off Bedi. The most common species in the area are *Nitzschia*, *Navicula*, *Skeletonema* and *Pleurosigma*.

Navlakhi: Variation in chlorophyll *a* is from 0.3 – 4.6 with an average value of 1.4 mg/m³ at the surface while at the bottom the range is from 0.1-2.1 (1.0) mg/m³. Seasonal variation of chlorophyll *a* during 1986 shows maximum concentration during postmonsoon period (November 1986) as compared to monsoon (August 1986) and premonsoon (February 1987) periods (Table 3.2.6). Phaeophytin values are generally lower than chlorophyll *a* values and the average concentration for surface and bottom are respectively 0.8 and 1.2 mg/m³. Cell

count is moderate at the surface with an average value of $14.6 \times 10^3/l$ as well as bottom with an average value of $17.4 \times 10^3/l$. Total number of genera in the area is 17 with predominance of *Amphiprora*, *Biddulphia* and *Coscinodiscus*.

Kandla: Information on phytoplankton of Kandla is for the period 1985 to 1998 (Table 3.2.7). Levels of chlorophyll *a* for surface and bottom are respectively 0.5-4.3 with an average value of 1.5 mg/m^3 and 0.5-4.3 with an average value of 1.4 mg/m^3 . Though values for 1985 are low the concentration increased from 1986 onwards with maximum value in October 1996 with an average value of 2.6 mg/m^3 . Phaeophytin levels are lower than chlorophyll *a* with an average of 1.1 mg/m^3 for surface as well as bottom. Cell count on an average was $40.1 \times 10^3/l$ for surface and $30.2 \times 10^3/l$ for bottom. Generic diversity does not indicate variation between years. 27 genera are recorded from the area. The predominant genera in the area are *Coscinodiscus*, *Thalassiosira*, *Thalassiothrix* and *Nitzschia*.

Luni: Data from a single set of observation is available and the details are given below.

Parameters	Level	March 1997
Chlorophyll <i>a</i> (mg/m^3)	S	0.3-2.7 (1.0)
	B	0.5-1.6 (0.9)
Phaeophytin (mg/m^3)	S	0.1-1.0 (0.5)
	B	0.1-3.6 (0.5)
Cell count (no. $\times 10^3/l$)	S	62.4-262.0 (181.9)
	B	120.5-293.0 (223.6)
Total genera (no.)	S	7-18 (12)
	B	13-16 (14)
Major genera	S	<i>Thalassionema</i> , <i>Rhizosolenia</i> , <i>Nitzschia</i> , <i>Skeletonema</i> , <i>Fragilaria</i> , <i>Gyrosigma</i> , <i>Chaetoceros</i>
	B	<i>Rhizosolenia</i> , <i>Nitzschia</i> , <i>Skeletonema</i> , <i>Thalassiosira</i> , <i>Chaetoceros</i> , <i>Gyrosigma</i>

Levels of chlorophyll *a* and phaeophytin are low in the surface as well as bottom. Cell count is high in the surface with an average value of $181.9 \times 10^3/l$ as well as bottom ($223.6 \times 10^3/l$). Number of genera in the samples vary from 7-18 with an average value of 13. The common genera are *Thalassiosira*, *Rhizosolenia* and *Nitzschia*.

Mundra: Though observations off Mundra have been done recently (1997-2000), the available data are extensive to make an evaluation. Chlorophyll *a* levels are high compared to southern segments of the Gulf. Variation for surface and bottom are respectively 0.5– 16.6 with an average value of 2.3 mg/m^3 and 0.5– 5.9 with an average value of 1.8 mg/m^3 (Table 3.2.8). Seasonally the monsoon period with an average value of 3.3 mg/m^3 shows higher levels of chlorophyll *a* than the other two seasons with an average value of 1.3-1.4 mg/m^3 . Concentration of phaeophytin is invariably low recording average values of 1.0 mg/m^3 for surface as well as bottom. Cell count fluctuates widely with respective average of 123 and $101 \times 10^3/l$ for surface and bottom. Cell count is maximum during September 1999 followed by March 1997. Generic diversity does not show much variation except for the relatively low values in July – August 1998. 22 genera are observed in the area. The most common genera are *Thalassiosira*, *Nitzschia*, *Fragilaria*, *Skeletonema*, *Melosira* and *Navicula*.

Jakhau: Only one series of observations are made off Jakhau. Details of information are given below.

Parameters	Level	November 1995
Chlorophyll <i>a</i> (mg/m ³)	S	0.5-1.6 (0.9)
	B	0.5-1.6 (1.1)
Phaeophytin (mg/m ³)	S	0.4-2.3 (1.3)
	B	0.4-2.7 (1.0)
Cell count (no.X 10 ³ /l)	S	67-519 (173)
	B	138-194 (169)
Total genera (no.)	S	13-20 (17)
	B	14-21 (18)
Major genera	S	<i>Guinardia</i> , <i>Nitzschia</i> , <i>Chaetoceros</i> , <i>Navicula</i> , <i>Skeletonema</i>
	B	<i>Guinardia</i> , <i>Nitzschia</i> , <i>Navicula</i> , <i>Chaetoceros</i>

Variations in chlorophyll *a* at the surface and bottom are comparable. Phaeophytin levels are marginally higher as compared to chlorophyll *a*. Cell count is moderate. Generic diversity in the area is high (13-21, av. 17). The dominant genera are *Guinardia* and *Nitzschia*.

Kharo creek: Continuous observations of the creek are made from December 1994 to May 1995 (Table 3.2.9). Chlorophyll *a* on an average records 2.1 mg/m³ at the surface as well as bottom. From January 1995 to April 1995 an increasing trend is observed with maximum value with an average value of 5.3 mg/m³ in April. Cell count is unusually low compared to the values of chlorophyll *a*. 18 genera are recorded from the area (Table 3.2.2.). The most common species were *Amphora*, *Chaetoceros*, *Bacillaria*, *Navicula* and *Biddulphia*.

Kori creek: Variation in chlorophyll *a* in the surface and bottom are respectively 0.5 – 6.9 with an average value of 2.3 mg/m³ and 0.5 – 7.5 with an average value of 2.4 mg/m³ (Table 3.2.10). Chlorophyll *a* is maximum during October 1998 (Table 3.2.10). Phaeophytin values are lower than chlorophyll *a* with respective averages of 1.3 and 1.6 mg/m³ for surface and bottom. Cell count is relatively low as compared to the chlorophyll *a* values. Average cell count for surface and bottom are respectively 59.1 and 32.3 x 10³/l. A total of 28 genera are recorded from the Kori creek. The common genera in the area are *Thalassiosira*, *Synedra*, *Nitzschia*, *Skeletonema*, *Rhizosolenia*, and *Anabaena*.

3.3. Zooplankton

3.3.1. Standing stock and composition

Okha: Zooplankton standing stock in terms of biomass varies from 0.02 to 40.4 with an average value of 3.4 ml/100 m³ during 1981 to 1999 (Table 3.3.1) indicating the low productivity off Okha. Biomass shows a fluctuating trend with the values lowering during 1991 to 1995 and again rising during 1997 to 1999. Seasonal variation of biomass is not well defined. Zooplankton population ranges between 0.02 and 7120 (av.209.3) x 10³/100 m³ without showing any pattern of distribution. Total groups represented in the collection range from 3 to 19 (av. 10). Total zooplankton groups represented in the area are 230 (Table 3.3.2). The most common groups identified from the area are copepods, decapods, chaetognaths and foraminifera.

Salaya: For this segment there is only a single observation and details are given below.

Parameters	March 1985
Biomass (ml/100m ³)	1.9-76.3 (28.8)
Population (no.X10 ³ /100m ³)	3.7-150.6 (62.9)

Total groups (no.)	9-14 (12)
Major groups	Copepods, Gastropods, Decapods, Ostracods, Chaetognaths, Siphonophores, Medusae, Fish Eggs and larvae

Zooplankton biomass and population are fairly high in the area. Group diversity is high and a total of 16 groups are represented in this area. The most common groups in the area are copepods, gastropods, decapods and ostaracods.

Vadinar: Variation in zooplankton biomass and population do not indicate a consistent pattern (Table 3.3.3). The respective variation in biomass and population are respectively 0.1 – 50.8 (av. 4.9) ml/100 m³ and 0.3 – 730.5 (av. 24.9) x 10³/100 m³. Standing stock of zooplankton is relatively high during 1994 which decreased subsequently in 1995 & 1996 and later enhanced values are observed. November appears to be the most productive month. Total number of groups in the collection vary from 5-19 (av. 12). 21 groups of zooplankton are recorded from the area with the predominance of copepods, decapods, siphonophores, chaetognaths and medusae.

Sikka: There is fairly extensive data for Sikka covering 1985 to 2000. Range in biomass and population are 0.1 – 97.3 (av. 11.2) ml/100 m³ and 0.3– 140.0 (av. 34.2) x 10³/ 100 m³ respectively (Table 3.3.4). Though secondary production potential was high in 1985 it has reduced considerably over the years from an average value of 26.6 ml/100 m³ in 1985 to 2.1 ml/100 m³ in 2000. Population also shows a similar trend except during 1997. Range in group diversity is from 5-19 (av. 12). Off Sikka a total of 23 groups are represented. The common groups in the area are copepods, decapods, siphonophores, medusae and gastropods.

Bedi: Zooplankton standing stock varies widely from 0.5 to 112.9 (av. 8.7) ml/100 m³ suggesting moderate production. Seasonally postmonsoon period has relatively higher biomass as compared to the premonsoon period (Table 3.3.5). The pattern of distribution of zooplankton population is comparable to that of biomass. Number of groups represented during both the seasons is comparable. Total number of groups found in the area is 20 with predominance of copepods, decapods, siphonophores, medusae and gastropods.

Navlakhi: Biomass and population fluctuate respectively between 1.8 and 95.0 (av. 22.1) ml/100 m³ and 0.3 and 96.0 (av. 15.3) x 10³/100m³. Standing stock of zooplankton biomass is high while population shows only fairly rich potential. Seasonal variation during 1986-87 shows that maximum production is during premonsoon as compared to monsoon and postmonsoon seasons (Table 3.3.6). However, population density was maximum in August 1986. Group diversity does not show variation between years and the average value is 11. 18 groups are reported from the area and the common groups are copepods, decapods, foraminiferans and siphonophores.

Kandla: Data available for the area are for 1985 to 1998 (Table 3.3.7). The area has high zooplankton standing stock (0.5-163.7, av. 26.2 ml/100m³) and fairly high population density (1.2-217.6, av. 33.5 x 10³/100 m³). However, there is decrease in production during 1996 and 1998 which is more evident for biomass. Seasonal variation during 1986-87 indicates maximum standing stock in terms of biomass and population during the premonsoon period (February 1987). Range and average values for groups show consistent values. 19 groups are present off Kandla. The common groups found at this segment are copepods, chaetognaths and decapods.

Luni: A single observation is made during 1997 for the area and the details are given below.

Parameters	March 1997
Biomass (ml/100m ³)	0.4-72.7 (14.8)
Population (no.X10 ³ /100m ³)	1.6-144.1 (37.4)
Total groups (no.)	9-16 (13)
Major groups	Copepods, Decapods, Ostracods, Chaetognaths, Acefes, Gastropods

Zooplankton biomass and population density are fairly high in the area. Group diversity is comparable to the adjacent zones. 13 groups of zooplankton are found in the area with predominance of copepods, decapods and ostracods.

Mundra: Continuous observations for the area are available from 1997 to 2000 (Table 3.8.8). Zooplankton biomass shows a fluctuating trend (0.1 – 343.5, av. 17.0 ml/ 100 m³) due to its characteristic patchiness in distribution. Population density of zooplankton followed the same trend like that of biomass (0.1 – 573.0, av. 46.6 x 10³/100m³). However, average values for population are more consistant as compared to biomass. Group diversity is steady and 20 groups are present in the region. The most common groups found off Mundra are copepods, decapods larvae, gastropods and chaetognaths.

Jakhau: The area sustains high production potential as indicated by the values of biomass (1.8-70.1, av. 20.0) ml/100 m³) and population (1.1 – 93.1 av. 16.2 x 10³/ 100 m³) (Table 3.3.9). Group diversity is high (5-18, av. 10) with relatively low values during August 1995. 16 groups are present in the area and the common groups are copepods, decapods, cladoceran and *Lucifer*.

