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of
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CONTENTS

1. DISTRIBUTION OF ZOOPLANKTON IN UPPANAR BACKWATERS OF CUDDALORE, SOUTHEAST COAST OF INDIA 1-7
G. Ananthan, P. Sampath Kumar, P. Soundarapandian and L. Kannan
2. EFFECT OF THE PHARMACOLOGICALLY ACTIVE SUBSTANCES FROM THE VENOM OF CONUS ZEYLANICUS 9-14
D. Annadurai, R. Kasinathan and P.S. Lyla
3. A PRELIMINARY REPORT ON THE DIVERSITY OF THE VENOMOUS MARINE CONE SNAILS FROM TAMIL NADU COAST 15-19
D. Annadurai, R. Kasinathan and V. Ravi
4. DIVERSITY OF PERCHES ALONG THE CORAMONDAL COAST AND IT'S ECONOMIC VALUATION 21-39
A. Anrose, K.N.V. Nair and S. Ramachandran
5. DECLINE OF COASTAL BIRDS ALONG THE SOUTH-EAST COAST OF INDIA 41-51
S. Balachandran
6. BRACHYURAN BIORESOURCES OF COASTAL ANDHRA PRADESH 53-66
M.K. Dev Roy and N.C. Nandi
7. BENTHIC POLYCHAETES OF TAMIL NADU COAST 67-88
Olivia J. Fernando and R. Rajasekaran
8. ECONOMIC VALUATION OF MARINE BIODIVERSITY
A CASE OF MANGROVES IN GUJARAT 89-116
Indira Hirway and Subhrangsu Goswami
9. DISTURBANCES TO CORAL REEF COMMUNITIES OF ANDAMAN & NICOBAR ISLANDS 117-124
R. Jeyabaskaran
10. JELLYFISH POPULATION OUT BREAKS-A REVIEW 125-128
G. Kanagaraj, P. Sampathkumar and G. Ananthan
11. NESTING BIOLOGY OF GREEN AND OLIVE RIDLEY TURTLES ALONG THE SAURASHTRA COAST, GUJARAT AND IMPACT OF INCIDENTAL CATCH ON THE NESTING POPULATIONS 129-137
P. Kannan and M. Rajagopalan
12. IMPACT OF INCIDENTAL CATCH ON DOLPHINS IN VIZHINJAM, SOUTH WEST COAST OF INDIA 139-143
P. Kannan and M. Rajagopalan

13. BIODIVERSITY AND UTILIZATION OF BRACHYURAN CRABS OF THE
EXCLUSIVE ECONOMIC ZONE OF INDIA 145-160
M. Kathirvel, A. Gokul and P. Thirumilu
14. INDIAN PENAEID SHRIMPS-THEIR BIODIVERSITY
AND ECONOMICAL VALUES 161-176
M. Kathirvel, P. Thirumilu and A. Gokul
15. BIODIVERSITY AND ECONOMICAL VALUES OF INDIAN LOBSTERS ... 177-200
M. Kathirvel, P. Thirumilu and A. Gokul
16. DISTRIBUTION AND ABUNDANCE OF PHYTOPLANKTON
ALONG WEST COAST OF INDIA 201-218
O. S. Kotiwar
17. BIODIVERSITY OF EPIFAUNA ASSOCIATED WITH SARGASSUM SP.
AROUND KUDANKULAM NUCLEAR POWER PROJECT,
EAST COAST OF INDIA 219-230
Y. Leninraj, S. Satheesh and S. Godwin Wesley
18. CONSERVATION STRATEGIES AND SUSTAINABLE USE OF MARINE
BIODIVERSITY FOR COASTAL SOCIO-ECONOMIC
DEVELOPMENT IN INDIA 231-241
P. Nammalwar, V. Sundararaj, K. Pukazhendhi and T.D. Babu
19. STATUS OF INDIAN MANGROVES AND THE LEGEND OF MANGROVE
RESTORATION IN GUJARAT 243-253
Oswin D. Stanley
20. STUDY OF DIATOMS OF NANDGAON AND DAHANU COAST
FROM KONKAN REGION, NORTH WEST MAHARASHTRA 255-285
Shilpa P. Patel and G. Ragothaman
21. OBSERVATION ON THE DISTRIBUTION AND ABUNDANCE OF TUNA
RESOURCES IN THE EXCLUSIVE ECONOMIC ZONE
(EEZ) OF ANDAMAN & NICOBAR ISLANDS 287-299
P. Paul Pandian, A.B. Kar, M.K. Sinha and S.K. Pattnayak
22. EFFECT OF EARTHQUAKE AND TSUNAMI ON MARINE
FAUNAL DIVERSITY OF ANDAMAN & NICOBAR ISLANDS 301-307
D.V. Rao
23. INVESTIGATION ON IMPOSEX IN DIFFERENT SPECIES OF
NEOGASTROPODS ALONG THE INDIAN COAST 309-329
C. Raghunathan, A. Tewari and Yasmin Khambhaty
24. BIODIVERSITY OF CRABS IN PICHAVARAM
MANGROVE ENVIRONMENT 331-340
S. Ravichandran and T. Kannupandi

25. SEASONAL DISTRIBUTION OF BIOFOULING COMMUNITIES IN
KUDANKULAM WATERS EAST COAST OF INDIA 341-349
S. Satheesh, and S. Godwin Wesley
26. INDIAN MARINE SPONGES–THEIR BIODIVERSITY AND
CONSERVATION 351-358
G. Sivaleela and K. Venkataraman
27. OBSERVATIONS ON THE CHANGES IN FISHERY RESOURCES STRUCTURE
IN RELATION TO TSUNAMI ALONG THE TAMIL NADU COAST 359-363
**P. Sivaraj, J.C. Dhas, L. Ramalingam, V. Sivaji, K. Govindaraj,
P. Tamilarasan, G. Nagarajan, G.V.A. Prasad, H.D. Pradeep and M.U.
Veeresh**
28. BIRDS DIVERSITY OF MUTHUPET MANGROVES SOUTHEAST
COAST OF INDIA 365-377
C. Sivasubramanian
29. GASTROPOD DIVERSITY ON THE CHENNAI COAST 379-386
R.J. Ranjit Daniels
30. SEAWEED DIVERSITY CULTURE AND CULTIVATION 391-393
P.V. Subba Rao
31. DIVERSITY OF COMMERCIALY IMPORTANT FISHERY RESOURCES OF
TAMIL NADU COAST 395-415
**M.U. Veeresh, V. Sivaji, P. Sivaraj, H.D. Pradeep,
J. C. Dhas and G.V.A. Prasad**
32. SEA SNAKES OF CHENNAI COAST, SOUTHERN INDIA 417-421
C. Venkatraman, J.T. Jothinayagam and C. Raghunathan
33. MOLLUSCAN FAUNA OF PULICAT LAKE, TAMIL NADU,
SOUTHERN INDIA 423-427
C. Venkatraman and J. T. Jothinayagam
34. THREATS TO CORAL REEFS AND A PREVENTIVE CONSERVATION
STRATEGY FOR INDIAN REEFS..... 429-445
Ch. Satyanarayana

DISTRIBUTION OF ZOOPLANKTON IN UPPANAR BACKWATERS OF CUDDALORE, SOUTHEAST COAST OF INDIA

G. ANANTHAN, P. SAMPATH KUMAR, P. SOUNDARAPANDIAN
AND L. KANNAN

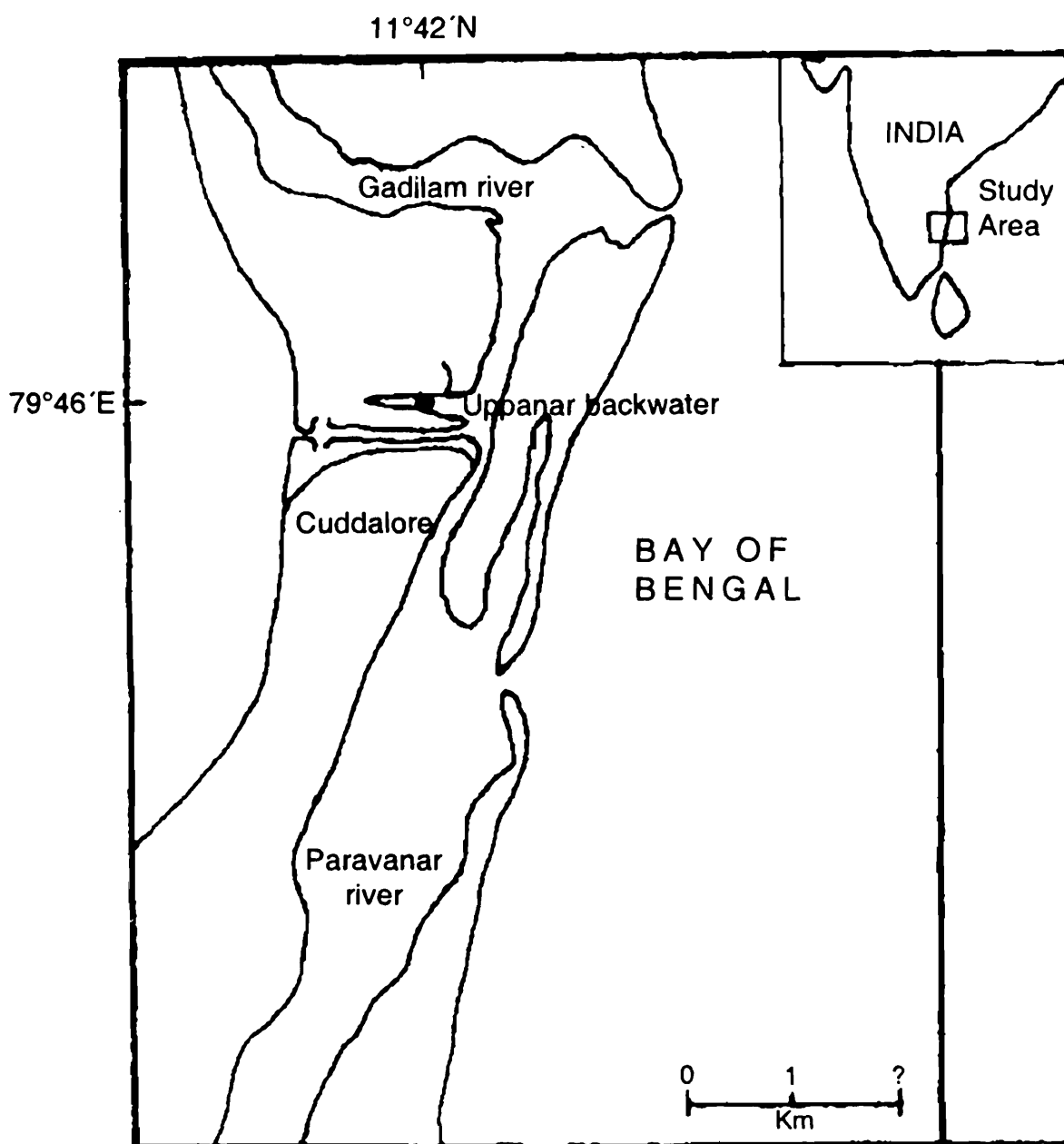
Centre of Advanced Study in Marine Biology Annamalai University, Parangipettai-608 502

ABSTRACT

A total of 28 species of zooplankton were identified from Uppanar backwaters of Cuddalore along South-East Coast of India. A higher population density of copepods was observed during the summer season when the salinity was high and relatively stable. Among the copepods, *Oithona* was the most dominant genus followed by *Eucalanus* and *Acartia*. Temperature and salinity greatly influenced their distribution. The zooplankton population density observed was less compared to the earlier reports from other parts of the South-East Coast of India.

INTRODUCTION

The hydrographical parameters undergo considerable variations due to seasonal climatological changes, which in turn influence the spatial and temporal distribution of planktonic communities (Damodara Naidu *et al.*, 1977; Krishnamurthy and Santhanam, 1975; Asok Prabu *et al.*, 2005). Zooplankton function as intermediate link in the pelagic food- web. They transfer the energy derived from the phytoplankton to the higher trophic levels. Investigation on the species composition, population density and community structure of the zooplankton is necessary to assess the potential fishery resource of a place (Tiwari and Nair, 1991). Species composition and distribution of zooplankton have been well studied from some tropical estuaries of India (Madhupratap, 1987; Sivaswamy, 1990; Ananthan, 1991; Saraswathi, 1993; Krishnakumari and Goswami, 1993; Reddy and Reddeppa Reddi, 1994), (Wellershaus, 1974; Thompson, 1991) and Rambha Bay of Chilka lake, Pattanaik and Sarma, 1997). In the present study an attempt has been made to investigate the seasonal fluctuation of zooplankton in relation to hydrographic features in uppanar backwaters of Cuddalore, South-East Cost of India.



Map showing the study area

MATERIAL AND METHODS

Description of the study area : The present study was made at Uppanar backwaters of Cuddalore (Lat. 11° 42' N; Long. 79° 46' E) (Fig. 1), South-East Coast of India. Cuddalore town has a coastline of 11 Km surrounded with river Gadilam, Paravanar and the Uppanar backwaters. The Uppanar backwaters are widely used as a navigational route by many mechanised and indigenous crafts, as a harbour port. It is situated near their mouth and the sewage from the Cuddalore old town and its industrial complex is discharged into these backwaters. Cuddalore is one of the fishing centers with an annual fish landing of about 3000 tones. The crafts used for fishing at Cuddalore include about 1500 non-mechanised boats, 1000 catamarans and 150 mechanised trawlers.

Zooplankton and water samples were collected from January to December 2005 at monthly intervals from the surface waters of the study areas by horizontal towing of plankton net (0.35 m mouth diameter) made of bolting silk (No.10, mesh size 158 μ M), for half an hour. These samples were preserved in 4% neutralized formalin and used for qualitative analysis. The zooplankton was identified using the classical works of Scott (1909), Wilson (1932), Rose (1933), Dakin and Colefax (1940), Davis (1955), Kasthurirangan (1963) and Wickstead (1965). For the quantitative analysis of zooplankton, a known quantity of water (100 litres) was filtered through a bag net of same mesh size and the numerical plankton analysis was carried out using Utermohl's inverted plankton microscope. Zooplankton species diversity, richness, evenness and dominance indices were calculated by using computer statistical software package, 'ECOSTAT' Standard methods were followed for estimating the various physico-chemical features of the water sample.

RESULTS AND DISCUSSION

Zooplankton recorded in the present study consisted of 28 species (Table 1). The copepods constituted the dominant group and were numerically abundant throughout the study period. Among the copepods, *Oithona* was the most dominant genus followed by *Eucalanus* and *Acartia*. Numerical abundance of copepods was also recorded by different coastal system of India (Jegadeesan 1986; Anbazhagan 1988; Saraswathi 1993). Further, the important factors that controlled the distribution of copepods were rainfall, river discharge and salinity as opined by Bijoy Nandan and Abdul Aziz (1990). Among the larvae, *Pilidium* larva, polychaetes, polydora larva, nephtys larva, fish eggs and larva, bivalve veliger and gastropod veliger were recorded.

Table 1. Checklist of zooplankton species recorded from Cuddalore backwaters

S. No	Name of the species	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
	Ciliata												
1	<i>Tintinnopsis</i> sp.	+	+	-	+		+		-	+	+		
2	<i>Favella</i> sp.	-	+	+	-	+	+		+				
	Chaetognatha												
3	<i>Sagitta enflata</i>	-	-	+	+		-	+		-	+		-
	Cladocera												
4	<i>Evadne tergestina</i>	+	-	-	+	-	+	+	-	-	+		+
5	<i>Podon</i> sp.	+	-		+	-	-	+	+			+	
6	<i>Penilia avirostris</i>		-	+		-	+			+			+
	Ostracoda												
7	<i>Cypridina</i> sp.	-	+	+	-			+	+			+	+

S. No	Name of the species	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
	Decapoda												
8	<i>Lucifer hensani</i>	+	-	-	-	+	-	-	-	-	-	-	-
9	<i>L. reynaudi</i>	-	-	+	-	-	-	-	-	-		-	-
	Copepoda												
10	<i>Eucalanus subcrassus</i>	+	+	-	+	+	+	-	-	+	+		-
11	<i>Acrocalanus gracilis</i>	-	-	+	-	+	-	+	+	-	+		-
12	<i>Paracalanus aculeatus</i>	+	+	-	-	+	-	-	-	+	+	-	-
13	<i>P. parvus</i>	-	+	+	+	-	+	-	+	+	-	+	+
14	<i>Pseudodiaptomus aurivillii</i>	-	+	-	-	+	+	-	-	+	-	-	-
15	<i>Acartia spinicauda</i>	+	+	+	-	+	-	-	-	+	-	+	+
16	<i>Oithona rigida</i>	+	+	+	+	+	+	+	+	+	+	+	+
17	<i>O. brevicornis</i>	+	+	+	+	+	+	+	+	+	+	+	+
18	<i>Corycaeus danae</i>	+	-	-	-	+	-	-	-	-	-	-	-
	Mysidacea												
19	<i>Mesopodopsis</i> sp.	-	+	-	+	-	-	+	-	-	+	-	-
20	<i>Neomysis</i> sp.	+	-	-	+	-	+	-	-	-	+	-	+
	Larva and other forms												
21	<i>Pilidium</i> larva	-	-	-	-	+	-	-	-	+	-	-	-
22	Polychaetes	-	+	-	+	+	-	-	-	-	-	-	+
23	Polydora larva	-	-	-	-	-	+	-	-	+	-	-	-
24	<i>Nephtys</i> larva	-	+	-	+	-	-	-	+	-	-	-	-
25	Fish eggs	+	+	-	-	+	-	-		-	-	+	-
26	Fish larva	-	-	-	-	-	-	-	+	-	+	-	+
27	Bivalve Veliger	+	+	+	-	+	+	+	-	-	-	-	-
28	Gastropod Veliger	-	-	+	+	-	+	-	-	-	+	-	-

In the present study maximum zooplankton density was observed during the summer season and minimum was during the monsoon season (Fig. 1). This is due to the decisive role played by the monsoonal flood, as suggested by Shanmugam *et al.* (1986) and Anbazhagan (1988). Diversity index (H') varied from 2.664 to 3.787. Minimum was recorded during the monsoon season and maximum during the summer season (Table 2).

Maximum species richness (0.921) was recorded during the summer season. During this season, population density of the zooplankton also increased with increasing species richness. Low value (0.828) of species diversity and richness were noticed during the monsoon season in association with low value of population density. Similar trend was observed earlier by Jegadeesan (1986) in the Coleroon estuary.

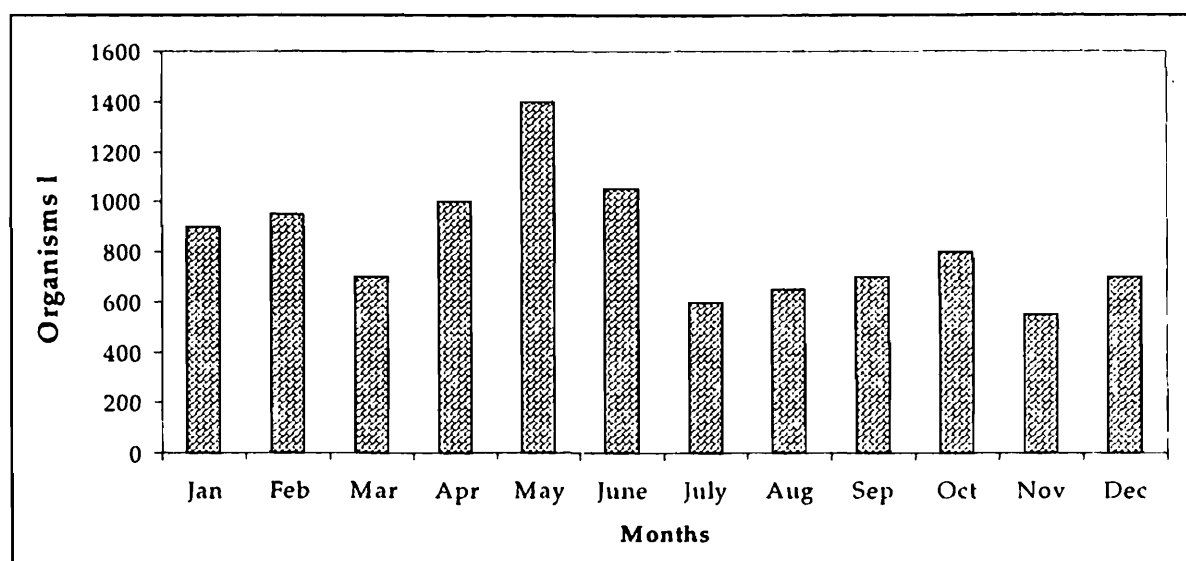


Fig. 1. Monthly variations of Zooplankton Population Density

Table 2. Zooplankton species diversity, richness, evenness and dominance indices during the study period.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug.	Sep	Oct	Nov	Dec
Species Diversity (H')	3.614	3.607	3.522	3.787	3.676	3.499	3.085	3.085	3.379	3.500	2.664	3.236
Species richness (d)	0.915	0.914	0.909	0.921	0.916	0.899	0.876	0.877	0.899	0.907	0.828	0.889
Evenness index (J')	0.977	0.975	0.969	0.982	0.966	0.946	0.973	0.973	0.977	0.976	0.949	0.974
Dominance index (D)	0.085	0.086	0.091	0.079	0.084	0.101	0.124	0.123	0.101	0.093	0.172	0.111

Maximum evenness (0.982) was recorded during the summer season. Population density, species diversity and species richness value were high during the summer season along with high values of evenness index, suggesting the equal distribution of species during this season. During the summer season when the maximum zooplankton population density, species diversity and species richness were observed, the dominance index was low, suggesting the even distribution of the species.

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EFFECT OF THE PHARMACOLOGICALLY ACTIVE SUBSTANCES FROM THE VENOM OF *CONUS ZEYLANICUS*

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ABSTRACT

The predatory cone snails are among the most successful living marine animals and they have developed distinct venoms containing biologically active substance as part of an envenomation survival strategy for feeding and defense. In the present study, muscle relaxant effect of the venom of *Conus zeylanicus* was carried out.

INTRODUCTION

The cone snails consist of a large group of marine molluscs, belonging to the family Conidae of the Class Gastropoda which are found in reef environment throughout the world (Kohn, 1963). The prey is other marine organisms, immobilizing them with their unique venom (Olivera *et al.*, 1985a). The cone snail's venom has long been fascinating researchers because of their greater pharmacological effect, consists of small peptides that are targeted to various neuromuscular receptors, and may be equivalent in their pharmacological diversity as that of alkaloids from plants or secondary metabolites from microorganisms (Olivera *et al.*, 1995). The active components of the venom are small peptide toxins, typically 12 - 30 amino acid residues in length and are highly constrained peptides due to their high density of disulfide bonds (Olivera *et al.*, 1985a; McIntosh *et al.*, 1999). The complement of peptides found in any one of the *Conus* venom is strikingly different from that found in the venom of any other *Conus* species (Olivera *et al.*, 1990). The present work is to establish the muscle relaxant effect of the venom of *Conus zeylanicus* since it is expected to possess similar kind of effect was produced by *C. striatus* venoms (Endean *et al.*, 1976), *C. magus* venom (Kobayashi *et al.*, 1985) upon the guinea-pig ileum and neuromuscular blocking properties of a-conotoxins (Marshall and Harvey, 1990).

MATERIAL AND METHODS

Preparation of venom extract : The *C. zeylanicus* were collected in live condition from the Cuddalore coastal region (Lat. 11° 24' N; Long. 79° 46' E), South East Coast of India. The live cones were cracked in a vice and the soft body of the animal was removed from

their shells. The venom duct and venom bulb of each animal were dissected out by cutting the anterior end of the duct at its junction with the pharynx and the posterior end of the duct at its junction with the bulb and the venom was obtained from venom ducts by placing each duct on an ice-cold metal spatula. Then cutting out of the duct in 2cm segments and then squeezing out the contents with a pair of forceps were done. The collected venom was taken up with distilled water. The extract was then freeze-dried and stored in sealed ampoules. The freeze-dried material was weighed and taken up with 0.9% saline solution following Endean *et al.* (1974 a, b) and Cruz *et al.* (1976).

Rabbit's intestine preparation : This preparation was put up by the method as described by Magnus (1952). The jejunum part of the intestine of 1" length was isolated from the body of a freshly killed rabbit and mounted in an organ path kept at 37°C, constantly perfused with oxygenated Ringer locke solution. Contraction responses were recorded for 5mg dose of acetylcholine and the effect of venom in doses of 0.4mg and 0.6mg was also recorded on a smoked paper fixed in a kymograph.

Frog's rectus abdominus muscle preparation : A frog was pithed and the skin of the anterior abdominal wall was cut by a midline incision and then cut laterally to expose the anterior abdominal wall. The two recti were running from the base of sternum to the base. The sternum was cut across just above the xiphisternum at its base and the pair of muscles attached to it were dissected out and transferred to a dish containing frog Ringer solution at room temperature. They were carefully cleaned, divided (unless they were small), and trimmed to the prescribed size and mounted in an organ bath in frog Ringer solution at the room temperature and aerated. These preparations were equilibrated at passive tension until the steady state was achieved. Stability and viability of these preparations were tested by contraction elicited by acetylcholine (ACh). Graded close responses to acetylcholine (ACh) were recorded, and then venom extracts were added to study the effect of various doses of extract upon acetylcholine induced contraction (Burn, 1904).

Frog's nerve muscle preparation : A frog was pithed and the skin was peeled off around the trunk and at the toes of the hind limb. The frog was then placed on a vertical surface and the skin were cut, the sciatic nerve could be seen converging or emerging from the vertebral column along the gastrocnemius muscle and the tendon of the gastrocnemius muscle was separated by cutting it. A thread was tied around the tendon. The tibia and fibula were cut off above the knee joint. The nerve and muscle were carefully transferred into the bath containing frog Ringer solution. The thread attached to the tendon was hooked to the vertical arms of the writing lever. The materials used in the experiment were a low voltage unit of a simple and short circulating key, an induction coil, frog muscle trough, low resistance wire, tuning fork, stimulating electrodes, kymograph and frog Ringer solution. The recordings of the twitch were done by engaging the kymograph of the fastest speed and activating a key which switches on the short circuit at that moment. The striker just passes the contact lobule and does not open it, but closes it again as the muscle twitch is over. The interval between the point of stimulus and the rise of the curve (latent period) was marked with a tip of writing point. A line was drawn from the summit of curve through the basement by dividing the curve into contraction and relaxation periods. The periods were calculated with the help of time passing using a tuning fork.

RESULTS AND DISCUSSION

Effect of venom upon isolated rabbit's intestine (fig. 1) experiment, the acetylcholine (ACh) at the dose of 5mg induced the contraction effect upon smooth muscle, which was antagonized in the presence of 0.4mg *C. zeylanicus* venom. The induced contraction was further reduced in the presence of 0.6mg venom as in the records. In this experiment, it was conspicuous that the *C. zeylanicus* venom contains d-tubocurarine like principle, which blocks nicotinic receptors (AChRs). Similar kind of effect was produced by *C. magus* and *C. striatus* venoms (Endean *et al.*, 1976). The myotoxin purified from the venom of *C. magus* (Kobayashi *et al.*, 1985) caused relaxation of the guinea-pig ileum following transient and rhythmic contractions of the vas deferens whereas *C. striatus* caused biphasic contraction of the ileum (Kobayashi *et al.*, 1981).

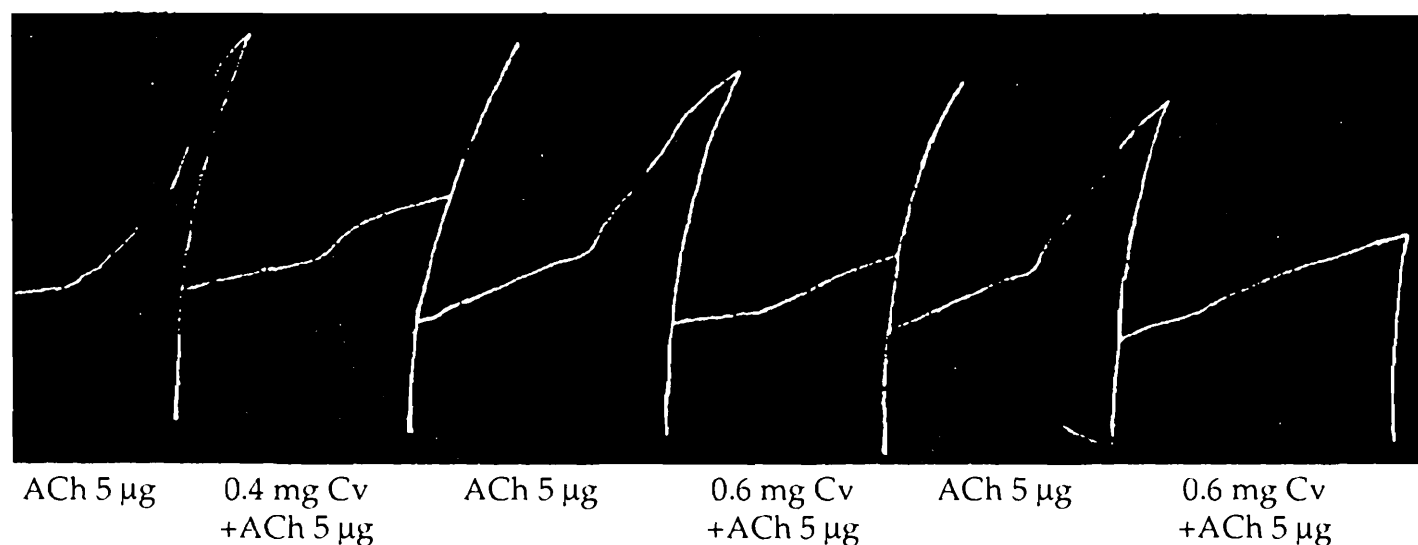


Fig. 1. Effect of *C. zeylanicus* venom upon isolated rabbit's intestine

Frog's rectus abdominus muscle preparation (fig. 2), the recording of the figure shows the normal contraction of the acetylcholine (ACh) and also the contraction of ACh in the presence of 0.6 mg *C. zeylanicus* venom. Neither potentiation nor antagonism was produced by the venom upon ACh produced contraction. From this result it could be understood that the venom could not produce any relaxant effect when applied directly to the muscle. During the nerve muscle preparation experiment, the venom antagonized the extent of contraction only when applied to the nerve. Similar results were obtained from the venom of *C. loroisii* (Saminathan, 1997).

Simple muscle twitch on the electrical stimulation of frog's gastrocnemius muscle, the presence of venom enhanced amplitude of the curve. Further stimulation of the muscle developed fatigue and the amplitude was reduced. There was an increase in the relaxation period of the muscle when treated with *C. zeylanicus* venom as against control. The contraction period decreased with the increase in the concentration of venom at 20 mg, 40 mg and 80 mg, with the simultaneous increase in the relaxation period. The normal simple muscle twitch was recorded using gastrocnemius muscle of the frog with the

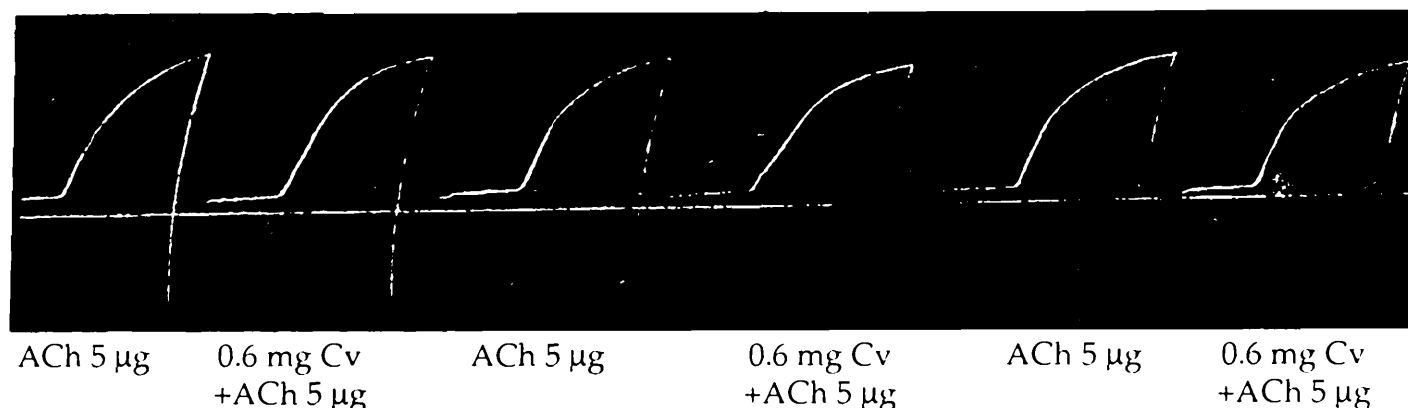


Fig. 2. Effect of *C. zeylanicus* venom upon isolated frog's rectus abdominus muscle

attack of sciatic nerve. The duration of the contraction phase was 0.04 second, then the duration of the relaxation phase 0.04 second. Therefore, the rate of depolarization wave was equal to the rate of repolarization wave. The height of the contraction amplitude was measured about 28 mm and the latent period was 0.02 second (Fig. 3. I). The simple muscle twitch of the nerve muscle preparation of the frog was recorded after the application of 20 mg of the venom to the nerve. The venom treatment was not changed into the latent period, which remained the same (0.02 second). The intensity of the contraction amplitude (the force of contraction) seemed to be reduced from 28 mm to 19 mm that is 32.1% reduction. The duration of contraction phase and relaxation phase increased tremendously. The period of contraction phase was equal to 0.07 second and the period of relaxation phase was equal to 0.12 second. Therefore, the venom increased the rate of depolarization wave by 75% and that of repolarization wave by 200% (Fig. 3a-ii). The venom treatment with 40mg of concentration rapidly reduced the extent of muscle contraction from 28 mm to 14 mm that is 50% reduction. The duration of contraction phase was 0.045 second and that of relaxation phase 0.055 second. Therefore the venom treatment increased the duration of contraction phase by 12.5% and the duration of relaxation phase by 37.5%. The latent period also increased from 0.02 second to 0.03 second that is 50% increase (Fig. 3a-iii). The venom treatment with 80 mg concentration changed the record of simple muscle twitch to a greater extent. The extent of contraction amplitude was reduced from 28 mm to 10 mm that is 64.2% reduction. The period of contraction phase was reduced from 0.04 second to 0.025 second (37.5% decrease) and the relaxation period was tremendously prolonged from 0.04 second to 0.28 second (600% increase). There was no change in latent period as compared with the control (Fig. 3a-iv).

The simple muscle twitch experiment showed that the *C. zeylanicus* venom increased the relaxation period and an increase in the dose caused reduced contraction period. The relaxant effect of *C. zeylanicus* venom produced a blocking effect on the neuromuscular junction (muscle endplate region), and thereby preventing the depolarization phenomenon (Endean *et al.*, 1976). Freeman and Turner (1972) noticed that the venom of *C. achatinus* may bind to Ca^{++} sites in the muscle membrane, leading to membrane instability and the production of depolarization by subsequent entry of Na^+ . Consequently, the intensity of the action potential generated in response to electrical stimulation was reduced. Selective

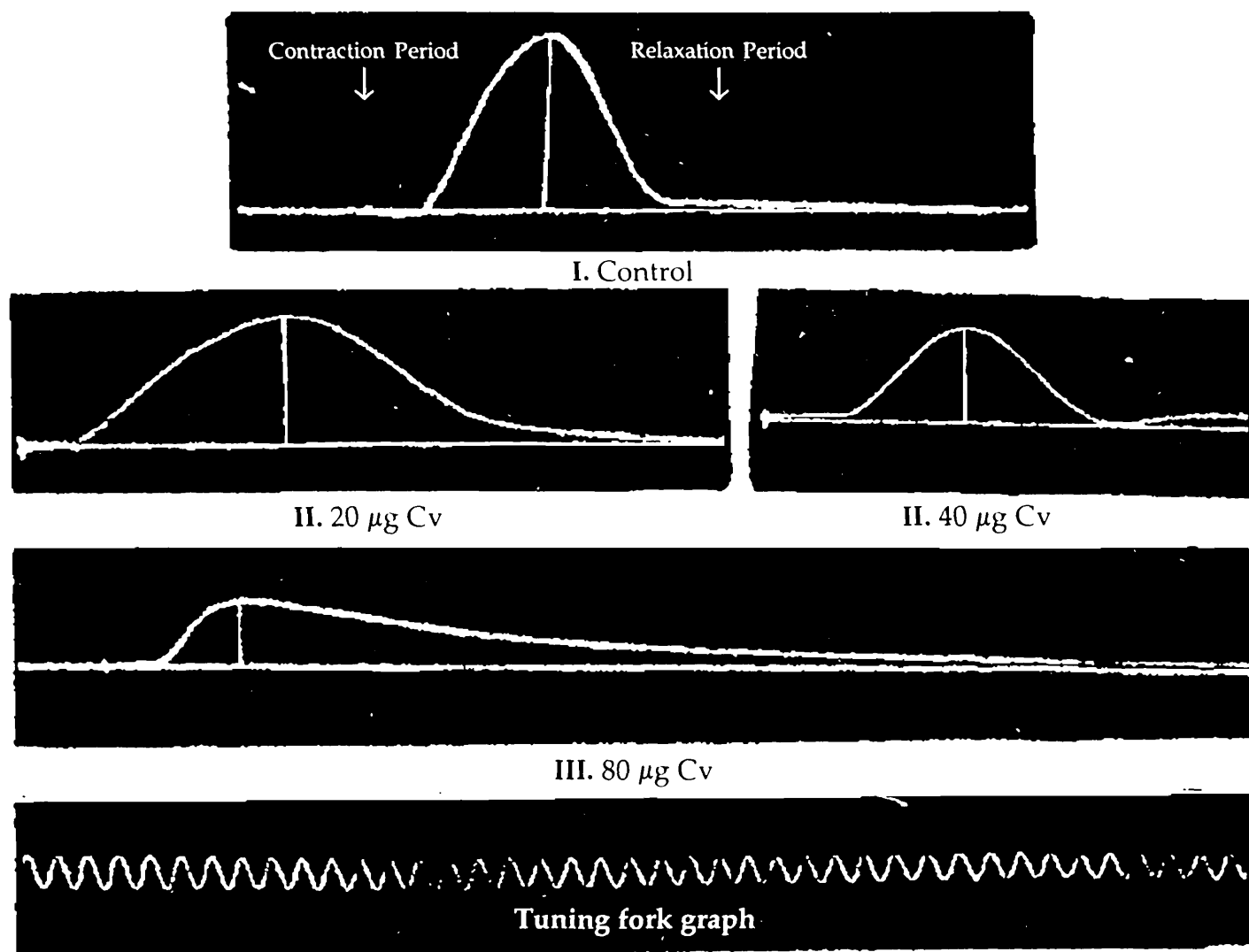


Fig.3. Effect of *C. zeylanicus* venom upon isolated frog's nerve muscle preparation (simple muscle twitch).

neuromuscular blocking properties of α -conotoxins were studied by Marshall and Harvey (1990). Freeman *et al.* (1974) found that the venom of *C. striatus* upon toad sciatic nerve and rat phrenic nerve diaphragm preparations revealed that it blocked the compound action potentials in toad nerves.

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A PRELIMINARY REPORT ON THE DIVERSITY OF THE VENOMOUS MARINE CONE SNAILS FROM TAMIL NADU COAST

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ABSTRACT

In the present study, twenty six species of cone snails belonging to single genus *Conus* (Gastropoda : Conidae) were recorded from Tamil Nadu Coast, South East Coast of India. The survey was conducted for a period of one year from January to December 2004. The cone snails were collected every month from 9 landing centers, all along the Tamil Nadu Coast.

INTRODUCTION

The cone snails are more than 500 species in the family Conidae and all of them are members of the single genus *Conus*. They are distributed throughout the tropical Pacific and Indian waters (Kohn, 1963). They are sheltered in the shallow waters of the coral reefs and sandy or coral rubble substrates (Kohn, 1959a, b; 1978) and usually found between 9 and 18 m depths and at a distance of 5-8 km from the shore. The cone snails inject a highly poisonous paralyzing toxin by means of a harpoon-like mechanism near the tip and a few of the larger species can fatally sting humans. There have been 30 recorded cases of human envenomation by *Conus* species, some of which were fatal (Kohn 1958).

The largest group of venomous molluscs is divided into two of the major Classes of the Phylum Mollusca viz. Gastropoda and Cephalopoda. Among the Gastropoda, several Families of carnivorous marine snails are known to produce toxic venoms, which are used in the capture of prey (Kohn, 1956a). The three families Terebridae, Turridae and Conidae are grouped under the superfamily Conacea (Toxoglossa) because of the similarities in the structure of their venom apparatus (Ponder, 1973), but only the latter is known to be actively venomous to man (Kohn, 1963). These are advanced marine gastropods, in which the radula, the rasping organ of the snails, normally used for scraping food off surfaces, has been modified for injection of venom into the prey (Owen, 1966).

Based on the food preference of the *Conus*, they are classified as vermivorous (feeding worms), molluscivorous (feeding other molluscs) and piscivorous (feeding small fishes) (Kohn, 1959 a, b). Cone snails having all the three types of feeding habits are available in Indian waters. Among these the vermivorous cones are more predominant than the other two (molluscivorous and piscivorous). Most of the work done on these organisms is focused on the venom of homicidal piscivorous and molluscivorous cones, because they pose a real threat to humans. However, the distribution and abundance of the cones is limited. Hence the present study was undertaken to investigate the distribution of cone snails from Tamil Nadu coastal waters, South-East Coast of India.

MATERIAL AND METHODS

The study area include all along the Tamil Nadu coast *viz.* Chennai, Cuddalore, Pazhayar, Nagapattinam, Mandapam, Rameswaram, Kizhakkurai, Thoothukudi and Kanniyakumari. The stations are mentioned as 1 to 9 respectively. Among them, the Gulf of Mannar (Rameswaram, Mandapam, Kizhakkurai and Thoothukudi) is one of the Marine Biosphere Reserves in India, situated on South-East Coast of India, with 21 Islands covering from Rameswaram to Tuticorin. These are highly productive and biologically wealthy in nature. The cone snails were collected from January to December, 2004. As they are littoral form they were collected in the trawl net. The identification of the cone snails were made following Walls (1979).

RESULTS AND DISCUSSION

During the study period, a total of 26 species of cone snails belonging to single genus were recorded from the 9 stations of Tamil Nadu coastal waters and the distribution of cones vary from 2 to 20 species, station wise species numbering 13 were recorded at station 1 while in stations 2 to 9 were 14, 11, 6, 10, 9, 20, 13 and 2 respectively (Table 1 & Fig. 1). The most common species occurring in all the stations were *C. amadis*, *C. betulinus*, *C. figulinus*, *C. inscriptus*, *C. lorisii*, *C. monile*, *C. tessulatus* and *C. zeylanicus* whereas *C. amadis*, *C. lorisii*, *C. malacanus*, *C. monile*, *C. incryptus*, *C. zeylanicus* were abundant at Chennai, Cuddalore and Pazhayar (stations 1, 2 and 3 respectively); *C. betulinus*, *C. figulinus*, were at Nagapattinam (station 4) and *C. araneosus*, *C. marmoreus*, *C. terebra*, *C. virgo* and *C. rattus* were at Kizhakkurai and Thoothukudi (stations 7 and 8).

The heterogeneity of habitat, physical environmental stresses, and food partitions and space resources are important determinants of species diversity patterns in assemblages of *Conus* inhabiting Tropical intertidal regions and subtidal coral reef platforms (Kohn, 1959a and Kohn and Nybakken, 1975). Information on the *Conus* species diversity was attracted the researchers from all over the world as they are known for their venom (Kohn, 1963) which is highly dangerous to human. The venom contains a number of neurotoxic peptide (Olivera *et al.*, 1985a) and the symptoms of the victims can be recognized with loss of vision, speech and hearing, numbness, local pain, swelling etc and also severe

Table 1. List and distribution of *Conus* species from Tamil Nadu coast

Class	GASTROPODA									Stations
Order	NEOGASTROPODA									
Family	CONIDAE									
S. No.	Species	1	2	3	4	5	6	7	8	9
1	<i>Conus amadis</i>	□	□	□	□	□	□	□		
2	<i>C. araneosus</i>					□	□	□	□	
3	<i>C. bayani</i>	□		□	□					
4	<i>C. betulinus</i>	□	□	□	□			□	□	
5	<i>C. characteristicus</i>		□	□						
6	<i>C. coronatus</i>					□	□		□	
7	<i>C. ebraeus</i>					□	□	□		
8	<i>C. figulinus</i>	□	□	□	□	□	□	□	□	
9	<i>C. floridanus</i>	□	□							
10	<i>C. geographus*</i>							□	□	
11	<i>C. glans</i>							□		
12	<i>C. inscriptus</i>	□	□	□		□	□	□	□	
13	<i>C. lividus</i>							□		□
14	<i>C. loroisii</i>	□	□	□		□		□		
15	<i>C. malacanus</i>	□	□		□					
16	<i>C. marmoreus*</i>	□				□	□	□		
17	<i>C. milne- edwardsi*</i>			□				□		
18	<i>C. monile</i>	□	□	□			□	□		
19	<i>C. quercinus</i>		□						□	
20	<i>C. rattus</i>					□		□		
21	<i>C. striatus</i>							□	□	
22	<i>C. terebra</i>							□	□	
23	<i>C. tessulatus</i>	□	□	□	□			□	□	
24	<i>C. textile*</i>	□	□					□	□	
25	<i>C. virgo</i>		□			□	□	□	□	
26	<i>C. zeylanicus</i>	□	□	□				□	□	□

* Schedule Species (Wild Life Protection Act, 1972 (53 of 1972) Part IV B – Mollusca)

□ Presence of Species

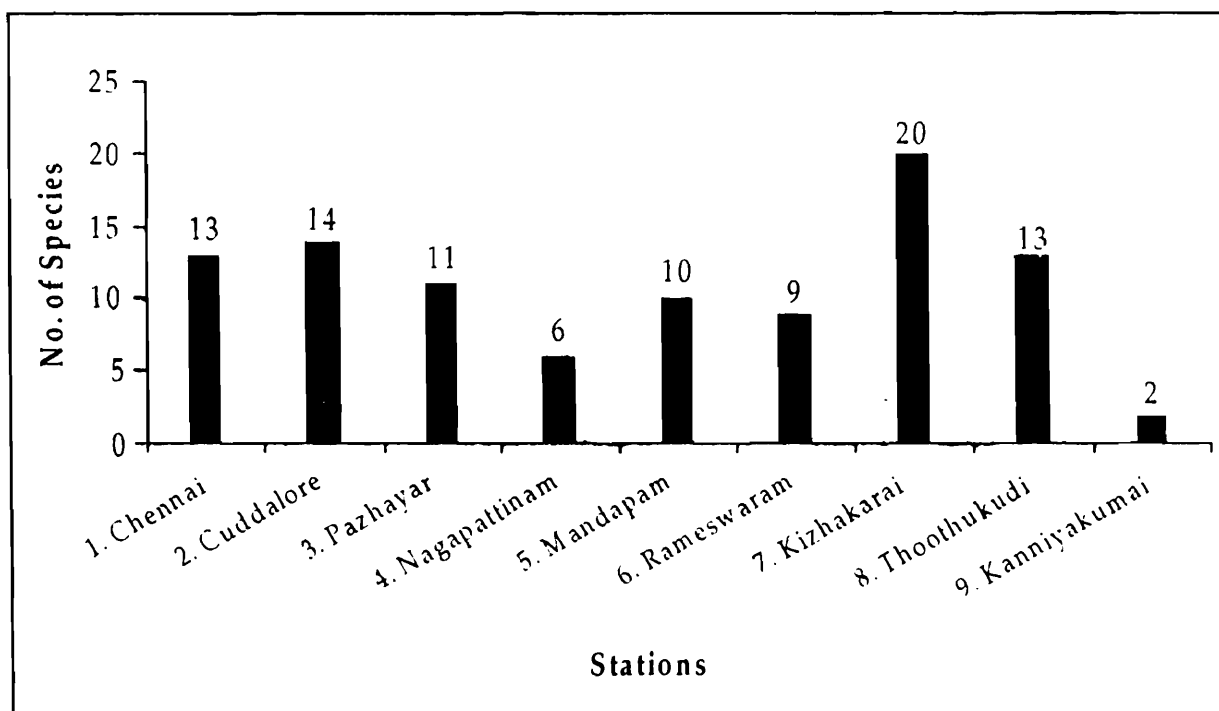


Fig. 1. Distribution of Cone Snails in Tamil Nadu Coast

envenomation causes respiratory muscle paralysis which may lead to death (Kohn, 1958). More than 500 species in the family Conidae belonging to the single genus *Conus* which are distributed throughout the Tropical Pacific and Indian waters (Kohn, 1963). In India, the first report on *Conus* species by Sathyamurthi (1952) who noticed 16 species from the Krusadai Island of Gulf of Mannar, Tamil Nadu. Similarly Kohn (1978) encountered 48 species from India. Subba Rao (1980) listed 51 species from Andaman and Nicobar Islands but Ramakrishna and Dey (2003) observed 68 species of *Conus* from India and of these 53 were reported from Andaman and Nicobar Islands. Meanwhile, Kasinathan *et al* (1997) catalogued 28 species from southeast coast of India. In this paper, we have reported twenty six species of *Conus* from Tamil Nadu coast.

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DIVERSITY OF PERCHES ALONG THE CORAMONDAL COAST AND IT'S ECONOMIC VALUATION

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ABSTRACT

The Coramondal Coast between Lat. 10°N and 16°N having a stretch of more than 402 kms. with nearly 200 landing centres contribute a sizable perch and perch like fishes landing in Tamil-Nadu. Perches are landed mainly as by – catch by bottom trawlers. The information on the diversity of perch resources along the Coramondal Coast is inadequate, as there is no exclusive fishing method for perches of reef and rocky habitat. An attempt was made by Fishery Survey of India by operating bottom set long line for exploiting perch resources along the Coramondal Coast between the depth range 29 and 130m from September 1992 to March 2001. The study was also attempted for measuring the diversity of economically important fishes such as perch and perch like fishes.

INTRODUCTION

Perch available in Indian waters are represented by more than 20 families viz. Serranidae (Groupers), Lutjanidae (Snappers) Lethrinidae (Pig face bream) Nemipteridae, Priacanthidae Sparidae, Acanthuridae, Siganidae and Haemulidae (James *et al.*, 1994). The seranidae family composed of 159 species. Lutjanidae 103 species of mostly reef dwelling marine fishes collectively known as snappers and Lethrinidae constituted by 24 species. The fishes are exploited along the reef and rocky grounds of the Continental Shelf of Indian Coast.

Perches are landed mainly as by-catches of bottom trawlers, hand line and the bottom set long lines are exclusively developed to catch perches in Tamil Nadu Coast (Sathiadhas *et al.*, 1995). In India mainly Artisanal fishermen are using hand line and traps for catching perches in the near shore areas of coral reefs and rocky grounds where they are familiarized. Literature on the important perch resources in India is scanty and mostly dealt with some aspects of experimental fishing (John 1948,; Chidambaram and Rajendran, 1951; Gopinath 1954; Silas 1969; Bapat *et al*, 1982, and Anon, 1978) catch statistics (Chacko and Rajendran 1955; Rao, 1973; Madan Mohan, 1983; Rao 1973; and Kasim *et al*, 1989) and

Perch-trap fishery (Prabu 1954, Lal Mohan, 1985) status of Major Perch fisheries in India (James *et al.*, 1994).

Information on the perch resource availability and the suitability of specific gear on the ground along the South East Coast of India is almost nil. Studies on diversity of perch and perch like fishes and its spatio-temporal distribution in Indian waters are limited as the habitat of the perches are mostly unsuitable for the operation of gears for sampling. Hence FSI has made an experimental perch resource survey programme to collect data on the availability of perch resources along South East Coast of India and also to study the suitability of bottom set longline for the effective exploitation of perch resources.

MATERIAL AND METHODS

Survey vessel and Gear : The perch resources survey was carried out from September 1992 to March 2001 along the South East Coast of India between Lat. 10°N and 16°N by employing bottom set vertical long line from the vessel *Matsya Harini* attached to Chennai base of FSI. The vessel *Matsya Harini* is a combination purse seiner cum long liner with OAL of 32.49m, GRT 273 tonnes and BHP 750. The vessel is equipped with Satellite navigator, Radar Direction finder and Echo sounder.

Specification of the fishing Gear : The detailed specifications of the bottom set vertical perch long line used for the survey is as follows. A unit of perch long line gear is called one basket which consists of 5 branch lines, each branch line has 8 hooks. Main line 50 mts x 6 pieces (300 mts. 6.5 mm tetron dyed black) branch line 15mts.x 5pieces (No. of branches 5/basket.) the rigging details of the gear operated for the survey is given in Fig. 1.

- i) Length of Nylon monofilament attached with hooks 75 mm (1 mm f)
- ii) Hook size = No. 4, 6 & 7 (barbed perch hook)
- iii) Weight attached with branch line = 2.5 kg
- iv) Float line 6.5 mm tetron, black dyed 25 mts x 1 piece. (Float line length is altered according the depth of operation). Float (HDP) 300 mm f and PVC 32 mmf.

Snap clip is used to attach the branch line with main line and swivel is used in branch line to avoid twist as indicated in the diagram. Marking flag is attached with bamboo pole connected with float line which is rigged with main line in between on basket to other keeping distance of 300 mts (Fig. 1).

METHOD OF OPERATION

The survey cruises normally of 20 days duration were conducted in every month and 32 bottom set long line operations were made in each cruise. Two sets were made in a day one in the forenoon and the other in the afternoon by immersing 300 hooks/set,

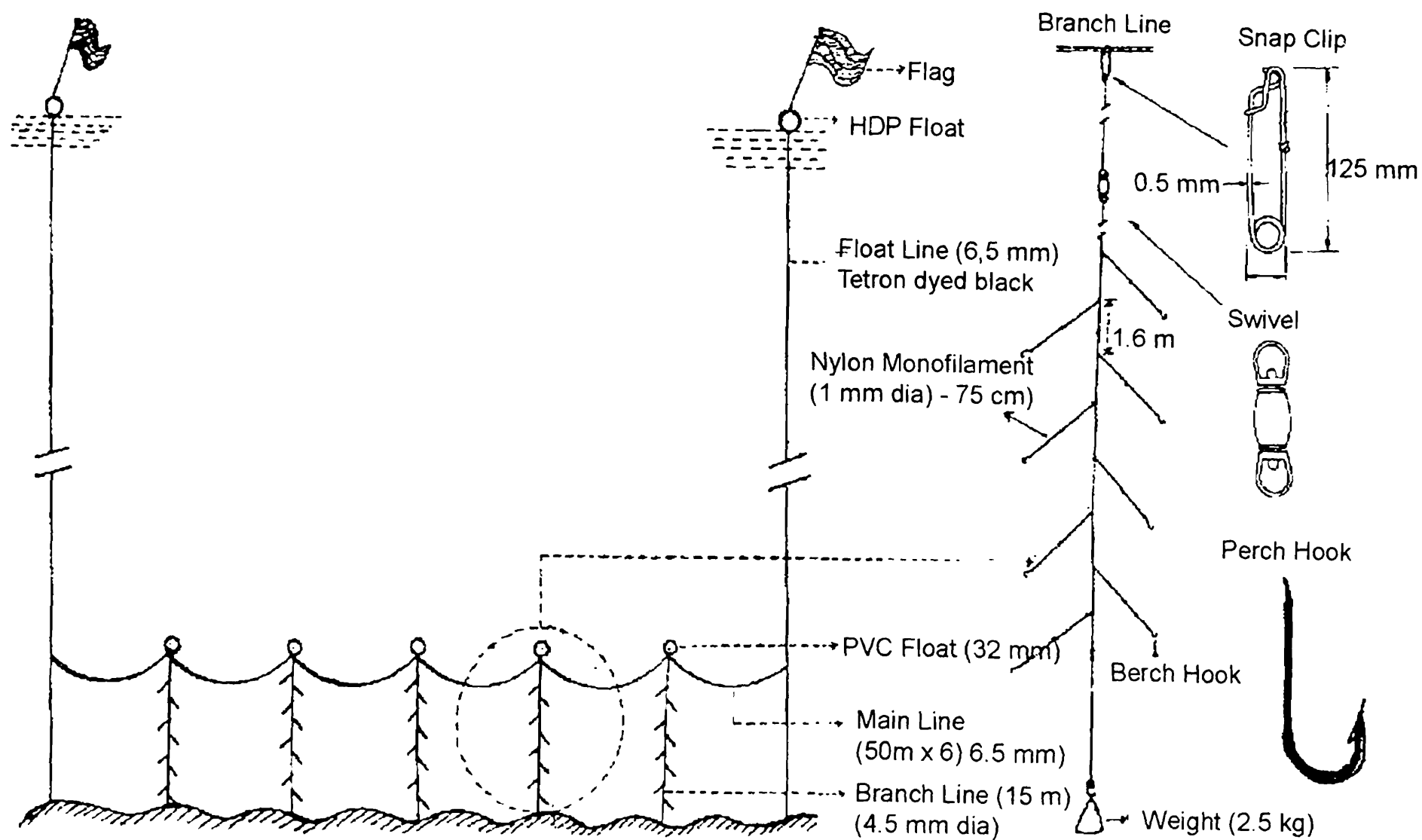


Fig. 1. Schematic diagram of one Basket of bottom set perch Long Line

having an immersion time of one hour duration. During the survey, the shooting of the perch longline was done from the stern and hauling was made from the star board side of the vessel.

Area and period of operation : The survey was carried out between Lat. 10° N and 16°N in the depth range of 30 – 150m which includes area viz., 10°N – 79°E, 10°N – 80°E, 11°N–79°E, 11°N - 80°E, 12°N–80°E, 13°N–80°E, 14°N–80°E, 15°N–80°E, 16°N–81°E, 16°N–82°E. The month wise operational details are given in table 1. In the text the name of the area is mentioned as 10–80 can be referred as 10°N–80°E (1° lat x 1°long.).

Intensity of sampling : During the period from September 1992–March 2001, 30 cruises were made and actual fishing was conducted for 324 days, a total of 576 sets were made by operating 180186 hooks. The distribution of sampling effort in terms of number of hooks operated in each 1° lat x 1° long. Grid is given in Fig. 2.

Measurement of Diversity : The species richness was measured by Shannon diversity index (H') using the following equation

$$\text{Shannon Index } H' = - \sum_{i=1}^n P_i \ln P_i$$

The Simpson's index is another index that is commonly used to characterise about community composition (i.e., the No. of species and it's relative contribution to the community) that was calculated by the following Magurran, 1988 equation's.

RESULTS

Bottom topography : Inadequate information on the nature of bottom topography was a serious hurdle for the initial operation of bottom set perch longline survey. Rocky grounds, corals, clusters of rock, hard substratum were monitored during the survey and observed in patches. In between these rocks or hard substratum, sand and muddy grounds were also observed during the survey. Hard and rocky grounds are found off Kovalm, Mahabalipuram, Pondichery and Sriharikotta in the depth range of 29–120mts.

Spatio -Temporal distribution : A total catch of 1135 numbers of perch and by-catch fishes weighing 1320.94 kgs was recorded during the survey. The data collected from the survey were analysed to obtain the composition of catch and seasonal abundance and distribution of the perch resources in the surveyed area. The fishing effort and group wise number of fishes recorded in different areas (1° Lat. x 1° Long.) are presented in table 1. In all 1135 number of fishes hooked were identified and recorded (Table 2). The distribution of different varieties of fishes and species recorded in different areas are furnished in table 3.

The fish caught were sorted in to 5 groups namely rock cod, snappers, other perches, carangids and others. Among the rock cod there are 17 species of which 14 nos. of *Epinephelus* spp. 2 species of the genus *Plectropomo* and one *Cephalopholis sonnerati*. In the

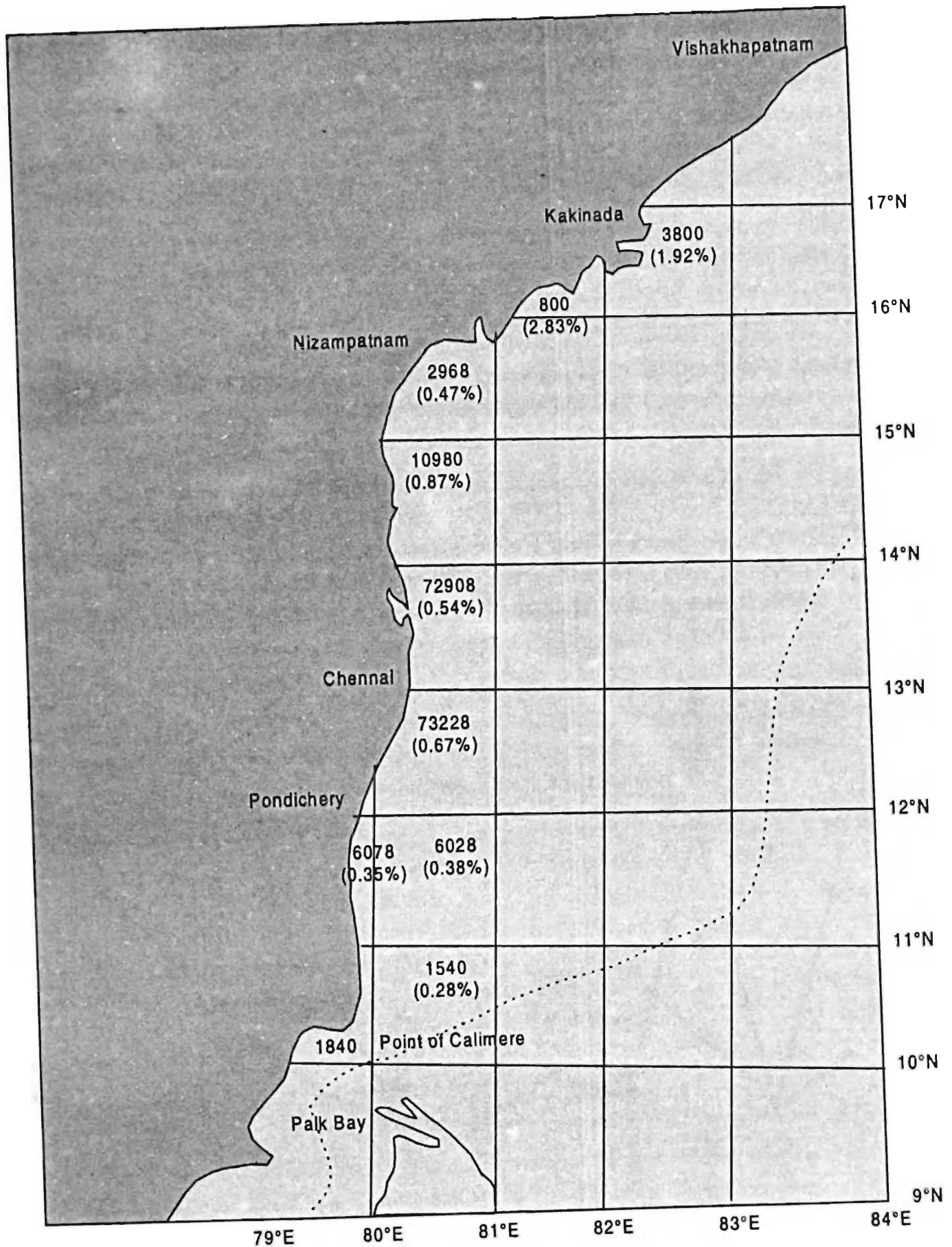


Fig. 2. Survey area & Distribution of Sampling (No. Hooks) and Aggregate hooking rate in parenthesis

other group (Snappers) there are 16 species of which 9 species belongs to the genus *Lutjanus*, 2 species of *Pristipomoides*, one species of *Etelis murshi* and *Aprian viracens* and 2 species belongs to the genus *Aphareus*. In the group of other perches, there were 11 species of which 3 species of *Lethrinus*, 2 species of *Pomadasys*, , and also the other species included are *Diagrama punctatum*., *Nemipterus bleekeri* and *Acanthurus bleekeri*. The another group comprised of 7 species of carangids and others included 18 species. The details are given in table 3.

The average month wise hooking rate recorded for the 30 cruises ranging from 0.12 to 1.56. The maximum hooking rate 1.56% was obtained during March the minimum hooking rate of 0.12 was during January.

Month wise combined fishing effort and aggregate hooking rate obtained are given in table 2. The results indicated that the highest aggregate hooking rate of 1.44 was recorded during March (Fig. 3 & 4).

In terms of fish distribution, aggregation observed to be more in area Lat. 16°N. The area 16–81 recorded hooking rate 2.83% followed by 16–82 (1.92%). In the area 16–82, 17nos. of Ghol (*Pseudosciaena diacanthus*) was recorded in single day of operation. The next highest hooking rate recorded was 0.87% in the area 14–80. where the rock cod constituted 0.26% hooking rate, snappers 0.1%, other perches 0.18% In the area 12–80

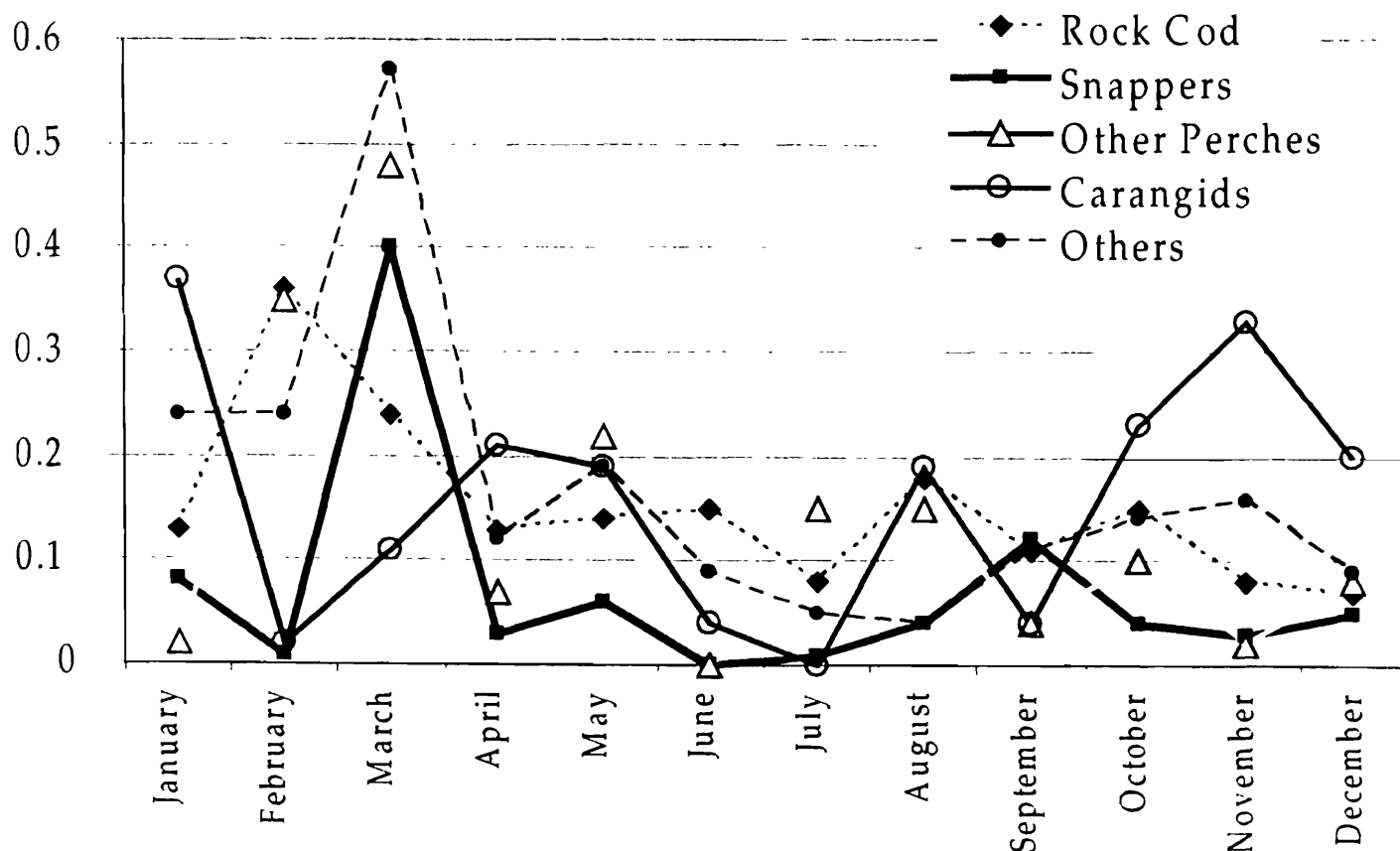


Fig. 4. Seasonal variation of occurrence of various perch groups in Tamil Nadu coast during the period from 1992– 2001

recorded a hooking rate of 0.67% and 0.47% in area 12–79. In the area 11–80 hooking rate recorded was 0.36% and 11–79 hooking rate was 0.35% in 10–80, the hooking rate was 0.26% and 10–79 no fish was hooked.

Distribution, Abundance and Fish composition : The number of fishes hooked were 1135 of which, perches contributed 53.8% (611 nos.) which was shared by rock cod–41.45% (254 nos.), snappers 23.6% (144 nos.) and other perches 34.9% (213 nos.). The month wise aggregate hooking rate of fishes recorded during the survey is illustrated in fig. 5.

Rock cod (Family Serranidae) : There are 17 species recorded in this group. The distribution pattern of the rock cods, indicated that rock cods are more abundant in the area 12–80 (129 nos.) followed by 13–80 (84 Nos.), 14–80 (29 nos.), 11–79 (6 nos), 11–80 (4 nos.) 10–80 and 15–80 each 1 no. The Fig. 4 indicate that the rock cod catch was more during February to March and also during August to September. Details of species composition of the family Serranidae is depicted in Fig. 6.a. *Epinephelus diacanthus* contributed 21% followed by *E. faciatus* (19%) and *Cephalopholis sonnerati* (12%).

Snappers (Family Lutjanidae) : There are 144 nos. of snappers constituting 16 species. The better results of snapper were recorded during January to May and also August to December. The highest hooking rate of 0.36% was obtained during February. Details of species composition of the family Lutjanidae is depicted in Fig. 6.b.

The concentration of Snappers is found more in the area 12–80 (58 nos.) followed by 13–80 (56 nos.) 11–79 (10 nos.) 14–80 (7nos.) 15–80 (5 nos.) 11–80 (5 nos.) and 10–80 (3nos). *Pristipomoides* spp. contributed 36% of the total snapper landings followed by *Lutjanus lutjanus* (18.35%) and *L. malabaricus* (14.3%) (Fig 6.b.).

Other perches : Under this group 213 nos. of fishes of 11 species were recorded. The distribution and abundance of the other perches were observed more in the area 12–80 (103 nos.) and 13–80 (81 nos). In the area 16–82, Ghol (*Pseudosciaena diacanthus*) 17 numbers were hooked. The good catch of other perches were recorded during February to April and August to December. The highest hooking rate 0.48% was recorded during March cruise (fig. 6.c). *Diagramma punctatus* contributed 20% of the total other perches caught during the study period followed by *L. nebulosus* (14.5%) and *Pseudosciaena diacanthus* (9.4%)

Carangids (Family Carangidae) : There are 256 numbers of fishes hooked constituting 7 species of carangids. *C. malabaricus* (57 nos.) *C. sansun* (1no.) *C. ignobilis* (3 nos.) *Megalaspis cordyla* (146 nos.), *C. sexfasciatus* (1 no.) *C. armatus* (5 nos). The relative abundance is observed in the area 12–80 (121 nos.) followed by the area 13–80 (91 nos). Details of the distribution pattern of carangids hooked in bottom set long line are given Fig. 5. The maximum hooking rate was obtained during March. The better hooking rate recorded was during January to May and August to December. Species composition of the family Carangidae is depicted in Fig. 6.d.

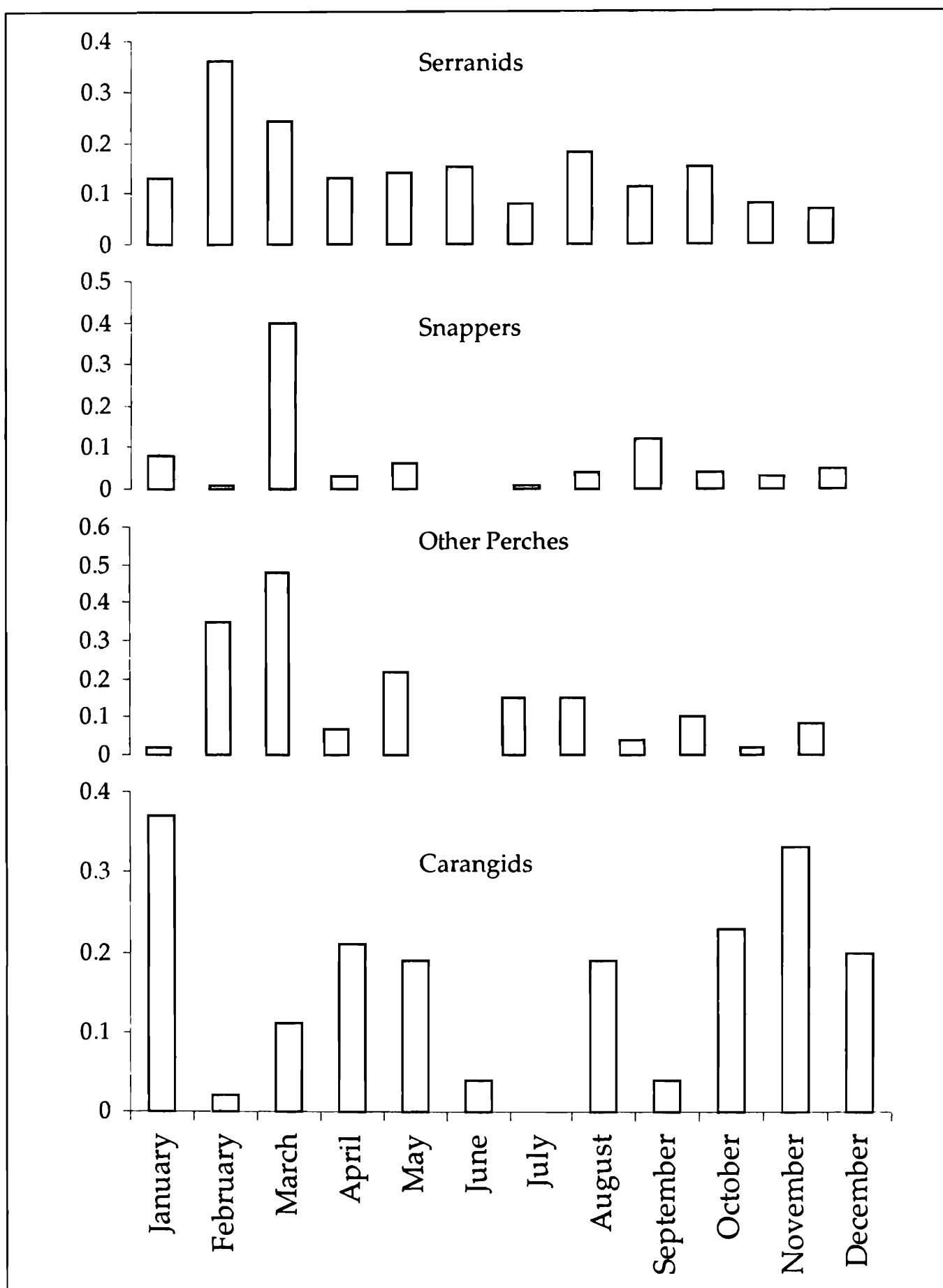


Fig. 5. Month Wise Aggregate Hooking rate (%) of different perch groups

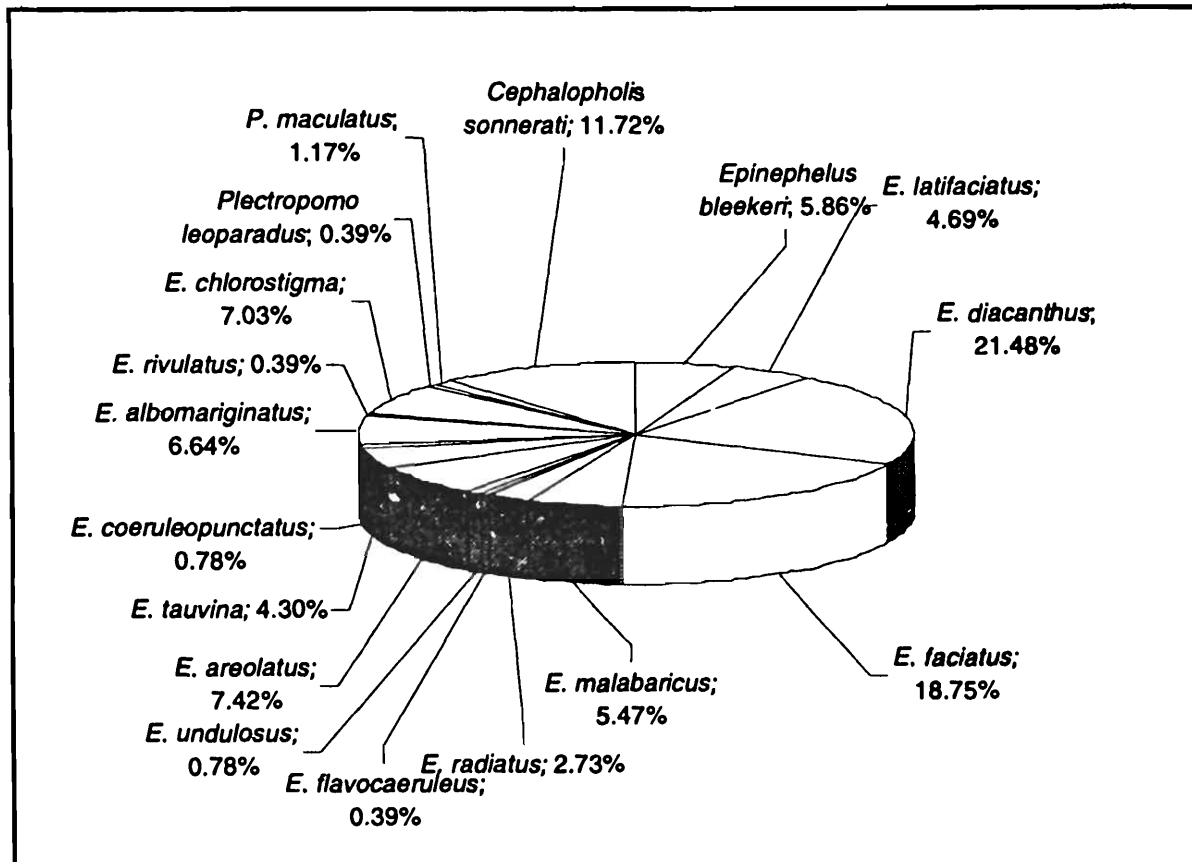


Fig. 6a

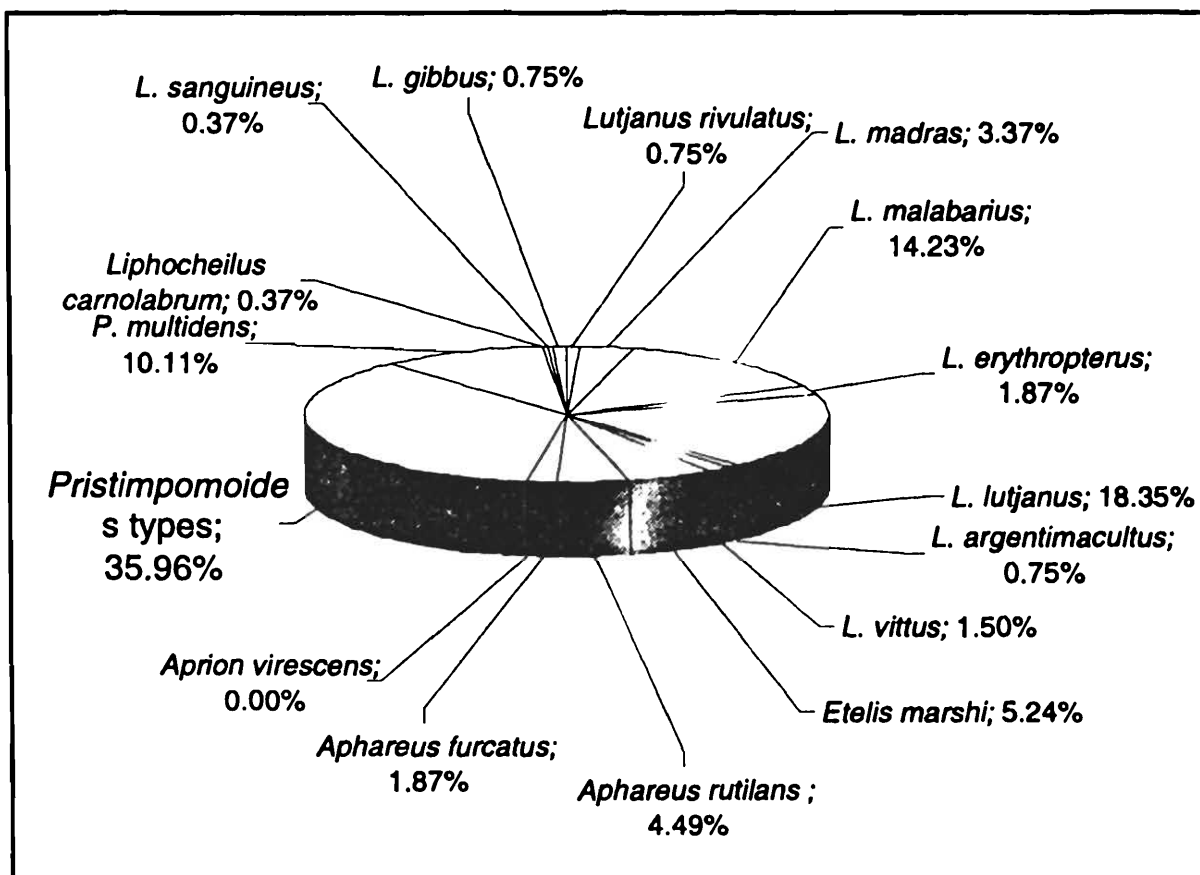


Fig. 6b

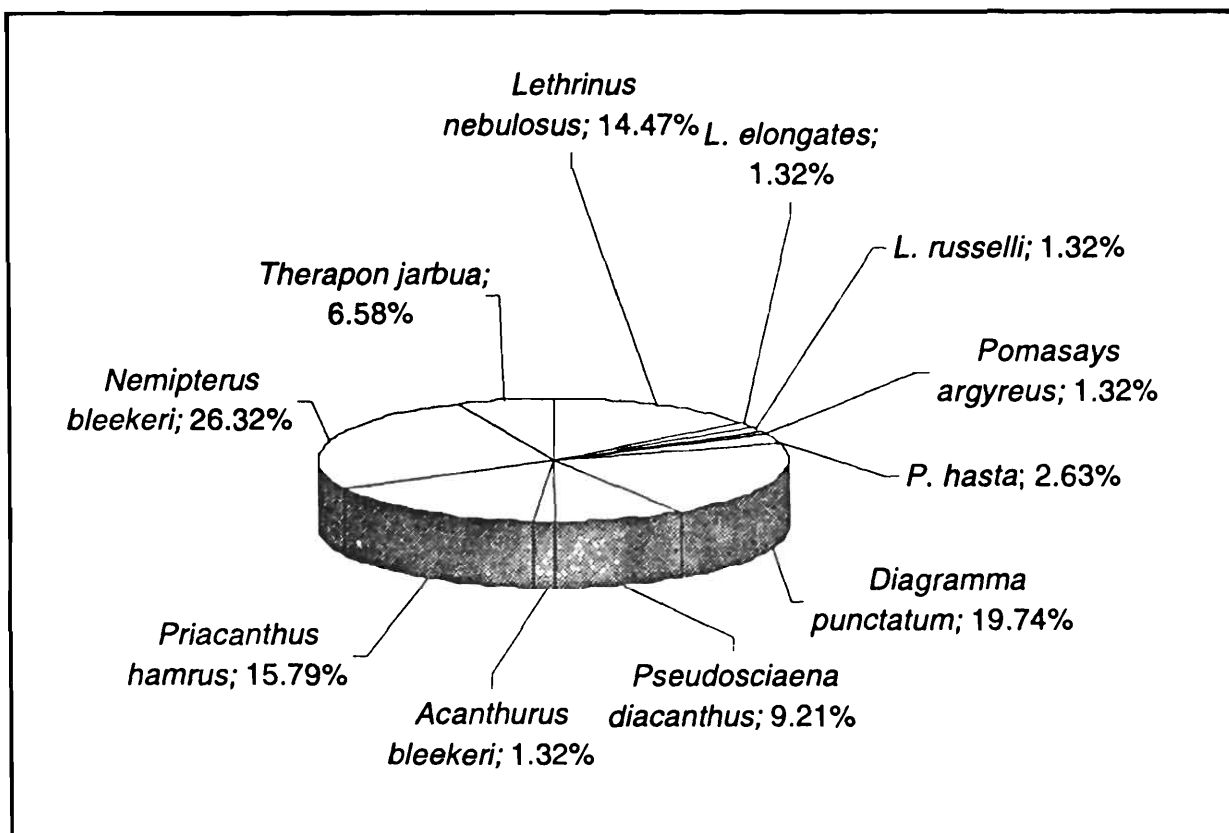


Fig. 6c

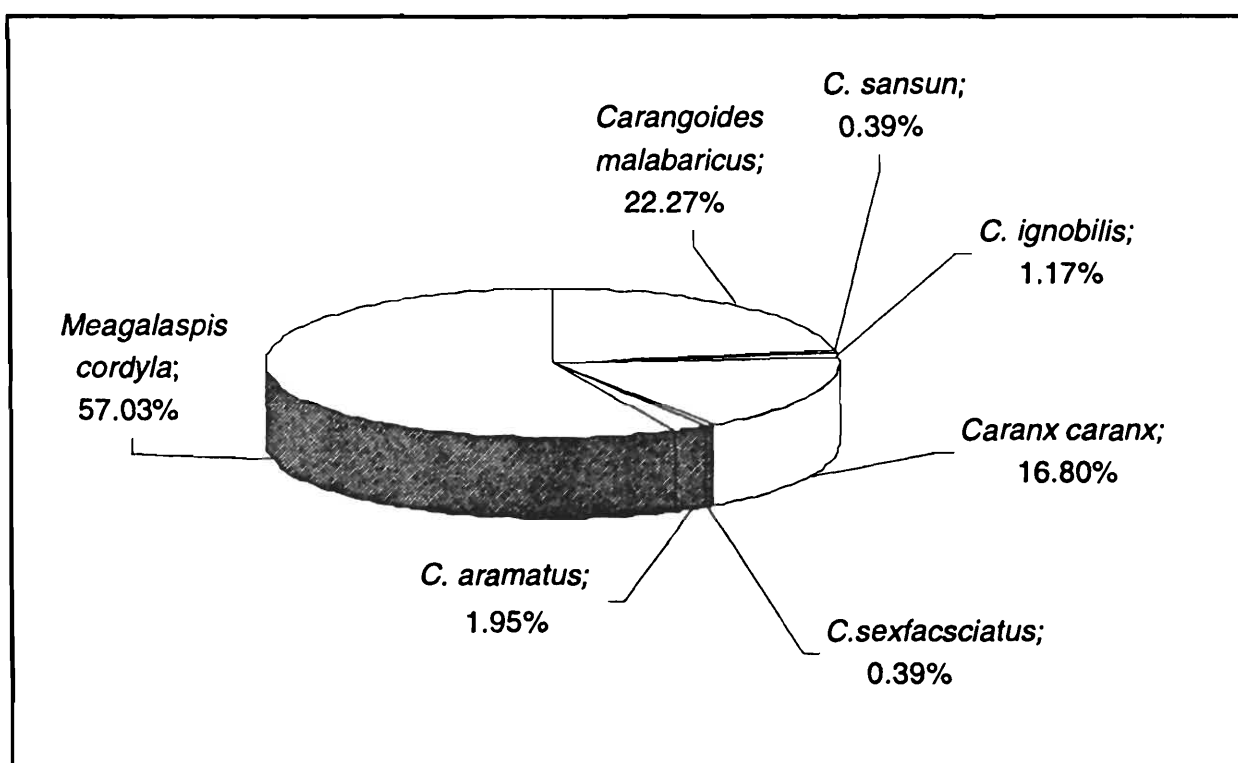


Fig. 6 d

Fig. 6 (a – d) Species composition of perches caught in bottom set long line

Other fishes : The other fishes constituted 18 species. In total 268 nos. of fishes hooked are included in this group. The distribution pattern of its abundance observed in the area 12–80 (85nos.), 13–80 (81 nos.), 16–82 (51 nos.), 16–81 (23 nos.), 14–80 (14 nos.) 15–80 (6nos.), 11–80 (5nos.) and 11–79 (3nos.) are given in table 3. The highest hooking rate of 0.57% was obtained during March (fig 5).

Diversity index : Area wise species richness and distribution of perch shows the area 13–80 has more species richness ($H' = 3.4$) followed by 12–80 ($H' = 3.0$), 14–80 ($H' = 2.8$), 15–80 ($H' = 2.3$) and 11–80 ($H' = 2.1$) Fig. 7. Similarly the Simpson's index $1/D$ was also higher in 13-80 ($1/D = 23.02$) followed by 15–80 ($1/D = 19.4$), 12–80 ($1/D = 13.8$) and 14–80 ($1/D = 11.1$). It is interesting to note that there was a lower species richness occurred in the area 15–80 than 12–80 the relative contribution of species occurred in the community distributed more evenly in the area 15–80 than 12–80 (Fig. 7).

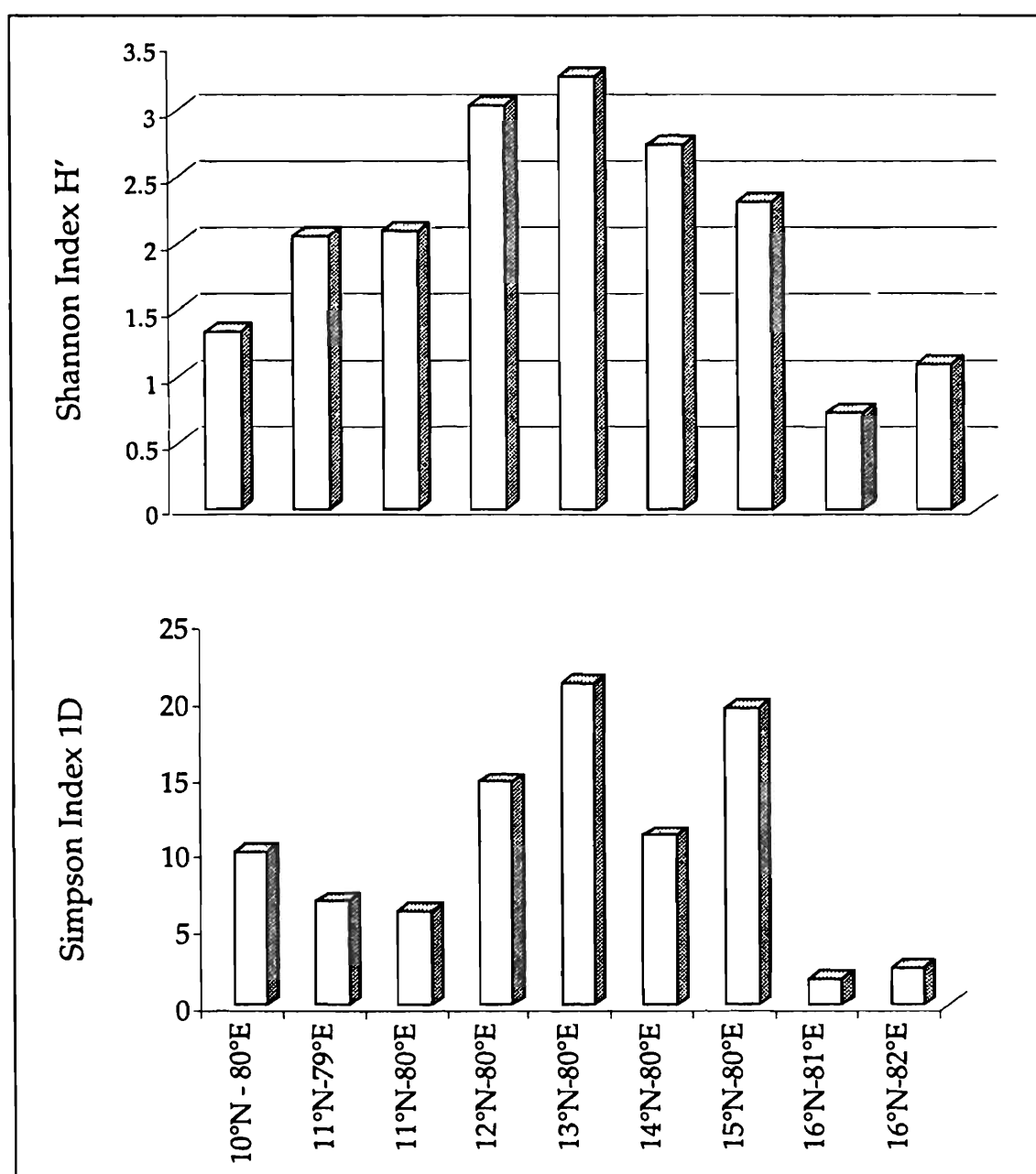


Fig. 7 Diversity indices in different areas of the Coramondal Coas

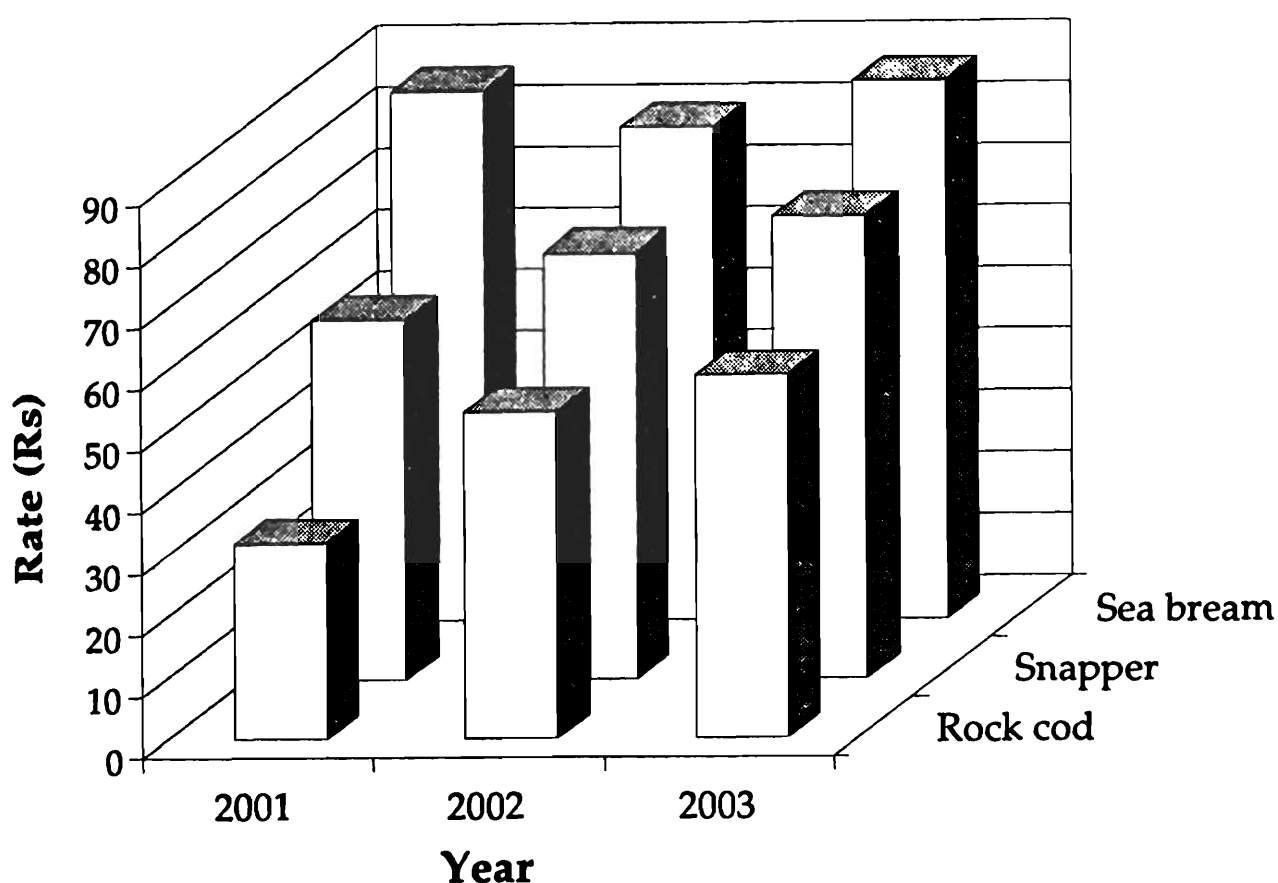


Fig. 8. Average value Realized for the perches during the period from 2001–2003 in International market

DISCUSSION

Production of perches from the Tamil Nadu and Pondichery coasts was 17,457 tonnes during the year 2003, that is 33% of the total perch landings of India (ANON, 2003), however it is lesser than the earlier records (42.4%) during 1985–98 (James *et al.*, 1994). According to James *et al.*, (1994) annual average perch landings in India were estimated as 89031.8 tonnes and form about 5% of total landing of the country. Bulk of the perch landings (60%) come from two southern states viz Tamil Nadu and Kerala contributing 37627.8 tonnes (42.3%) and 15648.8 tonnes (17.6) respectively. However based on the statistically designed survey conducted by Fishery Survey of India, an annual sustainable yield of 2,36,135 tonnes of perch can be harvested from the Indian EEZ.

The coastal districts viz., Chengalpeta, Chennai, South Arcot and Tanjore together with union territory of Pondicherry including Karaikal and also Nellore and Prakasam districts of Andhra Pradesh comprising the Coramondal Coast. The existence of suitable perch fishing ground was confirmed by bottom set long line survey along the South East Coast of India between the lat 10°N and 16°N with characteristic rocky grounds especially off Mahapallipuram. Kovalam, Pondicherry, Cuddalore, Sriharikota between depth range 29 and 136 ms. The rocks and reefs of these area support variety of corals and sponges

that are suitable for the perches that scattered along the coast in dense schools with more abundance.

The rocky grounds present along the surveyed areas are not continuous in nature are found in patches. It is also recorded that the branch of the bottom set long line operated fell on the rocky grounds used to record even 8 nos. of fishes in each branch line. It is interesting to note here that nearly 75% of the total perch landing in Tuticorin (Tamil Nadu coast) is enhanced by line fishing. The area 16–82 is observed to be a good ground for Ghols (*Pseudoscianea diacanthus*). The species specific fishing can be made in the area as in a single day operation of bottom set long line 17 numbers of Ghol were hooked. The second highest hooking rate of 1.92% was recorded in the area. Thereby it is suggested to operate hand line in exact location of the rocky ground in order to have good catch of perches which is considered to be the most important one from the commercial point of view.

The survey results indicated that better fishing for perches can be made of January to May and August to December. The highest hooking rate 2.83% was observed in the area 16–81. In Gulf of Mannar area highest landings of perches were observed during Jan.–March and September.

From the survey, it is observed that different group of perches are caught and their hooking rate is also changing from month to month. The maximum hooking rate of 1.44% recorded was during March. The results of the survey indicated that the distribution pattern of the perches (rock cod, snappers and other perches) are more abundant in the area 12–80 and 13–80 between the depth range 29–75 mts. Perch grounds are easily accessible as the grounds are lying in between 29–130 mts. depth along the coast.

It is suggested that mother boat (fitted with GPS/ Echosounder) towing catamarans to the perch ground to operate perch long line as well as hand line to have better catch of perches, as the catamarans having very low free board and the fishes caught by the catamarans can be stored in the mother boat for keeping it in ice or preserving in good quality. The mechanised catamarans can also venture in to the fishing with ice box for keeping the fishes caught by the hook and line and perch long line fishing.

Economic valuation : Embracing various technologies due to competition among the fishermen for maximum catch leads structural changes in the marine fishery economy in India as it is a common property resource unlike agriculture or other industries. Tamil Nadu and Pondichery have a vast coast line with 98848 active fishermen engaged in 45262 non-mechanized and 3630 motorized crafts during 1993 (Sathiadhas *et al.*, 1995). Area available per active fishermen in these coasts is 63 ha during 1990 (Sathiadhas *et al.*, 1995). An attempt was made to evaluate the economic performance of artisanal fishing unit for perch fishing using Hook & Line in traditional & motorised crafts of the Coramondal Coast as it is the eco friendly way of exploitation of perch from the rocky & reef habitat. Sathiadhas, (1997) evaluated the economic performance of artisanal fishing unit and revealed that the average cost per Kg of fish was Rs.5.33 and value realized for

perch was Rs. 6.0 kg⁻¹. During 2003 the total landing of major perches was 16398 tonnes (ANON, 2003), an approximate income per year was Rs. 15,728 per boat, however this value was higher than the value evaluated by Sathiadhas (1997). It is questionable that how far consumer rupee reaching the fishermen in order to unknot this problem. Studies on the share of fishermen in the consumer rupee (Sathiadhas, 1998) in all India level was carried out and found to be with in the range of 30–68% depend on the species and area. This value for some perch species was 42% whereas the same in Tamil Nadu was 53%.

The major perches belong to the families Serranids (Rock cod), Lutjanids (Snapper) Lethrinids (Sea bream) are having good market value in India and abroad. Because of their economic importance they are being exploited intensively and their landing have shown marked increase in last two decades. Moreover the products such as fillets are capable to fetch high price ranged between Rs. 79 and 351 kg⁻¹ (ANON, 2003). The price for perches realised in the international market is given in the Fig. 8 which indicated an increasing trend during the past 3 years. Nevertheless the information on the price of the fishes may be disseminated to fishermen can improve the socio economic status of the marine fisheries in India

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Table-1. Details of Month wise fishing Effort and average aggregate Hooking Rate along the Coramondal Coast

Period	Days fished	No. of Hooks (' 000)	No. of Set	Aggregate hooking rate
September, 1992	14	13.92	24	0.32
December, 1992	15	13.8	23	0.23
March, 1993	12	9	15	1.33
July, 1994	4	2.12	5	0.09
September, 1994	14	6.72	21	0.25
September, 1996	10	6.102	20	0.56
October, 1996	12	6.7	22	0.69
November, 1996	4	1.1	4	0.25
December, 1996	7	2.8	13	0.63
January, 1997	6	2.9	10	0.92
April, 1997	10	6.024	22	0.12
July, 1997	15	7.5	30	0.27
May, 1998	13	7.2	26	0.99
June, 1998	16	7.4	25	0.28
August, 1998	16	7.7	27	0.76
October, 1998	9	4.6	17	1.05
December, 1998	14	6.9	25	0.69
April, 1999	11	6	20	1.03
May, 1999	5	2.9	10	0.34
July, 1999	8	3.8	13	0.42
April, 2000	13	5.9	25	0.54
July, 2000	9	3.9	16	0.31
August, 2000	8	3.6	14	0.19
September, 2000	12	7.3	24	0.67
October, 2000	9	4.5	18	0.24
November, 2000	11	4.9	21	0.71
December, 2000	14	6	25	0.92
January, 2001	3	1.7	6	0.7
February, 2001	17	8.8	30	0.98
March, 2001	13	7.8	25	1.56

Table-2. Seasonal variation of Average Aggregate Hooking rate of different Perch groups

	Hooks operated (' 000)	Aggregate Hooking Rate (%)	Rock Cod	Snappers	Other Perches	Carangids	Others
January	4.64	0.84	0.13	0.08	0.02	0.37	0.24
February	8.832	0.98	0.36	0.01	0.35	0.02	0.24
March	16.8	1.44	0.24	0.4	0.48	0.11	0.57
April	17.98	0.56	0.13	0.03	0.07	0.21	0.12
May	10.2	0.82	0.14	0.06	0.22	0.19	0.19
June	7.44	0.28	0.15	0	0	0.04	0.09
July	17.32	0.29	0.08	0.01	0.15	0	0.05
August	11.424	0.6	0.18	0.04	0.15	0.19	0.04
September	34.06	0.43	0.11	0.12	0.04	0.04	0.11
October	15.784	0.67	0.15	0.04	0.1	0.23	0.14
November	6.14	0.62	0.08	0.03	0.02	0.33	0.16

Table-3. Spatial Distribution of Perch species (in Nos.) along the Coramondal Coast between the Lat. 10°N–16°N

Name of Species	10°N - 80°E	11°N- 79°E	11°N- 80°E	12°N- 80°E	13°N- 80°E	14°N- 80°E	15°N- 80°E	16°N- 81°E	16°N- 82°E
<i>Epinephelus bleekeri</i>	0	0	1	4	2	8	0	0	0
<i>E. latifaciatius</i>	0	0	0	7	1	4	0	0	0
<i>E. diacanthus</i>	0	2	0	30	20	2	1	0	0
<i>E. faciatus</i>	0	0	0	28	18	2	0	0	0
<i>E. malabaricus</i>	0	0	3	3	3	5	0	0	0
<i>E. radiatus</i>	0	2	0	0	4	1	0	0	0
<i>E. flavocaeruleus</i>	0	0	0	1	0	0	0	0	0
<i>E. undulosus</i>	0	1	0	0	1	0	0	0	0
<i>E. areolatus</i>	1	1	13	4	0	0	0	0	0
<i>E. tauvina</i>	0	0	0	4	4	3	0	0	0
<i>E. coeruleopunctatus</i>	1	0	0	1	0	0	0	0	0
<i>E. albomarginatus</i>	0	0	0	12	5	0	0	0	0
<i>E. rivulatus</i>	0	0	0	0	0	1	0	0	0
<i>E. chlorostigma</i>	0	0	0	12	5	1	0	0	0

Table-3. Contd.

Name of Species	10°N - 80°E	11°N- 79°E	11°N- 80°E	12°N- 80°E	13°N- 80°E	14°N- 80°E	15°N- 80°E	16°N- 81°E	16°N- 82°E
<i>Plectropomo leoparadus</i>	0	0	0	0	1	0	0	0	0
<i>P. maculatus</i>	0	0	1	0	2	0	0	0	0
<i>Cephalopholis sonnerati</i>	0	0	0	12	16	2	0	0	0
<i>Lutjanus rivulatus</i>	0	0	1	0	0	1	0	0	0
<i>L. madras</i>	0	0	0	6	3	0	0	0	0
<i>L. malabarius</i>	0	1	0	13	18	4	2	0	0
<i>L. erythropterus</i>	0	0	2	3	0	0	0	0	0
<i>L. lutjanus</i>	0	0	2	33	13	1	0	0	0
<i>L. argentimacultus</i>	0	0	0	1	1	0	0	0	0
<i>L. vittus</i>	0	0	0	0	4	0	0	0	0
<i>Etellis marshi</i>	0	0	0	0	14	0	0	0	0
<i>Aphareus rutilans</i>	1	8	0	0	3	0	0	0	0
<i>Aphareus furcatus</i>	2	1	0	2	0	0	0	0	0
<i>L. sanguineus</i>	0	0	0	0	0	0	1	0	0
<i>L. gibbus</i>	0	0	0	0	0	0	2	0	0
<i>Pristimpomoides types</i>	0	0	0	69	27	0	0	0	0
<i>Liphocheilus carnolabrum</i>	0	0	0	0	1	0	0	0	0
<i>P. multident</i>	0	0	0	4	23	0	0	0	0
<i>Aprion virescens</i>	0	0	0	0	0	0	0	0	0
<i>Lethrinus nebulosus</i>	0	0	0	8	3	0	0	0	0
<i>L. elongates</i>	0	0	0	0	1	0	0	0	0
<i>L. russelli</i>	0	0	0	0	1	0	0	0	0
<i>Pomadasys argyreus</i>	0	0	0	0	1	0	0	0	0
<i>P. hasta</i>	0	0	0	1	1	0	0	0	0
<i>Diagramma punctatum</i>	0	0	0	2	7	5	1	0	0
<i>Pseudosciaena diacanthus</i>	0	0	0	0	0	0	0	0	7
<i>Acanthurus bleekeri</i>	0	0	0	0	1	0	0	0	0
<i>Priacanthus hamrus</i>	0	1	3	4	4	0	0	0	0
<i>Nemipterus bleekeri</i>	0	0	0	10	9	1	0	0	0
<i>Therapon jarbua</i>	0	0	0	5	0	0	0	0	0

Table-3. Contd.

Name of Species	10°N - 80°E	11°N- 79°E	11°N- 80°E	12°N- 80°E	13°N- 80°E	14°N- 80°E	15°N- 80°E	16°N- 81°E	16°N- 82°E
<i>Carangoides malabaricus</i>	0	1	3	18	19	13	3	0	0
<i>C. sansun</i>	0	0	0	0	0	1	0	0	0
<i>C. ignobilis</i>	0	0	0	0	3	0	0	0	0
<i>Caranx caranx</i>	0	0	0	18	24	0	1	0	0
<i>C. sexfasciatus</i>	0	0	0	0	1	0	0	0	0
<i>C. aramatus</i>	0	0	0	1	4	0	0	0	0
<i>Mengalaspis cordyla</i>	0	0	0	84	40	21	1	0	0
<i>Rachicentron cannadum</i>	0	0	0	5	13	3	0	0	0
Eel	0	2	2	15	27	2	2	18	0
<i>Saurida tumbil</i>	0	0	0	9	3	0	0	0	0
<i>Thunnus albacares</i>	0	0	0	0	5	2	0	0	0
Shark	0	0	1	23	7	2	2	0	36
Sudar fish	0	1	0	19	9	1	0	0	0
Cat fish	0	0	0	0	5	2	0	2	7
Flat fish	0	0	0	0	1	0	0	0	0
<i>Trichiurus savala</i>	0	0	0	0	0	0	0	0	9
Star fish	0	0	0	0	0	0	1	0	0
Rast tellige	0	0	0	2	1	1	0	0	0
<i>Argyropis spinefer</i>	0	0	0	0	0	1	0	0	0
<i>Sphyraena bleekeri</i>	0	0	2	5	10	0	0	0	0
<i>Decapterus russelli</i>	0	0	0	0	1	0	0	0	0
<i>Katsuwona pelamis</i>	0	0	0	1	0	0	0	0	0
<i>Scombromorus guttatus</i>	0	0	0	2	0	0	0	0	0
<i>Seriolenia nigrofasciata</i>	0	0	0	4	0	0	0	0	0
<i>Gastrophysus scleratus</i>	0	0	0		0	0	0	4	0

DECLINE OF COASTAL BIRDS ALONG THE SOUTH-EAST COAST OF INDIA

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ABSTRACT

The major wintering grounds of waders migrating from the Arctic breeding ground to India along the Central Asian Flyway (CAF) are located along the East Coast. The important migratory birds utilizing the coastal wetlands are ducks, shorebirds, gulls, terns and flamingos. The coastal wetlands such as Great Vedaranyam Swamp (Point Calimere) Gulf of Mannar, Kaveli Tank, Pulicat Lake of South East Coast are important for long distance migratory waders or shorebirds as stopover, wintering and refueling sites. Throughout winter, birds use these wetlands for food and nutrients to sustain them for their return trip to the breeding grounds. The decline in population of these coastal birds for the last two decades caused due to habitat degradation in major key sites had great impact on the global population of these species. The major causes for the decline of coastal waders in India and the threats to their major key wintering sites, and the possible restoration measures are discussed in the paper

INTRODUCTION

The birds of any coastal wetlands can be divided into at least four groups based on their seasonal occurrence. 1. Summer (breeding) residents; 2. Winter residents (occurring throughout the winter); 3. Transients (passing through during either fall or spring migrations or both); and 4. Permanent residents. Furthermore, because of their frequently high abundances and their substantial food requirements resulting from high metabolic rates, birds often have a substantial impact on the infaunal invertebrates of intertidal habitats.

Most waterbird populations that breed in central Asia are highly migratory, with migration routes occurring as loosely organised flyways¹ (where many species follow similar migratory paths). Breeding populations in central Asia may migrate South-West to Southern Asia (Central Asian Flyway), or to East and South-East Asia and Australasia

1. *Flyway is defined as the migration route(s) and areas used by species or population of a species moving between its breeding and wintering grounds.*

(East Asian-Australasian Flyway), or Southern Europe (the Black Sea/Mediterranean Flyway) or Eastern Africa (West Asia-East Africa Flyway).

The Central-Asian Flyway (CAF) extends from Central Siberia through the Himalayas to the Indian subcontinent is least known among all the flyways and is used by about 50 species of waders, 20 species of ducks, several species of gulls, terns, storks, cranes and a number of passerines wintering and/or passing through India.

Some shorebirds (waders) weighing as low as 25g fly as far as 9,000, kms between the Arctic breeding grounds and South Indian wintering grounds. Prior to breeding they again fly Northwards to their nesting grounds, thus in one year they may fly 18,000 km. During the annual migrations, the birds depend on a great diversity of habitats, ranging from Arctic tundra to forests, grasslands, rivers and estuaries, lakes and marshes, sandy beaches, intertidal mud flats, coral reefs, atolls, and mangroves most of which are wetlands. Such long distant migrant coastal birds frequent in more numbers in the coastal wetlands along the South East Coast than the wetlands of other regions in India. During the migration flights the birds need to feed (refuel) and to do this they stop (and feed) at a number of sites along the route. These sites need to be productive (to provide enough food) and also undisturbed (to provide a safe roosting area). The major traditional wintering grounds for the waders of the Central Asian Flyway are located in India, especially on the Eastern Coast. Besides waders South Indian coastal wetlands provide wintering and passage sites for hundred thousands of ducks, terns, gulls and flamingos, which migrate from central and West Asia, and Europe. The wintering population at these traditional wetlands in the last three decades had shown a decline trend in most of these species.

STUDY AREAS

Point Calimere Wildlife Sanctuary and the adjoining Great Vedaranyam Swamp

The Point Calimere Wildlife Sanctuary (10°18' N; 79°51' E) is situated on a low promontory on the Coromandel Coast (Southern Deccan Plateau) in the Bay of Bengal. The Great Vedaranyam Swamp (henceforth referred to as GVS or swamp) stretches parallel to the Palk Strait for about 48 kms and is separated from it by a sand-bank. Its North to South dimensions varies from about 10 kms at its broadest in the East, to about 8 kms in the central part and about 6 kms in its Western portion. Five freshwater channels, connected to the Cauvery river, empty into the swamp. In total, it has an area of about 349 km².

Pulicat Lake

The Pulicat wetland is situated in South Coastal Andhra Pradesh (13°25' to 13°55' N and 80°03' to 80°19'E) on the Eastern seaboard of India with an area of about 450 sq. kms thereby making it the second largest brackish water lagoon in India next to Chilika Lake. The lake was declared as a bird sanctuary by the Andhra Pradesh Forest Department in the year 1976. The entire area is a vast brackish to saline lagoon with extensive mud and

sand flats. The sanctuary is bounded on its Eastern side by the spindle shaped Sri Harikota Island.

Gulf of Mannar

Mandapam (9°17' N; 79°8' E) lies on a narrow strip of land projecting from South East Coast of India surrounded by Gulf of Mannar in the South and Palk Bay in the North. At distances ranging from 5-8 kms from the mainland, the Gulf of Mannar has a chain of Islands running roughly parallel to the coast. These Islands are mainly of coral origin probably of the nature of fringing reefs. Manali Island, Hare Island, Pillaimadam Lagoon and Dhanuskodi Lagoon are the major bird congregation areas in Mandapam. Manali Island is an intertidal zone with an area of 24 hectares.

Kaliveli Lake

Kaliveli Lake (11°56' N : 79°50' E) is an important wetland in South India for migratory waterfowl, waders, terns and gulls. It is a semi-permanent, fresh to brackish water lagoon, which empties into the sea through a narrow channel connecting the tank with the Yedayanthittu Estuary to the North East. The hydrology of the lake is complex as it contains mainly freshwater during the rainy season (October to January) and gradually dries up and becomes brackish during March and April. Hence, the lake acts as a wintering site for both freshwater wader species as well as migratory waterfowl during winter and as a passage site for coastal waders, terns and gulls during spring.

MATERIAL AND METHODS

In India the migration study is being carried out through bird ringing/banding by the Bombay Natural History Society (BNHS). Bird ringing is one of the methods of marking a bird by placing an aluminium ring carrying a serial number and a legend "INFORM BOMBAY NATURAL HISTORY SOCIETY" on a bird's leg. When a banded bird is reported (recovered) from a second locality a definite fact related to its movements becomes known. A study of many such cases develops more and more complete knowledge of the details of migration. The birds retrapped (recaptured) in subsequent seasons help to predict the percentage of turnover, which are the yardsticks to assess the habitat quality.

The coastal waders banded and counted at different coastal wetlands along the East-Coast namely, Point Calimere, Gulf of Mannar, and Pulicat Lake under the Bird Migration Project of the Bombay Natural History Society (BNHS) carried out between 1980 and 1992 were taken as the baseline data to assess the population of coastal birds during 1980s and 1990s. The banding and counting data obtained between 1998 and 2003 at Point Calimere and Pulicat Lake under the Bird Banders Training Programme of the BNHS were compared with the earlier data to assess the decline in coastal bird population. The number of birds ringed for individual species and the capture rate per day are also used for comparison. The recapture rate of 1980s and 1990s were also compared with the present data to access the decline.

RESULTS AND DISCUSSION

The ringing data obtained at Point Calimere - the only site which has been intermittently monitored for bird banding for the last three decades and is an important wintering and staging site of over 10,00,000 waders and other waterbirds indicates that the decline of waders is over 70% for certain species. The most affected species are the two Arctic breeding *Calidrid* sandpipers, Little Stint *Calidris minuta* and Curlew Sandpiper *Calidris ferruginea*. These could be seen in many thousands in all the study sites, but are now becoming uncommon at many of these sites. At Point Calimere, the total number of Curlew Sandpiper (599) and Little Stint (517) ringed in 100 days during 1998-2002 were less than the two days catch during the 1980s. It is interesting to mention that during the 1980-81 migratory season, the number of Little Stint and Curlew sandpiper ringed were 9500 and 5600 respectively. The number of birds caught per season was still high during 1970s. Due to the scattered congregations the number of birds trapped per day also drastically reduced. The decline could also be predicted from the retrap data for the subsequent years. During the last four years the percentage of retrap for Little Stint and Curlew Sandpiper was 0%, as compared to 1-1.5% during 1980s, which declined to 0.25% for Little Stint in the early 1990s. The percentage of retrap for the Lesser Sand plover in subsequent seasons was over 3-6% in earlier and current studies. For other waders, like the Redshank, Greenshank, Grey Plover and Black-tailed Godwit the re-trap percentage was around 3.5%. The lower re-trap percentage for the Curlew-Sandpiper and Little Stint is not only due to their relatively less life span as compared to the other species, but also due to their vulnerability to the clap trap. Moreover, the shrinkage of shallow mudflats deprived them of suitable feeding sites, which prefer the shallow mudflats more than the other medium-sized waders.

The smaller waders are more susceptible to be caught in large numbers through the traditional method of trap called the claptrap. The population of large waders, such as Black-tailed Godwit *Limosa limosa*, Grey Plover *Pluvialis squatarola*, and Greenshank *Tringa nebularia* was not much affected, probably due to the difficulties in catching them through the same trap (Table 1).

Table-1. Decline of waders in catches at Point Calimere

Species Name	# ringed in one season & maximum single day catch			Average catch/day		
	1980-82	1990-92	2000-02	80-82	90-92	99-03
<i>Calidris ferruginea</i>	3569 (180)	1330 (110)	599 (35)	20	14	6
<i>Calidris minuta</i>	9876 (376)	1137(170)	513 (40)	56	20	5
<i>Charadrius mongolus</i>	1063 (45)	658 (48)	705 (34)	7	8	7
<i>Philomachus pugnax</i>	564 (80)	184 (47)	74 (17)	3	2	1

The decline in waterbird population is very conspicuous not only to the ornithologists, but also to laymen in the area. Any local villager, especially above 40 can recall the drastic changes in the wader and other waterfowl congregations of the Point Calimere. The disappearance of fabulous sights of clouds of waterbirds (waders, ducks, terns, flamingos, egrets) passing through the villages for their feeding and roosting sites up to the late 1980s is a visible indicator of the decline. The appearance of large mounds of salt in the adjoining mudflats of the village, which were once thronged by several thousand waders, ducks and flamingos till the late 1980s, not only indicates habitat loss but also its degradation. The most affected species are the two arctic breeding *Calidrid* sandpipers, Little Stint and Curlew Sandpiper, which are the most abundant winter visitors of Point Calimere. Besides these reservoirs, intertidal and other brackish zones provided enormous feeding habitats for these species. Hence, the population exceeded over 200,000 for the former and 1,50,000 for the latter in the 1980s. It appears that these two species were earlier benefited by the shallow water levels in the reservoirs, which carried many littoral forms (crustaceans, polychaetes) into the environment. The plentiful rains also helped to increase the productivity of these habitats during that period. The population of Curlew Sandpiper and Little Stint never exceeded 25,000 during the last four years. The extension of salt based industries; the diminishing rainfall and disturbances caused by fishermen have altered the habitats. The two long legged waders namely Avocet *Recurvirostra avosetta* and Blackwinged Stilt *Himantopus himantopus*, which were wintering in several thousands in the late eighties, have become scarce at Point Calimere. Crab Plover *Dromas ardeola* and Pied Oystercatcher *Haemotopus ostralegus* are the two waders not sighted since 1992.

