MECOS 09

International Symposium

Marine Ecosystems Challenges and Opportunities

9 - 12 February 2009, Cochin

MBAI

Book of Abstracts

Marine Ecosystems
Challenges and Opportunities
(MECOS 09)

BOOK OF ABSTRACTS

Organised by

MARINE BIOLOGICAL ASSOCIATION OF INDIA
COCHIN

February 9 - 12, 2009
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MBAI

Marine Ecosystems
Challenges and Opportunities (MECOS 09)

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FOREWORD

Marine ecosystems contain several unique qualities that set them apart from other ecosystems. Of the 89 elements occurring in nature, the presence of 80 has been confirmed in seawater. It is perhaps true that the remaining 9 elements are also present, but in concentrations too small to be detected. This wide range of substances dissolved in seawater has placed the marine organisms in a more advantageous position than their freshwater counterparts. These elements provide the essential materials required for the synthesis of all the basic nourishments of the body including the skeletal support of marine animals. In the terrestrial ecosystems, the physical boundaries are well marked and environmental variabilities are rather wide. The terrestrial organisms and ecosystems have developed internal mechanisms to cope up with variabilities. In contrast, in the marine ecosystems, the physical variability is small and extends over very long time scales due to the large thermal capacity of the oceans and the long periods of exchange between deep and near shore waters. Consequently, the marine ecosystems are more vulnerable to large-scale environmental changes because they do not have the internal adaptability inherent in the terrestrial systems.

Marine ecosystems cover over 70% of the earth's surface, and harbour 32 of the 33 known animal phyla. However, only 15% of the world's recorded species inhabit the sea. Scientists of Census of Marine Life have recorded about 235,000 species of marine organisms. This is in comparison to about 1.5 million terrestrial plants and animals. Nevertheless, the diversity and productivity of marine ecosystems are important to human survival and well-being. These habitats provide us with a rich source of food, medicine and income, and support species that serve as animal feed, fertilizers, food additives and cosmetics. Mangroves, reefs and sea grass beds provide protection to coastlines by reducing wave action, and helping to prevent erosion, while areas such as salt marshes and estuaries act as sediment sinks, filtering runoff from the land. Despite the importance of marine ecosystems, increased human activities such as overfishing, coastal development, pollution and urbanization have caused immense damage and pose serious threat to marine biodiversity. Climate change exacerbates this situation. Raising seawater, sea level, salinity and acidity would seriously affect the distribution and abundance of plants and animals in the oceans.

To address these concerns, and to discuss about the possibilities of converting the challenges into opportunities, the Marine Biological Association of India (MBAI) is conducting the International Symposium Marine Ecosystems Challenges and Opportunities (MECOS 09) during February 9 – 12, 2009 at Cochin. The MBAI, established in 1958, has completed 50 years of service for the cause of research on marine biology. It has a membership of over 600 scientists, researchers and teachers. It has conducted nine symposia and seminars.

The announcement of MECOS 09 attracted abstracts from scientists, researchers and teachers from India and a few Middle East countries. A total of 231 abstracts were accepted for oral and poster presentations. The abstracts were categorized into

six sessions *viz*., Ecosystem Services (44 abstracts), Management Strategies (51), Ecosystem Assessment (47), Opportunities (41), Ecosystem Health (33), and a special session on Climate Change (15 abstracts). The Book of Abstracts contains all these 231 abstracts and in addition, three invited keynote addresses. In all, 755 authors have contributed and the presenting authors are from 60 affiliations such as research institutions, universities and colleges. Central Marine Fisheries Research Institute, Cochin (73 abstracts), Cochin University of Science and Technology, Cochin (22 abstracts) and Annamalai University (13 abstracts) are the major contributors.

A perusal of the abstracts indicated the topics prioritized for research in this region. When the first announcement of the Symposium was made, seven sessions were proposed, but abstracts were received for only six sessions. There was no abstract for the session on Economics of Ecosystem Restoration. For the special session on Climate Change, we received only 15 abstracts. These two important areas of research should receive increased attention of institutions and universities in the future. Abstracts on several marine plant and animal groups including dinoflagellates, yeast, bacteria, fungi, corals, mangroves, seagrass, finfish, shellfish and cetaceans were received and are presented in this Book. Maximum number of abstracts was on finfish (43) and fisheries (40). Abstracts on sea snakes and sea birds were conspicuously absent. In general, abstracts on linkages between organism-climatic/oceanographic factors-populations-ecosystems were, to a large extent, missing. Nevertheless, the Symposium is expected to contribute immensely to gain an insight into the challenges of preserving, and to advantageously use the goods and services of the marine ecosystems.

We thank all those who have contributed abstracts to the Symposium.

February 2, 2009

Editors
Book of Abstracts
MECOS 09

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Ecosystem Services - ES

ESO 01 **MECOS 09**

EASTERN ARABIAN SEA MARINE ECOSYSTEMS

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Two distinct marine ecosystems are identified in the Eastern Arabian Sea namely, the North East Arabian Sea Ecosystem (NEASE) and the South East Arabian Sea Ecosystem (SEASE) that lie broadly north and south of the Findlater jet. NEASE extends between 15º and 22ºN, and SEASE between 8º and 15ºN latitudes and contributed almost equal share to the average annual fish yield (47.1% and 52.9%, respectively) from the west coast for the period 1995-2004. However, the physical forcing mechanisms, energy transfer systems and the structure of the biotic community of these ecosystems are remarkably diverse, justifying the need to treat them as two distinct ecosystems.

Data and samples for this study were gathered from the cruises of *FORV Sagar Sampada* covering the Summer Monsoon – SM (June to September), Fall Intermonsoon – FIM (October), Winter Monsoon – WM (November to February) and Spring Intermonsoon (March to May) seasons of the Eastern Arabian Sea during the period 1998 to 2006. This work was conducted under the Marine Living Resources Programme. During SM, the SEASE is under the influence of upwelling all along the coast as evidenced by the upslope of the 26 ºC isotherm towards the coast, low SST (26 ºC), higher surface nutrients (NO_3 > 1μM) and low levels of dissolved oxygen (~190 μM) in the surface waters. The nutrient rich upwelled waters are transported offshore up to ~200 km by the combined actions of Ekman transport and westward propagating Rossby waves, transferring the entire shelf region of SEASE to an area of high primary production (average: 43 mg $C.m^{-3}.d^{-1}$). This is followed by a proportionate increase in zooplankton biomass (5 $ml.m^{-3}$), thereby striking a balance between primary production and grazing, which explains the limited export flux and sinking of organic carbon to deeper waters of SEASE in comparison to NEASE. Herbivory is dominant due to the abundance of grazing zooplankton (copepods, euphausiids) and larvae and adults of herbivorous fishes like *Sardinella longiceps*. Peak spawning period for many of the fish stocks in SEASE fall within this season. A maximum abundance of 25,473 fish larvae per 1000 m^3 were recorded. The influence of SM on NEASE are rather limited to the zone of divergence north of Findlater jet where open ocean upwelling occurs as evidenced by relatively low SST (26.3 to 28 ºC) and chlorophyll values above 1 $mg.m^{-3}$. This area of the NEASE appears to be a major breeding ground of the myctophid *Diaphus arabicus,* evident from the collections of more than 20000 larvae/1000 m^{-3} during SM. During the season, the area is covered by the Arabian Sea High Saline Waters (ASHSW) with surface salinity

of 35.5 and 36 psu for coastal and open ocean waters, respectively. The SST varies between 28.5 and 29 °C. Primary productivity ranges from 3.81 mg $C.m^{-3}.d^{-1}$ in coastal waters to 4.15 mg $C.m^{-3}.d^{-1}$ in the open ocean.

Productive season in NEASE corresponds with the WM. Under the influence of the cold and dry northeasterlies, the surface water along the coast and open ocean becomes more dense and sinks causing convective mixing of waters. These maintain the supply of nutrients to the surface and promote primary production (13 to 27 mg $C.m^{-3}.d^{-1}$). Secondary production is rather low (0.2 to 0.4 ml. m^{-3}), which may perhaps explain the appearance of extensive Oxygen Minimum Zones (OMZ) in the intermediate waters of NEASE through bacterial decomposition of the exported organic matter. Peak spawning season of fishes such as the sciaenids, eels, leiognathids, ribbonfishes, bombay duck etc is during the WM. Carnivory is dominant in view of the abundance of zooplankton such as the chaetognaths, ostracods and carnivorous fishes like bombay duck, ribbonfishes etc. During WM season, the SEASE is characterized by SST which are higher by 2°C than the NEASE, less saline surface waters (~ 34.00 psu), low primary productivity (2 to 4 mg $C.m^{-3}$ d^{-1}) and below average zooplankton biomass (0.1 to 0.2 $ml.m^{-3}$). The fishery habitats of the two ecosystems are also quite diverse. While pelagic fishes such as the oil sardine, Indian mackerel and whitebaits (*Stolephorus* sp.) contribute 23.2%, 12.3% and 3.9% respectively to the annual average yield from the SEASE, their counterparts in the NEASE are dominated by the bombay duck (9.3%) and *Coilia* sp. (3.3%). The semi-pelagic realm of the SEASE is dominated by the scads, *Decapterus* sp. (4.5%), whereas the NEASE is dominated by the ribbonfishes (10.1%) and white pomfret. On the whole, the pelagic realm of the SEASE is more productive in comparison to the NEASE, whereas the demersal realm of NEASE is more diverse and abundant than the SEASE.

ESO 02 **MECOS 09**

SEASONAL VARIATION, DIVERSITY, SPATIAL AND VERTICAL DISTRIBUTION OF MAJOR ICHTHYOPLANKTON IN THE ARABIAN SEA

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Ichthyoplankton assemblages and the factors affecting their spatial and vertical distribution in the Arabian Sea were explored. A total of 1325 samples from 240 stations between 8°N and 22°N in the Indian EEZ were analysed. The samples were collected during the Marine Research Living Resources programme from May 1998 to June 2002. The total number of larvae collected during summer monsoon was the maximum (63%) of all seasons and was three times higher than that of other seasons. Myctophidae represented 35.61%, Clupeidae 19.96% Phosichthyidae 9.95%,

Gobiidae 9.66%, Scombridae 6.71%, Bregmacerotidae 5.07% and Carangidae 3.23%. The abundance of fish larvae indicated that majority of fishes spawn during summer monsoon. However, the abundance of priacanthid, bregmacerotid and hemiramphid larvae during intermonsoon fall showed that the peak spawning of these fishes is in October.

Abundance of 3 families of mesopelagic fish larvae (Myctophidae, Phosichthyidae and Bregmacerotidae) was the highest during winter monsoon among which the myctophid larvae were very high. Pelagic fish larvae showed abundance of Scombridae and Carangidae during intermonsoon spring, but Clupeidae in summer monsoon. Pockets of high density of distribution were the characteristic feature of the summer monsoon.

It was found that Myctophidae was the most abundant family. In all seasons, the myctophid larval abundance was noticed in the northern latitudes above 300-BT strata. The data also revealed that there was no specific breeding season. In all the seasons and depths, the larvae obtained were composed of pre-flexion, flexion and post-flexion stages. Almost all myctophid larvae undergo diel vertical migration. Myctophid larvae were less in the strata below thermocline layer. The low density of myctophid larvae in deeper strata might be due to intolerance to low oxygen. Distribution of Myctophidae shows remarkable seasonal changes; the densities were high during summer and winter monsoon period. Among the mesopelagic fishes, *Diaphus arabicus* had the highest abundance.

Gonostomatidae was distributed mainly in the deeper strata (1000-500 m and 500-300 m). It was observed that the densities of gonostomatid larvae were more in the southern latitudes in all seasons and strata unlike the myctophids. *Cyclothone* sp., the most abundant genus of gonostomatid larvae in the coastal assemblage during intermonsoon spring was widely distributed in the northern latitudes. Phosichthyidae were distributed vertically from 0-1000 m depth, but abundant at 300-BT strata. Very high densities (30500/1000 m^3) of phosichthyid larvae during winter monsoon from the surface layers of 19 °N, 70°E consisted of preflexion, flexion and postflexion stages indicating the spawning ground. *Vinciguerria nimbaria* was the dominant species.

Bregmacerotid larvae were concentrated in the thermocline and mixed layers. Bregmacerotidae comprised 7.93% of the total catch. Maximum concentration was during intermonsoon fall, and widely distributed in the northern latitudes than in the southern latitudes.

The larvae of clupeoids contributed 13.65% to the total catch, and were abundant during summer monsoon. *Sardinella longiceps* larvae were dominant, concentrated in the shelf area off Cannanore. Eleven species of Clupeiformes were obtained in the survey area.

Carangidae larvae contributed 4.69% with maximum abundance during intermonsoon, spring and summer monsoon. *Decapterus* sp. and *Megalaspis cordyla* were the major species. Gobiidae constituted 7.51% of the total catch in all the

seasons, maximum during summer monsoon and least during intermonsoon fall. Scombridae contributed 5.81% with *Auxis thazard*, *Rastrelliger kanagurta* and *Katsuwonus pelamis* as major species with the highest densities during spring and summer monsoon. Scorpaenid larvae were obtained from the mixed and thermocline layers. They seem to have a prolonged breeding season, as they were collected in all seasons except summer monsoon.

Larvae of Sternoptychidae were located in the 1000-500 m strata. They are absent from the surface layers. The common genus *Angyropelecus* sp. was present in all seasons, maximum during summer monsoon, and distributed mainly in the southern latitudes. Chauliodontid larvae were also observed only during summer monsoon at 1000-500 m strata. Synodontid larvae occurred in all seasons particularly in transitional and oceanic stations. Major species was *Saurida tumbil*.

Paralepidid larvae were mainly distributed in the transitional and oceanic stations in all months except October. Carapid larvae were recorded at oceanic and transitional stations at 10°N during summer monsoon.

Ceratiid larvae were present in all the seasons in the mixed and thermocline layers. High densities of these larvae were observed off Mumbai. Belonid larvae were obtained from the coastal station during intermonsoon fall. Hemiramphid larvae were absent during winter monsoon; densities were found to be more during October (intermonsoon). Exocoetid and Holocentrid larvae were observed during summer monsoon. Coryphaenidae were abundant in the mixed layer during intermonsoon fall.

Bothid larvae were distributed at all depth strata up to 0-1000 m, and occurred in all seasons. The distribution of Soleidae larvae was limited to 300 m. Cynoglossid larvae were abundant in the shelf waters. Larvae of Balistidae and Tetraodontidae were collected from only few stations, and both were absent during intermonsoon spring.

The distribution pattern of the larvae of Carapidae and Ceratiidae has been reported for the first time from the Arabian Sea. The results of the distribution pattern of various families of fish larvae show that pelagic fishes spawn during intermonsoon spring and summer monsoon while mesopelagic fishes have no such definite spawning pattern. They are continuous breeders.

DISTRIBUTION OF CETACEANS IN RELATION TO OCEANOGRAPHIC PARAMETERS IN THE INDIAN EEZ AND CONTIGUOUS SEA

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Study on species occurrence in relation to environmental parameters is important to understand the spatial distribution of species. Data on spatial distribution provide the best approaches for conservation and management of cetaceans. Though all the cetaceans are protected under the Indian Wildlife (Protection) Act (1972), there is no information on the distribution of cetaceans *vis-a-vis* oceanographic parameters in the Indian Seas. The present study is the first effort to correlate the cetacean distribution with oceanographic parameters in the Indian EEZ and contiguous seas.

Opportunistic visual surveys were carried out onboard FORV *Sagar Sampada* from September 2003 to February 2007. A total of 35 cruises were conducted in the Indian EEZ and the contiguous seas. The number of observation days was 657 and the cetaceans were sighted on 299 days. The total observation effort was 5254 hours. Data on the distribution of cetaceans were collected along with four oceanographic variables (Sea Surface Temperature, Sea Surface Salinity, maximum depth at the location of sighting and distance from the shore). In all, 473 sightings of 13 species comprising of 5865 individuals were recorded. This includes species and individuals of confirmed as well as unconfirmed (but possible) identities. Balaenopteridae, Physeteridae and Delphinidae were the three families recorded during the study. The oceanographic characteristics were related with distribution of species to examine the habitat preference of cetaceans. Of the ten confirmed species sighted during the study, adequate number of sightings are available for 5 species, namely *Physeter macrocephalus* (sperm whale), *Tursiops aduncus* (Indo-Pacific bottlenose dolphin), *Stenella longirostris* (spinner dolphin), *Delphinus capensis* (long-beaked common dolphin) and *Sousa chinensis* (Indo-Pacific humpback dolphin).

The sightings of *Physeter macrocephalus* were recorded in oceanic waters where depth ranged from 340 m to 3696 m (Table 1). The average SST and salinity in the sighted area were 28.4 °C and 33.6 ppt respectively. The distribution of *Stenella longirostris* was wide from coastal waters to high seas. The majority of *Stenella longirostris* sightings were recorded at >300 m depth. The average SST was 28.2 °C and salinity was 29.2 ppt. *Tursiops aduncus* was also observed in the coastal as well as oceanic waters in the depth range between 34 m and 3973 m. The average SST was 28.2 °C and that of salinity was 33.6 ppt. The maximum number of *Delphinus capensis* sightings were beyond 100 km from the shore, but were found nearer to the shore where >100m depth is close to the coast. The majority of the sightings

were found between 200 and 3000 m depth, but considerable number of sightings was on continental shelf as well. The average SST at the location of the sightings was 28.5 °C and the average salinity was 32.7 ppt. The distribution of *Sousa chinensis* was confined to the coastal waters of 0.05 km from the shore at 15 m depth. One sighting was observed at a distance of 86.7 km. The average SST and salinity were 26.8 °C and 33.5 ppt, respectively.

Table 1. Distribution of cetaceans in relation to oceanographic parameters

Species	Distance from shore (km)	Depth (m)	SST (°C)	Salinity (ppt)
Balaenoptera musculus	19 - 144	1200 - 2919	26.0 - 28.3	33 - 36
Balaenoptera physalus	48	1227	28.3	34.1
Balaenoptera acutorostrata	214	3080	26	33
Megaptera novaeangliae	222	3853	27.9	33.7
Balaenoptera sp	23 - 490	176 - 3647	26.7 - 29.4	29.5 - 35.8
Physeter macrocephalus	4 - 579	340 - 3696	26.8 - 29.8	29.3 - 37.5
Globicephala macrorhynchus	5 - 675	292 - 3072	27.6 - 28.5	32.5 - 33
Pseudorca crassidens	228 - 274	1700 - 2000	28.0 - 29.7	33.0 - 35.2
Grampus griseus	26 - 350	50 - 2600	22.3 - 31.0	33.9 - 35.7
Stenella coeruleoalba	62 - 186	2500	27.5 - 28.6	34.3
Stenella longirostris	9 - 683.5	18 - 4270	26.0 to 29.6	29.2 - 35.7
Stenella sp.	27 - 716	26 - 3860	25.9 - 32.0	32 - 34
Tursiops aduncus	22 - 700	34 - 3973	26.0 - 31.2	30.6 - 36
Delphinus capensis	3 - 624	28 - 3701	27 - 32	30.0 - 34.7
Sousa chinensis	0.05 - 86	15 - 75	26.8 - 29.9	33.5 - 34.1

ESO 04 **MECOS 09**

A SURVEY ON DENSITY AND BIODIVERSITY OF PHYTOPLANKTON IN THE PERSIAN GULF (BOUSHEHR PROVINCE)

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Plankton survey of the Persian Gulf was conducted in the coastal waters off Boushehr Province for 4 seasons during 2001-02. A total of 173 species were identified consisting of 97 species of Bacillariophyta, 70 species of Dinophyceae, 4 species of Cyanophyceae, 1 species of Chrysophyceae and 1 species of Euglenophyceae.

Result showed that the density and diversity of phytoplankton have changed considerably when compared to a previous study. The density of phytoplankton

increased from east to west of the Gulf exhibiting two major peaks, one in late summer and the other in late winter. Density and diversity of phytoplankton in Khoozestan region were more than in the other region. The average density of phytoplankton in Boushehr was 1440411/m^3. Shannon diversity index in winter (1.9) was more than the other seasons.

Density of phytoplankton increased from surface to 200 m depth but decreased below that depth. However, during winter, increase of phytoplankton was observed upto 30 m. *Oscillatoria thieubautii* was prevalent than the other species in spring and summer. *Thallassiothrix frauenfeldii* and *Pleurosigma angulata* were prevalent in autumn and winter, respectively.

Statistically, the difference in the density of phytoplankton at different depths was not significant but showed seasonal significance. Tuky test and clustering analysis showed that Shannon Weiner diversity indices at Khoozestan and Bushehr were significantly different.

Compared to an earlier study, the density of diatoms has decreased in all the regions.

ESO 05 **MECOS 09**

DIFFERENCES IN GROWTH AND REPRODUCTIVE STAGES OF FARMED GREEN MUSSEL *PERNA VIRIDIS* IN A SEMI- ENCLOSED BAY, ESTUARY AND OPEN SEA ALONG KERALA COAST, INDIA

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The green mussel *Perna viridis* was farmed in three different ecosystems, *viz.,* a semi-enclosed bay (Kollam Bay), estuary (Ashtamudi Lake) and open sea (off Narakkal) along Kerala coast during the period 2002-2004. In the bay and sea, the seeded mussel ropes were suspended from a wooden raft while in the estuary, the farm structure was a wooden rack. Seed mussels of the length range 25 to 32 mm were collected from the intertidal zone along the Kollam-Narakkal region and seeded on to nylon ropes. The growth in length (L), total weight (TWT) and meat weight (MWT) were measured at monthly intervals. The condition index (CI), meat percentage and their reproductive stages were also observed. The farm ecology was monitored and the variations in salinity, temperature, nutrients and productivity during the culture period were recorded and correlated with Specific Growth Rates (SGR).

The differences in the SGR were compared. The SGR was higher in the bay than in the estuary and sea. It was also observed that the SGR was higher in the

initial stages than in the later stages of culture period (Table 1). The CI was the highest during June while the percentage of meat was the highest during October (Fig. 1). In the estuary, during the first 30 days of culture, the SGR was high (0.012 ± 0.001) and it reduced to 0.003 ± 0.002 in 105 days. In the open sea farm, the initial SGR was 0.017 ± 0.003, higher than that observed in the estuary and bay.

Table 1. Variations in SGR of total length, total weight and meat weight of *Perna viridis* grown in a semi-enclosed bay

	Specific Growth Rates ± Standard Deviation		
Period (2003)	Length (L)	Total weight (TWT)	Meat weight (MWT)
Feb - Mar	0.0084 ± 0.0021	0.0290 ± 0.0012	0.0422 ± 0.0028
Mar - Apr	0.0099 ± 0.0015	0.0240 ± 0.0010	0.0233 ± 0.0032
Apr - Jun	0.0062 ± 0.0023	0.0143 ± 0.0045	0.0137 ± 0.0043
Jun - Jul	0.0024 ± 0.0030	0.0082 ± 0.0023	0.0104 ± 0.0030
Jul - Sep	0.0005 ± 0.0024	0.0035 ± 0.0024	0.0021 ± 0.0041
Sep - Oct	0.0026 ± 0.0034	0.0099 ± 0.0021	0.0120 ± 0.0024
Oct - Dec	0.0019 ± 0.0039	0.0034 ± 0.0031	0.0034 ± 0.0021

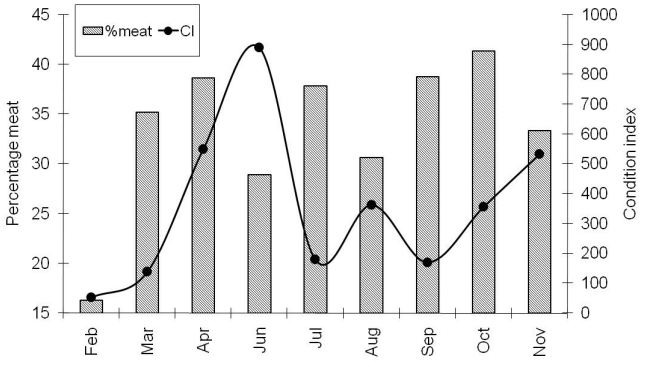

Fig. 1. Variations in the condition index and percentage meat content of farmed mussels in Kollam Bay

In the bay and open sea farms, all the reproductive stages were observed; mature and spent female mussels indicated that the recorded mussels were reproductively active at these sites. However, in the estuarine farms, spent mussels were not observed. The ecological conditions indicate that it is possible to have two crops from the bay and sea while in the estuary only one crop is recommended. The observations on the reproductive stages of mussels indicate that it is also possible to collect seed mussels from the bay and sea farms during the spawning period of mussels.

ESO 06 **MECOS 09**

ALPHA, BETA AND GAMMA DIVERSITY OF FISHED MARINE TAXA OF SOUTHWEST COAST OF INDIA DURING 1970-2005

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The three terms for measuring biodiversity over spatial scales are alpha, beta, and gamma diversity. Alpha diversity refers to the diversity within a particular area or ecosystem, and is usually expressed by the number of species (*i.e.*, species richness) in that ecosystem**.** Beta diversity is a comparison of diversity between ecosystems, usually measured as the amount of species difference between the ecosystems. Gamma diversity is a measure of the overall diversity for the different ecosystems within a region.

For the analysis, the primary records of NMLRDC (National Marine Living Resources Data Centre, CMFRI) containing species-wise and gear-wise catch and effort were the principal data source (period 1970-2005). The actual number of species caught was from the original field data sheets using appropriate software. On a spatial level, Kerala and Karnataka had 27 fishing zones as per the stratification of the sampling design (17 in Karnataka and 10 in Kerala). For the 35 year period, 1.89 lakh and 1.12 lakh records were created for Kerala and Karnataka respectively. The data records thus created were used for analyses of biodiversity indicators. The biodiversity rich and poor areas in Kerala and Karnataka were identified through beta diversity.

Table 1. Alpha, Beta and Gamma diversity values for Kerala (A)

Zones	Beta value K1	K2	K3	K4	K5	K6	K7	K8	K9	Alpha Value
K1										346
K2	87									259
K3	218	306								565
K4	103	17	322							243
K5	233	321	16	336						579
K6	94	8	313	9	326					253
K7	146	60	365	43	378	53				200
K8	12	100	207	115	220	107	158			358
K9	34	54	253	69	266	61	112	46		312
K10	138	52	357	35	370	45	8	150	104	208
Gamma value	818									

In the present analysis, each fishing zone was taken as a specific area and the fished taxa species richness was represented as the alpha diversity. The inter-zone comparison was made for deriving the beta diversity and the sum total of all fished taxa richness was taken as an estimate of gamma diversity.

Table 2. Alpha, Beta and Gamma diversity values for Karnataka

Zones	Beta value KN1	KN2	KN3	KN4	KN5	KN6	KN7	KN11	KN12	KN13	KN14	KN15	KN16	Alpha value
KN1														136
KN2	15													151
KN3	24	9												160
KN4	388	373	364											524
KN5	55	40	31	333										191
KN6	77	62	53	311	22									213
KN7	118	103	94	270	63	41								254
KN11	176	161	152	212	121	99	58							312
KN12	154	139	130	234	99	77	36	22						290
KN13	33	18	9	355	22	44	85	143	121					169
KN14	26	11	2	362	29	51	92	150	128	7				162
KN15	54	39	30	334	1	23	64	122	100	21	28			190
KN16	24	9	0	364	31	53	94	152	130	9	2	30		160
KN17	39	24	15	349	16	38	79	137	115	6	13	15	15	175
Gamma Value	519													

In Kerala, zone K5 (Cochin) and K3 (Kollam-Neendakara) had the highest alpha diversity values, and consequently the beta diversity values were also high for these zones (Table 1). The high beta values indicate uniqueness in species richness when compared to other zones. The gamma diversity was 818 for Kerala. In Karnataka, the highest alpha values were recorded for KN4 zone (Gangolli-Coondapur – northern Udupi district) followed by KN11 zone (Mangalore) (Table 2). The beta diversity values for KN4 were also very high indicating the uniqueness of many of the species occurring in the area. KN4 zone is very close to the Netrani Island which has been recently reported to have a submerged coral reef and this may be the reason for the high alpha and beta diversity values.

ESO 07 **MECOS 09**

BENTHIC BIODIVERSITY IN DEVELOPED (PICHAVARAM) AND DEVELOPING MANGROVES (VELLAR ESTUARY), SOUTHEAST COAST OF INDIA

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An attempt was made to study the benthic biodiversity in a developed (Pichavaram) and a developing (Vellar estuary) mangrove ecosystem. Samples were collected in duplicate from three stations each. As many as 20 species of benthic macrofauna were recorded in Pichavaram mangroves (14 species of polychaetes, 4 species of crustaceans and 2 species of molluscs), and 18 species of macrofauna were recorded in Vellar (11 species of polychaetes, 4 species of crustaceans and 3 species of molluscs). The population density differed between the habitats (9,014 to 14,600 m^{-2} in Pichavaram and 5,438 to 8,604 m^{-2} in Vellar estuary). Diversity indices also showed variations between the two areas. Species diversity was in the range of 2.469 – 3.100 in Pichavaram and 2.382 – 3.270 in Vellar estuary; species richness ranged from 0.783 to 0.845 in Pichavaram and from 0.641 to 0.854 in Vellar estuary; species evenness ranged from 0.617 to 0.758 in Pichavaram and from 0.595 to 0.837 in Vellar estuary. The possible reasons for the variations in abundance and diversity are discussed in the paper.

ESO 08 **MECOS 09**

OCCURRENCE OF BLACK YEASTS IN INDIAN WATERS

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The term 'black yeast' indicates those melanised groups of fungi, of which several representatives are able to reproduce by unicellular growth. Factors, which are of ecological significance, include the presence of melanin and carotene, formation of thick cell walls and meristematic growth, thermo and osmotolerance, adhesion, hydrophobicity, production of extra cellular polysaccharides, siderophores and acidic or alkaline secondary metabolites. Melanised yeasts are of particular interest, since

the presence of melanin protects the organism against a number of environmental factors. Melanin possesses antioxidant and antiradical activities.

Sediment samples were collected from 200, 500 and 1000 m depths along the west and east coasts of India. Black yeasts (Figs. 1 and 2) were isolated by employing spread plate method, using Wickerham's agar supplemented with chloramphenicol. Altogether 38 strains were obtained, 34% from 200 m, 42% from 500 m and 24% from 1000 m depth. All the isolates showed filamentous growth. Asexual reproduction was observed, *i.e.*, either budding or fission or both. All the isolates were found to produce lipase, protease and amylase. More than 55% of the isolates produced urease and about 45% produced ligninase (Fig. 3). Optimum temperature, salinity and pH were estimated. The isolates were identified by PCR amplification and sequencing of ITS region (ITS1-5.8S-ITS2). Black yeasts are found to be highly versatile agents of organic matter break down and this is the first report of black yeasts from the Indian waters.

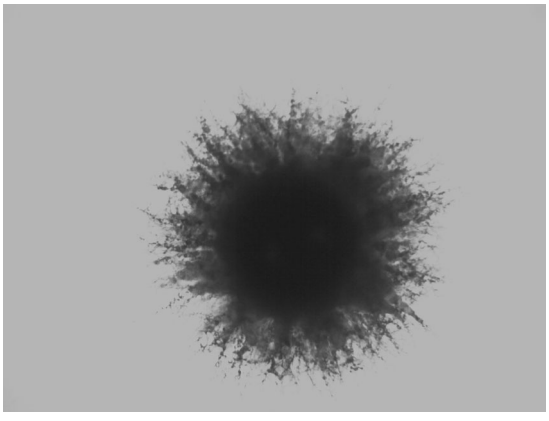

Fig. 1. A single colony of black yeast (4x)

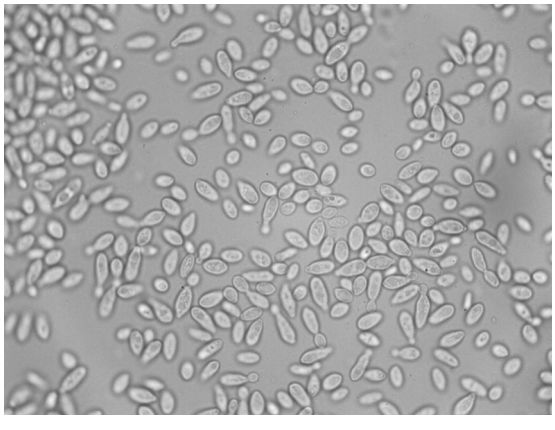

Fig. 2. Photomicrograph of wet mount (100x)

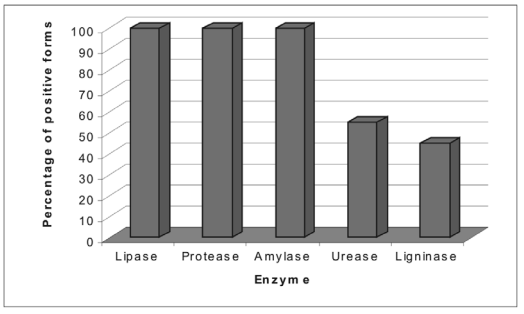

Fig. 3. Hydrolytic enzyme production by black yeast

ESO 09 **MECOS 09**

DISTRIBUTION, ABUNDANCE AND BIODIVERSITY OF PERCHES IN ANDAMAN AND NICOBAR WATERS

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The perch and allied resources are highly valued for the quality of meat. Perch fishing has gained importance for recreational sport fishing also in the recent past. Live fish trade of perches has expanded rapidly in recent years and now many species are targeted for the purpose. A large portion of the perch resources are caught by the artisanal fishers in the Andaman and Nicobar (A&N) Islands, which are bestowed with fringe type of coral reefs conducive for the perches and perch-like fishes to inhabit.

Development of suitable fishing methods for harvesting the perches is an essential requirement. As such, handlines, longlines and gillnets can be considered for harvesting these resources. However, the knowledge on the distribution, abundance and biodiversity of these resources in A&N Islands is very scanty.

An attempt was made by the Port Blair Base of Fishery Survey of India to design a suitable ecofriendly fishing method for the harvest of these resources during 2000-2007 and also to assess the diversity, distribution and abundance of the resources around the islands. From the experimental survey by deploying the bottomset vertical longline, 47 species belonging to 6 families were recorded. Lutjanidae was represented by 13 species belonging to 4 genera, Lethrinidae by 10 species belonging to 3 genera, Serranidae by 13 species belonging to 4 genera, Ephipidae by one species, Haemulidae by one species, Carangidae by 7 species belonging to 4 genera and Sphyraenidae by 2 species. In Lutjanidae, *Lutjanus* spp. dominanted the catch followed

by *Pristipomoides* spp. and *Aprion* spp. In Lethrinidae, *Lethrinus* spp. dominated the catch while the genus *Gymnocranius* and *Wattasia* were represented by one species each. In the family Serranidae, *Epinephelus* spp. dominated the catch followed by *Plectopomos* spp., *Cephalopholis* spp. and *Variola* spp. The percentage composition observed among the various genera were *Lutjanus* 26%; *Aprion* 21%; *Epinephelus* 17.6%; *Lethrinus* 16.5%, *Pristipomoids* 5.5%; *Gymnocranius* 4.3%; *Variola* 4.2%; *Plectopomos* 2.5%; *Cephalopholis* 1.8%; and *Wattasia* 0.1%. It is observed that among the families, Lutjanidae dominates the catch, followed by Serranidae and Lethrinidae.

Lat. 8°N - Long. 93°E yielded the maximum hooking rate of 4.26% followed by Lat. 7°N - Long. 93°E (3.98%) and Lat. 7°N - Long. 92°E (3.81%) in Nicobar waters whereas in Andaman waters Lat. 10°N – Long. 93°E registered the highest hooking rate of 3.64% followed by Lat. 13°N – Long. 93°E (2.92%) and Lat. 13°N – Long. 92°E (2.64%). Overall, the Andaman waters recorded higher aggregate hooking rate of 3.2% as compared to Nicobar waters with 2.29%.

An attempt was made to study the distribution and abundance of perches by focusing on their biodiversity. Shannon's index and Simpson's index were used to study the diversity index and species richness respectively. The Shannon's diversity index (H') of perches in Andaman waters with reference to Lat. 1° X Long. 1° squares was found in the range of 2.593 - 2.867 and in the Nicobar waters it was in the range of 2.088 - 2.678. Similarly, the Simpson's Reciprocal index (1/D) was found to vary from 13.283 to 15.056 for Andaman waters and from 7.29 to 10.001 for Nicobar waters.

ESO 10 **MECOS 09**

STOCK CHARACTERISTICS AND POPULATION DYNAMICS OF *HETEROCARPUS WOODMASONI*

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Owing to higher export value and heavy demand from major world markets, deep sea prawns have gained a prime position among the exploited marine fishery resources of Kerala in recent years. However, the shrimp trawlers exerted high fishing pressure on deep sea prawns, regardless of their stock size and regeneration capability, which ultimately led to a drastic decline in their landings. *Heterocarpus woodmasoni* Alcock, 1901 is a major species among the deep sea prawns landed in Kerala. This paper describes the stock characteristics and population dynamics of *H. woodmasoni*, which constituted the exploited stock in commercial trawlers. The length composition of male *H. woodmasoni* ranged from 50 to 150 mm in total length with a modal

length of 97 mm. Females ranged from 40 to180 mm TL and the modal length was found to be 92 mm. Based on the length composition of male and female prawns sampled from commercial landings, growth parameters were estimated using ELEFAN I program. The growth equations for both sexes can be expressed as follows:

$$\text{Males} \quad L_t = 160.59\ [\ 1 - \exp^{-0.82(\ t\ +0.97)}]$$
$$\text{Females}\ Lt = 188.0\ [\ 1 - \exp^{-0.60(\ t\ +0.96)}]$$

The growth performance index of both males and females were estimated as 4.33. The life span of males estimated using the equation $t_{max} = 3/K$ was 3.66 years while the same of female was 5 years. The lengths attained by males following VBGF equation at the end of I, II, and III years were estimated at 91.51 mm, 130.16 mm and 147.19 mm respectively. On the other hand, the lengths of females at the end of I, II, III, IV and V years were estimated at 87.19 mm, 132.61 mm, 157.62 mm, 171.39 mm and 178.98 mm respectively. Results of the length converted cohort analysis revealed that prawns in the length groups 50-60 mm and above were vulnerable to exploitation. However, heavy exploitation of the length class 80-90 mm was discernible.

ESO 11 **MECOS 09**

STANDARDIZATION OF POLYAMIDE MONOFILAMENT YARNS FOR FABRICATION OF GILLNET WITH REFERENCE TO PHYSICAL AND MECHANICAL PROPERTIES

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Synthetic netting materials have greatly extended the endurance of fishing gear as they have better uniformity, continuity, breaking strength and rot resistance compared to natural materials. At present, many groups of synthetic fibres are produced for the fishing industry. The introduction of polyamide (nylon) monofilament yarn revolutionalised the fishing industry especially the gillnet sector. However, not much study has been carried out in India on this material. Materials of different quality and dimensions are dumped into the market and for many of the dimensions, no standards exist. The properties of many of these new dimensions of monofilament yarns available for fishing purpose are not assessed and documented. In this communication, the standard specifications worked out for the yarns for fabrication of gillnet with special reference to physical and mechanical properties are detailed. The effect of wetting, knotting, and weathering on the strength properties of the yarns is also discussed.

South India plays significant role in production of nylon yarns for fishing purpose. Yarns of 37 different dimensions ranging from 0.08 to 3.0 mm diameter were found

to be in use. The physical and mechanical properties *viz*., the linear density, runnage and the tensile break load and elongation of nylon monofilament yarns of diameter 0.08 to 3.0 mm were assessed and made into a database. Of the 37 diameters tested, only for 17, Bureau of Indian Standards (BIS) had made standards. Out of these 17 dimensions of yarns tested, only 12 conformed to the standards with reference to runnage, 4 for break load and all for elongation.

A reduction in strength of 38% and nearly 36% reduction in elongation was observed due to knotting. As the thickness of the material increased, the percentage reduction in knot breaking load and elongation also increased. A decrease of 42% of breaking load and 36% of elongation was noticed due to wetting and knotting. The relationship between wet knot break load and Rtex was found more significant than the wet knot break load and diameter. The breaking strength reduced linearly with increase in sunlight exposure time indicating that this can help in predicting the service life of the material. The effect of weathering depends on the thickness of material as samples of lower specification showed faster degradation in break load and elongation than the higher ones due to sunlight exposure. Samples of 0.16 and 0.20 mm diameter lost 55% of their original breaking load at the end of 300 days while 0.23 mm lost 49% and 0.32 mm diameter lost 31% of original breaking load. The standard specifications required for yarns of each diameter were worked out for the material suitable for fabrication of gillnets, which would help in selection of yarns for a specific fishery.

ESO 12 **MECOS 09**

BIOPHYSICAL STATUS OF CORAL REEFS OF ANDAMAN WATERS AND THE CONSERVATION PERSPECTIVES

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Among the four major coral reef areas of India, those of Andaman and Nicobar groups of Islands are quite extensive and characterized with multiplicity of types, such as windward reefs, channel reefs, bay reefs, knolls, patch reefs etc. Most of the reefs are fringing the islands and islets, numbering over 570, with a total coast line of 1912 km. These coral reefs, along with a reported existence of 300 km long submerged coral banks, akin to a barrier reef, on the western side of Middle and North Andaman Islands, cover areas of more than 2000 km^2 and harbor rich biodiversity. Until 1980s, only qualitative assessment of these reefs had been done. The first comprehensive quantitative assessment of selected reefs of Andaman and Nicobar Islands was done during 1988-90, using a field survey method, namely, the Line Intercept Transect. More than 110 reef sites located right from Diglipur of North

Andaman, down to Great Nicobar, in the south were surveyed. From these surveys, it could be surmised, based on the estimation of live coral cover in relation to other hard substrata, that 2% of coral reefs were in 'excellent' condition (75-100% live coral cover); 34% were in 'good' condition (50-75% live coral cover); 50% were in 'fair' condition (25-50% live coral cover); and 14% were in 'poor' condition (0-25% live coral cover). The coral reefs, surveyed in Middle Andaman group, were almost in pristine condition as nearly 82% were either in excellent or good condition. The reefs in North Andaman were either in good (50%) or in fair condition (50%). In Richie's Archipelago, 40% were in good and 60% were in fair condition. The reefs in South Andaman were mostly either in fair (50%) or in good (33%) condition. In Little Andaman, about 67% of the reefs were in poor condition and the remaining was in fair condition. Among the Nicobar group, 21-25% reefs were in good condition and 67-72% were in fair condition. Similar surveys conducted in five islands of Wandoor Mahatma Gandhi Marine National Park, revealed that the live coral cover in the reefs ranged from 40 to 53%. The above-mentioned surveys also brought to light the nature of composition of various species of corals, fishes and other reef associated macrofauna.

A limited survey conducted in South Andaman and Richie's Archipelago in April 1998, indicated that the live coral cover in the reefs ranged from 20 to 60%. However, the surveys undertaken in South, Middle and North Andamans, Richie's Archipelago and Great Nicobar revealed that a 'mass bleaching' phenomenon had set in late May 1998 which continued beyond July 1998. It was presumed that the rise in mean SST (surface seawater temperature) might have been responsible for extrusion of symbiotic micro algae from corals causing those organisms to bleach due to loss of colour imparted by the algae. The effect of bleaching phenomenon varied. In South Andaman while 8 to 26% corals did not bleach, 4 to 76% corals were either partially or fully bleached. The dead corals formed 12 to 96% in different reefs. In Middle Andaman, 16 to 50% of corals did not bleach; 19 to 77% were either partially or fully bleached; and 4 to 32% were dead. In North Andaman, 14 to 16% were not affected; nearly 70% were bleached and about 16% were dead. In Ritchie's Archipelago, 41% of corals were not affected, while 12% bleached and 48% died. In Great Nicobar, 18 to 38% of corals were not affected; 54 to 76% were bleached; and about 22% died. The partially and fully bleached corals in most of the reefs could recover substantially in subsequent months.

During 2002-03 remote sensing and ground truth comparison studies were undertaken in some reefs of South Andaman to determine the feasibility of using the satellite data for large scale application in identification of various reef components and assess the status of reefs. The studies proved useful as more than 70% accuracy could be seen in delineating the coral reef substratum components.

LIT surveys were done in 2004 and 2005 in South Andaman and Richie's Archipelago, which could inadvertently provide the opportunity to compare the status of the coral reefs before and after the devastating earthquake/tsunami that lashed the shores of the Andaman and Niciobar Islands on 26 December 2004. It was observed that the damage to coral reefs were more due to earthquake rather than tsunami.

A lot of cracks and fissures observed in the coral reefs were due to earthquake. Breakages of branched and massive corals, overturning of massive corals and smothering of many life forms of corals were observed. In Havelock Island, where the coral reef is facing the open sea, the live coral cover in reef flat was between 53 and 63% in 2004 which reduced to 25 to 56% in 2005. However, in the reef slope area the live coral cover remained between 77 and 83%. In Jolly Buoy Island, which is a protected area, the reef flat area showed live coral cover between 41 and 63% in 2004 and 40 and 57% in 2005. In North Bay, the coral reef is within the bay. The live coral cover was between 37 and 62% in reef flat area in 2004 and between 22 and 54% in 2005. In both the reefs, the live corals in the reef slopes were from 53 to 84% and did not significantly change after tsunami. In Pongi Balu, the reef is along the tidal creek. The live coral cover in the reef was between 39 and 51% in 2004 and almost same in 2005. In May 2005, there was considerable mass bleaching but overall the coral reefs were found to be resilient and recovered remarkably within a short time. During the surveys, 98 coral species, 130 fish species, and 48 other reef associated macrofauna were observed. Even though 209 to 219 species were observed in 2004, the richness reduced in 2005 to 179 to 186 in the same surveyed sites.

In conclusion, it may be stated that the coral reefs of Andaman group of islands are resilient and remain in good condition in spite of the natural impacts and anthropogenic impacts in some areas. The relevant conservation perspectives, in terms of periodical assessment and monitoring of resources, protective and regulatory measures for sustainable development, capacity building for management, local community participation in management, creation of public awareness, linkage and coordination of multi-sectors in reef management, R&D needs, database management, precautionary approaches pertaining to global warming and sea level rise etc., are discussed.

ESO 13 **MECOS 09**

TEMPORAL VARIATION IN THE ABUNDANCE AND AVAILABILITY OF DEEPSEA FISHES IN THE INDIAN EEZ BASED ON FISHERY SURVEY CRUISES OF FORV *SAGAR SAMPADA*

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The result of the exploratory survey of FORV *Sagar Sampada* during 1998-2002 and 2005-2007 were computed and the data were analysed to investigate the distribution, biology and life history traits of some deepsea fishes inhabiting the continental slope of Indian EEZ. The study area included the entire coastline of India

covering the southwest coast, northeast coast and the Andaman waters; 8-16^0 latitude in the west and 8 to 21^0 latitude in the east. A comparison of the results shows that during the period 2005 – 2007, more number of species was recorded. During 1998-2002, the investigation was mainly focused in the depth range of 200-500 m, whereas during 2005-2007 the survey was conducted at depths above 500 m. In terms of depthwise distribution, 200-700 m depth range harbored most of the fish groups. Analysis revealed that lat 9^o -10^o and 10^o -11^o N along the west coast are rich in species diversity, whereas 14 -15^o N latitude showed the lowest diversity. Along the east coast, 11^0-12^0, 12^0-13^0, and 14^0-15^0 latitude showed rich species diversity when compared to 19^0-20^0 latitude with the lowest diversity. Distributional pattern of deepsea fishes along east and west coast of India are discussed. *Saurenchelys taeniola* dominated the catches in the west coast and *Lamprogrammus exutus* in the east coast. Selected species were analyzed for biological parameters such as food and feeding, maturity stages, sex ratio, length-weight relationship etc. Majority of the species were in the maturing stage. Ideal sex ratio was observed in a few species though the sheerness of male population was observed in respect of very few other species. All the fishes analyzed were carnivores with a predatory food habits. Most of the species showed an ideal b value of around 3 which is an indication of isometric growth. The exponential value "b" for different species varied from 0.007 to 4.56. The paper also stresses the need for more scientific and exploratory strategies to exploit the least explored deepsea resources for future use.

ESO 14 **MECOS 09**

DIVERSITY OF THE DEEPSEA FINFISH RESOURCES OF THE INDIAN CONTINENTAL SLOPE

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During the period 2005-2007, four exploratory deep sea cruises were carried out by FORV *Sagar Sampada* in the Arabian Sea (9^{0}N-12^{0}N), Bay of Bengal (8 -20^0 N) and Andaman Seas (11-13 ^{0} N) of the Indian EEZ. Trawling was carried out during the daytime using EXPO trawls and HSDT nets. Catch per hour (CPH) as well as depth-wise (200-400, 400-600, 600-800, 800-1000 and >1000 m) distribution and abundance of deepsea finfish resources in the three regions were assessed.

In the Arabian Sea, the catch varied from 1793.7 kg (CPH:53.4kg) to 3013.9 kg (CPH: 231.8 kg). The finfish component of the catch varied from 55 to 60%. A total of 126 species belonging to 29 families were recorded. In the Arabian Sea the maximum number of families occurred in the depth range 600 -800 m with 29 families followed by 400 m with 21 families, and 400 -600 m depth with 20 families. Families

which showed the highest abundance in terms of catch were Chloropthalmidae, Ophiididae, Muraenidae, Stromateidae and Macrouridae. The most abundant species were *Chloropthalmus bicornis*, *C. punctatus, Uranoscopus archionema, Eridacnis radcliffei, Lampogrammus exutus, Gavialiceps taeniola* and *Bembrops caudimaculata*.

In the Bay of Bengal (including the Andaman Sea), 17 trawl operations were carried out at 11 stations between 50 and 770 m depth and 91 species belonging to 28 families were recorded. Regionwise diversity of fishes including elasmobranchs was studied using the presence/absence of families as well as the number of species within each family and their biomass. While 22 families were represented in the catches at 200 - 400 m depths, 28 families were observed at 400 -600 m depths. Compared to this, only nine families were recorded in 600 - 800 m depth and six families in the depth beyond 1000 m. The most common family in the 200 - 400 m depth was Priacanthidae represented by *Priacanthus hamrur* and Rhinochimaeridae in the 400 -600 m depth represented by *Neoharriotta pinnata*. The eel *Bathyuroconger brauei* (Congridae) was recorded in the 600 -800 m depth.