Kharo creek: Continuous monthly observations were made at Kharo creek during December 1994 to May 1995 (Table 3.3.10). The creek has very low biomass of zooplankton which ranges from 0.01 – 5.1 (av. 0.9) ml/100 m³. Compared to biomass values population density is higher (2.8-1230.3, av. 181.2 x 10³/100 m³). Seasonal variation in biomass and population are not evident. Group diversity is comparable during the entire period of study. A total of 14 groups are found in the area. Copepods, brachuran larvae, decapods, cirripede nauplii and chaetognaths are common in the area.

Kori creek: This creek region has fairly high standing stock of zooplankton (0.01 – 68.9, av. 9.5 ml/100 m³). Population density varies from 0.01 – 254.2 (av.48.8) x 10³/100 m³ (Table 3.3.11). Standing stock is maximum during postmonsoon period. Group diversity maintained constant values. A total of 21 groups are found. The most common groups are copepods, decapods and chaetognaths.

3.3.2. Decapods, fish eggs and fish larvae

Larval stages of decapods and fish larvae from zooplankton collection have been identified for some set of observations and details of the available data are summarized below.

Okha: Decapods form one of the predominant group of zooplankton off Okha (Table 3.3.12). Average population during 1999 is 2867/100 m³ indicating an average contribution of 27% to total zooplankton. Seasonally premonsoon period shows higher density as compared to postmonsoon period. Population of fish eggs (av. 65/100 m³) is relatively higher as compared to fish larvae (av. 27/100 m³). Seasonally eggs are better represented during premonsoon than post monsoon period while a reverse trend is observed for the larvae.

Bedi: Ranges in decapod population is from 2.37 x10² to 2.99 x10⁴ with an average value of 1.5 x10⁴/100 m³ (Table 3.3.13) with an average contribution of 25% to total zooplankton. Crab

zoea, alpheids, pagurids and palaemonids predominated the diverse decapod community. Penaeids are represented mainly by *Peaneus semisulcatus*, *P. indicus* and *Metapenaeus* spp. Fish larvae contributed a low percentage to total zooplankton and the population varies from 1-51 (av. 10)/100m³. Fish larval community indicates high diversity and the most common species are *Thryssa purava*, *T. dussumieri*, Gobiidae and Scorpaenidae.

Navlakhi: Population of decapods is low off Navlakhi (av. 19/100m³) with maximum density during the monsoon period (Table 3.3.14). Most common species in the area are *Acetes indicus*, *Metapenaeus affinis* and *M. kutchensis*. Fish eggs are rarely represented in the collection. Fish larval population on an average is 37/100 m³ with maximum density during the monsoon period. Common fish larvae of the region are *Boleophthalmus glaucus*, *Engraulis mystax* and *Clupeid* sp.

Kandla: Range in decapod population is from 7-182 (av. 33)/100 m³ with maximum density during monsoon period (Table 3.3.15). Common species in the area are *Acetes indicus*, *Exhippolysmata ensirostris* and *Penaeus indicus*. Fish eggs are rarely represented. Fish larval population is also more during monsoon (av. 134/100 m³) as compared to postmonsoon (42/100 m³) and premonsoon (10/100 m³) seasons. Larval diversity is fairly high and the area is predominated by *Engraulis mystax*, *Boleophthalmus glaucus* and *Clupeid* sp.

Mundra: Decapods are abundant off Mundra and sometimes even outnumbered the copepod population. Average population is more for the monsoon (17129/100 m³) compared to the premonsoon period (11856/100 m³). On an average contribution to total zooplankton ranges from 19-54% (Table 3.3.16). However, larval diversity is low with predominance of crab zoea, alpheids and *Lucifer* sp. The percentage contribution of fish eggs is low with an average population of 9/100 m³. Fish larvae vary between 0 and 566 (av. 54/ 100 m³). Larval diversity is high. *Gobius* sp. *Thryssa purava*, *Scopaeniformes* and Percoidei are common in the area.

Kori creek: Though population density of decapods in the area is fairly high their contribution to total zooplankton is very low (Table 3.3.17). *Lucifer* sp., pagurid and crab zoea predominated the decapod community. Penaeids are represented by *Penaeus indicus* and *Metapenaeus dobsoni*. Fish eggs shows a range of 5-104 (av. 47)/100 m³ while fish larval density is from 2-909 (av. 163)/100 m³. *Thryssa* sp., *Illisha* sp., *Stolephorus* sp. and *Gobius planiceps* are common in the area.

3.4 Macrobenthos

Okha: Intertidal macrobenthic biomass and population at Okha vary enormously. The respective ranges for biomass and population are from 0 to 91.1 (av. 11.7)g/m² and 0 to 62750 (av. 4504)/m² indicating moderate standing stock. Seasonal observation done during 1999 suggests the enhanced level of intertidal macrobenthos during premonsoon period as compared to postmonsoon season (Table 3.4.1). Group diversity is high (av. 18) and a total of 32 groups are recorded from the area (Table 3.4.2). The most common groups are polychaetes, amphipods, hydrozoans, nemertines and anthozoans.

Extensive data for subtidal benthos are available for 1981 to 1999 (Table 3.4.3). There is no consistency in the distribution pattern of benthic biomass and the variation is from < 0.01 to 490.3 g/m². The average biomass value of 30.5 g/m² suggests good standing stock of subtidal macrobenthos. March appears to maintain relatively stable biomass as compared to other months. Population density also indicates enormous variation from 10-59600 (av. 9244)/m². Group diversity ranges from 1-21 (av. 11). A total of 42 groups are reported from Okha segment (Table 3.4.4) with the predominance of polychaetes, amphipods, copepods, gastropods, tunicates, foraminiferans and ostracods.

A comparison between intertidal and subtidal macrobenthos indicates that the latter zone is two times more productive.

Salaya: Information on subtidal macrobenthos off Salaya is based on a single set of observations and the details are given below.

Parameters	March 1985
Biomass (g/m ² wet wt.)	0-4.8 (4.9)
Population (no./m ²)	0-936 (312)
Total groups (no.)	4
Major groups	Polychaetes, Crustaceans, Echinoderms, Pelecypods

The area is not rich in subtidal benthic standing stock as well as group diversity. Among the 4 groups recorded polychaetes formed the dominant group.

Vadinar: Intertidal area of Vadinar is very rich in macrobenthos, but variability is enormous for biomass (0.2-1787.0, av. 148.0 gm²) as well as population (95-383700, av. 28284/m²). Intertidal benthic biomass values are comparable during 1994-95 and 1996 onwards; it started increasing with very high biomass. November 1997 and January 2000 (Table 3.4.5). Population shows a fluctuating trend till May 1996 and later the values enhanced at a high rate. Group diversity varies from 1 to 20 (av.10). 41 groups are found off Vadinar (Table 3.4.2) the most common groups are polychaetes, amphipods, tanaidaceans, decapods, ostracods, cumaceans, nemertines and nematodes.

Subtidal benthic biomass range is from <0.1 to 80.8 (12.1g/m²). Seasonally premonsoon period sustains relatively high biomass and population (Table 3.4.6). Population density shows a variation of 13-24900 (av. 3165)/m². Group diversity varies from 1-18 (av.10) with a representation of 28 groups (Table 3.4.4). The most common groups in the area are polychaetes, amphipods, decapods, nemertines, foraminiferans and hydrozoans.

The intertidal zone is very productive in macrobenthos while the subtidal production is only moderate. However, group diversity is comparable for both the habitats.

Sikka: The intertidal macrobenthic biomass and population show variation of < 0.1-1787 (av. 151.0 g/m²) and 88-354042 (av. 29525)/m² respectively. Standing stock of intertidal Macrobenthos shows almost constant values from 1993 to 1997 (Table 3.4.7) and their values enhanced at a very high rate. Total number of groups present varies from 2 to 17 (av.10). 31 groups are reported from the area. The most common groups are polychaetes, decapods, amphipods, ostracods, crustaceans, nemertines and nematodes.

The subtidal macrobenthic biomass and population vary at a rate of 0.2-116.0 (av.14.5) g/m² and 126-24900 (av. 4104)/m². There is no constant pattern in the distribution of biomass as well as population with relatively higher values for the premonsoon period (Table 3.4.8). Variation in groups is from 2 to 17 (av. 9). A total of 25 groups are present off Sikka with the predominance of foraminiferans, hydrozoans, polychaetes, amphipods, ostracods, crustaceans and tanaidaceans.

There is glaring difference between intertidal and subtidal macrobenthos, the former being 10 and 7 times more productive in terms of biomass and population respectively.

Bedi: Intertidal area off Bedi is rich in macrobenthos. The range in biomass is 0.4– 1259.4 (av. 64.5) g/m² (Table 3.4.9). Seasonal variation indicated higher standing stock during

postmonsoon (av. 92.2 g/m²) as compared to premonsoon period (36.8 g/m²). Population followed the same trend like that of biomass (341-86864, av. 12038/m²) with higher density during postmonsoon (av. 14038/m²) as compared to premonsoon period (av. 10037/m²). The faunal diversity varied from 3-18 (av. 9). Total number of groups recorded from the area is 26 (Table 3.4.2) and the common groups in the area are nematodes, polychaetes, tanaidaceans and pycnogonids.

The subtidal macrobenthic biomass and population vary respectively from 0.2-554.5 (av. 44.5) g/m² and 125-9664 (av. 3528)/m² suggesting a rich benthic production (Table 3.4.10). Similar to intertidal macrobenthos subtidal region also sustains higher productivity during postmonsoon (av. 81.2 g/m² and av. 4112/m²) than the premonsoon period (av. 7.8 g/m² and av. 2944/m²). On an average group diversity (9) is comparable for both the seasons. The total number of groups present are 24 (Table 3.4.4) with predominance of polychaetes, foraminiferans, cumaceans and nemertines.

The area is rich in intertidal as well as subtidal macrobenthos with higher standing stock at the former zone. However diversity is comparable at both the zones.

Navlakhi: Data for Navlakhi segment are available only for subtidal benthos. This region is very low in macrobenthic production and the variability is from 0.02 – 2.7 (av. 0.3) g/m² for biomass while population fluctuated between 14 and 3900 (av. 157.0)/m² (Table 3.4.11). There is marginal enhancement in benthic biomass during 1994 as compared to 1985 to 1987. Group diversity is also low (1-5, av. 2). A total of 9 groups are found in the area with predominance of polychaetes, crustaceans, plelecyopods and copepods.

Kandla: Intertidal benthic biomass and population vary respectively from 0.02-112.3 (av. 5.8) g/m² and 0-4774 (av. 0.76)/m² (Table 3.4.12) indicating the low productivity of the area. Seasonally postmonsoon period (av. 11.1 g/m²) sustains higher biomass as compared to the premonsoon period (av. 3.2 g/m²). Number of groups ranges from 4-12 (av. 9). 23 faunal groups are found in the intertidal area and the predominant groups are polychetes, amphipods, crabs and mysids.

Data for subtidal area are available from 1985 to 1998 (Table 3.4.13). The pattern of distribution of benthos is irregular with low standing stock (0-17.1, 1.3 g/m²). Population density is also low showing a variation of 0-2601 (av. 312)/m². Though seasonal variation is not well defined, on an average the monsoon period (August) recorded the lowest biomass and population. Groups present in the area are also low (av. 3). 23 groups have been recorded from the area. The most common groups are polychaetes, crustaceans, amphipods and bivalves.

A comparison of the intertidal and subtidal macrobenthos indicates that intertidal zone is about 2 to 4 times higher productive in terms of population and biomass.

Luni: A single set of data is available for this segment for intertidal as well as subtidal macrobenthos. Details of intertidal benthos are given below.

Parameters	March 1997
Biomass (g/m ² wet wt.)	1.0-114.8 (17.2)
Population (no./m ²)	375-15950 (3543)
Total groups (no.)	13-14 (13)
Major groups	Polychaetes, Amphipods, Brachyurans, Gastropods, Pelecypods

Biomass and population of intertidal benthos show fairly high standing stock. The area sustains an average faunal diversity of 13. 16 faunal groups have been recorded from the area. Polychaetes, amphipods, brachyurans and gastropods formed the most abundant groups.