Table-2. Population trend of common waders at Point Calimere

Species Name	1980s	1990s	2000-03
Curlew Sandpiper	> 1,50,000	> 80,000	< 25,000
Little Stint	> 2,00,000	> 1,00,000	< 20,000
Lesser Sand Plover	> 1,00,000	> 75,000	< 40,000
Ruff	> 1,00,000	30,000	< 10,000
Black-tailed Godwit	> 50,000	> 40,000	>15,000
Black-winged Stilt	> 15,000	3,000	>1,000
Pied Avocet	> 7,000	> 500	< 100

Mandapam (Gulf of Mannar) supported overall 50,000 coastal birds (waders, terns and other wading birds) including 13,000 flamingos during 1980s (Balachandran, 1990 and 1995) and it ranks third as an important wintering ground for Greater Flamingos *Phoenicopterus ruber* along the East Coast. Its proximity to Sri Lanka makes Mandapam as an important site in the Central Asian Flyway for migratory birds. Among the waders, the Lesser Sand Plover *Charadrius mongolus*, Curlew Sandpiper and Little Stint were the most abundant. Red Knot *Calidris canutus* and Great Knot *Calidris tenuirostris* are the regular winter visitor in small numbers, and these species are not vagrant species as reported previously. It provides breeding grounds for Lesser Crested Tern, Little Tern



Fig. 1. Major Wader habitats in India

Sterna albifrons, Kentish Plover *Charadrius alexandrinus*, Stone Plover *Esacus magnirostris* and Stone Curlew *Burhinus oedicephalus*. Among the important sites along the South East Coast, Point Calimere, Pulicat and Mandapam forms important link for migrant waders. The population estimates of the common wader species in the last two decades at Mandapam showed a declining trend (Table-3) probably due to habitat degradation. Now, the major bird congregation area of Dhanuskodi lagoon, which falls in the Coastal Regulation Zone (CRZ) in the Rameswaram Island, is proposed to construct the administrative block for the massive 'SethuSamuthram Shipping Canal' project.

Table-3. Population trend of common waders at Gulf of Mannar

Species Name	1985-88	1993	2001	2005*
Curlew Sandpiper	>10,000	>8,000	>5,000	< 1,000
Little Stint	>8,000	>3,000	>2,000	< 500
Lesser Sand Plover	>13,000	>8,000	>4,000	< 2,500
Crab Plover	900	150	65	< 20
Eurasian Curlew	450	120	67	55
Grey Plover	970	230	180	100
Great Knot	350	140	450	< 200
Red Knot	300	85	90	< 50
Common Greenshank	250	>3,500	180	< 50

* Status up to October

The major groups of birds wintering in Pulicat Lake are ducks, terns, gulls, flamingos and waders. Over 200,000 waterbirds were recorded during 1988 and 1989 at Pulicat. Out of them, over 30,000 were Greater Flamingo. Other dominant waders were Little Stint, Curlew Sandpiper and Lesser Sand Plover, Black-tailed Godwit and Ruff. A total of 88 species of birds has been recorded from Pulicat Bird Sanctuary during a BNHS Study (Rao and Mohapatra, 1993). The population data available for the last two decades showed the declining trend (table-4).

Table-4. Population Estimates for common waders at Pulicat

Species Name	1988-89	1998-99
<i>Calidris ferruginea</i>	> 35,000	> 20,000
<i>Calidris minuta</i>	> 60,000	> 35,000
<i>Charadrius mongolus</i>	> 25,000	> 15,000
<i>Philomachus pugnax</i>	> 40,000	30,000
<i>Limosa limosa</i>	> 20,000	>18,000
<i>Himantopus himantopus</i>	> 5,000	3,000
<i>Recurvirostra avosetta</i>	> 1,000	> 400

Table-5. Population trend of Greater Falmingo

Species Name	1980s	1990s	2000-05
Point Calimere	> 40,000	> 10,000	< 5,000
Pulicat	> 30,000	> 8,000	< 3,000
Gulf of Mannar	>13,000	> 7,000	< 4,000

Several federally listed threatened and near threatened coastal bird species, which were recorded in the South East Coast, are becoming rare now. The threatened species, namely Spotted Greenshank *Tringa guttifer*, Spoonbill Sandpiper *Calidris pygmeus*, and Spot-billed Pelican *Pelecanus philippensis*, and the near threatened Darter *Anhinga melanogaster*, Painted Stork *Mycteria leucocephala*, Lesser Flamingo *Phoenicopterus minor* and Asian Dowitcher *Limnodromus semipalmatus* are some of them. The present status of these birds in the above wintering habitats showed that the birds are at high risk. Pied Avocet, Crab Plover and Eurasian Oystercatcher are some of the other species which have declined drastically.

Among the ducks the Arctic breeding species such as Northern Pintail, Garganey *Anas querquedula* and Northern Shoveller migrate to the coastal wetlands up to the Southern most part of India. Decline in population of the above species are less when compared to other coastal wetland species. In waders Black-tailed Godwit, Ruff and Wood Sandpiper, the decline is also relatively less. It is because of that the former two species also prefer the paddy fields for their survival like the two duck species Northern Pintail and Garganey. Intensive cultivation during the winter season in the adjacent areas of the above coastal wetlands is very helpful for those species to maintain the populations. Fewer declines in population were recorded in gulls and terns as they mostly depend on the sea for feeding. The abundant food sources of the coastal wetlands and the nearby sea for the piscivorous birds are the reasons for the fewer declines in those bird groups.

THREATS TO THE HABITATS

In India, due to the degradation of wetlands habitats, populations of various waterbird species are dwindling in their traditional wintering sites

Poaching

Poaching is one of the major threats at Point Calimere. The three traditional methods of trapping are claptrap, mesh-nets (like gill nets operated during night), and nooses, which are operated outside the sanctuary limits of Point Calimere. Among the coastal birds, the two gregarious species (Little Stint and Curlew Sandpiper) are more vulnerable to clap trap, as mudflats with shallow water, which are the ideal habitats to operate this method. It is interesting to note that one claptrap on a single day yielded 376 Little Stints for ringing in 1980. Similarly, 180 Curlew Sandpipers were caught on a single day through

this method. The havoc can be visualized, since over 100 trappers were operating these highly effective traps during the migratory season between August to March in the 1980s and 1990s in the Muthupet and Adirampatinam areas outside the sanctuary. However, in recent times, the number of trappers involved in poaching has reduced, as the trapping is not as productive due to the fall in wader populations.

Depletion of ground water and salt intrusion

The ground water extraction has increased manifold to cater to the needs of the floating fisherfolk population, which is on the increase at Point Calimere. The ground water recharge is inadequate due to the consistently diminishing rainfall in the area over the last two decades. The flushing/dilution of high saline water stored in reservoirs and condensers of salt industries and saltpans have been hampered due to the embankments made in the swamp by the chemical companies and other salt works. The ingress of seawater into larger areas of the swamp affected by the strong summer wind, made the swamp not only habitable for the waterbirds during summer, but also helped to prevent the mudflats from drying up completely. The salinity ingress has made the area unsuitable for raising traditional crops like paddy, while the fresh water wells have become unpotable. The hyper saline conditions has not only altered the texture of the mudflats of the reservoirs, but affected the adjoining bird habitats also.

Lack of awareness

The general lack of community understanding or education of shorebird related conservation issues are significant threats to shorebird survival. By far the greatest threat, even today, remains the ignorance of the importance of wetlands and the roles they play in coastal birds conservation.

Least importance to coastal bird research

In India not much attempt is made to study the coastal migratory birds mostly due to the lack of knowledge on these amazing group migrating from the high Arctic region. The coastal birds roles in maintaining the coastal biodiversity and local fisheries through guano deposition are not recognised.

Disturbance

One of the greatest threats to the sustainability of the coastal birds is human disturbance to the shoreline. When shorebirds take flight because a person (e.g. fishermen), vehicle or vessel disturb them, they use up critical energy. This means the birds might not gain enough condition for migration and/or breeding. Now, the major bird congregation area of Dhanuskodi lagoon, which falls in the Coastal Regulation Zone (CRZ) in the Rameswaram Island, is proposed to construct the administrative block for the massive 'SethuSamuthram Shipping Canal' project. Industrial development on the shores of the lake, siltation and illegal Prawn farming are the major threats to the Pulicat Lake.

MANAGEMENT RECOMMENDATIONS

Protect coastal bird habitats

- Enhance and maintain Coastal bird habitats,
- Avoid further degradation or loss of critical wintering and staging sites,
- Restrict coastal development to areas where its impact on coastal bird habitat is minimal.

Community Education

- Educate the community about coastal birds conservation,
- Collaborate with the primary stakeholders (wildlife division) in the delivery of key messages about coastal birds conservation
- Encourage establishment of eco-tourism programs that provide coastal bird education and interpretation.

Research and monitoring

- Monitoring population of coastal birds in key wintering and staging sites.
- Collaboration with relevant organisations (BNHS, ZSI, SACON etc)
- Investigate the use of coastal birds as bio-indicators in ecosystem health assessment
- Encourage research on shorebird migration and conservation

CONCLUSION

Reduction in overall flyway population for the coastal birds was evident as their numbers are on the decline globally. Most of the threats are either at the wintering and staging/refueling sites whereas threats (natural and human-induced) at the breeding grounds are negligible due to the inaccessibility. Hence, habitat degradation complemented by poaching (at unprotected buffer zone) forms the major threats during their migration journeys. Point Calimere, the traditional and the famous wintering ground of waders has certainly undergone tremendous changes, which was evident from the salt-water intrusion. The increase in salt content was basically caused by the extensive salt works (both edible and industrial salts), excessive pumping of ground water especially for the floating fishing population by the villagers, heavy decline in annual rainfall, and flocking of feeder channels to the swamp by the extensive bunds raised for the salt works. The degradation in soil quality can also be felt through the changes in traditional livelihood practices- rain fed agriculture (paddy cultivation) to salt works and fishing. This ultimately affected the microhabitat diversity, which in turn affected the bird population, which are the visible indicators. The low rainfall and feeder channels blocking prevent the flushing of high

saline water in to the sea during monsoon. The sand deposited due to the *Tsunami* also affected the feeding areas of the coastal species especially smaller waders at Point Calimere. It is interesting to mention here that over 500,000 waders wintered during the 1980s at Point Calimere, which have become less than 100,000. Being the best wintering ground along the East Coast, the decline in shorebirds population at Point Calimere had severe impact on the other important places Pulicat Lake and Kaliveli Lake, which ultimately affected global population as well. It is more true because the wintering shorebirds of Point Calimere using these wetlands as stop-over sites during their return journey was established through banding. Similarly heavy decline in other migratory species such as flamingos has been observed.

Coastal waterbirds, with their range of specialized feeding and migration ecologies are sensitive indicators of change in their environments. Knowledge of the status of coastal bird populations can provide important information on the wider environment, including that caused by climate changes as well as from habitat loss, harmful industrial developments, unregulated agricultural practices, human disturbance, climatic and environmental changes, they are becoming scarce at many key sites. The ringing and bird count data shows that among the coastal birds the two Arctic breeding birds, Curlew Sandpiper and Little Stint, and large legged wading bird Greater Flamingo have declined drastically when compared to other species. Like that the threatened and near threatened coastal species are becoming rare in the South Indian wintering grounds. Diminishing food resources along the shorelines and coastal wetlands are probably the other major reasons for the declining in the coastal species. The highly preferred prey species such as *Chironomid* larvae, isopods and amphipods are declining in the above South Indian coastal wetlands due to habitat destructions and unpredictable reasons. Through protection of coastal bird habitats, community education, research and monitoring with the co-operation of other flyway countries these migrant bird population can be enhanced and maintained.

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BRACHYURAN BIORESOURCES OF COASTAL ANDHRA PRADESH

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ABSTRACT

The state of Andhra Pradesh with its 960 km long coastline and diversified habitats is endowed with rich and varied brachyuran fauna. Inventory and field surveys of brachyuran bioresources conducted during 1995–1999 have revealed the occurrence of 106 species of crabs including 2 species recorded for the first time from Andhra Pradesh. These crabs represent 57 genera and 17 families. Among these, 59 are marine and 33 estuarine while 14 species occur both in marine and estuarine waters. The crabs are caught in gill net, boat seine, shore seine and *Chinna Alivi* in inshore waters and by trawl net in offshore waters, while stake net, drag net and lines are generally used in backwaters and estuaries. The export of crabs from this region is also discussed.

INTRODUCTION

The coastal India and its environment plays a pivotal role in maintaining national economy due to its natural resources, productive habitats and valued biodiversity including crabs. The past few decades have witnessed the rapid development of assessing and managing marine resources which play a key role as component of marine products as food and ornaments, items for international trade and as a source of hard currency for developing countries. Protection of biodiversity and conservation of the resources often pose so many challenges, which has to be tackled wisely and judiciously. Hence, knowledge of resource availability and its utilization is essential for efficient planning. In this context, study of brachyuran resources of Andhra coast is undertaken to inventorize crab faunal diversity for sustainable utilization of resources indicating untapped resources from this coast, which supports a lucrative fishery almost all the year round. The brachyuran fauna of Andhra coast has been studied earlier by Wood-Mason and Ilevck (1891), Alcock (1896-1899 abc), Lalitha Devi (1981, 1986) and recently by Dev Roy and Bhadra (2001, 2005) in which 4 species were reported for the first time from India.

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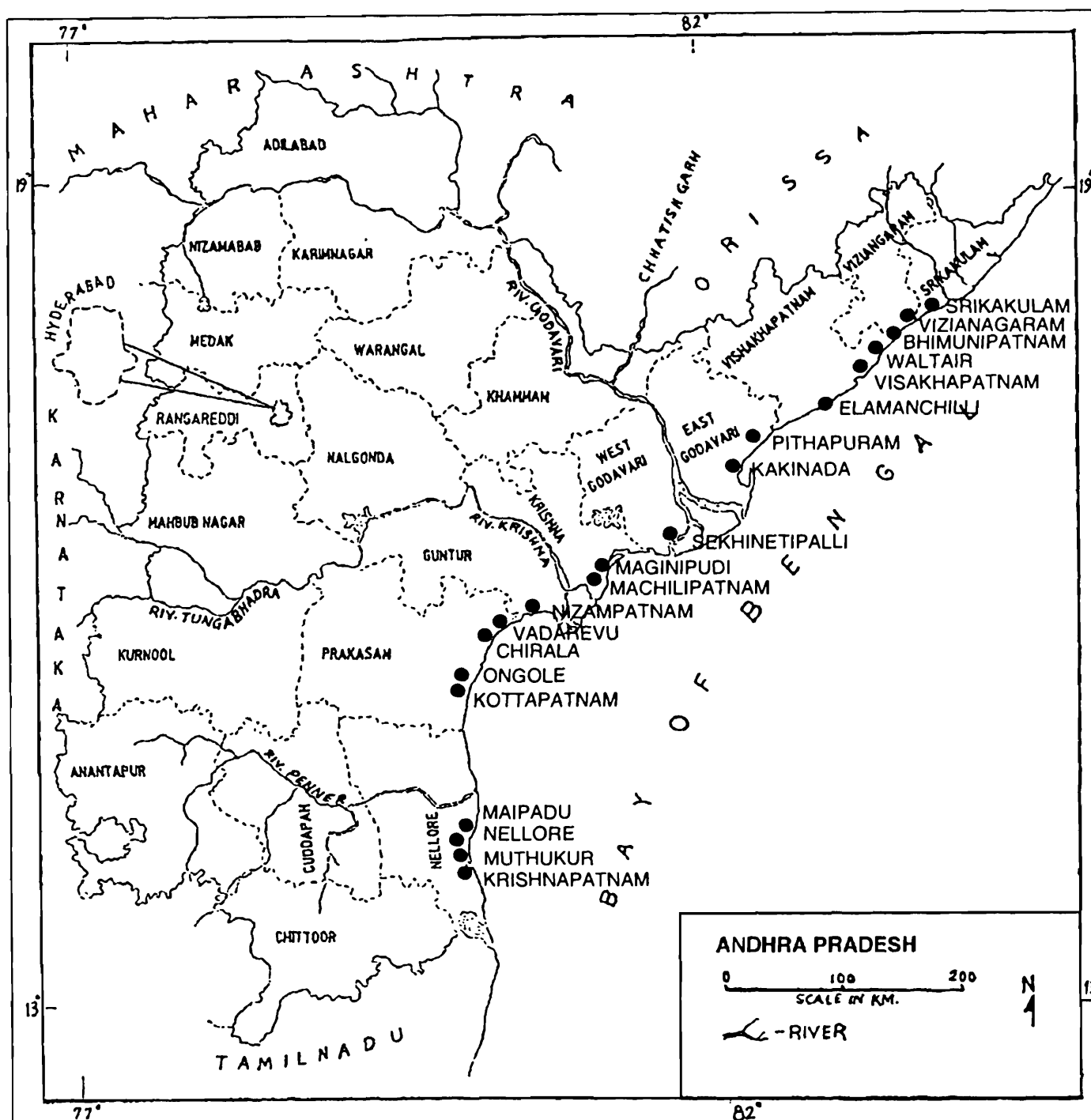


Fig. 1 : Map of Andhra Pradesh showing the districts and important collecting stations (●).

MATERIAL AND METHODS

The extensive coast line of Andhra Pradesh (960 km) with varied biotopes support an excellent wealth of diversified carcinological fauna comprising of both marine and estuarine species. The collected data for this study is based on field surveys (Fig. 1) carried out during 1995-1999, as well as materials present in National Zoological Collection (NZC) of Zoological Survey of India and also from published literature. Export data has been collected from Marine Products Export Development Authority (MPEDA). In the present communication, backwater species have been considered as estuarine species as backwater environment is almost akin to estuarine conditions.

BRACHYURAN BIORESOURCES

A total of 106 species of brachyuran crabs belonging to 57 genera and 17 families has been encountered in this study including 2 species recorded for the first time from Andhra Pradesh (Table-1). Out of these, 59 species are marine and 33 estuarine while 14 species occurs both in marine and estuarine waters. Their family-wise distribution shows highest diversity of species (22) in the family Portunidae followed by Grapsidae (16), Ocypodidae (14) and Leucosiidae (12) which corresponds to 20.75%, 15.1%, 13.2% and 11.32% respectively of the total number of brachyuran crabs reported from Andhra Pradesh (Fig. 2A & B). The district-wise distribution reveals maximum number of species in Visakhapatnam (73 species) which is followed by East Godavari (32 species), Nellore (24 species), Prakasam (21 species) and Krishna (19 species) (Fig. 3). A list of new taxa so far described from Andhra Pradesh is presented in Table-2.

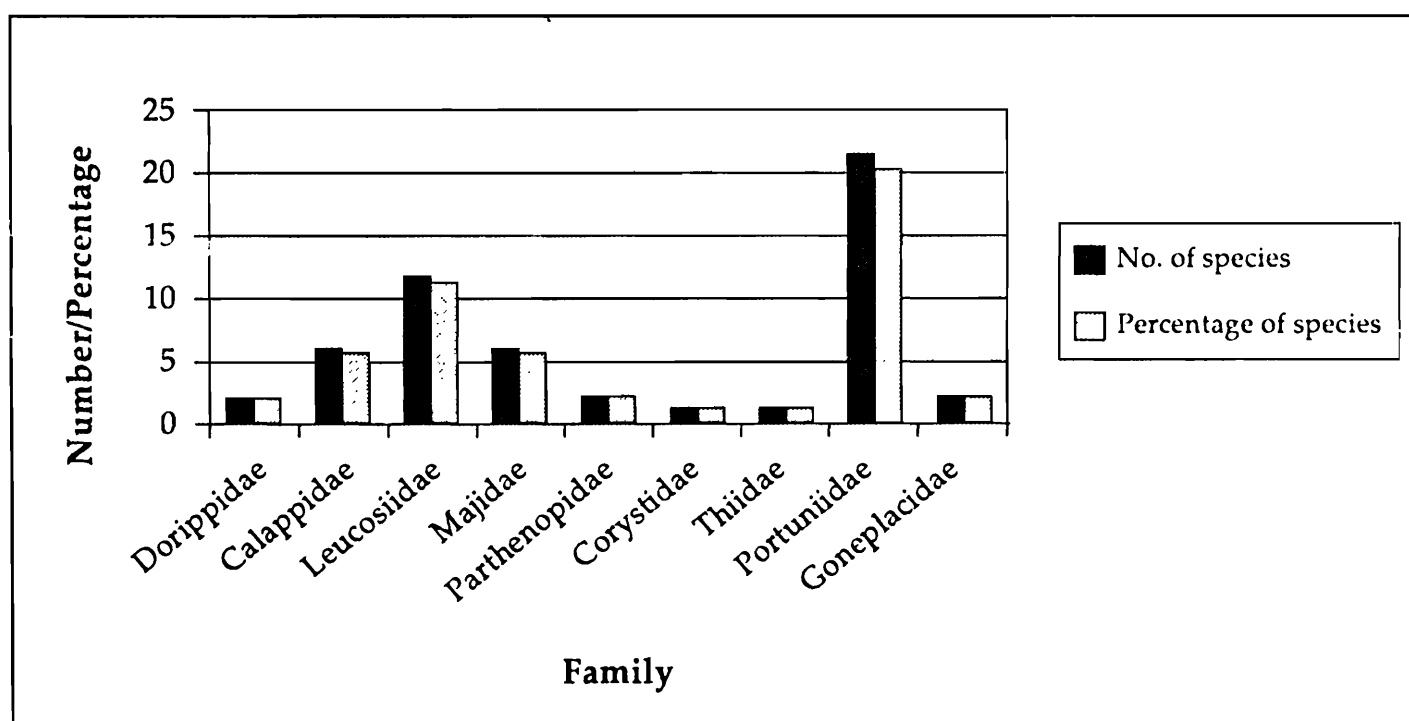


Fig. 2A. Family-wise distribution of crabs of Andhra Pradesh

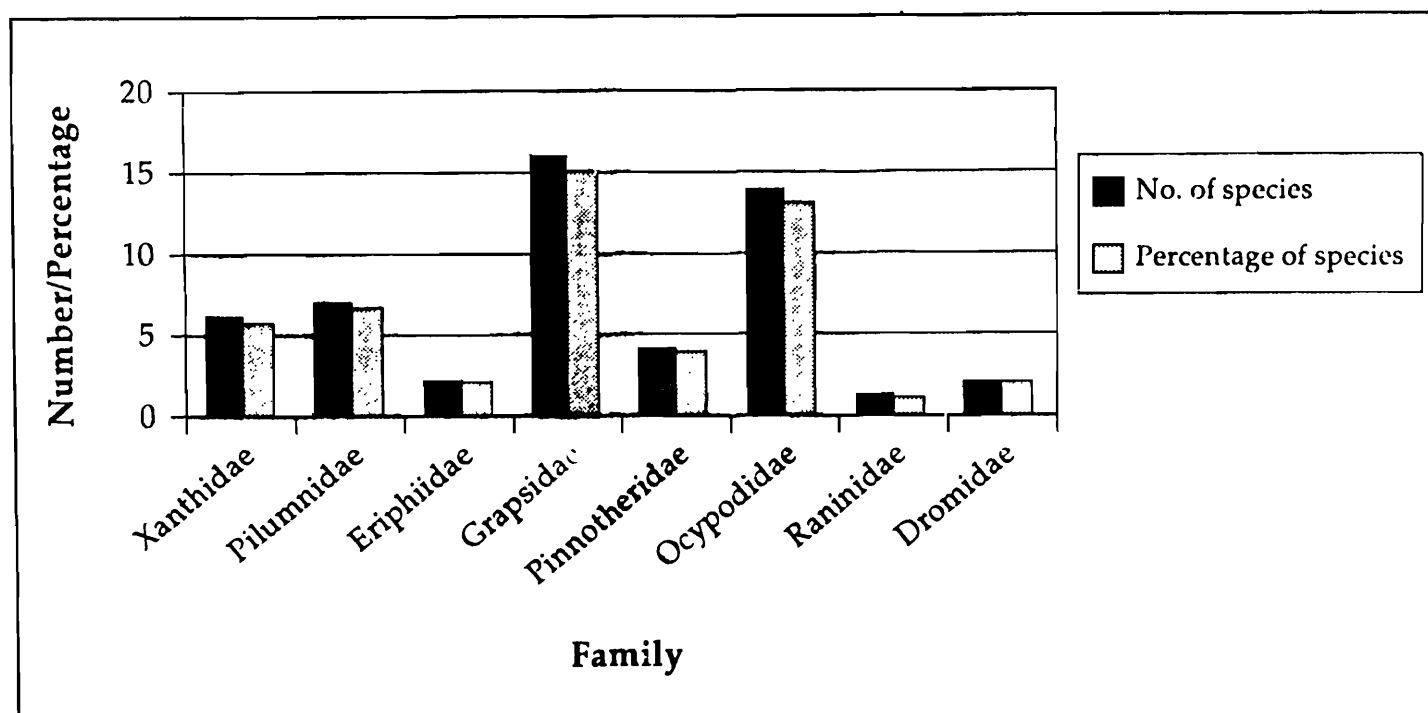


Fig. 2B. Family-wise distribution of crabs of Andhra Pradesh

Table 1. List of brachyuran bioresources of Andhra coast

MARINE	
	Section RANINIDEA Family Raninidae
**1.	<i>Raninoides personatus</i> Henderson, 1888
	Section DROMIACEA Family Dromiidae
2.	<i>Lauridromia dehaani</i> (Rathbun, 1923)
3.	<i>Sphaerodromia kandelli</i> (Alcock and Anderson, 1894)
	Section OXYSTOMATA Family Dorippidae
4.	<i>Dorippoides facchino</i> (Herbst, 1785)
	Family Calappidae
5.	<i>Calappa lophos</i> (Herbst, 1790)
6.	<i>C. pustulosa</i> Alcock, 1896
*7.	<i>Ashtoret lunaris</i> (Forskål, 1775)
8.	<i>A. miersi</i> (Henderson, 1887)
9.	<i>Matuta planipes</i> Fabricius, 1798

Table 1. *Contd.*

10.	<i>M. victor</i> (Fabricius, 1781)
	Family Leucosiidae
11.	<i>Ebalia sagittifera</i> Alcock, 1896
12.	<i>Arcania quinquespinosa</i> (Fabricius, 1787)
13.	<i>A. septemspinosa</i> (Fabricius, 1787)
14.	<i>A. undecimspinosa</i> (de Haan, 1841)
15.	<i>Ixa cylindrus</i> (Fabricius, 1787)
16.	<i>Ixoides cornutus</i> MacGilchrist, 1905
17.	<i>Parilia alcocki</i> Wood-Mason, 1891
18.	<i>Philyra globosa</i> (Fabricius, 1787)
19.	<i>P. globulosa</i> H. Milne Edwards, 1837
20.	<i>P. scabriuscula</i> (Fabricius, 1798)
21.	<i>Leucosia craniolaris</i> (Linnaeus, 1758)
	Section OXYRHYNCHA Family Majidae
22.	<i>Encephaloides armstrongi</i> Wood-Mason, 1891
23.	<i>Doclea ovis</i> (Fabricius, 1787)
24.	<i>D. hybrida</i> (Fabricius, 1798)
25.	<i>D. muricata</i> (Fabricius, 1787)
26.	<i>Phalangipus indicus</i> (Leach, 1815)
27.	<i>P. longipes</i> (Linnaeus, 1758)
	Family Parthenopidae
28.	<i>Cryptopodia angulata</i> H. Milne Edwards, 1841
	Family Corystidae
29.	<i>Jonas</i> sp.
	Family Thiidae
30.	<i>Nautilocorystes investigatoris</i> Alcock, 1899
	Section BRACHYRHYNCHA Superfamily PORTUNOIDEA Family Portunidae
*31.	<i>Portunus pelagicus</i> (Linnaeus, 1758)
*32.	<i>P. sanguinolentus</i> (Herbst, 1790)
33.	<i>P. gladiator</i> Fabricius, 1798

Table 1. Contd.

34.	<i>P. hastatoides</i> (Fabricius, 1798)
35.	<i>Portunus spinipes</i> Miers, 1886
36.	<i>Charybdis</i> (<i>Charybdis</i>) <i>affinis</i> Dana, 1852
37.	<i>C.</i> (<i>Charybdis</i>) <i>annulata</i> Fabricius, 1798
38.	<i>C.</i> (<i>Charybdis</i>) <i>callianassa</i> (Herbst, 1801)
*39.	<i>C.</i> (<i>Charybdis</i>) <i>feriatus</i> (Linnaeus, 1758)
40.	<i>C.</i> (<i>Charybdis</i>) <i>helleri</i> A. Milne Edwards, 1873
41.	<i>C.</i> (<i>Charybdis</i>) <i>lucifera</i> (Fabricius, 1798)
42.	<i>C.</i> (<i>Charybdis</i>) <i>natator</i> (Herbst, 1794)
*43.	<i>C.</i> (<i>Charybdis</i>) <i>rostrata</i> A. Milne Edwards, 1861
44.	<i>C.</i> (<i>Goniohellenus</i>) <i>hoplites</i> Wood-Mason, 1877
45.	<i>C.</i> (<i>Goniohellenus</i>) <i>truncata</i> (Fabricius, 1798)
46.	<i>C.</i> (<i>Goniohellenus</i>) <i>vadorum</i> Alcock, 1899
47.	<i>Thalamita admete</i> (Herbst, 1803)
*48.	<i>T. crenata</i> (Latreille, 1829)
*49.	<i>Podophthalmus vigil</i> (Fabricius, 1798)
	Family Goneplacidae
50.	<i>Carcinoplax longimanus</i> (de Haan, 1835)
51.	<i>C. longipes</i> (Wood-Mason, 1891)
	Family Xanthidae
52.	<i>Banareia banareias</i> (Rathbun, 1911)
53.	<i>Demia splendida</i> Laurie, 1906
54.	<i>D. toxica</i> Garth, 1971
55.	<i>Nectopanope rhodobaphes</i> (Wood-Mason, 1891)
56.	<i>Etisus</i> sp.
57.	<i>Liagore erythematica</i> Guinot, 1971
	Family Pilumnidae
58.	<i>Galene bispinosa</i> (Herbst, 1783)
59.	<i>G. granulata</i> Miers, 1884
60.	<i>Eurycarcinus grandidieri</i> Miers, 1867
*61.	<i>E. orientalis</i> A. Milne Edwards, 1867

Table 1. *Contd.*

62.	<i>Xenophthalmus moebii</i> Richters, 1880
	Family Eriphiidae
63.	<i>Menippe rumphii</i> (Fabricius, 1798)
*64.	<i>Myomenippe hardwickii</i> (Gray, 1831)
	Family Grapsidae
65.	<i>Grapsus albolineatus</i> Lamarck, 1818
66.	<i>Metopograpsus latifrons</i> (White, 1874)
*67.	<i>M. messor</i> (Forskål, 1775)
*68.	<i>Plagusia depressa tuberculata</i> (Lamarck, 1818)
	Family Ocypodidae
*69.	<i>Ocypode ceratophthalma</i> (Pallas, 1772)
70.	<i>O. cordimana</i> Desmarest, 1825
71.	<i>O. macrocera</i> H. Milne Edwards, 1837
*72.	<i>O. platytarsis</i> H. Milne Edwards, 1837
*73.	<i>Dotilla intermedia</i> de Man, 1888
	ESTUARINE
	Section OXYSTOMATA Family Dorippidae
1.	<i>Neodorippe callida</i> (Fabricius, 1798)
	Family Leucosiidae
2.	<i>Philyra sexangula</i> Alcock, 1896
	Section OXYSTOMATA Family Parthenopidae
3.	<i>Parthenope longimanus</i> (Linnaeus, 1764)
	Family Portunidae
4.	<i>Scylla serrata</i> (Forskål, 1775)
5.	<i>S. tranquebarica</i> (Fabricius, 1798)
6.	<i>Thalamita chaptali</i> (Audouin, 1826)
	Family Pilumnidae
7.	<i>Benthopanope indica</i> (de Man, 1888)
8.	<i>Typhlocarcinus rubidus</i> Alcock, 1900

Table 1. Contd.

	Family Grapsidae
9.	<i>Pachygrapsus minutus</i> A. Milne Edwards, 1873
10.	<i>Varuna litterata</i> (Fabricius, 1798)
11.	<i>Ptychognathus barbata</i> (A. Milne Edwards, 1873)
12.	<i>Parasesarma plicatum</i> (Latreille, 1803)
13.	<i>Episesarma taeniolata</i> (White, 1847)
14.	<i>E. tetragonum</i> (Fabricius, 1798)
15.	<i>Metaplex crenulata</i> (Gerstaecker, 1856)
16.	<i>M. distinctus</i> H. Milne Edwards, 1852
17.	<i>M. elegans</i> de Man, 1888
18.	<i>M. indica</i> H. Milne Edwards, 1852
19.	<i>M. intermedia</i> de Man, 1888
20.	<i>Metasesarma rousseauxii</i> (H. Milne Edwards, 1853)
	Family Pinnotheridae
**21.	<i>Chasmocarcinops gelasimoides</i> Alcock, 1900
22.	<i>Pinnotheres alcocki</i> Rathbun, 1910
23.	<i>P. gracilis</i> Bürger, 1895
24.	<i>P. placunae</i> Hornell and Southwell, 1909
	Family Ocypodidae
25.	<i>Uca dussumieri</i> (H. Milne Edwards, 1852)
26.	<i>U. lactea</i> (de Haan, 1835)
27.	<i>U. triangularis</i> (A. Milne Edwards, 1873)
28.	<i>Macrophthalmus (Macrophthalmus) brevis</i> (Herbst, 1804)
29.	<i>M. (Mareotis) depressus</i> Rüppell, 1830
30.	<i>M. (Mareotis) tomentosus</i> Souleyet, 1841
31.	<i>Dotilla blanfordi</i> Alcock, 1900
32.	<i>D. myctiroides</i> (H. Milne Edwards, 1852)
33.	<i>Baruna socialis</i> Stebbing, 1904

Note: * Asteriks indicate species occurring in both marine and estuarine habitats.

** Indicates new record from Andhra Pradesh

Table 2. List of new taxa described from Andhra Pradesh

Family and Species	Type locality	Remarks
Dromiidae <i>Sphaerodromia kendalli</i> Alcock and Anderson, 1894	Nellore coast, 112 fathoms.	Also known to occur in Indonesia, Moluccas Islands, Philippines, Taiwan and Japan (Dev Roy and Bhadra, 2005).
Leucosiidae <i>Parilia alcocki</i> Wood-Mason, 1891	Godavari Delta, 70 fathoms (=127.4 m).	Also recorded from Mahanadi Delta, Orissa. Restricted to Bay of Bengal. Not known to occur outside the limits of Indian waters (Dev Roy and Bhadra, 2005).
<i>Philyra sexangula</i> Alcock, 1896	Godavari coast, Sacramento Shoal, 6 fathoms (=10.92 m)	Subsequently recorded from Parangipettai coast, Tamil Nadu (Sethuramalingam and Khan, 1991) and Persian Gulf (Alcock, 1896).
Majidae <i>Nautilocorystes investigatoris</i> Alcock, 1899	Visakhapatnam, 15 -17 fathoms (=27.3 – 30.94 m)	Endemic to Andhra Pradesh (Dev Roy and Bhadra, 2005).
Thiidae <i>Encephaloides armstrongi</i> Wood-Mason, 1891	Godavari coast.	Also occurs in Ganjam coast of Orissa. Subsequently recorded from Gulf of Oman and Arakan coast. Occurs near 100 fathoms (= 182 m) from the coast of Arakan to Godavari. One of the most distinctive Indo-Pacific majid crab (Griffin, 1974).

ECONOMIC SPECIES

The economically important species of crabs occurring in coastal and estuarine waters of Andhra Pradesh are presented in Table-3. A list of ill-tapped and untapped brachyuran bioresources is shown in Table-4. In the inshore waters (estuaries, backwaters and brackishwater lakes), two species of the genus *Scylla* viz. *S. serrata* and *S. tranquebarica* contributes largely to fishery. They are found mostly in estuaries fringed with mangroves. During field surveys, the largest size of *Scylla serrata* caught by fisherman in traps

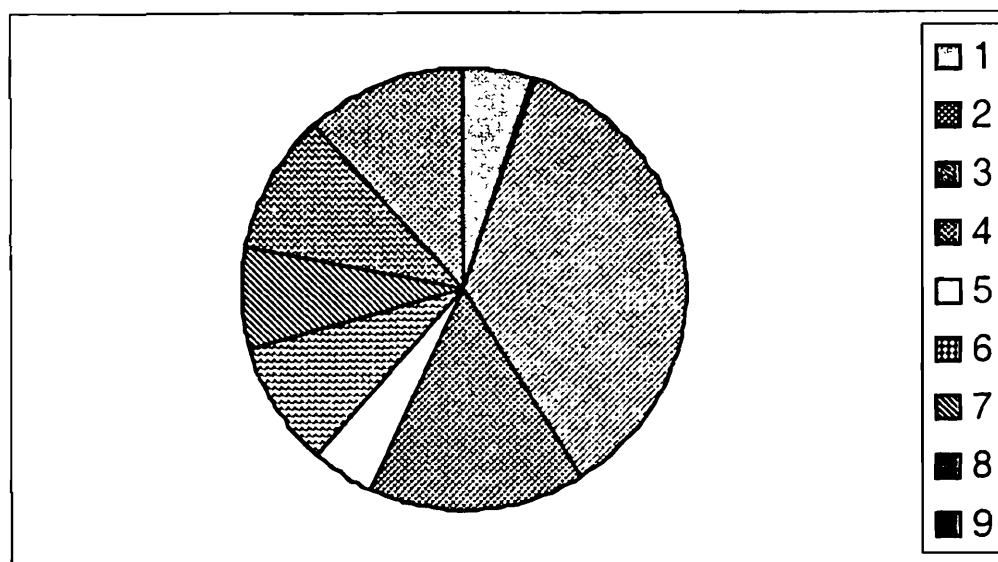


Fig. 3. District-wise distribution of crabs from Andhra Pradesh (1 = Srikakulam; 2 = Vizianagaram; 3 = Visakhapatnam; 4 = East Godavari; 5 = West Godavari; 6 = Krishna; 7 = Guntur; 8 = Prakasam; 9 = Nellore)

measuring 210.0 mm and weighing over a kg was noted at Nagayalanka (Krishna estuary). Both the species of *Scylla* have a good demand in the market, their larger sizes are found to be exported in live condition. Apart from mud crabs, other economic species such as *P. pelagicus* and *P. sanguinolentus* also occur in large quantities in this coast.

LANDING

Andhra Coast harbours a number of commercially important crabs. The major landing of crabs in the State are from coastal areas and also from Godavari estuary, Krishna estuary and Pulicat lake. In the offshore areas, crabs are caught in trawlers whereas in inshore waters, they are caught in gill net, boat seine, shore seine and *Chinna Alivi* and from backwaters in stake net, drag net, and lines. The lower reaches of Godavari estuary with an area of about 211.0 sq km supports a lucrative fishery which was estimated at 3,37 tons during October 1967 to September 1968 (Rao *et al.*, 1973). In this estuary, *Thoka Vala*, *Pakkadevu Vala*, lines with bait and scoop net are used for catching crabs comprising mostly of *Scylla serrata*, *P. pelagicus* and *P. sanguinolentus*. Visakhapatnam backwater and Pulicat lake are also important areas of crab production. About 907.78 tons of crabs have been landed in Pulicat lake (Anonymous, 1960). Crabs are also caught in large numbers in and around Kakinada region. In this coast, crabs are encountered in good quantities below 20 m depth (Lailtha Devi, 1985). A minor modification of gill net locally known as *Peethu Valai* are employed in Kakinada area. Baited lines are also used to attract the crabs in Kakinada region. Exclusive fishing by lines is practiced in backwaters during November to March.

The trawl collection of Visakhapatnam, Machilipatnam, Krishnapatnam, Nizamabad, Chirala, Ongole, Narsapur and Kakinada consists mainly of *P. pelagicus* and *P.*

Table 3. Economically important species occurring in Andhra coast

Sl. No.	Species	Occurrence in coastal landing Centres				
		1	2	3	4	5
	Family Portunidae					
1.	<i>Scylla serrata</i>	C	C	C	C	C
2.	<i>S. tranquebarica</i>	A	A	A	A	A
3.	<i>Portunus pelagicus</i>	A	A	A	C	A
4.	<i>P. sanguinolentus</i>	A	A	A	C	A
5.	<i>Charybdis (Charybdis) feriatus</i>	O	O	O	O	O

Note 1 = Visakhapatnam 2 = Machilipatnam 3 = Kakinada 4 = Nagayalanka 5 = Nellore
 A = Abundant C = Common O = Occasional

Table 4. List of untapped/ ill-tapped resources of Andhra Pradesh

Sl. No.	Species	Size (width x length) (mm)	Occurrence
	Family Portunidae		
1.	<i>Charybdis (Charybdis) annulata</i>	56.9 x 40.3	Medium
2.	<i>C. (Charybdis) lucifera</i>	72.1 x 46.75	Medium
3.	<i>C. (Charybdis) natator</i>	59.8 x 36.55	Medium
4.	<i>Thalamita crenata</i>	46.6 x 31.5	Low
5.	<i>Podophthalmus vigil</i>	117.0 x 44.25	High
	Family Eriphiidae		
6.	<i>Myomenippe hardwickii</i>	58.45 x 41.8	Medium
	Family Grapsidae		
7.	<i>Varuna litterata</i>	29.0 x 26.55	Medium
	Family Calappidae		
8.	<i>Matuta planipes</i>	30.4 x 38.2	Medium

sanguinolentus. The species-wise bulk production in offshore waters of *P. pelagicus* is 82.0% and *P. sanguinolentus* 99.7% (Lalitha Devi, 1985.). Their production from backwaters are negligible being about 4.48 and 0.3% respectively. The other crabs namely, *Charybdis (Charybdis) feriatus*, *Charybdis annulata*, *Podophthalmus vigil*, *Matuta planipes* and *Ashtoret lunaris* are often landed in appreciable quantities. Among these, only the first two species are occasionally found in local markets for sale. The remaining species though edible are not sold in local markets. Mention may be made that *Podophthalmus vigil* which is sold in large numbers in fish markets in Pacific countries is also not consumed in this coast (Dev Roy and Bhadra, 2005). Same is the case with *Myomenippe hardwickii*, a meaty and

tasty crab of the family Eriphiidae occurring in Andhra coast. The grapsid crab, *Varuna litterata* which occurs in good quantities in rivers and estuaries is also not tapped adequately. This crab was found to occur in plenty at Nagayalanka and Sekhinetipalli. These species have enough potential as alternative source of protein especially for the poorer sections of people of the state.

Major landing areas of mud crabs in Andhra Pradesh are villages around Kakinada such as Peddavalasala, Chinnayalasala, Pedagadimoga, Lakshmipathipuram, Dowleswaram, Uppada, Matlapalem, Boddu Venkatayapalem and Rajahmundry near Godavari estuary (Lalitha Devi, 1986, Raj, 1992). During our survey work good quantities of mud crab was found to be landed at Visakhapatnam, Krishnapatnam, Narsapur, Nizamabad, Rapalle and Nagayalanka. The entire population of Pedavalasala is dependent chiefly upon mud crab fishing whereas other villages namely, Chinnayalasala, Gadimoga and Lakshmipathipuram depend mostly upon this fishery (Raj, 1992). However, information of landing data in recent years is not available.

EXPORT

Export data of swimming crabs for the years 1998–2001 is presented in Fig. 4. A total of 212.61 tons of frozen cut swimming crab valued at Rs. 2, 07, 87, 800 crores was exported from Andhra Pradesh during the year 2000. Beside this, frozen whole crab and frozen crab meat are also exported from this state. Kakinada and Nagayalanka are important centres of live crab for export. There are agents who collect and send these crabs to Chennai for air-lifting to foreign countries.

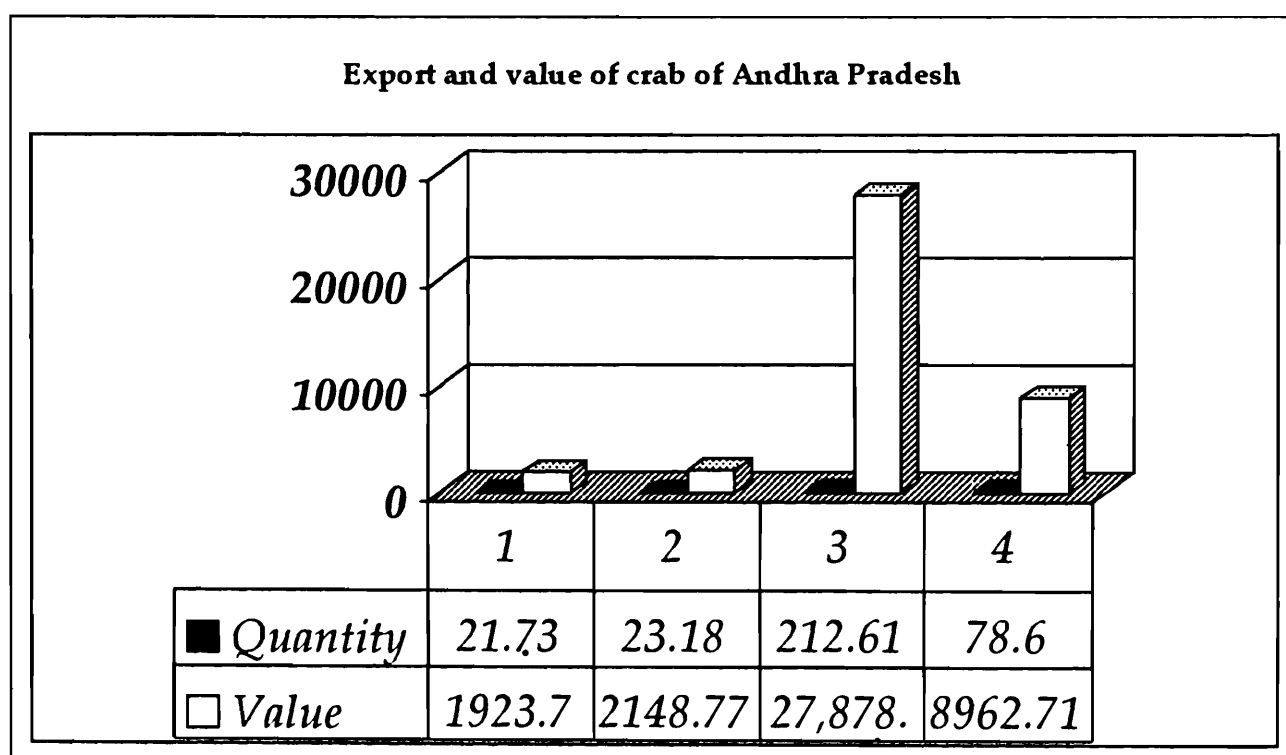


Fig. 4. Export of crabs from Andhra Pradesh for the years 1998–2001, (1 = 1998; 2 = 1999; 3 = 2000, 4 = 2001; Quantity in tons; value in crores)

CONCLUDING REMARKS

Even though the existing crab fishing does not support a major industry in Andhra Pradesh, the present study shows the existence of enough brachyuran bioresource potential from this state. There is also a great possibility of tapping hitherto untapped/ ill-tapped resources of crab from Andhra Coast. The existing crab fishery of this Coast requires intensive survey as well as the extent of exploitation from different landing centres of this State. As there has been substantial landing of crabs in the recent past and a few more species could be brought under resource exploitation, there is scope for augmenting crab fishery in this State.

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BENTHIC POLYCHAETES OF TAMIL NADU COAST

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ABSTRACT

A taxonomic evaluation of the polychaetes from shallow (50m) benthic waters along Tamil Nadu coast (South-East India) is presented. It is based on material collected from seven stations. In the present study 39 species in 29 genera belonging to 19 families were reported for the first time from Indian waters. Fifteen of them.

INTRODUCTION

Studies on the polychaete fauna of the Indian coast began in the early 1900's and have been mostly confined to the intertidal region. On the West Coast the polychaete fauna of Gujarat (Rao & Soota, 1981), Maharashtra (Parulekar, 1971), and Cochin (Sunil Kumar, 2002) were described in great detail. On the East Coast polychaetes of Sagar Island and its environs along the Sunderbans and the Orissa Coast were studied extensively from the collections of Zoological Survey of India (Misra & Chakraborty, 1983, Misra, 1995, Soota & Rao 1977). Besides which the polychaetes of estuaries and brackish water bodies like Vashishta Godavari estuary (Srinivasa Rao & Rama Sarma, 1991), Chilka Lake (Rao, 1995) Mahanadi estuary (Rao, 1998), Pulicat Lake (Sunder Raj & Sanjeeva Raj, 1987) and Vellar estuary (Srikrishnadhas *et al.*, 1987) have also been described.

Hartman(1974a,b) has made an important contribution to the polychaete fauna of India by giving a catalogue and bibliography of species collected during the International Indian Ocean Expedition. Another catalogue of polychaetes from the reference collection of the Central Marine Fisheries Research Institute (Kumaraswamy Achari, 1976) gives a list of all polychaetes collected and also a brief mention of the area of collection.

Samples for the present study was collected from Ennore (13°13'54" N; 80°23'25" E), Chennai (13°06'82" N; 80°20'89" E), Cooum (13°04' N; 80°20'76" E), Cuddalore (11° 42'21" N; 79°49'90" E), Vembar (9°02'99" N; 78°24'16" E) Koodankulam (8°33'88" N; 78°10'57" E) and Tuticorin (8°47'89" N; 78°10'57" E) at depths of about 50 m, during July-Sept. 2003. Thirty-nine species of polychaetes belonging to 29 genera and 19 families were observed

in the present collection. Fifteen of them are reported for the first time from Indian waters (Table-1). To avoid repetition only the diagnostic features are mentioned and only relevant synonyms have been given as they have already been given by Fauvel (1953) and Day (1967).

SYSTEMATIC ACCOUNT

Family MALDANIDAE

Maldane cristata Treadwell, 1923

Maldane cristata Treadwell, 1923; pp. 9-10 figs 5-8; Hartman 1956, pp. 295-296; 1969. pp. 457,458, figs. 4; Fauchald, 1972, pp. 262-263; Imajima & Shiraki, 1982, pp. 84-86 fig. 40 a-n.

Maldane sarsi McIntosh, 1885. pp. 392-393; Okuda. 1939, pp. 239-240; Imajima & Harman, 1964, pp. 317-318. (Not *Maldane sarsi* Malmgren, 1865, pp. 188).

Maldane corinata Moore, 1923, pp. 233-235.

Material examined : Off Ennore

Description : The body is cylindrical; the anterior segments are spotted with dark brown pigments. The sixth setigerous segment has an anterior flange dorsally, slightly overlapping the base of the fifth setiger. The cephalic plate is elliptical, and the cephalic rim is divided into three parts by a pair of deep lateral incisions. The posterior rim is well developed and elevated into a collar forming a deep pocket. The cephalic median keel is strongly arched and extends from the prostomial palpode into the pit at the posterior end. The nuchal organ are short and divergent anteriorly.

The first setigerous segment lacks neuropodial setae. The notopodial setae in the anterior segments are either bilimbate capillaries or slightly geniculate setae with slender tips. They are replaced by spinous capillaries and geniculate setae with slender tips further back along the body. Uncini are typically rostrate with eight large teeth in a transverse arc and several rows of small teeth above the main fang; the two median teeth in the first area are much larger than the others.

The pygidium has a slightly oblique anal plate with a pair of lateral incisions; the ventral margin is slightly crenate. The anal pore is present dorsally to the plate.

Distribution : Southern California to Western Mexico; Japan, India.

Euclymene lombricoides (Quatrefages, 1865)

Clymene lombricoides Quatrefages, 1865, II : 236

Clymene (Euclymene) lombricoides, Fauvel 1927 : 172, fig. 59 a-e.

Euclymene lombricoides (Quatrefages, 1865), Day 1967, p. 363, fig. 30.5. e-k.

Material examined : Off Kudankulam

Description : Prostomium broadly rounded in front with indistinct ocellii. Nuchal grooves straight and half the length of the cephalic plate. Cephalic rim with the posterior part divided into 10 lobes. Anterior segment a little longer than broad, posterior ones two to four times as long as broad. The three preanals together slightly longer than the length of the last setiger. Funnel with very numerous cirri alternately long and short. Anal funnel sunken without a ventral valve. Notochetae include winged capillaries and feathered forms. Setigers 1-3 each with one to two smooth acicular neurochetae. Later neurochetae are numerous hooks each with a vertical series of five to six teeth above the main fang and well marked tendons below.

Distribution : North Atlantic from Scotland and the English Channel to Morocco, Mediterranean, India (new record to Indian fauna)

Family OPHELIDAE

Ophelia agulhana Day 1961

Ophelid agulhana Day, 1961 : 513, fig.10a

Material examined : Off Cuddalore

Description : Body of 36-37 setigers including nine (or occasionally 10) anterior abbranchate segments, 23-26 branchiferous segments, one to three posterior abbranchate setigers and a doubtful achaetous preanal segment in front of the pygidium. Branchiferous segment with rows of pits in the lateral body wall. Branchiae irregularly annulated. Notochetae twice as long as neurochetae in the branchiferous region. Crimped dorso-lateral ridges from setigers 33 to pygidium which has two stout ventral cirri and a dorsal arc of 15 small ones.

Distribution : S. Africa, India (new record to Indian fauna).

Table 1. List of polychaetes from different stations along the Tamil Nadu coast (Enn-Ennore, Chh-Chennai, Cum-Coom, Cud-Cuddalore, Vem-Vembar, Kud-Kudankulam, Tut- Tuticorin)

Family	Genera & species	Enn	Chh	Cum	Cud	Vem	Kud	Tut
Maldanidae	1. <i>Maldane cristata</i>	X					X	
	2. <i>*Euclymene lombicoides</i>						X	
Ophelidae	3. <i>*Ophelia agulhana</i>				X			
	4. <i>Ophelina acuminata</i>			X			X	
Dorovillidae	5. <i>*Protodorovillea biarticulata</i>		X	X				X
Eunicidae	6. <i>Eunice indica</i>				X			

Table 1. Contd.

Family	Genera & species	Enn	Chh	Cum	Cud	Vem	Kud	Tut
	7. <i>*Diopatra cuprea punctifera</i>	X			X			
	8. <i>D. montoi</i>	X						
	9. <i>*Marphysa purcellana</i>				X			
Lumbrineridae	10. <i>*Ninoe</i> sp.						X	
	11. <i>Lumbrineridae magalhaensis</i>		X					
Onuphidae	12. <i>Onuphis holobranchiata</i>					X	X	
Aphroditidae	13. <i>Sthenalais boa</i>			X				
	14. <i>*S. limicola</i>					X		
	15. <i>Pseudoeurythoe</i> sp.		X	X	X			
	16. <i>Eupanthalis kinbergi</i>	X						
	17. <i>Panthalis oerstedii capensis</i>	X						
Glyceridae	18. <i>Glycera tessalata</i>				X			
	19. <i>G. convoluta</i>				X			
	20. <i>*Glycera natalensis</i>					X		
	21. <i>*Hemipodus</i> sp.						X	
Nephtyidae	22. <i>Nephtys (Aglaophamus) dibranchis</i>	X						
	23. <i>*N. lyrochaeta</i>			X		X	X	
	24. <i>N. sphaerocirrata</i>			X				
Nereidae	25. <i>Nereis</i> sp.	X						
	26. <i>Tylonereis bogoyavlenskii</i>				X			
Pilargidae	27. <i>Ancistrosyllis constricta</i>			X				
	28. <i>*A. parva</i>				X			
	29. <i>*Synelmis dineti</i>			X				
Oweniidae	30. <i>Owenia fusiformis</i>		X					
Sabellidae	31. <i>*Jasmineira</i> sp.				X			
Magelonidae	32. <i>Magelone cincta</i>	X	X		X			
	33. <i>M. papillicornis</i>			X		X		
Poecilochaetidae	34. <i>Poecilochaetus serpens</i>			X			X	
Spionidae	35. <i>*Prionospio (Aquilospio) sexoculata</i>				X			
	36. <i>Polydora</i> sp.		X					

Table 1. *Contd.*

Family	Genera & species	Enn	Chh	Cum	Cud	Vem	Kud	Tut
Flabigelleridae	37. * <i>Diplocirrus capensis</i>			X				
	38. <i>D. sp.</i>		X					
	39. <i>Pherusa sp.</i>						X	
Terebellidae	40. <i>Terebellides stroemi</i>						X	
Scalibregmatidae	41. <i>Scalibregma inflatum</i>	X						

*New records to Indian waters

Ophelina acuminata Oersted, 1843

Ophelina acuminata Oersted, 1843 : p. 46; Day, 1967, p. 579, fig. 25.2. i-j; Tang & Sun, 1988. p. 248, fig. 115a-b.

Annotrypane aulogaster, Rathke, 1843 : 188, p. 10, figs 1-3; Fauvel, 1927: 133, fig.47a-e; Okuda, 1936a, p. 149-150 text figs. 2,3; Imajima & Hartman, 1964, p. 305-306; Imajima, 1982, p. 159.

Material examined : Off Cooum and Koodankulam

Description : Body vermiform, narrow at both ends. A deep ventral and a pair of lateral grooves extending throughout length. Prostomium conical with a filiform tip. Cirriform branchiae beginning on setiger 2 and continues almost to posterior end. Parapodia with short setigerous lobe, biramous fascicle with capillary chetae. Pygidium spoon-shaped, with many small marginal papillae and 2 much stouter ones arise at the anterior end of the slit and flank, a long median internal cirrus.

Distribution : Japan, Atlantic, Bering Sea, Indian Ocean, India (off Porto Novo, Madras Harbour, Palk Bay).

Family DOROVILLIDAE

Protodorovillea biarticulata Day 1963

Protodorovillea biarticulata Day 1963b, p. 414, fig. 8g-l, Day, 1967, pp. 452-454 fig. 17.20 g-l.

Material examined : Off Chennai, Cooum and Tuticorin

Description : Prostomium ovoid anteriorly with one pair of eyes. Palps long, irregular, wrinkled and end in well-marked palpostyle. Antennae small with two elongated joints. Body segments short, parapodia relatively large. Dorsal cirri arise from the distal end of the feet. They are small, ovoid and present on all feet including the first. No notoaciculum nor dorsal cirrophore. Setigerous lobe with a conical presetal lip and a much smaller postsetal one. Superior chetae include 2 capillaries with the base of the blade serrated,

and one forked chetae with a smooth shaft and short, subequal prongs which are flanged on their inner margins. Inferior chetae are three to four heterogomph falcigers with serrated shaft-heads and minutely bidentate blades of varying length.

Distribution : S. Africa, India (new record to Indian fauna).

Family EUNICIDAE

Eunice indica Kinberg, 1865

Eunice indica Kinberg, 1865, 562 : Crossland, 1904 : 318, pl. 21 Figs. 9-12 : Fauvel, 1953 : 241, fig. 119g : Okuda, 1938a, p. 95 : Miura, 1986, p. 302-305 figs. 28,29, Table-1 : Imajima 1997a, p. 183.

Material examined : Off Cuddalore.

Description : Head small with the palps mainly fused so that the anterior margin is only faintly notched. Prostomium slightly notched anteriorly, with 2 eyes and 5 small occipital antennae. Branchiae present from setiger 3, increasing to maximum of 10 filaments. Compound falcigers bidentate with long pointed hoods. Aciculum almost straight yellow and blunt. Acicula chaetae yellow and boldly tridentate and occurs as a transverse series four in a parapodium beginning on setiger 20.

Distribution : Indonesia, East China Sea, Japan, Red Sea, Tropical West Indo Pacific, India (Palk Bay)

Diopatra cuprea punctifera Ehlers, 1908

Diopatra punctifera Ehlers, 1908 : 78, pl. 10 fig.1-11

Diopatra cuprea var. *punctifera* : Day, 1960 : 351, Day, 1967, p. 418. Fig. 17.12.e-f.

Material examined : Off Ennore and Cuddalore

Description : Though it generally resembles *Diopatra cuprea cuprea* it differs from it in the following characters. Instead of being uniformly brown, there is a pattern of dark spots on the anterior segments. Anterior segments have a transverse row of four spots. Further back the two spots on either side of the mid-dorsal line fuses leaving a pale streak down the middle of the back. Comb setae have only 9-15 teeth.

Distribution : S. Africa, India (new record to Indian fauna).

Diopatra monroi Day, 1960

Diopatra monroi Day, 1960 : 345, fig. 10 a-f, Day 1967 : 415, fig 17.11, k-p.

Material examined : Off Ennore

Description : Brown in colour anteriorly with a dark spot just behind the median occipital antenna and dark bars across the anterior branchiferous segments. Ceratophore

of median occipital antenna with 6-8 rings. Gills from the fifth foot and have fairly long filaments. Pseudocompound chetae hooded and strongly bidentate. Comb chetae appears on 6-8 foot and have 15-25 teeth. Bidentate acicula chetae appears about the 16th foot.

Distribution : South Africa, India.

***Marphysa purcellana* Willey, 1904**

Marphysa purcellana Willey, 1904 : 263, pl. 13 fig.17 : Kay, 1953 : 453; Day, 1967 p. 397-399 gih. 17.6 k-o

Material examined : Off Cuddalore

Description : Anterior margin of head bilobed with a reddish brown pattern anteriorly. Antenna short, smooth and as long as the prostomium. Gills start at the eighth foot as four filaments, reach a maximum of 18 filaments on the 18th foot and then decrease to end on the 28th foot. Dorsal cirri as long as the setigerous lobe in the prebranchial region, increases to the same length as the branchial filament in the branchial region and remain much longer than the setigerous lobe in the post branchial region. Acicular chetae yellow and strongly bidentate and small guards. Acicula blunt and yellow. Ventral chetae compound and falcigerous with two rather longer teeth.

Distribution : S.Africa, India (new record to Indian fauna).

Family LUMBRINERIDAE

***Ninoe* sp.**

Ninoe sp.

Material examined : off Kudankulam

Description : Prostomium without antennae, maxillae consists of four pairs of toothed plates with short, broad supports. Mandibles well developed. Cirriform gills arise from the postsetal lobes of some parapodia. Setae include capillaries and hooded hooks.

New record to Indian Fauna

***Lumbrinereis magalhaensis* Kinberg, 1865**

Lumbrinereis magalhaensis Kinberg, 1865, p. 568; Ehlers, 1897, p. 74; Day, 1960, p. 362, fig. 12h-j.

Material examined : Off Chennai

Description : Prostomium conical. Feet with low, rounded presetal lobe throughout. Postsetal lobe conical and compressed anteriorly; later the base of the foot becomes longer and in posterior feet the small posterior lobe is hardly longer than the anterior one. Chetae include long winged capillaries in anterior feet plus short bladed compound

hooks from setiger 1-4 to setiger 12-15. In posterior feet there are only simple hooks. Acicula yellow.

Distribution : Chile, S. Africa, India.

Family ONUPHIDAE

Onuphis holobranchiata Marenzeller 1879

Onuphis holobranchiata Marenzeller, 1879, pp. 132-134, pl. 4, fig. 1; Izuka, 1912, pp. 106-108. pl. 11, figs. 10-12; Fauchald, 1982, p. 48; Imajima, 1986a, pp. 94-96, fig. 2; Maekawa & Hayashi 1999, pp. 176-178, fig. 5; Imajima 2003, pp. 208-209.

Nothria holobranchiata Hartman, 1944b, p. 83; Imajima & Harman, 1964. pp. 244-245, pp. 208-209.

Material examined : Off Vembar and Kudankulam

Description : Prostomium narrow anteriorly with pair of frontal lips and two pairs of small eyespots. Antennae with ceratophore consisting of 6-14 short rings. Peristomial cirri present, longer than peristomium. First three parapodia directed forwards; presetal lobe low, transverse fold, post-setal lobe spindle shaped. Branchiae first present on setiger 1, all simple and strap-like, and continuing throughout. Digitiform postsetal lobes present on first ten parapodia thereafter reduced to short conical knobs through setigers 30. Ventral cirri digitiform through setiger 4, and transitional in setiger 5 and distinctly pad-like thereafter. Tridentate pseudocompound hooks with blunt hoods present on first four setigers. Posterior simple setae somewhat geniculated distally with minute serrations. Bidentate subacicular hooks appearing from setiger 12. Pectinate setae distally oblique, with 12 fine teeth.

Distribution : Japan, Maldives Archipelago, India (Nicobar Islands, Gulf of Mannar).

Family APHRODITIDAE

Sthenelais boa (Johnston, 1839)

Sigalion boa Johnston, 1839 : 439.

Sthenelais boa Fauvel, 1923, p. 110, fig. 41 a-l; Fauvel, 1953, p. 61, fig. 28 a-k.

Material examined : Off Cooum

Description : Prostomium rounded; a long smooth median antenna with large basal lappets on the very stout ceratophore. Setiger 1 with a long dorsal cirrus, a shorter ventral cirrus and a presetal bract. Setiger 3 with a cirrophore but no dorsal cirrus. Notopodia with 3 ctenidia at base and 3-4 digitiform papillae at apex. Notochaetae long, fine and spinulose. Neuropodium conical with an apical papilla and three lamellae, one superior, one inferior (papillose) and one posterior and bilobed. Neurochaetae of several kinds; 2

to 3 superior, simple bipectinate chaetae, numerous compound chaetae with blades short and bidentate and an inferior series of compound chaetae with multiarticulate blades ending in bidentate tips. Elytra reniform and overlapping, with a simple external fringe of long papillae; surface covered with minute rounded tubercle and usually with an arc of brown pigment on the postero-medial margin.

Distribution : cosmopolitan

***Sthenelais limicola* (Ehlers, 1864)**

Sigalion limicola Ehlers, 1864, p. 120. pl. 4, fig. 4-7, ol.5.

Sthenelais limicola Fauvel, 1923, p. 113, fig. 42 a-g.

Material examined : Off Vembar

Description : Colour pale with diffuse brownish patches on the elytra. Prostomium rounded with four eyes and a median antenna arising from a long ceratophore with large basal lappets. Setiger one with a long dorsal tentacular cirrus, a small filiform ventral cirrus and a very large presetal bract. Palps very long and slender. Setiger 2-4 bear numerous cirriform stylodes on both rami but these are reduced on subsequent feet. The fourth and subsequent feet bears a cirriform gill and three saucer-shaped ctenidia. Notopodia with three to four digitiform stylodes. Notochaetae are numerous finely spinulose capillaries. Neuropodia stout, each with a superior lobe, a single apical stylode and a posterior bract. Neurochaetae of three kinds – two to three bipectinate simple setae; a few falcigerous setae with simple bidentate blades; numerous compound chaetae with long pluriarticulate blades. Elytra overlap and cover the whole back. The first eleven have a few pointed marginal projections but each of the posterior ones has a deep excision on the external margin and lack marginal projections.

Distribution : North Atlantic, Scotland and North Carolina, Tropical Western Africa, Mediterranean, India (a new record to Indian fauna)

***Pseudoeurythoe* sp.**

Pseudoeurythoe sp.

Material examined : Off Chennai, Cooum and Cuddalore

Description : Body elongate and square in cross section. Prostomium divided transversely with the anterior part bilobed and bearing a pair of antennae and a pair of palps; the posterior part square with two pairs of eyes and a median antenna. Caruncle small or absent, usually sunk into the first setiger. Parapodia with notopodia and neuropodia well separated. A single dorsal cirrus per notopodium. Branchiae as single branching tufts limited to the anterior part of the body. Chetae all hollow and brittle; notochaetae include harpoon-chaetae and capillaries; neurochaetae all spurred. No hooks in first setiger.

***Eupanthalis kinbergi* McIntosh, 1876**

Eupanthalis kinbergi McIntosh, 1876a, p. 404, pl. 72, figs. 12-16; Fauvel, 1923, p. 100, fig. 38 i-q.

Material examined : Off Ennore

Description : Prostomium bilobed with four sessile eyes in a rectangle. Median antenna postero-doral in origin, laterals terminal and longer than the prostomium. Palps very long. Jaws with 4-5 denticles at the base. The papillae on the dorsal margin of the proboscis are simple or bifid, the ventral ones trilobed. Dorsal cirri short and conical. Elytra smooth and oval; the first few meet over the back but the posterior ones are lateral. A spinning gland from the eighth or ninth notopodium onwards. No branchial vesicles. Notopodium compressed and bears a few serrated capillaries. Neuropodium stout and truncate with three groups of setae ; a superior group of spinulose setae, a middle group of stout aristate setae which develops tapered hairy ends inferiorly and an inferior group of serrulate setae with curved and spirally serrated blades.

Distribution : North Atlantic, Mediterranean, Angola and India.

***Panthalis oerstedii capensis* McIntosh, 1925**

Panthalis oerstedii variety *capensis* McIntosh, 1925 : 31.

Material examined : Off Ennore

Description : Length upto 120 mm. Prostomium small with the median antenna extending forwards beyond the eye stalks. Lateral antennae thicker than the median and each with a brown spot. Elytra smooth and covers the head but further back most of the dorsum is naked. Notochaetae slender and minutely spinulose. Neurochaetae of three groups : superior group unknown, stout acicular chaetae (aristate chaetae) with rather flattened spear-like tips bearing a group of spinules and an inferior group of serrated setae with hairy tips projecting from a basal group of long spinules.

Distribution : South Africa, Eastern Cape, India.

Family GLYCERIDAE***Glycera tessalata* Grube, 1863**

Glycera tessalata Grube, 1863, pp. 41-42, pl. 4, fig. 4; McIntosh, 1885, p. 343, pl. XLII, fig. 5; Moore, 1903a, p. 464; Izuka, 1912, pp. 241-242, pl. 24, figs. 5-6; Fauvel, 1923, p. 387, fig. 152a-c. Imajima & Hartman, 1964, p. 165; Day, 1967, p. 359, fig. 16.2.a-c. Imajima 2003, p. 117, fig. 69 j-l.

Material examined : Off Cuddalore

Description : Prostomium elongate, pointed consisting of 12-15 annuli. Proboscis closely covered with numerous long, filiform and few conical papillae without rings. Eyes present in basal prostomial annulus. Ailerons with inner ramus widely separated from outer

ramus with an apophysis. Mid-body segments biannulate. Parapodia with 2 slender, conical presetal lobes and 2 shorter, rounded postsetal lobes; notopodial postsetal lobes slightly shorter than neuropodial. Dorsal cirri spherical, above parapodia; ventral cirri conical, distally pointed, projecting slightly beyond postsetal lobes. Branchiae absent.

Distribution : Atlantic from Scotland to Morocco, North Carolina, Mediterranean, Red Sea, Tropical Indian Ocean, Japan, W.Canada to Southern California.

***Glycera convoluta* Keferstein, 1862**

Glycera convoluta Keferstein, 1862, p. 106; Fauvel, 1923, p. 383, fig. 150a-h.

Material examined : Off Cuddalore

Description : Prostomium with 15-16 rings. Papillae on proboscis with a distal flange shaped like a fingernail. Jaw support with two unequal limbs but no notch between them. First two parapodia uniramous; following parapodia biramous. Two slender triangular to digitiform prechaetal lobes of about same length; in last parapodia notopodial lobe shorter than neuropodial ones. In the middle parapodia the superior postsetal lobe is pointed, the inferior one shorter and rounded; this is better marked in posterior feet. Dorsal cirrus from third parapodium, conical to oval; ventral cirrus slender triangular to digitiform, about as long as neuropodial post chaetal lobe. Simple digitiform branchiae, situated termino-dorsally on parapodia, from anterior to near posterior end.

Distribution : Eastern Atlantic from English Channel to Tropical Western Africa and Tristan da Cunha; Mediterranean, Persian Gulf; Western Canada to southern California, Japan, South West Africa, Natal, Mocambique and Madagascar, India.

***Glycera natalensis* Day, 1957**

Glycera natalensis Day, 1957, p. 86, fig. 5 k-o.

Material examined : Off Vembar

Description : Body pale and slender and prostomium indistinctly annulated. Proboscis with long delicate papillae terminating in a fingernail-like expansion and a few ovoid forms. Jaw supports forked, the shorter ramus being half the length of the longer and with triangular base. No gills. Two equal pointed presetal lobes and a postsetal lobe which might be termed one and a half, where the superior pointed portion is united without a notch to an inferior rounded part.

Distribution : South Africa, India (new record to Indian fauna).

***Hemipodus* sp.**

Hemipodus sp.

Material examined : Off Kudankulam

Description : Body with numerous segments, elongated tapering at both ends, segments more or less distingly triannulate. Prostomium consisting of more than five rings, appendages relatively short. Ailerons rod-like. All parapodia uniramous with one prechaetal and one postchaetal lobe; ventral cirri from first, dorsal cirri from third parapodium. Branchiae absent. Notopodia absent, neuropodia with spinigerous compound chaetae.

New record to Indian fauna.

Family NEPHTYIDAE

Nephtys (Aglaophamus) dibranchis Grube 1877

Nephtys (Aglaophamus) dibranchis Grube, 1877, p. 536; Fauvel, 1932, p. 117; Fauvel, 1953, p. 225, fig. 114e.

Aglaophamus dibranchis, Hartman, 1950 : 121.

Material examined : Off Ennore

Description : Prostomium pentagonal, and straight in front with well-developed, subequal and tapered antennae. Eyes visible through the skin. Proboscis with 14 rows of four to five papillae each plus a much longer medial dorsal one. Dorsal cirrus of first foot well developed, cirriform gills start on setiger 4 and project straight out or are involute, each having a finely tapered notopodial cirrus at the base. Parapodial rami markedly divergent and setigerous lobes pointed. In anterior notopodia the presetal lamella is small and auricular and the postsetal lamella similar but larger; in middle feet the postsetal lamellae projects dorsally and in posterior feet the posterior lamellae hardly exceeds the acicular lobe. In anterior neuropodia there are three lamellae; an anterior auricular one, a superior tongue-like lamella and a postsetal auricular one. In middle feet the superior one becomes elongated and strap-like and in posterior feet all three lamellae decrease and the superior one disappears. The setae are well developed. The anterior fan consists of laddered capillaries, and the posterior fan consists of numerous long, rather flattened capillaries and a row of forked setae.

Distribution : New Zealand, Natal, Tropical Indian Ocean

Nephtys lyrochaeta Fauvel 1902

Nephtys lyrochaeta Fauvel 1902, p. 72, figs 9-12; Augner, 1918, p. 160. pl. 2 fig. 12, pl. 3 fig 59.

Material examined : Off Cooum, Vembar, Kudankulam

Description : Prostomium pentagonal and straight in front. Eyes not visible. Proboscis with 14 rows of four to five papillae each plus a larger median dorsal one. Gills from fourth or fifth setiger, each involute with a notopodial cirrus at its base. In anterior feet all lamellae exceed the setigerous lobes. The notopodium has a round presetal lamella

and a larger orbicular postsetal one. The neuropodium has an oval presetal lamella, a blade-like superior lamella and a large orbicular postsetal lamella. In posterior feet all lamellae decrease so that they are shorter than the setigerous lobes and the superior lamella of the neuropodium disappears. Setae include the usual anterior fan of laddered capillaries and a posterior fan of long bladed setae and in both rami there are also numerous forked setae though they are difficult to find.

Distribution : Morocco, Western Africa, Persian Gulf, India (new record to Indian fauna).

***Nephtys sphaerocirrata* Wesenberg-Lund 1949**

Nephtys sphaerocirrata Wesenberg-Lund 1949, p. 294, figs. 24-26.

Material examined : Off Cooum

Description : Prostomium pentagonal with a straight anterior margin and rather long, slender and knobbed antennae. Eyes far back, opposite setiger 2. Proboscis with 22 rows each with 6-9 tapered papillae. No enlarged median dorsal papilla. Parapodia with vestigial lamellae, the first having a knobbed ventral cirri. Subsequent feet have small papilliform notopodial cirri but lack branchiae entirely. The setigerous lobe of the notopodium is bluntly conical without visible lamellae. The setigerous lobe of the neuropodium is conical with a small postsetal lamella.

Setae include an anterior fan of laddered capillaries and a posterior fan of very long capillaries with a spinulose margin and 2-3 short forked setae with spinules on their inner margins.

Distribution : S.W.Africa, Persian Gulf, India.

Family NEREIDAE

***Nereis* sp.**

Nereis sp.

Material examined : Off Ennore

Description : Prostomium with two antenna. Peristomial segments apodus. Proboscis with conical chitinous paragnaths on both the basal and the maxillary ring. The first two feet are uniramous, the rest biramous. Both spinigers and falcigers are present.

***Tylonereis bogoyawlenski* Fauvel, 1911**

Tylonereis bogoyawlenski Fauvel, 1911, p. 373, pl. XIX, figs. 1-7; Fauvel 1953, pp. 168-169, fig. 85 e-f.

Material examined : Off Cuddalore

Description : Prostomium slightly wider than long, the centre of anterior margin with shallow median groove. The longest peristomial cirri extending to the setiger 3-4. Oral and maxillary rings without hard paragnaths, with different shaped soft papillae only.

The first two paired parapodia uniramous. Ventral cirri extend beyond parapodial lobe, slender digitiform. From the setigers 7-8 parapodia enlarged, dorsal and ventral cirri short, small, not exceeding beyond parapodial lobe, supra-notoligule inflated, blade-form. Neuropodium with a acicular lobe and 2 postsetal lobe. Middle parapodium similar to the posterior ones, dorsal cirri short, small, coiling around basal portion of notoligule, supra-ligule extending greatly beyond other parapodial lobes, ventral cirri very small. Notosetae and neurosetae of all parapodia are homogomph spinigers.

Distribution : Tropical and Sub-Tropical, Persian Gulf, India.

Family PILARGIDAE

Ancistrosyllis constricta Southern 1921

Ancistrosyllis constricta Southern 1921, p. 573, pl. 19, figs.1 A-G; Day, 1957, fig. 2 a-d.

Material examined : Off Cooum

Description : Prostomium with three cirriform antennae and two pairs of eyes. Palps massive, bent ventrally and bear slender palpostyles. Pharynx muscular but without jaws. Peristomium distinct from prostomium and bears two pairs of tentacular cirri. No constricted neck region. Each setiger with tapered dorsal and ventral cirri and a blunt setigerous lobe. No ventral cirrus on setiger two. Typical notopodia with an aciculum, one to fine capillaries and a stout recurved hook which first appears on setiger eight. Neurosetae are serrated capillaries.

Distribution : India (Chilka Lake), Natal

Ancistrosyllis parva Day, 1963

Ancistrosyllis parva Day, 1963a : 395, fig. 3 g-k.

Material examined : Off Cuddalore

Description : Prostomium broader than long with the posterior margin straight. Palps very wide with minute palpostyles. No eyes. Antennae equal to half the peristomial width, the median being slightly longer than the laterals. Proboscis with 10-12 marginal papillae of which the dorsal ones are slightly larger. Tentacular cirri similar to the antennae, the ventral pair being slightly shorter. Body smooth with rather crowded segments anteriorly but longer ones posteriorly. First setiger with dorsal cirrus longer than the tentacular cirri, a normal setigerous lobe and a ventral cirrus. Second setiger with a short dorsal cirrus and no ventral cirrus. Posterior feet all essentially similar with a tapered dorsal cirrus borne on a stout cirrophore, a square setigerous lobe and a smaller ventral

cirrus. Notochaetae absent from setigers 1-3; from setiger 4 onwards a stout hook appears above the dorsal cirrophore but there are no notopodial capillaries. Neurochaetae are all simple capillaries, the short outer ones with spinulose blades and the longer central ones with smooth blades.

Distribution : Cape, Natal, India (new record to Indian fauna).

Synelmis dineti Katzmann, Laubier et Ramos, 1974

Synelmis dineti Katzmann, Laubier et Ramos, 1974, pp. 28-31 fig.11; Imajima, 1987, p. 158, fig. 5.

Material examined : Off Cooum

Description : The body is subcylindrical with smooth and rigid integument and distinct segmental grooves. The prostomium is subrectangular, wider than long, with a median antenna on the posterior middle margin and paired antennae on the distal margin; the paired palps are triangular, with ventral palpostyles. The peristomium is comparatively long, with two pairs of tentacular cirri as long as the median antenna. Parapodia are subbiramous. The dorsal cirrus on the first parapodium is thick basally and tapered distally; the neuropodium is cylindrical and provided with four limbate capillary setae; the ventral cirrus is smaller than the dorsal one. A normal parapodium has a cylindrical dorsal cirrus, a pyriform ventral cirrus, and a bluntly rounded neuropodium. Neurochaetae are distally pointed with broad, serrated, limbate margin. The acicular notopodial spine appears first from the ninth parapodium, above the dorsal cirrus; the spine are slightly S-shaped, with a bidentate tip, accompanied by a small distal tooth. The pygidium is rounded, with a pair of slender, digitate anal cirri.

Distribution : Adriatic sea, Japan, India (new record to Indian fauna)..

Family OWENIIDAE

Owenia fusiformis Delle Chiaje, 1842

Owenia fusiformis Delle Chiaje, 1844, p. 31, Fauvel, 1927, pp. 203- 204, figs. 71 a-f; Okuda, 1937, pp. 252-253, fig. 27; Uschakov, 1955, p. 346, fig. 128 A-E; Imajima & Hartman, 1964, p. 322; Day, 1967, pp. 649-651, fig. 31.1. e-j; Nilsen & Holthe, 1985, pp. 19-21, fig. 1 a-b.

Ammochaeres fusiformis : Berkely & Berkeley, 1952 pp. 42-43, figs. 79,80.

Material examined : Off Chennai

Description : The body is anteriorly cylindrical and posteriorly tapered; a crown of tentacles projects forward from the head region. The tentacular crown is divided into two lobes; each lobe has three to four flattened trunks with four dichotomously branched tentacles. The mouth is terminal and enclosed by tentacles. A low collar encloses the tentacular bases, and has two short slits ventrally. A pair of lateroventral eye-spots is present at the base of the crown. Pigmentation is sometimes present in the tentacles and the anterior body region.

The first two notopodia are located at the lateral sides of the body, while the third to tenth notopodia are situated along the mid-dorsal line. The first two chaetal fascicles are larger than those of the following. The notopodial chaetae are all spinous capillaries. Neuropodial tori appear from the fourth setiger and continue to the posterior end. Uncini are arranged in regular rows on the tori; each uncini has two teeth arranged side by side nearly at the same level. The tube is fusiform, tapering at both ends and coated with small shell fragments and sand grains.

Distribution: Worldwide areas, circumpolar in Arctic seas, Eastern and Western North America; the Gulf of Mexico; Iceland, South West Africa, Mediterranean; Red Sea, Japan, Indian Ocean.

Family SABELLIDAE

Jasmineira sp.

Jasmineira sp.

Material examined : Off Cuddalore

Description : Body small, elongate and colourless except for faint brown stripes of pigments on ventrum. Branchial lobes not spiral. Radioles without eyes or external stylodes. Branchial crown with eight pairs of branchioles; webbing completely absent. A pair of narrow long palps. Collar well-developed, complete ventrally but divided dorsally with the two lobes overlapping.

Thorax of 8 setigers and abdomen of 16 setigers, with two asetigerous segment prior to the pygidium. Setiger 1 with notochaetae only. Thoracic notochaetae include capillaries and hastate chaetae. Thoracic uncini gently curved, long handled hooks with strongly crested heads. Setae reverse at junction of thorax and abdomen. Abdominal chaetae include capillaries and short-handled avicular uncini with strongly-crested heads. Pygidium a simple cone.

New record to Indian fauna.

Family MAGELONIDAE

Magelone cincta Ehlers, 1908

Magelone cincta Ehlers, 1908, p. 111, pl. 15, figs. 9-12; Wilson, 1958, p. 620, figs. 2-3.

Material examined : Off Chennai, Ennore and Cuddalore

Description : Prostomium a truncate triangle with a pair of muscular strands diverging anteriorly to end in antero-lateral projections. The whole prostomium about as broad as long. The anterior region has slightly larger lamellae on the neuropodia. The notopodial postsetal lamellae are ligulate and there is no erect superior lobe or 'dorsal cirrus'. The neuropodial lamellae are more infrasetal than postsetal and on setiger 8 is distinctly

larger than the notopodial lamella. Prosetal lamella absent. Setiger 9 short. Abdominal parapodia from setiger 10 onwards have subequal, tongue-shaped postsetal lamellae on both rami which curve towards one another and end in pointed tips. Chaetae of setiger 9 similar to those of setiger 8. Abdominal chaetae are rows of hooks with 2 teeth side by side above the main fang.

Distribution: Morocco and Tropical Western Africa, India.

***Magelone papillicornis* Muller, 1858**

Magelone papillicornis Muller, 1858, p. 216; Fauvel 1927, p. 64, fig. 22 a-h.

Material examined : Off Cooum and Vembar

Description : Prostomium bluntly spear-shaped with a median thickening. Anterior end smoothly rounded. In the anterior region the notopodia have low, rounded presetal lips and much larger tongue-shaped lamellae. In addition setigers 1-8 have a small, erect digitiform lobe above the notochaetae. The anterior neuropodia have smaller lamellar lamellae than the notopodia. The presetal lamella of the neuropodium is produced inferiorly below the neurochaetae. The postsetal lip is small except on setigers 7 and 8. Setiger 9 is short with subequal prechaetal and post chaetal lobes in both rami. Abdominal segments from setiger 10 onwards have equal, tongue-shaped postchaetal lamellae in both rami curving towards one another. Lateral pockets are present on several segments after setiger 25. Setigers 1-8 have narrow-winged capillaries in both rami. Setiger 9 has a few capillaries and numerous chaetae each with a subterminal expansion preceeding the fine tip. Abdominal chaetae are rows of hooks each with 2 teeth side by side above the main fang.

Distribution : Atlantic, from Scotland and English Channel to North Carolina and Brazil, Tropical W.Africa, Mediterranean, Madagascar, India.

Family TROCHOCHAETIDAE

***Poecilochaetus serpens* Allen, 1904**

Poecilochaetus serpens Allen, 1904, p. 79, pls. 7-12 text-gig.1; Fauvel 1927, p. 67, fig. 23 a-m; Day, 1961, p. 497, 1967, pp. 520, 521, fig. 21.1.a-j.

Material examined : Off Cooum and Kudankulam

Description : Prostomium rounded with four eyes. Palps long and grooved. A digitiform process arising from the dorsal lip. Three long nuchal process arising from the occipital region. First setiger often with a vestigial notopodial postsetal lobe and a long cirriform postsetal neuropodial lobe. Notopodial and neuropodial lobes are tapeing from setiger 2 to 6, club shaped with swollen bases, slender shafts and knobbed tips from setiger 7-13, and tapering again from setiger 14 with two to four filamentous gills behind middle and

posterior parapodia; Long capillaries of setiger 1 directed forwards to form a cephalic cage. Two to four curved spine in the neuropodia of setigers 2 and 3. The rest of the anterior setae are all smooth capillaries plus a few feathered chetae in middle segments; these persist in posterior parapodia. On the last 16 or 17 setigers the notochaetae are replaced by simple or serrated spines.

Distribution : N. Atlantic from Scotland, Ireland and English Channel to Morocco, Mediterranean, S. Africa, India.

Family SPIONIDAE

Prionospio (Aquilospio) sexoculata Augner, 1918

Prionospio sexoculata Augner, 1918, pp. 405-408, pl. 6, fig. 159, 172, text-fig. 52; Day, 1955, p. 414, 1967, p. 489, fig. 18.8. m-o.

Aquilospio sexoculata, Foster, 1971, p. 106.

Prionospio (Aquilospio) sexoculata Imajima 1990a, pp. 2-5, fig. 2.

Material examined : Off Cuddalore

Description : Prostomium rectangular, with a minute medial protuberance on anterior margin, slightly inflated at level of eyes, truncated for two third length, then narrowing to form caruncle, extending to setiger 1; two pair of eyes, anterior pair largest. Peristomium dorsally fused with setiger 1, forming moderate lateral wings. Branchiae present on setigers 2 and 3, both pairs with digitiform pinnules extending to near tip of branchiae; first pair of branchiae usually larger, extending back to setigers 7-9.

Setiger 1 reduced, with only digitiform neuropodial lamellae bearing neurochetae, smaller than subsequent setigers notopodia lacking. Parapodia of setiger 2 with erect lanceolate notopodial postsetal lamellae and triangular neuropodia with long axis extending ventrally. Notopodial lamellae of setiger 3 enlarged, triangular with pointed tip, slightly folded anteriorly; neuropodial lamellae broadly triangular. Median parapodia with small, blunt triangular notopodial lamellae and flattened neuropodial lamellae. No membranous dorsal crests.

Anterior noto- and neuropodial chetae all moderately granulated capillaries with distinct sheath; chetae arranged in two rows. Ventral sabre chetae from setiger 10, numbering 1 per fascicle, each setae rather slender, bilimbate, moderately granulated. Neuropodial hooded hooks from setiger 16-17, numbering upto 8 per fascicle; notopodial hooks from setiger 29-30, numbering upto four per fascicle; hooks accompanied by capillaries throughout; hooks with four tiers of two small teeth and one single apical tooth above main fang or with three small teeth in lower tier; secondary hood small.

Distribution : South West Africa, Japan, India (new record to Indian fauna).

***Polydora* sp.**

Polydora sp.

Material examined : Off Chennai

Description : Prostomium blunt or bilobed anteriorly but extending back as a dorsal keel. Eyes present. Anterior parapodia with winged capillaries in both rami. Setiger 5 enlarged and bears stout hooks for burrowing. Posterior notochetae may include specialized chetae as well as capillaries. Bidentate and usually hooded hooks present in the neuropodia from setiger 7-10 onwards. Branchiae start behind setiger 5 and are not united to the notopodial lamellae. Pygidium swollen, glandular and often saucer-shaped.

Family FLABELLIGERIDAE***Diplocirrus capensis* Day, 1961**

Diplocirrus capensis Day, 1961, p. 509, fig. 9a-f.

Material examined : Off Cooum

Description: Body arenicoliform and long with well-defined posterior segments and the whole surface covered with flask-shaped papillae which are longer dorsally than ventrally. No cephalic cage. No visible nephridial papillae. Cephalic lobe semicircular with a median ridge bearing eyes at its base. Eight stout branchial cirri of which 6 arise from the margin of the tentacular lobe and two of the same size or slightly stouter arise from inner surface. A pair of grooved palps twice as stout as the tentacles. Mouth ventral with poorly defined lips. Both notochetae and neurochetae are annulated but the neurosetae are stouter than the notopodial capillaries and end in minutely hooked tips.

Distribution : South Africa, India (new record to Indian fauna).

***Diplocirrus* sp.**

Diplocirrus sp.

Material examined : Off Chennai and Vembar

Description : Body cylindrical or fusiform, most forms with epidermis covered by papillae. Prostomium and peristomium retractable with palps situated posteriolaterally. Peristomium with an expanded dorsal membrane bearing branchiae. Notosetae capillaries either smooth or annulated; Neurosetae either similar or more thickened spines, sometimes compound with falcate, unidentate or didentate appendages.

***Pherusa* sp.**

Pherusa sp.

Material examined : Off Kudankulam

Description : Body cylindrical anteriorly but often narrowed to a well marked tail posteriorly. Surface papillose and often covered with sand and debris. Introvert with a pair of grooved palps, 2-3 cushion-shaped lips and a dorsal cephalic hood bearing numerous similar branchial filaments along its edge. A well developed cephalic cage formed by the elongated setae of the first 2 or 3 segments. Notochetae are annulated capillaries. Neurocheatae of the head region are annulated capillaries, but in the body region they are simple hooks.

Family TRICHOBRANCHIDAE

Terebellides stroemi Sars, 1835

Terebellides stroemi Sars, 1835, p. 48; Malmgren, 1865, p. 396, pl. 20, fig. 48; Moore, 1903, p. 478; Hesse, 1917, pp. 138-139; Fauvel 1927, pp. 291-292, fig 100i-q; Caullery 1944, pp. 184-186, pgs. 147-148

Material examined : Off Kudankulam

Description : Body uniformly tapered. Tentacular lobe erect and frilly bearing numerous short tentacles on its upper surface. No eyes. Gills arise from segments 2-4 as a stout trunk bearing four lamellate lobes which are partially fused. The two outer lobes are larger than the inner pair. Anterior ventral margins of the third and succeeding segment prominent. Eighteen segments with smooth-tipped notopodial capillaries starting on segment 3. Neurochetae start on segment 8. The first row of uncini are stout, unidentate and acicular with a right angle bend below the rostrum; uncini of subsequent rows are more slender with a small rostrum surmounted by a series of minute denticles. Abdominal uncini are borne on long projecting pinnules and each is avicular with one to two arcs of denticles above the main fang.

Distribution : Cosmopolitan.

Family SCALIBREGMATIDAE

Scalibregma inflatum Rathke, 1843

Scalibregma inflatum Rathke, 1843, p. 184, pl. 9 figs, 15-21; Fauvel 1927, p. 123, fig. 44a-f

Material examined : Off Ennore

Description : Body short and stumpy or long and slender, often anteriorly inflated, but narrowed posteriorly. The prostomium is bifid or with T-shaped frontal horns; otherwise lacking appendages. The first few segments triannulate and the remainders quadriannulate. No eyes. Buccal segment achaetous. Arborescent branchiae are present on setigerous segments 2-5. Parapodia biramous with small triangular or button shaped parapodia. Dorsal and ventral cirri are present from parapodium 18, continue posteriorly. The setae include capillaries, and furcated setae, and occasionally acicular spines.

Distribution : Cosmopolitan; Norway, Atlantic and Pacific oceans, Alaska, Japan, Cape, India.

SUMMARY

The present study resulted in the report of 39 species in 29 genera belonging to 19 families of which fifteen are new records to Indian waters. All specimens have been deposited at the museum of the Centre of Advanced Study in Marine Biology, Annamalai University. Thus it appears that further studies of polychaetes from the benthic region may make a considerable addition to the Indian polychaete fauna already described.

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ECONOMIC VALUATION OF MARINE BIODIVERSITY A CASE OF MANGROVES IN GUJARAT

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INTRODUCTION

Coastal ecosystems, which are an important part of the natural resource base in Gujarat, include several ecosystems like salt marshes, mangroves, coral reefs, sea grass etc. Of these, mangroves are particularly important in view of its pivotal role both from the ecological and economic points of view. Mangroves are defined by botanists as 'a tree, shrub, palm, ground fern or a grass, exceeding half a metre in height and growing above the mean sea level in the inter-tidal zone of marine coastal environments or estuary margins in the tropical and subtropical coastal regions' Mangroves, the salt tolerant forest ecosystem, provides a wide range of ecological and economic products and services, and also supports a variety of other coastal and main eco systems, which again provide several ecological and economic benefits.

Till about 1960s, mangroves were largely viewed as "economically unproductive areas" and were therefore destroyed for reclaiming land for various economic activities. Gradually, however, the economic and ecological advantages of mangroves have become visible and their importance is appreciated. The full value of mangroves is, however, still not recognized in most economics, as most of these benefits do not enter the market. Consequently, mangroves have been highly undervalued and neglected ecosystems, resulting in their heavy depletion and degradation in most parts of the world. Recently some scholars have compiled their value in monetary terms in some parts of the world Ruitenbeck. Most of these studies are conducted for developed countries and even when they are conducted for developing countries, the nature of the benefits and costs estimated are very much different from the same in Gujarat and in India, where mangroves play an extremely important role in the life and livelihood of coastal population. There is therefore a need to compute monetary value of mangroves in Gujarat to understand its importance in state economy.

CHANGING STATUS OF MANGROVES IN GUJARAT

For the purpose of valuation it is important to have data on the changing status of mangroves in the state. To start with, there are no comprehensive data available on the status of mangroves before 1991 as the Forest Survey of India started collecting the data on mangroves forest only in 1991. After 1991 there are biannual reports of the Forest Survey of India that provide data on the area covered under mangroves. However, it is only in 2001 that the FSI provided data on quality of mangroves (dense and sparse mangroves) for the first time. There are two more sources of data on mangroves in Gujarat, namely, the data generated by SAC of ISRO and the GEER Foundation both of which conducted special studies on mangroves.

Status of Mangroves Between 1960s and 1980s : The first evidence of rich mangroves forest in the state comes from the vegetation map of Khathiawad prepared by the French Institute of Pondicherry in 1960. It shows that there were dense mangrove forest at Kandla, at southern coast of Gulf of Kachchh and western coast of Gulf of Khambhat. Earlier, the Imperial Gazetteer of India Vol. XV111 (1908) also had recorded that Navanagar state (Now Jamnagar) had mangrove swamps lined on the shores of the Gulf. The studies carried out Nagak & Bahuguna (2001) scat (1983) and untwab (1983) have shown that these has been severe degradation in all parts of the Gujarat Coasi between 1960 and 1980.

Status of Mangroves in 1990s: According to the Forest Survey of India, Gujarat had 427 Sq. Km. area under mangroves in 1987. This declined to 412 Sq. Km. in 1989 and to 397 Sq. Km. in 1991. During 1991-1999, however this area has continuously increased, reaching 1,039 Sq. Km in 1999. It declined thereafter reaching to 911 Sq. Km. in 2001 (Table-1).

Table-1. District-wise mangrove cover in Gujarat State (in Sq. Km.)

District	1991	1993	1995	1997	1999	2001
Ahmedabad	-	-	-	-	-	2
Bharuch	7	35	12	13	6	28
Bhavnagar	16	16	19	20	25	16
Jamnagar	118	118	118	118	140	142
Junagadh	-	-	-	-	1	1*
Kheda	-	-	-	-	-	-
Kachchh	239	242	536	836	854	706
Rajkot	-	-	-	-	-	1
Surat	14	8	4	4	4	13
Valsad	3	-	-	-	1	2**
Gujarat	397	419	689	991	1031	911

Sources : State of Forest Reports by Forest Survey of India(1991 to 2001)

*As per FSI report (2001) its in Porbandar ** As per FSI report (2001) its in Navsari

Note : Data from 1991 to 1999 were interpreted in a scale of 1 : 1,25,000 and data of 2001 was interpreted in a scale of 1 : 50,000

There are alternative estimates available of the quality of mangrove forests in the state for different years. These estimates are not strictly comparable with each other. The estimates of FSI for the year 2001 (FSI has given these estimates for the first time) indicates that of the total 908 Sq. Km. of mangrove only 182 Sq. Km. (20 %) are dense and the remaining 726 Sq. Km. (80 %) are sparse or open. The share of dense forest is very low in both Kachchh and Jamnagar districts where the area under mangroves is the highest. The SAC estimates of 1992 put the %age of dense mangroves to 15.20 % while the GEER Foundation (1998) put this to 48.4 %. The GEER estimates of 1998 and FSI estimates of 2001 are on the same scale and therefore are comparable with each other. According to these estimates there has been a severe degradation of mangroves during this period.

Table. 2 District-wise dense and sparse mangrove cover in Gujarat (in Sq. Km.)

District	SAC 1992 *	Dense GEERF 1998 **	FSI 2001***	SAC 1992*	Sparse GEERF 1998 **	FSI 2001***	SAC 1992 *	Total GEERF 1998**	FSI 2001***
Ahmedabad	-	0.09	1	28.1	0.7	1	14.6	0.79	2
Bharuch	-	5.69	17	27.5	8.99	11	27.5	14.7	28
Bhavnagar	-	9.19	10	32.3	5.96	6	32.3	15.2	16
Jamnagar	24.8	78.65	28	188.3	62.8	114	213	141	142
Junagadh #	-	0.65	1	0.6	10.4	0	0.6	1	1
Kachchh	134	344.19	118	575.6	383	588	710	727	706
Kheda	-	-	-	17.5	0	-	17.5	0	-
Rajkot	0	0.98	0	0	4.59	1	0	5.57	1
Surat	-	12.2	8	8.1	9.64	5	8.1	21.8	13
Valsad ##	-	3.78	1	-	6.5	1	-	10.3	2
Total	158.8	455.42	182	878	483	726	1037	938	911

* Source : Singh H.S., (1994, **Source : Singh H.S., (2000), ***Source : FSI, State of Forest Report 2001,

As per FSI report its in Porbandar ## As per FSI report its in Navsari

Note : Data of 1992 was interpreted in a scale of 1 : 1,25,000 and data of 1998 and 2001 were interpreted in a same scale of 1 : 50,000

In short, the area under mangroves declined between 1987 and 1991 but it increased between 1991 and 2001.

Mangroves grow only on suitable inter-tidal mudflats, especially at mouths of rivers and along the creeks. Scientists have identified five factors that control growth of mangroves: Climate, Salinity, Tidal fluctuations, Wind velocity and Substrata and Soil. Keeping in mind these points, H.S. Singh has identified potential areas for mangroves

using the remote sensing data provided by SAC, Ahmedabad (1999). The following table presents these data.

Table. 3. Potential area of inter-tidal zone suitable for mangrove regeneration
(Area in ha.)

District	Present Mangrove Cover in the State	Potential area in inter-tidal mudflat for mangroves	%age Mangroves Cover to Potential Area
Kuchchh	72740	32730	45.00
Rajkot	560	2830	505.36
Jamnagar	14140	11150	78.85
Porbandar	100	40	40.00
Bhavnagar	1520	2000	131.58
Ahmedabad	80	5250	6562.50
Kheda	-	1620	-
Bharuch	1470	3730	253.74
Surat	2190	2100	95.89
Valsad	1030	2260	219.42
Total	93830	63710	67.90

Source : Singh H.S., (2000)

The table shows that there is a good potential for growth of mangroves in the state. It is possible to bring about additional area of 637.10 Sq.Km. under mangroves. This comes to about 68% of the present area! That is, it is possible to raise the area under mangroves to 1,575.40 Sq.Km.

APPROACH TO VALUATION OF MANGROVES

A framework for estimating the total economic value of mangroves needs to be multidimensional, as the value needs to be seen in multiple ways:

Replacement value : To start with, the value of mangroves can be seen as preservation /replacement value as well as developmental value. The preservation value or the replacement cost will refer to the cost that one has to incur to regenerate the lost mangroves. This cost will generally refer to the cost of getting / buying mangroves seeds, setting up a nursery, cost of plantation, cost of care & protection till mangroves are matured, cost of gap filling and other related costs. The developmental cost will include the value of mangroves in terms of its use and non-use values. The replacement cost will be much less

than the developmental cost and the former will be the floor cost or the lowest value of mangroves. The gap between the two sets of values will indicate that it costs relatively less to regenerate mangroves, but it will cost much more if mangroves are not regenerated and restored.

Use and Non Use Value : The production value of mangroves can be broadly divided into two parts, namely, Use Value and Non Use Value. The use value will consist of the value of the goods and services provided by mangroves to the economy, while the non-use value will be the value that will arise from the mere existence of mangroves.

Option value is the value people attach to the environment just to hold or preserve it or have the option of using it in the future. Bequest Value is the value people are willing to pay to preserve the resources for the sake of their future generation, and stewardship value refers to a situation upon people act as stewards of mangroves. The following table presents the different economic value of mangroves.

Table-4. Total Economic Value of Mangroves

Use Value		
Direct Use Value	Direct Consumptive Use Value	Fodder, fuel wood, timber, medicine, food etc. Industrial input on site and offsite fishery
	Direct Non Consumptive Use Value	Recreation, tourism etc
Indirect Use Value	Functional Benefits	Flood Control, protection against strong winds, cyclone, Biodiversity, Shoreline stabilization, Carbon Sequestration
Option Value	Future Direct and Indirect Values	Biodiversity, Conserved habitats
Non Use Value		
Bequest Value	Preservation of Mangroves for future generations	
Existence Value	Value from knowledge of continued existence and Cognitive Value	

Value of Mangroves at Different Levels : The total value of mangroves can also be seen at the local or community level, at the state level, at the country level and at the global level. At the local or community level, mangroves provide fodder, fuel wood, timber etc; supply crabs, mud skippers etc by way of on site fishing; protect local communities from saline winds, cyclone etc. At the state level, the benefits are much wider. Mangroves, at the state level, enrich coastal and marine life, promote biodiversity, promote offsite fisheries etc; while at the national level. Mangroves can contribute

significantly by promoting carbon sequestration as well as biodiversity. Rich growth of mangroves on the coast of Gujarat is likely to have a significant impact on the marine biodiversity to other coastal regions, particularly in neighboring states. Also, carbon sequestration promoted by mangroves has impact on the environment of the entire country. At the global level also, a rich growth of mangroves can make a contribution in reducing global warming. In short, the value of mangroves needs to be seen beyond its local value.

Livelihood Protection and Distributional Dimension of Valuation : An important dimension of the value of mangroves is that it protects and promotes livelihood of lakhs of people on the Gujarat coast. Mangroves support the livelihoods of the thousands of households engaged in animal husbandry and fishery, they protect coastal lands from the strong winds and salinity ingress, they meet basic needs like fuel wood, timber etc and protect the life and property of thousands of households living in the coastal areas. This contribution of mangroves cannot be captured adequately in monetary terms, as it has an important dimension of distribution of benefits. If mangroves are destroyed for an industrial unit, the loss will occur to hundreds of households, who will be deprived of their livelihoods. It will be necessary to include this dimension while taking any decision about clearing mangroves for any developmental project like industrial project, infrastructural project, etc. For example, it will be necessary to give a high priority to these losers in the distribution of benefits of the developmental project.

Present and Potential Value of Mangroves : Another important dimension of valuation of mangroves is about the wide gap between its present and potential values. This is because the value of mangroves increases multifold when the patchy, stunted and under grown mangroves turn in to matured plants.

Valuation of mangroves needs to be seen in terms of its potential contribution to the economy and any decision about mangroves should be based on its long-term contribution to the economy and not on the basis of its present status. Since the value of mangroves increases at an exponential rate with the improvement in its quality, its value for the coming years should be calculated accordingly. A rich belt of well-grown mangroves can contribute to the economy at all the levels, starting from local level to the global level. It will contribute not only to local community by supplying fodder, fuel wood, timber, food and fisheries etc., but it will contribute significantly at the state economy by promoting its multiple uses like raw material for a number of medicines, industrial products, etc and by enriching biodiversity and at the country and global level by rich carbon sequestration.

It will be necessary to incorporate this dimension of mangroves while estimating its value in the coming years, say coming 5 to 10 years. To sum up, the total framework for valuation of mangroves can be presented as follows :

Table-5. Framework For Valuation of Mangroves

Level of Valuation	Use Value		Non Use Value		Replacement Value (Coming 5-10yrs)
	Present	Potential	Present (Coming 5-10yrs)	Potential	
Community/ Local level	✓	✓	✓	✓	✓
State level	✓	✓	✓	✓	✓
Country level	✓	✓	✓	✓	-
Global level	✓	✓	✓	✓	-

METHODOLOGY FOR THE PRESENT STUDY

The Replacement Method : Two period have been selected for computing replacement value of mangroves: Firstly, the value has been calculated for the loss of mangroves during the past three years from 1998 – 2001, the period for which the latest and comparable data on mangroves are available. The value of the gain or loss in the area under mangroves has been calculated by computing the cost of restoring this area under mangroves. Attention has also has been given to the changes in the quality of mangroves that has taken during this period. Secondly, valuation has also been done from the longterm perspective. Here the cost of regeneration of mangroves has been calculated for the potential area under mangroves. As we do not have any time series data on the status of mangroves in the state, there are no estimates available for the long-term loss of mangroves. Keeping this in mind the replacement cost of mangroves has been calculated for all the potential area identified as suitable for growth of mangroves. This potential area for mangroves, as seen earlier, has been estimated by H.S. Singh (1999).

The seven models/sites of the REMAG project have been used for computing the cost of mangroves. The coastal region of the state, as discussed above, can be divided into five regions : (1) The Rann of Kachchh, (2) The Gulf of Kachchh, (3) The Saurashtra coast, (4) The Gulf of Khambhat and (5) The South Gujarat coast. The area for restoration of mangroves has been estimated for each of the regions separately and the cost of restoration for each region has been calculated using the costs incurred under different REMAG experiments/models. In addition, the different models of mangroves plantation used in the Marine National Park also have been used for the purpose of valuation. This valuation provides full estimates of the cost of restoration of mangroves on the coast of Gujarat, keeping in mind the differences in the costs in the different regions. It provides the estimate of the cost that the government and other stakeholders need to incur to ensure healthy growth of mangroves on the suitable sites on the Gujarat coast.

ESTIMATING DIRECT AND INDIRECT USE VALUE OF MANGROVES

An alternative value of mangroves has been calculated using the direct and indirect use value of mangroves. This has been done with the help of primary surveys in the selected villages from each of the coastal regions as well as using the available studies / literature on mangroves. The available studies on mangroves have been used when (1) conducting primary studies on the coast is not likely to help and (2) when the available studies are relevant to Gujarat's coastal regions.

Present Use Value of Mangroves : The present use value of mangroves, based on its present uses by people on the coast, has been calculated with the help of well designed primary surveys in the selected coastal villages.

The selection of villages has been done in a way that (1) they are coastal villages with relatively good growth of mangroves, (2) the villagers depend on mangroves for their different needs and (3) there is a scope for regeneration of mangroves. The selected villages also are the villages where GO/NGOs have undertaken regeneration of mangroves. These villages thus provide the cost of regeneration of mangroves in the different regions in the state. Table-6 presents information about the selected villages from the different coastal regions in the State.

Table-6. Selected Villages for Valuation

Sl. No.	Regions	Districts	Talukas	Villages
1.	Kachchh and Jamnagar	Kachchh	Jakhau	Asirwandh, Gunao
			Lakhpatt	Lukky
		Jamnagar	Jamnagar	MNP area
2.	Saurashtra (for)	Ahmedabad	Dhandhuka	Mahadevpura Bhangadh
3.	Gulf of Khambhat	Ahmedabad	Dhandhuka	Mahadevpura Bhangadh
		Anand	Khambhat	Tada talav
4. .	South Gujarat (for)	Bharuch	Hansot	Kantiajal
			Jambusar	Neja, Nada

The sample villages located in the different coastal region of the State represent the typologies of mangroves in the state. The selected villages also differ considerably in terms of their amenities and facilities, non-agricultural employment avenues, and their poverty. However, in spite of these variations, they all have some important common features: (1) They suffer from degraded coastal environment, (2) they depend on mangroves

for livelihood to a significant extent and (3) ecological regeneration including regeneration of mangroves will help considerably in improving life and livelihood of their population. As no data are available for the Saurashtra region, it is assumed that the cost of regeneration will be similar to the costs in Dhandhuka, which is close to this region. Similarly, as no regeneration data are available for South Gujarat, it is assumed that the costs of regeneration in this region will be equal to the costs in Hansot taluka, which is in some ways similar to South Gujarat coastal region.

Estimating Dependences of Sample Villages on Mangrove : A primary survey was conducted to estimate the dependence of the selected villages on mangroves for direct and indirect use value.

Estimating Non-use Value of Mangroves : The non-use value of mangroves, i.e. Existence value and Bequest Value, can be compiled using Contingency Valuation methods.

Potential value of Mangroves : Though mangroves have a large number of economic uses, it is used for limited purposes in Gujarat. This study therefore includes additional uses of mangroves. These will include use of mangroves for dyes, medicines, bee wax & honey, on site and off site fisheries, recreation and tourism, biodiversity benefits, shoreline stabilization, protection from cyclones, carbon sequestration etc. Another aspect of the potential value of mangroves is the exponential rate at which the benefits from mangroves will grow. The present benefits from mangroves, such as fodder, fuel wood, timber etc will increase at a much faster rate with the growth of mangroves. While compiling the value of mangroves for the coming 5-10 years, it will be necessary to take note of this phenomenon.

ESTIMATION OF VALUES

Replacement Value of Mangroves : Two periods have been selected for valuation here: Firstly, the value has been calculated for the loss of mangroves during the past three years from 1998–2001, the period for which the latest data on mangroves are available. The value of the gain or loss in the area under mangroves has been calculated by computing the cost of restoring this area under mangroves. Attention has also been given to the changes in the quality of mangroves that has taken during this period. Secondly, valuation has also been done from the long term perspective. Here the cost of regeneration of mangroves has been calculated for the potential area under mangroves.

Replacement value for 1998–2001 : As seen above, the estimates of GEER Foundation for the year 1998 and the FSI estimates of 2001 are used to compute the replacement value of mangroves. Both the sources provide data on mangroves under dense forests and under sparse forests. The adjoining table shows that the total area under mangroves has declined from 938.12 Sq. Km. to 908 Sq. Km., i.e. by 29.12 Sq. Km. during the period. The dense mangroves area has also declined considerably in both Kachchh and Jamnagar area (by about 50 Sq. Km. and by 226.18 Sq. Km. respectively during 1998–2001) and in

Surat, Valsad and Rajkot. It has increased marginally in Ahmedabad, Bhavnagar and Junagadh and significantly in Bharuch, (from 5.69 Sq. Km. in 1998 to 17.00 Sq. Km. in 2001). The decline in dense forest seems to have taken place due to natural causes as well as due to lack of protection, as most of the mangroves in the State (except for those in Jamnagar and Kachchh districts) are outside the preview of the forest department. The increase on the other hand appears to mainly due to new plantation or due to degraded dense mangrove turning into sparse mangroves. The per hectare cost of regeneration of dense mangroves in each region has been calculated using the different NGO experiments of regeneration.

Table-7. Cost of Regeneration of Mangroves (In Rs. per Ha.)

Type of Cost	As per NGO Models					As per MNP Models		
	Asira-wandh	Maha devpura	Neja	Nada	Kantiyajal	SLM-I	SLM-II	SLM-III
Capital Cost of plantation	3988	4230	7609	2513	6948	4841	2568	6064
Gap filling Cost after one year	3584	2500	909	734	288	914	564	1092
Cost of Protection (for 5 years)	9000	9000	9000	9000	9000	2520	2520	2520
Total cost	16572	15730	17518	12247	16236	8275	5652	9676

Source : Estimated from the actual expense on regeneration at different sites in 2003-04.

Table 7 shows that the costs are not the same in the different locations. This is mainly because the physiographic conditions i.e. the climate, salinity; tidal flows, wind velocity sub strata soil etc are different in different regions. The other reasons are (1) the seeds are not always available locally, with the result that in some regions seeds are brought from distance raising the cost of seeds, (2) the methods adopted for plantation are different, as in some regions direct plantation is possible while in other regions plant nursery is a necessity, which raises the cost of plantation, (3) the rates of success are different in different regions, resulting in the differences in the costs of gap feeling, and (4) the need for protection differs from region to region, depending on the local situation. Using the data on the cost of plantation in different regions of the State, the value of the changing area under mangroves has been calculated. The value of the loss of dense mangroves in the state during 1998-2001 comes to Rs. 40.71 crores. Similarly, the value of the increase in sparse forests has been calculated under the assumption that the per hectare cost of regeneration of sparse mangroves is half of the cost of regeneration of dense mangroves. It has been estimated that there was an increase of about Rs. 17.4 crores in the value of sparse mangroves during 1998-2001. In short, the state has lost Rs. 23.3 crores worth of mangrove resources during the period 1998-2001. The value of the loss per year comes to about Rs 7.8 crores

Table-8. Total Cost of Regeneration (in Crores of Rs.)

District	Cost of Regeneration in Potential Area	Cost of Regeneration of Dense Mangroves Area during 1998-2001	Cost of Regeneration of Sparse Mangroves Area during 1998-2001	Total Cost of Regeneration of Mangroves
Ahmedabad	-8.26	+0.14	+0.02	-8.10
Bharuch	-5.72	+1.73	+0.15	-3.83
Bhavnagar	-3.14	+0.13	+0.00	-3.01
Jamnagar	-8.53	-3.99	+2.01	-10.50
Junagadh	-0.06	+0.06	-0.79	-0.80
Kheda	-2.84	+0.00	0.00	-2.84
Kachchh	-54.25	-37.48	+16.97	-74.76
Rajkot	-4.69	-0.16	-0.14	-4.99
Surat	-3.41	-0.68	-0.38	-4.47
Valsad	-3.67	-0.45	-0.45	-4.57
Total	-94.58	-40.71	+17.41	-117.88

Source : Primary Survey, 2003

Note : Negative (-ve) signs indicate the cost to be incurred for regeneration where as Positive (+ve) signs indicate the gain due to natural increase in area under mangroves.

The long-term replacement value or full regeneration value of mangroves has been computed under the assumption that the mangroves in the past covered its full potential area. The cost of regeneration has been calculated region wise, using the same costs per ha. as in the above exercise. The value of restoration on the potential area comes to Rs. 94.6 crores. Tthe total cost of regeneration of mangroves for the State will be Rs.117.8 crores, which implies that the State can regenerate mangroves on all the possible coastal area, which includes the present area as well as the potential area, by spending a relatively small amount of Rs. 117.8 crores. The regeneration will of course take about five years.

DIRECT USE VALUE OF MANGROVES

The direct use value of mangroves will include the value of mangroves for (1) fodder, (2) fuel wood, (3) timber for constructing fishing boat, roof etc, (4) vegetable, (5) medicines and other products and (6) collection of mud skippers, crabs and small fish in water ways of mangroves. This valuation has been done using the results of the household surveys conducted in the selected village.

Value of Mangroves as Fodder : An important use of mangroves to the coastal population in the state is for fodder. About 50% of the households living in the selected coastal villages own animals and about 82% of these owners use mangroves as fodder.

Table-9. Dependence of selected villages on mangroves

Village	% of household having livestock	Total livestock in the village	% Owners of livestock using mangroves as fodder
Asirwandh	76.7	266	91.3
Gunao	80.0	376	97.9
Lukky	89.3	210	96.0
Bhangadh	30.8	763	95.6
Mahadevpura	25.4	419	100.0
Tadatalao	51.4	244	8.8
Kantiyajal	42.0	271	78.0
Neja	66.3	160	30.6
Nada	65.8	629	94.7
Total	47.6	3338	81.6

The Table 10 shows that the annual consumption of mangroves per household varies from 282 Kg in Tadatalav to 6118 Kg in Kantiajal. When these averages are multiplied with the corresponding total numbers of households using mangroves for fodder in these villages, the total consumption for the villages comes to 3180588 Kg. The money value of mangroves fodder comes to Rs. 1.46 Crore in the selected villages.

Table-10. Annual Consumption and Value of Mangrove used as Fodder by villagers

Villages (Name)	Sample HH (No.)	Total use (‘000 Kg)	Average use per HH (Kg)	HH using Mangroves (No.)	Total Consumption (‘000 Kg.)	Market Value (Rs./Kg.)	Total Value (Lakhs of Rs.)
Asirawandh	14	49.2	3517	29	102.0	3	3.06
Gunao	25	8.5	340	48	16.3	3	0.49
Lukky	12	6.0	501	24	12.0	3	0.36
Bhangad	130	340.3	2617	288	753.8	4	30.15
Mahadevpura	45	154.6	3434	97	333.1	4	13.33
Tadatalao	5	1.4	282	5	1.4	4	0.06
Kantiyajal	40	244.7	6118	78	477.2	5	23.86
Neja	15	56.4	3762	59	222.0	5	11.10
Nada	116	579.0	4991	253	1262.7	5	63.14
Total	402	1440.1		881	3180.6		145.54

When this value is scaled up for the total area under mangroves in the state at present, it comes to Rs. 82.76 Crores. This is the current value of mangroves used for fodder in the state for the year 2003-04.

Value of Mangroves as Fuel wood and for Construction : The next important direct use of mangroves is fuel wood and construction. Our study shows that about 24.2 % households (one fourth households) in coastal region use mangroves for fuelwood and about 10 % households use it for construction. The total value of the consumption of this fuel wood for the selected households comes to Rs. 7.54 lakhs. This value has been scaled up for the total area under mangroves in the State by calculating region wise consumption of mangroves for fuel wood. This comes to 4.49 Crores per year.

Value of mangroves as timber: The value of mangroves as timber has been calculated on the same lines. There is a practice of using mangroves as timber for construction work – of fishing boats, house etc. The value of the mangrove as timber used by people in Gujarat coast comes to Rs. 17. 10 lakhs. The current value of mangroves used for medicine, for vegetation is also noted in the field survey. However, the use is very small and therefore not quantified

Table-11. Annual Consumption and Value of Mangrove as Fuel Wood

Villages (Name)	Sample HH (No.)	Total use (‘000 Kg)	Average use per HH (Kg.)	Total consumption of the village (‘000 Kg.)	Market value (Rs./Kg.)	Total value (Lakhs of Rs.)
Asirawandh	14	3.24	231	6.94	2	0.14
Gunao	25	10.12	405	24.29	2	0.49
Lukky	12	0.48	40	1.12	2	0.02
Bhangad	130	55.73	429	189.48	2	3.79
Mahadevpura	45	28.16	626	133.29	2	2.67
Tadatalao	5	0	0	0	2	0
Kantiyajal	40	0.74	19	4.40	2	0.09
Neja	15	0	0	0	2	0
Nada	116	5.10	44	17.63	2	0.35
Total	402	103.57	257.6	377.16		7.54

Source : Estimated from Primary Survey, 2003

Collection of crabs, mudskippers and fish from mangrove waters : Though all the villages reported that they collect crabs, mudskippers etc from mangrove waters for self-consumption or for sale, no concrete data were available about the quantity or the value of such collections. The base line study by GUIDE, however, includes a study on this for

the Kachchh area. According to this study, per hectare output of crabs and mudskippers in mangrove waters is about 400 Kg per year. Assuming that the value remains the same in all mangrove areas, we have calculated the value for the State. At the rate of Rs. 20 per Kg, the monetary value comes to Rs. 72.88 crores.

Total Direct Use Value of Mangroves in Gujarat : The total (current) annual value of the products of mangroves emanating from their direct use comes to Rs. 160.3 crores. The most important source of direct value fodder, which contributes about 51.6% of the total direct value. This is followed by is mudskippers and crabs in mangrove waters (45.5%), fuel wood (2.8%) and construction (0.1%). It needs to be noted that this direct value is occurring even when the quality of mangroves is not very satisfactory in the State.

Table-12. Estimated Direct Use Value of Mangroves per ha. Per year

Regions	Per ha. Value for the year (In Rs) for				
	Fodder	Fuelwood	Construction	Crabs and Mudskipper	Total
Kachchh and Jamnagar	8689	462	0	8000	17151
Saurashtra	8689	462	0	8000	17151
Gulf of Khambhat	13114	1578	577	8000	23269
South Gujarat	23860	88	0	8000	31948

Table-13. Direct use value of present area under mangroves in Crores of Rs. (for 2003)

Regions	Value of Fodder	Value of Fuel	Value of mudskippers and crabs	Value of construction	Total Direct Use Value	% Share
Kachchh and Jamnagar	73.77	3.92	67.92	0.00	145.62	90.8
Saurashtra	1.48	0.08	1.36	0.00	2.92	1.8
Gulf of Khambhat	3.93	0.47	2.40	0.17	6.98	4.4
South Gujarat	3.58	0.01	1.20	0.00	4.79	3
Total	82.76	4.49	72.88	0.17	160.30	100
% Share	51.6	2.8	45.5	0.1	100	

Source : Estimated from Per ha. Values as shown in table 5.4

Direct Use Value of Mangroves For the Potential areas : In addition to the current direct use value of mangroves, we have also calculated direct use value for the areas that

have been identified as potential areas for mangroves in the state. The direct use value of mangroves for the current year for the potential area is Rs. 122.22 crores. If the current direct use value added to it, the Total Direct Use Value comes to Rs. 282.53 crores.

Table-14. Direct Use Value For Potential Area Under Mangroves in Crores of Rs.