Table 1. Number of deepsea fish species recorded

Order/Family	Arabian Sea	Bay of Bengal
Order - Anguilliformes		
Family – Congridae	1	1
Muraenidae	2	1
Nemichthyidae	1	1
Synaphobranchidae	1	1
Order – Aulopiformes		
Family – Evermannellidae		1
Chlorophthalmidae	3	3
Paralepididae	1	
Order - Beryciformes		
Family – Berycidae	1	
Holocentridae	1	
Trachichthyidae	1	
Order – Carcharhiniformes		
Family – Proscyliidae	1	1
Scyliorhinidae	2	2
Order – Chimaeriformes		
Family – Chimaeridae		1
Rhinochimaeridae	1	1
Order – Gadiformes		
Family – Macrouridae	3	3
Moridae	1	
Order – Lophiiformes		
Family – Ceratiidae	1	1
Chaunacidae	1	1
Diceratiidae	1	1
Lophiidae	1	1
Melanocetidae	1	1
Ogcocephalidae	1	1
Oneirodidae	1	

Order - Myctophiformes		
Family – Myctophidae	2	1
Neoscopelidae	2	1
Order – Ophidiiformes		
Family – Carapidae	1	1
Ophidiidae	9	4
Order – Perciformes		
Family – Acropomatidae	2	
Apogonidae		1
Bathyclupeidae	1	1
Cepolidae		1
Gempylidae	2	2
Gobiidae		1
Nemipteridae	1	1
Nomeidae	1	1
Percophidae	1	1
Priacanthidae	1	1
Serranidae	1	
Stromateidae	1	1
Uranoscopidae	1	
Order – Pleuronectiformes		
Family – Bothidae	2	1
Cynoglossidae	1	
Order – Rajiformes		
Family – Rajidae	2	1
Plesiobatidae		1
Order – Salmoniformes		
Family – Alepocephalidae	6	2
Platytroctidae	2	
Order – Scorpaeniformes		
Family – Peristiediidae	1	3
Scorpaenidae	1	1
Triglidae	1	1
Order – Squaliformes		
Family – Echinorhinidae	1	
Squalidae	6	2
Order – Stomiiformes		
Family – Astronesthidae	1	2
Chauliodontidae	1	1
Gonostomatidae	1	1
Idiacanthidae		1
Malacosteidae		1
Sternoptychidae		1

ESO 15 MECOS 09

EDIBLE OYSTER AND MUSSEL RESOURCES OF ANDAMAN (INDIA) WATERS AND THE POTENTIAL FOR SUSTAINABLE ECONOMIC DEVELOPMENT

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The Andaman and Nicobar groups of islands, lying between 6°N and 14°N latitudes and 92°E and 94°E longitudes in Bay of Bengal, comprise more than 570 islands, islets and rocky outcrops. They encompass nearly 0.6 million km^2 EEZ, around an aggregate coastline of 1912 km, both forming almost one third of India's total. The continental shelf, even though is narrow around the Islands, has been estimated to be between 16,000 and 32,000 km^2. The Islands, having a hilly terrain, are bestowed with long stretches of rocky shoreline, providing favourable niches for distribution of edible oysters. Further, due to the undulated terrains of the Islands and extended rainfall through southwest and northeast monsoons, a large number of tidal creeks exist, which are also providing favourable brackishwater habitats for edible oysters and mussels, mainly the green mussel. During late 1970s, two species of edible oysters, namely, *Crassostrea madrasensis* and *Saccostrea cucullata* were reported from these Islands. The extensive surveys and other studies conducted during 1997-2004 revealed that two more species, namely, *Crassostrea rivularis* and *C. gryphoides* also occur, the former being the predominant species. The occurrence of *C. madrasensis* in Andamans is doubtful as it could not be observed in the surveyed sites and it is likely that the earlier reports might pertain to *C. rivularis.* It was found that *C. rivularis* occurs in association with *S. cucullata* but in comparatively deeper zone in the intertidal area. *C. gryphoides* is normally found in the tidal creeks where salinity is low and highly fluctuating. While the edible oysters are distributed in all the Islands, the green mussel, *Perna viridis* is restricted to South Andaman only, confining to creek extensions of Flat Bay and Shoal Bay. The brown mussel, *P. indica* is absent.

The distribution of oyster beds, predominantly with *C. rivularis* in different islands of North, Middle and South Andamans and Richie's Archipelago, extends from 180 to 4800 m^2. The density of *C. rivularis* ranged from 13 to 102 oysters/m^2 and the average biomass varied between 1.4 kg to 30.9 kg/m^2. The estimated total biomass of the species in any given bed was between 672 and 83,360 kg. The beds of *S. cucullata* extended between 700 and 10000 m^2 at different sites. The average distribution of the species was between 30 and 666 oysters/m^2. The average biomass was between 0.6 and 38.7kg/m^2 and the total biomass on any particular bed varied between 1096 and 88,999 kg.

The size of *C. rivularis* in natural beds was upto 175 mm. The individual weight ranged from 96 to 364 g in different beds. The edibility (percentage of meat weight

in total weight) ranged from 1.8 to 7.9%. The size of *S. cucullata* was up to 130 mm. The individual weight ranged from 13 to 58 g in different beds. The edibility ranged from 5.6 to 12.7%.

Since both the species are least exploited in the Islands but have potential for economical utilisation, the biological characteristics were studied. In both the species, the females were dominant almost throughout the year. The overall female:male ratio was 1:0.52 in *C. rivularis* and 1:0.56 in *S. cucullata*. The size at first maturity in both the species was between 25 and 35 mm. Both the species showed much similarity in their breeding habits. Both the species breed almost throughout the year with peaks following the onset of both the monsoons, the southwest monsoon from late May and northeast monsoon in late October. The peak breeding season corresponding to SW monsoon is comparatively shorter but more intensive than that corresponding to NE monsoon. The spat settlement was comparatively more on the substratum below the Mean Low Tide level and the settlement of spats of *C. rivularis* was in much deeper zone, facilitating the separation of settlement of *C. rivularis* and *S. cucullata* when both the species occur in the same habitat but in different niches. The settled spats of *C. rivularis* have been observed to grow to more than 60 mm in 7-8 months, but those of *S. cucullata* do not reach even the half of that size in the same period.

The length-weight relationship of *C.rivularis* is $W = 0.0002631L^{2.948}$. The age and growth analysis indicated that the population in the natural habitat comprises mostly one-year and two-year old oysters, the former being more dominant.

The green mussel, *Perna viridis*, which had been recorded earlier only in a small area of Flat Bay was further recorded from a few more locations, including Shoal Bay in South Andaman. The extent of mussel distributional areas ranged from 80 to 300 m^2 and the average density varied between 18 and 158 mussels/m^2. The size of the mussels ranged to a maximum of 201 mm. The total mussel biomass in different sites ranged from 755 and 3886 kg. Mostly females dominated. The edibility ranged from 18 to 35%. The species exhibited prolonged breeding habit with two peak seasons, one starting from June corresponding to the onset of SW monsoon and the other from November with the onset of NE monsoon. The spat settlement had a major peak in July-August and a minor one in November-December. Among the different cultches used for spat settlement, the Mangalore tiles and asbestos sheets were found to attract significant settlement of spats. The young mussels could attach firmly to asbestos sheets and coir ropes and grew well to reach harvestable sizes of over 80 mm in about six months. Inducement of spawning of both sexes and larval rearing could be achieved under controlled conditions which would facilitate seed and stock enhancement.

In view of the abundance of edible oyster and green mussels, especially the large-sized edible oyster, *C. rivularis* in Andaman waters, which are hitherto least exploited and the vast potential they offer to harness as protein rich seafood through regulated exploitation from natural beds and also through coastal aquaculture, the strategies for the sustainable development of these resources as part of promoting

the Islands' economy are discussed in the paper. These strategies include inventorisation, land and water use policies, incentives, hatchery and seed production for mariculture, entrepreneur development, integrated mariculture with different components, post-harvest and value addition management, diversified product promotion, marketing linkages for domestic and export trade and other related conservation measures.

ESO 16 **MECOS 09**

SPATIAL AND TEMPORAL VARIATIONS IN SEAGRASS BIOMASS AND SHOOT DENSITY IN MINICOY LAGOON, LAKSHADWEEP, INDIA

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Spatial and temporal variations in the distribution of seagrass biomass and shoot density were assessed for two years (2000-2002) in Minicoy lagoon of Lakshadweep, India. Four stations were selected for the study, which have five species of seagrass, namely, *Thalassia hemprichii*, *Halophila ovalis*, *Syringodium isoetifolium*, *Halodule uninervis* and *Cymodocea serrulata* which covered an area of 0.396 km^2 in the lagoon. *H. ovalis* contributed to the major share of the biomass and shoot density in station I and the remaining species were the major components in other stations. Spatially, the highest mean shoot density of 1021.67 $\pm$ 949.6 shoots.m^{-2} was recorded at station IV and the lowest of 230.5 $\pm$ 165.7 shoots.m^{-2} was at station I. Seasonally, the highest mean shoot density of 1050.9 $\pm$ 921.4 shoots.m^{-2} and the highest mean biomass of 87.62 $\pm$ 79.74 g dry wt.m^{-2} was recorded during monsoon. Spatially, the highest mean biomass (85.59 $\pm$ 70.66 g dry wt.m^{-2} was recorded at station III. The results of *ANOVA* showed significant variations both in seagrass shoot density (r^2 = 0.620) and biomass (r^2 = 0.518). Temperature, pH and dissolved oxygen showed significant correlations with biomass and shoot density, while nutrients were not significant. Abundance – Biomass Curve Plot indicated an 'undisturbed' seagrass ecosystem in the Minicoy lagoon.

ESP 01 **MECOS 09**

ROLE OF MANGROVES IN THE ESTUARINE ECOSYSTEMS OF SOUTH IRANIAN COAST (PERSIAN GULF)

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Investigations were carried out on the mangrove plants of the Iranian coastline (Persian Gulf) during March 2007 – February 2008. Thirteen stations near the coast were covered in Hormozgan Province and one station in Bushehr Province. Halophyte mangrove plants grow in abundance along the intertidal zone of lagoons, and in the muddy areas. *Avicennia marina* (Harrah) is dominant in the areas of Harrah and *Rhizophora mucronata* in the Chandal region. The mangrove area in terms of hectares in the different stations are: Harrah and Kabrik 2700 ha; Shahre Noo 1400 ha; Jask 5000 ha; Sirik and Ziarat 2150 ha (part of this area is Chandal); Tiab and Kolahi 6000 ha; Callbi and Hassan Beygi 1200 ha; Qeshm and Bandar-e-Khamir 6317 ha of Hormozgan Province; and Naybend Gulf 450 ha of Bushehr Province.

Species density is recognized as dispersed, medium and concentrated. More than 90% of the penaeid shrimps breed in these two provinces of Hormozgan and Bushehr in the Persian Gulf.

ESP 02 **MECOS 09**

DENSITY OF BLUE-GREEN ALGAE (*CYANOPHYTA*) IN THE PERSIAN GULF (KHOOZESTAN PROVINCE)

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The present paper embodies the findings on the blue-green algae (Cyanophyta) of the waters off Khoozestan province in the Persian Gulf. The study was conducted during 2001-02 covering three seasons. Four species of blue-green algae were identified; three species were observed in spring and the annual average density recorded was 619708/m^3. The numerical abundance observed for spring, summer and winter was 719789, 1049843 and 89494 respectively. The predominant species recorded was *Oscillatoria thieubautii*. Cyanophyta formed 27.7% of the total phytoplankton collected from this area. It showed a decline of 36.1% in the Hormozgan waters and 46.1% in the Bushehr areas when compared to earlier reports. The reason for this decline is attributed to the low temperature and higher salinity

prevailing in the Khoozestan waters. Apart from these, the density of blue-green algae was more in the study site than in the other areas of Persian Gulf. Besides, concentrations of blue-green algae were high in the shallow areas upto 10 m depth. The highest density was observed during summer. Statistically the variation of the algae was significant ($p < 0.05$) in different seasons but not significant between different depths and stations.

ESP 03 **MECOS 09**

MORPHOLOGY AND ORIENTATION PATTERN OF SAND BUBBLES OF THE SAND BUBBLER CRAB *DOTILLA CLEPSYDRODACTYLUS*

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The sand bubbler crab, *Dotilla clepsydrodactylus* is an important inhabitant of sandy beaches. They feed during low tide by sorting sand and expelling pseudofaecal pellets. An attempt was made to study the distribution and orientation of the pseudofaecal pellets by the crab around its burrow in the sandy beach of Carbyn's Cove, Port Blair (Andaman) for 12 days during (December 2007 – March 2008).

The orientation pattern was studied by manipulating the feeding area by removing the pseudofaecal pellets without disturbing the burrow. The length of the carapace of the crab was measured along with the length of the trench to find the relationship between the two. To study the adaptive features of the crab, the mouthparts and appendages were dissected and photographed.

The crab was found to recommence its feeding activity after manipulation at the same trench where it stopped and orienting in the same direction as done previously. It made two types of patterns of pseudofaecal pellets *i.e.,* spike and concentric rings. The length of the trench ranged between 8 cm and 15 cm, occasionally reaching to about 25-30 cm. There was no relationship between the length of the trench and the length of the carapace of the crab. The 2nd and 1st maxillipeds were found to have spoon-tipped setae and maxilla with comb-like setae to separate organic matter from the substrate. The shape of the cheliped was found to be hour-glass shaped, which helped in carrying greater quantity of sand to the mouth.

The crab is ecologically very important in the sandy beaches as it forms a connecting link between dead and living organisms. The most common prey of *D. clepsydrodactylus* is the ghost crab.

ESP 04 **MECOS 09**

AN OVERVIEW OF DISTRIBUTION AND BIOMETRIC RELATIONSHIPS OF THE INDIAN PEARL OYSTER *PINCTADA FUCATA* (GOULD) ALONG THE INDIAN COAST

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Out of 28 species of pearl oysters that are known from different parts of the world, eight are present in the Indian waters.

Pinctada fucata (Gould) has a wide distribution from Western Pacific Oceania (Korea and southern China), Australia, and Indian Ocean to the Red Sea and the Persian Gulf, with Lessepian (migrants through the Suez Canal) into the Mediterranean.

In the Indian region, *Pinctada fucata* occurs in the Gulf of Mannar (off the coasts of Tamil Nadu and Sri Lanka), the Gulf of Kutch (coast of Gujarat), and southwest coast of India (Kerala), Lakshadweep Islands and Andaman and Nicobar Islands.

Observations showed that *P. fucata* from Gujarat had maximum body dimensions. The measurements were Dorso-Ventral-Measurement (DVM) : 92.11 mm, Antero-Posterior-Measurement (APM) : 84.24 mm, hinge length (HL) : 75.68 mm, thickness (depth) : 25.94 mm and weight : 45.2 g. The colouration of the shell was different with ash green radial lines on a yellowish brown background. The oysters of Gujarat had thicker nacre / periostracum/ shell thickness than those of other places.

On examination of the thickness (depth) of the shell, it was found that there was no significant difference ($p > 0.05$) between the thickness of pearl oysters from Gujarat, Tuticorin and Vizhinjam, but thickness of Mandapam oysters was significantly less ($p < 0.05$) than that of oysters from other areas.

ESP 05 MECOS 09

OCCURRENCE AND DISTRIBUTION OF FUNGAL ENDOPHYTES IN MANGROVES AND MARINE PLANTS

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Fungal endophytes survive within living plant tissues without causing any overt symptoms. The interest shown in studying fungal endophytes of different plant species is mainly due to the fact that their ecology and nature of interaction have not been thoroughly investigated and they are known to produce novel bioactive compounds useful in pharmaceutical industries. Furthermore, fungal endophyte associations are known to be beneficial to the host plants, which they colonize, and this is especially well documented in the case of grass-endophyte symbiosis. Many tree species have been screened for the presence of endophytes in the tropics and subtropics but, the studies on the fungal endophytes of mangroves and marine plants are meager. Therefore, an attempt is made here to understand the ecology of this cryptic group of organisms occurring in mangroves and other marine plants.

Mitosporic fungi, ascomycetes and mycelia sterilia were isolated as endophytes from mangroves and marine plants. The number of endophyte species recorded from different mangroves and marine plants ranged from 4 to 21. Although different species of mangroves were growing close to each other, their endophyte assemblages were dominated by different fungal species and similarity between any two pairs of endophyte assemblages was less (as exemplified by the similarity coefficient values that ranged from 0% to 21.2%) suggesting some host preference. Cluster analysis using Jaccard similarity coefficient of endophyte assemblages of mangroves and mangrove associates showed that the mangrove associates *Acanthus ilicifolius*, *Arthrocnemum indicum, Sesuvium portulacastrum* and *Suaeda maritima* harboured more similar endophytes.

Phomopsis and *Phyllosticta* are considered to be true endophytes and recorded as dominant endophytes from many of the terrestrial plant species that have been studied so far. These fungi were found to colonize the mangroves too. But *Phomopsis* has not been found to dominate the endophyte assemblage of any of the plants growing in saline environment. The strategies of the mangrove endophytes to adapt themselves to the harsh microenvironment and the observations regarding the dissemination of mangrove endophytes will be discussed.

ESP 06 **MECOS 09**

DIVERSITY OF FINFISH AND SHELLFISH IN EIGHT LANDING STATIONS OF SRIKAKULAM DISTRICT OF ANDHRA PRADESH, INDIA

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Srikakulam District on the east coast of India has a long coastal region with estuaries, backwaters and fishery resources. The diversity of the fishery was studied with special reference to the mud crabs from eight important landing centres, namely Bhavanapadu, Rajaramapuram, Kalingapatnam, Bandaruvanipeta, Komaravanipeta, Mogadharapadu, Srikurmam and Kallepalli. The dominant variety of the mud crabs (*Scylla serrata* and *Scylla tranquebarica*) were studied and reported from each station. The fishery diversity of each landing centre is reported in the present study.

ESP 07 **MECOS 09**

FLORISTIC STUDY ON SANDY BEACH OF CHAVAKKAD, THRISSUR DISTRICT, KERALA, INDIA

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Beach usually consists of loose particles composed of rock, sand, gravel, shingle, pebbles or cobble. Being an unstable environment, beach exposes plants and animals to changeable and potentially harsh conditions and thus organisms are adapted to salt spray, tidal overwash and shifting sands. The beach provides a unique habitat for a variety of angiospermic plants.

The present study deals with the current status of floristic composition of Chavakkad beach 10º 34′ 19"N and 76º 0′ 2′′E. Chavakkad beach is an important tourist spot and one of the best beaches along the west coast of India. This beach is sandy type. This work was conducted during April -August 2008. Two sites were selected along the beach and ten field trips were made. In each trip, plants were collected along with its inflorescence. Habitat, height, distance from the beach where the plants were seen and other details were noted at the time of collection. The collected samples were identified with the help of standard references.

A total of 76 plant species were identified from site 1 and 57 plant species from site 2. Altogether 133 plant species were identified from Chavakkad beach. Of

these, 83 were collected during pre monsoon season and 50 during monsoon season. Among 133 plant species, 29 were shrubs, 84 were herbs, 4 were climbers, 2 were twiners and 12 were trees. Dominant families of the area were Fabaceae, Euphorbiaceae, Rubiaceae, Malvaceae and Asteraceae. Plants seen only in this coastal area are *Launaea sarmentosa, Ipomoea pescaprae, Gisekia pharnaceoides, Crotalaria verrucosa, Allmania nodiflora var. roxburghi, Wedelia biflora* and *Canavalia maritima.* A total of 36 medicinal plants were also recorded.

Eight soil samples were collected from the study area. Soil analysis showed that soil near the sea had more salinity than that of sand far from the sea. Monsoon season showed slight decrease in salinity than the pre-monsoon period.

Nineteen beach plants were occupying the area nearest to the shoreline (pioneer zone) and the remaining plants were seen in the midshore and hindshore zone. *Launaea sarmentosa* and *Ipomoea pescaprae form* the dominant vegetation of pioneer zone. Midshore zone and hindshore zone were conspicuous with *Hibiscus tiliaceus, Cyanotis cristata* etc. and *Cocos nucifera, Casuarina equisetifolia, Pongamia pinnata* etc.

Human activities like fishing, picnics and careless beach use may leave a lot of waste and it may harmfully affect the vegetation of beach and may endanger many rare species that are endemic to the beach. Beach flora should be protected from these interventions.

ESP 08 **MECOS 09**

ASSESSMENT OF HYDROGRAPHIC PARAMETERS AND ANALYSIS OF MANGROVE FLORA IN POYYA BACKWATERS OF THRISSUR DISTRICT, KERALA, INDIA

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The present investigation deals with physico-chemical parameters and the diversity, distribution and abundance of mangrove vegetation at Poyya backwaters of Thrissur district, Kerala, India. Poyya backwater is connected to the Kodungallur backwaters. The study was conducted at Koshavankunnu (site 1), Chenthuruthy (site 2) and Poyya (site 3) in Kodungallur taluk during April-August 2008. This study area lies between $10^0 10'$ to $10^0 15'$N latitudes and $76^0 13'$ to $76^0 17'$E longitudes.

The hydrological parameters analyzed were temperature, pH, conductivity, total alkalinity, acidity, DO, salinity, total hardness, calcium, magnesium and BOD. The study revealed that hydrographic parameters fluctuated with seasons and stations.

Every parameter showed fluctuation due to rainfall during monsoon. The temperature ranged from 25 to 31^{0}C and total hardness between 30 to 52 mg l^{-1}. The pH of water was generally alkaline and fluctuated from 7.03 to 7.34. The salinity varied between 19.9 and 31.2 ppt during premonsoon season and 19.9 to 28.4 ppt during monsoon season.

A survey on the distribution of mangroves was conducted and the vegetation analysis was done by line transect method. Four true mangroves belonging to 4 genera were observed from three stations. The true mangrove species were *Aegiceras corniculatum, Avicennia officinalis, Acanthus ilicifolius* and *Excoecaria agallocha*. The mangrove associated species were *Derris uliginosa, Clerodendron inerme, Sphaeranthus indicus, Achrostichum aureum, Mariscus javanicus* and *Cyperus* species.

Acanthus ilicifolius was the dominant and abundant mangrove among the vegetation followed by *Avicennia officinalis*. *Aegiceras corniculatum* and *Excoecaria agallocha* were found only in site 3. The diversity index of the mangrove and associated flora in Poyya backwaters was 3.1 in site 3 and 2.4 in sites 1 and 2. The line transect analysis showed that *Acanthus ilicifolius* was abundant in site 2 and 3 and *Avicennia officinalis* in site 2 and 3.

ESP 09 **MECOS 09**

DIVERSITY OF MARINE FINFISH LARVAE IN VARIOUS ECOSYSTEMS OF IRANIAN WATERS (PERSIAN GULF)

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Studies were conducted on the breeding and nursery grounds of economically important fishes from the northern part of the Iranian side of Persian Gulf. The study site was in Bushehr coastal province with 625 km of coastline. Marine ecosystems of this area are highly diverse with estuary, creek, rocky bed, mangrove forest, coral reef dominated by various types of animals. Totally 25 stations were selected in three sub areas in the north, middle and south of Bushehr Province. Plankton samples were collected. Monthly samples were collected using a Bongo-Net with 500 μ of mesh size.

The following 31 families of fish larvae were identified: Belonidae, Blenniidae, Bothidae, Carangidae, Callionymidae, Carangidae, Clupeidae, Cynoglossidae, Engraulididae, Fistularidae, Gerreidae, Gobiidae, Hemiramphidae, Leiognathidae, Lutjanidae, Mugilidae, Mullidae, Paralichtydae, Platycephalidae, Polynemidae, Sciaenidae, Scorpaenidae, Siganidae, Soleidae, Sparidae, Sphyraenidae, Syngnathidae, Synodontidae, Teraponidae, Triacanthidae and Triglidae.

Among them, dominant families were Gobiidae, Sillaginidae, Sparidae, Gerreidae and Engraulididae with 46% of total abundance. Identification for some of them was based on species taxon and in other cases they were separated into different types. Most of fish larval groups were observed from late April to September and some of them such as Clupeidae, Gobiidae, Engraulididae and Sillaginidae were found in all months. Northern sub-area showed high diversity (1.64) and the southern sub-area showed low diversity (0.48).

ESP 10 **MECOS 09**

PLANKTON DIVERSITY IN A TROPICAL MARINE PROTECTED AREA-MAHATMA GANDHI MARINE NATIONAL PARK, WANDOOR, SOUTH ANDAMAN

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Mahatma Gandhi Marine National Park (MGMNP) is a Marine Protected Area in Andaman and Nicobar group of Islands in the Indian Ocean. Taking into consideration the significance of acquiring biodiversity knowledge in a tropical marine protected area, the present study was initiated. This study is based on the hydrographic and plankton samples collected from five stations covering two seasons namely, February (Winter monsoon, WM) and May (Inter monsoon, IM) of 2005. Environmental variables showed moderate seasonal variation. No significant spatial and temporal variations were observed in *Chla* distribution. Phytoplankton density and diversity showed clear seasonal variation. A total of 47 phytoplankton species was recorded during WM and 51 species during IM. Diatoms dominated in both seasons, followed by dinoflagellates and flagellates. Eventhough mesozooplankton biomass showed marginal variation between seasons, density and community structure showed significant seasonal disparity. In both seasons, copepods were the most dominant group. Dominance of copelates was noticed during WM. A total of 38 species of copepods belonging to 26 genera of 17 families was observed in WM and 31 species belonging to 27 genera of 18 families were noticed in IM.

ESP 11 **MECOS 09**

STUDIES ON THE AVAILABILITY OF LIVE BAITFISHES FOR POLE AND LINE FISHING WITH SPECIAL REFERENCE TO BIOLOGY OF DIFFERENT SPECIES OCCURRING IN ANDAMAN ISLANDS

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Availability of suitable live baitfishes forms an integral part of Pole and Line fishing for tunas. In the Indian waters, a traditional Pole and Line fishery exists in Lakshadweep Islands. Due to the availability of lagoons, the live baitfishes are easily caught prior to proceeding to the fishing grounds. However, in Andaman and Nicobar waters, the Pole and Line fishing is not practiced due to the lack of knowledge on the availability of live baits and the technique to catch them. The Fishery Survey of India made extensive studies on the availability of live baitfishes suitable for pole and line fishing in the Andaman waters during March 2006. Experiments were carried out on the fishing techniques because unlike in Lakshadweep Islands, the lagoon area is limited in the Andaman seas. The studies were conducted as part of the tuna-tagging programme implemented by the FSI in the Andaman waters during 2008. A review of the literature shows that no studies on tuna live baits in Andamans were carried out earlier. The present paper provides information on the availability of baitfish species in the Andaman waters, and the fishing technology adopted to catch them with special reference to the biology of different species. The study is of preliminary nature since the data collection was for a limited period only. The catch rate of tuna live baits collected from the four baitfish grounds, *viz*., Chidiyatapu, west side of Comeo, east side of Comeo and Havelock Islands are presented. Length frequency, length-weight relationship, food and feeding, maturity and fecundity of major live bait species, *Atherinomorus lacunosus*, *Spratelloides delicatulus, Herklotsichthys quadrimaculates,* and *Sardinella melanura* are presented and the suitability of these species as tuna live baits in Pole and Line fishing is discussed. The information on the baitfishes will enable the islanders to develop Pole and Line tuna fishery for effective exploitation of resources especially the skipjack and yellowfin tunas which are abundant in the Andaman and Nicobar waters.

ESP 12 **MECOS 09**

DIVERSITY OF FINFISHES IN THE FISHERIES OF UTTAR KANNADA, KARNATAKA, INDIA

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Inventorisation of finfishes landed along the coastal Uttar Kannada district of Karnataka listed 241 species from 85 genera. Commercially viable fishes, constituted by only 44 species from 18 genera, formed the bulk of the landings. Maximum species diversity was seen among the carangids (23 spp.) followed by sciaenids (13 spp.), leiognathids (11 spp.), clupeids (10 spp.), lutjanids (8 spp.) and cynoglossids (6 spp.). The remaining constituted either negligible or stray landings. One of the most highly priced food fishes, *Sillago sihama*, was landed only in negligible quantities. A total of 184 species were caught by trawlers in which *Cynoglossus macrostomus* was the dominant species, forming 36%, which is markedly different from trawl landings in any other regions in India. Gearwise landings of the finfishes showed that 21 species occurred in purse seine fishery with *Sardinella longiceps* constituting 79.3% of the landings; 78 species from 44 genera in gill netters and 104 spp. belonging to 52 genera from shore seines. A large number of juveniles of commercially valuable species were observed in the shore seine landings. Diversity indices for comparison between gears and seasons were worked out for trawlers and purse seiners.

ESP 13 **MECOS 09**

SEASONAL VARIATION OF BENTHIC MACROFAUNAL DIVERSITY IN ARKATTUTHURAI (PALK STRAIT) REGION, SOUTHEAST COAST OF INDIA

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The present study has been done to map out the seasonal variation of macrofaunal diversity at different depths, *viz*., 0, 5, 10 and 20 m in Arkattuthurai region of Palk Strait, southeast coast of India during March 2007 to February 2008. A total of 66 species of macrofauna was recorded. Among the faunal groups, polychaetes were found to be the dominant group with 38 species, followed by bivalves with 15 species and gastropods with 13 species. The density of organisms varied from 62 during post-monsoon period at a depth of 10 m to 126 during summer

at 20 m depth. The species diversity varied from 4.075 at 10 m depth during pre-monsoon to 4.935 at 20 m depth during summer. In conclusion, the distribution of macrofauna was found to increase with increasing depth and the probable reasons is discussed in the paper.

ESP 14 **MECOS 09**

POSSIBILITIES OF PRODUCTION OF BIOFUEL FROM ALGAE

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Algae from the oceans offer a sustainable energy source of the future. It is known that algae contain hydrocarbon reserves in them, but much attention has not been paid in exploiting the same due to availability of oil in sizable quantities from fossil deposits. Algae are tiny biological factories that use photosynthesis to transform carbon dioxide and sunlight into energy so efficiently that they can double their biomass several times a day. As part of the photosynthesis process, algae produce oil and can generate fifteen times more oil per acre than other plants used for biofuel, such as corn and soya. Microalgae contain lipids and fatty acids as membrane components, storage products, metabolites and sources of energy. Algae can grow in seawater, freshwater or even contaminated water, and on land not suitable for crop production. Studies carried out in Kansas State University show that it is possible to obtain fuel from the marine algae.

Compared with second generation biofuels, algae are high-yield (thirty times more energy than terrestrial crops) resources which produce biofuels. Since the whole organism uses sunlight to produce lipids, or oil, algae can produce more oil in a given area.

Petroleum alternatives have to be developed before the exhaustion of petroleum supplies in natural beds. The majority of petroleum has its origin in algae, which were grown using CO_2 as a sole carbon source. Several studies relevant to the production of oil using microalgae have been reported. These include hydrocarbon production by *Botryococcus* by thermochemical liquefaction of algae and algal hydrocarbon processes.

Laboratory studies have shown that the lipid and fatty acid contents of microalgae vary according to culture conditions. The lipid content can be increased by imposition of nitrogen starvation and stress. In *Botryococcus,* 90% increase in lipid content was reported under unfavourable conditions such as different levels of salinity regimes. In the microalga *Nannochloropsis* cultured under marine conditions, the lipid content as high as 70 to 85% on dry weight basis was reported and in diatom *Navicula pelliculosa*, the lipid content increased by about 60% during 14 hours of silicon starvation period.

The favorable features for of biofuel from microalgae are their small size and the ease with which can be treated chemically. They can be grown under conditions which are unsuitable for other crops during photosynthesis. They are capable of fixing atmospheric CO_2 and reduce the gas in the atmosphere. The cost of harvesting and transportation is very low. Unlike other raw material, such as soya or corn, they can be harvested day after day. Up to 50 percent of an alga's body weight comprises of oil, whereas oil-palm trees currently the largest producer of oil to make biofuel, yield about 20 percent of their weight in oil. The biofuels are free of sulphur and are non-toxic.

The microalgae identified so far, as the source of hydrocarbons are *Botryococcus braunii*, *Nannochloropsis*, *Navicula* sp., *Chlorella pyrenoidosa*, *C. vulgaris*, *Euglena gracilis*. *Dunaliella* sp. etc. The macroalgae *Gracilaria* and *Sargassum* have also been reported recently as potential sources.

Investigations carried out by University of Tokyo, Japan; University of Minnesotta, Central Food Technological Research Institute, Mysore, National Institute for Pharmaceutical Education & Research, Mohali, Punjab and Institute of Engineering & Technology, Massey University, New Zealand indicate encouraging results on the possibilities of extraction of biofuel from cultured algae. In the light of this, there is a need for further studies to identify candidate algal species and develop viable technology for production of biofuels.

ESP 15 **MECOS 09**

DIVERSITY, DISTRIBUTION AND COMPOSITION OF THE HOLOPLANKTON OF THE CONTINENTAL SLOPE WATERS ALONG THE NORTHWEST COAST OF INDIA

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A comprehensive study was undertaken to assess the spatial distribution, diversity and group composition of holoplankton along the northwest coast of India. The holoplankton samples were collected during FORV *Sagar Sampada* Cruise Number 219, using Bongo net by subsurface hauling. The sampling was done from stations located at 200 m, 500 m and 1000 m depth off Goa, Ratnagiri and Dhabol transects.

The results showed that copepods formed the largest group in all stations except 1000 m off Goa. The other major taxonomic groups were Chaetognatha, Oikopleura, Siphonophora, and Cladocera. Amphipods, mysids and euphausids were found in moderate density. Decapods, lamellibranchs, salps, isopods, pteropods and *Tomopteris* were represented in lower quantity.

The results of biomass estimation indicated that during the post-monsoon season, the biomass in the continental slope was moderately high. Of the nine stations covering the three transects, 1000 m depth off Goa transect was found to be more productive in terms of both population density (523590/1000m^3) and total zooplankton biomass (7343.5ml/1000m^3). This could be due to the occurrence of ostracod swarm in the 1000 m depth station off Goa. The lowest biomass was recorded at 1000 m depth station off Dhabol (687. 4 ml/1000m^3). The 500 m station off Goa showed the lowest population density (50795/1000m^3). On estimating the depth-wise biomass, the highest average zooplankton biomass was found at 200 m depth stations (3705.3ml/1000m^3). When all the nine stations were considered, the highest average population density was that of copepods (82742/1000m^3) and the lowest was that of *Tomopteris* (5/1000m^3). The average population density of all holoplankton was 172528/1000m^3.

An interesting finding was on the trophic relationship between siphonophores and copepods. The correlation between copepods and siphonophores in all the nine stations were of high significance, with a correlation coefficient 0.831 and p value 0.00555. Earlier studies indicate that copepods comprise 80-100% of the prey of some siphonophores in oligotrophic waters and the distribution of actively swimming siphonophores can be linked with the predominance of their prey, particularly copepods.

ESP 16 **MECOS 09**

DISTRIBUTION OF BIVALVES IN KANDLERU ESTUARY, NELLORE DISTRICT, ANDHRA PRADESH

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Survey was conducted on the distribution of bivalves in Kandleru estuary during 2004 from bar-mouth upto Lingapuram village in the south. Totally 16 stations were fixed and collections were made by using a quadrate and the biomass of each species was estimated for each station. Studies were made on the gonad smear of all bivalves to note the sex ratio, percentage edibility and maturity stages.

The potential resources of bivalves in Kandleru estuary comprised *Meretrix casta, Anadara granosa, M. meretrix, Crassostrea madrasensis, Mercia opima* and *Perna viridis*. Among the bivalves, the clam *M. casta* was found to be the dominant species and the biomass was estimated at 283.3 t in a total area 41.4 ha, which constituted 52.7% of the total bivalve biomass of the estuary. *Anadara granosa* was the second highest population of bivalves found to occur in 12 stations in the estuary. The extent of the bed was 40.9 ha and the total biomass was 112.9 t which formed 20.9% of the total bivalve population. *M. opima* occurred in 7 stations and the total bed was 30.4 ha with a biomass of 30.8 t which formed 5.7% of the total bivalves.

The edible oyster *C. madrasensis* was noticed in four stations and were found grown on the wharf of harbour, granite stones opposite to port office, laterite and granite stones in the intertidal region along the western side of the harbour and Buckingham Canal. The oysters were sparsely distributed near the villages of Gummaladippa and Lingapuram. The oyster biomass was estimated as 41.1 t in a total area 1.01 ha, which formed 7.6% of the bivalve biomass of the estuary.

The mussel *P. viridis* was recorded in 4 stations and the total biomass was estimated as 5.8 t forming 1.1% of bivalve population of the estuary. Mussel population was moderately distributed on the granite stones near the wharf, and sparsely distributed on the concrete structures in the Buckingham Canal and laterite groynes near the lock area.

There was a regular fishery for bivalves in Kandleru estuary especially for the shells which were used for lime making and the meat was supplied to shrimp industry to feed the shrimps. The fishery composed of *A. granosa* (50%), *M. casta* (30%), *M. opima* (10%), *M. meretrix* (5%) and miscellaneous bivalves (5%).

ESP 17 **MECOS 09**

MARINE SPONGES - A BOON TO BIOWORLD

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Studies on marine sponges are one of the major areas of research. They have attracted significant attention from various scientific disciplines, such as evolutionary biology, chemical ecology, microbiology, cell biology, biotechnology and marine biology. A number of novel bioactive compounds have been isolated from this group, which include cytotoxins, antibiotics, antiviral and anti-inflammatory compounds. They have found their way in biotechnological application. The diversity of secondary metabolites from sponges ranges from derivatives of amino acids and nucleosides to macrolides, porphyrins, terpenoids to aliphatic cyclic peroxides and sterols. Three nucleosides were isolated from the Caribbean sponge *Cryptotethya crypta*, which exhibit antiviral properties. Synthesis of analogues were initiated which led to the first antiviral compound Arc A and antitumor compound Arc C. Several anticancer metabolites from marine sponges such as discordermolide, halichondrin B and bryostastin 1 have progressed to pre-clinical or clinical-trial phases and they are thought to be produced from their microbiotic consortia. Halicyclamine-A obtained from the marine sponge *Haliclona* sp, showed inhibition against *Mycobacterium tuberculosis*. The marine sponge *Haliclona exigua* yielded a fraction rich in bis-1-oxaquinolizidine alkaloids, active against several strains of fouling bacteria as well

as cyprids of the cosmopolitan barnacle, *Balanus amphitrite*. Cell biology provides us with new perspectives on the ecology and biology of cells, leading to the cultivation of sponges and ultimately to sustainable use of marine resources. Despite the wide range of functional roles performed by marine sponges, they are still poorly represented in many research, monitoring and conservation programmes.

ESP 18 **MECOS 09**

SEASONAL DISTRIBUTION OF ZOOPLANKTON IN ESTUARIES AND BACKWATERS IN CHENNAI

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Water and zooplankton samples were collected from two estuaries of Chennai city *viz*., Adyar and Cooum; the backwaters Ennore and Muttukadu; and the Pulicat Lake during dry and wet season of 2007 and 2008. The dominant zoolplankton groups were copepods, rotifers, tintinnids and polychaete larvae. Copepods contributed the maximum. Irrespective of seasons and habitats the copepods were encountered more in number. The percentage of copepods was high during wet season in Cooum, Adyar and Pulicat Lake than in the backwaters of Muttukadu and Ennore. It may be concluded that the copepods could withstand different environmental conditions and may be considered as a potential bioindicator to study pollution and other related aspects.

ESP 19 **MECOS 09**

SEASONAL VARIATION OF PLANKTON ABUNDANCE, STANDING STOCK AND COMMUNITY STRUCTURE IN COCHIN BACKWATERS

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Investigations on phytoplankton and zooplankton abundance, biomass and community structure were studied in the Cochin backwaters during the pre-monsoon and monsoon months in relation to environmental conditions. The estuary was characterized by low salinity (<6 psu) and high nutrient levels during the monsoon months, whereas during the pre-monsoon period, it was highly saline with less nutrient

levels. Phytoplankton biomass was two times higher in the estuary during the pre-monsoon as compared to the monsoon, whereas the density showed an inverse pattern. In the case of zooplankton, both biomass and density were double during pre-monsoon. Irrespective of the seasons, diatoms and copepods formed the abundant groups of phytoplankton and zooplankton, respectively. The highest diversity and richness of phytoplankton (0.887 and 1.491) and zooplankton (0.293 and 0.561) were encountered during the pre-monsoon period. *Thalassiosira subtilis* was the most abundant diatom (mean: 1122.29 x 10^3 cells L^{-1}) during pre-monsoon,

Table 1. Population density (number/1000m^3) of various holoplanktonic groups

Groups	Stations				Average					
		GOA			RATNAGIRI			DHABOL		
	27	28	29	30	31	32	33	34	35	
Copepods	85293.78	17133.81	154507.07	54512.54	63263.19	85639.44	161746.61	68995.19	53591.81	82742.60
Ostracods	51627	8098.62	274108.07	2680.94	5588.13	1206.64	23645.87	5121.38	13006.12	42786.97
Chaetognaths	50247.21	5950	31772.84	6101.46	12452.57	19179.17	10398.26	2827	5471.92	16044.49
Oikoplura	5082.21	10632.88	1762.44	20276.57	24663.68	11367.79	33674.08	655.54	852.41	12107.51
Siphonophores	4392.32	6280.56	15225.51	5454.34	5484.65	9367.31	25718.12	2048.55	1704.82	8408.46
Cladocerans	988.85	440.74	31479.1	986.09	1310.80	5334.60	2146.26	327.77	3354.64	5152.10
Amphipods	8071.75	1212.04	6560.19	2126.27	241.46	1174.88	2701.33	81.94	164.98	2481.65
Mysids	1816.72	330.56	342.7	277.34	137.98	4636.02	0	3646.42	632.43	1313.35
Euphauasids	0	550.93	7196.62	0	103.48	222.28	703.09	491.65	577.44	1093.94
Heteropods	0	0	0	0	137.98	95.26	0	778.45	247.47	139.91
Decapods	114.98	0	293.74	30.82	68.99	285.78	0	40.97	82.49	101.97
Lamellibranchs	206.97	165.28	293.74	61.63	0	0	0	0	0	80.85
Salps	23	0	0	61.63	413.94	0	0	0	0	55.40
Isopods	0	0	0	0	0	0	0	0	54.99	6.11
Pteropods	0	0	48.96	30.82	0	0	0	0	0	8.86
Tomopteris	0	0	0	0	0	0	0	40.97	0	4.55
TOTAL	207864.79	50795.42	523590.98	92600.45	113866.85	138509.17	260733.62	85055.83	79741.52	172528.72

whereas it was *Leptocylindrus danicus* (mean: 6182.9 x 10^3 cells L^{-1}) during monsoon. Among zooplankton, the second dominant group was the decapod larvae during pre-monsoon, whereas it was the cladocerans during monsoon. It may be concluded that high salinity due to seawater incursion during pre-monsoon and enormous freshwater input during monsoon led to an inconsistency in distribution and community structure of plankton in Cochin backwaters.

ESP 20 **MECOS 09**

MACROBENTHOS AND SEDIMENT CHARACTERISTICS OF THE INNER SHELF OF CENTRAL SOUTHWEST COAST OF INDIA

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The macrofaunal community and sediment characteristics of inner shelf of the Central Kerala, southwest coast of India (9º15'N to 10º10'N) in November 2000 are presented. Data were collected at 45 stations along nine transects across the shelf, within the depth range of 2-40 m. Mainly clay and silty clay sediments prevailed in the study area. Clay was the predominant sediment in shallow depths and sand was high in deeper depths. Organic matter varied from 0.06 to 7.02% and high values were observed in shallow and intermediate depths, in association with fine sediment. Polychaete was the dominant group followed by molluscs and crustaceans. Biomass (wet weight) and population density of macrobenthos varied from 0.2 to 154 g/m^2 and 21 to 13651/m^2 respectively. Biomass, density and diversity showed an increasing trend towards greater depths. Stations along Cochin and Alleppey accounted for high benthic density, and production (biomass). This could be due to seasonal mud bank formation in the region. This study showed that offshore regions are more productive in terms of biomass and density than nearshore regions. The possible reason may be the homogenous sediment such as sandy or clayey sediment (not conducive for organisms) in the nearshore region and heterogeneous sediment (clayey sand) with increased sand content (favorable for organism) in the offshore region.

ESP 21 **MECOS 09**

DISTRIBUTION OF ZOOPLANKTON IN SELECTED CENTRES OF COCHIN BACKWATERS, KERALA

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Seventeen groups of zooplankton were recorded from nine stations along the Cochin backwaters, during the period from August 2000 to July 2002. Qualitative and quantitative distributions of these groups in the nine stations are presented. Of the 17 zooplankton groups, 16 groups were recorded from Station I (Vypeen) as well as from Station VI (Fisheries Harbour) and the number of groups was minimum (9) at Station V (Eloor). Quantitatively, the zooplankton was maximum at Station II (Puthuvypu) followed by Station III (Narakkal) with 42% and 39% respectively and

the zooplankton density was minimum at Station V (Eloor) with 0.7%. Among the different groups of zooplankton, 52% composed of rotifers, followed by copepods which formed 40%. Rotifers were dominant at Stations II, III and VIII while copepods contributed to the maximum in all the other six stations.

ESP 22 **MECOS 09**

DISTRIBUTION AND ABUNDANCE OF MYCTOPHIDS OFF THE SOUTHWEST COAST OF INDIA

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Lanternfishes of the family Myctophidae are considered as one of the most dominant fish groups of the mesopelagic realm of the world oceans. GLOBEC has estimated a stock of 100 million tonnes of *Benthosema pterotum*, a myctophid in the Arabian Sea, which is considered as the largest single stock of fish species in the world. During the exploratory survey carried out from February, 2004 to April, 2005 by *M.V. Matsya Varshini* for assessing the distribution and abundance of non-conventional deep-sea fishes, an attempt was made to understand the systematics, distribution and abundance of myctophid resources off the southwest coast of India (lat. 7^0N-10^0N).

Five species belonging to two genera were recorded during the study (Table 1). They were recorded areawise from 8^0N-10^0N (Table 2). Distribution of myctophids was found to be restricted to 300 m depth and above (Table 3). The average catch per unit effort (CPUE) of 39.3 kg. h^{-1} obtained from the 400-500 m depth zone indicates that they prefer deeper waters. Biomass of the lanternfishes was estimated using the swept area method as 1202 tonnes. Differences in the catch rate recorded during different quarters in a year and species composition indicate that seasonal variation exists in the case of lanternfishes. A comparative study on the efficiency of the 45.6 m Expo model fish trawl and 45.1 m shrimp trawl indicated that during day time the myctophids are bentho-pelagic in distribution. They were available in the shrimp trawl catches in significant quantity, but their presence in fish trawl was very meager. Length frequency of *Diaphus splendidus*, the dominant myctophid recorded during the period was determined. Specimens with a length range of 9-17 cm with mean length of 14.5 cm was recorded during the study period. Results of the present study were compared with that of earlier works. There is need for a systematic comprehensive study to understand the dynamics of the resource, utilisation strategy, introduction of new techniques and methods for making value added products and to evolve a policy for the sustainable exploitation of lanternfishes in Indian waters.

Table 1. Myctophids collected during the study

S.No.	Species	Area of collection Lat (N) / Long (E)	Depth (m)	Total length (cm)
1	*Diaphus splendidus* (Brauer, 1904)	$09^0$20.2′ $75^0$44.4′	357	16.5
2	*Diaphus antonbruuni* Nafpaktitis, 1978	$08^0$14.2′ $76^0$32.4′	435	15.3
3	*Diaphus* sp.	$08^0$45.0′ $75^0$53.0′	410	7.8
4	*Diaphus* sp.	$08^0$08.4′ $76^0$36.4′	418	6.6
5	*Lampadena luminosa* (Garman, 1899)	$08^0$15.7′ $76^0$30.7′	455	12.1

Table 2. Catch details

Parameter	7^0-8^0N	8^0-9^0N	9^0-10^0N
Depth (m)	200-500	200-500	200-500
Effort (h)	3.0	13.33	9.25
Myctophids (kg/h)	0	20.20	3.5
Non-conventional finfishes (kg/h)*	1070.00	665.12	142.70
Others (crustaceans, molluscs, sharks etc) (kg/h)	13.30	17.48	143.50
Total	1083.33	682.60	286.20

* including myctophid

Table 3. Depthwise catch ($kg.h^{-1}$)

Parameter	200-300 m	300-400 m	400-500 m
Effort (h)	6.5	12.83	6.255
Myctophids (kg/h)	0	4.3	39.3
Non-conventional finfishes (kg/h)*	1829.37	50.07	137.93
Others (crustaceans, molluscs, sharks etc) (kg/h)	174.01	34.61	4.01
Total	2003.38	84.68	141.94

* including myctophids

ESP 23 **MECOS 09**

FATTY ACID SIGNATURES OF THE INDIAN MACKEREL *RASTRELLIGER KANAGURTA* (CUVIER) FROM THE ARABIAN SEA ALONG INDIAN COAST

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Fatty acid profile of the Indian mackerel *Rastrelliger kanagurta* (Cuvier), an important food fish in India, was studied with respect to seasons, sex and maturity conditions. The polyunsaturated fatty acids (PUFAs) form the largest component followed by saturated fatty acids (SFA) and monounsaturated fatty acids (MUFA) with a mean of 46.9%, 41.8% and 11% of the total fatty acids respectively. The major constituent among the SFA was palmitic acid (16:0, 24.8%) followed by stearic acid (C18:0, 9.8%) and myristic acid (C14:0, 3.5%). The major monounsaturated fatty acids were oleic acid (C18:1, 6.9%) and palmitoleic acid (C16:1, 2.9%). Among the polyunsaturated fatty acids, docosahexaenoic acid (C 22:6n3, 29.6%), eicosapentaenoic(C 20:5n3, 6.2%) and arachidonic acid (C 20:4n6, 4.5%) were the major constituents. Mean levels of SFA, MUFA and PUFA did not show significant seasonal variations. When SFA, MUFA and PUFA levels were compared across sex and maturity stages, only MUFA levels showed significant variations ($p < 0.05$). However individual fatty acids in all the three groups showed variations related to seasons, sex and maturity.

ESP 24 **MECOS 09**

A STUDY ON THE INCIDENTAL LANDINGS OF WHALE SHARK *RHINCODON TYPUS* (SMITH, 1828) JUVENILES ALONG THE INDIAN COAST

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On May 17, 2008, a single female juvenile whale shark, *Rhincodon typus* measuring 115 cm total length (TL) and weighing 6.1 kg was landed by a drift gillnet unit at Cochin Fisheries Harbour. The whale shark was commercially exploited on a large scale along the Saurashtra coast of Gujarat until the hunting of these species was banned on 28, May 2001 due to agitations by whale shark conservationists and animal welfare organizations. Presently, this is a protected species under the Schedule-1 of Indian Wildlife Protection Act, 1972 but stranding and occurrence as by-catch

is reported along the Indian coast. The length at first maturity of whale shark is reported as 10 m TL and size below 550 cm is considered as juveniles. This communication reports a detailed morphometric study on the juvenile specimen collected from Cochin Fisheries Harbour (Table 1) and also compiles all the available information on the juvenile whale shark landing and stranding along the entire Indian coast during 1900– 2008 (Fig. 1).

Literature survey on incidental landings of juvenile whale shark along in the Indian coast for the period indicated 45 reports. About 47% of landings were reported from the southeast coast. Tamil Nadu was the leading state followed by Kerala in the reported incidental landings. January to March was the peak season of landings, forming 60% of the total landings. The sex of 23 of the specimens was reported of which 16 were males and 7 were females. Juveniles were reported to occur between 10 - 90 m depth with maximum landings from 20 – 30 m depth. Nearly 60% of the total incidental landings were by gillnets.