The standing stock in terms of biomass is moderate while the population density is fairly high. Total number of groups indicates the presence of a diverse fauna. 18 groups are recorded from the area. The most common groups are polychaetes, copepods, amphipods and gastropods.

Details of subtidal benthos and composition are shown below.

Parameters	March 1997
Biomass (g/m ² wet wt.)	4.4-10.5 (7.8)
Population (no./m ²)	3700-10350 (7306)
Total groups (no.)	9-12 (11)
Major groups	Polychaetes, Copepods, Amphipods, Gastropods, Foraminiferans, Nematodes

In terms of biomass the intertidal area sustains higher standing stock of macrobenthos, while the population density is higher in the subtidal zone.

Mundra: As is evident from Table 3.4.14 intertidal macrobenthic population varies from 0-487.0 (av. 25.9) g/m² and the population density fluctuates between 0-133056 (av. 4604)/m². The area is moderate to high in benthos with relatively low biomass for monsoon (av. 18.9 g/m²) as compared to premonsoon (av. 32.9 g/m²). The area is quite diverse in benthic fauna (10-24, av. 16). 28 groups have been recorded from the area. Hydrozoans, anthozoans, nemertines, polychaetes, foraminiferans and nematodes are the most common groups.

The subtidal macrobenthic standing stock in terms of biomass is moderate (0-63.1, av.7.2 g/m²). Biomass during monsoon period (av. 4.5 gm²) is much lower than that recorded for the premonsoon period (av. 9.2 g/m²). Population density of subtidal Macrobenthos varies from 0-78625 (av. 3906)/m² (Table 3.4.15). Faunal diversity is high (1-18, av. 10). Among the 24 groups recoded from the area the most common groups are foraminiferans, nematodes, anthozoans, polychaetes and cumaceans.

In terms of biomass intertidal area is 3.6 times more productive as compared to the subtidal area. The faunal diversity, however, is comparable.

Jakhau: The intertidal area of Jakhau has low standing stock of macrobenthic biomass (0-25.3, av. 5.3 g/m²) and population (0-2165, av.797/m²). The faunal diversity is 0-11 (av. 5) (Table 3.4.16). 15 groups are present in the area. Polychaetes, amphipods and isopods formed the predominant groups.

The subtidal biomass (0.01 – 48.6, av. 9.2 g/m²) and population (76-32200, av. 6754/m²) indicate moderate standing stock of macrobenthos (Table 3.4.17). Maximum biomass and population are seen during premonsoon period. Range in faunal group is low (3-9, av. 5). Total groups found in the area are 17. The most common groups are polychaetes, amphipods, copepods, nemertines and isopods.

The subtidal area is more productive as compared to the intertidal zone with comparable faunal diversity.

Khara creek: Very high intertidal macrobenthic biomass (48.5 – 935.7 av. 509.1 g/m²) and population (17170-78080, av. 59173/m²) are observed at Khara creek (Table 3.4.18). The faunal diversity is moderate (av. 6). Among the 6 groups observed, the most common are foraminiferans, gastropods, polychaetes and bivalves.

Continuous observations for the subtidal area have been done during December 1994 to May 1995 (Table 3.4.19). The variation in biomass is from 1.2 – 466.4 (av.40.0) g/m² indicating high standing stock. During January to April 1995 biomass maintained almost stable values followed by very high biomass in May 1995. Population density also indicated comparable trend like that of biomass (201-198400, av. 14098/m²). Range in faunal diversity is from 5-6 (av. 5). A total of 6 groups are identified from the area and the dominant faunal groups are foraminiferans, polychaetes, gastropods and bivalves.

There is remarkable difference in intertidal and subtidal macrobenthic biomass and population. The former sustains about 4 to 13 times higher standing stock.

Kori creek: The creek has fairly high subtidal macrobenthic standing stock. The biomass and population vary respectively from < 0.01 – 269.5 (av. 42.2) g/m² and 22-4796 (av. 1073)/m² (Table 3.4.20). There is reduction in biomass in February 2000 as compared to May 1998 and February 1999. Faunal groups represented are low (1-8, av. 4). 13 groups are reported from Kori creek. Polychaetes, amphipods, brachyurans and gastropods are the predominant groups.

Standing stock of subtidal macrobenthos is low in terms of biomass (0-53.7, av. 4.6 g/m²) and population (0-11392, av. 970/m²). Group diversity is low and the values ranged from 2-8 with an average value of 4 (Table 3.4.21). 13 groups are found in the area. The predominant groups are polychaetes, amphipods, brachyurans and pelecypods.

A comparison of intertidal and subtidal Macrofauna shows difference only in biomass, the former being 9 times more productive as compared to subtidal zone.

3.5 Meiobenthos

Data on Meiobenthos is available only for Positra bay in Okha segment. Details of meiobenthic fauna of the region are given below.

Parameters	September 1997
Biomass (mg. dry wt./10cm ²)	0.4-2.3 (1.5)
Population (no./10cm ²)	631-3643 (2362)
Total groups (no.)	6-9 (8)
Major groups	Nematodes, Harpacticoids, Turbellarians

Biomass and population of meiobenthos indicate fairly good standing stock. A total of 10 groups of meiobenthos are recorded from the area. The list of subtidal meiobenthic groups excluding major groups are oligochaeta, gastrotricha, ostacoda, tardigrada, kinorhynca, polychaeta and crustacean nauplii.

3.6. Biofouling and corrosion

Information on biofouling and corrosion are available only for the Khara creek area. This is an important aspect as materials exposed to marine environment are prone to deterioration either due to corrosion and or marine growth. Fouling and corrosion are closely

interconnected processes of material deterioration and are two important aspects to protect structural material at site or collectively the two aspects provide an insight into the environmental aggressiveness.

The biofouling potential at the Kharo creek is fairly high and is dominated by hard-shelled fouling organisms like barnacles and oysters. The other organisms observed on the panels were hydroids, bryozoans, serpulids, amphipods, cirripeds, polychaetes and actinarians. The biomass build-up during six months of observation indicated a maximum of 5.95 kg/m².

The maximum corrosion rate was found to be 32.98 mils per year (mpy), while the six months cumulative rate scaled down to 16.48 mpy. The rebar in concrete mix 1:2:4 with w/c ratio 0.4 showed a corrosion rate of 0.66 mpy and the corrosion potential of – 390 mV at the end of 180 days of exposure.

3.7. Fishery

Gujarat tops among the different states of India in marine fish production. During 1999 – 2000 total landing for Gujarat was 6.71 x 10⁵t (Table 3.7.1) contributing 23.64% to the National total of 28.34 x 10⁵t. Percentage increase in marine fish landing for the year 1999-2000 was 21.62 while the growth rate of fish production for India was 5.12%. Value wise Gujarat earned 7.61% (Rs. 389.38 crores) of the country's marine products export earning (Rs. 5116.67 crores).

The three districts of Gulf namely Rajkot, Jamnagar and Kachchh have 1, 23 and 51 fishing centres respectively (Table 3.7.2). The collective contribution of Gulf for 1999-2000 was 21.98% to the total production of Gujarat State. The major share is from Jamnagar and Kachchh districts with very low landings from Rajkot (Table 3.7.3). Though there are fluctuations in total landings there is steady growth in fish production from 1983-84 onwards except for minor fluctuations in 1995-96 and 1998-99. A total of 27 categories of fish were recorded from the Gulf during 1999 to 2000 (Table 3.7.3). Sciaenids predominated the area. Common fishes in the area were pomfrets, Bombay duck, shrimps, ribbon fish, clupeids, shark and catfish.

Details of fishermen population in the three districts indicate that active fishermen are more in Kachchh as compared to Jamnagar and Rajkot districts (Table 3.7.2). The number of trawlers are more at Jamnagar while the gill netters are more at Kachchh district. Highest number of mechanised boats operates from Jamnagar followed by Kachchh district. The ratio of total gear for Jamnagar, Kachchh and Rajkot districts shows a respective percentage contribution of 74, 22 and 4.

Okha

No large-scale commercial fishing operation prevails on the eastern side (shallow bay) except for minor shore-based hand- and gill-net operations. This is mainly due to high tidal movements, uneven topography and strong currents which make trawling or gill-netting risky. However, along the western coast of Okha fishing by trawlers is common particularly off Dwarka. Depending on the topography of the coast and type of fishing, necessary modifications are made to economize fishing operations by local operators. Small, plank built canoes and traditional crafts like the sail boat locally known as "Machuwa" are also deployed for fishing. The gear commonly used by these traditional crafts is drift nets, gill nets and large bag nets.

Contribution of Okha to the marine fish landing of Jamnagar district varied from 27.5 to 64.4%. The catch rate over the years at Okha indicates a fluctuating trend (Table 3.7.4). Average composition of landing at Okha for the 1990-1995 period (Table 3.7.5) indicates incidence of 27 groups with predominance of scienids, shrimps/ prawns, ribbonfish, cuttle/ squids, catfish and shark. The monthly landing calendar shows that March and November are the peak months while June and July are the lean periods.

The total number of active fishermen at Okha is relatively low (101) as compared to other centres in Jamnagar district (Table 3.7.6). The total number of fishing craft is the second lowest at Okha, next to Vadinar.

Experimental trawling done during March and November 1999 showed a catch rate between 4.0 and 23.5 (a.v. 11.0) kg/h (Table 3.7.7). Being the fishing season, relatively higher catch rate fish was observed during November. *Metapenaeus* sp. was the only shrimp recorded from the area. The catch composition showed 3 times more species during November as compared to March 1999. The total number of species reported from the area is 23 (Table 3.7.8). The most common species were *Mugil*, sp., *Johnius glaucus*, *Lepturacanthus savala*, *Hilsa* sp., *Harpadon nehereus*, *Thryssa dussumieri*, *Polynemus indicus* and *Cynoglossus arel*.

Salaya

Salaya accounts for about 4-19% of the total landings of Jamnagar district (Table 3.7.4). Fish landings at Salaya indicate a fluctuating trend. Composition of marine fish landing at Salaya during 1990 to 1994 shows the occurrence of 22 groups of fishes (Table 3.7.9). The dominant group found in the area is sciaenids followed by shrimps, mullets, white pomfret, catfish and shark (Table 3.7.10). Total number of fishing crafts at Salaya amounts to 330 and the fishermen population engaged in fishery operations are 1220 (Table 3.7.6).

Vadinar

Vadinar does not contribute much to the fish landing of Jamnagar district. Marine fish landings for Vadinar during 1997-98 and 1998-99 were respectively 513 and 356 t (Table 3.7.4). The total number of fishing craft in the area is only 26 and the fishermen population is 204 (Table 3.7.6).

Experimental trawling showed fairly high fishery potential (av. 41.3 kg/h). The most common species in the catch were *Sardinella longiceps*, *Ilisha megaloptera*, *Cynoglossus arel*, *Johnius glaucus*, *Parapenaeopsis* sp., *Penaeus monodon* and *Metapenaeus* sp. (Table 3.7.11). The list of species caught during different seasons given in Table 3.7.12 indicates higher diversity during postmonsoon as compared to the premonsoon period. Altogether 74 species are reported from this segment (Table 3.7.8).

Sikka

Fish landings (Table 3.7.1) for the last 15 year indicate a steady increase for the Jamnagar district since 1988 while landings at Sikka have stagnated (Table 3.7.13). It is also evident that the landings at Sikka contribute meagre 1% to the total landings of the Jamnagar district. The common groups encountered in the landings at Sikka (Table 3.7.9 and 3.7.13) are mullets, catfishes, clupeids, shrimps, prawns, pomfrets, seer fishes, small sciaenids and perches. The Gulf is an important ground for *Hilsa*, prawns, lobsters, pomfrets, catfishes, mullets, sharks, leather jacket, clupeids and sciaenids. Percentage contribution of shrimps is fairly high during postmonsoon with *Penaeus indicus*, *Parapenaeopsis stylifera*, *Solenocera* sp., *Metapenaeus* sp and *Metapenaeopsis stridulens* dominating the catch. However, fishes like Bombay duck and anchovies have been rarely recorded at Sikka.

