

4. BIOLOGICAL CHARACTERISTICS OF SELECTED ZONES

4.1. Salt works

The enclosed space of a salt work is divided in sequence into reservoirs, condensers and crystallizers. The reservoir receives water directly from the adjacent coastal marine environment and is allowed to evaporate and when the required salinity is attained water is allowed to flow into the condenser for further evaporation. After a few days water is transferred to the crystallizer, where crystallization of salt takes place. This special ecosystem is characteristically subjected to a wide range of environmental stress manifested mainly through salinity changes.

Information on water quality and biological characteristics of salt works are limited. Chemical and biological characteristics of the existing salt work at Mundra were investigated by NIO in October 1999. The typical salinities and other chemical constituents in the various components of the salt works are given below.

Component	Salinity (ppt)	DO (ml/l)	Po ₄ ³⁻ -P (µmol/l)	No ₃ ⁻ -N (µmol/l)	No ₂ ⁻ -N (µmol/l)	NH ₄ ⁺ -N (µmol/l)
Reservoir	60-176	2.9-4.2	0.1-0.9	0.1-1.1	0.1-0.4	0.1-0.5
Condenser (Third stage)	330-340	1.1-1.3	0.1-0.4	0-0.7	0.1-0.3	0-0.15
Crystallizer	340-345	1.0-1.1	0.2-3.2	0.1-1.3	0.2-0.7	0.4-1.1

Among the two distinct evaporating areas namely primary concentrator and crystallizer areas, the former is large and constitutes 90% of the total salt field area. In these ponds there is a resident system of active biological matter that ranges from the fish to bacteria. Reservoir sustains a large number of species and this number decreases as salinity increases since few species can tolerate high salinities, Most marine-derived, hypersaline environments can be divided into four classes based on salinity and organism distribution as shown below:

Salinity (ppt)	Biotic character
60-100	Diverse biota of marine origin
100-140	Halophitic and halotolerant organisms
140-300	Phototrophic and non-phototrophic bacteria
> 30	Microscopic organisms

Thus, reservoir is expected to sustain diverse flora and fauna. However, apart from salinity, their relative abundance would also be controlled by the availability of nutrients for primary producers and DO as well as food for higher organisms.

The water quality data given above indicate that the conditions in the reservoir would promote primary productivity though nitrogen would be a growth-limiting factor. Also, adequate DO levels would be available for higher organisms particularly in the reservoirs. The phyto-pigments and phytoplankton populations with averages in parenthesis in the existing salt works at Mundra are as given below:

Parameter	Reservoir	Condenser	Crystallizer
Phytopigment			
Chlorophyll <i>a</i> (mg/m ³)	3.2-5.9 (4.3)	1.6-5.3 (3.0)	1.1-2.1 (1.4)
Phaeophytin (mg/m ³)	2.2-6.5 (3.5)	1.6-7.4 (4.5)	0.4-1.9 (1.2)
Phytoplankton			
Cell count (no x 10 ³ /l)	84.2-4647 (2381)	885-2746 (1512)	332-2376 (1023)
Total genera (no)	7-13 (9)	5-5 (5)	4-4 (4)
Major genera	<i>Anacystis</i> <i>Spirulina</i> <i>Hemiaulus</i> <i>Holopodium</i> <i>Ankistrodestrus</i> <i>Oscillatoria</i>	<i>Microcystis</i> <i>Spirulina</i> <i>Ankistrodesmu</i> <i>s</i> <i>Anabaena</i> <i>Oscillatoria</i>	<i>Microcystis</i> <i>Spirulina</i> <i>Ankistrodesmu</i> <i>s</i> <i>Oscillatoria</i>

These results suggests good primary productivity in the reservoirs with fair species diversity. Even condensers and crystallizers sustain fairly high and moderate concentration of chlorophyll *a* respectively with moderate species diversity and good number of phytoplankton cells. The prevailing phytoplankton production supports fairly high zooplankton productivity with good species diversity particularly in the reservoirs. The standing stock of zooplankton, however decreases from the reservoir to crystallizer, as expected and the details are shown below.