Table I. Morphometric measurements (cm) of juvenile whale shark landed at Cochin

Characteristics	Measurement (cm)
Total length	115
Fork length	94.5
Pre-caudal length	81
Pre-second dorsal length	66
Pre-first dorsal length	46
Head length	25.5
Pre-branchial length	17.5
Pre-spiracular length	7.9
Pre-orbital length	5.1
Pre-pectoral length	23.9
Pre-pelvic length	50.9
Snout-vent length	52
Pre - anal length	67
Inter dorsal space	11.4
Dorsal–caudal space	10.5
Pectoral–pelvic space	20.4
Pelvic- Anal space	33.4
Anal- Caudal space	10.4
Pelvic-Caudal space	24.3
Eye length	1.5
Inter gill length	9.7
First gill slit height	9.4
Fifth gill slit height	7
Pectoral - fin length	12.9
Pectoral - fin base length	9.1

Dorsal caudal margin	34.9
Preventral caudal margin	17
First dorsal fin length	12.3
First dorsal base length	8.8
Second dorsal length	8.3
Second dorsal base length	4.3
Pelvic length	7.4
Pelvic base length	4.8
Anal length	7.8
Anal fin base	4.1
Second dorsal origin- anal origin	0.7
First dorsal midpoint–pectoral insertion	18.2
First dorsal midpoint–pelvic origin	1.6
Pelvic midpoint–first dorsal insertion	17.8
Pelvic midpoint–second dorsal origin	3.1
Inter orbital space	20
Eye spiracle space	1.9
Mouth width	15

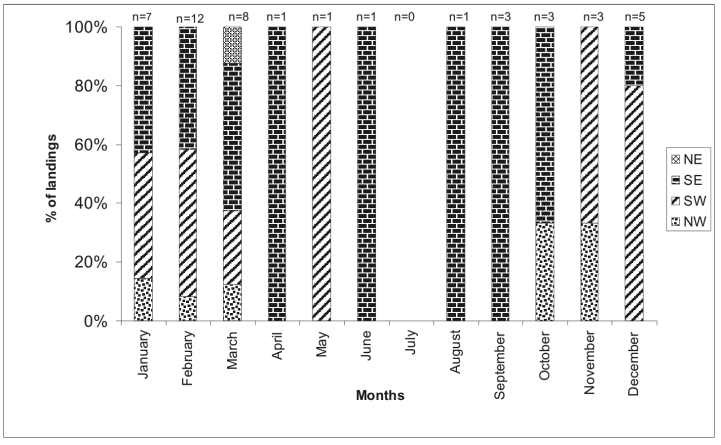

Fig. 1. Reported incidental landings of juvenile whale sharks along the Indian coast during 1900- 2008

ESP 25 MECOS 09

SOME ASPECTS OF FISHERY AND BIOLOGY OF COBIA *RACHYCENTRON CANADUM* (LINNAEUS, 1766) IN THE INDIAN WATERS

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The cobia, *Rachycentron canadum* (Linnaeus, 1766) is widely distributed in tropical and subtropical waters. Being an excellent table fish with a high growth rate in captivity it is targeted in capture fisheries as well as aquaculture. World production of cobia including that raised in culture was reported to be about 10,416 tonnes in 2002, with Taiwan, Pakistan, Philippines, Brazil and the UAE listed as the top producers. During the year 2007 the estimated annual landings of cobia in India was 2582 tonnes. State wise production trends during 2007 indicate that Kerala topped in cobia landings with an estimated production of 1350 tonnes that formed (52%) of the all India cobia landings followed by Maharashtra (534 t) whose contribution was 21% (Fig. 1). Production from West Bengal (144 t) and Karnataka (158 t) was 6% each while Gujarat (134 t) contributed 5%.

Along the Indian coast, cobia occurs mainly as a by-catch in the drift gillnet-cum-hook and line tuna and shark fishery, in the trawls targeting shrimps and in purse seine fishery. Gillnets and hook & line accounted for majority of the catch followed by trawls. Predominantly large sized cobia measuring 60-163 cm (in fork length, FL) were landed by gillnets cum hook and line fleet while in the shrimp trawls 30- 110 cm FL specimens were caught but juveniles measuring 30-50 cm FL were dominant.

In the last few years the development of multi-day distant water fishing has largely contributed to the increased landings of cobia at Cochin Fisheries Harbour. In 2008, a good fishery was observed at Cochin Fisheries Harbour with an estimated annual landing of 81 t. Peak landings occurred during the 3rd quarter of the year with nearly 60% of the estimated catch in weight landed during September. Monthly size range (FL) of cobia during 2008 was: August (30–163 cm) September (59-155 cm), October (58-150 cm), November (30-150 cm) and December (30 -170 cm). During August, 12 % of the cobias landed were below the reported length at first maturity (L_m) of 70 cm. The length-weight relationship was estimated as $W = 0.007951\ L^{3.024}$ (length in cm, weight in g) (Fig. 2) and did not differ significantly between the small (<60 cm FL) and larger size groups (>60 cm FL). The food and feeding studies revealed that the major food item was finfishes followed by crustaceans (crabs and prawns) and cephalopods.

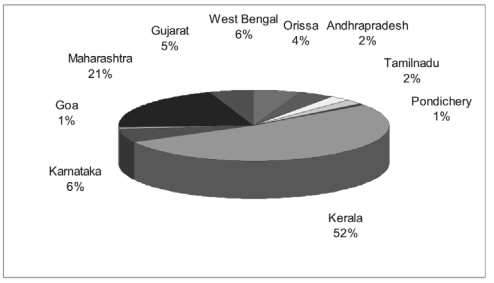

Fig. 1. Contribution of maritime states to all India cobia landings during 2007

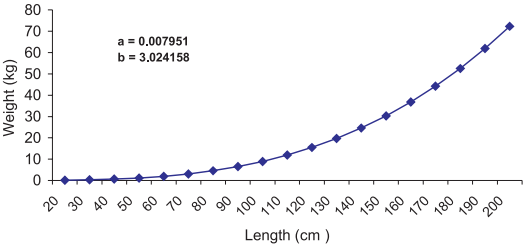

Fig.2. Length-weight relationship of cobia, Rachycentron canadum

ESP 26 **MECOS 09**

AN APPRAISAL OF RING SEINE FISHING SYSTEMS OPERATED OFF COCHIN, INDIA

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Ring seine or mini-purse seine is one of the prominent fishing gears in the artisanal fisheries sector of Kerala. Since its introduction in the mid-eighties, the ring seine has caused displacement of gears such as *thanguvala*, operated from the traditional boat seines. The design and operational features of the ring seine prevalent in the Cochin coast have been described in this paper along with a review of the important changes that have taken place in the design and operation of the gear since its introduction. Data for this study were collected from the coastal villages of Chellanam and nearby landing centers and technical details of craft and gear such as length, width, mesh size, and catch were made. Data on capital investment, material costs, engine, fuel cost and auction charges were analysed. Fishing area, depth, haul details, duration of fishing etc were collected. *Thanguvala* with mesh size of 20 mm, length of 600 -1200 m, and *choodavala* with a mesh size of 8- 10 mm, length of 250- 500 m, depth of 45- 75 m are being currently operated. The

length of the craft vary from 24 to 28 m. There is a gradual shift of boat building material from wood to steel. The huge capital investment for craft and gear in the fishery is found to cause indebtedness among fishermen. About 55 - 60% of the total investment is from loans taken from cooperative societies, auctioneers, local money lenders, banks etc. It is estimated that the major share of the total operational cost in OBM operated vessels is spent on fuel. Sardines contribute 60-70%, mackerel 20% and the rest by the shrimps *Metapenaeus dobsoni, Fenneropenaeus indicus* and *Parapenaeopsis stylifera*, carangids, pomfrets, scads and cephalopods. Juveniles are mainly caught in *choodavala* units.

ESP 27 **MECOS 09**

A MOLECULAR APPROACH TO REVEAL THE GENETIC IDENTITY OF PARROT AND SYMPATRIC MUSSEL SPECIES DISTRIBUTED ALONG THE KERALA COAST

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Two commercially important mussel species are recorded from the Indian coast: the green mussel *Perna viridis* (Linnaeus, 1758) and the brown mussel *P. indica*. A third type referred to as parrot mussel which has shell shape of brown mussel, but with green shell coloration and suspected to be the hybrid of the above two species has been reported from Kollam coast of Kerala, where both brown and green mussels co-exist. The genetic identity of green, brown and parrot mussels were determined using protein and genomic DNA markers in this study. Protein markers *viz*. Sodium Dodecyl Sulphate Polyacrylamide Gel Electrophoresis (SDS-PAGE) and allozymes and the genomic DNA marker Random Amplified Polymorphic DNA (RAPD) were used for determining the genetic identity of the three mussels.

SDS PAGE pattern clearly differentiated the green and brown mussels. The parrot mussel protein pattern was similar to that of the brown mussel, except for an additional band of molecular weight 48.7 Kda, which is unique to the brown mussel. Allozyme electrophoresis also followed a similar pattern. Of the 10 allozyme loci studied, seven revealed species-specific diagnostic differences between *P. viridis* and *P. indica*. They were *AAT-1** (Aspartate Amino Transferase-1*), *AAT-2*, ME* (Malic Enzyme)*, *PGM-2** (Phospo Gluco Mutase-2*), *EST-1** (Esterase-1*), *EST-2*, IcDH** (Isocitrate Dehydrogenase)*. Parrot mussel shared all the alleles of brown mussel and no hybrid pattern was observed. Species-specific alleles clearly differentiated green mussel from both brown and parrot mussels. The Nei's genetic distance of green mussel from the brown mussel, estimated from allozyme data was 1.1145% and with parrot mussel 1.105%. The genetic distance between parrot mussel and brown mussel was negligibly low (0.0005). The RAPD analysis using 7 Operon random primers also indicated

comparatively higher genetic similarity between the parrot mussel and brown mussel (0.9141) as compared to the green mussel (0.4743). The genetic distance between parrot and brown mussels were negligibly low (0.0898) and the same between green and brown mussels was high (0.7460). Based on the electrophoretic pattern and genetic distance values, it can be concluded that the parrot mussel is only a morphotype of brown mussel and not a true hybrid of the two, as reported by previous authors.

ESP 28 **MECOS 09**

ALLOMETRIC STUDIES ON THE ASYMMETRIC CLAWS OF THE SNAPPING SHRIMP *ALPHEUS EUPHROSYNE* FROM VEMBANAD LAKE

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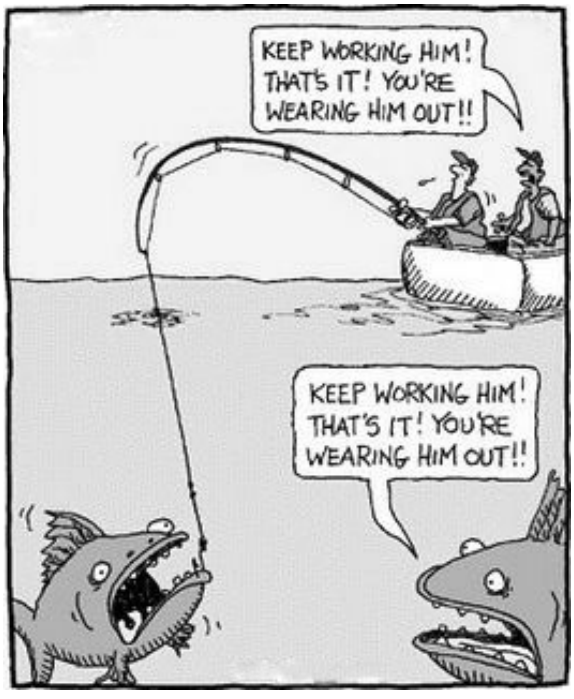
Snapping shrimps of family Alpheidae are characterized by bilaterally asymmetric first pair of chelipeds, comprising of a snapper claw and a pincer claw. The snapper claw is a much hypertrophied structure almost half the size of the entire animal. The contra-lateral pincer is comparatively small and is primarily used for burrowing and feeding. The presence of snapper claw is either on the left side or on the right side, by which males and females belonging to the same population can be distinguished into two morphological kinds. Morphometric measurements were recorded from 480 specimens of the snapping shrimp *Alpheus euphrosyne* (2.14 to 5.68 mm TL) collected from Vembanad lake. Fourteen morphometric measurements such as total length, carapace length, stretched length of pincer and snapper claws and their podomeres were taken from males with right snaper (MR), males with left snapper (ML), females with right snapper (FMR) and females with left snapper (FML). Higher mean lengths were recorded in males, especially in podomere lengths. The mean propodus length of ML was 51% longer than the same of FML. Similarly, a 20% longer mean propodus length was noticed in MR in contrast to FMR. Allometric studies of peraeopod lengths in relation to carapace lengths revealed positive correlation in all cases. It could be noticed that the first pair of peraeopods followed a positive allometric growth in relation to carapace length in all morphological groups except in FMR. The present study brings out differences in the relative growth of podomeres in relation to carapace length of the two morphological kinds of male and female *A. euphrosyne*. The analysis of covariance of growth of snapper and pincer propodus in relation to carapace length were found to be significantly different ($p < 0.01$) between male and female morphotypes. The snapper propodus of MR was found to follow a positive allometric growth whereas the same of other morphotypes followed isometry. In contrast, the pincer propodus of FMR was found following a negative allometry with respect to carapace length.



Management Strategies - MS

MSO 01 **MECOS 09**

NEED TO REGULATE *THALLUVALAI* FISHERY ALONG PALK BAY, SOUTHEAST COAST OF INDIA

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Along the coast of Palk Bay, the juveniles of the green tiger prawn *Penaeus semisulcatus* are indiscriminately exploited from the nursery grounds by the artisanal gear "thalluvalai" in all the months except during the 45-day ban period imposed by the Tamil Nadu Government. The "thalluvalai" fishing operation is carried out from many fishing villages along the Palk Bay coast by the local fishermen in the inshore waters upto a depth of about 4 m. Studies on the "thalluvalai" fishery from one of such fishing village namely, Thirupalaikudi was carried out during the years 2006-08. The fishing ground, where the net is operated comprise mostly seagrass and seaweed beds, serving as a potential nursery grounds for the juveniles of *Penaeus semisulcatus*.

The landings of *P. semisulcatus* by "thalluvalai" at Thirupalaikudi landing centre fluctuated widely from month to month with an average estimated monthly landing of 3.4 t. The maximum landing of 10.0 t was recorded in March 2007. It was observed that a large number of females was exploited even before first spawning during all the months of observation. *P. semisulcatus* measuring less than 125 mm total length constituted high proportions with the annual composition varying from 81.4% to 90.4%. The total number of immature females landed at Thirupalaikudi landing centre during the study period was estimated at 3.9 million constituting on an average 85.4% of the total number of females landed by "thalluvalai". Juveniles of females measuring less than 100 mm in total length constituted on an average 39.1% of the total landings of females with the annual composition ranging from 32.9% to 46.7%.

The size composition of *P. semisulcatus* landed by "thalluvalai" was compared with that landed by trawlnets and gillnets operated in the Palk Bay. The exploitation of juveniles and sub-adults of *P. semisulcatus* by "thalluvalai" from the nursery grounds of Palk Bay may affect the harvestable stock in the conventional trawling grounds in the long term. Therefore, certain regulatory measures are suggested in the paper in order to overcome the indiscriminate exploitation of juveniles and sub-adults from the nursery grounds along the coast of Palk Bay.

MSO 02 **MECOS 09**

STUDY ON MARINE COASTAL HABITATS AND ECOSYSTEMS FOR INTEGRATED COASTAL ZONE MANAGEMENT (ICZM) OF IRAN, BY GIS

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This study is part of "Integrated Coastal Zone Management" (ICZM) with emphasis on "Environment Management Plan" (EMP) that was performed as a national project during 2005-2008 in the Iranian coastal zone in the northern (Caspian Sea) and southern (Persian Gulf and Oman Sea) parts. Due to diverse ecosystems and habitats, and also richness of faunal and floral communities in marine–coastal boundaries, the coastal zone is identified as an ecoton area.

Being a natural boundary between the land and water, the coastal area is a zone of interactions between two distinct environments, thereby creating a naturally evolved, but the most complicated ecosystem.

The Iranian coastline is of two different types : a) Caspian Sea coast with 818 km border, 6.3 million population, 140 people per km^2 in 23 main cities of three coastal provinces, and b) Persian Gulf and Oman Sea coast with 3032 km border, 5.8 million of population, 33 people per km^2 in 15 main cities of four coastal provinces.

The total number of protected areas in the northern coastal zone are 18, and in the south 23. The management strategies adopted by Department of Environment of Iran (DoE) are: Marine-Coastal National Park (2 sites), Wildlife Refuges (9 sites), Protected Areas (14 sites), National Natural Monument (1 site), Forbidden Hunting Areas (5 sites), Biosphere Reserves (2 sites) and International Wetlands–Ramsar Sites (8 sites).

Marine coastal ecosystems include three main groups: a) Sandy Beaches, b) Rocky Shores and c) Mud Flats. Due to sub-tropical ecological condition, connection with open sea (Indian Ocean region from Arabian Sea) and tide phenomenon, the diversity of these ecosystems and marine coastal habitats in the southern part (Persian Gulf and Oman Sea), is more than the northern part (Caspian Sea).

MSO 03 **MECOS 09**

MUSSEL RESOURCES AND FISHERY ALONG THE EAST COAST OF INDIA

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Surveys were conducted on the occurrence of mussel resources and their extent of distribution in the estuaries, backwaters, lakes and lagoons in the states of Orissa, Andhra Pradesh, Tamil Nadu and Puduchery in the last decade. The survey in Orissa has brought to light that the mussel resources were found in small quantities in Gopalpur backwaters, port, rocky shore of Gopalpur, and Bahuda estuary, Ganjam District. The extent of the mussel bed area was 6.1 ha and the total mussel biomass was around 44.1 t. About 75% of the mussel resources were occurring in Bahuda estuary and the remaining 25% at the Gopalpur area. In Andhra Pradesh, the resources occurred in moderate quantities in places like Bhimunipatnam backwaters, Visakhapatnam harbour, Kakinada fishing harbour, Dommulupeta, Chinnamyavanilanka, Gundamala creek and Krishnapatnam basin. In Tamil Nadu, extensive mussel beds were observed in Pulicat lake, Ennore estuary, Kasimedu fishing harbour, Alambarai estuary, Gadilam estuary, Uppanar estuary, Vellar estuary and Coleroon estuarine complex. In Puducherry, mussels were found in Thengaithittu estuary and Puducherry harbour jetty. Details on the occurrence, distribution, area and nature of the bed, size range, dominant size groups, biomass, sex ratio and percentage edibility of the mussels in all the beds were collected.

The mussel fishery was seasonal and exploited in small quantities in Orissa and Andhra Pradesh for local consumption and also to feed the shrimp in aquaculture farms. The data collected at Cuddalore during 2003, 2004 and 2005 showed that the quantity of mussel exploitation was 229, 573 and 756 t respectively. The values were estimated as Rs.3.44 lakhs, 12.89 lakhs and 26.46 lakhs for the above three years. There were no organized fishery for mussels during 2006, but they formed bycatch along with edible oysters. The mussel fishery was also observed in Pulicat, Pondicherry and Vellar estuary in 2004. Mussels were packed in gunny bags and transported to Kerala markets for domestic consumption.

MSO 04 **MECOS 09**

QUANTITATIVE CHANGES IN TRAWL LANDINGS AT KASIMEDU, CHENNAI DURING 1998-2007

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Based on the catch and effort data collected at Kasimedu Fishing Harbour, Chennai, the changes in fishing effort, catch rate and catch composition of bottom trawl landings were analyzed. During the period, the annual average landings by trawlers were 20,898 tonnes by expending a mean annual effort of 35,608 units (7,84,466 actual fishing hours). The annual catch showed fluctuations between 12,182 t in 2005 and 35,838 t in 2002 (Fig.1). The annual effort of 13 lakh h in 1998 declined to 5 lakh h in 2007 which was reflected in the decline in annual catch from 36,364 t in 1998 to 17,293 in 2007 (decrease of 52.5%). However, the catch per hour (CPH) increased from 27.5 kg in 1998 to 34 kg in 2007. The annual average catch during the period 1998-2002 was 26,299 t while the annual average catch during 2002-'07 was only 15,498 t. The annual number of units and actual fishing hours during 2003-'07 reduced to almost half that of 1998-2002.

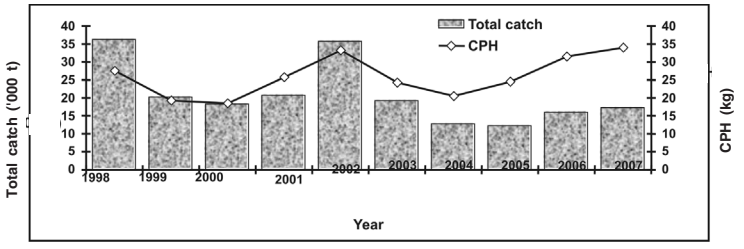

Fig. 1. Annual Catch ('000 t) and catch per hour (kg) for trawlers at Chennai during 1998-2007

Over the years, a distinct change in fishing practice was evident with an increase in multiday fishing operations. While multiday fishing operations contributed only 20-25% to the total trawl landings at Chennai in the early 1990s, more than 75% of the catch is now accounted for by multiday trawl operations. Multiday trawl units, which formed only about 8% of the annual operational units during 1989-'91, accounted for 39% and 31% of the operational units in 1998 and 2006, respectively.

Seasonal abundance of catch indicated that maximum catch was landed during the third (July-September) and fourth (October-December) quarters of the year, which contributed 34.2% and 25.1% to the annual average catch during 1998-2007.

Minimum catch was always recorded during the second quarter, except in the year 2005. A 45-day fishing ban during April-May is being observed for all mechanized vessels since 2001. In the wake of the widespread loss of life and material on account of the tsunami that hit the Tamil Nadu coast on December 26, 2004, all seafaring activities were halted during January and February 2005 and fishing activities resumed only in the last week of March 2005.

Demersal finfish contributed the maximum (38.1%) to the annual average catch during the period 1998-2007, followed by pelagic finfish (25.4%), crustaceans (15.1%) and cephalopods (5.6%). Miscellaneous finfishes and shellfishes that were either landed in small quantities or were of low economic value, along with juveniles of various species, and other marine resources like echinoderms, seaweeds etc., together accounted for about 15.8% of the catch. The contributions of demersal and pelagic finfishes revealed a declining trend over the ten-year period. Crustaceans showed an increase from 1998 to 2002, after which the trend was negative. Cephalopods, on the other hand, showed an increasing trend from 1998 to 2007. The share of the miscellaneous catch decreased from 17.7% in 1998 to 9.4% in 2002, and thereafter increased to 24.2% in 2005 (Fig.2).

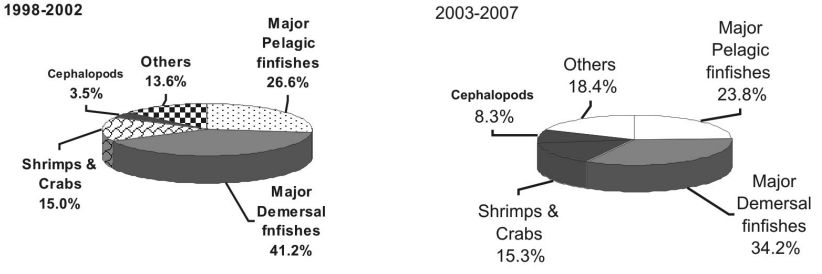

Fig. 2. Percentage contribution of resources to annual average trawl landings at Chennai during 1998-2002 and 2003-2007

The resources that regularly contributed to the bulk of the catch were elasmobranchs, carangids, threadfin breams, silverbellies, ribbonfishes, tunas, goatfishes, lizardfishes, croakers, barracudas, clupeids, whitebaits, snappers, shrimps, crabs and cephalopods. The contribution of these resources showed fluctuation between every three year period during 1998-2006. A comparison with the information available for the period 1989-91 revealed a marked decline in the contribution of threadfin breams, silverbellies, goatfishes, silverbiddies, large perches and clupeids. The contribution of carangids, shrimps, crabs and cephalopods have significantly increased over the years. Further, the analysis revealed perceptible changes in the species composition of major groups such as sharks, goatfishes and lizardfishes.

MSO 05 **MECOS 09**

SALINITY AND pH TOLERANCE BY THE MUDSPINY LOBSTER *PANULIRUS POLYPHAGUS* (HERBST, 1793) AND THE SAND LOBSTER *THENUS ORIENTALIS* (LUND, 1793) HELD IN CAPTIVITY

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The mudspiny lobster *Panulirus polyphagus* and the sand lobster *Thenus orientalis* support the lobster fishery along the Gujarat coast. Growing pressure on the natural stocks in the coastal waters demands effective fishery management in combination with lobster culture and stock enhancement through sea ranching programmes to effect conservation and augment production at the same time. While captive rearing of lobsters remains a priority area of research, there is a pressing need to understand some of the intrinsic and extrinsic factors that affect their growth and reproductive performance in captivity. The present study was undertaken to study the response of the animals to extremities of water pH and salinity. Short-term acute bioassay experiments were conducted on the juvenile *P. polyphagus* (carapace length: 29-42 m) and juvenile *T. orientalis* (CL 28-38 mm) to determine the optimum tolerance level.

Two sets of assays were conducted. The test range of pH was 4.5 to 12.0, and for salinity 31 to 80 ppt. Observations were made at the end of 1.5, 3, 6, 12, 24, 48 and 96 hours from the start of the experiments and mortality was noted. The cumulative mortality (in percentage) at the end of 96 hours was then plotted on a probit scale against the test doses to derive the LD50 (dose at which 50% mortality occurs). The confidence limits for LD50 were derived through probit regression using SPSS 13.0 (version 1.0) software package.

In *P. polyphagus*, the 96 hr LD50 for pH was 6.2 (with 95% confidence limits : 4.3, 7.2) on the acidic realm and 9.8 (with 95% confidence limits : 9.3, 10.2) on the alkaline realm. The optimal pH spectrum was 7.2 to 8.4 (Fig. 1a). The 96 hr LD50 for salinity was 23.1 ppt (with 95% confidence limits : 19.9, 26.6) on the lower range and 42.5 ppt (with 95% confidence limits: 42, 43) on the higher range. The optimal salinity range, within which there was no mortality, was 31 to 37 ppt (Fig.1b).

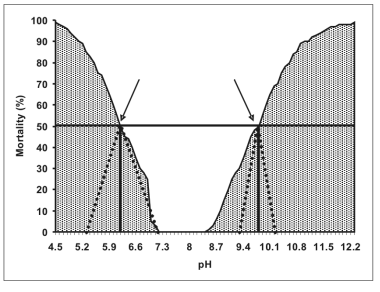

Fig. 1a. Tolerance limits of *P. polyphagus* to pH variations

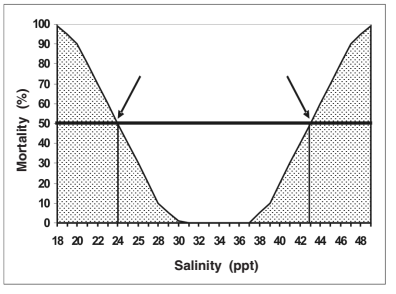

Fig. 1b. Tolerance limits of *P. polyphagus* to salinity variations

In *T. orientalis*, the 96 hr LD50 for pH was 6.4 (with 95% confidence limits: 5.6, 7.2) on the acidic realm and 9.8 (with 95% confidence limits: 9.0, 10.5) on the alkaline realm. The optimal pH range was 7.2 to 8.5 (Fig. 2a). The 96 hr LD50 for salinity was 26.1 ppt (with 95% confidence limits: 22.9, 33) on the lower range and 43.3 ppt (with 95% confidence limits : 43.6, 44.2) on the higher range. The optimal salinity range, within which there was no mortality, was 30 to 39 ppt, with 95% confidence limits of 26 and 44 ppt (Fig. 2b).

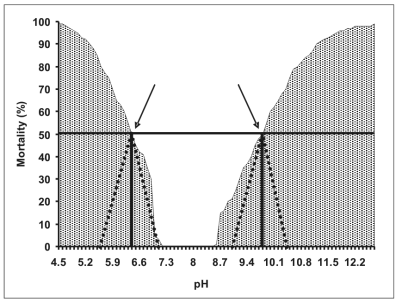

Fig. 2a. Tolerance limits of *T. orientalis* to pH variations

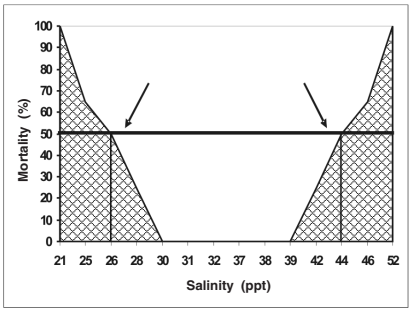

Fig. 2b. Tolerance limits of *T. orientalis* to salinity variations

In both species, prolonged exposure to low pH (<7.5), caused tail fan necrosis, leading to erosion of abdominal musculature, reduced feed intake and high mortality rates. At low salinities, *T. orientalis* showed a high rate of Moult Death Syndrome (MDS).

MSO 06 **MECOS 09**

EFFECT OF DIET ON GROWTH OF THE MUDSPINY LOBSTER *PANULIRUS POLYPHAGUS* (HERBST, 1793) AND THE SAND LOBSTER *THENUS ORIENTALIS* (LUND, 1793) HELD IN CAPTIVITY

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Experiments were carried out to assess the effects of some natural diets on the growth of the mudspiny lobster *Panulirus polyphagus* and the sand lobster *Thenus orientalis* reared in captivity. The inferences drawn from the study were compared with the natural diet preferences of these lobsters assessed from the examination of the gut contents of 50 random samples of the two species collected from the trawl landings at Veraval and Mangrol during the period 2001 – 2002.

Live juvenile *P. polyphagus* in the size range of 29 - 42 mm carapace length (CL) and weight range of 26.3 – 61.2 g and juvenile *T. orientalis* in the size range of 28.1 – 38.5 mm CL and weight range of 12.9 – 37.3 g collected from gillnet and trawl landings along the Veraval- Mangrol coast were used for the study. The test animals were grouped into 5 sets of 4 animals each, maintaining a sex ratio of 1 : 1. All animals were tagged, measured and weighed before the start of the experiment. *P. polyphagus* were stocked in 1 tonne flat-bottomed cylindrical FRP tanks holding 850 l of filtered seawater maintained through a closed recirculatory system with the help of external biofilters. Asbestos shelters were provided in the tanks. *T. orientalis* were stocked in 750 l flat-bottomed rectangular FRP tanks holding 600 l of filtered seawater maintained through a closed recirculatory system with the help of external biofilters. The floor of these tanks were provided with a thick layer of beach sand to allow the lobsters to remain buried as in the natural environment. Water temperature ranged uniformly in all the tanks between 27 ºC and 30 °C; water salinity and water pH were maintained at 36 to 37 ppt and 7.8 to 8.0, respectively. The animals were fed *ad libitum* twice a day with fresh meat of the gastropod *Turbo intercostalis*, the clam *Mercia opima*, fresh crab meat, fresh squid meat and fresh fish meat. Uneaten food and faecal matter were siphoned out daily. Water exchange was carried out at the rate of 30% every day. Records of moults and increments in morphometrics of the whole moults were noted. The experiment was run for a period of 90 days, at the end of which the final CL (mm) and wet weight (g) of the animals were recorded. ANOVA on these measures of growth was done to interpret the effects of different diets on the growth of the lobsters.

P. polyphagus fed with *T. intercostalis* showed a higher rate of growth as compared to the ones fed on other diets (Fig. 1). The average daily growth of males and females fed on *T. intercostalis* were 0.14 mm CL and 0.12 mm CL respectively. Lobsters fed on *Turbo* exhibited maximum daily weight increments of 0.47 g and 0.33 g in males and females respectively. No mortality was recorded during the experimental period of 90 days in any of the experimental tanks. *ANOVA* showed that there was a significant difference between the growth increments, in terms of carapace length and weight among animals fed on different diets. Both males and females showed similar feed preferences.

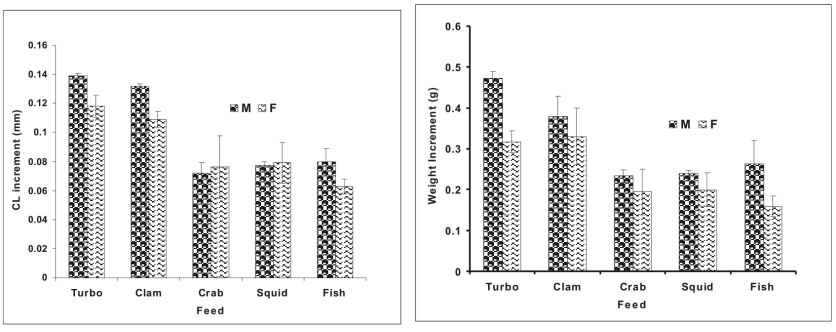

Fig. 1. Average daily growth increment in *P. polyphagus* maintained on different diets in captivity for 90 days

In *T. orientalis*, the maximum growth rate was observed in animals fed on fresh clams, followed by those fed on fresh gastropods and fresh squid meat (Fig. 2). Mortality was recorded among animals fed on fish meat and crab meat before the end of the experiment. It was found that 75% of the animals that died were females. Lobsters fed on fresh clam showed the highest average daily growth rate of 0.17 mm CL and 0.42 g. *ANOVA* showed that there was significant difference between the growth in terms of carapace length and weight, among animals fed on different diets.

Gut content analyses of 50 random samples of the two species collected from the landings revealed the dominance of gastropods *T. intercostalis* and *Turbo* sp. This is probably due to the abundance of gastropods and the relative scarcity of bivalves in the coastal waters.

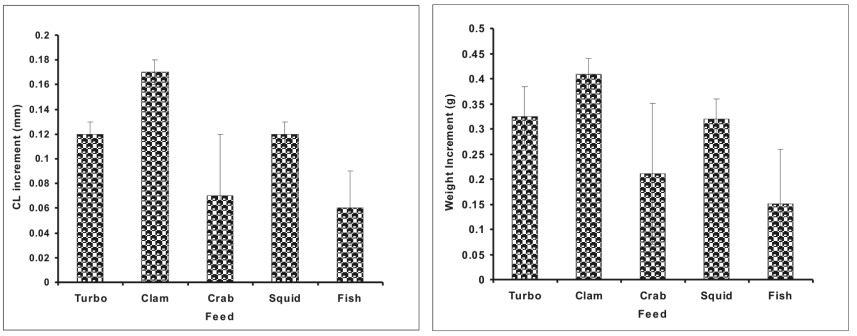

Fig. 2. Average daily growth increment in *T. orientalis* maintained on different diets in captivity for 90 days

MSO 07 **MECOS 09**

TECHNOLOGIES FOR RESPONSIBLE FISHING

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One of the greatest challenges before modern fisheries, in recent times, is the development and improvement of fishing technology that minimizes bycatch or selectively target fish in a way that promotes long-term sustainability and protection of biodiversity and minimizes environmental impacts. The shrimp trawl is a nonselective gear that commonly has an associated catch of non-targeted organisms including finfish and miscellaneous invertebrates. Trawl fisheries in different parts of the world are now being required to use bycatch reduction devices as a result of pressure from conservation groups and legal regimes introduced by the

governments. The FAO's Code of Conduct for Responsible Fisheries, which gives guidelines for sustainable development of fisheries, stresses the need for developing selective fishing gears in order to conserve resources, protect non-targeted resources and endangered species like sea turtles. Some of the advantages in reducing the amount of unwanted bycatch in shrimp trawls are: (i) Reduction in impact of trawling on non-targeted marine resources, (ii) Reduction in damage to shrimps due to absence of large animals in codend, (iii) Shorter sorting times, (iv) Longer tow times and (v) Lower fuel costs due to reduced net drag. In addition to the non-targeted finfishes and invertebrates, bycatch also involves threatened and protected species like sea turtles. The contribution of juveniles and sub-adults in the bycatch is also another cause for discard. While the discards were very less in small trawlers engaged in daily fishing, more discards were reported from vessels engaged in multi-day fishing, mainly due to the shortage of storage facilities. Devices developed to exclude the endangered species like the turtles, and reduce the non-targeted species and other unwanted catch in shrimp trawling are collectively known as Bycatch Reduction Devices (BRDs). Turtle Excluder Devices are specific form of BRD, designed to protect sea turtles. These devices were developed taking into consideration the differential behaviour pattern of shrimp and other animals inside the net. Various types of BRDs have been developed around the world. BRDs can be broadly classified into three categories based on the type of materials used for their construction, *viz.,* Soft BRDs, Hard BRDs and Combination BRDs. Soft BRDs make use of soft materials like netting and rope frames for separating and excluding bycatch. Hard BRDs are those, which use hard or semi-flexible grids and structures for separating and excluding bycatch. Combination BRDs use more than one BRD, usually hard BRD in combination with soft BRD, integrated into a single system. In this paper, recent trends in development and salient features of the important BRDs and TEDs are discussed in the context of their application in sustainable seafood production.

MSO 08 **MECOS 09**

PRELIMINARY RESULTS OF TUNA TAGGING STUDIES CONDUCTED IN THE INDIAN EEZ

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With the increase in fishing pressure on tunas, especially on the yellowfin and skipjack tunas in the Indian Ocean by large-scale industrial fishing, concerns were raised on the need for a comprehensive assessment of the effect of such increases on the productivity of the resources. Tagging is an extremely useful technique for studying several facets of highly migratory tunas including their migration pattern, interaction between fisheries, stock size, growth rates etc. In the Indian seas, tuna tagging was attempted for the first time in Lakshadweep islands during 2005-06

followed by another exercise in Andaman and Nicobar islands during 2008. These two small-scale tagging programmes were implemented by Fishery Survey of India (FSI) with the support of Indian Ocean Tuna Commission (IOTC) and Food and Agricultural Organisation (FAO).

The small-scale tuna tagging programme in Lakshadweep islands, covering the Western Indian Ocean (WIO) was the first in the series of this exercise undertaken the during 2005-06. The programme had a target of tagging and releasing 5000 tunas from four different platforms *viz*. pole and lines, troll line, hand line, and long line vessels. The programme was implemented in two phases from Minicoy, Kavaratti, Agatti and Suhali islands. Under this programme, 4958 tunas were successfully tagged and released from different islands in Lakshadweep using the pole and line, and troll line platform while a few tunas were tagged and released from the longline survey vessel, MFV *Matsya Vrushti* of FSI. Out of these releases, a total of 267 tunas were recaptured registering about 6% of recovery. The recoveries were mostly from inter-island waters in Lakshadweep and a few from distant places like Maldives, Sri Lanka, Thailand, Mauritius and Seychelles.

The second programme of small scale tuna tagging supported by the IOTC was executed in Andaman waters covering the Eastern Indian Ocean (EIO) during January-March 2008. This programme was undertaken by the FSI independently based on the experience and expertise gained from the first project in Lakshadweep. Due to the absence of Pole and Line boats in Andamans, the FSI chartered two pole and line boats along with crew from Lakshadweep to Andamans. The tagging cruises were conducted from two locations, *viz* Burmanelah in the South Andaman Islands and Neil Island while bait fishing was conducted from Chidiyatapu, Comeo and Havelock Islands. Under this programme, 1332 tunas were tagged and released using pole and line, and troll line gears. So far, four recaptures have been reported by gill netters operating from Junglighat, near Port Blair. Besides the tagging activity, the FSI had also taken the opportunity to provide short term training to the local fishermen of Andamans in pole and line fishing for catching tunas and bait fish collection which is a prerequisite for undertaking this fishing technology, and processing of tunas to prepare a dried and smoked product called *masmeen* practiced in Lakshadweep. This paper provides a detailed account of the tagging exercise undertaken from two islands, *viz*., Lakshadweep and Andamans. A preliminary analysis of the recapture of tagged tunas is indicative of the migration pattern and also the growth rate registered during the period from their release to recapture.

STATUS OF FISHERIES OF ANDROTT (LAKSHADWEEP)

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Lakshadweep, with 11 fishing villages has about 4200 sq.km of lagoon, 20,000 sq.km of territorial waters and about 4,00,000 sq.km of EEZ. The fishery potential of Lakshadweep at the most conservative estimate, is about 1,00,000 t. The average annual production by the Island fishermen is around 11,000 tonnes, of which, 75% are tuna with a size range of 3-5 kg. Concentration of fishery on tuna is mainly due to their marketability and the over- emphasize given to pole and line tuna fishing. Other high value resources including larger yellowfin tuna and reef fishes are totally neglected and basic infrastructure and marketing facilities for exploiting these resources is lacking. Considerable quantities of the resources are also taken away by the deep sea vessels operating from the mainland and the foreign vessels poaching in the Lakshadweep waters. Pole and Line live-bait technique is the most important fishing method practiced in all the Islands except Andrott.

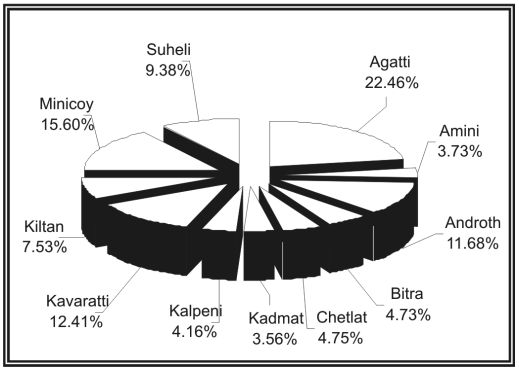

Fig.1. Contribution of each island to the fish landings at Lakshadweep during 1992-2007

Andrott Island (10^0 49′ N latitude and 73^0 41′ E longitude), the largest (4.90 sq.km) and the most populated among the Lakshadweep group of Islands, has of late emerged as the 4th most important fishing centres after Agatti, Minicoy and Kavaratti with a contribution of about 11.7% to the total catch of Lakshadwep (Fig.1). This was achieved with the help of 40 pablo boats, 22 OBM 'thonies' and 6 traditional craft. The catches would have been higher if there had been proper cold storages and marketing facilities available in the Island.

The major gears employed were troll line, encircling gill net, drift gill net and hand line (Fig. 2). Harpooning was also employed to a limited extent. All these gears

require comparatively much less effort and fuel input. Pole and line unit is operated with 9 fishermen and on continuous steaming for 10-12 hrs. The other gears are operated with 4 fishermen and with 4-6 hrs of steaming. The fishing operations except the drift gillnetting and handlining to a limited extent are carried out between 0600 – 1100 hrs in the morning and 1500 – 1800 hrs in the evening.

The species composition in the landings at Androtт Island is different from the other centres, which landed more than 75% *Katsuwonus pelamis*. At Androtт, the species composition widely varied from gear to gear. *Euthynnus affinis* was the most important species in the landings followed by *Auxis thazard*, *Thunnus albacares*, *Tylosurus* spp, exocetids etc. (Fig. 3).

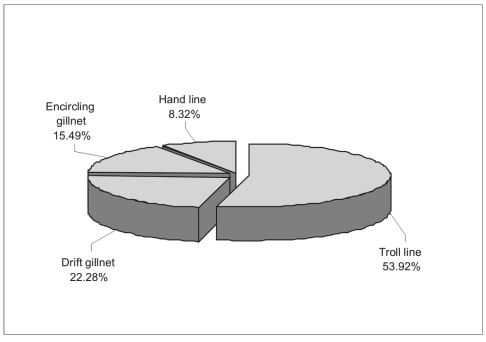

Fig. 2. Percentage contribution of various gears to the catch of Androtт Island

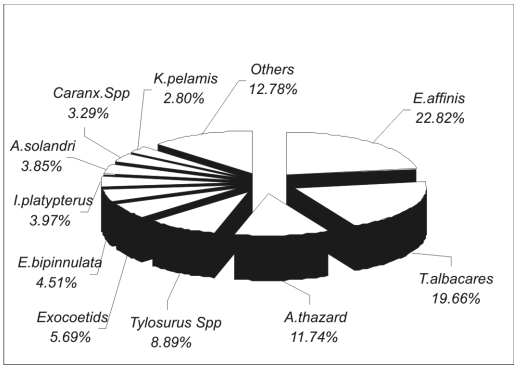

Fig. 3. Species composition in the landings at Androtт Island

Tunas form the most important group with 57.2% of the total catch and groups such as carangids, belones, flyingfishes, sailfishes, wahoo, serranids, lutjanids, lethrinids etc. are also very important and more valuble. Further, the study indicates that the landings of groups other than tuna increased considerably as and when the efforts were diversified for the purpose. The catch and the catch rates of all important groups at Eli Kalpeni Bank area were found to be very high. As the continental shelf area around Androtт was comparatively wider, resources like the serranids, lutjanids,

lethrinids, balistids etc. were more. Many high value resources such as larger yellowfin tuna, snappers, groupers, carangids, sharks, belones, flyingfishes etc. need to be tapped and the efforts managed effectively for the growth of the sector. Development of the sector will not take place without proper preservation and storage facilities and effective marketing system.

Introduction of new generation larger vessels with living and storage facilities, diversification and judicious management of the existing crafts and gears, promotion of 'dory fishing' with mother ships from the hitherto underexploited distant waters and Eli Kalpeni Bank, establishment of shore-based preservation and storage facilities, effective marketing strategy, fish and fisheries-based tourism promotion in the form of sport fishing/turtle /mammal watch etc. would generate employment opportunities, augment fish production and boost the overall economic growth of the Island.

MSO 10 **MECOS 09**

COMPARISON OF BIOLOGICAL CHARACTERISTICS OF CUTTLEFISH EXPLOITED BY FAD-ASSISTED AND UNASSISTED FISHING METHODS

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In Karnataka, cephalopods comprising of squids, cuttlefish and octopus are predominantly exploited by trawlers and to a lesser extent by other gears. In 2004, fishing operations for cuttlefish using fish aggregating devices (FADs) became prevalent. In the present study, the FAD-assisted cuttlefish fishery was compared with cuttlefish catch in benthic trawls operated near the FAD site in November 2007 and February 2008.

Cuttlefish were caught by handjigs operated near FADs constructed using coconut fronds (50-60 numbers tied at ~20 cm interval) anchored at depths of 25-55 m. The operational area for the fishery extended from Manjeshwara in south (north Kerala) to Karwar in north (Karnataka). The FAD-assisted fishery was represented by a single species, *Sepia pharaonis*. In the unassisted fishing method, *S. pharaonis* (97%) dominated the catch and *Sepia elliptica* (2%) and *S. prashadi* (1%) were also represented in November (Fig. 1). With overall reduction in cuttlefish landings In February, *S. pharaonis* contribution reduced to 12% and the inshore species *Sepiella inermis* (86%) gained prominence followed by *S. elliptica* (2%) in the unassisted catches. The length frequency distribution of *S. pharaonis* by the two fishing methods differed during the months. The FAD-assisted samples were represented by larger specimens of the size group 170-380 mm, dorsal mean length (DML). On the contrary, the unassisted school was supported by 30-370 mm sized cuttlefishes (Fig. 2). The smaller size groups of 30-120 mm DML were observed in the unassisted catch in

February. The unassisted cuttlefish were an assemblage of immature, maturing, spawning and spent individuals, whereas, almost 99% of the FAD assisted group was spawning individuals. Spawning females were represented in the FAD fishery only, whereas 96% of the males were in spawning stage and 4% in post-spawning stage.

Though FADs can be an effective fisheries enhancement tool, there are a few negative aspects in their deployment. In the current observation, the presence of only spawning individuals in the FAD-assisted fishery indicates that the cuttlefish are attracted towards the submerged substratum for attaching the spawned eggs. In the process, the spawning individuals aggregate and therefore increase their susceptibility to exploitation. Despite the fact that fish aggregation may be highly adaptive, imparting several advantages to group members such as decreasing the risk of predation, increasing foraging efficiency and increasing reproductive success, such methods that are targeting spawners should be discouraged considering the long-term sustainability of the resource.

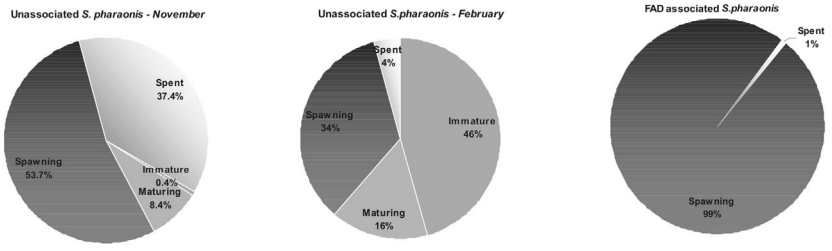

Fig. 1. Proportion of *S. pharaonis* in different maturity stages in FAD-assisted and unassisted catches

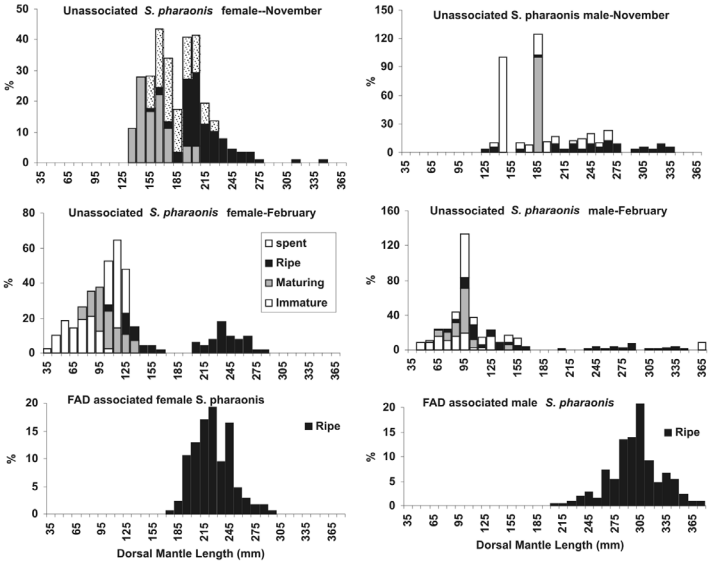

Fig. 2. Length-frequency distribution of *S. pharaonis* in FAD-assisted and unassisted catches

MSO 11 **MECOS 09**

FUEL CONSUMPTION BY MOTORIZED FISHING SECTOR IN ANDHRA PRADESH

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The fishing industry in India is mainly supported by 53,684 mechanized and 44,578 motorized craft, of which the share of Andhra Pradesh is 3 and 12 % respectively. About 25% of the marine fishing operations in India is accounted by the motorized sector. Mechanized and motorized sectors together contribute 61% to the total landings in Andhra Pradesh. To assess the fuel consumption by fishing boats and its impact on the fishing economy, it is imperative to carry out studies in major fishing centres of the country. The present study aims at fuel utilization pattern by the motorized fishing craft, and estimate the total quantity consumed in Andhra Pradesh. The study was carried out in Visakhapatnam district of Andhra Pradesh during the year 2004-05. The actual quantity of fuel utilized per trip was taken as the fuel utilized for reaching and returning from the fishing ground and the fuel spent for fishing. A total of 200 trips were covered for the study. The estimates were made for Visakhapatnam district and for Andhra Pradesh state as a whole. The number of trips performed by motorized craft during the period of study was worked out at 1,28,616 for Visakhapatnam district and it was 12,40,459 for the state as a whole. The consumption by motorized crafts were 1820.54 kilolitre (kl) and 17558.59 kl per year for Visakhapatnam and Andhra Pradesh respectively. The average per day fuel utilization by the craft was 14.15 l. In addition to the estimates on fuel utilization, the general specifications of the craft and their operational aspects and constraints are also presented in the paper. The expenditure on fuel in the fishing sector is highly substantial and calls for optimum fuel utilization measures like the use of engine with appropriate horse power, proper maintenance of engines, introduction of new generation fuel efficient fishing along with appropriate management measures like optimization of the fishing fleet, adequate fuel subsidies etc. The findings of the present study would be helpful in planning and implementing suitable policy interventions in the sector.

MSO 12 MECOS 09

RAY FISHERY BY TRAWLERS OFF CHENNAI AND SOME ASPECTS OF BIOLOGY OF THE SCALY WHIPRAY *HIMANTURA IMBRICATA* (BLOCH & SCHNEIDER, 1801)

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Rays are important components in the elasmobranch landings by different gears at Chennai fisheries harbour. Trends in the exploitation of rays and species composition were analyzed from catch and effort data of trawlers at Chennai fisheries harbour during the period from 2002 to 2007. Length frequency and biological data pertaining to *Himantura imbricata* were used for studying the monthly sex ratio, length-weight relationship and food and feeding habits.

Rays contributed about 75.4% to the annual average elasmobranch landings. The total catch of rays during the period was 3529.8 t and the maximum catch of 1297.4 t was recorded in the year 2002. The catch rate for rays was highest in 2002 (1.24 kg/hour).