Regions	Value of Fodder	Value of Fuel	Value of mudskippers and crabs	Value of construction	Total Direct Use Value	% Share
Kachchh and Jamnagar	40.59	2.16	0.00	37.37	80.11	65.54
Saurashtra	1.77	0.09	0.00	1.63	3.50	2.86
Gulf of Khambhat	13.91	1.67	0.61	8.48	24.68	20.2
South Gujarat	10.41	0.04	0.00	3.49	13.94	11.4
Total	66.68	3.96	0.61	50.97	122.22	100
% Share	54.55	3.24	0.5	41.7	100	

INDIRECT USE VALUE OF MANGROVES

The major indirect use values arising from the ecological functions of mangroves can be listed as follows :

- Its value in fisheries—on shore and off shore fisheries (fish, shrimp, prawns, crabs etc.)
- Its value for protection to agriculture from winds, cyclones, salinity etc.
- Its value for providing protection to life, property infrastructure etc to coastal settlements.
- Its value for promoting biodiversity in coastal and marine ecosystems as well as improving quality by coastal water and ground water.

Indirect Use Value of Mangroves For On-shore Fishery : The discussion in the earlier section has shown that fishery is an important occupation in these villages. The development of fisheries depends on the availability of fish, which to a considerable extent depends on the status of mangroves. Mangroves supply food to marine communities via a detritus food chain starting from fallen mangroves leaves. They also provide a habitat for some commercially exploited marine organisms like prawn, crabs, fish etc. at critical phases of their life cycle by functioning as a feeding ground for juveniles (nurseries). The areas with thick mangroves therefore have good fishing industry and the areas with degraded and sparse mangroves have poor fishing industry.

We have assumed that the mangroves contribute about 50 % of the value of the fishery caught by fishermen. This assumption is based on empirical studies conducted in other parts of the world. The total value of the fish catch in the selected villages has been estimated at Rs. 20.67 lakhs.

Table-15. Value of fish-catch in the selected villages

Villages (Name)	Fishing HH (No.)	Fish catch per HH per Year (Kg.)	Total fish catch of the village for the Year (Kg.)	Average value of fish (Rs./Kg.)	Value of fish catch for the Year (Rs.)
Asirawandh	7	300	2100	30	63000
Gunao	11	190	2090	30	62700
Lukky	2	775	1550	30	46500
Bhangad	12	350	4200	30	126000
Mahadevpura	6	600	3600	30	108000
Tadatalao	4	200	800	30	24000
Kantiyajal	36	270	9720	30	291600
Neja	5	700	3500	30	105000
Nada	52	795	41340	30	1240200
Total	135	500	68900	30	2067000

Source : Estimated from Primary Survey, 2003-04

Using the available data, per ha. value of onsite fish catch has been calculated for different regions. The indirect use value of mangroves for fisheries for the present area under mangroves has been calculated as Rs. 8.7 crores. This value for the potential has been estimated at Rs.6.0 crores. The total value, that includes present area under mangroves as well as the potential area, will come to Rs. 15.68 crores.

Value of Mangroves for Offshore Fisheries : Studies show that a mangrove forest of 1 hectare can support more than 1 ton of fish production of off shore fishery per hectare per year (Schatz, 1991). With this assumption we have calculated the amount of offsite marine fish catch that is likely to be supported by mangrove forest for the present area as well as the potential area. This comes to Rs 221.4 crores per year and is about 12.5 % of the total marine fisheries production of the state for the year 2002-03. Similarly, the value of off-site fisheries for the potential area of mangroves in the state comes to about Rs. 154.8 crores. If the current indirect use value of offsite fishery is added, it comes to a total of 376.2 crores.

Indirect Use Value of Mangroves for Protection : Indirect use value of mangroves for protection of life and property of people and for protection of agricultural lands from

saline waters and saline winds has been calculated using the WTP approach. A question was asked to all households as to how much is the value of mangroves for the village for the protection it provides to life and property and for the protection it provides to its agricultural lands. The question about the protection to life etc was replied by the households on the basis of their experiences in the past and their perception about the protection that mangroves would provide to the village.

Table-16. Indirect Use Value of Mangroves for Protection in Sample Villages

Villages (Name)	Average Value of protection from Cyclone (Lakhs of Rs.)	Protection Cost of Agricultural land (Lakhs of Rs.)	Total (Lakhs of Rs.)
Asirawandh	1.50	0.00	1.50
Gunao	0.69	0.84	1.53
Lukky	1.26	0.39	1.65
Bhangad	10.60	10.11	20.71
Mahadevpura	10.32	3.94	14.25
Tadatalao	6.32	3.51	9.83
Kantiyajal	12.18	6.31	18.48
Neja	0.97	1.16	2.13
Nada	11.02	22.14	33.16
Total	54.86	48.39	103.25

Source : Estimated from Primary Survey, 2003

The question about protection to agricultural lands was replied by households in terms of their individual assessments for their respective farms. These were totaled up and scaled up to arrive at village level estimates

Table-17. Estimated Indirect Use Value per ha. of Mangroves cover

Regions	Value of Mangrove Cover (Rs. Per Ha.) for			
	Protection from cyclone	Protection Cost of Agricultural land	Value of On-site Fish catch	Value of Off- site Fish catch
Kachchh and Jamnagar	3839	2039	957	24300
Saurashtra	3839	2039	957	24300
Gulf of Khambhat	3569	3275	658	24300
South Gujarat	12175	6307	1458	24300

Source : Estimated from Primary Survey, 2003

Table-18. A Total Indirect Use Value of Mangroves : For the Present Cover of Mangroves

Regions	Total Value (In Crores of Rs.)				
	Protection from cyclone	Protection of Agricultural land	On-site Fish catch	Off-site Fish catch	Total
Kachchh and Jamnagar	32.59	17.31	8.12	206.31	264.33
Saurashtra	0.65	0.35	0.16	4.13	5.29
Gulf of Khambhat	1.07	0.98	0.20	7.29	9.54
South Gujarat	1.83	0.95	0.22	3.65	6.64
Total	36.14	19.59	8.70	221.37	285.80

Table-18B. Total Indirect Use Value of Mangroves: For the Potential Area of Mangroves

Regions	Total Value (In Crores of Rs.)				
	Protection from cyclone	Protection of Agricultural land	On-site Fish catch	Off-site Fish catch	Total
Kachchh and Jamnagar	17.93	9.52	4.47	113.50	145.42
Saurashtra	0.78	0.42	0.20	4.95	6.35
Gulf of Khambhat	3.79	3.47	0.70	25.77	33.73
South Gujarat	5.31	2.75	0.64	10.60	19.30
Total	27.81	16.16	6.00	154.83	204.80

Source : Estimated from Primary Survey, 2003

The total indirect use value of mangroves will be Rs. 490.6 Crores (Rs. 285.8 Crores + Rs. 204.8 Crores) for the current year.

It needs to be underlined here that the perceived value of mangroves as a protective shield against strong winds, cyclones and *tsunami* waves etc. depends on the experience or the living memory of the population. For example, if the population has experienced a major crisis in the recent past, they are likely to put a very high value to the protection. The present study was conducted before the *tsunami* disaster, but if it was conducted after the *tsunami* disaster, the value given to mangroves as a protective wall against cyclones etc would have been much higher.

Value of Mangroves for Their Ecological Functions: As seen earlier, mangroves perform several important ecological functions like promoting biodiversity in coastal and marine ecosystems as well as improving quality by coastal water and ground water. However, valuation of these functions requires a larger study, which is beyond the scope

of this study. The present study therefore uses some other relevant studies for the purpose of valuation of the ecological functions of mangroves.

POTENTIAL DIRECT USE VALUE OF MANGROVES

Mangroves in Gujarat are used for limited purpose only. However, there are many other uses, which can contribute significantly to the total use volume of mangroves.

Wood Products : Timber: Some species of mangroves, including the *Avicennia* (i.e. *A. officinalis*, *A. marina*, *A. aeba* etc.) which is predominant in Gujarat and *Rhizophora* which is grown in some parts of State, can produce good quality timber, when the mangroves achieve good growth. Mangroves are already used in the state for construction of fishing boats and houses/huts when the growth of mangroves is good. This potential of mangroves can be tapped to its maximum when mangroves acquire good growth. This implies that mangroves can generate Rs. 117.04 Crores worth timber per year in Gujarat if they achieve good growth in the present and potential areas of mangroves.

Fuel Wood-Charcoal : Mangroves fuel wood can carry more value when converted into charcoal. *Avicennia* and *Rhizophora* wood (both growing in Gujarat) have a high calorific value meaning that they produce relatively more heat for the same weight as compared to other wood and can therefore produce good charcoal. Mangrove based charcoal is produced in Indonesia, Malaysia and Thailand. Gujarat can also produce charcoal from mangroves once mangroves grow very well. The annual net return per hectare of charcoal obtained from mangroves forests is estimated to be equivalent to Rs. 13591 (Sathirathi 1997). The total revenue that can be generated from mangroves based charcoal in the state will be about 210.4 Crores.

Raw material for Industries : Mangroves are also used as raw material for a number of wood based industries, like chip board, pulp wood (news papers and card board), synthetic materials (e.g. rayon) etc.

Non-Wood Products : Food: Mangroves can be used as human food. The seedlings as well as seeds of *Avicennia* and *Bruguiera* species are consumed by people in several parts of the world.

Tannins and Dyes : Bark of mangroves are harvested as a source of tannin for tanning industry, as high tannin content is found in some species of mangroves, particularly *Rhizophora*. Mangroves can also be used to make black dye for dyeing cloth in some East African Countries. Many tannin factories in Bangladesh depend on mangrove extracts. This use of mangrove is also observed in Sundarbans, where about 10,000 tonnes of mangroves bark is harvested annually for the purpose.

Medicinal Use : Mangroves are useful as medicinal plants in many parts of the world. A study conducted in Indonesia (Ruitenbeek 1992) established that medicinal plants from mangroves generate about US \$ 15.00 medicinal value per hectare. It is a potential benefit

of mangroves that can be captured if mangroves are well grown. Some other studies of mangroves based pharmaceutical values show that the value can go up to US \$ 61.00 per hectare. That way in Gujarat the amount of revenue that can be generated from medicinal use of mangroves varies from Rs. 10.9 crores to Rs. 44.3 crores.

Honey and Bee Wax : Honey and bee wax are important products of mangroves in India as well as in some other countries like Bangladesh. In Bangladesh honey and pollen are used as medicines, high energy food and as a source of vitamins and minerals. Honey is collected using traditional methods and is sold to nearby communities (Basit, 1995). Honey and bee wax collection provides a seasonal source of income to many in Bangladesh and India.

Other Products : Mangroves have several other uses, such as, raw material in manufacturing of alcohol, vinegar, gum, mosquitocides etc.; as a source of tea; for manufacturing feed for prawn etc. (Subramonia Thangam 1990, Premanathan 1991, Xavier Ramesh and Kathiresan 1992, Moorthy 1995, Ravi Kumaran 1995, Palanisselvan 1995, Kathiresan 1995 etc.)

Wildlife Resources : Mangroves are a habitat for wild life like tigers (Sundarbans, West Bengal) as well as other animals and reptiles. These resources can produce meat, skin, fur etc. In addition they can also serve as attractive tourist sites.

Recreation and Eco-Tourism : Tourism is both a strong source of foreign exchange and a sustainable source of income if appropriate tourist sites can be developed and maintained in good condition. Mangrove areas can become important tourism and recreational sites.

Table-19. Economic Value of Ecotourism in Mangroves Forests as per previous studies

Study	Year	Area	Value (Rs. per Ha. per annum)
Bennet and Reynolds	1993	Sarawak	19652
Costanza	1997	Global	22990
Leong	1999	Kuala Selangor, Malaysia	42874

In Gujarat the Marine National Park of Jamnagar is an ideal place for developing Ecotourism. With proper planning much of the area under dense mangroves in Gujarat can be developed for Ecotourism. In the case of Gujarat, two spots, namely Kachchh and Jamnagar, can be developed as tourist spots in the near future, while in the long run, two more spots, at Bhavnagar and Surat can be developed. The last two sites have the potential of dense growth of mangroves in the long run. We have used the average value of above three studies i.e. Bennet and Reynolds (1993), Costanza (1997) and Leong (1999) for estimating the probable value of Ecotourism that can be developed in Gujarat in near

future (Table 5.12 A). The value comes to about **41.6 Crores** per annum. In long run the value may go up to **115.14 Crores** (Table. 5.12 B).

In a majority of protected areas in India, tourism is low either due to the fact that these places are unknown to all but the most avid of wildlife lovers, or because of a complete absence of facilities for tourists.

Table-20. A. Potential Value of Mangroves for Eco-tourism in Near Future

Districts having potential for development of Eco-tourism	Dense Mangroves*	Value of Ecotourism per ha. per annum	Total Value of Ecotourism per annum
(Name)	(Ha.)	(Rs.)	(Crores of Rs.)
Kachchh	11800	28506	33.64
Jamnagar	2800	28506	7.98
Total	14600	28506	41.62

Table-21B. Potential Value of Mangroves for Eco-tourism in long run

Districts having potential for development of Eco-tourism	Present cover of Dense Mangroves*	Dense mangroves in potential area in long run**	Value of Ecotourism per ha. per annum	Total Value of Ecotourism per annum
(Name)	(Ha.)	(Ha.)	(Rs.)	(Crores of Rs.)
Kachchh	11800	16365	28506	80.29
Jamnagar	2800	5575	28506	23.87
Bhavnagar	1000	1000	28506	5.70
Surat	800	1050	28506	5.27
Total	16400	23990	28506	115.14

* Source : Singh, H.S. (2000)

** It has been assumed that in long run there will be dense mangroves cover in at least fifty per cent of the potential area in respective regions.

SUMMARY PICTURE OF DIRECT AND INDIRECT USE VALUE

The summary picture of direct and indirect use value is presented in the following tables. The tables shows that the total direct and indirect use value of mangroves is Rs 773.13 crores per year. In addition, the potential direct use value of mangroves is Rs 486.88 crores per year. In other words, the total use value of mangroves per year will be Rs 1260.01 crores per year. This is an under estimation as it does not include the potential indirect use value of mangroves

Table. 22. Direct Use Values of Mangroves in the State

Goods and Services	Value per annum (in Crores of Rs.)			
	From Present area of Mangroves	From Potential area of Mangroves	Total Direct Use Value	Value per Ha per annum (in Rs.)
Direct Use Values				
Fodder	82.76	66.68	149.44	9652.83
Fuel wood	4.49	3.96	8.45	545.92
Mudskippers and crabs	72.88	0.61	73.49	4747.10
Total value of construction	0.17	50.97	51.15	3303.63
Indirect Use Values				
Value of protection :				
Protection property from cyclone	36.14	27.81	63.95	4130.96
Protection of Agricultural land	19.59	16.16	35.75	2309.26
Value of On-site Fish catch	8.70	6.00	14.70	949.41
Value of Off-site Fish catch	221.37	154.83	376.20	24300.00
Total direct and indirect value	446.11	327.03	773.13	49939.12

Table-23. Potential Use Values of Mangroves Goods and Services

Goods and Services	Value per annum (in Crores of Rs.)	Value per Ha per annum (in Rs.)
Wood Products :		
Timber	117.04	7559.99
Fuel Wood-Charcoal	210.40	13590.41
Raw material for Industries :	-	-
Non-Wood Products.		
Food	-	-
Tannins and Dyes:	-	-
Medicinal Use	44.30	2861.48
Honey and Bee Wax	-	-
Other Products	-	-
Wildlife Resources	-	-
Eco-Tourism :	115.14	7437.26
Total	486.88	31449.15

In this study we have estimated two types of nonuse values namely,

- Non-use value of mangroves for Carbon Sequestration
- Non-use value of mangroves for Coastline Stabilization

Carbon Sequestration : The relationship between climate change (one of today's leading environmental concerns) and the conservation and development of the world's forest has become a major issue today. Tropical forests, including mangroves, have an important role in regulating carbon dioxide in the global atmosphere through the processes of respiration and photosynthesis, whereby plants absorb carbon oxide/ dioxide and store it in their biomass. A major ecological function of mangroves is to serve as carbon sink. The general approach in estimating the potential of a forest in sequestering carbon involves calculating the total biomass per hectare (biomass density), and then applying appropriate conversion factors to get the carbon equivalents. Several studies have been conducted on aboveground biomass and productivity of mangrove forests in terms of Carbon Sequestration (*e.g.*, Golley *et al.*, 1962; Lugo & Snedaker, 1974; Briggs, 1977; Christensen, 1978; Suzuki & Tagawa, 1983; Tamai *et al.*, 1986; Day *et al.*, 1987; Lee, 1990; Kusmana *et al.*, 1992; Saintilan, 1997ab), but few on the belowground biomass (Golley *et al.*, 1962; Lugo & Snedaker, 1974; Briggs, 1977; Komiyama *et al.*, 1987; Saintilan, 1997ab).

Estimation of the potential of a forest in sequestering carbon involves calculating the total biomass per hectare (biomass density), and then applying appropriate conversion factors to get the carbon equivalents. Ong, Gong and Clough (1995), estimated the Biomass and Productivity in a 20 yearold Stand of *Rhizophora apiculata* Mangrove Forest as 7.14 tC per ha per year.

Mangrove forests usually create thick, organically rich sediments as their substrata. Mangrove forests have great belowground productivity and play a significant role in carbon sequestration not only above ground but also below ground. The rate of carbon sequestered in mangrove mud is estimated to be around 1.5 t C ha⁻¹ yr⁻¹ (Ong, 1993). The upper layers of mangrove sediments have a high carbon content (a conservative estimate is 10%). Each hectare of mangrove sediment would then contain some 700 tonnes of carbon per metre depth (Ong, 2002)

In estimating a monetary value of the carbon sequestered by the forest, an international price per unit amount of carbon reduced will have to be applied. For this study, the adopted price is \$150 per ton of carbon (based on the tax rate in Norway). The indirect use value of mangroves in terms of carbon fixation thus adopted in this study includes both carbon fixations in the mangrove biomass as well as in the mangroves sediment. The total value for carbon sequestration in mangroves forest in Gujarat has been calculated. (Table 5.15).

The total value of Carbon Sequestration for the present and potential area of mangroves in Gujarat comes to about 929.97 Crores per annum.

Table-24. Value of Mangroves For Carbon Sequestration in Present and Potential Area

(In Crores of Rs.)

Regions	Value of Carbon Sequestration in Present Cover of Mangroves per Annum from			Value of Carbon Sequestration in Potential Area of Mangroves per Annum in		
	Biomass of Mangroves*	Mangroves Sediment**	Biomass+ Sediment	Biomass of Mangroves*	Mangroves Sediment**	Biomass+ Sediment
Kachh and Jamnagar	421.45	88.54	509.99	231.86	48.71	280.57
Sourashtra	8.44	1.77	10.21	10.12	2.13	12.25
Gulf of Khambhat	14.89	3.13	18.02	52.65	11.06	63.71
South Gujarat	7.45	1.56	9.01	21.66	4.55	26.21
Total	452.23	95.01	547.23	316.29	66.45	382.73

* After Ong, Gong and Clough (1995)

** After Ong (1993)

Shoreline Stabilization / Erosion Control : When land is a traded commodity, the value of the shoreline stabilization functions of mangroves might involve estimating the land area lost due to erosion, and valuing that loss at the current land price (i.e., the value of land lost). The value of property lost as a result of shoreline erosion might also be estimated.

Table-25. Non-Use Value of Mangroves : For Erosion Control

Regions	Value of Coastline protection in Crores of Rs. for		
	Present Cover of Mangroves	Potential Area for Mangroves	Total Area of Mangroves
Kachh and Jamnagar	1168.27	642.72	1810.99
Sourashtra	23.39	28.06	51.45
Gulf of Khambhat	41.28	145.94	187.23
South Gujarat	20.64	60.04	80.68
Total	1253.59	876.76	2130.35

The value (cost) of mangroves for shoreline stabilization and erosion control in Gujarat. comes to Rs. 2130.34 Crores

CONCLUDING OBSERVATIONS AND INFERENCES

One major observation emerging from the study is that mangroves are extremely valuable forest ecosystem. Its various economic uses and ecological functions make it very important to the ecology and economy of any country. This study, has shown that the monetary value of mangroves, if calculated carefully, is highly significant.

On the other hand, the use and non-use value of mangroves is quite high. The direct use value of mangroves for the present area under mangroves in the State is Rs. 160.30 crores per year (2003) while it is Rs. 122.22 crores per year for the potential area. This implies that the State can gain Rs. 282.53 crores per year (at 2003 prices) from mangroves as its direct use value. It needs to be noted that this value is low because it has been calculated for the present state of mangroves. With the improvement in the quality of mangroves, this value will rise at an exponential rate.

The indirect use value of the current status of mangroves is Rs. 285.80 crores per year, while the same value for the potential area is Rs. 204.80 crores per year. The total indirect use value of mangroves thus will be Rs. 490.60 crores per year. This value is also low and with the improvement in the quality of mangroves, it will rise at an exponential rate.

In short, the total use value of mangroves is about Rs. 773.13 crores per year for the State (at 2003 prices). That is, the State can earn Rs. 773.13 crores per year as use value of mangroves by restoring mangroves in the State.

It has been estimated that the wood products of mangroves (for timber and fuel wood – charcoal) alone can generate an income of about Rs. 327.44 crores per year. This excludes other industrial uses of timber based product like pulp wood, chips etc, for which we do not have adequate database. Mangroves can be used in the production of several non-wood products like tannin and dyes, medicine products, honey and wax and many other products. It is not easy to calculate the potential values of these products in the absence of the required data. We have some data on the medicinal values from a study in Indonesia, according to which the medicinal value (potential) of mangroves in can go up to Rs. 44.30 crores per year.

Gujarat has two mangrove sites, which can be developed, as eco tourism sites in the near future. These sites are at Kachchh and Jamnagar. The eco-tourism value, the potential increase that can be generated from these sites, has been estimated to be Rs. 41.6 crores per year. (Based on other studies). Two more sites can be developed within 5-7 years at Bhavnagar and Surat, which can also generate similar amounts for the state. In long run the value can go up to 115.14 crores per year. In short, the total potential use value of mangroves can be around Rs. 486.88 crores per year.

The non-use value of mangroves is extremely important due to the immense contribution of mangroves to the ecology of the State, country as well as the world. Two sets of values, namely, carbon sequestration and shoreline stabilization, have been estimated using the studies conducted in other countries. It has been estimated that the

present value of carbon sequestration is about Rs. 547.23 crores per year while the same for the potential mangroves area will be Rs. 382.74 crores per year. In other words, both the value, put together will come to about Rs. 929.97 crores per year. The non use value of mangroves as shoreline stabilizer has been estimated at Rs. 1253.59 crores for the present area and Rs. 876.76 crores for the potential area, bringing the total to Rs. 2130.35 crores per year. The total non-use value thus comes to Rs. 3060.31 crores per year.

In short, the value of the benefits–use and non-use values - generated by mangroves at present in Gujarat is about Rs 2246.93 crores per year. Thus one can say that by spending Rs. 118 crores, we can generate more than Rs. 4000 crores (from present as well as potential area for mangroves) from mangroves resources of Gujarat. Also, the entire contribution of mangroves in terms of protecting and enhancing bio diversity has been excluded – except for the inclusion of on-shore and offshore fisheries. Mangroves are one of the best promoters and supporters of biodiversity.

The mangroves planted on the potential areas will generate additional Rs. 586.52 crores of value per year. We do not calculate the incremental value here, as this will be new area for mangroves. Within the coming five years this mangroves can generate the value of about Rs. 7930 crores. Adding both the values, one can say that mangroves can produce Rs 12,465.00 crores worth value for the economy within the coming five years.

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DISTURBANCES TO CORAL REEF COMMUNITIES OF ANDAMAN & NICOBAR ISLANDS

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ABSTRACT

Andaman and Nicobar Islands are considered as 'Marine Biodiversity Centre' of several species, which do not occur in other parts of the Indian Sub-Continent. Fringing, Patchy and Barrier reefs are present in these Islands covering about 948.8 km². The total mangrove area is about 762 km². There are about 6540 species of fauna and 2500 species of flora were reported from these Islands. The available data indicate that the marine biodiversity constitutes about 63.7% of total reported species. The coral reefs of the Islands are the largest reef formations of the Indian Sub-Continent and contain as many as 235 coral species. Natural and human impacts on reefs have been increasing greatly in recent years and will likely to escalate further in the near future. The Indian Ocean *Tsunami* on December 26, 2004 caused extensive damage to coral reefs of the Andaman and Nicobar Islands. Most of the Islands' coastline was eroded by the *Tsunami* surge and sediments were dumped on adjacent reefs. Natural disturbances human disturbances and other disturbances are discussed in detail.

INTRODUCTION

The Andaman and Nicobar Islands consist of 948.8 km² coral reefs and 789 km² mangrove areas. There is also a barrier reef formation on the Western side of Andaman Islands between 10°26' N and 13°40' N Latitude, for a distance of approximately 360 km. Both the Andaman & Nicobar Islands reefs are the healthiest and least impacted of the other Indian reefs and the average live coral coverage of these Islands are estimated as 55.0% (Jeyabaskaran, 1999). The coral reef fauna and flora known so far from these Islands include : 750 species of fishes, 1422 species of molluscs, 430 species of echinoderms, 112 species of sponges, 235 species of hard corals, 111 species of soft corals, 411 species of crustaceans and 64 species of algae.

Coral reefs are providing food, serving as habitat for other commercial species, supporting the tourism industry, supplying sand for beaches, and acting as barriers against wave

action and coastal erosion. Current estimates of the global value of coral reefs range from nearly US \$ 30 billion to around US \$ 375 billion per year (Cesar *et al.*, 2002). Unfortunately, coral reefs are also among the most vulnerable ecosystems in the world. Today, an estimated 20% of worldwide coral reefs have been destroyed, while 24% are in imminent danger and a further 26% are under long term danger of collapse (Wilkinson, 2004).

DISTURBANCES

Disturbances not only damage or kill the structural species *i.e.* plants, corals etc, but also can affect their physical and biological environment, either directly or indirectly. There are two types of disturbances *i.e.* acute and chronic. Acute disturbance are short-term, whereas chronic disturbances are long term, analogous to “pulse” and “press” experimental treatments, respectively (Bender *et al.*, 1984). Corals usually recovered from acute disturbances on Indo-Pacific reefs. In contrast, corals did not recover from chronic disturbances of either natural or human origins, or from gradual declines. Recovery was slower after acute disturbances that altered the physical environment than after disturbances that simply killed or damaged corals. Natural and human disturbances on coral reefs of Andaman & Nicobar Islands have been increasing greatly in recent years and will likely to escalate further in the near future. Natural disturbances such as coral bleaching, earthquake & *Tsunami*, volcanic eruptions, outbreaks of crown of thorn star fish, coral diseases and anthropogenic disturbances like pollution, waste disposal, coastal development, sedimentation, tourism cause severe mortality of corals in these Islands.

NATURAL DISTURBANCES

Coral Bleaching

Coral bleaching occurs when the symbiotic algae that live in corals become stressed and are expelled. This turns coral white, leaving them in an unhealthy state. Coral bleaching may result from stressors acting alone or synergistically. These stressors include sea surface temperature, light, salinity, pollution, sedimentation, aerial exposure, diseases, and others (Hoegh-Guldberg, 1999). But all corals do not react the same way. Some coral species do not bleach when others are completely white. Some species recover after a short period of bleaching, while mortality may be as high as 95% in others. Bleaching causes reduced coral fecundity and, when extreme, losses in reef biodiversity, degradation of biological and physical functions of the reef ecosystem, and impacts on adjacent mangrove and sea grass habitats and resources. Mass coral bleaching has not been reported prior to 1979. In 1998, the world experienced the largest and most widespread example of mass bleaching with an estimated 16% of the worlds living corals were eliminated in a single warming event (Wilkinson, 2000). The overall economic cost of the 1998 bleaching event on tourism, shoreline protection and fisheries in the Indian Ocean is estimated to be between US \$ 608 and 8026 million, and the great variation in those figures highlights the uncertainty and need for research (Cesar *et al.*, 2002).

The Andaman and Nicobar Islands reefs were not been affected by the May 1998 bleaching event except reefs in Little Andaman Island which was severely affected and the live coral coverage was only 12.0% (Jeyabaskaran, 1999). These Islands are bestowed with lot of creeks. The tidal currents along the creeks associated with fast water flow could have protected corals against bleaching by removing harmful oxygen radicals. Cloud cover is usually more during the rainy season which normally starts in May every year in these Islands. The shading of corals by clouds, high Islands, rocks or other corals, or the screening of corals by suspended particulate matter, can protect them against UV radiation and allow them to avoid bleaching in some cases. For example, shading by cloud cover protected coral reefs in Tahiti in 1998 from bleaching whereas coral reefs in the rest of French Polynesia were severely bleached (Mumby *et al.*, 2001).

Earthquake, Tsunami & Volcanic eruptions

Recently there was an undersea earthquake in the Indian Ocean originated about 30 km deep within the earth's crust off Banda Aceh in Northern Sumatra (3° 09' N, 94° 26' E) at 00 : 58 : 49 GMT (06 : 28 : 51hrs IST) on Sunday December 26, 2004, with a magnitude of $M_w = 9.3$. It set off a 'chain reaction' with the rupture of a 1,200 km segment of fault running Northward through the Andaman and Nicobar Islands resulting in a wave of secondary earthquakes. The total energy released was equivalent to a 100-gigaton bomb more than 1,500 times that of the largest nuclear bomb ever detonated. These earthquakes resulted in major uplifts and subsidence of the ocean floor and displaced more than 30 cubic kilometers of seawater. The earthquake generated a *Tsunami* surge that was among the deadliest disasters in the modern history. The *Tsunamis* following the earthquakes damaged coral reefs through 3 mechanisms: wave action which dislodged, smashed and moved coral and rubble; smothering of corals by increased sediment movement; and mechanical damage and smothering by debris from the land. It has been found that the area had moved SouthWestward about 4-5 metres at North Andaman (Diglipur), about 4.5 metres at Middle Andaman and about 3-4.5 metre at South Andaman. In addition to this the North Andaman landmass was lifted up by 0.60-0.90 cm resulting in a fall in the water level. Due to this, almost all reef flats of about 4000 ha area and mangroves on the Western side of Northern group of Islands were exposed and dried up. Almost all corals in the reef flats and other associated fauna seemed dead beyond regeneration level appearing like graveyards of corals. But the corals in reef slopes were not affected by *Tsunami* and the live coral percentage was 55-60%. In contrast, South Andaman had subsided by 1-2 metre and seawater inundated, especially the agriculture fields and coastal mangrove swamps had died. Heavy load of sediments were deposited over the reef flats of Nicobar group of Islands and it led to mass mortality of corals. Nearly 2 km² mangrove areas were completely submerged in these Islands.

Outbreaks of crown of thorns starfish

The coral eating crown of thorns starfish (COTS) *Acanthaster planci* causes extensive damage to reefs. The starfish prefer branching corals mainly *Acropora* sp, because they

can hang on to them easier, whereas the large boulder corals like *Porites*, *Favia* and *Diploastrea* sp are not affected, because the starfish are washed off by waves. In Andaman, outbreaks were noticed in Mahatma Gandhi Marine National Park and Outram Island of Rani Janshi Marine National Park (Jeyabaskaran, 1999). The outbreak was first noticed in Wandoor during the year 1991 (Venkataraman and Rajan, 1998). Eradication of specialist predators such as hump-headed wrasse fish, *Cheilinus undulates*, the puffer-fish, *Arothron hispidus* and a mollusc (*Charonia tritonis*) and in some cases, nutrient enhancement due to terrestrial runoff have been implicated as possible causes of outbreaks. It is necessary to kill the starfish on reefs to protect valuable corals. Repeated outbreaks can lead to the degradation of reefs and divers should collect the crown of thorns starfish and kill them on the land. The best method is to use large mechanical syringes to inject small volumes of the swimming pool chemical 'dry acid' into each starfish.

Sea level rise

Normally coral reef growth can keep up with rising sea levels, but with projected rises of 1 to 9 mm/year (Intergovernmental Panel on Climate Change, 2001) some coral reefs may 'drown' because of a lack of light as increased water volumes above the coral reefs reduce the light levels reaching them. However, it is expected that growth rates of most coral reefs will keep up with predicted sea level rises, and a more likely threat from sea level rise is increased sedimentation due to shore erosion (Buddemeier *et al*, 2004). The sea level rise of 0.5 m in the next 100 years may not seem much, but people on many low lying sandy Islands will have to move to higher Islands or build expensive protective barriers. Reef growth will keep up with sea level rise, but Islands cannot accumulate new sand and rock fast enough to stay above the rising sea. Reef flats that are exposed at low water, which limits their upward growth, may benefit from such a rise. However, corals are weakened by temperature increase and reduced calcification rates. The elevated sea surface temperatures affect the sensitivity of *Zooxanthellae*, as this light that is essential for photosynthesis causes damages to the cell. Global emissions of greenhouse gases have raised concentrations of carbon dioxide in the atmosphere and in the oceans to a level that may gradually reduce the ability of coral reefs to grow through normal calcification processes. High concentrations of carbon dioxide increase the acidity of seawater, which reduces the calcification rates of corals (Hoegh Guldberg, 1999).

Diseases

Coral diseases are detrimentally impacting individual coral species, coral populations, and entire reef ecosystems. Eighteen coral diseases, affecting at least 150 scleractinian corals, gorgonian, and hydrozoan zooxanthellate species, have been described from the Caribbean and the Indo-Pacific. Among the 400 coral species in the Indo-Pacific, only 98 have been documented with 1 or more diseases. Worldwide, 22 coral species are affected by 4 or more different diseases. Increases in the number of new diseases and species affected may be directly linked to human induced alterations in coral reef environments both in terms of land based sources of pollution as well as global climate change issues

like global warming (Sutherland *et al.*, 2004). Five species of corals *Porites lutea*, *P. lichen*, *Montipora tuberculosa*, *Goniopora* sp., *Goniastrea* sp from the Andaman Islands had been regularly found to have single or multiple necrotic patches. Sections revealed a septate dark brown mycelial fungus *Scolecobasidium* sp on the surface and subsurface of the dead patches in five coral species. The occurrence of such corals with necrotic patches varied from 10-50% in the field (Raghukumar and Raghukumar, 1991). Recent survey results by the author showed the presence of White pox, White band and Black band diseases in the North Bay, Snake Island and New Wandoor reef corals.

ANTHROPOGENIC DISTURBANCES

Tourism

The Andaman and Nicobar Islands have variety of ecosystems with an extremely rich biodiversity and productivity. Tourists been increasing in every year and their interest is towards the Islands with clean beaches and healthy corals. About 1,10,000 tourists are visiting the Islands including nearly 5,000 foreigners during the period of calm weather season from October to February. The Department of Tourism under Andaman & Nicobar administration proposed regulations for expansion of tourism in these Islands (DOT, 2004).

The “sister city” agreement (June 2005) between Phuket (Thailand) and Port Blair has already been made and implementation of others will cause extensive damage to the coral reef ecosystem. Tourism derived damages on reefs includes the construction of infrastructure causes increased runoff and sedimentation, trampling of corals by snorkellers and swimmers, and anchoring of boats leads to breakage of the branching corals and causing lesions on the massive type corals. For example, Cesar *et al.* (2002) estimated the current and future financial losses to coral reef due to tourism in Indonesia will be between US \$ 27,900 and US \$ 100,800 per one square kilometer. SCUBA Diver induced damages range from indirect fin-hits through forceful contact with corals when buoyancy maintenance is poor and intentional trampling like standing on corals for photographs. This can be avoided by educating the divers before they enter water. Other damages associated with diving activities include anchor damage which could be easily avoided by provision of mooring buoys, unfortunately such simple gestures are lacking in almost all reefs of India. Best management practices would strive to remove these damages by addressing the root causes – by providing mooring buoys, by ensuring that the divers to know the site and type of coral there, educating tour guides themselves and finally regulating the number of divers. The coral reefs of Jolly Buoy, Redskin and North Bay Islands of Andaman have severely been damaged by the tourists. The tourists leave behind various waste materials.

Poaching

Poaching is a serious problem in the Andaman & Nicobar Islands. About 184 fishing boats were apprehended during the last one decade. There are two basic types of poaching

activities prevailing in the A & N region i.e. poachers coming from neighboring countries mainly from Myanmar in small dinghies (boats) to the coast for collecting marine wealth and poaching by modern mechanized trawlers of neighboring countries particularly from Thailand and Indonesia in the Exclusive Economic Zones (EEZ). The EEZ around Andaman and Nicobar Islands are 5, 95,217 square kilometers. During the last one year, 19 vessels of 7 foreign littoral nations were apprehended which carried 118 foreign personnel, who were actively engaged in transnational piracy in Indian EEZ. The Andaman Nicobar Command has booked 5 Indian owned and Indian registered fishing boats manned by 134 foreigners and Indian mixed crew operating in the EEZ of India surrounding Andaman & Nicobar Islands without license. Intensive patrolling is needed to control the poaching menace in these Islands.

Pollution

The Andaman and Nicobar Islands are not been much affected by the pollution except the Port Blair in South Andaman. Port Blair Town is the capital of these Islands and has an area of 17.74 square kilometers, with a population of about 1,25,000 and it was 7789 persons in 1951. The total population of these Islands has arisen from 24,649 in 1901 to 3,56,265 in 2001 that is an increase of more than 14 times in a period of 100 years. Due to increasing population and developmental activities the waste generated is being released into the adjoining coastal environment affecting its quality. The untreated sewage generated from the hotels, restaurants and household garbage are discharged into the sea, that seriously affects the coral reefs of North Bay, Minnie Bay, Snake Island and Navy Bay. Bacteriological analysis of sea water and ground water around Port Blair indicated that they are contaminated with faecal matters (Mahajen *et al.*, 1996). The coastal marine waters of Port Blair and its vicinity were reported to be generally contaminated with organochlorine pesticides viz., gBHC (lindane) and p, p'-DDT (Shadbar Qureshi, 1998). Occurrence of substantial quantity of marine plastic debris was observed along the shore and coastal regions of Great Nicobar and Nancowry group of Nicobar Islands (Dharani *et al.*, 2003). Oil contamination from fishing and shipping vessels has been observed in and around the Port Blair area.

Sedimentation

Clearing of forests in the hills for housing and agriculture practices causes soil erosion and increase the sediment load in near shore waters. Widespread sediment discharge associated with heavy rainfall caused high turbidity and damaged the reefs in New Wandoor, Snake Island and Minnie Bay. This was observed during the survey by the author in 2005 and sediment reaching a coral reef blocks sunlight, which is required by the *Zooxanthalae* for photosynthesis, thereby affecting the growth of the coral. Rapid increases in sedimentation can kill corals directly, inhibit coral larval settlement and facilitate diseases and slow growth. Sediment also comes from dredging of ports and boat marinas and clearing of mangrove forests. Sand mining is the major activity that leads to destruction of coral reefs in many Islands of Andaman and Nicobar. Construction of

jetties, road and buildings need a lot of sand material. Approximately 223,937 m³ of sand was officially extracted from the beaches of the Islands in the three years 1998-2001. A total of 72 beaches around the Islands were used for extraction. In addition, it is alleged by local people that there is illegal extraction of sand in considerable quantities. Between 1981 and 2000, 21 marine turtle nesting beaches in ANI have been completely destroyed due to sand mining (Andrews *et al.* 2001). Last year (2005) alone 18000 m³ of sand was officially extracted for *Tsunami* rehabilitation works. Massive soil excavation and leveling hills in different parts the South Andaman and particularly Brookshabad area is being taken up in the name of reconstruction and it will lead to high siltation and sedimentation to nearby coral reefs. There is about 100% mortality of corals at reef flat of Sisostries Bay (Near Marina Park) to siltation from land run off at nearby areas.

CONCLUSION AND RECOMMENDATIONS

The coral reefs of Andaman and Nicobar Islands are the biodiversity hot spot of India. The increase of population in these Islands at alarming rate will lead to resource depletion and coral reef degradation. There is an urgent need for evolving effective management to protect the coral reefs.

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JELLYFISH POPULATION OUT BREAKS–A REVIEW

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ABSTRACT

Jellyfish population outbreaks are reported to significantly diminish the standing fish-stock and lead to great economic loss. As global fisheries begin to decline, medusae appear to come to the fore and there is evidence that they may be responsible for localized recruitment failures of some economically important fishes. Taxonomy, biology and ecology of jellyfishes are still in its infancy in South-East Asia. Information on their seasonal fluctuations, population dynamics, breeding pattern, life-history and their role in marine ecosystem may serve in finding reasons for their sudden bloom.

INTRODUCTION

Populations of jellyfish are increasing globally in recent years, went through a series of massive disruptions that greatly impaired local economics and system functions. Currently, there is apprehension that they are becoming more prevalent in a variety of regions around the world. As most of these jellyfish may manifest itself causing great variations in the planktonic communities, both by reducing the impact of zooplankton, grazing upon phytoplankton which may subsequently blooms and by acting as a food competitor for fish eggs and larvae. The increase of their biomass may reduce the fish standing stock and commercial harvest. As global fisheries begin to decline, medusae appear to come to the fore and there is indication that they may be responsible for localized recruitment failures of some commercial fishes. The regular long-term biological and physical sampling, which are fundamental to understanding blooms and outbreaks, but they remain too few. In this paper, an attempt is made to review the reason behind the bloom, impact upon ecosystem and their economical commodity.

Factors regulating jellyfish blooms : The factors responsible for blooms are many and complex and their consequences can be serious. A number of explanations have been put forward to explain these increases including climate change (Mills, 2001), eutrophication (Arai, 2001) and overfishing (Purcell and Arai, 2001). Once the physical conditions are favourable, an opportunistic species must take an advantage of a situation. The long term

records have shown that increases in jellyfish populations are correlated with environmental indices and warm ocean conditions like warm temperature, stable water column, low rainfall, high atmospheric pressure (Purcell *et al.*, 1999). Suchman *et al.*, (2001) suggested that physical factors such as climate regime, strength of summer upwelling, onshore retention and predation play important roles.

Purcell (1997) suggested that medusa feed on a large variety of prey types. The predation may play a significant role to determine the population size and they are usually large so they are not subjected to predation by small species.

Many field studies indicated that the starvation tolerance may be an important factor influencing the population of medusae. Hamner and Jenssen (1974) found that the scyphomedusae *Aurelia aurita*, endured periods of starvation by metabolizing body tissue and decreasing body mass through a process termed degrowth. Medusae exhibit seasonal patterns of abundance (Kramp, 1961) and are often have short duration, so that they tend to catch the scientific community off guard and discourage systematic long term studies. The jellyfish population may be enhanced by other human induced changes in marine ecosystem such as eutrophication, over fishing, species introductions and augmentation of substrates such as harbors for the benthic stages (Purcell, 1991).

The understanding of jellyfish blooms has been hindered by a general lack of knowledge such as jellyfish ecology, historical patterns of abundance, oceanography and the effects of variation in local ecosystems and changes in global climate. Further, progress in understanding the population dynamics of jellyfishes at a single species level that should result from considering entire life cycles rather than only those stages which cause outbreaks (Boero *et al.*, 1996).

Impact upon marine food-webs : The jellyfish outbreak has been shown to have a major impact on the dynamics of plankton communities (Phillips *et al.*, 1969; Shushkina and Musayeva, 1983; Feigenbaum and Kelly, 1984; Purcell, 1992) and can rapidly deplete large quantities of plankton standing stock and the effects of fisheries were enormous (Boero, 2001). Number of studies has demonstrated that inverse correlation between medusa and zooplankton populations and most researchers to propose that these predators can influence ecosystem structure (Feigenbaum and Kelly 1984; Baird and Ulanowicz 1989; and Behrends and Schneider 1995). The ecological role of these animals especially those represented by a medusa stage can be immaterial due to their general ability to feed upon fish eggs (Purcell, 1989; Arai, 1997) and larvae or the plankton that feed upon. They also act as potential predators and or competitors of commercial species which reduce the availability of food for exploded species (Larson, 1987).

Jellyfish Fisheries : Apart from the ecology of jellyfish out break, some of the jellyfish are considered to be a delicious food in many Asian countries. Jellyfish fishing has become very popular in South-East Asia and they are also supposed to have beneficial medicinal properties and are traditionally used to treat ailments such as arthritis, hypertension and back pain (Hsieh and Rudloe, 2001). They have been harvested off the coast of China for

more than 1700 years but since 1970s, however, the developments of large-scale commercial fisheries have shown the annual harvest increase almost exponentially and catches now regularly exceeded 500,000 mt per year (FAO, 2000). Although jellyfish fisheries are traditionally confined to Asia and now it occurs in the USA, UK, Namibia and Australia (FAO, 2000). More recently the exploitation of jellyfish has also commenced in India especially along the South-East Coast.

CONCLUSION

Jellyfish outbreaks are an increasing threat for some key economic activities in coastal areas such as fisheries, aquaculture, tourism and industrial development negatively. Lack of information on jellyfish is a bottleneck in marine ecological process studies. The information from experimental and fieldwork will be used in modeling approaches to predict competitive ability of jellyfish, development and spreading of jellyfish swarms. The studies on the functional biology of key species, the mechanisms behind trophic interactions especially with fish larva, and how biotic and abiotic factors govern survival, growth and reproduction should be carried out. The toxic effects on fish and a serious problem in aquaculture will also be studied. To generate accurate qualitative predictions, however, it is clear that a detailed knowledge of the species biology and natural history is required. Our knowledge on the role of species ecosystem is so scant that we cannot consider any species as unimportant. This lack of knowledge prevents their occurrence incorporate into models of ecosystem functioning. Further, continuous studies will explain the mechanisms behind mass developments and quantify their ecological and socio-economical consequences.

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NESTING BIOLOGY OF GREEN AND OLIVE RIDLEY TURTLES ALONG THE SAURASHTRA COAST, GUJARAT AND IMPACT OF INCIDENTAL CATCH ON THE NESTING POPULATIONS

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ABSTRACT

The nest and clutch characteristics of the green turtle *Chelonia mydas* and olive ridley *Lepidochelys olivacea* were studied in the Saurashtra coast, Gujarat. The average nesting density of green and olive ridley turtles were 5.1 and 1.5 nests/km. Among the area surveyed high number of nests were found in Mangrol (58) followed by Makthavpur (47) Shill (46) and Anthroli (25).

INTRODUCTION

In most parts of their distributional range, sea turtles nest sporadically, however, at certain selected locations, the members of the green turtle *C. mydas* and olive ridley *L. olivacea* nests in large numbers involving hundreds of individuals nesting taken place. These circumtropical migratory species nests in Tropical and Sub Tropical regions. Several researchers have cautioned severe depletion of these turtle stocks around the world oceans (Marcovaldi *et al.* 2003). In India the Gujarat has the longest coastline covering more than 1600 km, where four species of sea turtles have been reported of which only the olive ridley *L. olivacea*, the green turtle *C. mydas* nestings were established by very few researchers in Saurashtra coast, (Bhaskar, 1984, Sunderraj *et al.* 2002). A significant population of green and olive ridley turtle nests all along the Saurashtra coast. In India, intensive efforts are being made for the last 30 years to conserve the olive ridley *L. olivacea*. As the olive ridley mass nests for a limited period (December-March) in a specific stretch of beach at Gahirmatha, Orissa coast, the egg and hatchlings could be protected effectively from predation. Comparatively, attempts to conserve the green and olive ridley turtles in other regions are lukewarm. It is laborious to encounter and collect information on the

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green turtle because they are non-aggregating and nest sporadically. However, it is equally important, to collect information on the nesting habitats, predation on nests, clutch size, hatching and emergence success and threats posed by incidental catch on the nesting population, which will be useful to conserve them. Various industrial developmental projects in the nesting habitats of Saurashtra coast necessitated this present study to assess the present status of the breeding population.

STUDY AREA

The study was restricted to a 38 Km stretch in the 80 km beach between Mangrol (Lat. 21° 6' N Long. 70° 6' E) and Porbandar (Lat. 21° 38' N Long. 69° 37' E) in the Saurashtra coast. The survey project was broadly divided into three stages. Efforts were made to gather all available information on the Gujarat coast and the sea turtle nesting here from secondary sources and published and unpublished literatures. In the second and third stages, data were collected through field surveys and observations. The field survey was carried out in three phases—pre-nesting, nesting and post-nesting.

MATERIAL AND METHODS

Pre-nesting survey : The pre-nesting survey was conducted during May 1999 in the Saurashtra region, West Coast of India. The entire coastline between Veraval to Okha was surveyed. A total of 8 coastal fishing villages including fisherman camps and fish landing centres were visited, the village residents, fishermen were interviewed for information on sea turtle nesting in and around their localities. Forest officials of coastal forest divisions were also interviewed on sea turtle nesting in the coastal areas under their jurisdiction. Turtle tracks and dead and stranded sea turtles on the beaches were taken into account to determine their presence in different areas along the Gujarat coast. Based on the information collected, eight probable nesting sites were selected for intensive monitoring during the nesting survey. The important and probable nesting sites were: Athroli to Madhavpur, Chingaria to Gorsad, Chingaria to Patha, Athroli to Devasa, Mangrol to Bara, Odathar to Gorsar, Narwaimandir to Gorsar, Shil to Looghae, Makthavpur to Mangrol, Barabandar to Mangrol and Thukkada to Odathar beaches.

Nesting survey : The nesting survey was conducted in two periods, viz., May–November 2002 (4 days/month; a total of 28 days) and May 2001–January 2002 (16 days continuously in December 2001 and January 2002; a total of 48 days). Two survey teams consisting of 3 persons were employed in each transect at night (from 20:00 to 03:00 hrs) and the following day (07:00 to 10:00 hrs). The survey area was divided into 11 transects and each transect was surveyed by foot during night and day. Wherever the turtle crawl mark was clear and beyond doubt, the crawl width was measured by using a standard measuring tape. The green turtle crawl marks and the nest were identified and differentiated from the crawl marks of other turtles such as the olive ridley following the

method suggested by Pritchard and Mortimer (1999). The presence of clutch was ascertained by (i) directly observing egg deposition; or (ii) excavating the nesting pits; or (iii) observing the predation on eggs; or (iv) probing. The nesting density was determined by using the following formula :

Nesting density = Number of nesting pits/Distance covered (km). For each nesting crawl mark and nest, the distance from the high tide line (HTL) to the nesting pit was measured.

RESULTS

Nesting density : During the survey between December 2001 and January 2002, a total of 253 nests were recorded of which 195 were the Green turtle nests and the rest were of Olive ridley nests. Nesting of Leather back (*Dermochelys coriacea*) and Hawksbill (*Eretmochelys imbricata*) were not recorded. The overall nesting density of Green turtle and Olive ridley turtles was 5.1 and 1.5 nests/km. Among the area surveyed high number of nests were found in Mangrol (58) followed by Makthavpur (47), Shil (46) and Anthroli (25), Chingaria (21). Low number of nest were recorded in Thukkada (14), Oduthar (12), Barabandhar (10) Very low density were recorded in Narwaimandir (8) and Gorsar (7) Devasa (5).

Location of Nests and collection of eggs : The nests were located following the tracks of the turtle when the female had already completed the nesting process during the earlier days. Data such as assessment of nesting crawls, whether fresh or old, measuring crawl width, track type, distance from the spring high tide line (SHTL), slope enumeration, vegetation in the nesting area and nest predation by animals and humans were counted. Instances of turtles coming ashore but failing to nests were not considered, the false nesting crawls have also been counted. Once the nest was located, the top sand was removed and the nest was dug open. Care was taken while removing the eggs from the nests. The eggs were then placed in plastic bags with some amount of sand from the nest in the bottom, sides on the top of the bag. The collected eggs were immediately transported to the hatchery for incubation.

Nest measurements : Nest depth and width was measured for 31 nests. Nest depth ranged from 61 to 146 cm and width ranged from 15 to 67 cm.

Clutch characteristics : As soon as the nest was dug out, the total number of normal and abnormal eggs was counted; data such as the colour, shape and size of the eggs were also noted. Clutch sizes of about 15 nests were determined during the survey. Clutch size ranged from 61 to 127 eggs.

Egg morphometrics : The maximum and minimum diameters of 10 eggs per clutch were measured using vernier calipers. Weight of ten eggs per clutch was also taken with

monopan. The egg diameter ranged from 4.1–4.9 cm and weight ranged from 41.45–53.4 g. The abnormal eggs (twin eggs, 2-3-4 eggs joined together, very small or very large and unshaped eggs) were removed from the clutch. Morphometric measurements of these eggs were taken separately.

Hatching success and Emergence success : Hatching success refers to the number of hatchlings that hatch out of their egg shell (equals the number of empty egg shells in the nest); emergence success refers to the number of hatchlings that reach the beach surface (equals the number of empty egg shells minus the number of live and dead hatchlings remaining in the nest chamber) (Miller, 1999).

Hatching success : Success (%) = # shells * 100/ # shells + # UD + # UH + # UHT + # P

Emergence succes : Success (%) = # shells - (#L + #D) * 100/# shells + # UD + # UH + # UHT + # P Where # shells = No. of empty shells counted; # L = Live hatchlings left among shells ; # D = Dead hatchlings that have left their shells; # UD = No. of unhatched eggs with no obvious embryo ; # UH = No. of unhatched eggs with obvious embryo (excluding UHT); # UHT = No. of Unhatched apparently full term embryo in egg shell / pipped (with a small amount of external yolk material); # P = Open, nearly complete shells containing egg residue.

The results of different clutches and its hatching success, emergence success were present in the Table-1.

Table-1. Different clutch sizes and its percent hatching success & emergence success of *Chelonia mydas* hatchlings in Saurasra coast of Gujarat, India

Sl. No	Clutch Size (# of eggs)	# shells	# L	# D	# UD	# UH	# UHT	# P	% HS	% ES
1	120	75	3	7	25	12	8	0	62.5	54.2
2	84	66	2	3	9	6	3	0	78.6	72.7
3	117	72	1	6	20	10	10	5	61.5	55.6
4	81	52	2	5	13	9	6	1	64.2	55.6
5	110	86	2	1	12	6	5	1	78.2	75.5

Morphometrics of hatchlings : The mean length and weight of hatchlings of sea turtle varies among the species (Miller, 1999). In the present study ten hatchlings from each clutch has been measured and weighed (Table-2) to establish hatchling size. Straight carapace length measured using calipers from the nuchal scute to the division between the post central scales. The same hatchlings from each clutch weighed using monopan.

Table-2. Morphometric measurements of the *Chelonia mydas* hatchlings

Sl. No	Carapace Length (cm)	Carapace Width (cm)	Plastron Length (cm)	Plastron Width (cm)	Head Length (cm)	Head Width (cm)	Tail Length (cm)	Total Body Length (cm)	Weight (g)
1	5.2	3.8	3.7	2.9	1.9	1.5	0.9	7.9	31
2	5.2	3.8	4.1	2.8	2.3	1.5	0.7	8.3	34
3	5.4	3.9	4.1	2.8	2.3	1.7	0.8	8.3	34
4	5.1	3.8	3.7	2.7	2.1	1.5	0.6	8.4	34
5	5.0	3.6	3.8	2.6	2.1	1.5	0.4	8.2	34
6	5.2	3.8	4.0	2.6	2.2	1.5	0.6	8.3	34
7	5.2	3.8	3.7	2.9	2.3	1.6	0.6	8.8	33
8	5.4	4.0	4.2	2.7	2.3	1.6	0.7	8.9	34
9	5.0	3.9	3.6	2.8	2.3	1.6	0.9	8.3	32
10	5.1	3.83	3.8	3.6	2.2	1.5	0.7	7.9	32

Slope preference : During the nesting process of Green and Olive ridley turtles, 52.6% of nests have been recorded in high slope followed by the medium slope 41.5% and low beach 5.9%. Several clutches have been noticed nearer to the vegetations such as Kash (type of grass spp.) and Casuarina plantations.

Landscape behind the nesting beach : The nesting beaches were packed by sand dunes. The top region of the sand dunes of the coastline has been planted with casuarinas and is packed by kash grass and dense Acacia trees. These are the major vegetations which is packed in the coastal areas from Mangrol to Porbandhar.

Fauna : The scrub jungle forest which was dominated by Acacia tree is a home for jackal, fox, some of the mammals, reptiles, birds and other animals.

Human population : There are several human settlements, fishing jetties near the nesting beach was noticed along the Saurashtra coastal areas.

Soil texture of nesting beaches : Periodic collections of the nesting soils in the turtle nesting beach from Mangrol to Porbandar were made and analysed for soil texture. The olive ridley and green turtle nest, the composition of grain size is as follows : 0.15 mm grain size : 0.0 to 0.7%; 0.25–0.15 mm grain size : 0.7 to 5.6%; 0.35–0.25 mm grain size : 8.1 to 23.4%; 0.5–0.35 mm grain size : 15 to 28.6%; 0.9–0.5 mm grain size : 21.8 to 52.2%; 1.2–0.9 mm grain size : 1.7 to 17.4% and 2.4 mm grain size : 2.4 to 18.3%. The green turtle prefers relatively maximum 0.9–0.5 mm grain size due to its bigger in size.

Threats to sea turtle population : Along the Gujarat coast the major threats which hamper the egg developments is nest predation, followed by human disturbance, fishing intensity, beach erosion, exploitation of eggs in certain pockets which are high tourist activities.

Nest predation : Out of 253 nests recorded in the present study area, 57.1% were highly predated by animal in Chingharia to Ghorsad sector followed by 50% in Nirvaimandir to Ghorsad sector, moderate predation by animals in these sectors, Arthroli to Madhavpur (16%) and Makthavpur to Mangrol (17%) and least predation in sectors such as Odadhar to Ghorsad (8.3%) and Thukkada to Odadhar (7.1%). There was no predation in Chingharia to Patha sector (Table-3).

Table-3. Nest predation recorded in Saurashtra Coast

Area	No. of nest	No. of Predated nest	% of predation
Anthroli-Madhavpur	25	4	16.0
Chingharia-Ghorsad	21	12	57.1
Chingharia-Patha	7	0	0
Antholi-Devasa	5	2	40.0
Mangrol-Bhara	58	8	13.8
Odadhar-Ghorsad	12	1	8.3
Nirvaimandhir-ghorsad	8	4	50.0
Shil-Looghae	46	14	30.4
Makthavpur-Mangrol	47	8	17.0
Barabandar-Mangrol	10	1	10.0
Thukkada-Odadhar	14	1	7.1

Turtle mortality : During the study period, a total of 69 washed ashore green turtles were recorded along the Saurashtra coast. The other species such as the olive ridley, hawksbill and leatherback turtles were not recorded during this period. The gear trawl was responsible for such incidental catch. All the stranded turtles were discarded of fishing and were found dead on the beaches. Males, females and sub-adults were encountered during the survey (Table-4). Incidental catch was comparatively higher along Shill and Okha beach (14.4%), followed by Veraval and Porbandar (11.5%), Mangrol (9%), Madhavpur (7.2%), Dwarka and Gorsar (6%), Somnath, Bewt Dwarka and Athroli (4.3%), Diwasa (2.8%), Chingariya (1.5%) Narwaimandir and Odathar (1.4%). In the Shill and Okha beaches, males were more (22.4% and 12.9%) whereas in Okha, Porbandar, Dwarka and Veraval beaches females were more (17.6%, 14.7% 11.7% and 11.7%).

Table-4. Incidental catches of different sex of the green turtle *Chelonia mydas* in different beaches along the Saurashtra coast, Gujarat

Beaches	Green turtles recorded		Male		Female		Sub-adult	
	No	%	No	%	No	%	No	%
Shill	10	(14.4)	7	(22.4)	3	(8.8)	-	
Okha	10	(14.4)	4	(12.9)	6	(17.6)	-	
Veraval	8	(11.5)	3	(9.7)	4	(11.7)	1	(25)
Porbandar	8	(11.5)	3	(9.7)	5	(14.7)	-	-
Mangrol	6	(9.0)	3	(9.7)	3	(8.8)	-	-
Madhavpur	5	(7.2)	2	(6.5)	3	(8.8)	-	
Dwarka	4	(6.0)	-	-	4	(11.7)	-	
Gorsar	4	(6.0)	3	(9.7)	-	-	1	(25)
Somnath	3	(4.3)	-	-	3	(8.8)	-	-
Bewt Dwarka	3	(4.3)	2	(6.5)	-	-	1	(25)
Athroli	3	(4.3)	2	(6.5)	-	-	1	(25)
Diwasa	2	(2.8)	1	(3.2))	1	(3.0)	-	-
Chingariya	1	(1.5)	1	(3.2)	-	-	-	-
Narwaimandir	1	(1.4)	-	-	1	(3.0)	-	
Odathar	1	(1.4)	-	-	1	(3.0)		
Total	69	100%	31	(45%)	34	(49.2%)	4	(5.8%)

Size composition of incidentally caught green turtles : The curved carapace length of 69 green turtles *Chelonia mydas* ranged from 20 to 118 cm (mean = 85.6 ± 22.3 cm), curved carapace width from 21 to 107 cm (mean = 77.2 ± 19.3 cm), plastron length from 18 to 90 cm (mean = 66.8 ± 16.9 cm), plastron width from 18 to 89 cm (mean = 65.5 ± 16.4 cm). The mean body weight was 71.8 ± 25.6 and it ranged from 2 to 160 kg.

DISCUSSION

In the present study a total of 253 nests (5.1 and 1.5 nets/km) of the green and olive ridley were recorded during December 2001-January 2002. Sunderraj *et al.* (2002) recorded 76 nests between Bhara and Navabandar along the Saurashtra coast in September 2000 i.e., 1.3 nets/km. Bhaskar (1984) reported that in December 1980 and October 1981, the nesting density of green and olive ridley were 4.6 nets/m and 4.2 nests/km respectively along the 110 km stretch from Veraval to Porbandar. From these studies, it is clear that the nesting season of the green and olive ridley turtles extended from September to

January with peak in December and January along the Saurashtra coast. Simultaneously 69 green turtles were incidentally caught by fishing gears and these catches were during the breeding season. There were also records of sub-adults being landed during the study period, and probably these individuals were incidentally caught while feeding in shallow waters (Carlson, 2000). Shrimp trawling has been identified as one of the single largest source of human associated mortality for sea turtles throughout the world (Hillestad *et al.* 1982; Magnuson *et al.* 1990; Robins, 1995). Despite the wide acceptance of this fact that the trawlers cause more deaths of sea turtles than that of any other gear type, from the present study it can be seen that the mortality of sea turtles by trawl nets is of serious concern. Even though 18,536 fishing vessels were operating from these coastal areas, record of only 69 turtles showed low mortality. Offshore survey of fishing vessels may give the exact picture of turtle mortality due to incidental catch. It was generally believed that introduction of Turtle Excluder Device (TED) in the trawl would effectively reduce the incidental catch of sea turtles.

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IMPACT OF INCIDENTAL CATCH ON DOLPHINS IN VIZHINJAM, SOUTH WEST COAST OF INDIA

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ABSTRACT

A total of 30 dolphins consisting of 6 *Tursiops truncatus* (bottlenose dolphins) 7 *Sousa chinensis* (humpback dolphin) 4 *Stenella longirostris* (spinner dolphin) 3 *Delphinus delphis* (saddleback dolphin) and 10 unidentified dolphins were caught incidentally at Vizhinjam, South West Coast of India between May and August 2001. by various fishing gears. Among the 12 species of dolphins known from the Indian waters, incidental catch of 4 species of dolphins were studied at Vizhinjam coast. The fishing gears responsible for the incidental catch of dolphins were drift gill net, shore seine and other fishing gears.

INTRODUCTION

Gill net fisheries are known to be a major cause of death for whales and dolphins (Woodley, 1993). Some cetaceans seem unable to sustain incidental kill rates as low as 2% per year, depending on the life history of the species. Consistently, incidental catches appear to be contributing to the decline of several populations. Incidental mortalities in drift and set gill net fisheries are of particular concern. Wherever cetaceans and gill nets are found in the same area, at least some cetaceans are caught (Anonymous 1990). Several species of cetaceans are killed incidentally in this fishery, most of which are striped *Stenella coeruleoalba* and common dolphins *Delphinus delphis*. Fishing is the most important source of human associated mortality to the marine mammals particularly dolphins, the gill net fisheries having undesirable effect on the economy of marine capture fisheries in India (Kumaran, 2002). Though there is no fishery for the dolphins along the Indian coasts, the smaller cetaceans, are caught in large numbers in the gill nets. Mohan (1985a) has noted that about 30-40 dolphins are caught along the Calicut coast annually by the gill nets and he pointed out that dolphins are caught incidentally along the coastal waters of Cochin, Calicut, Malpe, Karwar, Goa and Bombay. Accidental and incidental catches

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of marine mammals in fishing nets is increasing greatly, these catches need to be monitored so that the numbers, species composition, seasonality and sizes are known and the possible effects on the populations can be evaluated. Studies on these dolphins from the Indian waters are limited. Very few information is available on the stranding and accidental catch of dolphins due to fishing operations along the Indian coasts (Jones 1976a; Mohan, 1982 and 1983, Krishna Pillai and Kasinathan, 1985; Lipton *et al.* 1995; Balasubramanian *et al.* 2000; Balasubramanian and Jesi Selvarani, 2000; Joel, 2000 and Krishna Pillai, 2002). The objectives of this study are to evaluate the potential effect of incidental mortalities of dolphins due to fishing gears in the Vizhinjam fish-landing centre. It is situated in Thiruvananthapuram District in the state of Kerala, India, Lat: 08°22'30" N and Long : 76°59'15"E. It is 16 km South of Thiruvananthapuram. The beach in Vizhinjam is very narrow with two rocky promontories jutting into the sea, known as Mathilpuram on the Western side and Kottapuram on the Eastern side enclosing the fishing area as a protected bay providing excellent facilities for fishing operations even during South West monsoon season. Until the 1980s, indigenous gears formed the basis of the fishing activities at Vizhinjam. From 1981, small-mechanized boats started operating in this area using traditional drift nets. Traditional craft fitted with outboard motors also started operating from Vizhinjam. Due to the low capital and operational costs and high profit obtained by the fishermen from the outboard motors when compared to those from the mechanized boats, the former became popular in this area. A total of 400 crafts with outboard motors operate in Vizhinjam area. There are ten types of fishing gears employed to exploit the fishery resources. Of these, the boat seine, hooks and line, achil and shore seine together contribute to the bulk (75.87%) of the total fish landings and the rest (25 %) by drift gill nets (Radhakrishnan *et al.* 1988).

MATERIAL AND METHODS

The study was conducted At Vizhinjam fish landing centre from May to August 2001. The fish landing centre was monitored daily except on Sundays, which is usually a holiday for the fishermen. Daily visits were made to the landing centre during 0600 hrs to 1200 hrs and 1500 hrs to 1800 hrs. Further, inquiries on the number of dolphins landed and stranded were also made from the fishermen. The landed dolphins were identified up to species level by counting the number of teeth and various morphometric measurements such as total body length, caudal length, head length etc. The approximate weight, whether alive or dead, types of craft and gear and the mode of final disposal of dolphins were recorded.

RESULTS

Landings of Dolphins at Vizhinjam : During the study period, a total of 30 dolphins were landed at Vizhinjam fish landing centre. Of these, 6 (20%) were *Tursiops truncatus*, 7 (23.3%) were *Sousa chinensis*, 4 (13.3%) were *Stenella longirostris*, 3 (10%) were *Delphinus delphis* and 10 (33.4%) individuals could not be ascertained the species. Between May

and August 2001, 17 dolphins were caught incidentally in drift gill nets. The Indo Pacific humpback dolphin *Sousa chinensis* were higher in percentage (35.3%) followed by *Stenella longirostris* (23.5%), *Tursiops truncatus* (17.6%) and *Delphinus delphis* (17.6%). The unidentified species accounted for 6%. Only 2 individuals of *Tursiops truncatus*, were caught in the shore seine. In other gears such as chalavala, netholivalaa, konchuvala and achil a total of 11 dolphins were caught during the entire period of observation. 10 dolphins were unidentified and one was *Tursiops truncatus*.

Month wise incidental catch of dolphins showed that a maximum catch of 18 (60%) was recorded during June followed by 6 (20%) during July and 4 (13.4%) during May and the minimum catch of 2 (6.6%) during August. The total length of *Tursiops truncatus* ranged between 173 and 263 cm, *Sousa chinensis* from 190 to 238 cm, *Delphinus delphis* from 142 to 219 cm and *Stenella longirostris* from 120 to 172 cm.

DISCUSSION

Records of incidental catches of dolphins are available from all over the world. The gill-net fishery has proved to be detrimental to the smaller cetaceans off the coast of England (Kuiken *et al.* 1994). The greatest threat to dolphins probably comes from fish traps and gill nets due to continued growth of human populations deployed in more areas endangering dolphins. Woodley (1993) stated that some cetaceans seen unable to sustain incidental kill rates as low as 2% per year depending on the life history of the species. Calves are indirectly affected by the incidental mortalities of their mothers (Reilly and Barlow, 1986). Anonymous (1990) expressed that the best available information indicates that the striped dolphin in the Mediterranean sea were unable to sustain current levels of incidental mortalities in passive net and trap fisheries and the same is true of striped dolphins in the north east Atlantic. Anonymous (1993) suggested that the by catch rates estimates for the French drift net fleet should be increased by 30% to account for the additional mortalities occurring in Irish and UK fisheries. According to Woodley (1993) the striped dolphins in the North East Atlantic are declining from incidental mortalities in the French drift net fishery for albacore tuna. Incidental captures in fisheries are a major source of mortality of small cetaceans throughout South East Asia (Perrin *et al.* 1996).

In case of dolphins though the magnitude of destruction along the Indian coast is not very high when compared to eastern Pacific, there is all possibilities that the dolphin catch may increase in the future due to introduction of purse seines for pelagic fishes. Kumaran (2002) suggested that the increase in the records is due to intensified fishing activity along the Indian coast during the last three decades and the consequent increase in the number of incidental/intentional capture of marine mammals, especially by gill net fishery. The number of marine mammals caught in the fishing gears is not properly monitored and the mortality due to fishing operations may be much higher. Among the fishing gears the damage caused by gill nets is more than by any other gears. Moreover, it is reported that cetaceans get entangled in other fishing gears such as shore seines, trawls and long lines but their impact is negligible compared to gill nets.

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BIODIVERSITY AND UTILIZATION OF BRACHYURAN CRABS OF THE EXCLUSIVE ECONOMIC ZONE OF INDIA

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ABSTRACT

A perusal of taxonomic records from the Indian coasts and Islands of Lakshadweep, Andaman and Nicobar since 1861 has shown that there are 886 species belonging to 21 super families. Among these crabs, those belonging to the super family Xanthoidea formed 32.2%, followed by Portunoidea (10.5%), Leucosioidea (10.5%), Majoidea (9.3%), Grapsoidea (8.8%), Ocypodoidea (7.3%), Parthenopoidea (3.8%) and Hexapodoidea (3.7%). For other families, the percentage varied from 0.2–2.2. These crabs showed a definite pattern of distribution among the areas studied. There are 24 economically important species belonging to the families Calappidae, Portunidae, Xanthidae, Gecarcinidae, Ocypodidae and Grapsidae which are exploited by both indigenous and mechanized crafts and gears. Those larger Portunid crabs are considered for sea food export trade and their frozen, canned and live categories are fetching a considerable foreign exchange annually. To sustain the biodiversity the utilization of brachyuran crabs, appropriate conservation measures are suggested.

INTRODUCTION

Taxonomy of the brachyuran crabs from the Indian waters has been dealt with by Linnaeus (1766); Wood-Mason and Alcock (1891); Wood-Mason (1892; 1893); Henderson (1893); Alcock and Anderson (1894); Alcock (1895; 1896; 1898; 1899a;b; 1900); Thurstan (1895); Henderson (1906); Hornell and Southwell (1909); Kemp and Sewell (1912); Kemp (1915; 1917; 1919; 1923); Gravely (1927); Chopra and Das (1930; 1937); Chopra (1931; 1933; 1935); Pearse (1932); Hora (1933); Balss (1935); Panikkar and Aiyar (1937); Borradaile (1907); De Man (1908; 1909; 1920); Sewell (1934); Pillai (1951); Chacko *et al.* (1953); Kurian (1953; 1954); Panikkar and Prasad (1953); Chhapgar (1957; 1958); Sankarankutty (1961a;b; 1962a; b; 1967; 1975); Sekharan *et al.* (1962); Sankarankutty and Thomas (1963); Premkumar (1964); Sankarankutty and Rengarajan (1965); George, and Vedavyasa Rao (1967); Macnae (1968); Serene (1968); Ganapathy and Ramasastry (1969); George and Noble (1970); Premkumar and Daniel (1971); Stephenson (1972); Suseelan (1972); Chandy (1973); Kakati and Sankolli (1973); Kathirvel and Gopalakrishnan (1974); Sankolli and Shenoy (1975); Daniel and Chakrapany (1977); Radhakrishnan (1979); Joel and Sanjeeva Raj (1980); Selvaraj

and Kathirvel (1980); Kathirvel (1981); Parulekar (1981); Radhakrishnan and Samuel (1982); Joel and Sanjeeva Raj (1983); Bairagi (1985); Bhadra (1985); Deb (1985a; b; c; d; 1986; 1987; 1989a;b; 1992; 1998); Ghosh (1985); Aravindakshan and Karbhari (1985); Chakraborty *et al.*, (1986); Lalithadevi (1987); Bairagi and Misra (1988); Prasad *et al.* (1988); Dev Roy and Nandi (1991); Goswami (1992); Kathirvel and Srinivasagam (1992); Poddar and Choudhury (1992); Dhandapani (1993); Deb and Rao (1993); Jeyabaskaran *et al.* (2000); Dineshbabu (2005); Rao and Sastry (2005).

To understand the extent of diversity and their economical values of brachyuran crabs an attempt has been made and the results are presented below.

ENUMERATION OF SPECIES

A review of the literature mentioned in the introduction part has revealed that a total of 837 species belonging to 255 genera and 32 families are reported from Indian waters. The numerical abundance of species in maritime state-wise is presented in fig. 1.

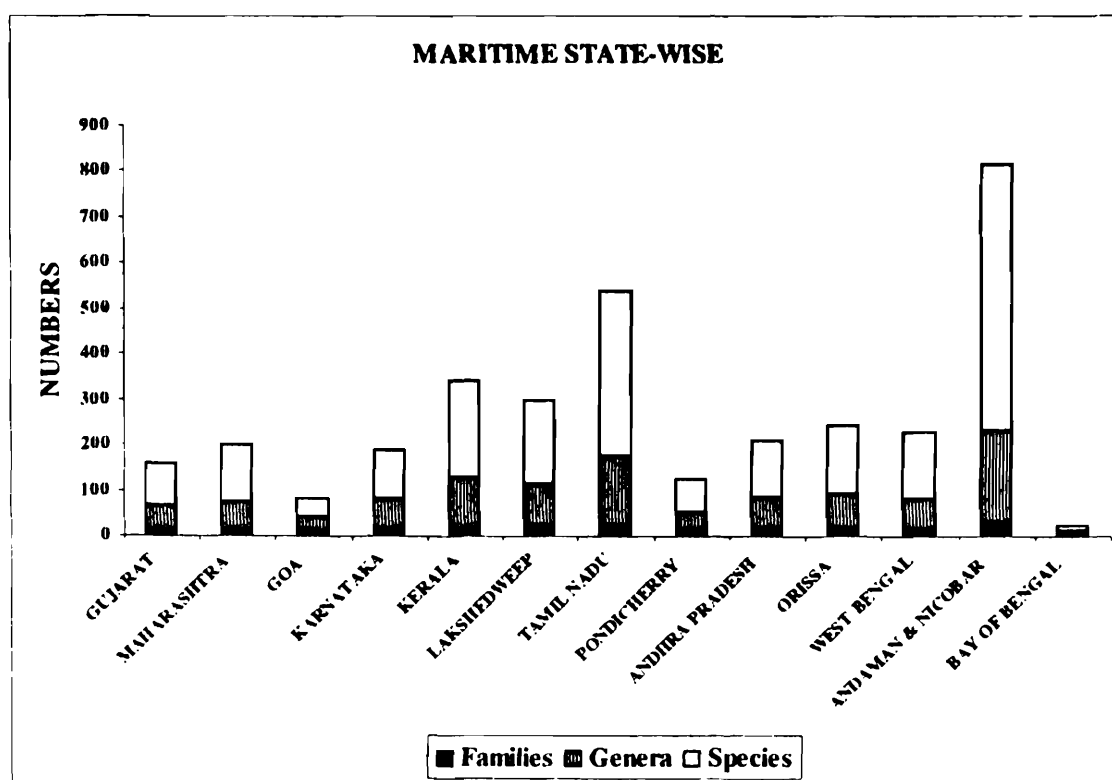


Fig. 1. Maritime state-wise diversity of the brachyuran crabs in India

Along the West Coast, the number of families ranged from 13 to 28. While the maximum number of genera and species were recorded from Kerala and the least was from Goa. In the East Coast, the maximum number of families, genera and species were recorded at Tamil Nadu, followed by Orissa, West Bengal, Andhra Pradesh and Pondicherry. From the Lakshadweep, the number of families, genera and species were reported at 24, 92 and 182 respectively. In the Andaman and Nicobar Islands, the number of families,

genera and species were recorded at 30, 204 and 582 respectively. Among the regions studied the maximum diversity was from Andaman and Nicobar Islands and Tamil Nadu. This may be perhaps due to different ecological habitats such as sandy sea shore, sandy or muddy bottom, coral reef environment and deep sea sand or muddy bottom present in the two regions. Whereas, in other regions the number of habitat are less which explains the lesser diversity.

COMMERCIALY IMPORTANT MARINE CRABS

Among the marine edible crustaceans, crabs rank third by virtue of their delicacy and demand from both domestic consumption and export trade, while the first two are shrimps and lobsters. Prior to 1960, crabs in the columnar waters were exploited by indigenous gears such as gill net and boat seine and those living at the bottom by shore seine. During 1960-2004, the intensification of mechanized trawling both in the inshore and deep sea regions have brought to light the rich abundance of several species of crabs in the Exclusive Economic Zones of India. In Indian water, there are about 750 species of brachyuran crabs occurring in the littoral (inshore) and deep sea regions. Some of crabs which can tolerate wide range of salinities migrate into estuaries, backwaters and coastal lakes where they grow fast and support a sustenance fishery (Rao *et al.*, 1973). Out of 837 species enumerated in the present account, 23 are commercially important and they are listed below.

- Swimming crabs—13 species belonging to family Portunidae
- Box crabs—4 species & sand crab-1 species under Family Calappidae
- Rectangular crab—1 species belonging to Family Xanthidae
- Floating crab—1 species in Family Grapsidae
- Shore crabs—2 species in Family Ocypodidae
- Land crab—1 species in Family Gecarcinidae

IMPORTANT COLOUR AND MORPHOLOGICAL FEATURES

The important colour and morphological features of all the 23 commercially important species are given below for easy field identification.

1. *Scylla tranquebarica* (Plate Ia) Mud or Green crab (larger species)

Polygonal markings on all legs; 2 spines on the outer margin of wrist of chelipeds; 9 uniform sized anterolateral teeth; last walking leg paddle-shaped; maximum weight attained is 2.5 kg.

2. *Scylla serrata* (Plate Ib)
Mud or Red crab (smaller species)

No polygonal marking on legs; 1 spine on the outer margin of chelipeds; 9 uniform sized anterolateral teeth; last walking leg paddle-shaped. Maximum weight attained is 0.7 kg.

3. *Portunus pelagicus* (Plate Ic)
Blue swimming crab

Reticulate marking on carapace; chelipeds, walking & swimming legs bluish in colour; first 8 teeth on anterolateral border of carapace uniform in size and the last one (9th) elongated; last walking leg paddle-shaped. Maximum weight attained is 0.350 kg.

4. *Portunus sanguinolentus* (Plate Id)
Three red spots swimming crab

Three prominent red spots on posterior border of carapace; first 8 teeth on anterolateral border of carapace uniform in size and the last one (9th) elongated; last walking leg paddle-shaped. Maximum weight attained is 350 kg.

5. *Charybdis (Charybdis) lucifera* (Plate Ie)
Four spots swimming crab

Four prominent white coloured spots on middle and lateral sides of carapace; 6 uniform sized anterolateral teeth; last walking leg paddle-shaped. Maximum size attained is 0.150 kg.

6. *Charybdis (Charybdis) feriatus* (Plate If)
Cross swimming crab

A prominent "Cross" marking on carapace; 6 uniform sized anterolateral teeth; last walking leg paddle-shaped. Maximum size attained is 0.4 kg.

7. *Charybdis (Charybdis) annulata* (Plate IIa)
Banded swimming crab

Alternate white and light red bands on walking legs; 6 uniform sized anterolateral teeth; last walking leg paddle-shaped. Maximum size attained is 0.15 kg.

8. *Charybdis (Charybdis) natator* (Plate IIb)
Rock or Coral swimming crab

Prominent dark red coloured ridges on carapace; white and red tubercles on walking and swimming legs; 6 uniform sized anterolateral teeth; last walking leg paddle-shaped. Maximum size attained is 0.4 kg.

9. ***Charybdis (Charybdis) granulata*** (Plate IIc)
Red Swimming crab

Anterolateral teeth placed apart and blunt; numerous granules on chelipeds and legs; last walking leg paddle-shaped. Maximum size attained is 0.1 kg.

10. ***Charybdis (Goniohellenus) smithii*** (Plate IId)
Deep sea Swimming crab

Among the six anterolateral teeth, the first 5 were blunt and their upper border toothed saw-like and sixth one; last walking leg paddle-shaped. Maximum size attained is 0.1 kg.

11. ***Podophthalmus vigil*** (Plate IIe)
Long eye-stalked swimming crab

Two anterolateral teeth and eyes with long stalk; last walking leg paddle-shaped. Maximum size attained is 0.2 kg.

12. ***Thalamita crenata*** (Plate II f)
Brown swimming crab

Five equal anterolateral teeth; 3 pairs of frontal teeth; chelipeds with dark-red coloured movable and fixed fingers; last walking leg paddle-shaped. Maximum size attained is 0.1 kg.

13. ***Thalamita danae*** (Plate IIIa)
Green or weedy swimming crab

Five anterolateral teeth, the first one being broadest; prominent ridges on carapace; last walking leg paddle-shaped. Maximum size attained is 0.1 kg.

14. ***Calappa lophos*** (Plate IIIb)
Rose coloured box crab

Polished carapace more convex with 2 longitudinal depressions; chelipeds massive; short spines on posterior border of carapace. Maximum size attained is 0.2 kg.

15. ***Calappa philargius*** (Plate IIIc)
Brown coloured box crab

Polished carapace more convex with 2 longitudinal depressions in the middle; chelipeds massive; long and stout spines on posterior border of carapace. Maximum size attained is 0.1 kg.

16. *Calappa hepatica* (Plate III d)

Green coloured box crab

Carapace more convex with 2 longitudinal depressions in the middle, pronounced postero-lateral expansion and large sized tubercles; chelipeds massive. Maximum size attained is 0.1 kg.

17. *Calappa japonicus* (Plate III e)

Deep sea box crab

Carapace more convex with 2 longitudinal depressions in the middle and numerous large round tubercles; chelipeds massive. Maximum size attained is 0.2 kg.

18. *Matuta lunaris* (Plate III f)

Yellow legged sand crab

Two long spines in the middle of lateral border of carapace and all the legs paddle-shaped. Maximum size attained is 0.05 kg.

19. *Galene bispinosa* (Plate IV a)

Rectangular xanthid crab

Carapace rectangular shaped with 1 blunt and 2 tubercle-like spines on anterolateral corner. Maximum size attained is 0.1 kg.

20. *Varuna litterata* (Plate IV b)

Floating grapsid crab

Carapace square shaped with 3 teeth on anterolateral corner; legs flat and paddle-shaped. Maximum size attained is 0.07 kg.

21. *Ocypode ceratophthalma* (Plate IV c)

Ghost or shore crab

Carapace rectangular shaped with serration starting beyond orbit to lateral border; eyes with an elongated tip. Maximum size attained is 0.08 kg.

22. *Ocypode cordimana* (Plate IV d)

Red ghost/shore crab

Entire crab red coloured with ormental marking on carapace; eye without elongated tip. Maximum size attained is 0.06 kg.

23. *Cardisoma carnifex* (Plate IV e)

Land crab

Carapace almost rectangular; stalked eyes; massive chelipeds; walking legs with spine-like hairs on both the borders. Maximum size attained is 0.5 kg.

EXPLOITATION OF CRABS

Marine sector : In the marine sector, the crafts and gears were operated by both indigenous and mechanized methods. The details of crafts and gears operated in the marine sector are given below.

Crafts : (a) Indigenous : catamaran, plank-built boat, dug-out canoe and out-rigger canoe.

(b) Mechanised : Trawler (small and medium sized) & Larger sized for deep sea fishing.

Gears : (a) Indigenous : Gill net, boat seine and shore seine.

(b) Mechanised: Trawl net.

Brackishwater sector : Similar to the marine sector, crafts and gears were operated widely in the brackish water also. Like marine sector, the mechanized crafts as well as gears were not familiar in brackish waters.

Crafts : Indigenous : Catamarans, dug-out canoe and out-rigger canoe and theppam.

Gears : Indigenous : Shore seine, stake net, drag net, cast net, dip net, scoop net, basket trap, line with bait and hooked iron rod.

EXTENT OF EXPLOIATION

The average annual landings of crabs during 1999-2003 derived from the reports of fisheries organizations of central and state governments are given in Table-1.

Table-1. Maritime state-wise exploitation of the brachyuran crabs in India

States	Catch in tonnes						
	Marine			Brackish water			Grand Total
	Mud Crab	Other Crabs	Total	Mud Crab	Other Crabs	Total	
Gujarat	382	6,415	6,797	200	50	250	7,047
Maharashtra	31	524	555	30	5	35	590
Goa	54	924	978	50	10	60	1,038
Karnataka	63	1,085	1,148	93	20	113	1,261
Kerala	140	2,397	2,537	714	200	914	3,451
Tamil Nadu	485	8,103	8,588	650	200	850	9,438
Pondicherry	34	368	391	0	0	0	391

Table-1. Contd.

States	Catch in tonnes						
	Marine			Brackish water			Grand Total
	Mud Crab	Other Crabs	Total	Mud Crab	Other Crabs	Total	
Andhra Pradesh	148	2,413	2,561	385	200	585	3,146
Orissa	13	240	263	149	70	219	482
West Bengal	5	122	127	474	200	674	801
Andaman & Nicobar Islands	500	21	521	0	0	0	521
Total	1,844	22,622	24,466	2,745	9,55	3,700	28,166

Table-2. Category-wise exploitation of the brachyuran crabs in India (in tonnes)

Sector	Marine	Brackishwater	Both sectors
Mud crab	1,844	2,745	4,589
Other crabs	22,622	955	23,577
Total	24,466	3,700	28,166

Potential resource : Rao *et al.* (1973) have estimated the potential yield of commercially important marine crabs at 30,607 tonnes and 13,209 tonnes from marine and brackishwater sectors. The present level of exploitation is 79.9% from marine sector and 28.0% from the brackishwater sector. Thus, it appears that the present level of exploitation for crabs can be increased.

Export : Average annual quantity and value of crab products exported from India during the period from 1996 to 1997 and from 1999 to 2000 are given in Table-3.

Table-3. Export quantity and value of the marine crabs in Indian waters

Category	Quantity in tonnes	Value in crores
Frozen crab meat	811	10.9
Whole frozen crab	30	0.24
Cut crab	1,468	16.7
Stuffed crab	108	1.6
Frozen mud crab	31	0.3
Soft shell crab	12	0.5
Pasteur crab	27	1.1

Table-3. *Contd.*

Category	Quantity in tonnes	Value in crores
Crab claws	2	0.02
Crab shells	12	0.74
Live mud crabs	1,544	25.4
Total	4,045	57.5

SUMMARY

This report is the first attempt to enlist the number of species of brachyuran crabs from the Indian waters. This study indicated the richness in crab diversity. From the published accounts it could be possible to enumerate the number of species at 837. There may be some omissions while enumerating the diversity. Among the 837 species, 23 are commercially important and are exploited both by indigenous and mechanized crafts and gears from both marine and brackish water sectors. The protein-rich crabs are the cheapest marine edible food item when compared to the costly penaeid shrimps and lobsters. Among the commercially important brachyuran crabs, mud crabs belonging to the genus *Scylla* are known to grow to larger size (700–2500 gms) and are in great demand from both internal consumption and export trade. The export of marine crab products fetches an annual foreign exchange of Rs. 57.5 crores. The mechanized trawling along the inshore waters of India is the major gear for the capture of more than 100 species in a day from any one of the major trawling centers which include the capture of juveniles, adults and berried females. This leads to the destruction of the juvenile and breeding population which may affect the diversity of brachyuran crabs in the coming years. To avoid the capture of berried crabs, the fisherman community may have to be educated to return those live berried females back into the sea which may help to sustain the rational exploitation of brachyuran crabs of India.

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PLATE-I



a. *Scylla tranquebarica*



b. *Scylla serrata*



c. *Portunus pelagicus*



d. *Portunus sanguinolentus*

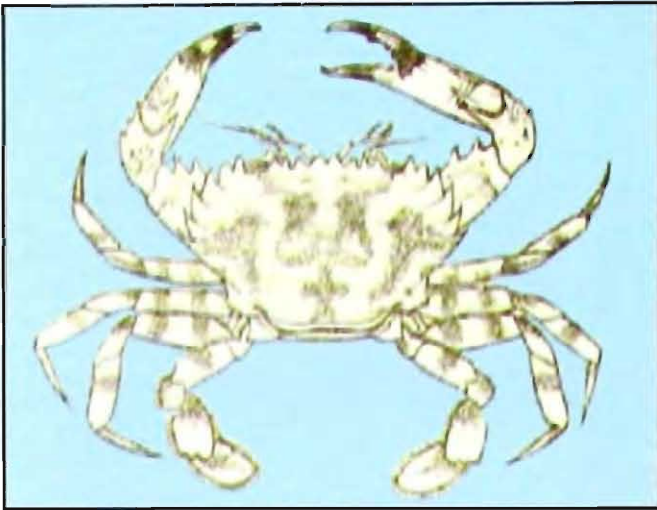


e. *Charybdis (Charybdis) lucifera*



f. *Charybdis (Charybdis) feriatus*

PLATE-II



a. *Charybdis (Charybdis) annulata*



b. *Charybdis (Charybdis) natator*



c. *Charybdis (Charybdis) granulata*



d. *Charybdis (Goniohellenus) smithii*

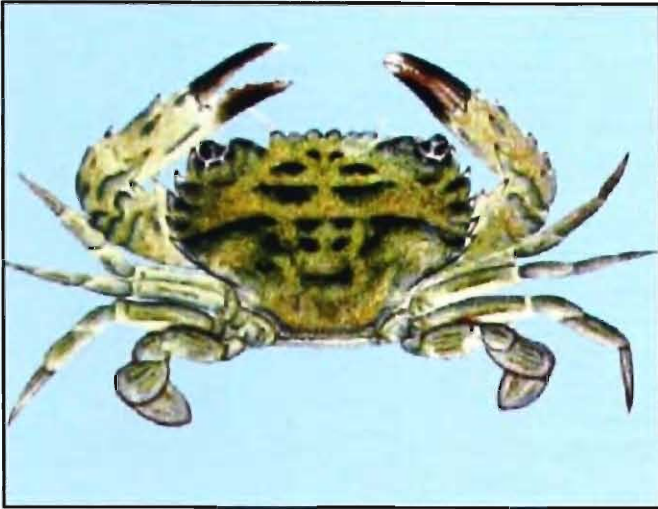


e. *Podophthalmus vigil*



f. *Thalamita crenata*

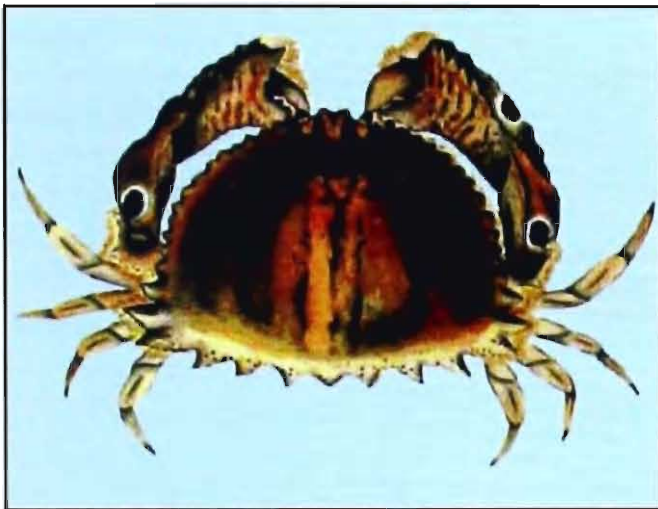
PLATE-III



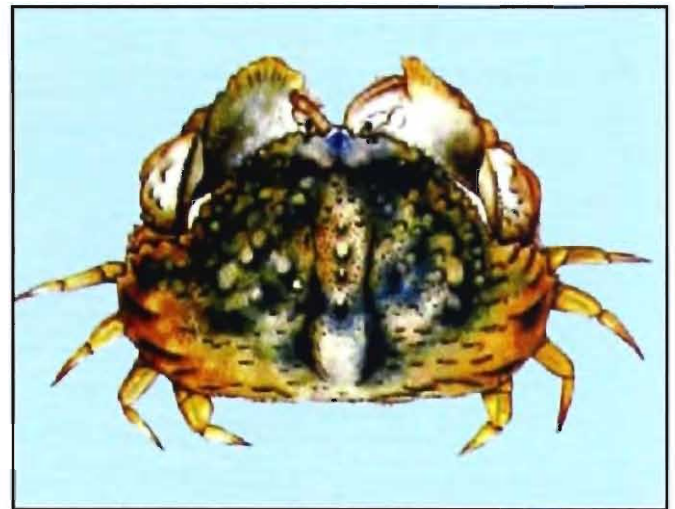
a. *Thalamita danae*



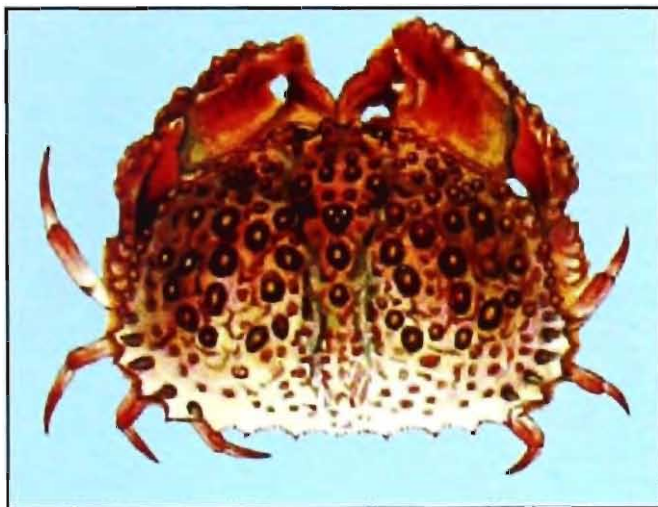
b. *Calappa lophos*



c. *Calappa philargius*



d. *Calappa hepatica*



e. *Calappa japonicus*



f. *Matuta lunaris*

PLATE-IV



a. *Galene bispinosa*



b. *Varuna litterata*



c. *Ocypode ceratophthalma*



d. *Ocypode cordimana*



e. *Cardisoma carnifex*

INDIAN PENAEID SHRIMPS–THEIR BIODIVERSITY AND ECONOMICAL VALUES

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ABSTRACT

A total of 84 species of penaeid shrimps belonging to the families Solenoceridae, Benthesicymidae, Aristiidae, Penaeidae and Sicyonidae were recorded from the marine littoral and deep sea regions of Exclusive Economic Zone of India. A critical analysis of diversity of penaeid shrimps in different regions of Indian waters has shown a definite pattern for their occurrence and distribution. The introduction of mechanised trawling in both littoral and deep sea waters during 1960s and the intensification of commercial indigenous and mechanized gears during 1971-2004 enhanced the exploitation of more than fifty species significantly. The extent of exploitation, utilisation and economical values of Indian penaeid shrimps are also presented. Conservation measures are outlined to sustain the biodiversity and utilization of this valuable resource in the years to come.

INTRODUCTION

Records and findings of several new species of Indian penaeid shrimps have been brought to light in the pioneering works carried out for a century from 1834 to 1934 by Milne Edwards (1834), Miers (1884), Bate (1888), Wood-Mason (1891), Wood-Mason, Alcock (1891a, b), Alcock and Anderson (1894, 1899a, b), Alcock and Macardle (1901), Alcock (1901, 1905, 1906), Nobili (1903), Alcock *et al.* (1907), Kemp (1910, 1915, 1917), De Man (1908, 1911, 1920), Kemp and Sewell (1912), Balss (1925) and Sewell (1934). The specimens were mostly collected by dredging carried out both in inshore and deep water regions of seas around India and from traditional gears operated in brackishwater areas. The exploratory mechanised trawling during 1950's and 1960's and commercial trawling from 1970 to 2004 in littoral and deep sea regions of our country revealed the occurrence of several species which were reported by Nataraj (1945, 1953), Kurian (1953, 1954, 1964, 1965), Menon (1956), Mehendale and Tembe (1958), John and Kurian (1959), Kunju (1960 a, b), George *et al.* (1963), Ramamurthy (1964), George (1964, 1966, 1969, 1972, 1975, 1979, 1980), Muthu (1965, 1971, 1972 a, b), George and Rao (1966 a, b), Nair *et al.* (1967), George and Muthu (1968 a, b), Thomas, 1968, 1969, 1970, 1972, 1977, 1979, 1986), Muthu and

George (1971), Mohamed and Suseelan (1973), Muthu and Sampson (1973), Kathirvel *et al.* (1976), Silas and Muthu (1976a, b), Kagwade (1978), Rao (1984), Ravindranath (1989), Ramaseshaiah and Murthy (1991), Pathan and Jalihal (1997). The exploitation by mechanised trawling and introduction of efficient indigenous gears such as trammel net etc. has resulted in the capture of appreciable quantities of penaeid shrimp during 1970-2004, which has culminated in earning a huge amount of foreign exchange per annum. The present paper deals with the biodiversity of Indian penaeid shrimps in terms of their occurrence in different region, status of their exploitation and strategies for conservation for judicious exploitation in the coming years.

REGION-WISE ENUMERATION OF SPECIES

From the published accounts of the research workers mentioned in the introduction, the number of species recorded from different regions has been arrived at and presented below on regional-basis as well as maritime state-wise.

North-West (comprising the Coastal line of Gujarat and Maharashtra) Total no. of species : 32., Which includes 31 littoral and 1 deep sea form under 3 families and 12 genera.

South-West (comprising the Coastal line of Goa, Karnataka and Kerala) Total no. of species : 52, which has 34 littoral and 18 deep sea forms under 5 families and 21 genera.

North-East (comprising the Coastal line of West Bengal and Orissa) Total no. of species : 35 including 31 littoral and 4 deep sea forms under 2 families and 10 genera.

South-East (comprising the Coastal line of Andhra Pradesh, Tamil Nadu and Pondicherry) Total no. of species : 57 including 44 littoral and 13 deep sea forms under 5 families and 18 genera.

Lakshadweep Islands—Total no. of species : 10 including 5 littoral and 5 deep sea forms under 3 families and 8 genera.

Andaman and Nicobar Islands—Total no. of species : 48 including 30 littoral and 18 deep sea form under 5 families and 20 genera.

MARITIME STATE-WISE

CHECKLIST OF INDIAN PENAEIDS

5 families, 23 genera and 84 species (57 littoral and 27 deep sea species)

Family SOLENOCERIDAE (4 genera and 13 species)

- *1. *Gordonella villosa* (Alcock & Anderson, 1894)
- *2. *Haliporus taprobanensis* (Alcock & Anderson, 1899)
- *3. *H. microps* (Smith, 1884)

- *4 *Hymenopenaeus laevis* (Bate, 1881)
- *5. *H. neptunes* (Bate, 1888)
- *6. *H. aequalis* (Bate, 1888)
- 7. *Solenocera crassicornis* (H. Milne Edwards, 1837)
- *8. *S. annectans* (Wood-Mason, 1891)
- 9. *S. pectinata* (Bate, 1888)–Littoral
- *10. *S. hextii* Wood-Mason & Alcock, 1891
- 11. *S. choprai* Nataraj, 1945
- 12. *S. melantho* De Man, 1907
- 13. *S. waltairensis* George and Muthu, 1968

Family BENTHESICYMIDAE (2 genera and 3 species)

- *14. *Benthescymus investigatoris* (Alcock & Anderson, 1899)
- *15. *Gennadas propinquus* Rathbun, 1906
- *16. *G. scutatus* Bouvier, 1906

Family ARISTAEIDAE (4 genera and 7 species)

- *17. *Aristomorpha rostridentatus* (Bate, 1881)
- *18. *A. woodmasoni* Calman, 1925
- *19. *Aristeus virilis* (Bate, 1881)
- *20. *A. alcocki* Ramadan, 1938
- *21. *Pseudoaristeus crassipes* (Wood-Mason, 1891)
- *22. *Plesiopenaeus edwardsianus* (Johnson, 1867)
- *23 *P. coruscans* (Wood-Mason, 1891)

Family PENAEIDAE (12 genera and 59 species)

- 24. *Atypopenaeus stenodactylus* (Stimpson, 1860)
- 25. *A. compressipes* (Henderson, 1893)
- *26. *Funchalia balboae* (Faxon, 1893)
- *27. *F. villosa* (Bouvier, 1905)
- 28. *Fenneropenaeus indicus* H. Milne Edwards, 1837
- 29. *F. merguiensis* De Man, 1888
- 30. *F. penicillatus* Alcock, 1905
- *31. *Metapenaeopsis philippi* (Bate, 1811)
- 32. *M. palmensis* (Haswell, 1879)

33. *M. barbata* (De Haan, 1844)
- *34. *M. andamanensis* (Wood-Mason, 1891)
- *35. *M. coniger* (Wood-Mason, 1891)
36. *M. mogiensis* (Rathbun, 1902)
37. *M. stridulans* (Alcock, 1905)
38. *M. borradailei* (De Man, 1911)
39. *M. hilarula* (De Man, 1911)
40. *M. tolensis* Hall, 1962
41. *M. ceylonica* Starobogatov, 1972
42. *Metapenaeus monoceros* (Fabricius, 1798)
43. *M. affinis* (H. Milne Edwards, 1837)
44. *M. brevicornis* (H. Milne Edwards, 1837)
45. *M. ensis* (De Haan, 1844)
46. *M. dobsoni* (Miers, 1878)
47. *M. lysianassa* (De Man, 1888)
48. *M. moyebi* (Kishinouye, 1896)
49. *M. intermedius* (Kishinouye, 1900)
50. *M. elegans* De Man, 1907
51. *M. baramensis* Hall, 1962
52. *M. krishnatrii* Silas and Muthu, 1976
53. *M. stebbingi* Nobili, 1904
54. *M. kutchensis* George, George & Rao, 1963
55. *M. alcocki* George & Rao, 1968
56. *Melicertus canaliculatus* (Olivier, 1811)
57. *M. latisulcatus* Kishinouye, 1896
58. *Marsupenaeus japonicus* Bate, 1888
59. *Parapenaeopsis stylifera* (H. Milne Edwards, 1837)
60. *P. sculptilis* (Heller, 1862)
61. *P. hardwickii* (Miers, 1878)
62. *P. tenella* (Bate, 1888)
63. *P. cornuta* (Kishinouye, 1900)
64. *P. acclivirostris* Alcock, 1905

65. *P. nana* Alcock, 1905
66. *P. uncta* Alcock, 1905
67. *P. maxillipedo* Alcock, 1906
68. *P. coromandelica* Alcock, 1906
69. *P. indica* Muthu, 1972
- *70. *Parapenaeus fissures* (Bate, 1881)
- *71. *P. investigatoris* Alcock & Anderson
72. *P. longipes* Alcock, 1905
- *73. *P. fissuroides indica* Crosnier, 1985
- *74. *Penaeopsis jerryi* Perez Farfante, 1979
75. *Penaeus monodon* Fabricius, 1798
76. *P. semisulcatus* De Haan, 1844
77. *Trachypenaeus curvirostris* (Stimpson, 1860)
78. *T. pescadoreensis* Schmitt, 1931
79. *T. sedili* Hall, 1961
80. *T. fulvus* Dall, 1957
81. *T. asper* Alcock, 1906
82. *Trachypenaeopsis minicoyensis* Thomas, 1972

Family SICYONIDAE (1 genus and 2 species)

83. *Sicyonia lancifer* (Olivier, 1811)
84. *S. longicauda* Rathbun, 1906

*Deep sea species

DISTRIBUTION IN INDIAN WATERS

The distribution of penaeid shrimps of different families in Indian waters is given in Table 1–8.

Table 1. Family SOLENOCERIDAE

S. No.	Species	1	2	3	4	5	6	7	8	9	10	11
1	<i>Gordonella villosa</i>					●	●					
2	<i>Haliporus micropes</i>						●					●
3	<i>H. taprobanensis</i>							●				
4	<i>Hymenopeaneus aequalis</i>					●						●

Table 1. Contd.

S. No.	Species	1	2	3	4	5	6	7	8	9	10	11
5	<i>H. neptunus</i>											●
6	<i>H. laevis</i>						●					●
7	<i>Solenocera crassicornis</i>	●	●	●	●	●		●	●	●	●	●
8	<i>S. pectinata</i>					●			●	●	●	●
9	<i>S. annectans</i>											●
10	<i>S. hextii</i>	●	●	●	●	●		●	●	●	●	
11	<i>S. melanthero</i>					●			●		●	
12	<i>S. choprai</i>	●	●	●	●	●		●	●		●	●
13	<i>S. waltirensis</i>								●			

1-Gujarat; 2-Maharashtra; 3-Goa; 4-Karnataka; 5-Kerala; 6-Lakshadweep Islands; 7-Tamil Nadu & Pondicherry; 8-Andhra Pradesh; 9-Orissa; 10-West Bengal; 11-Andaman and Nicobar Islands.

Three deep water species such as *G. villosa*, *H. laevis* and *H. microps* are recorded from Lakshadweep seas. In *Solenocera*, except *S. annectans* and *S. hextii*, which are deep sea forms, other 5 species are littoral in habit. Regarding their distribution, *S. crassicornis* and *S. hextii* are reported all along the West and East Coasts and A & N Islands. Other littoral species *S. pectinata* and *S. melanthero* are confined to South-West and East Coasts, while the former has been reported from A & N Islands also. *S. waltirensis* has been described from Kakinada and Visakhapatnam in Andhra Pradesh.

Table 2. Family BENTHESICYMIDAE

S. No.	Species	1	2	3	4	5	6	7	8	9	10	11
1	<i>Gennadas propinquus</i>					●		●				
2	<i>G. scutatus</i>					●		●				
3	<i>Benthesicymus investigatoris</i>					●		●				●

1-Gujarat; 2-Maharashtra; 3-Goa; 4-Karnataka; 5-Kerala; 6-Lakshadweep Islands; 7-Tamil Nadu & Pondicherry; 8-Andhra Pradesh; 9-Orissa; 10-West Bengal; 11-Andaman and Nicobar Islands.

This family is represented by 3 deep sea species, two belonging to *Gennadas* and one to *Benthesicymus*.

Table 3. Family ARISTEIDAE

S. No.	Species	1	2	3	4	5	6	7	8	9	10	11
1	<i>Aristomorpha rostridentatus</i>											•
2	<i>A. wood-masoni</i>					•		•				•
3	<i>Pseudoaristeus crassipes</i>					•	•	•				•
4	<i>Aristeus virilis</i>											•
5	<i>A. alcocki</i>					•		•		•		
6	<i>Plesiopenaeus edwardsianus</i>					•		•		•		•
7	<i>P. coruscans</i>											•

All the species of this family are from deep sea and belong to 4 genera, namely, *Aristomorpha*, *Pseudoaristeus*, *Aristeus* and *Plesiopenaeus*.

Family PENAEIDAE

Table 4. Distribution of *Atypopenaeus*, *Funchalia* and *Metapenaeopsis*

S. No.	Species	1	2	3	4	5	6	7	8	9	10	11
1	<i>Atypopenaeus stenodactylus</i>	•	•	•	•	•		•			•	
2	<i>A. compressipes</i>							•				
3	<i>Funchalia balbone</i>					•						
4	<i>F. villosa</i>					•						•
5	<i>Metapenaeopsis barbata</i>							•	•			
6	<i>M. palmensis</i>											•
7	<i>M. philippi</i>					•			•			
8	<i>M. andamanensis</i>				•	•		•	•			•
9	<i>M. coniger</i>			•	•	•		•	•			•
10	<i>M. mogiensis</i>		•	•	•	•		•	•			•
11	<i>M. stridulans</i>	•	•	•	•	•		•	•	•		•
12	<i>M. hilarula</i>		•	•	•	•		•	•			•
13	<i>M. borrodailei</i>						•		•			
14	<i>M. ceylonica</i>								•			
15	<i>M. tolensis</i>							•	•			

This is the largest family, comprising 13 genera and 59 species, of which 9 are deep sea and the rest (50) littoral. The distributional pattern is given in Table 4 for *Atypopenaeus*, *Funchalia* and *Metapenaeopsis*, Table 5 for *Metapenaeus*, Table 6 for *Parapenaeopsis*, Table 7

for *Parapenaeus*, *Penaeopsis*, *Penaeus* and *Melicertus*, Table 8 for *Fenneropenaeus*, *Marsupenaeus*, *Trachypenaeus* and *Trachypenaeopsis*.

Both *F. balboae* and *F. villosa* are pelagic shrimps hauled from greater depths. There are 11 species in the genus *Metapenaeopsis*, of which, 3 are from deep sea and the rest 8 from littoral.

Table 5. Distribution of *Metapenaeus*

S. No.	Species	1	2	3	4	5	6	7	8	9	10	11
1	<i>Metapenaeus monoceros</i>	●	●	●	●	●		●	●	●	●	
2	<i>M. affinis</i>	●	●	●	●	●		●	●	●	●	●
3	<i>M. brevicornis</i>	●	●	●	●	●		●	●	●	●	●
4	<i>M. ensis</i>							●	●	●	●	●
5	<i>M. dobsoni</i>	●	●	●	●	●		●	●	●	●	●
6	<i>M. lysianassa</i>	●		●	●	●		●	●	●	●	●
7	<i>M. moyebi</i>	●		●	●	●		●	●			●
8	<i>M. intermedius</i>											●
9	<i>M. elegans</i>											●
10	<i>M. baramensis</i>											●
11	<i>M. stebbingi</i>	●										
12	<i>M. kutchenis</i>	●	●								●	
13	<i>M. alcocki</i>	●										
14	<i>M. krishnatrii</i>											●

In the genus *Metapenaeus*, there are 14 species, of which, *M. monoceros*, *M. affinis*, *M. brevicornis*, *M. dobsoni* and *M. lysianassa* have a wider distribution all along West and East Coasts and A & N Islands.

Table 6. Distribution of *Parapenaeopsis*

S. No.	Species	1	2	3	4	5	6	7	8	9	10	11
1	<i>Parapenaeopsis stylifera</i>	●	●	●	●	●		●	●	●	●	●
2	<i>P. sculptilis</i>	●	●	●	●	●		●	●	●	●	
3	<i>P. hardwickii</i>	●	●	●	●	●		●	●	●	●	
4	<i>P. tenella</i>							●	●			●
5	<i>P. cornuta</i>		●	●	●	●		●	●	●		●
6	<i>P. acclivirostris</i>	●	●	●	●	●		●	●		●	

Table 6. Contd.

S. No.	Species	1	2	3	4	5	6	7	8	9	10	11
7	<i>P. uncta</i>			●	●			●	●	●	●	
8	<i>P. nana</i>							●	●	●		
9	<i>P. maxillipedo</i>	●	●	●	●	●		●	●		●	
10	<i>P. coromandelica</i>					●		●	●		●	●
11	<i>P. indica</i>							●	●			

Table 7. Distribution of *Parapenaeus*, *Penaeopsis*, *Penaeus* and *Melicertus*

S. No.	Species	1	2	3	4	5	6	7	8	9	10	11
1	<i>Parapenaeus fissures</i>									●		●
2	<i>P. investigatoris</i>					●		●	●			
3	<i>P. longipes</i>	●	●	●	●	●		●	●	●	●	
4	<i>P. fissuroides indica</i>				●							
5	<i>Penaeopsis jerryi</i>			●	●	●		●	●	●		●
6	<i>Penaeus monodon</i>	●	●	●	●	●		●	●	●	●	●
7	<i>P. semisulcatus</i>	●	●	●	●	●		●	●	●	●	●
8	<i>Melicertus canaliculatus</i>	●	●	●	●	●	●	●	●	●	●	●
9	<i>M. latisulcatus</i>	●	●	●	●	●	●	●	●	●	●	●
10	<i>Fenneropenaeus indicus</i>	●	●	●	●	●		●	●	●	●	
11	<i>F. merguensis</i>	●	●	●	●	●		●	●	●	●	●
12	<i>F. penicillatus</i>	●	●						●	●	●	
13	<i>Marsupenaeus japonicus</i>	●	●	●	●	●		●	●	●	●	●

In the genus *Parapenaeus*, there are 4 species, of which, 3 are deep sea and 1 littoral.

Table 8. Distribution of *Fenneropenaeus*, *Marsupenaeus*, *Trachypenaeus* and *Trachypenaeopsis*

S. No.	Species	1	2	3	4	5	6	7	8	9	10	11
1	<i>Trachypenaeus curvirostris</i>	●	●	●	●	●	●	●	●	●	●	●
2	<i>Trachypenaeus pescadoreensis</i>	●				●		●	●			
3	<i>Trachypenaeus sedili</i>				●	●		●	●			
4	<i>Trachypenaeus asper</i>							●				
5	<i>Trachypenaeus fulvus</i>											●
6	<i>Trachypenaeopsis minicoyensis</i>						●					

ECONOMIC VALUES OF PENAEID SHRIMPS

Exploitation : Prior to 1960, penaeid shrimps were caught only by indigenous gears such as shore seine, boat seine, gill net and cast net in the inshore seas, while stake net, dip net, drag net, cast net and trap were used in the estuarine region for capture of juvenile population. After the introduction of mechanised trawling during the sixties and sustaining of trawling from seventies to date and the demand from foreign markets made the shrimp as the gold from the sea. The average annual landings of penaeid shrimps during 1951 to 2004 is given in Table 9.

Table-9. Landings of penaeid shrimps in India during 1951-2004

Period	Total crustacean landings (in tonnes)	Quantity of penaeid shrimps (in tonnes)	% by penaeid shrimps in total crustacean landings
1951-1960	1,02,653	52,927	52
1961-1970	95,739	57,884	61
1971-1980	1,97,921	1,11,128	56
1981-1990	2,31,248	1,32,227	57
1991-2000	4,16,050	1,94,346	47
2001-2004	4,02,162	1,93,827	48

The total landings of the penaeid shrimps gradually increased and registered a 3 fold increase (1, 94, 346 tonnes) in 1991-2000. However there is a slight decrease of penaeid shrimps during 2001-2004.

The maritime statewise contribution of penaeid shrimps is given in Table-10.

Table-10. Contribution of penaeid shrimps at different maritime states

Maritime states	Percentage
Gujarat	10
Maharashtra	41
Goa	3
Karnataka	4
Kerala	22
Tamil Nadu	9
Pondicherry	1
Andhra Pradesh	6
Orissa	2
West Bengal	1
A&N Islands	1

Table-11. Export of frozen shrimps and its values

Export	Quantity (in tonnes)	Value (in lakhs)
1961-1970	9960	11
1971-1980	41851	121
1981-1990	54323	376
1991-2000	83983	1966
2001-2004	132594	4246

During 1961-1970, the quantity of frozen shrimps exported stood at 9,960 tonnes and during 2001-2004, the quantity exported was 1,32,594 tonnes valued at rupees 4246 lakhs. This is nearly 12 times more than that of what was exported during 1961-1970. In case of the value increase was about more than 386 times.

GENERAL REMARKS

A critical evaluation of published accounts on the occurrence of penaeid shrimps during 1834–1997 has brought to light 84 species. Out of 84 species, 43 species are commercially important. The greater demand from export market has necessitated the introduction of mechanised trawling in both inshore and deep sea regions of India's Exclusive Economic Zone. From 1971 onwards commercial fishing by trawlers has gradually taken place. Based on the exploratory inshore trawling during the sixties, George (1973) has estimated the potential yield for penaeid shrimp at 2 lakhs tonnes per annum. The average annual landings during 1991-2000 and 2001-2004 was at 1,94,346 tonnes and 1,93,827 tonnes. This indicated the rate of exploitation varied from 96.9–97.2 %. Now the present status of the exploitation has reached almost the maximum level. To conserve the present resources, annual fishing holidays (45 days) are imposed by different maritime states for bottom trawling operations. This will go in a long way to replenish the natural stock.

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BIODIVERSITY AND ECONOMICAL VALUES OF INDIAN LOBSTERS

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ABSTRACT

A total of 34 lobsters (7 species in the family Nephropidae, 1 each in Polychelidae, Synaxidae and Thalassinidae, 11 in Palinuridae and 10 in Scyllaridae and 3 in Callinassidae) are recorded from Indian waters. The occurrence and Distribution of these lobsters in different Habitats have been studied. Data on the exploitation, utilization and export trade of commercially important 3 nephropid, 10 palinurid and 4 scyllarid lobsters are presented with a note on the conservation measures for future rational exploitation. Illustrative colour drawings of 31 species are presented for an easy field identification and creation of awareness on this valuable marine resource.

INTRODUCTION

Among the marine edible crustaceans, lobsters rank second by virtue of their delicacy and higher price they command in the export trade, the first being the penaeid shrimps. Lobsters belonging to the families Palinuridae, Scyllaridae, Nephropidae and Homaridae are marine forms and exploited in considerable quantities from both the littoral and deep sea areas of the world oceans. According to Holthuis (1991), 90 species of commercially important lobsters belonging to the families Thaumastochelidae (2 species), Nephropsidae (23), Polychelidae (1), Palinuridae (29), Synaxidae (2), Scyllaridae (23), Thalassinidae (1), Upogebidae (2) and Callinassidae (8) are known to occur in the Indian and Pacific Oceans, of which, 7 nephropsid, 1 each of Polychelidae, Synaxidae and Thalassinidae, 10 each in Palinuridae and Scyllaridae and 3 in Callinassidae are recorded from India's Exclusive Economic Zone. The present paper deals with the biodiversity, exploitation and export trade of Indian species with remarks on the conservation measures.

BIODIVERSITY OF INDIAN LOBSTERS

Based on the taxonomical records by Heller (1865), Henderson (1893), Thurston (1894), Alcock and Anderson (1894), Alcock (1901; 1906), Nobili (1903), Borradaile (1906), Lloyd

(1907), Sewell (1913), De Man (1916), Balss (1925), Gravely (1927; 1929), Patil (1953), John and Kurian (1959), Satyanarayana (1961), Chhapgar and Deshmukh (1961; 1964), Kurian (1963, 1965; 1967), George and Rao (1965; 1967), George and George (1967), Radhakrishna and Ganapati (1969), Nair *et al.* (1973), Hossain (1975), Meiyappan and Kathirvel (1978), Thomas (1979), Parulekar (1981), Tikader and Das (1985), Tikader *et al.* (1986), Mustafa (1990), Radhakrishnan *et al.* (1990; 1995), Holthuis (1991), Srikrishnadhas *et al.* (1991), Goswamy (1992), Kathirvel (1998), Thiagarajan *et al.* (1998), Kizhakudan (2002), and Kathirvel and Nair (2002) brief notes on common name, Diagnostic characters, Habitat, maximum size attained, Distribution in Indian waters and other localities and Status of occurrence are given below with available colour drawings.

Family NEPHROPIDAE

1. *Acanthocaris tenuimana* Bate, 1888

(Plate 1 A)

Common name (FAO) : Prickly deep sea lobster.

Diagnostic characters : Fingers of the First chelipeds longer than palm; maximum size : 400 mm in Total Length (TL).

Habitat : Muddy; 160-1640 m deep.

Distribution : Lakshadweep Sea; Other localities : Natal, Mosambique, Madagascar, Japan, the Philippines, South China Sea, Indonesia and New Caledonia.

Status : Rare.

2. *Nephropsis carpentari* Wood-Mason, 1885

(Plate 1 B)

Common name (FAO) : Ridge-back lobsterette.

Diagnostic characters : Rostrum with a pair lateral teeth; median dorsal carina present in 3rd to 6th abdominal segments; 120 mm in TL.

Habitat : Muddy, 200-500 m.

Distribution : Lakshadweep sea, off Visakhapatnam in Bay of Bengal; Other localities : Japan.

Status : Rare.

3. *Nephropsis stewarti* Wood-Mason, 1872

(Plate 1 C)

Common name (FAO) : Indian Ocean lobsterette.

Diagnostic characters : Rostrum with a pair of lateral teeth; no median dorsal carina on any of the abdominal segments; 150 mm in TL.

Habitat : Muddy, 170-1060 m.

Distribution : Off West Coast, off Tamil Nadu and Orissa Coasts and Andaman & Nicobar Islands in Indian waters; Other localities : Gulf of Aden, East Africa, the Philippines, Indonesia, Western Australia, Taiwan and Japan.

Status : Commercially potential.

4. *Nephropsis ensirostris* Alcock, 1901
(Plate 1 D)

Common name (FAO) : Gladiator lobsterette.

Diagnostic characters : Rostrum without lateral teeth; abdominal segments 3rd to 6th with median dorsal carinae.

Habitat : Sand or mud, 580-1160m.

Distribution : Lakshadweep Sea, off Chennai Coast and Andaman & Nicobar Islands; Other localities : Gulf of Aden, Maldives, the Philippines and Indonesia.

Status : Rare.

5. *Nephropsis suhmi* Bate, 1888
(Plate 2 A)

Common name (FAO) : Red and white lobsterette.

Diagnostic characters : Rostrum with 3 pairs of lateral teeth; Abdominal segments without mid-dorsal carina; 100 mm in TL.

Habitat : Muddy, 750-1150 m.

Distribution : Lakshadweep Sea; Other localities : Gulf of Aden, Madagascar, Indonesia, Australia and New Caledonia.

Status : Rare.

6. *Nephropsis sulcata* Macpherson, 1990
(Plate 2 B)

Common name (FAO) : Grooved lobsterette.

Diagnostic characters : Rostrum with 2 pairs of lateral teeth; median groove of rostrum distinctly reaching beyond anterior pair of lateral rostral teeth; 100 mm in TL.

Habitat : Muddy, 750-1180 m.

Distribution : Lakshadweep Sea; Other localities : South Africa, Madagascar, South China Sea, the Philippines, Australia and New Caledonia.

Status : Rare.

7. *Metanephrops andamanicus* (Wood-Mason, 1894)
(Plate 2 C)

Common name (FAO) : Andaman lobster.