Parameter	Reservoir	Condenser	Crystallizer
Biomass (ml/100 m ³)	160-800 (480)	20-300 (120)	24-80 (45)
Population (no x 10 ³ /100 m ³)	2.0-151 (76.5)	15-102 (45.7)	2-7.4 (3.9)
Total groups (no)	3-11 (7)	2-7 (4)	3-5 (4)
Major groups	Copepods Cladocera Decapods Gastropods Fish eggs Mysids <i>Acetes</i> sp.	Insect larvae Foraminifera Copepods Decapods Polychaetes <i>Artemia</i>	Insect larvae Copepods Decapods Mysids Gastropods

Copepods formed the predominant zooplankton group in the reservoir. Some copepod species like *Acartia southwelli*, *Bestiola similis*, *Oithona* sp. and *Mesochara* are tolerant to high salinities. Two new species of copepods namely *Pseudodiaptomus pankajus* and *Acartia (Euacartia) Sarojus* have been reported from the saltpans at Singach near Jamnagar respectively during 1992 and 1994.

The saltpans at Mundra were however devoid of macrobenthos. One of the reasons could be that the sampling was done a few days after the levelling of the bed of the reservoirs. The post-leveling period was perhaps not enough for benthic fauna to settle and establish.

Available information nevertheless, indicates that macrobenthic fauna do occur atleast in reservoirs and survive upto a salinity of 100 ppt.

Though salt works affect certain species like Plovers and Sandpipers, they support some bird populations particularly during monsoon (off season for salt works). Fish eating birds are generally benefited from salt works.

No piscivore species is recorded in the study sites. On the other hand, survey in two salt works recorded 25 and 27 species respectively. Out of 6 threatened species recorded on the whole, species like Flamingo (*Phoenicopterus ruber*), Lesser Flamingo (*P. minor*), Dalmatian Pelecan (*Pelecanus cripus*) and Eurasian Spoon Bill (*Platalea leucorodia*), were recorded only from the existing salt works. In fact, salt works are usually important for birds, for feeding and breeding and also acts as an alternative site for roosting during high tide.

Most of the available informations on saltpans are associated with culturing, occurrence and ecology of *Artemia*. Availability of *Artemia* in Gulf was first reported in 1979. Availability of *Artemia* cysts in salt condensers of Jamnagar and Kutch districts is limited to the premonsoon period. Procedure for simulated saltpan system, its design, *Artemia* inoculation, pan management and cyst collection have been reported in 1990.

The biological production potential of the saltpan is a positive index for utilizing such unique systems for culture of fish and prawns. Importance and viability of saltpans for aquaculture were tested and methodology to transfer the technology of prawn farming in saltpans has already been proposed.

4.2. Creek systems

The creek systems connected to the Little Rann of Kachchh have been extensively studied. Data available are for Kandla creek, Nakti creek, Sara creek, Phang creek, Chach creek, Chotta Kuttathuki and Hansthal creek. Kandla creek is among the major drainage routes to the Little Gulf of Kachchh. The high tidal influence and flat land topography results in inundation of vast nearshore areas. Sara and Phang creeks are the tributaries to Kandla creek which in turn form an intricate net work of tidal channels inland (Fig. 4.2.1). Nakti creek, another important tributary to the Gulf also joins Kandla creek at the confluence of Sara and Phang creeks.

Bacteria

Kandla creek: It is evident from Table 4.2.1 that TVC in Kandla creek are fairly high (av. 9.1×10^3 /ml) while average level of TC is 42/ml. Populations of VLO, ECLO, PKLO, VCLO, SFLO and SHLO are common in the creek. VPLO, SLO and PALO are absent or present in very low numbers. At these concentrations the chances of pathogenic bacterial contamination of seafood is low, though their presence suggests possible low-level contamination by sewage. TVC in sediment (av. 122.8×10^2 /g dry wt.) are almost of the same order as in water perhaps due to low organic matter in sediment of Kandla creek. Also, the sediment associated pathogen like bacteria are restricted to a few types.