Table 1. Annual catch and effort of elasmobranchs and rays landed by trawlers at Chennai during 2002-2007

Parameters	2002	2003	2004	2005	2006	2007	Average
Actual fishing hours ('000 h)	1047.3	912.1	525.8	326.4	499.4	457	628
Elasmobranchs (t)	1644.1	956.5	488.8	493.8	534.6	561.3	779.9
Rays (t)	1297.4	694.8	369.6	367.5	377.5	423	588.3
Proportion (%) of rays in elasmobranchs	78.9	72.6	75.6	74.4	70.6	75.4	75.4
Catch rate of rays (kg/ h)	1.24	0.76	0.7	1.13	0.76	0.93	0.94

The major species that contributed to the landings of rays by trawlers at Chennai during the period 2002-2007 were *Himantura jenkinsii*, *H. imbricata, H. bleekeri*, *H. uarnak*, *Hypolophus sephen*, *Dasyatis kuhlii*, *D. alcockii*, *Gymnura poecilura*, *Aetobatus narinari*, *Rhinoptera javanica* and *Mobula diabolus*. These eleven species together formed about 97.2% of the rays landed during the period. *H. jenkinsii* dominated the catch, forming about 29.1%. *H. imbricata* formed 6.0% of the catch.

The length range of *H. imbricata* in the commercial trawl landings at Chennai during the period 2002-2007 was 110-229 mm and 130-289 mm for males and

females, respectively. The average annual mean size was greater in females. The annual average sex ratio for the period 2002-2007 was 1.00:1.11. The annual sex ratio did not show significant variation between the years.

The length-weight relationships derived for male and female *H. imbricata* were:

Males : $W = 0.00022\ L^{2.676}$ ($r = 0.933$)

Females : $W = 0.00005\ L^{2.965}$ ($r = 0.936$)

Analysis of covariance showed that the slopes differed significantly between the sexes.

More than 95% of the fishes sampled were in well-fed condition. In 62.1% of the samples, the gut was half-full, and in 33.9% the gut was full. Empty gut condition was encountered in only 4%. Analysis of the gut contents revealed *H. imbricata* to be a benthic carnivore feeding mostly on small crustaceans, cephalochordates (*Amphioxus* sp.), molluscs, polychaetes and small fishes. It was found that 83.5% of the sampled fishes fed on crustaceans, 26.2% on *Amphioxus* sp., 11.7% on gastropods, 6.3% on polychaetes and 6.1% on small fishes (Fig. 1). Among the crustaceans, small crabs, shrimps, amphipods, mysids and stomatopods were encountered. Among molluscs, gastropod shells were encountered in greater number. Chaetognaths and fish eggs were also observed in a few samples.

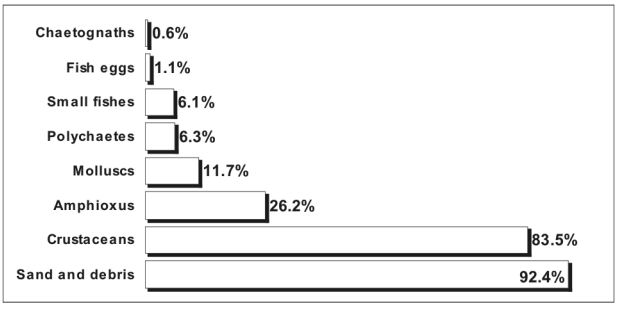

Fig. 1. Occurrence of different diet in the gut of *H. imbricata* (number of fishes in %)

MSO 13 MECOS 09

TECHNOLOGICAL ADVANCEMENT IN SHRIMP TRAWLING NECESSITATES LIFE-CYCLE BASED RESOURCE MANAGEMENT FOR SUSTAINABLE PRODUCTION

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New challenges to the shrimp fishery management in the light of modernization of fishing operation and its probable solutions are discussed in the paper. In the process, the study analyses the trends in shrimp fishery and species composition of shrimp landings during 1981-2004 and the distribution of shrimp juveniles along Mangalore coast. Till 1990, shrimp fishery along the coast was constituted by species like *Parapenaeopsis stylifera, Metapenaeus dobsoni, M. monoceros, Fenneropenaeus indicus* and M. *affinis*. Later, with the extension of fishing grounds, considerable changes have been observed in the species composition. Commercially important shrimps like *M. monoceros*, *Penaeus monodon, P. semisulcatus*, *P. canaliculatus* and *F. indicus* were landed. Unprecedented increase in shrimp landings occurred during 1991-2004 due to the heavy landings of non-conventional resources like *Trachypenaeus* spp. *Solenocera choprai*, *Parapenaeus fissuroides* and other deep sea shrimps. However, the decline in the fishery was rapid, and happened within a short span of time. For example, *Trachypenaeus* spp. which emerged as an important fishery in 1994, recorded the highest landings in 1999 (450 t), but from 2001 onwards, it almost disappeared from the fishery. *S. choprai*, which formed a fishery from a depth beyond 70 m from 1994 onwards, showed a steady progress till 2002 with highest landing of 2,746 t. Later, it showed a decline and by 2004 the landings reduced to 746 t. Deepsea shrimps, mainly constituted by the red rings *Aristeus alcocki*, also showed a phenomenal increase in 2002 (679 t), which subsequently declined to 334 t in 2004. The landings pattern of these non-conventional resources indicated that the production of these species cannot be sustained unless appropriate management measures are introduced.

It is still a matter of debate whether the successful recruitment to shrimp fishery can be ensured by protecting the spawning stock biomass by restricting the fishing pressure or it depends on the environmental factors which determine the larval and juvenile survival. It is felt that a common management measure for all the shrimp stocks may not be appropriate. Considering this, estuarine and nearshore juvenile occurrence studies were carried out during 2005-2006. In the estuaries along the coast, M. *dobsoni, M. monoceros*, *M. affinis, F. indicus, P. monodon* and *P. semisulcatus* were found in varying proportions during pre-monsoon and post-monsoon seasons. Even though *Parapenaeopsis stylifera* was not found in the estuarine collection, juveniles of the species were found in the inshore collection within 5 to 10 m in considerable quantity forming 53% of the total shrimp juvenile collection

during post-monsoon season. On the basis of the study, the shrimps along the Mangalore coast were classified into (1) estuarine and nearshore dependant species and (2) estuarine and near-shore independent species. It is found that the species of the first group such as *M. dobsoni*, *M. monoceros*, *M. affinis*, *F. indicus*, *Penaeus* spp. and *P. stylifera* are the major species, which contribute to shrimp production along the coast over the last three decades.

Maximum sustainable yield for shrimps caught by single-day and multi-day trawlers (*M. monoceros, S. choprai* and deep-sea shrimps) were estimated using holistic model. In the case of *M. monoceros,* which is the most important species determining the success of the shrimp fishery along the Mangalore coast, the study revealed that when the landing exceeded the estimated MSY, the mean size reduced considerably, even lower than the length at maturity. This may be detrimental to the shrimp fishery. For all the important species, which are exploited by multi-day trawlers, the present effort is found to be more than f_{MSY} level. The impact of heavy fishing pressure is found to affect the non-conventional shrimps very heavily and the recovery from the impact takes longer time. The study of distribution of shrimp juveniles from nearshore areas of Mangalore coast revealed that all the traditional shrimp varieties are having estuarine and nearshore connectivity. This dependency is found to enable them to recover from the catch reduction due to heavy fishing pressure in a shorter period of time. These findings necessitate the use of independent management measures and determination of biological reference points.

MSO 14 **MECOS 09**

ENHANCED COOPERATION AND COLLABORATION FOR MEETING THE 2012 GLOBAL TARGET OF ESTABLISHING A NETWORK OF MARINE AND COASTAL PROTECTED AREAS IN SOUTH ASIA

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Following the 2002 World Summit on Sustainable Development, increased international commitments promoting the sustainable use of coastal and marine resources have been made at various fora which are receiving wide acceptance. Countries are now more than ever in need of 'win-win' situations where they can cater both to the competing demands of expanding human populations and biodiversity conservation. In this context, an ecologically representative network of effectively managed protected areas has been identified as a viable tool.

The five maritime countries of South Asia are now facing the challenge of meeting the 2012 target of developing a scientifically based and well-managed network of marine and coastal protected areas (MCPA) for conserving their vast coastal and marine biodiversity heritage. The region harbours some of the most extensive

and undisturbed examples of tropical marine ecosystems including ten and six percent of the world's mangrove and coral reef areas respectively. The marine waters also maintain more than one third of the total global dolphin and whale populations. However, the region is presently lagging far behind in MCPA coverage, making the Northern/Central Indian Ocean, one of the most poorly protected areas of the world.

Enhancing the effective coordination between the existing MCPAs is a necessity for governments and stakeholders. Actions are needed not only at the local, national, and regional levels, but at global level. Regional initiatives such as the South Asian Seas Programme and the SAARC Coastal Resources Management Center should play an important role in facilitating the collaboration of national activities at a regional level, especially in the protection of shared marine resources such as the Sundarbans or the coral atoll systems.

There is an urgent need for advancing beyond 'paper park' status and incorporating MCPAs into wider Integrated Coastal Zone Management approaches. Given that, establishing an MCPA network carries a high financial burden. Inscribing important ecosystems under Global Conventions such as Ramsar will provide enhanced opportunities for attracting donor funding. There is a need to categorize the MCPAs according to an internationally recognized classification system to harmonize the regional efforts with global approaches.

MSO 15 **MECOS 09**

CHANGES IN DOMINANCE IN MARINE FISH LANDINGS OF COMMERCIALLY IMPORTANT SPECIES IN KERALA AND KARNATAKA PREDICTED THROUGH MARKOV CHAIN ANALYSIS

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Kerala and Karnataka in southwest coast of India, contribute 30-35% to the total fish landings in the country. Data on estimates of different marine fish species landed in these states during 1970-2005 were used to examine the changes that have taken place in the dominance of commercially important species in terms of ranks they possess with respect to the quantity landed. Markov chain analysis was carried out for predicting the limiting probabilities of different species to remain in different ranks or rank classes in the long run.

Out of 818 species landed in Kerala and 519 species landed in Karnataka during 1970-2005, 19 commercially important species were selected for the analysis. The species/ groups considered were the oil sardine, mackerel, *Metapenaeus dobsoni*,

threadfin, catfishes, *Stolephorus*, ribbonfishes, cuttlefish, sharks, soles, squids and *Lactarius*. Apart from these species/groups, silverbellies, *Parapenaeopsis stylifera*, seerfish and wolfherring were also considered for Kerala, and squilla, *M. monoceros* and *Penaeus indicus* for Karnataka.

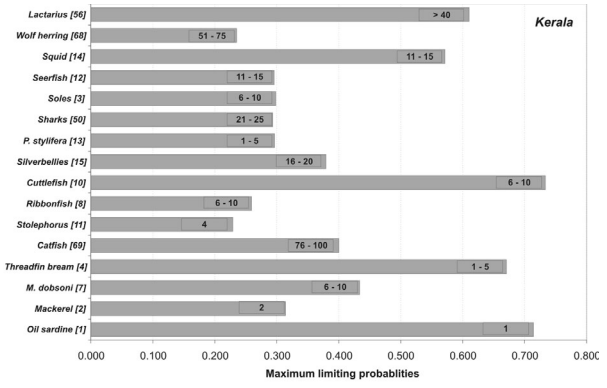

Fig.1. Results showing maximum of the resulting probabilities for selected species of Kerala. Figures in boxes indicate the predicted rank classification the species would reach in the long run; current ranks (2005) are given in parenthesis on y-axis

The Markov Chain analysis for Kerala revealed that only three species/groups are expected to improve their landings compared to their position in 2005; sharks from 50th rank to between 21 and 25, *P. stylifera* from rank 13 to between 1 and 5 and *Stolephorus* from rank 11 to 4. A decrease in ranking from 3 to 6-10 is predicted for the soles. All other species examined for Kerala are not expected to have any significant change in their ranks, indicating an apparent stability in the dominance system. Maximum of the limiting probabilities for Kerala are shown in Fig. 1.

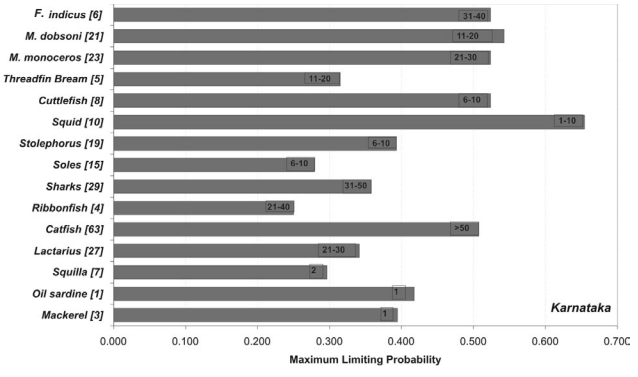

Fig.2. Results showing maximum of the resulting probabilities for selected species of Karnataka. Figures in boxes indicate the predicted rank classification the species would reach in the long run; current ranks (2005) are given in parenthesis on y-axis

Predictions for Karnataka indicated that the oil sardine and mackerel are likely to continue and dominate the catches in future also, although oil sardine has higher

probability to be at first rank. Many species, such as *M. dobsoni*, *M. monoceros*, cuttlefish, squid, sharks, catfishes and *Lactarius* are likely to remain in the same rank in the future. Key demersal species such as the threadfin breams and ribbonfish have high probability of decrease in catch and rankings. On the other hand, *Stolephorus*, soles and squilla are likely to increase in catch and rankings. Maximum of the limiting probabilities for Karnataka are shown in Fig. 2.

MSO 16 **MECOS 09**

GASTROPOD DISTRIBUTION, DIVERSITY AND DISCARDS IN TRAWL FISHERY ALONG THE COAST OF KARNATAKA, WEST COAST OF INDIA

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Gastropods constitute about 2% of marine molluscs fished worldwide and form a discard in the trawl fishery. Although gastropods are a non-target group in trawl fishery, they play a key role in marine food webs that fortify ecosystem processes and functions, which in turn determine the productivity of marine capture fisheries. They also form an important constituent of the benthic community. The diversity and distribution of gastropods in the trawling grounds off Karnataka was examined for a period of one year from the collections from multiday bottom trawlers and discards in the landings. Sampling was done on daily basis onboard commencing from August 2007 to August 2008 based on 24 fishing trips each of 7-10 days duration. Fishing grounds were within an area defined by coordinates 11° 45.81′ N - 74° 41.93′ E and 17° 13.1′ N and 72°.42.5′ E in the depth range of 30 to 150 m. The observations based on the three depth zones, *viz*., within 50 m (intensive trawling ground), 50-100 m and 100-150 m were grouped and analysed. The study shows that about 16.3% of species caught by the trawlers is discarded, in which gastropods constituted about 6.6%. About 44 species belonging to 24 families and 5 orders were recorded from the trawling grounds. Major families contributing to the catch of gastropods were Muricidae (13.6%), Strombidae (9.1%), Conidae (9.1%), Naticidae (6.8%) and Bursidae (6.8%). The most dominant species recorded in all the depth zones were *Turris* sp. followed by *Phalium* sp., *Murex* sp. and *Conus* sp.

Species diversity indices were used to examine variations in species richness and species relative abundance in three different depths. Multivariate technique was used to explore differences in species composition between the three depths. In line with the abundance and number of species, Shannon diversity index (H′) was 3.1 for 50 m depth, 2.3 for 100 m depth and 2.5 for 150 m depth. The evenness (J′) of species distribution ranged between 0.84 at 50 m depth and 0.90 at 150 m depth. The dominance plot indicates that upto 50 m depth, the species diversity of gastropods

was more, followed by 100-150 m (Fig. 1). Between 50-100 m depth the species diversity and abundance was low when compared to the other two depth zones. The similarity in species composition and abundance in the three depth range estimated by Bray-Curtis Coefficient (Cluster Analysis) resolved the depth range into two clusters in the range of 45.7 to 59.4%. The dendrogram plotted for three regions shows that gastropods at 50-100 m and 100-150 m formed a group with maximum similarity of 59.4% to which gastropods at 50 m got linked at 45.7 (Fig. 2). The 95% confidence funnel generated for the variation in taxonomic distinctness values of three depths shows that all the groups fall within the confidence funnel showing no deviation from normal distribution.

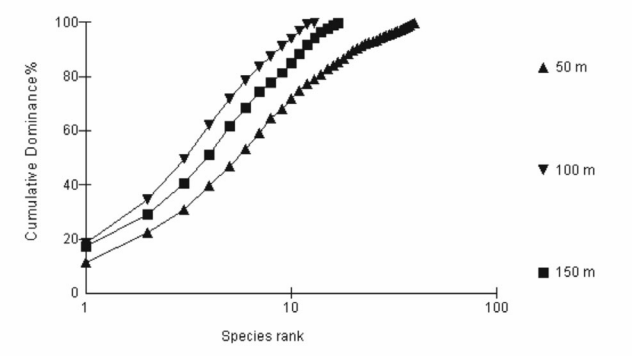

Fig. 1. Dominance plot for gastropods showing higher diversity upto 50 m depth

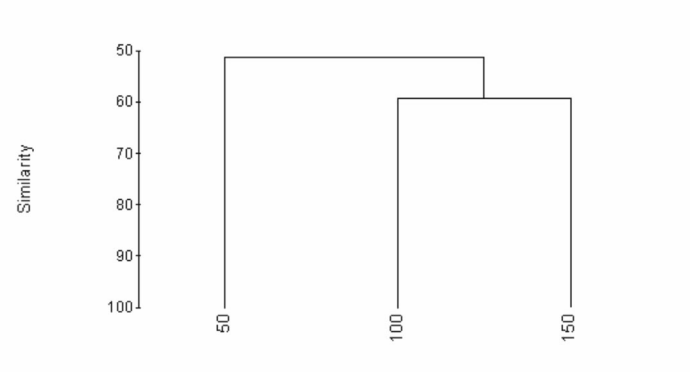

Fig. 2. Dendrogram of gastropods recorded in three regions showing grouping of areas

From the study it is observed that high species richness was observed within 50 m depth which decreased between 50-100 m and increased beyond 100 m depth. The variation in species composition and distribution of gastropods at different depths in relation to sediment texture is discussed.

MSO 17 **MECOS 09**

REPRODUCTION OF *OCTOPUS AEGINA* IN MANDAPAM WATERS

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Octopus aegina is a moderate sized octopus species. They occur in muddy coastal waters, on soft substrates at a depth of atleast 40 m. *Octopus aegina* is distributed in the coastal waters of continental Asia from China to Malaysia and to Madras, India.

Monthly samples (50-75 numbers) were collected from trawl landings at Mandapam (southeast coast of India) for a period of one year. Mantle length and weight of each specimen were recorded and sexed based on the external characters. The male and female octopus can be easily differentiated with presence or absence of hectocotylus arm. The right 3rd arm is modified into hectocotylysed arm in *O.aegina*. Gonads were examined for maturity based on a four-stage maturity scale for females and two-stage scale for male. The spawning season was determined from the maturity stages and gonadosomatic index. Other parameters like sex ratio, size at first maturity, fecundity were also studied.

The female reproductive system consisted of a single ovary and two oviducts, one opening on either side of the midline about halfway along the mantle cavity. The ovary is oval/round shaped with thin walls and positioned at the extreme posterior of the mantle cavity. The male reproductive system consisted of an unpaired testis, elongated slender penis and a large coiled diverticulam curved towards the midline. The testis of a mature male is round but variable in size. The spermatophores are long and slender, armed with small teeth on anterior part of the mid section. The length of spermatophore ranged from 2.7 to 3.8 mm.

Males dominated in all the size groups and proportion of males in the samples increased as the size increased. The male: female ratio was 1.71:1.00. Males in mature gonadal condition occurred throughout the year, as indicated by the presence of spermatophore in the Needhams sac. This indicated a year round reproductive capability. The analysis of occurrence of various maturity stages in females indicated that *O.aegina* has a prolonged breeding season extending from July to February with a primary peak spawning activity during January –February followed by a second peak in October. High mean GSI values were noticed during October and in January–February, with maximum value in February for females. In males, the GSI values were almost same throughout the year, indicating a year round maturity in males. The size at first maturity was estimated as 5.1 cm mantle length for males and 7.1 cm mantle length for females.

Fecundity varied from 2962 to 8820 in the individuals of mantle length ranging from 67 to 85 mm. The number of eggs per gram of ovary was estimated as

488 ± 51.9. Fecundity was related to ovary weight and mantle length by the following regression equations:

Log fecundity = log (2.5651) + 1.12 log ovary weight

Log fecundity = log (-4.3954) + 4.3204 log dorsal mantle length

MSO 18 **MECOS 09**

MODELLING MARINE FISHERIES OF SOUTHWEST COAST OF INDIA: COMPARISON OF EXPONENTIAL SMOOTHING, ARIMA AND ARTIFICIAL NEURAL NETWORK MODELS

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The southwest coast of India comprising the states of Kerala, Karnataka and Goa is the most productive and significant contributor to India's marine fish landings. The estimated quarterly and annual marine fish landings of the major exploited resources along the southwest coast during the years from 1965 to 2004 formed the database for the study. Time series analysis techniques and artificial neural networks (ANNs) were used to model the marine fish landings. Data for the analysis were collected from Central Marine Fisheries Research Institute, Kochi.

The fitted models were evaluated on the basis of Akaike Information Criteria, Root Mean Square Error and Coefficient of Determination (R^2). ARIMA (0,2,1) fitted the data very precisely (Fig. 1). The ANN model fitted to the annual time series outperformed other models based on R^2 values (Table 1). The R^2 value for ANN model showed improvements in comparison to those of the exponential smoothing and ARIMA models. However, among the smoothing model and the ARIMA model, the latter was found to be a better performer.

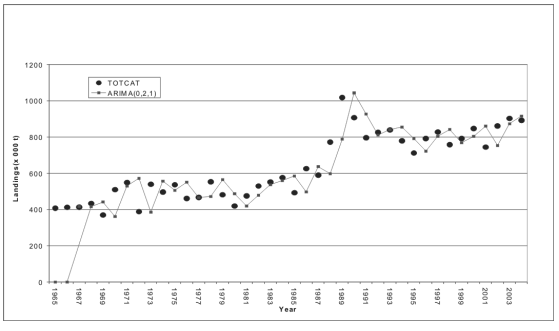

Fig. 1. ARIMA model for southwest coast of India

Table 1. Summary of ANN models for the annual log-transformed landings for the southwest coast of India

Resource	Model	R^2
Penaeid Prawns	MLP 5-6-1	0.335
Cephalopods	MLP 5-4-1	0.957
Carangids	RBF 5-8-1	0.835
Croakers	RBF 5-10-1	0.694
Mackerel	MLP 5-8-1	0.435
Oil Sardine	MLP 5-5-1	0.644
Perches	MLP 5-8-1	0.859
Soles	MLP 5-8-1	0.749
Tuna	MLP 5-8-1	0.815
Total landings	RBF 3-8-1	0.85

One of the significant observations is that all the models used in the study fitted to time series of penaeid prawns, oil sardine and mackerel had relatively lower predictive ability. This was because of high degree of wild and erratic inter-annual variations in their landings. Models fitted to perches, cephalopods, carangids, tuna and whitebait had better forecasting ability.

MSO 19 **MECOS 09**

STATUS OF THREATENED AND PROTECTED SPECIES TRADE IN THE MARINE FISHERY SECTOR OF INDIA

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A survey was carried out along the coastline of nine maritime states and two islands of India from December 2005 till May 2008 to assess the present status of the trade of protected marine species listed in various schedules of the Indian Wildlife (Protection) Act, 1972.

In addition to the marine fish landing centers, coast-based tourist centers, pilgrim sites, and other trade centers were surveyed. Informal interviews were conducted with fisherfolk, traders and concerned officials of state and central Governments and NGOs at various levels to collect the data, apart from the information gathered from the existing literature from various research and academic institutions.

In the organized fishery sector, protected species land mostly as by-catch, whose discard rate is almost nil due to market demand at national and international levels.

Trawlers land most of the protected species in comparison to gillnetters and seiners. Among the states, Tamil Nadu dominates in the number of protected species landed (n = 6), followed by Kerala (n = 5). Molluscs, sea-cucumbers, dolphins, turtles and elasmobranchs are the major groups of protected species that are obtained as by-catch in the organized fishing sector. In the unorganized fishery sector, protected species are targeted, mostly at subsistence level by individual fishermen. The catches are exported mostly to the South-East Asian countries. Though the trade is persistent throughout the country at various degrees, main sources of collection through unorganized fishery sector are observed to be Gulf of Kutch, Gulf of Mannar and Andaman and Nicobar group of islands

Low success rate of the awareness programmes targeted on this sector, coupled with a lack of proper enforcement mechanism and raising market demand are the major reasons for the persistence of this illegal trade, which may be countered by promotion of suitable alternate livelihood options and setting up of coast-based marine anti-poaching/ trade-monitoring centers.

MSO 20 **MECOS 09**

MARINE FISH LANDINGS IN INDIA - A MULTIVARIATE CLUSTERING OF SPATIAL FOUNTAINHEADS

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The marine fish landings in India are characterized by complex pattern of spatial and seasonal variabilities, with wide fluctuations from year to year and from region to region. As these two dimensions are interwoven, it needs a synchronized effort to study the various resources landed in centres which are characterized by regular and sustained levels of effort and commensurable catch. Single centre zones have been formed in the sampling plan for the estimation of marine fish landings, developed by Central Marine Fisheries Research Institute with purely quantum of landings in mind. But there are peculiarities associated with the fishing patterns of east and west coasts. This work is an attempt to group the 49 declared single centre zones of the 10 maritime states purely based on the total landings. An attempt has also been made to re-cluster the landing centres by way of annual and average monthly landings during the five year period 2002-2006. Further the numbers of clusters were statistically determined by way of studying the error function of within cluster variability for different numbers of clusters.

The methodology was rooted to the classical multivariate clustering technique, which is based on derived measures of (dis)similarity. For this purpose, the *K*-means cluster analysis was performed to find the suitable number of clusters based on error function. The monthly data was subjected to *K*-means cluster analysis with varying

number of clusters ranging from 2 to 10. To apply the least square error in this function, analysis of variance (ANOVA) was performed for estimation of between and within cluster variances. The within cluster sum of squares was plotted against the number of clusters (Fig. 1). The within cluster variation gets stabilised after 5 clusters and hence it can be safely assumed that the optimum number of clusters is five.

Based on Euclidean distance, hierarchical clustering was done to classify monthly fish landings into 5 similar clusters (Table 1). The results indicate that though the patterns indicate perfect mixing up of east and west coast landing centres in the total annual landings based clustering, significant re-grouping on the geographic lines is noticed in the clustering based on average monthly landings. This probably indicates impact of the seasonality related issues like monsoon trawl ban. The east coast pattern is less dissimilar with their centroids falling closer as compared to west coast centres. This indicates a more upheavels in the quantum and pattern of landing in the west coast as compared to east coast.

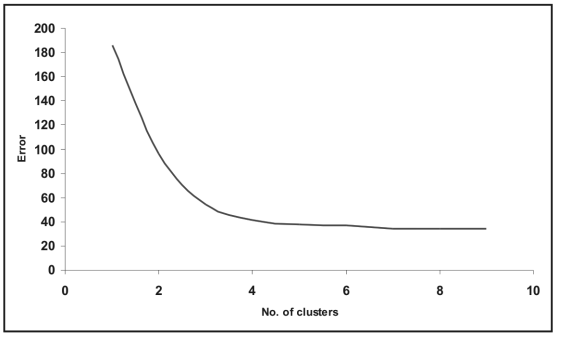

Fig.1. Error function obtained with *K*-means algorithm for different number of clusters

Table 1. Fishing zones in different clusters

	Zones	
Cluster	East coast	West coast
1	-	Mangalore, Neendakara, Porbander, Sassoondock
2	-	New Ferry Wharf, Veraval
3	Colachel, Devanampattinam, Gilakaldini, Vembar, Kaveripatinam, Kottaipattinam, Pamban, Pazhayar, Muthuvaduganathan pattinam, Mallipattinam, Sethubavachatram, Therkuvadi, Thauvaikulam, Uppada, Vodrevu, Veerapandiyapattinam	Arnala, Bassen Kolliwada, Satpati
4	Bhaviravipalem, Jagathapatanam, Kakinada, Mandapam, Nagapatanam, Nizampatanam,	Bhatkal, Ganjam, Kasaragode, Karwar, Munambam, Versova, Vypin, Tadri
5	Paradeep, Rameswaram, Tutucorin, Vishakhapatanam, Cuddalore	Cochin, Malpe, Mangrol, Sakhtikulangara

MSO 21 **MECOS 09**

AN ASSESSMENT OF THE LOW-VALUE BYCATCH IN BOTTOM TRAWL LANDINGS AT CHENNAI

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It was observed that 65-70% of the average annual bottom trawl landings at Kasimedu Fisheries Harbour (Chennai) is comprised of non-targeted fishery resources, *i.e.*, the by-catch. Of this, about 15-20% forms low-value bycatch (LVB) which is either not fit for market sale or is composed of highly undersized or poor quality fish. During July 2005 – June 2008, an estimated 48493 t of marine resources were landed at Chennai by the trawlers expending 1,403,036 actual fishing hours. The monthly quantum of low-value bycatch in the total trawl landings ranged from 1.9% in August 2005 to 21.1% in December 2007 (Fig. 1).

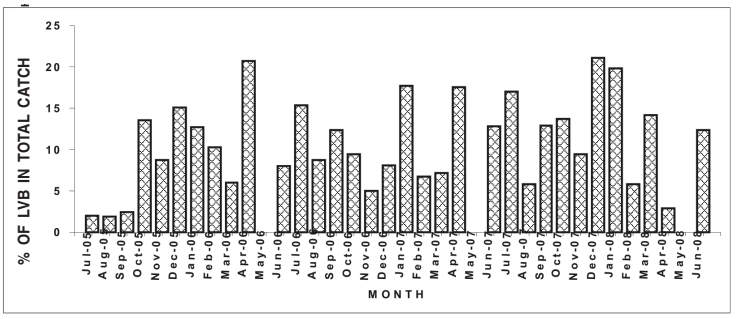

Fig. 1. Monthly proportion (%) of low-value bycatch (LVB) in trawl landings at Chennai

The quantum of LVB was the lowest during the first half year of observation (July-December 2005). During January-June 2006, the proportion increased by more than 5%, after which it declined marginally by 0.5% (Fig. 2). During July-December 2007 the proportion of LVB in the total catch increased by 2.2% from the previous half year (Fig.2). Fishes contributed maximum (60.0%) to the average monthly LVB, followed by crustaceans (34.2%) and molluscs (4.6%). Other groups like echinoderms and sponges formed 1.2%. Occurrence of crustaceans was more during August-November (Fig.3).

The dominant fishes observed in the LVB were the silverbellies (25-30%), cardinalfishes (20-25%), flatheads (8-10%), scorpionfishes (6-8%), lizardfishes (4-6%), whitebaits (5-6%), anchovies (6-7%), carangids (3-4%), threadfin and monocle breams (3-5%), pufferfishes (3-4%), flatfishes (2-4%), dragonets (2-3%), glasseyes (2-3%), rays (1-2%), eels (1-2%), filefishes (1-2%) and goatfishes (1-2%). Among the crustaceans,

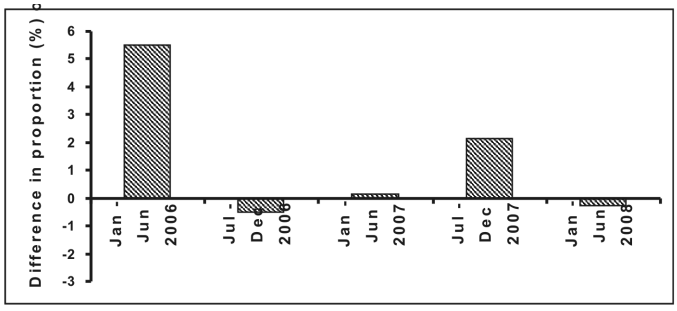

Fig. 2. Difference in the proportion (%) of LVB in the trawl landings at Chennai between successive six-month periods

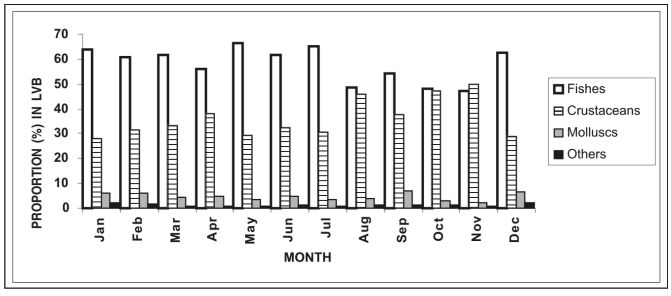

Fig. 3. Proportion (%) of groups in the landings

crabs were the dominant group forming 52.5%, followed by stomatopods (22.0%), shrimps (18.3%) and lobsters (7.2%). The bulk of the crabs in the LVB was juveniles of commercially important species like *Portunus sanguinolentus, P. argentatus, P. gladiator, Charybdis lucifera* and *C. hoplites*. Others include *Calappa* spp., *Dorippe frascone, Arcania heptacantha* and *Liagore rubromaculata*. Shrimps in the LVB were mainly constituted by the juveniles and damaged adults of *Metapenaeopsis stridulans* and *Parapenaeus longipes*. Stomatopods, another important constituent in the LVB, were represented by several species like *Oratosquilla nepa, O. woodmasoni, O. gonyptes, Harpiosquilla harpax, H. annandeli, H. raphidae* and a few other species. Lobsters in the LVB comprised of the scyllarids *Petractus rugosus* and *Thenus orientalis*. Gastropods contributed 72.8% to the molluscan component in the LVB while bivalves formed 14.8% and cephalopods 12.4%.

MSO 22 MECOS 09

INVESTIGATIONS ON THE TRAWL DISCARDS ALONG THE MALABAR COAST

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Commercial trawling activity has increased in the last few decades along the Malabar coast. After each haul, the fishermen discard large quantities of commercially low-value fishes in to the sea. Studies were carried out to quantify these discards. Samples (10-15 kg) of discards were collected from selected trawlers and the details regarding number of hauls, duration of fishing, number of fishing days, catch composition and quantity of discards were collected from Calicut on weekly intervals during June 2007 – May 2008. These samples were weighed and analysed in the laboratory upto species level and the data were then raised to the day's and month's catch as per the method followed by CMFRI.

The estimated trawl catch at Calicut during June 2007 – May 2008 was 43,734 t from an effort of 1.1 million fishing hours. The estimated discarded catch during the period was 11,584 t (26.5%) at a catch rate of 10.6 kg/h. Maximum discards were recorded in November and March, but the catch rate was highest in March. Finfishes formed 49.9% of the discard followed by crustaceans (40.4%), molluscs (9.6%) and others (0.1%). In the discards, 97 species of finfishes, 14 species of crustaceans and 7 species of molluscs were observed. Flatheads (8.9%), threadfin breams (8.3%), sciaenids (3.2%), lizardfishes (2.7%), bullseye (2.3%), *Stolephorus* spp. (1.9%), silverbellies (1.8%) and pufferfishes (1.5%) were the major finfishes in the discard. Among the crustaceans, stomatopods, crabs and prawns formed 30.1%, 5.3% and 4.2% respectively. Octopus and shells of molluscs were the dominant molluscan components. Among the discards, 80.6% was constituted by low-value finfishes/ shellfishes. The average annual price of discards at Calicut during the last one year was only Rs. 5/kg. The economic value of the discarded catch for this period was estimated as Rs. 58 crores.

The present study reveals that a large quantity of non-targeted species are killed and thrown back into the sea. It is suggested that for reducing the discard, the mesh size of trawl may be increased. The economic loss due to discarding the edible portion can be minimised by increasing the storage facility in the multi-day fishing vessels.

MSO 23 **MECOS 09**

YELLOWFIN TUNA FISHERY OF ANDHRA PRADESH, EAST COAST OF INDIA

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Pelagic fishes contributed nearly 55% to the total marine fish landings of Andhra Pradesh during 2007, and tunas, especially the yellowfin tuna, formed an integral component of the oceanic pelagic catch. Of the six species of tunas observed in the fishery, *Thunnus albacares* and *Katsuwonus pelamis* were the oceanic species. They were mainly harvested by the traditional hook and line fishermen of a few coastal villages of Andhra Pradesh. Of late, mechanized units refitted to operate the longlines have been deployed to harvest the oceanic tuna resources. The average annual oceanic tuna landings during 2004-2007 by the traditional sector at Visakhapatnam was 1,626 t. The fisherfolk from Poodimadaka and Bimili coastal villages too contributed significantly to the tuna fishery of Andhra Pradesh. Yellowfin tuna catch formed 83% of the total tuna catch. Water temperature and availability of food are known to play key roles in the distribution and abundance of yellowfin tuna in the oceanic waters. October-December followed by May-July were the peak landing periods (Fig. 1).

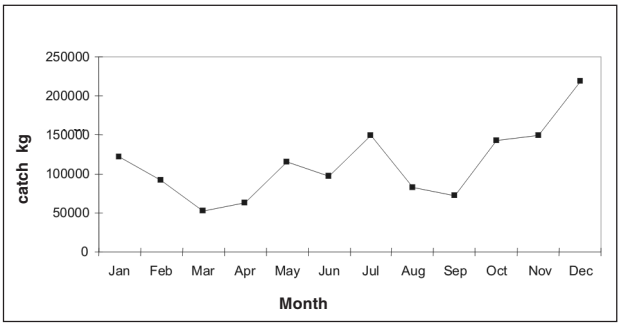

Fig. 1. Monthly landings of yellowfin tuna at Visakhapatnam

The fork length of yellowfin tuna ranged from 25 cm to 190 cm with mode at 130 cm. The length – weight relationship was $W = 0.017077 * L^{2.976}$. Length at first maturity was estimated at 87.5 cm and the male: female ratio was 1.00:0.58. Spawning was prolonged and fishes in mature condition were dominant during November-December. Yellowfin tuna is a voracious feeder and the gut content included crustaceans, fishes and molluscs.

MSO 24 **MECOS 09**

USE OF DIFFERENT SAMPLING STRATEGIES FOR THE ESTIMATION OF MARINE FISH LANDINGS: A STUDY BASED ON LANDINGS DATA FROM NEENDAKARA FISHERIES HARBOUR, KERALA, INDIA

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The marine fish landings data plays an important role in the assessment of the exploited fish stocks and fishery management. The Central Marine Fisheries Research Institute (CMFRI) has been collecting the marine fish landings data from the state of Kerala, India by employing a stratified two stage sampling design, with landing centre days as first stage unit and boats landed as the second stage unit. In the present study, the average quantity of fish landed per day is estimated by four sampling estimators, the mean estimator, unbiased estimator, ratio to size estimator and the estimator based on the existing stratified two stage sampling design and their performance is compared.

In Kerala, Neendakara is a major fishing harbour and it has a prominent place with regard to marine fish landings. The total marine fish landings from Neendakara harbour was 53,825 tonnes in the year 2006, which accounts for 10% of the total marine fish landings in the state. The data on daily marine fish landings at Neendakara fisheries harbour during January-December 2006 were collected from Fishery Resources Assessment Division of CMFRI and used for the study. The estimators and estimates of variance were worked out for all the months except for July. The estimates and percentage standard error of estimates are given in Table 1.

Table 1. Estimates of average quantity of fish landed (in tonnes) and percentage standard errors of four estimates

Month	Average quantity of fish landed (in tonnes)				Percentage standard errors			
	Existing mean estimator $\hat{\bar{Y}}$	The mean estimator $\hat{\bar{Y}}_2$	Unbiased estimator	Ratio to size estimator $\hat{\bar{Y}}_{R2}$	Existing mean estimator $\hat{\bar{Y}}$	The mean estimator $\hat{\bar{Y}}_2$	Unbiased estimator	Ratio to size estimator $\hat{\bar{Y}}_{R2}$
January	0.94	0.96	0.96	0.96	19.9	15.8	17.4	16.0
February	0.79	0.89	0.86	0.86	16.3	16.2	18.1	15.3
March	0.83	0.93	1.01	1.01	12.3	10.1	23.5	9.3
April	0.91	1.15	1.26	1.26	16.4	15.3	20.4	14.9
May	0.96	1.17	1.25	1.25	15.0	15.6	20.9	15.9
June	0.63	0.92	0.99	0.99	10.9	17.8	36.7	20.9
August	1.30	1.45	1.33	1.33	13.8	19.5	19.6	22.3

September	1.04	1.26	1.37	1.37	16.9	14.0	22.4	16.3
October	1.47	1.60	1.81	1.81	19.9	16.0	27.9	18.7
November	0.69	0.76	0.76	0.76	35.6	32.7	33.4	33.3
December	0.62	0.74	0.78	0.78	23.2	21.5	27.8	22.5

The mean estimator $\hat{\bar{Y}}_2$ has less standard error than those of the other estimates. The number of units landed is found to vary considerably from one day to another, thereby pointing to the need for testing the nature and magnitude of the bias arising from the use of the mean estimator $\hat{\bar{Y}}_2$ to estimate of average quantity of fish landed $\bar{Y}$ per day. The bias in is found to be negligible, suggesting the preference of $\hat{\bar{Y}}_2$ over ratio to size estimator ($\hat{\bar{Y}}_{u2}$) to estimate $\bar{Y}$. The is found to be more efficient than the unbiased estimator, $\hat{\bar{Y}}_{u2}$. It can be concluded that, when the the number of units vary considerably, the ratio to size estimator $\hat{\bar{Y}}_{R2}$ is found to be the most efficient among the four estimators.

$\hat{\bar{Y}}_{R2}$

MSP 01 **MECOS 09**

TECHNOLOGICAL DEVELOPMENTS OF FISHING CRAFT AND GEAR IN CALICUT

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In Calicut, the fish catch increased from an annual average of 28,400 tonnes during 1980- 1984, to 1.14 lakh tonnes during 2001-2007, an increase of more than 300%. The trawl landings increased from 3,800 t during 1980-84 to an average of 52,519 t during 2001-2007. This increase is mainly due to the technological developments and the consequent change in the fishing practices. In Calicut, the craft and gear have undergone changes both in the mechanized and traditional sectors. Some gear and craft are fully replaced while some are modified. In some units, additional fittings were also made. A brief description of these changes is given below:

Ringnetter: This outboard driven craft was introduced in 1988. The craft was the *chundan vallam* that was in use in the southern part of Kerala with one carrier boat of overall length (OAL) 8m. The major changes in craft thereafter are: 1.Replacement of the *chundan vallam* with craft (18m to 20m OAL) having transom stern initially made of wood and now made of fibreglass with a capstan and drum near the bow side for the hauling the net; 2. Replacement of outboard motor with inboard motor of 120-140 hp capacity; 3. Fitting with fish finders; 4. Equipping with GPS besides mobile phone; 5. Fitting of roof.

Gill-netter: The use of outboard motor in the canoes started during 1984-85. Simultaneous to this, the canoes were replaced with flat-bottom plank-built boats (OAL 8 m) with transom stern having provision to fit the outboard motor. This was followed by the introduction of fiberglass coated plywood boats which later became the dominant craft even though the other craft were also used. Now the outboard motor has become very common. *Ozhukku vala* are operated both from outboard driven fibreglass boats as well as from bigger boats of length 40′ fitted with inboard engines of 80-90 hp. These bigger boats have an endurance of 5-10 days and both driftnet and troll line are operated from this. These boats have GPS and communication facilities.

Trawlers: Puthiappa and Beypore are the main trawl landing harbours in Calicut. In both the centres, more than 75% of the trawl fleet are now multiday vessels (MDF). The length of single day fleet (SDF) boats does not exceed 11 m whereas the MDFs are above 15 m. SDFs are all made of wood whereas majority of MDFs are made of wood coated with fiberglass or aluminum sheets and a few are made of steel. In Puthiappa, around 3% boats are steel boats whereas in Beypore, 65% of the boats are steel boats. Earlier the engines were mostly below 90 hp. Now the boats are fitted with engines of 164-170 hp. All the bigger vessels are with otter board made of iron. All the MDFs are fitted with Koden CVS 118 or FURUNO FCV 612 echo

sounders, Garmin 128 or Furuno GP 32 GPS, and wireless system ICOM IC-V8000 having a coverage area of about 40 nm. The MDFs are operated throughout the year except during monsoon ban whereas the SDFs are operated from October/November to May. The general tendency is to replace the existing boats with bigger-sized boats every four or five years.

Ringnet: The gear is of two types. One has a mesh size of 15-22 mm and another has a mesh size of 8-12 mm. The net with smaller mesh size is used for catching whitebaits and juvenile sardines and their operation is seasonal. This is operated near the shore. The one with larger mesh size is the common gear and is mostly operated in deeper areas. The size of the gear now has increased up to 1000 x 90 m though net ranging from 350 to 400m in length and 50 to 60 m in depth is in common use. There is frequent damage to the net when dolphins try to eat the sardines or mackerel in the net. In order to avoid this, an indigenous gear was developed which is locally called as *yedi vala* (dolphin net).

The ringnet contributes 44% to the total landings. Sardines and Indian mackerel together formed more than 90% of the total catch of the ringnet. Gear such as the boat seines locally known as *mathikolli vala*, *ayila kolli vala*, *nethali vala* etc are obsolete now.

Gillnet : The gillnets are *mathichala vala*, *ayilachala vala*, *ozhukku vala* and *laksham vala*. The *mathichala vala* (40-45 mm mesh size) is purely a surface gear aiming mainly oil sardine and has not undergone major change. But when there is good catch for the ringnet, many gillnet units are engaged as carrier boats for the ringnets. The operation of *ayila chala vala* (60 mm mesh size) is either in the surface or bottom depending on the availability of the resource and the position of the gear is adjusted by adding or removing the floats. These are the two gear which have withstood the dominance of ringnet. The driftnet (*ozhukku vala* of 130-140 mm mesh size) operation was for single day earlier, but now they undertake multiday operation. *Laksham vala* of 60-65 mm mesh size targeting mainly medium-sized seerfish, mackerel etc is of recent introduction. Each net is about 150m x 20m. The operation is like *ozhukku vala*.

Trawlnet: In SDFs, v-cut net or its variant with a cod end mesh size of 20 mm is used aiming mainly prawns and soles. In this, along the foot rope, iron chain is attached so as to enable the net to penetrate the muddy bottom. In MDFs, two types of nets are used depending on the availability of different resources. Immediately after monsoon ban, *charadu vala* (24 mm and 40 mm cod end) aiming mainly cephalopods and fishes is operated till October/November. In this net, different varieties are made by changing the wing portion. There are nets starting from a mesh size of 2000 mm in the wing portion to 600 mm. The large mesh size in the wing portion is to reduce the resistance in water. From November onwards, *choodan vala* (18 mm cod end) is operated for prawns and *Stolephorus* sp. In each trip of 5 days duration, 5 to 6 nets of required type is taken besides one or two numbers of other types of net. More number of same types of net is taken to replace damaged one. In bigger boats of OAL 18 m and above, up to 20 nets of different types are taken.

MSP 02 **MECOS 09**

LOCAL KNOWLEDGE ON MUD CRAB: ETHNOECOLOGY OF *SCYLLA SERRATA* IN RATNAGIRI COAST, MAHARASHTRA

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The present study explores the knowledge of fishers of Ratnagiri coast on the ecology and biology of the mud crab *Scylla serrata*, an important food species. It attempts to address the differences and similarities between the information provided by fishers with published biological data about the mud crab. A total of 30 fishers in the traditional crab fishery were interviewed using semi-structured interview schedule. Similarities were noted in respect of habitat, migratory movement for feeding, burrowing habit, size at first maturity and peak spawning season of crabs. The information provided by the fishers differed with the published data with respect to breeding migration and feeding preferences. Abundance of *Scylla serrata* along with edible oysters was noted by most fishers. Apart from this, the effect of various ecological phenomena such as rainfall, light, temperature, tides, wind and lunar cycle on the availability of mud crab was studied. Local ecological knowledge held by fishers agrees with the available scientific literature about *Scylla serrata* providing hypotheses to be investigated through biological research. The present study highlights the importance of fishers' local knowledge, which may be useful for the local management of *Scylla serrata,* to improve the scientific knowledge and sensitize the scientists to local conditions as well as to promote the interaction between fishers and scientists.

MSP 03 **MECOS 09**

REARING OF THE CTENOPHORE *PLEUROBRACHIA BACHEI*

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Ctenophores, also known as comb jellies, are delicate gelatinous marine zooplankton belonging to the phylum Ctenophora. Collection of intact specimens and captive rearing are challenging tasks, given the highly fragile nature of these organisms. The ctenophore *Pleurobrachia bachei* (Fig. 1), commonly found in the Indian waters belongs to the order Cydippida. This species is closely associated with the lobster phyllosoma. The advanced phyllosoma of the sand lobster, *Thenus orientalis,* have been found to feed upon *P. bachei*. As a prerequisite for successful

sand lobster larval rearing, captive rearing of *P. bachei* assumes great importance as a source of steady and constant supply of live feed for the developing lobster larvae. The length-weight relationship, some aspects of reproductive biology, feeding behaviour and amino acid profile of *P. bachei* reared in captivity at the Kovalam Field Laboratory of Central Marine Fisheries Research Institute, India are presented in the paper. Early larval development is also described.

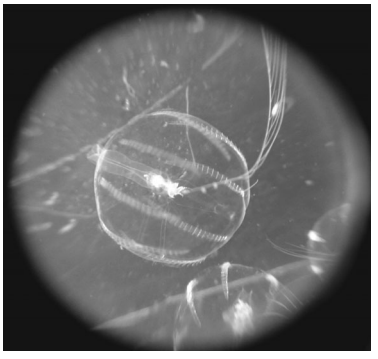

Fig. 1. The comb jelly *Pleurobrachia bachei*

Live specimens of *P. bachei* were isolated from zooplankton collections from the coastal waters of Kovalam. The low-density rearing experiments were conducted in glass aquaria and glass jars. The different diets tried were the clam meat, *Artemia* nauplii, copepods, *Lucifer*, *Nanochloropsis* sp. and *Chlorella* sp. Aquaria with mild aeration and dripping water exchange proved to be a better rearing system than the steady tank system. Survival was higher in this system and the animals survived up to 25 days, while in the steady tank system, the mortality rate was very high and the experiment lasted for only 7 days.

High-density rearing trials were carried out in large cement tanks of 40 t capacity. *P. bachei* collected from the wild were stocked at densities of 2 to 5 per litre. The rearing medium (filtered seawater) was fertilized by urea and phosphate in order to produce thick algal growth. Other zooplankton, particularly copepods and mysids were added. Chopped clam meat was also added daily. Feeding was voracious and the bottom of the rearing chambers was coated with a film of organic repels from the ctenophores. Maintenance was easy in large cement tanks holding water at lower salinities of 26-30 ppt, with sufficient shadow areas, algal scum on tank surface and large densities of live *Lucifer*, copepods and *Artemia* nauplii (in order of preference). Several specimens carried developing gonads. These specimens were isolated and transferred to glass aquaria.

Larval development was recorded in 12 hours but survival to the final larval stages was poor. Larval rearing was found to be easier in clear seawater with no adult ctenophores. High levels of ammonia and nitrates were not tolerated but turbidity and low oxygen levels were tolerated. Aeration is not preferred in rearing. Although there is no cannibalism, competition for food was very high. Lysis of captured feed and ingestion rates were very fast.

MSP 04 **MECOS 09**

MARKET INTEGRATION IN SHRIMP AND TUNA AMONG MAJOR COASTAL MARKETS OF INDIA

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For many years, marine exports contribute a substantial source of foreign exchange to India's exchequer. However, the domestic fish marketing system has long been neglected in India due to various reasons, which in turn has taken a toll on its efficiency, over a period of time. In the context of a new global economic order, the efficiency of markets is a subject, which deserves primary attention. An efficient marketing system is one where there is perfect market integration and full price transmission, with prices adjusting instantaneously to any changes from within or outside the system. Such a system would enable the producers, middlemen and consumers in the marketing chain to derive maximum gains. Furthermore, this would help in eliminating unprofitable arbitrage and isolation of spatially differentiated markets and ensure that efficient allocation of resources across space and time is achieved. In fish marketing system, the price movements in different markets depend to a great extent on the cross market movement of the available catch, which in turn is governed by the demand and supply factors. The extent of price transmission from one market to another and its direction are important aspects to be looked upon, as it would give valuable information on the degree of integration, and in turn the efficiency of these markets.