Experimental trawling during 1985 and 2000 indicated that catch rate has decreased over the years (Table 3.7.14). In general postmonsoon period sustained relatively higher catch rate as compared to the premonsoon period. Diversity was maximum during the postmonsoon period (Table 3.7.15). The most common species were *Arius* sp., *Drepane* sp., *Cynoglossus* sp., *Johnius dussumieri*, *Pampus argenteus*, *Thryssa mystax*, *Coilia dussumieri*, *Parapenaeopsis* sp., *Metapenaeus* sp. and *Penaeus* sp. Gill netting done in March 1985 indicated a catch rate of 4.2 kg/h recording the presence of 6 species. Gill net catch dominated by *Carcharias laticaudus* and *Arius* sp. Species diversity off Sikka is high and the number of species reported are 108 (Table 3.7.8)

Bedi

Fish landings of Bedi during 1992-97 indicates enhancement in fish production over the years (Table 3.7.16) and 17 groups were represented in the area. Though catfish and jew fish predominated the area the landings represent a fairly good catch of quality fishes such as white pomfret, mullet and seer fish though prawns are generally absent.

Among the different centres in Jamnagar district Bedi supports the second highest number of fishing craft (Table 3.7.6). Number of active fishermen population in the area is 474.

Experimental trawling during premonsoon and postmonsoon (Table 3.7.17) indicates higher catch rate during postmonsoon (av. 73.8 kg/h) as compared to premonsoon (av. 3.9 kg/h). Diversity of species was also very high during postmonsoon recording 63 species while for the premonsoon the total number of species was only 25. Significant contribution of prawns was observed during the postmonsoon period. The most common species in the trawl catch were *Pampus argenteus*, *Arius caelatus*, *Coilia dussumieri*, *Lepturacanthus savala*, *Ilisha* sp., *Parapenaeopsis sculptilis*, *P. stylifera* and *Peneaus indicus*. The total number of species found in the area is 73.

Navlakhi

Fish landing data for Navlakhi indicate a fluctuating trend (Table 3.7.18). The catch composition indicates the incidence of 15 categories of fish (Table 3.7.19). The common groups are Bombay duck, scienids, catfishes, sharks, mullets, perches, jew fishes, and prawns. Navlakhi port is the only port in Rajkot district with landing facilities; the data given in Table includes the catch not only from Navlakhi but other nearby regions also. Even then the landings at the Navlakhi port contribute meagre 1 per cent or less to the total landings of the inner Gulf regions which include Jamnagar, Rajkot and Bhuj districts.

During 1986-87 experimental trawl catch was maximum in February 87 (av. 12.7 kg/h) as compared to the other two sets of observations (Table 3.7.20). However, diversity was maximum during the postmonsoon period (28). Gill net catch was also maximum during February 1987 with relatively low diversity. The most common species in trawl catch were *Carcharias laticaudus*, *Chiloscyllium arabicum*, *Polynemus tetradactylus*, *Harpadon nehereus*, *Ilisha* sp., *Parapenaeopsis hardwickii* and *P. sculptilis*. In the gill net catch *Pampus argenteus*, *Carcharias laticaudatus* and *Engraulis mystax* dominated. During the the experimental fishing in December 1994 the fish catch rate varied between 7.5 and 60 kg/h (av 26.1 kg/h). These catches consisted of 25 species of fishes, 3 species of prawns and 4 other species like *Charybdis cruciata*, *Charybdis annulata*, *Matuta planipes* and *Squilla*. *Harpadon nehereus*, *Coilia dussumieri* and *Arius maculatus* are the most dominant species (Table 3.7.20). Among prawns, *Parapenaeopsis* sp, and *Metapenaeus* sp. are the most common species. Relatively

higher species diversity of fishes was evident in the vicinity of the mouth region of Hansthal creek. Fifty-six species are found off Navlakhi (Table 3.7.8).

Kandla

High tidal movements and unusually strong currents make trawling or gill-netting for fish difficult and risky in Kandla creek. Evidently, no large-scale commercial fishing operations are conducted in the area except for minor shore-based hand-net and gill net operations. Experimental trawling could be conducted only around tidal slacks when currents were relatively weak.

Kandla, Mitha and Tuna ports are three major fish landing centres in the region. However, their contribution to the district landing is meagre (Table 3.7.21). During 1994-95, the total fish catch for Kandla and Mitha ports was 2403 and 270 t respectively and contributed less than 4% to the landings of Kachchh district though subsequent years reveal declining trends. The composition of fish landings at these centres reveals the incidence of 19 different groups (Table 3.7.22); the common groups being Bombay duck, *Coilia*, white pomfret, jew fish, Indian salmon, thread fin, Hilsa, cat fish, mullet, other sciaenids, prawns and shrimps. Higher landings occur at Kandla during postmonsoon with a peak during October-December (Table 3.7.23). This is due to the heavy landings of Bombay duck and *Coilia* which formed 54 and 27% respectively of the landings for October 1996. High group diversity on the contrary was recorded during March 1997 (17 groups). Tuna and Mitha ports also follow more or less similar pattern. District wise details of fishing activities, total number of fishermen and fishing gears are given in Table 3.7.2.

During experimental fishing, the fish catch rate (Table 3.7.24) varied between 0.6 and 40.5 kg/h (av 11.3 kg/h). On an average the catch consisted of 19 species of fishes, 6 species of prawns and 5 species of other groups. *Harpadon nehereus*, *Coilia dussumieri*, *Pampus argenteus*, *Scoliodon laticaudus*, *Lepturacanthus savala* *Boleophthalmus* sp are the most dominant species. The other common species are *Johnius glaucus*, *Cyanoglossus arel*, *Otolithoides biauritus*, *Ilisha metastoma*, *Thryssa vitrirostris*, *Trypauchen vagina*, *Gobbiessp*, *Euryglossa orientalis*, *Chiloscyllium arabicum*, *Arius arius*, *Otolithes cuvieri*, *Lutjanus johni*, *Johnius* sp, *Congresox talabonoides*, *Protonibeia diacanthus*, *Arothron* sp. and *Thryssa mystax*. Among prawns, *Exopalaemon stylifera*, *Parapenaeopsis sculptilus*, *Parapenaeopsis* sp, *Metapenaeus* sp, *Penaeus indicus* and *Metapenaeus kutchensis* are the most common species.

Gill netting in inner part of Kandla creek during 1985-1987 indicated a better catch rate (av. 4.1 kg/h) as compared to 1996 (av. 1.1 kg/h). The composition of gill net catch during 1985-87 indicates dominance of *Pampus argenteus*, *Carcharias laticaudus*, *Hilsa* sp. and *Pellona* sp. In 1996 only 5 species are recorded with the predominance of *Clupea lile* and *Thryssa mystax*. The total number of species recorded from the area is 114 (Table 3.7.8)

Luni

Fish landing at Luni during 1998-99 was 1694 t (Table 3.7.26). The total landing of Luni is comparable to the fish landings at Mundra (1660 t) for the same period and 21 groups were present in the landings. The common group of fishes found in the landing are Bombay duck, *Coilia*, cat fishes, mullet, shrimps, clupeids, and seer fish. Experimental trawling off Luni shows the following results.

Parameters	March/April 1997
Fish catch (kg/h)	21.6 (21.6)
Total species (no.)	Fishes 6 Prawns 3 Others 3
Common species	Fishes: <i>Bempros</i> sp., <i>Harpadon nehereus</i> , <i>Lepturacanthus savala</i> , <i>Pampus argenteus</i> , <i>Pseudotricanthus strigilifer</i> , <i>Scoliodon laticaudes</i> .
	Prawns: <i>Exhipolismata ensirostris</i> , <i>Exopalaemon styliferus</i> , <i>Metapenaeus</i> sp.
	Others: <i>Charybdis annulata</i> , Octopus, Squilla

Though catch rate is moderately high species diversity is low. The number of species recorded from the area is 12.

Mundra

No large-scale commercial fishing operations prevail in the shallow creek regions of Mundra except for minor shore based hand net and gill-net operations. However, along the northern coast of the Gulf, fishing by trawlers is common off Mundra. The landings of Mundra contribute about 0.6 to 3.9% to the landings of the Kachchh district as per the details given below.

Year	Kachchh District (t x 10 ³ /y)	Mundra (t x 10 ³ /y)	Percentage of district landings
1991-92	61.8	2.4	3.9
1992-93	63.0	0.4	0.6
1993-94	63.2	0.8	1.2
1994-95	76.8	0.6	0.8
1995-96	72.7	2.7	3.8
1997-98	70.8	1.3	1.8

Source: Department of Fisheries, Government of Gujarat

The composition of fish catch at Mundra indicates incidence of 21 different groups (Table 3.7.25) with November to December as the peak landing period.

Navinal, Jarpara, Mundra, Chenkhedia, Luni, Bhadreshwar and Kukadasar are the seven major fish landing centres in the Mundra region (Table 3.7.26). Their contribution to the district landings is meagre. The composition of fish landings reveals the incidence of 21 different groups, the common groups being Bombay duck, *Coilia*, mullet, cat fish, white pomfret, shrimps, prawns and small scienides (Table 3.7.25). During 1998-99, the total catch from different centres around Mundra contributed more than 11% to the landings of Kachchh district (Table 3.7.26).

During experimental trawling from 1997 to 2000 the catch rate varied from 0.8 to 33.1 kg/h (Table 3.7.27). Maximum catch rate was recorded during March with relatively low values during the monsoon season (July-August). Diversity was marginally more during premonsoon (av. 22) as compared to monsoon period (av. 20). The most common species were *Pampus argenteus*, *Harpadon nehereus*, *Coilia dussumieri*, *Mugil* sp., *Scoliodon laticaudes*,

Parapenaeopsis sculptilis, *Peanaeus* sp. and *Metapenaeus* sp. Mundra segment sustains 76 species of fishes, prawns and others groups.

Jakhau

The rich fishing grounds off Jakhau have been identified during late 70's. Since then the number of fishing boats operating from this centre is ever increasing. The present landing centre at Jakhau has been used for the berthing and landing facilities to several fishing boats. The number of resident boats belonging to Jakhau, however, is considerably small as compared to the migrant boats from other parts of Gujarat and Maharashtra operating from Jakhau port during fishing season. Although majority of resident boats (65%) are non-mechanised, nearly 95% of the total fishing crafts operating off Jakhau are mechanized. Evidently, majority of mechanized boats (995) are migratory.

Trawlers of 11-14.8 m with 88-105 HP engines are quite common at Jakhau. Fishing crafts of 9.8-11 m with outboard engines are also very popular and are invariably used for gill netting operations. The fishing gears usually operated in this region are gill net, bag net, trawl net and cast net. The mechanised boats operate upto 70 m depth whereas the operations of traditional crafts are confined to 35 m depth.

Fish landing is generally confined to 5 months period from September to February due to prevailing hostile weather conditions during rest of the year. The period between October and December is considered as the peak fishing season. Very high fishery potential of the regions has also been revealed through exploratory fishery expeditions by the Fishery Survey of India (FSI). The operational area for marine fisheries has been estimated at 7960 km² off the Kachchh district which includes Jakhau, Lathedi, Mandvi and Mundra. The total exploitable fishery resource in the above area is estimated at 43000 t/y at a rate of 5.4 t/km². Vessels operating from Jakhau port alone account for an average annual landing of over 30,000 t or 70% of the estimated resource of the area. The data on fish landings (Table 3.7.28) at Jakhau indicate an increasing trend. The major composition of fish landings consists of prawns, shrimps, lobsters, pomfrets, Bombay duck, mullets, *Coilia*, sciaenids, sharks, catfishes, jewfishes, clupeids, seerfishes, silverbars, ribbonfishes, perches and *Hilsa*. About 58% of the total catch is contributed by quality fishes (Table 3.7.29). The major portion of trawl catch (50-60%) is trash fish, which is, sun dried or converted into fish manure. The gill net catch invariably comprises of good quality fish like pomfret, ghol, dhara, ravas, shark, surmai, dhoma etc. The commercial status of the fish caught is shown in the Table 3.7.30.