Diagnostic characters : Rostrum without lateral teeth; 2nd to 6th abdominal segments with a marked dors-median carina, flanked by a pair of conspicuous longitudinal groove; 200 mm in TL.

Habitat : Muddy, 250-750 m.

Distribution : Andaman Sea; Other localities : East Africa, South china Sea and Indonesia.

Status : Rare.

Family POLYCHELIDAE

8. *Polychaelus tiplops* Heller, 1862
(Plate 2 D)

Common name : Deep sea lobster.

Diagnostic characters : Carapace rectangular with serrated lateral margins; antennular and antennal flagellum almost equal in length; median carina present in all six abdominal segments; 200 mm in TL.

Habitat : Muddy, 400-600 m.

Distribution : Andaman Sea.

Status : Rare.

Family PALINURIDAE

9. *Linuparus somniosus* Berry and George 1972
(Plate 3 A)

Common name (FAO) : African spear lobster.

Diagnostic characters : General body colour rose; short antennal flagellum; 'V' shaped groove across the carapace; two spines in the middle region of each abdominal segment; 350 mm in TL.

Habitat : Rocky or sand or mud, 215-370 m.

Distribution : Andaman and Nicobar Islands; Other localities : East Coast of Africa.

Status : Commercially potential.

10. *Linuparus andamanensis* Mustafa, 1991
(Plate 3 B)

Common name : Andaman spear lobster.

Diagnostic characters : General body colour rose; short antennal flagellum; apart from 'V' shaped groove, two parallel grooves up to the posterior border of carapace; two spines in the middle region of each abdominal segment; 350 mm in TL.

Habitat : Rocky or sand or mud, 400-415 m.

Distribution : Andaman Islands; No other records till date.

Status : Rare.

11. *Palinustus waguensis* Kubo, 1963
(Plate 3 C)

Common name : Indian blunt-horn spiny lobster.

Diagnostic characters : General body colour orange brown; two rows of spines on carapace; 180 mm in TL.

Habitat : Sand or mud with shells, 72-200 m.

Distribution : South-West and South-East Coasts and Andaman & Nicobar Islands; Other localities : Indonesia, the Philippines and Japan.

Status : Commercially potential.

12. *Panulirus homarus* (Linnaeus, 1758)
(Plate 3 D)

Common name : Indian spiny lobster.

Diagnostic characters : General body colour green; sculptured groove on each abdominal segment; 310 mm in TL.

Habitat : Rocky, 1-90 m.

Distribution : East and West Coasts, Lakshadweep, Andaman and Nicobar Islands; Other localities : Red Sea, East Coast of Africa, Madagascar, Mauritius, Seychelles, Gulf of Aden, Arabia Coast, Pakistan, Sri Lanka, Myanmar, Thailand, Indonesia, Malaysia, the Philippines, South China Sea, Taiwan, Japan, Northern Australia and New Caledonia.

Status : Commercially exploited.

13. *Panulirus penicillatus* (Olivier, 1791)
(Plate 4 A)

Common name (FAO) : Prong-horn spiny lobster.

Diagnostic characters : General body colour blue; long white streak along the entire length of each leg; antennal spines fused at the base; groove on each abdominal segment.

Habitat : Rocky & coral reefs, 1-4 m.

Distribution : East and West Coasts, Lakshadweep, Andaman and Nicobar Islands;
Other localities : Red Sea, East Coast of Africa, Madagascar, Mauritius, Seychelles, Gulf of Aden, Arabia Coast, Pakistan, Sri Lanka, Myanmar, Thailand, Indonesia, Malaysia, the Philippines, South China Sea, Taiwan, Japan, Northern Australia and almost all Pacific Islands.

Status : Commercially exploited.

14. *Panulirus longipes* (A. Milne Edwards, 1868)
(Plate 4 B)

Common name (FAO) : Long-legged spiny lobster.

Diagnostic characters : General body colour bluish; groove on each abdominal segment; numerous white spots on abdominal segments, legs longer in shape; 250 mm in TL.

Habitat : Turbid waters in rocky and coral areas, 1-18 m.

Distribution : East and West Coasts, Lakshadweep, Andaman and Nicobar Islands;
Other localities : Middle of East African Coast, Madagascar, Seychelles, Sri Lanka, Thailand, Indonesia, Philippines, Taiwan, Japan, New Guinea, Eastern Australia and New Caledonia.

Status : Commercially exploited.

15. *Panulirus ornatus* (Fabricius, 1798)
(Plate 4 C)

Common name (FAO) : Ornate spiny lobster.

Diagnostic characters : General body colour green with prominent white spots on the outer margin of each abdominal segment; legs with alternate white and dull black bands; No groove on abdominal segments; 500 mm in TL.

Habitat : Turbid Coastal waters, sandy or muddy bottom, 1-8 m.

Distribution : East and West Coasts, Lakshadweep, Andaman and Nicobar Islands;
Other localities : Red Sea, East Coast of Africa, Madagascar, Mauritius, Seychelles, Gulf

of Aden, Arabia Coast, Pakistan, Sri Lanka, Myanmar, Thailand, Indonesia, Malaysia, the Philippines, South China Sea, Taiwan, Japan, northern Australia and almost all Pacific Islands.

Status : Commercially exploited.

16. *Panulirus polyphagus* (Herbst, 1793)
(Plate 4 D)

Common name (FAO) : Mud spiny lobster.

Diagnostic characters : General body colour brown; white band on each abdominal segment; 400 mm in TL.

Habitat : Muddy, 3-90 m.

Distribution : East and West Coasts, Lakshadweep, Andaman and Nicobar Islands;
Other localities : Pakistan, Sri Lanka, Myanmar, Thailand, Malaysia, Indonesia, the Philippines, Vietnam, North-Western Australia and the Gulf of Papua.

Status : Commercially exploited.

17. *Panulirus versicolor* (Latreille, 1804)
(Plate 5 A)

Common name (FAO) : Painted spiny lobster.

Diagnostic characters : General body colour bluish steel; rose colour vertical band on lateral borders of carapace; white band on each abdominal segments; 400 mm in TL..

Habitat : Rocky & coral reefs, 1-15 m.

Distribution : East and West Coasts, Lakshadweep, Andaman and Nicobar Islands;
Other localities : Red Sea, East Coast of Africa, Madagascar, Mauritius, Seychelles, Gulf of Aden, Arabia Coast, Pakistan, Sri Lanka, Myanmar, Thailand, Indonesia, Malaysia, the Philippines, South China Sea, Taiwan, Japan, northern Australia and almost all Pacific Islands.

Status : Commercially exploited.

18. *Puerulus sewelli* Ramadan, 1938
(Plate 5 B)

Common name : Indian deep sea lobster.

Diagnostic characters : General body colour orange yellow; three rows of spines on carapace and few spines in the middle portion of each abdominal segments.

Habitat : Coarse sand, hard mud and shells, 180-1300 m.

Distribution : East and West Coasts, Andaman and Nicobar Islands; Other localities : Somalia, Gulf of Aden, Pakistan and Sri Lanka.

Status : Commercially exploited.

19. *Pueurulus angulatus* (Bate, 1888)

(Plate 5 C)

Common name (FAO) : Banded whip lobster.

Diagnostic characters : Three or more teeth between frontal horn and cervical groove; median keel of carapace with 3 post-cervical and 2 intestinal teeth; fifth walking leg of male not chelate; 210 mm in TL.

Habitat : Sand or mud, 200-550 m.

Distribution : Nicobar Islands; Other localities : East and South-East Coast of Africa, Mozambique, the Philippines, Indonesia, New Guinea and Western Australia.

Status : Occasionally caught.

Family SYNAXIDAE

20. *Palinurellus wieneckii* (De Man, 1881)

(Plate 5 D)

Common name (FAO) : Indo-Pacific Furry lobster.

Diagnostic characters : Rostrum triangular, longer than wide; 140 mm in TL.

Habitat : Coral reefs and marine caves, 9-27 m.

Distribution : Karwar, South-West Coast and Andaman & Nicobar Islands; Other localities : Arabian Coast of Red Sea, East Africa, South Africa, Mauritius, Thailand, Japan, the Philippines, Indonesia, New Guinea, Solomon Islands, Caroline Islands, New Caledonia, New Herbrides, Hawaiian Islands and Tuamotu Islands.

Status : Adults rarely caught; phyllosoma larvae frequent in the inshore plankton from the West Coast and Andaman & Nicobar Islands (Kathirvel, 1990; Kathirvel and James, 1990).

Family SCYLLARIDAE

21. *Scyllarides elisabethae* (Ortmann, 1894)

(Plate 6 A)

Common name : Cape slipper lobster.

Diagnostic characters : Anterior margin of carapace between eye and antero-lateral angle very concave; 200 mm in TL.

Habitat : Sand or mud or rocky, 37-380 m.

Distribution : Inshore waters of Vizhinjam, South-West Coast; Other localities : South-East Africa and Mozambique.

Status : Rare.

22. *Scyllarides tridacnophaga* Holthuis, 1967
(Plate 6 B)

Common name : Clam killer lobster.

Diagnostic characters : General body colour yellow with red spots; 3 round spots between carapace and abdomen; 300 mm in TL.

Habitat : Rocky and coral reefs, 5-112 m.

Distribution : South-East and South-West Coasts; Other localities : Red Sea, Gulf of Aden, Pakistan and West Coast of Thailand.

Status : Occasionally caught.

23. *Parribacus antarticus* (Lund, 1793)
(Plate 6 C)

Common name (FAO) : Sculptured mitten lobster.

Diagnostic characters : General body colour yellow; seven prominent spines on lateral border of carapace; a notch in the middle of each abdominal segment; 200 mm in TL.

Habitat : Sand and coral reefs, 1-20 m.

Distribution : Lakshadweep and South-East Coast; Other localities : Western Atlantic region from Florida to North-East Brazil, East Africa, Malaysia, Indonesia, the Philippines, and Pacific Islands.

Status : Common.

24. *Bathyarctus rubens* (Alcock & Anderson, 1894)
(Plate 6 D)

Common name : Deep sea brown lobster.

Diagnostic characters : Anterior margin of sternum truncate or slightly concave; median carina of 4th abdominal segment higher than that of 3rd; 70 mm in TL.

Habitat : Muddy, rocky and hard stone with fragments of shells, 183-732 m.

Distribution : Off Cochin, South-West Coast; Other localities : Sri Lanka, the Philippines, Indonesia, Australia, New Caledonia, Vanuatu and Fiji Islands.

Status : Rare.

25. *Scammarctus batei* (Holthuis, 1946)
(Plate 7 A)

Common name (FAO) : Soft locust lobster.

Diagnostic characters : Anterior part of thoracic sternum gutter-like sunken; 70 mm in TL.

Habitat : Sand or mud, 16-489 m.

Distribution : Off Kozhicode, South-West Coast and Andaman & Nicobar Islands; Other localities : Mozambique, Kenya, Gulf of Aden, South China Sea, Taiwan, the Philippines, Indonesia, Australia, New Caledonia, Vanuatu and Fiji Islands.

Status : Rare.

26. *Petrarctus rugosus* (H. Milne Edwards, 1837)
(Plate 7 B)

Common name (FAO) : Hunch-back locust lobster.

Diagnostic characters : Posterior branchial carina of carapace straight; 2nd abdominal segment at either side of median transverse groove with a smooth transverse carina; 3rd abdominal segment elevated than that of 2nd and 4th ; 60 mm in TL.

Habitat : Sand or mud, 20-60 m.

Distribution : East and West Coasts and Andaman & Nicobar Islands; Other localities : Red Sea, Kenya, Mozambique, Madagascar, Myanmar, Thailand, South China Sea, Taiwan, the Philippines, Indonesia, Australia, New Caledonia, Vanuatu and Fiji Islands

Status : Frequently caught in trawl catches from both east and West Coasts of India.

27. *Chelacrctus cultrifer* (Ortmann, 1897)

Common name : Brown lobster.

Diagnostic characters : 2nd to 4th abdominal segments uniformly reddish brown in colour without conspicuous transverse row of round spots;

Habitat : Sand and mud, 35-300m.

Distribution : East and West Coasts and Andaman & Nicobar Islands; Other localities : Somalia, Kenya, Saya de Malha Bank, Seychelles, Madagascar, Japan, the Philippines, Indonesia and Hawaiian Islands.

Status : Common.

28. *Eduarctus martensii* (Pfeffer, 1881)
(Plate 7 C)

Common name (FAO) : Striated locust lobster.

Diagnostic characters : Distinct median and postlateral carina on carapace; 3rd abdominal segment elevated than that of 2nd and 4th. 60 mm in TL.

Habitat : Sand or mud, 6-79 m.

Distribution : East and West Coasts; Lakshadweep Sea and Andaman & Nicobar Islands; Other localities : Somalia, Kenya, Mozambique. Seychelles, Madagascar, Sri Lanka, Myanmar, West of Malay Peninsula, Japan, South China Sea, Vietnam, Gulf of Thailand, Singapore, the Philippines, Indonesia, Australia, Chesterfield islands, New Caledonia and Fiji Islands.

Status : Most common. Records of either plenty, or sometimes swarming of phyllosoma larvae caught in the inshore and offshore plankton collections from East and West Coasts of India and Indian Ocean.

29. *Biarctus sordidus* (Steimpson, 1860)
(Plate 7 D)

Common name : Small brown lobster.

Diagnostic characters : Cardiac tooth on carapace well developed and triangular in shape and as high as gastric tooth.

Habitat : Sand or mud with shells, corals and sponges, 1-40 m.

Distribution : East and West Coasts; Other localities : South China Sea, Thailand, Malaysia, Singapore, the Philippines, North Borneo and Australia.

Status : Most common.

30. *Thenus orientalis* (Lund, 1793)
(Plate 8 A)

Common name : Sand or mud lobster

Diagnostic characters : General body colour brown; three spines on the antero-lateral border of carapace; a notch in the middle of each abdominal segment; 250 mm in TL.

Habitat : Sand or mud, 8-70 m.

Distribution : East and West Coasts, Andaman & Nicobar Islands; Other localities : Red Sea, East Coast of Africa, Gulf of Aden, Mauritius Seychelles, Sri Lanka, Myanmar,

Thailand, Malaysia, Indonesia, the Philippines, South China Sea, Taiwan, Japan and Australia.

Status : Commercially exploited.

Family THALASSINIDAE

31. *Thalassina anomola* (Herbst 1804)

Common name (FAO) : Scorpion mud lobster.

Diagnostic characters : Carapace oval shaped; rostrum narrowly triangular and short; telson as long as the sixth abdominal segment; uropods styliform; 300 mm in TL.

Habitat : Mud, living in burrows, 1-2 m.

Distribution : North-West Coast, East Coast, Andaman & Nicobar Islands; Other localities : Sri Lanka, Myanmar, Thailand, Malaysia, Indonesia, the Philippines, Japan, Australia and New Caledonia.

Status : Frequently caught.

Family CALLIANASSIDAE

32. *Callianassa audax* (De Man 1911)
(Plate 8 B)

Common name : Mud shrimp.

Diagnostic characters : 70 mm in TL.

Habitat : Rostrum very short and depressed; eye lobes nearly twice as long as broad, reaching the basal segment of the antennular peduncle; first abdominal segment triangular shaped; telson broader than long, much shorter than sixth abdominal segment; Mud, 1-4 m.

Distribution : Cannanore, South-West Coast; Other locality : Straits of Malacca.

Status : Occasionally caught.

33. *Callianassa kraussi* Stebbing 1900
(Plate 8 C)

Common name (FAO) : Pink ghost shrimp.

Diagnostic characters : Rostrum triangular; oval-shaped eyes; antennular peduncle longer than antennal peduncle; lateral margin of telson convex; 70 mm in TL.

Habitat : Mud, inshore seas & brackishwaters, 1-4 m.

Distribution : Cochin backwaters, South-West Coast; Other localities : South Africa and Mozambique.

Status : Rare.

34. *Callinassa maxima* Milne Edwards
(Fig.)

Common name : Large mud shrimp.

Diagnostic characters : 75 mm in TL.

Habitat : Mud, inshore seas and brackishwaters, 1-5 m.

Distribution : Kayamkulam Lake in Kerala, SouthWest Coast, Chennai and Chilka Lake, East Coast.

Status : Occasionally caught.

COMMERCIALLY IMPORTANT SPECIES

Family NEPHROPIDAE

1. *Nephropsis carpentari*
2. *N. stewarti*

Family PALINURIDAE

3. *Palinustus waguensis*
4. *P. homarus*
5. *P. penicillatus*
6. *P. longipes*
7. *P. ornatus*
8. *P. polyphagus*
9. *P. versicolour*
10. *P. sewelli*

Family SCYLLARIDAE

11. *Thenus orientalis*

EXPLOITATION

Traditional fishing gears : In the rocky Coast of Kanyakumari district in Tamil Nadu, anchor hook and bamboo trap were employed in lobster fishing during the sixties

(Miyamoto and Sheriff, 1962), while the bag net, barrier net, lobster net and baited traps (ring net with bait) are used in the Coastal districts of Thana, Mumbai suburb, Kolaba and Ratnagiri in Maharashtra (Chhapgar and Deshmukh, 1971). Bow and arrows and small shooting net were employed by the aborigines of Andaman and Nicobar Islands (Radcliffe-Brown, 1922)

Introduction of new gears : Under the auspices of FAO, the Central Institute of Fishery Technology (CIFT), Cochin has introduced bottom set gill net during the sixties which became popular and now one of the major gears operated not only along the South-West Coast but also along the South-East Coast from Cape Comorin to Chennai (Balasubramanian *et al.* 1960, 1962). During the eighties, CIFT has designed new traps made up of iron rods coated with plastic (Meenakumari and Mohan Rajan, 1985). Recently, four types of traps developed by Thoothkudi Fisheries College were introduced for lobster fishing off South-East Coast (Balasuramanian *et al.* 2001). The trawl net has become one of the most efficient gears for capturing the lobster which preferred the muddy Habitat along Gujarat and Maharashtra Coasts (Kagwade *et al.*, 1991).

Vernacular names : The vernacular names for different species of lobsters in different Indian languages given by several authors (Dan *et al.*, 1994a & 1994b; Gurusamy, 1994; Joseph, 1994; Karbhari, 1982; Rao *et al.*, 1978; Savaria, 1994; Thirumilu *et al.*, 1991; Wagmere and Sawant, 1994) are presented in Table-1

Table-1. Vernacular names for some of commercially exploited species

Species	Gujarati	Marathi	Malayalam	Tamil	Telugu	Oriya	Bengali
<i>P. polyphagus</i>	Titan	Shevandi	Kadal Konchu	-	Meesala royya	-	-
<i>P. homarus</i>	-	-	-	Thalaeral	Pedda royya	-	-
<i>P. ornatus</i>	-	-	-	Manieral	Patu royya	-	-
<i>P. versicolour</i>	-	-	-	Ramaeral	-	-	-
<i>P. longipes</i>	-	-	-	Singieral	-	-	-
<i>P. sewelli</i>	-	-	-	Singieral	-	-	-
<i>T. orientalis</i>	Kako	Phatphati	Adippan	Matta	-	Toptepa	Patal
<i>T. orientalis</i>				singieral			Chingri

Fishing season at selected centres : The fishing season at selected lobster fishing centres is given in Table-2 (CMFRI Annual Reports).

Table-2. Fishing season for lobsters at different localities.

Locality	Season		
	Trawl net	Bottom set gill net	Bottom set gill net & trap
Veraval	Oct-Jan	-	-
Mumbai	Oct-Jan	-	-
Tikkodi	-	Oct-Apr	-
Vizhinjam	-	-	Oct-Apr
Kanyakumari dt.	-	-	Oct-Apr
Thoothukudi	Jan-Jul	Nov-Feb	-
Mandapam	Oct-Mar	Apr-May	-
Kovalam	-	Jan-Mar	-
Chennai	Jul-Feb	-	-

Species composition of lobsters in different localities

Species composition of lobsters in different gears at various localities is given in Table-3 (CMFRI Annual Reports).

Table-3. Species composition of commercially important lobsters

Locality	Percentage by weight							Gears
	1	2	3	4	5	6	7	
Veraval	0	0	45	0	0	55	0	Trawl
Mumbai	0	0	51	0	0	49	0	Trawl (1981-1990)
Mumbai	0	0	99	0	0	1	0	Trawl (1991-2000)
Tikkodi	77	18	3	2	0	0	0	Gill net
Vizhinjam	95	2	1	1	1	0	0	Gill net & trap
Kanyakumari dt	89	10	1	0	0	0	0	Gill net & trap
Thoothukudi	29	69	0	1	1	0	0	Trawl
Thoothukudi	29	69	0	1	1	0	0	Gill net
Mandapam	29	65	0	2	1	0	3	Gill net
Kovalam	68	20	0	12	0	0	0	Gill net
Chennai	17	0	0	0	0	83	0	Trawl

1-*P. homarus*; 2-*P. ornatus*; 3-*P. polyphagus*; 4-*P. versicolour*; 5-*P. penicillatus*; 6-*T. orientalis*; 7-*P. longipes*

Maritime state-wise annual landings : Based on the data available from the annual reports of CMFRI, MPEDA and the Ministry of Agriculture and Co-operation, Govt. of India, the average annual landings of lobsters during the last three decades of the twentieth century in different maritime states of India are generated and presented in Table-4.

Table-4. Average annual landings of lobsters in different maritimes states of India.

Average Annual landings (in tonnes)

Maritime State	1971-1980	1981-1990	1991-2000
Gujarat	796	831	1082
Maharashtra	705	930	571
Goa	9	17	3
Karnataka	12	14	18
Kerala	34	86	263
Tamil Nadu	344	343	429
Pondicherry	15	15	9
Andhra Pradesh	28	7	15
Orissa	0	8	9
West Bengal	0	0	40
Andaman &			
Nicobar Islands	0	9	No data
Total	1,963	2,260	2,439

In general, there is an increasing trend during the last thirty years in most of the maritime states due to the sustained exploitation, except in Maharashtra and Goa. In Maharashtra, the sand lobster (*Thenus orientalis*) which formed nearly half of the total lobster landings (49% during 1981-1990) has reduced to 1% during 1991-2000, which was due to the over-fishing (CMFRI Annual Reports; Deshmukh, 2001). Heavy exploitation of either mature or berried female lobsters of both *P. polyphagus* and *T. orientalis* during the peak fishing season could have led to the prevention of possible breeding and recruitment of fresh brood in the subsequent years (Kagwade 1988b). As pointed out by Kagwade *et al* (1991), no suitable conservation measures could be introduced to sustain the lobster catch, the lobsters formed one of the components of a lesser magnitude in the bye-catch of the trawl fishery off Maharashtra Coast.

Exploitation of deep sea lobsters : Recently there were some reports on the exploitation of deep sea lobster resources by converting the existing shallow water trawlers with larger wire drums or going for larger vessels (more than 32 feet long). The vessels were

operated off Mangalore, Cochin and Quilon along the South-West Coast (Dinesh Babu *et al.*, 2001) and off Chennai, Pondicherry and Nagapatinam along the South-East Coast (Thirumilu and Rajan, 2003)

Potential resource for littoral species : George (1973) estimated the potential lobster resources of India at 1,000 tonnes based on the rate of exploitation prevailed during the sixties, while George *et al* (1977) gave a combined potential production of 40,000 tonnes for lobsters and crabs based on the exploitation during the first half of seventies.

Potential resource for deep sea species : Based on the early surveys during 1967-68, Rao and George (1973) estimated the potential resources of the deep water lobster *P. sewelli* off Quilon at 108 tonnes. Later Joseph (1972) estimated the potential yield at 2,000 tones and the standing crop at 6,000 tonnes based on the catch landed during 1967-71. Recently, Oommen (1985) assessed the standing stock of *P. sewelli* at 12,941 tonnes from the South-West Coast and 1,869 tonnes from the Gulf of Mannar. The sustainable yield at 60 % level of exploitation is 7,765 tonnes. James *et al* (1987) estimated the sustainable potential for deep sea lobster as 8,000 tonnes for the South-West Coast and 1,200 tonnes for the South-East Coast.

EXPORT

The export of lobster products from India has started from 1962 and the average annual quantity and value realised in foreign exchange is given in Table-5 and different types of products during 1990-2000 in Table-6 (MPEDA Annual Reports).

Table-5. Average annual lobster product export during 1962-2000

Period	Frozen lobster meat	
	Average annual	
	Quantity in tonnes	Value in crores
1962-1970	185	0.4
1971-1980	499	2.6
1981-1990	1241	14
1991-2000	1481	49.3

There was a steady increase in the export of quantity from 1962-1970 to 1991-2000, registering 8 times increase. Like-wise, the same increasing trend was observed in value also (123 times increased).

Table-6. Export of different types of products of lobster from India during 1990-2000

Year		Frozen rock lobster tail	Frozen, sand/slipper lobster tail	Frozen deep sea lobster tail	Frozen whole cooked lobster	Chilled lobster	Live lobster
1990	Q	447	0	64	0	0	0
	V	660	0	97	0	0	0
1991	Q	365	0	191	1063	0	1
	V	731	0	557	3696	0	2
1992	Q	290	0	260	1062	1	17
	V	720	0	886	3185	3	62
1993	Q	268	0	49	1155	5	159
	V	603	0	128	3226	20	122
1994	Q	281	0	70	952	3	22
	V	791	0	105	3568	8	154
1995	Q	173	138	88	1011	9	30
	V	511	294	209	208	26	248
1996	Q	106	101	61	998	68	0
	V	398	323	164	3625	192	0
1997	Q	201	124	66	953	0	0
	V	734	410	182	3645	0	0
1998	Q	138	103	98	986	0	1
	V	507	304	562	3439	0	1
1999	Q	163	56	241	873	0	31
	V	561	188	1593	4135	0	139
2000	Q	61	53	426	1000	0	9
	V	269	185	2149	5391	0	15

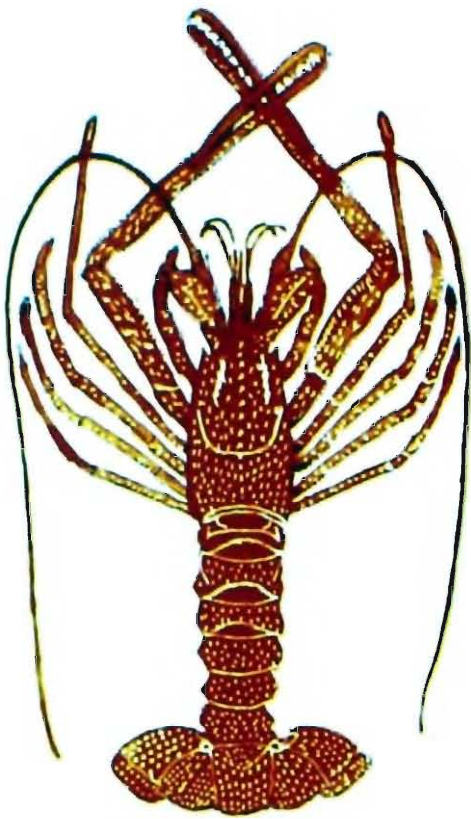
Q-Quantity in tones; V-Value in Lakhs

During 1990-2000, a gradual demand for whole cooked lobster instead of frozen lobster tail has been noticed. Another significant contribution to the total export quantity has come from the exploitation of deep sea lobsters from the South-West and South-East Coasts.

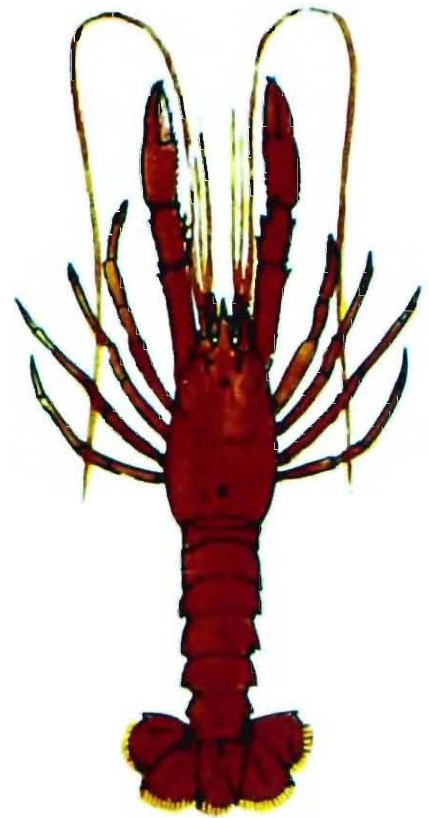
GENERAL REMARKS

Faunistical records of Indian lobsters have shown that a total of 34 species (7 nephropsid, 1 each of Polychelidae, Synaxidae & Thalassinidae, 11 in Palinuridae and 10 in Scyllaridae

PLATE-I



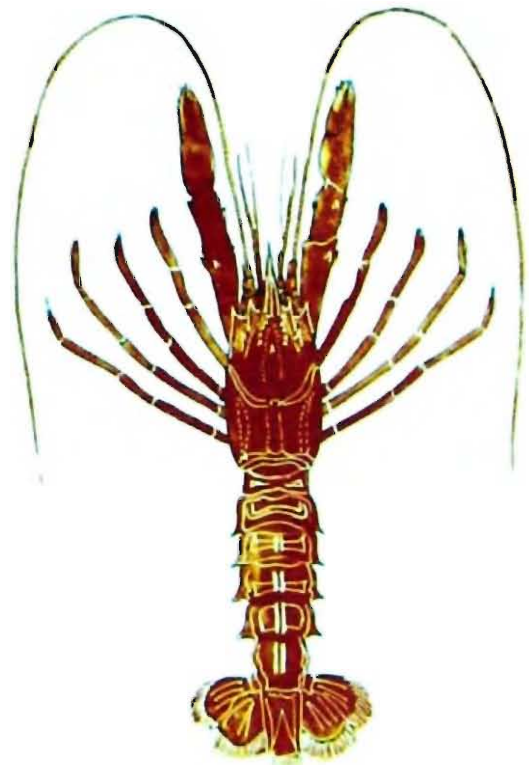
A. *Acanthocaris tenuimana*



B. *Nephropsis carpentari*



C. *Nephropsis stewarti*



D. *Nephropsis ensirostris*

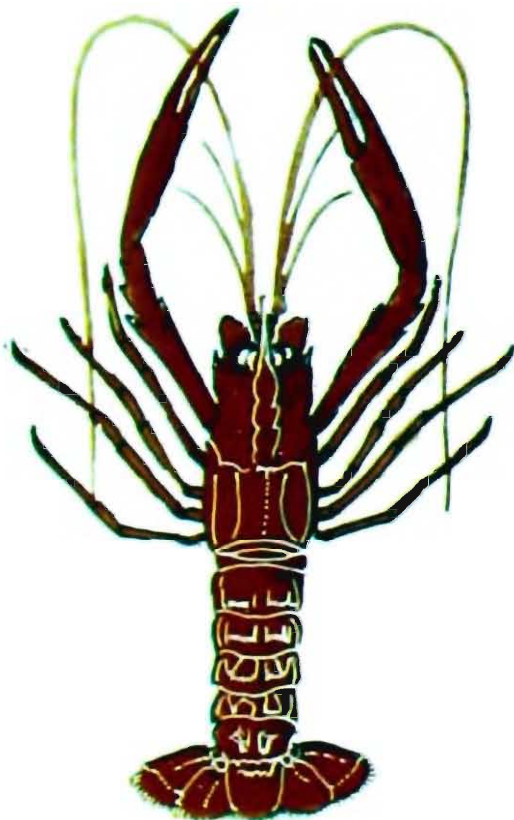
PLATE-II



A. Nephropsis suhmi



B. Nephropsis sulcata



C. Metanephrops andamanicus



D. Polychaelus tiplops

PLATE-III



A. *Linuparus somniosus*



B. *Linuparus andamanensis*



C. *Palinustus waguensis*



D. *Panulirus homarus*

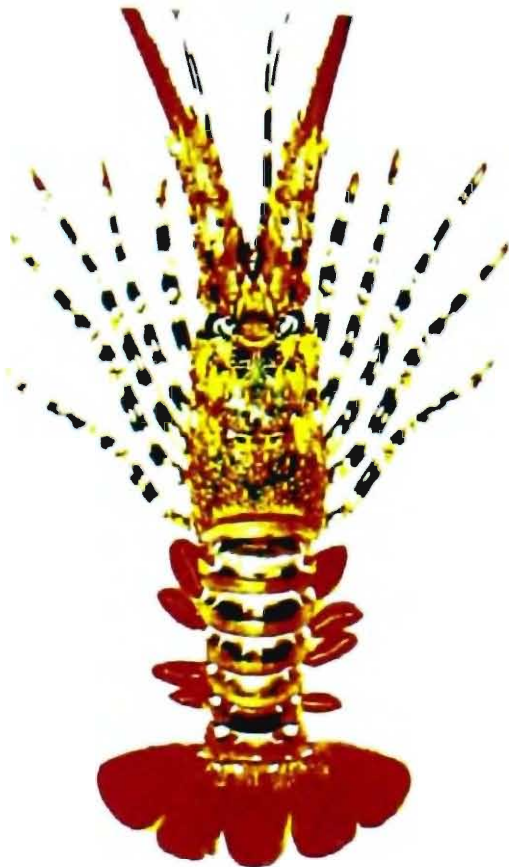
PLATE-IV



A. *Panulirus penicillatus*



B. *Panulirus longipes*



C. *Panulirus ornatus*



D. *Panulirus polyphagus*

PLATE-V



A. *Panulirus versicolor*



B. *Puerulus sewelli*

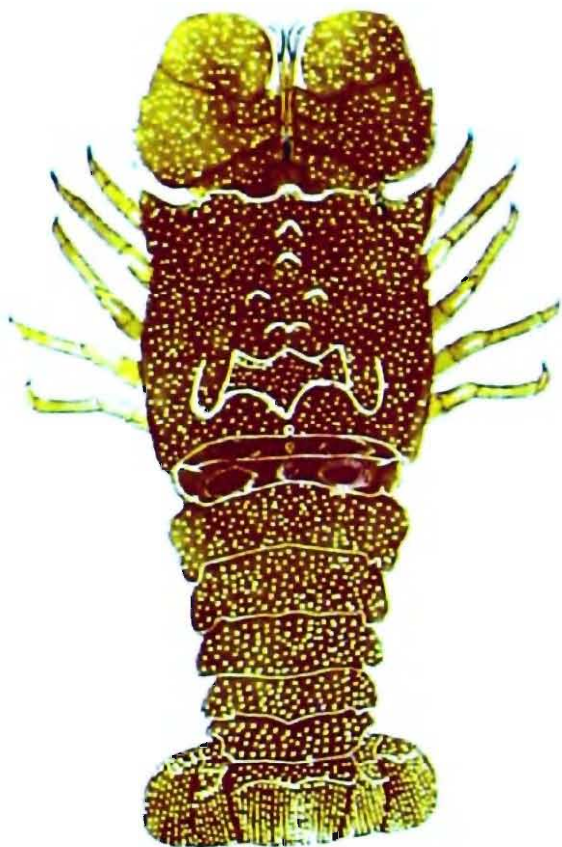


C. *Puerulus angulatus*

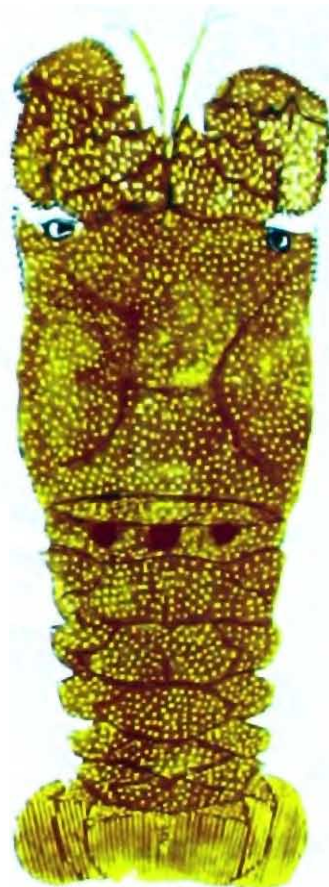


D. *Palinurellus wieneckii*

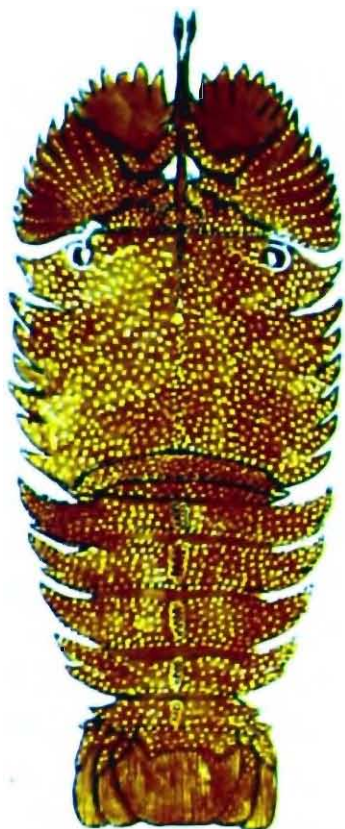
PLATE-VI



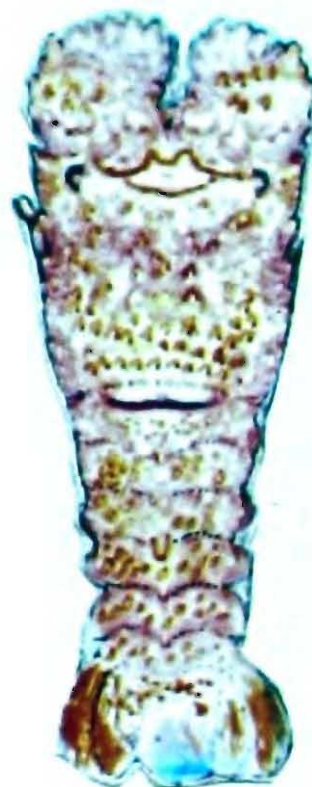
A. *Scyllarides elisabethae*



B. *Scyllarides tridacnophaga*

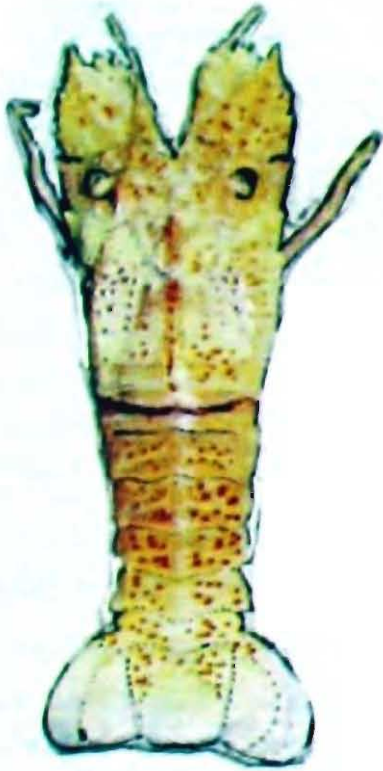


C. *Parribacus antarcticus*



D. *Bathyarctus rubens*

PLATE-VII



A. *Scammarctus batei*



B. *Petrarctus rugosus*



C. *Eduarctus martensii*



D. *Biarctus sordidus*

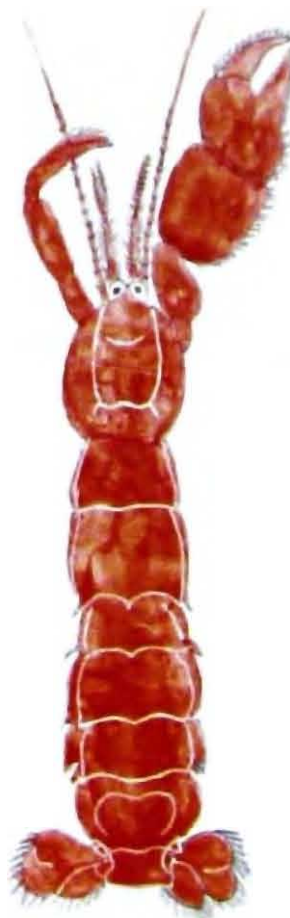
PLATE-VIII



A. *Thenus orientalis*



B. *Callianassa audax*



C. *Callianassa kraussi*

and 3 in Callinassidae) are known to occur in the Exclusive Economic Zone of India. The introduction of new fishing gears such as bottom set gill net (Balasubramaniam *et al.*, 1960; 1962), trawl net in the shallow waters off Gujarat and Maharashtra (CMFRI annual reports) and the deep sea trawling (Rao and George, 1973; oommen, 1985) has increased the lobster production significantly, which has reflected in more foreign exchange earnings as seen in Table-5.

The biological studies on the shallow water species (Kagwade, 1988; Kagwade and Kabili, 1996) and the deep water species (Rao and George, 1973; Kathirvel *et al.*, 1989) have indicated the peak fishing season coincided with the breeding Habitats, which has resulted in the capture of 40-60% of berried females has a negative effect on the recruitment in the subsequent year. In the case of sand lobster (*Thenus orientalis*), the entire family was collapsed off Bombay waters (Deshmukh, 2001).

In order to conserve the natural stock and also to enhance the wild production, the following conservation strategies are suggested :

(1) Fishing season for lobsters coincides with their breeding season. 60 to 80% of females caught are berried. Due to this, chances of breeding and release of phyllosoma larvae is prevented. For example, a total collapse of sand lobster fishery off Mumbai has been recently witnessed. A declining trend is also noticed in other lobster fishery centres. To ensure the release of phyllosoma larvae, a total ban on capture of berried female lobster is suggested.

(2) Like U.S.A., Australia and New Zealand, a licensing system for lobster fishing should be introduced.

(3) A legal size may be fixed (i.e. immature male and female) such immature live specimens should be released back into the sea.

(4) Sea ranching of hatchery produced phyllosoma larvae at major fishing areas to enhance the natural stock.

(5) Tagging programme should be undertaken to study the movement and growth of commercially important species.

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DISTRIBUTION AND ABUNDANCE OF PHYTOPLANKTON ALONG WEST COAST OF INDIA

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ABSTRACT

This paper highlights the distribution and abundance of phytoplankton community from Kandla to (Gujarat) Alang along West Coast of India. The highest phytoplankton count (4372 No. L⁻¹) was observed from Porbandar and the lowest count was from Alang (232 No. L⁻¹). *Coscinodiscus* was the predominant phytoplankton at Porbandar, Dwaraka, Okha, Mahuva and Kandla transect. Other Stations were mostly occupied by *Chaetoceros*, *Navicula*, *Nitzschia* and *Rhizosolenia*. High abundance and density were recorded at the near shore line station. The study provides baseline data on the phytoplankton assemblages (community) which would be a useful tool in any type of studies related to the fishery and the productivity of that particular area under study.

INTRODUCTION

Phytoplankton is the prime component in the food chain of an aquatic ecosystem, which initiates the aquatic food chain. The diatoms commonly known as 'pasture of the sea' or 'meadows of the sea' are unicellular autotrophic organism and form about 90 % of the phytoplankton biomass. "The ocean's invisible forest"- marine phytoplankton play a critical role in regulating the earth's climate (Falkowski, 2002). Plankton particularly phytoplankton have been used as indicators of water quality (Rawson, 1956; Stoermer and Yang, 1969 and Palmer, 1963 & 1969).

The Indian peninsula is surrounded by the Arabian Sea, Bay of Bengal and Indian Ocean. India has a long coastal line of about 7,500 km and the area of Exclusive Economic Zone of the country is about 2.02 million sq. km. The vast marine environment supports various ecosystems rich in biodiversity and multivarious economic development activities. Keeping in view of this subject the Department of Ocean Development (DOD) New Delhi, formulated ocean dealing mega project "Coastal Ocean Monitoring and Prediction System (COMAPS)" and allotted to the Central Salt and Marine Chemicals Research Institute, Bhavnagar for continuous monitoring of the health of the Ocean (Environmental quality) from Kandla to Porbandar and Mahuva to Aliyabet sector. The main objective

of this paper is to elucidate the distribution and abundance of major genera of phytoplankton along West Coast (Gujarat) of India.

MATERIAL AND METHODS

The plankton samples were collected from Kandla to Porbandar and Mahuva to Aliyabet sector on the West Coast of Gujarat covering seven transects viz., Kandala (29°53' to 23°60' N Lat. and 70°13' to 70°13' E Long.), Bedi (22°36' to 23°43' N Lat. and 70°02' to 70°04' E Long.), Okha (22°30' to 23°39' N Lat. and 69°03' to 69°05' E Long.), Dwaraka (21°08' to 21°15' N Lat. and 68°47' to 68°57' E Long.), Porbandar (21°31' to 21°39' N Lat. and 69°27' to 69°38' E Long.), Mahuva (21°01' to 21°05' N Lat. and 71°47' to 71°52' E Long.), Alang (21°18' to 21°22' N Lat. and 72°10' to 72°15' E Long.) (Fig. 1) during March–April 2000. From each transect, three to five sampling stations were fixed at near shore or 1 km, 5 km, 10 km, 15 km and 20 km away from the shoreline.

For phytoplankton studies 100 lit- of surface seawater were collected at different height of the tide from the above said transects and they were filtered through 20 μ mesh size plankton net. The collected phytoplankton were kept in 250 ml seawater and preserved with 4 % formalin and Lugol's Iodine solution for further studies in the laboratory. The Sedgwick Rafter counting chamber was used for qualitative enumeration of phytoplankton by using a light microscope. Standard monographs and other published literature were utilized for taxonomic identification (Husted, 1930; Subrahmanyam, 1946; Peragallo, 1965 a b; Hendy, 1964; Santhanam *et al.*, 1987 and Desikachary, 1988, 1989).

The Generic Diversity of phytoplankton was calculated according to the Shanon and Weaver (1949). Shanon index of general diversity.

$$\bar{H} = \sum (n_i/N) \times \log (n_i/N) \quad \text{or} \quad -\sum p_i \log p_i$$

Where n_i —Importance value for each genera.

N —Total of importance values.

P_i —Importance probability for each species = n_i/N

$\bar{H}$ —is the diversity of a theoretically infinite population.

The similarity index(s) was calculated by using the following formula (ICMAM, 1998).

$$S = (2C/a+b) \times 100$$

or

$$S = 2C / a+b \times 100$$

Where – C —Number of species common at any two stations.

a —Number of species at one station and

b —Number of species at the other station.

RESULT AND DISCUSSION

The results on qualitative and quantitative estimation of different genera of phytoplankton are depicted in Tables 1-7. Seventy genera of phytoplankton were recorded from all seven transects comprising 51, 52, 43, 55, 56, 37 and 36 genera at Kandla, Bedi, Okha, Porbandar, Dwaraka, Mahuva and Alang transects respectively. The maximum number of genera (56) were observed in Dwaraka transect and the least at Alang (36). Thirty genera were common to all seven transects. However, *Lyngbya*, *Ornithocercus*, *Noctiluca*, *Planktoniella* and *Spirulina* were observed only at Dwaraka. *Belleriochea*, *Distephanus* and *Schroederella* were recorded from Kandla transect, while *Pyrophacus*, *Aucalodiscus* found only in Mahuva & Kandla transect. Similarly *Oxytoxum* was recorded from Kandla and Okha transect only. Whereas, *Pinnularia* and *Coccolithophora* were only recorded from Alang transect, likewise *Hyalodiscus* recorded from Mahuva and Alang transect. *Eusynedra* was recorded only from Bedi transect.

The total count of phytoplankton in Kandla transect ranged from 912 at 15 Km offshore to 1170 No. L⁻¹ at near shore i.e. 1 Km, while for Bedi transect it varied from 497 at 5 Km offshore to 2061 No. L⁻¹ at near shore. Similarly in Okha transect it ranged from 739 at 15 Km offshore to 1456 No. L⁻¹ at near shore station. While in Porbandar transect it varied from 2203 at 5 Km offshore to 4372 No. L⁻¹ at 1 Km. In Dwaraka transect total count of phytoplankton ranged from 1155 at 20 Km offshore to 3079 No. L⁻¹ at 5 Km offshore. while for Mahuva transect it varied from 416 at near shore station to 598 No. L⁻¹ at 15 Km offshore station and finally in Alang transect it ranged from 232 at 10 km offshore to 421 No. L⁻¹ at near shore station. The total count of phytoplankton showed the transect wise trend. Porbandar > Dwaraka > Bedi > Okha > Kandla > Mahuva > Alang.

In general, *Coscinodiscus* was the most abundant phytoplankton as compared to other genera at all seven transects. The count of *Coscinodiscus* ranged from 6.51% in Bedi transect to 55% in Kandla transect out of total count of these genera at seven transects. Where as, the other stations of the transects were mostly occupied by *Chaetoceros*, *Navicula*, *Nitzschia* and *Rhizosolenia*. However, the total count of phytoplankton at near shore station was high probably due to the sufficiently higher concentration of plant nutrient at this station.

The generic diversity of phytoplankton in all stations and transects were low. The generic diversity within all stations of seven transects ranged from 0.90 to 0.96 at Kandla, 1.00 to 1.31 at Bedi, 0.99 to 1.26 at Okha, 1.10 to 1.26 at Porbandar, 1.10 to 1.41 at Dwaraka, 0.78 to 1.02 at Mahuva and 1.09 to 1.19 at Alang transect. However, the similarity index ranged from 84.33 to 85.36 at Kandla, 61.76 to 66.66 at Bedi, 57.69 to 62.51 at Okha, 78.94 to 86.48 at Porbandar, 87.9 to 93.18 at Dwaraka, 60.46 at Mahuva to 81.35 at Alang. The similarity index indicated that all the transects were more or less similar. However the Dwaraka was slightly more similar with Porbandar than the other transects.

CONCLUSION

The highest phytoplankton density (4372 No.L⁻¹) was recorded in Porbandar transect at near shore Station and the lowest density (232 No.L⁻¹) was observed from Alang at 10 km offshore Station. *Coscinodiscus* was the most dominant phytoplankton at all the transects compared to other genera. Other Stations were mostly occupied by *Biddulphia*, *Chaetoceros*, *Navicula*, *Nitzschia* and *Rhizosolenia*.

High density of phytoplankton at Porbander might be due to the availability of nutrient rich water and run off of nutrient from surrounding land area. While low density of phytoplankton at Alang may be due to high turbidity of seawater which attenuates the penetration of light through water column, affecting the growth & productivity of phytoplankton (Tewari *et al.*, 2004).

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Table 1. Qualitative and quantitative estimation of phytoplankton in Kandla transect

Genera	1 km	%	5 km	%	10 km	%	15 km	%
<i>Amphiprora</i>	8	0.68	2	0.20	3	0.40	-	-
<i>Amphora</i>	3	0.25	2	0.20	2	0.30	2	0.20
<i>Asterionella</i>	11	0.94	-	-	6	0.80	2	0.20
<i>Aucalodiscus</i>	-	-	5	0.50	4	0.60	2	0.20
<i>Bacillaria</i>	11	0.94	16	1.50	17	2.30	33	3.60
<i>Biddulphia</i>	15	1.28	3	0.30	2	0.30	5	0.50
<i>Bellerochea</i>	6	0.51	8	0.80	21	2.90	9	1.00
<i>Campylodiscus</i>	10	0.85	-	-	2	0.30	2	0.20
<i>Ceratium</i>	4	0.34	2	0.20	3	0.40	7	0.80
<i>Chaetoceros</i>	4	0.34	10	1.00	8	1.10	12	1.20
<i>Climacosphenia</i>	8	0.68	-	-	4	0.60	2	0.20
<i>Cocconeis</i>	-	-	3	0.30	2	0.30	4	0.40
<i>Coscinodiscus</i>	561	47.94	571	55.0	287	39.5	411	45.1
<i>Cyclotella</i>	8	0.68	5	0.50	3	0.40	19	2.10
<i>Detonula</i>	3	0.25	32	3.10	4	0.60	2	0.20
<i>Dinophysis</i>	2	0.17	2	0.20	3	0.40	7	0.80
<i>Distephanus</i>	-	-	3	0.30	2	0.30	-	-
<i>Ditylum</i>	-	-	-	-	26	3.60	7	0.80
<i>Eucampia</i>	6	0.51	-	-	10	1.40	4	0.40
<i>Fragillaria</i>	11	0.94	13	1.30	18	2.50	-	-
<i>Guinardia</i>	7	0.59	3	0.30	4	0.60	-	-
<i>Gymnodinium</i>	10	0.85	12	1.20	3	0.40	-	-
<i>Gyrosigma</i>	2	0.17	10	1.00	2	0.30	3	0.30
<i>Hyalodiscus</i>	4	0.34	5	0.50	4	0.60	-	-
<i>Lauderia</i>	10	0.85	3	0.30	7	1.00	4	0.40
<i>Leptocylindrus</i>	24	2.05	14	1.30	24	3.30	20	2.20
<i>Licmophora</i>	10	0.85	3	0.30	6	0.80	-	-
<i>Melosira</i>	-	-	2	0.20	3	0.40	2	0.20
<i>Navicula</i>	8	0.68	17	1.60	8	1.10	12	1.30
<i>Nitzschia</i>	88	7.52	7	0.70	16	2.20	22	2.40

Table 1. Contd.

Genera	1 km	%	5 km	%	10 km	%	15 km	%
<i>Oscillatoria</i>	-	-	56	5.40	9	1.20	151	16.60
<i>Oxytoxum</i>	8	0.68	4	0.40	-	-	2	0.20
<i>Peridinium</i>	3	0.25	2	0.20	4	0.60	4	0.40
<i>Phaeocystis</i>	4	0.34	3	0.30	24	3.30	10	1.10
<i>Pleurosigma</i>	18	1.53	20	1.90	4	0.60	14	1.50
<i>Pyrophacus</i>	-	-	2	0.20	-	-	2	0.20
<i>Rhabdonema</i>	8	0.68	10	1.00	-	-	2	0.20
<i>Rhizosolenia</i>	10	0.85	6	0.60	8	1.10	7	0.80
<i>Schroederella</i>	-	-	3	0.30	2	0.30	7	0.80
<i>Skeletonema</i>	11	0.94	4	0.40	-	-	7	0.80
<i>Staureneis</i>	-	-	7	0.70	-	-	2	0.20
<i>Stephanopyxis</i>	7	0.59	10	1.00	53	7.30	4	0.40
<i>Surirella</i>	42	3.58	27	2.60	18	2.50	10	1.10
<i>Synedra</i>	10	0.85	57	5.50	12	1.70	3	0.30
<i>Thalassionema</i>	71	6.06	16	1.50	27	3.70	51	5.60
<i>Thalassiosira</i>	85	7.26	10	1.00	43	5.90	28	3.10
<i>Thalassiothrix</i>	56	4.78	46	4.40	15	2.10	15	1.60
<i>Triceratium</i>	3	0.25	3	0.30	4	0.60	5	0.50
Total count No. L⁻¹	1170		1039		727		912	
Total No. of Genera	39		43		43		41	
Generic Diversity	0.96		0.94		0.90		0.92	
Similarity Index	85.36				84.33			

Km—Distance in Kilometer, %—Composition of genera in per cent.

Table 2. Qualitative and quantitative estimation of phytoplankton in Bedi transect

Genera	1 km	%	5 km	%	10 km	%	15 km	%
<i>Amphiprora</i>		-	7	1.40	-	-	1	0.19
<i>Amphora</i>	-	—	2	0.40	-	-		-
<i>Bacillaria</i>	23	1.11	29	5.83	-		7	1.33
<i>Bacteriostrum</i>	18	0.87			-	-	-	-

Table 2. Contd.

Genera	1 km	%	5 km	%	10 km	%	15 km	%
<i>Biddulphia</i>	50	2.42	35	7.04	8	1.27	56	10.70
<i>Bellerocha</i>	5	0.24	-	-	-	-	-	-
<i>Campylodiscus</i>	5	0.24	-	-	-	-	1	0.19
<i>Cerataulina</i>	6	0.29	2	0.40	21	3.34	8	1.52
<i>Ceratium</i>	72	3.48	43	8.65		-	15	2.86
<i>Chaetoceros</i>	414	20.02	82	16.49	92	14.67	50	9.56
<i>Climacodium</i>	4	0.19	1	0.20	-	-	-	-
<i>Climacosphenia</i>	41	1.98	-	-	-	-	7	1.33
<i>Corethron</i>	13	0.63	48	9.65	-	-	3	0.57
<i>Coscinodiscus</i>	13	0.63	12	2.41	91	14.5	64	12.2
<i>Cyclotella</i>	12	0.58	-	-	6	0.95	1	0.19
<i>Detonula</i>	50	2.42	12	2.41	-	-	15	2.86
<i>Dinophysis</i>	9	0.44	4	0.80	-	-	-	-
<i>Ditylum</i>	63	3.05	-	-	14	2.23	18	3.44
<i>Eucampia</i>	23	1.11	7	1.40	-	-	1	0.19
<i>Eusynedra</i>	5	0.24	-	-	-	-	-	-
<i>Exuviella</i>	-	-	-	-	-	-	18	3.44
<i>Fragillaria</i>	32	1.55	13	2.61	-	-	-	-
<i>Grammatophora</i>	63	3.05	-	-	-	-	-	-
<i>Guinardia</i>	99	4.79	4	0.80	35	5.58	-	-
<i>Gymnodinium</i>	-	-	-	-	1	0.15	-	-
<i>Gyrosigma</i>	5	0.24	7	1.40	7	1.11	7	1.33
<i>Lauderia</i>	15	0.73	4	0.80	-	-	7	1.33
<i>Leptocylindrus</i>	83	4.01	-	-	29	4.62	14	2.67
<i>Licmophora</i>	24	1.16	1	0.20	-	-	-	-
<i>Melosira</i>	-	-	6	1.20	14	2.23	14	2.67
<i>Navicula</i>	140	6.77	29	5.83	8	1.27	9	1.72
<i>Nitzschia</i>	59	2.85	0.48	0.10	43	6.85	15	2.86
<i>Oscillatoria</i>	63	3.05	-	-	-	-	-	-

Table 2. Contd.

Genera	1 km	%	5 km	%	10 km	%	15 km	%
<i>Peridinium</i>	1	0.05	-	-	7	1.11	-	-
<i>Planktoniella</i>	5	0.24	18	3.62	1	0.15	-	-
<i>Pleurosigma</i>	14	0.68	-	-	28	4.46	28	5.35
<i>Podocystis</i>	3	0.15	-	-	-	-	-	-
<i>Protoperidinium</i>	1	0.05	-	-	-	-	-	-
<i>Rhabdonema</i>	32	1.55	29	5.83	28	4.46	14	2.67
<i>Rhizosolenia</i>	126	6.09	-	-	133	21.2	92	17.5
<i>Skeletonema</i>	27	1.31	-	-	-	-	-	-
<i>Staureneis</i>	9	0.44	-	-	-	-	-	-
<i>Stephanopyxis</i>	10	0.48	-	-	-	-	-	-
<i>Surirella</i>	5	0.24	-	-	-	-	-	-
<i>Synedra</i>	27	1.31	-	-	-	-	8	1.52
<i>Thalassionema</i>	27	1.31	-	-	8	1.27	8	1.52
<i>Thalassiosira</i>	14	0.68	54	10.86	28	4.46	42	8.03
<i>Thalassiothrix</i>	14	0.68	-	-	25	3.98	-	-
<i>Triceratium</i>	11	0.53	-	-	-	-	-	-
Total count No. L⁻¹	2061		497		627		523	
Total No. of Genera	44		24		21		27	
Generic Diversity	1.31		1.00		1.07		1.17	
Similarity Index	61.76				66.66			

Table 3. Qualitative and quantitative estimation of phytoplankton in Okha transect

Genera	1 km	%	5 km	%	10 km	%	15 km	%	20 km	%
<i>Amphiprora</i>	-	-	14	0.97	-	-	-	-	8	0.76
<i>Amphora</i>	-	-	7	0.48		-	40	5.41	-	
<i>Asterionella</i>	7	0.48	-	-		-	-	-	6	0.57
<i>Bacillaria</i>	-	-	26	1.80	-	-	50	6.76	-	-
<i>Biddulphia</i>	52	3.57	156	10.85	88	8.48	15	2.02	44	4.19
<i>Camylodiscus</i>	20	1.37	58	4.03	-	-	-		-	
<i>Cerataulina</i>	10	0.68	-	-	22	2.12	28	3.78	-	

Table 3. Contd.

Genera	1 km	%	5 km	%	10 km	%	15 km	%	20 km	%
<i>Certium</i>	-	-	10	0.69	-	-	28	3.78	-	-
<i>Chaetoceros</i>	26	1.78	48	3.34	-	-	50	6.76	139	13.26
<i>Climacodium</i>	10	0.68	-	-	-	-	28	3.78	44	4.19
<i>Cocconeis</i>	13	0.89	5	0.34	4	0.38	63	8.52	4	0.38
<i>Coscinodiscus</i>	169	11.60	204	14.19	165	15.91	3	0.40	118	11.25
<i>Detonula</i>	31	2.12	-	-	-	-	-	-	21	2.00
<i>Dinophysis</i>	-	-	7	0.48	24	2.41	38	5.14	4	0.38
<i>Diploneis</i>	-	-	-	-	-	-	50	6.76	-	-
<i>Ditylum</i>	150	10.30	108	7.51	33	3.18	-	-	21	2.00
<i>Eucampia</i>	-	-	-	-	11	1.06	-	-	21	2.00
<i>Exuviella</i>	8	0.54	-	-	-	-	58	7.84	-	-
<i>Fragillaria</i>	156	10.71	108	7.51	88	8.48	8	1.08	82	7.82
<i>Guinardia</i>	26	1.78	-	-	-	-	28	3.78	4	0.38
<i>Gyrosigma</i>	3	0.20	-	-	-	-	-	-	88	8.39
<i>Isthmia</i>	91	6.25	-	-	66	6.36	-	-	-	-
<i>Lauderia</i>	26	1.78	-	-	22	2.12	-	-	34	3.24
<i>Leptocylindrus</i>	85	5.83	-	-	13	1.25	-	-	15	1.43
<i>Licmophora</i>	13	0.89	-	-	-	-	25	3.38	-	-
<i>Melosira</i>	33	2.26	-	-	-	-	-	-	-	-
<i>Navicula</i>	46	3.15	41	2.85	13	1.25	8	1.08	32	3.05
<i>Nitzschia</i>	91	6.25	132	9.18	35	3.37	40	5.41	32	3.05
<i>Oscillatoria</i>	-	-	192	13.36	99	9.54	-	-	-	-
<i>Oxytoxum</i>	-	-	-	-	-	-	-	-	2	0.19
<i>Peridinium</i>	-	-	-	-	44	4.24	5	0.67	-	-
<i>Phaeocystis</i>	-	-	-	-	22	2.12	-	-	-	-
<i>Pleurosigma</i>	52	3.57	-	-	44	4.24	50	6.78	78	7.44
<i>Prorocentrum</i>	13	0.89	-	-	11	1.06	8	1.08	-	-
<i>Rhabdonema</i>	33	2.26	22	1.53	-	-	-	-	-	-
<i>Rhizosolenia</i>	59	4.05	168	11.69	88	8.48	28	3.78	55	5.24
<i>Skeletonema</i>	30	2.06	-	-	-	-	-	-	-	-

Table 3. Contd.

Genera	1 km	%	5 km	%	10 km	%	15 km	%	20 km	%
<i>Staureneis</i>	-	-	-	-	22	2.12	-	-	-	-
<i>Stephanopyxis</i>	46	3.15	28	1.94	44	4.24	-	-	38	3.62
<i>Synedra</i>	23	1.57	60	4.17	44	4.24	-	-	80	7.63
<i>Thalassionema</i>	98	6.73	-	-	-	-	80	10.82	-	-
<i>Thalassiothrix</i>	20	1.37	36	2.50	24	2.31	-	-	65	6.20
<i>Triceratium</i>	13	0.89	7	0.48	4	0.38	-	-	13	1.24
Total count No.L⁻¹	1456		1437		1037		739		1048	
Total No. of Genera	31		21		24		23		25	
Generic Diversity	1.26		1.25		1.18		0.99		1.20	
Similarity Index	57.69						62.5			

Table 4. Qualitative and quantitative estimation of phytoplankton in Porbandar transect

Genera	1 km	%	5 km	%	10 km	%	15 km	%	20 km	%
<i>Amphiprora</i>	35	0.80	26	1.18	10	0.42	7	0.18	22	0.96
<i>Amphitetra</i>	14	0.32	-	-	6	0.25	14	0.37	-	
<i>Amphora</i>	35	0.80	7	0.32	-	-	-	-	-	
<i>Asterionella</i>	23	0.53	10	0.45	7	0.29	14	0.37	7	0.31
<i>Bacillaria</i>	127	2.90	65	2.95	26	1.10	10	0.26	8	0.35
<i>Biddulphia</i>	115	2.63	24	1.09	36	1.52	28	0.73	7	0.31
<i>Campylodiscus</i>	81	1.85	-	-	-	-	-	-		
<i>Celoneis</i>	12	0.27	48	2.18	28	1.18	16	0.42	10	0.44
<i>Cerataulina</i>		0.00	17	0.77	-	-	-	-	28	1.22
<i>Ceratium</i>		0.00	1	0.05	-	-	1	0.03		
<i>Chaetoceros</i>	449	10.26	168	7.62	110	4.64	90	2.35	55	2.40
<i>Climacodium</i>	8	0.18	10	0.45	30	1.26	8	0.21		
<i>Climacosphenia</i>	184	4.20	50	2.27	24	1.01	189	4.93	56	2.44
<i>Cocconeis</i>	345	7.89	139	6.31	17	0.72	86	2.24	20	0.87
<i>Corethron</i>		0.00	-	-	-	-	6	0.16	8	0.35
<i>Coscinodiscus</i>	529	12.08	322	14.61	160	6.74	90	2.35	110	4.80

Table 4. Contd.

Genera	1 km	%	5 km	%	10 km	%	15 km	%	20 km	%
<i>Cyclotella</i>	9	0.21	10	0.45	-	-	-	-	-	-
<i>Detonula</i>	30	0.68	70	3.18	120	5.06	178	4.64	168	7.33
<i>Dinophysis</i>	1	0.02	-	-	-	-	-	-	1	0.04
<i>Diploneis</i>	46	1.05	19	0.86	30	1.26	10	0.26	7	0.31
<i>Ditylum</i>		0.00	-	-	-	-	392	10.22	84	3.67
<i>Eusynedra</i>	18	0.41	-	-	-	-	-	-	-	-
<i>Exuviella</i>		0.00	24	1.09	8	0.34	19	0.50	6	0.26
<i>Fragillaria</i>	667	15.23	216	9.80	129	5.44	88	2.29	70	3.06
<i>Grammatophora</i>		0.00	6	0.27	-	-	-	-	-	-
<i>Guinardia</i>	35	0.80	24	1.09	10	0.42	6	0.16	5	0.22
<i>Gymnodinium</i>	10	0.23	-	-	10	0.42	-	-	3	0.13
<i>Gyrosigma</i>	23	0.53	9	0.41	6	0.25	8	0.21	10	0.44
<i>Isthmia</i>	85	1.94	30	1.36	40	1.69	20	0.52	10	0.44
<i>Lauderia</i>	-	0.00	12	0.54	24	1.01	28	0.73	-	-
<i>Leptocylindrus</i>	126	2.88	70	3.18	14	0.59	49	1.28	38	1.66
<i>Licmophora</i>	30	0.68	48	2.18	50	2.11	246	6.41	70	3.06
<i>Lyngbya</i>	23	0.53	-	-	26	1.10	10	0.26	7	0.31
<i>Melosira</i>	12	0.27	-	-	84	3.54	70	1.83	-	-
<i>Navicula</i>	334	7.63	24	1.09	50	2.11	-	-	-	-
<i>Nitzschia</i>	138	3.15	141	6.40	84	3.54	588	15.33	24	1.05
<i>Oscillatoria</i>	115	2.63	70	3.18	240	10.11	163	4.25	660	28.81
<i>Peridinium</i>	2	0.05	50	2.27	-	-	21	0.55	-	-
<i>Phaeocystis</i>	23	0.53	-	-	-	-	-	-	-	-
<i>Planktoniella</i>		0.00	-	-	-	-	15	0.39	17	0.74
<i>Pleurosigma</i>	69	1.58	38	1.72	10	0.42	21	0.55	-	-
<i>Podocystis</i>	14	0.32	-	-	-	-	-	-	-	-
<i>Rhabdonema</i>	253	5.78	204	9.26	80	3.37	70	1.83	110	4.80
<i>Rhizosolenia</i>	5	0.11	-	-	72	3.03	70	1.83	72	3.14
<i>Skeletonema</i>	35	0.80	96	4.36	288	12.14	325	8.47	208	9.08
<i>Staureneis</i>	69	1.58	17	0.77	10	0.42	9	0.23	-	-

Table 4. Contd.

Genera	1 km	%	5 km	%	10 km	%	15 km	%	20 km	%
<i>Stephanopyxis</i>		0.00	14	0.64	8	0.34	-	-	6	0.26
<i>Streptotheca</i>		0.00	-	-	7	0.29	-	-	-	-
<i>Surirella</i>	23	0.53	2	0.09	-	-	-	-	-	-
<i>Synedra</i>	69	1.58	72	3.27	126	5.31	462	12.05	254	11.09
<i>Tabellaria</i>	14	0.32	-	-	-	-	-	-	-	
<i>Thalassionema</i>	12	0.27	-	-	60	2.53	21	0.55	7	0.31
<i>Thalassiosira</i>	30	0.68	10	0.45	20	0.84	49	1.28	10	0.44
<i>Thalassiothrix</i>	35	0.80	40	1.82	204	8.60	108	2.82	90	3.93
<i>Triceratium</i>	46	1.05	-	-	26	1.10	10	0.26	19	0.83
Total count No. L⁻¹	4372		2203		2369		3829		2287	
Total No. of Genera	44		38		39		39		35	
Generic Diversity	1.23		1.18		1.10		1.12		1.26	
Similarity Index	78.04		-		-		86.48		-	

Table 5. Qualitative and quantitative estimation of phytoplankton in Dwaraka transect

Genera	1 km	%	5 km	%	10 km	%	15 km	%	20 km	%
<i>Amphiprora</i>	54	1.87	72	2.33	6	0.24	15	1.04	2	0.17
<i>Amphitetra</i>	-	-	10	0.32	-	-	-	-	-	-
<i>Amphora</i>	-	-	60	1.94	11	0.44	5	0.35	2	0.17
<i>Asterionella</i>	68	2.36	14	0.45	8	0.32	20	1.39	5	0.43
<i>Bacillaria</i>	19	0.66	113	3.65	30	1.20	15	1.04	11	0.95
<i>Bacteriostrum</i>	61	2.12	103	3.33	65	2.60	17	1.18	-	-
<i>Biddulphia</i>	94	3.26	96	3.10	76	3.04	53	3.68	30	2.59
<i>Campylodiscus</i>	10	0.35	84	2.72	38	1.52	17	1.18	27	2.33
<i>Celoneis</i>	3	0.10	-	-	-	-			-	-
<i>Cerataulina</i>	12	0.42	26	0.84	11	0.44	5	0.35	-	
<i>Ceratium</i>	9	0.31	41	1.33	29	1.16	10	0.69	40	3.45
<i>Chaetoceros</i>	264	9.16	156	5.05	114	4.56	119	8.25	94	8.10
<i>Climacodium</i>	3	0.10	-	-	8	0.32	-	-	7	0.60
<i>Climacosphenia</i>	73	2.53	48	1.55	40	1.60	7	0.49	-	-

Table 5. Contd.

Genera	1 km	%	5 km	%	10 km	%	15 km	%	20 km	%
<i>Cocconeis</i>	-	-	7	0.23	29	1.16	14	0.97	-	-
<i>Corethron</i>	43	1.49	-	-	-	-	10	0.69	-	-
<i>Coscinodiscus</i>	736	25.55	132	4.27	171	6.84	145	10.06	41	3.53
<i>Cyclotella</i>	-	-	22	0.71	13	0.52	2	0.14	-	-
<i>Dactyliosolen</i>	1	0.03	-	-	-	-	-	-	-	-
<i>Detonula</i>	30	1.04	34	1.10	57	2.28	19	1.32	-	-
<i>Dinophysis</i>	3	0.10	60	1.94	70	2.80	22	1.53	8	0.69
<i>Diploneis</i>	2	0.07	-	-	-	-	-	-	-	-
<i>Ditylum</i>	71	2.46	60	1.94	76	3.04	5	0.35	2	0.17
<i>Eucampia</i>	34	1.18	36	1.16	10	0.40	14	0.97	-	-
<i>Fragillaria</i>	74	2.57	48	1.55	114	4.56	15	1.04	18	1.55
<i>Guinardia</i>	34	1.18	36	1.16	49	1.96	5	0.35	7	0.60
<i>Gymnodinium</i>	-	-	-	-	4	0.16	-	-	-	-
<i>Gyrosigma</i>	51	1.77	108	3.49	21	0.84	78	5.41	63	5.43
<i>Isthmia</i>	34	1.18	60	1.94	38	1.52	20	1.39	36	3.10
<i>Lauderia</i>	7	0.24	9	0.29	21	0.84	6	0.42	14	1.21
<i>Leptocylindrus</i>	102	3.54	17	0.55	29	1.16	5	0.35	23	1.98
<i>Licmophora</i>	26	0.90	36	1.16	66	2.64	30	2.08	12	1.03
<i>Lyngbya</i>	-	-	-	-	-	-	-	-	11	0.95
<i>Melosira</i>	12	0.42	29	0.94	27	1.08	5	0.35	-	-
<i>Navicula</i>	111	3.85	168	5.43	25	1.00	17	1.18	5	0.43
<i>Nitzschia</i>	262	9.09	456	14.75	551	22.04	379	26.28	333	28.71
<i>Noctiluca</i>	2	0.07	-	-	-	-	-	-	2	0.17
<i>Ornithocercus</i>	-	-	-	-	-	-	-	-	2	0.17
<i>Oscillatoria</i>	26	0.90	72	2.33	67	2.68	26	1.80	8	0.69
<i>Peridinium</i>	9	0.31	192	6.21	17	0.68	5	0.35	16	1.38
<i>Phaeocystis</i>	19	0.66	19	0.61	8	0.32	-	-	-	-
<i>Planktoniella</i>	34	1.18	-	-	6	0.24	-	-	5	0.43
<i>Pleurosigma</i>	10	0.35	192	6.21	105	4.20	39	2.70	45	3.88
<i>Protoperidinium</i>	7	0.24	14	0.45	15	0.60	-	-	-	-

Table 5. Contd.

Genera	1 km	%	5 km	%	10 km	%	15 km	%	20 km	%
<i>Pyrophacus</i>	-	-	-	-	-	-	-		2	0.17
<i>Rhabdonema</i>	73	2.53	20	0.65	38	1.52	12	0.83	-	-
<i>Rhizosolenia</i>	99	3.44	134	4.33	19	0.76	43	2.98	32	2.76
<i>Skeletonema</i>	5	0.17	48	1.55	48	1.92	7	0.49	11	0.95
<i>Spirulina</i>	12	0.42	6	0.19	-	-	-	-	-	-
<i>Staureneis</i>	-	-	8	0.26	29	1.16	12	0.83	-	-
<i>Stephanopyxis</i>	60	2.08	96	3.10	38	1.52	43	2.98	4	0.34
<i>Synendra</i>	43	1.49	12	0.39	57	2.28	17	1.18	-	-
<i>Thalassionema</i>	43	1.49	72	2.33	95	3.80	34	2.36	198	17.07
<i>Thalassiosira</i>	60	2.08	36	1.16	76	3.04	34	2.36	14	1.21
<i>Thalassiothrix</i>	51	1.77	-	-	10	0.40	77	5.34	25	2.16
<i>Triceratium</i>	17	0.59	17	0.55	8	0.32	7	0.49	-	-
Total count No. L⁻¹	2873		3079		2443		1430		1155	
Total No. of Genera	47		44		46		42		35	
Generic Diversity	1.29		1.41		1.23		1.15		1.10	
Similarity Index	87.9		-		-		93.18		-	

Table 6. Qualitative and quantitative estimation of phytoplankton in Mahuva transect

Genera	1 km	%	5 km	%	10 km	%
<i>Amphiprora</i>	2	0.35	19	3.36	-	-
<i>Amphora</i>	4	0.70	-	-		-
<i>Aulacodiscus</i>	-	-	-	-	6	1.00
<i>Biddulphia</i>	-	-	43	7.61	11	1.83
<i>Campylodiscus</i>	-	-	-	-	1	0.17
<i>Ceratium</i>	11	1.94	-	-	10	1.67
<i>Cocconeis</i>	-	-	-	-	10	1.67
<i>Coscinodiscus</i>	178	31.34	104	18.41	309	51.50
<i>Cyclotella</i>	11	1.94	24	4.25	26	4.33
<i>Detonula</i>	-	-	6	1.06		-
<i>Distephanus</i>	-		-	-	6	1.00

Table 6. Contd.

Genera	1 km	%	5 km	%	10 km	%
<i>Ditylum</i>	2	0.35	-	-	-	-
<i>Fragillaria</i>	2	0.35	27	4.78	-	-
<i>Guinardia</i>	-	-	3	0.53	16	2.67
<i>Gymnodinium</i>	5	0.88	-	-	6	1.00
<i>Gyrosigma</i>	-	-	14	2.48	6	1.00
<i>Hyalodiscus</i>	-	-	-	-	10	1.67
<i>Leptocylindrus</i>	-	-	44	7.79	11	1.83
<i>Melosira</i>	-	-	7	1.24	-	-
<i>Navicula</i>	4	0.70	53	9.38	-	-
<i>Nitzschia</i>	67	11.80	24	4.25	8	1.33
<i>Oscillatoria</i>	-	-	26	4.60	18	3.00
<i>Peridinium</i>	-	-	22	3.89	2	0.33
<i>Phaeocystis</i>	4	0.70	-	-	-	-
<i>Pleurosigma</i>	4	0.70	-	-	8	1.33
<i>Pyrophacus</i>	2	0.35	-	-	-	-
<i>Rhizosolenia</i>	90	15.85	-	-	40	6.67
<i>Skeletonema</i>	9	1.58	-	-	-	-
<i>Staureneis</i>	6	1.06	-	-	-	-
<i>Stephanopyxis</i>	4	0.70	60	10.62	6	1.00
<i>Surirella</i>	4	0.70	32	5.66	18	3.00
<i>Synedra</i>	-	-	-	-	3	0.50
<i>Tabellaria</i>	2	0.35	-	-	2	0.33
<i>Thalassiosira</i>	5	0.88	-	-	24	4.00
<i>Thalassiothrix</i>	-	-	39	6.90	16	2.67
<i>Triceratium</i>	-	-	17	3.01	10	1.67
Total count No. L⁻¹	416		564		598	
Total No. of Genera	20		18		25	
Generic Diversity	0.78		1.02		0.88	
Similarity Index	-		60.46		-	

Table 7. Qualitative and quantitative estimation of phytoplankton in Alang transect

Genera	1 km	%	5 km	%	10 km	%
<i>Amphiprora</i>	5	1.19	5	1.33	4	1.72
<i>Amphora</i>	3	0.71	4	1.07	-	-
<i>Bacillaria</i>	78	18.57	23	6.13	27	11.59
<i>Ceratium</i>	15	3.57	76	20.27	12	5.15
<i>Climacosphenia</i>	11	2.62	11	2.93	7	3.00
<i>Coccolithophora</i>	-	-	2	0.53	-	-
<i>Cocconeis</i>	4	0.95	2	0.53	-	-
<i>Coscinodiscus</i>	46	10.95	88	23.47	43	18.45
<i>Cyclotella</i>	10	2.38	-	-	-	-
<i>Dinophysis</i>	3	0.71	4	1.07	-	-
<i>Diploneis</i>	17	4.05	4	1.07	-	-
<i>Ditylum</i>	5	1.19	-	-	10	4.29
<i>Fragillaria</i>	7	1.67	5	1.33	-	-
<i>Grammatophora</i>	5	1.19	-	-	-	-
<i>Gymnodinium</i>	7	1.67	11	2.93	3	1.29
<i>Gyrosigma</i>	9	2.14	-	-	2	0.86
<i>Hyalodiscus</i>	3	0.71	2	0.53	7	3.00
<i>Lauderia</i>	2	0.48	2	0.53	-	-
<i>Leptocylindrus</i>	24	5.71	7	1.87	20	8.58
<i>Melosira</i>	2	0.48	-	-	-	-
<i>Navicula</i>	17	4.05	4	1.07	2	0.86
<i>Nitzschia</i>	2	0.48	7	1.87	-	-
<i>Peridinium</i>	-	-	-	-	3	1.29
<i>Phaeocystis</i>	5	1.19	5	1.33	3	1.29
<i>Pinnularia</i>	-	-	4	1.07	-	-
<i>Pleurosigma</i>	24	5.71	23	6.13	19	8.15
<i>Rhizosolenia</i>	22	5.24	11	2.93	18	7.73
<i>Skeletonema</i>	7	1.67	-	-	8	3.43
<i>Staureneis</i>	-	-	3	0.80	-	-
<i>Stephanopyxis</i>	5	1.19	9	2.40	5	2.15

Table 7. Contd.

Genera	1 km	%	5 km	%	10 km	%
<i>Surirella</i>	4	0.95	-	-	-	-
<i>Synedra</i>	19	4.52	9	2.40	-	-
<i>Thalassionema</i>	-	-	18	4.80	2	0.86
<i>Thalassiosira</i>	19	4.52	9	2.40	25	10.73
<i>Thalassiothrix</i>	12	2.86	25	6.67	9	3.86
<i>Triceratium</i>	2	0.48	2	0.53	-	-
Total count No. L⁻¹	421		374		232	
Total No. of Genera	31		28		20	
Generic Diversity	1.19		1.12		1.09	
Similarity Index	81.35		-		-	

BIODIVERSITY OF EPIFAUNA ASSOCIATED WITH SARGASSUM SP. AROUND KUDANKULAM NUCLEAR POWER PROJECT, EAST COAST OF INDIA

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ABSTRACT

Seaweeds are fascinating and diverse group of marine organisms and play very important ecological role in coastal ecosystem. It provides food and shelter for variety of marine organisms and forms the base of some food webs. The epifaunal assemblages of *Sargassum* sp. in Kudankulam coastal waters were studied for a period of ten months from August 2004 to May 2005. Three stations along the Kudankulam coast were selected for this study. The hydrological parameters were recorded throughout the study period and correlated with epifaunal density and diversity.

INTRODUCTION

The macro algae of the rocky shores houses diverse group of small invertebrates and provide many resources, which are not available on bare rocks. The algae increase the amount of space for attachment, provide shelter from wave action, desiccation and heat. Small crustaceans (amphipods, isopods) and gastropods are abundant on the surface of seaweeds and may be an important food source for juvenile fishes, which are also abundant in macro algae (Jones, 1988). The invertebrates are taxonomically and morphologically diverse, and exhibit a range of trophic habits. They may filter feed (Caine, 1977), graze epiphytic algae (Brawley and Fei, 1987), eat detritus (Zimmerman *et al.*, 1979), prey upon other epifauna (Roland, 1978), or consume on other host plant itself (Duffy, 1990).

Although several studies are available on epifaunal assemblages of marine plants (Edger and Moore, 1986; Aoki, 1988; Taylor, 1998), very little is known about the macro faunal assemblages of seaweeds from Kudankulam coastal waters. The main objective of the present study is to establish a baseline data about the epifauna found on the surface of seaweeds of Kudankulam coastal waters. A study of this kind is of paramount importance in this region due to the emerging mega Atomic Power Project. When the Power Plant attains criticality, the warm water released from the heat exchangers may

elevate the ambient temperature. The warm water may replace the natural flora with less desirable algae. As the algal community forms a good shelter for highly sensitive macro fauna, the results will be helpful for environmentalists and Power Plant authorities to formulate strategies.

MATERIAL AND METHODS

Topography of the study area

The investigation was carried out at Kudankulam coast, Gulf of Mannar. Three stations were selected along the coast to carry out this study (fig 1). A brief description of each station selected for sampling is given below. Seasons at Kudankulam can be conveniently classified into pre-monsoon (Feb.-May.), monsoon (June-Sep.) and post-monsoon (Oct-Jan).

Station I : Chinnamuttom

This station is situated very close to Kanyakumari in the East coast ($8^{\circ}5'81''$ N and $77^{\circ}33'72''$ E), about 23 km South of the Kudankulam Nuclear Power Project. A fishing harbour is located in this area and it is one of the important fish-landing centres.

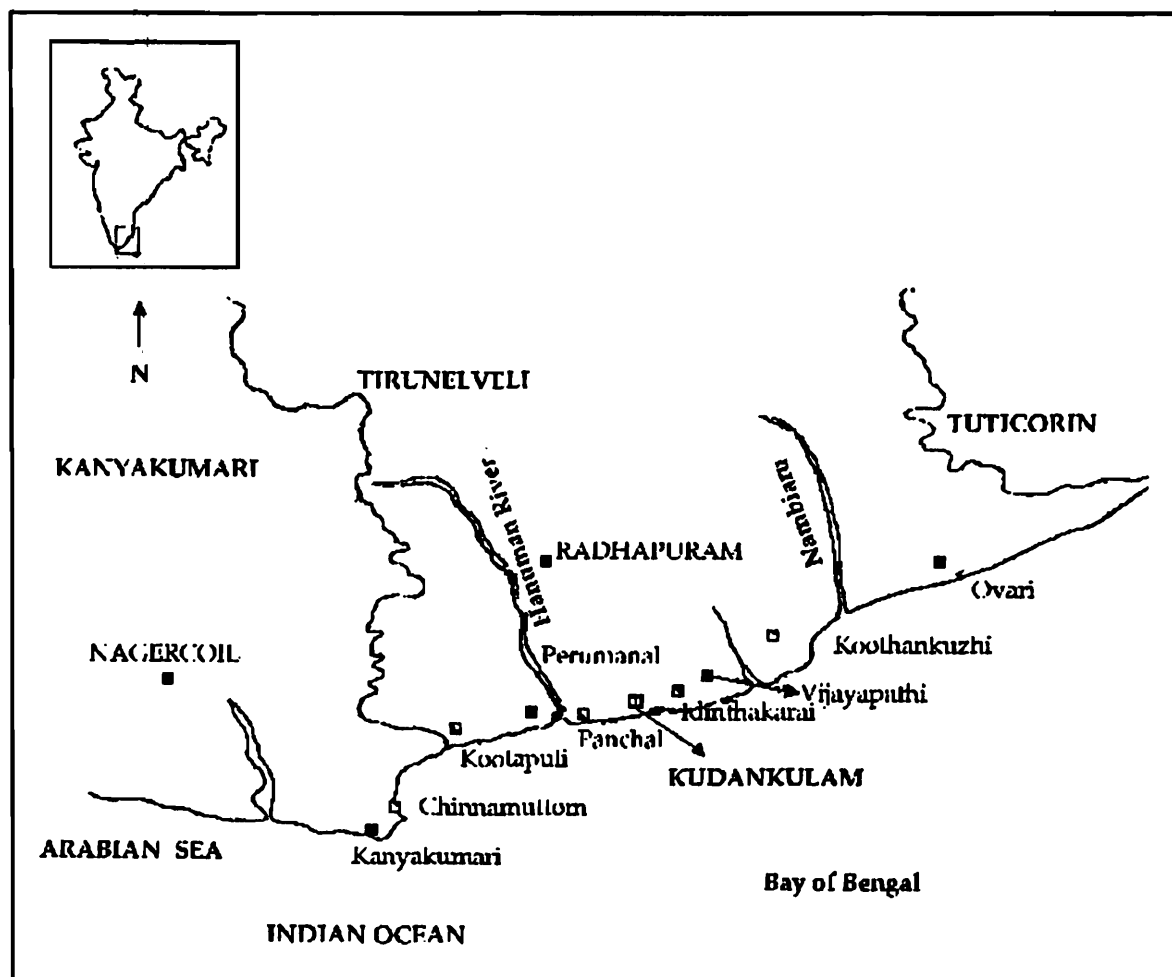


Fig. 1. Study area

Station II. Panchal

A small coastal village situated in between the satellite town Anu Vijay Township and the Atomic Power Project (8°9'5" N and 77°39'59" E). It is about 3 km SouthWest of the Nuclear Power Project.

Station III. Kuthankuzhi

It is a fishing village, located about 9km North-East of the Atomic Power Project (8°12'98" N and 77°46'95" E). This station is rocky and *Sargassum* sp. is one of the dominant seaweed found in this area.

Sampling of epifauna

The sampling of fauna was made at monthly intervals for a period of ten months (August 2004- May 2005) during low tide times. For the epifaunal collection *Sargassum* sp., from the seaweed bed was detached and stored in polythene bags and transported to the laboratory. In the laboratory the algae were washed in a trough, filled with seawater and drops of formalin to remove the epifauna (Taylor and Cole, 1994). The water from the trough was filtered through plankton net. From the filtrate the macro fauna were separated and preserved in 5% neutral formalin. Using standard manuals animals were identified up to the species level wherever possible and the density was expressed as numbers per 100g of algal wet weight. The hydrological parameters considered in this study include surface water temperature, salinity, pH and dissolved oxygen content.

Data analysis

Data on the number of species and the abundance of individual species were used to estimate faunal diversity indices. The relative importance of each species was calculated by the Shannon-Weiner index (Shannon, 1948) using the following expression (Zar, 1984)

$$H' = \frac{n \log n - \sum f_i \log f_i}{n}$$

Where, N–Size of the sample

f_i – number of observation in each category

The distribution of individual species was assessed using evenness index of Pielou (1966).

$J' =$	H
	$H'_{\max}$

$$H'_{\max} = \log k \text{ (k is the number of categories)}$$

The maximum possible diversity ($H'_{\max}$) was also calculated. Correlation coefficient was used to find out the relationship between faunal assemblages and hydrological parameters.

RESULTS AND DISCUSSION

Hydrological parameters

The changes in the hydrological parameters at station I, II and III are given in Tables 1. At station I, the surface water temperature ranged from 25°C to 31°C. At station II and III, the surface water temperature ranged between 27 and 31°C. The salinity ranged between 30 and 36 ppt at station I. The minimum value was noticed during January and the maximum was during September. At station II the salinity ranged between 30 and 35.2ppt with the maximum value during September and the minimum in November. At station III, the salinity ranged from 31 to 36ppt.

Table-1. Hydrological parameters of the study area

Month	Temperature(°C)	Salinity(ppt)	pH	DO(ml/l)
Station I				
August	25	34.5	8.35	4.27
September	28	36	8.45	5.01
October	27.5	34	8.25	4.65
November	28	31.5	8.1	5.12
December	27.5	33	8.2	5.02
January	27	30	8.2	6.3
February	28.5	32	8.25	6.49
March	28.7	32	8.25	3.4
April	29	32.5	8.1	4.1
May	31	34	8.2	3.9
Station II				
August	27	33	7.95	5.12
September	27	35.2	8.4	5.12
October	28.5	34	8.25	4.78
November	29	30	8.1	4.89
December	27.5	33.5	8.15	4.44
January	28	32	8.25	5.69
February	28.5	32	8.32	5.8
March	28.5	32.5	8.27	5.52
April	30	33	8.2	4.7
May	31	35	8.15	4.7

Table-1. Contd.

Month	Temperature(°C)	Salinity(ppt)	pH	DO(ml/l)
Station III				
August	27	35	8.25	4.89
September	29	36	8.4	5.12
October	27.6	35.3	8.4	4.2
November	29.3	32	8.04	5.21
December	28	34	8	5.76
January	28.2	31	8	6.46
February	29.3	33	8.3	4.53
March	29	33	8.25	5.35
April	31	33.5	8.2	4.46
May	29.5	35	8.3	4.5

Maximum pH (8.45) was observed during September at station I and minimum value (8.1) was noted during April and November. At station II the maximum pH (8.4) was noticed in September and minimum (7.95) was in August. The lowest pH (8) at station III was recorded during December and January and the maximum (8.4) value was observed during September and October. At station I, the minimum dissolved oxygen content (3.4 ml/l) was noticed during the month of March and the maximum (6.49ml/l) was in February. At station II, the minimum (4.44ml/l) value was noticed during December and the maximum (5.8ml/l) was in February. The peak value (6.49ml/l) at station III was noticed during January and minimum value (4.2ml/l) was recorded in October.

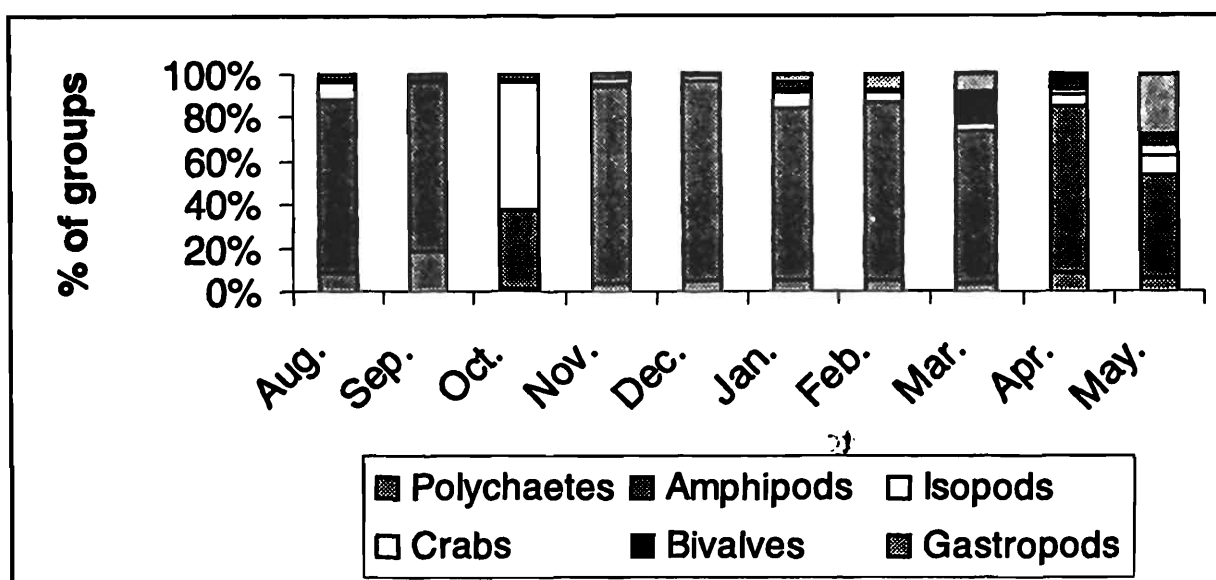
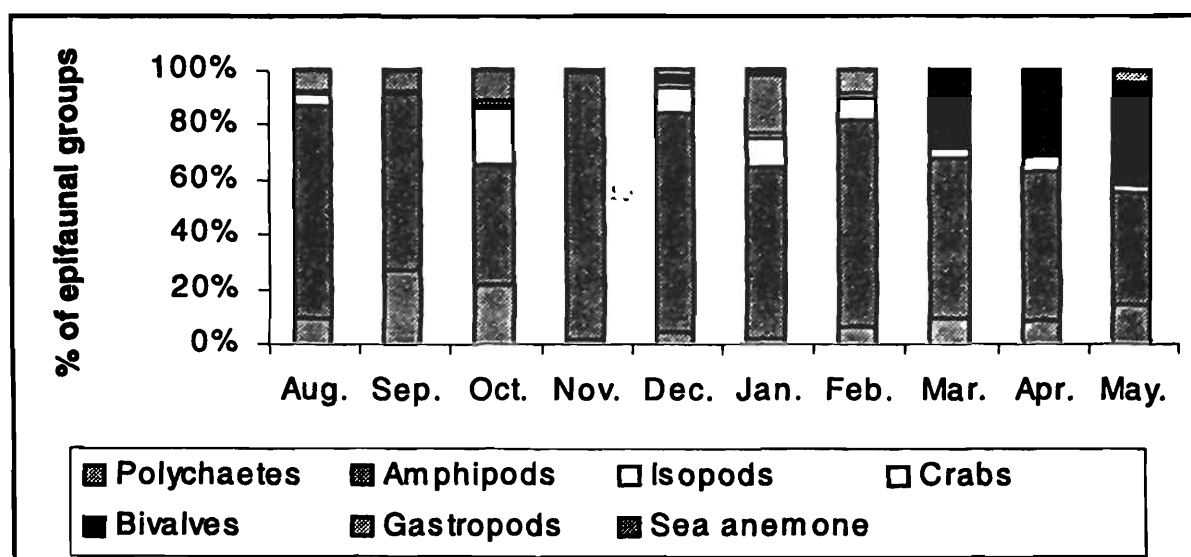
Epifaunal composition

The epifauna found on the surface of seaweeds in Kudankulam coast was rich and varied. As many as 21 species were observed during the study period. Of these gastropods was the dominant epifaunal component with seven species, followed by polychaetes with five species. The other major taxa observed include amphipods, isopods, crabs and bivalves. A detailed checklist of the common epifauna collected during the study period is given in Table-2.

The major epifaunal groups of *Sargassum* sp. at station I, II and III is given in figures 2-4. The total density of epifaunal communities from three stations is illustrated in fig. 5. The epifaunal density was high at station II, when compared to the other two stations. At station I, the density was maximum during October (185/100 g.) and the minimum density of 60/100g. was observed during February. At station II, the peak density was noticed during November (494/100g.) and the density was low during the month of

Table-2. List of common epifauna associated with *Sargassum* sp., in Kudankulam coast.

Phylum			Unidentified groups
ANNELIDA	MOLLUSCA	ARTROPODA	
<i>Syllis gracilis</i>	<i>Cellana radiata</i>	<i>Hyastenus</i> sp.	Brittle star Sea anemone Bivalves
<i>Psudonereis</i> sp.	<i>Trochus radiatus</i>	<i>Gammarus</i> sp.	
<i>Perinereis cultifera</i>	<i>T. stellatus</i>	<i>Podoceros</i> sp.	
<i>Platynereis dumerelli</i>	<i>Turritella</i> sp.	<i>Corophium</i> sp.	
<i>Terebella</i> sp.	<i>Thais rudolphi</i> .	<i>Sphaeroma</i> sp.	
	<i>Nassa dorsata</i>	<i>Cirolina</i> sp.	
	<i>N. jacksoniana</i>		

Fig. 2. Monthly variation of epifaunal groups in *Sargassum* sp., at station IFig. 3. Monthly variation of epifaunal groups in *Sargassum* sp., at station II

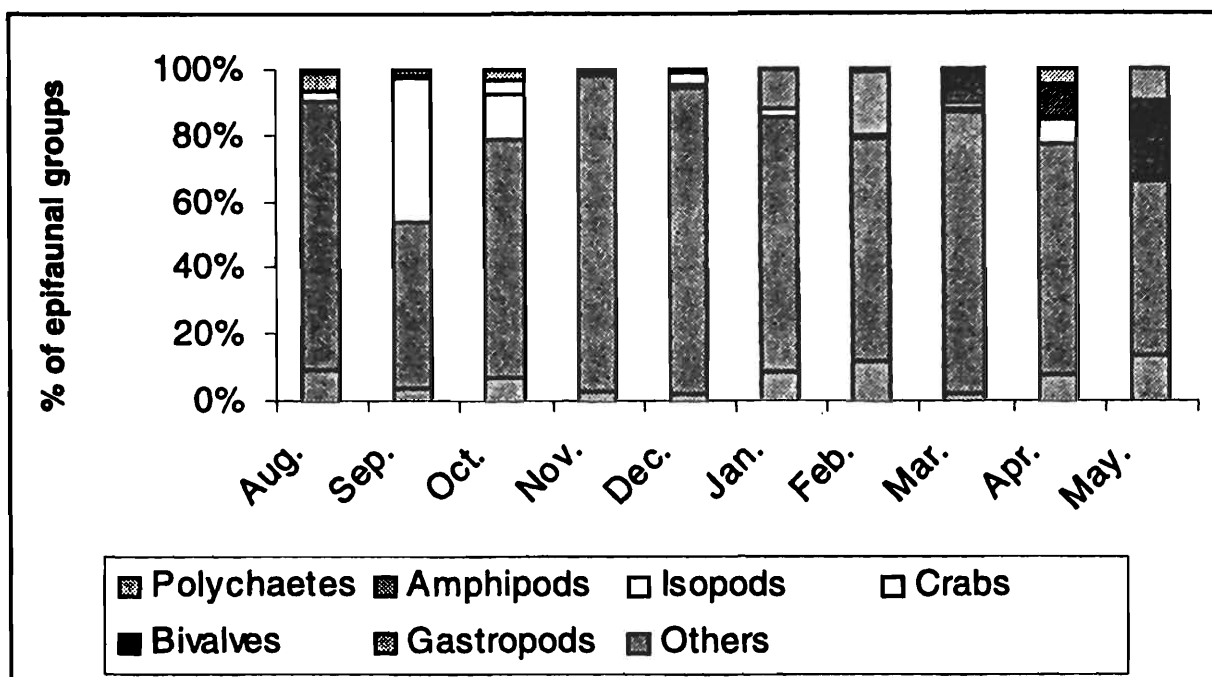


Fig. 4. Monthly variation of epifaunal groups in *Sargassum* sp., at station III

January (47/100 g.). The epifaunal abundance at station III was high during September (323 ind.) and it was low during October (29 ind.).

Five species of polychaetes were observed during the study period. At station I and II, the maximum density of polychaetes (18 and 59 respectively) was observed during September. Polychaetes were high during August (21 ind.). The abundance of polychaetes was low during October at station I and III, and at station II it was less abundant during January (fig. 9). The amphipod peak was observed during October at station I (197 ind.), and at station III it was during September (302 ind.) The maximum density of amphipod

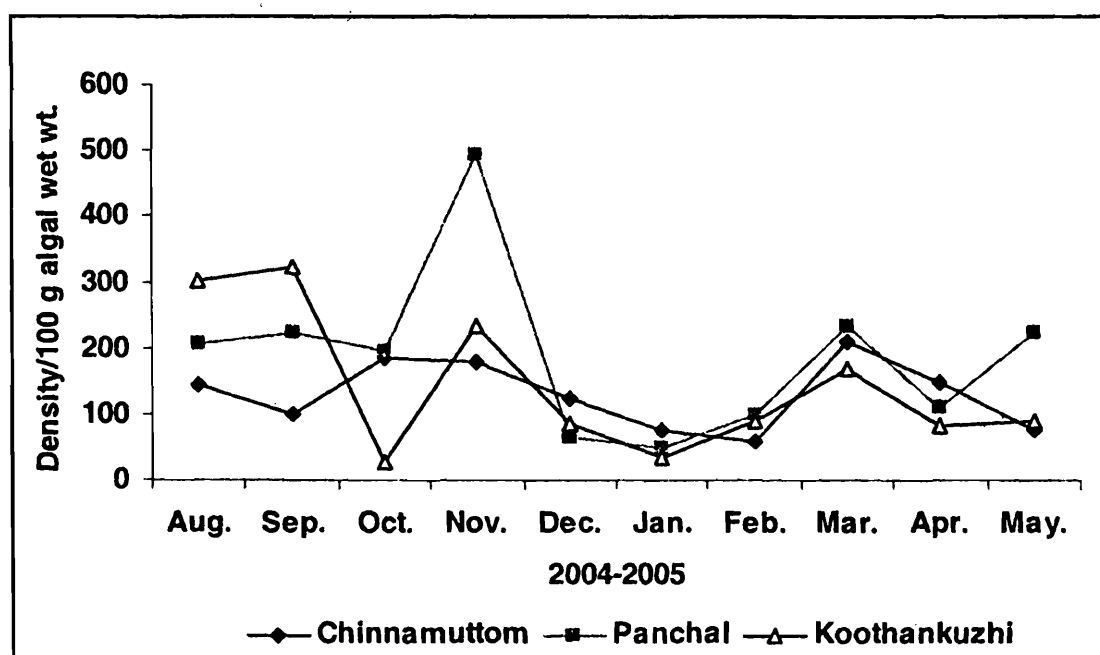


Fig. 5. Total Epifaunal density on *Sargassum* sp.

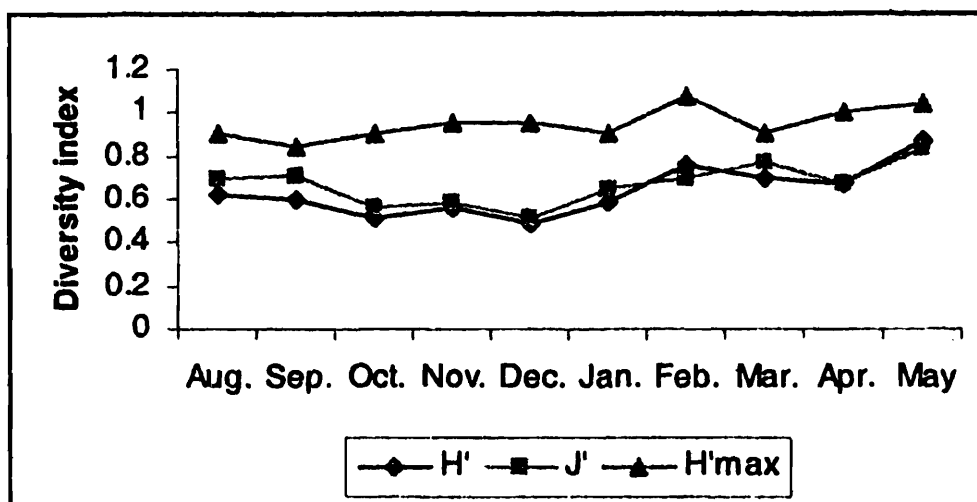


Fig. 6. Diversity indices at station I

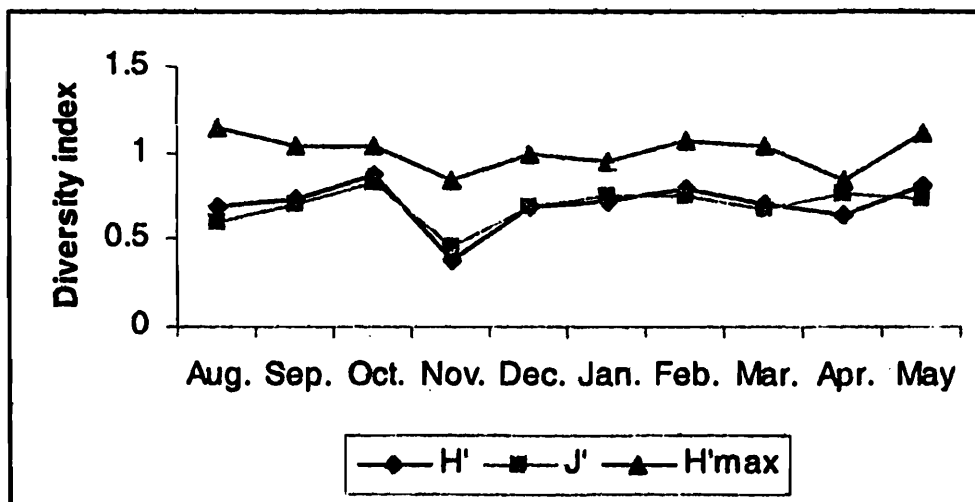


Fig. 7. Diversity indices at station II

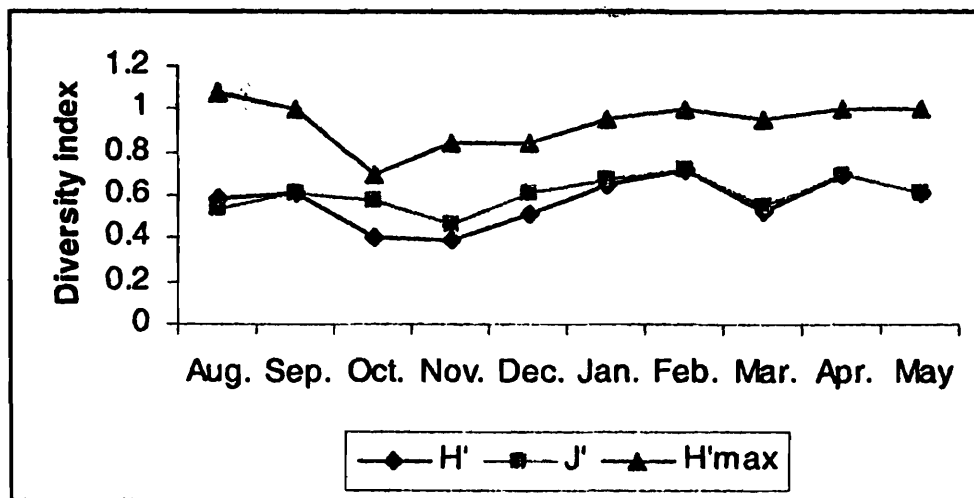


Fig. 8. Diversity indices at station III

was noticed during November (482 ind.) at Station II. The lowest number of amphipods was observed during March at station I (38), during January at station II (49) and during October at Station III (29).

The gastropod abundance was high (23 ind.) during May at station I, at station II it was low (17 ind.) during August. At station III the maximum density (17 ind.) of gastropod was observed in February. The bivalve density was maximum (31 ind.) during March at station I. At station II and III, the maximum bivalve density (81, 27 respectively) was observed during May. The bivalve abundance was observed during the months of March, April and May in all the three stations. The other miscellaneous groups like brittle star and sea anemone were occasionally noticed during the study period. At station II, the sea anemone abundance was high (21) during October.

The seasonal variation of diversity indices of epifauna associated with *Sargassum* sp. is given in figures 6-8. At station I, the maximum H' index of 0.869 was observed during May and minimum of 0.407 was obtained in December. The Shannon-Weiner index of station II varied between 0.387 (November) and 0.867 (October). The H' index at station III varied from 0.389 to 0.727. The maximum index was observed in February and the minimum during November.

The epifaunal density during the study period was high during monsoon season when compared to other two seasons. Similar results of seasonal variation from Tropical Coasts were also observed by Russo (1988) and Martin-Smith (1994). The seasonal variation in species density and diversity observed in the present study was possibly due to the limitation of epifaunal populations by primary production of plant material (Edgar, 1991) and food source of epifauna. Those epifauna that grazed directly upon the seaweeds were likely to be influenced by seasonal fluctuations in food quality. Edgar (1990) presented evidence from microcosm experiments in sea grass beds that the dramatic decline in epifaunal densities that frequently followed seasonal peaks were due to emigration rather than starvation and predation, and speculated that this emigration was due to a falling production of epiphytic algae. Seasonal predation pressure from fish or decapods was another factor, which influenced population dynamics of the epifauna.

The density of some epifaunal groups associated with seaweeds showed a clear variation over the study period. The increase in density of some groups such as polychaetes and amphipods during monsoon months and bivalves during pre-monsoon season could have been caused by different factors such as recruitment peaks and dispersal ability of juveniles. The reduction in density could be explained by migration and reduction of seaweed abundance. Similarly, epifaunal group variation was also observed from Flamingo of Brazil Bay (Fosco and Alexander, 2003). Many epifaunal taxa, especially amphipods and isopods, are demersal zooplanktons, and spend time in the water column at night, resettling on various substrata before day break. Depending on how far they have moved and resettled also affected the epifaunal density.

The most frequently cited abiotic factors controlling the distribution of epifaunal assemblages are tidal rhythm, wave action, water current, light, temperature, salinity, pH, concentration of nutrients and dissolved gases. In the present study, the hydrological parameters such as salinity, pH, dissolved oxygen content, nitrate, nitrite and phosphate did not show much influence on the epifaunal abundance as evidenced from the observed non significant correlation coefficient values (Table-3).

Table-3. Correlation coefficient between epifauna density and hydrological parameters

Hydrological parameter	r- value
Surface water temperature	-0.155
Dissolved oxygen content	-0.234
pH	0.183
Salinity	0.199

The structure of communities may also be strongly influenced by the anthropogenic impacts such as the harvesting of seaweeds by the local people. The present study showed that the density of polychaetes and gastropods declined during the months of November and December possibly due to the disturbances created by the local people during seaweed collection. The decline in the density of polychaetes during the same period due to *Sargassum* harvesting was also observed by Satheesh and Wesley (2005).

The diversity and abundance of the epifauna associated with *Sargassum* sp., indicates that more attention needs to be paid to their functional role. These epifauna appear to influence the distribution and abundance of other organisms, because as prey items, they regulate populations of many reef fishes. The epifauna provide a potentially important trophic link between fish and primary producers such as the host seaweed with its associated periphyton and phytoplankton from the surrounding water. This study was only a preliminary one conducted in this coastal zone and hence an elaborative study on the ecology, trophic structure, and host specificity is required for understanding the role of seaweed assemblages in Kudankulam coastal ecosystem, which is likely to get affected when the power plant reaches its criticality.

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CONSERVATION STRATEGIES AND SUSTAINABLE USE OF MARINE BIODIVERSITY FOR COASTAL SOCIO-ECONOMIC DEVELOPMENT IN INDIA

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ABSTRACT

The coastal marine environment plays a vital role in India's economy by virtue of their resources, productive habitats and wide biodiversity. India has a long coastline of 8129 kms with Exclusive Economic Zone (EEZ) of 2.5 million sq.kms. This zone suffers from the absence of an integrated attention to conservation and development. As these regions form a vital link between the terrestrial and aquatic ecosystems their conservation is essential to maintain the ecological balance and biodiversity. Various conservation strategies and sustainable use of marine biodiversity are suggested for coastal socio-economic development in India.

INTRODUCTION

The marine and coastal areas play an important role today, as they provide protein from fish and other seafoods. The current problems of environment destruction in Tropical coastal seas, and the effects on the productivity of fish and other seafood from these areas are therefore of primary importance. Continued destruction of estuaries and lagoons, mangrove forests, sea grass beds and coral reefs will add to the poor people living in these areas. The use of Integrated Coastal Zone Management (ICZM) as a toolbox to develop coastal resources in a sustainable manner and to mitigate conflicts between users has proven to be a possible solution in many countries (Annon, 2002). The ICZM is a method that can lead to sustainable development because it has the advantage of securing government participation as well as stakeholder involvement.

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MAINTENANCE OF SPECIES DIVERSITY

Man made changes have the effect of reducing the number of species inhabiting the area. For example, eutrophication leading to lowered oxygen concentration in the water and the sediments limits the number species to those few to tolerate those conditions. In areas where large-scale aquaculture is practiced, the cultured species often occupy a disproportionately large amount of the habitat, forcing out many of the natural species. A case in point is in the mangrove forest of Southeast Asia where there has been great development of ponds for shrimp culture. Many of these operations rely on the natural spawning of shrimps to provide juveniles for introduction to the ponds, yet the mangrove ecosystems are so damaged in many areas that the natural shrimp populations are declining. In general, most adverse impacts on coastal ecosystems are characterized by decreasing species diversity. Monitoring of species diversity is therefore a useful technique for assessing damage to the system and maintenance of good species diversity is a positive management objective.

Of several plants and animals inhabiting the coastal ecosystems including the coral reefs, mangroves and estuaries only some species are exploited for human use. However, such species are often irrationally exploited with powerful harvesting techniques, sometimes leading to collapse of their respective habitats. It is, therefore, appropriate to deal with the question of biodiversity management from the point of view of "species-habitat" units in the case of the more sensitive and vulnerable ecosystems in the coastal zone.

PROTECTED AREAS

The first Marine National Park in India came into existence in the Gulf of Kutch (Pirotan area) in 1980 followed by Gulf of Mannar and Wandoor Marine National Park in the South Andamans. Though these three marine habitats have been declared as protected areas, delineation of the core areas and the park limits and regulations on various human activities in the protected areas remain to be implemented. Proposals have been initiated to establish marine parks and preserves in Malvan-Vengrula (Coast of Maharashtra), Minicoy, Kavaratti, Chetlat, Kadamat and Kalpeni (in Lakshadweep).

MANAGEMENT METHODS FOR BIODIVERSITY

Biodiversity or biological diversity can mean many different things. In its general sense, it refers to the dazzling variety of life forms that occupy the planet earth. In its working sense, it mainly encompasses efforts to protect the species of flora and fauna from extinction. Protection of species requires protection of their special habitats as well as preventing the hunting and harassing them. Humans have been transforming the oceans as dumping grounds for their wastes and modifying the natural composition of its environment. Endangered species are major beneficiary of coastal habitat protection, for example: Coastal birds, turtle and even marine mammals.

Some marine ecosystems—coral reefs for example have high species diversity but despite increasing marine pollution and degradation of coastal habitats, there is little evidence for an imminent major loss of marine biodiversity at the species level. This may be due the typical marine life history. Marine species live in wide-open systems and have greater ranges and fecundity than the terrestrial species. This confers on them a greater resilience to exploitation and environment change. Similarly endemism is rare. Many marine species particularly fish and invertebrates are so called strategists, producing large number of seeds, but having short lives. Recent species extinction is almost unknown among marine organisms with a planktonic larval stage and among the many species of migratory, highly mobile and wide spread fishes.

MARINE BIODIVERSITY CONSERVATION IN INDIA

India has a long coastline of about 8129 km, stretching along ten States and two Archipelagos. The coast is indented by a number of rivers, which forms estuaries at their confluence with the sea. The complex coastal ecosystems are comprised of estuaries, lagoons, mangroves, backwaters, salt marshes, mud flats, rocky shores and sandy stretches. Besides, there are three Gulfs, one on the East Coast, the Gulf of Mannar, and two on the West Coast, Gulf of Kutch and Gulf of Cambay. The two Island ecosystems Lakshadweep and Andaman and Nicobar. Islands add to the ecosystem diversity in India. The Gulf of Mannar, Gulf of Kutch and the two Island ecosystems have rich coral reefs and mangroves harbouring valuable marine biodiversity (Annon, 1998).

STRATEGIES FOR CONSERVATION

A well-defined set of biodiversity lessons learnt in other regions of the world is proposed for implementation in several different types of regional scale marine ecosystems (Venkataraman, 2003), which needs biodiversity information data bank (Madhav Gadgil and Seshagiri Rao, 1998). These information will permit meaningful comparisons across different habitats of the causes and consequences of changes in biodiversity due to human activities. This lesson requires significant improvement in taxonomic expertise for identifying marine organisms and documenting their distribution, knowledge of local and regional natural patterns of biodiversity and in understanding the processes that create and maintain these patterns in space and time. (i) Need for rapid expansion in taxonomy in order to interpret, manage, conserve and use biodiversity sustainability and the need to pool together the existing data from all sources by forming an information network of all agencies in the country. (ii). Priority for the biodiversity conservation to understand what values are important, which genes/species/habitat and how much biodiversity should be conserved. (iii). Improve the methodologies for different programmes, evolve more effective policy and target with priority. (iv). Practice of the biodiversity conservation programme with precise definition and clear targets. (v). Recognition of priority of the communities. (vi). Application of anthropogenic objectives of maintaining biodiversity so that it is of possible value to the mankind. The conservation

of coral and mangrove habitats has attained great significance in developing countries in the context of its functional role in ecological and socio-economic sustainable development and the Ministry of Environment and Forest, Govt. of India can formulate decisive policies for conservation and the management of coral and mangrove habitats along the Indian coast (Annon, 2002; Kathiresan and Qasim, 2005).

A major need for biodiversity maintenance is protection of special or critical, littoral habitats including mangrove forest, coral reef, sea grass meadows, shallow water bodies like shallow water lagoons and beaches. Few oceanic species are in danger of extinction because of habitat damage. But along the coast and beaches many species (Turtles) jeopardized by habitat degradation and loss. Five aspects of marine biological diversity are paramount for consideration (Ray and McCormick, 1992). 1. The diversity of marine fauna is much greater than for terrestrial fauna at higher taxonomic levels. 2. The marine fauna is also much well known. 3. Most marine species are widely dispersed. 4. Most marine communities are highly patchy and variable in species composition. 5. The response type to environmental perturbations is relatively small. Major strategic objectives for ICZM is to preserve the habitats of the species that have been designated as especially valuable are in danger of extinction. Therefore, an important motivation for designating "Ecologically Critical Areas" (ECAS) for special conservation is species protection; other purposes might be protection of specially productive or scenic natural resources. Threats to the productivity of unique biological systems of the coastal zone, species and their habitats arise from development activities and their side effects, including reef and beach mining, shoreline filling, lagoon pollution, sedimentation and marine construction activities that are quite distinct from those on land. The strategy plan must recognize that species and the habitats of coastal zones are so different from their terrestrial counterparts as to require different and special forms of conservation. For example, coral reefs, beaches, coastal lagoons, submerged seagrass meadows and intertidal mangrove forests have no counterparts in terrestrial systems. In addition to habitat management, there may be other appropriate actions to be taken under the ICZM programmes, for example, banning exploitation of endangered species.

The species at risk are quite different from terrestrial ones. e.g., oyster, octopus, porpoises whales, sea fishes, sea turtle, dugong. The occurrence of endangered and threatened species is less in the sea because it is an open system with few boundaries to migration. While several of the sea mammals and sea turtles are endangered, the fishes and shellfishes are usually not. The species protection by designating protected natural reserves is relatively inexpensive and simple to administer. This strategy can be implemented on a site-specific basis, and commensurate with available information, staffing or expertise. It can be reinforced with regulatory measures that combine "wet side" (estuarine or marine area) protection with "dry side" (shorelines) management strategies offering the possibility of managing whole coastal ecosystems. But first, it is necessary for ICZM process to identify during strategy planning, the critical coastal habitats that merit high degree of protection, so they can be addressed specifically in the Master Plan (Gustavson *et al.*, 2000).

EAST COAST OF INDIA

The development of coherent and directed multidisciplinary research program for the East Coast is considered a priority. This region has a major but not well-understood influence on our climate. It contains major recreational values, and potential for and effect of tourism require further investigation. The area supports the valuable finfish, a growing aquaculture industry and a high level of biodiversity that has not been studied intensively. This biodiversity includes, particularly in southeastern waters, a high degree of diversity of species unique to Indian marine ecosystems.

Although the East Coast is highly productive, there are signs that this environment is under pressure. Several bays and estuaries are under threat from degradation, such as Palk Bay, Gulf of Mannar, Pulicat Lake, Chilka Lagoon and Krishna and Godavari Estuaries. Major seagrass losses have occurred in Palk Bay and Gulf of Mannar. Major Fisheries are under threat or in decline. The prawn fishery suffered a major collapse some years ago, and some species show that its spawning population is reduced to dangerously low levels.

As a first step, collaborative linkages between research institutes and universities in region should be strengthened, for the purpose of better existing research activity, and developing new multidisciplinary programs in priority areas. The activity would include studies designed to improve understanding of biodiversity and biological processes, and the development of new long-term monitoring programs. Such targeted collaborative research programs are important to the development of the knowledge base as an under pinning to the effective operation of resource based marine industries in the area, and to protect against environment threats. Specific initiatives would include:

- Studies on the ecosystem dynamics of East Coast of India;
- Establishing long-term monitoring programs and baseline data sets and
- Refurbishing or establishing field research stations in Andaman and Nicobar Islands.