Nakti creek: TVC and TC in water indicate low values of 219 and 69/ml. SLO, PKLO, VPLO and SFLO are absent while others are present in low numbers (Table 4.2.1). TVC and TC in sediments are very high compared to water.

Sara creek: TVC values range from $1.9 - 3.5 \times 10^4$ /ml (av. 2.7×10^4 /ml) and the recorded value of TC on an average is 35 ml/l. PALO, SHLO and SLO are not observed. TVC and other type of bacteria in sediment are in much lower level as compared to the water (Table 4.2.2).

Phang creek: Ranges in TVC and TC are respectively, $40 - 1.2 \times 10^5$ (av. 13.5×10^3) and 7-55 (28)/ml. SHLO, SLO and PALO are absent in water or present in low numbers. TVC level in sediment is lower than that in water (Table 4.2.2). Coliforms and pathogens are not detected from the sediment.

Phytoplankton

Kandla creek: As shown in Table 4.2.3 chlorophyll *a* values in Kandla creek at the surface (0.1 – 4.3, av. 1.6 mg/m³) and bottom (0.1-4.3, av. 1.4 mg/m³) are comparable. Levels of chlorophyll *a* between 1986 and 1998 indicates almost stable levels. Phaeophytin values are comparable with chlorophyll *a* and the average levels for surface and bottom are respectively 1.8 and 1.2 mg/m³. Cell count is moderate with marginal difference between surface (av. $40.2 \times 10^3/l$) and bottom (av. $31.1 \times 10^3/l$). Number of genera in the collection varies between 2 and 15 (av. 7) with a record of 26 genera for the creek area (Table 4.2.4). *Coscinodiscus*, *Thalassiosira*, *Thalassiothrix*, *Nitzschia*, *Melosira* and *Fragilaria* are the most common genera in the area.

Nakti creek: A single set of observations are made and the results are given below.

Parameters	Level	March 1997
Chlorophyll <i>a</i> (mg/m ³)	S	0.5-2.0 (0.8)
	B	0.5-1.6 (1.1)
Phaeophytin (mg/m ³)	S	0.2-4.2 (1.5)
	B	0.2-2.1 (1.2)
Cell count (no.X 10 ³ /l)	S	391.0-1659.0 (809.0)
	B	181.2-792.0 (520.0)
Total genera (no.)	S	7-16 (11)
	B	7-12 (9)
Major genera	S	<i>Thalassiosira</i> , <i>Fragilaria</i> , <i>Nitzschia</i> , <i>Gyrosigma</i> , <i>Hemiaulus</i>
	B	<i>Thalassiosira</i> , <i>Fragilaria</i> , <i>Nitzschia</i> , <i>Thalassionema</i> , <i>Thalassiothrix</i> , <i>Gyrosigma</i> , <i>Coscinodiscus</i>

Chlorophyll *a* values indicate the low productivity of this creek. However, cell count suggests existence of a moderate phytoplankton community. The creek has diverse phytoplankton fauna and a total of 8 groups. The most common species are *Thalassiosira*, *Fragilaria* and *Nitzschia*.

Sara creek: The details of observations done in 1998 are given below.

Parameters	Depth	February 1998
Chlorophyll <i>a</i> (mg/m ³)	S	1.1-1.6 (1.4)
	B	0.5-2.1 (1.3)
Phaeophytin (mg/m ³)	S	0.1-1.4 (0.8)
	B	1.3-1.6 (1.5)
Cell count (no.X 10 ³ /l)	S	20.5-29.9 (25.2)
	B	19.2-34.5 (26.9)
Total genera (no.)	S	9-9 (9)
	B	5-13 (9)
Major genera	S	<i>Melosira</i> , <i>Nitzschia</i> , <i>Coscinodiscus</i> , <i>Thalassiothrix</i>
	B	<i>Nitzschia</i> , <i>Fragilaria</i> , <i>Coscinodiscus</i> , <i>Thalassiothrix</i>

Pigment values are low at the surface as well as the bottom. Cell count is also low in the creek. However the generic diversity is fairly high and the creek supports 14 genera. The most common genera are *Melosira*, *Nitzschia*, *Fragilaria* and *Coscinodiscus*.