Experimental trawling results of August and November 1995 showed a variation from 27 kg/h to 44 kg/h (av 34 kg/h) with high species diversity (Table 3.7.31). Overall 9-26 species of fishes, 3-4 species of prawns and 4 other species are recorded. The major species are *Pampus argenteus*, *P. chinensis*, *Cynoglossus arel*, *Scoliodon laticaudus*, *Lepturacanthus savala*, *Ilisha megaloptera*, *Parapenaeopsis styliifera*, *P. sculptilis*, *Atypopenaeus stendodactylus* and *Charybdis annulata*. A total of 44 species are found in the area.

Kori creek

High tidal movements, uneven topography and unusually strong currents make trawling or gill netting difficult and risky in the creek. Evidently, no large-scale commercial operations prevail in the creek except for minor shore-based hand-net and gill-net operations. Similar to Okha small, plank built canoes, and "Machuwa", the traditional crafts are deployed for fishing. The gears commonly used are drift nets, gill nets and large bag nets.

Narayan Sarovar and Lakhpatt are the two fish landing centres on the Kori creek region. However, their contribution to the landings of the district is low ranging from 1.3 to 2.3% with

September to January as the peak landing periods (Table 3.7.32 and 3.7.33). Composition of fish landing at Narayan Sarovar and Lakhpat shows the occurrence of quality fishes like white pomfret and sharks, though the major catch is due to catfish and jew fish. The composition of fish landings at these centres reveals the incidence of 15 to 19 different groups (Table 3.7.32 to 3.7.34)).

Experimental trawling done during 1998 to 2000 reveals that catch varied from 9.2 to 115.2 kg/h. The total number of species varied from 11 to 21 in the catch (Table 3.7.35). The common species are *Harpadon nehereus*, *Coilia dussumieri*, *Otolithes* sp., *Thryssa vitrirostris*, *Lepturacanthus savala*, *Johnius glaucus*, *Arius* sp., *Metapenaeus* sp. and *Parapenaeopsis* sp. Total species recorded from the area is 35 (Table 3.7.8).

3.8. Mangroves, algae, seaweeds, and sand dune vegetation

Algae and seaweeds: There is glaring difference between the two coasts of the Gulf as regards species diversity and biomass of algae with luxuriant growth of algae on the southern shores. The intertidal expanse varies from 1-5 km with gradual slope and mostly coralline substratum on the south which is a conducive environment for algal growth. The MNP area supports 89 species of algae. Species recorded from a few Islands are 79 from Bet Shankhodar, 43 from Karumbhar, and 40 from Pirotan. The list of algae recorded from the Gulf (Table 3.8.1) shows that Rhodophyceae (red algae) dominated with 48 species followed by 30 species of Phaeophyceae (brown algae) and 29 species of Chlorophyceae (green algae). The northern shore of the Gulf has very poor algal growth as the substratum is of sand/ mud. Only *Enteromorpha* (Chlorophyceae) and some blue green algae were found in the mangrove region of Mundra.

The supra-littoral zone of the southern shore was dominated by *Ulva* spp. Other common algae in this region were green algae, *Ernodesmis*, *Struvea* and *Microdictyon* and red algae *Melobasia*. Brown algae *Padina*, *Dictyota*, *Colpomenia*, *Iyengaria*, dominated the mid littoral zone. Red algae *Kjellmania*, *Halymenia*, *Griffithsia* were predominant in the lower mid-littoral and subtidal zones. Subtidal region below 5 m depth was dominated by *Sargassum*, *Turbinaria* and *Kjellmania*.

Marsh vegetation grows on the intertidal mud-flats, and sometimes extends as far as supra tidal area. It is found growing in between mangroves or after the mangrove belt towards landward side. This vegetation prefers saline sandy mud as its substrate. In the Gulf of Kachchh, marsh is found near Balachhadi and from Navlakhi to Kandla. *Suaeda fruticosa*, *Tamarix dioica*, etc., are some examples of commonly observed species in the Gulf. A rich gregarious growth, e.g., the mat-like growth of *Ulva* spp. and *Sargassum* spp. is found on the edges of the reefs and reef flats on Bural, Chank, Ajad, Paga, Munde, Narara, Pirotan and other coral pinnacles.

Several seaweed species from Gulf region are being harvested commercially. These are *Gelidiella acerosa*, *Gracilaria* spp., *Sargassum* spp, *Cystosiera* spp, *Turbinaria* spp, *Hypnea* and *Halymenia*.

Seagrass: Seagrass species exist in the subtidal regions of a few Islands. Two *Halophila* species occur off Karumbhar and *H. ovalis* and *Thalassia* are observed off Pirotan. Rich seagrass beds off Karumbhar Island indicate high prospects for the presence of the rare and endangered sea cow, *Dugong dugon*.

Mangroves: The area covered by mangroves along the Gujarat coast is the second largest in India next to the Sundarbans. Of the 991 km² for the state, the Gulf with 954 km² mangrove

area forms 96% of the total. Majority of this mangrove area belongs to the Kachchh district, encompassing an area of 836 km² (89%) of which over 800 km² borders the Kori creek with a dense patch of about 640 km². The coast of Jamnagar district is reported to cover an area of 118 km² (11%). As per NIO report mangroves along Jamnagar district occupy an area of 98.3 km². The notified mangrove forest area is 1142.5 km² for Kachchh and Jamnagar districts together. Although this region has the maximum mangrove cover in the state, it displays the least diversity – with only a single dominating species *Avicennia marina* along with associate species like *Salvadora persica*, *Salicornia brachiata*, *Suaeda* spp. and *Aluoropus* grass. However, Jamnagar region supports 5 species, *A. marina*, *A. officinalis*, *Rhizophora mucronata* and *Ceriops tagal* at the MNP in Pirotan Island. Some trees of *Aegiceras corniculatum* exist on Karumbhar (Kalubhar) Island. These mangroves have the associate halophytes as given above. General features of the mangroves around the Gulf are given in Table 3.8.2. The available information on the distribution of mangroves in the Gulf is shown in Table 3.8.3.

Mangroves of the Gulf are of scrubby type forming narrow discontinuous patches on soft clayey mud. Due to high salinity, grazing and cutting pressure on the Gulf mangroves, they have stunted growth being 1-2 m tall. Patches of degraded mangroves (*Avicennia* spp.) are observed near Okha, Positra, Pindhara, Dhani, Narara, Jindra, Pirotan and Jakhau port. However, trees in some unaffected patches gain a height of about 5 m at Pirotan Island and more than 10m in Kori creek with fairly good girth of the trunk. Very often salt encrustation on the ground level hampers the growth of plant and turns the land denuded and unproductive. The best-conserved mangroves of Gujarat are those lies along the Kori creek located in sparsely populated area.

The State Forest Department has undertaken an afforestation programme of mangroves in Kachchh and Jamnagar districts adopting the relatively risky mono-species plantation of *A. marina*. The plantation so far undertaken in the MNP of the two districts are respectively 24.03 and 1.5 km² respectively.

Okha

Avicennia marina is the only species occur in degraded patches and fringe the eastern shore of Positra Bay. The height of the mangroves varies from 0.5 to 2m and the plants are more dense and taller towards the east in the regularly inundated zones. The width of the mangroves belt varies from 25 to 200 m. Mangroves are rarely noticed along the western side of the Positra Bay. The density of mangroves varies from 10 to 25 plants/100 m². The seedling density is also very high. The open mud flats support the populations of *Enteromorpha clathrata*. Drifted masses of *Iyengaria stellata* are common among the mangroves of the region. Other obligate halophytes such as *Sueda maritima* frequently occur in the supra littoral region.

It is evident from Table 3.8.4 that Okha and surroundings support a diverse algal community. Okha and Bet Shankhodar harbour rich algal flora of about 120 species. However, during an observations made by NIO only 31 species of algae were recorded from Okha and surroundings. As is evident from Table 3.8.4 fifty-nine species of algae are reported from Okha. Low diversity of marine algae and extensive growth of *Ulva lactuca* and *Chaetomorpha media* in sedimented western regions of Positra Bay indicates localised impact of SS.

Though the east region of the bay has dense mangrove areas represented by the species *Avicennia marina*. Flora associated with *Avicennia* are *Suaeda maritima* and *Sesuvium portulacastrum*. These plants appear to be under stress due to sedimentation. A number of *Avicennia* seedlings and plants are observed to have been withered due to

deposition of SS on leaves and pneumatophores. The deposition of SS perhaps results in reduction in photosynthesis and poor or no exchange of gases due to blockages of lenticels, ultimately killing the plants and seedlings. It is therefore feared that mangroves may suffer an extensive damage over a period of time.

Sea weeds recorded from Positra Bay during November 1995 are listed below.

Seaweed species	Status
<i>Enteromorpha clathrata</i>	Common
<i>Enteromorpha linza</i>	Common
<i>Chaetomorpha media</i>	Dominant
<i>Cladophora prolifera</i>	Common
<i>Hypnea valentaie</i>	Rare
<i>Ceramium</i> spp.	Rare

Salaya

Sikka – Salaya region has extensive growth of mangroves bordering the mainland as well as several mud banks in the vicinity. Some of the mangrove area had deposits of tarry materials indicating that minor oil spill occasionally occurred in the Gulf. Due to high soil salinity and the pressure of camel grazing *Avicennia* stands near Salaya are of scrubby nature.

Dominant species is *Avicennia marina* forming almost pure stands at places. In some localities these are associated with *Avicennia officinalis*, *Rhizophora mucronata*, *Bruguiera gymnorhiza* and *Salicornia brachiata*.

Vadinar

Vast stretches of intertidal areas around Vadinar such as Narara reef, Kalubhar reef and Dhani reef are protected under MNP/ MS because of their rich biodiversity.

A general cross section of the intertidal area of Narara Bet is illustrated in Figure 3.8.1

Narara bet:

Narara bet harbours a dense mangrove forest covering an area of 5.5 km² along the eastern and western side near Kandla Port Trust. *Avicennia marina* is the dominant species (Table 3.8.5). About 0.5 km² area of Narara Bet is afforested with *A. marina* by the MNP Authorities. About 6 species of mangroves and 4 associated species are recorded at Narara Bet. Species like *Rhizophora mucronata* and *Ceriops tagal* are rarely noticed. *Salvadora persica*, *Salicornia brachiata* and *Suaeda fruticosa* are occasionally seen along high saline zones at the supralittoral and nearby saltpans. The height of *Avicennia marina* varies from 0.5 to 2 m.

The mangrove stand density varies from 5 to 20 plants/100 m² (av 12/100 m²). The seedling density is 5-10 seedlings/m² (av 6 seedlings/m²).

The intertidal expanse at Narara Bet varies from 2.5 km to 3.8 km. The main algal zone is however confined to 1.2 to 2.5 km. A total of 62 species of algae and 3 species of sea grasses are recorded from this region (Table 3.8.6). *Lyngbya*, *Caulerpa cladophota*, *Ulva cystoseira*, *Dictyota*, *Hydroclathrus*, *Padina*, *Sargassum*, *Acanthopora*, *Amphiroa*, *Champia*, *Centroceros*, *Gracilaria*, *Hypnea* and *Polysiphonia* are common. *Padina* and *Gracilaria* are most dominant (50-70%) at the lower reef flat. Seagrasses such as *Halophila ovata* and

Halodule uninervis are common in patches on sandy regions of the reef. *Halophila beccarii* occasionally occur at the mudflat along the water channels.

The open mudflats at Narara Bet are covered with algae like *Enteromorpha*, *Ulva*, *Lyngbya* and *Polysiphonia*. The upper sandy shore and mangrove areas are associated with *Enteromorpha* and *Ulva*.

Kalubhar:

The intertidal expanse around the Island varies from 3.5 to 4 km. The south-west region is heavily silted and extensive mudflats are dominated by mangroves. The north-east and north-west regions are very rich in marine flora and fauna.

The mangrove zone, represented by six species is dominated by *A. marina* (Table 3.8.5). Supralittoral zone harbours *Salvadora*, *Salicornia* and *Suaeda*. The plant density varies from 10 to 15 plants/100 m². The intertidal segments harbour 47 species of marine algae and three species of seagrasses (Table 3.8.6). The reef areas are dominated by *Digenia*, *Gracilaria*, *Padina*, *Hydroclathrus*, *Ulva* and *Hypnea*. The open mudflats and sandy regions at the upper intertidal zone are represented by *Enteromorpha*, *Ulva*, *Lyngbya* and *Polysiphonia*. The sandy region of the reef flat supports the growth of seagrasses like *Halophila* and *Halodule*.