WEST COAST OF INDIA

There is a strong case for establishment of a multidisciplinary research facility in the West Coast to develop an understanding of the region's marine resources and ecosystems. The major demand for marine science is to build the basic knowledge needed:

- For the continuing sustainable use of marine resources, including traditional uses by Lakshadweep Islanders;
- For the continuing success of growing commercial fishing, and aquaculture and pearl industries;
- To understand the marine environment that supports oil and gas industries and

- Supportive research activity such as mapping of seabed topography, studies designed to improve understanding of biodiversity and biological processes, the designed and implementation of monitoring fisheries development, and development of an understanding of industry impact programs, and research supporting sustainable use of marine environment.

The shared borders with Pakistan, Bangladesh, Maldives and Sri Lanka, and large coastlines supporting similar tropical marine ecosystems in other areas, are further considerations in planning the management of resources in this region, and encourage the concept of joint research programs.

STRATEGIES FOR SUSTAINABLE DEVELOPMENT

The investigation of marine biodiversity possesses a considerable scientific and conservation challenge because of the great size and relative inaccessibility of marine ecosystems (UNESCO, 1992). The International Association of Biological Oceanography (IABO) in co-operation with UNESCO has launched an international co-operative programme on biological diversity during 1990. The major objective of the programme is to understand biological diversity within the context of the structure and function of ecosystem. The IABO/UNESCO International Marine Biodiversity programme is of particular importance to global change research given the forecasted climatic changes and their implication for the function of natural and man identified marine ecosystems, within the context of sustainable development. It is extremely important to select representative ecosystems for experimental studies that involve improving the outcome of this prediction, as well as for long-term monitoring of biodiversity, in estuaries, lagoons, coral reefs, mangroves and salt marshes believed to be vulnerable to pronounced climatic and environmental change. One of the most important problems is the necessity to tackle simultaneously global climatic changes, marine biodiversity and sustainable development (Lasserre, 1992). As part of that effort, much more attention and visibility needs to be given to the link between pollution regulation and the ecosystem function of biological diversity.

AREAS RICH IN BIODIVERSITY

The priority towards the conservation of marine biodiversity is to identify/locate the areas, which are highly critical and rich in species distribution and their favourable habitats (Ray, 1991). Species diversity can be made as the criteria for ranking the areas for conservation (Grassle *et al.*, 1991). An area that harbours smaller assemblage of species is to be given more importance, evolutionary significance, ecological importance and endangerment. An area with lower diversity might be better at providing ecological services important to people. Species diversity differs markedly on both ecological and biogeographic special scales. On an ecological scale, it is important to conserve coral reefs and mangrove forests, which are unusually species rich for its ecosystem type (Bakus,

1994). On a biogeographic scale, using species diversity/richness as the sole criterion for priority conservation. Areas of high biodiversity may not be most critical to the sea as a whole, for various reasons (Sasikala, 2004). Coral reefs generally have high species diversity but tend to be low in other biological attribute such as endemism. The salt marshes, mangrove forests and seagrass beds can have special importance than coral reefs because they serve as significant nursery areas and their productivity supports important food webs (De Roy and Thadani, 1992) a. Moreover, some areas are especially important seasonally because they are critical to key elements of marine biological diversity, even if their diversity is low. These include courtship, spawning areas, nursery grounds, and migration areas and stop over points. The areas rich in productivity, spawning grounds, nursery grounds, migrations are to be protected.

CONSERVATION OF MARINE BIODIVERSITY THROUGH COASTAL ZONE MANAGEMENT

Some coastal ecosystems are particularly at risk, including saltwater marshes, coastal wetlands, coral reefs, coral atolls and river deltas. Other critical resources, such as mangroves and seagrass beds, submerged systems and mud flats are at risk from climate change impacts, exacerbated by anthropogenic factors (Masan, 1999). At the global scale, while climate has fluctuated through out time, a global warming scenario could lead to accelerated sea level rise, changes in rainfall patterns and storm frequency or intensity and increased siltation. The consequences may include shore-line erosion and associated loss of habitats, such as salt marshes, mangroves and mud flats. A future, more integrated coastal zone management process should include:

- Integration of programmes and plans for economic development, environment quality management and ICZM
- Integration of ICZM with programmes for such sectors as, fisheries, energy, transportation, water resources management, disposal of waste, tourism and natural hazards management.
- Integration of responsibilities for various tasks of ICZM among the level of government- local state/ provincial, regional, national, international and between the public and private sectors.
- Integration of all elements of management, from planning and design to implementation, that is, construction and installation, operation and maintenance, monitoring and feedback and evaluation over time.
- Integration among the disciplines; for example, ecology, geomorphology, marine biology, economics, engineering, political science and law.
- Integration of management resources of the agencies and entities involved.

The rapid industrialization along the coast especially in the areas along the metropolitan cities has caused enormous damage to the coastal ecosystem. Hence, the laws governing the coastal land use should be framed with a view to promoting the economic development designed in tune with the coastal ecosystem. Threats to marine biodiversity could be categorized which include: Habitat loss, population, pollution, natural disasters and over exploitation. Destruction of thousands of mangrove forests and coastal wetlands for the construction aquaculture farms in certain coastal states were reported. Besides these threats, the coral reefs are also subjected to man made pollution such as heavy metals, fertilizers and sewage and industrial wastes. Together, the unintended consequences of over fishing, by-catches and habitat degradation can alter the very biodiversity, productivity and resilience of marine ecosystems on which economically valuable species and fisheries depend (Menon and Pillai, 1996).

NATIONAL ACTION PLAN FOR SUSTAINABLE COASTAL RESOURCES MANAGEMENT AND INTEGRATED COASTAL ECOSYSTEMS MANAGEMENT

Sustainable Coastal Resource Management

- Documentation of the status of exploited finfish and shellfish stocks for identification of region/area specific problems and transfer of relevant management models.
- Awareness creation among the members of participating and user societies, especially the youth on the needs of ecological security for their own livelihood security.
- Selection of socially acceptable management regimes and assessment of socio-economic impact of interventions.
- Implementation of regulations with willful involvement and participation of the society.
- Recognition of the traditional rights of coastal communities to use the natural resources in their surrounding natural habitats for their livelihood, while formulating and implementing regulations and conservation measures.
- Generating a willful, total commitment by all levels of government and participating communities in the sustainable management programme.
- Conservation of vulnerable edible and bio-medically important species with the involvement of local communities in *in situ* preservation of germplasm through national parks and protected areas.

Integrated Coastal Ecosystem Management

- Survey of coastal ecosystems like coral reefs, estuaries, wetlands including mangroves, sea grass beds, and other spawning and nursery grounds for any possible alteration, shrinkage, biodiversity degradation and pollution.

- Preparation of inventories of fauna and flora in each of the region/area specific life supporting systems. Protection and restoration of endangered species in the various ecologically fragile, but biologically rich habitats.
- Establishment of community-owned systems of marine protected areas that are consistent with the social economic, political and cultural characteristics of the region, with active community involvement supported by local NGOs and government agencies.
- Development and implementation of suitable integrated Island ecosystem management package to meet the essential needs of the Island communities and to improve their quality of life without compromising the geographic, environmental, cultural and socio-economic characteristics of the Islanders.
- Introducing tested coastal mariculture technologies at selected centers; but replicable elsewhere, for offering ecological and economic security to the communities taking into confidence the traditional knowledge and interest of local communities.
- Implementation of an integrated national conservation strategy involving *in situ* and *ex situ* and *in vitro* and *in vivo* methods, to be developed for all marine endangered, vulnerable and rare species.

Recognition of marine biodiversity as an essentiality for human survival

- Recognition of biodiversity preservation, protection and monitoring as a national obligation.
- Preparation of inventories of biological resources and categorizing their status of abundance and rarity.
- Formulation of socially relevant conservation strategies for all such rare, endangered and vulnerable species.
- Cataloguing the deepwater biodiversity in the EEZ.

Development of nature preserves, genebanks and genegardens for threatened and vulnerable species.

ECONOMICAL BENEFITS OF MARINE BIODIVERSITY

For the conservation of the earth's natural marine environment, the Govt. of India must impose the Coastal Regulation Zone notification for the conservation of marine biodiversity. For balanced sustenance of life in any ecosystem, the biodiversity must be conserved. Ecosystem dependence for survival is a universal phenomenon in which ecosystem like coral reefs and mangroves rank high among coastal population. Traditional fisherman without much access to modern facilities solely depends on such ecosystems for survival. Mangrove and coral reefs play a vital part in maintaining the productivity

of coastal areas acting as breeding grounds, nursery and as habitat for many economically important species. They prevent coastal erosion and mangroves act as sink for pollutants apart from protecting the coastal region from storms and cyclones.

The diversity of coral reefs benefits us directly through harvestable food, medicine, raw materials and coastline protection and indirectly by sustaining the ecological process that provides these resources (Annon, 1997). Coral reefs are also high productive ecosystems and support large number of organisms, whether measured in numbers or biomass. For these reasons the coral ecosystems are considered of great economic importance. Today resource harvest from Indian reefs- be it food fish, mining of coral blocks, collection debris or collection sea shells – is only for the sustenance for the reef dependent population.

Mangrove ecosystems are important coastal habitat in tropical regions, directly or indirectly supporting subsistence and commercial fisheries (Annon 1987). However, they are under threat in developing countries where they are being disturbed by a variety of human activities. The destruction of these ecosystems would inevitably affect the coastal productivity and in turn the livelihood of those who depend on it for their survival. The lack of knowledge among the fishermen about the role of mangroves and corals in coastal productivity will make them insensitive to the fragile ecosystems and unknowingly they are using destructive fishing methods to save time and effort. The need to educate fisher folk or the primary stakeholder is crucial for the management and conservation of corals and mangroves, which will pave way to its maintenance and sustainable fishing. The primary aspects of any conservation programme are to initially assess the awareness of the core population who depend on the ecosystems for survival. Accordingly, strategies can be devised for conservation and management. The rapid industrialization along the coast, especially in the areas around the metropolitan cities has caused enormous damage to the coastal ecosystems. Hence, the laws governing the coastal land use should be framed with a view to promote the economic development designed in tune with the coastal ecosystems.

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STATUS OF INDIAN MANGROVES AND THE LEGEND OF MANGROVE RESTORATION IN GUJARAT

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INTRODUCTION

Mangroves are one of the ecologically and economically valuable ecosystems. Mangrove swamps have been nature's protection for the coastal regions from the large waves, weathering the impact of cyclones, and serving as a nursery for three-fourth of the commercial fish species that spend part of their life cycle in the mangrove swamps. The present status of mangrove degradation in India is indicated to alert the habitants to be aware of the future drought on fishery resources and other bio-geo oceanic disasters. It is also intended to bring out the past and present status of mangroves and associated coastal floral diversity with special reference to Gujarat coastline. The aim of the paper is to alarm and recommend the mandate of 'Code of conduct for Mangrove Regeneration'

GLOBAL AND NATIONAL STATUS OF MANGROVES

Mangroves occur in 112 countries between the latitudes of 32° North and 38° South Tropical waters. The maximum mangrove area coverage occurs in Indonesia, Brazil, Australia, Nigeria, etc., and India is having 3% of the global mangroves (Table-1).

Table 1. Global distribution of Mangroves (ITTO/ISME, 1993)

Country	Mangroves (1000 ha)	Global Percentage (%)
Indonesia	4250	30
Brazil	1376	10
Australia	1150	8
Nigeria	970	7
Malaysia	641	5
Bangladesh	611	4
Myanmar	570	4

Table 1. *Contd.*

Country	Mangroves (1000 ha)	Global Percentage (%)
Vietnam	540	4
Cuba	530	4
Mexico	525	4
Senegal	440	3
India	360	3
Columbia	358	3
Cameroon	350	2
Madagascar	327	2

According to the Government of India (1987), India has lost 40 percent of its mangrove area in the last century. The National Remote Sensing Agency (NRSA) recorded a decline of 7000 ha of mangroves in India within the six-year period from 1975 to 1981. In Andaman and Nicobar Islands about 22 400 ha of mangroves were lost between 1987 and 1997. Between 1999 and 2001 (FSI), 8% of mangrove forests have been lost in the Indian coastlines with the greater loss occurring in Andaman and Nicobar Islands (18.3% decline) followed by Andhrapradesh and Gujarat (16.2% and 11.7% reduction). Thus, in a span of 2 years the country has lost 8% reduction of mangrove forests and States with larger mangrove distribution recorded over 10% decline (Table-2).

Particularly the area increase (+9.5 %) in Tamil Nadu may not be always a healthy indication of the future mangrove existence. The reason is thought provoking and serious. In the lagoons and estuaries of East Coast and Tamil Nadu, especially Muthupet, development of micro-deltas has been informed since decades in a very alarming way. Land accretion inside the water bodies and mangrove invasion on all the micro-deltas have increased the greenery. However, this is not an encouraging phenomenon, as micro-delta formations in other way is loss of water holding areas. Sediment deposition in long run may stop water flow and regular inundation required for mangroves ultimately affect the biodiversity loss and death of mangroves.

Table 2. Distribution-Past, Present Status and Percent Reduction of Mangroves in India (Forest Survey of India-FSI)

State/Union Territory	Govt of India (1999)	Govt of India (2001)	% Reduction from 1999
Andaman and Nicobar Islands	966	789	18.3
Andhra Pradesh	397	333	16.2
Goa	5	5	0
Gujarat	1031	911	11.7

Table 2. Contd.

State/Union Territory	Govt of India (1999)	Govt of India (2001)	% Reduction from 1999
Karnataka	3	2	33.4
Maharashtra	108	118	+9.3
Orissa	215	219	+1.9
Tamil Nadu	21	23	+9.5
West Bengal (Sundarbans)	2125	2081	2.1
Total	4476	4811	8.0

MANGROVES IN GUJARAT

In Gujarat, mangroves are mainly concentrated in the Western part of the Kachchh district especially in the Kori Creek area around Jakhau. Of the total mangrove forests in Gujarat (911 sq.km), the region around the Gulf of Kachchh (706 sq.km) alone accounts for 77.5% of the total and the rest 15.8% (144 sq.km) is located in Porbander, Rajkot and Jamnagar, the Southern region like Surat, Navsari and Bhavnagar comprises 3.4% (31 sq.km), where Gulf of Khambhat - (Ahmedabad, Bharuch) (30 sq.km) comprises 3.3%. Majority of these mangroves are notified Reserved Forest under the control of Department of Forest and Environment (West Mangrove Reserved Forest).

At present natural existence of mangroves are seen at places like Ghogha-Bhavnagar, Dholera, Khambhat, from Neja to Nada villages on the coast of Jambusar taluka, and Narmada and Tapti estuaries in Gulf of Khambhat. *Avicennia* with stunted growth is sparsely distributed along the Coast of the Gulf except near the Mahi, the Dhadhar, the Narmada, the Kim and the Sena rivers. Small patches of mangroves are also observed in Alia bet. The dominant areas under mangroves are seen near Bhavnagar, Devla (Bharuch, Mangrol, Pardi, Jankhsi and Dandi in Surat. In South Gujarat to the North of Mindhola River the coast is characterized by marshy land. Along the estuaries of rivers Mindhola, Purna, Ambika, Auranga and Damanganga mudflats and marsh vegetation are present. Numerous tidal creeks also occur with *Avicennia marina*. However pressures like grazing, industrial and effluent discharge are more.

Mangroves of the Marine National Park, Jamnagar (District Jamnagar: 142 sq.km) constitutes the second largest patch of mangroves in Gujarat. Extending up to 11,000 ha, these mangroves represent the richest area in Gujarat comprising seven genera of mangroves and 55 associated species (Tables-3 & 4).

Table 3. Mangrove Flora of Gujarat: Past and Present Scenario

S. No.	Species	Past			Present		
		Kachchh	Khambhat	South Gujarat	Kachchh	Khambhat	South Gujarat
1.	<i>Acanthus ilicifolius</i>	*	*	*	*	*(Tapti)	*
2.	<i>Aegiceros corniculatum</i>	*	*	*	*	NA	*
3.	<i>Avicennia marina</i>	*	*	*	*	*	*
4.	<i>A. officinalis</i>	*	*	*	*	NA	*
5.	<i>Bruguiera sp</i>	*	NA	*	*	NA	*
6.	<i>Ceriops tagal</i>	*	NA	*	*	NA	*
7.	<i>Rhizophora apiculata</i>	*	*	*	*	NA	NA
8.	<i>R. mucronata</i>	*	NA	*	*	NA	NA
9.	<i>Sonneratia apetala</i>	*	*	*	*	*(Tapti)	*

NA-Not Available, *-Available

Source : Oswin D. Stanley, Personal Observation and Past records from Gazetteer of Gujarat

- Most of the area is sandy in Saurashtra coast except for negligible area at Dwarka, which has only *Avicennia marina*;
- Past occurrence of *Xylocarpus* was mentioned in an old dated torn report, but no authenticity for the statement.

Table 4. Salt marsh and other associated coastal flora in Kachchh, Khambhat, South Gujarat and Saurashtra coastline

S. No.	Species	Kachchh	Khambhat	South Gujarat	Saurashtra
1.	<i>Aeluropus lagopoides</i>	*	*	*	-
2.	<i>Anthrocnemum indicum</i>	*	-	*	-
3.	<i>Aristida adscensionis</i>	*	-	-	-
4.	<i>A. funiculata</i>	*	-	-	-
5.	<i>Atriplex stocksii</i>	*	*	*	-
6.	<i>Borassus flabellifer</i>	-	*	*	*
7.	<i>Calophyllum inophyllum</i>	*	*	*	*
8.	<i>Cenchrus biflorus</i>	*	-	-	-
9.	<i>C. ciliaris</i>	*	*	*	*
10.	<i>C. setigerus</i>	*	*	*	*

Table 4. Contd.

S. No.	Species	Kachchh	Khambhat	South Gujarat	Saurashtra
11.	<i>Chloris barbata</i>	*	*	*	*
12.	<i>Clerodendrum inerme</i>	*	*	*	*
13.	<i>Cressa cretica</i>	*	*	*	*
14.	<i>Crotolaria medicaginea</i>	*	*	*	*
15.	<i>Cyperus arenarius</i>	*	*	*	*
16.	<i>C. conglomeratus</i>	*	*	*	*
17.	<i>C. rotundus</i>	*	*	*	*
18.	<i>Derris sp</i>	-	-	*	-
19.	<i>Desmostachya bipinnata</i>	*	-	-	-
20.	<i>Dichanthium-annulatum</i>	*	-	-	-
21.	<i>Digitaria sanguinalis</i> , Scop. Var <i>Ciliaris</i> Prain	*	-	-	-
22.	<i>Eleusine bianata</i>	*	*	-	-
23.	<i>Eleusine coracana</i>	*	*	*	*
24.	<i>Elysecarpus rugosus</i>	*	-	-	-
25.	<i>Eragrostis bulbosa</i>	*	-	-	-
26.	<i>E. minor and major</i>	*	-	-	-
27.	<i>E. trimula</i> .	*	-	-	-
28.	<i>Halophyllum mucronatum</i>	*	*	*	*
29.	<i>Heliotropium curassavium</i>	*	*	*	*
30.	<i>Heylandia latebrosa</i>	*	-	-	-
31.	<i>Indigofera cordifolia</i>	*	*	*	*
32.	<i>Ipomoea pes-caprae</i>	*	*	*	*
33.	<i>Kochia sps.</i>	*	-	—	-
34.	<i>Malanocenchrus jacquemontii</i>	*	-	-	-
35.	<i>Phoenix obtusifolia</i>	*	*	*	*
36.	<i>P. sylvestris</i>	*	*	*	*
37.	<i>Pongamia pinnata</i> = <i>P. glabra</i>	-	*	*	*
38.	<i>Prosopis chilensis</i> = <i>P. juliflora</i>	*	*	*	*
39.	<i>Salicornia brachiata</i>	*	*	*	*

Table 4. Contd.

S. No.	Species	Kachchh	Khambhat	South Gujarat	Saurashtra
40.	<i>Salvadora oleroides</i>	*	*	*	*
41.	<i>S. persica</i>	*	*	*	*
42.	<i>Sesuvium portulacastrum</i>	*	*	*	*
43.	<i>Setaria rhachitrich</i>	*	-	-	-
44.	<i>Sida</i> sps.	*	*	*	*
45.	<i>Spinifex littoreus</i>	*	*	*	*
46.	<i>Sporobolus diander</i>	*	-	-	-
47.	<i>S. helvolus</i>	*	-	-	-
48.	<i>S. virginicus</i>	*	*	*	*
49.	<i>Suaeda fruticosa</i>	*	*	*	*
50.	<i>S. maritima</i>	*	*	*	*
51.	<i>S. monoica</i>	*	*	*	*
52.	<i>S. nudiflora</i>	*	*	*	*
53.	<i>Tamarix troupii</i>	*	*	*	*
54.	<i>Thespesia</i> sp	-	-	*	-
55.	<i>Urochondra setulosa</i>	*	*	*	*

Source : Oswin D.Stanley, Eco-Balance Consultancy, Personal Observation

* (Available)–(Not observed)

LEGEND OF MANGROVE RESTORATION IN GUJARAT

The NRSA (National Remote Sensing Agency) has recorded decline of 7000ha of mangroves in India and Gujarat State has acknowledged a big share (Environmental Information System Centre-EISC, 1997). Evidences exemplify that the State has experienced severe degradation and depletion of mangroves in the recent past. The vegetation map of Kathiawad prepared by the French Institute of Pondicherry in 1960 is a proof for rich mangroves in Gujarat. The dense mangroves in Kandla, Southern coast of Gulf of Kachchh and West Coast of Gulf of Khambhat are obvious in the map. The Imperial Gazetteer of India Vol. XVIII (1908) also had recorded that there was dense mangrove availability in Navanagar state (Jamnagar) and was extensively used by the local community for fodder and fuel requirements. The mangrove area has been reduced in Okha to Surajbari (South coast of Gulf of Kachchh), in the Jamnagar and Rajkot districts into small isolated patches or small Islands (bets) in Marine National Park and Sanctuary.

Jani from FED (2003) states that Marine National Park underwent severe degradation during 1975 to 1992. The dense mangroves declined from 158.4sq.km in 1975 to 21.8sq.km in 1982 and to 23.4sq.km in 1985, the sparse mangrove patches declined from 80.1sq.km in 1975 to 28.2sq.km to 10.00sq.km in 1985. That is the decline from 238.5sq.km in 1975 to 33.4sq.km in 1985. Therefore the total reduction is 205.1sq.km in 10 years time span.

Table 5. Mangrove area changes in Marine National Park

Categories	Area in Sq.Km				
	1975	1982	1985	1988	1992-93
Mud Flats	7.7	125.6	163.2	81.1	81.1
Mangroves	138.5	50	33.4	55.7	55.7
Dense Mangroves	58.4	21.8	23.4	28.6	28.6
Sparse mangroves	80.1	28.2	10	27.1	27.1
Salt pans	8.4	13.7	17.5	18.4	18.4

Source : Bahuguna A., HH.B. Chauhan and Shailesh Nayak, 1997. In the proceedings of the workshop on integrated coastal zone management, 1997.

Severe degradation was experienced in Gulf of Kachchh during 1975 to 1985, especially in coast of Kandla and Navlakki between 1970's and 1980's. In Kachchh the degradation was due to excessive camel grazing and 95 percent of mature trees were cut for fuel wood and timber between 1975 and 1985.

Mangrove reduction and degradation was also recorded in many regional reports. Khambhat (Bhal area) had faced a reduction from 438 sq.km in 1870 to 325 sq.km in 1960's to 100 sq.km in 1980 and to a mere 13 sq.km in 1993. Non-Bhal areas in Khambhat showed a decline during 1975 to 1983. Mangroves that was present 30 years ago in the villages (Sigam, Zamdi, Malpore and Nada) of Jambusar are (1990's) reduced to small discontinuous patches which is seen only in Nada.

South Gujarat mangroves (mainly Umargoan, Vansiborsi, etc) are degrading due to industrial pollution. Alia bet in South Gujarat had dense mangroves some 25 years ago but now it is in a very bad shape. Records show that there were mangroves in the past near Hazira at the North of Tapi River as well as Dandi, Mangrol, Pardi Zankhri in Surat, Navsari and Valsad districts (near Umargoan). Hazira mangroves are now in a few hectares and at the verge of extinction due to the massive land reclamation by Shell Gas Hazira, Essar and many other Industrial units. The area is now made more sandy than muddy due to frequent excavations. Presently occurrences of mangroves along the rivers are unhealthy discontinuous patches posing a perpetual threat from ports and docks and industrial effluents.

GUJARAT MANGROVES INCREASING OR DECREASING

The authentic Forest Survey of India (FSI) data shows that area under mangroves increased during 1987 to 1991 and declined during 1999 to 2001. Significant reduction of 120 sq.km i.e., 12 % (1031sq.km to 911sq.km) between two years duration is shown despite of the greater efforts on plantation activities. The data perhaps needs to be clarified for statistical and ground reality.

MANGROVE RESTORATION EFFORTS

Mangrove Plantations have been carried out in Kachchh district right from the first five-year plan period (1951-56). Sinha and Joshi (working plan 1973-83) of Kachchh district documented that an area of about 1,360 ha in the district was afforested between 1951 and 1966. Most of these plantation activities have been concentrated in the Marine National Park area in Gulf of Kachchh and predominately planted with *Avicennia marina* by gap filling method and in few hectares of *Ceriops tagal* planted of late.

The Forest and Environment Department (FED) has undertaken the plantation of mangrove in all the major coastal regions, namely Jamnagar, Kachchh, Junagadh, Amreli, Bhavnagar, Surat and Valsad. So far 149.83 sq.km of plantation has been covered by the department in the last 17 years, which comes to about 8.8 sq.km plantations per year. Maximum plantation is done in Marine National Park (100.87 sq.km) and in Jamnagar and Kachchh districts (37.23 sq.km), adding up to 138.1 sq.km area, which comes to more than 92 % of the total plantation by the forest department in the state. About 1.45 sq.km are planted in Junagadh, 0.53 sq.km in Amreli, 1.75 sq.km in Bhavnagar and about 7.00sq.km in South Gujarat. Recently the State government has designed a plan for mangrove plantation of about 24 sq.km at the cost of 9.97 crores.

Gujarat Ecology Commission, the nodal agency along with the partner NGO's in Gujarat are also in the process of developing (5000 ha reduced to 3901 ha) mangroves through ICEF funds in a community base mode. The major problem in Gujarat with these community-based plantations are that they do not possess effective monitoring system and neither the community nor the project implementing NGO has the accountability of the survival of the plantation, hence existence of plantations are under severe scepticism. Industries with mandate of developing mangroves too have higher claims. The existence of the plantation has to be confirmed by periodical and continuous monitoring system, which needs to be incorporated to succeed such community mangrove plantation projects.

EMERGING THREAT : NEEDS ATTENTION

The mangrove restoration activities themselves are a major threat to the naturally prevailing mangroves. The reasons are :

- The target or area of restoration that has been taken by many organizations is a fantasizing figure, for example like: 5000ha by Gujarat Ecology Commission in six years duration.

- In order to cater the large areas seeds from the natural forests near by are depleted in abundance.
- Therefore the process of natural regeneration in that particular area as well as the area up to the seed reaches is interrupted.
- Continuous process of razing off seeds from natural patches would in long term affect the existing mangroves from regenerating future forests
- Neither the mangrove restoration plantation would exist due to the improper management nor the natural forests exists in future due to severe stress of seed extraction
- Hence, community based projects promises the extraction of benefits from the project and it was taken for granted or even at times compelled by the organizations to graze or collect fodder.
- The indicator of a successful project is accounted to be the area covered by plantation and not the survival or growth performance of forest, hence NGOs or Industries have not realized the fact that actually they are degrading the existing as well as the future fragile ecosystems.

The most important aspects to be taken into account for any mangrove plantation or restoration Project by the funding agencies are:

- The area of mangrove plantation given to any organization should not exceed 20 to 50 ha per season
- The available potential area for restoration/regeneration or the proportion of coastline available and related details needs to be checked before project allocation
- Assessment of fodder/fuel requirement of the target coastal village and Alternative fodder or fuel projects to be implemented before suggesting any mangrove project
- The implementing organization should have the schemes to counter/reduce the pressures on mangroves at least to 30-50%
- The direct pressures are to be solved or addressed before mangrove plantation for the success of community based mangrove plantation
- A perfect balanced system of project implementation monitoring to be ensured
- Compulsory Continuous Monitoring Scheme for forest performance assessment to be implemented periodically with stakeholders, local Forest Department and mangrove ecologists
- The members of the Monitoring Committee or the Advisory Board need to be energetic enough to move into the muddy areas to really advice the site specific facts than speculate or hypothesize with their experiences elsewhere

- The monitoring reports need to be made public for any scrutiny from any level
- Unless the community is cent percent mangrove dependent the usage of mangrove area may be reduced by providing alternative schemes
- The protection right of any community developed mangrove forests needs to be shared with the Forests and Environment Department for long term security

The existing and planned port and industrial activities still paves a grave threat to the mangrove ecosystem. Unless the development authorities and managers rationally and consciously treat the ecosystem, mangroves of Gujarat may be increasing in statistical papers not in real grounds. Being a mangrove ecosystem manager working for industries to accomplish the mandate of developing mangroves, could feel that the commitment of many are just for the sake of environmental clearance.

HYDROLOGICAL RESTORATION

Long Term Solution for Canal system building and mangrove restoration is what Eco Balance Consultancy is suggesting the mangrove managers and ecosystem developers. Re-establishment of mangroves is always site specific and the strategies of restoration also vary with site. Apart from the regular nursery development and transplantation methods, dredging canals is also in practice. Let us go for the replicable long term sustainable hydrological restoration models.

Day to day mending of the restoration model is not necessary when our model merge with basic principles of ecology with ecological engineering approach. Important feature in designing a successful mangrove restoration project is determining the normal hydrology (depth, duration and frequency and of tidal flooding) of the existing natural mangrove plant communities (a reference site) in the area in which we wish to do restoration (Lewis, 2005). It has been suggested to follow nature and the natural hydrological pattern while trying to restore mangrove areas. Manipulation of the hydrology over the natural pattern would be long lasting and successful. This type of hydrological restoration has been successfully carried out in the developed countries like America in vast areas more than 500 to 600ha in single plots. We too have all the facilities and in house expertise to understand the hydrology of the forests and let us try to explore the everlasting success with genuine increase in the mangrove area coverage of our country.

CONCLUSION

The values both ecological and economical rendered by mangroves could be only understood once we honestly realize the services. Protection of mangrove ecosystem composed of a sea and land interface should receive top priority. Each hectare of mangrove forest destroyed results in an estimated 737 kg loss in marine harvest. Alterations in mangrove ecosystems in fact are irreversible and restoring the original mangrove ecosystem with its pristine glory is close to creating a replica. Efforts on trying for those identical

systems at least should be made sincere with the motive of providing support to the ecosystems and to the community dependent thereof. There should be an authoritative strict regulation for the protection of mangroves exclusive of whether it is community made or natural which are present in the CRZ-I and Department of Forests should play a major role in lobbying for implementation of the Coastal Regulation Zone requirement of a 200 to 500 metre 'no development' zone. A code for mangrove restoration/regeneration should be made as a mandate for anybody who wishes to serve the ecosystem.

Despite of enormous efforts on mangrove restoration, are we hiding the fact that Indian or Gujarat mangrove ecosystem is entering Endangered Red List or really is it increasing? Or with out realizing are we thrusting the ecosystem to go extinct? Or, Are we awaiting another natural disaster to reply?

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STUDY OF DIATOMS OF NANDGAON AND DAHANU COAST FROM KONKAN REGION, NORTH WEST MAHARASHTRA

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ABSTRACT

The present investigation deals with the study of diatoms of Nandgaon and Dahanu Coast of North West Maharashtra—carried out for a period of two years from September 1999 to September 2001. Altogether 191 forms were recorded represented by 50 genera of diatoms of which 35 species are centrales and 156 species are of pinnate diatoms. Among the forms recorded *Cyclotella*, *Coscinodiscus*, *Biddulphia*, *Fragillaria*, *Navicula*, *Diploneis*, *Pinnularia*, *Pleurosigma*, *Gyrosigma*, *Amphora* & *Nitzschia* were present almost throughout the year.

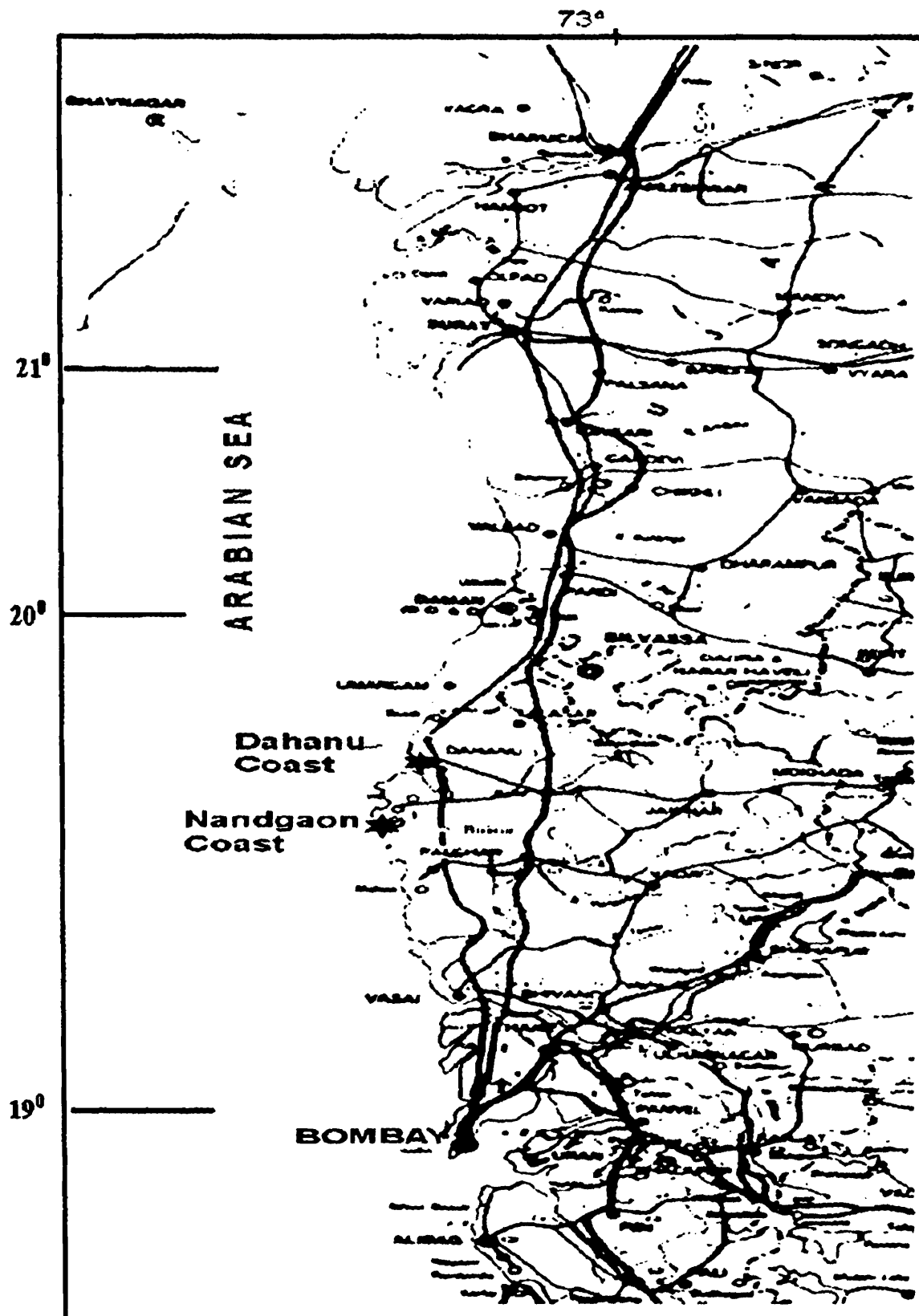
INTRODUCTION

The most unique feature of the earth is its oceans which covers approximately 70% of the earth's surface. Throughout this area algae are distributed and act as primary producers. The phytoplankton's (Microscopic plankton) are responsible for approximately one quarter of the world's plant photosynthesis. Amongst phytoplankton's, diatoms form the bulk in the marine environment and serve as a direct source of food for other aquatic organisms. Hence all other 'production' in the aquatic habitats is only a transfer of organic matter from one trophic level to another. The present investigation deals with the study of diatoms of Nandgaon and Dahanu coast with reference to the ecological characteristics of phytoplankton along these coasts.

MATERIAL AND METHODS

The samples were collected from Nandgaon and Dahanu coast, 100 km & 125 km South of Mumbai respectively. Nandgaon is situated at 72°, 38' latitude and 19°, 47' longitude, it receives effluent from MIDC, Tarapur; Dahanu is situated at 72°, 42' latitude and 19°, 58' longitude. It receives water from B. S. E. S. and M/s. Reliance Energy Ltd. Both are sandy beaches.

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Map Showing Location of Nandgaon & Dahanu Coast

The samples collected were preserved in 4% formalin with few drops of Iodine. The preserved samples were then treated with conc. H_2SO_4 and kept for 2–3 days and then heated with a pinch of K_2CrO_7 . Treated samples were cleaned by centrifugation, dried and a drop was mounted in DPX mountant.

Identification of species was done with the help of standard books and journals. Cupp; (1943); Subramanyan; (1946); Hendey; (1964); Hajos; (1976).

ENUMERATION

Genus *Melosira*

Melosira sulcata (Ehrenberg) Kützing.
(Plate I, Figure :1)

Subramanyan R., 1946, Page 86, Figure 1 and 2.

Dimensions : L : 18μ . in diameter; Breadth : 6μ in height

Genus *Cyclotella*

Cyclotella Kützingiana. Thwaites.
(Plate I, Figure 2)

Venkataraman.G., 1939, Page 299, Figure 9.

Dimensions : Diameter 19μ

Cyclotella menighniana, Kützing
(Plate I, Figure 3)

Subramanyan. R., 1946, Page 92, Figs. 25, 26 and 27; Venkataraman. G., 1939 , Page 299, Fig. 11.

Dimensions : Diameter : 10μ

Cyclotella caspia, Grunow
(Plate I, Figure 4)

Hendey N., 1964, Page 74.

Dimensions : Diameter 12.5μ

Cyclotella striata (Kützing) Grunow in Cleve and Grunow
(Plate XV, Figure 5)

Subramanyam R., 1946, Page 92, Figure 31, Hendey N., 1964, Page 74.

Dimensions : Diameter 16μ

Genus *Coscinodiscus* Ehrenberg***Coscinodiscus excentricus* Ehrenberg****(Plate I, Figure 6)**

Subramanyan R., 1946, Page 93 , Figure 29 and 30. Cupp. E., 1943, Page 52, Figure 14.

Dimensions : Diameter 81 μ

Coscinodiscus lineatus* Ehrenberg*(Plate I, Figure 7)**

Subramanyan R., 1946, Page 93, Figure 24 and 28. Cupp E., 1943, Page 53, Figure 15.

Dimensions : Diametre 51 μ .

Coscinodiscus sub-lineatus* Grunow.*(Plate I, Figure 8)**

Subramanyan. R., 1946, Page 95, Figure 34.

Dimensions : Diametre 26 μ

Coscinodiscus rothii* (Ehrenberg) Grunowvar. *Subsalsa* (Juhllin-Dannfelt) Hustedt.*(Plate I Figure 9)**

Subramanyan R., 1946, Page 95, Figure 36 and 40.

Dimensions : Diametre : 48 μ ; Areolae : 8-9 in 10 μ

Coscinodiscus nitidus* Gregory.*(Plate I Figure 10)**

Cupp E., 1943, Page 55 , Figure 18.

Dimensions : Diametre : 12 μ

Coscinodiscus marginatus* Ehrenberg*(Plate II Figure 11)**

Subramanyan R., 1946, Page 96, Figure 41; Cupp E., 1943 , Page 55, Figure 19.

Dimensions : Diametre : 11a-54 μ , 11b-72 μ

Coscinodiscus granii* Gough*(Plate : II Figure 12)**

Subramanyan R., 1946, Page 96, Figure 33, 35 and 39. Cupp E., 1943, Page 56, Figure 21.

Dimensions : Diametre-84 μ

***Coscinodiscus oculus-iridis* Ehrenberg.**
(Plate II Figure 13)

Subramanyan. R., 1946, Page 101, Figure 66, 68 and 72. Cupp E., 1943, Page 62, Figure 26.

Dimensions : Diametre : 142 μ

***Coscinodiscus symbolophorus* Grun. var. *oamaruensis*. A. Schmidt**
(Plate II, Fig 14)

M. Hajos ., 1976, Page 826, Plate 6, Figure 1 and 2.

Dimensions : Diametre : 27 μ

***Coscinodiscus subtilis* Ehrenberg**
(Plate III Figure 15)

Subramanyan R., 1946 page 93, Figure 32 and 38.

Dimensions : Diametre : 49.5 μ

***Coscinodiscus jonesianus* (Greville) Ostenfeld. var. *commutata* (Grun.) Hustedt**
(Plate III Figure 16)

Subramanyan R., 1946, page 97, figure 43, 46, 47.

Dimensions : Diametre : 132 μ .

Genus *Actinoptychus* Ehrenberg

***Actinoptychus undulatus* (Bailey) Ralfs.**
(Plate III Figure 17)

Subramanyan R., 1946, page 105, figure 82.

Dimensions : Diametre : 51 μ .

***Actinocylus*, Ehrenberg**

Actinocylus octanarius* Ehrenberg. var. *octanarius
(Plate III Figure 18)

Hendey N., 1964, page 83, plate XXIV, figure 3.

Dimensions : Diametre : 118.5 μ .

Genus *Roparia* Gurnow

***Roparia tessellata* (Roper) Grunow ex Van Heurck**
(Plate III Figure 19)

Hendey N., 1964, page 85, plate XXII, figure 3.

Dimensions : Diametre : 6.6 μ .

Genus *Podosira* Ehrenberg*Podosira montagnei* Kützing
(Plate IV Figure 20)

Subramanyan R., 1946, page 87, figure 5,6 and 10.

Dimensions : Diameter : 20a-44 μ , 20b-41 μ

Genus *Auliscus* Ehrenberg*Auliscus sculptus* (Wn. Smith) Ralfs in Pritchard
(Plate IV Figure 21)

Subramanyam R., 1946, page 109, figure 93, 97. Hendey N., 1964, page 98, plate XXIII, figure 4.

Dimensions : Diameter : 44 μ .

Genus *Dactyliosolen**Dactyliosolen mediterraneus*. H. Peragallo
(Plate IV Figure 22)

Cupp E., 1943, page 77, figure 38.

Dimensions : L : 22b-765 μ ; D : 22a-13 μ , 22b-10 μ ; Bands : 22a-5 in 10 μ , 22b-4 in 10 μ .

Genus *Leptocylindricus**Leptocylindricus danicus* Cleve
(Plate IV Figure 23)

Subramanyan R., 1946, page 113, figure 169 and 110; Hendey N., 1964, page 140, plate V, figure 2; Cupp E., 1943, page 78, figure 39.

Dimensions : L : 24.5 μ ; B : 5 μ

Genus *Biddulphia* Gray*Biddulphia pulchella* Gray
(Plate V Figure 24)

Subramanyan R., 1946, page 154, figure 283 and 284; Hendey N., 1964, page 101, plate XXV, figure 1; Cupp E., 1943, page 152, figure 109.

Dimensions : Length : 24a-165 μ , 24b-453 μ ; Breadth : 24a-70 μ , 24b-31 μ

Biddulphia sinensis Greville
(Plate V Figure 25)

Subramanyan R., 1946, page 154, figure 281 and 289;

Hendey N., 1964, page 105, plate XX, figure 1.

Dimension : Length : 135 μ ; Breadth : 87 μ .

***Biddulphia regia* (M. Schultze) Ostenfeld**
(Plate VI Figure 26)

Hendey N., 1964, page 104, plate XX, figure 2.

Dimensions : Length : 153; Breadth : 76 μ .

***Biddulphia mobliensis* Bailey**
(Plate VI Figure 27)

Subramanayan R., 1946, page 155, figure 286, 287, 291-296 and 299. Cupp E., 1943, page 153, figure 110.

Dimensions : Length : 27a-49 μ , 27b-55 μ , 27c-50 μ , 27d-40 μ

***Biddulphia aurita* (Lyngbye) Brebisson and Godey**
(Plate VI Figure 28)

Cupp E., 1943, page 161, figure 112; Hendey N., 1964, page 103, plate XXIV, figure 6.

Dimension : Length : 71 μ .

***Biddulphia heteroceros* Grunow**
(Plate VII Figure 29)

Subramanyan R., 1946, page 155, figure 288, 289, 303.

Dimension : Length : 29a-90 μ , 29b-82 μ ; Breadth : 29a-40 μ , 29b-62 μ

***Biddulphia rhombus* (Ehrenberg) W.Smith forma *rhombus*.**
(Plate VII Figure 30)

Subramanyan R., 1946, page 157, figure 285, 290 and 302.

Hendey N., 1976, page 103, plate XXV, figure 08; Cupp E., 1943, page 163, figure 113.

Dimension : Length :- 30a-80 μ , 30b-46.5 μ ; Breadth : 30a-46 μ , 30b-32 μ

***Biddulphia dubia* (Brightwell) Cleve**
(Plate VII Figure 31)

Cupp E., 1943, page 164, figure 114.

Dimension : Length : 31a-65 μ , 31b-68 μ ; Punctae : 31a-8 μ .

Genus *Triceratium* Ehrenberg

***Triceratium favus* Ehrenberg**
(Plate VIII Figure 32)

Subramanyam R., 1946, page 106, plate 25, figure 4.

Dimension : Length : 32a-95 μ , 32b-78 μ .

***Triceratium reticulum* Ehrenberg**
(Plate IX Figure 33)

Subramanyan R., 1946, page 151, figure 279 and 280.

Dimension : Length : 80 μ .

Genus *Trinacria*

***Trinacria triscitia* Hajos**
(Plate IX Figure 34)

Hajos M. 1975, page 932, plate IX, figure 5, 6

Dimension : Length : 34a-43 μ , 34b-51 μ .

***Chaectoceros* sp. Ehrenberg**
(Plate IX Figure 35)

Hendey N., 1964, page 116, plate XIII, figure 1

Dimension : Length : 25 μ .

Genus *Rhizosolenia* Ehrenberg

***Rhizosolenia habetata* Bailey, form *semispina* (Hensen) Grun.**
(Plate IX Figure 36)

Cupp E., 1943, page 150, plate III, figure 50B; Hendey N., 1964, page 150, plate III, figure 5.

Dimension : Length : 234 μ ; Breadth : 13 μ .

***Rhizosolenia alata* Brightwell**
(Plate IX Figure 37)

Subramanyan R., 1946, page 126, figure 141, 145 and 146; Hendey N., 1964, page 146, plate II, figure 2/3/4; Cupp E., 1943, page 90, figure 52i.

Dimension : Length : 603 μ ; Breadth : 7–18 μ (10 μ).

Genus *Fragillaria* Lyngbye

***Fragillaria oceanica* Cleve**
(Plate X Figure 38)

Subramanyan R., 1964, page 165, figure 336–339.

Dimension : L : 38a-17 μ , 38b-13 μ , 38c-9 μ , 38d-17 μ , 38e-20 μ , 38f-23 μ ; B : 38a-5 μ , 38b-8 μ , 38c-5 μ , 38d-5 μ , 38e-5 μ , 38f-8.5 μ ; Punctae : 38a-19 μ , 38b-14 μ , 38d-20 μ , 38e-13 μ .

***Fragillaria islandica* Grunow ex Van Heurck**
(Plate X Figure 39)

Hendey N., 1964, page 153.

Dimension : Length : 34 μ ; Breadth : 5 μ ; Striae : 10 in 10 μ

***Fragillaria schulzi* Brockman**
(Plate X Figure 40)

Hendey N., 1964, page 154, plate XXVI, figure 16.

Dimension : L : 40a-17 μ , 40b-23 μ ; B : 40a-44 μ , 40b-3.5 μ ; Striae : 40a-12, 40b-10.

***Fragillaria brevisstrata* Grunow. forma. *elongata* f. nov.**
(Plate X Figure 41)

Venkatraman G., 1939, page 305, figure 25,26.

Dimension : Length : 26 μ ; Breadth : 9 μ .

Genus ***Raphoneis* Ehrenberg**

***Raphoneis discoides*. sp. nov.**
(Plate X Figure 42)

Subramanyan R., 1964, page 166, figure 347 and 350.

Dimension : Diametre : 38 μ .

Genus ***Synedra* Ehrenberg**

***Synedra tabulata* (Agardh) Kützing**
(Plate X Figure 43)

Hendey N., 1964, page 162.

Dimension : Length : 100 μ ; Breadth : 7 μ ; Striae : 10 in 10 μ .

***Synedra superba* Kützing**
(Plate X Figure 44)

Hendey N., 1964, page 163.

Dimension : Length : 405 μ ; Breadth : 8 μ ; Striae : 10 in 10 μ .

***Synedra investiens* Wm. Smith**
(Plate X Figure 45)

Hendey N., 1964, page 162.

Dimension : Length : 15 μ ; Breadth : 4.5 μ .

***Synedra crystallina* (Agardh) Kützing**
(Plate XI Figure 46)

Hendey N., 1964, page 164.

Dimension : Length : 779 μ , Breadth : 11 μ .

Genus *Thallasiothrix* Cleve and Grunow*Thallasiothrix longissima* Cleve and Grunow

(Plate XI Figure 47)

Subramanyan R., 1946, page 169, figure 352, 353, 358 and 359; Hendey N., 1964, page 165.

Dimension : Length : 431 μ ; Breadth : 5.60 μ ; Striae : 12 in 10 μ .*Thallasiothrix frauenfeldii* Grunow

(Plate XI Figure 48)

Subramanyan R., 1946, page 169, figure 349, 351, 354, 357 and 360, Cupp E., 1943, page 184, figure 135; Hendey N., 1964, page 165.

Dimension : Length : 74 μ ; Breadth : 2 μ .*Thallasiothrix mediterranea*

(Plate XI Figure 49)

Cupp E., 1943, page 185, figure 136.

Dimension : Length : 881 μ ; Breadth : 7 μ .Genus *Thalassionema* Grunow*Thalassionema nitzschioides* Grunow. Hustedt

(Plate : XII Figure 50)

Subramanyan R., 1946, page 167, figure 344–346; Hendey N., 1964, page 165.

Dimension : L : 50a–30 μ , 50b–83, 50c–30, 50d–34; B : 50a–2.5 μ , 50b–8 μ , 50c–5 μ , 50d–4;
Striae : 50b–8, 50c–12.Genus *Campylosira* Grunow ex Van Heurck*Campylosira Cymbellaiformis* (A. Schmidt) Grunow ex Van. Heurck.

(Plate XII Fig 51)

Hendey N., 1943, page 180, figure 130.

Dimension : Length : 20 μ ; Breadth : 2.5 μ .Genus *Plagiogramma* Greville*Plagiogramma staurophorum* (Gregory) Heiberg

(Plate XII Figure 52)

Hendey N., 1964, page 166, plate–XXXVI, figure 1

Dimension : Length : 51 μ ; Breadth : 14 μ ; Striae : 7 in 10 μ

***Plagiogramma brockmanni* Hustedt**
(Plate XII Figure 53)

Hendey N., 1964, page 166.

Dimension : Length : 13 μ ; Breadth : 6 μ .

Plagiogramma vanheurckii
(Plate XII Figure 54)

Cupp E., 1943, page 180, figure 129.

Dimension : Length : 22 μ ; Breadth : 4 μ .

Genus ***Licmophora*** Agardh

***Licmophora abbreviata* Agardh**
(Plate XII Figure 55)

Subramanyan R., 1946, page 163, figure 330–332.

Dimension : L : 55a-87 μ , 55b-28 μ ; B : 55a-17 μ , 55b-18 μ ; Striae : 55b-18 in 10 μ .

Genus ***Grammatophora*** Ehrenberg

***Grammatophora marina* (Lyngbye) Kützing**
(Plate XII Figure 56)

Hendey N., 1964, page 170; Cupp E., 1943, page 174.

Dimension : Length : 56a-46 μ , 56b-49 μ , 56c-46 μ ; Breadth : 56a-14 μ , 56b-15 μ , 56c-15 μ .

***Grammatophora undulata* .Ehrenberg.**
(Plate XII Figure 57)

Subramanyan R., 1946, page 163, figure 320, 324 and 326.

Dimension : Length : 46 μ ; Breadth : 15 μ .

Genus ***Rhabdonema*** Kützing

***Rhabdonema arcuatum* (Lyngbye) Kützing**
(Plate XII Figure 58)

Hendey N., 1964, page 172, plate XXXV, figure 10-12.

Dimension : Length : 50 μ ; Breadth : 8 μ .

Genus ***Eunotia*** Ehrenberg

***Eunotia monodone* Ehrenberg**
(Plate XII Figure 59)

Venkatraman G., 1939, page 310, figure 40.

Dimension : Length : 26 μ ; Breadth : 4.5 μ ; Striae : 8 in 10 μ).

Eunotia sp.

Plate XII Figure 60)

Dimension : Length : 26 μ ; Breadth : 6 μ ; Striae : 15 in 10 μ .

Eunotia sp.

(Plate XII Figure 61)

Dimension : Length : 10 μ ; Breadth : 4 μ .

Genus *Achnanthes* Bory

Achnanthes longipes Agardh

(Plate XIII Figure 62)

Hendey N., 1964, page 174, plate XXVII, figure 1-6, plate XLII, figure 2.

Cupp E., 1946, page 192, figure 141.

Dimension : L : 62a-31 μ , 62b-22 μ ; B : 62a-17.5 μ , 62b-12 μ ; Striae : 62a-9 in 10, 62b-16 in 10 μ .

Achnanthes brevipes Agardh

(Plate XIII Figure 63)

Hendey N., 1964, page 174, plate XXVII, figure 7, 8.

Dimension : Length : 54 μ ; Breadth : 40 μ .

Achnanthes parvula Kützing

(Plate XIII Figure 64)

Henedey N., 1964, page 175.

Dimension : Length : 21 μ ; Breadth : 9 μ .

Achnanthes subsessilis Kützing

(Plate XIII Figure 65)

Hendey N., 1964, page 175.

Dimension : Length : 27; Breadth : 10 μ , Puncta : 6 in 10 μ .

Achnanthes haukiana Grunow

(Plate XIII Figure 66)

Hendey N., 1964, page 176.

Dimension : Length : 66a-24 μ , 66b-14 μ ; Breadth : 66a-6 μ , 66b-3 μ ; Striae : 66a-9 in 10 μ .

Nitzschia irregularis.
(Plate XXII Figure 181)

Hendey N., 1964, page 283.

Dimension : Length : 30 μ ; Breadth : 4 μ ; Puncta : 9 in 10 μ .

***Nitzschia longissima* (Brebbison) Ralfs.**
(Plate XXII Figure 182)

Hendey N., 1964, page 283, Subramanyan R., 1946, page 191, figure 435–437.

Cupp E., 1943, page 200, figure 154.

Dimension : Length : 294 μ , Breadth : 11 μ ; Keel puncta : 7 in 10 μ .

***Nitzschia closterium* (Ehrenberg) W. Smith.**
(Plate XXIII Figure 183)

Hendey N., 1964, page 283, plate XXI, figure 8, Subramanyan R., 1964, page 189, figure 426, 428 and 429, Venkatraman G., 1939, page 356, figure 132, 133, Cupp E., 1943, pg. 200, fig. 153.

Dimension : Length : 145 μ ; Breadth : 9 μ .

***Nitzschia seriata* Cleve**
(Plate XXIII Figure 184)

Hendey N., 1964, page 284, plate XXI, figure 432–434, Cupp E., 1943, pg. 201, fig 155.

Dimension : Length : 184a-104 μ , 184b-91, 184c-92 μ ; Breadth : 184a-6 μ , 184b-5 μ , 184c-5 μ ;
Striae : 184b-7 μ , 184c-8 μ .

***Nitzschia polaris* (Grunow in Cleve and Grunow)**
(Plate XXIII Figure 185)

Michel Poulin and Andre Cardinal., 1983, page 113, figure 119.

Dimension : Length : 61 μ ; Breadth : 7 μ .

Genus *Surirella* Turpin

***Surirella hispida* Ross and Abdin**
(Plate XXIII Figure 186)

Hendey N., 1964, page 289.

Dimension : Length : 75 μ ; Breadth : 20 μ .

***Surirella fastuosa* (Ehrenberg) Kützing**
(Plate XXIII Figure 187)

Cupp E., 1943, page 288, plate XL, figure 4.

Dimension : L : 187a-54 μ , 187b-64 μ ; B : 187a-40 μ , 187b-42 μ ; Costae : 187a and b-2 μ .

Surirella striatula Turpin
(Plate XXIII Figure 188)

Hendey N., 1964, page 288, plate XI, figure 2, 3.

Dimension : Length : 102 μ ; Breadth : 47 μ .

Surirella gemma (Ehrenberg) Kützing
(Plate XXIII Figure 189)

Hendey N., 1964, page 288, plate XL, figure 5.

Dimension : Length : 78 μ ; Breadth : 39 μ .

Genus *Campylodiscus* Ehrenberg

Campylodiscus iyengarii sp. nov.
(Plate XXIV Figure 190)

Subramanyan R., 1946, page 192, figure 440.

Dimension : Length : 63 μ ; Breadth : 47 μ

Campylodiscus angularis Gregory
(Plate XXIV Figure 191)

Hendey N., 1964, page 291.

Dimension : Length : 84 μ ; Breadth : 50 μ .

RESULTS AND DISCUSSION

All together 191 forms were recorded out of which 35 species are centrales diatoms and 156 species are of pinnate diatoms. The number of pinnate diatoms is more than the centrale diatoms on both the coasts.

Out of the 50 genera of diatoms recorded the species of *Cyclotella*, *Coscinodiscus*, *Biddulphia*, *Fragillaria*, *Navicula*, *Diploneis*, *Pinnularia*, *Pleurosigma*, *Gyrosigma*, *Amphora* and *Nitzschia* were present almost throughout the year.

Results indicate that Dahanu coast is more productive than Nandgaon coast. The present study in addition to rendering information on the bio-diversity of diatoms of Nadgaon and Dahanu coast, will also help in providing baseline information for future monitoring of the system considering the fact that both the coastal areas are providing food and employment to local people and at present are highly productive in terms of aquatic products and also considering the industrial growth taking place around the coast through which effluents are received.

Dominance of pinnate diatoms over the centric diatoms at both the stations indicated that the pinnate diatoms are well adapted to varying nature of the sediments especially

high organic content. Similar observations were made by Rajan (1984) in the sediments of velar estuary, Mathevan Pillai (1994) from the Cuddalore marine environment and Anantharaman (1994) from the Pondicherry coastal area, Kannan *et al.*, (1997) in Tamil Nadu coast.

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OBSERVATION ON THE DISTRIBUTION AND ABUNDANCE OF TUNA RESOURCES IN THE EXCLUSIVE ECONOMIC ZONE (EEZ) OF ANDAMAN & NICOBAR ISLANDS

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ABSTRACT

Tuna forms a major component of the commercially important fishes of the Exclusive Economic Zone (EEZ) of Andaman & Nicobar Islands. In the oceanic waters of Indian EEZ, three varieties of tuna are commonly caught viz. Yellow fin tuna *Thunnus albacares*, Skipjack tuna *Katsuwonus pelamis* and big eye tuna *Thunnus obesus*. Among these varieties, the exploitation level of Yellow fin tuna and Skipjack tuna is more in comparison to the exploitation level of big eye tuna. In the present paper, an attempt has been made to study the distribution and abundance and some biological parameters of Yellow fin tuna and Skipjack tuna based on the data collected during tuna long lining, deploying the departmental exploratory survey vessel, MFV *Blue Marlin* (OAL 35.76m) during the period 2000-2005.

INTRODUCTION

India is one of the luckiest nations having two sets of Exclusive Economic Zones (EEZ), one along the mainland and Lakshadweep and second one; around Andaman and Nicobar Islands and having the international waters and high seas. It is aware that the coastal waters had been subjected to tremendous fishing pressure over the past few years resulting in over-exploitation of some of the resources. Therefore, it is imperative that the need of the hour is the diversification of fishing activities by extending the operation in to deep sea and oceanic waters. In this line, the Fishery Survey of India (FSI) being the nodal organization for survey, has studied and provided valuable information on the highly migratory and straddling species like tuna and allied resources of the Indian seas, based on the exploratory survey conducted in the Indian EEZ.

Tunas are widely distributed species of the Tropical and Sub-Tropical waters and constitute one of the economically important marine fisheries resources of the Exclusive Economic Zone (EEZ) of Andaman and Nicobar Islands. The three commercially important

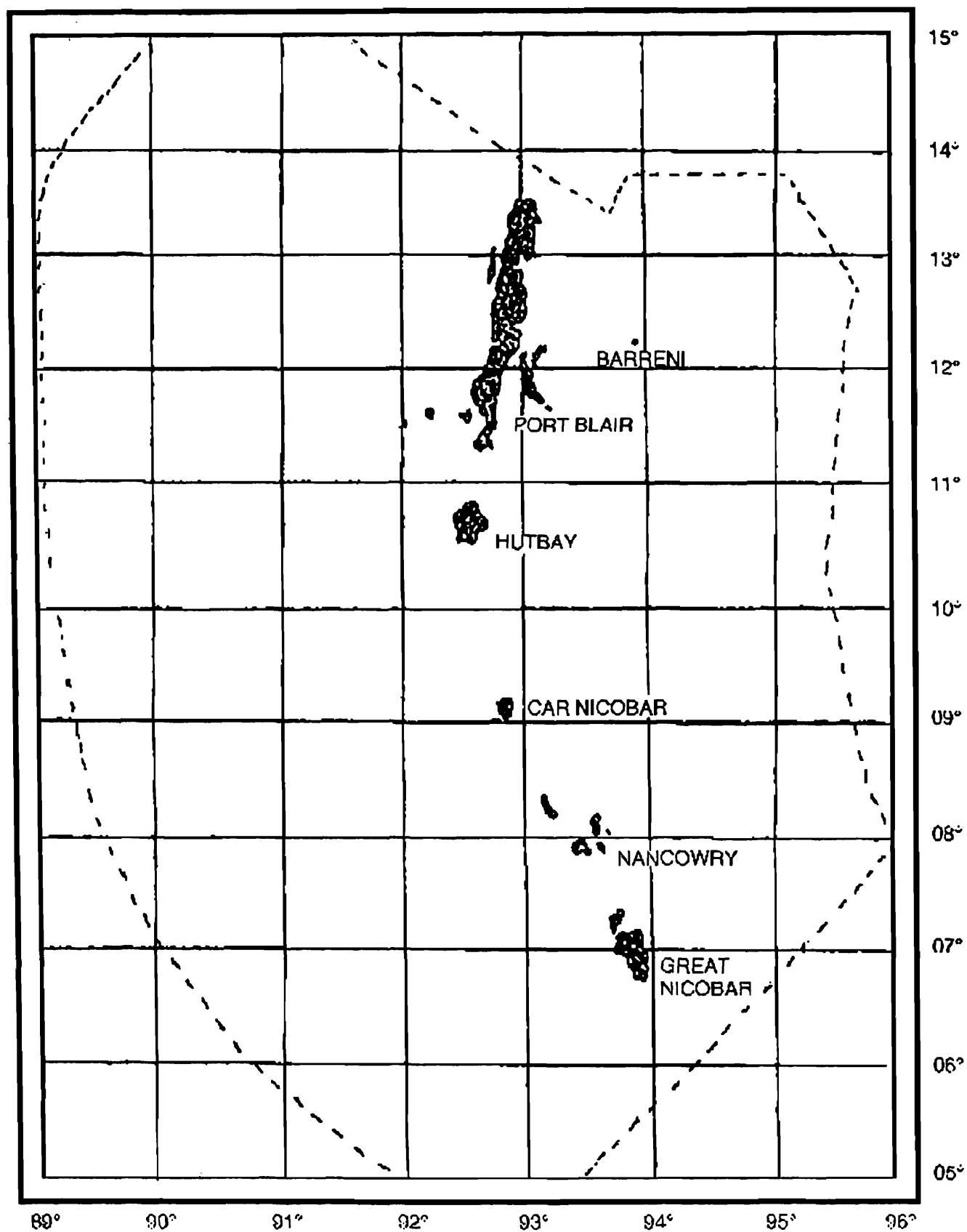


Fig. 1. Exclusive Economic Zone of Andaman & Nicobar Islands

species of tuna recorded in Andaman and Nicobar waters are Yellowfin tuna (*Thunnus albacares*), Big eye tuna (*Thunnus obesus*) and Skipjack tuna (*Katsuwonus pelamis*). Among these species, the exploitation level of Yellowfin tuna and Skipjack tuna is more in comparison with that of Big eye tuna. Andaman and Nicobar chain of Islands are situated between Latitude 06°45' and 13°41'N and Longitude 92°12' and 93°56'E in the South East Bay of Bengal comprising more than 572 Islands with a total area of 8249 Sq.km. The Islands are spread over a length of about 700 kms and breadth of about 250 kms. The coast line of Andaman and Nicobar Islands is about 1962 kms with an EEZ of 0.6 million Sq.km, which is about 30 % of the EEZ of India. The continental shelf area is 25,000 Sq.kms. which is about 7.7 % of the total Indian continental shelf area (Fig. 1).

The important marine fishery resources of these Islands are mackerels, sardines, carangids, silver bellies, perches, anchovies, hilsa, mullets, elasmobranchs, seer fishes, shrimps and crabs. The major fishing gears operated in the Islands are gill nets, cast nets, hook and lines, shore seines, anchor nets etc., and these gears are employed from traditional crafts like dinghies and motorized small mechanized boats.

The fishing effort, hooking rate and catch data generated during the multifilament tuna long line survey in and around Andaman and Nicobar waters, by deploying the Exploratory resource survey vessel, *M.F.V. Blue Marlin* (OAL 35.76M) attached to the zonal base of Fishery Survey of India, Port Blair during the period from 2002–2005 are considered as data base in this present study. The spatial distribution and abundance of the two major oceanic tuna resources *T. albacares* and *K. pelamis* and some biological parameters of the above two species are also studied and presented in the paper.

Estimates on Fishery potential of Oceano-pelagics : The estimates on the fishery potential of oceano-pelagics in the Indian EEZ is estimated as 2,46,000 tonnes and the group wise estimates are furnished in Table-1. The Yellowfin tuna comprises to the extent of 108.9 thousand tonnes, Skipjack tuna 100.2 thousand tonnes, Big eye tuna 0.3 thousand tonnes, Shark 31.6 thousand tonnes and other fish 5.0 thousand tonnes. Marine fishery resources of Andaman and Nicobar Islands are vast and abundantly diversified and various experts have estimated the marine fishery potential in the EEZ of Andaman and Nicobar Islands adopting various methods of stock assessment packages. Jones and Banerji (1973) estimated 12,000 tonnes (Both .. vdomisal resouses). Kumar (1973) estimates 50,000 tonnes. Sudarsan (1978) estimated 45,000 tonnes (only demersd), Artoing Raja (1980) estimated 1,00,000 tone. Josph (1985) estimated 72.500 tonne and Sudarsan *et al.* (1990) enlisted 2,43,500 tonne.

John *et.al* (2005) estimated the marine fishery resource potential of Andaman and Nicobar EEZ as 1,48,000 tonnes which is comprised of demersal resources (32,000 tonnes), Neritic-pelagic resources (56,000 tonnes) and Oceanic resources (60,000 tonnes). The major components of the oceanic resources are tunas (76.7%), shark (11.7%) and bill fishes

Table-1. Potential estimates ('000 tonnes.) of oceano-pelagics in the Indian EEZ

Species/group	Subsurface fishery	Surface fishery	Total
Yellowfin tuna	27.0	81.9	108.9
Skipjack tuna	0.1	100.1	100.2
Big eye tuna	0.3	—	0.3
Bill fishes	3.8	—	3.8
Pelagic sharks	15.8	15.8	31.6
Other fishes	1.2	—	1.2
TOTAL	48.2	197.8	246.0

Table-2. Potential yield of oceanic fishery resources in the EEZ around Andaman and Nicobar Islands.

Sl. No.	Species / group	Potential yield (tonnes)
1.	Yellowfin tuna	24,000
2.	Skipjack tuna	22,000
3.	Bigeye tuna	500
4.	Bill fishes (marlin, sail fish, sword fish)	2,800
5.	Wahoo (<i>Acanthocybium solandri</i>)	200
6.	Pelagic sharks	7,000
7.	Dolphin fish (<i>Coryphaena spp.</i>)	200
8.	Barracuda (<i>Sphyraena barracuda</i>)	200
9.	Flying fish (<i>Exocoetidae</i>)	300
10.	Oceanic squids	2,000
11.	Others	800
	Total	60,000

(4.7%) and the potential yield of oceanic fishery resources estimated in the Exclusive Economic Zone around the Andaman and Nicobar Islands are furnished in Table-2. The annual landings of tuna including coastal and oceanic in Andaman and Nicobar waters recorded during the year 2000–2005 are furnished in Table-3. The total annual landings of tuna in Andaman and Nicobar waters varied from 217 tonnes to 801 tonnes during the period of study, which contributed a meager proportion of 0.85 to 2.94% of the total marine fish landings.

Table-3. Annual landings of Tuna in Andaman & Nicobar waters during 2000-'05

Year	Total fish landings in (tonnes)	Tuna landings (in tonnes)	% contribution
2000	30,339	467	1.53
2001	27,173	801	2.94
2002	25,561	217	0.85
2003	30,636	536	1.75
2004-05	17,765	302	1.69

(*) Directorate of Fisheries, A & N Administration.

RESULTS AND DISCUSSION

Hooking rate and catch rate : Survey of oceanic tuna and allied resources by the resource specific multifilament tuna long lining around Andaman and Nicobar Islands by the exploratory survey vessel, *M.F.V. Blue Marlin*, registered an aggregate hooking rate of 0.81%. During the period under study, an average hooking rate of 0.19% was registered for Yellowfin tuna. During the year 2004-'05 the hooking rate of all fishes was highest with 1.01% in comparison to other years, and was followed by 0.91% and 0.73% during 2002-03 and 2000-01 respectively. Proportionately, the study reveals that the hooking rate of Yellowfin tuna was highest (0.46%) during 2004-05 followed by 0.20% and 0.14% during 2002-03 and 2000-01 respectively (Fig. 2.a). Similarly, the catch rate(Kg/1000 hooks) of all fishes was highest (298 Kg.) during 2004-05 followed by 242 and 238 Kg. in the year 2000-01 and 2002-03 respectively (Fig. 2.b). The catch rate of Yellowfin tuna was

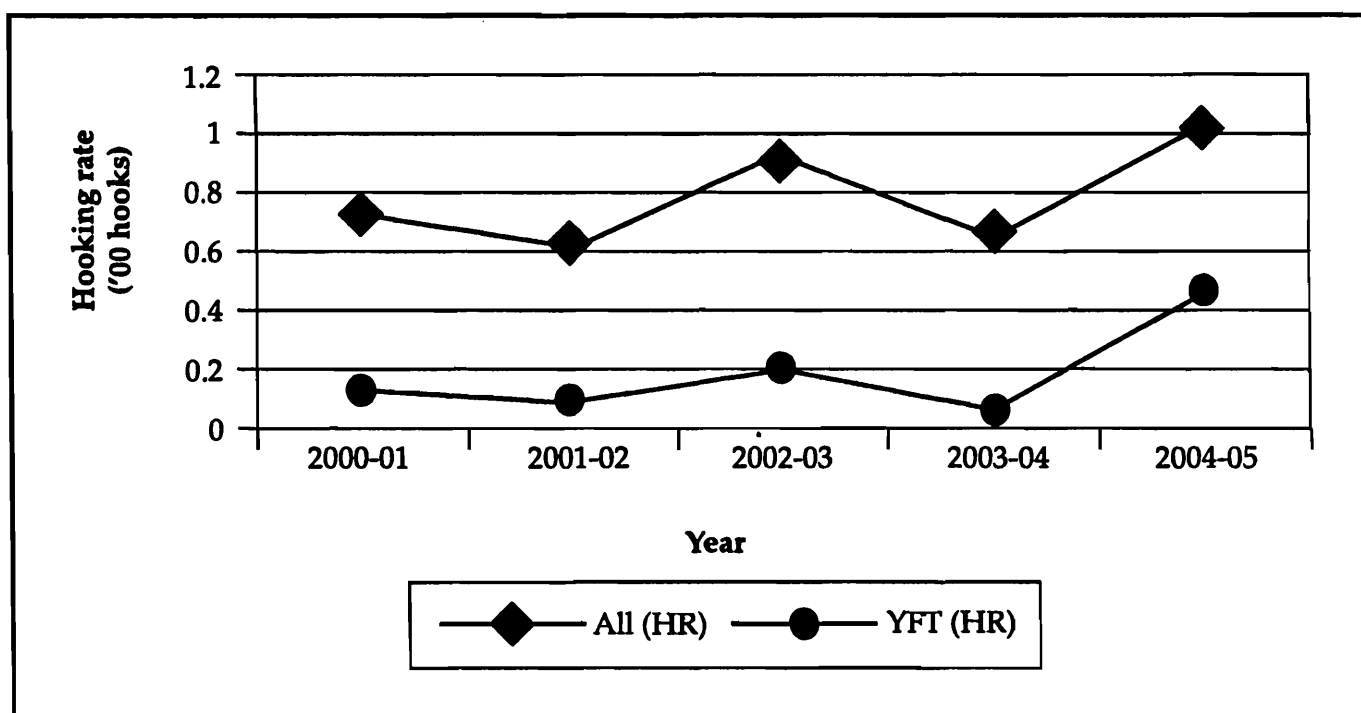


Fig. 2a. Hooking rate for all fishes and YFT in Andaman & Nicobar waters.

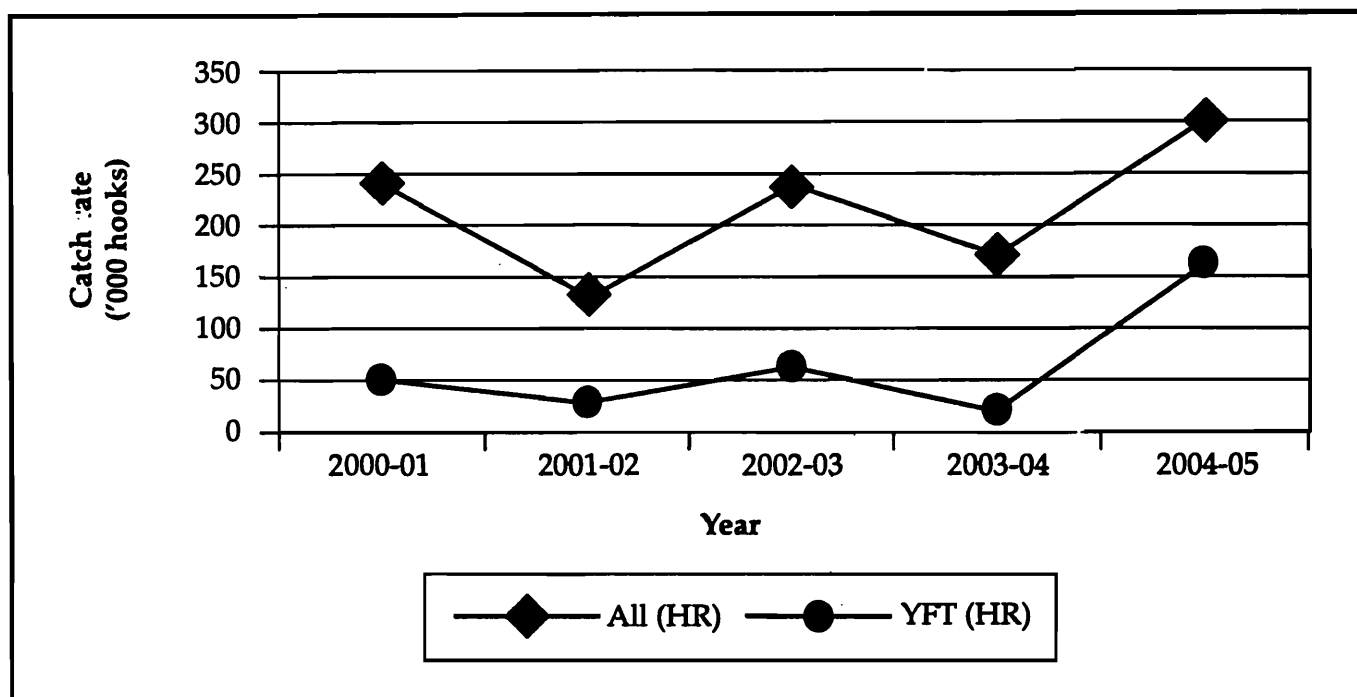


Fig. 2b. Catch rate for all fishes and YFT in Andaman & Nicobar waters.

highest with 157 Kg. during 2004–05. The aggregate hooking rate registered for Skipjack tuna was very less with 0.02%. It was inferred from the result that the distribution and abundance of Skipjack tuna was comparatively poor in the area surveyed and might be due to the depth of operation also. However, the highest catch rate of 1.08 Kg of Skipjack tuna was recorded during 2002–03 which was followed by 0.78 Kg. during 2004–05 and 0.47 Kg. during 2001–02 (Fig. 3.a & b).

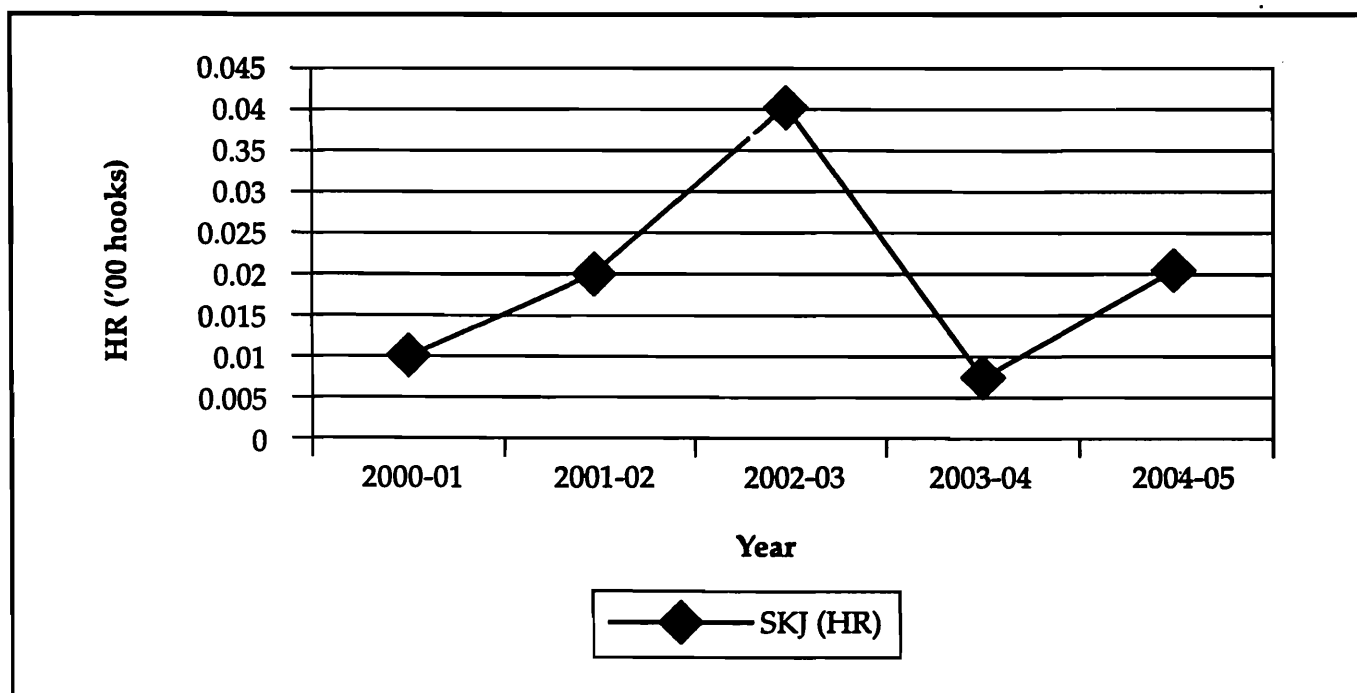


Fig. 3a. Hooking rate for SKJ in Andaman & Nicobar waters.

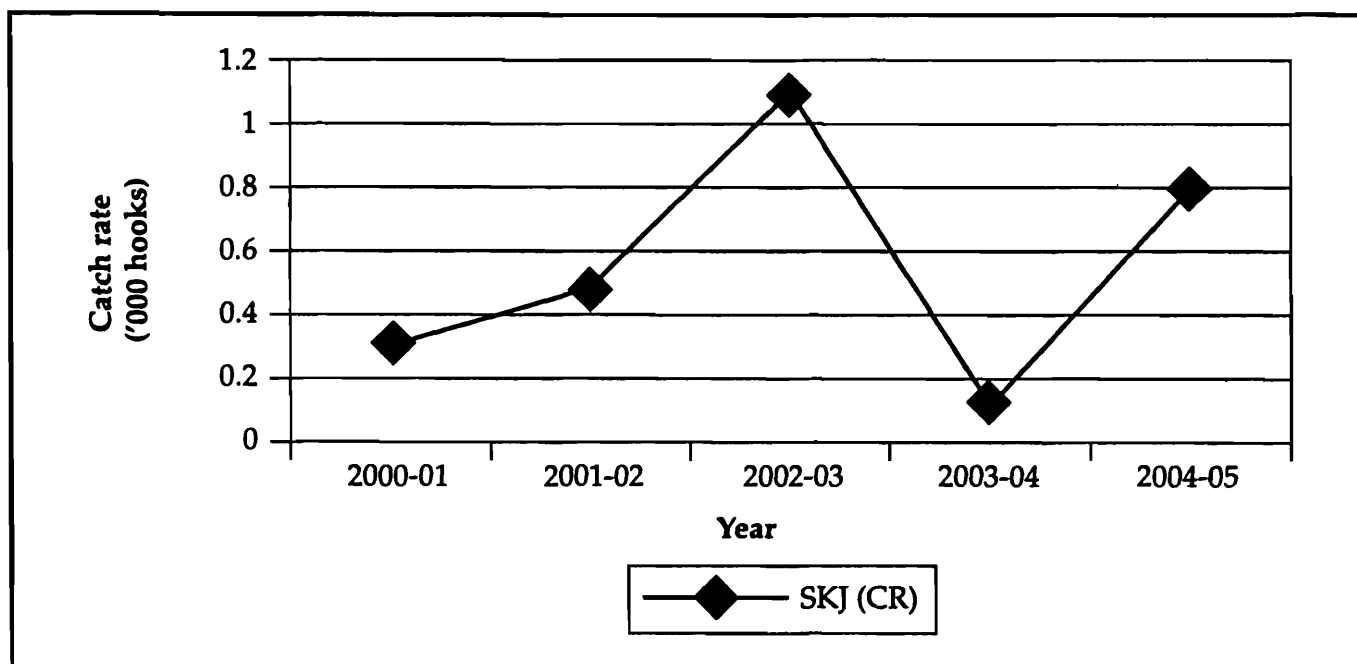


Fig. 3b. Catch rate for SKJ in Andaman & Nicobar waters.

In the long line catch, the Yellowfin tuna contributed about 27.9% by weight and Skipjack tuna about 0.27% by weight. The trend in catch composition reveals that Yellowfin tuna has steadily increased from 20.7% in 2000–01 to 52.7% in 2004–05. Similarly, the catch composition of Skipjack tuna also has shown an increasing trend. The CPUEs registered for Yellowfin tuna was 0.19 fishes weighing 6.2 Kg per 100 hooks and for Skipjack tuna it was 0.02 fish weighing 0.06 Kg per 100 hooks. The data collected were analysed to study the monthly and seasonal distribution and it shows that the aggregate hooking rate of all fishes was high during post-monsoon followed by pre-monsoon and monsoon periods. Species wise, the hooking rate of Yellowfin tuna was high during December (0.42) and January (0.65) whereas, for Skipjack tuna, the hooking rate was highest during July and December. (Fig. 4.a & b).

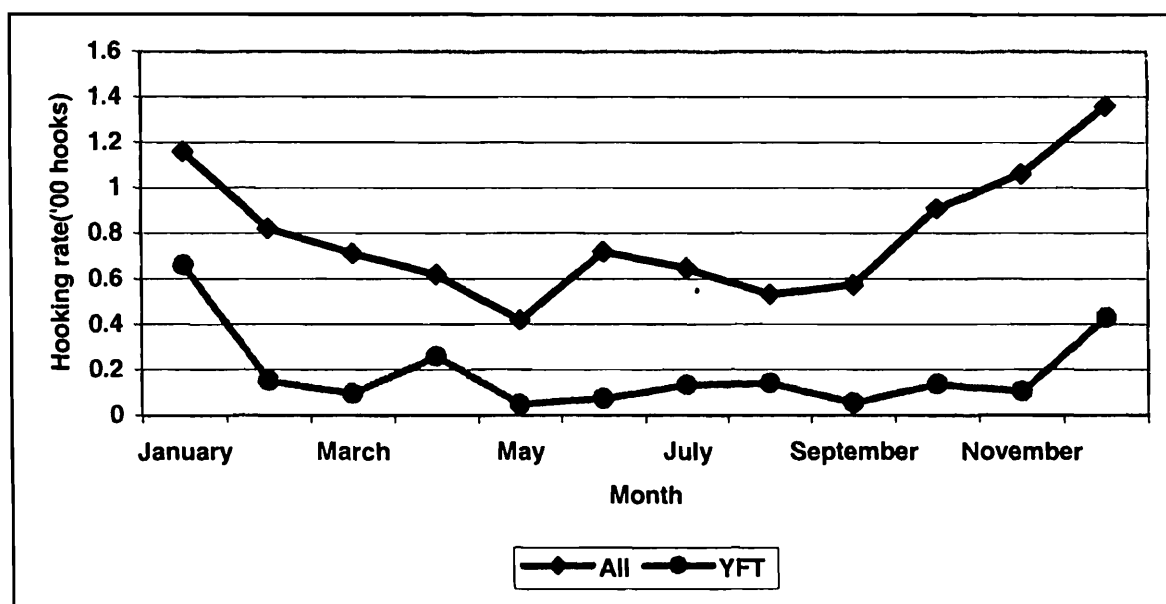


Fig. 4a. Hooking rate recorded for all fishes and YFT in A & N waters.

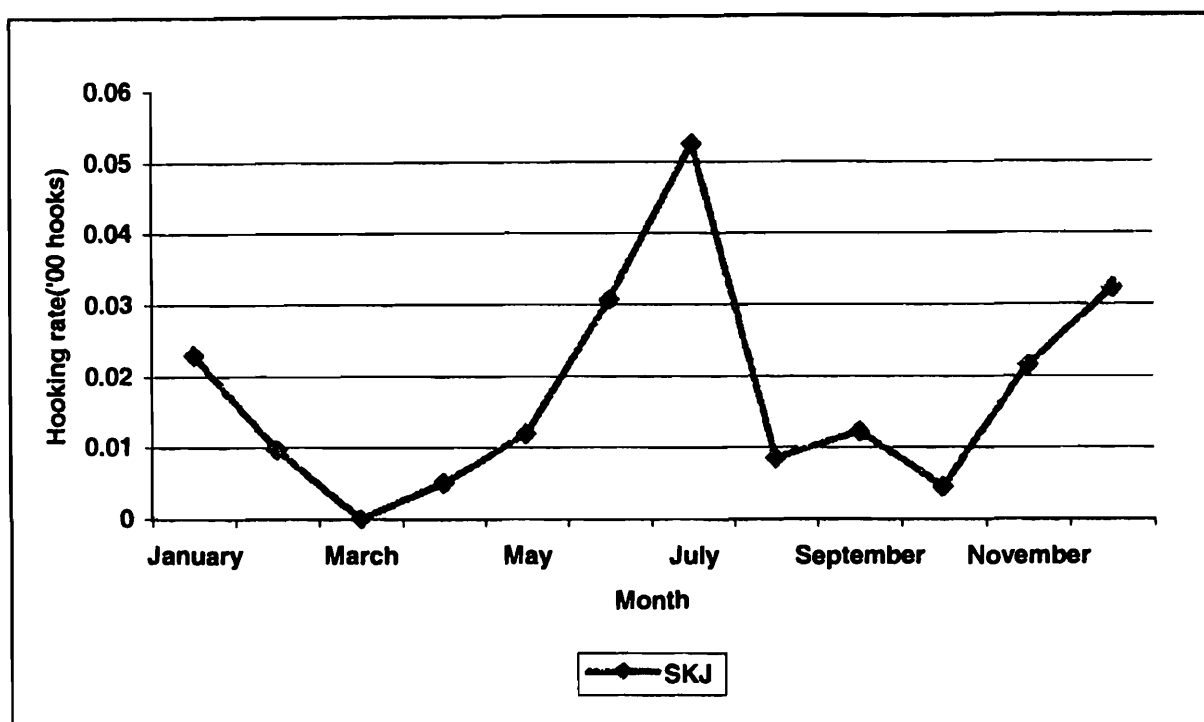


Fig. 4b. Hooking rate recorded for all fishes and SKJ in A & N waters.

Biological studies : Studies on biological aspects such as length weight relationship, length frequency distribution, population growth parameters and sex ratio of Yellowfin tuna and skipjack tuna occurring in the waters of Andaman and Nicobar Islands were attempted by various authors viz., Pillai *et.al* (1993), Yohanan *et.al*(1993), John (1995), Pillai & Pillai (2000), Varghese *et.al* (2002) and Pillai and Gopakumar (2003). Scientific data for attempting biological studies were collected from the samples caught on board, *M.F.V.Blue Marlin* during the survey and were analysed on board. A total of 534 specimens of Yellowfin tuna and 62 numbers of Skipjack tuna were utilized for biological studies in detail.

Length frequency distribution : The length frequency distribution and the percentage frequency of different size range of Yellowfin tuna recorded during the period under study are furnished in fig.5.a. It is observed that the male specimens of the population of Yellowfin tuna were in the length range of 69–176 cm in fork length with the mean length at 123.1cm. The fishery was dominated by the species of the model length of 111–150 cm. The females of Yellowfin tuna were in the size range of 48–145 cm in fork length with the mean length at 115.6 cm. The model length of the population was recorded at 111–140 cm. The mean weight of male and female Yellowfin tuna recorded was 32.88 kg and 26.55 Kg respectively. Usually, the Skipjack tuna are smaller in size when compared to the size of Yellowfin tuna in the fishery and the size distribution of Skipjack tuna and the length group wise percentage frequencies are furnished in fig. 5.b It is recorded that, the males of Skipjack tuna were in the length range of 45–69 cm in fork length with the mean length at 54.5cm and mean weight at 2.8 kg, whereas the females were in the length range of 44–65 cm with the mean length at 54.7cm and mean weight at 3.1 kg. The model length of the group dominating the fishery of Skipjack tuna was at 51 to 56 cm and 51 to 59 cm.for male and female respectively.

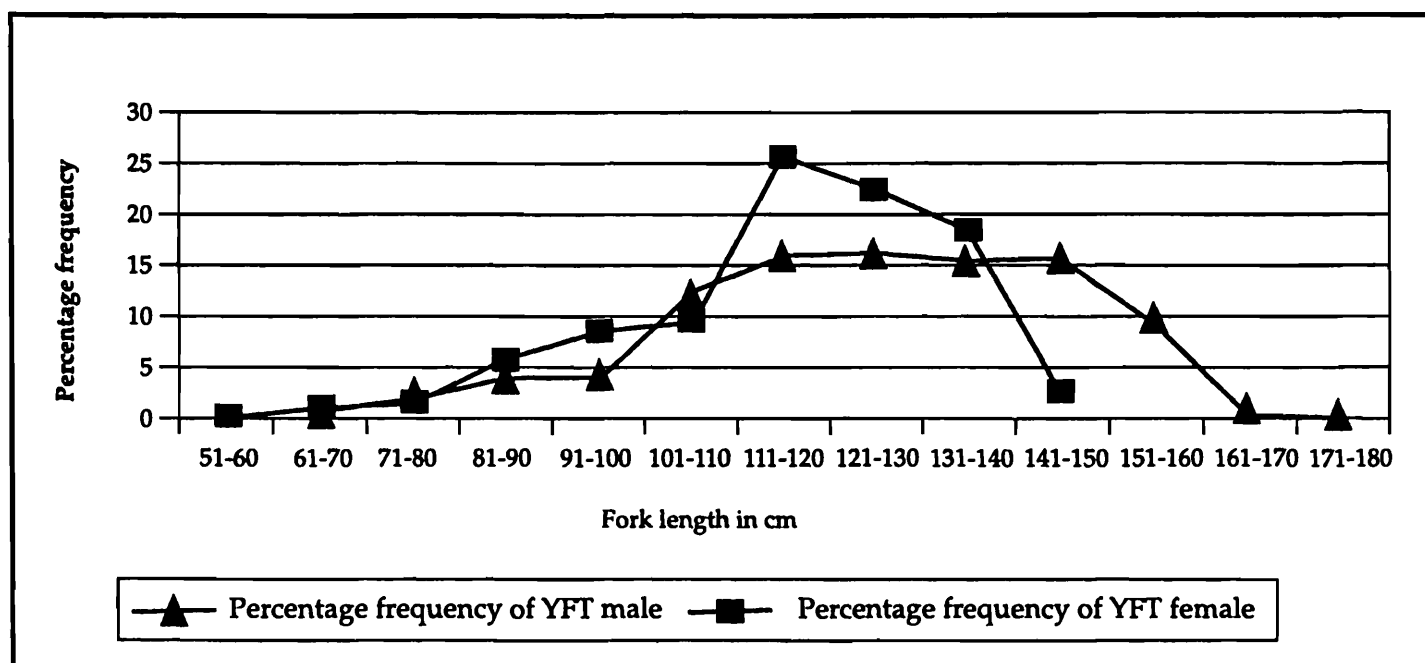


Fig. 5a. Length frequency of Yellow fin tuna during 2000-05

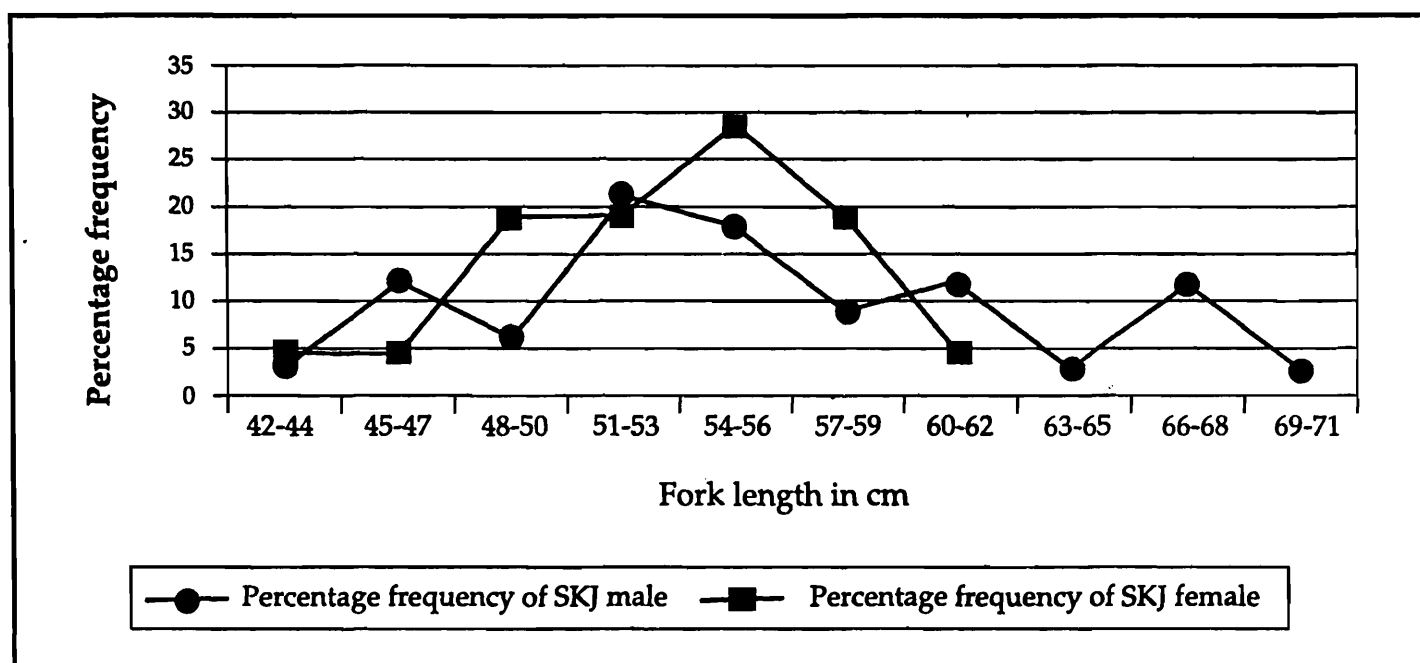


Fig. 5b. Length frequency of SKJ during 2000-05

Sex ratio : A total of 534 specimens of Yellowfin tuna were examined for sex ratio analysis of which, 374 were males and 162 females. The details on the record of male and female Yellowfin tuna recorded in various months and their percentage composition and the sex ratio are furnished in Table-4. The study on sex ratio revealed that males are predominant in almost all the months and the month wise sex ratio of male and female was in the range of 1 : 0.1 in August and 1 : 0.80 in March. The overall sex ratio (m : f) of Yellowfin tuna obtained was 1 : 0.44. Similarly, the percentage frequency of males were always dominating and were in the range of 55.56 to 90.63. The sex ratio with respect to different size groups of Yellowfin tuna also revealed that males are predominant

at all sizes. The observations on major domination of males at large sizes are in agreement with several reports of the previous studies. The overall male and female sex ratio with respect to size group was found to be 1 : 0.43. A total of 62 Nos. of Skipjack tuna were studied for the sex ratio analysis and the overall sex ratio of male : female was worked out to be 1 : 0.71, again the males were found to be dominant in all the months.

Table-4. Month wise sex ratio of Yellowfin tuna in Andaman and Nicobar waters (2000 -'05)

Month	Total No. of fishes	Male		Female		Sex Ratio (M : F)
		Number	Percentage	Number	Percentage	
January	194	136	70.10	58	29.90	1 : 0.42
February	46	33	71.74	13	28.26	1 : 0.39
March	18	10	55.56	8	44.44	1 : 0.8
April	16	12	75.00	4	25.00	1: 0.33
May	19	15	78.95	4	21.05	1 : 0.26
June	19	13	68.42	6	31.58	1 : 0.46
July	33	19	57.58	14	42.42	1 : 0.73
August	32	29	90.63	3	9.37	1 : 0.10
September	17	11	64.71	6	35.29	1 : 0.54
October	25	16	64.00	9	36.00	1 : 0.56
November	22	19	86.36	3	13.64	1 : 0.15
December	93	59	63.44	34	36.56	1 : 0.57
TOTAL	534	372	69.70	162	30.30	1 : 0.44

Length weight relationship : Length weight relationship of Yellowfin tuna found in the Andaman sea was studied by Sudarsan (1993) and John (1995). In the present study, 372 nos. of male Yellowfin tuna were taken for length weight analysis. The relationship (fig. 6.a) obtained was

$$W = 0.000025972 L^{2.9088} \quad (r = 0.926)$$

which agrees well with the earlier studies. Similarly 158 specimens were taken for the length weight analysis of females of Yellowfin tuna.. The relationship(fig.6.b) obtained was

$$W = 0.00010376 L^{2.6184} \quad (r = 0.9093)$$

and the 'b' value was slightly deviated from the earlier studies. Silas and Pillai (1985) estimated the length-weight relationship of Skipjack tuna using 38 specimens caught by

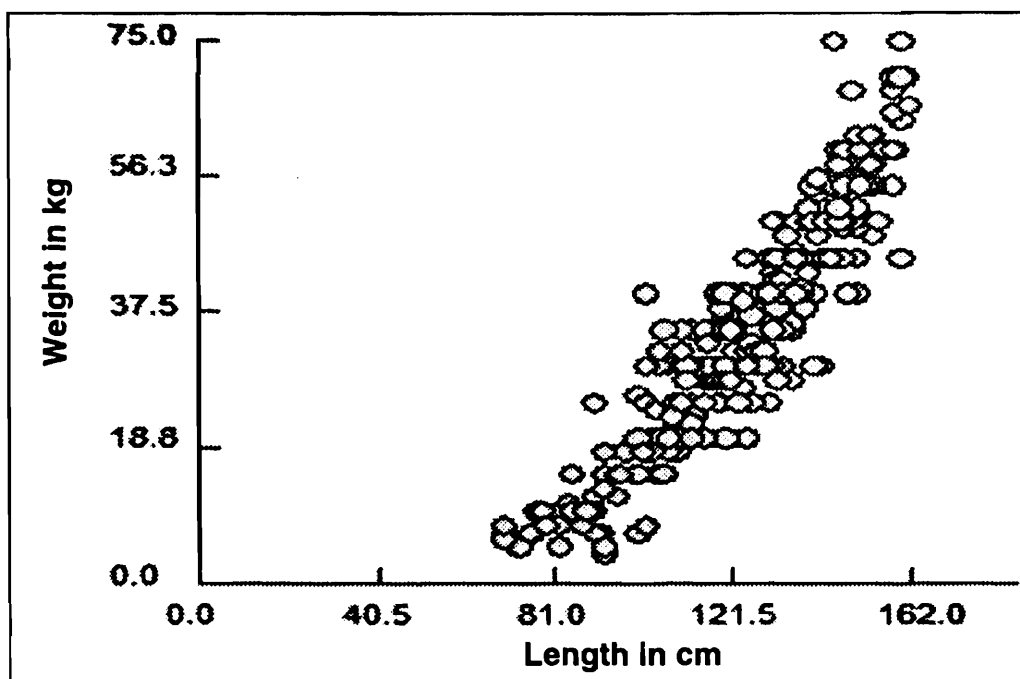


Fig. 6a : Length weigh relationship of Yellowfin tuna Male
Function : $\log(Y) = a + b \cdot \log(X)$

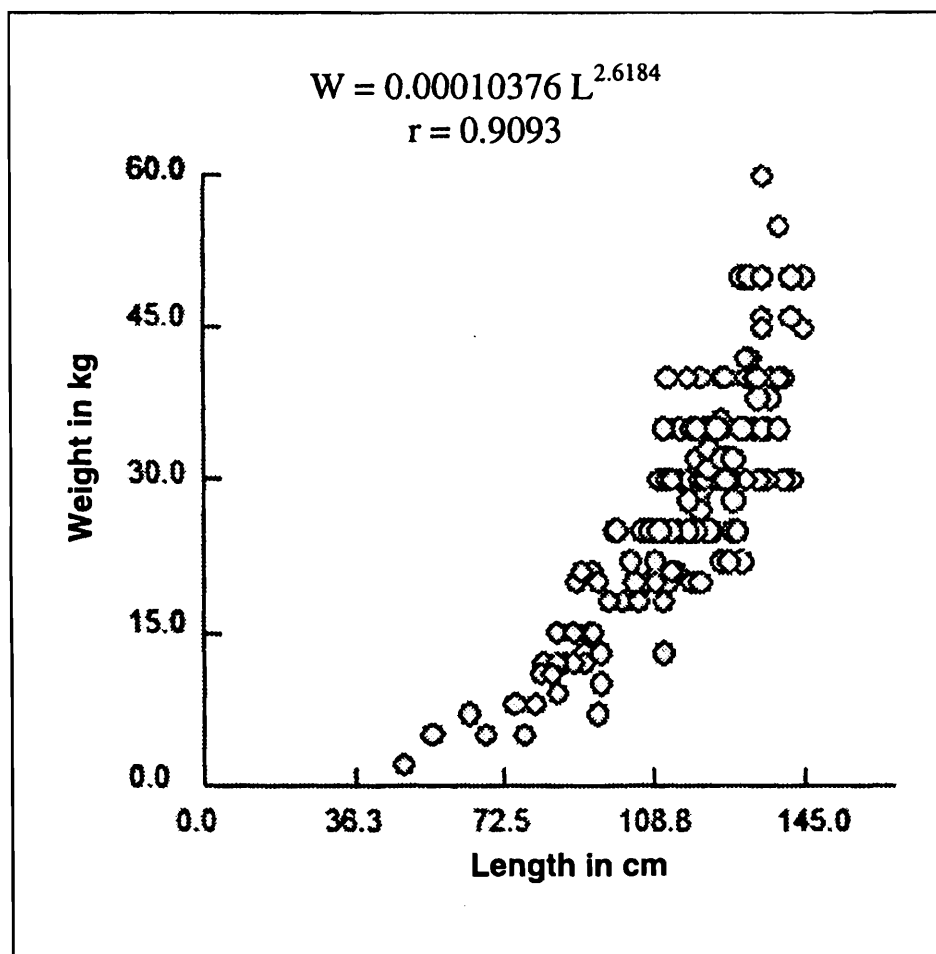


Fig. 6b : Length weigh relationship of Yellowfin tuna Female
Function : $\log(Y) = a + b \cdot \log(X)$

drift nets on board R.V. *Varuna*. Madan mohan and Kunhikoya (1985) estimated the length weight relationship of Skipjack tuna of Minicoy waters. In the present study, 62 Nos. of Skipjack tuna were utilised for length weight analysis and the analysis shows the relationship as :

$$W = 0.00004399 L^{2.7735} \quad (r = 0.7285)$$

Growth parameters of Yellowfin tuna : Growth parameters of Yellowfin tuna were studied by various researchers viz., John and Reddy (1989), John and Sudarsan (1993), Pillai *et. al* (1993) and John (1995). In the present study, an attempt has been made to estimate the growth parameters of Yellow fin tuna, with the length frequency data of Yellowfin tuna collected from 2000–2005 on board M.F.V. *Blue Marlin*. The data collected were pooled together and major growth parameters estimated for Yellowfin tuna are :

$$L_8 = 179.03 \text{ cm and } K = 0.32 \text{ (Year}^{-1}\text{)}$$

The EEZ around Andaman and Nicobar Islands is conventionally known for distribution and occurrence of tunas and allied resources such as marlins, sword fish, sail fish, sharks, etc., and the distribution of different resources in relation to space and time were worked out by various researchers. While Andaman waters were found to yield higher abundance index of Yellowfin tuna, the availability of big eye tuna was found to be relatively higher in Nicobar waters. As oceanic resources are highly migratory or straddling stocks, their assessment for a small oceanic province has obvious limitations. Nevertheless, tentative estimates are to be projected to enable planning development strategies.

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EFFECT OF EARTHQUAKE AND TSUNAMI ON MARINE FAUNAL DIVERSITY OF ANDAMAN & NICOBAR ISLANDS

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ABSTRACT

The long coastline of 1962 kms around A & N Islands with a large number of bays, creeks, and lagoons provides extensive marine ecosystems of rocks, sand, mud, mangrove swamps and coral reefs. The recent earthquake and *tsunami* changed the scenario of littoral habitats and further damaged the faunal composition. The post *tsunami* studies indicate that the impact is patchy and low to extreme at several places. Erosion of sand, deposition of hard debris on the beaches and exposure of rocky and coral habitats that have been noticed are potential barriers for turtle nesting at the usual places necessitating a search by the turtles for new beaches. These and other aspects of the recent earthquake and *tsunami* related to the marine biodiversity of the Andaman and Nicobar Islands are presented.

INTRODUCTION

The Andaman and Nicobar Islands are summits of submarine mountain range of hills connecting the Arkoan Yomas of Burma with the Achin Head in Sumatra of Indonesia. This Archipelago comprises an arcuate chain of more than 352 Islands and many islets and rock outcrops in the Bay of Bengal lying between latitudes 06° -14° N and longitudes 92° and 94° E (Plate 1). The Islands extend in North South direction covering a linear distance of about 726 kms. The ten degree channel distinctly separates the Andaman and the Nicobar groups of Islands. They have a total land area of 8,249 sq. kms. and a coastline of 1962 km. The marine ecosystem of the Islands has 6 lakh sq. km. of EEZ including 35 sq. kms. of continental shelf. The shelf abruptly plunges down into a steep slope. The coastline is wavy with bays, lagoons and creeks, supporting sandy, rocky and muddy beaches. Extensive sand and mud flats are common in sheltered areas and mangrove swamps. Mangroves are quite rich along the bays and creeks, while fringing coral reefs are common in shallow coastal waters often getting partly exposed during low tide. The complexity of habitats offered by the vast expanse of marine ecosystem is well known to support a rich biological diversity. The proximity of Islands to the 'Marine

Faunistic Centre' of Indo-Malayan Region and vast stretches of fringing reefs facilitated colonization of several species, which do not occur along the mainland coast. The fish, crustaceans and molluscs are the most important marine living resources of these Islands are being continuously exploited. The exploitation of molluscan resources has reached saturated levels. There are dangers of over fishing of target species of sharks, groupers, crabs and lobsters. Increasing population and over exploitation in recent decades is the main cause of stress on the marine ecosystem seriously affecting the faunal diversity, density and distribution. In addition, the recent 26th Dec. 2004 earthquake generated *tsunami* waves in the Andaman Sea caused extensive damage to the marine habitats and fauna of Andaman and Nicobar Islands also. The destruction due to impact of the *tsunami* waves is less than the destruction caused by the earthquake as far as fauna is concerned. Due to earthquake, the Islands experienced uplift and subsidence of landmasses at different places. In this connection, the present paper briefly gives an account of the marine faunal diversity in the littoral region, status of the important faunal groups, observations made on the impact of earthquake and *tsunami* waves on faunal wealth of the Islands.

MARINE FAUNAL DIVERSITY

The marine ecosystem of A & N Islands is one of the over 200 sites identified as global ecoregions. The vast expanse of marine ecosystem supporting large number of diversified fauna ranging from microscopic meiofauna to large marine mammals. The number of faunal species recorded in the Islands was first compiled in 1989 (Subba Rao, 1989) and subsequently further additions were made to it. So far about 5,344 faunal species (Table-1) were recorded from different marine ecosystems of the Islands. The available data indicate that the marine faunal diversity constitutes about 65% of the total species, both terrestrial and marine (7968 approx.). While, only 5.5% of plant species are marine. However, endemism in marine fauna is not very significant as many of these species are wide spread in the Indo-Pacific region and due to greater chances of dispersal of adults and their larvae by means of oceanic currents (Rao and Dev Roy, 1985). But as an exception, the meiofauna of littoral regions showed a higher degree of endemism due to their special mode of existence in a restricted habitat combined with the absence of pelagic larval stages in their life history of many meiofaunal elements. During the last four decades many new records and few new species were added to the marine faunal list. The last species in the list is not the end, there may be many more species awaiting the attention of taxonomists.

Marine vertebrate biodiversity : Seven species of marine mammals were reported in the near shore and oceanic waters of the Islands. The sea cow *Dugong dugon* normally occurs in shallow coastal waters. As this animal is exclusively herbivorous, feeding on seagrasses and weeds, found near the seagrass beds and other vegetation grounds. The other important mammal is dolphin. Species of *Delphis delphus* are common in the bays. The other mammals are represented by whales are rarely sited in off shore waters of the Islands.

Out of the 12 species of the reptiles, the most important are the four species of turtles *Chelonia mydas*, *Dermochelys coriacea*, *Lepidochelys olivacea* and *Eretmochelys imbricata* found frequently encountered in the waters. Large numbers of these species regularly visit the beaches for nesting. The two species of amphibious snakes, *Laticauda laticauda* and *Laticauda colubrina* come to the shores to lay their eggs. The Andaman water monitor, *Varanus salvator andamanicus* and the salt-water crocodile *Crocodylus porosus* frequently found near the coastal areas. After marine mammals and reptiles, the fish is the most important and dominant vertebrate group. The marine fish diversity is very rich which constitutes about 26% of the total marine fauna recorded. Over 1300 species, more than 50% of fish are found in and around reef habitats.

Marine Invertebrate Biodiversity : After fish, marine molluscs are the dominant group represented by 1282 species that constitutes about 24% of the total fauna. The molluscs like *Trochus*, *Turbo*, scorpion shells, cones, cowries, abalones, giant clams, pearl oysters, winged oysters, mussels, etc are the most common and commercially important components. The crustaceans are the next dominant group constituting about 19% followed by 8% of echinoderms. The rest of the animal groups such as polychaetes, sipunculids, hard corals, soft corals, sponges etc. constitute 1 to 4%. Four species of lobsters (*Panulirus homarus*, *P. versicolor*, *P. ornatus*, *P. pencillatus*), twelve species of prawns (species of *Metapenaeopsis*, *Metapenaeus*, *Penaeus*) and three species of crabs (*Scylla serrata*, species of *Portunus*) are the most important commercial crustaceans. The sea cucumbers *Holothuria*, *Stichopus*, *Bodaschia*, *Actinopyga* and *Synapta* are commercially important species. During the last few decades these valuable marine living resources like molluscs, crustaceans, sea cucumbers, lobsters, shrimps, crabs and target fish species like sharks, groupers, snappers, scombrids etc. of shelf area are exploited continuously. These resources once found abundant have already been depleted due to large-scale exploitation. The exploitation of molluscs and sea cucumbers has already reached unsustainable levels. Over exploitation and indiscriminate destruction of marine habitats in the Islands are severely affecting the composition, density and distribution of marine fauna. In addition, the destruction of coastal habitats due to natural and other anthropogenic pressures has also caused irreparable damage to the coral reefs, reef building organisms as well as the large community of other animals living associated with them. The reef habitats have largely been damaged due to heavy inflow of freshwater, sedimentation and turbidity due to deforestation and soil erosion of coastal regions, accumulation of toxics from pesticides and chemical fertilizers. Some times stress may be delivered through the change in climatic conditions such as currents, waves and storms led to the depletion of faunal populations. The recent catastrophe, due to earthquake generated killer *tsunami* waves proved destructive and caused immense damage to the marine habitats and fauna of several Islands.

Table-1. Marine Faunal Diversity and endemism in Andaman & Nicobar Islands

Group	No. of Species	Endemics	Endemism (%)
Meiofauna	486	102	21.0%
Porifera (Sponges)	72	—	—
Hexacorals (Hard corals)	177	—	—
Octocorals	221	—	—
Other Cnidarians	44	2	4.5%
Polychaeta	184	4	2.1%
Sipuncula	29	—	—
Crustacea	1029	6	0.6%
Mollusca	1282	177	14.0%
Pycnogonida	8	—	—
Echinodermata	425	4	1.0%
Pisces	1368	2	0.1%
Reptilia	12	—	—
Mammalia	7	—	—
Total	5344	297	5.0%

Impact of on Marine fauna : In the early hours of the fateful day of 26th Dec. 2004 an earthquake epicentered at Indonesia generated the most devastating *Tsunami* in the history. The killer waves swooped all the fauna, flora, people, dwellings and establishments all along the coastline or its way. The earthquake occurred along the plate boundary marked by subduction zone between Indian and Burmese plate. As a result of the movement of these tectonic plates, the Andaman and Nicobar Islands have experienced uplift and subsidence at different places (Jain *et al*, 2005). It is quite evident that among Andaman group of Islands, North Andaman and Middle Andaman areas were uplifted whereas South of South Andaman to Nicobar Islands were submerged from one to three meters.

The *tsunami* studies have been made around Andaman and Nicobar Islands during March-April 2005 to assess the impact of earthquake and *tsunami* on marine fauna. Changes in the habitats and their ecological conditions, biophysical status of coral reefs and status of faunal elements were examined. The extensive survey and random LIT (Line Intercept Transects) studies around the Islands revealed large-scale destruction of habitats and fauna due to submergence and uplifting of Islands at many places. The North and Middle Andaman group of Islands are uplifted more than two metres and also tilted towards East. This resulted in mass mortality of vast coral beds and their associated fauna. But, interestingly, there is no much destruction of habitats and fauna on East Coast side of this belt. But the South Andaman and surrounding areas are submerged around one metre.

The productive habitats in the Southern group of Islands are covered with huge silt and sand led to the loss of biodiversity. Whereas the Southern group of Islands (Nicobar group) sunk by about 1 to 3 metres, led to the submergence of coastal regions. At many places 20 to 30% of mangrove belts and their associated fauna have been destroyed.

The Interview Island located on the West side of North Andaman range is about 8-9 km long with extensive reefs and mangrove belts and rocky and sandy beaches all around. The powerful *tsunami* waves pushed all the corals towards shore leaving few patches on reef slope on West side of the Island. Over two to three hundred metres of reef for a length of more than 7 km was exposed and entire associated fauna was destroyed. Due to uplifting, the water level was very much reduced on the reef even during high tide and this became a barrier for the movement of sea turtles to the sandy shores. But the damage to the habitats of eastern side is negligible.

Extensive patches of reefs around North Reef and Latouche, South Reef Island, Anderson Island etc. were also exposed. But corals on the deeper reef slopes are safe and absolutely no impact on them. The reefs of almost all the Islands located on the West and North-West side of the North Andaman including West Island, Landfall Island, East Island etc. are exposed extensively due to elevation of land mass. The damage caused to the corals and their associated fauna at these places was about 60 to 75%. All the associated fauna such as sea stars, sea lillies, feather stars, sea urchins, sea cucumbers, large number of molluscs, crustaceans, sipunculids, worms, fishes died and washed ashore in large quantities at many places. The algae and seaweeds are growing at fast rate on the disturbed reef habitats. The mangroves and sea grass beds of Andaman group of Islands were extensively damaged.

Interestingly, There was no significant damage on the Eastern side of the Andaman group of Islands such as Ritchie's Archipelago, Long Island, Sound Island, Aves Island, Smith Island, Ross Island, Table Islands, Turtles Islands, Delgarno Island, Excelsior Island, Pocock Island etc. Even though, the waves first lashed the Eastern side of the island chain, the corals or their associated fauna withstood the impact. Only few massive and plate coral colonies were tilted and over turned at some places and some coral colonies on deeper reef slopes were also covered with sand and silt brought by the waves. Unlike the Western side there was no exposure of coastal habitats on the Eastern side. The reef habitats and their fauna were almost in stable condition. Because of subsidence of landmass of Nicobar group, many small Islands and vast coastal belts were submerged at different places. The corals, their associated fauna and reefs were mostly damaged due to deposition of huge amount of sand and mud. But the corals in the sheltered areas around Nancowry group of Islands were not much damaged.

The salient features of impact on coral reefs are summarised below :

Impact on reefs and other habitats

- ☐ the impact was very patchy and low to extensive at different places
- ☐ worse in the Nicobar group of Islands than in the Andaman group of Islands

- ☐ few reefs on the west side of Middle and North Andaman have lost structural integrity and ecological functionality
- ☐ wave patterns around coastal regions have changed
- ☐ damage was mostly mechanical, breakage of branched and plate coral colonies, and toppling and tilting of massive coral blocks
- ☐ clear loss of many invertebrate and fish habitats and changes in fish composition
- ☐ at some areas there was an extensive deposition of sand and sediments brought by giant waves resulting in loss of extensive coral beds
- ☐ mangroves and sea grass beds suffered extensive mortality
- ☐ wetland patches have been dried up in some areas due to extensive deposition of sand near stream mouths resulting in loss of habitat for endangered wetland birds like Andaman Teal (Ex: North Reef Id.)
- ☐ significant increase in dead coral cover, coral rubble and sand
- ☐ beach topography changed at several places, many beaches submerged, uplifted reefs becomes barriers for turtles
- ☐ at some places the stream mouths wide opened (Ex: Galathea River mouth, G. Nicobar)
- ☐ submergence of coastal belts in Nicobar group resulting in destruction of habitats of coastal endangered animals like robber crab (*Birgus latro*) and megapode bird (*Megapodius freycinet*)
- ☐ further damaged the already stressed and degraded ecosystems and resources of the Islands

The loss of men and material due to killer waves can be assessed and necessary steps can be taken up for restoration and rehabilitation. But in the case of destruction of marine habitats particularly the coral reefs, it is very difficult to restore the habitats. Unless stringent conservation measures are taken up and leave the damaged habitats without any further resource exploitation for a couple of decades, the lost legacy of the coral reefs cannot be restored in the Islands.

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PLATE-I

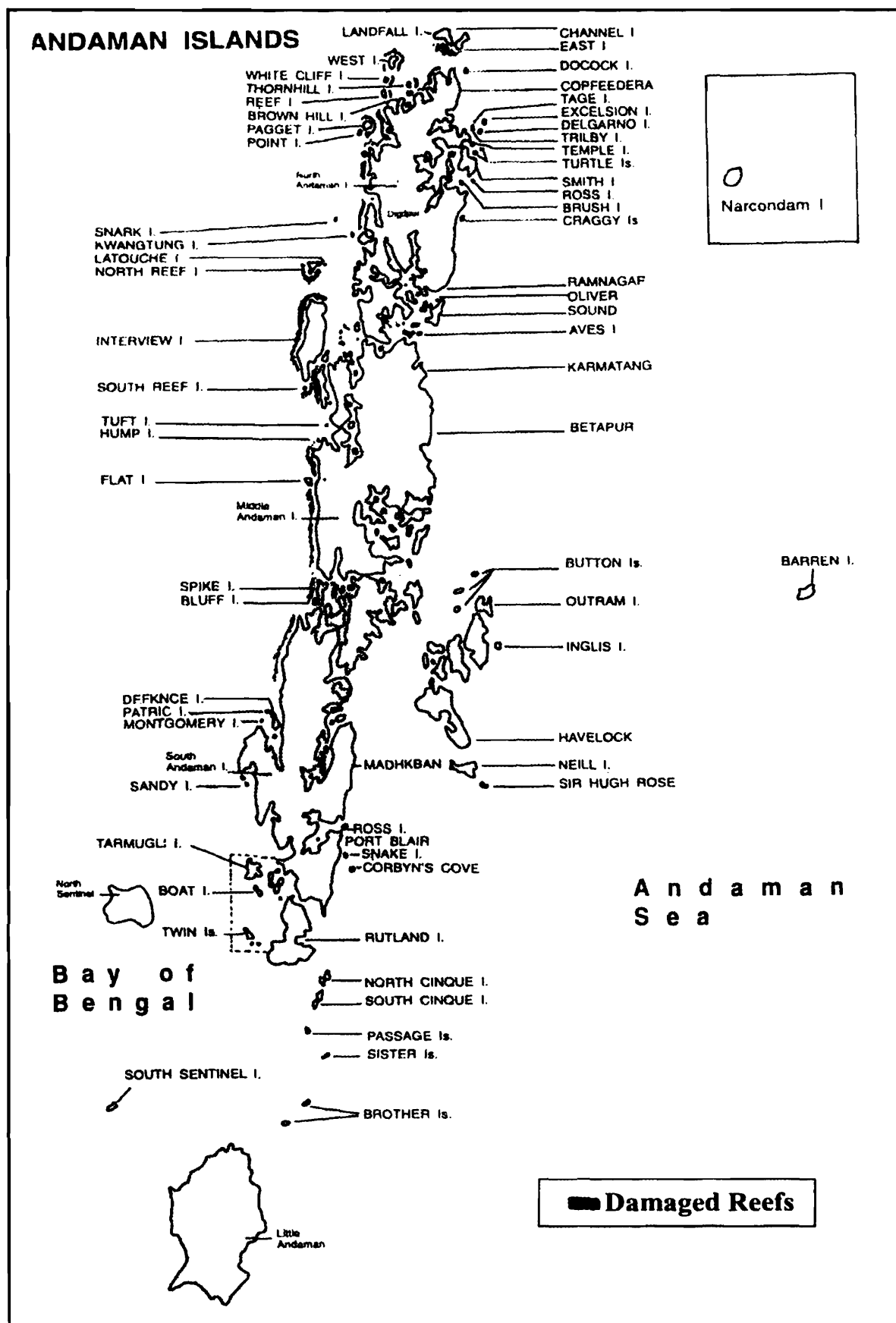


Plate 1. Map showing Andaman & Nicobar Islands

PLATE-II



a. Coral Graveyard–West of Interview Island



b. Drived up Wetland at North Reef Island

PLATE-III



a. Devasted Reef at North Reef Island



b. Undamaged Reef at Sound Island (East side of N. Andaman)

PLATE-IV



a. Death of Corals due to land elevation at Anderson Island



b. Exposed Reef flat at East Island

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INVESTIGATION ON IMPOSEX IN DIFFERENT SPECIES OF NEOGASTROPODS ALONG THE INDIAN COAST

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ABSTRACT

The studies were performed at twenty four sampling stations spread over eight Coastal States of India. Imposex was observed from all the coastal regions of India, however, Conversion of Potential Female to Imposex Index and percentage of imposex in *Thais bufo*, *T. rudolphi*, *T. tissoti*, *Drupa konkanensis*, *Ocenebra bombayana* and *Natica tigrina* was very high in Bombay region (Marine Drive, Colaba and Bandra) and Chennai Port. The findings also proved that the formula developed by Tewari *et al.* (2002) for calculating CPFII is a better indicator for severity of imposex in natural population as compared to commonly used RPSI and VDSI. This has been confirmed at much larger population size and species diversity. The numerical and biomass density of all species of neogastropods are not inhibited due to TBT contamination caused by shipping activity. *Thais rudolphi* can be used as bioindicator for TBT contamination.