Phang creek: Levels of chlorophyll *a* in the surface and bottom do not show any variation (0.5 – 2.1 mg/m³). There is slight enhancement in chlorophyll *a* from 1986 to 1996 (Table 4.2.5). Seasonal variation during 1986-87 shows relatively higher concentration (av. 1.6 mg/m³) during premonsoon period. Cell count is low at the surface (av. 28.7 x 10³/l) as well as bottom (av. 21.2 x 10³/l). Generic diversity varies from 3-10 (av.6) and the total number of genera reported from the area is 14. *Thalassiosira*, *Coscinodiscus*, *Nitzschia*, *Fragilaria* and *Melosira* predominated the area.

Other creeks: Only phytoplankton pigment values are available for Chach creek, Chotta Kuttathuki and Hanstal creek (Table 4.2.6). The average levels of chlorophyll *a* in the surface for Chach creek, Chotta Kuttathuki and Hanstal creek are respectively 1.6, 1.5 and 1.8 mg/m³. Average values of phaeophytin in the same order are 2.9, 1.6 and 0.8 mg/m³. Seasonal variation in pigments suggests relatively higher values for the monsoon period except at Hansthal creek where the maximum values are for the postmonsoon period. During November 1986 swarming of the algae *Microcystis litoralis* (Cyanophyceae) was observed at the above 3 creeks, Kandla creek and Phang creek.

Zooplankton

Kandla creek: From the Table 4.2.7 it is evident that Kandla creek supports high standing stock in terms of biomass (0.5 – 163.7, av. 37.4 ml/100 m³) but moderate values for population density (0.9 – 217.6, av. 22.6 X 10³/100 m³). Seasonal variation during 1986 shows unusually high biomass during the postmonsoon period (av. 109.9 ml/100 m³). From 1996 onwards there is considerable reduction in zooplankton biomass and this trend is at a much lower rate for population density. Faunal group diversity is moderate (5-10, av. 9). A total of 18 groups are reported from the area (Table 4.2.8.). The most common groups are copepods, decapods and chaetognaths.

Nakti creek: The details given below are based on a single series of collection for Nakti creek.

Parameters	March 1997
Biomass (ml/100m ³)	1.6-71.9 (19.9)
Population (no.X10 ³ /100m ³)	19.8-189.2 (89.3)
Total groups (no.)	6-10 (9)
Major groups	Copepods, decapods, chaetognaths, <i>Acetes</i> , gastropods

Zooplankton biomass and population are high with moderate group diversity suggesting good secondary production potential of the area. The total groups found in the area are 10 with dominance of copepods and decapods.

Sara creek: The data given below show that Sara creek supports only moderate zooplankton standing stock but maintains a fairly high diverse faunal assemblage. The total number of groups present in the area is 11 with predominance of copepods and decapods.

Parameters	February 1998
Biomass (ml/100m ³)	4.3-13.9 (9.1)
Population (no.X10 ³ /100m ³)	24.8-38.4 (31.6)
Total groups (no.)	8-11 (10)
Major groups	Copepods, decapod larvae, chaetognaths

Phang creek: The area has a fairly good standing stock of zooplankton biomass (2.3– 78.7, av. 15.2 ml/m³), but with moderate population density (1.6-37.9, av. 18.4 x 10³/100 m³). Seasonal variation during 1986-87 reveals the low zooplankton production during the monsoon (av. 7.4 ml/100 m³) as compared to postmonsoon (av. 31.3 ml/100 m³) and premonsoon period (av. 30.1 ml/100 m³). However population density is maximum during the monsoon period of 1986 (Table 4.2.9). During 1996 and 1998 biomass values has drastically reduced (av. 2.3 ml/100 m³) and the same trend is observed also for population. Group diversity is low (4-11, av.7). Number of groups represented in the area is 12 and the dominant groups are copepods and decapods.