Sikka

The marine flora were studied from subtidal (8 m depth) to HHWS tide level. The subtidal area upto 2 m depth from reef ridge supports growth of various marine algae like *Sargassum*, *Cystoseira*, *Dictyota*, *Champia indica*, *Lyngbya majuscula* and *Caulerpa*. The main channel with silt/ clay bottom does not sustain significant populations of marine algae.

However, the reef flat immediately behind the reef ridge upto 1 km from the low tide level supports diverse and abundant algal flora. A total of 42 species of marine algae are reported from this region (Table 3.8.7) with the dominance by species of *Sargassum*, *Lystoseira*, *Dictyota*, *C. indica*, *L. majuscula* and *Caulerpa*. The biomass of *Sargassum* varies from 0.5 to 3 kg/m² (wet wt) and is locally harvested for alginate production. Extensive intertidal mudflats at the upper zone are dominated by filamentous algae like *Enteromorpha clathrata*, *L. majuscula* and *Polysiphonia platycarpa*. *Ulva lactuca* and *E. clathrata* are commonly associated with mangroves at the upper intertidal area. The salt pans and water pools in the saline bank regions are also dominated by *E. clathrata*.

Mangroves in varying density occur at the upper intertidal zone off the eastern side of the GSFC jetty in about 7.5 ha of the mudflats. These mangroves are comprised mainly of *Avicennia marina* (Table 3.8.7). However, dense (100% canopy cover) mangrove occurs only in about 2 ha area. The mangroves stand density varies from 2 to 20 plants/10m². The seedling density ranges from 20 to > 100 plants/m². The height of the mangrove standings ranges from 0.5 to 3m. Other species of halophytes such as *Salvadora persica* and *Suaeda fruticosa* are rarely noticed in the supralittoral zones, just above high tide limit. The open intertidal swamps and mudflats towards high tide on the eastern part of the existing mangrove areas are quite suitable for mangrove afforestation. State Forest Department has already taken up measures to afforest the open mudflats in the region and about 5 ha are already being planted with *A. marina*.

Bedi

Distribution and status of marine macrophytes indicates that the substratum in the deeper (> 7 m) region along the proposed Bedi Super port as well as the intertidal creek areas

are muddy. However, the shallow areas and intertidal segments towards the northwest (< 7 m) of Pirotan Island are composed of rocks, boulders, coral debris, sand, sandy clay and fine clay. The coral reef towards the north-west of the light house at Pirotan Island is about 2 km wide, which from seawards to landwards can roughly be zoned into five segments namely (i) reef slope (50m width) (ii) reef flat (50 m width) (iii) coral debris and corals (800 m width) (iv) sandy region (800 m width) (v) sandy clay (250 m width).

The seaweeds are mainly confined to the first 3 zones mentioned above. Seagrass patches occur in the fourth zone, while sandy clay and mudflat regions harbour luxuriant growth of swamp algae. The open mudflats (500-800 m) along the creeks are totally devoid of mangroves due to the unstable nature of the substratum. Continuous fringing thick stretches of mangroves of approximately 500 m width however exist along the creeks towards the mainland. Mangroves on the Chaad, Jindra and Pirotan Islands occur in large patches, particularly towards the north-east regions.

Pirotan swamp stretching from Bedi Port to Pirotan Island has a total area of about 1478 ha under various categories as given below.

Type of ecosystem	Area (ha)
Mangroves	
Dense	67.8
Sparse	40.3
Marsh vegetation	52.7
Mudflat/ Marshy land	60.9
Sandy grass land/ Beach vegetation	69.3
Sand stretches	93.9
Dead coral reef	354.6
Reef vegetation	274.2
Intertidal mudflat with vegetation (Seagrass)	163.4
Sandy beach	94.1
Algae (dense)	206.7
Total	1477.9

The mangroves cover has been estimated to be about 108 ha with the population dominated by six species of mangroves (Table 3.8.8). However, the stretches along the creeks, towards the mainland sustain dwarf (1.5-3 m) and dense (10-15 plants/100 m²) thickets of *Avicennia marina* mixed with *A. officinalis*. Mangroves at Chaad, Jindra and Pirotan Islands are also dense and dominated by *A. marina* and *A. officinalis*. However, at Pirotan Island patches of *Rhizophora mucronata*, *Ceriops tagal* and *Agiceros corniculatum* exist. The mangrove thickets are relatively taller (2-6 m) on the Islands. In general the crown density of the mangroves in the region is > 90%. The natural regeneration rate is high with a seedling density of 25 to > 100 no/m².

Salvadora persica commonly occur in the supralittoral as well as on the mainland. Obligate halophytes (Table 3.8.8) such as *Sueda* spp and *Salicornia brachiata* commonly occur in the supralittoral regions. *Sesuvium portulacastrum* grow commonly among the creeks and also in the marshy supralittoral regions.

The mangroves around the mainland are being cut for firewood and fodder and those in the vicinity of the proposed Superport are under considerable pressure from the local people. The cattle grazing on *Avicennia* species is also common in the Gulf region.

Occurrence of vast mudflats and availability of natural seedlings as well as high rate of regeneration provides an excellent scope for the restoration of the coastal habitats through mangrove afforestation. The Marine National Park Authority has already initiated such afforestation at Pirotan Island since 1983. About 60 ha of the swamp towards the north-east of the light house have been restored by planting *Avicennia* spp. The survival rate of plantation is reported to be > 80% and the growth is faster and healthy.

The beach vegetation on the Pirotan Island is estimated at 69.3 ha. The sand-dune flora is mainly represented by *Ipomea pescaprae*, *Launea nudicaulis* and *Sporobolus* sp. The marsh grass *Aleuopus lagopoides* is also common. Extensive growth of seaweeds on the reef of Pirotan Island occurs during the postmonsoon period. A total of 44 species of marine algae are recorded from the area particularly on the coral reef of Pirotan Island (Table 3.8.9). However, the abundance of algae is poor. The dominant species are *Acanthophora delilei*, *Caulerpa racemosa*, *C. taxifolia*, *Chaetomorpha linum* and *Colpomenia simosa*. A few forms like *H. musciformis*, *Padina tetrastromatica*, *Dictyota dicholoma* occur in the subtidal regions upto 4 m depth. The intertidal sandy areas on the reef harbour small patches of seagrasses like *Halodule uninervis* and *Halophila ovata* (Table 3.8.8). The swamps also support the growth of *Enteromorpha intestinalis*.

Navlakhi

Mangroves of Navlakhi region are of fringing type and are mainly confined to intertidal zones between mean tide level and high tide level. A part of the upper mudflat area is devoid of mangroves perhaps because of the absence of regular tidal incursion of seawater, longer exposures, and high salt content of soil and overexploitation. The flora of the mudflat is comprised of four mangrove species and two associate species as given below:

Mangroves	
<i>Salicornia brachiata</i>	Dominant
<i>Salvadora oleoides</i>	Common
<i>Avicennia marina</i>	Common
<i>Sueada fruticosa</i>	Rare
Associated species	
<i>Portucoea</i> sp	Common
<i>Aleuopus lagopoides</i>	Common

Almost 80 per cent vegetation of the mudflat is composed of *Salicornia brachiata*. Dwarf (0.3-0.7 m) and stray (density <1 plant/10 m²) plants of *Avicennia marina*, generally occur towards waterfronts and in shallow areas of channels. Remnants of the stumps, and information obtained from local people, indicated that the mudflat had a good cover of *Avicennia marina* a few decades ago. Regular overexploitation mainly for fuel and fodder, has resulted in the existing stray and scrubby vegetation. The dominance by *Salicornia* clearly indicates the high content of salts in the substratum.

Though part of the mudflats are mainly represented by scattered shrubs of scrubby mangroves, their roots form a thick network upto 1-2 m underground. Hence, their presence accelerates sedimentation and stabilization of mudflats and thus help in building up the new land. Besides, the mangroves provide shelter to a variety of birds and wildlife. At some locations the northern periphery of the mudflats shows signs of erosion. It is desirable to arrest this erosive trend by promoting extensive mangroves afforestation. Incidentally, the Department of Forests, Government of Gujarat has established mangrove nurseries on nearby mudflats to the east of Navlakhi port.

Kandla

General distribution pattern of mangroves and other vegetation along Kandla creek is given in Fig. 3.8.2. A survey of the littoral region along the Kandla creek covering transects on the western and eastern shores reveals that the area can broadly be divided into six zones (Table 3.8.10). The intertidal open mudflat of 50-120 m width, adjacent to the waterfront is totally devoid of vegetation. However, a few patches of green algae (*Enteromorpha* sp.) occasionally occur on the swamp. The seaweed flora is poor in the region mostly growing on the marine port structures. The next zone of 30-80 m width harbour mangroves in patches which are mainly comprised of *Avicennia marina* of height 0.5 – 1.5 m. The dwarf nature of *Avicennia* could be due to frequent cutting and high salinity. The remains of large size mangrove stumps just beyond open mudflat indicate that the area in the past (about 50 years back) was rich in mangroves; possibly contributed by *Avicennia marina*. The seedling density of *Avicennia* in general is very poor, and favoured rivulets and water channels. *Sesuvium portulacastrum*, an obligate halophyte occurs in large patches and long stretches along the edge of rivulets and channels. The supralittoral region stretches > 1.5-2 km and can be further divided into lower and middle zones. The lower supralittoral zones of 50-100 m width harbour luxuriant thickets of *Salicornia* vegetation. The vegetation thins down in the middle supralittoral regions (150 m). The vast saline bank (upper supralittoral) segment is salt encrusted and totally devoid of vegetations.

The flora is dominated by three mangroves and obligate halophyte species each. Apart from *Avicennia marina* (mangrove) and *Salicornia brachiata* (obligate halophyte), which are common, other species such as *Avicennia officinalis*, *Salvadora persica*, *Sesuvium portulacastrum*, *Sueda maritima* and *Aleropus lagopoides* also occur (Tables 3.8.10 & 3.8.11). Stretches and patches of *Sesuvium portulacastrum* are commonly in the upper intertidal regions. *Salvadora* is mixed with *Salicornia* in the middle littoral and upper littoral areas and *Sueda* is rare in the upper littoral, saline and reclaimed regions (Table 3.8.10).

Avicennia marina is dominant in the upper intertidal segments of regular inundation zones of width 30-50 m, along the eastern bank at Sathsaida, with a density of 10 to 25 plants/10 m². The height of the stand ranges from 0.5 to 1.5 m. The frequency of occurrence of *Avicennia marina* is estimated at 60%. *Salicornia* the other dominant crop is denser in the lower supralittoral zone of 50-100 m. The biomass (wet wt) decreases from 4.2 to 0.21 kg/m² from the lower supralittoral to the uppermost supralittoral areas. The other common obligate halophytes like *Sesuvium portulacastrum* which are more common along the western bank in the upper intertidal region of regular inundation sustain average biomass of 2 to 3 kg/m². The other species have negligible biomass.

Though the soil in general is fairly rich in organic matter that increases towards the upper supralittoral zone (Table 3.8.12), the *Salicornia* vegetated regions are devoid of soil as well as benthic fauna. This could be due to poor flushing of these zones due to low frequency of inundation. The reduced density of vegetation, stands, biomass and absence of soil fauna in the *Salicornia* above the mean high tide level could be due to higher salt content of the soil, longer exposure to solar radiation and low frequency of inundation.

The substratum in the intertidal region is clayey while loamy soil covers the adjacent zone. The salt content of the soil varies from 0.2 to 0.8% with an increasing trend towards the saline bank. The absence or low occurrence of seaweeds and seagrasses may be due to unsuitable conditions such as muddy substratum, high turbidity and high velocity currents.

Though Kandla Port is operational for several years now, no adverse impact of port activities is evident on the surviving mangrove flora, perhaps since Kandla creek is well flushed by tides and any anthropogenic input of pollutants is dispersed and removed from the water fairly quickly.

Luni

The intertidal region here is sandy or sandy-clayey. The marine alga, *Enteromorpha* sp is commonly observed in the intertidal area. The stray mangroves, mainly *A. marina*, occur in the muddy regions though several intertidal mudflats in the vicinity are devoid of mangroves. The supralittoral area occasionally supports the growth of *Sueda maritima*.