INTRODUCTION

Imposex is the superimposition of male sex organs, penis and vas deferens on the female genital system in gonochoristic gastropods. It is also called pseudohermaphroditism. In advance cases imposex may bring out reproductive failure and consequential population decline (Bryan *et al.*, 1986). The reproductive failure is caused due to the development of a vas deferens on the oviduct which leads to sterility in females and in extreme cases the whole population vanishes from that area (Santos *et al.*, 2004). Imposex is reported to be caused by organotin compounds like tributyltin (TBT), triphenyltin (Horiguchi *et al.*, 1995) etc. which are used as anti-fouling paints in ships, fishing nets and mariculture cages (Gibbs *et al.*, 1987; Bryan *et al.*, 1988). Imposex occurs at levels of TBT contamination as low as parts per trillion. It can also be caused by agents other than TBT including parasitic trematode larvae (Curtis, 1994) and other important pollutants such as copper compounds (Nias *et al.*, 1993) and nonylphenol (Evans *et al.*, 2000a). However the effect

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Map showing the sampling stations along Indian coast

of copper on imposex has not been proved (Cllaisse & Alzieu, 1993). The other two causative agents require further proof for their effectiveness.

TBT may also induce another masculinised phenotype termed intersex. This condition is only documented to occur in the periwinkle *Littorina littorea* and develops under higher TBT concentrations ($> 10 \text{ ng l}^{-1}$ as Sn). Both intersex and imposex are irreversible conditions provoking female sterility (Wolf *et al.*, 2004). The morphological changes in the genital system of the females leading to sterility have been described by Bauer *et al.* (1995).

All ships including Indian ships use the antifouling paint containing TBT as there is no regulation as on date in India and several other countries to ban the use of TBT in antifouling paints. International Maritime Organization (IMO) was expected to endorse a recommendation from its Maritime Environmental Protection Committee that the application of TBT based coatings should be prohibited from January 2003 onwards. Vessels must be free of these coatings altogether by 2008. However, the treaty was not ratified by the required number of countries and has not been put into practice yet (Camillo *et al.*, 2004). Nevertheless the use of TBT has been banned in antifouling paints for ships larger than 25 m in length in developed countries, such as many European countries, Canada, the United States, Australia, New Zealand and Hong Kong since 1980s. The production, import and use of organotins (TBT and TPhT) have been restricted by law and administrative guidance since 1990 in Japan, resulting in no domestic production in 1997. TBT-based antifouling paints, however, are still used in developing countries, such as most Asian countries including India and their use has also continued worldwide for most of the vessels larger than 25 m in length. (Horiguchi *et al.*, 2003; Wolf *et al.*, 2004).

Imposex has been reported in 150 species of neogastropods, belonging to 63 genera (Pellizzato *et al.*, 2004). The concentration of TBT in seawater (Ichiro *et al.*, 1999; Reitsema & Spickett, 1999; Michel *et al.*, 2001) and in several species of gastropod (Ten Hullers *et al.*, 1994; Evans, 2000b; Svarvasson, 2000; Power & Keegan, 2001; Horiguchi *et al.*, 2003; Vishwakiran *et al.*, 2005) has been reported from different parts of the world and is extensively used as a biomarker to assess and monitor TBT pollution all over the world: (Italy, UK, Ireland, North Sea, Iceland, Malaysia, Japan, Australia and New Zealand, Pellizzato *et al.*, 2004).

Muricid gastropods especially *Chicoreus*, *Thais*, *Murex* etc. are commercially important as regular diet and for preparation of other products. As it has got widespread economic importance, the present study was undertaken. The studies on imposex in neogastropods except a small pocket from Indian coast is meagre and the health of the coast cannot be predicted based on some such small data (Tewari *et al.*, 2002). A significantly high degree of imposex has been observed in the neogastropods of Gujarat region, therefore, it was thought desirable to study this phenomenon from other parts of the Indian coast. The study was also aimed to test the new formula on CPFII developed by Tewari *et al.* (2002) for calculating the severity of imposex, on a large population to prove its field worthiness with different species.

MATERIAL AND METHODS

Sampling of Neogastropods : The specimens of neogastropod, *Thais bufo* (Lamarck), *T. rudolphi* (Lamarck), *T. tissoti* (Petit), *Drupa konkanensis* (Blainville), *Ocenebra bombayana* (Melvill) and *Natica tigrina* (Roding) were collected from Okha, Porbandar and Mahuva of Gujarat; Marine Drive, Colaba and Bandra (Bombay) of Maharashtra; Baga beach, Dona Paula, Anjuna beach and Vasco-da-Gama of Goa; Someswar beach, Mangalore port and Suratkal of Karnataka; Cochin port and Kanamaly of Kerala; Mahaballipuram, Chennai port and Royapuram of Tamil Nadu; Visakhapatnam port, Ramakrishna beach and Bhimunipatnam of Andhra Pradesh; Puri, Konark and Paradip port of Orissa coast (Fig.1). All sampling stations were situated between 22°30'N, 69°03'E and 20°15'N, 86°40'E in the Northern and 09°51'N, 76°15'E and 12°37'N, 80°11'E in the Southern part of India. They were collected from the inter tidal region of the rocky coasts during September-November 2001 on West Coast and December 2001 on East Coast of India. Specimens of each species were randomly collected during low tide in considerable numbers (more than 100) for imposex studies. Soon after collection, the epiphytic flora and fauna on the surface of the shells were thoroughly removed and washed with clean seawater. The animals were preserved in ice cold condition and transported to field laboratories.

Morphometric measurements and imposex examination : The morphometric measurements such as length and weight of organisms along with shells were measured by vernier caliper and analytical balance respectively. The shells of the neogastropods were cracked carefully and the soft tissues were gently removed for the determination of sex and imposex. Only reproductively matured individuals were studied during the investigation. Sex was determined by the presence of bright yellow ovaries in the case of females and orange testes for males and both of these are located ventrally in the coiled section adjacent to the digestive gland on the posterior of the animal. In addition to that sex was also confirmed by the presence of capsule gland, sperm ingesting gland and albumen gland on the anterior to the ovary for females and prostate gland for males in the same position. Imposex was identified in females by the formation of vas deferens and development of penis behind the right cephalic tentacle. The length and width of the penis of males and imposex specimens were measured from its tip to junction with the wall to 0.1 mm accuracy using an eye piece graticule mounted on a binocular stereo zoom microscope. The penises were then excised at their bases and dried to constant weight at 60°C and the dried tissue was weighed to the nearest 10 µg using an analytical balance. The intensity of imposex development in animals was calculated by Relative Penis Size Index (RPSI) using the following formula (Gibbs *et al.*, 1987);

$$\text{RPSI} = \frac{\text{Mean length of imposex penis}^3}{\text{Mean length of male penis}^3} \times 100$$

The severity of imposex was also calculated, further to test the effectiveness of this formula, by the new index known as Conversion of Potential Female to Imposex Index

(CPFII) developed by Tewari *et al.* (2002). The formula for the index is given below.

$$\text{CPFII} = \frac{\text{Number of imposex animals}}{\text{Number of females} + \text{Number of imposex animals}} \times 100$$

The density of above said species at all sampling stations were also estimated from their natural habitat along the intertidal belt by 0.5m² quadrat having 10 × 10 cm sub quadrates. Data were collected at every 5 m interval starting from lowest low water of the tide at the time of sampling and extending towards to the highest high tide mark. The numerical density and biomass per unit area were determined. The species were identified referring standard books and monographs (Peter, 1992 ; Apte, 1998; Subba Rao, 2003) The number of ships operating from the port were collected from the concerned port authorities. The one-way ANOVA was analysed by Microsoft Excel software (version 9.0.2).

RESULTS

Growth state, sex ratio and severity of imposex : The length, weight, percentage occurrence of male, female and imposex, CPFII and RPSI of *Thais bufo*, *T. rudolphi*, *T. tissoti*, *Drupa konkanensis*, *Ocenebra bombayana* and *Natica tigrina* are presented in Tables 1-6.

The maximum CPFII and RPSI were observed in *T. bufo* at Chennai Port (93.41) and *T. rudolphi* at Royapuram (65.84) respectively ($p < 0.01$). Similarly minimum values of these 2 indices were observed in *O. bombayana* at Mahuva (20.00) and in *T. bufo* at Puri (6.82).

The maximum percentage occurrence of imposex, male and female organism were observed in *T. rudolphi* at Chennai Port (74%), *O. bombayana* at Mahuva (45%) and *T. tissoti* at Mahuva (45%) respectively ($p < 0.01$). However the minimum percentage occurrence of imposex, male and female organism were observed in *O. bombayana* at Mahuva (11%), *O. bombayana* at Dona Paula (13%) and in *T. bufo* at Chennai Port (5.17%) respectively.

Sixty or more than 60% imposex in the organisms were recorded in *T. bufo* at Mangalore Port, Mahaballipuram, Chennai Port, Royapuram, Visakhapatnam Port, Ramakrishna beach, Bhimubnipatnam, Paradip Port, in *T. rudolphi* at Someshwar beach, Mahaballipuram, Chennai Port, Royapuram, Visakhapatnam, Ramakrishna beach, in *T. tissoti* at Marine Drive, Colaba, Bandra, Chennai Port, Royapuram, Visakhapatnam, Ramakrishna beach, in *D. konkanensis* at Marine Drive and in *N. tigrina* at Marine Drive and Colaba.

The results indicated that the CPFII, RPSI and percentage imposex in places of very high shipping activity were higher than with those of no shipping activity (with one exception). This also confirms that CPFII is a better index of imposex than RPSI ($p < 0.01$).

The results also indicated that the CPFII in all the recorded species from Bombay and Mahuva, Mangalore Port and Suratkal, Cochin Port and Kanamaly, Chennai Port and

Mahabalipuram, Visakhapatnam and Bhimunipatnam, Paradip Port and Konark, decreased significantly as distance from the port having high shipping traffic decreased.

The length of shells between imposex and female organisms did not reveal clear trend of variation in *T. bufo*, *T. rudolphi* and *O. bombayana* whereas length of the female shells were higher than imposex organisms in *T. tissoti*, *D. konkanensis* and *N. tigrina*.

However, the weight of the organism with shells were higher in normal female than imposex organisms in *T. bufo*, *T. rudolphi*, *O. bombayana* and *N. tigrina* ($p < 0.05$) while it did not show clear trend of variation in *T. tissoti* and *D. konkanensis*.

The results for the penis morphometry in imposex and male organisms for all the studied species of neogastropods are as follows. The dry weight (mg), length (mm) & width (mm) of penis in males as compared to imposex organisms were more in *T. rudolphi* at Chennai Port (13.82 ± 2.16) than in *T. bufo* at Chennai Port (6.98 ± 0.75) however the minimum width was observed in *D. konkanensis* at Vasco-de-Gama (1.19 ± 0.3) and in *T. tissoti* at Marine Drive (1.87 ± 0.11) in male and imposex organism respectively. The dry weight, length and width of the penis in males were always higher at all the places as compared to imposex organisms ($p < 0.05$).

The stations with high degree of shipping activity / TBT pollution (Chennai Port on East Coast and Marine Drive, Bandra and Colaba on West Coast) were compared to stations with no shipping activity / low degree of pollution (Bhimunipatnam on East Coast and Mahuva on West Coast) for different morphometric measurements of penis. The results indicated that the dry weight, length and width of the penis of normal males as compared to imposex organisms were higher in *T. bufo*, *T. rudolphi*, *T. tissoti*, *O. bombayana* at Chennai Port, Marine Drive, Bandra and Colaba as compared to Bhimunipatnam and Mahuva. However the above said morphometric parameters were higher in Mahuva than Marine Drive, Bandra and Colaba in *T. tissoti* ($p < 0.01$).

The numerical and biomass density of *T. bufo*, *T. rudolphi*, *T. tissoti* and *O. bombayana* were always more at stations with high shipping activity (Marine Drive, Colaba, Bandra of West Coast and Chennai of East Coast) than stations of no shipping activity (Mahuva on West Coast and Bhimunipatnam on East Coast; $p < 0.01$). However in the case of *T. tissoti* these two parameters showed reverse trend only on East Coast (Table-7).

These results indicate that the numerical and biomass density as well as reproductive capacity of these organisms are not inhibited due to TBT contamination of the environment.

Severity of imposex in relation to shipping activities : The commercial vessel traffic at different ports of India is presented in Table-8. The above results indicate that the percentage of imposex and CPFII in all 6 species of neogastropods was very high in Bombay region (Marine Drive, Colaba, Bandra) and Chennai Port, where shipping activity was very high while it was least at Okha as well as stations of no shipping activity like Mahuva and Bhimunipatnam (Tables 1-6; 8).

In general, the length and weight of the male individuals of all 6 species did not show any clear trend of variation with intensity of vessel traffic.

T. bufo, *T. rudolphi*, *T. tissoti*, *D. konkanensis*, *O. bombayana* and *N. tigrina* from different parts of India have shown very high CPFII and RPSI in total population. It seems that these species are very sensitive to environmental conditions especially TBT which induce imposex. Therefore these organisms especially *T. rudolphi* may be used as bioindicator for TBT contamination. However, this aspect needs further studies to prove this observation.

DISCUSSION

The present results indicated that widespread imposex is present in all the studied 6 species. Very high CPFII (78.08-95.50) was observed in Chennai and Mumbai regions (Bandra and Marine Drive). Similarly percentage of imposex was also very high (57.00-74.00) in these species at the above said places. The maximum CPFII and percentage of imposex were highest at Chennai (95.50 and 74.00% respectively) and lowest at Mahuva. This coincided with very high vessel traffic at Chennai and Mumbai regions and no traffic at Bhimunipatnam and Mahuva regions (Tables 1-6; 8). Similar correlations have already been reported (Ten Hulder- Tjubber, *et al.* 1994; Tewari *et al.*, 2002; Santos *et al.*, 2005). This indicates that the TBT in the antifouling paints might be the causative agent for imposex in the six species studied. The results also indicate that situation on Indian Coast is already serious and may be worst in times to come as 63.63% of organisms have shown more than 40% imposex near the ports.

High percentage of imposex in neogastropods has also been reported from the different parts of the world (Wilson, *et al.* & Thompson, 1993; Evans & Leksono, 1996; Evans *et al.*, 2000b; Santos, *et al.* 2000). In these cases the percentage of imposex ranged from 42-100%.

Imposex is reported to be caused mainly by organotin compounds especially by tributyltin which is reported to be most effective (Reitsema & Spickett, 1999). A very low concentration (< 1.0 ng TBT Sn/L) has been reported to cause imposex in neogastropods (Gibbs *et al.*, 1988; Santos *et al.*, 2005). Imposex in neogastropods has been reported as bioindicator of organotin compounds especially tributyltin in the marine environment (Horiguchi *et al.*, 1994; Horiguchi *et al.*, 1995; Evans *et al.*, 1996; Reitsema & Spickett 1999; Evans *et al.*, 2000b). The present study also indicates that *T. rudolphi* could be an ideal species as bioindicator under tropical conditions, especially under Indian condition as this organism is very much sensitive to TBT and is found all over India. TBT is used as a constituent of anti-fouling paints on ships, fishing nets and mariculture cages (Gibbs *et al.*, 1987; Bryan *et al.*, 1988). As the present study sites are nearer to the ports where shipping activities are very common (Table-8), TBT is the causative agent of imposex in India also. It may be noted that TBT at a concentration as low as parts per trillion in seawater induces imposex in neogastropods (Reitsema & Spickett, 1999). The tissues of imposex samples of *T. clavigera* and *T. bronni* have been reported to contain 10-20 ng g⁻¹ of dry weight (Horiguchi *et al.*, 1994). Total concentration butyltin compounds in *Hexsplex*

trunculus ranged from 102 ± 17 to 432 ± 27 ng Sn g⁻¹ d.w in visceral coil and from 96 ± 24 to 297 ± 107 ng Sn g⁻¹ d.w in rest of the soft body. Phenyltins were found at far lower concentrations ranging from 8 ± 1 to 41 ± 3 ng Sn g⁻¹ d.w (visceral coil) and from 0.25 to 32 ± 22 ng Sn g⁻¹ d.w (rest of soft body) (Pellaizzato *et al.*, 2004).

No published information on TBT and other organotin compounds in the body of Indian neogastropods have been reported. Therefore it is essential to determine the concentration of TBT and other organotin compounds in seawater, sediment and marine organisms of India. As quite a number of marine organisms are edible, it may have an effect on human health. Effect of TBT/ organotin compounds on human health has already been recorded (Kannan *et al.*, 1995a). The concentration of TBT in seawater, sediment and fish has been reported (Kanthak & Jayaraman, 2001; Kannan *et al.*, 1995b; Vishwakiran *et al.*, 2005). Its concentration at Alang- Sosiya ship breaking yard in seawater varied from 74.1 to 10900 ng/l while in sediment it ranged from 78.4 to 19400 μ g/Kg. The level found here is approximately between 10 and 100 million times higher than internationally recognized limits (0.005 to 0.05 μ g/Kg) for TBT in marine sediment. Sediments having a concentration of TBT more than 768 μ g/Kg have been classified as hazardous waste by the European Union (Kanthak & Jayaraman, 2001).

The concentration of DBT plus TBT varied between 2.4 and 8.3, 163 and 363 ng/ l, 5 and 2853 ng/g d.w in the suspended particulate matter, seawater and sediment samples respectively of the Marmugoa harbour (Goa). This study along the central West Coast of India also showed the presence of localized areas on contamination. From this perspective the incidence on increased imposex at sites with shipping or ship related activity becomes obvious (Vishwakiran *et al.*, 2005). The concentration of TBT in Indian coastal water are very much above the threshold limit (< 1.0ng/l) and that is why the whole Indian coastal waters have imposex with varying degree of severity and species diversity.

Fortunately, a treaty for the worldwide ban of TBT was adopted at the International Maritime Organization (IMO) in October 2001, and it was expected to start from January 2003. There has been considerable research on TBT and imposex in coastal waters of Canada, including British Columbia. Extensive butyltin contamination and widespread neogastropod imposex were observed in British Columbia around 1990. Recovery of neogastropods from imposex began to be observed after the mid 1990s, due to the decrease of TBT concentration in the marine environment following the TBT control in 1989, except for contaminated sites near harbours, such as Vancouver Harbour and Victoria. Biological/environmental monitoring of neogastropod imposex and TBT contamination is still necessary because of the long persistence of TBT in sediment (Horiguchi *et al.*, 2003). As there is no effective cure for fouling, ban on TBT should not be enforced until that time. However, there are a number of drawbacks associated with the worldwide ban on TBT as well. These drawbacks relate to (1) the additional economic and environmental costs that are associated with an increased fouling and thus increased fuel consumption and (2) the use of surrogate antifouling agents which may be less toxic but which are not as effective as TBT and which therefore need to be reapplied over shorter time intervals (Wolf *et al.*, 2004).

In many species of muricids imposex in females is characterized by the presence of a pseudopenis whose relative size with respect to the male penis is routinely used for quantify imposex severity (Kanthak & Jayaraman, 2001). In the present study highest/ next higher RPSI (65.84/ 34.14) was observed in *T. rudolphi* and *T. tissoti* at Royapuram and Suratkal respectively. This does not clearly correlate with maximum percentage of imposex in total sample size and maximum conversion of females to imposex at Royapuram and Suratkal. This further confirms that RPSI is not a foolproof indicator of imposex in neogastropods (Tewari *et al.*, 2002). It is reported that the RPSI may not be entirely appropriate for all species of neogastropods as they have different penis shapes (Wilson, Ahsanullah & Thompson, 1993; Horiguchi *et al.*, 1994; Kanthak & Jayaraman, 2001). The RPSI has inherent difficulty in measuring the length of the penis and change in penis size depending upon the environmental conditions (Oehlmann, Stroben & Fioroni, 1991). In addition to this Vas Deferens Size Index (VDSI) (Gibbs *et al.*, 1987; Stewart *et al.*, 1992) has so far been unsuccessful for species affected by imposex. This was the case for *T. clavigera* and *T. bronni* in Japan (Horiguchi *et al.*, 1994), *Dicathais orbita* and *Lepsiella vinosa* in Australia (Nias *et al.*, 1993) and *T. gradata* and *Chicoreus capucinus* in Singapore (Bech, 1999). The CPFII gives an impact of environment on the total potential female population in relation to imposex animals of that area. Therefore it is more reliable than RPSI and VDSI as these two indices are based on individual organole which change their shape and size depending upon environmental conditions like the tidal level at which the animal grows, pollution status of the environment etc. (Marshall & Rajkumar, 2003).

The imposex response to neogastropods has shown that TBT is an endocrine disrupter according to a definition produced by European Commission (Tan, 1999): An endocrine disrupter is an exogenous substance that causes adverse health effects in an intact organism, or its progeny, secondary to changes in endocrine function. In fact TBT induced imposex is the only known case of endocrine disruption to occur at the population level (EC, 1997). Sex differentiation in molluscs is a highly plastic process, which is under neuroendocrine control. There is evidence that TBT interferes with it by stimulating the release of a morphogenetic factor by the pedal gland in female *O. erinacea* (Harrison *et al.*, 1997). It could be concluded that TBT contamination from the paints severely increase the imposex in some of the species of neogastropods, consequently reducing the female population in that area. This may lead to extinction of these species in the area where TBT contamination is severe.

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Table-1. Percentage of imposex, males and females of *Thais bufo* and their biometry and RPSI

Station	Sample size	Imposex			Male			Female			CPFII	RPSI
		%	Mean length (mm)	Mean weight (g)	%	Mean length (mm)	Mean weight (g)	%	Mean length (mm)	Mean weight (g)		
Okha	100	33.00	39.25	17.08	42.00	40.89	19.27	25.00	40.21	20.28		
Porbandar	110	49.09	42.16	20.28	38.18	40.52	19.21	12.73	41.56	24.29		
Someswar beach	100	59.00	31.28	15.86	20.00	32.26	16.74	21.00	32.02	17.07	73.75	12.90
Mangalore Port	100	64.00	28.56	14.50	22.00	30.25	15.52	16.00	31.22	16.52	80.00	32.65
Suratkal	100	54.00	27.18	14.08	35.00	28.56	15.89	11.00	28.58	16.67	83.08	16.84
Mahaballipuram	128	61.72	40.52	17.50	23.44	41.86	18.50	14.84	40.82	20.15	80.61	21.054
Chennai Port	116	73.28	41.08	17.82	21.55	42.06	19.66	5.17	41.88	22.78	93.41	23.56
Royapuram	110	67.27	40.93	16.95	24.55	40.56	17.35	8.18	40.32	20.23	89.16	24.01
Visakhapatnam Port	100	67.00	37.82	16.07	20.00	38.23	18.00	13.00	37.32	21.62	83.75	21.39
Ramakrishna beach	98	63.27	36.50	16.00	20.41	37.50	17.90	16.32	38.21	20.45	79.48	15.76
Bhimunipatnam	92	61.96	36.90	17.12	25.00	36.00	18.63	13.04	36.12	22.07	82.61	23.15
Puri	88	56.82	30.05	15.10	31.82	31.62	16.31	11.36	30.14	20.05	83.33	6.82
Konark	95	58.95	31.09	15.28	26.32	32.19	15.73	14.73	31.45	18.54	80.00	11.40
Paradip Port	120	64.17	32.66	15.86	23.33	33.40	16.14	12.50	32.11	19.63	83.70	8.14

Table-2. Percentage of imposex, males and females of *Thais rudolphi* and their biometry and RPSI

Station	Sample size	Imposex			Male			Female			CPFII	RPSI
		%	Mean length (mm)	Mean weight (g)	%	Mean length (mm)	Mean weight (g)	%	Mean length (mm)	Mean weight (g)		
Okha	100	45.00	40.75	21.70	38.00	42.12	24.18	17.00	43.78	24.78	72.58	52.81
Porbandar	100	51.00	41.87	22.24	37.00	44.68	28.75	12.00	43.72	27.18	80.95	55.82
Someswar beach	100	60.00	33.79	15.81	24.00	35.29	17.85	16.00	35.25	16.25	78.95	65.53
Mahaballipuram	96	62.50	44.26	20.18	25.00	46.85	21.50	12.50	46.11	22.50	83.33	54.80
Chennai Port	100	74.00	45.72	22.14	20.00	45.60	22.67	6.00	44.25	23.81	92.50	54.55
Royapuram	100	67.00	45.15	21.87	22.00	46.21	23.83	11.00	45.82	23.09	85.90	65.84
Visakhapatnam Port	110	69.09	37.84	17.55	22.73	39.51	19.16	8.18	40.20	21.47	89.41	42.22
Ramakrishna beach	98	64.28	36.19	17.60	22.46	37.14	18.26	13.26	39.13	20.26	82.89	37.92
Bhimunipatnam	100	59.00	37.09	18.15	27.00	37.58	19.50	14.00	38.45	19.25	80.89	39.29
Puri	90	53.33	33.51	15.63	26.67	35.15	16.62	20.00	37.14	16.84	72.73	43.24
Konark	90	56.67	35.11	17.27	22.22	36.44	18.31	21.11	38.30	19.17	72.86	42.77
Paradip Port	100	58.00	35.27	18.19	20.00	36.37	20.15	12.00	37.40	20.23	82.86	43.11

Table-3. Percentage of imposex, males and females of *Thais tissoti* and their biometry and RPSI

Station	Sample size	Imposex			Male			Female			CPFII	RPSI
		%	Mean length (mm)	Mean weight (g)	%	Mean length (mm)	Mean weight (g)	%	Mean length (mm)	Mean weight (g)		
Mahuva	100	13.00	21.26	2.17	42.00	21.00	2.68	45.00	21.82	2.73	22.41	12.64
Marine Drive	100	66.00	19.80	2.50	22.00	20.10	2.78	12.00	20.40	2.38	84.61	18.03
Colaba	100	68.00	23.10	2.68	25.00	23.60	3.59	7.00	22.60	2.76	90.67	21.46
Bandra	100	67.00	20.70	2.30	26.00	21.10	2.58	6.00	21.00	2.42	91.78	20.45
Baga beach	100	49.00	24.70	3.77	50.00	24.92	3.81	21.00	24.70	3.90	70.00	21.68
Dona Paula	100	51.00	21.10	2.67	28.00	23.90	3.44	24.00	24.20	3.66	68.00	18.01
Anjuna beach	100	48.00	21.70	2.85	32.00	25.20	3.80	20.00	25.10	3.72	70.59	19.56
Mangalore Port	100	54.00	23.10	2.68	30.00	23.90	3.59	16.00	24.60	2.76	77.14	26.96
Suratkal	100	52.00	21.20	2.72	28.00	20.12	2.58	20.00	21.18	2.60	72.22	34.14
Cochin Port	100	58.00	19.60	2.51	30.00	19.80	2.17	12.00	19.30	20.01	82.86	22.58
Kanamaly	100	55.00	18.00	1.89	31.00	18.82	2.02	14.00	19.02	2.05	79.71	17.37
Mahaballipuram	105	58.10	20.23	2.31	28.57	19.75	2.52	13.33	20.28	2.32	81.33	22.10
Chennai Port	120	65.00	22.81	2.86	27.50	23.15	2.92	7.50	24.14	3.08	89.66	20.97
Royapuram	100	63.00	20.58	2.11	26.00	21.44	2.70	11.00	20.78	3.12	85.14	20.81
Visakhapatnam Port	100	62.00	19.56	1.94	27.00	20.36	2.80	11.00	21.56	2.93	86.30	23.19
Ramakrishna beach	96	61.46	19.24	2.07	25.00	20.82	2.28	13.54	21.70	2.98	81.94	21.24
Bhimunipatnam	80	58.75	19.00	2.12	25.00	20.76	2.97	16.25	21.52	2.27	78.33	18.17
Puri	90	42.22	20.72	2.54	36.67	21.58	3.02	21.11	30.34	2.84	66.67	18.59
Konark	94	46.81	19.52	2.18	37.23	21.62	2.50	15.96	22.52	3.05	74.58	13.51
Paradip Port	100	52.00	20.84	2.15	35.00	22.63	2.62	13.00	22.07	3.12	80.00	14.51

Table-4. Percentage of imposex, males and females of *Drupa konkanensis* and their biometry and RPSI

Station	Sample size	Imposex			Male			Female			CPFII	RPSI
		%	Mean length (mm)	Mean weight (g)	%	Mean length (mm)	Mean weight (g)	%	Mean length (mm)	Mean weight (g)		
Marine Drive	100	61.00	17.10	1.01	17.00	18.10	1.33	22.00	19.60	1.01	73.49	19.84
Colaba	100	53.00	22.20	2.00	38.00	22.38	2.16	9.00	23.28	2.17	85.48	13.34
Bandra	100	52.00	23.10	2.42	41.00	23.20	2.90	7.00	23.86	2.98	88.13	14.61
Baga beach	100	47.00	15.20	1.03	31.00	18.10	1.37	32.00	16.10	1.19	59.13	15.89
Dona Paula	100	48.00	15.10	1.06	32.00	17.10	1.27	20.00	17.60	1.18	70.58	14.81
Anjuna beach	100	42.00	21.90	1.91	36.00	24.30	3.06	22.00	25.18	3.12	65.62	26.07
Vasco-da-gama	100	58.00	15.20	1.08	26.00	15.10	1.18	16.00	19.10	1.59	78.37	18.31
Someswar beach	100	38.00	14.60	0.84	30.00	15.10	1.15	32.00	16.28	1.17	54.28	13.49
Mangalore Port	100	49.00	15.12	1.06	29.00	16.60	1.78	22.00	17.21	1.28	69.01	19.27
Suratkal	100	41.00	14.76	1.02	24.00	16.78	1.80	35.00	18.26	1.33	53.84	14.01
Visakhapatnam Port	94	51.06	18.72	1.86	24.47	19.52	2.02	24.47	18.54	2.07	67.61	30.28
Bhimunipatnam	108	48.15	17.34	1.62	32.41	19.07	1.89	19.44	19.25	1.83	71.23	28.91

Table-5. Percentage of imposex, males and females of *Ocenebra bombayana* and their biometry and RPSI

Station	Sample size	Imposex			Male			Female			CPFII	RPSI
		%	Mean length (mm)	Mean weight (g)	%	Mean length (mm)	Mean weight (g)	%	Mean length (mm)	Mean weight (g)		
Mahuva	100	11.00	26.72	3.28	45.00	28.83	3.67	44.00	26.15	3.53	20.00s	23.57
Marine Drive	100	57.00	28.15	3.98	27.00	29.25	4.52	16.00	28.60	4.76	78.08	14.07
Colaba	100	53.00	28.65	4.17	29.00	28.62	4.18	18.00	28.70	4.53	74.65	14.99
Bandra	100	53.00	27.41	4.28	26.00	28.27	4.29	21.00	27.63	4.28	71.62	13.16
Dona Paula	100	52.00	27.81	4.78	13.00	29.52	5.12	35.00	28.63	4.60	59.37	17.57

Table-6. Percentage of imposex, males and females of *Natica tigrina* and their biometry and RPSI

Station	Sample size	Imposex			Male			Female			CPFII	RPSI
		%	Mean length (mm)	Mean weight (g)	%	Mean length (mm)	Mean weight (g)	%	Mean length (mm)	Mean weight (g)		
Marine Drive	100	62.00	20.20	3.13	29.00	21.40	3.33	9.00	21.20	4.61	87.32	12.67
Colaba	100	61.00	25.20	5.59	28.00	25.30	6.66	10.00	25.35	7.70	86.11	12.66
Bandra	100	58.00	22.60	6.17	31.00	26.16	7.76	11.00	27.00	8.15	65.16	9.89
Dona Paula	100	43.00	16.50	2.17	28.00	23.20	5.28	29.00	25.70	7.18	59.72	13.99
Vasco-da-gama	100	55.00	18.10	3.08	17.00	20.10	3.57	28.00	21.10	5.00	66.26	24.16
Cochin Port	100	28.00	20.30	4.19	37.00	24.70	6.61	35.00	38.21	7.56	44.44	12.31
Kanamaly	100	21.00	21.20	5.02	39.00	25.36	8.25	40.00	26.71	8.98	34.42	12.41

Table-7. Numerical and biomass density of different species of gastropods at different stations along the Indian coast

Station	<i>Thais bufo</i>		<i>Thais rudolphi</i>		<i>Thais tissoti</i>		<i>Drupa konkanensis</i>		<i>Ocenebra bombayana</i>		<i>Natica tigrina</i>	
	Density (No. m ⁻²)	Biomass (gm ⁻² Fr wt.)	Density (No. m ⁻²)	Biomass (gm ⁻² Fr wt.)	Density (No. m ⁻²)	Biomass (gm ⁻² Fr wt.)	Density (No. m ⁻²)	Biomass (gm ⁻² Fr wt.)	Density (No. m ⁻²)	Biomass (gm ⁻² Fr wt.)	Density (No. m ⁻²)	Biomass (gm ⁻² Fr wt.)
SAURASHTRA COAST												
Okha	41.71	1163.78	30.29	813.07	-	-	-	-	-	-	-	-
Porbandar	50.29	1457.83	42.86	1462.95	-	-	-	-	-	-	-	-
Mahuva	-	-	-	-	25.71	63.04	-	-	20.00	65.70	-	-
MUMBAI COAST												
Marine Drive	-	-	-	-	36.00	81.95	28.00	63.60	46.25	263.45	33.00	107.73
Colaba	-	-	-	-	34.29	117.61	28.57	73.53	43.84	248.52	33.50	184.77
Bandra	-	-	-	-	28.00	70.39	35.71	69.51	44.18	236.67	20.50	130.33
GOA COAST												
Baga beach	-	-	-	-	21.71	81.05	20.05	32.02	-	-	-	-
Dona Paula	-	-	-	-	26.86	76.15	35.57	36.05	42.29	203.59	24.00	54.35
Anjuna beach	-	-	-	-	21.71	62.77	29.71	31.99	-	-	-	-
Vasco-da-gama	-	-	-	-	-	-	24.57	26.08	-	-	21.00	66.53
MANGALORE COAST												
Someswar beach	25.71	408.07	23.43	367.42	-	-	22.29	22.09	-	-	-	-
Mangalore port	22.86	356.78	-	-	14.29	38.45	20.57	22.49	-	-	-	-
Suratkal	28.57	415.39	-	-	14.29	40.41	21.71	23.41	-	-	-	-
COCHIN COAST												
Cochin port	-	-	-	-	17.33	43.94	-	-	-	-	16.57	17.18

Table-7. Contd.

Station	<i>Thais bufo</i>		<i>Thais rudolphi</i>		<i>Thais tissoti</i>		<i>Drupa konkanensis</i>		<i>Ocenebra bombayana</i>		<i>Natica tigrina</i>	
	Density (No. m ⁻²)	Biomass (gm ⁻² Fr wt.)	Density (No. m ⁻²)	Biomass (gm ⁻² Fr wt.)	Density (No. m ⁻²)	Biomass (gm ⁻² Fr wt.)	Density (No. m ⁻²)	Biomass (gm ⁻² Fr wt.)	Density (No. m ⁻²)	Biomass (gm ⁻² Fr wt.)	Density (No. m ⁻²)	Biomass (gm ⁻² Fr wt.)
Kanamaly CHENNAI COAST	-	-	-	-	16.00	30.36	-	-	-	-	17.14	99.18
Mahaballipuram	40.25	1283.20	41.63	1463.27	21.28	68.32	-	-	-	-	-	-
Chennai Port	43.89	1552.16	44.00	1638.56	23.54	71.86	-	-	-	-	-	-
Royapuram	43.23	1489.23	43.21	1602.36	20.86	65.20	-	-	-	-	-	-
VISAKHAPATNAM COAST												
Visakhapatnam port	39.81	1238.15	38.31	1137.63	45.00	152.28	29.63	78.26	-	-	-	-
Ramakrishna beach	38.92	1193.65	37.54	1098.36	42.66	134.84	-	-	-	-	-	-
Bhimunipatnam	37.16	1038.63	32.45	968.55	40.28	120.07	26.75	63.59	-	-	-	-
ORISSA COAST												
Puri	36.12	986.28	32.00	728.65	16.60	39.27	-	-	-	-	-	-
Konark	37.21	1103.65	33.28	796.25	17.00	44.68	-	-	-	-	-	-
Paradip Port	34.54	1150.20	34.52	818.33	18.31	45.76	-	-	-	-	-	-

Table-8. Vessel traffic at different ports along the Indian coast

Sl. No.	Name and Place of the Port	Vessel Traffic (No./year)					Mean Vessel Traffic
		1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	
1	Okha Port Okha	91	105	62	96	73	85.4 $\pm$ 17.53
2	Porbandar Port Porbandar	117	123	72	113	95	104.0 $\pm$ 20.71
3	Mumbai Port Trust Mumbai	4600	4255	4030	4201	3614	4141.8 $\pm$ 360.03
4	Jawaharlal Nehru Port Mumbai	596	785	1122	1505	1656	1132.8 $\pm$ 453.12
5	Mormugao Port Trust Goa	524	626	543	525	613	566.2 $\pm$ 49.45
6	New Mangalore Port Mangalore	839	809	777	791	800	803.2 $\pm$ 23.24
7	Cochin Port Trust Cochin	930	1006	1113	1096	1100	1049.0 $\pm$ 78.92
8	Chennai Port Trust Chennai	2069	2320	2258	2291	2201	2227.8 $\pm$ 99.16
9	Visakhapatnam Port Trust Visakhapatnam	1471	1571	1514	1681	1674	1582.2 $\pm$ 93.98
10	Paradip Port Trust Paradip	592	676	692	741	923	724.8 $\pm$ 123.12

BIODIVERSITY OF CRABS IN PICHAVARAM MANGROVE ENVIRONMENT

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ABSTRACT

Biodiversity studies on crabs in the Pichavaram mangroves for the first time has shown that there are 46 species from the five different Stations. The neritic zone (Chinnavaikal) was rich in species composition (35 species). The freshwater zone was poor in species composition (14 species) and population density. Among the crab species *Sesarma* and *Uca* species were dominant in almost all the Stations. Grapsid crabs were the most dominant species. Neritic and *Avicennia* zones showed more number of crab species and less number of species was noted in slightly saline zone.

INTRODUCTION

The macrobenthic faunal composition in the mangrove forest is diverse. Crabs are among the most dominant species in many mangrove forests which constitute about 80% of the macrofaunal biomass (Golley *et al.*, 1962) and they can reach densities of about 80-90 per m² (Macintosh, 1988). Two families of crabs the Grapsidae (63 species) and the Ocypodidae (30 species) are particularly associated with mangrove ecosystem (Jones, 1984). Chakraborty and Choudhury (1994) reported eighteen species of brachyuran crabs belonging to 11 genera and 4 families from the intertidal belt of Prentice in Sunderban mangroves. However studies on biodiversity of crabs in Pichavaram mangroves have not been attempted so far. The present study reports for the first time data on the number of crab species occurring in five different sites of the Pichavaram mangroves, their distribution, relative abundance and also zonation in relation to the plant species.

MATERIAL AND METHODS

Pichavaram mangrove (Lat. 11°27' N; Long 79°47' E) represents a heterogeneous mixture of mangrove elements. It lies between the Vellar and Coleroon estuaries, located at 250 Kms South of Chennai City on the SouthEast Coast of India. Field study was carried out

in the Pichavaram mangrove from February 2004 to January 2005 at monthly intervals. The study was undertaken in both creek and fringe mangroves in five sampling sites, varying in microclimatic niche (Fig. 1). Crab burrow density was recorded in 5 randomly placed one square meter quadrates as per Jones (1984). Crabs were collected at low tide and preserved in 70% alcohol for identification (Rathburn, 1918, 1930; Chhapger, 1957; Sakai, 1976 and Williams, 1965, 1984).

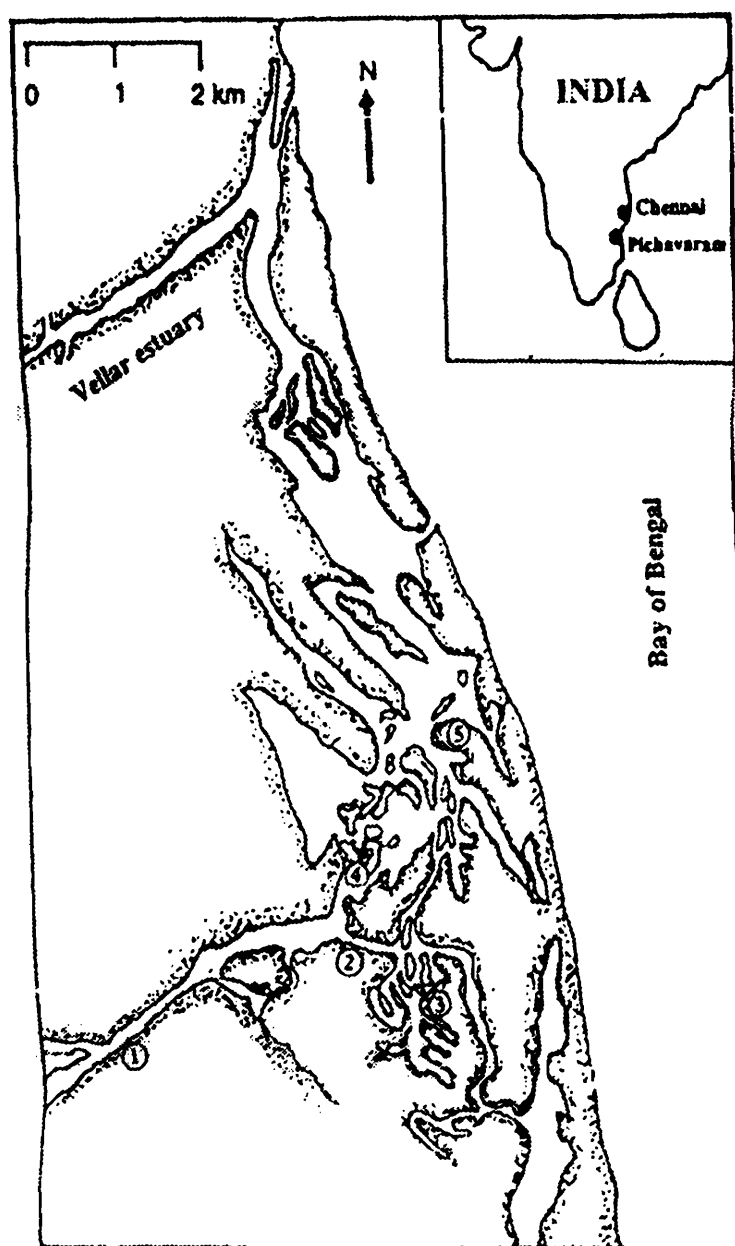


Fig. 1. Sampling stations in Pichavaram mangrove; (1) Khan Sahib canal region, (2) Kanankeluthi canal region, (3) Periakadavu, (4) Alasi odai, (5) Chinnavaikkal

The general survey involved, collection of various species of crabs from the creek and fringe mangrove vegetations to describe their species richness. Density of the crabs were estimated random sampling in the Pichavaram Islands by number of crabs active on the substrate enclosed within the quadrant or by digging the crabs from their burrows. The atmospheric temperature and surface water temperature were recorded using a Celsius thermometer and salinity was also estimated (Stickland and Parsons, 1968).

RESULTS

Species Composition : A total of 46 species of crabs were recorded from five sites (Table 1). Maximum number of species (31) were observed during the postmonsoon especially in January (31) and minimum (12) during the summer particularly in May.

Number of crab species recorded was maximum at station 5 (35) and minimum number (14) at station 1 (Table-1). Among the crabs species of *Sesarma* and *Uca* were the most dominant in almost all the islets. *Sesarma brockii*, *S. plicatum*, *Neopisesarma tetragonum*, *Metapograpsus messor*, *Pseudograpsus intermedius*, *Macrophthalmus depressus*, *Uca triangularis* and *U. annulipes* were commonly found in all the five stations. But, *Plugusia depressa*, *Grapsus tenuicrustatus* and *N. medri* were observed only in the core mangrove site (Periyakadavu station) and *Portunus*, *Podapthalmus*, *Ocypods*, *Dotilla*, *Dromia*, *Leptodius* and species only in the neritic zone (Chinnavaikkal station) in the present study. The abundance of crab species among the stations is given in the following order.

Chinnavaikkal > Periyakadavuu > Alasi odai > Kanankeluthi canal > Khan Sahib canal.

Table-1. Station wise distribution of crabs

S. No.	Name of the species	Total					Total
		I	II	III	IV	V	
1.	<i>Sesarma brockii</i>	71	68	104	122	107	472
2.	<i>S.plicatum</i>	30	69	41	27	33	200
3.	<i>S.andersoni</i>	4	7	13	4	-	28
4.	<i>S.bidens</i>	-	-	7	-	5	12
5.	<i>Neopisesarma tetragonum</i>	30	19	51	5	26	131
6.	<i>N. medri</i>	-	1	2	-	-	3
7.	<i>Nanosesarma minutum</i>	-	-	4	8	-	12
8.	<i>N.batavicum</i>	1	3	5	-	1	10
9.	<i>Plugusia dentipes</i>	-	-	2	-	13	15
10.	<i>P.depressa</i>	-	-	3	-	-	3
11.	<i>Grapsus strigosus</i>	-	-	10	2	-	12
12.	<i>G.tenuicrstatus</i>	-	-	3	-	-	3
13.	<i>Metapograpsus maculatus</i>	11	-	27	5	-	43
14.	<i>M.messor</i>	16	7	34	26	14	97
15.	<i>Ptychognathus altimanus</i>	-	-	2	2	-	4
16.	<i>Pseudograpsus intermedius</i>	5	3	9	2	3	22
17.	<i>Cardisoma carnifex</i>	23	7	21	7	-	58
18.	<i>Ocypode macrocera</i>	-	-	7	9	32	48

Table-1. Contd.

S. No.	Name of the species	Total					Total
		I	II	III	IV	V	
19.	<i>O. platytarsus</i>	-	-	-	—	5	5
20.	<i>Uca(celuca)lactealannulipes</i>	197	193	252	170	210	1022
21.	<i>Uca trianularius bengali</i>	187	197	198	137	186	905
22.	<i>Macopthalmus depressus</i>	31	28	33	24	20	136
23.	<i>M. erato</i>	-	-	3	-	9	12
24.	<i>Dotilla myctiroides</i>	-	-	-	-	6	6
25.	<i>Metaplex elegans</i>	-	6	-	-	3	9
26.	<i>M.distincta</i>	-	4	-	-	3	7
27.	<i>Heteropanope indica</i>	5	1	6	-	-	12
28.	<i>Galene bispinosa</i>	6	14	7	-	11	38
29.	<i>Charybdis feriata</i>	-	-	-	2	5	7
30.	<i>C.granulata</i>	-	-	-	-	2	2
31.	<i>C.lucifera</i>	-	-	-	6	2	8
32.	<i>C.helleri</i>	-	-	2	5	4	11
33.	<i>Scylla settata</i>	-	14	21	12	17	64
34.	<i>S.tranquebarica</i>	-	-	9	3	5	17
35.	<i>Portunus sanguinolentus</i>	-	-	-	-	4	4
36.	<i>P. pelagicus</i>	-	-	-	5	13	18
37.	<i>P. gladiator</i>	-	-	-	2	4	6
38.	<i>Thalamita crenata</i>	-	-	4	7	11	22
39.	<i>T.chaptali</i>	-	-	5	1	6	12
40.	<i>Pinnotheres sinensis</i>	-	-	-	-	3	3
41.	<i>Varuna altimana</i>	-	-	-	2	-	2
42.	<i>Podapthalmus vigil</i>	-	-	-	-	8	8
43.	<i>Dotilla clepsydrodactylus</i>	-	-	-	-	4	4
44.	<i>Leptodius crassimanas</i>	-	-	-	-	3	3
45.	<i>Dromia dehanni</i>	-	-	-	-	2	2
46.	<i>Dorippe facchino</i>	-	-	-	-	4	4
	Total	617	641	885	595	784	3522

Population Density : The crab population density varied between 595 and 885 individuals among the stations. Minimum (595) was documented at station 4 and the maximum (885) in station III (Table 1 & Fig. 2). Crab population varied significantly between months and station-wise analysis.

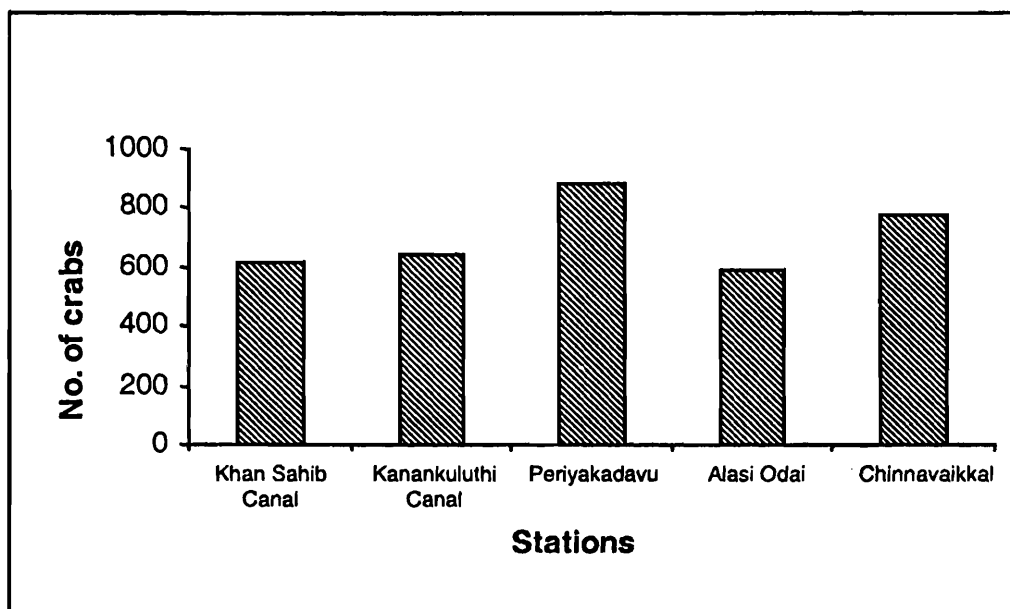


Fig. 2. Station wise distribution of Crabs

Zonation : Higher number of crab species was observed in the Neritic zone (36) and core mangrove zone (29). Very less number of species was noticed in the freshwater zone (14). Among all the zones, dominant representative was Sesarmid group of crabs (Fig. 3).

Based on vegetation, Pichavaram mangrove is divided into *Rhizophora* zone, *Avicennia* zone, back mangrove zone and non-saline or slightly saline zone. Among these zones,

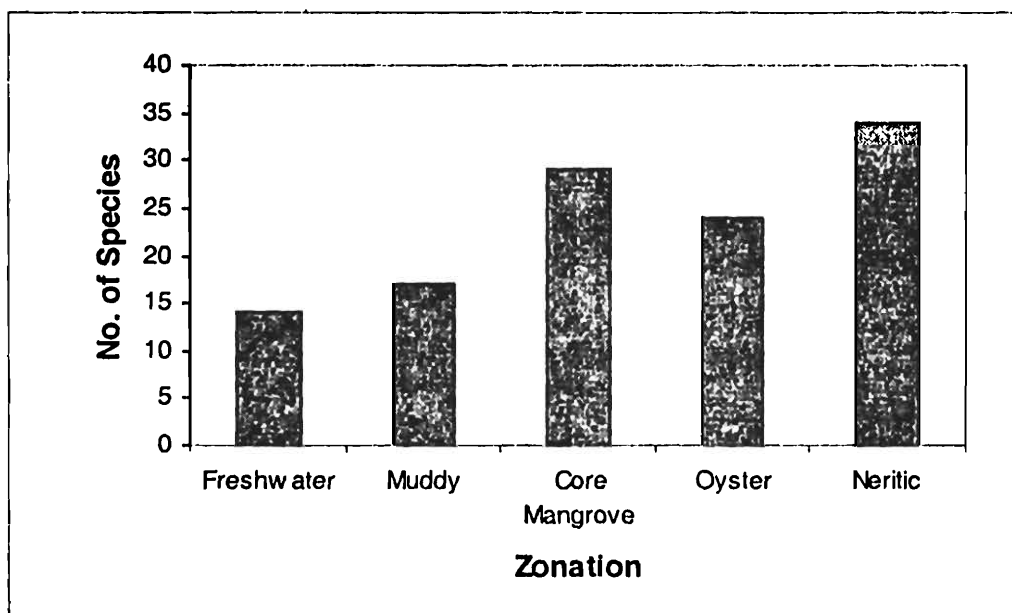


Fig. 3. Zonation of Crabs based on the environment

Avicennia zone was found to have more number of crab species (22) and very less number (1) of crabs in the non-saline zone. *Cardisoma carnifex* was found commonly in all the zones except in *Rhizophora* zone while *Thalamita*, *Charybdis* and *Ptychognathus* species were seen only in the *Rhizophora* zone (Fig. 4).

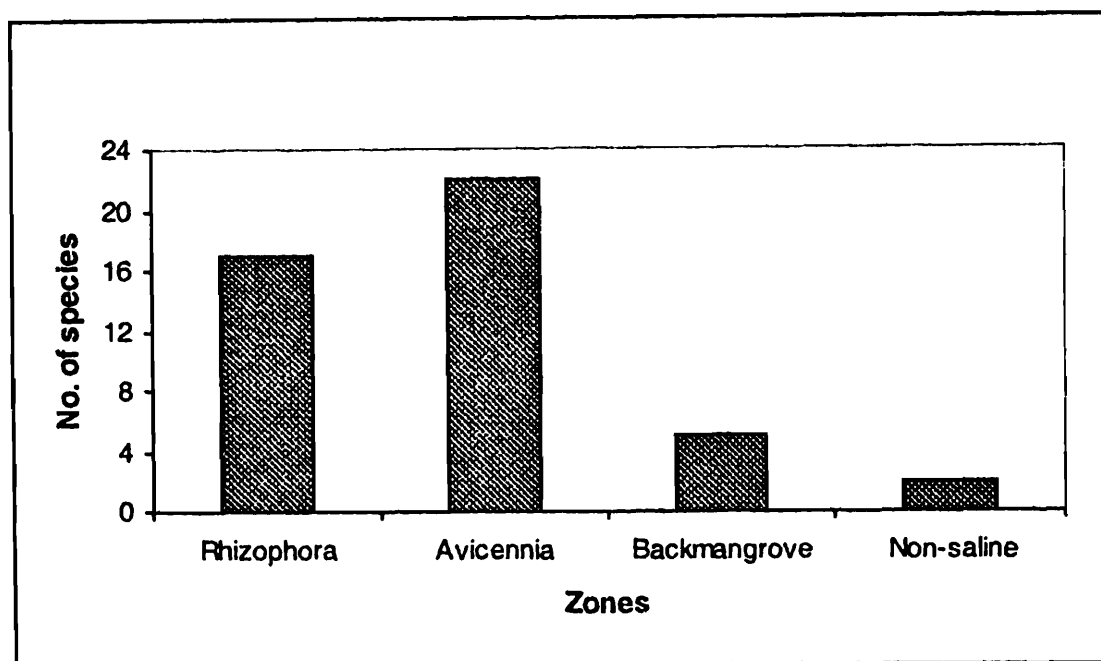


Fig. 4. Zonation of Crabs based on mangroves

Salinity and Temperature : The salinity ranged from 0.6 to 36.2‰ during the study period (February 2004 to January 2005). The maximum salinity of 36.2‰ was reported in the month of April and minimum salinity of 0.6‰ in December. Salinity varied significantly between month and station-wise analysis.

The atmospheric temperature ranged between 18.2 and 37.6°C. The surface water temperature varied from 16 to 36.2°C. Maximum atmospheric temperature was recorded in May 2004 and minimum in December 2004. (Table 2). Atmospheric and surface water temperature varied significantly between month of analysis but not station-wise analysis.

The statistical analysis indicates that the environmental variables such as salinity, atmospheric temperature and surface water temperature have tremendous influence on the population density of the crabs.

DISCUSSION

Of all benthic macrofauna inhabiting the mangrove swamps, brachyuran crabs are the most important taxa with regard to species diversity and total biomass. Crabs depend directly on mangrove for survival and are adapted to the special sediment conditions, tidal fluctuations and varying salinities found in mangroves (Cocelho, 1967).

Species composition and diversity were high during post-monsoon and less during summer. High floral and faunal diversities during post-monsoon season increase the

Table-2. Month-wise average salinity, atmospheric and surface water temperature

Parameters	Stations	Months												Mean
		Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	
Salinity ‰	1	0.6	23.1	24.2	25.0	28.5	30.7	30.0	17.4	18.9	14.6	1.3	0.8	17.0
	2	1.9	24.8	25.3	25.8	28.8	29.7	31.2	17.8	20.7	15.9	1.5	1.8	18.8
	3	1.2	23.9	24.0	25.2	27.0	32.5	31.7	22.7	21.2	18.4	1.8	1.8	19.2
	4	2.0	24.7	25.8	24.8	35.7	34.8	32.2	24.2	22.3	19.0	2.3	2.1	20.8
	5	2.1	25.0	24.7	25.3	36.2	35.0	34.0	25.0	24.3	22.3	2.0	2.0	21.5
	Mean	1.56	24.3	24.8	25.2	31.2	32.5	31.8	21.42	21.4	18.0	1.7	1.7	
Atmospheric temperature (°C)	1	18.2	33.5	32.0	31.5	36.8	38.0	36.2	31.2	20.8	27.5	19.5	19.0	28.7
	2	19.0	31.0	32.5	32.0	36.0	38.5	36.3	30.2	29.5	28.0	19.8	20.1	29.4
	3	19.5	32.6	32.8	31.0	35.2	37.0	35.8	30.2	30.7	27.5	19.0	20.0	29.3
	4	20.0	33.5	33.0	31.3	35.8	36.0	37.0	28.5	29.7	27.3	20.2	20.0	29.3
	5	20.0	34.0	33.3	33.0	37.0	37.6	37.1	29.5	30.4	27.5	20.1	20.5	30.0
	Mean	19.3	32.9	32.7	31.76	36.1	37.4	36.4	29.9	28.2	27.5	19.7	19.9	
Surface water temperautre (°C)	1	17.5	30.4	30.1	30.7	35.8	36.1	27.0	35.4	28.1	26.5	18.0	17.5	27.8
	2	16.8	31.8	29.5	28.4	35.0	35.9	26.5	35.8	27.5	27.0	18.5	19.5	27.7
	3	17.7	30.0	28.0	29.5	36.1	36.0	26.8	35.0	28.0	27.2	17.9	18.7	27.5
	4	16.0	31.5	29.0	28.5	35.5	36.2	27.0	35.1	27.2	26.6	18.4	18.4	27.5
	5	17.5	30.2	30.2	28.7	36.0	36.0	26.9	36.0	27.0	26.5	17.0	17.2	27.4
	Mean	17.1	30.7	29.3	29.1	35.6	36.0	26.8	35.4	27.5	26.7	18.0	18.2	

availability of food along with maximum organic carbon due to rain, optimum salinity, also temperature and physical changes in the substrate composition. Ocypodid and Grapsid crabs (Table 1) are the dominant forms in the Pichavaram mangrove but in the intertidal zones of Hoogly estuary, Sundarbans *Metaplex intermedia* constitutes the dominant faunal component (Chakaraborthy *et al.*, 1992). However, in the present study, *Uca triangularis*, *U. annulipes* and *S. brockii* are found to be the dominant species in the Pichavaram mangrove. The minimum density was observed during the summer is related to high temperature and salinity which may reduce the availability of nutrients (Kathiresan, 2000; Ravichandran and Kannupandi, 2004). An increasing trend was reported in macrobenthic population towards post-monsoon in the tidal creeks of Sagar island (Bhunia and Choudhury, 1981) but the lowest population during the premonsoon from Sundarban mangrove (Chakaraborthy and Choudhury, 1994). Parulekar *et al.* (1980) also recorded more benthic faunal population in the estuaries and backwaters of Sagar Island of Sundarban mangrove during the post-monsoon season.

Distribution and zonation of crabs are based on the substratum, waterlevel and floral distribution. The species components were dissimilar among the stations studied. The Ghost crab *Ocypode macrocera* preferred sandy substratum, whereas *Macrophthalmus* species preferred only muddy substratum. *Uca* species was found in dry or grassy, elevated and muddy substratum. The *Ocypode* was found above the high water mark, while members of the sub family Ocypodidae were dwellers in the mud below high water neap (Snelling, 1959). In the present study high population density was noticed in station 3, which has dense mangrove and low population density was observed in station 1 lacking forest cover.

Habitat structural complexity influences the density and diversity of marine organisms and contributes to zonation, where the level of complexity varies significantly with tidal height (Laher *et al.*, 2000). Chinnavaikkal region is divided (Pichavaram) into five different zones based on crab species (Ravichandran *et al.* 2000; Ravichandran and Kannupandi, 2004). In the present study also, maximum number of species was observed in the neritic zone and very less number of species in freshwater zone. Similarly in the *Avicennia* zone more number of species were recorded and least number of crabs in the slightly or non-saline zone. The leaves of *A. marina* contain rich nutrients and more palatable compared to other mangrove leaves (Lee, 1989; Rajendran and Kathiresan, 2000; Ravichandran and Kannupandi, 2004). This perhaps may be the reason for maximum number of grapsid crabs present in the *Avicennia* zone.

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SEASONAL DISTRIBUTION OF BIOFOULING COMMUNITIES IN KUDANKULAM WATERS EAST COAST OF INDIA

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ABSTRACT

The seasonal changes in the settlement of fouling organisms at Kudankulam Coast was studied by suspending wooden test panels for a period of one year, from May 2003 to April 2004. Barnacles, polychaetes, amphipods and seaweeds were the major fouling groups observed from the test panels. The results on the seasonality of fouling community settlement are reported. The hydrological parameters which influence the settlement of fouling communities, were also studied.

INTRODUCTION

Coastal environments throughout the world have experienced a proliferation of introduced marine structures such as piers, pilings, jetties, power plant heat exchange systems, desalination plants, aquaculture cages etc. Many species of invertebrates and macro algae concentrate on these structures. Fouling organisms form an important part in the short detritus and grazing food chain operating there. These sessile biota also act as biofilters, passing large volumes of water through themselves, extracting pollutants and pathogenic microbes and thereby purifying and clearing the water. The fouling communities are also used as an efficient instrument of environment protection, in particular restoring the disrupted ecosystem by means of artificial reefs.

The marine fouling community along the Indian coastline appears to be a typical representative of Tropical fauna and flora. The common fouling communities include hydroids, bryozoans, polychaetes, barnacles, bivalves, ascidians and seaweeds. Various aspects of biofouling community development in Indian waters have been studied by Menon *et al.*, (1977); Wesley (1980); Sasikumar *et al.*, (1989) and Srinivas *et al.*, (1992). The present paper reports the results of a detailed study on the seasonality of fouling community settlement at Kudankulam coast. Results gathered in this study on settlement, abundance and other related aspect is of considerable interest because of the emerging Nuclear Power Project in Kudankulam region.

MATERIAL AND METHODS

Study Area

The study was carried out at Kudankulam (8°9'52" N and 77°42'41" E), which is situated about 25 km North-East of Kanyakumari along the Coast of Gulf of Mannar. The rocky shore inhabits an astonishing array of species representing nearly almost all the Invertebrate Phyla and Urochordates. The seasons at Kudankulam can be conveniently classified into pre-monsoon (February–May), monsoon (June–September) and post-monsoon (October–January).

Experimental design and sample collection

Wooden panels (10×10 cm) fitted with a raft and suspended at a depth of about 2 m were used to study the fouling community. Panels are exposed on short-term basis and observed at fortnightly intervals. The fouling organisms were scrapped off from the panels using scalpel and the total biomass was estimated. These organisms were dried in a hot air oven at 60°C for 24 hours and weighed again to find out the dry weight. Each panel was studied for biomass (total and differential), fouling volume, species composition and numerical abundance.

For hydrological parameters, surface water samples were collected in plastic containers during early hours (6–6.30 Am). Surface water temperature was measured using a Centigrade thermometer. For the estimation of dissolved oxygen, water samples were collected in 125 ml BOD bottles and fixed immediately (Winkler's method). For all other analysis about one litre of water sample was tightly sealed and kept in an icebox before they were brought to the laboratory. Standard methods as described by Venugopalan and Paulpandian (1989) were followed for the estimation of chemical parameters.

RESULTS AND DISCUSSION

Hydrological parameters

The monthly observations of the surface water hydrographical conditions are given in Table-1. The surface water temperature ranged between 26.2°C and 30.5°C. The minimum value was noted in September 2003 and the maximum temperature during April 2004. The salinity values varied from 30.5 ppt to 34.5 ppt. The peak value was observed in August and October 2003 and the minimum value was recorded in November 2003. The dissolved oxygen content ranged between 3.58ml/l and 5.8 ml/l. The nitrate content of the surface water varied from 1.49mg-at N/l to 3.75 mg-at N/l, the nitrite ranged between 0.518mg-at N/l and 4.196mg-at N/l and the phosphate content was between 0.06 mg-at P/l and 0.123 mg-at P/l.

Fouling biomass and fouling volume

Seasonal distribution of fouling biomass is given in Fig. 1. The biomass values were relatively high during monsoon season and low during pre-monsoon season. Maximum

fouling biomass of $5.32\text{g}/10\text{cm}^2$ was obtained during September 2003 and a minimum value of $0.233\text{g}/10\text{cm}^2$ was recorded in April 2004. The high biomass build up during monsoon period was due to the heavy settlement of barnacles and tubiculous polychaetes. The fouling volume ranged between $18.25 \pm 8.28\text{ ml}$ and $0.8 \pm 0.25\text{ ml}$. The maximum fouling volume was noted during September 2003 and the minimum value was observed in November 2003.

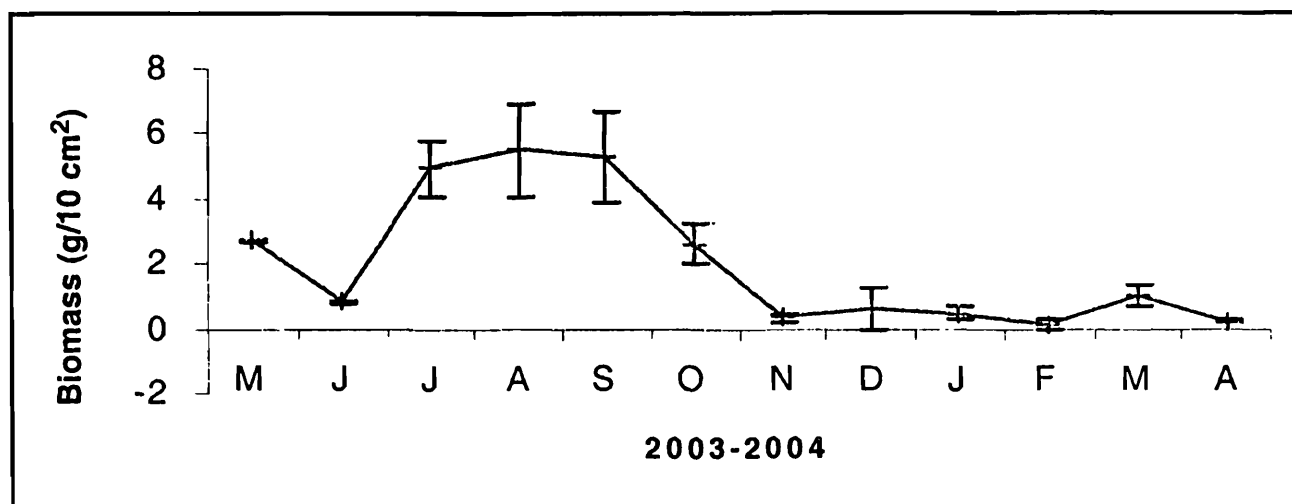


Fig. 1. Monthly distribution of fouling biomass

Macro fouling organisms

The macro fouling organisms collected from test panels include sponges, hydroids, anthozoans, bryozoans, polychaetes, barnacles, amphipods, isopods, decapods, mussels, oysters, gastropods, brittle stars, tunicates and fishes. Although fouling occurs throughout the year, seasonality of settlement and variations in abundance were exhibited by different species. Such fluctuations were well marked in barnacles and colonial ascidians. The settlement of fouling organisms on test panel was maximum during monsoon season and low during pre-monsoon and post-monsoon periods.

Protozoans were the early colonizers on the test panels along with macro algae. Only two species of foraminiferans, *Elphidium* sp. and *Spirillina* sp. were observed during the study period. The contribution of sponges to the fouling assemblages was not appreciable. The settlement of encrusting Demospongiae was noticed on test panels mainly during post-monsoon period. *Obelia* sp. was found on panels mainly during post-monsoon period. Colonies sometimes covered the entire panel as a dense growth. Occasional settlement of sea anemones was also noticed along with *Obelia* sp. during the post-monsoon season. Quite a large number of both errant and sedentary polychaetes were observed from the test panels. Nereids were the dominant errant polychaetes found on the test panels throughout the study period with changes in density. *Perinereis cultifera*, *P. nigropunctata* and *Platynereis dumerilii* were the common nereids encountered on the panels. The abundance of polychaetes was high during monsoon season and low during post-monsoon season (Fig. 2).

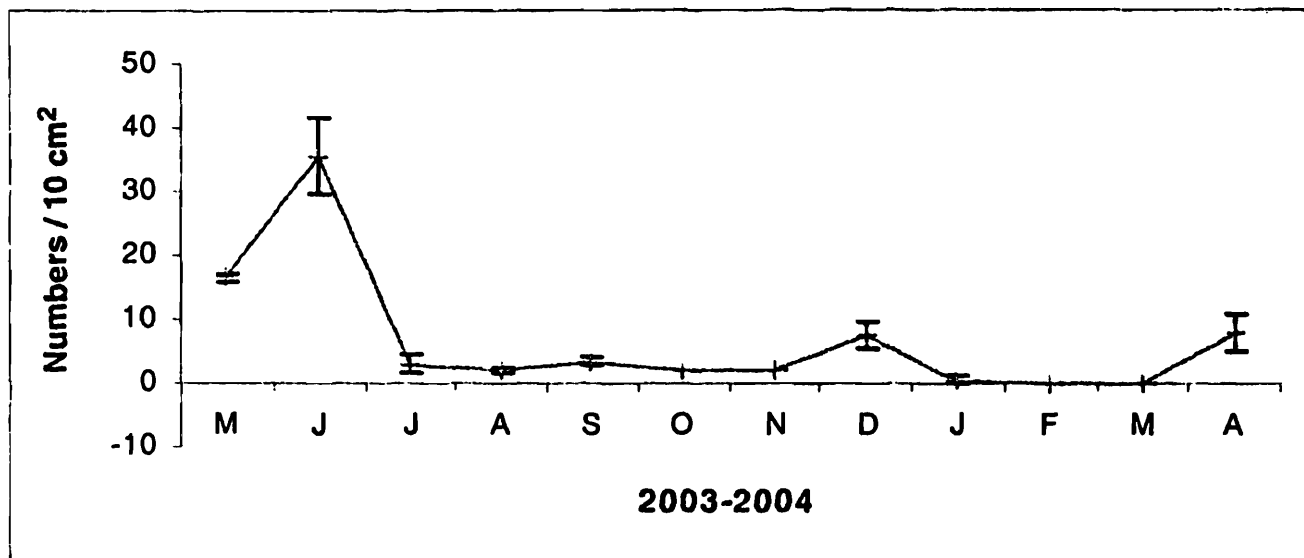


Fig. 2. Seasonal abundance of Polychaetes

Barnacle settlement was observed throughout the study period except during January and February 2004. *Balanus variegatus* was the dominant fouling organism in Kudankulam waters and it reached a mean of about 4460/10cm² during September 2003 (Fig. 3). Other common barnacles found on panels include *Balanus amphitrite amphitrite*, *Megabalanus tintinnabulum* and *Balanus amaryllis*. Amphipods were found almost throughout the year (Fig. 4) and the peak abundance was observed during monsoon season. *Gammarus* sp., *Corophium* sp. and *Podoceros* sp. were the common amphipods noticed on the test panels. Caprellids were also observed from the test panels during monsoon period. The formation of silt on test panels may be one of the reasons for the abundance of polychaetes and amphipods, where these organisms get food and shelter. Isopods such as *Sphaeroma* sp. and *Limnoria* sp. were also observed on test panels occasionally.

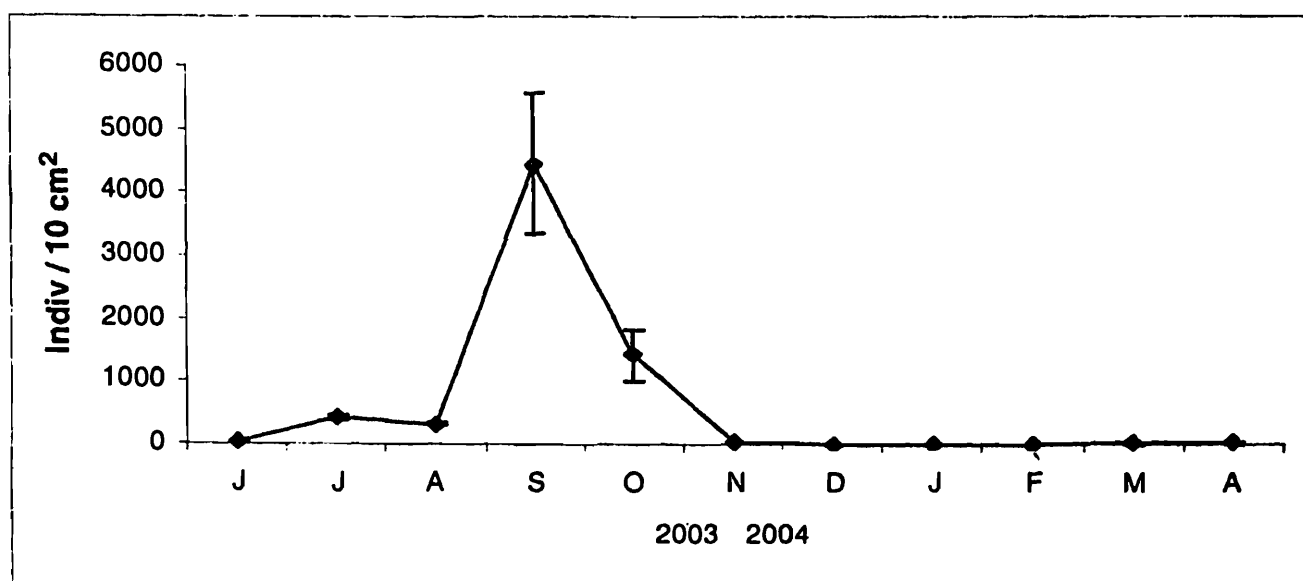


Fig. 3. Seasonal settlement of *Balanus variegates*

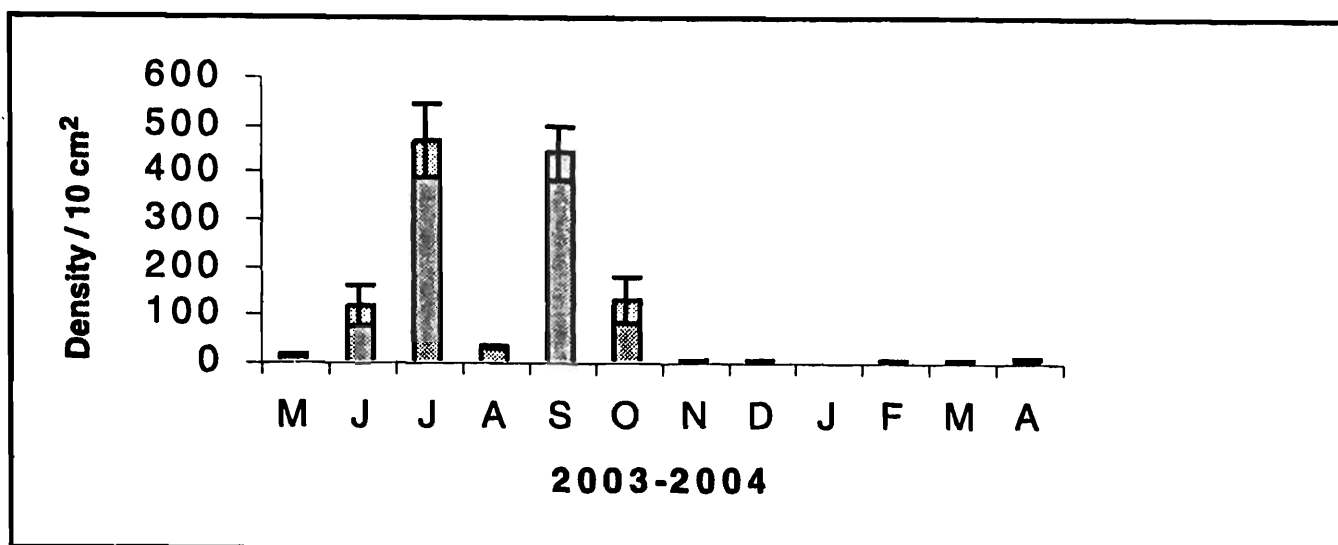


Fig. 4. Seasonal abundance of amphipods on test panels

The settlement of brown mussel *Perna indica* in Kudankulam waters started from July (monsoon) and extended up to January (post-monsoon). Peak settlement was observed during October (Fig. 5). However, the bivalve settlement was not observed during pre-monsoon season. Echinoderms did not contribute much to the fouling communities, few specimens of *Opicnemus marmorata* and *Ophiocoma* sp. were observed during the post-monsoon period. Another important group, which formed a main part in fouling assemblage, was the ascidian, *Didemnum* sp. with the maximum density of 11 colonies/10 cm² observed during August 2003. The settlement of *Botrylloides* sp. was mainly confined to post-monsoon period.

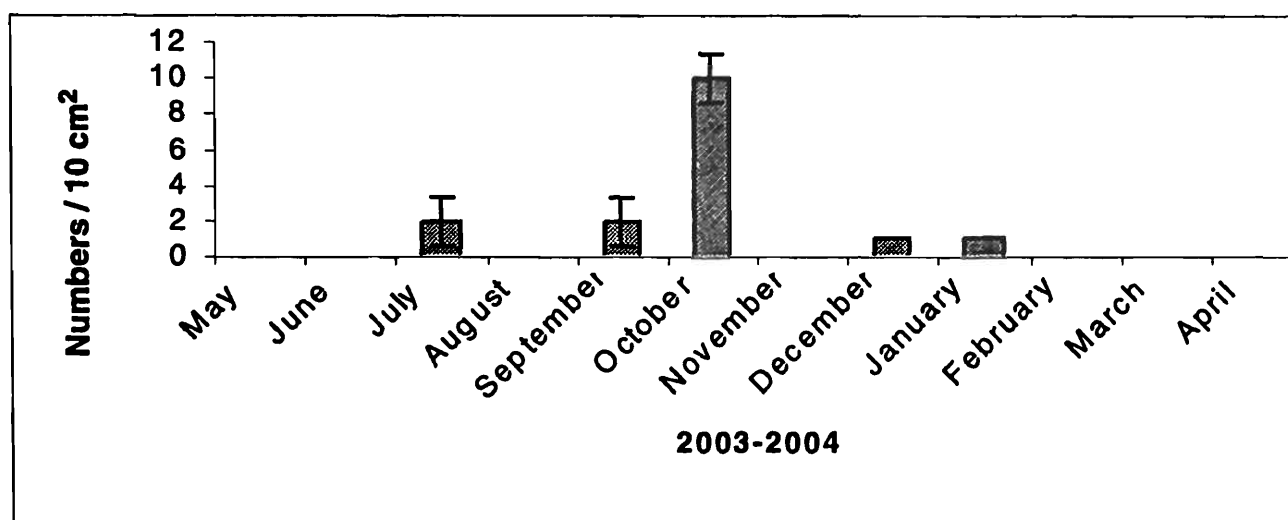


Fig. 5. Seasonal variation in seaweed settlement

Seaweeds that settled on panels comprised of seven species belonging to five families. *Gracilaria* sp., *Enteromorpha* sp., *Cladophora* sp., and *Ulva* sp., were the common seaweeds observed on the test panels. In the present study two annual peaks in seaweed settlement was observed. The primary peak was in May 2003, mainly due to *Enteromorpha* sp. and

the secondary was during June 2003 due to *Gracilaria* sp. The monthly settlement varied between 0.004g/10 cm² (Feb. 2004) and 2.5g/10 cm² (May 2003). The settlement of seaweeds on test panels was high during the pre-monsoon period and low during post-monsoon months (Fig. 6).

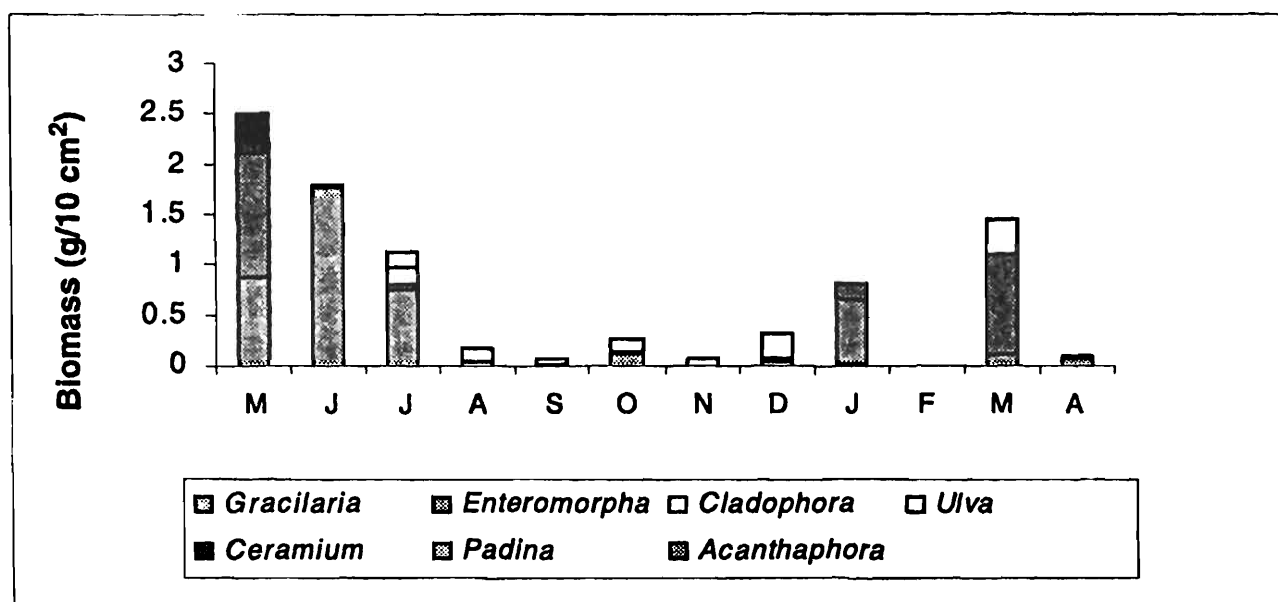


Fig. 6. Seasonal variation in seaweed settlement

Settlement of fouling organisms in Kudankulam waters appeared to be a year round phenomenon with seasonal fluctuations. The seasonal distribution of fouling communities mainly depends on the life histories of relevant species and hydrological parameters of the water. The dispersal of sessile organism is accomplished by a phase of motile larval stage. The level of recruitment and their fluctuations mainly depend on the abundance of larvae and the level of larval food supply. Comparison of the peak settlement period of barnacles in Indian waters reveals the following details. In Visakhapatnam harbour the barnacles were abundant during April, May and August (Ganapati *et al.*, 1958). Maximum settlement of barnacles at Cochin harbour was observed during May, October, November and December (Nair, 1967). At Kalpakkam it was during June, September and November (Wesley, 1980). In Kudankulam waters the peak settlement was observed during September and November.

The most frequently cited abiotic factors controlling the distribution of fouling organisms are tidal rhythm, wave action, water current, light, temperature, type and orientation of substratum, pressure, turbidity, salinity, pH, concentration of nutrients and dissolved gases. The observed low abundance of fouling community during the post-monsoon months may be due to the drop of salinity during November and December. Most authors working in Indian waters suggested that among the various factors, salinity plays a major role in the settlement of marine fouling organisms (Daniel, 1954; Menon and Nair 1971). Similar results of low settlement of fouling communities, possibly due to the lowering of surface water salinity were also reported by Sasikumar *et al.*, (1989) from Kalpakkam coastal waters.

Macro algae were the major-soft foulers, and their settlement on test panels attains significance, as the algae provide food and shelter to the errant foulers such as polychaetes, amphipods and isopods. The macro algal settlement increased the abundance of errant epifauna like polychaetes and amphipods during monsoon period. Barnacles and bivalves were the common hard foulers found on the test panels and the hydrodynamic loadings produced by them on marine structures could cause huge economic damages for the under water structures of Kudankulam Nuclear Power Project. Therefore, the extend of fouling problem in Kudankulam coast mainly depends on their settlement pattern, growth rate, breeding ecology and distribution.

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Table-1. List of common fouling organisms settled on test panels

Protozoa <i>Elphidium</i> sp. <i>Spirillina</i> sp. Porifera Sponges (unidentified) Coelenterata <i>Obelia</i> sp. Sea anemone (unidentified) Annelida <i>Perinereis nigropunctata</i> <i>P. cultifera</i> <i>Platynereis dumerili</i> <i>Pseudonereis</i> sp. <i>Syllis gracilis</i> <i>Phyllodoce</i> sp. <i>Paleonatus</i> sp. <i>Hydroides</i> sp. <i>Sabellaria</i> sp. <i>Terebella</i> sp. Arthropoda Cirripedes <i>Megabalanus tintinnabulum</i> Linnaeus <i>Balanus amphitrite amphitrite</i> Darwin <i>B. variegatus</i> Darwin <i>B. amaryllis</i> Gruvel Amphipods <i>Gammarus</i> sp. <i>Corophium</i> sp. <i>Podoceros brasiliensis</i> <i>Caprellids</i>	Isopods <i>Sphaeroma</i> sp. <i>Iodotea</i> sp. <i>Cirolana</i> sp. <i>Mesanthura</i> sp. Pycnogonids <i>Endeis mollis</i> Decapods <i>Charybdis annulata</i> <i>Thalamita</i> sp. <i>Hyastenus</i> sp. Anomurans (Unidentified) Mollusca <i>Trochus</i> sp. <i>Nasa</i> sp. <i>Perna indica</i> Kurikose & Nair Echinodermata <i>Ophiothrix</i> sp. <i>Ophiocoma</i> sp. Urochordata <i>Botrylloides</i> sp. <i>Didemnum</i> sp. Seaweeds <i>Gracilaria</i> sp. <i>Enteromorpha</i> sp. <i>Ulva</i> sp. <i>Cladophora</i> sp. <i>Ceramium</i> sp. <i>Acanthaphora</i> sp. <i>Padina</i> sp. <i>Sargassum</i> sp.

Table-2. Hydrological parameters of the study area

Month 2003 -04	Temperature °C	Salinity (ppt)	pH	Dissolved oxygen (ml/l)	Phosphate (µg- at P/l)	Nitrite (µg- at N/l)	Nitrate (µg - at N/l)
August	27.7	34.5	8	4.8	0.06	4.196	2.93
May	28	33	8.2	3.58	0.12	1.12	1.49
June	27.5	33	7.9	3.64	0.11	1.34	2.78
July	27.5	33.5	8.1	3.92	0.07	0.77	2.84
August	27.7	34.5	8	4.8	0.06	4.196	2.93
September	26.2	32.5	7.95	3.78	0.12	1.47	2.48
October	29	34.5	8.07	3.64	0.06	1.89	3.05
November	29	30	8.02	5.8	0.12	1.5	2.19
December	27.9	30.5	8	5.12	0.08	0.51	1.99
January	27	32	7.92	5.41	0.06	1.2	3.21
February	27.7	32.5	7.97	5.52	0.09	1.12	3.75
March	28.7	33.5	7.95	5.52	0.07	0.87	3.15
April	30.5	34	8.07	5.58	0.06	0.72	3.36

INDIAN MARINE SPONGES–THEIR BIODIVERSITY AND CONSERVATION

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ABSTRACT

Marine sponges belonging to 584 species under 288 genera and 81 Families of 21 orders are reported in India. This forms 30% of the world fauna. Diversity in East and West Coast, Andaman, Nicobar and Lakshadweep Islands are presented. In the East Coast especially in the Gulf of Mannar region the sponge diversity is rich compared to West Coast. In the present paper sponge resources of the various ecosystems and their ecological relationships are analyzed. The causes for the reduction in the sponge growth and possibilities for sponge culture are discussed. Threats to sponge biodiversity both by man and nature are pointed out and the commercial and biomedical values of sponges are discussed.

INTRODUCTION

The sponges are known to serve as home to many species of fish and Invertebrates. According to scientific estimates there are 15,000 species of sponges in the world of which an estimated one third being found in Indian waters. Sponges play an important roles in many marine habitats. But we still know very little about, their biology and ecology as compared with other animal groups. Sponges have close relationship with many marine organisms like algae, shrimp, brittle stars and coral reefs. These animals rely on each other for protection and food.

ECOLOGICAL RELATIONSHIPS

Most of the 5000 or more Indian sponge species are marine, although some 150 species of the demospongiae live in fresh water. They are present in all seas and at all depths, and a few even exist in brackish water. Although the larvae are free swimming, the adults are always attached, usually to rocks, shells, corals, or other submerged objects. Some benthic forms even grow on sand and mud bottoms. Many animals live as

commensals or parasites in or on sponges. The larger sponges tend to harbour a large variety of invertebrate commensals. On the other hand, sponges grow on many other living animals, such as molluscs, barnacles, brachiopods, corals, and hydroids. Some crabs attach pieces of sponge on their carapaces for camouflage and for protection. A number of toxic or noxious substances have been found in sponges. Some reef fishes, however, are known to graze on shallow-water sponges. Vast ecological communities and systems are thus centred on Sponges.

COASTAL ECOSYSTEM

About 584 species of sponges are recorded from India indicating the species richness in the marine environment. 320 species are recorded from Gulf of Mannar and Palk Bay suggest that the ecosystem is a storehouse of invaluable species. 49 species from Gulf of Kachch, 124 species from Andaman and Nicobar islands and 91 species from Lakshadweep are known. Six species of boring sponges are known to have devastating effect on chanks, pearls oysters, rock oyster, mussels etc. Only about 60% of the total species have been explored from Indian coastal waters. Sponges protect against erosion from storms and waves, filter pollutants, and oxygen supply to coral reefs, estuaries, lagoons and shallow coastal waters. All these systems serve as nurseries and feeding grounds for many coastal and pelagic species of fish.

CORAL REEF ECOSYSTEM

Cavities and depressions of coral mass give shelter and feeding ground for many bottom living organisms like sponges, sea fans, sea anemones etc. This ecosystem contains a number of species representing most of the marine organisms. Thomas (1986) recorded more than 428 sponge species in India. *Hercinia fusca*, *Dysidea fragilis*, *Spirastrella inconstans* and *Callyspongia diffusa* are a few massive sponges which are distributed in good concentration along the reef area in Palk Bay. The Indian seas harbour about 34 boring sponges and this number is high when compared to any other parts of the world ocean. These sponges are constant threat for coral reefs ecosystem Thomas (1972)

DIVERSITY OF SPONGES IN LAGOON

Some area of the lagoon bottom is exposed to mass mortality of sponges, which is probably due to excessive siltation (Minicoy Island, Pillai 1983). Dredging and blasting of the reefs result in sedimentation, which result in filling up of the lagoon. *Callyspongia fibrosa*, *Haliclona cribriculis*, *Tethya diploderma*, *Oceanapia fistulosa* are a few sponges which are distributed in the lagoonal area.

MANGROVE ECOSYSTEM

The mangrove ecosystem is highly productive and exchanges matter and energy with the marine ecosystem. The ecosystem constitute an important reservoir and feeding and

breeding grounds of large number of commercially important and ecologically significant animal species.

Tedania ignis—Fire sponge; *Haliclona viridis*—green sponge; *Geodia gibberosa*—white sponge. These sponges are found in mangroves.

Sponges associated with seaweed : Associations between Sponges *Sigmadocia petrosioides* and algae are very common in the Gulf of Mannar. Sponges are seen as encrusting masses or projections growing on hard substratum or larger seaweeds. They are abundant where rocky or coral formations occur.

Sponges associated with seagrasses : Nutrients including Nitrogen and Phosphorus compounds enter the seas from sewage effluent from near by cities and towns and dredging can also initiate eutrophication. These excessive nutrients encourage the growth of sea grasses and algae, which in turn results in lot of dissolved nutrients. These nutrients from sewages stimulate phytoplankton blooms, which decrease water clarity and favour the growth of sponges and other filter-feeding organisms (Murugesan and Sukumaran, 2000)

DIVERSITY OF MARINE SPONGES

Studies on the diversity of marine sponges is very limited around the world and only very few institutes are carry out the taxonomic studies.

The sponge fauna of Indian seas reveals that it is dominated by Demospongian species (88.8 %) followed by Hyalospongiae (9.1 5) and Calciospongiae (21%). Thomas (1969–98) recorded 428 species of marine sponges of Class Demospongian in India belonging to 8 Orders, 32 Families and 134 genera. The diversity of Indian marine sponges in various regions are reported by Thomas (1985).

451 species a sponge belonging to 3 classes, 17 orders, 65 families and 169 genera are reported (Pattanayak, 2001) by from Indian region. Out of 451 species, 111 are endemic to India.

Boring sponges of Indian seas : A total of 34 species of boring sponges referable to 13 genera under 3 orders have been recorded by Thomas (1988).

ECONOMIC IMPORTANCE

From time immemorial sponges find their place in a number of household uses. Bath sponges are used for cleaning & polishing. These sponges (*Spongia officinalis*) occur in good numbers in the Gulf of Mannar Coast. Some sponges such as the boring sponge *Cliona* is a pest of oyster in some countries. Sponges have provided many important bioactive compounds of high commercial value and continue to be routinely screened for new bioactive compounds. These searches have been successful and two-thirds of antibiotics have been isolated from sponges (Delaubenfels, 1950).

Toxins produced by corals or sponges have a protective function not only against predators but also against larval forms of sessile animals, which settle and encrust upon the coral sponge.

BIOMEDICAL PROPERTIES OF SPONGES

Over 70% of potentially useful compounds are discovered from marine sponges. With the discovery of arabinose nucleosides from *Tethya crypta* which has proven to contain cancer-inhibiting property many compounds isolated are found to be useful in treating respiratory, cardiovascular & gastro-intestinal diseases and also have anti-inflammatory & antibiotic properties. Table 1 shows that the number of bioactive compounds isolated from some of the common genera and species of sponge.

Table 1. Bioactive Compounds of Sponges

S. No.	Species	Compounds isolated	Activity
1.	<i>Discodermia dissolute</i>	Monoalide	Anti inflammation & Pain killer
2.	<i>Dysidea avara-</i>	Averal & Avarone	Anti-HIV
3.	<i>Dysidea ciniria</i>	Meroterpenoid	Cytotoxic & Anti Hiv
4.	<i>Heteronema ercta</i>	Heteronemin	Antinelmin+ Nic
5.	<i>Dysidea herbacea</i>	Dysidenin-	Cytotoxic

Very recently in New Zealand, a group of scientists have successfully developed farming methods for the culture of sponges aimed at producing bioactive metabolites successfully.

THREAT OF SPONGES

Natural factors like storms, cyclones and flood are the primary cause for damage of sponge habitat. During 1964, sponge habitat of Gulf of Mannar was destroyed by a cyclone. Rajendran have reported that only two earth quakes (1881 and 1941) have caused *tsunami* run up in the East Coast of India. Further the 26 December 2004 *tsunami* has caused extensive damage to the marine resources in India.

Gulf of Mannar Region

Gulf of Mannar biosphere reserve is supposed to be one of the marine protected areas of the country. However various activities such as fishing, gear operation, anchoring of boats, collecting corals for ornamental fish culture, shrimp culture etc add to the complexity of management problems.

Sedimentation : These activities reduce feeding & respiration of sponges, quarrying

of corals for industrial purposes from Mandapam to Tuticorin lead to the exploitation of sponge fauna.

Human Impact : Bottom trawling has damaged or destroyed reefs in many areas (Devaraj, 1987). Trawlers are major causes for the over fishing of many species along with non-target animals such as sponges.

Oil Pollution : Oil pollution is an extreme example of how chemicals in this case can affect reefs. Industrial wastes discharged into the sea near Tuticorin Islands are standing example of how pollution deteriorates the sponge ecosystem Pillai (1973)

Gulf of Kachchh

Dredging of coral reef and construction activity in the near shore region are very significant threats to the sponge ecosystem in Gulf of Kachchh. Extensive destructive to mangrove along the coast is also one of the causes for the depletion of the sponge fauna (Subba Rao and Sastry, 2005). The damage was apparently due to large scale silting caused by extensive dredging for calcareous raw materials for the nearby cement factory in the Pirotan Island.

Coral Mining : The beach of Kachchh is blessed with large reserves of strategic and economically important heavy minerals and hence active mining operations are going on. During mining operations a number of organisms are affected because of the employees who never bother about beach dwelling. This in its long run will affect the biodiversity of several organisms. Eg. Mining is centred on the reef of Pirotan Island (Pillai, 1996).

From Okha to Jodia along the Gujarat coast has been brought under Gulf of Kachchh Marine National Park is administered by the protection and conservation of the reef ecosystem and mining activities are banned now a days.

Over Fishing : The reefs are used to carry out reef & fishery, squid fishery, chanks and pearl fishery, ornamental shell trade and illegal mining of corals. Villagers around Gujarat harvest holothurians. Trawling causes damages to sponges & reefs around Kachchh Islands. Extensive & indiscriminate fishing by divers of Kachchh Islands for *Trochus* sp, *Turbo* sp causes decrease in the landings in the recent years.

Andaman & Nicobar Islands : Tourism on coastal causes damage to the marine resources like sponge fauna. Pollutants from fishing vessels, mills, powerhouses, timber industries are causing severe damage for sponge habitat and their associated organisms.

Disease : In Andaman & Nicobar Islands parasites cause white band disease (WBD) and for coral-boring sponges and bivalves (Dorairaj, 1998).

Population pressure : Increasing human pressure for domestic needs and development industries put an increasing pressure on the marine ecosystem. Much of the biodiversity had been exploited by the local tribal for their daily requirement of food and shelter.

(CMFRI, bulletin, no. 34, 1983). From Nicobar where the tribal use a fruit to immobilize the reef fishes and leaving the unwanted in the same water, change the effect of the ecosystem. Disposal of the sewage causes bacterial infection. These activities affect the breeding habitats of several sponge species and reduce the density of the some species.

Laskshadweep region : An interesting feature noticed with the sponge fauna, both morphozone wise and transect wise is the dominance of boring sponge in relation to non-boring ones. Sponges on a transect morphozone revealed that mortality of coral due to sponge attack was high as 80% (CMFRI bulletin no. 43, 1989). The major threat to the sponges and their biodiversity are natural processes like sea erosion, siltation, predation, (*Acanthaster-planci*) and diseases. (CMFRI bulletin, 43 1989). The vast sponge resource available in these atolls may be exploited for initiating R & D programmes on marine organisms based drug industry.

Bleaching : *Chondrilla australiensis*, a dominant sponge species was found bleached. This species had lost colouration up to 6 metres depth and those below 6 metres had not bleached. Bleached individuals also die later on. Bleaching has occurred in East and West coast of Australia at Puerto rico in 1987-88. (Incente, 1990). Bleaching affects sponge growth, reproduction and regeneration.

Conservation : The wild life act include areas as sanctuaries, national parks and closed areas under the environment protection act. The central government declares ecologically sensitive areas as protected areas. Many acts and rules related to coastal and marine activities in the country are being implemented in the state are the Indian fisheries act 1897, and its amendments 1920, wild protection act 1972, and environment protection act 1986. As per the environmental protection act 1986, Setting up of new industries, Fish processing units, Disposal of waste and effluent from industries, land reclamation, Mining of sand are prohibited. However industrial wastes, aquaculture waste, thermal plants materials are prohibited in environmentally sensitive areas. The institutions such as CMFRI, DOD, NIOT, FSI, MPEDA, CIBA, NBA, ZSI, GSI, BSI, and ANNAMALI UNIVERSITY are engaged in the research & conservation and management of marine & coastal ecosystem.

Aquaculture activities, increased tourism and population influx leads to biodiversity conservation problems in India. Creating awareness among general public can conserve sponge ecosystem. The presence or absence of indicator species may be an index of environmental stress or pressure on reefs. The taxonomically extended surveys of sessile organisms such as sponges, alcyonarians can give clues to the actual environment conditions. Assessment of heterotrophic macro invertebrates such as sponges, barnacles, hydroids etc may yield clues to stress conditions due to pollution. Such studies are very important for management of the marine resources.

The national wild life action plan identified the protected by remote sensing techniques joined with land surveys to assess the rate of degradation of the ecosystem.

RECOMMENDATIONS

- In order to conserve the Marine ecosystem the following steps are to be taken into account.
- To stop the activities such as aquaculture, overfishing, Mining and industrialization.
- Reasons for the degradation of the area should be analyzed.
- Sponges culture aspects should be taken up in all the suitable places including degraded areas.
- Awareness programmes should be organized about the importance of marine ecosystems to people for better management.

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OBSERVATIONS ON THE CHANGES IN FISHERY RESOURCES STRUCTURE IN RELATION TO TSUNAMI ALONG THE TAMIL NADU COAST

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ABSTRACT

The effects of *tsunami* had its impact on the shoreline and contiguous contours where it hit. An attempt has been made to study the impact of *tsunami* on the marine fishery resources structure in the waters of Tamil Nadu Coast, between the area 10°N and 12°N where the effect was more pronounced. The data collected by the vessels *Matsya Jeevan* and M.F.V. *Samudrika* based on the fishery resources survey from July 2004 to July 2005 form the basis of this paper and analysis of the data reveal that there is a decline in catch per unit effort in the area lat.10°N and lat.11°N whereas the area lat.12°N has registered increased catch rate of some important groups of fishes in the 50-100m depth zone alone during post-*tsunami* period.

INTRODUCTION

A trial of death and destruction caused by the 26th December, 2004 *tsunami*, resulting from underwater earthquake off Indonesia in the Indian Ocean left an indelible mark in the economic condition of coastal population of the countries which bore the brunt of this unusual phenomenon in recent history. The water mass with its intensive energy carried chemical matters and other biotic and abiotic factors, which may have had the effect on the recruitment pattern of the marine fishery. Fishery Survey of India (FSI), which is the nodal agency for survey and assessment of fishery resources in the Indian EEZ, took a major leap in conducting the fishery resources survey in the most affected areas of lat.10°N to 12°N to investigate whether any change occurred in the constitution of species assemblage and catch rate in demersal fishery. The study period consists of two components, (i) pre-*tsunami* investigation from July 2004 to November 2004 and (ii) post-*tsunami* studies from December 2004 to July 2005.

MATERIAL AND METHODS

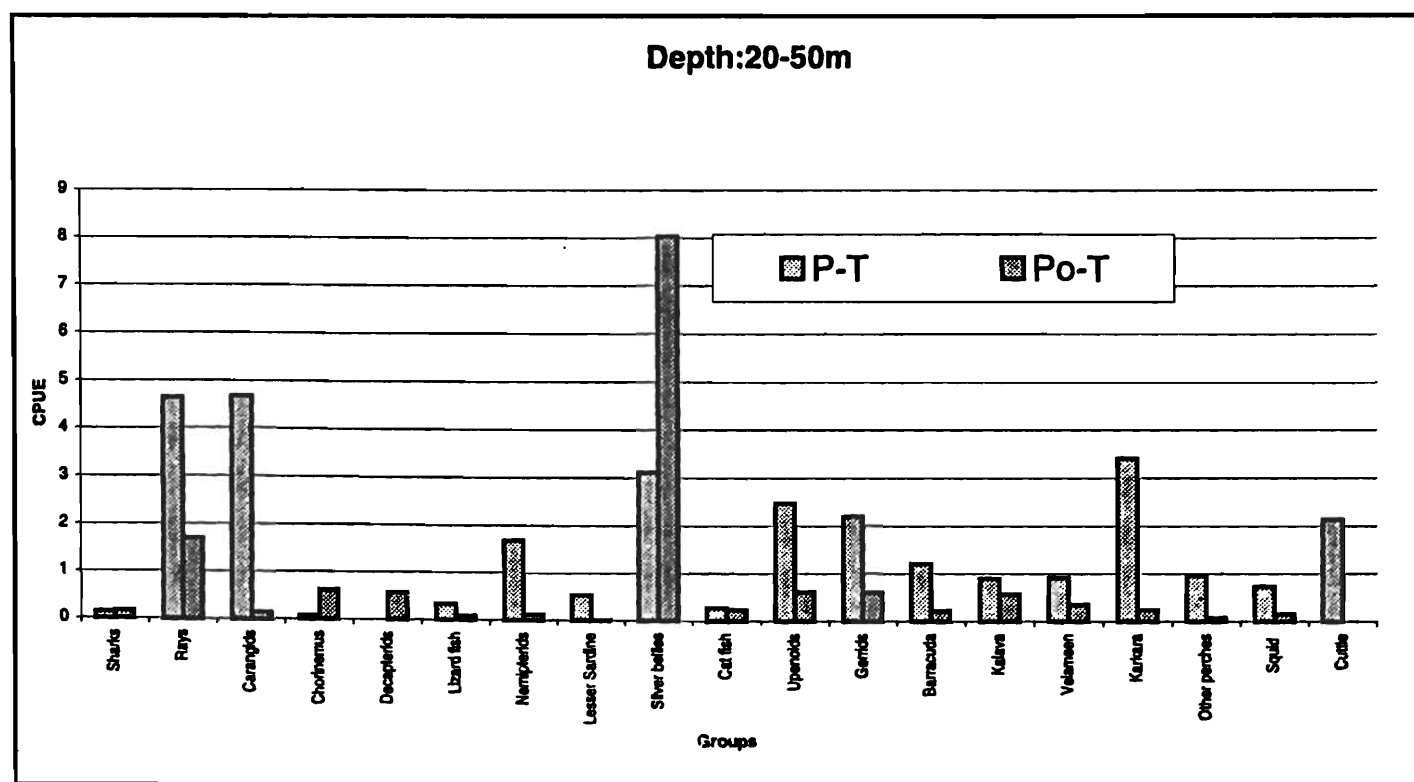
The data collected by the Chennai base vessels of FSI, *Matsya Jeevan* (OAL : 36.5m) and M.F.V. *Samudrika* (OAL : 28.8m) employing demersal gears such as Fish Trawl (27.5m) and Shrimp trawl(30m) in the areas between lat.10°N and 13°N during the period July 2004 to July 2005 in the lower East Coast, have been utilized for the analysis.

The stratified random sampling aimed at variance and achieving higher precision of estimates was followed in the survey. An average trawling speed of 3.5 knot was maintained and each haul was made for 90 minutes. The CPUE has been calculated for each area and depth taking into account the quantity of each group of fish landed and the actual hours of fishing operation. 19 groups of fish have been taken in for the study as these groups are available uniformly in all the study area and throughout the study period.

RESULTS AND DISCUSSION

Pre & Post-Tsunami observations

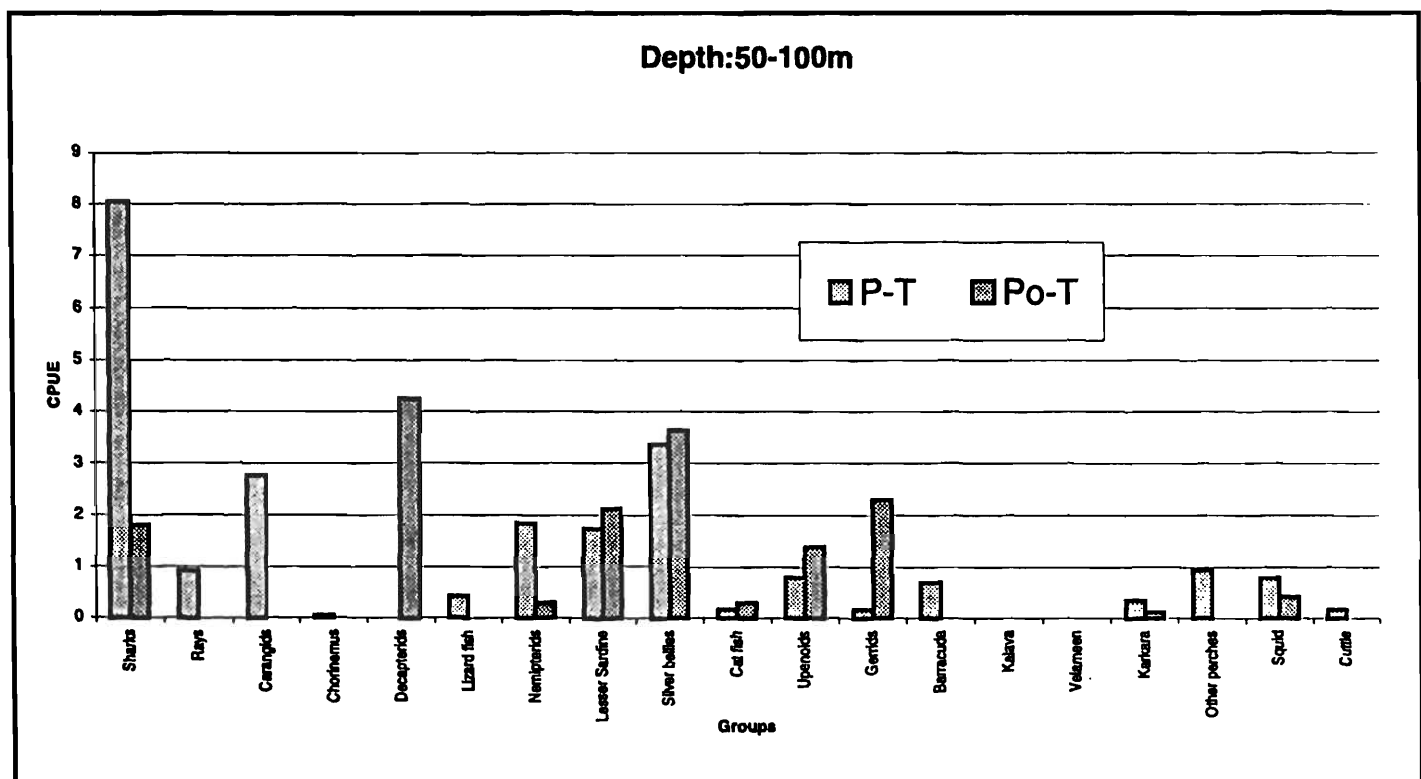
In the lat. 10°N (Fig. 1) which covers the area off Nagapattinam, where the fury of *tsunami* wave was felt much, the species composition was observed in appreciable trend in the 20-50m depth zone during pre-*tsunami* observations. The catch per unit effort (CPUE) for the following group of fishes recorded during pre-*tsunami* period were upenoids (9.17Kg/hr), decapterids (6.5Kg/hr), lesser sardine (5.03Kg/hr), nemipterids (2.03Kg/hr) and carangids (1.23Kg/hr). But after the *tsunami* the above species assemblage and CPUE were declined in the catch.



In 50-100m depth zone also the group of fish recorded was much higher during pre-*tsunami* period rather than post-*tsunami* occurrence. Rays, decapterids, lizard fish, nemipterids, silverbellies, upenoids, gerrids, barracuda, perches and squid & cuttle fish made their presence in the pre-*tsunami* period considerably. After *tsunami* the presence of these groups was not significant in the catch recorded.

In 200-300m-depth range the species composition became comparatively lesser to other depth ranges; only two groups such as sharks and squids were recorded during pre-*tsunami* period. No occurrence was noticed of these groups after *tsunami*. The deep sea varieties such as green eye and Indian ruff had also followed the same trend.

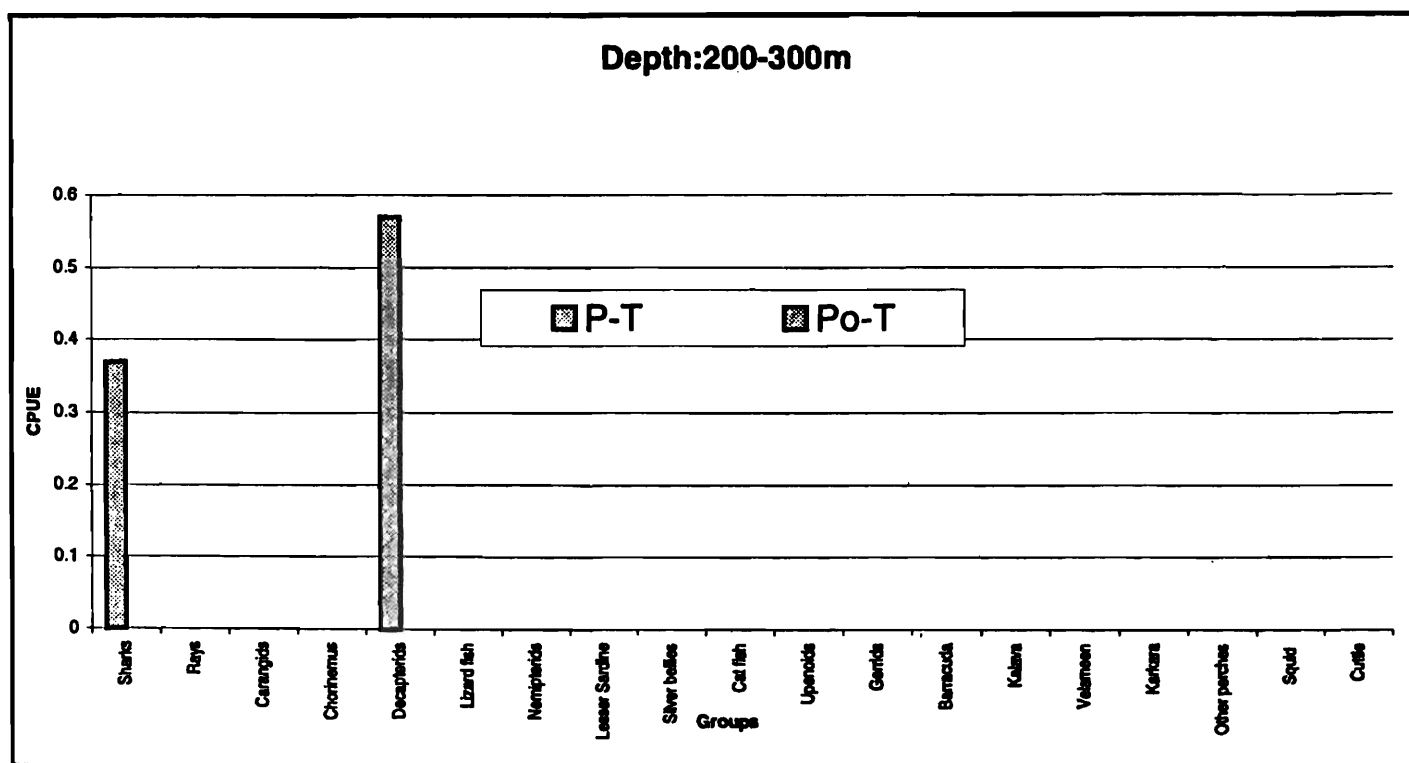
Lat.11°N (Fig.2) : In 20-50m depth contour there was no specific change in the species composition. Upenoids stood first in catch rate by recording 4.66Kg/hr and declined during post-*tsunami* (2.16Kg/hr). Carangids whose catch rate was recorded as 3.34Kg/hr during pre-*tsunami* decreased to 1.5Kg/hr. Decapterids also registered good catch (3.24Kg/hr) during pre-*tsunami* and decreased after the *tsunami* to the level of 0.77Kg/hr and other varieties such as lesser sardine, catfish, gerrids, barracuda and cephalopods registered marginal decline during the post-*tsunami* observations.



In the 50-100m-depth zone the composition became lesser gradually. During pre-*tsunami* period this depth area recorded more than 17 groups of fish but after *tsunami* registered only 8 groups. In the catch rate also there was specific change in this depth zone: sharks, rays, decapterids, silverbellies, upenoids, barracuda and cephalopods registered significant catch rate during the pre-*tsunami* period. In the next strata of 200-300 depth zone during pre-*tsunami* period, sharks, decapterids and squids were obtained

in the catch and after the *tsunami* these groups were not found in the catch. Like wise Indian ruff which registered good catch rate of 24.5Kg/hr before *tsunami* was more or less absent in the catch.

Lat.12°N (Fig. 3) : In the coastal waters, the depth range of 20-50m showed significant difference in the catch rate between pre & post *tsunami* periods. During pre-*tsunami* period the groups such as rays, carangids, nemipterids, upenoids, gerrids, barracuda, karkara, squid and cuttle fish showed increased trend of catch rate by registering 4.64Kg/hr, 4.67Kg/hr, 1.69Kg/hr, 2.48Kg/hr, 2.2Kg/hr, 1.21Kg/hr, 3.41Kg/hr, 0.74Kg/hr and 2.13Kg/hr respectively and marked decline was noticed during post-*tsunami* period. In 50-100m depth range sharks (8.06Kg/hr), carangids (2.76Kg/hr), lizard fish (0.42Kg/hr), nemipterids (1.84Kg/hr), barracuda (0.7Kg/hr), perches (0.95Kg/hr) and squid (0.79Kg/hr) had registered good catch during pre-*tsunami* but groups like decapterids, lesser sardine, silverbellies, upenoids and gerrids, after *tsunami* had registered an increased trend in the catch. In 200-300m depth range during pre-*tsunami* sharks and decapterids were alone found in the catch.



The *tsunami* impacted the entire stretch of Coramandel coastline, the height of the waves on Northern part of the Coramandel coast being considerably less than the South. It still had devastating effect there too, killing, destroying property and covering everything in sediment, trees and rubbles.

Echogram analysis of demersal trawl sampling comparison of pre & post-*tsunami* period suggest major variation in bottom relief of post-*tsunami* period from the charted soundings of hydrographic charts. Catch rates of demersal species such as *Pristipomides* and *Lethrinids* which generally have a cent percent zonal attachment (a function of time

and biomass) to these areas have reduced to just one percent of its previous strength. The destruction of demersal fish stocks and fish habitats by the surging *tsunami* waves was evident from the samples collected from the trawls operated in these areas. Consistently comparable catches of invertebrates such as mollusks shells; slugs, snails, lamp shells, sea cucumbers and brittle stars were taken from all sampling hauls operated immediately after *tsunami*. Removal of food items and predators from food chains had a cascading effect in which fish down perches and whole sedimentary fauna changes. Whether it is not in a state and where it can flex back quickly will be a matter hard to predict. Catches taken during post-*tsunami* period included high percentages of juveniles and under sized fishes. A worry over the current fishing at Tamil Nadu, however, is whether high catches with high percentage of juveniles are reducing a large percentage of juveniles for further spawning.

The situation has not been that bad in the area of pelagic and mesopelagic stocks as sampling results indicated. Though no definite relation between *tsunami* and pelagic fish stock decline could be made, the landings of good volumes of *Ambligaster sirm* during post-*tsunami* period points to the fact that this species which forms a major component of gill net fishery off Sri Lankan coast (Karunasinghe, 2003) got swept out of the coast by the Northerly surging *tsunami* current at a faster pace.

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BIRDS DIVERSITY OF MUTHUPET MANGROVES SOUTHEAST COAST OF INDIA

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ABSTRACT

The mangroves of Muthupet in Tamil Nadu are integral environment of forest and fisheries. These mangroves stabilize the shoreline and act as bulwark against the devastating impact of hurricanes and cyclones as well as encroachments by the sea and check soil erosion. Muthupet mangroves also have an economic significance. They provide a wide variety of goods and services such as durable timber, fuel wood of high calorific values, and protein rich fodder for cattle and traditional medicines. The vegetation creates a unique ecological environment that has assemblages of species. The avifauna of mangrove forest is diverse (172 species), include varieties of aquatic birds, migratory waterfowl, raptors and a number of colourful resident birds of Asia such as storks, herons, egrets and king fishers. The structural diversity of the habitat enables a variety of passerines and non-passerine birds. The fragile ecosystem is under much pressure from both human beings and cattle. This paper emphasizes the significance of mangrove habitat for the survival of bird's life. The roles of mangroves in preserving the ecology, the threat and conservation aspects have also been discussed.