Other creeks: Zooplankton biomass on an average at Chach creek, Chotta Kuttathuki and Hansthal creek are respectively 40.7, 8.6 and 30.4 ml/100 m³ (Table 4.2.10). The population density for these creeks in the respective order is 50.2, 19.1 and 13.7 x 10³/100 m³. Maximum biomass is noticed during monsoon period at Chach creek whereas at the other two creeks, highest standing stock is observed during postmonsoon period. At Chach creek during monsoon period unusual congregations of the crustaceans *Streptocephalus*, *Dichotomus*, *Caenestheriella indica* and cladocerans often contributed 90% to the total population.

Larval population: Prawns/ shrimp larvae (Decapoda) and fish larvae have been identified from the creek environments and the details are given in Table 4.2.11. Shrimp population varies from 3-548 (av. 95)/100 m³ in the creeks. Maximum population is seen at Chotta Kuttathuki in August 1986. Maximum population density of shrimps is observed during monsoon than other seasons. The creek environment supports larval stages of economically important species of prawns. The most common species are *Metapenaeus affinis*, *M. kutchensis*, *Acetes indicus* and *Exopalaemon styliferus*.

Variation of fish larvae in the creek is from 0-1224 (av. 240)/100m³. Fish larvae are maximum during premonsoon followed by monsoon period. Kandla creek shows the lowest incidence of fish larvae while Phang creek supports the maximum population. The most common species are *Boleophthalmus glaucus*, *Engraulis mystax* and *Clupeid* sp.

Benthos

Kandla creek: Intertidal macrobenthic biomass and population vary at a rate of 0.02-112.3 (av. 5.8) g/m² and 0-4774 (av. 759)/m² registering a low potential for the area (Table 4.2.12). Relatively high standing stock is observed during postmonsoon period. Faunal group diversity varies from 4-12 (av. 9). The list of intertidal macrobenthic groups found in the Kandla creek is given in Table 4.2.13 and 25 groups are recorded from the area. The most common groups are polychaetes, amphipods, crabs and mysids.

Subtidal macrobenthic biomass (0-9.8, av. 0.9 g/m²) and population (0-2601, av. 413/m²) are very low with lowest production during the monsoon period (Table 4.2.14). There is enhancement in benthic production during 1996 to 1998 as compared to 1986-87. Faunal diversity is low (0-8, av. 3) and the total number of groups found in the area are 22 (Table

4.2.15). The common groups recorded are polychaetes, foraminiferans, crustaceans and brachyurans.

Nakti creek: The distribution pattern of intertidal macrobenthos in the Nakti creek is shown below.

Parameters	March 1997
Biomass (g/m ² wet wt.)	0.01-0.5 (0.3)
Population (no./m ²)	11-44 (24)
Total groups (no.)	3-4 (3)
Major groups	Fish larvae, brachyurans, macrurans, insects

The creek sustains very low intertidal macrobenthic standing stock and faunal diversity. A total of 4 groups are reported for the area. The most common groups are fish larvae and macrurans.

Details of subtidal Macrofauna of Nakti creek are given below.

Parameters	March 1997
Biomass (g/m ² wet wt.)	0.2-2.2 (0.9)
Population (no./m ²)	63-315 (151)
Total groups (no.)	2-6 (4)
Major groups	Polychaetes, brachyurans, insects

The subtidal macrobenthic standing stock is higher as compared to the intertidal values. Faunal diversity, however, does not show much variation between the two habitats. The total subtidal faunal groups reported for the area is 9 and the common groups are polychaetes and brachyurans.

Sara creek: The details of subtidal macrobenthos of this creek are as shown below.