Mundra

The mangroves around Mundra Port are some of the best mangroves formations along the northern shore of the Gulf. Mangroves are represented by a few species and 3 obligate halophytes (Table 3.8.13). General distribution of mangroves and other vegetation along Mundra coast is given in Fig. 3.8.2. Mangroves are of fringing type in regularly inundated zones along the water ways. These mangroves are dominated by *Avicennia marina* with thick and tall plants (3-7 m height) in the belt of 20-25 m width beyond open mudflats, along the banks of creeks. The western bank of Navinal creek is devoid of mangroves upto 2 km stretch. Inland of 2 km, the bank and the mudflats sustain dense but degraded mangroves. The eastern bank of Navinal creek however has dense stands of *A. marina* right at the mouth which extend interior all along the creek as well as to the nearby entire Bocha Island.

Mangrove belts of *Avicennia* bordering short segments of Baradi Mata Creek and mouth of Kotdi are degraded and under pressure of camel grazing and cutting for firewood. The stray plants *Rhizophora mucronata* also occur among *Avicennia* stands. *Salvadora persica* commonly occur in the supralittoral regions above the HTL. *Avicennia* thickets are generally dwarf (0.5– 1.5 m height) and sparse in regions away from the waterways. However, the height (> 3 m) and density (10-20 no/100 m²) improves along the waterways in about 20-50 m belt, beyond the open mudflat. The seedling density is very high and ranges from 40 to > 100 no/m² in dense thickets along the creek.

Sesuvium portulacastrum is common at the HTL along the creeks. Beds of *Salicornia brachiata* commonly habit the areas inland of regularly inundated zones or above the mean HTL. The *Salicornia* stands are denser towards waterways and become sparse in saline banks. *Sueda maritima* is sparsely distributed in the saline bank regions. The total mangroves cover in the Navinal – Bocha – Baradi Mata – Kotdi creeks complex is estimated at 1800 ha, with about 60% are covered with dense mangroves. The proposed railway route cuts through a small stretch of dense mangroves while the major routing is an areas devoid of vegetation.

Salt marshes: The vegetation of this zone consists of predominantly *Aeluropes lagopoides* supported by *Sporobolus* sp. *Cressa cretica* also occur in dried salt marshes and salt pans. Presence of species such as *Cyperus pangorei*, *Bergia odorata* and *Oldenlandia umbellata* is probably an indication of retrogression due to the detrimental effect of salt works.

Sandy stretches: In the sandy patches between the scattered rocks, a few species such as *Cyperus conglomeratus*, *Asparagus demosus* are identified.

Inland shrubs: The shrub forest on sandy plains along the coast is composed of *Acacia senegal*, *A. leucophloea*, *A. nilotica*, *Capparis decidua*, *Balanites aegyptica*, *Euphorbia nirula* etc.

Jakhau

The coastal wetland with its extensive mudflats and dense mangroves is highly rich in marine wealth. The various creek systems including Godia and Kherla creeks of this region provide a vast coastal wetland ecosystem harbouring mangroves. A portion of this rich mangrove ecosystem has already been classified under "Reserve Forest". The dominant species of mangrove is *Avicennia marina*. These are sometimes associated with *A. officinalis*, *Rhizophora mucronata*, *Bruguiera gymnorhiza*, *Ceriops tangal*, *Aegiceros corniculata* and *Sonneratia apetata*.

The vegetation of the salt marsh zone is predominantly of *Aeluropes lagopoides* supported by *Sporobolus* sp., *Cressa cretica*, sometimes occur on dried salt marshes and salt pans.

The scrub forests which exist in patches on sandy plains are composed of *Accacia senegal*, *A. leucophloea*, *A. nilotica*, *Capparts decidua*, *Balanites aegyptica* and *Euphorbia nirula*.

Kharo creek

Patches of mangroves are seen towards the interior part of Kharo creek while they were not observed towards mouth. The species found is *Avicennia marina* with a density of 15-20/10m². The trees measure about 3-4 m in height.

Kori creek

The Kori creek has vast mangrove coverage both along east and north shores. Along the east shore the distribution of mangroves is restricted from the creek mouth to downstream of Koteshwar. Upstream of Koteshwar upto Lakhpat mangroves are rare and in isolated patches wherever present. The region around Moti Chher is totally devoid of mangroves, whereas along the west shore mangroves cover almost the entire creek stretch. *Avicennia marina* is the dominant species. Associated mangrove flora like *Suaeda maritima*, *Atriplex stocksii*, *S. fruticosa*, *Salicornia branchiata*, *Salvadora* sp., *Tamarix* and *Aleuopus* sp. are common in the Kori creek.

3.9. Corals and associated biota

The southern coast of Gulf is known for its coral reefs with associated reef dependant flora and fauna which are the northernmost in the Indian Ocean. The coral formations of the Gulf are found between 22° 15'N and 22° 40'N latitudes and 69°E and 70° 20'E longitudes (Fig. 3.9.1). Most of the Islands in the Gulf support fringing reefs and the coral patches are also found between Islands. The present day coral growth is patchy rather than reefs as they are supported by intertidal sandstones or wavecut eroded shallow banks. Based on the existing classification, these reefs are classified into fringing reefs (north of Okha, north of Bet Shankodar, fringing the mainland from Dhani bet to Sikka, Jindra and Chad, Pirotan, near Valsura), platform reefs (Paga reef, Bural Chanks, Kalubhar, Munde reef etc.) Patch reef (Goose and Ajad), and several coral pinnacles (e.g. Chandri etc.). The most northerly reefs or coral patches are found at Munde reef and Pirotan Island, but solitary corals are found as far as Jakhau in the east and Dwarka on the Saurashtra coast. Recently, live corals with associated flora and fauna have been observed off Mundra on the Kachchh coast, for the first time in March 1999.

The reefs are generally restricted to areas exposed to the strongest tidal currents and live corals are generally confined to the northern and western sides of the Islands. The diversity of coral species in the Gulf is the lowest of all Indian reefs. In 1985 a total of 44 species of Scleractinian corals and 12 species of soft corals were reported while in 1988 the

record was 38 species of stony corals belonging to 24 genera (Table 3.9.1). However, a recent monograph (1996) lists 40 species and 23 genera of stony corals, 3 species of soft corals and 4 species of sea fans from the same area. Most of these corals are hermatypes (reef forming) while only a few are ahermatypes from the Gulf.

Remote sensing satellite data

Observations have been carried out by satellite imagery combined with ground truth data collection and visual observations. Major limitation of satellite imagery is its poor depth of penetration and therefore its usefulness is largely restricted to assessing coral cover of emergent and extremely shallow reef flats. Hence, the available imageries are only for those reefs and reef flats, which are shallow, intertidal and get almost completely exposed during low tide, leaving the sub-tidal regions unexplored. Salient findings emerged from these observations are given below.

Satellite imagery indicated that the total reef area in the Gulf was 217 km² in 1975, which decreased to 118 km² in 1985 and 123 km² in 1986 with a net loss of 94 km² of coral cover, equivalent to 43%. No mud depositions were observed in the 1975 satellite data. The satellite pictures show that the reefs that are interpreted as having died out between 1975 and 1985 in fact lie buried under mud, proving conclusively that the important, if not the only, cause for coral damage is the heavy silt load.

Satellite imagery also showed clearly that within the core area of the MNP, coral reef, which covered 116 km² in 1975 was reduced to 83 km² in 1982 and 53 km² in 1985. The Remote sensing data supported by ground truth data collection revealed that between 1985 and 1991 a net improvement (from 53 to 85 km²), in coral cover within the core area of the MNP has taken place (Fig.3.9.2).

The Gulf reefs mostly consist of dead coral boulders and pebbles and are the most degraded reefs. Vast areas with dead corals are an indication that the mortalities are of recent origin. Some of the hard stony corals encountered in some reefs indicate that these could not have been dead for more than a couple of decades. In fact, even in areas normally referred to as coral reefs or patches, live coral covers rarely exceed 20-30%. Due to extreme conditions of temperature and salinity and high turbidity coral growth is patchy with poor diversity of living corals. Several of the reefs are degraded with dead corals in a majority. While good water circulation is conducive for coral growth, high current velocities are hardly ideal. This is one of the causes for the near-absence of corals in the northern shores of the Gulf. Prolonged exposure to air due to the high tidal amplitude is not also very conducive to the survival of the corals, as this limits the degree of colonization of corals and associated animals. It has been suggested that some live colonies may occur in deeper waters. But siltation appears to be the major cause for the mortality and the consequent reduction in species diversity of corals in the Gulf. Siltation results from mining of corals and coralline sand for industrial purposes, mainly for manufacture of cement, dredging, filling and shore erosion caused by falling of mangrove vegetation. Construction of harbours in the vicinity of coral reefs is another reason for siltation and their consequent destruction. The whole coral reef area is under heavy silting and most of the genera recorded have large polyps that can combat the deleterious effect of silting.

Observations by SCUBA diving

The existence of live corals at the sub-tidal regions is substantiated by observations made during SCUBA diving in February 1999 at four Islands, viz. Pirotan, Karumbhar (Kalubhar), Boria and Bet Shankhodar coral reefs (Table 3.9.2).

Live corals – both soft and stony are abundantly present in the sub-tidal regions of the reefs at various stages of growth. The genera observed for stony corals are: *Favia*, *Favites*, *Goniopora*, *Montipora*, *Sinularia*, *Tubastrea*, *Turbinaria* and *Acropora*. The soft coral genera are *Dendronephthya* and *Nephthya*. Stony corals dominate the Pirotan reef while soft corals dominate the other reefs. A total of 12 species of stony corals, 7 species of soft corals, 28 species of benthic marine algae and 23 species of benthic fauna could be recorded during the underwater survey (Table 3.9.2).

The abundance of live corals decreased from the inner to the outer reefs, from 75 to 80 per cent at Pirotan and Karumbhar to around 50 per cent at Boria and Bet Shankhodar. Siltation varied from moderate to fairly high from the inner to the outer reefs. Underwater tidal currents were stronger at the inner reefs.

The Munde reef and Pirotan Island mark the northernmost extent of coral patches and the easternmost limit is the Mungra reef near Jodia (Fig.3.9.1). Solitary corals are believed to exist as far as Jakhau in the north and Dwarka on the Sourashtra coast.

The dredging survey off Mundra, about 2-3 km off Adani Port, covering an area of around 8 km² revealed high density of live corals, *Tubastrea* sp. and live polyps with plenty of gorgonians, soft coral *Dendronephthya* sp., bryozoans, brittle star, sea urchins, holothurians, polychaetes with the algae *Ulva* sp. and dead *Acropora* branches. Dredging off Mandvi covering 3.5 km² revealed similar assortment of live corals with their associate flora and fauna. These observations indicate a considerable area in the northwestern Gulf of Kachchh may have live corals (Table 3.9.2). Inclusion of these sub-tidal live corals will certainly change the currently held belief that there are 20-30% corals in the Gulf of Kachchh which are alive.

Okha

There are many Islands adjoining the Okha coast and Positra Bay. The major reef systems are Paga, Boria, Gora, Chandri, Bet Shankhodar, Dholio Gugar, Dona, Mangunda and Savaj. The status of corals of these areas is given in Table (3.9.3). A total of 34 species are recorded from the area. It is evident that forms like *Pacillopora* and *Acropora* are absent which is also a cause for their low diversity. Presence of semi-fossilized forms of *Acropora* is indicative of their presence in the past and provide evidence for their degradation in recent years. The intertidal area of Positra Bay is muddy and devoid of live corals.

SCUBA diving was done for under water visual survey in the southern central part of the Bay. Survey within 10 m depth in about 100 m radius indicates that the area does not sustain corals with the bed material compound of plain and sand mixed with shells at some places. On some occasions sponges in low density are recorded.

Salaya

Corals off Salaya have a moderate live coral population with variety. These corals are under environmental stress due to heavy sedimentation. The sturdy corals like *Goniopora*, *Porites*, *Favia* and *Goniastrea* are the common species. Live corals are mainly confined to the lower littoral and shallow subtidal zones (< 8 m).