The present study has attempted to analyse the degree of spatial market integration and price transmission between the major coastal markets in India using monthly retail price data on important marine fish species *viz.,* shrimp and tuna. The study used monthly price data for a ten year period from January, 1998 to December, 2007 of the selected fish species from important coastal markets in Andhra Pradesh, Gujarat, Karnataka, Kerala, Maharashtra, Orissa, Tamil Nadu and West Bengal. The retail markets near major landing centres in each of these states were selected for this purpose. The data was collected through regular and systematic primary surveys conducted by Central Marine Fisheries Research Institute (CMFRI), Cochin. A linear regression-cum-co-integration framework was used for quantifying the degree of price transmission between the various markets. The speed of adjustment in the short-term price fluctuations were captured by using an Error Correction Model (ECM). The direction of causality was ascertained using granger causality test and was confirmed using the Schwarz Information Criteria (SIC) from the respective regression equations.

The results suggested that the degree of integration and rate of price transmission differed among markets. In the case of shrimp, the integration analysis showed that a long-run equilibrium existed between Orissa and West Bengal prices with a price

transmission elasticity of 0.81, meaning, 81 per cent of the price fluctuations in the West Bengal market would get transmitted to the Orissa market in a month. The direction of movement of price signals was from West Bengal to Orissa market, as the former being a much bigger market compared to the latter. Gujarat and West Bengal markets were also found to be integrated with around 58 per cent of the price changes in Gujarat getting transmitted to West Bengal. While Gujarat and Orissa markets were in long term equilibrium with regard to movement of prices, Tamil Nadu and Karnataka markets were observed to be co-integrated with short term disequilibria arising intermittently. However, the long-run price transmission elasticity between these markets was very high to the tune of 0.90 implying a near full pass over of price changes. The bivariate vector error correction equation for Tamil Nadu-Karnataka market pair suggested an 18 per cent recovery of short run divergences towards the statistic long-run equilibrium per month. In spite of being large producers, Kerala, Maharashtra and Andhra Pradesh shrimp markets were not integrated with any other domestic markets, possibly because of their larger market share outside the country.

A low level of price integration was observed among the various markets for tuna. Only three out of twenty market pairs were found integrated with some degree of price transmission. Others were found to be unrelated and the prices in these markets moved in different directions. Among the integrated markets, a high price transmission was observed between Tamil Nadu and Andhra Pradesh. The coefficient of price transmission was 0.75. Tamil Nadu and Maharashtra, Andhra Pradesh and Maharashtra were the other two integrated pairs with elasticity of price transmission, 0.63 and 0.53 respectively. All these three market pairs were in long-run equilibrium and did not show any short-term price disequilibria. The high export demand for tuna from other foreign markets is supposed to be the reason for low integration between the domestic markets.

The study unveiled the complicated price transmission mechanism between various fish markets in the country and gives an important message of the necessity of price integration between the markets as a remedy to address the supply side constraints existing in these markets. It also throws light on the lack of integration between important markets of major marine fish species and appeals to devise strategies to bring greater integration between these markets, so that both the fishermen and the fish eating community in the country are benefitted.

MSP 05 MECOS 09

TRADITIONAL KNOWLEDGE AND METHODS IN LOBSTER FISHING IN GUJARAT

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The lobster fishery of Gujarat is predominantly supported by the mudspiny lobster, *Panulirus polyphagus* and the sand lobster *Thenus orientalis*. Sand lobsters are relatively new entrants into the fishery, and until about 4 decades ago, *P. polyphagus* formed the mainstay of Gujarat's lobster trade. Other lobster species that occur in the fishery are the rock spinylobster *P. homarus* and the painted spinylobster *P. versicolor*. The predominant gears used for lobster fishing are trawlnet, trapnet, dolnet, stakenet and umbrellanet. The major landing centres are Veraval, Porbandar, Mangrol, Jakhau, Okha and Jaffrabad.

Commonly called "titan" or "jinga", the spiny lobsters were exploited in Gujarat even before the introduction of mechanization in the fishing sector. However, lobster fishing was almost restricted to select communities of traditional fishermen in remote pockets along the coast. Lobster fishing was then a sustenance fishery of low intensity and hence production statistics seldom reflect the existence of these fisheries. Interaction with local fishermen along the Saurashtra and Kuchchh coasts revealed that the lobsters were fished and locally consumed during lean fishing seasons. Lobster fishing was also treated as a sport in early days, when the sizes of the lobster caught were much bigger than what is now available to the fishery. Traditional knowledge imparted to later generations over the years within the fishing communities, are still applied by the non-mechanised and artisanal sector to exploit the lobsters.

The fishing communities engaged in lobster fishery were the Machis and Muslim fishers and some tribal communities involved in coastal activities. The traditional fishing villages are usually situated near a reef-lined coast (Jaleshwar, Hirakot, Sutrapada, Muldwaraka, Dhamlej, Okha, Jakhau, Ummergaon, Mangrol Bara, Rupen, Veraval, Chorwad, Shil, Salaya, Dwaraka Bet, Belapur) and most of them are adjacent to river openings or barmouths (Muldwaraka, Veraval, Dhamlej, Jaleshwar, Sutrapada, Chorwad, Navibandar, Shil, Mahuva, Bhavnagar, Diu, Mangrol Bara).

Based on the habitat, the fishermen classify the lobster population into calcite reef population, muddy bottom population and deeper sandy bottom population. The aggregations found in muddy bottoms were classified as the 'safed titan' or 'jinga' (white pale-grey) and the ones collected from the rocks/reefs areas as the 'kalo titan' (black, dark green). The reef populations also had the 'pattovala titan' (*P. versicolor*) and 'kantavala titan' (*P. homarus)*. One of the earliest methods of hunting lobsters was spear them out from hiding premises on shallow water reefs, practiced by the

fishermen in the Gulf of Kuchchh and Gulf of Khambhat. The lobster would often be caught along with reef crabs (*Carcinus* sp.) and mudcrabs (*Scylla* sp.). Although spearing is no longer practiced now, handpicking is still practiced out in reef patches beyond Mundra (in Kuchchh) and Mahuva (in Bhavnagar).

Adjacent to shallow water reefs, framed nets (circularnets or umbrellanets) were used to catch lobsters. The nets would be lowered with some fish (ribbonfish or Bombayduck) to lure the lobsters. These operations were carried out in the shallow water reef surfaces in the Kuchchh and Bhavnagar zones. Other gears predominantly used were the long and short tidal stakenet and gunja jaal (bagnet) in Kuchchh and Bhavnagar.

The fishermen had a good understanding of the behaviour of spiny lobster aggregations and used the knowledge to their advantage. For example, the fishermen of Jaleshwar and Sutrapada villages, while employing trap gillnet on the reefs, were aware that large spiny bodied "Titan" assembled during August - October at the edge of the reefs for breeding, and these animals when baited are easily trapped. Another information that has been passed down the generations is that large-bodied mudspiny lobsters (pale greenish coloured) are available more in muddy areas and the ones caught in the nearshore/reef areas are darker and usually juveniles. The fishermen also relate lobster availability to season, lunar periodicity, water current etc.

MSP 06 **MECOS 09**

PRIMARY, SECONDARY AND TERTIARY SECTORS IN MARINE FISHERIES: A SOCIOECONOMIC PROFILE

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Marine fisheries sector is a conglomeration of different categories of stakeholders. The socio-economic characteristics of each of these categories have a major bearing on the fisheries economy. The present study was conducted at Malpe Fisheries Harbour of Udupi district of Karnataka. The major categories of stakeholders were identified in the primary sector, followed by the secondary and the tertiary sectors. The study was conducted among a sample of 300 respondents, consisting of 74 from the primary, 133 from the secondary and 93 from the tertiary sectors. The findings of the study revealed that among primary sector stakeholders, 86.66 per cent of the purse-seine operating labourers had undergone high school level of education. With respect to the average monthly income, the purse-seine operating owners had the highest average monthly income of Rs. 3.63 lakhs. This was followed by mechanized multi-day trawler operating owners with an average monthly income of Rs. 60,000. The purse-seiner single day labourer had an average monthly income of Rs. 9316 followed by the multi-day trawler labourer with an average monthly income of

Rs. 6700. Majority (60 per cent) belonging to the mechanized multi-day trawler operating owner category had availed loans during the current year. The major source of loans was from public banks.

Among the secondary sector stakeholders, the wholesalers (58.06%) had high school level of education. Among women fish vendors (70.00%) had undergone lower primary level of education. With respect to the average monthly income, wholesalers had the highest average monthly income of Rs. 21,096. Decision making with respect to investments in business done largely by men was among the secondary sector stakeholders.

Among the tertiary sector stakeholders, majority of the petty shop owners of landing centres (80.64%) had undergone high school level of education. The average monthly income was maximum for the suppliers of auxiliary items.

MSP 07 **MECOS 09**

MANAGEMENT OF BREEDING PRACTICES OF *RUTILUS FRISII KUTUM* MIGRATING TO TONEKABON RIVER (NORTH OF IRAN)

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Rutilus frisii kutum (Cyprinidae) native to the south of the Caspian Sea is a commercially valuable species in the north of Iran. Due to overfishing, damming, and water pollution, the abundance of natural stocks has declined in the past several decades (commercial landing 6000 t in 1940 compared to 350 t in 1982). Artificial breeding using wild adults migrating to the rivers was carried out by Iranian Fisheries Organization and restocked annually up to 200 millions of 1 g fry. In this study percentage of ovulated females in different locations of river (river mouth, middle of river and below the bridge), time of ovulation, percentage of females ovulated, fertilization rate, serum testosterone and cortisol were measured using RIA. Such information is important for effective management of artificial breeding and restocking programs in the south Caspian Sea. Unovulated females caught from river mouth were transported using plastic containers (60l) in two densities (1ind/l and 2ind/l of river water) and placed in wooden boxes in the river to ovulate without inducement at two temperatures (10-15ºC and 16-24ºC). Percentage of ovulated females caught from below the bridge was higher ($p < 0.05$) than the two locations as the fish migrated some distance in the river. Egg fertilization rate was lower in females kept in boxes than the ovulated spawners. The time required to ovulate was between 12-40hr depending on temperature. Plasma testosterone decreased during confinement while cortisol increased ($p < 0.05$). The results compared with hormone injection method indicated that females should be permitted to migrate into the river as the environmental cues affect maturation and ovulation.

MSP 08 **MECOS 09**

SOCIOECONOMIC TRANSFORMATION OF FISHING COMMUNITIES AFTER THE INDIAN OCEAN TSUNAMI OF 2004

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The Indian Ocean tsunami of 26th December 2004 caused considerable destruction and casualties in the coastal regions of the States including Tamil Nadu, Pondichery, Kerala, Andhra Pradesh and Andaman & Nicobar Islands. In Kerala, 187 villages were affected, registering a death toll of 180 persons and huge damage to assets and livelihood. The short term loss assessments indicate that motorized and non mechanized sectors were affected severely. The tsunami caused widespread damage to housing and almost 1,54,000 houses were either destroyed or damaged. Almost all the affected houses in Kerala belonged to pucca category. Many huts and temporary shelters used for marketing and fishing related activities along the coastline were not included in the initial assessment of losses. Though there was initial confusion in relocating the tsunami victims in permanent shelters, settlements were granted to a few victims two years after tsunami. The present study was conducted among the tsunami victims in Kerala with respect to their socio-economic conditions before and after tsunami. It was found that those covered under the permanent settlement arrangement given by agencies including the Government made them better off compared to their position before tsunami. Possession of physical assets like dwelling and fishing equipments has added to their improved socio-economic background. NGOs with national and international connections contributed to restoration and rehabilitation efforts in the tsunami affected regions of Kerala. Alternative employment generating activities were encouraged in the area by distribution of sewing machines among the households. Even if there is a threat of another tsunami, the fishers were found reluctant to relocate from nearshore areas considering the accessibility and sentimental attachment to the sea.

MSP 09 MECOS 09

OCEANIC TUNA RESOURCE IN ANDAMAN AND NICOBAR WATERS AND ITS PRESENT STATUS

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Andaman and Nicobar (A&N) group of islands is situated between Lat. 6°45′N and 13°30′N and Long. 90°20 and 93°56′E in the southeast Bay of Bengal with a total area of 8249 sq. km. The coastline of Andaman and Nicobar Islands is about 1962 km with an EEZ of 0.6 million sq. km., which is about 30% of the EEZ of India. The total potential of fishery resources of A&N waters has been estimated and projected to be 1,48,000 tonnes by Fishery Survey of India. Tuna forms a major component of the commercially important fishes of EEZ of A&N Islands. The potential yield of neritic and oceanic tunas in the Andaman Sea is about 64,500 tonnes. The commonly caught tuna species are the little tunny (*Euthynnus affinis*), longtail tuna (*Thunnus tonggol*), Oriental bonito (*Sarda orientalis*), frigate tuna (*Auxis thazard*), dogtooth tuna (*Gymnosarda unicolor*), yellowfin tuna (*Thunnus albacares*) and skipjack tuna (*Katsuwonus pelamis*). The contribution of tuna to the marine fish landings of the island varied from 1.4% in 2003 to 8.6% in 2006. The highest landings of 2359 tonnes were recorded during 2007, which is meager as compared to the available potential.

Commercial fishing gears used for the exploitation of tuna resources are gillnet, hook and lines and resource specific longlines. As per the survey results of Fishery Survey of India (FSI), yellowfin tuna is observed abundantly in A&N waters and high abundance of bigeye tuna were observed towards equatorial region. In the present paper, an attempt has been made to study the oceanic tuna resources and their potential based on the data collected during tuna longlining, deploying the FSI's exploratory survey vessel *MFV Blue Marlin* (overall length : 35.76m) during the period 2003-2007 in the island waters.

MSP 10 **MECOS 09**

OPPORTUNITIES OF COMMUNITY BASED FISHERIES MANAGEMENT IN ORISSA

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Fisheries resources are not inexhaustible, and if not managed properly, may exhaust one day. Hence, proper management of marine fishery is the need of the hour. Fisheries management is not management of fish, but management of fisher's behavior and the way they catch and maintaining the quality of the fish for the local and international market demand. Orissa state is having a coastline of 480 km (about 8% of the coastline of India), which is contributing a good share to the total marine fisheries production of India. The fisheries sector is contributing around 2.2% to the state's gross domestic product (GDP). The export earnings from the marine fisheries sector is around Rs. 350 crores from Orissa. In the last couple of years, the production has stabilized at around 1,20,000 tonnes. But, the demand for fish is increasing day-by-day. The pressure to the marine environment may come down if the fishers get a perfect price for their catch in the market, *i.e.,* more money for their output and allied products. This can be achieved by omitting some of the intermediaries in the market chain. To achieve this, the fishers have to organize themselves into groups with participatory decision and common consensus. In Orissa, we could find two major fishing groups, the traditional and motorized boats/sector, and mechanized boats/ sector. Always, there is a conflict between these two sectors on accessing the fishing zones. Strategies and common interests need to be derived between these two groups with definite set of norms and agreeable terms and conditions, which will be looked after by a statute authority. The women are playing a crucial role in marketing and processing. This needs to be strengthened and enhanced for a hygienic processing and better value additions to fetch good market value.

In Orissa various organized institutions are functioning in their own domain for e.g. Traditional Fish Worker Union (OTFWU), which fights for traditional fishermen's development and rights, SMUDRAM, which is women federation working for fish marketing and providing proper price to fishers, Trawler Owners Association, Seafood Exporter Association etc. Government organizations like, Fisheries Department of Orissa, MPEDA (The Marine Products Export Development Authority), NETFISH (a sister concern of MPEDA for awareness generation for sustainable fishing and quality control), FSI and CMFRI in Visakhapatnam, CDA (Chilika Development Authority in Orissa. Voluntary organizations like UAA (United Artist's Association), AFPRO (Action for Food Production), WWF (World Wildlife Fund for Nature), OMRCC (Orissa marine resources conservation consortium) etc. are working for the development of fisherfolk and conservation of marine resources. Despite a number of organizations/institutions working in Orissa, a proper coordination and collective effort for marine fisheries development and management is lacking. For the proper management of Orissa

marine fisheries, it is required to have a collective effort and convergence of all the institutions for their active participation. From the primary stakeholder *i.e.,* fisherfolk (represented by all the fisherfolk associations, federation etc), secondary stakeholders (govt. departments, research institutions, voluntary organizations) and the tertiary stakeholders *i.e.,* buyers (other players in the marketing chain) need to participate actively. This can be achieved by involving the primary stakeholders in the policy decision and proper coordination among all the institutions. The role of government institutions and other private institutions will be of only facilitator, whereas, the decision making and the implementing aspect need to be governed by the primary stakeholders. This may lead to the generation of more profits from the marine fisheries sector by the bottom-up approach in planning, development and management.

MSP 11 **MECOS 09**

SOCIOECONOMIC APPRAISAL ON SECONDARY AND TERTIARY SECTORS OF MARINE FISHERIES OF GUJARAT: A CASE STUDY

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A case study was made on the socioeconomic appraisal of secondary and tertiary sectors of marine fisheries of Gujarat state. The major objectives are assessing the market dynamics, capital investment, socio economic perspectives and behavioural dimensions of stakeholders of the secondary and tertiary sectors of marine fisheries in Gujarat. While the primary stakeholders are those who involve exclusively in active fishing, the secondary stakeholders comprise those who involve exclusively in fish related activities in the pre or post harvest sector. Tertiary stakeholders are those who engage in activities other than fishing / post harvest sector but which in turn depend on fisheries. This case study focused attention on secondary and tertiary stakeholders which form a major chunk of fishing population in Gujarat.

The data collecting protocols were finalised with major variables and dimensions to be quantified for initiating the final data collection with expert consultation and standardisation. Veraval and Jafrabad were selected for data collection. Local enumerators were identified and trained for data collection in these locations. Data collection was undertaken on socioeconomic and behavioural aspects from respondents selected among the different types of stakeholders. The proportional random sampling method was followed for selection of the sample size for each category in such a way that the sample size for each category was proportional to the population of that particular category. The data on population size was collected through secondary information and triangulation and was done in consultation with

secondary sources of information such as fishermen co-operative societies, trawl owners association, census reports and also through the survey staff of the FRAD division of CMFRI, Veraval Research Centre. Socioeconomics and behavioural patterns of stakeholders were measured using scales and indices.

In the secondary sector, the major stakeholder categories identified are fish vehicle drivers, wholesalers, fish vendors and supplier of ice / fuel etc. In the tertiary sector, the stakeholder categories are suppliers of auxiliary items, hoteliers/ teashops/ suppliers of eatables, petty shop owners etc. The major parameters taken into consideration for assessment from the secondary sector stakeholders were age, education and average monthly income, peak season of employment and number of days engaged in a year, daily take home income and average volume of goods handled/day, alternate livelihood options, decision making at home, average earnings/ day and average household expense per month, lindebtedness, awareness on fishing regulations etc. Similarly in the tertiary fisheries sector, age, education and average monthly income, peak season of employment and number of days engaged/ year, daily take home income and investment made in the avocation etc. were taken into consideration for assessment.

The data analysis on secondary sector in which fish vehicle drivers were taken, revealed that (64%) had undergone high school level of education, and their average monthly income was Rs 4,100/-. The peak season of their activity was from September to November when they were engaged for 45 days, medium season of activity was during February-May when they were engaged for 32 days and the lean season of activity was during December-January when they were engaged for 27 days. The average wages/day was Rs 150 and the average duration of work hours/day was 10.

Among the secondary sector stakeholders, the fish vendors formed an important category of which majority of the respondents (55%) were illiterate, 28% had lower primary level of education, 21.4 % had upper primary level of education, 11.7 had high school level of education and 5.9% had higher secondary level of education. The average monthly income was Rs. 4,021. The average number of days engaged was 295 days. The average investment in the avocation was Rs 1748 and the average turnover was Rs 187 and the average daily take home income of the respondents was Rs 76-102.The average volume of goods handled per day was 18 to 22 kg and the average duration of work/day was 8.5 hours.

In the tertiary sector, the tea shop owners formed an important category of stakeholders. Of these, 48 percent were old, 39.5 percent were middle aged and 12.5 percent were young. The average monthly income of this category was Rs 4676. The average number of days in a year was 298. The average investment in the avocation was Rs 7395. The average profit per day was Rs 213. Among the tertiary sector stakeholders, the suppliers of auxiliary items and spare parts had an average monthly income of Rs 5836. About 70 percent had undergone high school level of education and the average earnings/day was Rs 186. The average investment in the avocation was Rs 21, 500. The public bank was ranked as the most important source of income, followed by private banks and cooperative societies.

The Conservation Orientation Index score in these two types of stakeholders indicated 89% in the secondary sector and 91% in the tertiary sector. Nearly 80% of the fisherfolk houses were found to be pucca. Average family size was 5.5. About 94% if the families have electrification and 90% of the villagers' holdings were connected by road.

This case study on the socioeconomic appraisal of marine fisheries sector of Gujarat state is an introspection to the extent of involvement of secondary and tertiary stakeholders depending indirectly on fisheries. Viable strategies are to be formulated and recommended for the upliftment and progress of these stakeholders on a sustainable basis. This particular case study made a pertinent effort in that perspective also.

MSP 12 **MECOS 09**

MARINE FISHERY RESOURCES OF GUJARAT

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The annual average marine fish landings in Gujarat during 2002 – 2007 was 4.43 lakh tonnes. The landings declined from 4.68 lakh t in 2002 to 3.56 lakh t in 2005 but increased to 5.08 lakh t and 4.75 lakh t in 2006 and 2007respectively. The major contributors to the fishery during this six year period were the pelagic finfishes (39.3%), demersals (31.2%), crustaceans (22.2%) and cephalopods (7.4%). The pelagic resources were dominated by the ribbonfish *Trichiurus lepturus* and Bombayduck *Harpadon nehereus*, which formed 35.4% and 29.3% respectively of the pelagic catches. The major demersal resources were the sciaenids forming 31.2% of the demersal fish catch while nonpenaeid prawns dominated the crustacean landings forming 62.6%. Majority of the catch were landed by trawlers (58.2%), followed by dolnetters (27.3%) and gillnetters (14.5%). Among the trawlers, the contribution of multiday and singleday trawlers were 46.1% and 12.1% respectively. Maximum landings were recorded during October-December (48.8%) and the lowest landings during April-June (13.9%). There was a distinct change in species composition of sciaenids caught by dolnetters over the years with smaller sciaenids (*Otolithes cuvieri* and *Johnius glaucus*) replacing the commercially important larger sciaenids like the koth (*Otolithoides biauritus*) and ghol (*Protonibea diacanthus*). However in gillnets, the catches of commercially important kingseer (*Scomberomorus commerson*), yellowfin tuna (*Thunnus albacares*), skipjack tuna (*Katsuwonus pelamis*) and larger sciaenids (koth and ghol) increased. The mean lengths for *Harpadon nehereus*, *Trichiurus lepturus*, *Scomberomorus guttatus*, *Thunnus tonggol*, *Auxis thazard* and *Euthynnus affinis* increased from 15.9 cm, 69.1 cm, 43.9 cm, 57.8 cm, 32.5 cm and

43.9 cm in 2003 to 19.3 cm, 73.3 cm, 46.1 cm, 67.1 cm, 38.7 cm and 50.9 cm, respectively in 2007. The momentum to the fishery has been provided in recent years by the increased landings of high value groups like the cephalopods, mackerel, seerfishes and tunas.

MSP 13 **MECOS 09**

STATUS OF BIVALVE FISHERY IN ENNORE ESTUARY

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Observations were made on the fishery of bivalves particularly the edible oysters, mussels and clams during the period from 1990 to 1996. The edible oyster fishery was carried out from January to October every year, and the quantity of oyster production were 1062, 747, 4290, 1000, 1868 and 1200 t during the years 1990, 91, 92, 93, 94, and 95 respectively. The maximum man-days deployed was 1,768 in August 1991, when 1061 t of oysters were collected. The minimum effort was 180 man-days in October 1994 when 88 t of oysters were collected. A maximum of 525 catamarans and vallam were deployed for collecting 1008 t oysters in February 1992. The size of oysters ranged between 23 mm and 147 mm and the dominant size groups were 75-79, 80-84, 85-89, 90-94 mm and 65-69 mm during the years 1991, 92, 93, 94 and 95 respectively. There was no fishery during November and December every year due to monsoon rains. The oysters were shucked and the meat was sold in the local market. The shells were sundried and sold at the rate of Rs. 500/- per tonne to the lime industry.

The clam fishery was operated in the upper reaches of the estuary especially during May to August and a maximum of 32 tonnes were landed in 1990. The green mussel fishery was seasonal and it was carried out when there was a great demand for mussels in Kerala market. The fishery begins in February and extends upto August. Totally, 77 tonnes of mussels were collected during 1996 and transported to Kerala for domestic consumption.

In recent years, the oyster fishery dwindled very much due to large scale exploitation in the natural beds and also most of the natural stocks denuded as a result of large scale discharge of sewage and industrial effluents into the estuary. The natural settlement of mussel seeds has also reduced considerably.

MSP 14 **MECOS 09**

STUDIES ON SEASONAL VARIATIONS IN *PENAEUS MONODON* CULTURE

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Shrimp culture is widely carried out along the coastal areas of India. The exports of culture shrimp and prawn increased two fold in the last two decades. Shrimp farms located in Andhra Pradesh are widely spread in 9 coastal districts for the culture of *Penaeus monodon*, *Macrobrchium rosenbergii* and *Litopenaeus vannamei*. The common species cultured in Andhra Pradesh is *Penaeus monodon*. The culture is carried out throughout the year in most of the areas and the shrimps are cultured at different physical, chemical and biological conditions. These parameters change seasonally by having deviation from the normal optimum ranges, which influence the shrimps. Wide differences are observed in moulting, feeding and growth in different seasons. In our present study, observations were taken during summer, rainy and winter seasons. The productivity, survival rate, food conversion ratio and the quality of the shrimp were observed. There was a clear difference in the comparative data in the three seasons of culture period. The best management practices in shrimp culture at different seasons were also studied.

MSP 15 **MECOS 09**

FISHERY AND BIOLOGY OF THE EDIBLE OYSTER *CRASSOSTREA MADRASENSIS* FROM THE UPPANAR ESTUARY, CUDDALORE

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Vast edible oyster resources exist in the Uppanar estuary, Cuddalore, which has been regularly exploited since 2003. Monthly observations were made on the fishery during 2006 and data on the magnitude of fishery, manpower and craft deployed were collected. Sub-samples from the fishery were analysed in the laboratory. Monthly data revealed that a minimum and maximum catch of 22.5 t and 93.8 t were landed in November and May respectively. During 2006, a total of 480.1 t were fished by deploying 1950 mandays and the value of the meat realized was Rs.6,00,125/-.

Analysis of gonadal stages showed that fully ripe oysters occurred during April and September and the spent ones during the subsequent months indicating peak spawning activity in May and October synchronizing with high temperature and low salinity respectively. The oysters ranged between 27 and 132 mm in size. Male was dominant in the population except during October and the edibility was varying between 5.4% in May and 8.8% in September/October reflecting the spent and ripe gonads.

MSP 16 **MECOS 09**

EFFECT OF GLYCINE, A FEED ATTRACTANT AFFECTING GROWTH AND FEED CONVERSION OF JUVENILE BELUGA *HUSO HUSO*

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Feeding experiments were conducted to determine the effect of the feed attractant, glycine on the growth and feed conversion ratio of *Huso huso* (mean initial weight : 26.04 $\pm$ 0.4g) in the trial carried out in Shahid Marjani Center for cultivation in Golestan Province of Iran. Three types of diets were prepared with the incorporation of glycine at 5, 10 and 15 $g.kg^{-1}$ levels along with an un-supplemented control. After 54 days, the weight gain, feed intake, feed conversion ratio (FCR), Daily Growth Index (DGI), Daily Growth Rate (DGR), Specific Growth Rate (SGR) and Condition Factor (CF), were higher in the beluga fed with the three glycine–added diets compared with the control feed. Among the glycine-added diets, the juvenile beluga fed with glycine of 5, 10 and 15 $g.kg^{-1}$ level showed highest weight gain (134 g) by registering 136.6% increase in growth over the control and higher feed intake (7.34) and better FCR (2.2). There were highly significant differences ($p < 0.01$) in weight gain, feed intake, DGR and FCR among the treatments. There was no significant difference ($p > 0.05$) in survival among various treatments.

MSP 17 **MECOS 09**

DEVELOPMENT AND VALIDATION OF COASTAL ZONE MANAGEMENT PLAN - A CASE OF ACTION RESEARCH THROUGH COMMUNITY PARTICIPATION

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Coastal area is one of the most population-intense zones in India. The problems the local population faces in these areas range from lack of potable water to changes in the coastline. With increasing population, the natural resources and the traditional harmonious relation that existed between man and nature is under threat. This is being studied by experts in various fields but more importantly this is being felt and understood by the stakeholders themselves.

Management of any resource can be effective only with the active participation of the stakeholders. Their involvement in identification of problems and opinions about the solution are critical to the resource management process. Experts can guide and concretize opinion formation, explaining the scientific aspects of the problems, thereby increasing the awareness and insight of local stakeholders on the issues that concern them.

This paper presents the methodology and main findings of an action research project on Coastal Zone Management carried out with the involvement of the local stakeholders, specifically women and children in Chellanam village of Ernakulam District, Kerala. The identification of the main problems and the possible solutions were arrived at after a series of interactions over a two year period with the actual stakeholders. The perceptions and aspirations of the stakeholders were reflected in the whole process.

MSP 18 **MECOS 09**

APPLICABILITY OF TURTLE EXCLUDER DEVICE IN TRAWLNETS

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Turtle fishing has been banned in India since 1977 as turtles were declared as protected animals by placing them in Schedule I of the Indian Wildlife (protection) Act 1972 as per the amendments made to the schedule in September 1977. Similar restrictions were observed in many other countries. In spite of these restrictions, there is illegal fishing for turtles in some countries.

Apart from these illegal activities there is considerable amount of incidental mortality of turtles due to fishing activities like trawling and gillnetting. India, Australia and the USA are the major contributors to the mortality of turtles due to fishing activities, particularly the prawn fishing operations. Experiments were conducted on trawlnets to reduce the incidence of turtles, leading to the idea of Trawling Efficiency Device or Turtle Excluder Device (TED). Although experimentation started in the USA as early as 1975, it has materialized only in 1980. In 1980, a unique separator trawl design, called the turtle excluder device (TED), was developed by National Marine Fisheries Service (NMFS) of USA to reduce the incidental capture of endangered sea turtles by shrimp trawls as a technical option to mitigate Endangered Species Act violations by the shrimp industry. The NMFS developed a number of TED designs to improve their functioning. They promulgated regulations which required the use of TEDs on offshore shrimp vessels beginning in June 1987, depending upon vessel size, geographic location and fishing area. From the 1993 shrimp season, the USA implemented revised federal TED regulations which are more effective in reducing turtle mortality.

Following complaints by the American shrimp trawlers that the TEDs were adding costs and causing shrimp losses, which put them at a competitive disadvantage with foreign shrimpers, the American Congress enacted an embargo programme. Under this embargo, certain shrimp imports are prohibited unless the harvesting nation is 'certified' as having either a 'comparable' regulatory programme to that in the USA, or a shrimping programme which does not pose a threat to turtles.

In Australia, the name Trawling Efficiency Device is used for TEDs instead of Turtle Excluder Device to make it popular among fishermen. Australia also developed a number TED designs to suit to different fishing conditions and strictly implementing the TEDs. Australian researchers are trying to show that using TEDs is more profitable because of less accumulation of by-catch in the nets and it makes sorting the catch easier.

India also started testing different types of imported TEDs in view of the US embargo on imports from countries not implementing the TEDs. Fishery Survey of

India (FSI) and Central Institute of Fisheries Navigation and Engineering Technology (CIFNET) conducted experiments with imported TEDs. These experiments could not impress the fishermen as there are no comparable data from the trawlnets with and without TEDs simultaneously. Central Institute of Fisheries Technology (CIFT) has developed a CIFT-TED which is a top exiting, single grid, hard TED of 1000x 800 mm size, for use by small mechanized trawlers which predominate in Indian waters. Field trials of the CIFT-TED have been carried out off Cochin, Visakhapatnam and Paradeep. Demonstration of fabrication and operation of CIFT-TED was carried out in Orissa during the mass-nesting season of the olive ridley turtles (*Lepidochelys olivacea*) in February 2001. CIFT claims that the CIFT-TED permitted 100% escapement of turtle while keeping escapement of shrimp as low as 0.62%. CIFT-TED is now being popularized in maritime states in collaboration with MPEDA and respective state fisheries departments.

In spite of all the assurances of the government agencies in India, the USA, Australia and other shrimp trawl operating countries, fishermen still feel that there is considerable escapement of shrimp in TED attached trawlnets. This is the major problem for the implementation of TEDs in India and elsewhere.

MSP 19 **MECOS 09**

SIGNIFICANCE OF SMALL PELAGICS IN THE MARINE ECOSYSTEM IN SUSTAINING THE STOCK AND FISHERY OF INDIAN SEAS

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The marine fish landings along the Indian coast progressively increased from 0.58 million tonnes in 1950 to 2.89 m t in 2007, except for a period of stagnation or marginal decline during 1998-2005 (Fig. 1). An analysis of the catch indicated that the yield of several groups is on the decline with reduced contribution to the total production during the recent years. Demersal production as a whole increased till 2000, thereafter declined marginally. Production of elasmobranchs, flatfishes and croakers declined, whereas the yield of perches and catfishes improved and that of silverbellies and other demersal groups sustained during the period. Crustaceans, after an increase in production upto 1998, showed a declining trend thereafter. Among the crustaceans, the production of all resources except crabs is declining. Production of molluscs stagnated after 1995.

Among the pelagics, the yield of several major resources like carangids, mackerel, lesser sardines and anchovies declined since the mid-nineties. Despite this, the landings of pelagics increased mainly due to the increased contribution of oil sardine to the total yield (Fig. 2). During 2000-'07, the oil sardine production showed more than a two-fold increase over the previous decade and contribution to the total

yield also increased from 6.8 to 17.7%. Improved production exhibited by Bombayduck, ribbonfishes, tunas and seerfishes also added to the positive production trends.

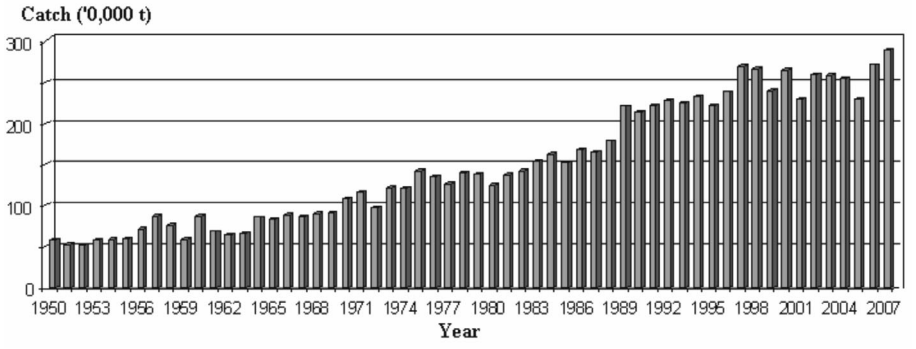

Fig. 1. Marine fish production from the Indian waters during 1950-2007

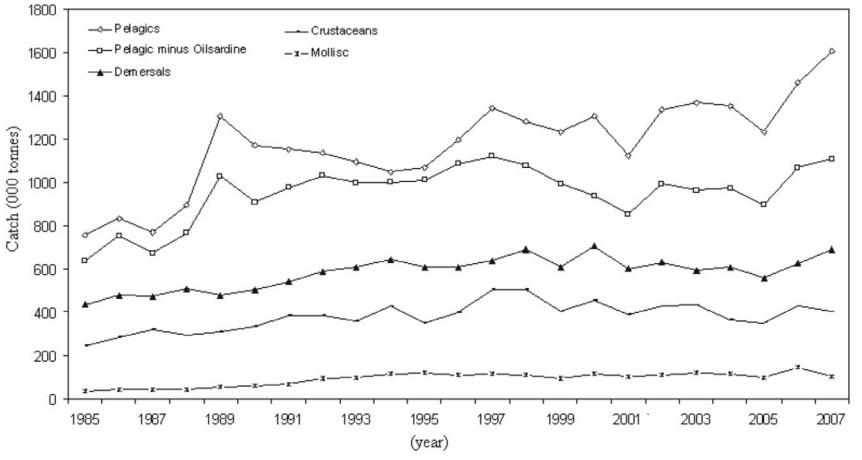

Fig. 2. All India production of pelagics, pelagics without oil sardine, demersals, crustaceans and molluscs during 1985-2007

Despite contributing to higher catches, the sardine, along with other small pelagics, play a vital ecological role in sustaining the stock and fishery of other predatory groups especially large pelagics by providing them the much needed forages. A study in the Gulf of Mannar shows that sardines and other small pelagics such as anchovies, scads, mackerel etc. form the major food for large pelagics. They support 46 to 87% of the total food of pelagic predators. For demersal predators, the crustaceans form the major food and pelagics contribute between 14 and 29%.

MSP 20 **MECOS 09**

RESURRECTION AND PROSPECTS OF BRACKISHWATER CANAL FISHERY – A CASE STUDY

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Canal fishery is useful for income generation of the weaker section with minimum capital investment and application of simple technology. In order to utilize the local resources in an ecofriendly way and for providing an alternate livelihood, a case study was conducted in a portion of brackishwater canal of 1 ha in South 24 Parganas district of West Bengal, India. Culture was made for a period of five months using the locally available fish seeds and involving individuals from Below Poverty Line (BPL) who were previously engaged with the wild collection of shrimp seeds (*Penaeus mondon*) from the backwaters. The benefit cost ratio was recorded at 1.34:1. The study revealed that necessary technological interventions coupled with policy support could lead to substantial increase in inland fish production and development of livelihood.

MSP 21 **MECOS 09**

ENDANGERED MARINE FISH SPECIES OF THE PERSIAN GULF, IRANIAN WATERS

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The Persian Gulf and Oman Sea located in a subtropical zone are extending between the longitudes of 51° 00´E and 61° 25´E and latitudes of 30ºN and 24ºN, which are surrounded by arid land masses in the subtropical zones. The Iranian southern coast includes the Persian Gulf, Hormoz Strait and Oman Sea, which are about 3800 km coastline, 6.2 million of population, 42 people per km² in 17 main cities of four coastal provinces (Khuzestan, Bushehr, Hormozgan and Sistan-Baluchestan from west to east).

A National Project was carried out during 2002–2007 for status determination of threatened and endangered marine fish species of the Persian Gulf and Oman Sea Iranian Waters. Marine fish species were classified into the following six ecological

groups: pelagic, rock-coralline, neretic, anaderm and cataderm migratory and demersal fishes. Of the 899 coastal fish species, several species are in the list of protected species. These species include *Blennis persicus, Callionymus persicus, Cheilodipterus bipunctitus, Istiogobius dayi, Herklotsichthys losseii, Petrus blaywi, Pseudochromis persicus, Thryssa whitheadi, Upeneus oligospilus, Pegasus volitans, Hippocampus kuda*, *Rhincodon typus* and *Rhynchobatus djidddensis*.

MSP 22 **MECOS 09**

GROWTH AND POPULATION DYNAMICS OF SHORT-NECK CLAM *PAPHIA MALABARICA* FROM DHARMADOM ESTUARY, NORTH KERALA, SOUTHWEST COAST OF INDIA

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World's clam and cockle production has been increasing steadily. The production of 988 t in 1991 showed fluctuations over the years and was estimated at 799 t in 2002. *Paphia* sp. contributed 5.4% to the total production. Indiscriminate fishing of clams in many estuaries along the coast of India has resulted in the reduction of these resources. Till now, no work has been initiated along the Malabar coast (North Kerala) to study the fishery and population dynamics of *P. malabarica*. It is assumed that self replenishing populations of clams have an advantage of free swimming larval life of approximately one to two months, permitting uniform dispersal and settlement in the fishing area. Considering these factors, in the present study, the stock assessment models used for population dynamics were applied in arriving at basic stock assessment parameters. The study of age, growth, survival and mortality, longevity and maximum sustainable yield are required for the judicious exploitation of the resources. The age and growth of *Paphia malabarica* were studied by continuous sampling of the population and analyzing the changes in size frequency distribution. The growth pattern thus obtained was applied in a mathematical form using von Bertalanffy's growth (VBG) equation.

The growth parameters of the von Bertalanffy growth function were $L\infty$ = 59 mm, K= 0.92 yr^{-1}. By using Pauly's formula, t_0 for *P. malabarica* was calculated as -0.1596. The life span estimated for clams in Dharmadom estuary was 2.5 to 3 years. By VBGF, it was estimated that *P. malabarica* attains a length of 35.5 mm at the end of first year and 49.6 mm at the end of second year in the estuary. Since the length at first maturity (Lm) has been estimated at 22 mm (reproduction part), 50% of the clam mature in 7 months of life. It was also observed that all the clams above 22 mm were mature. The total mortality coefficient (Z) estimated for 2003-2004 was 4.53. The natural mortality coefficient was 1.82 and the fishing mortality coefficient (F) was 2.83. Results of the VPA using the pooled length frequency data for the year showed that F was maximum in the largest size group. Apart from this,

higher value for F was noticed in the size classes 35 mm and 38 mm. The mean numbers and the length-wise catch pertaining to each length class showed that catch constituted mainly 35-38 mm length group and maximum catch (16.5 t) was obtained in the size class 35 mm. Average yield of *P. malabarica* for the period 2003-2004 calculated from the length-based Thompson and Bell prediction model was 115 t and the maximum sustainable yield (MSY) was 69.3 t. As per Thompson and Bell prediction model, with 80% of the present effort, the MSY is reached and with reduction of 20% of the present effort, maximum yield can be obtained. Subsequent addition of effort from the present level does not increase the yield.

The present study of age, growth, survival, mortality, longevity, maximum sustainable yield and population dynamics of *P. malabarica* is undertaken for stock assessment of the resource in the estuary and to formulate policies for judicious exploitation as well as for the conservation of the resource along the coast.

MSP 23 **MECOS 09**

AN ANALYSIS OF ELASMOBRANCH FISHERY AT RAMESWARAM

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The state of Tamilnadu has a coastline of about 1,000 km and a continental shelf of 41,000 km^2 with extensive shallow water trawling grounds. The fishery at Gulf of Mannar and Palk Bay shows wide variation both in species composition and catch trends. Trawlers fishing at Palk Bay land the catch at Rameswaram and Mandapam while trawlers operating in Gulf of Mannar land the catch at Palk Bay. At Rameswaram 500-630 trawlers operate daily; the boats operate at a distance of 15 -25 km from the coast where the depth is 10 -18 m. Cod end mesh size of fish trawl is 20 -25 mm and shrimp trawl is 15 -20 mm. Sharks are exploited mainly by trawlnet and gillnet and shrimp trawl chiefly exploits skates. Besides the trawl units which land elasmobranchs, in Palk Bay large meshed bottomset gillnets called *thirukkavalai* are operated for rays.

Data on landings of rays and effort expended by trawlers were collected from weekly observations in the fishing harbours at Rameswaram and Pamban during 1997-2000. To estimate catch (weight and numbers) of each species, the data collected at the observation centre were weighted to get estimates for each centre. During January – March, pair trawling is conducted using fish nets. At Pamban, mechanized nets are operated more at Thekkuvadi, southern side in the Gulf of Mannar. Wide fluctuation was noticed in the number of units operated at different months at Rameswaram with the maximum in April and July.

Trawl landings of elasmobranchs declined both at Rameswaram and Pamban from 816 t to 427 t and 70 t to 30 t respectively during the period 1997–2000. A decline was also noted in the catch per unit effort at both the centers. Peak trawl fishery for rays at Rameswaram was January –March, while at Pamban it was during December. Nine species of rays (*Pastinachus sephen, Himantura bleekeri, H. imbricatus, Dasyatis kuhlii, D. uarnak, Aetobatus narinari, Gymnura micrura, Taeniura melanospila, Rhinoptera javanica*), five species of sharks (*Sphyrna zygaena, Eusphyra blochii, Chiloscyllium indicum, Carcharhinus dussumieri, Scoliodon laticaudus*) and one species of skate (*Rhinobatos granulatus*) were landed at Palk Bay. Landings of *P. sephen* showed a steady increase from 266 t (33% of the total rays landed at Rameswaram) in 1997 to 354 t (83%) in 2000. Landings of *A. narinari* at Rameswaram decreased from 177 t in 1997 to 57 t in 2000 (decrease by 67%). Trawl landings of *H. bleekeri, H. uarnak* and *R. javanica* decreased to negligible amounts by the year 2000. Landings of *H. bleekeri* from trawlers of Gulf of Mannar (Pamban) increased by 10%. All the other species of rays occurred only in minor amounts in the trawl landings.

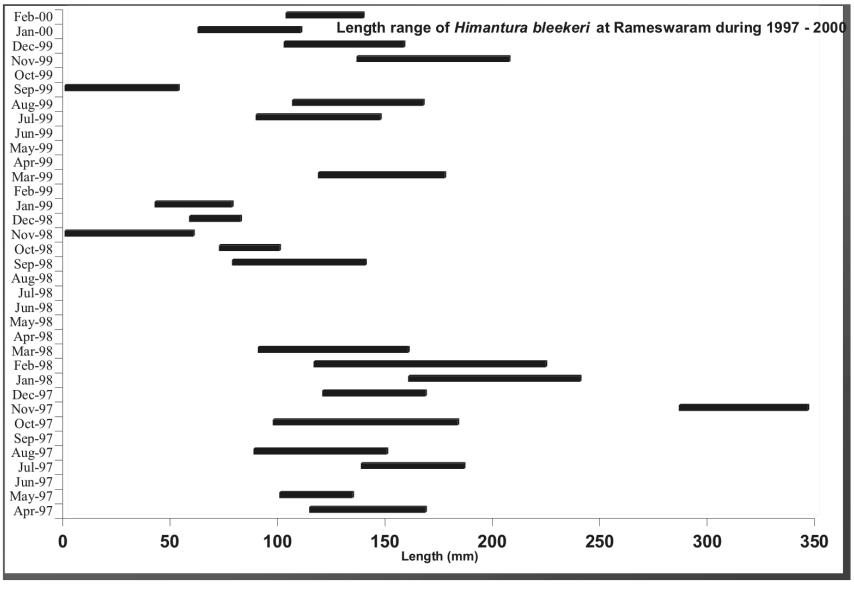

Fig. 1. Length range of *Himantura bleekeri* at Rameswaram during 1997-2000

The length range of *Pastinachus sephen* at Palk Bay ranged from 34 to 210 mm, and the length range of *H. bleekeri* was 34 -286 mm (Fig. 1). The two species were available throughout the study period.

MSP 24 MECOS 09

GEO-TEMPORAL DISTRIBUTION OF JUVENILE AND ADULT THREADFIN BREAM *NEMIPTERUS MESOPRION* IN THE TRAWL FISHERY OF KARNATAKA COAST

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Nemipterus mesoprion is one of the most important commercial species of fish in Karnataka. Recently, the fishery has been showing wide fluctuations and major part of the catch is constituted by juveniles. The species is caught generally from a depth range of 50 to 100 m. Since the present day trawling is extended to deeper waters and spread over wider areas crossing the state boundaries, fish landing in a particular landing centre is not reflecting the area of fishing. To overcome the difficulties of finding the location of the fishing ground and to give more accuracy in fishery management, an attempt has been made to prepare a spatial and temporal resource map of juveniles and adults of *N. mesoprion* off Karnataka. The resource map with distribution of the species in terms of quantity and season will provide a clear idea of stock potential and period of juvenile abundance and will enable in evolving policies for stock replenishment and sustainability. The resource mapping based on commercial trawl GPS data over a fishing season is the first attempt of its kind and similar studies with similar data collection techniques on different resources from more number of commercial trawlers will help us in development of management strategies for independent resources more efficiently.

The map is prepared on the basis of catch details and GPS reading collected from commercial trawlers operated from Mangalore fisheries harbor. GPS data on fishing ground (latitude and longitude), depth of operation, hauling time, number of hauls, catch and discard details of 96 hauls (August 2007–June 2008) were collected and analysed. *N. mesoprion* landing data at Mangalore fisheries harbour was used for estimating the percentage of juveniles in the commercial landing. Abundance of the species in each month is derived from the number of fishes caught per haul. Monthly distribution of the species were identified with the help of *"Ocean Data View"* software (Schlitzer, R., Ocean Data View, http;//odv.awi.de, 2008) using the latitude and longitude data.

In August, the fishing ground for *N. mesoprion* was identified between latitudes of 17.0^0N-17.5^0N and longitudes of 72.6^0E-72.9^0E. Similarly for each month fishing ground was identified using the software. Monthly catch of the *N. mesoprion* (number/haul), percentage of juveniles of discarded, percentage of juveniles in the sample and landing of adult fish is given in Table 1.

Table 1. Composition (%) of discarded juveniles, and juveniles and adults in the catch of *Nemipterus mesoprion* off Karnataka during 2007-08

Month	Catch (No./haul)	Discarded juveniles	Juveniles in commercial landing	Adult fish in commercial landing
August 07	6681	47.82	12.23	39.95
September	3771	41.87	9.72	48.41
October	1840	64.79	4.28	30.93
November	4566	97.38	1.37	1.24
December	3105	67.61	20.15	12.25
January 08	2789	50.48	29.50	20.02
February	17675	72.91	12.86	14.23
March	836	60.67	23.58	15.75
April	1119	2.71	40.45	56.84
May	7369	89.42	5.38	5.20
June	592	1.99	43.65	54.37

Annual distribution map of *N. mesoprion* shows that the fish landed at Mangalore fisheries harbour is generally caught and brought from a depth of 50 to 150 m and from the grounds extending off Maharashtra in the north to fishing grounds off central Kerala in the south. More than 40% of the *N. mesoprion* catch, which constituted exclusively juveniles, were discarded in all the months, except in April and June. The discard was maximum in November (97%). The resource map with distribution of the species in terms of quantity and month provides clear idea of adult and juvenile abundance. The spatio-temporal data on distribution and abundance will enable evolving policies for sustainable exploitation and management of the resource in terms of restriction of fishing period, fishing pressure *etc*. It will also help the policymakers to strictly implement restrictions regarding fishing ground and fishing season on the basis of similar database on juvenile abundance in space and time.

MSP 25 **MECOS 09**

CATCH ESTIMATION OF HILSA IN WEST BENGAL: AN APPROACH TOWARDS CONSERVATION

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The Indian shad hilsa, *Tenualosa ilisha* is abundant in the Hooghly estuarine system of West Bengal. Indiscriminate exploitation of young hilsa through small meshed nets prevailing in the area is not a healthy sign in terms of sustainability. The key to the improvement of the hilsa fishery is to be sought not in regulation of present exploitation but in other measures like improvement of the habitat and providing alternative source of fishery based employment. Under this circumstances, the Department of Fisheries, GOWB has initiated a project to study the present status of this fishery and to find the way of sustainable exploitation of hilsa through study on the ecological and environmental conditions of the migration route along with regular catch assessment and bio-geomorphological study. Impact of urbanization and pollution has been assessed during the survey. The main objective of this paper is the estimation of Maximum Sustainable Yield (MSY) for West Bengal.