Parameters	February 1998
Biomass (g/m ² wet wt.)	3.2 (3.2)
Population (no./m ²)	1876 (1876)
Total groups (no.)	4 (4)
Major groups	Polychaetes, brachyurans

Biomass and population of macrobenthos are low. The total groups found are 4 and polychaetes formed the predominant group.

Phang creek: Table 4.2.16 shows the very low potential of subtidal macrobenthos in terms of biomass (< 0.02 – 0.8, av. 0.5 g/m²) and population (6-415, av. 133/m²) at Phang creek. Faunal diversity varies from 1-6 (av. 2) and a total of 6 groups are found in the area. The dominant groups are polychaetes and pelecypods.

Other creeks: Results of studies done for Chach creek, Chotta kuttathuki and Hansthal creek are given in Table 4.2.17. All these creeks show low subtidal macrobenthic production. The recorded biomass for Chach creek, Chotta kuttathuki and Hansthal creek are respectively 0.13, 0.02 and 0.08 g/m² while the population in the same order is 91, 26 and 49/m². Faunal diversity is also low and comparable between creeks. The common groups in the three creek systems are polychaetes and crustaceans.

Fishery

Trawling or gill netting for fish is difficult and risky in Kandla creek due to high tidal movements and strong currents. Hence, large scale commercial operations are not conducted in the area except for shore based hand-net and gill net operations. Trawling is difficult also in other creek environments of the inner Gulf.

Kandla: Details of experimental trawling and gill netting done at Kandla are given in Table 4.2.18. During 1986-87 maximum trawl catch is during premonsoon period (13.1 kg/h) as compared to postmonsoon (8.2 kg/h) and monsoon (1.2 kg/h). However, catch rate in February 1998 is low (av. 2.2 kg/h). Species diversity varied from 19-26 (av. 23). The species list for the area shows the presence of 59 species (Table 4.2.19). The common species are *Chiloscyllium arabicum*, *Lepturacanthus savala*, *Ilisha metastoma*, *Otolithoides biauritus*, *Pampus argenteus*, *Harpodon nehereus*, *Parapenaeopsis hardwickii* and *Exopalaemon styliferus*.

Gill net catch rate is low (0.6 – 1.2 kg/h) with maximum during the postmonsoon period. Species diversity is low (2-8, av. 5). The common species are *Pampus argenteus*, *Polynemus tetradactylus* and *Harpodon nehereus*.

Nakti creek: Gill net catch data for this creek is given below.

Parameters	March/April 1997
Fish catch (Kg/h) (Gillnet)	4.4 (4.4)
Total species (no.)	Fishes 3 (3) Prawns 3 (3)
Common species	Fishes: <i>Lagocephalus</i> sp., <i>Escualosa thoracata</i> , <i>Ilisha</i> sp. Prawns: <i>Parapenaeopsis stylifera</i> , <i>Exopalaemon styliferus</i> , <i>Metapenaeus</i> sp.

The catch rate is low and species diversity is also low. The common species in the area are *Lagocephalus* sp. *Escualosa thoracata* and *Parapenaeopsis stylifera*. The total number species reported from the area is 6.

Phang creek: This creek shows very low potential during trawling (0.7 – 1.3 kg/h) as well as gill netting (0.2-0.4 kg/h). The species diversity for trawl catch varies from 6-10 (Table 4.2.20) and the common species found in the creek are *Johnius glaucus*, *Acetes indicus*, *Parapenaeopsis hardwickii* and *Exopalaemon styliferus*. Species present in the gill net catch is low also (2-4) and the dominant species are *Carcharias laticaudus* and *Johnius semiluctuosus*. 17 species are observed in the creek.

Chach creek: This creek also shows very low catch rate (Table 4.2.21). Trawl catch is relatively high for the monsoon period (9.9 kg/h) as compared to the very low values of other two seasons. Species diversity is also more for the monsoon period (18). The common species in the area are *Tachysurus maculatus*, *Harpodon nehereus*, *Parapenaeopsis hardwickii* and *Exopalaemon styliferus*.