INTRODUCTION

The mangroves are tree and shrub species that grow at the interface between land and sea in Tropical and Sub-Tropical latitudes, where they exist in conditions of salinity, tidal water flow and muddy soil. The vegetation creates unique ecological environments that host rich assemblages of species. Little information is available on the avifauna of Indian mangroves. (Mukherjee 1969, Samant 1985, Kar 1991, Prasad 1992, Sampath and Krishnamoorthy 1993, Sivasubramanian *et al.* 1995, Pandav 1996, Oswin 1998, 1999, Kathiresan 2000 and Balaji 2003,). Presence of flamingos *Phoenicopus roseus* and Pelicans *pelicanus philippensis* during winter in its backwaters and the large, inaccessible migratory birds make the Muthupet mangrove wetlands an excellent waterfowl habitat.

STUDY AREA

Pichavaram and Muthupet are the only two regions in Tamil Nadu Coast, which have fairly well developed salt marsh-mangrove complexes (Natarajan, 1990). The luxuriant patch of Muthupet mangrove forest extends to an area of 68.03 sq.km. Muthupet is situated 400km South of Chennai city and lies close to Point Calimere Birds and wildlife sanctuary on the South East Coast of Peninsular India (Latitude 10° 46' Longitude 79° 51E) (Fig 1). The dry seasons extends over 6-7 months from February to August. As summer advances the water and soil salinity shoots up even to 47 and 60ppt respectively (Oswin, 1998). During peak summer the water in the mud flats totally evaporates leaving hand pecked mud. The rainy season commences with the on set of the North East monsoon, which lasts till December. The soil in the forest is clayey-silt and towards the landward side it is silty clay due to fresh silt deposits.

The wetlands classification is based on Wentz (1981) Dwyer et-al (1983), Nagarajan and Thiyaagesan (1996) and Selvam (2003).

Mudflats : Mudflats are dominated by salt tolerant plant and are greatly affected by tides. The depth of water in the area is less than 30 cm

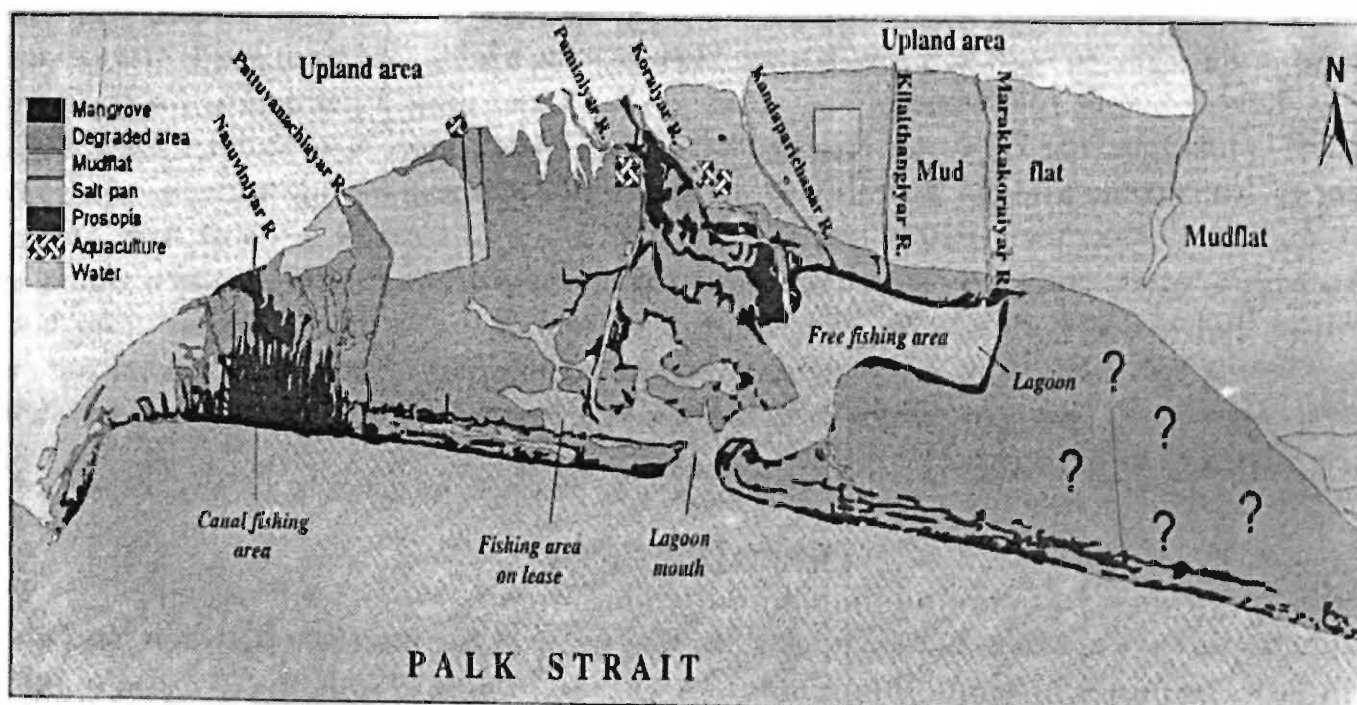


Fig. 1. Map of Muthupet Mangroves

Swamps : Swamps are partially inundated and contain more than 5% woody vegetation in the form of trees or shrubs.

Marshy areas : These areas are partially inundated and contain characteristic marsh vegetation such as *Rhizophora* sp. and *Avicennia* sp., which covers less than 5% of the area.

Open water : Open waters are vast expanses of water without vegetation.

Abandoned fields : These are fields that have been used for several years as pastures or for cultivation but still have less than 5% shrubs or tree cover. Ground cover usually consists of annual weeds and forbs with some woody vegetation.

Cropland : Cropland is cultivated lands used for growing food crops, particularly paddy. In the study area, a detailed survey was made on the flora and the faunal components.

MATERIAL AND METHODS

Areas within the sanctuary known for high concentration of waterfowl were measured each month by direct counts (Spindler *et al.*, 1983). In marshy areas and open waters, the total numbers of birds were estimated from boat (Bailey Taiman 1984, sjoberg 1989). In order to avoid double counting or missing birds a vantage point was used (Nagarajan & Thiayagesan 1996). Birds were observed from 07 hrs to 16hrs using a spotting scope and binoculars. Double counting was avoided by recording the birds that flew into and out of the plots during the census. Counts were not made on days with rain, strong wind or extreme temperatures to minimize the bias caused by effects of weather (Verner 1985). The nests of different species of birds were identified, either by direct observation of the adult birds and chicks, or by looking at the structure of the nest. Different types of nesting materials used by different birds facilitated the identification of the nests in the absence of the adult birds or chicks.

RESULTS

The mangrove swamps are ideal habitat for birds, many of which are migratory. In the Muthupet mangroves of Tamil Nadu, nearly 172 bird species belonging to 50 families were recorded that use the wetlands for feeding, nesting, roosting or other activities (Appendix). The families Scolopacidae, Laridae, Anatidae, Charadriidae and Corvidae represented the maximum species. The water birds are the Cotton Teal; *Nettapus coramandelianus* is an important resident species. A large proportion of water birds are migratory in habit. This includes, common teal *Anas creca*, Pintail *Anas acuta* coots *Fulica atra*, Open bill stork *Anastomus oscitans*, Painted stork *Mycteria leucocephala*, Red-wattled lapwing *Vanellus indicus*. Little ringed plover *Charadrius dubious*, Kentish plover *Charadrius alexandrinus*, Marsh sandpiper *Tringa stagnatilis*, Common sandpiper *Tringa hypoleucos*, Little stint *Chalidris minutus*, Black winged Still *Himantopus himantopus*, Little tern *Sterna albifrons* and caspian tern *Hydroprogne caspia* etc., the Little cormorants *Phalacrocorax Niger*, Darters *Anhinga rufa* and Dabehic *Podiceps ruficollis* are found through out the year. Several species of gulls and terns are very common in the coastal water and around large rivers especially in the fishing sites. Different species of plovers (Family Charadriidae) and sandpipers (Family-Scolopacidae) are frequently found hopping on the mud during low tide for food. They are popularly known as mud waders. The marshy birds which are found throughout the year are Grey heron *Ardea cinera* Large egret *A. Alba* Purple heron *A.*

purpurea median egret *Egret intermedia* in the scanty mangrove mudflats. Near the mud, banks, flocks of sand pipers, redshanks and whimbrels are commonly seen in winter as migratory species. Many species of birds build their nests in the mangrove trees. Hereons, egrets, cormorants and darters enjoy roosting in colonies on the tall trees. Several species of birds use trunk, branches and aerial roots of mangrove as observation post for feeding on fishes, mollusks, crustaceans and aquatic insects. The pond heron *Ardeola granjii* and night heron *Nycticorex nycticorex* are commonly found in lower branches of *Exoloccaria agallocha* and *Prosopis chilensis* along the landward creeks.

The lesser pied king fisher *Ceryle rudis*, common pied king fisher *Alcedo atthis* and white breasted king fisher *Haliyan symrensis* were seen while they were busy to fish along the creeks of rivers. The higher population of pond heron, night heron and king fishers in Muthupet lagoon are mainly due to availability of trees and bough hanging over the water on either side of the river which is connected to the brackish water area of the lagoons.

Passerine birds are found much in mangroves. Red vented bulbul *pycnonotus cafer*, common myna *Acridotheres tristis*, Brown shrike *Lanius cristatus* and Rose ringed parakeet *Psittacula krameri* are common, though not exclusive, to mangroves. Common non-passerine birds which occur during the flowering and fruiting seasons are spotted doves *Streptoplia chinensis*, crimson breasted barbets *Megalima haemacephala*, Indian rollers *Coracius benghalensis* and common hawk cuckoos *Cuculus varnus* and. Pariah kite *Milvas migrans*, Brahmini kite *Haliastur indus*, were observed at the upper canopy of the mangroves the nests of brahmini kite were constructed at the top branches of mangroves. The whole nests of small green bee-eater *Merops orientalis* were excavated at the sides of small mud elevations, found at the landward sides of the forest.

Change in land use pattern—a threat to the birds of Muthupet mangroves

The wetlands adjoining the mangrove forests of Muthupet mangrove harbour a sizable population of migratory waterfowl in winter. However, many of these wetlands do not come under the jurisdiction and lack protected area status. With the recent change in land use pattern all along the Tamil Nadu coast, the coastal wetlands and the agricultural fields adjoining these wetlands are increasingly being converted into brackish water prawn culture ponds. Conversion of the coastal wetlands around Muthupet mangrove has resulted in a loss of wintering ground for the migratory waterfowl.

The Asian open bill, which constitutes a significant percentage of wading birds in the mangroves, feeds exclusively on molluscs *Pila globosa*, obtained from the agricultural fields surrounding the wetlands. With the conversion of these agricultural fields into prawn culture ponds, the Asian open bills are facing a loss in their feeding grounds. This, in the near future, may affect the breeding behaviours of these birds in the heronry and may be detrimental to the survival of Asian open bills in the long run. The survival of several species of birds is dependent on the continued existence of this eco-system. The mangroves in the coast are important not only for conservation of birds but also for protection of

human beings in the hinterland from the fury of severe cyclonic wind and tidal surges. The Muthupet mangroves and its avian diversity should be prevented at any cost from various biotic and abiotic interferences.

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Appendix–Bird species recorded from the Muthupet Mangroves

In the list of the following codes are used B-Breeding, C-Common, Ra-Rare, R-Resident, L.M-Local Migrant, M-Migrant, U-Uncommon

Common Name	Scientific Name	Status
Family PODICIPEDIDAE		
1. Little grebe	<i>Podiceps ruficollis</i>	LM, B
Family PHALACROCORACIDAE		
2. Large cormorant	<i>Phalacrocorax carbo</i>	LM
3. Indian shag	<i>P. fuscicollis</i>	LM
4. Little cormorant	<i>P. niger</i>	LM
5. Darter	<i>Anhinga rufa</i>	LM
Family ARDEIDAE		
6. Grey heron	<i>Ardea cinerea</i>	R,C
7. Purple heron	<i>A. purpurea</i>	R,C
8. Large egret	<i>A. alba</i>	R,C
9. Little green heron	<i>A. striatus</i>	R,C
10. Pond heron	<i>A. grayii</i>	R,C
11. Cattle egret	<i>Bubulcus ibis</i>	R,C
12. Median egret	<i>Egretta intermedia</i>	R,C
13. Little egret	<i>E. garzetta</i>	R,C
14. Indian reef heron	<i>E. gularis</i>	R,U
15. Night heron	<i>Nycticorax nycticorax</i>	LM,C
16. Chestnut bittern	<i>Ixobrychus cinnamomeus</i>	R, U
17. Black bittern	<i>I. flavicollis</i>	R, U
18. Painted stork	<i>Mycteria leucocephala</i>	LM
19. Openbill stork	<i>Anastomus oscitans</i>	LM
20. White stork	<i>Ciconia ciconia</i>	M
Family THRESKIORNITHIDE		
21. White ibis	<i>Threskiornis acthiopica</i>	LM
22. Glossy ibis	<i>Plegadis falcinellus</i>	LM
23. Spoonbill	<i>Platalea leucorodia</i>	LM
Family PHOENICOPTERIDAE		
24. Flamingo	<i>Phoenicopterus roseus</i>	LM

Common Name	Scientific Name	Status
Family ANATIDAE		
25. Pintail	<i>Anas acuta</i>	M
26. Common teal	<i>A. crecca</i>	M
27. Spotbilled duck	<i>A. poecilorhyncha</i>	LM
28. Mallard	<i>A. platyrhynchos</i>	M
29. Gadwall	<i>A. strepera</i>	M
30. Wigeon	<i>A. Penelope</i>	M
31. Garganey	<i>A. querquedula</i>	M
32. Shoveller	<i>A. clypeata</i>	M
33. Cotton teal	<i>Nettapus coromandelianus</i>	LM
Family ACCIPITRIDAE		
34. Blackwinged kite	<i>Elanus caeruleus</i>	R,C
35. Pariah kite	<i>Milvus migrans</i>	R,C
36. Brahminy kite	<i>Haliastur Indus</i>	R,C
37. Shikra	<i>Accipiter badius</i>	LM
38. Sparrow-hawk	<i>A. ninus</i>	M, U
39. Basra sparrow-hawk	<i>A. virgatus</i>	M, U
40. Whitebellied sea-eagle	<i>Haliaeetus leucogaster</i>	LM
41. Egyptian vulture	<i>Neophron percnopterus</i>	LM
42. Pale harrier	<i>Circus macrourus</i>	M
43. Montagu's harrier	<i>C. phygargus</i>	M
44. Pied harrier	<i>C. melanoleucos</i>	M
45. Marsh harrier	<i>C. aeruginosus</i>	M,C
46. Osprey	<i>Pandion haliaetus</i>	M
Family FALCONIDAE		
47. Peregrine falcon	<i>Falco peregrinus</i>	M
48. Redheaded merlin	<i>F. chicquera</i>	LM
49. Kestrel	<i>Falco tinnunculus</i>	LM, U
Family PHASIANIDAE		
50. Grey partridge	<i>Francolinus pondicerianus</i>	R, C
51. Jungle bush quail	<i>Perdica asiatica</i>	R, C
52. Common bustard-quail	<i>Turnix suscitator</i>	R, U
53. Blue-breasted banded rail	<i>Rallus striatus</i>	R, C

Common Name	Scientific Name	Status
54. Banded crane	<i>Rallina eurizonoides</i>	R, C
55. Whitebreasted waterhen	<i>Phoenicurus Amaurornis</i>	R, C
56. Water cock	<i>Gallicrex cinerea</i>	R, C
Family HAEMATOPODIDAE		
57. Oystercatcher	<i>Haematopus ostralegus</i>	M, U
Family RECURVIROSTRIDAE		
58. Blackwinged stilt	<i>Himantopus himantopus</i>	LM, C
59. Avocet	<i>Recurvirostra avosetta</i>	M
Family BURHINIDAE		
60. Stone curlew	<i>Burhinus oedicephalus</i>	R, U
61. Great stone plover	<i>Esacus magnirostris</i>	R, U
Family GLAREOLIDAE		
62. Small Indian Pratincole	<i>Glareola lactea</i>	LM
Family CHARADRIDAE		
63. Redwattled lapwing	<i>Vanellus indicus</i>	R, C
64. Yellow-wattled lapwing	<i>V. malabaricus</i>	R, C
65. Grey or Blackbellied plover	<i>Pluvialis squatarola</i>	M, C
66. Eastern golden plover	<i>P. dominica</i>	M, C
67. Large sand plover	<i>Charadrius leschenaultii</i>	M, U
68. Little ringed plover	<i>C. dubius</i>	R, C
69. Ringed plover	<i>C. hiaticula</i>	M, U
70. Kentish plover	<i>C. alexandrinus</i>	R, C
71. Lesser sand plover	<i>C. mongolus</i>	M, C
72. Whimbrel	<i>Numenius phaeopus</i>	M, C
73. Curlew	<i>N. arquata</i>	M, C
74. Blacktailed godwit	<i>Limosa limosa</i>	M, C
75. Bartailed godwit	<i>L. lapponica</i>	M, Ra
76. Spotted redshank	<i>Tringa erythropus</i>	M, L
77. Common redshank	<i>T. totanus</i>	M, C
78. Marsh sandpiper	<i>T. stagnatilis</i>	M, C
79. Greenshank	<i>T. nebularia</i>	M, C
80 Green sandpiper	<i>T. ochropus</i>	M, C

Common Name	Scientific Name	Status
81. Wood sandpiper	<i>T. glareola</i>	M, C
82. Terek sandpiper	<i>T. terek</i>	M, U
83. Common sandpiper	<i>T. hypoleucos</i>	M, C
84. Turnstone	<i>Arenaria interpres</i>	M, C
85. Asiatic dowitcher	<i>Limnodromus semipalmatus</i>	M, Ra
86. Fantail snipe	<i>Gallinago gallinago</i>	M, C
87. Little stint	<i>Calidris minuta</i>	M, C
88. Temminck's stint	<i>C. temminckii</i>	M
89. Dunlin	<i>C. alpina</i>	M
90. Curlew sandpiper	<i>C. testacea</i>	M, C
91. Broadbilled sandpiper	<i>Limicola falcinellus</i>	M, U
92. Ruff and reeve	<i>Philomachus pugnax</i>	M
Family LARIDAE		
93. Herring gull	<i>Larus argentatus</i>	M, C
94. Great blackheaded gull	<i>L. ichthyaetus</i>	M, C
95. Brownheaded gull	<i>L. brunnicephalus</i>	M, C
96. Blackheaded gull	<i>L. ridibundus</i>	M, C
97. Whiskered tern	<i>Chlidonias hybrida</i>	M, C
98. Gullbilled tern	<i>Gelochelidon nilotica</i>	M, C
99. Caspian tern	<i>Hydroprogne caspia</i>	M, C
100. Common tern	<i>Sterna hirundo</i>	M, C
101. Little tern	<i>S. albifrons</i>	R, C
102. Indian lesser crested tern	<i>S. bengalensis</i>	M, C
103. Large crested tern	<i>S. bergii</i>	M, U
104. Indian river tern	<i>S. aurantia</i>	LM, O
Family COLUMBIDAE		
105. Blue rock pigeon	<i>Columba livia</i>	R, C
106. Indian ring dove	<i>Streptopelia decaocto</i>	R, C
107. Spotted dove	<i>S. chinensis</i>	R, C
108. Little brown dove	<i>S. senegalensis</i>	R
Family PSITTACIDAE		
109. Roseringed parakeet	<i>Psittacula krameri</i>	R, C

Common Name	Scientific Name	Status
Family CUCULIDAE		
110. Pied crested cuckoo	<i>Clamator jacobinus</i>	LM
111. Common hawk-cuckoo or Brainfever bird	<i>Cuculus varius</i>	LM
112. Koel	<i>Eudynamys scolopacea</i>	R, C
113. Crow-pheasant	<i>Centropus sinensis</i>	R
Family STRIGIDAE		
114. Barn owl	<i>Tyto alba</i>	R, U
115. Spotted owlet	<i>Athene brama</i>	R, C
Family APODIDAE		
116. House swift	<i>Apus affinis</i>	R, C
117. Palm swift	<i>Cypsiurus parvus</i>	R, C
Family ALCEDINIDAE		
118. Lesser pied kingfisher	<i>Ceryle rudis</i>	R, C
119. Common kingfisher	<i>Alcedo atthis</i>	R, C
120. Whitebreasted kingfisher	<i>Halcyon smyrnensis</i>	R, C
121. Blackcapped kingfisher	<i>H. pileata</i>	R, C
Family MEROPIDAE		
122. Chestnutheaded bee-eater	<i>Merops leschenaulti</i>	LM, U
123. Bluetailed bee-eater	<i>M. philippinus</i>	R, C
124. Green bee-eater	<i>M. orientalis</i>	R, C
Family CORACIDAE		
125. Indian roller	<i>Coracias benghalensis</i>	R, C
Family UPUPIDAE		
126. Hoopoe	<i>Upupa epops</i>	R, C
Family CAPITONIDAE		
127. Crimsonbreasted barbet	<i>Megalaima haemacephala</i>	R, U
Family PICIDAE		
128. Lesser goldenbacked woodpecker	<i>Dinopium benghalense</i>	R, C
Family PITTIDAE		
129. Indian pitta	<i>Pitta brachyura</i>	LM
Family ALAUDIDAE		
130. Bush lark	<i>Mirafra assamica</i>	LM, U

Common Name	Scientific Name	Status
131. Redwinged bush lark	<i>M. erythroptera</i>	LM
132. Ashycrowned finch lark	<i>Eremopterix grisea</i>	LM, U
133. Crested lark	<i>Galerida cristata</i>	LM, U
134. Eastern skylark	<i>Alauda gulgula</i>	R, C
Family HIRUNDINIDAE		
135. Eastern swallow	<i>Hirundo rustica</i>	M, C
136. Redrumped swallow	<i>H. daurica</i>	LM, C
137. Indian cliff swallow	<i>H. fluvicola</i>	M, U
Family LANIDAE		
138. Baybacked shrike	<i>Lanius vittatus</i>	LM, U
139. Rufousbacked shrike	<i>L. schach</i>	LM, O
140. Brown shrike	<i>L. cristatus</i>	R, U
Family ARTAMIDAE		
141. Ashy swallow shrike	<i>Artamus fuscus</i>	R, C
Family ORIOLIDAE		
142. Golden oriole	<i>Oriolus oriolus</i>	R, O
Family DICRURIDAE		
143. Black drongo	<i>Dicrurus adsimilis</i>	R, C
Family STURNIDAE		
144. Brahminy myna	<i>Sturnus pagodarum</i>	R, C
145. Rosy pastor	<i>S. roseus</i>	M, C
146. Common myna	<i>Acridotheres tristis</i>	R, C
Family CORVIDAE		
147. Tree-pie	<i>Dendrocitta vagabunda</i>	R
148. House crow	<i>Corvus splendens</i>	R, C
149. Jungle crow	<i>C. macrorhynchos</i>	R, C
Family	CAMPEPHAGIDAE	
150. Common wood-shrike	<i>Tephrodornis pondicerianus</i>	R, O
Family IRENIDAE		
151. Common iora	<i>Aegithina tiphia</i>	R, C
Family PYCNONOTIDAE		
152. Redvented bulbul	<i>Pycnonotus cafer</i>	R, C
153. Whitebrowed bulbul	<i>P. luteolus</i>	R, C

Common Name	Scientific Name	Status
Family MUSCICAPIDAE		
154. Common babbler	<i>Turdoides caudatus</i>	R, C
155. Brown flycatcher	<i>Muscicapa latirostris</i>	M, U
156. Brownbreasted flycatcher	<i>M. muttui</i>	M
157. Paradise flycatcher	<i>Terpsiphone patadisi</i>	LM
158. Plain wren-warbler	<i>Prinia subflava</i>	LM, U
159. Tailor bird	<i>Orthotomus sutorius</i>	R, C
160. Thickbilled warbler	<i>Arrocephalus aedon</i>	M
161. Blyth's reed warbler	<i>A. dumetorum</i>	M, C
162. Lesser whitehroat	<i>Sylvia curruca</i>	M, U
163. Largebilled leaf warbler	<i>Phylloscopus magnirostris</i>	M, U
164. Magpie robin	<i>Copsychus saularis</i>	R, C
165. Indian robin	<i>Saxicoloides fulicata</i>	R, C
Family MOTACILLIDAE		
166. Paddyfield pipit	<i>Anthus novaeseelandiae</i>	LM, U
167. Forest wagtail	<i>Motacilla indica</i>	M, Ra
168. Yellow wagtail	<i>M. flava</i>	M, C
169. Grey wagtail	<i>M. cinerea</i>	M, C
170. Pied or white wagtail	<i>M. alba</i>	M, C
171. Large pied wagtail	<i>M. maderaspatensis</i>	LM, C
Family DICAEDIDAE		
172. Tickell's flowerpecker	<i>Dicaeum erythrorhynchos</i>	R, C

GASTROPOD DIVERSITY ON THE CHENNAI COAST

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ABSTRACT

The largest and most diverse phylum in the sea is Mollusca. Molluscan species belonging to three Classes viz., Gastropoda, Cephalopoda and Bivalvia tend to dominate the marine ecosystem. Gastropods constitute the second largest Class in the animal kingdom, outnumbered only by insects. Gastropod communities are linked to other marine communities in complex ways as they form an important part of the food web, whether as herbivores, carnivores, or omnivores. The ecology of marine gastropods is diverse; species can inhabit an extremely wide range of habitats and fill any number of ecological niches. Marine gastropods are most diverse in Tropical habitats. The present study is an effort to understand the Gastropod diversity in the Coasts of Chennai. The results presented in the paper are a part of a long-term study of molluscan diversity in the coastal parts of Chennai.

INTRODUCTION

Systematic documentation and analysis of marine biodiversity is one of the challenges that the 21st century has placed before biologists. The recent discovery of carnivorous sponges in the ocean floor and that life exists even in the deep sea thermal vents have suggested the need for a greater focus on the yet-to-be discovered biological wealth of the marine ecosystems. While at one end we are faced with the challenges of discovering the unknown marine taxa, at the other we are embarrassed by the lack of understanding that becomes evident of the diversity and ecology of even common and well-known marine organisms. One good example in this regard is the Phylum Mollusca.

The largest and most diverse Phylum in the Tropical seas is Mollusca. The Phylum is dominated by species in three major Classes viz., Cephalopoda, Gastropoda and Bivalvia. Of the 5000 species of molluscans known in India, 1800 are considered as 'sea shells' – species that represent two major Classes viz.

Despite the popularity of marine gastropod shells as ornaments, currency and trinkets, very little is known about the ecology of most species, including the common ones,

especially of the factors that determine their distribution and abundance. Further, there is very little published information on the patterns of habitat choice and local diversity. Deepak Apte (1998) has made an attempt to inspire amateur shell collectors; thereby more data can be put together on the distribution and diversity of gastropod shells along the Coasts of India. While this is good beginning, there is a need to go further in understanding the role of gastropods in the vast marine ecosystem through a careful analysis of local patterns of species diversity, habitat choice and abundance. The present study is aimed at addressing the issue of lack of recent data on marine gastropods in India and also the need to look beyond the shells that are washed ashore and identify the habitats where the species actually live.

The *tsunami* of December 2004 has shown that shells can get washed ashore over considerable distances. The *tsunami* has also created newer ecological opportunities for species that have been dispersed by the waves. We began the study of gastropods along the Coasts of Chennai soon after the December 2004 *tsunami* and are in the process of establishing a long-term programme for monitoring the ecological changes along the Coasts of Chennai using gastropod species diversity as an indicator. The preliminary results of the study are being presented and discussed in this paper.

MATERIAL AND METHODS

During July-September 2005, the Kaasimedu fishing harbour (North Chennai) was visited 12 times at weekly intervals. Gastropods were collected from the fishing nets. Data on the type of boat used, the type of net and the depth at which the animals were collected were simultaneously recorded (Table-1). The collected animals were first categorised as alive or dead, dead and empty or dead and occupied by hermit crabs. The animals were then buried in the ground in a shallow pit of dimensions 100 cm length, 50 cm width and 25 cm depth or kept buried in a plastic bucket within layers of soil. The fleshy remains of the snails and hermit crabs were allowed to decompose for about one week. After this, the shells were washed in water and with diluted hydrochloric acid to remove the hard outer coat and to reveal the natural colours. The shells thus processed have been identified with the available keys and guides, sorted, measured and stored.

Table-1. Details of the Fishing equipment used in sampling

Boat type	Trawler (mechanised)
Net type	<i>Eral madi</i> (nylon)
Mesh size	2.2 x 2.2cm ²
Catch depth	60-100m

RESULTS AND DISCUSSION

A total of 882 gastropod shells representing 70 species were collected during the study. Analysis of the rate at which species were added has suggested that after some 400 individuals were collected (or after 8 sampling visits were made) the species richness saturated (Figs. 1-2).

A majority of the species were low in abundance. About 60% of the collected species were represented only by 5 individuals or less. Approximately 6% of the species had an abundance of 50 individuals or more; 3% had more than 80 individuals (Fig. 3).

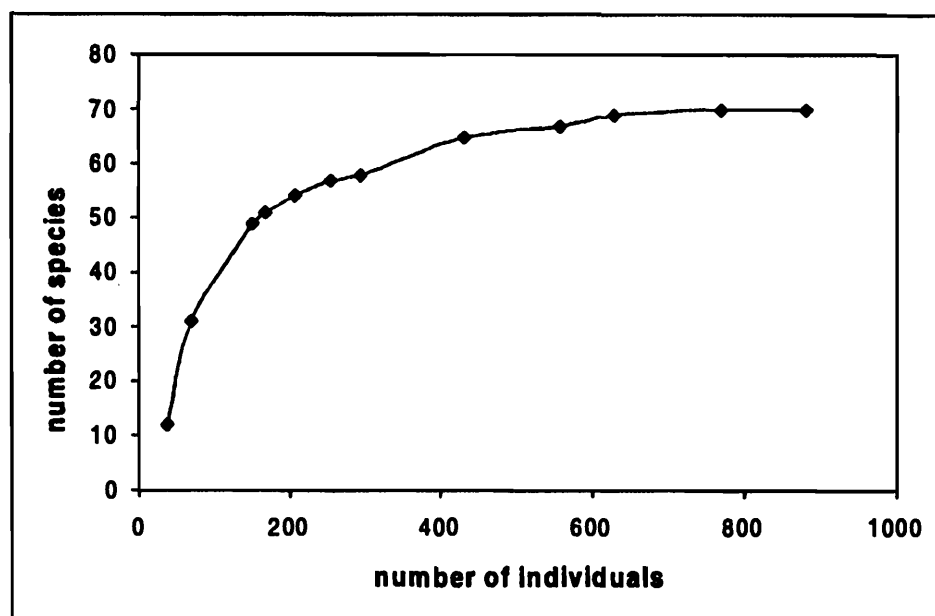


Fig. 1. Cumulative Number of Species

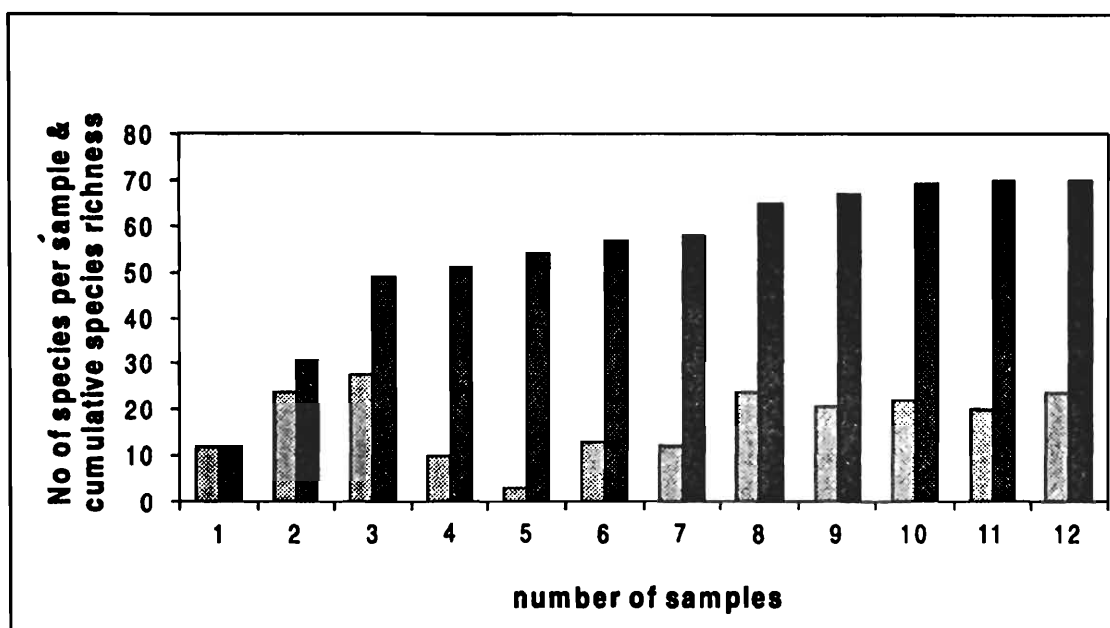


Fig. 2. Species accumulation versus Sampling Effort

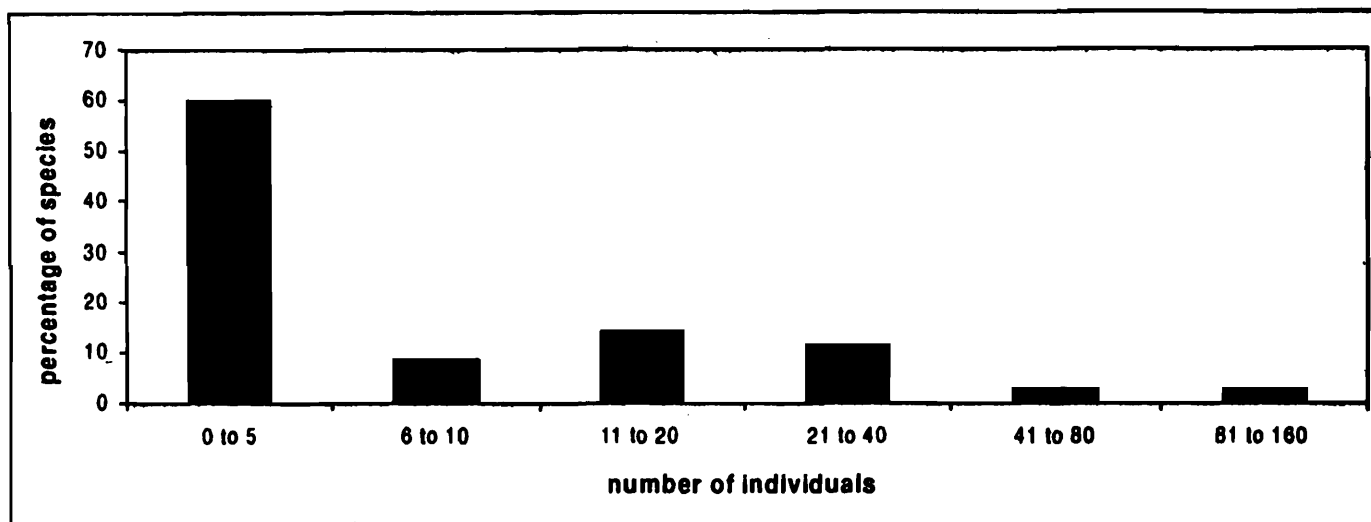


Fig. 3. Frequency Distribution of Species

Table-2. Gastropod Species Diversity along the Coast of Chennai

Order (Species & Abundance %)	Family	Species (%)	Abundance (%)
Archaeogastropoda 5.7% 1.47%	Turbinidae	1.43	0.11
	Neritidae	2.86	0.79
	Architectonidae (Solariidae)	1.43	0.57
Mesogastropoda 41.43% 29.59%	Cypraeidae	2.86	0.23
	Strombidae	1.43	0.11
	Tonnidae	4.29	2.15
	Ficidae	2.86	8.50
	Cassidae	5.71	0.91
	Bursidae	5.71	6.12
	Cymatidae	4.29	0.91
	Naticidae	7.14	3.85
	Planaxidae	1.43	4.31
	Mitricidae	1.43	0.23
	Turritellidae	4.29	2.2
Neogastropoda 50% 68.14%	Muricidae	7.14	11.34
	Conidae	10.00	17.23
	Terebridae	2.86	0.23
	Turridae	4.29	1.25
	Buccinidae	4.29	21.32
	Fasciolaridae	2.86	0.91
	Olividae	10.00	3.17
	Nassariidae	2.86	3.17
	Xancidae (Turbinellidae)	1.43	0.68
	Volemidae (Galeodidae)	2.86	6.24
	Harpidae	1.43	2.61

Table-2 provides the details of gastropod diversity along the Coast of Chennai. The 70 species represent 3 orders and 25 families. The Order Neogastropoda is apparently the dominant one in the study area. 50% of the species and 68% of the total individuals collected belonged to the Order Neogastropoda.

Species in the family Conidae and Olividae have together accounted for 20% of the species richness of the Chennai coast. Interestingly of the 25 families recorded, just 6 families (Buccinidae 21.32%; Conidae 17.23%; Muricidae 11.34%; Ficidae 8.5%; Volemidae 6.24%; Bursidae 6.12) have contributed 71% of the individuals of the gastropod shells collected (Table-2). The family Buccinidae owes its abundance/dominance to just 2 species of *Babylonia*. Individually, however, *Conus figulinus* followed by *Rapana bulbosa* have emerged as the most abundant gastropod species along the Coast of Chennai.

Of the 70 species collected during the study, 31 (54%) were obtained in a live condition. The rest were all dead and empty or occupied by hermit crabs (Appendix). 41.56% of *Babylonia spirata* and 45.45% of *B. zeylanica* shells were occupied by hermit crabs; the rest were found alive. As the two species are the most numerous shells on the Chennai coast (together 176 shells), it has to be tested whether the hermit crabs do show some preference for these shells or it is a matter of mere availability. However, as all individuals collected of the 3 species of *Turritella* (a genus represented by just 20 shells) were also occupied by hermit crabs. It does appear that hermit crabs apparently prefer shells that belong to *Babylonia* and *Turritella* species.

SUMMARY AND CONCLUSION

The results presented in the paper, despite being preliminary in nature, have raised a number of pertinent questions on the patterns of distribution, abundance and diversity of gastropod species along the Coasts of Chennai. As part of the ongoing study it is proposed that more data on the habitat choice, food guilds and life history strategies be compiled so as to enable a comprehensive analysis of the community ecology of marine gastropods and their role as indicators of the health of marine ecosystems.

ACKNOWLEDGEMENTS

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Appendix : Condition of the Gastropod Shells at the time of Collection

Order	Family	Species	Condition of the Shells		
			Alive	Dead/Empty	With Crab
Archaeogastropoda	Turbinidae	<i>Turbo brunneus</i>	+	-	-
	Neritidae	<i>Nerita albicilla</i> ^{ls}	+	-	-
Mesogastropoda		<i>Retina costata</i>	+	-	-
	Architectonidae	<i>Architectonica laevigata</i>	+	-	-
	Cypraeidae	<i>Erosaria nebrates ceylonensis</i>	-	+	-
		<i>Volva volva</i>	-	+	-
	Strombidae	<i>Tibia delicatula</i>	-	+	-
	Tonnidae	<i>Tonna cepa</i>	+	-	-
		<i>T. dolium</i>	+	-	-
		<i>T. fasciata</i>	-	+	-
	Ficidae	<i>Ficus gracilis</i>	+	-	-
		<i>F. variegata</i>	+	-	-
	Cassidae	<i>Phalium areola</i>	+	-	-
		<i>P. bisulcatum</i>	-	+	-
		<i>P. canaliculatum</i>	-	+	-
		<i>P. glaucum</i>	+	-	-
	Bursidae	<i>Bursa echinata</i>	-	-	+
		<i>B. elegans</i>	-	-	+
		<i>B. spinosa</i>	-	-	+
		<i>B. tuberculata</i>	-	+	-
	Cymatidae	<i>Cymatium cingulatum</i>	-	+	-
		<i>C. pileare</i>	-	+	-
		<i>Distortio reticulata</i>	+	-	-

Appendix : Contd.

Order	Family	Species	Condition of the Shells		
			Alive	Dead/Empty	With Crab
Mesogastropoda	Naticidae	<i>Natica didyma</i>	+	-	-
		<i>N. lineate</i>	+	-	-
		<i>N. rufa</i>	-	+	-
		<i>N. vitellus</i>	+	-	-
		<i>Polynices mamilla</i>	-	+	-
	Planaxidae	<i>Planaxis sulcatus</i>	+	-	-
	Mitridae	<i>Chrysom chrysostoma</i>	-	+	-
	Turritellidae	<i>Turritella duplicata</i>	-	-	+
		<i>T. terebra cerea</i>	-	-	+
		<i>T. terebra</i>	-	-	+
Neogastropoda	Muricidae	<i>Chicorus ramosus</i>	+	-	-
		<i>Murex malabaricus</i>	-	+	-
		<i>M. tribulus</i>	-	+	-
		<i>Rapana bulbosa</i>	+	-	-
		<i>Thais bufo</i>	+	-	-
	Conidae	<i>Conus amadis</i>	-	+	-
		<i>C. betulinus</i>	+	-	-
		<i>C. figulinus</i>	+	-	-
		<i>C. generalis</i>	-	+	-
		<i>C. leopardus</i>	-	+	-
		<i>C. tessulatus</i>	-	+	-
		<i>C. textile</i>	-	+	-

Order	Family	Species	Condition of the Shells		
			Alive	Dead/Empty	With Crab
Neogastropoda	Terebridae	<i>Terebra capensis</i>	-	+	-
		<i>T. dimidiata</i>	-	+	-
	Turridae	<i>Turris indica</i>	-	+	-
		<i>Surcula fulminata</i>	-	+	-
		<i>S. javana</i>	-	+	-
	Buccinidae	<i>Babylonia spirata</i>	+	-	+
		<i>B. zeylanica</i>	+	-	+
		<i>Cantharus spiralis</i>	+	-	-
	Fasciolariidae	<i>Fusinus longicauda</i>	-	+	-
		<i>F. nicobaricus</i>	-	+	-
	Olividae	<i>Oliva caerulea</i>	+	+	-
		<i>O. gibbosa</i>	+	-	-
		<i>O. nebulosa intricata</i>	+	-	-
		<i>O. sp1</i>	+	-	-
		<i>O. sp2</i>	-	+	-
		<i>O. sp3</i>	-	+	-
		<i>O. sp4</i>	-	+	-
	Nassariidae	<i>Nassarius canaliculata</i>	-	+	-
		<i>N. nodifera</i>	-	+	-
	Xancidae	<i>Turbinella pyrum</i>	+	-	-
	Volemidae	<i>H. cochlidium</i>	+	-	-
		<i>H. pugilinus</i>	+	-	-
	Harpidae	<i>Harpa conoidalis</i>	+	-	-
Total			31	32	8

SEAWEED DIVERSITY CULTURE AND CULTIVATION

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ABSTRACT

Seaweeds occurring in the intertidal and subtidal regions of the seas around Indian peninsula play a vital role as a source of income to the coastal rural people. The seaweed biodiversity is the number, variety and variability of the seaweed species. This biodiversity is mostly affected while harvesting the seaweeds indiscriminately for use as industrial chemicals such as agar and alginate. Although 844 seaweeds are reported from Indian waters only a few seaweeds of economic importance are exclusively exploited. There is an urgent need to conserve these seaweeds along with endemic flora. Culturing of these seaweeds in the laboratory may unravel the secret of life cycle on one hand and preserving the germplasm on the other hand. Ultimately the laboratory cultured germplasm may be transferred to the natural habitat in the sea so as to re-establish the population in nature. Seaweed cultivation provides coastal rural employment on one hand and improves the economy of the people from below the poverty line on other hand. In general the economy of the nation is very much improved by saving foreign exchange hitherto incurred for the import of the natural polysaccharide especially carageenan.

INTRODUCTION

India (08°04'–37°06' N and 68°07'–97°25' E) has a coast line of 7516 Km and its territory includes 1256 Islands (Subba Rao 2000) with 2 million km² Exclusive Economic Zone (EEZ). 844 seaweeds are reported from Indian waters (Oza and Zaidi 2001). Of these 216 belong to Chlorophyta, 191 to Phaeophyta, 434 to Rhodophyta and 3 to Xanthophyta. In a recent seaweed floristic study of Diu Island the occurrence and luxuriant growth of the seaweeds is attributed to the prevailing undisturbed environment projecting it as a paradise for seaweed biologists (Mantri and Subba Rao 2005).

While collecting the seaweeds indiscriminately from their natural habitat certain seaweeds like *Vanvoorsia spectabilis* Harvey, *Martensia indica* Krishnamurthy & Thomas, *Taenioma perpusillum* (J. Agardh) J. Agardh are being totally removed from their natural

habitats thus becoming endangered species. Besides over exploitation one of the industrially important agar yielding seaweed namely *Gelidiella acerosa* needs to be checked as its resources have been reported to have dwindled year after year at the rate of one third of the biomass during 1973–1976 (Subbaramiah 1977) and 1/10 during 1976–1978 (Subba Rao 1983) and as a consequence its conservation had been advocated to preserve the elite germplasm in-vivo (Subbaramiah 1977). Generally seaweeds grow abundantly from September to April in an year. The seaweed flora of India is highly diversified and comprises mostly tropical species, however, boreal, temperate and subtropical ones have also been reported. The assemblage, distribution and abundance of Indian seaweeds vary with habitat (mostly dependent on topography), substratum, geomorphology and tidal amplitude coupled with other prevailing biotic and abiotic factors. The tidal amplitude of the Saurashtra coast, as compared to other parts of the West Coast and including the entire East Coast is very high. This results in a great deal of rocky intertidal area being exposed, (for example upto 1 km at Okha), especially during spring tides resulting the growth of considerable quantity of seaweeds in the intertidal and shallow subtidal regions. In contrast, the Gulf of Mannar on the South-East Coast with smaller tidal amplitude represents most abundant submerged seaweeds.

SEAWEED ENDEMECITY

Bergesen (1934) is the first person to comment on endemism in Indian seaweeds. He reported 22 seaweeds endemic to India and later on a few workers like Srinivasan, (1969) and Mishra, (1960) have attempted this task. As a rule, endemism is prominent in geographically isolated areas. On land one can think of areas like valleys, high altitude mountaintops, deserts etc, where species can develop from closely related gene pool because of geographical isolation. But the situation in marine environment is all totally different, where dynamic temperature; microclimate and salinity boundaries play a vital role (Mantri, *et al.*, 2005). Along the Indian coast the endemic species concentrating mostly along Gujarat and Tamil Nadu coasts could be attributed to the rich seaweed floristic diversity for both the states. However, certain endemic seaweed species of India such as *Porphyra okhaensis*, *Acrochaetium dwarkense*, *A. erectum*, *Helminthocladia calvadosii* forma *indica*, *Grateloupia indica*, *G. wattii*, *Predaea feldmannii* var. *indica*, *Myriogramme bombayensis*, *M. okhaensis*, *Polysiphonia kappannae*, *P. parthasarathyi*, *Spirocladia barodensis*, *Sargassum tenerrimum* var. *prismaticum*, *Turbinaria indica*, *Enteromorpha gujaratensis*, *E. linza* var. *bicornuta*, *E. ovata*, *Boodlea composita* forma *robusta*, *Derbesia indica*, *Caulerpa fastigiata* forma *delicatula*, have restricted distribution only to Gujarat coast; yet some like *Porphyra kanyakumariensis*, *Acrochaetium iyengarii*, *A. krusadii*, *A. liagoraefilum*, *A. ligoroides*, *A. multisporum*, *Helminthocladia calvadosii* forma *comorinensis*, *Liagora mannarensis* *Gracilaria kilakkaraiensis*, *G. mannarensis*, *G. pudumadamensis*, *G. tuticorinensis*, *Hydrolithon iyengarii*, *H. krusadiense*, *H. verrucosum*, *Neogoniolithon crassifructum*, *N. desikacharyi*, *N. ganesanii*, *N. krusadii*, *N. palkense*, *N. pudumadamense*, *N. tiruchendurens*, *Pseudolithophyllum fosliei*, *P. lemoinei*, *P. mannarensis* *P. pambanense*, *P. setchellii*, *P. tuticorinense*, *Sporolithon indicum*, *Ceramium heterospinum*, *Crouania boergesenii*, *C. iyengarii*, *Desikacharella indica*, *Mazoyerella*

krishnamurthyi, *Wrangelia balakrishnanii*, *W. sundaralingamii*, *Dasya iyengaraii*, *Myriogramme quilonensis*, *Chondria transversalis*, *Laurencia parvula*, *Lenormandiopsis parthasarathyi*, *Feldmannia kanyakumariensis*, *Hamelella geminifrucata*, *Hincksia bhimlipatnamensis*, *H. thyrsoidea*, *Sphacelaria kovalamensis*, *Lobophora variegata* var. *indica*, *Lobophora variegata* var. *minima*, *Hecatonema sargassicola*, *Chnoospora bicanaliculata*, *Sargassum biserrula* var. *tranquebarensis*, *S. concinnum*, *S. divaricatum*, *S. flavicans* var. *nudum*, *Sargassum tenerrimum* var. *ambiguum*, *S. teretifolium*, *Ulva covelongensis*, *U. quilonensis*, *Struveopsis covalamensis*, *Trichosolen pambanensis*, *T. thikkodiensis*, *Caulerpa imbricata* forma *mixta*, *Udotea iyengaraii*, have restricted distribution only to South Indian Coast and a few like *Liagora indica*, *Dasya kamortensis*, *Hincksia andamanensis*, *H. mitchelliae* var. *neilii*, *H. prolifera*, *H. terminalis*, *Sargassum dumosum*, *S. lanceolatum* var. *nicobaricum*, *S. scherzerianum*, are restricted only to Islands of Andaman & Nicobar and species like *Gracilaria armata*, *Liebmannia laccadivarum*, are restricted only to Islands of Lakshadweep. All the above mentioned seaweeds need more attention with respect to their current distribution, as threat is prevailed upon due to pollution, habitat fragmentation as well as habitat destruction as a result of natural calamities like cyclones and *tsunami* and man made eventualities like ship breaking yards.

Estimates of the total number of species on earth vary from 5 to more than 50 million and the rates of species extinction are massive. Many of the taxa are becoming extinct even before they are being recorded (May, 1988). Periodic reassessment of seaweed biodiversity is imperative to understand the current status which may provide information on the occurrence of new species as well as rare species ignored in the previous assessments. For example a rare red alga *Bangia atropurpurea* (Roth) C. Agardh has been collected recently in August 2005, while studying the autoecology of food alga *Prophyra vietnamensis* (Mantri & Subba Rao, unpublished).

Culturing of these rare, endangered and endemic seaweeds in the laboratory provides some basic knowledge on the life history of the seaweed concerned which may be of academic interest but leads to fundamental and basic information to unravel the secrets of large scale cultivation and also serves to conserve the elite germplasm that may be used subsequently to transfer to the natural habitat in the sea for re-establishing the population in nature. For example the discovery of *Conchocilis* phase in the life history of *Porphyra* by Drew (1949) has revolutionized the entire nori (*Porphyra*) cultivation in Japan and elsewhere. Oza (1975, 1976) has studied the germination and development of reproductive structures like carpospores and tetraspores in *Gracilaria corticata* that has given basic information on the life history of this alga, which could be used in field cultivation for development of the progeny through spores. Further Oza (1989) has studied the effect of environmental factors like temperature, irradiance and photoperiod on the growth of *Falkenbergia rufolanosa* in the laboratory and it is another classical example to open up the life cycle i.e., *Asparagopsis* sexual plants are obtained from *Falkenbergia*—a tetrasporophyte. Although *Asparagopsis* and *Falkenbergia* appear in nature as two different species, they are the sexual and tetrasporic phases in the life cycle of *Asparagopsis*.

SEAWEED ECONOMICS

Certain economic seaweeds, viz agarophytes—*Gelidiella acerosa*, *Gracilaria edulis*, *G. crassa*, *G. folifera*, *G. verucosa* and alginophytes—species of *Sargassum* and *Turbinaria* find their use in industries for the manufacture of agar and alginate respectively, have been commercially collected from their natural habitat (Thirupathi and Subba Rao, 2004). In a recent review of seaweed resources of India and their exploitation at the beginning of the century, Subba Rao and Mantri (2005) have reported the seaweed natural resources in the range of 5,69,272 to 5,69,600 tons (fresh) and Tamil Nadu coast (both intertidal and deepwater) has contributed maximum resources. The total seaweed landings from 1978 to 2003 have varied from 1173 to 6417 tons (dry) of which agarophytes (*Gelidiella acerosa*, *Gracilaria edulis*, *G. crassa*, *G. folifera*, *G. verucosa*) and alginophytes (species of *Sargassum* and *Turbinaria*) are found in the range of 240 to 1518 and 651 to 5534 tons (dry) respectively (Kaliaperumal and Kalimuthu, 1997 and Kaliaperumal *et al.* 2004). As such there is no shortage of raw material for alginate production. However, 2,000 tons of (dry weight) agarophytes are needed for production of agar indigenously to make it self sufficient, but natural exploitation of these agarophytes has never exceeded 1,518 tons (dry weight) in 2000 and in subsequent years till 2003 the resource exploitation had declined (Kaliaperumal *et al.* 2004). This clearly shows inequality in need and demand that necessitates cultivation of agarophytes.

Central Salt and Marine Chemicals Research Institute, Bhavnagar had visualized this problem way back in 1970s and started working on developing cultivation technologies for agarophytes. The cultivation techniques of *Gracilaria edulis* (Raju and Thomas, 1971) and that of *Gelidiella acerosa* (Subbaramaiah *et al.*, 1975; Patel *et al.* 1986) have been developed successfully and subsequently these techniques have been refined further to make them economically feasible (Subba Rao, unpublished). While reviewing the work on cultivation of agarophytes in India, Subba Rao *et al.*, (2004) have detailed the aspects relating to retrospect, prospects and future strategies of cultivation.

CULTIVATION TECHNOLOGY

Among the various methods developed for *Gracilaria edulis* viz. Long Line Rope Method, Net Culture Method and Single Rope Floating Raft Technique (SRFT), the SRFT method is more productive and gave 5 kg (wet)/m² in four harvests as compared to 3.5 kg (wet)/m² in three harvests. A crop yield of 20 tons (dry weight)/ha/yr in three harvests is arrived using long line rope method (Krishnamurthy *et al.*, 1977), where as, 30 tons (dry weight)/ha/yr in four harvests is obtained using SRFT method (Subba Rao *et al.*, 2004). A carrageenan yielding seaweed *Kappaphycus alvarezii* has been domesticated and the cultivation technology has been developed by CSMCRI, Bhavnagar and commercialised by Pepsico India Holdings Ltd Gurgaon. Using raft method crop yields of 25 tones (dry)/ha/yr in 6 harvests from September to April (8 months) on Sourashtra coast (Anon 2005) and 40 tones (dry)/ha/yr in 8 harvests on South-East Coast of India around Mandapam region (Anon 2004) have been established. Cultivation of *Hypnea* species (*H. musiformis*

and *H. valentiae*) by vegetative propagation using long line method of Raju and Thomas (1971) at Kurusadai Island has provided a crop yield of 6 Kg (fresh wt)/m⁻¹ rope thus giving a total biomass of 4 tons (dry)/ha in 14 harvests. Cultivation of food algae *Enteromorpha compressa* at Okha gave a crop yield of 1.56 Kg (fresh)/sqm area in the tide pool as well as in the open sea (Anon 2005). Rediscovery of an interesting food alga *Caulerpa lentillifera* from Samiani Island, West coast of India opens up an avenue for taking up cultivation in large scale for its use as a source of human food (Mantri, 2004). The crop yields in the aquaculture systems could be enhanced by adopting new innovative biotechnological interventions involving development of progeny through tissue culture variants, viable mutants, transgenic plants and fast growing strains from the wild stalk.

The seaweed aquaculture industry in the world in 2000 accounted for 22.1% of world aquaculture production, 10.1 million tons (Chopin & Bastarache, 2004). Aquaculture represented 88% of world seaweed supplies (Hanisak, 1998, McHugh, 2001). Among the 220 species of seaweeds cultivated worldwide 4 genera viz., *Laminaria*, *Porphyra*, *Undaria* and *Gracilaria* accounted for 93% of aquaculture production (Zemke-White and Ohno 1999; McHugh, 2001). In India the seaweed aquaculture is yet to take up commercially.

India with vast coastline including the Island territories of Lakshadweep and Andaman and Nicobar Islands provides ample scope to take up commercial cultivation of seaweeds viz., *Gelidiella acerosa*, *Gracilaria edulis* and *Kappaphycus alvarezii* for which economically viable technologies have already been available. Cultivation is the forceful inclusion of wild populations of useful economic species into human society. Adopting integrated aquaculture systems for enhancing profitability through economic diversification of co-cultivating several value added marine crops may lead to environmental and social sustainability as well as acceptability. Further cultivation provides enormous rural coastal employment generation thereby improving the economy of the poverty stricken fisher folk by uplifting their standard of living. The raw material thus produced through aquaculture not only meets the indigenous demand but also paves the way for exports and thus earning foreign exchange. As a whole the country's economy will be boosted. In nutshell the cultivation leads to blue revolution in the sea where the entire area in the sea is used for seaweed production through mariculture and intensive farming.

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PLATE - I

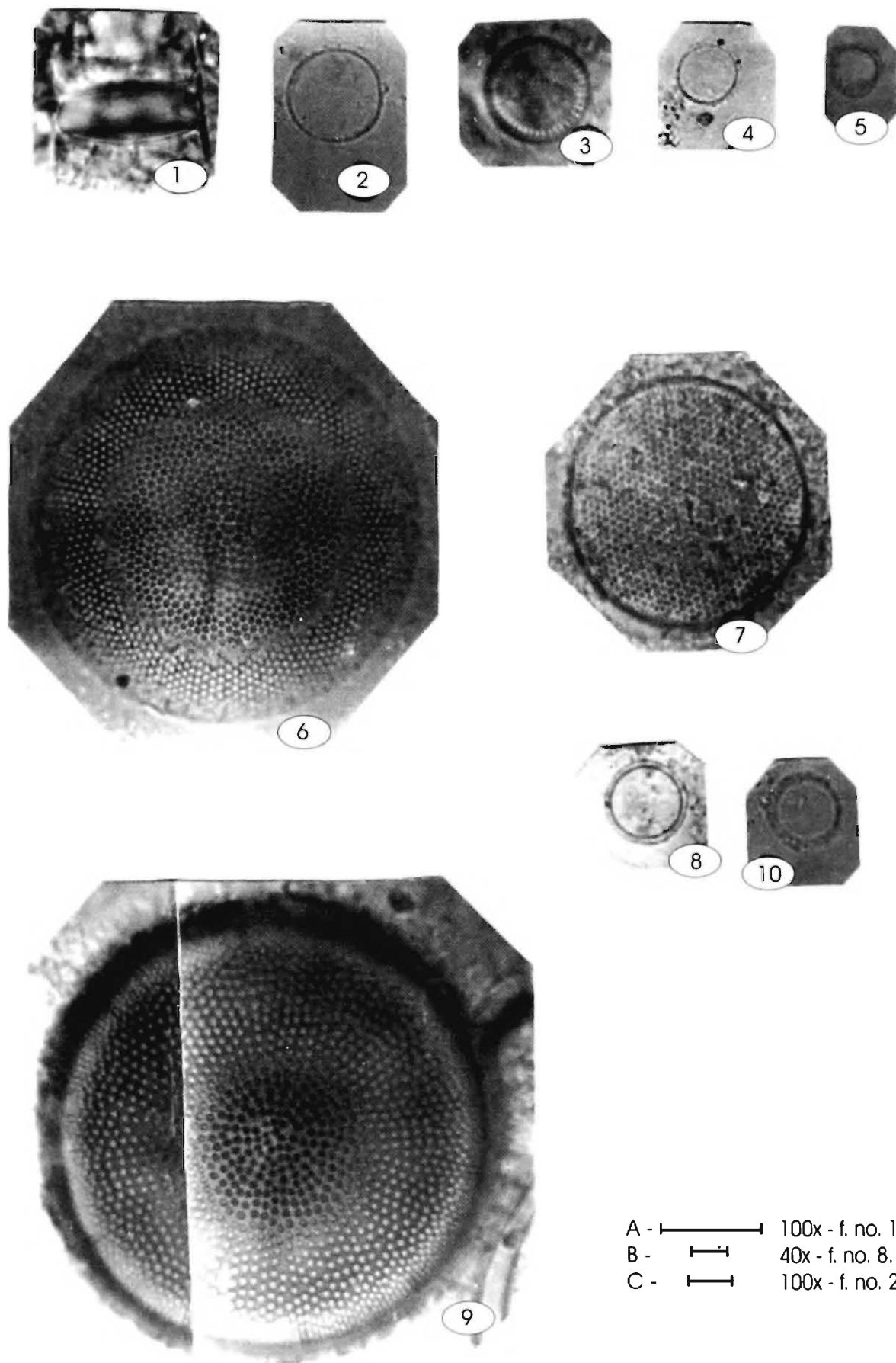


PLATE - II

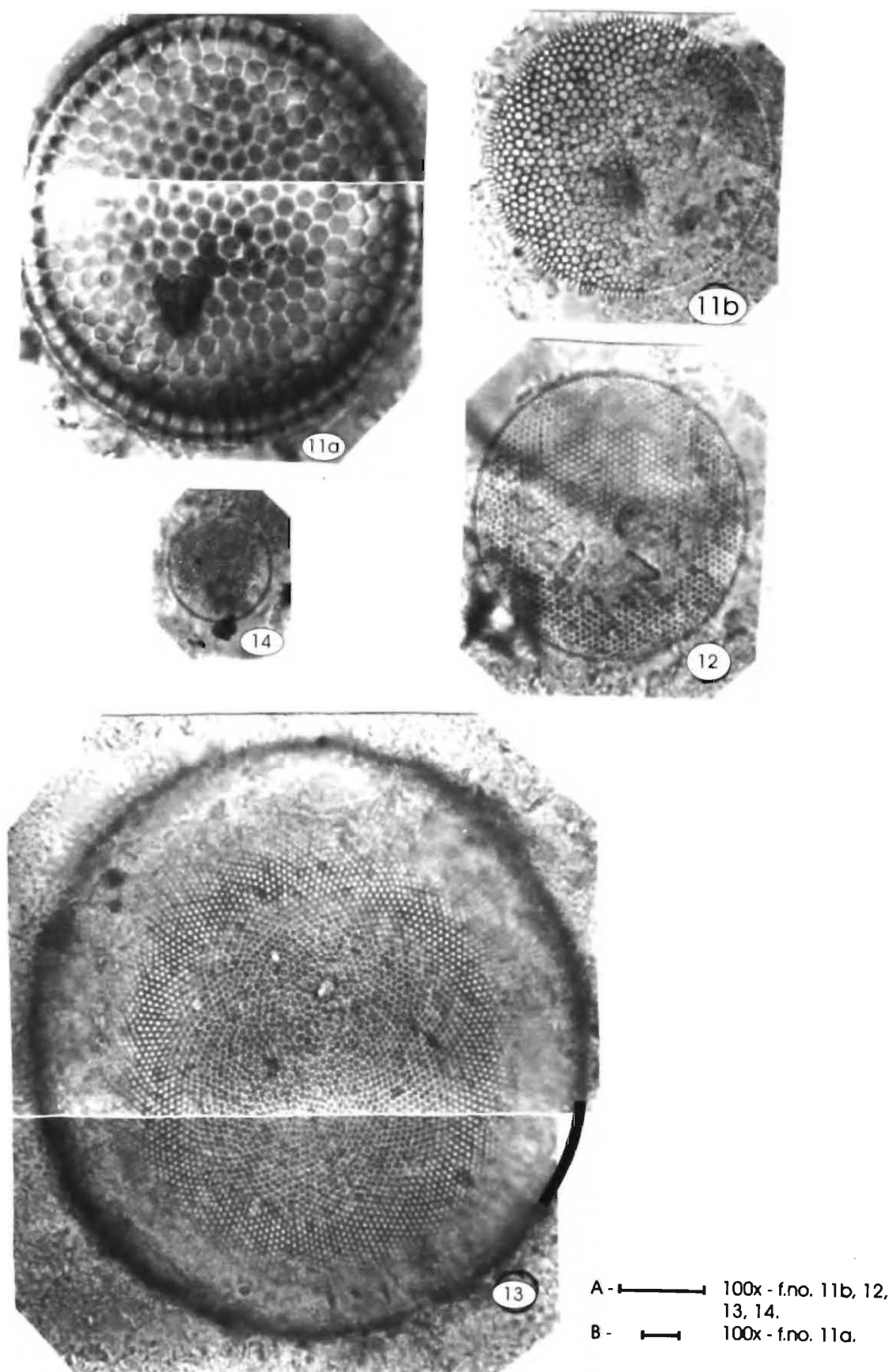


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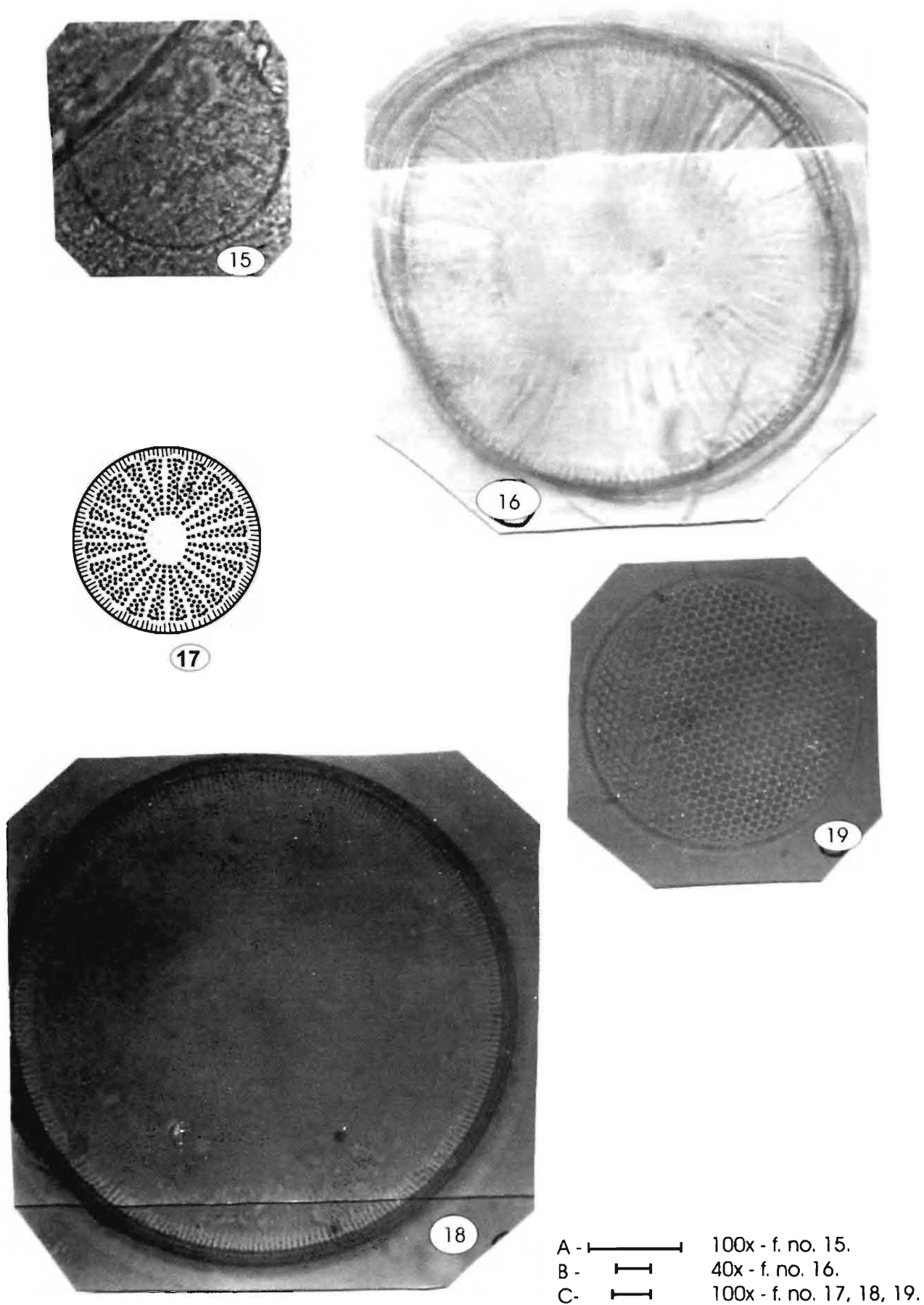
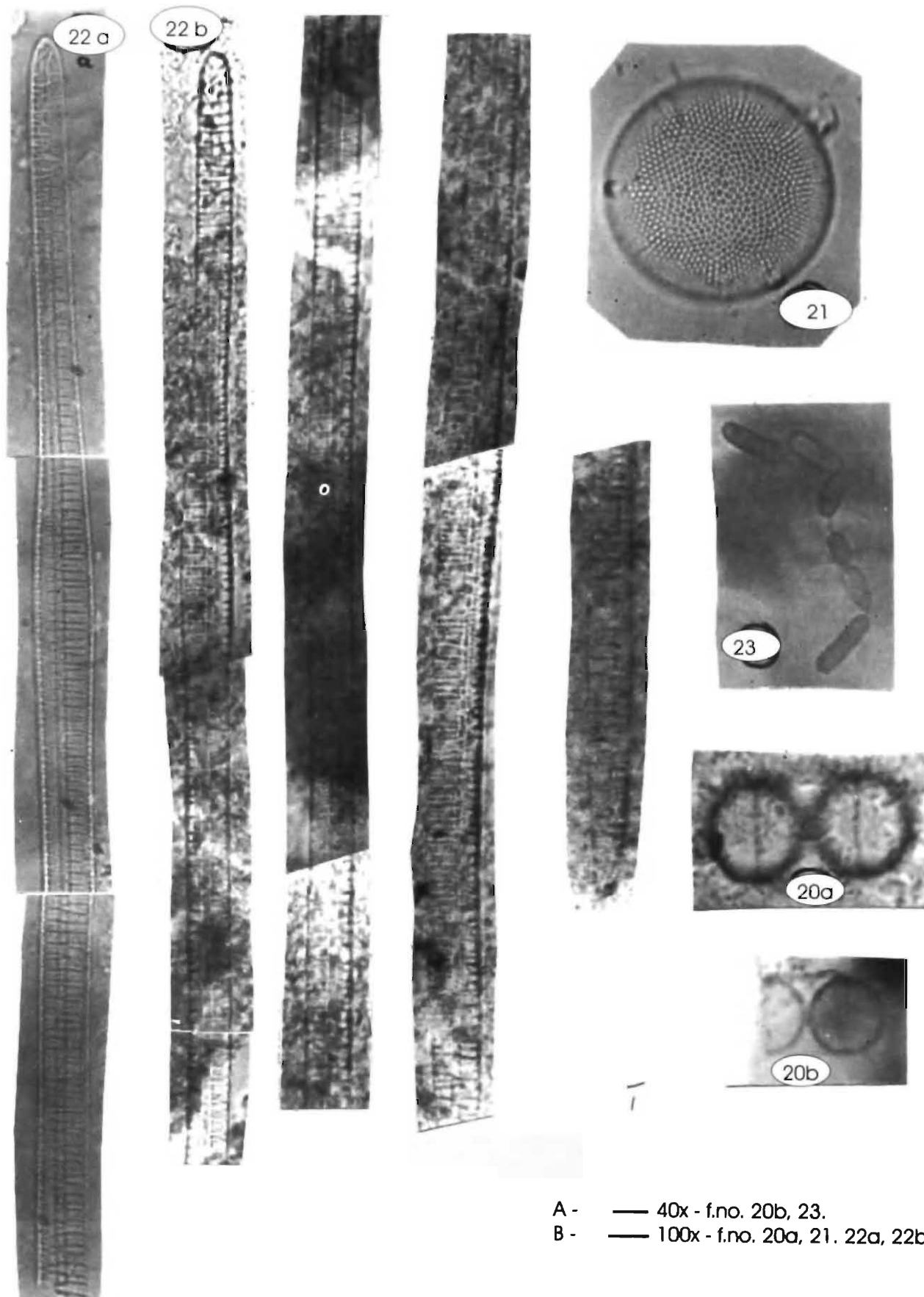
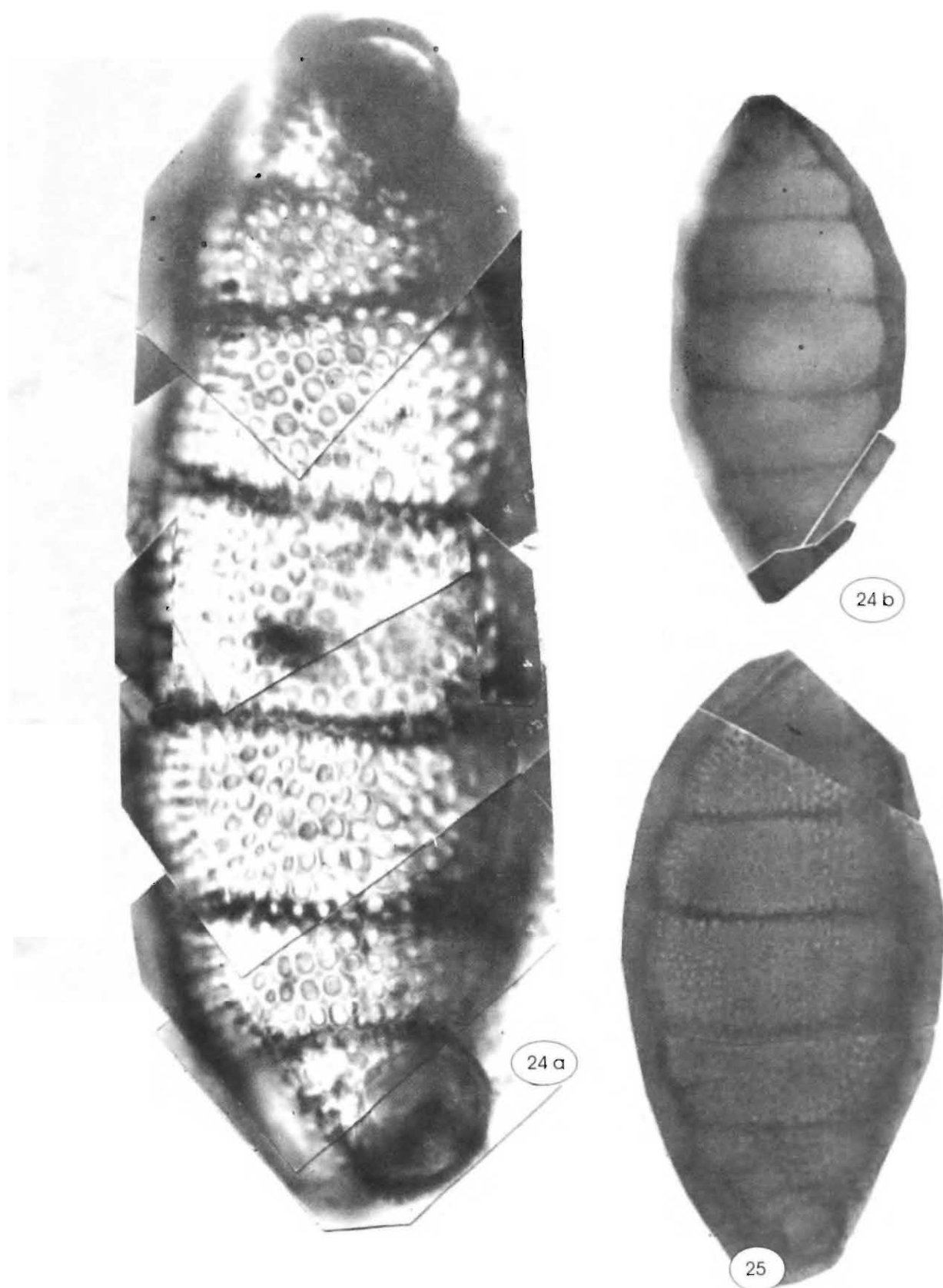


PLATE - IV



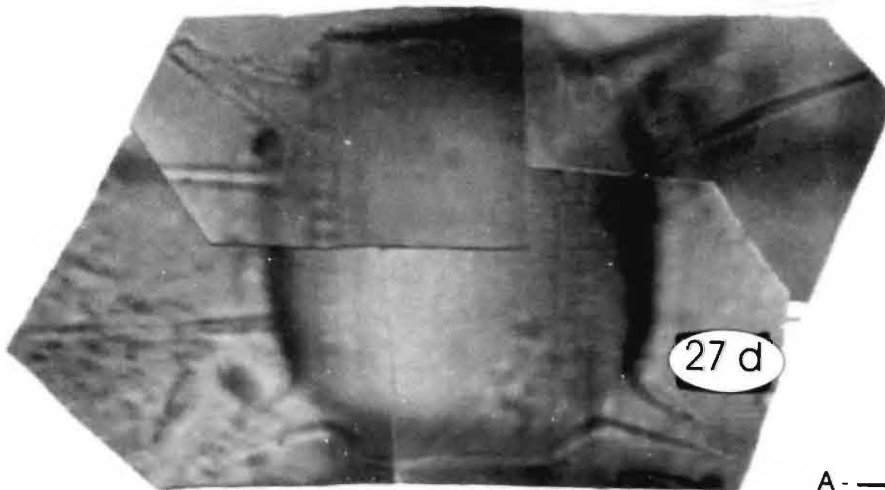
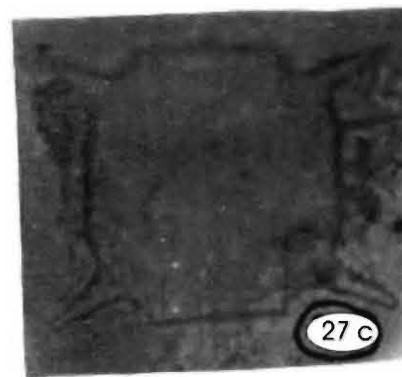
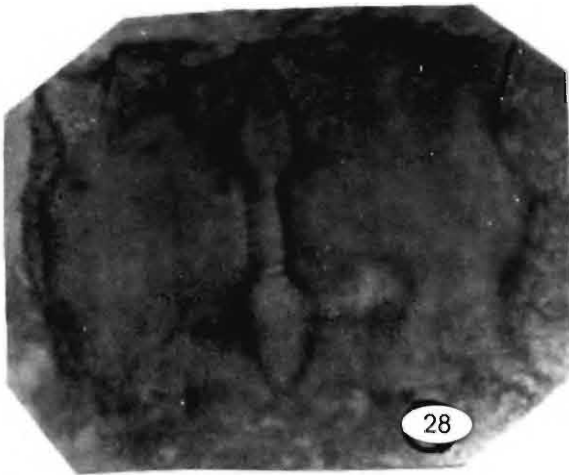
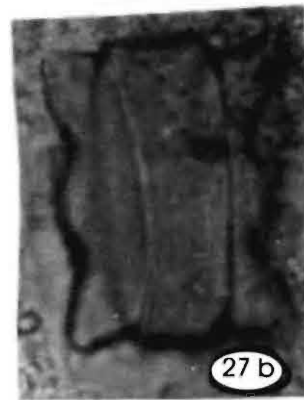
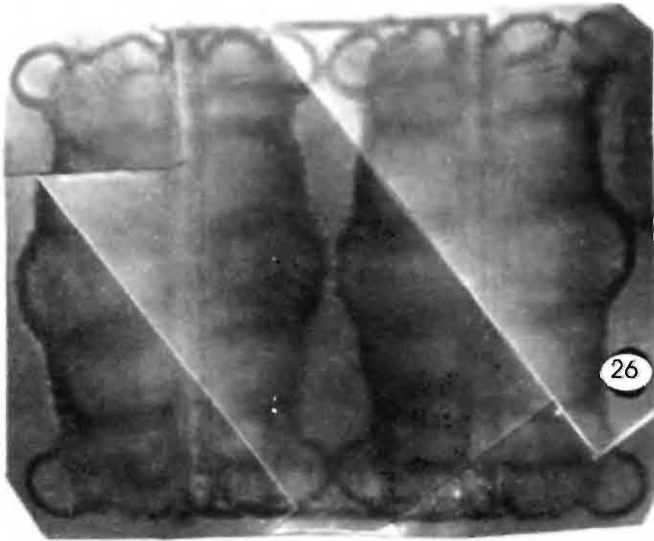
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B - — 100x - f.no. 20a, 21, 22a, 22b.

PLATE - V



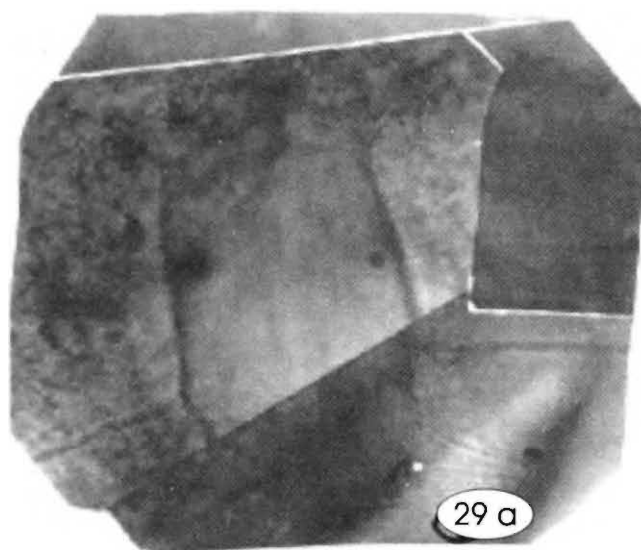
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B - ——— 40x f.- No. 24b.

PLATE - VI



- A - ——— 100x - f.no. 27d.
B - ——— 40x - f.no. 27a.
C - ——— 100x - f.no. 26, 27b, 27c, 28.

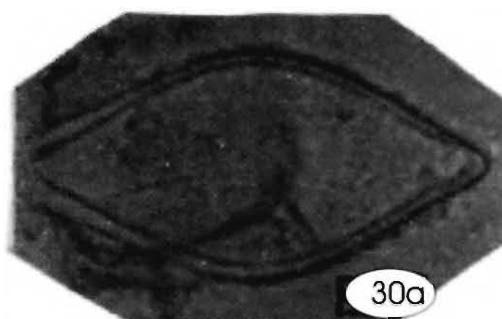
PLATE - VII



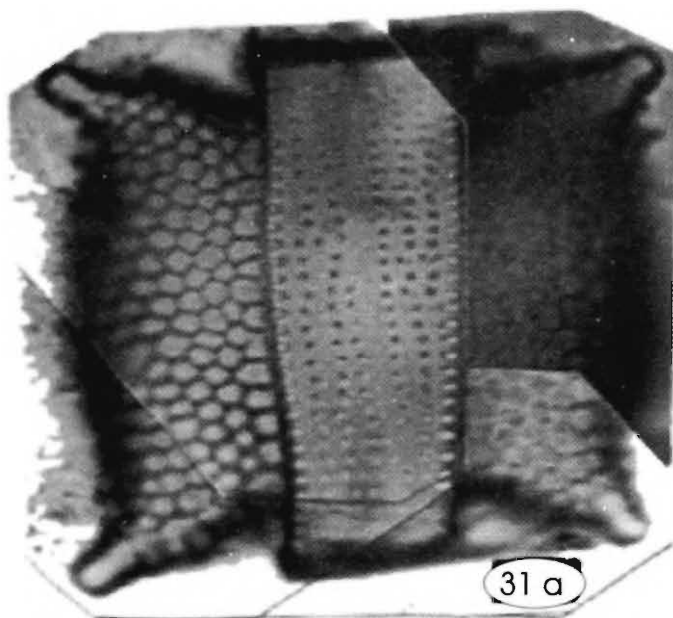
29 a



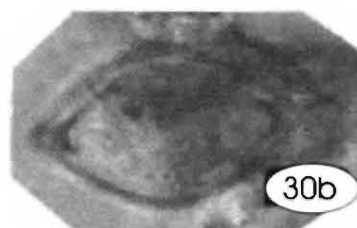
29b



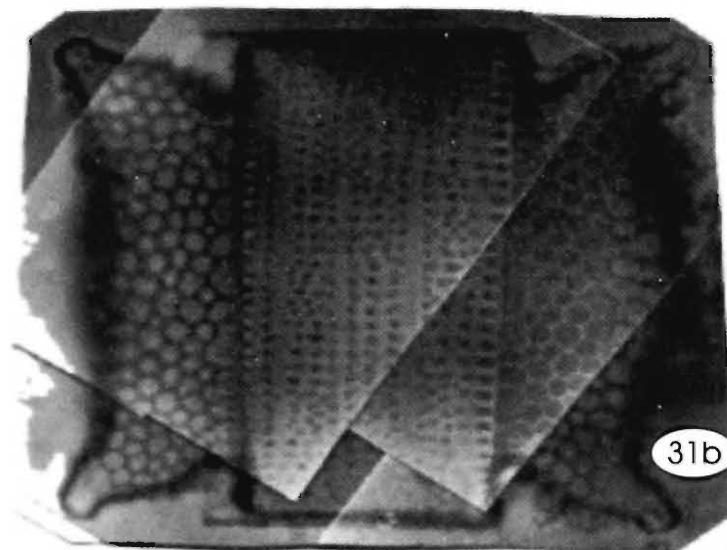
30a



31 a



30b



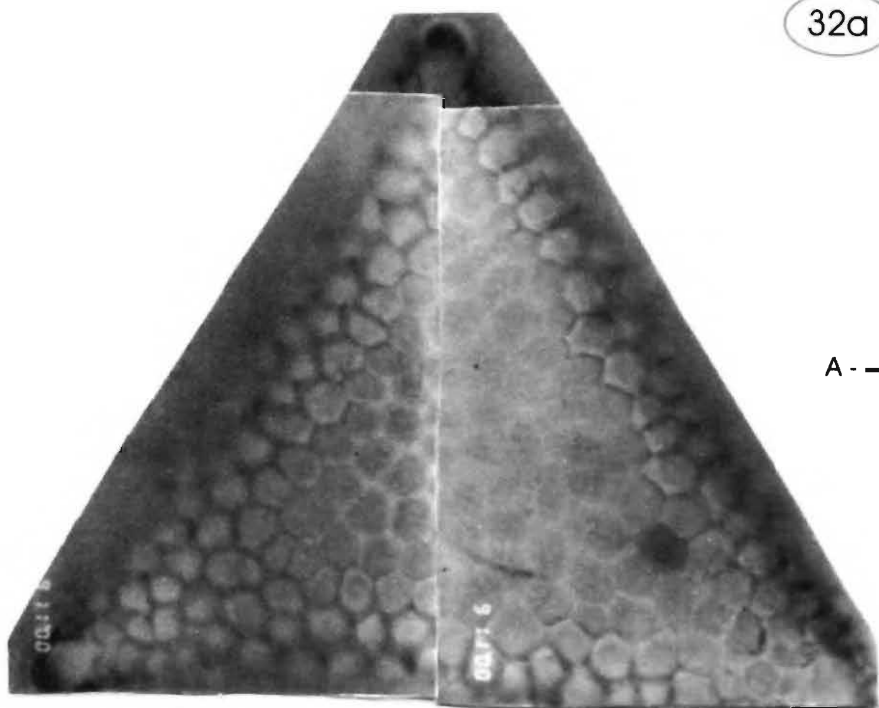
31b

A - ——— 100x - f.no. 31a, 31b.
B - ——— 100x - f.no. 29a, 30a, 30b.
C - ——— 40x - f.no. 29b.

PLATE - VIII



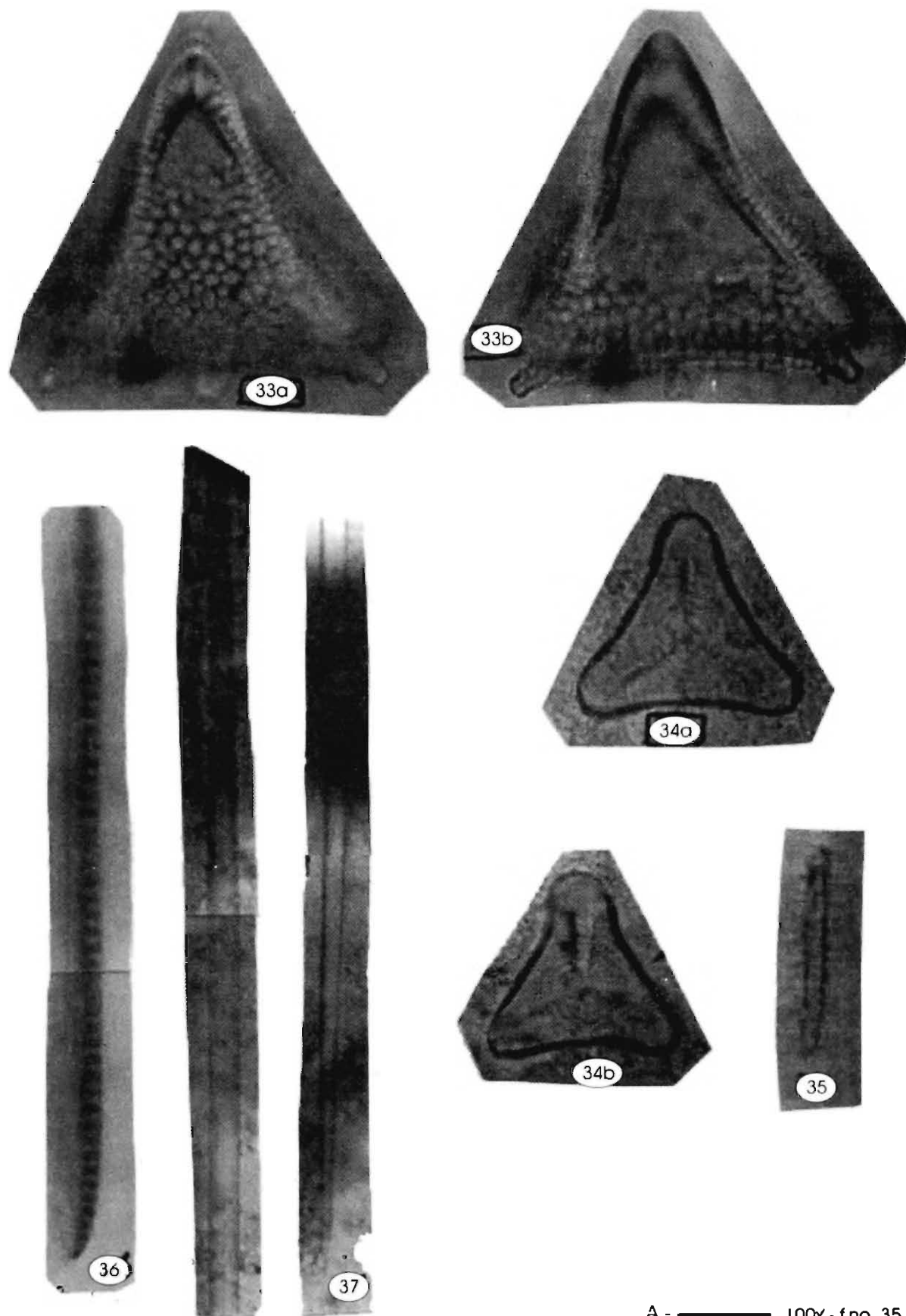
32a



A - ——— 100x - f.no. 32a, 32b.

32b

PLATE - IX



A - ——— 100x - f.no. 35.
 B - ——— 40x - f.no. 36, 37.
 C - ——— 100x - f.no. 33a, 33b, 34a, 34b.

PLATE - X

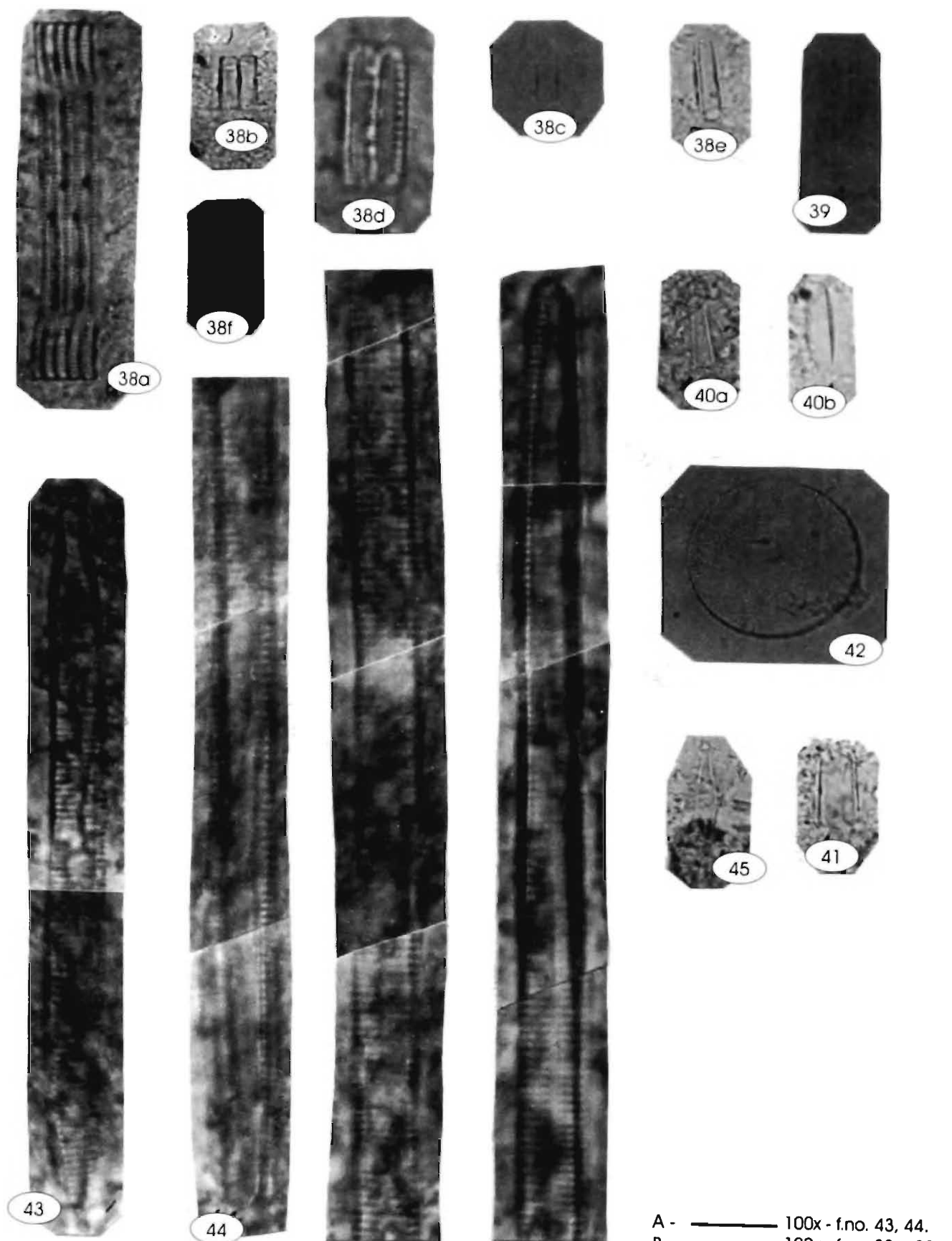
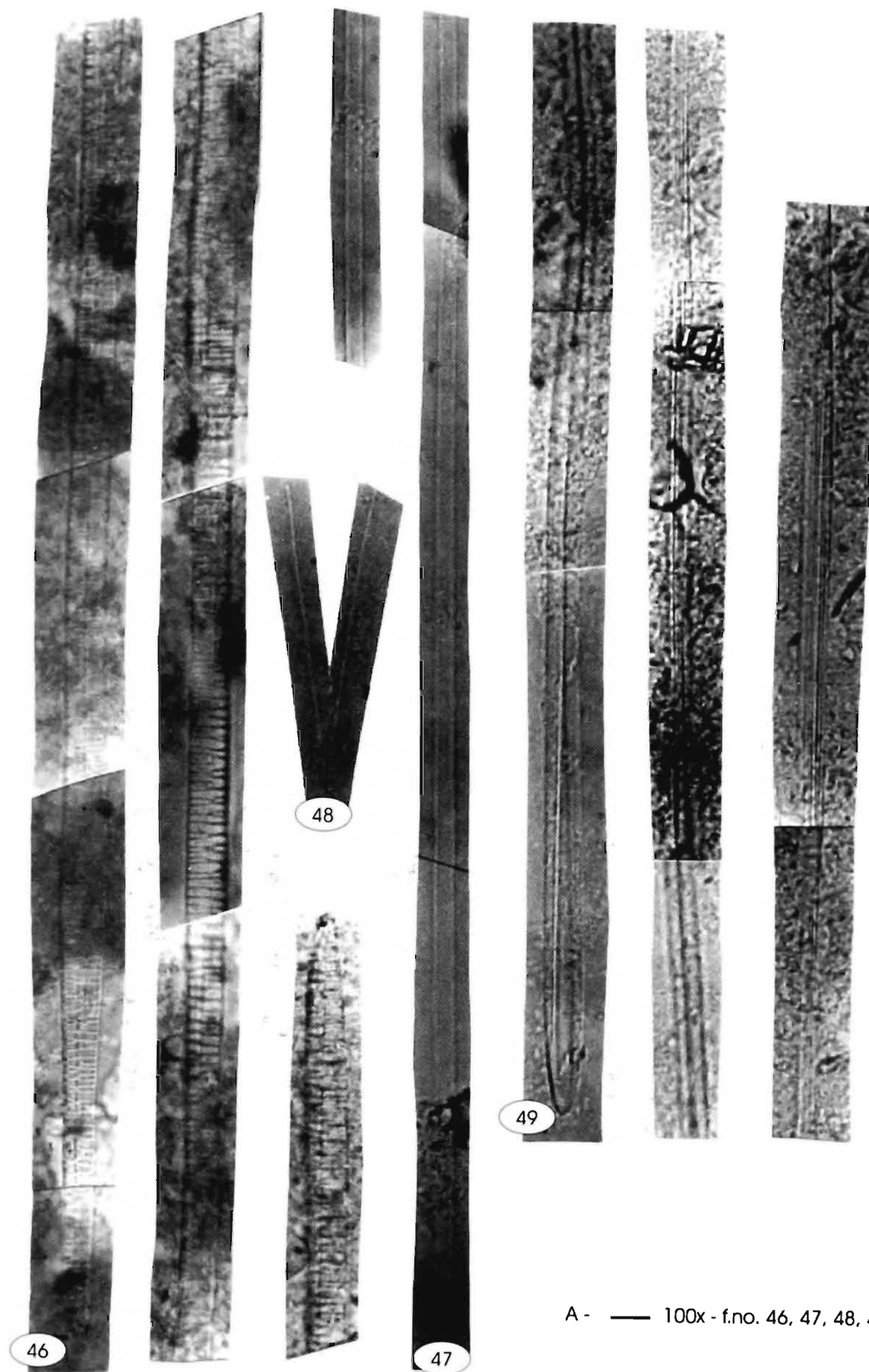


PLATE - XI



A - — 100x - f.no. 46, 47, 48, 49.

PLATE - XII

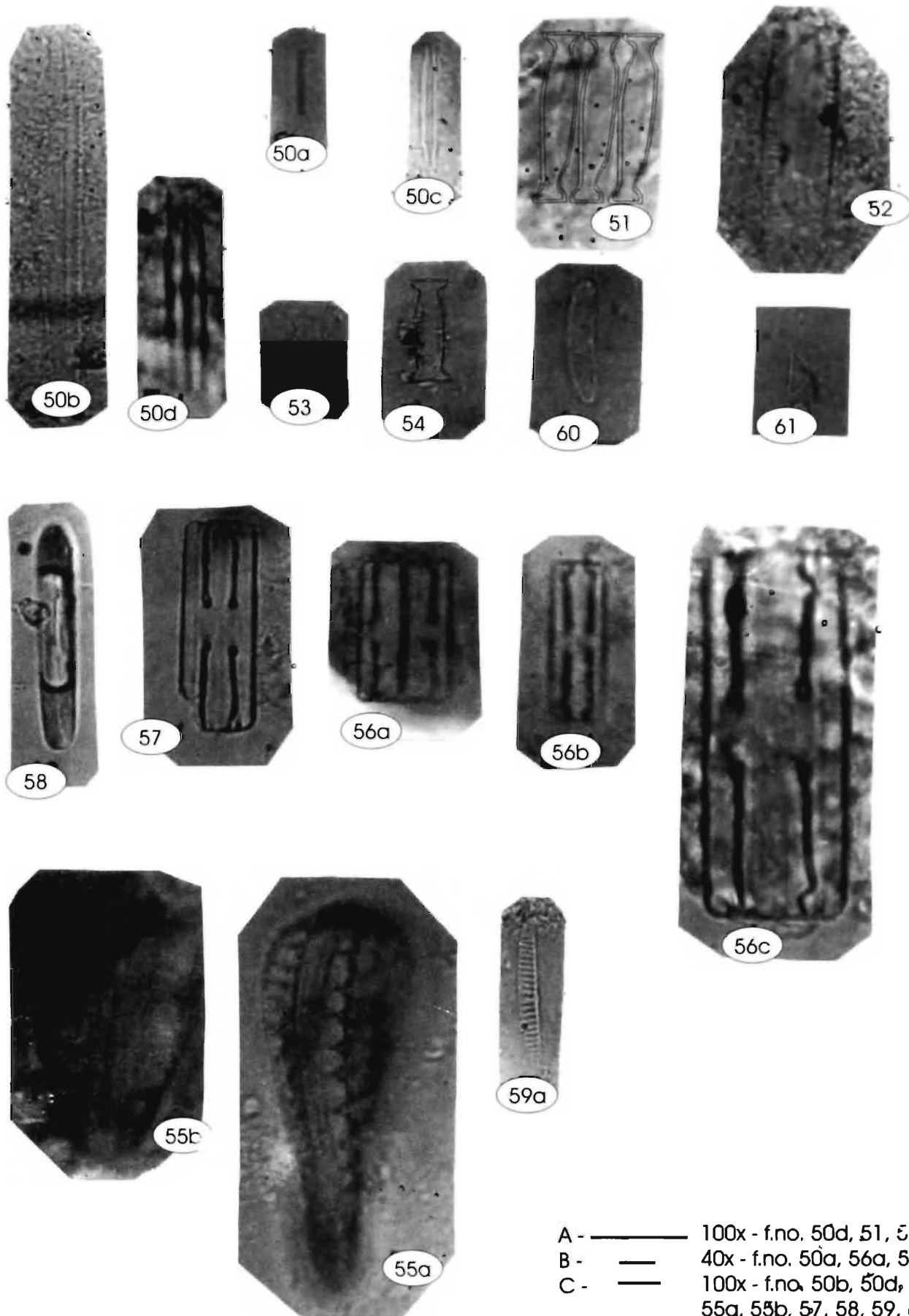
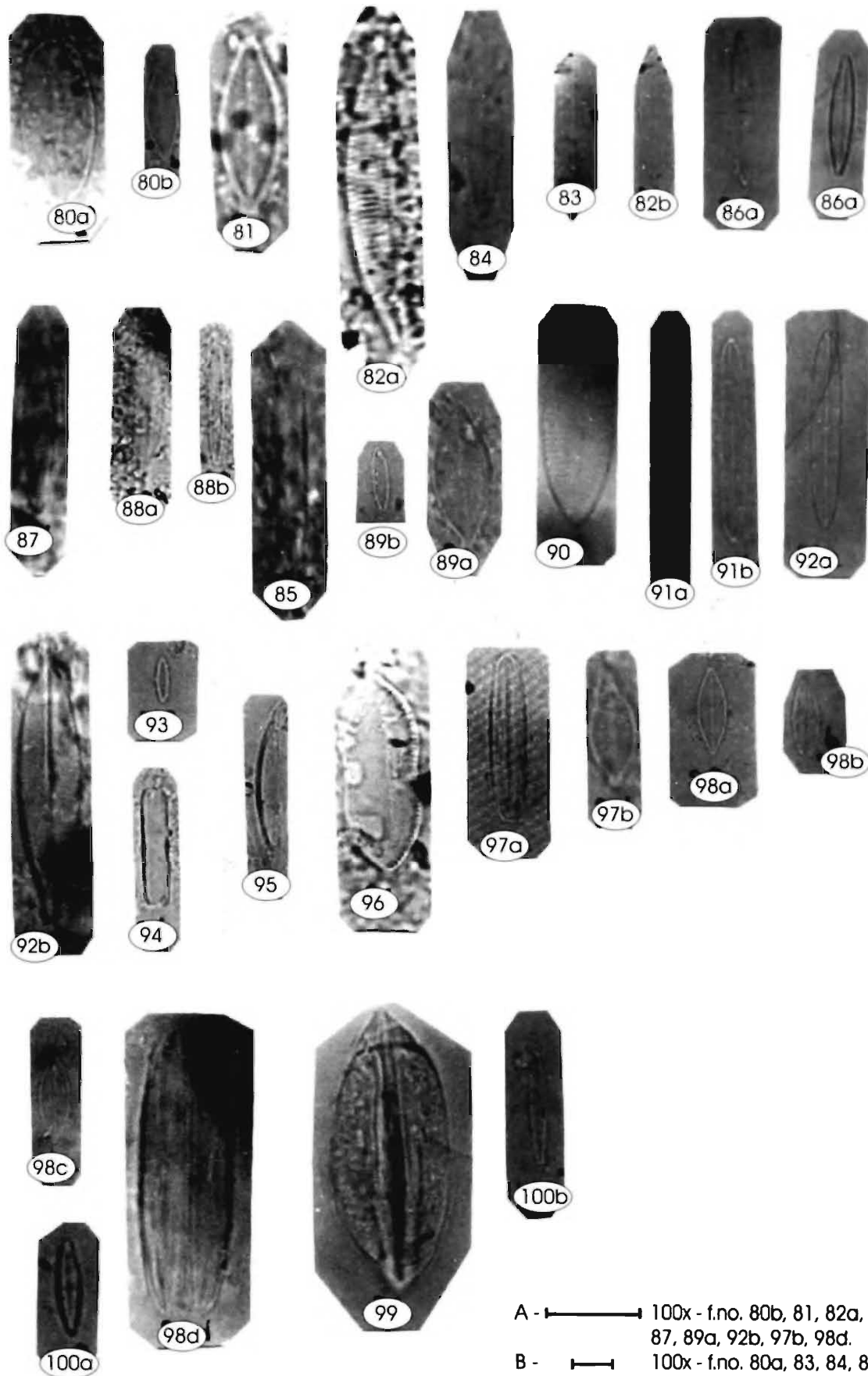


PLATE - XIII

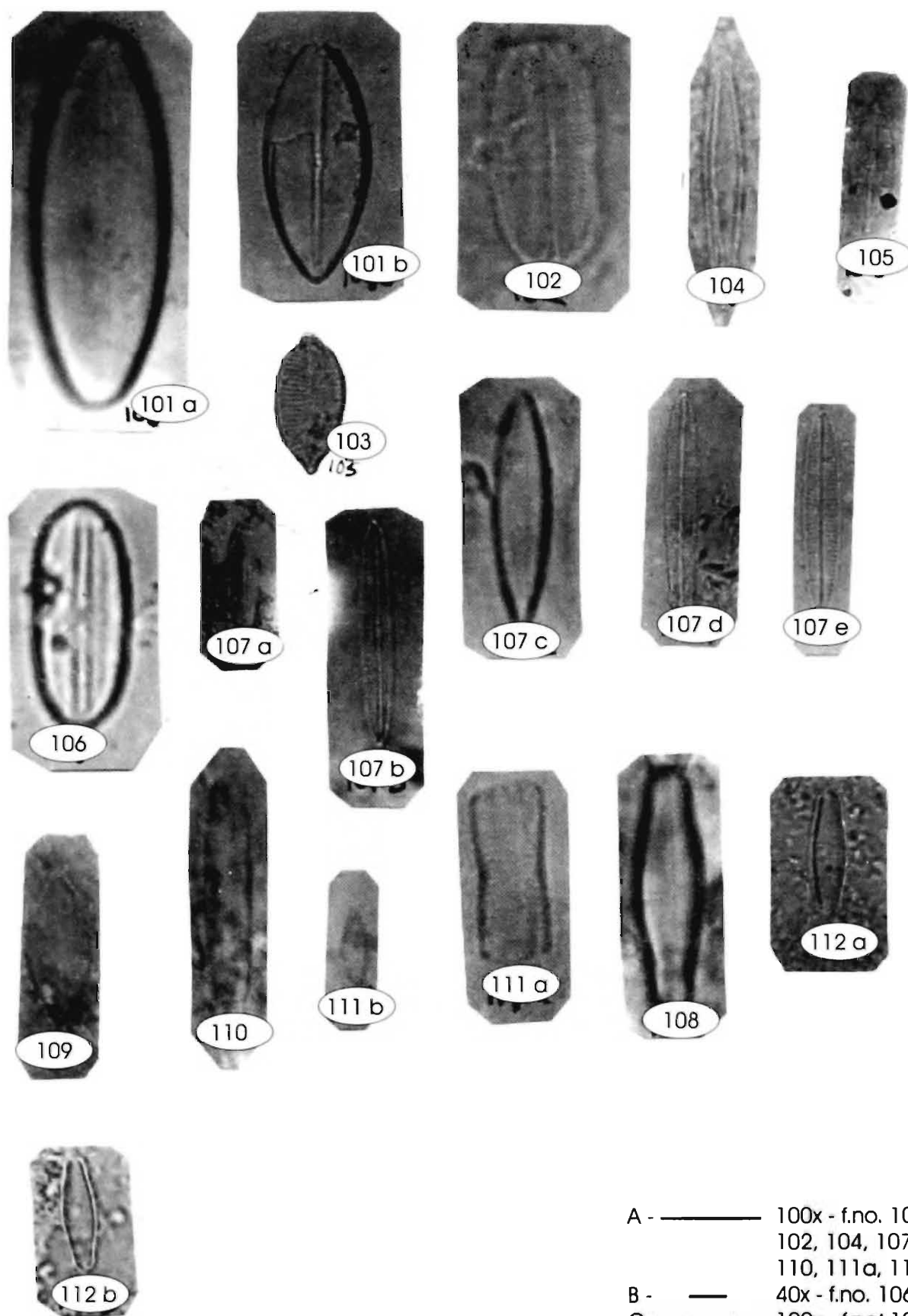


PLATE - XIV



- A - 100x - f.no. 80b, 81, 82a, 82b, 85, 87, 89a, 92b, 97b, 98d.
- B - 100x - f.no. 80a, 83, 84, 86a, 86b, 88, 89b, 91a, 91b, 92a, 93, 94, 95, 96, 97a, 98a, 98b, 98c, 99, 100a, 100b.

PLATE - XV



- A - ——— 100x - f.no. 101a, 101b,
102, 104, 107c, 108, 109,
110, 111a, 11b.
- B - ——— 40x - f.no. 106.
- C - ——— 100x - f.no. 103, 105, 107a,
107b, 107d, 107e, 112a,
112b.

PLATE - XVI

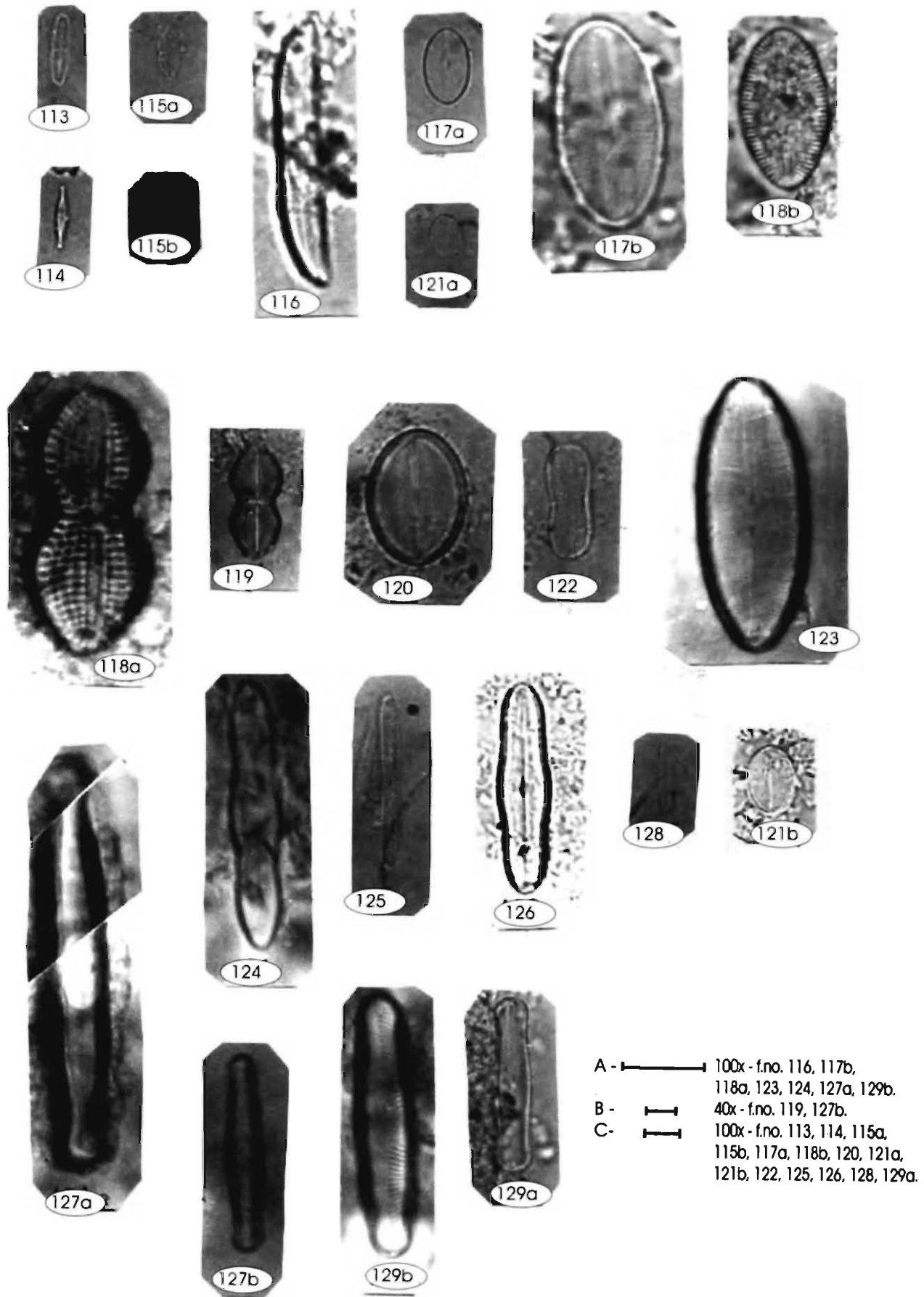
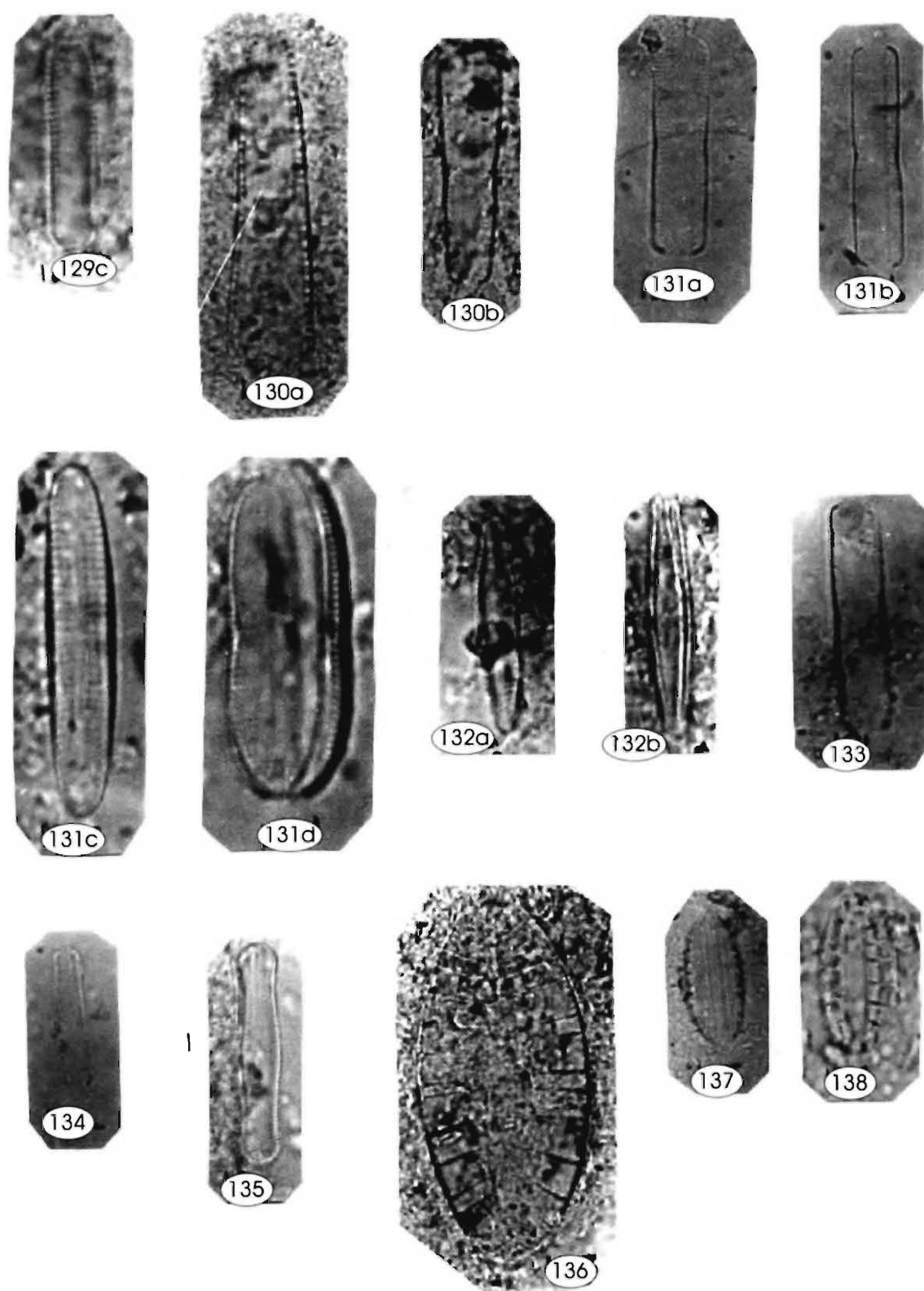


PLATE -XVII



A -  100x - f.no. 129c, 131c, 131d, 132a, 132b.
 B -  100x - f.no. 130a, 130b, 131a, 131b, 133,
 134, 135, 136, 137, 138.