Vadinar

Live corals in the intertidal area were studied along the western half of the Narara bet and the eastern half of the Kalubhar reef. The subtidal zone upto 16 m of Narara Bet as well as in the intertidal region of Kalubhar were investigated by SCUBA diving. The data obtained are useful to assess the species diversity and health of the corals. Live corals are mainly confined to the lower littoral (reef flat) and shallow subtidal zones (< 8m).

Sturdy corals like *Goniopora*, *Porites*, *Favia*, *Favites* and *Goniastrea* are the most common and dominant forms in the study region. In all 29 species of scleractinians at Narara Bet (Table 3.9.4) and 35 species at Kalubhar (Table 3.9.5) have been identified. The dominant genera are listed below:

Intertidal	Subtidal
Goniopora	Porites
Favia	<i>Goniopora</i>
Favites	<i>Favia</i>
Porites	
Goniastrea	
Symphillia	

Narara Bet

Major species of corals recorded at the subtidal diving areas (Lat 22° 29' 090"N and Long 69° 42' 694"E to Lat 22° 28' 667"N and Long 69° 42' 099"E) at 3-16 m depth are *Porites*, *Goniopora* and *Favia* (Table 3.9.4). The live corals occur at a depth of 3 to 8 m in all the diving locations. The coral coverage varies from 40 to 100% area at the above depths. In general, coral coverage of 80 to 100% area are observed within 3 m depth. Beyond 8 m depth corals are rarely noticed. The subtidal regions also harbour a few species of soft and brittle corals of Meralinaceae. In general, live corals are absent beyond the 15 m depth contour.

Live corals occur in varying densities at the intertidal regions of Narara Bet. The lower reef flat sustains on an average area cover of 20 to 60% live corals as compared to the upper reef flat (0.1 to 5%). Towards Kandla Port Trust side of Narara Bet the reef flat expands to over 800 m. The live coral densities drastically decrease at the upper reef flat and beyond due to steeper gradient of the reef profile. The mid-intertidal zone usually represents dead coral reef under heavy sedimentation.

The upper tidal zone is mostly sandy or muddy. The wave protected mud banks of Narara reef sustain dense mangroves.

The reef flat with live corals is associated with a rich and diversified marine flora and fauna. The rare faunal components like *Bonelia* sp., *Stoichacts giganteus* and *Pinna bicolor* are noticed in the study area. The reef flat sustains a variety of polychaetes, flatworms, crustaceans, sea anemones, hydroids, sponges, gastropods, pelecypods, nudibranchs, cephalopods, and echinoderms, apart from colourful coral fishes.

Kalubhar

The distribution of live corals (Table 3.9.5) along the intertidal reef flat of Kalubhar is closely comparable with that of Narara Bet. However, live coral colonies are relatively more especially at the lower reef flat of Kalubhar as compared to Narara Bet. The corals are mainly represented by the genera *Favia*, *Favites*, *Porites*, *Goniastrea*, *Goniopora*, *Pseudosiderastrea*, *Cyphastrea*, *Symphyllia* and *Turbinaria*. The live corals are absent at the reef edge of 50 m width while their coverage increases (90 to 100%) at the reef slope below 1 m depth. The corals were found in healthy and normal condition during the study period.

Overall, the Narara Bet has moderate live coral populations with variety. These corals are under high environmental stress due to heavy sedimentation which is more prevalent along the eastern side. The live corals are mostly confined to the subtidal and the lower reef flat and absent at the upper reef flat due to sedimentation. In general, the eastern segment of Narara Bet, represents a formation of vast mud flat which results in significant negative influence on the live coral population. Many regions along on the western side are exposed during low tide for prolonged periods resulting in poor distribution of live corals. If the present trend continues, the extension of mud flats over a period on the lower reef, may result in wide spread destruction of live corals in the region. The live corals are restricted to the subtidal regions upto 8 m depth while they are absent beyond 15 m depth due to sandy/ muddy bottom. The elimination of live corals in the reef flat would result in de-acceleration of reef formation, reef erosion due to weathering and ingress of adjacent creek water.

In general, Kalubhar Island has relatively better live corals at the lower intertidal and subtidal (< 1 m depth) as compared to Narara Bet. The north and north-west regions of Kalubhar have better coral density and diversity as compared to the east and south-east regions which are poorly represented with the live corals, due to heavy sedimentation of the reef flat and the subtidal zones.

Sikka

A transect and the intertidal areas especially the reef flat and the channel along the existing GSFC jetty were surveyed for live corals.

Live corals are mainly confined to the lower littoral (reef flat), shallow subtidal zones and the reef ridge (Table 3.9.6). The sturdy corals like *Goniastrea* and *Porites* are the most common and dominant forms in the region. The live corals are represented by 29 species of Scleractinians (Table 3.9.7). The dominant coral genera off Sikka are as follows:

Intertidal	Subtidal
<i>Favia</i>	<i>Symphyllia</i>
<i>Favites</i>	<i>Turbinaria</i>
<i>Goniopora</i>	<i>Platygyra</i>
<i>Goniastrea</i>	<i>Favia</i>
<i>Porites</i>	
<i>Symphyllia</i>	<i>Goniophora</i>
	<i>Goniastrea</i>

Corals are absent in the mid-channel which has a silt/clay bottom. Corals occur from about 8 m depth initially at a density of about 1 to 2 colonies/m² and reach 6 to 7 colonies/m² just below the low water level. Colony sizes widely vary with the type of the species and growth conditions; however, their size (diameter) varies from 5 to 25 cm, (av 15 cm). The subtidal belt within 250 m from the lowest low water level sustains the richest (45%) live corals in the region. The corals occur for about 1 km stretch along the cross section of Sikka creek

from the lowest low water. The coral density decreases drastically along the cross section reaches about 0.5% at a depth of 8 m. From the mid-channel towards Goose reef few scattered live coral colonies covered with mud and algae are observed.

The live corals thrive in varying densities in the lagoon which extends about 1.75 km towards the mid-tide level from the lowest low water mark of the ridge. The lower reef flat contributes about 5 to 25% coral coverage while the upper reef flat harbours poor corals (0.001 – 2%) due to heavy sedimentation. The substratum at the reef flat itself consists of a live coral reef, dead corals and coral/mud. The intertidal marsh behind the upper reef flat is covered with dead reef and mudflats over a length of 1 km towards the mangrove swamp which in turn extends upto a distance of about 750 m towards the high tide mark. Massive destruction of corals due to heavy sedimentation is evident, particularly in the upper algal zone or upper reef flat segment.

The mud-covered reef in the mid-intertidal zone clearly reveals the prevailing extensive coastal erosion and subsequent transport of the fine sediments towards the reef flat by ebb tidal currents. The GSFC causeway appears to act as a trap for the sediments transported from the Munde and Moti Khavdi regions. This perhaps could be one of the reasons for large-scale formation of mudflats on the eastern part of the GSFC jetty. If the prevailing scenario continues unabated, the live corals presently occurring in the reef flat are likely to be destroyed as the reef flat will be silted over a period of time.

The overall assessment indicates that the lower reef flat and subtidal region upto 4 m depth have moderate coral populations with variety.

Bedi

Pirotan Island forms the eastern limit of major coral formations in the Gulf with a well-developed reef. The coral reef towards the west and the northwest of Pirotan Island is healthy with the corals mainly confined to the reef slope, reef flat and beyond reef flat in a belt of about 800 m.

The density of coral varies from 1 to 5 colonies/m². Only about 40% of coral colonies are living and healthy. The corals are denser (3 to 5 colonies/m²) beyond the reef flat while their density is low (1 to 2 colonies/m²) on the reef flat. More than 50% of colonies beyond the reef flat are either dead or under severe stress from sedimentation. Though available records indicate the occurrence of 22 species of corals (Table 3.9.8), during a recent study only 13 species are identified of which species of *Goniophora*, *Goniastrea*, *Porites* and *Flavia* are more predominant.

The subtidal regions only upto 2 m (at low tide) support the growth of corals. Bryozoan colonies commonly known as sea mats or coralines of which *Tryphyllozoan* sp, look very similar to hard corals is more predominant in the subtidal areas upto 4 m depth. The deeper regions (5-20 m) are either sandy or muddy, and devoid of corals. A number of small patches of live coral colonies also occur in the creeks between Chaad and Pirotan Island. The area of the proposed approach way to the Superport jetty is largely devoid of corals though several localised colonies occur in the vicinity.

Navlakhi

The Navlakhi region does not have coral reefs as most of the intertidal area is muddy. Coral growth in subtidal areas is unlikely in view of very high-suspended load in the water column.

Kandla

The Kandla region however does not have corals, as most of the intertidal area is muddy. Coral growth in the subtidal areas is also unlikely in view of very high-suspended load in the water column, the conditions under which corals are unlikely to survive.

Luni

Live corals are absent along the coast between Jakhau and Kori creek.

Mundra

Mundra region does not sustain corals, as the intertidal area is largely sandy or muddy. Coral growth in the subtidal region is also unlikely in view of the high-suspended load in the water column, the conditions under which corals do not thrive. Recently in March 1999 live corals with associated flora and fauna have been observed off Mundra for the first time. During a dredging survey conducted 1.6 km off Mundra in an area of about 8 km² revealed existence of corals including soft corals such as *Dendronephthya* sp.

Live corals are absent along the coast.

3.10. Reptiles

In the Gulf, the reptiles are mainly represented by marine turtles *Chelonia mydas* and *Lepidochelys olivacea*. They breed and spawn on the sandy beaches along the coast as well as on the Islands particularly along the southern Gulf between Okha and Okha Madhi and Vadinar-Sikka coast as well as on the Islands within the MNP and MS. The marine turtles and their eggs in the sandy beach were noticed on several occasions (premonsoon period) during field visit of NIO team between 1996 and 1998.

3.11. Birds

The Gulf area which has many salt pans, Islands and intertidal coastal system with mangroves offers favourable conditions for feeding, breeding and shelter to a variety of birds. Birds find the most congenial environment in the mangrove forests lining the Islands, like Siri, Goose, Munde, etc and along the coasts. In addition, they are well placed to reach their food supply namely the shoals of fish, squids, mudskippers and other animals, during low tide. All along the creek and in and around several Islands tall mangrove trees are seen crowded with Grey herons, Pond herons, Painted storks, Large and smaller Egrets, Darters, Cormorants etc. During receding tide, hectic activity of various Gulls, Avocets, Whimbrel, Curlew, Terns, Egrets, Grebes, Plovers etc are common. A large number of migratory species pass through the Gulf and a small population of most species comprising mainly of juveniles and non breeding adults take shelter during summer. Salt work spread out along Vadinar – Sikka are usually important for feeding and breeding of birds. A total of 94 water birds have been reported from the Gulf area (Table 3.11.1).

A recent study which is carried out during November 1999 reveal high avifaunal diversity in the Mundra region. On the whole, 140 species are documented; 85 terrestrial and 55 aquatic. Out of these, 71 are resident species, 44 migrant and another 25 resident migrant. Based on sightings, 21 species are reported to be abundant, 42 common, 51 rare and 26 very rare. The scientific name, common name, abundance status etc of the aquatic birds of Mundra are given in Table 3.11.2. Exotic species like Greater Flamingo (*Phoenicia pterus rubber*), Lesser Famingo (*P. minor*) and Dalmatian Pelecan (*Pelecanus cripus*) and Eurasian Spoon Bill (*Platalea leucorodia*) were commonly recorded, thus emphasising the importance of the study site. Dalmation Pelecan, Greater Flamingo, Lesser Flamingo and Spoon Bills commonly occur in salt pans.

Islands support a variety of migratory as well as resident birds. The list of birds of Kalubhar Island (Table 3.11.3) indicates the presence of 29 species. The effect of rise in global mean sea level led to the displacement of the breeding in the Flamingo city, Great Rann of Kachchh to Thol lake sanctuary area in Ahmedabad. The flamingoes (Greater Flamingo) have been breeding in the great Rann of Kachchh, since time immemorial.

3.12. Mammals

The mammals are chiefly represented by dolphin (*Dolphinus delphia*), whale (*Balaenoptera* spp) and Dugong (*Dugong dugon*) in the Gulf especially along the Jamnagar coast but not sighted during the investigations conducted by NIO.

Stranded dugongs are reported from Pirotan Island and Bet Dwaraka Island. A sei whale (*Balaenoptera borealis*) is recorded for the first time from Salaya.