Gill net catch varies from 0.5-1.5 kg/h with a maximum catch during the monsoon period. A total of 22 are recorded from the creek and the common species found are *Johnius semiluctuosus*, *Carcharias laticaudus*, *Engraulis mystax* and *Harpodon nehereus*.

Hansthal creek: Details of trawling and gill netting are given in Table 4.2.22. Moderately high catch in this creek is seen during the premonsoon period (12.7 kg/h) than postmonsoon (2.7 kg/h) and monsoon period (1.6 kg/h). Total number of species present in the area is 56. The dominant species are *Harpadon nehereus*, *Trygon walga* and *Parapenaeopsis hardwickii*.

Gill netting data are available only for premonsoon (1.3 kg/h) and postmonsoon period (0.5 kg/h). The total number of species in the area amounts to 6. The most common species are *Johnius belangeri*, *Engraulis mystax* and *Tachysurus maculatus*.

Monsoon fishery of inner creek area: Penaeid larvae are abundant in the inner creek only during the monsoon period. The relatively low salinity of the creeks during July-September coupled with rich supply of planktonic organisms provides good nursery ground for the different larval stages of the prawns. The influx of rainwater into the Little Gulf of Kachchh and the tidal ingress of seawater facilitated migration of juveniles of prawns to this region where they grow to marketable size within 3 to 4 months. State Fisheries of Gujarat has reported on this fishery as a "Boon to fisher folk". Undoubtedly, this seasonal backwater fishery off Surajbari is important for nearby artisanal fishermen. The fishing season begins in July and lasts up to October every year depending on the monsoon spell and the influx of freshwater. Prior to this fishing season (June-July) the fishermen are engaged in Hilsa fishery. Since fishery here is mainly dependent on the rain, failure of monsoon may affect the seasonal prawn fishery of the area.

4.3. North - south sector

During February to March 1997 a north-south sector of the Gulf between Luni in the north and Sikka in the south was studied in detail. This investigation covers the south, middle and northern part of the Gulf providing data for the same period to make a comparative evaluation on the north – south variability.

The locations of sampling are shown in Figure 4.3.1. Stations S1, S2, S3 are considered as southern, M1, M2, M3 as middle and N1, N2, N3 as northern segment.

Bacteria:

It is evident from Table 4.3.1 that though TVC in water are low along the southern (av. 112/ml) and the northern (av. 91/ml) segment, relatively higher levels prevail in mid-Gulf (440/ml). However, the observed TVC is of the order expected for coastal waters, under moderate human impact and indicates a weak anthropogenic influence. The observed TC values in water are relatively low at the northern Gulf (av. 7/ml) as compared to middle Gulf (av. 18/ml) and southern Gulf (av. 19/ml). The average TC values in the sediment in the same order are 9.2, 1.0 and 0.2 X 10²/ml suggesting enhancement in sediment compared to their levels in water. Total SHLO, VLO, VCLO, SFLO are common at all the segments while ECLO, SLO, VPLO and PALO are absent or present in low numbers and restricted in their distribution. At these concentrations the chances of pathogenic bacterial contamination of seafood is low.

TVC in sediment is high (Table 4.3.1) and the average values for northern, middle and southern Gulf are respectively 39.5 x 10⁴, 15.2 x 10⁴ and 5.9 x 10⁴/g dry wt. This is due to the occurrence of relatively high organic matter in sediment which favours microbial growth. However, sediment associated bacteria are in general restricted to a few types all along the transect.