MSP 26 **MECOS 09**

MARINE BIODIVERSITY CONSERVATION: A MYTH OR REALITY?

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India is bestowed with a coastline of 8,129 km and an EEZ of 2.02 million km^2, endowed with vast and varied marine resources and their exploitation has been a source of livelihood for many, especially the coastal population. With innovations and development in the techniques for exploitation, the fisheries sector in the past decades has developed into a major industry and contributes a considerable share to the GDP of the country. Though it provides employment and livelihood to a large sector of people, the irrational exploitation has proved to be deleterious for the marine ecosystem. Most of the fishing activity is around the 50m depth zone, where excessive use of bottom trawls is observed. This gear has proved to be efficient in bringing good catches of shrimps to the fishermen. It has also proved to be deleterious to the bottom biota owing to their uncontrolled use. Other gears like purse seine, gill

nets etc. also cause destruction of juvenile fishes. In recent years the number of fishing craft with modern fishing gears have increased immensely thereby further worsening the already vulnerable situation. This has also affected the interests of traditional fishermen. Taking account of the situation, the government has introduced many regulations to control the fishing activities to save the resources as well as the ecosystem.

The need for fisheries legislation was felt way back in 1873, which led to the formulation of the first Indian Fisheries Act in 1897. The act was brought into effect in order to conserve the fishery resources (both inland and marine). On the basis of the Indian Fisheries Act, various State Governments have issued notification for the conservation of fishery resources within their territorial limits. The Central Government, after considerable deliberation, issued a model bill to be circulated among the ten maritime states of India. The bill was issued under the purview of controlling and protecting the exploitable marine resources. Acting on the basis of the model bill, many of the maritime states have formulated legislation that limits the exploitation of marine resources in their territorial waters. Among the maritime states, Kerala and Goa were the first to enact a Marine Fisheries Act in 1980 and others followed the suit. All these acts demarcate the fishing zone in the territorial waters for the mechanized and non-mechanized (traditional) sectors. The acts in various states also enforce a complete trawl ban for a stipulated period every year. Kerala, where the first trawl ban was introduced, has seen the claims and counter claims by the traditional and mechanized sectors on the issue of need of such a ban, often leading to violent clashes. The first ban was also legally challenged by the mechanized sector, where by the government was directed to conduct a detailed study on the issue. Accordingly, the government constituted a committee of experts to probe into the issue. The years followed have seen many more committees constituted for this purpose, a total of nine committees till date. All these committees unanimously recommended a trawl ban during the monsoon months and suggested a detailed study of its impact on conservation and optimum utilization of the resources. Though a 'simple ban' on trawling is enforced every year, other conservative measures, the most important one being the mesh size regulation; and to limit the number of fishing craft (modern fishing vessels), use of other destructive gears like purse seine, ring seines etc has not been implemented. It is also observed that a detailed study on the impact of these regulations, especially on the variation in fish landings, has not yet been carried out so far, which again give way to the claims by the mechanized sector who are opposing the ban on trawling. This has given rise to conflicts between the traditional and mechanized sector, which has worsened in these years. Clashes among the traditional and mechanized sector are common, especially during the trawl ban period, making it a more sensitive issue of the recent times.

In this context it is to be mentioned that the first Indian Fisheries Act was enacted more than a century ago with an aim to protect and conserve the fishery resources. One among the main measures in the Act was to limit the mesh size. Though the mesh size regulation was suggested at a time when the gears like trawl etc were not popular but has proved to be an important one, to regulate the capture of young ones, in the later years. The decades followed have seen many more regulations or

laws enacted by the Central as well as the State Governments to protect and conserve the marine resources. The Government also declared many areas in the sea as protected waters for the conservation of endangered species. The first is in Gulf of Kutch in Gujarat (as a Marine Sanctuary in 1980 and later as a Natural Park in 1982), Gulf of Mannar in Tamil Nadu (as Natural Park in 1986 and Biosphere Reserve in 1989), Bhitar Kanika in Orissa, to name a few. Apart from this many more National Regulations / Acts have been put forward during various periods of time in the purview of preserving the natural resources. It includes the Wild Life Act (1972), Indian Ports Act (1963), Environment (Protection) Act (1986), Declaration of Coastal Regulatory Zone (CRZ, (1991), Marine Fishing Policy (2004), Coastal Aquaculture Authority Act (2005) etc.

The mesh size regulation which was envisaged in the first Indian Fisheries Act, more than a century ago, has not been implemented as it should be, so as to prevent the fishing of juveniles and young ones. In this regard, it may be mentioned that the Food and Agriculture Organization (FAO) of the United Nations has formulated certain productive guidelines in the form of Code of Conduct for Responsible Fisheries (CCRF), aiming at long-term sustainable measures for the optimal exploitation of fishery resources. Based on these guidelines, a country is free to formulate their own regulatory measures or can implement the guidelines in the CCRF as such. It is also to be mentioned that the end users or the group on which the regulation has its effect is the fisherfolk and fishing being their means for earning livelihood, enforcing any regulation will have either favourable or adverse effect among the traditional or mechanized sectors. Since majority of the fisherfolk are uneducated or unaware of the 'what', 'why' and 'how' of these regulatory measures, it is inevitable that the fisherfolk should be made aware of the control measures so as to facilitate its successful implementation. Any regulatory measures in the fisheries sector will have an effect on the quantity of the catch taken and it can be a cause of concern to the fisherfolk. Hence a mass tailor-made awareness programme has to be initiated before the implementation of regulatory measures.

To conclude, it is worth mentioning that India has enacted ample number of regulations or acts or laws intended to protect and conserve the marine resources and its success depends on how effectively it is implemented at the grassroot level. It can only be implemented successfully among its beneficiaries i.e. fisherfolk, by propagating an awareness of its long term benefits to them. To this we can call for the active participation of the politicians, various religious leaders, and group or community leaders etc. who have a better influence on the fisherfolk and also the involvement of all the other stakeholders like scientists, aministrators, social workers, NGOs. Here the importance of the Marine Fishing Policy formulated by the Ministry of Agriculture in 2004, which was enacted in this direction, with an objective to safeguard the interests of the fishers as well as to conserve the resources can be referred to. Also worth mentioning is the activities of Marine Stewardship Council (MSC), in the certification of fishery resources on the basis of fishing form a well managed fishery, which is a right step in this direction. Though worldwide, many of the policies or regulations, on conservation, pertaining to each country have been implemented to an appreciable level, in India it is still in a budding stage. It is high

time to enforce our policies, effectively and successfully, failing which we may see the interests of India being sidelined in the international scenario. Hence need of the hour is not enacting new regulations but how the existing regulations are implemented or enforced effectively. This can save not only our vulnerable natural marine resources but also the economy of the country.

MSP 27 **MECOS 09**

POPULATION VARIATION IN THE INDIAN CICHLID, *ETROPLUS SURATENSIS* (BLOCH) THE PEARLSPOT OF PENINSULAR INDIA

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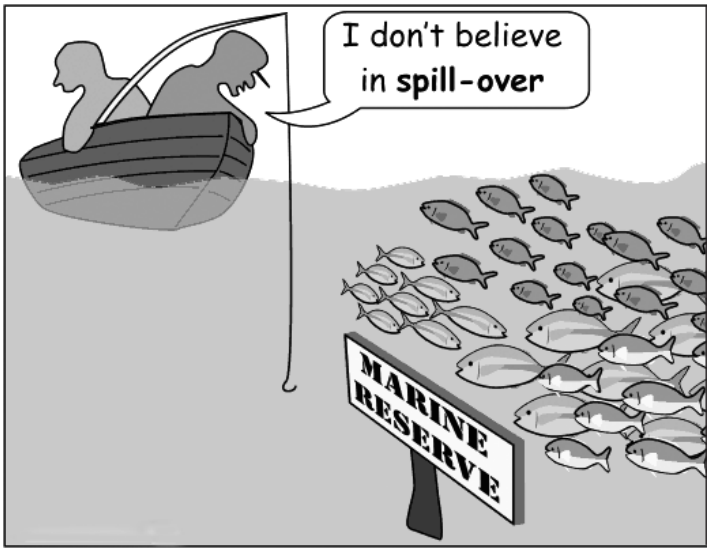
In view of widespread degradation of natural aquatic environments, often resulting in decline of fish stocks, it is important to evaluate the genetic diversity of fish resources. Considerable progress has been made towards understanding the genetic make-up and variability of the wild as well as farmed fish stocks for management and improvement of their genetic resources. However, our knowledge on these aspects in the Indian cichlids is scarce. An attempt has been made to study the genetic make-up of the populations through morphometric characters of *Etroplus suratensis* from peninsular India.

Samples of *E. suratensis* were collected at Cochin, Mangalore, Karwar, Goa, Pondicherry, Madras (Pulicat Lake) and Hyderabad. Of the total 31 morphometric characters studied, one volumetric, 12 linear, 11 vertical and 7 lateral measurements were taken. Nine characters were found to be highly significant when subjected to analysis of dispersion to the variation in respect of different localities.

Morphometric studies reveal that the populations of *E. suratensis* from the brackishwater of Cochin and the freshwater lake of Hyderabad showed no significant variation and hence considered as homogenous population. Similar homogeneity was observed in the populations from Karwar and Pondicherry.

Brackishwater populations of *E. suratensis* from Mangalore showed homogeneity in morphometric characters with similar populations of Madras. Karwar and Goa populations between them showed homogeneity.

The analysis of dispersion revealed significant differences between localities. The analysis indicated three groups of localities namely Cochin and Hyderabad under Group I, Mangalore, Muthukadu and Pulikat lake under Group II and Karwar, Goa and Pondicherry under Group III.



Ecosystem Assessment - EA

EAO 01 MECOS 09

SENSITIVITY OF GIS-BASED INTERPOLATION TECHNIQUES IN ASSESSING WATER QUALITY PARAMETERS OF PORT BLAIR BAY, A & N ISLANDS

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Accurate assessment of water quality parameters in a bay is vital for the conservation of coastal and marine ecosystems. As bay is one of the most dynamic ecosystems, the analyses of water quality parameters have to be carried out within a short span of time. Hence, only a limited number of points are surveyed for evaluation of water quality in a bay. Selectively studied water quality parameters are then interpolated for the entire bay area based on the measured data points. Geographical Information System (GIS) is a powerful tool for such interpolations. In the present study the surface water quality parameters such as temperature, salinity, conductivity, dissolved oxygen, pH and turbidity of Port Blair bay, A&N Islands were measured *in situ* over 104 sampling points using a digital multi-parameter water quality instrument (Hydrolab - Quanta) and a GPS (Garmin – eTrex) during high tide. These parameters were subsequently interpolated over the entire bay using three different methods *viz*., Inverse Distance Weighted (IDW), Spline and Kriging. Finally, the interpolated values over the sampling points were compared with the corresponding measured values by means of the following three statistical indices: Mean Absolute Error (MAE), Root Mean Square Error (RMSE) and Index of agreement (d). It was found that among the three interpolation methods, Kriging method showed better matching with the measured values for all the parameters with lower MAE and RMSE values and higher values of 'd'. This paper describes the details of interpolation methods and statistical analysis as well. In addition, it also highlights the capability of GIS as a tool to model spatial changes in environmental systems.

EAO 02 **MECOS 09**

ECOLOGICAL CHARACTERISTICS ASSOCIATED WITH THE POLAR BRYOZOANS

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Antarctic bryozoans are well known for their diversity. Over 300 species have been described from this unique ecosystem and new descriptions continue to appear. During the third Indian Antarctic expedition, 24 species of cheilomate bryozoans were collected. The most remarkable feature of the major species was a clear-cut coralline, fragile and thalloid morphology of the zoarium. Since this morphological feature was in striking contrast with the benthic bryozoans of the Indian Ocean, the possible reasons for the conspicuous difference in morphology were analyzed based on the ecological conditions prevailing in the mesobenthic regions of the Southern Ocean in general and the coastal waters of the Antarctic continent in particular. The existence of different hydrological fronts influences the ecology of the waters of the Southern Ocean. The animals were collected from 200 m depth where the hydrological conditions recorded were hostile. This is accompanied by rarity of organic debris, micro zooplankton and dead organic matter, which form the source of energy for the microbenthos of the Antarctic. Therefore, the peculiar morphology of the bryozoan colonies could be an environment induced modification ensuring and enhancing survival of this group in this hostile biological environment.

EAO 03 **MECOS 09**

CRAB FISHERY OFF KOZHIKODE, SOUTHWEST COAST OF INDIA WITH SPECIAL REFERENCE TO POPULATION CHARACTERISTICS AND STOCK ASSESSMENT OF *PORTUNUS SANGUINOLENTUS*

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Crab landing data for the period from 2001 to 2007 for Kozhikode district (Kerala), southwest coast of India was used for this study. During this period, a total of 12898 t of crabs were landed with an average annual catch of 1843 t, which formed 1.5% of the total landings. About 85% of the catch was landed by mechanized

trawlers, 12% by indigenous trawlers and 3% by gillnetters. The catch per unit effort (CPUE) in mechanized trawlers varied from 12.2 kg (2007) to 41.3 kg (2005), in indigenous trawls from 2.3 to 15.5 kg and in gillnet from 0.1 to 1.1 kg. The catch per unit hour (CPUH) varied from 0.6 to 2.7 kg, 0.8 to 2.3 kg and 0.1 to 0.6 kg respectively in the above gear. The average CPUE was 24.1kg in mechanised trawler, 4.9 in indigenous trawlers and 0.6 in gillnets. In mechanized trawlers, the catch showed an increase from 2001 onwards and reached a peak in 2005 (2392 t) and after that it showed a decline till 2007. Indigenous trawlers also showed a similar trend but in gillnet the maximum catch was in 2003.The percentage of crabs in total catch was only 0.8% in mechanised trawlers whereas in the indigenous trawlers, it was 2.4% and 1.8 % in gillnets. The main fishing season was from January to June with a maximum in April followed by May though the crabs were landed throughout the year. The annual peak fluctuated between March and June in different years. In mechanised trawlers, the peak was in April followed by May, in indigenous trawl it was in January followed by February and in gill net it was in April. But in all the gear, the maximum CPUE and CPUH were in April.

In the mechanised trawlers, *Portunus sanguinolentus* dominated (74.9%) in all the years. In 2001 and 2002, the second dominant species was *P. pelagicus* (7.8 %) whereas in all the other years and in the yearly total *Charybdis feriatus* (19%) was the second dominant species. *C. lucifera* (2.1%) and *C. natator* (1.9%) were also present in the catch occasionally in small quantities. In the monthly catch, upto August, *P. sanguinolentus* dominated, in September and October *C. feriatus*, and in November and December *P. pelagicus*. In the indigenous trawlers, *P. sanguinolentus* dominated (78%) followed by *P. pelagicus* (22%). In gillnets, 85.1 % of the crab catch consisted of *P. sanguinolentus* and the rest by *P. pelagicus* (14.9%). There was no landing of *C. feriatus* in indigenous gears.

As 66% of the total crab catch was contributed by *P.sanguinolentus* and 97.6% of the total landing of *P.sanguinolentus* was by mechanised trawlers, the data from this gear were used for biological and stock assessment studies.

The carapace width ranged from 36 to 170 mm in males and 26 to 155 mm in females. But 97% of the catch in males and 96% of the catch in females were in the width-group 61-140mm. The weight ranged from 3 to 140 g with an average of 49 g in males and 6.5 to 128 g with an average of 45 g. The length–weight relationship in male and female was as follows: Male: $W = 0.0000503\ L^{3.00}$, Female: $W = 0.0000440\ L^{3.03}$. The variation in relationship between sexes was significant. L_{∞} was 173 mm for male and 160 mm for female. The annual growth coefficient (K) was 1.85 in males and 1.7 in females. The t-max was 1.92 in males and 1.84 in females. The natural mortality was calculated from longevity as 2.404 in males and 2.502 in females. The width at first maturity (L_m 50) in female was 94 $\pm$ 1.302mm.

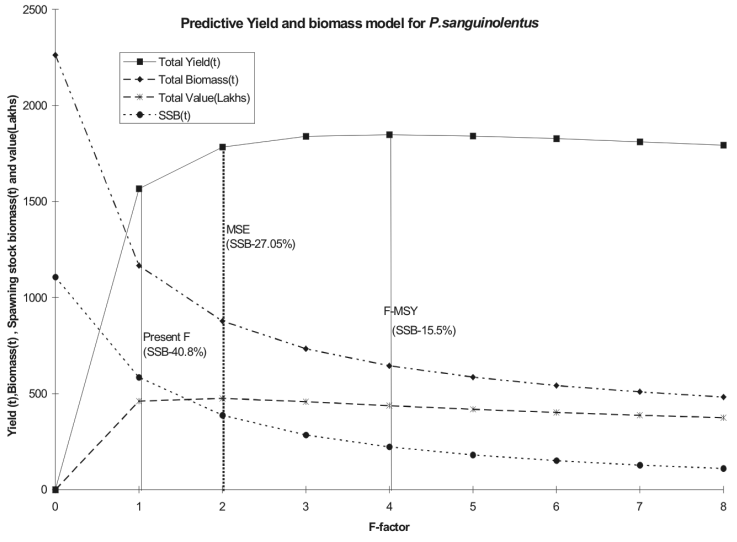

Fig. Predicted Yield and Biomass model for *P. sanguinolentus*

The stock assessment studies showed that the fishery can be increased four times to reach the Maximum Sustainable Yield (MSY) and 2 times to reach Maximum Sustainable Economic Yield (MSE) (Fig. 1). The spawning stock biomass with respect to the virgin stock biomass at these levels was 15.5% and 27.0% respectively. This means that there will be substantial decrease in the spawning stock if the effort is increased beyond MSE. It also showed that the present level of fishing is not affecting the stock adversely.

EAO 04 **MECOS 09**

SEDIMENTATION PATTERN IN PIROTAN REEF, GULF OF KUCHCHH, INDIA: A CASE STUDY

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Worldwide, coral reef ecosystems are increasingly getting threatened with the chronic problem of sedimentation. Sedimentation *per se* is a natural process, commonly associated with high turbidity. However, sedimentation can also be due to anthropogenic activities.

Reef building corals are delicate coelenterates, which flourish in tropical and subtropical clear waters within a narrow range of bio-physical environmental parameters. Long-term or episodic sediment influx in reef environment has deleterious

effect on coral communities, as it blocks the sunlight penetration to the photic depths, thereby considerably modifying the ambient underwater light field. Host coral polyps and their endo-symbiont photosynthetic algae (zooxanthellae) exchange nutrients among them. Suspended sediments check the availability of Photosynthetically Active Radiation (PAR) within the photic zone, thus hindering the photosynthesis of zooxanthellae, resulting in a low supply of nutrients to the host coral polyp. The drop in the symbiotic nutrient cycling leads to an overall decrease in the coral's growth, reproduction and distribution. To combat the smothering and abrasive effects of sediments in their corallum, corals try to remove sediment particles through their active cilliary, tentaclular movements and high epidermal mucocilliary system. Sediment removal from the coral polyp demands high energy by the coral, which is otherwise meant for other physiological activities. Sedimentation also affects the reproductive success and recruitment probability of new larvae. Sediment particles also affect corals through internal and external tissue damage and sometimes result in bleaching. Thus, sedimentation in a reef environment decreases the overall biological productivity of the entire ecosystem.

Efficacies of remote sensing techniques have been proved to monitor the problem of sediment loading in a reef environment over time as it can provide a repetitive, synoptic, reef scale coverages (images) with the operational earth observing satellites onboard with different sensors designed with various capabilities. Field methods, sometimes, have the disadvantage of being individual, small, site-specific studies, which fail to provide a comprehensive reef-scale picture. Multi-temporal, high spatial resolution, multi-spectral satellite images come handy as direct, digital input to identify sediment-substrate characteristics and to monitor reef-scale sediment dynamics. These inputs can be integrated on a GIS platform to identify the micro reef-zones vulnerable for future sedimentation.

This study attempts to identify micro-level regions (vulnerable for future sediment loading) of Pirotan Reef, identified as a core area of Jamnagar Marine National Park, Gujarat, India. Pirotan reef is situated in the interior of southern part of Gulf of Kuchchh – a macro-tidal and highly turbid environment in the north west coast of India. Satellite imagery based early records of Pirotan reef (habitat level maps prepared at Space Applications Centre; source: Coastal Habitat of Selected Marine Protected Areas: Atlas of India) shows a narrow, east-west transverse belt (adjacent to the central island) of mud deposition over the reef in 1975.

Within a span of next fifteen years, there was considerable extension of mud deposition in the eastern part of the reef. Over a short period of three years (1982-85), mud deposition over the reef transpired a particular pattern: a gradual, NE-SW orientation of the mud-spread along the eastern margin of the reef. Scenarios over the period 1990-2008 depict that eventhough the gross pattern of sedimentation remains the same, a careful observation reveals the gradual obscurity of the eastern margin of the reef under the column of mud with time. Interestingly, however, the relative spatial occupancy of sand and mud, over time demonstrates a high dynamicity.

RESOURCESAT (IRS-P6) LISS-IV sensor multi-spectral images of Pirotan reef have been used to study the reef-scale sedimentation pattern for a period of four years

from 2004 to 2007. Digitally classified images have been used as base reference to create vector inputs for identifying the micro level, reef–scale changes in sedimentation pattern on a GIS platform.

Close observations on the sedimentation pattern in Pirotan for four years reveal an ongoing process of sand filling in the central tidal pool, extension of a juvenile beach within the core region of the reef, a NE-SW trendline demarcating a clear distinction between the relatively sediment-free seaward face of the reef and the contrasting eastern and south-eastern areas showing high sediment loading (mud deposition).

EAO 05 **MECOS 09**

SPATIO-TEMPORAL VARIATION IN PHYSICO-CHEMICAL PROPERTIES OF COASTAL WATERS OF KALPAKKAM, SOUTHEAST COAST OF INDIA

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Physico-chemical properties in a coastal environment, particularly in the nearshore waters and estuaries, exhibit considerable variations depending upon the local conditions such as rainfall, quantum of fresh water inflow, tidal incursion and biological activities. It significantly affects the productivity of the coastal ecosystem and regulates the food web and biodiversity. Hence, it is important to gather information on the physico-chemical properties of any aquatic ecosystem on a long-term basis, which will be helpful for its management. Though information on general hydrography and biology of Kalpakkam coast has been published, reports on nutrients are scanty. In view of this, a study was organized to estimate the nutrient (nitrite, nitrate, ammonia, total nitrogen, phosphate, total phosphorous and silicate) contents in the coastal waters of Kalpakkam over a period of one year (February, 2006 to January, 2007) with the following objectives: I) to study the seasonal variation in nutrient contents, II) to find out any major change over the years due to anthropogenic impacts, III) to create baseline data for future impact studies and IV) to assess any change in physico-chemical properties of the coastal waters during the post-tsunami period. Total nitrogen (TN) and total phosphorous (TP) are reported for the first time, which would form the baseline data for future.

Kalpakkam (12^{o} 33' N Lat. and 80^{o} 11' E Long.) is situated about 80 km south of Chennai. At present a nuclear power plant (Madras Atomic Power Station, MAPS) and a desalination plant are located near the coast. MAPS uses seawater at a rate of 35 m^3sec^{-1} for condenser cooling purpose. The seawater is drawn through an intake structure located inside the sea at about 500m away from the shore. After extracting the heat, the heated seawater is released into the sea. Moreover, a Prototype Fast

Breeder Reactor (PFBR) is under construction, which would use about 30 m^3sec^{-1} of seawater for condenser cooling purpose. Edaiyur and the Sadras backwater systems are two important features of this coast. These two backwaters are connected to the Buckingham canal, which runs parallel to the coast. During the period of northeast monsoon and seldom during the southwest monsoon, these backwaters get opened into the sea discharging considerable amount of freshwater to the coastal milieu for a period of 2 to 3 months. Seawater samples were collected from five prefixed locations of different environmental stresses. The stations were fixed with the help of Global Positioning System (GPS) and are in a transect parallel to the shoreline, ~500 m inside the sea. The average depth of the water column at the sampling locations is about 7-8 m. The 1st and 5th stations are situated opposite to the opening of the Sadras backwaters and Edaiyur backwaters respectively. The 3rd and 4th locations are near to the intake point and the discharge point of MAPS respectively. The 2nd location is located opposite to thickly populated fishermen village. Standard methods were followed for estimation of different parameters.

Results of the study revealed that the coastal water was significantly influenced by freshwater input during the northeast (NE) monsoon and post monsoon periods (Table 1). Concentration of all the nutrients and dissolved oxygen (DO) was relatively high during the NE monsoon, whereas, salinity and chlorophyll-*a* (chl-a) were at their minimum during this period. Phytoplankton production peak was observed in summer during which a typical marine condition prevailed. The present observed values of nitrate, phosphate, silicate & turbidity are significantly high (5-10 times) as compared to that of the pre-tsunami period. Relatively low DO and chl-*a* concentration was noticed during the post-tsunami period. A notable feature of this study is that though nutrient concentration in the coastal waters during the post-tsunami period has increased significantly, turbidity, the most single dominating factor was found to adversely affect the phytoplankton production during the post-tsunami period as reflected by relatively low chl-*a* concentration. From the present study it is evident that along with the general increase in pollution levels during the previous years, tsunami has also considerable impact on the observed changes in water quality. Moreover, the influence of additional factors such as tidal and physical stirring by currents, presence of substantial quantities of benthic invertebrates and discharge from Sadras and Edaiyur backwater, on the distribution of dissolved inorganic nutrients are discussed in detail. Statistical analysis such as principal component analysis (PCA), clustering and simple correlation (Table 2) have also been carried out for data interpretation with respect to different seasons and locations.

Table 1. Variations in hydrographical parameters and nutrients (µ mol l^{-1}) in the coastal waters of Kalpakkam, east coast of India

Month	pH		Salinity (psu)		Turbidity (NTU)		DO (mg l^{-1})		Chl-a (mg m^{-3})		NO_2	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
February	8.28	0.05	32.89	2.1	6.49	4.02	5.43	0.14	2.45	1.29	0.15	0.05
March	8.22	0.02	35.11	0.33	8.58	5.3	5.11	0.5	3.36	2.2	0.16	0.09
April	8.25	0.33	35.77	0.1	10.74	3.17	5.03	0.73	6.49	1.29	0.14	0.07

May	8.01	0.08	35.91	0.06	13.99	2.02	4.64	0.19	5.32	1.5	0.38	0.28
June	7.8	0.04	35.75	0.06	11.67	3.18	5.13	0.57	4.7	0.35	0.33	0.25
July	7.84	0.05	35.71	0.04	10.14	2.77	5.67	0.19	4.4	0.24	0.47	0.44
August	7.81	0.04	35.68	0.04	11.53	0.9	5.53	0.13	5.01	0.26	1.49	0.18
September	8.04	0.06	33.64	0.84	12.81	1.21	5.48	0.2	4.03	0.35	0.62	0.53
October	7.98	0.08	31.76	0.41	13.09	0.99	5.59	0.13	3.43	0.18	0.11	0.1
November	8.0	0.16	25.72	0.9	7.46	3.18	5.96	0.29	2.21	0.62	0.37	0.27
December	8.09	0.1	27.84	0.39	10.27	0.97	6.01	0.24	2.57	0.68	2.13	2.09
January	8.13	0.11	27.73	3.72	10.99	2.15	6.3	0.22	1.17	0.73	0.23	0.07

Month	NO_3		NH_3		TN		SiO_4		PO_4		TP	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
February	0.10	0.07	0.24	0.39	13.3	2.12	5.19	2.11	0.31	0.24	0.54	0.35
March	0.16	0.22	0.03	0.09	17.09	3.87	7.56	1.36	0.2	0.05	0.4	0.08
April	3.6	8.58	1.19	3.71	18.66	17.97	7.84	3.25	0.23	0.12	0.7	0.37
May	10.97	11.64	0.31	0.14	25.75	19.78	7.25	0.88	0.21	0.08	0.33	0.16
June	11.61	18.46	0.47	0.16	37.77	36.55	10.56	6.66	0.27	0.16	0.62	0.16
July	1.55	1.53	0.3	0.56	27.51	21.22	5.47	2.65	0.28	0.15	0.6	0.21
August	23.03	6.04	0.61	0.59	47.16	2.64	9.84	1.44	0.46	0.06	0.77	0.12
September	3.37	2.5	0.94	1.00	11.75	2.39	12.57	9.82	0.87	0.37	1.21	0.43
October	4.32	3.8			12.41	5.4	5.48	1.42	0.27	0.19	0.4	0.16
November	39.44	29.24	2.95	0.36	103.52	67.46	8.94	1.56	0.37	0.12	0.49	0.16
December	28.27	6.23	0.79	0.46	60.26	10.01	9.05	4.89	0.9	1.21	1.01	1.22
January	13.33	27.57			31.65	39.17	38.43	32.93	0.34	0.08	0.44	0.13

Table 2. Correlation matrix of physico-chemical parameters

Variables	pH	Salinity	Turbidity	DO	NO_2	NO_3	NH_3	T N	SiO_4	PO_4	T P	Chl-*a*
pH	1											
Salinity	-0.172[b]	1										
Turbidity	-0.005	0.162[b]	1									
DO	-0.039	-0.541[a]	-0.155[b]	1								
NO_2	-0.178[a]	-0.187[a]	0.020	0.181[a]	1							
NO_3	-0.248[a]	-0.394[a]	0.025	0.104	0.294[a]	1						
NH_3	-0.073	-0.233[a]	-0.041	0.046	-0.091	0.221[a]	1					
T N	-0.248[a]	-0.412[a]	-0.003	0.122[c]	0.210[a]	0.846[a]	0.258[a]	1				
SiO_4	-0.016	-0.303[a]	-0.004	0.235[a]	0.103	-0.064	-0.109	-0.031	1			
PO_4	-0.030	-0.172[b]	0.122[c]	0.161[b]	0.524[a]	0.122[c]	0.106	0.074	0.080	1		
T P	-0.080	0.007	0.157[b]	0.075	0.461[a]	0.060	0.103	0.018	0.010	0.920[a]	1	
Chl-*a*	-0.029	0.610[a]	0.545[a]	-0.382[a]	-0.080	-0.238[a]	-0.045	-0.242[a]	-0.306[a]	-0.056	0.090	1

[a]$p \geq 0.000$, [b]$p \geq 0.005$, [c]$p \geq 0.01$

EAO 06 MECOS 09

IDENTIFICATION OF MARICULTURE SITES IN ANDAMAN GROUP OF ISLANDS, USING REMOTE SENSING AND GIS TECHNOLOGIES - A PILOT STUDY

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Andaman and Nicobar Island is located in the Indian Ocean in the southern reaches of the Bay of Bengal. It comprises of two island groups – the Andaman Islands and the Nicobar Islands, which separates the Andaman Sea to the east from the Indian Ocean. The total area of the Andaman Islands is 6408 km^2. The total coastline length is 1962 km, which is about 1/4th of the coastline of India. The EEZ around the island encompasses an area of 0.6 million sq.km, forming about 28% of the Indian EEZ. The pelagic and oceanic waters have been very little explored and the suitability of the non-polluted and clear coastal waters of these pristine islands has not been used exploited for mariculture. Until the last decade, mariculture was practiced at a minor level by the local fisherfolk and farmers. Now many companies and central institutions have come forward to explore the feasibility of utilizing Andaman waters for culturing marine organisms. As it is difficult to identify the potential sites for mariculture using manual surveys, remote sensing accompanied with GIS technologies can be applied to identify areas for mariculture.

An attempt was made to identify suitable areas for mariculture. To select the variables or factors that determine site suitability, a bibliographic database was prepared. Variables were classified as topographical, environmental, logistic and socioeconomic criteria. Surveys of India toposheets were used to create base maps. IRS P6 LISS III (2007) imageries were used to identify suitable areas for mariculture. Satellite imageries were digitized using ERDAS IMAGINE 9.2 software to delineate the coastal topography, prevailing coastal resources and shoreline marking. Based on the visual interpretation of the satellite imageries, 8 stations were selected and examined for suitability for mariculture. The field survey was carried out during November and December 2007 in these sites to collect information on the coastal resources, soil and water quality, water depth and substratum so as to interpret the field data with satellite images. The geographical locations of the sampling sites were recorded using a handheld GPS. The field data were incorporated into GIS platform using ArcView GIS 3.2a for interpretation. Buffer zones of 500 m were created from the shoreline and the existing critical coastal habitats. The shoreline, resource map, road network map, water quality and soil quality map were overlaid in GIS platforms. From the interpretation, out of the 8 stations selected for preliminary analyses, 5 sites were found suitable and are recommended for mariculture activities. This study was conducted at a preliminary level and more work needs to be carried out to identify potential mariculture sites in Andaman Islands using remote sensing and GIS.

HYDROLOGICAL CONDITIONS OF SEAGRASS BEDS IN PALK BAY AND GULF OF MANNAR, SOUTHEAST COAST OF INDIA

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Gulf of Mannar and Palk Bay in the Bay of Bengal are highly diverse marine ecosystems harbouring 12 and 10 species of seagrasses respectively. The distribution and growth of seagrasses is regulated by a variety of water quality and meteorological parameters. The availability of nutrients affects the growth, distribution, morphology and seasonal cycling of seagrass communities.

In the study during 2006 and 2007, comparison was made on the water quality parameters of the following seagrass sites: Sangumal (Palk Bay), Thonithurai (Gulf of Mannar), Farm pond (Palk Bay); and a non-seagrass site the Kundugal point (Gulf of Mannar). The sites were selected based on the variability in geological formation and changes in the current pattern. Sangumal seagrass site in Rameswaram island is located in Palk Bay (9° 17′ 22.7′′ N, 79° 19′ 49.5′′ E). There is a sewage outlet adjacent to this site. The seagrass beds are exposed during the lowest low tide during the southwest monsoon up to a distance of 1- 2 km from the shore. During northeast monsoon, the current is in the reverse direction, towards the coast from Bay of Bengal, and hence there will be no exposure of seagrass beds even during low tide. The seagrass beds are found at a distance of 50-75 m from the highest high tide, starting at 2-3 feet depth extending up to 4-5 m depth. Thonithurai seagrass site in the mainland is located in the Gulf of Mannar (9° 16′ 37.7′′ N, 79° 10′ 36.2′′ E). The seagrass bed is located 10-20 m from the high tide line up to a depth of 3-5 m. The coast is exposed during the northeast monsoon season and hence seagrass beds are exposed 600-800 m during the lowest low tide. Farm pond seagrass site is located along the Palk Bay coast (9° 17′ 28.4′′ N, 79° 7′ 45.6′′ E) adjacent to Pillaimadam lagoon which receives freshwater runoff during northeast monsoon. The seagrass beds are located at a distance of 400 to 500 m away from the mouth of the lagoon. The seagrass species diversity in this area is given in Table 1. Kundugal point, a non seagrass site located in the Gulf of Mannar (9° 15′ 28.3′′ N, 79° 13′ 15.4′′ E), Rameswaram island has a highly eroding shoreline which changes with the season.

Table 1. Seagrass occurrence in the three study sites

Species	Sangumal	Thonithurai	Farm pond
Cymodocea serrulata	+	+	+
Cymodocea rotundata	+	+	+
Syringodium isoetifolium	+	+	+

Halodule pinifolia	+	+	+
Halodule uninervis (broad leaf)	-	+	-
Halodule uninervis (narrow leaf)	+	+	+
Halophila ovalis	+	+	+
Halophila beccari	+	+	-
Halophila stipulacea	-	+	-
Enhalus acoroides	-	+	-
Thalassia hemprichii	+	-	-

+ presence - absence

For the four sites, the atmospheric temperature ranged between 24.8 ºC and 35.3 ºC, sea surface temperature between 25 ºC and 35 ºC, pH between 7.44 and 8.44, dissolved oxygen between 1.0 ml l^{-1} and 5.9 ml l^{-1} and total suspended solids between 10.7 mg l^{-1} and 122.0 mg l^{-1}. The maximum nutrients in the water column observed at the sites were phosphate, silicate, nitrite and nitrate as 1.22 μmol l^{-1}, 5.83 μmol l^{-1}, 0.632 μmol l^{-1} and 2.03 μmol l^{-1} respectively. Chlorophyll-a is a better indicator of the trophic status than nutrient concentrations as the latter is affected by biological uptake, which in turn is influenced by interaction with grazers, temperature , turbulence and turbidity levels. In Sangumal and Farm pond, both located in the Palk Bay, the highest chlorophyll-a values were observed in the northeast monsoon season. Minimum chlorophyll-a value of 1.987 mg m^{-3} was observed in the post-monsoon season. Wind velocity and direction influence the littoral currents and maintain the ecological balance of the region. Maximum wind velocity of 24.2 km hr^{-1} was observed during summer season which brings in dust from the coastal sand dune into the sea. The variation in total suspended solids for different seasons is shown in Fig. 1. Sangumal had the maximum input of nutrients especially in the northeast monsoon season (October to December) which is the dominant monsoon season in this coastal area contributing to more than 90% of the total rainfall. Maximum monthly rainfall observed was 518.3 mm in October 2006.

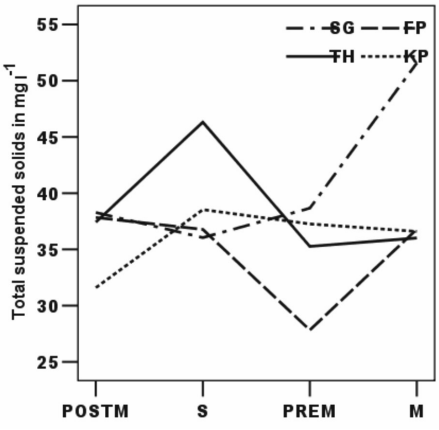

Fig. 1. Total suspended solids during postmonsoon, summer, premonsoon and monsoon seasons in Sangumal (SG), Thonithurai (TH), Farm pond (FP) and Kundugal point (KP)

Low level of phosphate was observed in Kundugal point and Farm pond compared to Sangumal and Thonithurai which indicates that phosphorous plays key role as a limiting factor in this region and regulates the competition between seaweeds and seagrass. Pearson's bivariate correlation coefficient showed significant positive correlation ($p < .001$) of sea surface temperature with pH and salinity while negative correlation was observed with total suspended solids, nitrite and ammonia. Though ANOVA did not show significant differences in water quality parameters of sites with and without seagrass, significant differences ($p < .001$) were observed seasonally in sea surface temperature, salinity, nitrite, ammonia, wind velocity, rainfall and number of rainy days, thereby indicating that seasonal variations in parameters influence the growth of seagrass beds in this region.

EAO 08 **MECOS 09**

BIODIVERSITY STRESSED FISHING ZONES IN KERALA AND KARNATAKA AND IDENTIFICATION OF MARINE PROTECTED AREAS

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Protection of biodiversity is usually implemented by demarcating marine protected areas. Marine protected area (MPA) is defined as 'an area of sea specially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means'. Kerala, and to a lesser extent, Karnataka have been the major contributors to the marine fish production of the country (having 12% of the total coastline and contribute 30-35% of the production). The intense exploitation of commercial marine species along these coasts has reportedly led to threats of species loss, for e.g., depletion of some species of marine catfish and goatfishes.

To identify stressed fishing zones, measures of fished taxa biodiversity over spatial scales such as alpha, beta, and gamma diversity were made for the period 1970-2005 (35 years). Each fishing zone (10 in Kerala and 14 in Karnataka) was taken as an area and the fished taxa species richness was represented as the alpha diversity. The inter-zone comparison was done for deriving the beta diversity and the sum total of all fished taxa richness was taken as an estimate of gamma diversity. Surrogacy methods incorporating average taxonomic distinctness (AvTD - $\Delta+$) and variation taxonomic distinctness (VarTD - $\Lambda+$) were determined from species records (presence/ absence) and were used to determine stressed zones.

Based on the AvTD and VarTD tables and funnel plots, the zones with highly fished taxa biodiversity and the zones which have poor biodiversity (shaded column), and are therefore stressed, are shown in Table 1.

Table 1. Biodiversity status of selected zones in the study area

State	Zones with high $\Delta+$ and $\Lambda+$	Zones with poor $\Delta+$ and $\Lambda+$	Years with high $\Delta+$ and $\Lambda+$	Years with low $\Delta+$ and $\Lambda+$
Kerala	$\Delta+$ = K3,K7 $\Lambda+$ = K3,K4,K6,K7	K1, K2	1987-89; 1991-92; 1994-95; 1997-2005	1985
Karnataka	Very high $\Delta+$ and $\Lambda+$ = KN3, KN15, KN16. Moderately high $\Delta+$ and $\Lambda+$ = KN5	KN14	1995-2005	1972 1984 1988

The spatial comparison of the data on AvTD and VarTD shows that K1 and K2 zones in Kerala and K14 zone in Karnataka are stressed habitats with respect to biodiversity, and this is presumed to be due to the impacts of fishing. Other zones in Kerala and Karnataka do not show signs of stress, although many zones have high VarTD values on account of high environmental variability.

K1 and K2 zones are in the extreme south of Kerala and are located in Thiruvananthapuram District. Although the seascape of much of this coast is not amenable to trawling due to the rocky and uneven nature of the bottom, the Wadge Bank is located offshore of these two zones and the focused fishing effort on this Bank from trawlers as far north as Cochin, is probably the reason for the poor taxonomic diversity values. The fishery in KN14 zone in Karnataka off Bhatkal (Uttara Kannada District of Karnataka) is mainly by purse seines in the post-monsoon and coastal trawlers in the pre-monsoon season. There are a number of small islands in the sea off Bhatkal, and very recently the presence of a submerged coral reef, about 25 km off Bhatkal, has been reported, making it an ecologically sensitive zone. Coincidentally, these fishing zones in Kerala also had comparatively poor alpha and beta diversity values.

The trophic level analysis for Kerala indicated that Zones K1 and K2 had the maximum trophic levels in the entire state (Table 2). A progressive decline was observed in the trophic level as we proceed to northern latitudes in the state of Kerala. Quite clearly, K1 and K2 zones were part of an oceanic (geographically close to Indian Ocean) ecosystem and distinct from the low trophic level small pelagic driven ecosystem, which is part of the Malabar Upwelling Zone and the Arabian Sea LME.

Table 2. Criteria used for identification of MPA in Kerala and Karnataka

Identified MPA	Landmarks	Part of LME?	Taxonomic Diversity	Trophic Levels	Remarks
KERALA Parts of Fishing Zone – K1 & K2	From Kollamgode in the south to Kappil in the north	Arabian Sea, could also be a transition zone between Indian Ocean and Arabian Sea	Very poor Delta+ values indicating low taxonomic diversity Poor alpha and beta diversity	Comparatively high trophic level	A predator driven oceanic ecosystem which needs conservation on account of biodiversity stress
KARNATAKA Parts of Fishing Zone – KN14	From Bhatkal in the south to Murudeswar in the north	Arabian Sea LME and part of Malabar Upwelling Zone	Poor Delta+ values indicating low taxonomic diversity Poor alpha and beta diversity	Not studied	A habitat with many small rocky islands and submerged coral reefs which needs protection and conservation on account of biodiversity stress

While debate continues on the optimal size and location of MPAs, a growing consensus points towards extensive networks of protected areas of at least 20 to 30% of each habitat as per IUCN guidelines**.** Therefore, these unique ecosystems in Kerala and Karnataka need to be preserved and conserved and also urgent steps are necessary to maintain it undisturbed so as to re-build the stressed habitats. Hence parts of these fishing zones are identified as MPAs.

EAO 09 **MECOS 09**

IMPACT OF RIVER DISCHARGE ON PHYSICOCHEMICAL CHARACTERISTICS AND PRODUCTIVITY OF COASTAL WATERS IN THE VICINITY OF THE BARMOUTH OF RIVER BHADAR AT NAVIBANDAR (GUJARAT)

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The River Bhadar is the major source of freshwater to the districts of Rajkot, Junagadh and Porbandar, and has been the subject of study upstream along its main course, to its merging with the River Mahi in the south. A tributary of this river enters Rajkot district near Vinchhia and flows westward, traversing the districts of Junagadh

and Porbandar, before flowing into the Arabian Sea at Navibandar. The main catchment is situated in Dungarpur district and has an area of 6047 sq.km. The length of the river from Vinchhia to its barmouth at Navibandar is about 300 km. The annual discharge at the barmouth is about $6.9x10^8$cu.m/year. The barmouth of the river is closed by natural sandbar formation for a major part of the year. The sandbar is broken by freshwater outflow following heavy rains at the onset of monsoon. This paper presents information on the seasonal hydrobiological profile of this river and the coastal waters in the vicinity of the barmouth at Navibandar. Seasonal variations in the values are related to the river discharge at the barmouth.

Six sampling stations were fixed for monthly sampling of water and soil from May 2001 to May 2003; three stations upstream from the barmouth, one barmouth station and two stations in the sea off Navibandar. The water parameters studied were: temperature, pH, salinity, conductivity, TSS, TDS, DO, extinction coefficient, BOD, COD, ammonia, nitrate, phosphate, silicate, gross productivity, net productivity, chlorophyll *a* and total chlorophyll. The sediment parameters studied were: wet pH, dry pH, salinity, organic C, sand content, silt content, clay content, nitrate, nitrite, available phosphorus, available potassium, total silica and heavy metal content.

Temperature, N:P ratio, Si:P ratio, chlorophyll *a* and total chlorophyll showed significant positive correlation with river discharge while BOD and ammonia showed significant negative correlation with river discharge. In the monsoon season, the salinity, TDS, COD, N:P ratio and Si:P ratio showed significant positive correlation with river discharge. BOD showed negative correlation with river discharge. In the river stretch, the TDS, silicate and Si:P ratio showed significant positive correlation with river discharge. Water parameters in the adjacent sea stretch did not show any significant correlation with river discharge. Significant positive correlation was observed between chlorophyll *a* and total chlorophyll in water with silt, clay, available potassium and nitrite content in the sediment. Both chlorophyll *a* and total chlorophyll showed negative correlation with sand content in the sediment. Silicate content in the water showed significant positive correlation with silt content in sediment and negative relationship with sand content while phosphate content in water showed significant negative correlation with silt content and positive correlation with sand content in the sediment. Lead showed significant positive correlation with river discharge in the River Bhadar. In the monsoon season, soil nitrate showed significant positive correlation with river discharge. In the river stretch, the available phosphorus showed significant positive correlation with river discharge.

Nutrient transfer from terrestrial to freshwater and marine systems assumes great relevance in studies relating to river basins and adjoining coastal waters. The nutrient status of the estuarine and coastal waters, and hence primary productivity, secondary productivity and the natural ecological food web that follows, are dependant on the freshwater influx towards the river mouths. The quantum and duration of river outflow into the sea play a major role in maintaining the estuarine ecosystem at the river mouths and also in flushing out toxic wastes. With two major dams and a number of check dams, river flow in the River Bhadar is obstructed at several points along its course. Poor river outflow for a major part of the year does

not help the opening of the barmouth to ensure sufficient tidal flushing in the estuary. The seasonal bouts of river discharge followed by periods of stagnation and de-linking from the sea results in extremities of nutrient/pollutant concentration at various points of time in the course of a year. Poor flushing and increased accumulation of industrial, agricultural and domestic wastes in the creeks result in an imbalance in the relative nutrient level, causing deviation from ideal river conditions.

EAO 10 **MECOS 09**

SPATIAL AND TEMPORAL DISTRIBUTION OF COMMERCIAL FISHERIES RESOURCES ALONG THE INDIAN COAST

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The compositional divergence in the landings of 17 commercially important fishery groups along the coastal areas of nine maritime states in four regions of India (northeast and southeast in the Bay of Bengal; and southwest and northwest in the Arabian Sea; Table 1) during 2002-2006 was analysed. The landings data were collected from Central Marine Fisheries Research Institute, Kochi. Linear Discriminant Function Analysis was performed over the log transformed data on fish landings with maritime states as the grouping factor. The fish landing data aggregated at zonal-year level as well as a summarized data at the state-year level were subjected to this analysis. Canonical Discriminant Function Plots were made for the whole data and annual data sets. The group plot for the transformed data is given in Fig. 1.

The landing patterns have definitive clustering across the spatial spectrum. The patterns of southwest region comprising Kerala, Karnataka and Goa form a separate group. Tamil Nadu and Andhra Pradesh of southeast region are closer to the southwest grouping in the first disciminant function axis, but marginally divergent in the second axis. The landing patterns of Maharashtra and Gujarat along the northwest, and Orissa and West Bengal from the northeast are closer to each other in the first axis itself, but have a distinct divergence from the other states. The primary axis clearly shows the spatial distinction across the latitudinal ascent. Hence it can be presumed that the pronounced difference induced by the latitudinal spread is the result of habitat preference by each fishery resource group.

Table 1. Latitudinal distribution of different regions and states

Sl. No	Sea	Region	State	Latitude/ Longitude
1.	BOB	Northeast	West Bengal	21° 37′- 22° 11′87 ° 30′ – 88 ° 11′
2.	BOB	Northeast	Orissa	19° 7′- 21° 19′84 ° 46′ – 88 ° 23′
3.	BOB	Southeast	Andhra Pradesh	14° 16′- 19° 5′79 °17′ – 84 °41′
4.	BOB	Southeast	Tamil Nadu	8° 16′- 13° 25′77 ° 7′ -80 °19′
5.	AS	Southwest	Kerala	8°19′- 12°44′74 °53′– 77 °4′
6.	AS	Southwest	Karnataka	12°45′- 14° 54′74 ° 15′ -74 ° 52′
7.	AS	Southwest	Goa	14° 58′- 14° 58′74 ° 2′- 74 ° 2′
8.	AS	Northwest	Maharashtra	15°43′- 19°57′72 ° 41′– 73 ° 40′
9.	AS	Northwest	Gujarat	20°9′- 21°6′70 ° 6′ - 72 ° 45′

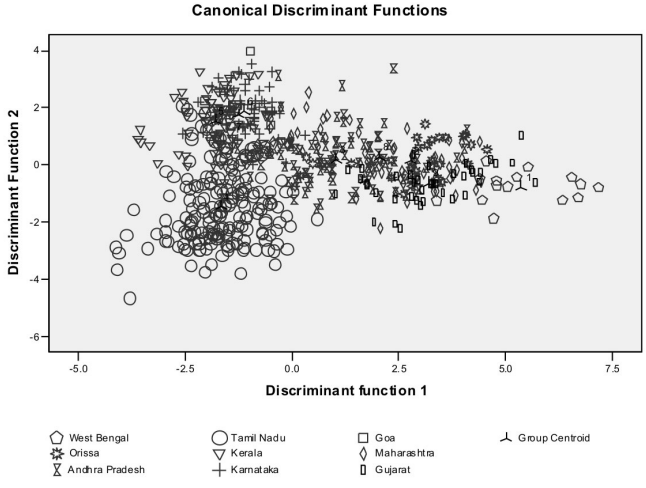

Fig. 1. Canonical Discriminant Function Plot for fish landings (based on 17 resource groups) across 9 states of India

Separate discriminant plots for each of the five years confirmed this, but there was some perceptible skew in the pattern of later years (2005 and 2006) as compared to the earlier years. Seawater warming appears to impact the distribution of fish.

The Hierarchical Cluster Analysis performed on standardized Euclidean distances between maritime state landing estimates corroborated the grouping pattern revealed by the discriminant function analysis.