PLATE - XVIII

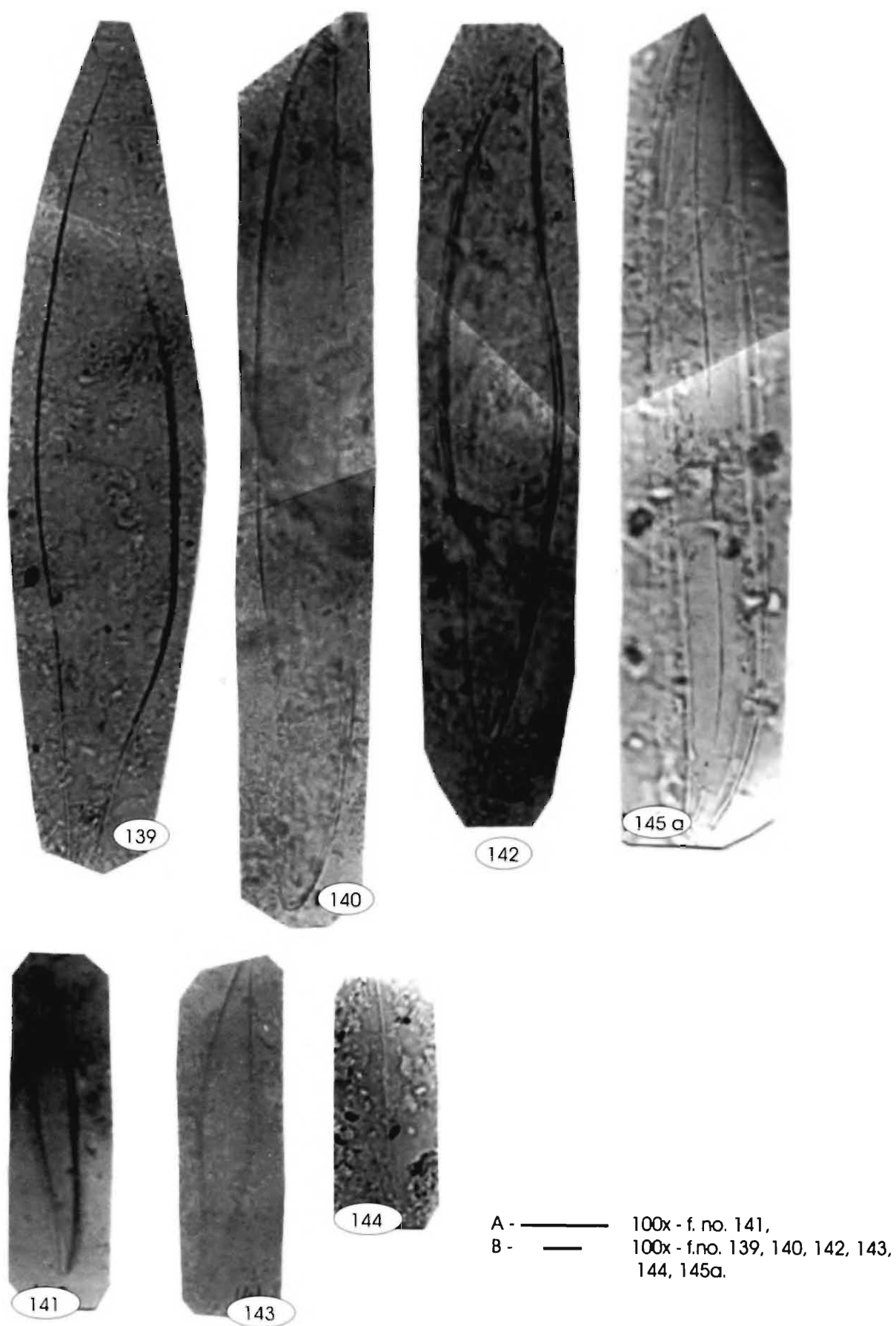
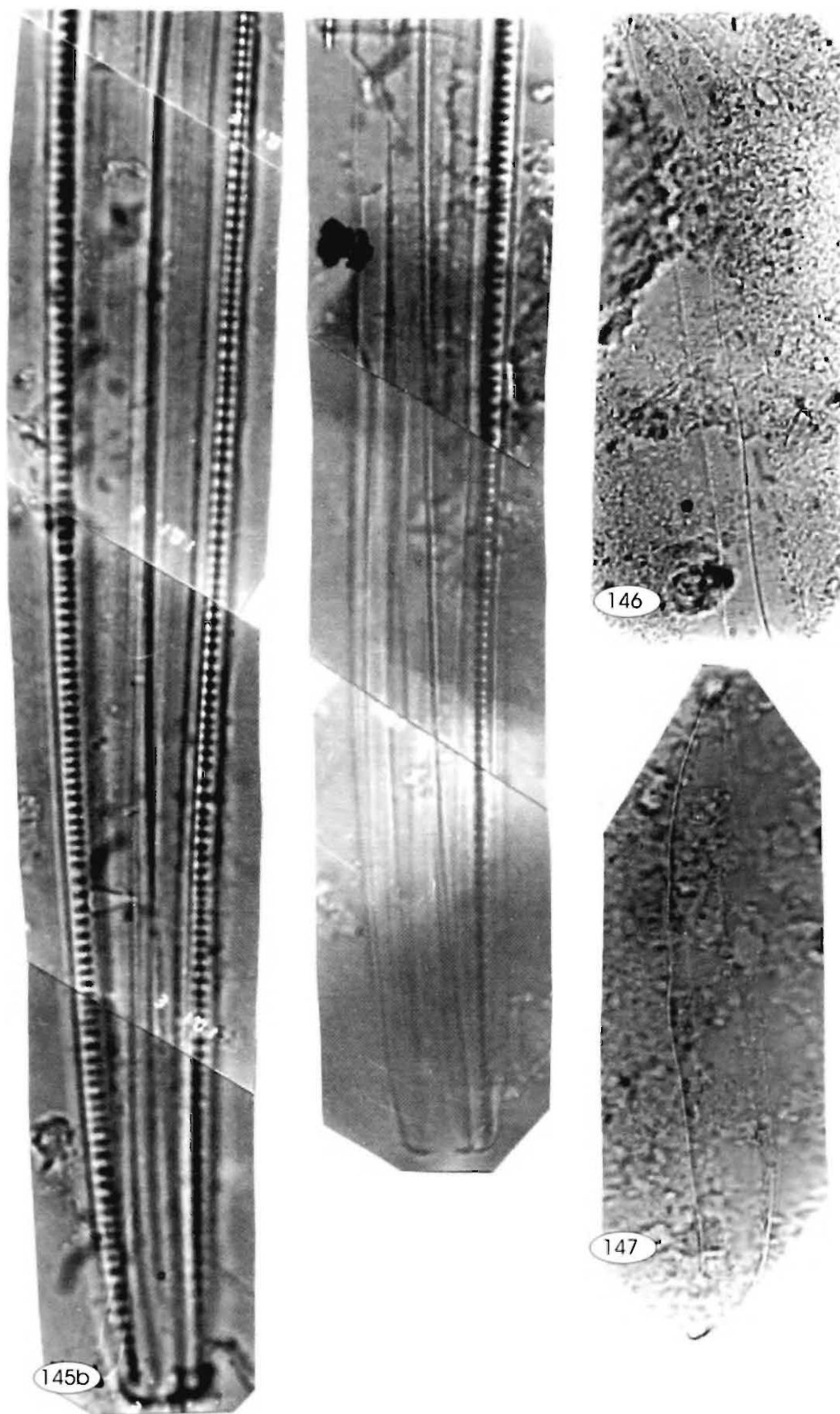
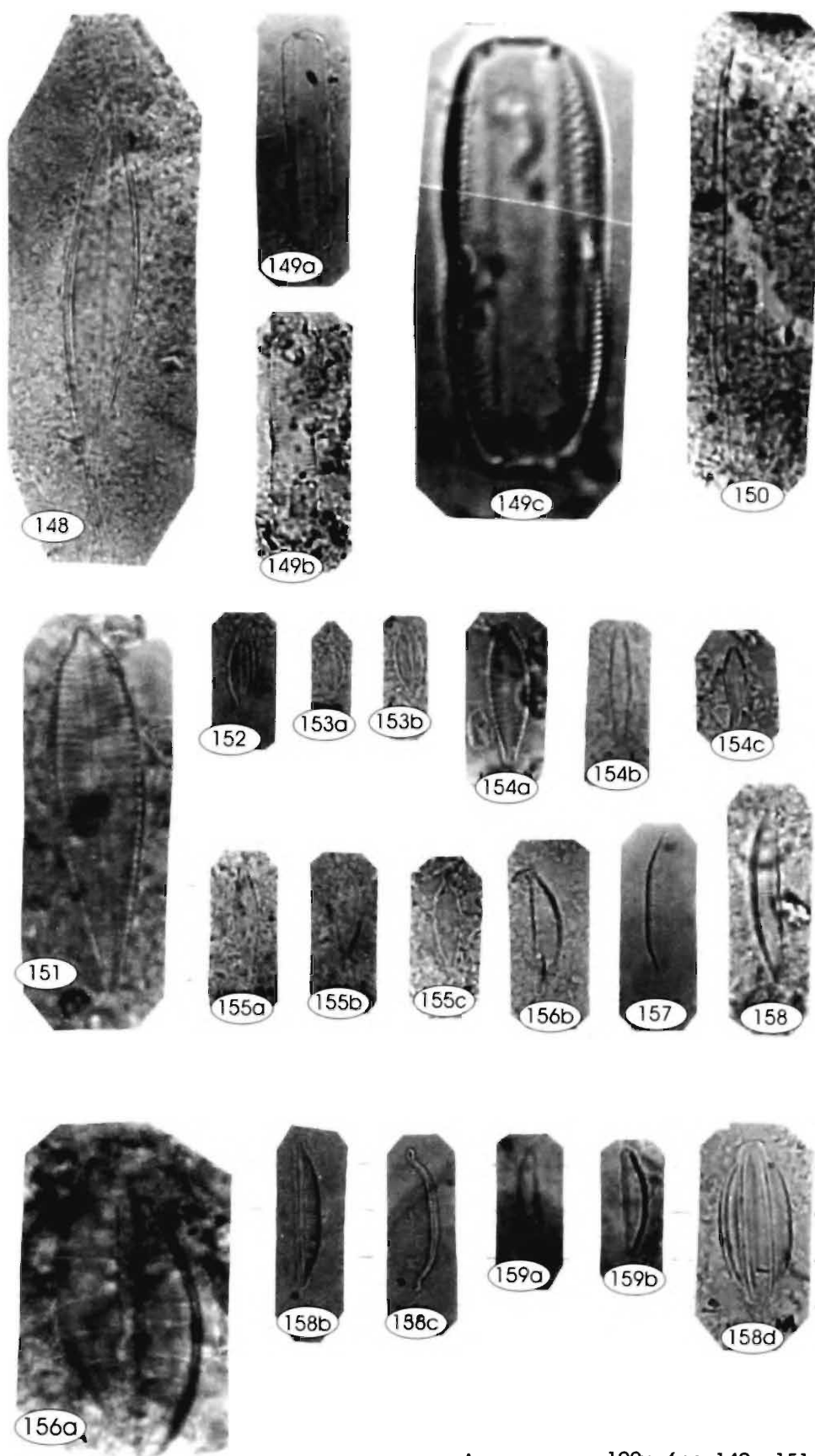


PLATE - XIX



A - 100x - f.no. 145b.
B - 100x - f.no. 146, 147.

PLATE - XX



A -  100x - f.no. 149c, 151, 154a, 156a, 159a.
 B -  100x - f.no. 148, 149a, 149b, 150, 152, 153, 154b, 154c, 155a, 155b, 155c, 156b, 157, 158a, 158b, 158c, 158d, 159d.

PLATE - XXI

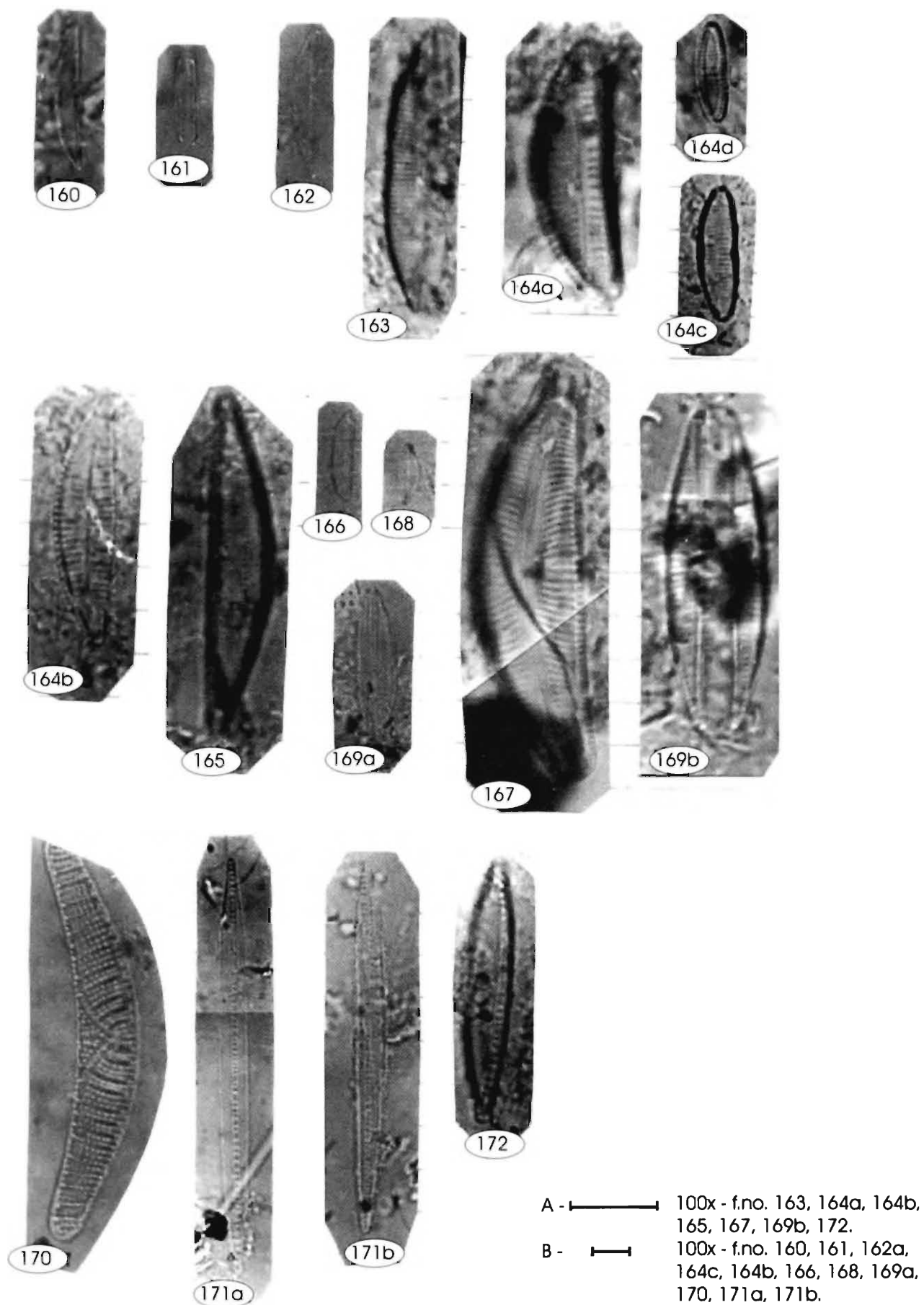
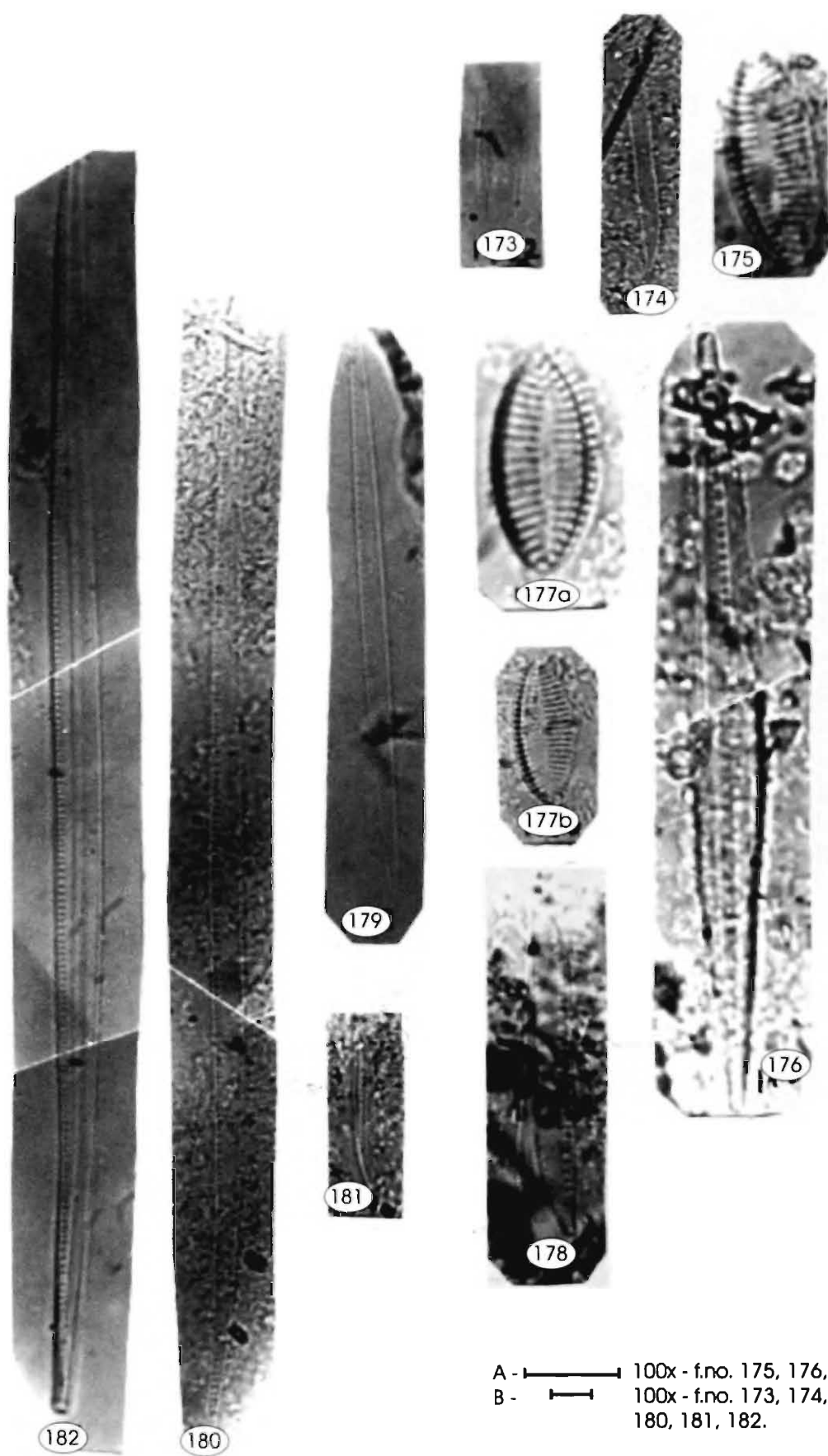
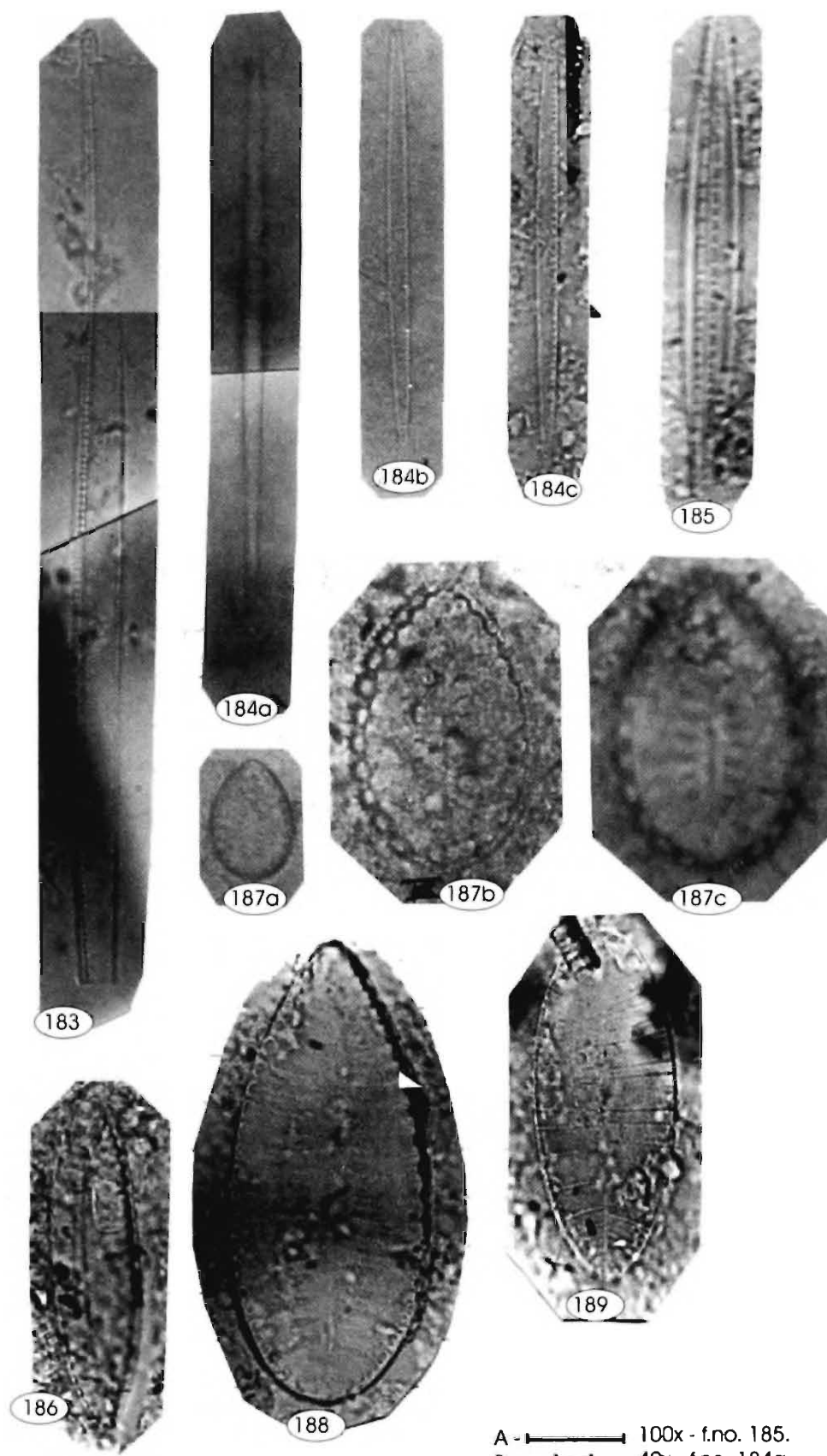


PLATE - XXII



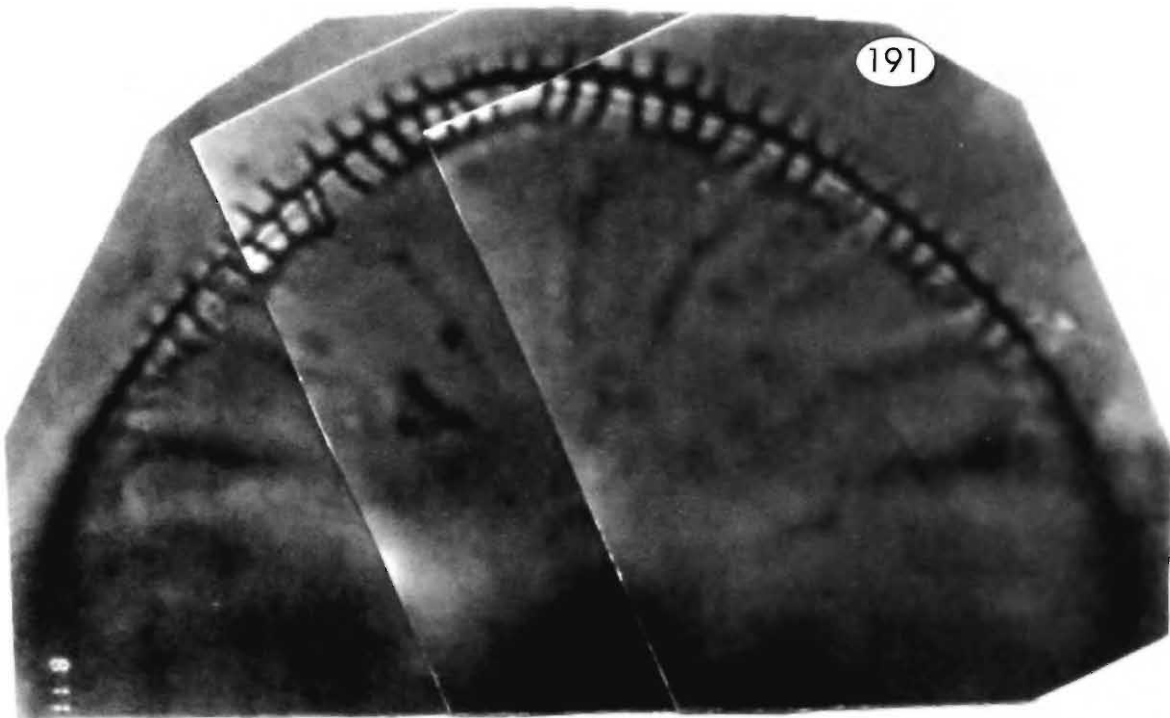
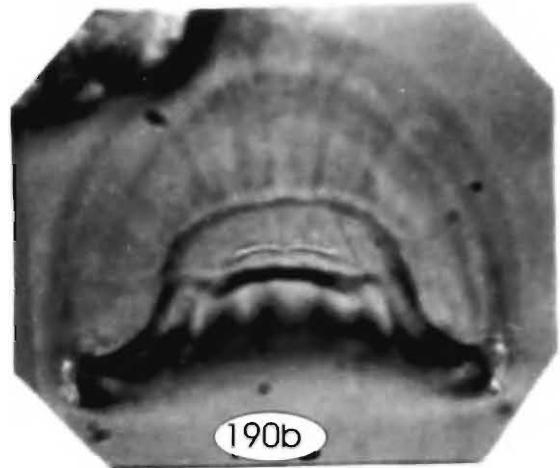
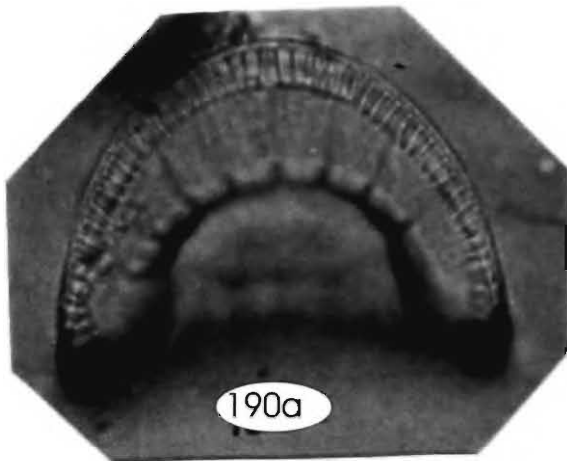
A - 100x - f.no. 175, 176, 177a, 178.
 B - 100x - f.no. 173, 174, 177b, 179,
 180, 181, 182.

PLATE - XXIII



A - 100x - f.no. 185.
 B - 40x - f.no. 184a.
 C - 100x - f.no. 183, 184b, 184c, 186,
 187b, 187c, 188, 189.
 D - 40x - f.no. 187a.

PLATE - XXIV



A -  100x - f.no. 191.
B -  100x - f.no. 190a, 190b.

DIVERSITY OF COMMERCIALY IMPORTANT FISHERY RESOURCES OF TAMIL NADU COAST

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ABSTRACT

Information on ecology and stocks of commercially important fish is of utmost importance for both fishermen and scientists for maintaining sustainable level of exploitation. As is the characteristic of Tropical countries, a multitude of species represent the marine fish community of Tamil Nadu Coast. The survey analysis indicates the three major fish communities such as (1) The fish community of the shelf areas (2) the deep-water fauna at the shelf edge and (3) Off-bottom and pelagic fauna of shelf area. Major marine fish species exploited include sea breams, groupers, red snappers as well as pelagics such as sardines, anchovies and mackerel. Marine invertebrates include several species of shrimps and spiny lobster.

INTRODUCTION

Tamil Nadu State with a coast line of nearly 1076 kms touches both East and West Coast of India which constitutes about 15% of Indian coastal length. The coastal stretches from Kanyakumari to Krishnapatinam encompasses some of the most productive fishing areas of India Viz Wadge Bank with its broad Continental Shelf area, Gulf of Mannar and the large shallow region of Palk Bay. The demersal shelf ecosystem of these areas from coast to the edge of the continental shelf is characterized by a long established benthic faunal community of sponge, coral, shells associated cryptic invertebrates and demersal fishes. The fish resources in these waters consist a multitude of species. Marine fisheries provide employment and revenue to about 7.4 lakhs marine fisher folk living in the 13 coastal districts of Tamil Nadu. All major sea bottom types are seen in these region, therefore rich diversity of bottom associated fishes also occur. Though the profusion of fish species of the area are generally high an attempt is made to identify the major food fishes of the area.

MATERIAL AND METHODS

Samples are collected by using Monofilament long line, Fish trawl (27.5m), Shrimp trawl (30m) and trap employed by the Fishery Survey of India, fishery resource survey vessels such as *Matsya Drushti* (OAL37.5), *Matsya Jeevan* (OAL 36.5), *Matsya Varshini* (OAL 36.5), *Matsya Sugundhi* (OAL 31.5) and *Samudrika* (OAL 28.8) and also from the landing centres all along the Tamil Nadu Coast; landed in different gears such as Bag net, Gill net, Hooks and line and purse Seine. All the collected samples were grouped into demersal and pelagic resources. The various families of fishes have been recognized as per the recent classification by Nelson (1994). The scientific, common and vernacular names of fishes are given for each species listed. A total of 226 species of fishes have been dealt with in this study (Table-1).

DISCUSSION

Ichthyodiversity of Indian Ocean and fresh water has already been reported by Day (1878) in his *Fishes of India*. Talwar and Kacker (1984) have documented more than 500 marine economically important food fishes. Ramamurthy *et al.*, (1988) have mentioned about 21 families of marine species including elasmobranchs from Coromendal coast. Sivaprakasam *et al.*, (1991) studied the marine fishery resources off the lower East Coast of India, which is a good document for the fishing industry. Fishing industry and other stock-holders in the marine fishery sector seeking a short term gainful returns from coastal fishery refused to see its long term fallout due to indiscriminate fishing activity. The fishery in the entire inshore of the Indian Ocean upto 100m depth range has been exploited beyond its optimum level. Bensam and Menon (1994) while accounting the endangered species of marine fauna, mentioned that less than 200 species are coming under exploitation of regular fishery operation though 1400 species are reported in Indian waters. Menon (2004) stated that a few families of marine fishes are threatened and spelt out the possible conservation measures. Present study indicates that more than 226 species are exploited commercially including crustaceans and cephalopods in Tamil Nadu Coast and certain low-value species are thrown overboard as by-catch during trawling. During fishing operation authors have noticed, that the catches of species like *Lactarius lactarius*, *Arius thalasinus*, *Arius dussumieri*, *Polydactylus plebeius*, *Pristigenys nipponia* and *Priacanthus tayenus*, and some members of coastal shrimps and cephalopods have become rare. Any in-depth assessment on the entire coastal fishery in the context of status of each species in the Indian waters would reveal the position of those species as to whether they are endangered, vulnerable or rare. There is not such holistic effort is in the offing in the Indian marine faunistic study. Exploitation beyond the sustainable level deploying all-sweeping gears like trawl may result in loss of biodiversity. To reduce the pressure on the coastal fishery, diversification of fishing strategy, reduction in the number of vessels, mesh size regulation etc would to some extent pay off.

ACKNOWLEDGEMENTS

This study was carried out under the project 'Investigation in Marine fish Biodiversity in the Indian EEZ' Funded by Ministry of Environment and Forests, New Delhi. We thank Dr. V.S. Somvanshi, Director General for support and encouragement and also to the Vessel staff of Chennai base and Cochin Base of FSI. MUV thanks the Ministry of Environment and Forests, New Delhi, for Research Fellowship.

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Table-1. Check list of species

Family/Groups	Scientific name	Common name	Vernacular name	Max. size (cm)
Hemiscylliidae	<i>Chiloscyllium griseum</i> Muller & Henle, 1839	Grey-bambooshark	Kurangu-sorrah	80
	<i>Chiloscyllium indicum</i> Gmelin, 1789	Indian cat shark	Coruhgun-sorrah	65
Alopiidae	<i>Alopias vulpinus</i> (Bonnaterre, 1788)	Thresher shark		600
Carcharhinidae	<i>Carcharhinus limbatus</i> (Muller & Henle, 1839)	Black tip shark/ Grey shark	Kundan-sorrah	247
	<i>C. melanopterus</i> (Quoy & Gaimard, 1824)	Black tip reef shark	Katta0sura,Thalan sorrah	200
	<i>C. sorrah</i> (Muller & Henle, 1839)	Spottail shark/ Sorrah shark	Katta-sorrah	160
	<i>C. macrostoma</i> (Bleeker)	Balfours shark	Pal-sorrah	60
	<i>Galeocerdo cuvier</i> (Lesueur, 1822)	Tiger shark	Vulluvan-sorrah	
	<i>Hemipristis elongatus</i> (Klunzinger, 1871)	Fossil shark	Peducan, Pal sorrah	
	<i>Loxodon macrorhinus</i> Muller & Henle, 1839	Sliteye shark	Cosorrah	91
	<i>Negaprion acutidens</i> (Ruppell, 1837)	Indian lemon shark	Pilal	310
	<i>Rhizoprionodon acutus</i> (Ruppell, 1837)	Milkdog shark	Co-sorrah	102

Table 1. Contd

Family/Groups	Scientific name	Common name	Vernacular name	Max. size (cm)
	<i>Scolidon laticaudus</i> Muller & Henle, 1838	Spadenose shark	Pillai-sorrah	74
Lamnidae	<i>Isurus oxyrinchus</i> Rafinesque, 1810	Shortfin mako	Ganumu-sorrah	400
Rhinodontidae	<i>Rhiniodon typus</i> Smith, 1828	Whale shark	Pulli-udumban-sravu	15M
Sphyrnidae	<i>Sphyrna lewini</i> (Gritfith & Smith, 1864)	Scalloped hammer-head shaek	Komban sorrah	420
	<i>Sphyrna zygaena</i> (Linnaeus, 1758)	Smooth hammer head shark	Komban sorrah	400
	<i>S. mokarran</i> (Ruppell, 1837)	Great hammerhead shark	Komban sorrah	
Skates & Rays				
Rhinobatidae	<i>Rhinobatos granulatus</i> Cuvier, 1829	Granulated shovelnose ray	Purrungun, Padangan	280
	<i>Rhinoptera javanica</i> Muller & Henle, 1841	Javanese cow ray	Surul thirukai	150
	<i>Rhynchobatus djiddensis</i> (Forsskal, 1775)	White spotted shovelnose guitar fish	Uluvai	310
Dasyatidae	<i>Dasyatis bleekeri</i> (Blyth)	Whit tail sting ray	Seman-tirike, Manalthirukai	
	<i>D. sephen</i> (Forsskal, 1775)	Cowtail stingray	Auda thirukai	183
	<i>D. uarnak</i> (Forsskal, 1775)	Honeycomb stingray	Puliyen thirukai	200

Table 1. Contd

Family/Groups	Scientific name	Common name	Vernacular name	Max. size (cm)
Myliobatidae	<i>Aetobatus narinari</i> (Euphrasen, 1790)	Spotted edged ray	Vaval thirukkai	200
	<i>A. flagellum</i>	Giant devil ray	Kueivi thirukkai	
Mobulidae	<i>Manta birostris</i> (Walbaum, 1792)	Giant manta	kombu thirukkai	800
Gymnuridae	<i>Gymnura poecilura</i> (Shaw)			
Clupeidae	<i>Dussumieria acuta</i> Valenciennes, 1847	Rainbow sardine	Matha kendou/Thondan	20
Sardines/Shads	<i>Sardinella longiceps</i> Valenciennes, 1847	Sharpnose sardine	Keerimeen-Chalai	23
	<i>S. dayi</i> Regan, 1917	Days sardine	Choodai	
	<i>S. gibbosa</i> (Bleeker 1849)	Goldstripe sardine	Cholai, Neethu-kavalai	17
	<i>Amblygaster sirm</i> (Walbaum, 1792)	Spotted sardine	Keerimeen-chalai	23
	<i>Anodontostoma chacunda</i> (Hamilton- Buchanan, 1822)	Gizzard sardine chacunda	Kulla-poykkendai	17
Engraulidae	<i>Stolephorus heterolobus</i> (Ruppell, 1837)	Shorthead anchovy		
Anchovies	<i>S. indicus</i> (valenciennes, 1848)	Indian anchovy	Nethilli	15.5
	<i>S. commersonii</i> Lacepede, 1803	Dussumiers anchovy	Semporuva	16
	<i>Thryssa mystax</i> (Schneider, 1801)	Thryssa anchovy	Nethili	16

Table 1. Contd

Family/Groups	Scientific name	Common name	Vernacular name	Max. size (cm)
	<i>Coilia dussumieri</i> Valenciennes, 1848	Golden anchovy	poruva/Kola/	20
Chirocentridae	<i>Chirocentrus dorab</i> (Forsskal, 1775)	Dorab wolf-herhing	Mullu-valai/Kiru-vahlah	100
	<i>C. nudus</i> Swainson, 1839	Whitefin wolf herring	Mull valai	100
Ariidae				
Sea cat fish	<i>Arius dussumieri</i> Valenciennes, 1840	Dussumiers cat fish	Mondai keliru	31
	<i>A. thalassinus</i> (Ruppell, 1837)	Giant marine cat fish	Mondaikeluru	185
Synodontidae	<i>Saurida undosquamis</i> (Richardson, 1848)	Brush tooth lizard fish	Thumbli	45
	<i>S. tumbil</i> (Bloch, 1795)	Greater lizard fish	Thumbil	40
	<i>Syndous indicus</i> (Day, 1873)	Indian lizard fish	Thumbil	33
	<i>Trachinocephalus myops</i> (Forster, 1801)	Blunt nose lizard fish	Thumbil	40
Exocoetidae				
Flying fish	<i>Cypselurus oligolepis</i> (Bleeker, 1866)	Largescale flying fish	Paravai kola	17
	<i>C. sottoi</i> (Valenciennes, Whittley & Colefax, 1938)	Indian spotted flying fish	Paravai kola	28

Table 1. Contd

Family/Groups	Scientific name	Common name	Vernacular name	Max. size (cm)
	<i>Exocoetus volitanus</i> (Linnaeus, 1758)	Tropical two winged flying fish	Thai-kola	18
	<i>Hirundichthys coromandelensis</i> (Hornell, 1923)	Coromandel flying fish	Paravai kola	19
Hemiramphidae				
Half beaks	<i>Hemiramphus far</i> (Forsskal, 1775)	Black-barred half beak	Mural/Usikalon	44
	<i>H. lutkei</i> Valenciennes, 1846	Lutkei half beak	Mural	40
	<i>H. marginatus</i> Forsskal, 1775	Barred half beak	Usikola	29.5
	<i>H. dussumieri</i> (Valenciennes, 1846)	Dussumiers half beak	Mural	
Belonidae				
Needle fishes	<i>Ablennes hians</i> (Valenciennes, 1846)	Flat needle fish	Valai-nural	120
	<i>Tylosurus osocodilus</i> (Peterson & Lesuveut, 1821)	Hound needle fish	Pahmum kola	
Serranidae				
Groupers	<i>Cephalopholis sonnerati</i> Valenciennes, 1828	Tomato hind	Siggapu-cullawah	57
	<i>Epinephelus diacanthus</i> (Valenciennes, 1828)	Sixbarred reef cod	Kalava	52

Table 1. Contd

Family/Groups	Scientific name	Common name	Vernacular name	Max. size (cm)
	<i>E. malabaricus</i> Schneider, 1801	Malabar reef cod	Kalava	100
	<i>E. tauvina</i> (Forsskal, 1775)	Greasy reff cod	Kalava	65
	<i>E. chlorostigma</i> (Valenciennes, 1828)	Brown spotted grouper	Thala kalava	75
	<i>E. areolatus</i> (Forsskal, 1775)	Areolated grouper	Kalava	35
	<i>Epinephelous bleekeri</i> Vaillant, 1877	Bleekers grouper	Kalava	70
	<i>E. undulosus</i> (Quoy & Gaimard, 1824)	Midwater grouper	Kalava	75
	<i>E. longispinis</i> (Kner, 1865)	Streakyspot grouper	Kalava	60
	<i>E. latifasciatus</i> (Kner, 1865)	Banded grouper	Kalava	70
	<i>E. epistictus</i> (Temminck & Schiegel, 1824)	Broken line grouper	Kalava	80
Teraponidae	<i>E. radiatus</i> (Day, 1867)	Oblique-banded grouper	Kalava	70
Grunters	<i>Terapon jarbua</i> (Forsskal, 1775)	Jarbua terapon	Palin-keetchan	30
	<i>T. theraps</i> Cuvier, 1829	Largescaled terapon	Kutta-keetchan	30
	<i>T. puta</i> (Cuvier, 1829)	Smallscaled banded terapon	Kove-keetchan	15

Table 1. Contd

Family/Groups	Scientific name	Common name	Vernacular name	Max. size (cm)
Centrolophidae	Alcock, 1890	Indian ruff		
Priacanthidae				40
Bigeyes	<i>Priacanthus hamrus</i> (Forsskal, 1775)	Dusky finned bulleye	Kakkasi	
	<i>P. blochii</i> Bleeker, 1853	Paeony bulleye	Kakkasi	
Sillaginidae	<i>P. tayenus</i> Richardson, 1846	Purple-spotted big eye		30
	<i>Pristigenys nipponia</i> (Cuvier, 1829)	Japanese bigeye		
Whittings	<i>Sillago sihama</i> (Forsskal, 1775)	Silver sillago	Kilangan/Culingah	25
Lactariidae				
Falsetrevallies	<i>Lactarius lactarius</i> (Bloch & Schneider, 1801)	False trevally	Sudumbu	40
Rachycentridae				
Cobias	<i>Rachycentron canadus</i> (Linnaeus, 1766)	Black king fish	Cuddul-verarl/ kadal-oiral	200
Carangidae				
Carangs	<i>Alectis indicus</i> (Ruppell, 1830)	Indian threadfin trevally	Chopata para	150
	<i>Alepes djedaba</i> (Forsskal, 1775)	Shrimp scad	Kiliso/Komara parai	29 (FL)
	<i>A. para</i> Cuvier, 1833	Goggle eye scad	Kalla-Parah	16(FL)
	<i>Atropus atropus</i> (Ruppell, 1830)	Cleftbelly trevally	Kunni papah	23(FL)
	<i>Atule mate</i> (Cuvier, 1833)	One finlet scad	warri parrah	28(FL)

Table 1. Contd

Family/Groups	Scientific name	Common name	Vernacular name	Max. size (cm)
	<i>Carangoides armatus</i> (Ruppell, 1830)	Long fin trevally	Tanga parrah	50(FL)
	<i>C. ferdu</i> (Forsskal, 1775)	Blue trevally	Tanga parrah	47(FL)
	<i>Carangoides malabaricus</i> (Bloch & Schneider, 1801)	Malabar trevally	Tanga parrah	47(FL)
	<i>C. ignobilis</i> (Forsskal, 1775)	Giant trevally	Tollam parah	24(FL)
	<i>C. sexfasciatus</i> Quoy & Gaimard, 1824	Yellow fin jack		146(FL)
	<i>Caranx sem</i> Cuvier, 1833	Blacktip trevally		78(FL)
	<i>Decapterus kuorroides</i> Bleeker, 1855	Yellow tail king fish		78(FL)
	<i>D. russelli</i> (Ruppel, 1830)	Indian scad	Kilichi	70(FL)
	<i>D. tabl</i> Berry, 1968	Redtail scad/ Rough ear scad	Kilichai	35(FL)
	<i>Elagatis bipinnulatus</i> (Quoy & Gaimard, 1824)	Rainbow runner	Kulkul	35(FL)
	<i>Ganathanodon speciosus</i> (Forsskal, 1775)	Golden toothless trevally	Rathi parah	100(FL)
	<i>Megalospis cordyla</i> (Linnaeus, 1758)	Torpedo scad	Pilli parah	80(TL)
	<i>Scomberoides commersonianus</i>	Talang quuenfish	Komara parah	94(FL)

Table 1. Contd

Family/Groups	Scientific name	Common name	Vernacular name	Max. size (cm)
	<i>Selar crumenophthalmus</i> (Bloch, 1793)	Big eye scad	Toal parah	60(FL)
	<i>Seriolina nigrofasciata</i> (Ruppell, 1829)	Black banded trevally		70(SL)
	<i>Uraspis helvalus</i> (Forster, 1801)	White tounge jack		46(FL)
	<i>Parastromateus niger</i> (Bloch, 1795)	Black pomfret	Vauval / Karuvauval	55(TL)
Coryphaenidae				
Dolphinfish	<i>Coryphaena hippurus</i> Linnaeus, 1758	Common dolphin fish	Vanna, Koppurai kela	200
Leiognathidae				
	<i>Leiognathus dussumieri</i> Valenciennes, 1835	Dussumiers poney fish	Vari kaaral	14
(Pongfishes	<i>Leiognathus elongatus</i> (Gunther, 1874)	Slender poney fish	Slender poney fish	12
	<i>L. bindus</i> (Valenciennes, 1835)	Orange fin poney fish	Orange fin poney fish	11
	<i>L. smithursti</i> (Ramsay & Ogilby, 1846)	Smithursti poney fish		
	<i>L. jonesi</i> James, 1971	Jones poney fish	Saluvatti kaaral	
	<i>L. brevirostris</i> (Valenciennes, 1835)	Poney fish	Mandai kaaral	13.5

Table 1. Contd

Family/Groups	Scientific name	Common name	Vernacular name	Max. size (cm)
	<i>L. equulus</i> (Forsskal, 1775)	Berbs pony fish	Porumand kaaral	24
	<i>L. berbis</i> (valenciennes, 1835)	Orange fin poney fish	ossi kaaral	11
	<i>L. splendens</i> (Cuvier, 1835)	Splendid ponefish	Tatnam-kare	
	<i>Gazza minuta</i> (Bloch, 1797)	Toothed poney fish	Kulli kare	
	<i>Secutor insidator</i> (Bloch, 1787)	Pognose poney fish	Kottokara/Kuthipu kaara	10.5
Lutjanidae				
	<i>Lipocheilus carnolabrum</i> (Chan, 1970)	Tangs snapper		
Snappers	<i>Lutjanus gilcheri</i> Fourmanoir, 1959	Yellowfin redsnapper		60
	<i>L. quinquelineatus</i> (Bloch, 1790)	Five-lined snapper		30
	<i>L. argentimaculatus</i> (Forsskal, 1775)	Mangrove red snapper	Pullikarayan/noolani	120
	<i>L. bohar</i> (Forsskal, 1775)	Two-spot snapper		75
	<i>L. fulvus</i> (Schneide, 1801)	Flame coloure snapper		50
	<i>L. gibbus</i> (Forsskal, 1775)	Humpback redsnapper		50
	<i>L. johni</i> (Bloch, 1792)	Johns snapper	Parithi valameen	70

Table 1. Contd

Family/Groups	Scientific name	Common name	Vernacular name	Max. size (cm)
	<i>L. lutjanus</i> (Bloch, 1792)	Rosy snapper/ Biogeye snapper	Noolani	25
	<i>L. malabaricus</i> (Bloch & Schneider, 1801)	Malabar redsnapper	Noolani	90
	<i>L. rivulatus</i> (Cuvier, 1828)	Bluelined snapper		65
	<i>L. sebae</i> (Cuvier, 1828)	Emperor redsnapper	Nai-kerruchi	100
	<i>L. vittus</i> (Quoy & Gaimard, 1824)	Brownstripe redsnapper		40
	<i>Pinjalo pinjalo</i> (Bleeker, 1850)	Pinjolo snapper	Polei oolavai/Mette-mirrei	80
	<i>Pristipomoides typus</i> Bleeker, 1852	Sharptooth snapper	Lomia	70
Nemipteridae				
Threadfin breams	<i>Nemipterus japonicus</i> (Bloch, 1792)	Japanese threadfin bream	Changarah/ Thullunkendai	30
	<i>N. nematophorus</i> (Bleeker, 1853)	Doublewhip threadfin bream	Changarah	30
	<i>N. metopias</i> (Bleeker, 1852)	Slender threadfin bream	Changarah	25
	<i>N. bleekeri</i> (Day, 1875)	Bleekers threadfin bream	Changarah	25
	<i>Scolopsis vosmeri</i> (Bloch, 1792)	white cheek inonoc bream	Kundul pompton	25
Gerreidae				
Mojarras	<i>Gerres filamentosus</i> Cuvier, 1829	Whip fin mojarras	Udagam/oodan/Poohan	25
	<i>G. abbreviatus</i> Bleeker, 1850	Deepbody mojarras	Oodan	25

Table 1. Contd

Family/Groups	Scientific name	Common name	Vernacular name	Max. size (cm)
	<i>Pentaprion longimanus</i> (Bloch, 1797)	Longfin mojarrs	Neersuthumbu	15
Haemulidae				
Grunters	<i>Diagramma pictum</i> (Thunberg, 1792)	Painted sweetlip	Kaakkan meen/ Ghorakan	60
	<i>Pomadasys kakkan</i> (Cuvier, 1850)	Lined silver grunters	Korukkai	80
	<i>P. maculatum</i> (Bloch, 1797)	Blotched grunter		50
	<i>Plectorhinus orientalis</i> (Bloch, 1793)	Orientalis sweetlip		50
Lethrinidae	<i>Lethrinus nebulosus</i> (Forsskal, 1775)	Spangled emperor	Valamin	87
Pigface-brems/ Valencinnes	<i>L. elongatus</i> Valencinnes, 1830	Longface pigface bream	Valamin	100
Emperors	<i>Lethrinus harak</i> (Forsskal, 1775)	Yellow banded pigface bream	Valamin	60
	<i>L. lentjan</i> (Lacepede, 1802)	Redspot emperor	Valamin	50
	<i>L. microdon</i> Valencinnes, 1830	Small tothed emperor	Valamin	60
	<i>L. ramak</i> (Forsskal, 1775)	Block spot emperor	Valamin	47
	<i>L. rubrioperculatus</i> Sato, 1978	Spotcheek emperor	Valamin	40

Table 1. Contd

Family/Groups	Scientific name	Common name	Vernacular name	Max. size (cm)
Sparidae				
Sea breams	<i>Argyrops spinifer</i> (Forsskal, 1775)	Longspine seabream	Pununtlai	65
	<i>Rhabdosargus sarba</i> (Forsskal, 1775)	Goldlined seabream	Vella mattawa	60
Sciaenidae				
Croakers	<i>Johinus amblycephalus</i>	Bearded croakers	Taru-kattelee	
	<i>J. dussumieri</i> (Cuvier, 1830)	Dussumieris croakers		40
	<i>J. macropterus</i>	Large finned croakers		
	<i>Niba maculata</i> (Schneider, 1801)	Blotched croaker	Vari katchelee	30
	<i>N. soldado</i> (Lacepede, 1802)	Solier-croaker	Vella-katchelee	60
	<i>Otolithes ruber</i> (Schneider, 1801)	Tiger-toothed croaker		70
	<i>Protonibea diacanthus</i> (Lacepede, 1802)	Spotted croaker	Kooral	120
Mullidae				
Goatfish	<i>Parupeneus indicus</i> (Shaw, 1803)	Indian gotfish	Kulnaveri/Mussara	40
	<i>Upeneus tragula</i>	Darkband gotfish	Navarei	
	<i>U. moluccensis</i> (Bleeker, 1855)	Goldband gotfish	Sennagarai	20
	<i>U. sulphureus</i> Cuvier, 1829	yellow gotfish		23
	<i>U. vittatus</i> (Forsskal, 1775)	yellow striped got fish		28

Table 1. Contd

Family/Groups	Scientific name	Common name	Vernacular name	Max. size (cm)
Drepanadae	<i>Drepane punctata</i> (Linnaeus, 1758)	Spotted sickle fish	Painthi Pulli	40
Spade fishes	<i>D. longimana</i>	Barred sicklefish	Pasanthi/Varipasanthi	
Ephippinidae	<i>Ephippus orbis</i> (Bloch, 1787)	Spade fish	Nulla-torriti	25
Mugilidae				
Mullet	<i>Mugil cephalus</i> Linnaeus, 1758	Flathead greymullet	Manla/Kasmeen	35
	<i>Valamugil buehanani</i> (Bleeker, 1853)	Buchanans blue mullet	Sarya	48
Sphyraenidae				
Barracuda	<i>Sphyraena jello</i> Cuvier, 1829	Banded barracuda	Ooli	150
	<i>Sohyraena obtusata</i> Cuvier, 1829	Obtuse barracuda	Ooli	40
Polynemidae	<i>Polynemus heptadactylus</i> Cuvier, 1829	Seven-finger threadfin	Nakola/Kola	27
	<i>P. sextarius</i> Bloch & Schneider, 1801	Black-spot threadfin	Kattikola/Kola	30
	<i>Polydactylus plebeius</i> Broussonet, 1782	Common threadfin	Polekala/Barmeen	45
Trichiuridae				
Ribbon fish	<i>Lepturacanthus savala</i> Cuvier, 1829	Small-headed ribbon fish	Savalai	100
	<i>Trichiurus lepturus</i> Linnaeus, 1758	Large headed ribbon fish	Sonaka-wahlah	120

Table 1. Contd

Family/Groups	Scientific name	Common name	Vernacular name	Max. size (cm)
Scombridae				
Mackerels & Tunas	<i>Acanthocybium solandri</i> (Cuvier, 1831)	Wahoo little tuna	Cheela meen	211(FL)
	<i>Euthynnus affinis</i> (Cantor, 1849)	Little tuna	Suraimin	100
	<i>Katsuwonus pelamis</i> (Linnaeus, 1758)	Skipjack tuna	Suraimin	100
	<i>Rastrelliger kanagurta</i> (Cuvier, 1817)	Indian mackerel	Kanagurta/ Kannangadatha	35
	<i>R. faughni</i> Matsui, 1967	Faughns mackeral	Kumla/Kanangeluthi	20
	<i>Sarda orientalis</i> (Temminck & Schlegel, 1844)	Oriental bonito	Suraimin	102
	<i>Scomberomorus guttatus</i> (Bloch & Schneider, 1801)	Indio-pacific seer fish	Vanjram/Naimeen	75
	<i>S. commerson</i> (Lecepede, 1801)	Narrow banded sear fish	Vanjram/Naimeen	220
	<i>Thunnus albacares</i> (Bonnaterre, 1788)	Yellow fin tuna	Soccer/Surai	195
	<i>T. tonggol</i> (Bleeker, 1851)	Longtail tuna	Suraimin	130
Xiphiidae				
Sword fish	<i>Xiphias gladius</i> Linnaeus, 1758	Sword fish	Kadu koppara	444

Table 1. Contd

Family/Groups	Scientific name	Common name	Vernacular name	Max. size (cm)
Istophoridae				
Marline & Sail fish	<i>Istophorus platypterus</i> (Shaw & Nodder, 1782)	Sail fish	Mayilmin/Yemungolah.	3.2m
	<i>Makaira indica</i> (Cuvier, 1832)	Black marline	Camban kola	4.6m
	<i>M. mazara</i> (Jordan & Synder 1901)	Blue marline	Camban kola	4.3m
Ariommidae				
Ariomma	<i>Ariomma indica</i> (Day, 1820)	Indian ariomma		25
Stromateidae	<i>Pampus argenteus</i> (Euphrasen, 1788)	Silver pomfret	Vavval/Vella-vavval	60
	<i>P. chinesis</i> (Euphrasen, 1788)	Chinese pomfret	Karu-vaval	40
Psettodidae				
Indian Halibuts	<i>Psettodes erumei</i> (Bloch & Schneider, 1801)	Indian halibuts	Erumei-nakku	64
Bothidae				
Floonders	<i>Pseudorhombus arbius</i>	Large-toothed flounder	Nakkumeen	
	<i>P. triocellatus</i>	Threespot flounder	Nakkumeen	
Cynoglassidae	<i>Cynoglassus lida</i>	Shoulderspot tong-sole	Nakkumeen	
	<i>C. lingua</i>	Long tong-sole	Nakkumeen	
	<i>C. arel</i> (Schneider, 1801)			38

Table 1. Contd

Family/Groups	Scientific name	Common name	Vernacular name	Max. size (cm)
Echenidae	<i>Echeneis naucratus</i> Linnaeus, 1758	Slender sucker fish	Attai neen/Ural/ Karungora	
Anguillidae	<i>Anguilla bengalensis bengalensis</i>	Long finned eel	Vellanagoo/Serum/Pambu	
	<i>A. bicolor bicolor</i>	Level finned eel	Vellangoo/Serum pambu	
Syngnathidae				
Sea horse	<i>Hippocampus kuda</i> Bleeker, 1852	Sea horse	Kadal kutjirai	
Holocentridae				
Squirrel fish	<i>Sargocentron rubrum</i> (Forsskal, 1775)	Redsolider fish	Chenguli/Parakanni	32
	<i>Myripristis mordjan</i>	Pinecone solider fish	Karuppuval /Putchakanni	
Acanthuridae	<i>Acanthurus bleekeri</i> Gunter, 1861	Bleekers surgen fish		40
Chlorophthalmidae	<i>Chlorophthalmus agassize</i> Bona parte, 1840	Shortnose green eye		15
	<i>C. bicornis</i> Norman, 1939	Spingjaw green eye		15
Percopnidae	<i>Bembrops caudimacula</i> Steindachner, 1875			
	<i>B. platyrhynchus</i> (Alcock, 1839)			
SHRIMPS				
Penaeidae	<i>Penaeus canaliculatus</i> Oliver	White prawn	Kathamba eral	
	<i>P. indicus</i> H.M. Edwards	Idine white prawn	Vella eral	
	<i>P. japonicus</i> Bate	Kuruma shrimp	Kathamba eral	

Table 1. Contd

Family/Groups	Scientific name	Common name	Vernacular name	Max. size (cm)
	<i>P. latidulcatus</i> Kishinouye	King prawn	Chori eral	
	<i>P. merguiensis</i> Deman	Banana shrimp	Vella eral	
	Fabricius	Giant tiger shrimp	Kathamba eral	
	<i>Metapenaeus affinis</i> H.M.Edwards	Jinga prawn	Chaya valucha eral	
	<i>Solenocera hextii</i> Wood-Mason & Alcock	Deep sea shrimp		
LOBSTERS				
Palinuridae	(Fabricius)	Orinate spiny lobster	Singi eral	
	<i>Panulirus homarus</i>	Green spiny lobster	Singi eral	
		Deep sea lobster	Singi eral	
Scyllaridae	(Lund)	Sand lobster	Kal eral	
CRABS				
Portunidae	<i>Charybdis cruciata</i> (Linnaeus)	Cross crab	Siluvai nandu	
	(Linnaeus)	Reticulate crab	Pulli nandu	
	<i>Portunussanguinoletus</i> (Herbst)	Spotted crab	Mukkannu nandu	
	(Forsskal)	Green mud crab	Pachai nandu	
Cephalopods				
Sepidae	<i>Sepia aculeata</i> Orbigny	Cuttle fish	Kadamba	
	Ehreberg	Cuttle fish	Kadamba	
Loligionidae	Orbigny	Squid	Kanava	
	Wakiya & Ishikawa	Squid	Kanava	

SEA SNAKES OF CHENNAI COAST, SOUTHERN INDIA

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ABSTRACT

This paper highlights the incidental catch of sea snakes collected from Chennai Coast, Southern India during November 2004 to October 2005. Of the 10 species reported from the previous studies, only five species were caught incidentally by various fishing gears.

INTRODUCTION

Sea snakes are one of the most successful groups of reptiles among marine animals. They are found in Tropical and Sub Tropical seas of the world. Of the fifteen living families of snakes, four are marine. Sea snakes belong to the Family Hydrophidae comprising 12 genera. The hydrophids are the most widely distributed group of marine snakes with 52 species. They occupy variety of habitats such as mangroves, swamps, estuaries and lower reaches of rivers (Heatwole, 1999).

Smith (1943) described 29 species of sea snakes in India, including the Coast of Pakistan, Bangladesh, Sri Lanka and Myanmar. Ahmed (1975) also described 29 species from Indian Ocean, of which 19 species are found in the collections of Zoological Survey of India. Murthy (1992) and Whitaker (2004) listed 20 species of sea snakes from Indian coasts.

Sea snakes of Chennai Coast have been reported by Aiyar (1907), M'Kenzinc (1820), Wall (1918), Murthy (1977, 1992) and Kalaiarasan and Kanagasabai (1994). From the above studies it was inferred that only 10 species were reported from Chennai Coast for the last 100 years (Table-1). From 1990 onwards there is no systematic study on Sea snakes of India. Lobo *et al* (2004) studied the morphometric relationships of marine snakes along the Goa coast. Significant difference in proportion of the fish families represented in the diet with the size or sex of *Lapemis curtus* along the Goa Coast were studied by Lobo *et al*. (2005) and their role in the tropic structure of coastal communities was described by Voris (1972).

Indian sea snakes have not been studied sufficiently. Knowledge on taxonomy and biology of sea snakes are fragmentary. Sea snakes are commonly encountered, as by catch in various fishing activities, yet there is little published information. Hence, the present study was aimed to collect additional information on the incidental catches of the sea snakes in the fishing gears along the Chennai Coast.

MATERIAL AND METHODS

The study was conducted at Chennai coast (Fig.-1) from November 2004 to October 2005. Chennai Coast is lying at 13°06'N and 80°18'E and comprises more than 60 coastal villages involved in active fishing. The Coast extends from Pulicat Lake to Kalpakkam and stretches for about 120 kms. In Chennai Coast, the Kasimedu is the largest fish-landing centre. The Chennai harbour is a protected area with placid waters. Effluents from the ships and docks pollute the seawater in and around the harbour area.

The information on sea snake was collected from local fisherfolk on the frequency of sea snakes trapped in their net. The fish landing centres (Kasimedu, Nochikuppam and Kovalam) were frequently visited during the early and late hours to examine the species caught in the net. The species brought alive to the Marine Aquarium of Marine Biological Station, Zoological Survey of India, Chennai by local fisherfolk were also included for our study. Periodical visits were undertaken all along the Coast in order to collect dead specimen washed a shore. Photographs were also shown to fisherfolk and enquiries made on their availability.

RESULTS AND DISCUSSION

During the study, a total number of 130 specimens belonging to three genera comprising 5 species; *Hydrophis spiralis*, *H. cyanocinctus*, *H. gracilis*, *Enhydrina schistosa* and *Lapemis curtus* were collected. Remaining five species recorded in earlier surveys were not found in the present survey. *H. spiralis* seems to be the common species while *H. gracilis* and *Lapemis curtus* are rare. Table-1 shows the occurrence of sea snakes reported by various authors in the Chennai Coast. The reason for the absence of 5 species could not be ascertained.

Out of 130 specimens collected, 74 are *H. spiralis* and 30 are *H. cyanocinctus*. Other two species *E. schistosa* and *H. gracilis* were represented by 18 and 7 specimens. Single specimen of *L. curtus* was recorded during September. Study of seasonal abundance indicated that maximum number (33) was recorded during June followed by July. Similarly the minimum number was recorded during May (Table-2).

The frequency, abundance and species composition of sea snakes varied with the seasons. Similar observation was also noticed by Heithaus (2001). The distribution and seasonality of sea snakes is influenced by various paramets such as salinity, temperature

Table-1. Sea snakes from the Chennai Coast reported by various authors

Sl. No.	Name of the species	Years			
		1975	1977	1990	2005
1	<i>Microcephalopsis gracilis</i>	-	*	*	*
2	<i>Enhydrina scchistosa</i>	-	*	*	*
3	<i>Hydrophis spiralis</i>	-	*	*	*
4	<i>H. Cyanocinctus</i>	-	*	*	*
5	<i>H. Caerles</i>	-	*	*	-
6	<i>H. fasciatus</i>	*	*	*	-
7	<i>Lapemis curtus</i>	-	*	-	-
8	<i>Kerillia jerdoni</i>	-	*	-	-
9	<i>Pelamis platurus</i>	-	*	-	-
10	<i>Praescutate vipirina</i>	-	*	-	-
	Total no. of species	1	10	6	4

Table-2. Seasonal availability of sea snakes during the study period

Name of the species	Months												
	Nov '04	Dec	Jan '05	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Total
<i>H. spirilis</i>	1	3	5	6	8	1	1	19	12	8	6	4	74
<i>H. cyanocinctus</i>	3	-	-	-	-	2	-	9	5	7	4	-	30
<i>H. gracilis</i>	-	-	-	-	-	-	-	3	1	1	1	1	7
<i>E. sachistosa</i>	4	-	2	-	-	1	1	2	6	-	-	2	18
<i>Lapemis curtus</i>	-	-	-	-	-	-	-	-	-	-	1	-	1
Total no. of individuals	8	3	7	6	8	4	2	33	24	16	12	7	130
Total no. of species	3	1	2	1	1	3	2	4	4	3	4	3	5

and depth. Some species of marine snakes nocturnal and others are diurnal. Other cycles may be of more importance than the day-night. In some cases, a combination of day-night and tidal cycle may influence the distribution and availability of sea snakes.

CONSERVATION MEASURES

Sea snake have been in great demand for leather industry for belts, wallets, watch bands, hand bags, jackets, ties, briefcases and shoes. Sea snake leather has been a part of the leather trade. Sea snakes are exploited for food in many Asian countries, Ryukyus and Manila. Sea snakes have long been considered to be of medicinal importance. In view of the above economic importance, the following conservation measures for the protection of sea snakes can be adopted :

1. Long term study on the seasonality and abundance of sea snakes and possible threats could throw more light on the conservation of Sea snakes in India.
2. As the fisher folk indiscriminately kill the Sea snakes due to fear, it is necessary to conduct awareness programme on Sea snakes.
3. The biology of sea snake has not been thoroughly studied in India. Hence the marine aquaria in Mumbai, Marine aquarium of Zoological Survey of India, Chennai and Chennai Snake Park Trust, Chennai can initiate the study on the biology of Sea snakes.

CONCLUSION

The absence of five species reported earlier could be due to impact of *tsunami* or changes in the marine eco system or due to insufficient effort. According to local fisherfolk, the species *K. jerdoni* and *L. curtus* were not trapped in their net in the last five years. The climatic changes could be the reason for the depletion of above species. It is the right time to undertake studies on the changes in the marine ecosystem with special reference to reptiles and in particular sea snakes.

ACKNOWLEDGEMENT

The authors are thankful to Dr. J.R.B. Alfred, Director, Zoological Survey of India, Kolkata for his encouragement and facilities provided.

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PLATE-I

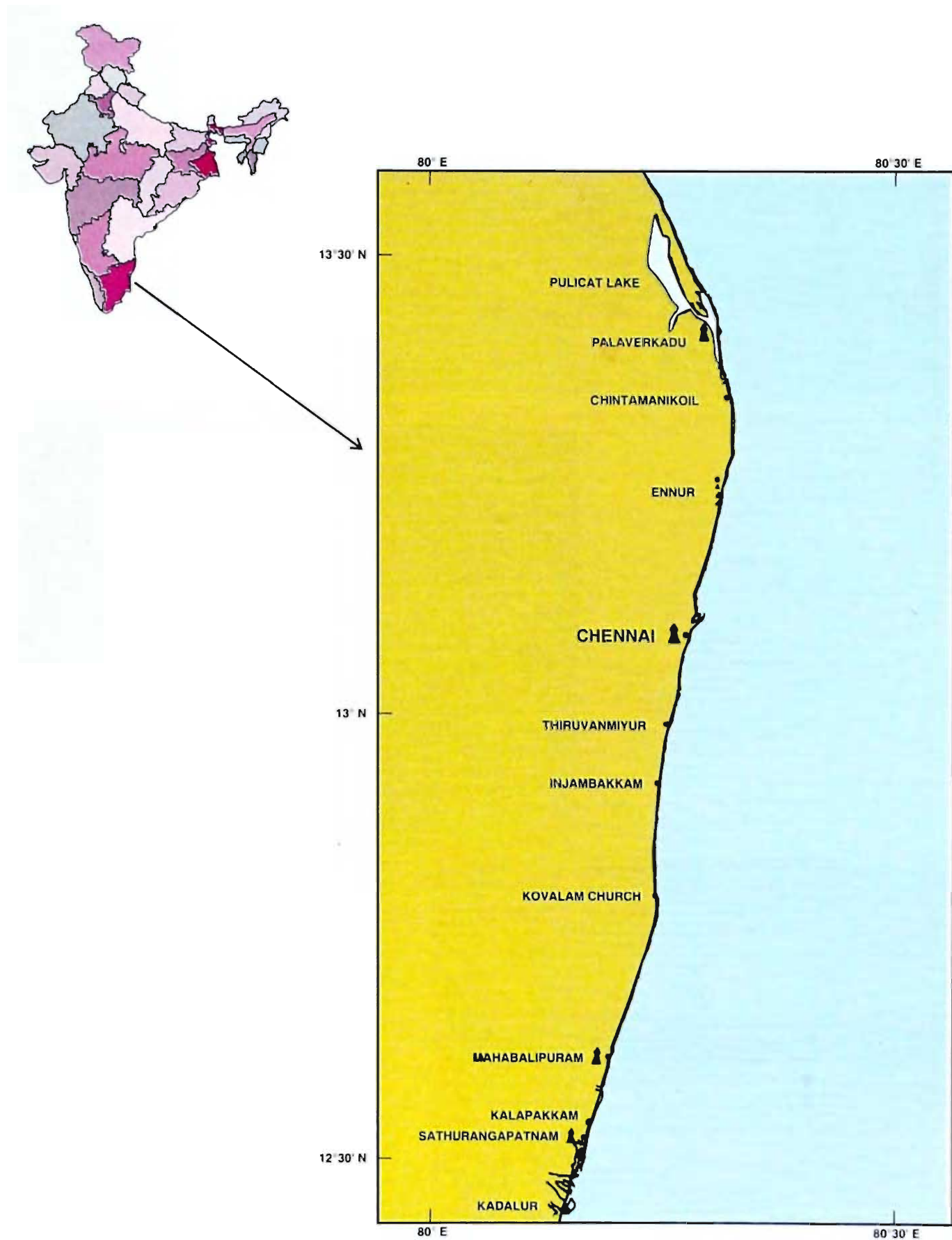
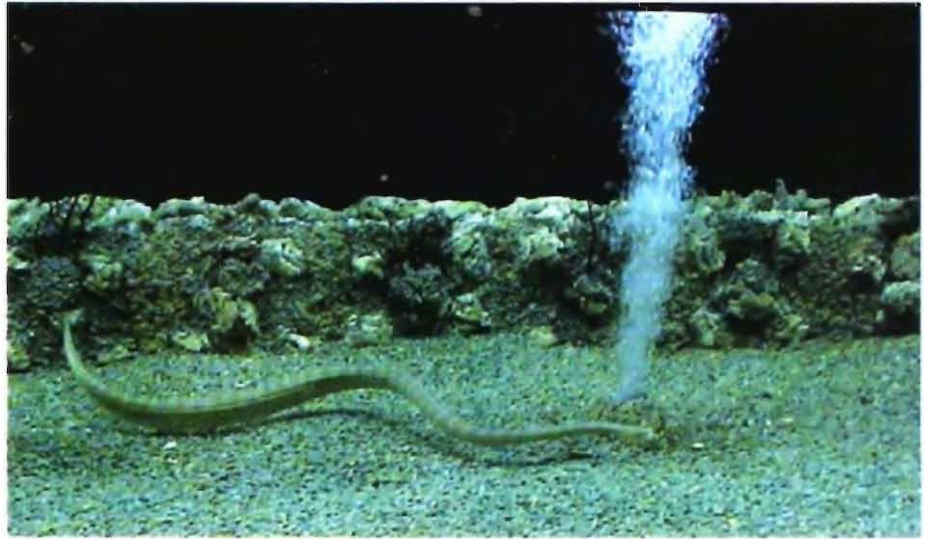


Fig. 1. Map showing Chennai coast

PLATE-II



Enhydrina sachistosa



Hydrophis spiralis



Hydrophis cyanocinctus

MOLLUSCAN FAUNA OF PULICAT LAKE, TAMIL NADU, SOUTHERN INDIA

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ABSTRACT

In the present study a total of 53 molluscan species were recorded at Pulicat lake from January to March 2000, of which 29 species were gastropods and 24 were bivalves. Among the 53, only four species were reported from the earlier studies. Remaining species are new records to Pulicat lake.

INTRODUCTION

Molluscs are soft bodied, heterogeneous group of animals with great antiquity and diversity. The shells of molluscs are extremely diversified in shape and colour. The majority of molluscs inhabit marine biotopes and they occur from the backwater zone, mangroves, intertidal, shelf and down to deeper waters.

The ecophysiology of the edible oyster was studied by Thangavelu (1983). The molluscan shell deposits, method and magnitude of exploitation, man power engaged, per capita income, percentage composition around Irakkam and Veynad Islands of Pulicat lake was studied by Thangavelu and Sanjeevaraj (1985). It is evident from the above literature that there had been little studies conducted on molluscan population from this area and hence this survey was carried out.

STUDY AREA

The Pulicat lake (lat 13°24' to 13°47' and Long 80°2' to 80°16' E) covers an average area of about 461 sq. kilometres. The average depth of the lake is about 1.5 metres with the maximum depth of about 7.0 metres. The lake at its Southern end, close to Pulicat town, opens in to the Bay of Bengal by a narrow mouth lagoon. In addition to this, there is also another seasonal pass near Duggirajapatnam. In the Northern part of the lake, there are two large Islands, Venadu and Irakkam and a much smaller one called Kurivithittu, on the Eastern side, the Sriharikota Islands extend North to South all along as a narrow strip

of Island, between the lake and the Bay of Bengal. After the establishment of the S.H.A.R. on the Sriharikota Island it is connected with Sulerpet town on the main land by a cement road. The Buckingham canal runs parallel to the entire length of the lake and it opens in to the lake here and there. The interesting feature of the lake is that during the flood season in November-December, the salinity is extremely low, but during the summer and post summer months (April to September) it is hypersaline. Hornell (1910) had observed fine sandy bottom along the shores of the lake near the lake mouth.

MATERIAL AND METHODS

Based on the nature of substratum (one zone characterized by the predominance of sand in the substratum, with little admixture of mud, a second zone having sand and mud on equal proportions with patches of weeds, and a third zone consisting entirely of mud) the sampling points were fixed. Of these three zones, the first and second zones are rich in flora and fauna. Sampling points were under following areas viz., Pulicat pass, Karimanal, Dhonirevu, light house kuppam, Kottaikuppam (Marine stations) Koraikuppam, Saththankuppam, Edamanikuppam, Kolathumedu, Moosamani lock, Annamalaicherry and Sunnambukulam (Brackish water stations) (Fig-1). Regular visits were made and dead specimens were collected for identification. Live specimens were also caught (which get trapped in fishermen's net) and released back after noting down the morphological features for identification. Collected specimens were preserved in 90% ethyl alcohol. The species identification was done by comparing with the collections of Marine Biological Station, Zoological Survey of India, Chennai, and Center for Advanced studies in Marine Biology, Porto novo, and in CMFRI Chennai.

RESULTS AND DISCUSSION

A total of 53 species of molluscs were collected and identified and given in the Table-1. 29 species were gastropods and 24 were bivalves. Except five species (which are restricted to estuarine zones *Meretrix casta*, *M. meretrix*, *Cardium sps*, *Sanguinalaria diphos*, and *Cymatium rhinoceros*) most of them belong to marine zones and *Oliva annulata* was found to be restricted to intertidal zone. The same observation was also made by Thangavelu and Sanjeevaraj (1988).

Rich beds of sub-fossil deposits are found around Irakkam and Venadu Islands of Pulicat lake. Collection of sub fossil deposits is also carried out by fisherman by mining and hand picking at Sunnambukulam, Kurivithittu and Arambakkam areas. Fishermen usually collect the shells, which are scattered and washed, ashore on the ground surface. Exploitation of sub-fossil deposits usually starts during the post monsoon period, i.e., in the months of January or February and extends till the onset of North-East monsoon. Six species were commercially exploited among which *Meretrix* was the most common. The other molluscs *Oliva*, *Bursa*, *Murex*, *Hemifuscus* and *Cardium* occur along with the sub-fossil deposits.

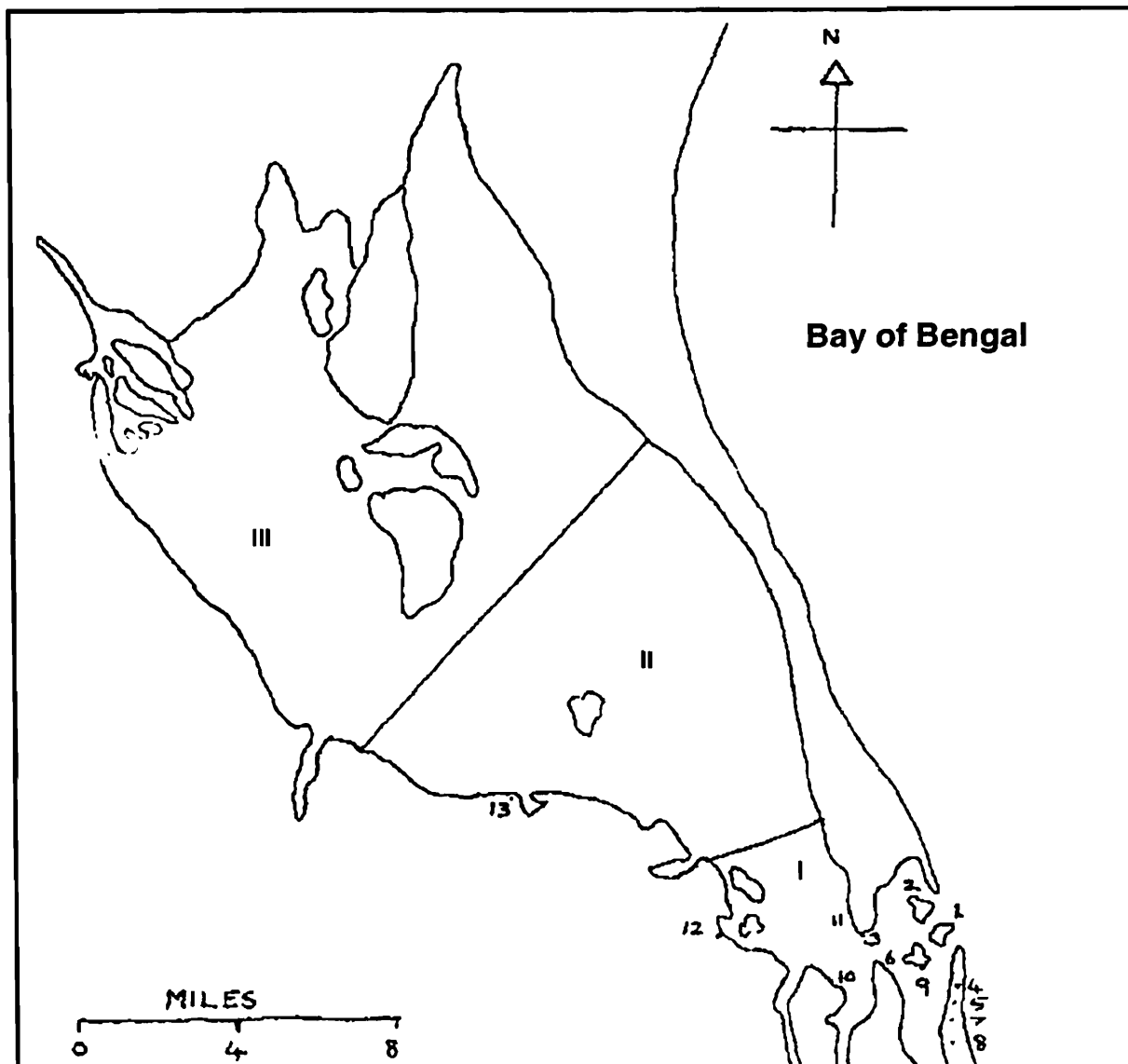


Fig. 1. Map of Pulicat Lake showing Maner

Zone I : Sand with little admixture of mu; Zone II : Sand and mud with equal proportions with patches of weeds; Zone III : Mud.

1. Pulicat Pass; 2. Karimanal; 3. Dhonirevu; 4. Gunankuppam; 5. Lighthouse-kuppam; 6. Kottaikuppam lock; 7. Koraikuppam; 8. Sattankuppam; 9. Edamani; 10. Kulathumedu; 11. Moonsamani lock; 12. Annamalaicheri; 13. Chunnambukulam.

The clams are regularly fished in this lake by poor fisher women residing at Athipattu, Minjur, Anuppampattu, Pakkam and Ennore. Green mussel *Perna viridis* also constitutes a major fishery at Southern part of Pulicat lake especially Pazhaverkkadu. Everyday about 3 tones of *P. viridri* is being harvested and sent to Cochin for processing..

Lime industry : The Pulicat Lake supports a lime shell industry with a shell production valued at Rs. 125 lakhs. The shell industry provides livelihood to about 900-1,000 fishermen who depend entirely on the collection of shells. Huge quantity of clam *Meretrix meretrix* and *Catelsia opima* are being collected for lime industry at Sunnambukulam.

Conservation of molluscan resources : Commercial exploitation greatly accounts for the reduction of molluscan population in the area. Pollution and environmental hazards

also cause death of molluscs in large numbers and to a lesser magnitude the professional shell collection from the wild. Indiscriminate fishing from natural bed may lead to depletion of stock of most of the molluscan resources. Very little is known about the destruction of molluscan stock by pollution and collection of ornamental shells by professional collectors from Indian coast.

Suitable farming techniques should be framed to increase the production of oyster fishery. The mining of sub-fossil deposits in the estuaries and river beds in the lakes damages the natural habitat and adversely affects traditional occupation of fisherman. The disturbance caused by dredging has affected the growth and survival of bivalves such as *Meretrix*. Well established licensing system for exploitation of clams should be attempted. To replenish the stock of live clams Clam Sanctuaries or Clam Parks are to be established.

Establishment of marine parks, total ban of exploitation of breeding stock, restriction of professional collection of ornamental gastropods, mesh-size regulation for commercial exploitation of molluscs and practice of farming techniques are some of the suggestions for conservation of molluscan resources from Pulicat Lake. In addition, the restriction to the season of operation may also go a long way towards improving the situation.

CONCLUSION

In the present survey 53 species were recorded. Among the fifty three (53), only four species were reported by Thangavelu and Sanjeeva Raj (1988). Remaining 49 species were new to this part of the Pulicat Lake. The species richness of mollusca has been found doubled over a period of two decades is interesting. In-depth study will yield the absence of 15 species as reported during 1980 or otherwise; the absence may be due to changes in habitat and water quality. As, the Pulicat Lake covers vast area; it is difficult to survey the mollusca within a short period. Hydrological parameters should also be monitored to throw more light on the factors influencing the distribution of molluscs and their species diversity and richness.

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Table 1. Check list of molluscan fauna of Pulicat lake

Gastropods	Bivalves
<i>Neverita didyma</i>	<i>Meretrix casta</i> *
<i>Turritella acutangula</i>	<i>Barbatia lacerata</i>
<i>Crenocrassatella attenuata</i>	<i>Macra sp</i>
<i>Babylonia spirata</i>	<i>Donax vittatus</i>
<i>Oliva annulata</i>	<i>Paphia sp</i>
<i>Solarium perspectum</i>	<i>Fulvia sp</i>
<i>Architectonica maxima</i>	<i>Vasticardium flauram</i>
<i>Chicoreus virgineus</i>	<i>Cardium sps</i>
<i>Bursa spinosa</i>	<i>Vepricaudum sinense</i>
<i>Murex adustus</i>	<i>Katelysia opima</i> *
<i>M. tribulis</i>	<i>Sanguinalaria diphos</i>
<i>Asprella cancellata</i>	<i>Azorinus minutus</i>
<i>Murex sp</i>	<i>Barbatia cometa</i>
<i>Epitomum scalase</i>	<i>Chlamys asperulata</i>
<i>Turritella attenuata</i>	<i>Nitticlotellinia iridella</i>
<i>Phalium glaucum</i>	<i>Meretrix meretrix</i>
<i>Natica didyma</i>	<i>Crassostrea madrasensis</i> @
<i>Babylonia japonica</i>	<i>Saccostrea cucullata</i> @
<i>Phatia tentilis</i>	<i>Anadara granosa</i> @
<i>Hemifusus pugilinus</i> *	<i>Perna viridis</i> @
<i>Cymatium rhinoceros</i> *	<i>Modiolus sp</i> @
<i>Fiscus fiscus</i>	<i>Lithophaga sp</i> @
<i>Cerithidea sp</i> @	<i>Donax sp</i> @
<i>Nassa sp</i> @	<i>Placenta placenta</i> @
<i>Hymnaea sp</i> @	
<i>Umbonium sp</i> @	
<i>Thais rudolphi</i> @	
<i>Turbo sp</i> @	
<i>Littorina sp</i> @	

@ – indicates recorded during present survey * – indicates recorded during 1988 survey

THREATS TO CORAL REEFS AND A PREVENTIVE CONSERVATION STRATEGY FOR INDIAN REEFS

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INTRODUCTION

Coral reefs, the highly productive ecosystems in the coastal zone are highly threatened in the recent years and are scientifically feared to extinction in just less than a half century. Conservationists are trying to keep pace with the degradation of the reefs. Due to their efforts, proper methodologies were formulated and baseline information is created in a record period. Even then, the impacts are compounding and more than 20% of the reefs were lost within 2 decades inflicting considerable economic loss to the countries to which they belong. Diagnosis indicate a stalemate, visualising the progress and degradation in the cross roads. Recent tsunami in the Indian Ocean region gave a jolt and it is feared that the threats are progressing in the race, breaking the deadlock.

India stands 10th in the world with a total coral area of 5,790 km², which is about 2.02% of world's reef area. Unfortunately, most of our reefs are considered to be in a very poor state. The threats to the Indian reefs are as varied as the reefs. This paper discussed in detail about the impacts of different threats and efforts taken by the conservationists. A prognosis for the progress of the Indian reefs is made with the studies carried out on the major reefs in India by Zoological Survey of India in the recent years, with the lessons learnt world wide and also by taking into reckoning the future threats, which is the need of the hour.

Human race is going to loose their another protective shield, which is the most beautiful and valuable. This time it is not the one from above, in the sky (Ozone layer depletetion), it is the one present below, in the sea. The news clipping given below from internet in 2001 clearly reiterates the statement made above.

WORLD CORAL REEFS TO DIE BY 2050, SCIENTIST WARNS : *The world's coral reefs will be dead within 50 years because of global warming, and there is nothing we can do to save them, a scientist warned Wednesday. "It is hard to avoid the conclusion that most coral in most*

areas will be lost," Rupert Ormond, a marine biologist from Glasgow University, told a science conference. "We are looking at a loss which is equivalent to the tropical rain forests."

Source : Reuters, http://enn.com/news/wire-stories/2001/09/09062001/reu_44864.asp

Coral reefs, the highly productive and beautiful ecosystems in the coastal zone are the highly threatened ecosystems. Most unfortunate fact is that their chief destroyer is none other than their own beneficiary. Ninety-three of the 109 countries containing reefs report that people have damaged their reefs. One scientist estimates that 5-10% of the world's reefs have been destroyed by human activity, and that at the present pace 60% could be lost in the next 20-40 years. Like never before, an ecosystem is subjected to unprecedented and unimaginable onslaught, both by natural and anthropogenic forces. The resulting damage is irreparable and *preventive* strategies alone can save this most valuable and most mishandled resources.

MAJOR THREATS TO CORAL REEFS, CONSEQUENCES AND ECONOMIC LOSS-WORLD SCENARIO

Coral reefs grow at a very slow rate, on an average of about 1.5 cm per year and require a calm environment with good circulation of water with specific physico-chemical conditions. They grow in waters with a temperature range of 25-30°C (never below 18°C) and salinity range between 27-38‰. Hence, their occurrence is limited between latitudes 35°N and 32°S and this adds to their quandaries making them vulnerable to endangerment when subjected to unfavourable conditions.

The major stresses to coral reefs around the world are 1. Sediment, 2. Inorganic and Organic pollution and 3. Over fishing, all directly created by humans. Another major threat to coral reefs is Bleaching due to Global warming and this is also an indirect pressure created due to faulty human activity.

Other anthropogenic impacts on coral reefs include, 1. Oil pollution, 2. Heavy metals and pesticides, 3. Engineering activities, 4. Destructive fishing, 5. Coral mining, 6. Physical damage from boat anchors and 7. Uncontrolled tourism. In a nut shell undoubtedly **much reef damage is anthropogenic.**

Natural threats to coral reefs are 1. Cyclones & Floods, 2. Coral Bleaching. 3. Coral predators (Crown of Thorns Starfish, *Drupella* etc.), 4. Coral diseases, 5. Coral borers (Sponges, Molluscs) and the latest addition in the Indian ocean region is Tsunami.

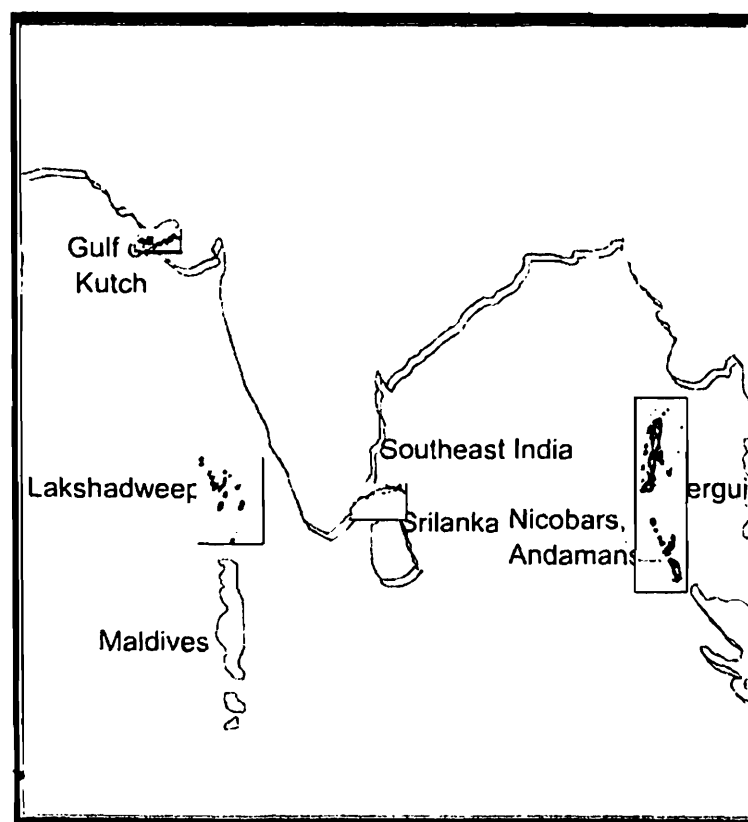
The resultant loss due to degradation of reefs is astounding. Few uses of Coral reefs are as follows: Reefs act as natural barriers against natural disasters and protect the shore from erosion, provide protein through fishery yield (occupying only 2% of earth surface and contributing 25% of world fishery yield), attract tourism, give us medicines, building material and support fancy industry, aquarium industry etc. They are called as Nature's natural sanctuaries of biological diversity and compared with tropical rainforests of the

land domain. Representative animals belonging to almost all the 43 animal phyla reported from the marine environment are found in coral reef areas. A 5 square meter reef microcosm sampled in the Caribbean yielded 534 species from 27 phyla, with a further 30 percent of species not fully identified (Spalding *et. al.* 2001). The skeleton of hard corals is being tried as alternative material for bone grafting. Coral growth depends on favourable climate, hence can be used as Indicators of climate change.

Economically, reefs are estimated to provide US \$ 375 billion per year in goods and services. Despite the great biological and economic value of coral reefs, anthropogenic threats to reefs have never been greater than they are today. Efforts to stall the degradation have increased multifold. Conservationists are trying to keep pace with the degradation of the reefs. Due to their efforts, proper methodologies were formulated and baseline information is created in a record period. Even then, the impacts are compounding and more than 20% of the reefs were lost within 2 decades inflicting considerable economic loss to the countries to which they belong and a recent diagnosis indicate a stalemate, visualising the progress and degradation in the cross roads. The prognosis for Indian Reefs is very discouraging with the result as, 'some good and many very poor' (Wilkinson, 2002).

CORAL REEFS OF INDIA, THREATS AND CONSERVATION STATUS

India stands 10th in the world with a total reef area of 5,790 km² which is about 2.02% of world's reef area. It is bestowed with all major reef types distributed discontinuously along its east and west coasts. Gulf of Kutch with 42 islands constitute the northern most



Map showing the four major reef regions in India

reefs of our country followed by isolated coral patches between Bombay and Goa (Nair and Qasim 1978). The occurrence of coral patches have been recorded in the intertidal regions of Ratnagiri, Malva and Rede, south of Bombay (Qasim and Wafer, 1979). Coral patches were also reported from Gaveshini bank about 100 km west of Malpe (Mangalore) (Nair and Qasim, 1978). The atoll reefs of Lakshadweep archipelago (about 20 reefs) are the next to follow on the west coast of India.

The coral formations in the east coast of India are not significant owing to the number of river inflows. The two major reef regions in the east coast are Gulf of Mannar and Palk Bay reefs on the South east coast of India (21 islands) and Andaman & Nicobar islands (more than 530 islands). Few stray recordings of corals were reported off Visakhapatnam and Orissa coasts.

The major anthropogenic threats in the Indian reefs are 1. Over fishing, 2. Destructive fishing, 3. Coral mining, 4. Pollution, 5. Sedimentation, 6. Uncontrolled tourism, 7. Coastal development and 8. Ornamental Trade. Natural threats which haunt coral reefs are 1. Tropical cyclones, 2. Bleaching, 3. Diseases, 4. Crown of Thorn Star fish (COT) and 5. Tsunami. Tsunami struck reefs in the Indian Ocean region at a time when the coral reef prognosis indicate a stalemate, visualising the progress and degradation in the cross roads. It gave an unexpected jolt and it is feared that the threats are progressing in the race, breaking the deadlock.

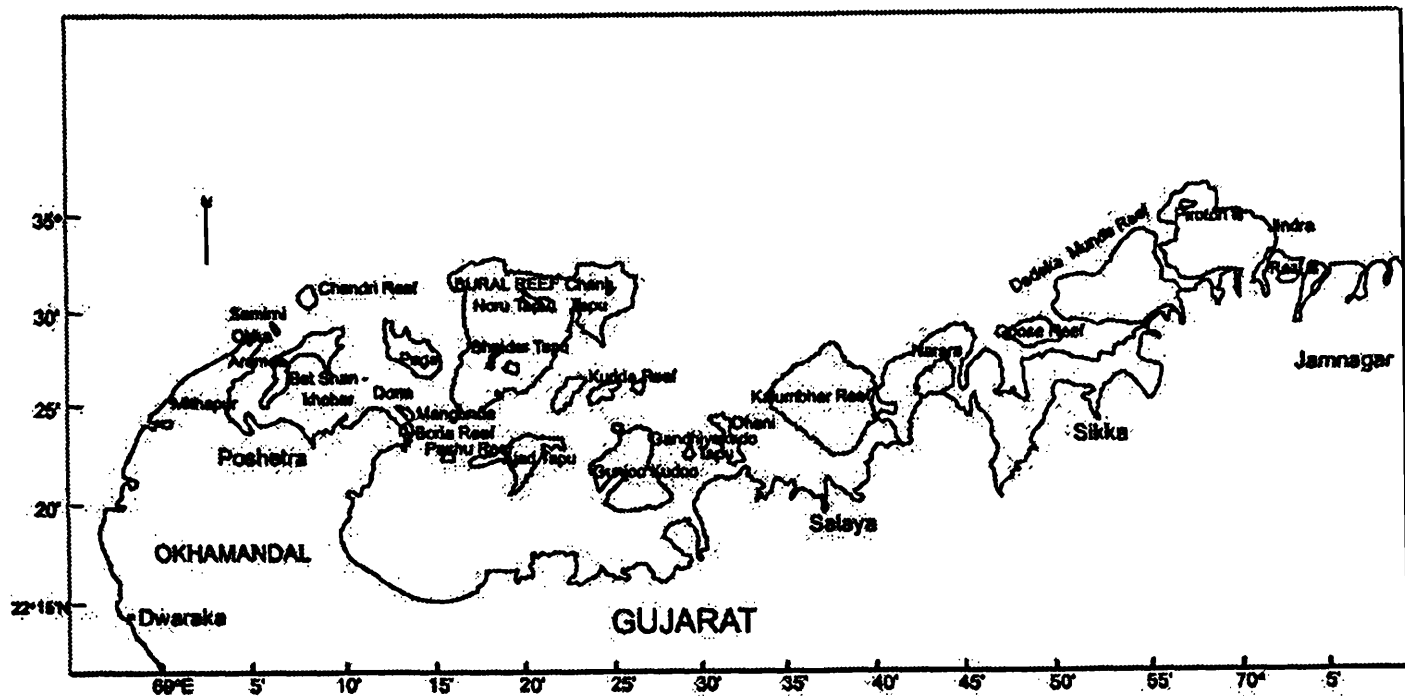
Inspite of India's initiation in coral studies and conservation in the form of the first ever Coral Reef Symposium organised at Mandapam, Tamilnadu on the banks of Gulf of Mannar in 1969, the follow up and progress was negligible due to lack of funds, cost and fear factor involved in diving operations etc. The momentum of reef studies once again picked up with the onset of world efforts in the South Asia region from 1997 and developed beyond expectations. But, the degradation is not stalled inspite of many conservation efforts. The most affected reefs are the reefs like Gulf of Mannar and Gulf of Kutch for which more attention is paid and the best reefs are the ones not much cared for (Andaman & Nicobar Island reefs).

Keeping in view, the fact that the threats are site specific, a critical analysis of the status of the coral reefs in the four major reef regions in India, Gulf of Kutch, Lakshadweep, Gulf of Mannar and Andaman & Nicobar islands with special emphasis to the major threats and conservation efforts is given below to detect the lacunas in the conservation efforts, which are responsible for the progression of the degradation in the Indian reefs.

REEF FORMATIONS OF GULF OF KUTCH

Location

This Northern most reefs of India are situated in the Gujarat state, which is located on the west coast. Gulf of Kutch is 170 km long and 7350 km² in area and consists of 42 islands in its southern part among which only 2 are inhabited. The reefs are mostly



fringing with patch, platform and coral pinnacles in some places. Gulf of Kutch is with characteristic arid climate, large semi-diurnal tidal amplitudes and negative water balance and is tectonically unstable.

Conservation status and hard coral diversity

Initially an area of 220.71 sq. km. located between Okha ($22^{\circ}30'N$, $69^{\circ}00'E$) and Khijadia $22^{\circ}30'N$ - $70^{\circ}05'E$ in the Kutch area is declared as the Sanctuary in 1980. Later in 1982 an area of 457.92 sq. km. located on the southern shores of Gulf of Kutch were redesignated into Marine National Park and Sanctuary owing to its importance in possessing the highly productive ecosystems in the marine environment the coral reefs and mangroves. The Marine National Park covers an area of 162.89 sq. km. and composed of 37 islands. It is the first Marine National park in India. The remaining 295.03 sq. km area of the sanctuary covers five islands and intertidal zone from Naiviakhi to Okha. Out of the 42 islands 34 islands have coral reefs with a reef flat area of 148.4 sq. km. The hermatypic scleractinian diversity is only 38 species belonging to 20 genera. On an average the live coral cover is about 36.03%. There are about 53 coastal villages with a population of 1,67,636 individuals.

Major Threats

The major anthropogenic threats of Gulf of Kutch are Sedimentation and increasing number of Industries. Coral Borers are the natural threats.

Prime Cure

Inspite of thick population at a rate of 526 individuals per square kilometre, it is the sedimentation which stands first in the list of threats instead of over exploitation, since

much of the population is vegetarian in food habits and not reef dependent. High siltation in kutch is attributable to high sediment input from River Indus which is located at about 100 km north west, tectonic instability, negative water balance, illicit felling of mangroves, dredging etc. As a primary effort to curb suspended sediment load in the waters the forest department has initiated various afforestation methods and achieved 30% success (Jani, 2005). Owing to its proximity to the Gulf countries many Oil industries have come up in the environs of Gulf of Kutch making the fauna and ecosystem live at the edge of endangerment.

An outline of the measures taken/to be taken in connection with Conservation of Reefs

Initiatives already taken

1. Coral mining banned.
2. Mangrove cutting banned.

Recent Initiatives

3. Mangrove afforestation programmes undertaken.

Areas which require attention

1. Strict decision about further industrial development.
2. Strict regulation of dredging activities.
3. Control over exploitation of living resources.
4. Development of oil spill management plans and their legislation.

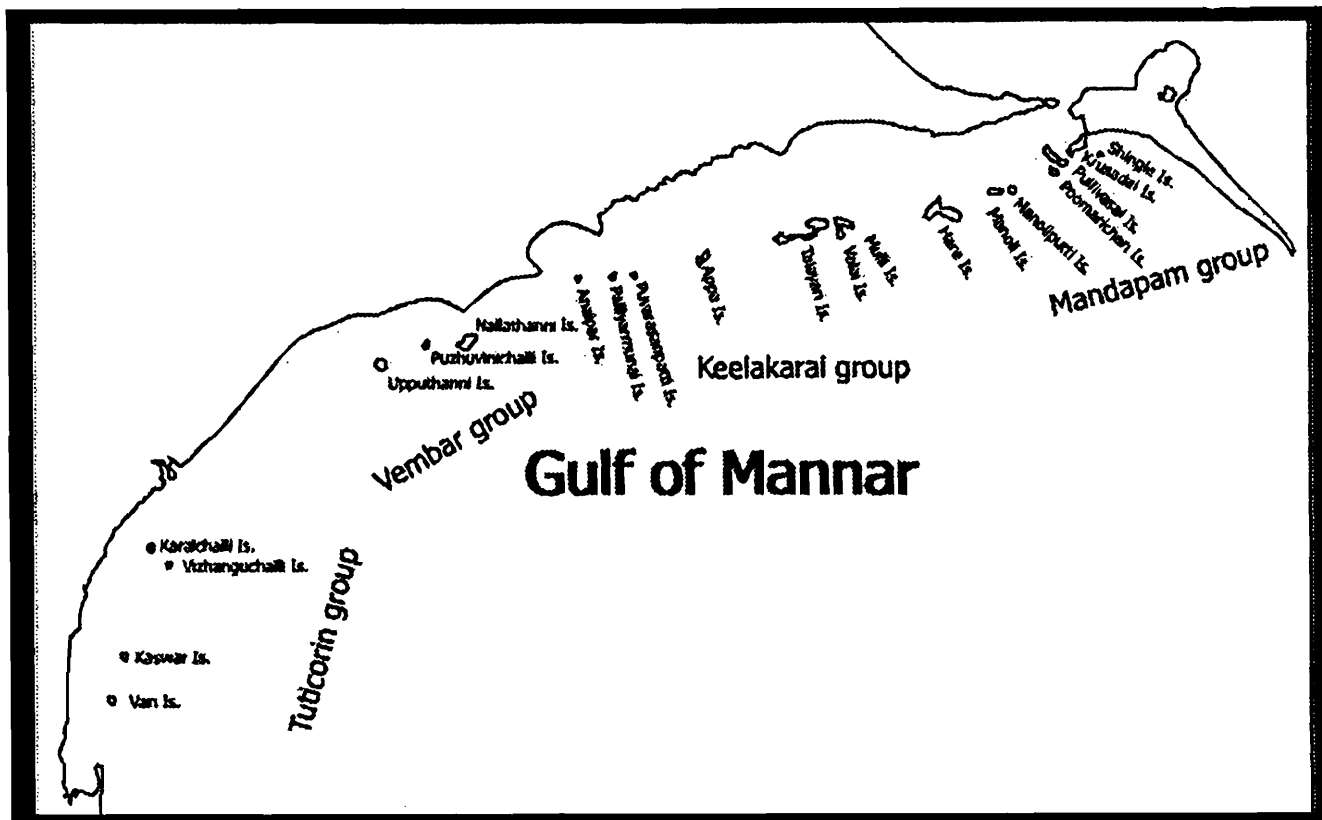
REEF FORMATIONS OF GULF OF MANNAR

Location :

Gulf of Mannar is the second of the mainland reefs of India and situated along the southeast coast in Tamilnadu State. Gulf of Mannar is one of the Marine Biosphere Reserves covering an area of 10,500 km.

Conservation Status and Hard Coral diversity

The 21 islands of Gulf of Mannar spread along a 140 km stretch between Rameswaram and Tuticorin were declared as Marine National Park in 1986 for the purpose of protecting wildlife and its environment (Upreti and Shanmugaraj, 1997). The Reef flat area of Gulf of Mannar is 64.9 sq. km. Nearly 3600 species of fauna and flora were recorded from this environment. The recorded hermatypic Scleractinian diversity is 83 species belonging to 28 genera. The recent average live coral cover in Gulf of Mannar is estimated as 36%. There are about 50 fishing villages along the Biosphere Reserve with a population of more than 50,000 individuals.



Major Threats

Over exploitation of reef resources, middlemen menace are the major anthropogenic threats recorded in this reef area. Bleaching and Cyclones are the natural threats.

The destruction to the reefs and reef associated organisms in the Gulf of Mannar and Palk Bay is perhaps unparalleled in the history of environmental damage to nature and natural resources in the recent past anguished Dr. Pillai (1975), the person instrumental for the conduction of the 1st International Coral Reef symposium in India. Tropical fish, sponges, gargonids, holothurions, pearl pars, chank beds, rare balanoglossus, curious sea horse, endangered turtles and the unique endangered herbivorous marine mammal, the *Dugong dugon*, each and every unique fauna mentioned above is commercially threatened and vanishing fast due to unabated anthropogenic activity.

Prime Cure

Considering the fact that the dependence of the local community on the reef resources as the major cause for the over exploitation of the resources, Gulf of Mannar Biosphere Reserve Trust (GOMBRT), Government of Tamilnadu based independent statutory trust with the help of GEF-UNDP funding support, initiated a management mechanism for people's participation with Community based Protection, Research, Eco-tourism, Awareness Creation and finally Community based Eco-development as tools to bring out the advancement (Naganathan, 2005). The management plan includes a component to eliminate the hidden and most dangerous problem of middle men menace. Middle men are money lenders who lend the money to the fisherfolk in advance and snatch away their catch at a

throw away prices, thus always keeping the fisherfolk below poverty line (Satyanarayana & Venkataraman 2000). This in turn increases the pressure on the reef resources.

An outline of the measures taken/to be taken in connection with Conservation of Reefs

Initiatives already taken

1. Coral mining banned.
2. Restrictions imposed on reef exploitation.

Recent Initiatives

3. Community based development.
4. Steps to curb Middlemen menace.
5. Steps to provide alternative employment.

Areas which require attention

1. Strengthening of the protective force.
2. Strict implementation of laws.

REEF FORMATIONS OF LAKSHADWEEP

Location

This Oceanic Reefs are of Atoll type and located in the Arabian Sea, western Indian Ocean, off west coast of India.

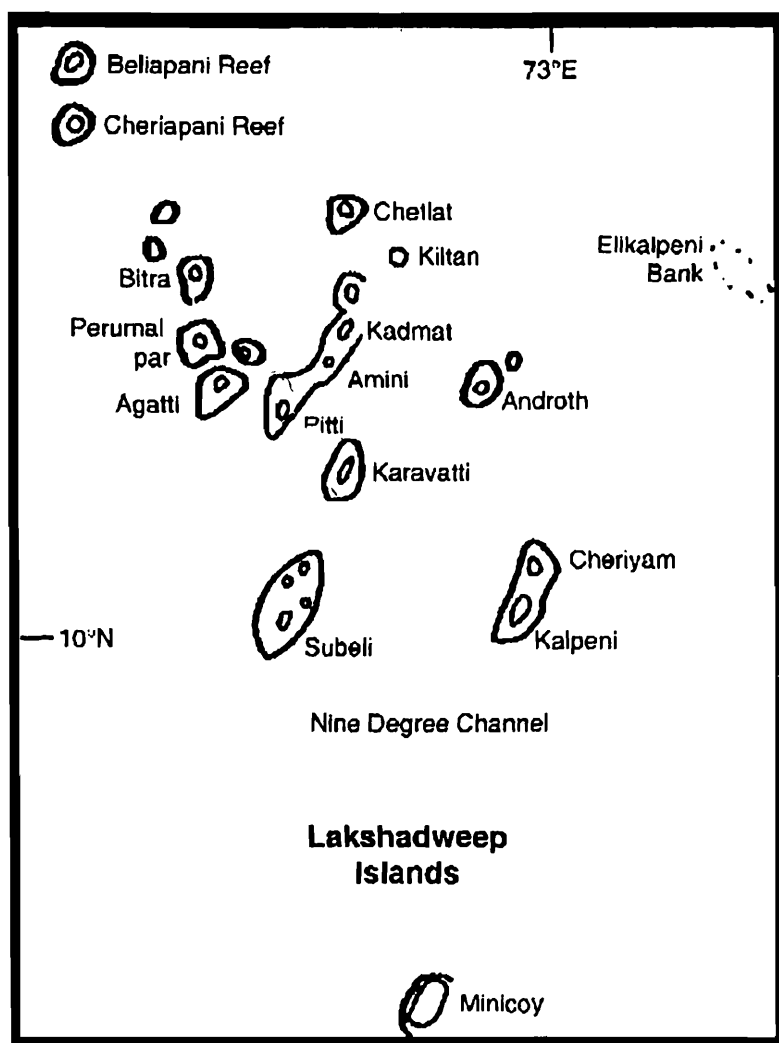
There are 12 atolls, 3 reefs and 5 submerged coral banks, located 220-440 km away from the coastal city of Kochi in Kerala. Lakshadweep archipelago is formed by a total of 36 islands ranging from 0.1 to 4.4. km² in size covering a total land area of 32 km². Out of 36, 10 islands are inhabited. It is the most thickly populated reef area in India with atleast 1,894 individuals per square kilometre. The Reef flat area of Lakshadweep is 140.1 km². It is an important biogeographic link between Southeast Asian reef region and East African Coast.

Conservation status and hard coral diversity

There is only one sanctuary meant for birds. Recorded Hermatypic Scleractinian diversity is 95 species belonging to 37 genera. About 80% of the coral cover is affected due to 1998 bleaching event and the average live coral cover is 18%. Coral reefs are recovering slowly and steadily after the mega bleaching event.

Major Threats

Major anthropogenic threats are Coral mining and dredging for construction purposes and navigational purposes, which are directly related to the thick population size. Coral bleaching is the major natural threat and it is the worst affected reef region in India during 1998 bleaching event.



Prime Cure

Population inflow is controlled by the Lakshadweep administration through issuing of permits. Local people are well informed about their socio-economic and environmental status by an array of NGOs through environmental education camps. Locals are trained to monitor their own reefs. Lakshadweep Coral Reef Monitoring Network (LCRMN) is the result of one of such efforts. The reef tourism in lakshadweep islands is the best when compared to other reef regions.

An outline of the measures taken/to be taken in connection with Conservation of Reefs Initiatives already taken

1. Permit to enter the islands.

Recent Initiatives

2. Community based development.
3. Regulations in dredging navigation channels.

Areas which require attention

1. Strict implementation of laws.

CORAL REEF FORMATIONS OF ANDAMAN & NICOBAR ISLANDS

Location

Andaman & Nicobar reefs are Continental reefs which rise from a submerged north-south trending ridge separating the Andaman Sea from the Bay of Bengal. There are approximately 572 islands in the chain, some of which are volcanic (Turner *et al.*, 2001). The reefs are mostly fringing type.

Conservation status and hard coral diversity

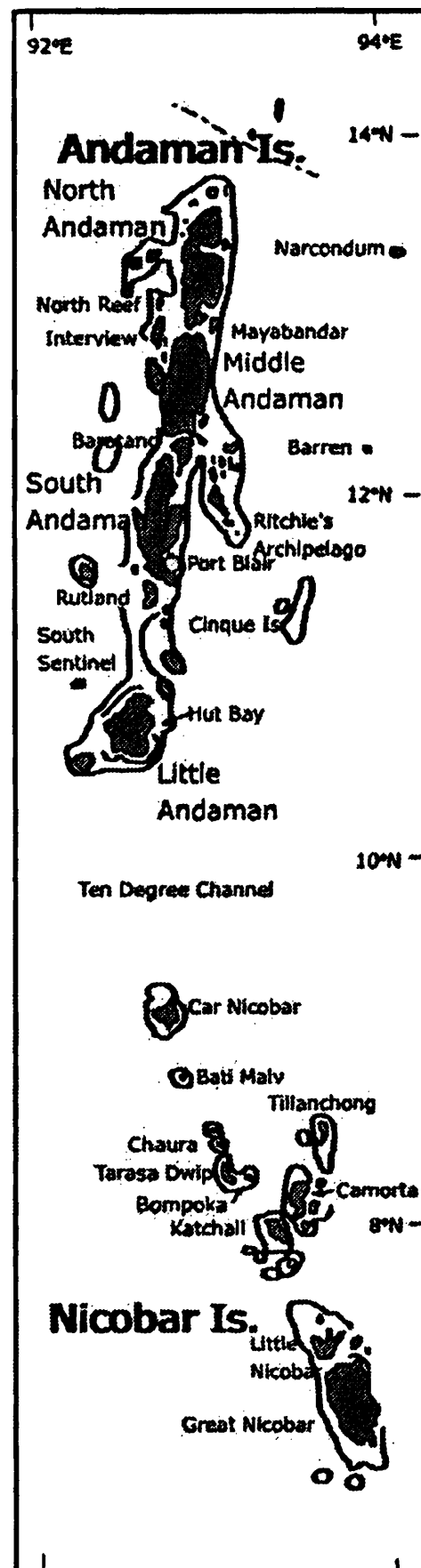
There are 5 Marine National Parks. 1 Biosphere Reserve and nearly 99 other protected areas covering an area of 8249 km². Out of 572 islands 38 islands alone are inhabited. Biodiversity of Andaman and Nicobar islands is less explored. The explorations so far made yielded 261 species of hermatypic scleractinians belonging to 59 genera. The live hard coral cover in the Andaman reefs on an average is 31.4 % (Turner *et al.*, 2001). The reefs are healthy and are considered as the best in the whole of Indian ocean region. The human population pressure is the least when compared to other reef regions with about 43 individuals per square kilometre (including tribes).

Major Threats

Poaching and rapidly growing coastal development are the major anthropogenic threats. Eventhough, Crown of Thorn Starfish blooms were the recorded natural threats, the recent 2004 Indian Ocean Tsunami struck these islands with great severity and changed the existing baseline information by tilting the land mass. Nicobar islands are submerged underwater atleast by 2 meters and North Andaman Reefs were lifted above by about 1.5 meters.

Prime cure

Combined efforts by the protective forces (forest department, police and coast guard) is being carried out to curb the menace of Burmese poaching and



regulations are strictly implemented to curb indiscriminate coastal developmental activities. Post-Tsunami assessments were made and efforts are being taken to install Indian Ocean Tsunami Warning System.

An outline of the measures taken/to be taken in connection with Conservation of Reefs

Initiatives already taken

1. Strict implementation of laws.

Recent Initiatives

2. Controlled tourism.

Areas which require attention

3. Strengthening of the protective force to curb poaching.

AN OVERVIEW OF THE MAJOR INITIATIVES TAKEN BY THE GOVERNMENT FOR THE PROTECTION OF THE REEFS

Sufficient legislative protection is provided by the Government for the protection of the reefs.

The Indian Forest Act 1927, Water (Prevention and Control of Pollution) Act 1974, Maritime Zones Act 1976, Forest (Conservation) Act 1980, National Forest Policy 1988, Wildlife (protection) Act 1972, Environmental (Protection) Act 1986, Coastal Zone Regulation Act 1991 and Coastal Zone Management Plans of State Governments and Maritime and Port Policy and the Port Act of states provide legislative protection to the Coral reef ecosystems and its fauna.

The following are the exclusive initiatives taken for the protection of mangrove and coral reef ecosystems

1. Formation of Special Committees for mangroves, wetlands & coral reefs.
2. Coral reefs and mangroves declared as ecologically sensitive areas.
3. Mining of corals and coral sands has been banned.
4. All exploitation and developmental activities in mangrove & coral areas banned.
5. Disposal of wastes from adjoining industries and carrying of wastes by pipelines through mangrove areas prohibited.
6. Capacity Building to monitor coral reefs and mangroves undertaken.
7. Amendment in Wild Life Protection Act 1972 (July 2001).

8. Creation of Biodiversity Authority of India.
9. Listing of Mangroves & Coral reefs in Coastal Regulation Zone-I (CRZ-I) and Category I of Marine Protected Areas.

A CRITICAL REVIEW OF THE PRESENT STATUS OF REEF CONSERVATION

All steps and initiatives for the protection of Coral reefs were meticulously taken. Programmes for creating awareness undertaken. Alternative employment plans drawn and carried out. Steps for community based development undertaken. Almost all legal aspects related to ecosystem protection covered and laws notified. Much of the reef areas are declared as Marine Protected Areas. Lot of Scientific projects sanctioned, Symposia organized, research carried out and results published. Capacity building is done and baseline information for all the reef areas almost created through regular monitoring.

In spite of all the above mentioned concrete steps taken and implemented, the degradation in the reef areas has slowed down negligibly. The blame is simply listed as 1. Lack of Awareness, 2. Poverty, 3. Greediness and 4. Loopholes in legal frame work and law enforcement.

A closer look at the problem exposes the following actual lacunae. Coming to the **Awareness creation**, each and every individual dependent on the reef areas is aware of what is happening to the reef because of his dependence on the reefs. In fact proper awareness is required for the people who are not dependent on reefs including the law enforcing personnel and members belonging to the reef management. There are instances where the major reef builders were not taken as the target species for protection and dead coral shingle is considered as mere inorganic material without proper knowledge about its importance in the development of a live coral reef. Much of the reefs are getting eroded due to exploitation of dead shingle and sand from the reef areas. Awareness have to be created to other stake holders who are not directly reef dependent.

None of the **alternative employment** activities were successful in discouraging the local population from their dependence on reef exploitation. In many instances they were considered as additional employment avenues for their economic growth.

Community based development was mostly unsuccessful since there is lack of belief among the involved parties and it is rather treated as a work to be carried out than as personal commitment.

Laws and protection related to ecosystems and associated fauna and flora always become weak when, the law breaker is poor and illiterate and his existence itself is in question. Non-coordination among different agencies related to coral reef areas due to conflicting mandates also is one of the reasons for poor law enforcement.

There is clear cut non-coordination among the reef researchers leading to duplication or repetition of work. There is no agency to check the authenticity of the work carried out, leading to publication of contradictory and confusing results. When one publication boosts the number of publications related to reef research as more than 2000 within a short span of time. Another publication projects that 'the scientists who have worked on coral reefs have tended to focus their attention on exploitation studies or taxonomic listings (Arthur, 1999).

Although baseline information related to reef monitoring is created for all the reef regions in India, the data collected is not standardized due to lack of proper training and understanding.

Capacity Building efforts are partially successful due to discontinued presence of the personnel or researchers trained, in the reef areas due to transfers and new employment opportunities.

In a nut shell, Lack of People's participation, Conflicting and confusing laws, Poverty and Illiteracy of Grass-root level stakeholders, Conflicting mandates of departments operating in the reef areas, Lack of awareness among non-reef dependent stake holders, Lack of proper baseline information and Lack of permanent capacity are responsible for the failure of our efforts to stall degradation.

A PREVENTIVE CONSERVATION STRATEGY

Much of the efforts taken so far are aimed at cure rather than prevention. A concrete preventive strategy is the need of the hour to save our valuable reefs.

Either cure or prevention is not possible in the reef areas without the participation of local people even though some frustrated economists put it as a futile effort. The direct reef dependent stakeholders have to be communicated properly and it must be for the community by the community, approach.

Sense of belongingness must be created among the local community. Local Media, Audio-visual projections, Small mementos like T-shirts, Awards for protecting reefs provide opportunities for involving local community with enthusiasm. **Children of the local community must be attracted, to catch them young.** Competitions and awards among students create awareness and ultimately a sense of belongingness as they grow. Visits by popular personalities like cinema artists and politicians bring remarkable changes in the attitude of the local community. *There is no epic Ramayana if the hunter was not turned into poet 'Valmiki'* There must be regular visits to get feed backs to sustain the involvement of the local community.

Community based management is doing wonders in many countries. Local people must be guided to empower themselves to manage the reefs in a sustainable way. Development of Reef Tourism with local community ownership creates alternative employment to many. Skilled fishermen have to be turned into reef boat operators and skilled reef trainers and guides. Initial infrastructure and technical know how about sustainable technologies like creating environmental friendly energies must be provided to them.

Local motivating groups composed of local people have to be developed. Local people have to be trained to monitor their own reefs scientifically. They must be encouraged by providing employment in reef related positions like reef watchers etc. Awareness creation to non-reef dependent stake holders must be done through the trained and talented people from the local community.

The net annual benefit of Indonesia through reefs is 1,647 million US dollars. Sustainable fisheries contribute 1,221, through Coastal protection 314, Tourism and Recreation yield 103 and Aesthetic activities another 9 (Burke *et. al* 2002). If properly handled and trained, especially because of the change in their life style, the local communities along the reef areas become the best protectors of the reefs. In Indonesia artificial reefs are developed by coastal communities to attract tourists to the resorts they have built along the coast.

INSTITUTIONAL CO-ORDINATION AND DEVELOPMENT

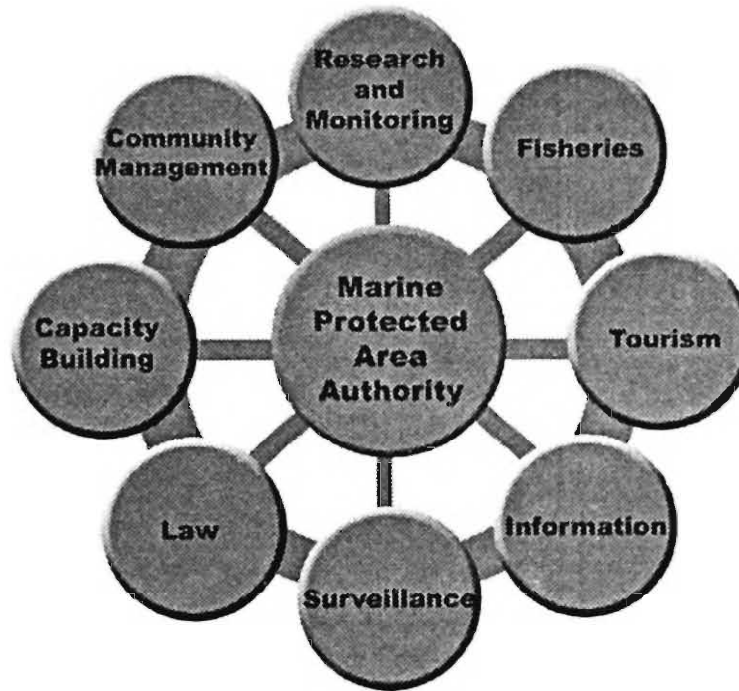
To streamline the reef related activities and to sustainably provide a direction to the conservation measures being taken, Institutional co-ordination is very very important and it must be a full-time duty of a separate Institution. Since almost all the marine ecosystems are interdependent and exchange faunal and floral components, a. Multi-disciplinary Institution with the name of **Marine Protected Area Authority** can be developed.

Divisions for Reef Research and Monitoring, Reef fisheries, Reef Tourism, Reef Information, Reef Surveillance, Reef law, Reef Capacity building and Reef community communication have to be developed.

Monitoring and maintaining the Health and water quality of the reefs is to be made as the prime objective of the Reef Research and Monitoring Division. Duplication of research is to be curbed through this division.

Identification and protection of breeding and nursery grounds of fin and shell fishes, establishing zonation, regulating reef fisheries and Aquarium trade will be the prime objectives of Reef fisheries division.

Formulating reef friendly tourism, like installing buoys to avoid anchor damage, Creation of movies and communication media to inculcate reef friendly activities among



Coral Reef Preventive Protective Shield Strategy Diagram

tourists and to regulate reef tourism with the local people participation should be the main mottoes of the Reef Tourism division.

Creation of databases (related to fisheries, ecology, reef health, socio-economics etc.,) GIS maps, Atlases, pamphlets, websites for easy accessibility of information about reefs should be the prime objective of Reef Information Division.

Reef Surveillance division must deal with the co-ordination and improvement of protection forces like Forest Department, Coast Guard and Police in the reef areas and ensure effective patrolling.

Since the threats are site specific. Specific laws are to be formulated depending upon the problem faced. Laws are also to be formulated depending upon the population and exploitation status of the reef biota. Conflicts arising due to fishing etc., also should be the mandate of the Reef law division.

Reef capacity building division has to train local people especially facilitators and motivators, formulate and implement different training courses depending upon the target group like policy makers, reef managers, judges, advocates, school children, laymen etc.

Reef Community Management division is the crucial and most important division at least in the initial stages of community based management and has to formulate innovative means and methods for empowering the local community to manage coral reefs in a sustainable way and also look into matters like alternative income generation and community related problems like middle men menace etc.

The most important aspect is to involve and employ the reef dependent population in every division and event and there must be always co-ordination and networking among different divisions and the regulating agency, the Marine Protected Area Authority (MPAA). Until the development of an Institution like MPAA atleast a networking must be established among all already existing institutions/departments to visualize the outcome of such a networking.

A global estimate made on the value of coral reefs of the world in goods and services was US \$ 375 billion. The investment in research, monitoring and management is probably less than US \$ 100 million per year i.e., less than 0.05% of the value (Wilkinson 2002). In our country the investment is much less and sure to improve our country's economy and ultimately in the conservation and management of our unique paradises underwater.

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