Phytoplankton

The concentration of chlorophyll *a* all along the transect is low for surface as well as bottom (Table 4.3.2) with marginal difference between northern (av. 1.0 mg/m³), middle (av. 1.3 mg/m³) and southern (0.9 mg/m³) Gulf. Phaeophytin follows the same trend like that of chlorophyll *a*. The cell count at the bottom is higher than surface at the northern and middle Gulf while cell count is more at the surface in the southern Gulf. Average cell count for the water column shows maximum count for northern (av. 209 x 10³/l) as compared to the middle (av. 140.1 x 10³/l) and southern (92.5 x 10³/l) Gulf. The area is quite diverse in phytoplankton genera except in the southern Gulf. The average number of groups represented in these collections are respectively 14, 10 and 6 for northern, middle and southern Gulf. Total number of genera for each segment in the above order is 22, 21 and 16 (Table 4.3.3). The most common genera of the northern segment are *Nitzschia*, *Skeletonema*, *Rhizosolenia* and *Thalassiosira*. *Nitzschia*, *Skeletonema*, *Thalassiosira* and *Coscinodiscus* predominate the middle Gulf. The most common genera for the southern Gulf are *Skeletonema*, *Nitzschia*, *Thalassiosira* and *Thalassistrix*.

Zooplankton

Variations in zooplankton biomass at the northern, middle and southern Gulf are respectively 3.3-17.3 (av. 9.0) ml/100 m³, 0.4–97.3 (21.2) ml/100 m³ and 1.5-17.9 (av. 5.6) ml/100 m³ (Table 4.3.4). Zooplankton population density is marginally higher at middle Gulf (av. 38.5x10³/100 m³) as compared to southern Gulf (av. 37.1x10³/100 m³) while the average value is relatively low for the northern Gulf (24.9 x 10³/100 m³). Total groups represented in the collections are comparable between segments (av. 10-12). Copepods, decapods, ostracods and chaetognaths predominated the southern and middle Gulf. However along the southern segment decapods, copepods, fish larvae and chaetognaths predominated. Faunal groups of zooplankton represented at different zones of the Gulf are given in Table 4. 3.5.

Benthos

Subtidal macrobenthic biomass is very high along the southern segment (6.4-116.0, av. 43.3 g/m²) supported by high population density (3153-22400, av. 11201/m²). Benthic biomass is moderate at the northern section (av. 8.9 g/m²) while population (av. 7842/m²) is fairly high (Table 4.3.6). The middle Gulf sustains relatively low biomass (av. 2.8 g/m²) and population (av. 3408/m²). Faunal diversity of macrobenthos is comparable at all the three segments (av. 10-12). Total number of groups reported from the northern Gulf is 16 (Table 4.3.7) and the predominant groups are nematodes, polychaetes, copepods and isopods. Major groups of middle Gulf are foraminiferans, polychaetes, ostracods and copepods registering a total of 13 groups. From the southern Gulf 18 groups have been identified and the common groups are coelenterates, polychaetes, amphipods and ophiuroids.

Fishery

Experimental trawlings done along the three segments show that the northern Gulf is more productive with an average catch rate of 21.6 kg/h as compared to the southern segment (6.8 kg/h) and middle Gulf (av. 6.0 kg/h) (Table 4.3.8). Total number of species at the southern, middle and northern Gulf are respectively 19, 13 and 12 (Table 4.3.9). The most common species at the southern Gulf are *Pampus argenteus*, *Thryssa mystax*, *Coilia dussumieri*, *Harpadon nehereus* and *Metapenaeus* sp. *Scoliodon laticaudes*, *Lepturacanthus savala*, *Harpadon nehereus*, *Coilia dussumieri* and *Metapenaeus* sp. are common at the middle Gulf. The predominant species of the northern segment are *Scoliodon laticaudes*, *Harpadon nehereus*, *Bempros* sp., and *Exhipolysmata*.

A comparison between the three zones of the Gulf indicates only marginal difference in biological production potential, probably due to limited observation. Chlorophyll *a*

concentration shows marginal enhancement in the middle Gulf. Cell count as well as generic diversity are more at northern Gulf which gradually decreased to southern segment. Zooplankton standing stock in terms of biomass and population are more at the middle zone. Benthic standing stock as well as faunal diversity are maximum along the southern Gulf followed by northern Gulf. Catch rate of fish is more at northern sector, but species diversity is more at southern zone. Community of benthos and fishes indicate difference between sectors.