EAO 11 MECOS 09

TEMPORAL PATTERNS IN CEPHALOPOD LANDINGS AND APPLICATION OF NON-EQUILIBRIUM PRODUCTION MODEL TO THE CEPHALOPOD FISHERY OF KARNATAKA

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This study describes the cephalopod fishery of the state of Karnataka by analyzing the major trends in the time-series of production with effort trajectories for 1987-2007. Cephalopods, typically caught as by-catch in shrimp trawl in the 1980s emerged as an important targeted group during the last decade. While the resource constitutes only 6.7% (2006) of the total marine landings in quantity, in terms of value, it contributed about one quarter (25.1%; INR 1,620 million) to the proceeds from marine fish production for the State. The non-equilibrium production model was applied to the cephalopod groups comprising squids, cuttlefishes and octopuses to arrive at the f_{MSY} using the catch rates (catch/unit hour) from the major gear.

Currently, cephalopods are chiefly exploited by trawlers, in addition to the incidental landings by gillnetters, purse seiners and other non-mechanized gears in certain seasons. The trawlers comprising of smaller vessels (<9 m OAL; single day fleet, SDF), undertake daily fishing in the inshore fishing grounds, within 20-30 m depth and the medium sized vessels (>9 m OAL; multi-day fleet, MDF) venture into the deeper waters up to 500 m depth for various resources. The cephalopods are targeted by the MDF but are landed in small quantity by SDF at present.

With changing trawling patterns, fluctuations in catch rates were evident during the different phases in the fishery. The catch rates that varied between 1.9 and 3.8 kg/h during 1987-1992, improved with targeted exploitation in the subsequent phases, peaking to 6.13 kg/h in 1997, thereafter reducing to 2.81 kg/h in 2002. Upgradation in fishing vessels by phasing out of wooden trawlers with steel trawlers, added to the focused interest in cuttlefish fishery; the catch rates in MDF improved from 2003 reaching 7.24 kg/h in 2005. Subsequently, from 2006, the catch rates declined and reached 3.34 kg/ h in 2007.

Table 1. Parameter estimates for cephalopod catch in multi-day fleet

Parameter	Fox model	Schaefer model
Fit	Log transformed fit	Log transformed fit
r^2	0.810	0.818
K	1,38,554	93,677
q	7.360698E-08	8.614675E-08

r	0.1903562	0.4033697
f_{MSY} (h)	24,94,611	23,41,178
$f_{0.1}$ (h)	19,49,538	21,07,060
Y_{MSY}	9,702 t	9,446 t
80 % Confidence Interval	8,284 -14,739 t	7,437-15,403 t
f_{now} (h)	29,32,214	
f_{2003} (h)	21,54,767	
f_{2002} (h)	18,32,615	
Average cephalopod catch 1993-2007 (range)	9,103 t (1,953 - 16,197 t)	
$Y_{current}$	9,783 t	
Recommended % reduction in f_{now} for $f_{0.1}$	33.5 % f_{now} or retain at f_{2003}	28.1 % f_{now} or retain at f_{2002}

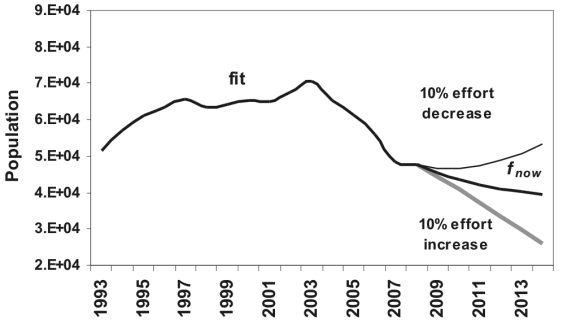

Fig. 1. Projection scenario for cephalopod population for different effort scenarios (Schaefer model)

The Schaefer and Fox production models were fitted to the cephalopod catch and effort data of MDF. The parameter estimates, *K* (carrying capacity), *r* (intrinsic rate of population growth) and *q* (catchability coefficient), were 1,38,554 t, 0.190 per year and 7.36E-08 for Fox model and 93,677 t, 0.403 per year, 8.614E-08 for Schaefer model for the time series of cephalopod catch rates in MDF (Table 1). The models estimated Y_{MSY} of 9,702 t (Fox) and 9,446 t (Schaefer). The corresponding f_{MSY} and $f_{0.1}$ values estimated were 23,41,178 h and 19,49,538 h by Fox model; and 24,94,611 h and 21,07,060 h by Schaefer model. The cephalopod catches exceeded Y_{MSY} during the period 2003-2007, when the average cephalopod catch in MDF trawlers was 12,555 t, peaking at 16,080 t in 2006 and declining to 9,783 t in 2007. Despite the fact that the 2007 catches are around the Y_{MSY}, the current effort, f_{now} expended in the trawling ground is 29,32,214 h for a trawling period of 97.4 h per MDF cruise. This indicates that f_{now} is 28-33% above the optimum levels for sustaining the fishery at MSY levels. Therefore, it is recommended that trawl effort for the MDF may be reduced so that the long-term catches of cephalopods corresponds to the Y_{MSY} levels in the present fishing area. The projection scenario for cephalopod population is presented in Figure 1.

EAO 12 MECOS 09

FORMATION OF PERSISTENT AND NON-PERSISTENT MUDBANKS OFF KERALA

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Mudbanks are calm patches of water within an agitated sea, formed due to wave damping. They appear close to the shoreline of Kerala during the southwest monsoon. They are well-known fishing grounds and help in protecting the coast from erosion. The mudbanks found along the Kerala coast can be classified into persistent and non-persistent types based on their activity and sustenance. The persistent mudbanks, which occur off Alleppey are very active during monsoon and are sustained throughout the year with decreasing intensity. On the contrary, at several places such as off Narakkal, Chetuva, Quilandi etc the mudbanks occur during monsoon and disappear after a short span of time. These are non-persistent mudbanks. They are characterized by non-periodicity and inconsistency. Their recurrence in the same area sometimes takes several years. The mudbank sediments are characterized by abnormally high water content (ranges from 220 to 255%) and lack of shear strength. Persistent mudbanks are formed due to the presence of zaherite (Al_{12} $(SO_4)_5$ $(OH)_{26}$. $20H_2O$) in the muddy sediments occurring in shallow waters. Bathymetry also has a key role in delineating the seaward periphery of mudbanks.

Our study on mudbank and non-mudbank sediments suggests that persistent mudbanks are formed due to the presence of zaherite and gibbsite whereas non-persistent mudbanks are formed due to gibbsite and/or gypsum. Like zaherite, the gibbsite ($Al(OH)_3$) and gypsum ($CaSO_4$. $2H_2O$) are also slightly bipolar with a positive aluminium end and a negative hydroxyl and sulfate ends respectively.

Mudbanks occur in shallow waters with their seaward periphery confined to the zone where the wavebase confronts with the seafloor strongly. In this zone, large quantity of wave energy is transferred to the seafloor, a phenomenon which is maximum during the southwest monsoon. Due to this, the bottom clay sediments undergo intense churning and are brought into re-suspension. During this process, the adsorbed cations are stripped off from the clay minerals due to the energy imparted by the waves, making them negatively charged. These charged minerals again flocculate by adsorbing cations from seawater. When these bipolar minerals are present in the sediments, the clay minerals get attracted towards the positive end rather than the less active sodium, potassium or magnesium ions available in seawater. In this process, the clay minerals flocculate by randomly sticking to them and settle. This clustering of clay particles causes the sediments to remain loosely packed. Loose packing with edge-to-edge and edge-to-face arrangement as well as grain segregation was noticed in the micrographs of SEM, which corroborates the above view.

Loose packing enables the sediments to carry large quantity of pore water. The loose mud at the top and consolidated mud at the bottom with transitional boundary in between is collectively called as 'dispersed mud' which is different from the suspended mud as there is a strong base of consolidated mud in the former, whereas the latter is devoid of any such base. This 'dispersed mud' efficiently resorbs the wave energy resulting in quelling of waves and the formation of mudbanks.

Our studies also indicate that mudbanks can be created artificially by introducing about 3 to 4% of zaherite-gibbsite-gypsum mixture in to the nearshore clayey sediments where waves exert maximum pressure on bottom sediments. If the coasts are protected by creating mudbanks artificially, the huge costs for creation and maintenance of coastal protection structures could be reduced. Moreover this will not affect the aesthetic view of beaches and will also help to increase fish productivity.

EAO 13 **MECOS 09**

PHYSICOCHEMICAL CHARACTERS AND TRACE METALS IN THE SURFACE WATERS OF INNERSHELF OF BAY OF BENGAL OFF CHENNAI, INDIA

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The nearshore water, which forms a major source of productivity, is under threat from pollution induced by human activities. Chennai is a metropolitan city with a high population density of 4 million and is drained by the Adyar River in the south, Cooum River in the central part and Ennore Creek on the northern side. In recent years, the discharge of effluents from major industries and operations of the second major harbour for coal import, which includes a thermal power plant situated nearby, have imparted severe stress on the marine ecosystem which has been severely affected.

The present study is aimed at examining the level of pollution and influence of seasonal variation on the physicochemical characteristics of surface water and selected heavy metals in the innershelf of Bay of Bengal (BOB) off Chennai. Water samples from 26 locations were collected along 5 traverses *viz*., Ennore, Fishing Harbor, Chennai Harbor, Cooum River and Adyar River. Offshore samples were collected using a non-metallic aqua-trap water sampler during two seasons in pre-monsoon (PRM) and post-monsoon (POM) of 2006 and 2007. Physical parameters such as temperature, pH, DO, EC, TDS and salinity were determined. Samples were analyzed for dissolved NO_3, SO_4, PO_4, Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl and Si. Trace element studies were performed for Cu, Ni, Co, Pb, Cr, Mn, Zn, Hg and Cd.

Among the important physicochemical characters, pH of surface water exhibited a uniform pattern in all the samples. The temperatures of all traverses during PRM

were high when compared with POM. The DO profiles for these samples varied. The TDS and EC were higher near the seashore when compared to the offshore samples. Salinity of the sample was found to be almost similar with minor variations.

The major ion content of the waters like Ca^{2+}, SO_4, Po_4, K^+ and Na^{2+} showed interesting trend. Higher ionic content was observed in surface waters near the shore whereas the samples taken away from the shore had a lower concentration of metal ions. Our results on trace metals exhibited similar distribution pattern in the surface water during both the seasons. The concentration of trace metals indicated enrichment in the samples which are very close to the shoreline and they varied in the following order: Pb > Ni > Cu > Cd > Hg > Co. The high values can be attributed to the terrestrial and atmospheric input, through runoff from the minor rivers that drain. In order to study the inter-elemental associations, the correlation coefficient matrix and varimax factor analysis and Hierarchical Cluster Analysis of surface water of the elements were computed for the PRM and POM seasons separately.

EAO 14 **MECOS 09**

DISTRIBUTION AND ABUNDANCE OF DEEP SEA FISHES ALONG THE WEST COAST OF INDIA

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A preliminary study on the species diversity, richness, composition and abundance of deep water piscifauna was carried out in the west coast of Indian EEZ by conducting five fishing cruises in 8^0-15^0 N latitude onboard FORV *Sagar Sampada* during 2005-2007. Bottom trawling was conducted with EXPO model fish trawl and HSDT (CV) trawlnets in depth ranging from 115 to 1070 m. A total of 123 species represented by 23 orders, 60 families and 96 genera were identified. Order Perciformes represented most of the species. Of the 123 species, 12 were new records from the Indian seas. Lat 9^o -10^o and 10^o -11^o N along the west coast were found to be rich in species diversity, whereas 14^o -15^o N showed the lowest diversity along the west coast. Fishes of the families Chlorophthalmidae, Trachichthyidae, Centrolopbhidae, Macrouridae, Gempylidae, Alepocephalidae, Ophidiidae, Gadidae etc were found to dominate the samples. Fishes of the families Ophidiidae and Macrouridae were found to have a wide distribution. Major species contributed to the landings were *Chlorophthalmus* sp., *Psenopsis cyanea*, *Lamprogrammus exutus, Bembrops caudimacula, Neoepinnula orientalis, Neoharriota pinnata, Charybdis smithi, Halaelurus lutarius, Plesionka spinipes, Alepocephalus bicolor, Hoplosteuthes mediterraneus, Lophious sp., Luciobrotula bartschi, Uranoscopus* sp. and *Neoharriota pinnata*. Latitude 11-12^0 N showed the highest CPUE of 1294.25 kg/hr whereas

latitude 14-15^0 N showed the lowest CPUE of 24.98kg/hr. The depth range of 200-700 m harbored most of the fish groups. Analysis revealed that the deep sea is highly diverse in terms of species richness and variety, which could be commercially exploited as an alternative source.

EAO 15 **MECOS 09**

DISTRIBUTION AND ABUNDANCE OF THE DEEPSEA FISH FAMILIES PHOTICHTYIDAE AND STERNOPTYCHIDAE IN THE INDIAN EEZ

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The Fishery and Oceanographic Research Vessel *Sagar Sampada* traversed the Indian EEZ (Lat. 6°02'-21°00'N and Long. 69°00'-73°00'E) to survey and investigate the nektonic components of the deep scattering layer (DSL) during 1998-2002. The Isaacs-Kidd Midwater Trawl was operated in the oceanic, pelagic depth realms from surface to 700 m depth. The biomass was estimated using 'Swept Area' method. The families Photichthyidae and Sternoptychidae contributed 29.31% to the nektonic biomass of the DSL. Of the two families studied, the family Photichthyidae contributed 97.2 % and family Sternoptychidae contributed 2.7%. The highest biomass of the family Photichthyidae was recorded during March (1507 tonnes). Distinct diurnal variation in biomass was observed. During the day time, the biomass ranged from 25 to 773 tonnes whereas during night it varied from 4 to 2,120 tonnes. The abundance varied between premonsoon (834 tonnes), postmonsoon (194 tonnes), and monsoon (150 tonnes) seasons. Bathymetrically, in the depth range of 50-100 mm a high biomass of 467 tonnes was recorded. *Vinciguerria nimbaria* was abundant when compared to *V. lucetia* in the Arabian Sea. For family Sternoptychidae (*Argyropelecus sladeni, Argyropelecus hemigymnus, Argyropelecus affinis* and *Polyipnus indicus)*, the biomass ranged from 0.49 to 1820 tonnes. The highest catch of family Sternoptychidae was recorded at Lat.9°30'N and Long. 75°20'E at an operational depth of 150 m and station depth of 958 m during the day. The day catches exceeded the night catches and fish of family Sternoptychidae were caught at greater depths both during night and day. Thus they show very little or no diurnal migration. The species of the family Photichthyidae are more abundant in the northwest coast during night, whereas that of Sternoptychidae are more abundant during day in the southwest coast. This paper describes the distribution and abundance of deepsea family Photichtyhidae and Sternoptychidae spatially, seasonally and bathymetrically.

EAO 16 MECOS 09

DISTRIBUTIONAL VARIABILITY OF PHYSICOCHEMICAL PARAMETERS IN AZHEEKODE ESTUARY, KERALA

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Azheekode Estuary is a tropical positive estuary and has a channel of about 500 m wide, which makes a permanent connection with the Arabian Sea. It is a major site of active fishing in Kerala. Though this region abounds rich fishery resources, no attempts have been made so far to investigate its hydrological parameters. A pioneering attempt was made to investigate the physicochemical parameters of Azheekode estuary. Eight stations were selected for this and the bottom and surface water samples were collected on monthly basis for two years (June 2005 – July 2007). The 8th station was very near the barmouth. Fifteen parameters were studied, which were measured and analyzed following standard procedures. The values were compared seasonally *i.e.*, premonsoon, monsoon and postmonsoon. The major hydrological variable in the estuary is salinity, which was found to increase during premonsoon and decrease during monsoon season in station 8. Conductivity and alkalinity showed the same trend as salinity is found to increase from estuarine to barmouth region. The minimum value of alkalinity was 13.57 and maximum was 68.4 and conductivity showed a minimum of 163.23 and the maximum was 464.85. DO was more in the surface layers and during monsoon, it showed the highest values. Temperature showed highest value in premonsoon and minimum during monsoon season in bottom samples. Turbidity and BOD showed slight increase in stations 5 and 6. The maximum value of turbidity was 56.25. Ammonia content ranged from 2.01 μmol/l to 5.14 μmol/l and nitrite values from 0.2 μmol/l to1.6 μmol/l in the middle stations, which were slightly high when compared to other stations. But these differences are not statistically significant. This study reveals that, even though the distributional features of hydrochemical parameters and nutrients vary seasonally, the water quality is not adverse to the flora and fauna of the estuary.

EAO 17 **MECOS 09**

STUDY ON PHYTOPLANKTON IN TAJAN ESTUARY, SOUTH CASPIAN SEA BASIN

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Plankton samples were collected from 6 stations in Tajan estuary during 2006 and 2007. Overall 5 phyla, 32 genera and 45 species of phytoplankton were identified. Among the identified species, most of the species belonged to phylum Bacillariophyta and Cyanophyta. Cyanophyta was the most abundant group during summer in all the stations and were comprised of *Microcystis* sp., *Osillatoria limosa* and *Anabaenopsis raciborskii*. *Diatops* sp. was observed throughout the year in all the stations with their abundance being higher in autumn, winter and spring. The dominant species of Bacillariophyta were *Cyclotella* sp., *Actinocyclos* sp. and *Rhizosolenia calcar*. *Exuviaella cordata*, belonging to Pyrrophyta dominated the estuary during autumn, while *Gymnodinium* sp. was abundant in summer. The spatial and monthly variation of phytoplankton biomass and primary production were estimated in different points from Upper Tajan River to the south Caspian Sea basin. Based on the results, the mouth and estuary could be categorized into three different classes. Category 1: station essentially related to river input and low net production (13.8 and 46.4 $mg.m^{-3}.year^{-1}$), Category 2: high net production (between 277.9 and 330.4 $mg.m^{-3}.year^{-1}$) and mild consumption (8.4 to 32.5 $mg.m^{-3}.year^{-1}$). The third category is in between the above two from the productivity point of view with 236.7 to 240.2 $mg.m^{-3}.year^{-1}$ and with consumption of 20.9 to 92.4 $mg.m^{-3}.year^{-1}$.

EAO 18 **MECOS 09**

HARD CORAL DIVERSITY ALONG THE SOUTHWEST COAST OF INDIA

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Patchy growths of hard corals are found to occur along the coast of Vizhinjam and Enayam in the southwest coast of India. This study gives the result of a survey conducted in Vizhinjam and Enayam for the assessment of the coral cover and biodiversity following the Line Intercept Transect method. A total of 13 species belonging to five genera of Scleractinians is reported in this study. The most common genus is *Pocillopora*, which is represented by five species. Relative abundance values were derived for each species and they were assigned the status of dominant,

abundant, common, uncommon and rare species. *Pocillopora verucosa* and *P. meandrina* were assigned the status 'abundant' in Vizhinjam and *Montipora aequituberculata* in Enayam. *Pocillopora damicornis* belonged to the category 'abundant' and all other species were of either 'common' or 'uncommon' status. Biodiversity indices were also estimated for each site. The coral fauna of the study area is more related to that of Gulf of Mannar in structure and composition than any other coral growing area.

EAO 19 **MECOS 09**

LIFE HISTORY TRAITS AND LENGTH-WEIGHT RELATIONSHIP OF SELECTED DEEPSEA FISHES INHABITING THE CONTINENTAL SLOPE BEYOND 400M ALONG THE WESTCOAST OF INDIA

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Length-weight relationship and biology of deepsea fishes namely *Alepocephalus bicolor, Bathyuroconger braveuri, Saurenchelys taeniola, Xenomystax trucidens* and *Neoepinnula orientalis* inhabiting the continental slope of southwest coast of India are presented. This paper aims to contribute the biology and length-weight relationship data for use in fishery assessment and also for allowing future comparisons between populations encountered at the same depth. Samples were collected from trawl surveys during 2005 – 2007 onboard FORV *Sagar Sampada* at a depth range of 438 – 822 m between 10 -11°N latitude. The parameters 'a' and 'b' of the length - weight equation $W = aL^b$, were estimated. The food and maturity stages were examined. All the above species were carnivorous with a predatory food habit. The composition of the diet was almost similar in all the fishes. The food items were crustaceans represented mainly by shrimps and crabs and cephalopods. The feeding intensity was generally very low. Fishes were found to feed on relatively low prey classes with low diversity and only a few items per meal. In most of the fishes, empty stomachs were very common. It may be due to the scarcity of food in the surrounding environment and regurgitation of stomach contents resulting from the struggle during dragging. Full stomach was found in very few individuals. Females dominated the catches in three of five species and majority of fishes were in maturing stage. Among the five selected species, *Bathyuroconger braveuri* had higher fecundity (99453 – 123760 eggs) whereas *Alepocephalus bicolor* recorded low fecundity (1111 – 1902 eggs).

EAP 01 **MECOS 09**

PRIMARY PRODUCTION AND NUTRIENT FLUXES IN A MICROTIDAL ESTUARY OF SEFID-ROOD RIVER (SOUTH CASPIAN SEA)

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There are over 350 rivers in the south Caspian Sea basin. Sefid-Rood River is the most important river in the area but is less investigated when compared with other systems. Sefidrood River estuary in the northern Iran is a shallow and turbid estuary. The aim of this study was to examine spatial and temporal variation of physico–chemical factors and pelagic primary production during a year and their fluxes. Monthly sampling was conducted at 5 stations. Station 1 was in the upper estuary and station 5 was in the mouth of the river. Annual means (ISD) of nutrients were: NH_4^+ 0.512 ± 0.66 mgL^{-1}, SiO_2: 5.68 ± 1.91 mgL^{-1}, TP: 0.136 ± 0.103 mgL^{-1}; T.O.C. 10.3 ± 9.9 mgL^{-1}. There was temporal variation according to season and river flow. Primary production was determined by dark and light bottle method and the GPP was estimated as 38.27 ± 34.12 $mgCm^{-2}h^{-1}$ and NPP 201.6 ± 289.9 $mgCm^{-2}d^{-1}$. Nutrients appear to be in excess to algal requirement throughout the estuary and did not influence the primary production. The most important factor was water temperature and the highest level of NPP determined was in August.

EAP 02 **MECOS 09**

AEROBIC HETEROTROPHIC BACTERIAL DIVERSITY IN THE ESTUARINE ENVIRONMENT IN THE SOUTHWEST COAST OF INDIA

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Coastal land regime and coastal waters are two components of coastal environment and the richest part of the coastal zone are the estuaries. Among the wetland ecosystems, estuary is the more productive one. Microbial biomass and hydrological factors play an important role in the productivity of the estuarine fauna and flora. In the present study, an attempt has been made to assess the diversity of aerobic heterotrophic bacterial population in the Rajakkamangalam estuary, a minor estuary in the southwest coast of India. For this, four sampling stations (S1 to S4)

were fixed in the estuary and monthly water and sediment samples were collected (2001 and 2002). Aerobic heterotrophic bacterial population in the aseptically collected samples was analyzed following standard methods. Irrespective of the sampling stations studied, the Total Viable Count (TVC) of water and sediment samples varied between sampling months and between stations. The maximum bacterial population was noticed at S1 in February 2001 (30.1×10^{-3} CFU.ml^{-1}) and in December 2002 (35.5×10^{-3} CFU.ml^{-1}). Low bacterial population densities of 12×10^{-3} CFU.ml^{-1} in August 2001 and 8.7×10^{-3} CFU.ml^{-1} in July 2002 were recorded at S2. The seasonwise data indicated that the maximum bacterial population of $26.80 \pm 5.18 \times 10^{-3}$ CFU.ml^{-1} and $28.60 \pm 5.35 \times 10^{-3}$ CFU.ml^{-1} were registered during the southwest monsoon season at S1 during 2001 and 2002 respectively. During the study period, the percentage composition of heterotrophic bacterial population also showed much variation between sampling stations and months. The significance of the results is discussed.

EAP 03 **MECOS 09**

COMPARISON OF DIFFERENT MULTI-SPECTRAL SENSORS FOR MAPPING SMALL MANGROVE AREAS – A STUDY IN VAROLI ESTUARY, SOUTH GUJARAT

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Mangroves are considered as the tropical forests of coasts, harboring an ecosystem in itself. The uniqueness of this ecosystem has caught the attention of many workers of the past and the present. Indian mangroves make up for about 3.1% of global cover of mangroves, with an area of 4,445 sq km, of which, Gujarat state supports 936 sq km.

The present work was carried out to study the mangroves of the estuarine area of Varoli River, south Gujarat, India. Field studies revealed these patches were small in size as well as few in number. Regardless of their size, they harbored high diversity comprising of six core mangrove species along with mangrove associates and salt marsh vegetation. Studies using remote sensing have generally been attempted in areas where extensive patches of mangroves occur and protocols for their study using satellites are already available. However, little information exists on the protocols for studying areas similar to Varoli. Study of such a habitat, which supports small and dispersed patches demands finer spatial resolution for easy selection of all the available few mangrove pixels and an equally finer spectral resolution for efficient separation of the mangrove diversity.

This study compares different multispectral remote sensing sensors for the purpose of monitoring dispersed and small patches of mangroves to suggest the best sensor. For the present study LISS III and LISS IV sensors of the Indian Remote Sensing P6 (IRS) satellite and the ETM+ sensor on board LANDSAT 7 satellite have been compared. The spatial, spectral and radiometric resolutions have been compared regarding the suitability for mapping such mangroves.

EAP 04 **MECOS 09**

TROPHIC LEVEL OF FISHES OCCURRING ALONG THE INDIAN COAST

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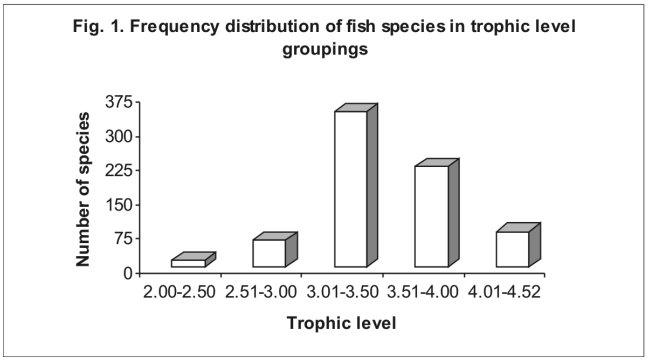
Extensive studies are available on the stomach content of marine fishes, crustaceans and cephalopods occurring along the Indian coasts. However, multispecies prey-predator models or food webs have not been constructed so far since the functional position of each species within the food web (known as trophic level, TrL) has not been assigned. The present paper has taken advantage of the trophic level values for the finfish species available in FishBase and supplemented them with the published records on the stomach contents of finfishes, occurring along the Indian coasts. These data sources provided trophic level values for 637 species of finfishes.

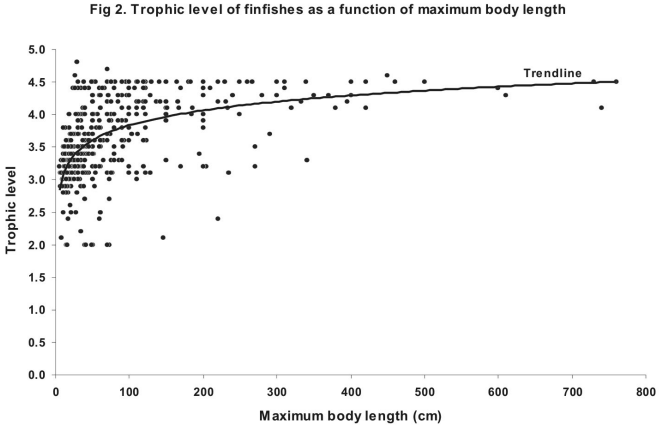
The TrL of 637 species of commercially exploited fish ranges from 2.0 (the shad, *Tenualosa ilisha*) to 4.7 (the ribbonfish *Eupleurogrammus muticus*). As a group, the mean trophic level of the billfishes (Family: Istiophoridae) was the maximum (4.52 $\pm$ 0.019). Based on the TrL, the exploited groups could be classified as (i) herbivores & detritivores (TrL: 2.00 to 2.50), (ii) omnivores (TrL: 2.51 to 3.00), (iii) midlevel carnivores (TrL: 3.01 to 3.50), (iv) highlevel carnivores (TrL: 3.51 – 4.00) and (v) top predators (TrL: $>$ 4.00). Maximum number of species (341; 53.5% of the total) are midlevel carnivores which feed at the TrL of 3.01-3.50 (Fig. 1). The mean TrL of all the 637 species is 3.50 $\pm$ 0.121.

The mean trophic level of the pelagics (n = 157) is 3.68 and the TrL decreases towards demersal habitat; the TrL of the demersals (n = 304) is 3.44. The pelagic habitat supports as high as 48 top predatory species (for example wolf herring, seerfishes, tunas, billfishes) compared to only 28 species of top predatory demersals (for example lizardfishes, halibut).

The maximum body length of finfishes occurring along the Indian coast ranged from 4 cm (the sleeperfish, *Eleotris lutea*) to about 2000 cm (the whale shark, *Rhiniodon typus*). The frequency distribution of small fish species is high at low TrL ($<$ 3.5). For instance, the TrL of 128 of 138 species (92.7%) in the 4-20 cm length



group is <3.5. On the other hand, the trophic level of 42 of 50 (84.0%) large-sized species (length: >200 cm) is > 4.0. Categorization of the maximum length into 20 cm (between 4 and 100 cm) and 100 cm (between 4 and 800 cm) length groups revealed a clearly increasing trend in the TrL with increasing length. The TrL increased from 3.15 ± 0.028 (SE) for the 4-20 cm length group to 4.44 ± 0.098 for the 401-500 cm length group, but there was no further increase in the TrL of fishes larger than the 401-500 cm length group (Fig. 2). Small fishes (21-100 cm) are adapted to feed at all TrL (2.0 to 4.6); but most large fishes (>400 cm) are adapted only for predation and could not feed at TrL lower than 4.0, *i.e.*, the large predators predate on other predators. Hence, the large predators, which are the target for many fisheries, operate within a narrow range of TrL and are most vulnerable to depletion of their preferred prey and overexploitation.



In this paper, the TrL values have been assigned by considering the entire Indian coast as one homogeneous ecosystem. However, there may be temporal and spatial differences in the TrL depending up on the type of prey available to the fish during different seasons and in different areas along the coast. Hence, the TrL analysis should be extended to include temporal and spatial information to verify the web structure.

EAP 05 **MECOS 09**

MAPPING SEAGRASS RESOURCES OF THE GULF OF MANNAR MARINE BIOSPHERE RESERVE

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The Gulf of Mannar Biosphere Reserve is the first of its kind in India and also in southeast Asia spreading from the Pamban Islands to Cape Comorin. The Gulf of Mannar is known for its coral and seagrass resources distributed along the 21 Islands with an average land area of 623.12 ha. Seagrass resource in the Gulf of Mannar is represented by 13 species, and as a meadow, they constitute important coastal ecosystem. Remote sensing technique is adopted for mapping the distribution of seagrass meadows and it also helps to detect environmental conditions that affect seagrass distribution. Remote sensing using IRS LISS III images during 2005 showed the potential to map the extent of seagrass cover and monitor changes with high accuracy in the shallow water areas along the Gulf of Mannar region. Digital analysis and visual interpretation techniques were employed using ERDAS version 8.6 software with some modifications in the visual interpretation keys. The distribution pattern of seagrass meadows in the Mandapam group, Keelakarai group, Vembar group and Tuticorin group of Island, were studied by remote sensing. The present study recorded dense seagrass area (3667.75 ha) in Mandapam region and minimum (123.56 ha) in Vembar group of Islands.

EAP 06 **MECOS 09**

BEAK LENGTH ANALYSIS OF *UROTEUTHIS DUVAUCELI (D'ORBIGNY, 1835 IN FÉRUSSAC AND D'ORBIGNY, 1834-1848)* AND *STHENOTEUTHIS OUALANIENSIS (LESSON, 1830 IN 1830-1831)* OCCURRING ALONG NORTHWEST INDIAN EEZ

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Food web studies in the marine environment have gained importance in recent years as the relevance of "ecosystem model" for management of fishery resources had been advocated by the top fishery managers all over the world. One of the main input data for developing such ecosystem models is food and feeding parameters. Cephalopods including squids, cuttlefishes and octopi are known to be an important

food source for many marine predators including fishes, marine mammals and birds, playing key roles in marine environments both as predators and as food of top predators, particularly in the deep oceans of the world. But the identification and quantification of cephalopods eaten by predators are greatly complicated since the cephalopods are digested more rapidly than fish and crustaceans as they lack protective scales or chitinous carapace. As digestion proceeds, the gladius also gets digested and buccal mass separates from the head and finally only the upper and lower chitinous mandibles (beaks), which are undigested, remains in the stomach. Since the shape and colour of these beaks are unique to each species, we can identify the species of the cephalopods consumed by the predator, if the identifying characters for that particular beak are available. The biomass of cephalopods eaten by the predators can then be back calculated using the relationship between beak measurements and the size and weight of cephalopods. The Indian squid, *Uroteuthis duvauceli* is the main species of squid occurring in the neritic waters of northwest Indian EEZ. In India, although extensive studies were conducted on the biology of squids, especially *U. duvauceli*, little or no comprehensive works had been carried out for describing the beak and its correlation with body size. Purpleback Flying Squid, *Sthenoteuthis oualaniensis* forms one of the main components of the oceanic food web in the Arabian Sea forming the food of large pelagics. The objective of the present study was to describe the characteristics of beaks and to establish the relationship between beak morphometrics and whole animal attributes to develop back calculation formulae for estimating body size and biomass of squids from the north-west Indian EEZ.

A total number of 155 specimens of *U. duvauceli* were studied for beak characteristics and morphometrics. The Dorsal Mantle Length (DML) of the specimens studied was in the range of 6.7 to 20.0 cm, while their total weight varied from 13.6 to 164.5 g. All specimens studied were in the advanced stage of sexual maturity. The sex ratio recorded was 42:58 (M:F). *S. oualaniensis* specimens were in the DML range of 10.5 to 14.9 cm and the total weight ranged from 19.1 and 64.2 g. The sex ratio was 14:86 (M:F). The specimens were in advanced stage of sexual maturity.

It is observed that, all beak measurements show significant correlation with DML and body weight with coefficients of determination (r^2) greater than 0.66. Since the samples of the species *S. oualaniensis* were collected from the gut contents of sailfish, no attempts were made to correlate the beak measurements with body weight even though the samples were intact, before digestion could take place. In the case of *U. duvauceli*, formulae for calculating both the body length (DML) as well as body weight were derived from beak measurements. It is expected that the results will encourage the scientific community to conduct similar studies on other species of cephalopods in the Indian waters.

EAP 07 **MECOS 09**

PLANKTON PRODUCTIVITY OF ANDAMAN WATERS DURING WINTER MONSOON

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Biological observations carried out in the waters around Andaman and Nicobar Islands during the winter monsoon 2003 are presented. The results showed high phytoplankton biomass and primary production in the western Andaman waters (28.1 ± 10 mgm^{-2} and 316 ± 57 mgC $m^{-2}d^{-1}$) as compared to the eastern Andaman (20 ± 7.3 mgm^{-3} and 177 ± 73 mgC $m^{-2}d^{-1}$). The phytoplankton composition did not vary significantly between western and eastern regions; and was dominated by diatoms (>80%) with an increasing numerical abundance of *Rhizosolenia alata* > *Nitzschia seriata* > *N. pungens* > *Thalassiosira gravida* >*Thalassionema nitzschioids* > *Chaetoceros socialis* > *Deploneis* sp. > *Coscinodiscus eccentricus*. The species richness and diversity were higher in the western region (3.9 ± 1.4 and 3.6 ± 0.9) compared to that of the east (3.5 ± 0.9 and 3.4 ± 0.4). *Trichodesmium erythraeum*, a blue - green algae (biological indicator of stratification), was observed in most of the locations. Unlike phytoplankton, the mesozooplankton biomass and abundance were high in the eastern region (239.5 ± 124.4ml $1000m^{-3}$ and 321028 ± 118630 individual $1000m^{-3}$) than the western region (166 ± 84 ml $1000m^{-3}$ and 231279 ± 51492 individual $1000m^{-3}$). The low phytoplankton biomass in the eastern Andaman waters may be due to the increased grazing by mesozooplankton (top down control). Copepoda formed the dominant group in mesozooplankton followed by Chaetognatha, Ostracoda, Decapoda, Copelata and Siphonophora. However, the abundance of fish larvae was prominently higher in the eastern Andaman waters.

EAP 08 **MECOS 09**

ENVIRONMENTAL AND BIODIVERSITY STATUS OF THE WETLAND ECOSYSTEMS OF INDIA AND WAYS FOR REJUVENATION

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The southwest coast of India has a series of wetland systems. These backwaters are a repository of varied bioresources, harbouring several threatened species. Thirty major backwaters forming the crux of the coastal wetlands harbour a variety of fishes. This paper reveals time scale changes in the environmental and biodiversity status

of these wetlands, during 1994-2005 period. Among the physicochemical parameters investigated, the pH was generally near neutral to alkaline in range. The salinity values indicated mixohaline condition ranging from 5 to 38 ppt, in 12 wetlands. The productivity values were generally low in most of the wetlands during the study, where the gross production varied from 0.22 gC/m^3/day in Kadinamkulam to 1.10 gC/m^3/day in the Kayamkulam estuary. The diversity of plankton and benthos was higher during the pre-monsoon period compared to that of the monsoon and post-monsoon periods in most of the wetlands. The average fish yield per hectare varied from 246 kg in Valapattanam to 2747.3 kg in Azhikode wetland. Retting of coconut husk in most of the wetlands led to acidic pH conditions with anoxia resulting in production of high amounts of sulphide, coupled with high carbon dioxide values leading to drastic reduction in the abundance of plankton, benthic fauna and fishery resources. The biggest Ramsar site in the region at the Vembanad lake ecosystem depicted remarkably low concentrations of dissolved oxygen and high sulphide and nutrient accumulation all along the peripheral regions receiving agricultural and domestic wastes in the pre-monsoon period. The water quality showed some negative impact towards the southern sector of the lake as compared to the northern sector. The fishery of *Macrobrachium rosenbergii* showed drastic reduction compared to the previous studies. Majority of these backwaters have a highly stressed environment, especially during the pre-monsoon period when the retting activity is at its peak. The study has revealed that a more restrained and cautious approach is needed to manage and preserve this unique backwater ecosystem.

EAP 09 **MECOS 09**

DISTRIBUTION OF MESOZOOPLANKTON IN THE COASTAL WATERS OF SUNDARBAN WETLAND, NORTHEASTERN BAY OF BENGAL, INDIA

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Community structure and distribution of mesozooplankton in the context of environmental parameters were studied in Sundarban wetland, northeastern Bay of Bengal for better understanding of ecological characteristics of secondary production. The wetland belongs to the Ganga river basin under the influence of both marine and estuarine processes. As a result, the wetland is characterized by strong spatiotemporal heterogeneity in biological and physical environmental conditions. Copepods are the most dominant taxa of mesozooplankton, in which calanoid copepods form bulk of the biomass representing 28 species of 11 genera. Cyclopoids form the next dominant group comprising 6 species of 3 genera followed by 3 monogeneric harpacticoid species. A typical aggregation of all the three cyclopoid

copepod species of genus *Oithona* (*O. rigida, O. similes* and *O. brevicornis*) revealed a greater degree of dominance as well as endemicity in a site infested with mangrove plants representing > 40 % of the total catch. Similarly harpacticoid copepods form a significant component of the total copepods in Bakkhali, located at the open sea, Bay of Bengal. Correlation matrix revealed interesting relationship among the 8 major copepod families. A general trend of high diversity index values (maximum 2.21) was associated with high richness (4.19) and evenness index (0.84) at Bakkhali. The representative species of each station was identified by Indicator value index (IndVal). Multiple regression analyses revealed high negative relationships with turbidity and transparency Dhamakhali, the sewage-fed site. The lowest numerical density of zooplankton was also observed in this same station. The epipelagic chaetognath *Sagitta bedoti* followed a similar trend of distribution with the total zooplankton where the maturity stage I exhibited higher percentage contribution.

EAP 10 **MECOS 09**

INFLUENCE OF PHYSIO-CHEMICAL PARAMETERS ON SEX RATIO AND SPAWNING OF GREEN TIGER PRAWN *PENAEUS (PENAEUS) SEMISULCATUS DE HAAN* AT PALK BAY AND GULF OF MANNAR

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The green tiger prawn *Penaeus (Penaeus) semisulcatus* was collected from the Gulf of Mannar and Palk Bay. The fishing grounds of Gulf of Mannar extended from Lat.8^0 50′N to 9^0 10′N and Long. 78^0 35′E to 79^0 40′E where the depth ranged between 15 and 50 meters. The fishing grounds in the Palk Bay region was located in Lat. 9^0 20′N to 10^0 05′N and Long. 79^0 05′E to 79^0 40′E where the depth was comparatively shallow ranging from 8 to 14 metres. During the present study, a random sample of 1 to 2 kg of prawns were collected during 1991 and 1992 from the trawl catch and analysed at the landing centre for sexwise length measurements and maturity based on size and colour of ovary visible through exoskeleton. Physio-chemical parameters of water, namely temperature, salinity, dissolved oxygen, pH, phosphate, silicate, nitrate and nitrite were analysed.

To find out the monthly sex ratio 1511 and 892 and 1755 and 758 animals were collected from Palk Bay and Gulf of Mannar respectively. To find out the monthly percentage distribution of maturity stages in Palk Bay and Gulf of Mannar during 1991 and 1992 of 936 and 514 and 1124 and 432 females were collected and analysed, respectively. Data on sex ratio indicated female dominance.

Examination of monthly percentage of fully mature females (stage IV) and spent ones (stage V) revealed that in the Palk Bay, peak spawning was during March to

May with a minor peak in November during 1991. In 1992, the peak spawning was noticed during March to June with two minor peaks, one in September and the other in December. In the Gulf of Mannar, very high percentage of mature females (58-77%) were recorded during May to September preceded by a minor peak for the abundance of mature prawns during February and March in 1991. Low values of silicates, nitrate and nitrite during March-June in Palk Bay and May-September in Gulf of Mannar were apparently associated with active spawning. The peak spawning coincided with the period (March-June and May-September) of higher salinity (30%0 to 35%0). The period (April-May) of active spawning was when the temperature was relatively higher (28.60-32.88^0 C).

A perusal of the data on temperature and monthly spawner abundance indicated that the maximum spawning activity was during March-June in the Palk Bay, which synchonised with the period of highest temperature condition. The only explanation that could be ascribed to the difference in spawning period between Gulf of Mannar and Palk Bay may be the depth difference. The positive relationship is more applicable to the shallower ground (Palk Bay) than the deeper one (Gulf of Mannar). The present data on spawner distribution clearly reveals that *P. semisulcatus* breeds actively in both the fishing grounds. The spawning takes place throughout the year with distinct peak spawning seasons, which are slightly different in the two waters. While major peak spawning season in Palk Bay is from March-June, the same in the Gulf of Mannnar is from May-September.

EAP 11 **MECOS 09**

POTENTIALLY HARMFUL DINOFLAGELLATES OF THE INDIAN EEZ

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The microscopic planktonic algae in the oceans form the base of the marine trophic structure providing food for filter-feeding invertebrates as well as larvae of commercially important crustaceans and finfishes. In most cases, the proliferation of planktonic algae is considered beneficial for coastal aquaculture and the herbivorous pelagics. However such blooms are known to disturb the biogeochemical cycles locally by altering the Redfield ratios for nutrients and the production- grazing equilibrium leading to flux of organic matter from the euphotic zone to deeper waters. Bacterial decomposition of the organic matter can produce hypoxic to anoxic conditions in the deep waters influencing mass mortality of fishes, shellfishes and bottom fauna. Similarly, survival of fish larvae and other sensitive marine living resources may be adversely affected due to changes in species composition and disturbances in the physico-chemical environment of the bloom area. Among the 5000 species of extant marine phytoplankton, around 300 species including diatoms,

dinoflagellates, raphidophytes, prymnesiophytes and silicoflagellates can at times cause blooms leading to discolouration of the surface waters (red tides), while only 80 or so have the capacity to produce potent toxins that can find their way through fish and shellfish to humans. Among these toxic species, approximately 60 species are dinoflagellates.

In Indian waters, as elsewhere, dinoflagellate blooms are the most harmful. The first recorded observation on algal blooms in Indian waters is by James Hornel in 1908. He witnessed massive fish mortality, largely of sardines floating on the dark yellow coloured waters that contained plankton. In 1916, he found *Euglenids* and *Noctiluca* species to be responsible for such episodes. Since then, there have been several reports on various blooms in the Indian EEZ.

Since 1998, as a part of regular monitoring of algal blooms in the Indian EEZ, Ministry of Earth Sciences have been conducting regular oceanic cruises for the surveillance, identification, enumeration and ecology of HABs in territorial waters and contiguous seas in the Indian EEZ. In all, 761 stations distributed in the study area were sampled by FORV *Sagar Sampada* during the study period.

Quantitative analysis was done employing Sedgewick- Rafter counting cell. Species identification was carried out using standard references and keys. Photomicrographs were taken by using Nikon Eclipse E 200 with Network camera. Both toxic and harmful microalgae are treated as harmful microalgae for convenience of presentation.

Altogether, 414 species of microalgae (phytoplankters) were recorded from the EEZ of India during the investigation. Among them, 164 species were dinoflagellates. Of the 164 species of dinoflagellates, 21 were found to be harmful. A total of 19 blooms were observed in the Indian EEZ during the period. Of the 19 blooms, 13 were of *Trichodesmium* sp., 4 of *Noctiluca miliaris* and one each of *Cochlodinium* and *Ceratium* sp. However, seven blooms were observed in the coastal (depth less than 10m) and estuarine areas along the coast of Kerala. Three blooms of *Gymnodinium veneficum*, two blooms of *Noctiluca scintillans* (= *N. miliaris*), one bloom each of *Anabaena spiroides* and *Coscinodiscus* sp. occurred along the coast of Kerala in the period 1998- 2006. The common harmful dinoflagellate species which were frequently observed in relatively higher density in the Indian waters were *Noctiluca* sp., *Gymnodinium* spp., *Cochlodinium* sp., *Ceratium* spp. and *Hornelia* sp.

So far only paralytic shellfish poisoning (PSP) toxins have been confirmed in shellfish from the coastal waters of Kerala. The causative species was believed to be *Gymnodinium* (not confirmed). However, other potentially important PSP producing species like *Gonyaulax* and *Alexandrium* were frequently observed during the present study. In addition, diarrhetic shellfish poisoning (DSP) producing species such as *Dinophysis* (8 species), the neurotoxic shellfish poisoning (NSP) producing species *Gymnodinium breve* (=*Ptychodiscus breve*) and the ciguatera fish poisoning (CFP) producing species *Gambierdiscus toxicus, Ostreopsis siamensis, Coolia monotis* and *Prorocentrum lima* were also observed during this study. It is true that there

are all kinds of potentially harmful algal species present which have been linked to PSP, NSP, DSP, CFP and amnesic shellfish poisoning (ASP) (produced by diatoms-*Pseudonitzschia multiseries,* present in the Indian waters), as well as fish kill species. In the Indian waters, among the harmful algal species, dinoflagellates play a very important role. Most importantly, the recent records of fish kill incidents in the Indian waters were caused mainly by the dinoflagellates, and/or in combinations of dinoflagellates and diatoms.

Harmful algal blooms in the coastal waters have increased in frequency, intensity and geographic distribution in the last two decades. It is necessary to accurately identify and establish the early monitoring programmes of these species in order to decrease the damage. The effects of these blooms in seafood quality, economic liabilities on fisherfolks, correct assessment of factors triggering blooms and subsequent effects in the trophodynamics are the aspects now being undertaken.

EAP 12 **MECOS 09**

BIOMONITORING HEAVY METALS IN MARINE MACROALGAE FROM KUDANKULAM COAST, GULF OF MANNAR, INDIA

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The usefulness of seaweeds as an indicator of metals is highlighted in this study. The study was carried out in Kudankulam coast, 25 km northeast of Kanyakumari, which is developing into a mega nuclear power station. Since radio nuclides behave similar to stable nuclei, the present study assumes greater importance for Kudankulam coast. Twenty five seaweed species were collected from the intertidal region of the Kudankulam coast which consisted of the chlorophytes *Caulerpa peltata*, *C. scalpelliformis*, *C. sertularioides*, *Chaetomorpha antennina*, *C. linoides*, *Enteromorpha compressa*, *Halimeda macroloba*, *Ulva fasciata* and *Valoniopsis pachynema,* phaeophytes *Colpomenia sinuosa*, *Padina pavonica*, *P. tetrastromatica*, *Sargassum linearifolium*, *S. wightii*, *Stoechospermum marginatum*, and the rhodophytes *Acanthopora muscoides*, *Hypnea* sp, *Ahnfeltiopsis densus*, *Amphiroa* sp. *Gracilaria edulis*, *G.corticata*, *G. fergusonii*, *Laurencia papillosa*, *Polysiphonia* sp, *Sarconema filiforme*. The collected samples were analysed for Cr, Mn, Fe, Co, Ni, Cu, Zn, Cd, Pb and the results are presented in Table 1. All the metals analysed were several orders of magnitude than the concentrations in seawater. This indicates that marine algae progressively uptake metals from seawater. The concentration of heavy metals in the Phaeophyta was found to be relatively higher compared to those in the other two algal groups (Chlorophyta and Rhodophyta) and was in the order of Phaeophyta > Chlorophyta > Rhodophyta. The concentration factor of trace elements

for chlorophytes and phaeophytes was in the order of Pb > Cd > Fe > Cr > Mn > Co > Ni > Cu > Zn. In rhodophytes, the metal concentration was in the order of Cd > Pb > Fe > Cr > Mn > Co > Ni > Cu > Zn. The result showed that the concentration of Fe and Mn in most of the seaweeds were higher and widely fluctuated. Interelemental relationship was also established. A significant linear correlation was observed between a total of 36 pairs of metals.

Table 1. Heavy metal concentration (μg/g dry weight) in Kudankulam seaweeds

Species	Cr	Mn	Fe	Co	Ni	Cu	Zn	Cd	Pb
Chlorophyta									
Caulerpa peltata	1.56	10.22	280.86	0.20	0.67	6.55	5.84	0.98	2.51
Caulerpa Scalpelliformis	2.74	22.00	338.16	0.29	1.84	3.59	13.30	1.72	1.75
Caulerpa sertularioides	2.91	46.64	876.00	0.65	3.34	3.92	14.68	3.97	5.19
Chaetomorpha antennina	3.32	24.56	845.77	0.67	2.36	8.95	14.57	3.92	4.32
Chaetomorpha linoides	4.39	27.55	1184.26	0.68	2.97	5.12	13.50	2.12	4.38
Enteromorpha compressa	6.65	7.70	308.44	0.22	1.87	5.74	6.29	2.03	1.65
Halimeda macroloba	8.68	39.94	967.00	0.90	2.85	3.41	12.51	3.72	2.82
Ulva fasciata	1.38	15.45	295.85	0.47	1.48	3.72	8.44	2.77	0.92
Valoniopsis pachynema	8.36	121.36	2455.31	2.71	6.35	7.46	19.51	4.86	4.35
Range	1.38-8.68	7.70-121.36	280.86-2455.31	0.20-2.71	0.67-6.35	3.41-8.95	5.84-19.51	0.98-4.86	0.92-5.19
Phaeophyta									
Colpomenia sinuosa	16.58	78.74	2869.91	1.20	4.54	5.72	20.19	5.49	6.50
Padina pavonica	17.07	115.43	2544.26	1.18	4.09	6.22	22.32	5.65	6.63
Padina tetrastromatica	15.80	109.48	3471.67	1.14	3.99	5.30	18.17	4.95	8.58
Sargassum linearifolium	1.27	16.80	248.50	0.53	1.59	1.85	5.22	4.38	1.38
Sargassum wightii	3.53	27.59	447.98	1.14	2.49	3.37	6.99	3.38	2.04
Stoechospermum marginatum	6.23	48.36	1417.69	1.13	4.42	4.45	18.71	4.81	3.35
Range	1.27-17.07	16.8-115.43	248.5-3471.67	0.53-1.2	1.59-4.54	1.85-6.22	5.22-22.32	3.38-5.65	1.38-8.58
Rhodophyta									
Acanthopora muscoides	9.07	27.40	1093.48	0.74	2.41	3.15	8.11	5.85	3.87
Ahnfeltiopsis densus	2.85	33.18	595.00	1.00	1.20	4.51	5.25	1.42	1.96
Amphiroa sp.	0.46	15.14	120.00	1.20	0.90	1.22	10.65	2.86	0.67
Gracilaria edulis	1.71	9.45	426.13	0.43	1.61	3.29	6.76	4.21	0.92
Gracilaria corticata	4.51	61.70	1162.80	0.81	2.07	3.50	12.20	3.05	2.39
Gracilaria fergusonii	3.35	30.89	855.90	0.50	1.72	1.91	5.85	1.04	2.00
Laurencia Papillosa	4.10	43.62	619.00	1.17	10.60	2.98	12.46	3.52	2.45
Polysiphonia sp	1.61	15.77	618.82	0.54	1.49	3.26	3.69	1.70	1.90
Sarconema filiforme	2.16	10.45	97.59	0.42	0.91	4.10	10.28	4.09	1.22
Hypnea sp.	8.37	149.47	1717.00	4.59	7.05	5.50	20.51	9.69	2.75
Range	0.46-9.07	9.45-149.47	97.59-1717	0.42-4.59	0.9-10.6	1.22-5.5	3.69-20.51	1.04-9.69	0.67-3.87

The metal contents of all the algae were subjected to Metal Pollution Index (MPI) analysis for comparing total metal load between species (Fig. 1). The highest MPI was found in *Hypnea* sp. The MPI for most of the brown algae were more or less similar except for *Sargassam* and *Stoechospermum marginatum*. Higher metal load was observed in some of the brown algae from the Metal Pollution Index and

this reflects the uptake capability of the algae. Preferential accumulation was noted in different algal species and the maximum concentration of most of the metals present among the green, brown and red algae were *V. pachynema* (Mn, Fe, Co, Ni, Zn, Cd), *P. pavonica* (Cr, Mn, Cu, Zn, Cd) and *Hypnea* sp (Mn, Fe, Co, Cu, Zn and Cd) respectively, as evident from Bio Concentration Factor (BCF). Because of high concentration of most of the metals, these species could be used as an indicator for metal pollution. This study provides baseline data for heavy metals of Kudankulam marine algae for assessing future change, if any, in this environment.

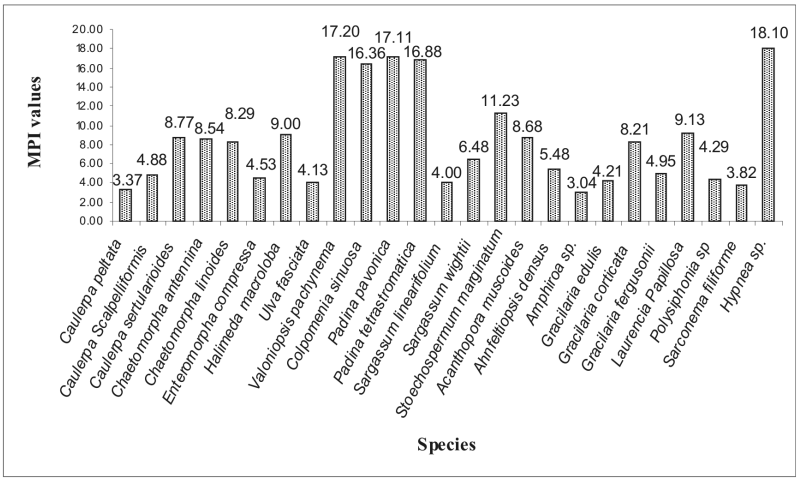

Fig.1. Metal Pollution Index of different species of seaweeds

EAP 13 **MECOS 09**

STATUS AND CONSERVATION NEED OF CORAL REEFS IN GULF OF KACHCHH, GUJARAT, INDIA

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Coral reefs are one of the most diverse and productive ecosystems of the world and are known as the rain forests of the oceans. India has four major coral reef zones *viz*., Andaman and Nicobar Islands, Lakshadweep Island, Gulf of Mannar and Gulf of Kachchh. Among these, the coral reefs of Gulf of Kachchh are the northernmost, falling almost on Tropic of Cancer. They are the northernmost reefs of the Asian continent. They have been subjected to a number of anthropogenic threats recently, such as excessive industrialization along the coast, offshore drilling and tourism. The environmental conditions are harsh in this region with high temperature, salinity and

turbidity. The tidal amplitude is so high that the reefs are exposed completely during low tides. Hence the coral species found here are the ones which have high tolerance capacity towards environmental fluctuations. The main objective of the research is to assess the present status of coral reefs in the Gulf of Kachchh and to study the key conservation issues along the coastline of this fragile zone. Qualitative and quantitative data have been collected by random stratified sampling technique and compared with the previous published data. High percentage live coral cover was recorded on the western part of Gulf of Kachchh whereas low coral cover was recorded on the eastern and central part of the Gulf of Kachchh. There is a direct correlation between industrialization, human disturbance and live coral cover. The area around Pirotan, Goose and Narara islands is under high industrial as well as anthropogenic activities whereas the reefs adjoining Poshitra are comparatively under low industrial activity. Hence the species diversity as well as the live coral cover is high in this region.

EAP 14 **MECOS 09**

BIOMASS AND PRODUCTIVITY OF SEAGRASS IN ANDAMAN AND NICOBAR GROUP OF ISLANDS

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Seagrass meadows are prominent components of the littoral zone of tropical seas, where they provide habitat and food for variety of organisms and play a major role in regulating sedimentary and biogeochemical processes. Such an important coastal habitat is under pressure in Andaman and Nicobar islands due to varied factors and the situation has worsened in the 2004 tsunami. Considering this, an assessment of seagrass biomass and productivity, percentage cover, canopy height of seagrasses in Andaman and Nicobar group of islands was made during November-December, 2007. The survey was carried out in 17 locations of Andaman Islands. Only 11 stations out of the 17 surveyed exhibited the presence of 9 species of seagrasses (*Enhalus acoroides, Halophila ovalis, H. ovata, Thalassia hemprichii, Cymodocea rotundata, C.serrulata, Halodule uninervis, H. pinifolia* and *Syringodium isoetifolium*). Distribution of these species varied widely and registered clear spatial variation. The percentage cover and canopy height of seagrass species varied widely at different locations. Seagrass biomass and productivity values showed clear variation within and between species at different locations. The lower nutrient level would have been the main reason for the lower seagrass canopy and percentage cover in these groups of islands. Seagrass ecosystem is well known for its higher productivity among all other marine ecosystems. Corals dominating the hard substratum in these groups of islands are another important factor limiting the distribution and biomass of seagrasses.

EAP 15 **MECOS 09**

ASSESSMENT AND MONITORING OF LAND AND WATER RESOURCES FOR FISHERIES – A MICROLEVEL STUDY USING GIS

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The availability of information on resources is of primary concern in the planning process and for policy decisions. This is more so in ecologically fragile areas like coastal zones. The vulnerability of the coastal zone was evident through the devastating impact of tsunami in 2004. To make the process of retrieval and analysis of data more perceivable and easy to visualise, it is ideal to put it on a GIS platform.

This paper illustrates the quantitative assessment and monitoring of land and water resources for fisheries development at panchayat level over a period of 20 years using GIS technology. For this study, Chellanam panchayat, a coastal village situated in the southwest part of Ernakulam district of Kerala state and a village adopted by the CIFT for its research and development programmes, was selected. The prime data used for this study were the topographic maps of the Ernakulam district over a gap of 20 years.

Based on the resource maps of 1968 and 1988 (1:50000 scale of 1968 and 1:25000 scale of 1988), the changes in land use pattern were quantitatively estimated using suitable geo-processing tools of the GIS. It is observed that 1.7553 sq.km of paddy field and aquaculture area of 1968 was converted to other land use by 1988, and 1.6155 sq.km of paddy field and aquaculture area was newly created, which shows a net decrease of 0.1308 sq.km of paddy field and aquaculture area in the panchayat. A decrease of 0.1554 sq.km of built-up/mixed crops area was observed in 1988.

Besides the topo-sheets procured from Survey of India, the data collected with GPS and socio-economic survey through field level study in the village were also used. The information was generated using GIS analysis of the data using the geo-processing tool ArcGIS, an ESRI software of GIS. In all, three resource specific maps were developed besides other figures and tables generated out of the survey and GIS analysis on the socio-economic characteristics.

EAP 16 MECOS 09

SEMIDIURNAL VARIATION AND NET TRANSPORT OF SOME CHEMICAL AND BIOLOGICAL CONSTITUENTS IN A TROPICAL ESTUARY

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Intratidal variabilities of dissolved inorganic nutrients (NO_3^-, NO_2^-, NH_4^+, PO_4^{3-} and Si), particulate organic carbon (POC), suspended particulate matter (SPM) and chlorophyll a (chl *a*) were assessed in a tropical estuary (Chaliyar river), and their transport into the adjoining coastal zone was quantified. Diurnal observation on currents, water level and water quality parameters were carried out during neap tide in March 2006. Vertical profiles of salinity and temperature were observed and samples of surface and bottom water were collected at hourly intervals. The transport of materials was calculated based on (a) concentration of nutrients, SPM, POC and Chl *a*; (b) velocity and direction of surface and bottom currents; and (c) the area of the estuarine cross section. The residual transport per day of nutrients into the sea was: 8.07×10^3 mol of dissolved inorganic nitrogen (DIN) (113 kg N); 1.45×10^3 mol of PO_4^{3-}(45 kg P-PO_4^{3-}); and 0.96×10^3 mol of Si (27 kg Si). The main form of DIN was NH_4^+, which may be due to the decomposition of organic material and effluents from the industries situated on the banks of Chaliyar River. The results also showed an upstream transport of 0.96×10^3 mol of Si (27 kg Si), 2807 kg of POC and 70 kg of chl *a*. The maximum chl *a* always occurred during the beginning of the ebb tide or the flood tide. The highest chl *a* (29 mg. m^{-3}) was recorded during the forenoon corresponding to the ebb tide. The high chl *a* may be as a result of abundant supply of nutrients and increased light levels in the water column during the forenoon. The decrease in nutrients, low N: P ratio and high water temperature (31.6°C) makes a thriving environment for bluegreen algae in the coastal waters during pre-monsoon period.

EAP 17 MECOS 09

DISTRIBUTION OF MEIOBENTHOS IN AND AROUND THE INDIAN OCEAN SECTOR OF SOUTHERN OCEAN

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Meiobenthos play a major role in the benthic ecosystem contributing significantly to benthic biomass and biogeochemical cycles, besides being an important source of food to macrobenthos and nekton. Meiofauna is also an important tool in the study of palaeoclimatology.

A study was undertaken on the distribution and numerical abundance of meiofauna of selected stations in the Indian Ocean sector of Southern Ocean where very few studies have been done on benthos. The present study is the first attempt to decipher the benthic faunal composition of the abyss. Samples were collected during Pilot Expedition in the Southern Ocean onboard *ORV Sagar Kanya* during January - February 2004. Four stations, two in the Indian Ocean situated north of Mauritius and two in the Indian Ocean sector of Southern Ocean situated south of Mauritius, were taken for the present study.

Analysis of sediment texture showed that there was no variation in the texture in the study areas. The texture was mainly silty-sand and sandy-silt with a low percentage of clay. Organic matter content was very low (0.040 - 0.076%). The major meiofaunal groups identified were nematodes, foraminiferans and crustaceans (Fig. 1). Nematodes dominated in numerical abundance in almost all the stations, followed by foraminiferans, crustaceans and others (turbellarians, nemerteans). The number of individuals in each category was much less than that usually encountered in the continental shelf and slope regions.

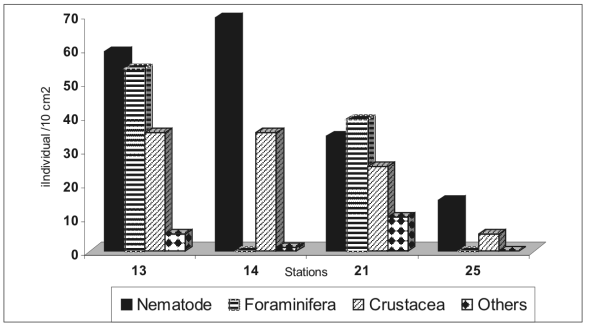

Fig. 1. Groupwise density of meiofauna

Organic carbon content of sediment failed to show any correlation with the pattern of meiofaunal density. Deep-sea organisms rely on particulate organic matter (POM) sinking from the surface waters or transported horizontally by various mechanisms. Direct correlation occurs between benthic density and diversity, and gradients in various proxies for POM flux such as depth, latitude, sediment organic carbon, detritus or combinations of these. Therefore quantity of sediment organic carbon alone is insufficient to predict variations in the meiofaunal distribution. Based on our limited knowledge of deep-sea ecosystems, it seems likely that multiple processes *i.e.*, physical, chemical and geological play a crucial role in regulating the faunal diversity, and these may interact in complex and subtle ways.

EAP 18 **MECOS 09**

SPATIAL AND BATHYMETRICAL DISTRIBUTION OF DEEPSEA PERCIFORM FISHES ALONG SOUTHWEST COAST OF INDIA

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A study on the distribution and abundance of the fishes of the Order Perciformes in depth beyond 200 m along the southwest coast of Indian EEZ was conducted. The results have shown that the order was represented by 17 families, 26 genera and 27 species in the study area between 7º N and 15º N latitude. The number of species found in each family was very less and most of them are represented by single species. The highest number of species was observed in the family Gempylidae (5) followed by Nomeidae (3). Fishes of the family Gempylidae showed wide bathymetric and spatial distribution with their presence in all depths as well as latitude zones. The fishes of the families Priacanthidae, Centrolophidae, Percophidae and Nomeidae were the other families with wide spatial distribution. Species like *Psenopsis cyanea*, *Bembrops caudimaculata*, *Neoepinnula orientalis* and *Psenes squamiceps* showed wide distribution in the study area. Highest CPUE was recorded in the depth zone 201 – 500 m. *Trichiurus auriga* showed dominance in 201-500 m depth in 7º-11º N latitude with a CPUE of 149.05 $kg.h^{-1}$. *Psenopsis cyanea* was found abundant in the three latitude zones with highest CPUE of 25.26 $kg.h^{-1}$ at 7º – 9º N latitude at the depth of 201-500 m. *Cubiceps caeruleus* with a CPUE of 7.4 $kg.h^{-1}$ also showed abundance in 9º-11º N latitude. The other major species contributed to the catches were *Bembrops caudimaculata*, *Neoepinnula orientalis* etc.

EAP 19 MECOS 09

DEEPSEA CHONDRICHTHYANS - A STUDY AT COCHIN FISHERIES HARBOUR, KERALA, INDIA

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Elasmobranchs consisting of sharks, skates and rays, contribute 2.5% to the annual marine production in India with the estimated annual landings during 2007 being 47,511 tonnes. A targeted fishery for deepsea sharks by drift gillnet-cum-hooks & line units operating at depths beyond 400 m has emerged recently at Cochin Fisheries Harbour. These deepsea fishing boats land sharks, skates, rays and chimaeras. Besides, certain species of deepsea sharks occur as by-catch in the deepsea shrimp trawlers too. Very little information on fishing and species composition of deepsea chondrichthyans are available from the Indian seas. Diversity and composition of deepsea resources of sharks, skates, rays and chimaeras landed by hooks & line, drift gillnets and deep sea trawlers at Cochin Fisheries Harbour is reported in this study.

During 2007, the elasmobranch fishery along the Kerala coast (Fig. 1) was dominated by species belonging to the family Carcharhinidae (49%) followed by Dasyatidae (17%), Myliobatidae (15%), Rhinobatidae (8%), Centrophoridae (5%), Sphyrnidae (3%) Alopiidae (1%) and Echinorhinidae (1%). In 2008, more than 14 species belonging to the family Hexanchidae, Echinorhinide, Centrophoridae, Squalidae, Carcharhinidae, Triakidae, Scyliorhinidae, Somniosidae, Alopiidae and Rajidae etc. were represented in the deepsea chondrichthyan landings. During the period July to October, the deepsea chondrichthyan landings by drift gillnets and trawls were mainly composed of bramble shark (*Echinorhinus brucus),* followed by chimaera *Neoharriotta pinnata* and gulper sharks (*Centrophorus* spp.). The sharks *Hexanchus griseum* (Hexanchidae) and *Deania profundorum* (Centrophoridae) were recorded for the first time in the Indian waters. The rare seven-gilled shark *Heptranchias perlo* was also observed. Maximum diversity was observed in Squaliformes with species such as *Centrophorus squamosus*, *C. granulosus*, *C. molluccensis*, *Centrophorus cf. atromarginates*, *Deania profundorum*, *Centroselachus crepidater* and *Squalus* spp. Size range of the chimaera, *Neoharriotta pinnata* (55-147 cm), *Echinorhinus brucus* (42-300 cm), *Heptranchias perlo* (80-107 cm) and *Deania profundorum* (60-66 cm) were recorded. Biology of *Neoharriota pinnata, Centrophorus squamosus*, *C. granulosus* and *C. molluccensis* were studied. Gut content of *N. pinnata* indicated the dominance of crustaceans while in *Centrophorus* spp. finfishes and cephalopods were predominant.

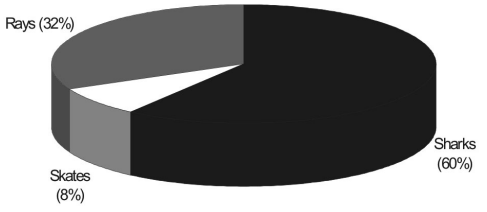

Fig. 1. Elasmobranch landings in Kerala during 2007

EAP 20 **MECOS 09**

ANTHROPOGENIC THREATS TO THE MARINE ECOSYSTEM WITH SPECIAL EMPHASIS TO THE REEF ECOSYSTEM

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Human activities are responsible for a major decline of the world's biological diversity, and the problem is so critical that combined human impacts could have accelerated present extinction rates. Human population has increased tenfold during the past 300 years, which greatly influence the biogeochemical cycles on earth. In marine environment also, the threat to marine fauna and flora comes in various forms, such as dumping of waste, industrial pollution, oil pollution, exotic species introduction, overexploitation, land reclamation, dredging and climate change. The period of most profound human impacts began in the 1950's with dramatic increases in land use, dam construction, urban development, fossil fuel CO_2 input and fertilizer use. This rapid increase in human activities directly influenced the marine organisms by affecting the breeding season, migration, biomagnifications and overall health. By 2025, approximately 75% of the world's population is expected to live in the coastal areas, adding more threat to the coastal ecosystem. Of the entire marine ecosystem, coral reef ecosystem plays a pivotal role, as it provides unlimited benefits to human and its marine environment such as, harboring nearly 25% of marine species, serves as a natural wave barrier, provides livelihood, etc. By and large it stands firm in the marine ecosystem and preserves biodiversity. Coral reefs of the type we see today have been around for about 25 million years. They are highly productive and biologically diverse. They are home to members of all the phyla or major groups of the animal kingdom. Coral reefs are also referred as the "rain forests" of the ocean. Though reefs are hard and seemingly indestructible, it is an equally fragile and sensitive ecosystem. As on today, the globe reef ecosystem are facing serious threats due to various anthropogenic activities *viz*. destructive fishing practices, boat

grounding and anchoring on reefs, dynamite fishing, improper gear operation, mining, pollution, industry development on coastal debris directly impact on coral reef ecosystem by bleaching, uprooting, continuous disruption, preventing the photosynthesis of associated algae (zooxanthellae) etc. In the present context, complete removal of anthropogenic activities is a tough task, but requires emergency action *viz*., creating awareness and research by government bodies. Various aspects with reference to the challenges of anthropogenic activities to the marine and reef ecosystem are discussed.

EAP 21 **MECOS 09**

ANALYSIS OF SURVEY DATA OF *NEMIPTERUS JAPONICUS* CAUGHT ALONG THE WEST COAST OF INDIA USING R-PACKAGE

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R is a high-level language and an environment for data analysis and graphics and is very similar in appearance to S-PLUS. The main reason for switching to R is to take advantage of its unrivalled coverage and the availability of new, cutting edge applications in the fields such as generalized mixed effects modeling and generalized additive models. A large number of the world's leading statisticians and scientists are using R. Another reason to use R is the quality of backup and support available. In addition to the built-in library spatial, other substantial contributed packages namely spatstat and spdep are used for analyzing spatial data. Using these capabilities of R, the following modeling work is attempted.

In the present study, Generalized Linear Modeling (GLM) is carried out, using a normal distribution and logarithm link function on the catch rate of *Nemipterus japonicus* from the vessels of Fishery Survey of India operating along the west coast of India. The best model goodness-of-fit is obtained by examining plots of the standardized catch rates and if they are found to be non-normally distributed, then the model distribution type or transformation would be changed until normality is attained. The fleet does not target this species, and it is a commercially valuable by-product of the finfish fishery.

Fishery surveys are being used to determine the best way to assess Maximum Sustainable Yield (MSY) and monitor the fish stocks. Using GLM, it is possible to detect changes in levels of catch rates of *N. japonicus* over the period of 10 years based upon the catch data from the surveys carried out during the period 1996 and 2006. It is seen that the model can be used for evaluating the effect of different factors on catch rates as well as estimating abundance indices. This model forms a set of valuable tools for analyzing the relationships between a key response variable and a number of other factors. In this paper an attempt is made to illustrate the use of this modeling technique (GLM) in survey data and also provide guidance on the

interpretation of the results. The finding of the present study provides vital information for making annual scientific assessments about the status of the spatial distribution of catch rates of *N. japonicus*.

EAP 22 **MECOS 09**

EFFECT OF FISHING AND AQUACULTURE ON COASTAL ECOSYSTEM

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Increasing demand for fish and fishery products has led into higher fishing pressure. The fishing pressure has increased to such an extent that the fish stocks are unable to replace their population that are removed. This situation leads to overfishing of some species in an unsustainable way. The types of gears used, fishing methods and fishing duration damage the physical and biological properties of inland and marine ecosystems. These activities also affect the entire chain from resource availability to production and consumption. Any stock enhancement programme should take into consideration the negative effects of newly introduced species in the food chain of the ecosystem.

Aquaculture farms, if not planned properly will affect the adjoining ecosystems. Wastewater discharge without proper treatment is a major cause for concern. In order to minimize the effects, and for sustainable development of the sector, a planned management strategy in the form of Integrated Coastal Zone Management should be employed.

EAP 23 **MECOS 09**

PROXIMATE COMPOSITION OF SELECTED SPECIES OF DEEP SEA FISHES OF INDIAN EEZ

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Proximate composition analysis of four deep sea fishes namely *Zenopsis conchifer*, *Ostichthys acanthorhinus, Hypopleuron caninum* and *Glyptophidium macropus* caught from the Indian EEZ during January 2007 was carried out. The samples were collected by deep sea fishing cruises of FORV *Sagar Sampada* at a depth

range of 200-822 m between 8^0-11^0 N latitude. Percentage composition of moisture, ash, crude protein and lipid were examined. Moisture content showed a range of 80.75% to 71.19%. *Glyptophidium macropus* showed the highest value and *Ostichthys acanthorhinus,* the minimum value. Percentage of ash varied from 5.06 to 3.37 with *Glyptophidium macropus* in the highest range and *Hypopleuron caninum* the lowest. Amount of crude protein and fat were found to be 21.13% to 11.50% and 6.03% to 1.33% respectively. Among the four selected species, protein and lipid were high in *Ostichthys acanthorhinus.* Initial evaluations suggest that the selected deep sea fishes contain a higher percentage of moisture than pelagic fishes, leading to a predictable decline in protein and lipid content. These variations might be related to the depth. Comparison of protein and lipid values shows that these deep sea fishes contain more protein than fat. The significance of the present study is that the four deep sea fishes under study especially *Ostichthys acanthorhinus* is high in protein, and hence could be utilized as an alternative source of nutritive sea food.

EAP 24 **MECOS 09**

LIFE HISTORY TRAITS OF DEEP SEA FISHES OF THE FAMILY CHLOROPHTHALMIDAE, WITH SPECIAL REFERENCE TO *CHLOROPHTHALMUS NIGROMARGINATUS* FROM THE SOUTHWEST COAST OF INDIA

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Fishes of the family Chlorophthalmidae (green eyes) are one of the most dominant deep sea fishery resources of the west coast of India. This paper describes the geographical and vertical distribution and abundance, feeding, spawning and length–weight relationships of *Chlorophthalmus nigromarginatus* of the west coast of India. Chlorophthalmids dominated the bottom trawl catches contributing around 63% to the total finfish catches with a CPUE 309.96 kg/hr. Among the green eye, *C. nigromarginatus* dominated the catch with an average CPUE 253.35 kg/hr followed by *C. bicornis* with a CPUE 56.2 kg/hr, while *C. maculatus* was collected from only one station. These species were found to be more abundant between the latitudes 7º and 8º N, mostly restricted to 200 – 400 m. *C. nigromarginatus* was found dominant in the depth range 200 – 300 m while *C. bicornis* in 300 – 400 m. Growth was found to be allometric for chlorophthalmids with 'b' values found to be deviating from the ideal value of 3. Spawning was found to be a continuous process resulting in the occurrence of mature fishes in all the seasons. Segregation of sexes was noticed with the predominance of females in most of the catches for both *C nigromarginatus* and *C. bicornis* while males predominated in *C. maculatus*. The size at first maturity was 21.5 and 15.5 cm while the modal size groups in the catches were 19 – 20 and 15 – 16 cm for *C. nigromarginatus* and *C. bicornis* respectively.

EAP 25 **MECOS 09**

DIETARY COMPOSITION OF THE SAILFISH, *ISTIOPHORUS PLATYPTERUS* SHAW AND NODDER, 1792 FROM PARANGIPETTAI, SOUTHEAST COAST OF INDIA

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The sailfish *Istiophorus platypterus* Shaw and Nodder is one of the major components in the billfish landings along the Indian coast. Totally 49 specimens (total length: 92 - 385 cm) were analyzed to find out its food off Parangipettai, southeast coast of India. The dietary components were studied based on numerical compositions (CN), percentage of gravimetric composition (CW), percentage and frequency of occurrence and index of relative importance (IRI). The results revealed that the sailfish are carnivores, feeding mainly on teleosts and cephalopods. Frequency of occurrence of prey items were anchovies (43.86%), rabbitfish (21.25%), cephalopods (21.21%), ribbonfishes (6.06%), tuna (3.03 %), carangids (3.03%) and Indian mackerel (1.56%). The details of the prey items and the index of relative importance (IRI) are presented and discussed in this paper.

EAP 26 **MECOS 09**

CORRELATION BETWEEN COLOURED DISSOLVED ORGANIC MATTER (C-DOM) AND PHYTOPLANKTON PRODUCTIVITY

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The ability of estuarine waters to transmit sunlight influences phytoplankton productivity. Changes in light transmission may be due to natural and anthropogenic factors. One of the indicators of health of the estuarine ecosystem is the ability of the water body to transmit sunlight to planktonic as well as other submerged vegetation for photosynthesis. Monitoring the optical properties of waters spatially and temporally provides valuable information on the natural and anthropogenic factors affecting the capacity of these waters to provide sufficient sunlight for photosynthesis and growth of plankton.

Coloured dissolved organic matter (C-DOM), suspended particulate matter and type of phytoplankton pigments affect the optical characteristics of estuarine waters.

In estuaries, C-DOM concentration is influenced by changes in salinity, anthropogenic input of domestic and industrial effluents, seaweed decomposition and primary productivity. C-DOM in turn influences the accuracy of remote sensing algorithms to predict chlorophyll *a* distribution and phytoplankton biomass of estuarine and coastal waters.

This paper analyses the temporal and spatial variation in the absorption of light by C-DOM in the Cochin estuary. It also attempts to decipher the relationship between C-DOM absorption and seasonal freshwater influx into the estuary and the associated salinity variations. This study is all the more important and very relevant because of the correlation between C-DOM and primary productivity.

C-DOM absorbance (over the range 220-400 nm) and chlorophyll a concentrations were determined from surface and sub-surface water samples collected from 10 stations along the Cochin estuary from August 2007 to July 2008. The environmental parameters such as turbidity, salinity, temperature, DO and pH were also estimated.

In Cochin estuary, C-DOM absorbance was found to be strongly linked to seasonal cycles of water column mixing. During the southwest monsoon, as a result of deep mixing, C-DOM and detritus rise to the surface creating conditions for enhanced C-DOM absorption. Further freshwater influx and associated lowering of salinity also favour increased absorption of CDOM.

Spatial pattern of C-DOM absorbance did not show clear gradation with salinity or any other environmental parameter. This indicates the complexity of C-DOM input into the estuary. At certain stations, it was found to be due to the enhanced phytoplankton degradation as evidenced from high Chl *a* values. In the case of polluted stations and those close to riverine influx, the terrestrial C-DOM inputs could be the major contributors. The effect of photo-bleaching on C-DOM may also explain, in part, the variability observed in C-DOM absorbance. The observations clearly show the influence of C-DOM as a major absorber of light over the same wavelengths favoured by phytoplankton, thus complicating the development of ocean colour algorithms to predict primary productivity by remote sensing.

EAP 27 **MECOS 09**

LENGTH-WEIGHT RELATIONSHIP OF *VINCIGUERRIA NIMBARIA* AND *V. LUCETIA*

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The length-weight relationship (LWR) of the fish from deep scattering layer, *Vinciguerria nimbaria* and *V. lucetia* was studied based on 846 specimens collected from IKMT operated from FORV *Sagar Sampada* during 1998-2000. The ANOVA analysis showed that there was no significant difference in slope or intercept of the LWR between the males and females in both the species. The LWR for pooled values of both sexes of *V. nimbaria* was $W = 0.00992839\ L^{2.81431017.}$. The LWR was found to be isometric for the pooled data. The linear regression obtained from log transformed data was significant at 1% level (<0.001). The significance of variation in the estimates of 'b' for this species from the expected value for ideal fish (3.0) was tested by 't' test and the result was –40.840699 (not significant). The LWR for *V. lucetia* was $W = 0.006483607\ L^{3.164497613}$. The significance of variation in the estimates of 'b' for this species from the expected value for ideal fish (3.0) was tested by 't' test and the result was 14.522 (significant). The LWR in *V. lucetia* was not found to be isometric for the pooled data. The "r" value showed good correlation between length and weight. The variation in the percentage of occurrence of the fish in different length classes and during different seasons is related to the sexual cycle and spawning in *Vinciguerria*.

EAP 28 **MECOS 09**

ASSESSING ESTUARINE BIOFILM BACTERIAL DIVERSITY BY 16S rRNA CLONE LIBRARY – A METAGENOMIC APPROACH

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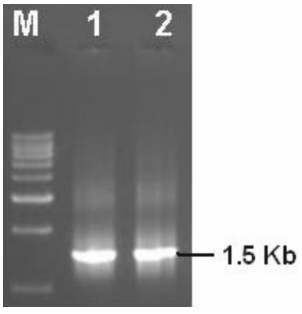
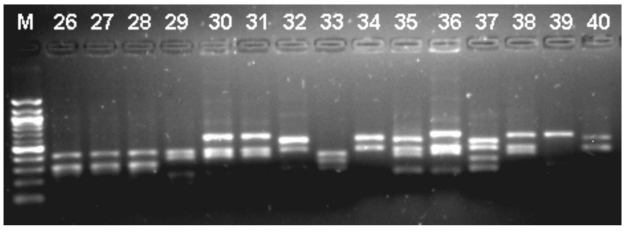
Biofilm communities contribute significantly to estuarine ecosystem productivity and biogeochemical cycling. Our knowledge on the bacterial diversity of these communities is limited compared to other components of estuarine ecosystems. It has been estimated that less than 1% of the total microbial population in the land environment and even less in the marine environment have been successfully isolated in pure culture. Many microorganisms cannot be cultured by the current culture-based

and traditional methods. Molecular approaches have greatly enhanced the knowledge of population structure in natural microbial communities. Metagenomics is a new and rapidly developing field that tries to analyze the complex genomes of microbial niches. Culture-independent molecular techniques, 16S rRNA clone library along with RFLP and phylogenetic analysis, were applied to investigate the bacterial diversity associated with the biofilm community from an estuarine ecosystem in Kerala. Acrylic plates were deployed in the estuary for seven day incubation for biofilm formation. Community profiling of the biofilm was achieved by total genomic DNA-based 16S rRNA clone library generation and sequencing. Clones with low identity with sequences retrieved from database as well as uncultured bacterial sequences were found in the biofilm community. Sequence analysis of 50 16S rRNA clones indicated a high diversity with in the biofilm communities with the majority of microbes being closely related to the *Proteobacteria*. Only a small fraction of the 16S rRNA sequences were highly similar to rRNA sequences from *Actinobacteria* and the *Cytophaga – Flavobacterium - Bacteroides* group. Biofilm formation and persistence in estuarine environments is governed by complex physical, chemical and biological processes. Since biofilm-associated microbes possess diverse metabolic capabilities and play a crucial role in biogeochemical cycling, knowledge on their community structure is imperative for the proper understanding of the ecosystem processes in estuaries.



Biofilm associated bacterial 16S rRNA amplified by PCR (M- 1 Kb DNA ladder; 1 -2 16S rRNA



RFLP patterns of biofilm associated bacterial 16S rRNA clones digested with restriction enzyme (M - 100 bp DNA ladder; 26 - 40 clones)

Opportunities - OP

SCOPE FOR RESEARCH ON SPAWN BIOLOGY OF TELEOSTEAN FISHES

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The discovery of using cadaveric sperm to successfully generate progenies has opened the possibility of adopting a widely practicable method of drawing sperm from freshly dead specimens of fishes preserved at -20°C. This simple technique can be developed to suit the desired fish species and used (i) to fertilize eggs of groupers at Cochin and (ii) to augment the sperm bank facility for a larger number of fish species at relatively cheaper cost at Lucknow.

With the absence of acrosome in the teleostean sperm and its micropylar entry into an egg, fertilization in fishes may not be a species specific event. For instance, the carp's sperm can activate development in eggs on a dozen species crossing the borders of species, genera and families. At Cochin, an investigation undertaken to activate the development in eggs of *Epinephelus* spp by the cadaveric sperm of economically not so important 'by-catch' of *E. maera* may prove rewarding.

Interspecific and intergeneric androgenetic clones of desired fish species can be generated by activating the development of genome-inactivated (using UV-irradiation) eggs of compatible alien species by fresh/cadaveric sperm of the desired species. Thus, clones of rosy barb and Bueno Aires tetra have been generated at Madurai using surrogate eggs of tiger barb and widow tetra, respectively. At Bhubaneswar, it is desirable that a long term research is undertaken to produce rohu seedlings throughout the year using its preserved sperm and surrogate eggs of tilapia and the like; at Barrackpore, *Hilsa* seedlings can be generated using the intergeneric androgenetic technique and thereby eliminate the migration component from *Hilsa* and avoid the environmental hussle. Kochi may also make an attempt to do the same with eels.

Shelf life of sperm of many teleostean fishes is limited to few seconds, whereas that of eggs lasts for a few minutes to a few hours. Hence, the classical concept of availability of sperm in surplus numbers may have to be reconsidered. Many fishes are known to adopt ingenious techniques to economically manage their sperm budget. In the heramic *Xyrichthys novacula*, the territorial male monopolizes all the matings with his members, whose number ranges from 4 to 17 females. Producing about 600 sperms per egg, a male successfully fertilizes 85-88% of all eggs spawned by 4 to 6 females in his harem. The male with 17 females successfully fertilizes 70% of all eggs at an amazingly lowest sperm egg ratio.

The classical concept of Operational Sex Ratio developed by Emlen and Oring in 1977 states that the OSR of gonochoristic fishes is the ratio of male to female

ready to mate at a given moment and the reproductive success of the male is limited by the availability of females. Simple experiments undertaken by college/university students and young scientists working in smaller fisheries institutions with limited facility may produce results that may have far reaching implications on some of these concepts. For instance, a series of simple experiments on the fecundity of gonochoristic fishes in combinations of 1 male to 1-10 females and 1 female to 1-10 males have clearly shown that a male can effectively handle/husband not more than 2-3 females. In other words, the reproductive success of a male certainly increases with increasing availability of females, but not beyond 2-3 females.

OPO 02 **MECOS 09**

PCR APPROACH FOR FOOLPROOF GENDER IDENTIFICATION OF MARINE MAMMALS

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Gender identification is of fundamental importance in the studies of population structure, social organization, distribution, behaviour or heavy metal accumulation in marine mammals. However, distinguishing males and females among these animals is difficult due to the poor sexual dimorphism, especially during their free-ranging state. By examining the carcass remains of stranded/beach-cast cetaceans, which are often at decomposition levels, accurate assessment of reproductive organs is not possible.

A PCR-based method for the identification of sex in mammals is available. In this approach, Y-chromosome specific *SRY* locus is amplified simultaneously with the homologous *ZFX*/*ZFY* genes on the X chromosome of females (*ZFX*) and XY chromosomes of males (*ZFX*/*ZFY*) as positive control for the absolute confirmation of sex. Females lack Y chromosome and the test is based on the absence of a *SRY* product in females. One set of primers amplifies a fragment from the *ZFX*/*ZFY* genes in males and females. The other set of primers amplifies a much shorter fragment from the *SRY* gene in males only.

In the present study, genomic DNA extracted from skin samples of the cetaceans and dugong obtained from either incidental fishery kills or from stranding along the east and west coasts of India was amplified in a PCR using specific primers for *SRY* and *ZFX*/*ZFY*. *SRY* gene produced band of size ranging from 220 to 224bp, which was present only in males, whereas *ZFX*/*ZFY* locus was with a size range of 442-445bp and appeared in both sexes (Fig. 1). Results indicate presence of longer *SRY* fragment in dolphins and porpoise compared to that in sperm whale and baleen

whales, whereas there was hardly any size difference of *ZFX/ZFY* fragment (Table 1).

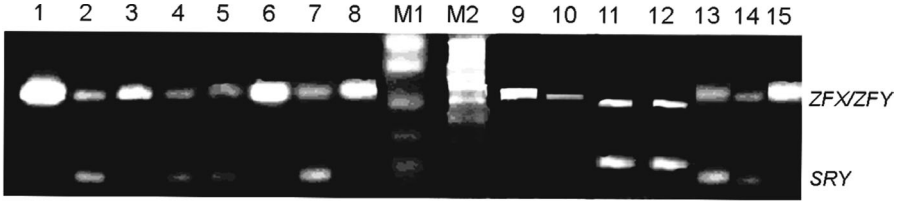

Fig. 1. PCR amplification of *SRY* and *ZFX/ZFY* specific fragments in different species of cetaceans and dugong (lane 1, female finless porpoise; 2, male finless porpoise; 3, female spinner dolphin; 4, male spinner dolphin; 5, male bottlenose dolphin; 6, female bottlenose dolphin; 7, male Indopacific humpbacked dolphin; 8, female humpbacked dolphin; 9, female Risso's dolphin; 10, female dugong; 11, male blue whale; 12, male Bryde's whale; 13, male Risso's dolphin; 14, male bridled dolphin; 15, female sperm whale; M1, pBR322 DNA/*MSP*I digest; M2, 100 bp DNA ladder).

The sex determination method used in this study for cetaceans and dugong is technically simple, requiring only PCR amplification and agarose gel electrophoresis. This technique is advantageous over the sex determination based on probe hybridization. It avoids the use of radioisotope, making it cheaper and less hazardous. Problems of failed or partial digestion associated with techniques relying on restriction digestion are obviated. The whole process, from the extraction of genomic DNA to visualization of amplification products would take approximately 9-12 h, as opposed to several days in the case of hybridization method.

Table 1. Particulars of PCR-based gender identification in different species of marine mammals

Species	Number of individuals sexed by PCR		Size of *SRY* band (bp)		Size of *ZFX/ZFY* band (bp)	
	Male	Female	Mean	SD	Mean	SD
Tursiops aduncus	2	1	224	2.1	443	0.7
Stenella longirostris	8	4	222	1.7	444	0.8
Stenella attenuata	1	-	222	0	444	0
Sousa chinensis	1	1	220	0	443	0
Grampus griseus	1	1	215	0	444	0
Neophocaena phocaenoides	7	5	222	1.2	444	0.5
Physeter macrocephalus	-	1	-	-	445	0
Balaenoptera musculus	1	-	210	0	445	0
Balaenoptera edeni	1	-	210	0	445	0
Dugong dugon	-	1	-	-	442	0

This method yielded 82% success in 42 individuals of 10 species tested. Every sample should produce at least one band and the absence of any amplification implies a failed PCR reaction. Testing the technique using samples of known sexes (determined by physical examination of stranded/accidentally caught individuals) from ten cetaceans and dugong indicated that this sexing method was effective across a broad taxonomic range. The method can provide the secondary confirmation necessary for positive sex identification in marine mammal specimens, or a primary method where accurate field observation of gender is not possible. In three cases, one each of spinner dolphin, sperm whale and Bryde's whale specimens, where external sex determination was not possible, molecular sexing was done. In two cases, one each spinner dolphin and finless porpoise, PCR based method revealed erroneous sexing by external examination. However, in 8 individuals molecular sexing failed probably due to the highly deteriorated condition or non-availability of genomic DNA of the particular specimens. This is the first Indian attempt to identify sex in marine mammals using PCR. It is expected that the PCR-based gender identification method standardized in the present work would help in the studies of conservation, population structure and forensic issues of marine cetaceans and dugong.

OPO 03 **MECOS 09**

BREEDING AND LARVICULTURE OF THE SAPPHIRE DEVIL DAMSELFISH *CHRYSIPTERA CYANEA*

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The sapphire devil damselfish, *Chrysiptera cyanea* is one among the top ten species of marine ornamental fishes in the international trade. Currently, the trade of this species is contributed entirely from wild caught fishes from coral reef habitats. It is well known that the indiscriminate exploitation of the species from coral colonies can lead to destruction of the reef habitat and the selective overharvesting of the species can result in depletion of the wild stock. Development of captive breeding and larviculture protocols can lead to commercial seed production. The hatchery produced fishes of many reef fishes are known to be hardier than their wild caught counterparts. Hence, the solution to develop a long term sustainable trade is through hatchery production. For the first time, broodstock development, breeding and larviculture techniques of *C. cyanea* have been developed and standardised and the details are presented.

Broodstock development was done in FRP tanks (capacity : 2 tonnes) with biological filter and by feeding *ad libitum* with natural feeds. The length of broodstock fish ranged from 5 to 6.5 cm and the number of eggs per spawning varied between

2000 and 2500. The interval between successive spawnings ranged from 5 to 20 days. The eggs were either attached to the sides of the broodstock tank or on the substratum provided. The eggs were oval-shaped and measured around 1.3 mm in length and 0.6 mm in width. Parental care by the male was noticed. Hatching occurred in the night of third day of incubation. The larvae were altritial type but with mouth opening at the time of hatching. The length of newly hatched larvae averaged to 2.5 mm and the mouth gape was around 150 μ.

Larviculture was done in five tonne capacity FRP tanks by employing greenwater produced by the microalgae *Nannochloropsis occulata*. Different larviculture systems were experimented by varying cell counts of greenwater and live feeds. The cell counts of green water employed for the experiments were 1×10^4 ml^{-1}, 1×10^5 ml^{-1} and 1×10^6 ml^{-1}. Three sets of experiments were conducted by feeding with different live feeds; one set with rotifer (*Brachionus rotundiformis*) alone, the second set with mixed culture of two copepods *viz., Euterpina acutifrons* and *Pseudodiaptomus serricaudatus,* and the third set with copepods and rotifers as live feed. The larval survival was recorded on the 15th day of post-hatch. It was noted that a cell count range of 1×10^5 cells ml^{-1} was optimum, yielding the maximum larval survival. Feeding experiments with *B. rotundiformis* alone and with *B. rotundiformis* and copepods, as starter live feeds were not successful. Co-culturing the two selected species of copepods in the optimum range of cell count of greenwater gave the highest survival. The survival rate of larvae on 15th day post-hatch ranged from 5 to 8%. After 15 dph, the larvae were fed with freshly hatched *Artemia* nauplii and no further mortality was noted. Metamorphosis of larvae started from 24th day and all the larvae metamorphosed by the 30th day. The technique developed can be scaled up to commercial level production.

OPO 04 **MECOS 09**

A RESEARCH REVIEW ON COPEPODS AS LIVE FEED FOR LARVICULTURE OF MARINE FINFISHES

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The need for rapid expansion of hatchery production of seeds for farming of many marine finfishes and the hatchery rearing of marine ornamental fishes to replace wild-caught fishes could not be fulfilled by conventional live feeds such as rotifers and *Artemia*. Use of copepods as live feed in finfish hatcheries is gaining impetus. Copepods are employed mainly because they are the only acceptably-sized prey for small larvae of many species of marine finfish including ornamental species. From first nauplii to adult copepodites, the copepods offer good size ranges for the entire

hatchery phases for certain species of finfish. When compared to rotifers and *Artemia* nauplii, the copepods can improve the larval growth, survival and the ratio of normally pigmented juveniles when fed either alone or in combination with conventional live feeds. Considerable research has been done on copepods as live feed for larviculture of marine finfish. In the present paper, research on the three vital aspects *viz*., culture, nutritional value and application of copepods in marine finfish larviculture are briefly reviewed.

The mass culture of copepods has several limitations especially due to their low multiplication rate when compared to rotifers. The species that are mass-cultured fall under three orders: Calanoida, Harpacticoida and Cyclopoida. In calanoids, species belonging to the genera *Acartia*, *Centropages* and *Eutemora* are in widespread use in mono and mixed cultures. Among the harpacticoids, species belonging to the genera *Euterpina*, *Tigriopus* and *Tisbe* have been widely used. Under cyclopoids, the *Oithona* spp. and *Apocyclops* spp. are recognized as suitable for marine finfish larvae. The protocols for development of new cultures, feed requirements and extensive and intensive culture methods are reviewed. Generally photoperiod is important for all copepods as it affects egg production. Most species tolerate gentle aeration, and hence, mild aeration is beneficial in cultures. The harvested nauplii can be stored in cool temperatures.

Improvements in larval growth, survival and/or rates of normal pigmentation have been reported in many species of marine finfish fed with copepods or feeds supplemented with copepods. This is attributed to levels of DHA, EPA and/ or arachidomic acid (ARA) in the diet. It is estimated that a minimum of 0.5 -1.0% of dry weight of n-3 HUFA is required for marine fish larvae and higher amounts are required for rapidly growing fish larvae. DHA levels in wild copepods can be more than ten times higher than in enriched *Artemia*. The optimum EPA: ARA ratios found in copepods allow the larval fish to cope better with stressful conditions. Copepods contain higher amounts of polar lipids, which are more rapidly digested and may also facilitate digestion of other lipids in the underdeveloped gut of early marine finfish larvae. Varying concentration of the carotenoid astaxanthin found in the copepods helps to develop normal pigmentation in marine fish larvae. Copepods are also an important source of exogenous digestive enzymes which play an important role in fish larval digestion.

Copepod nauplii form nutritious prey that can meet the specialized requirements of small fast growing fish larvae. In hatcheries, copepods have been used as first feed for larvae of the halibut *Hippoglossus hippoglossus*, turbot *Scophthalmus maximus,* cod *Gadus morhua*, mangrove red snapper *Lutjanus argentimaculatus*, sea bream *Archosargus rhomboidalis* and the lined sole *Achirus lineatus*. Early stage larvae of the grouper *Epinephelus coioides* preferred to ingest copepod nauplii over rotifers, although their abundance was relatively low. Higher growth rate and survival were obtained in larvae provided with copepods than larvae fed with rotifers alone. Copepod nauplii were successfully employed in the larviculture of marine ornamental species like *Dascyllus trimaculatus* (threespot damsel), *D.aruanus* (humbug damsel), *Pomacentrus caeruleus* (blue damsel) and *Chrysiptera cyanea* (sapphire devil).

In future years, the interest in copepods for larviculture of marine finfishes is expected to increase due to expansion and diversification of aquaculture of marine finfish and ornamental species. Hence, intensified research on development of reliable copepods mass production systems, its nutritional value and application of copepods as live feed in the larviculture of different finfish species deserves priority.

OPO 05 **MECOS 09**

EFFICACY OF SEAWEED PRODUCTS ON GROWTH AND RESISTANCE TO WHITESPOT SYNDROME VIRUS IN THE SHRIMP *PENAEUS MONODON* POSTLARVAE

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Aquaculture is one of the fastest food producing sectors in the world, greatly affected by disease outbreak caused by opportunistic pathogens of bacteria and viruses. The whitespot syndrome virus (WSSV) has become the greatest threat and a big challenge to the shrimp aquaculture sector. The usage of chemical therapeutics is of less interest due to the resistance developed by the microbes and also residual concentration of antibiotics in the cultivable species. In the light of the above, experiments were conducted to evaluate the efficacy of seaweed products on the growth and WSSV resistance in the shrimp, *Penaeus monodon* postlarvae. For this, four commercial seaweed products of *Sargassum autumnale, S. duplicatum, S. polycystum* and *Gracillaria tenuistipitata* were tested. The individual seaweed products of various concentrations (250, 500 and 750 mg/l) were enriched with *Artemia* nauplii (instar II), and fed to the respective group of *P. monodon* postlarvae for 20 days (PL 15-35). A control group was also maintained without the supplementation of seaweed products. The weight gain of the experimental group was higher (0.280 to 0.329 g) than the control group (0.267 g). Similarly the specific growth rate was also higher (15.95 to 16.73%) in the experimental groups than the control group (15.72%). After 20 days of feeding experiment, the shrimp postlarvae were challenged with WSSV for 21 days. During the challenge test, the control shrimp displayed 100% mortality within 6 days. The mortality percentage of the shrimp which received higher concentration (750 mg/l) of seaweed products-enriched *Artemia* ranged from 56 to 81%. The mortality was low in the group, which received the seaweed *S. polycystum* product. The PCR analysis indicated the concentrate independent disease resistant efficacy of seaweed products. The present results suggest the potential applications of seaweed products in aquaculture against the WSSV outbreak.

OPO 06 **MECOS 09**

ENRICHMENT OF EICOSAPENTANOIC ACID CONCENTRATES FROM SARDINE OIL BY BACTERIAL *(BACILLUS CIRCULANS)* LIPASE ISOLATED FROM SEAWEED *TURBINARAIA CONOIDES*

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Long-chain polyunsaturated fatty acids (PUFAs), *viz.,* eicosapentaenoic acid (20:5n3), docosahexaenoic acid (22:6n3) and linolenic acid (18:3n3) have special pharmacological and physiological effects on human/animal health. While saturated and monounsaturated fatty acids may be synthesised in the body of marine fish larvae and broodstock, polyunsaturated fatty acids cannot be synthesised *de-novo*. Therefore they require greater concentrations of PUFAs for their growth, reproduction and survival. Since these physiological functions drew attention to these essential fatty acids, the production of PUFA-rich fish oil as a food material is one of growing research areas. For commercial exploitation of high value added products such as PUFA concentrates, the acids must first be separated from their triglycerides and purified to a high degree based on differences in physico-chemical properties for their effective end use. Most of the existing chemical purification methods are non-selective to different fatty acids. Bacterial lipases particularly belonging to *Bacillus* are being used to selectively concentrate targeted fatty acids in triglycerides by virtue of their substrate, positional, stereospecificity, and higher stability. The mild conditions used in enzymatic reactions offer a promising alternative to chemical hydrolysis to avoid the formation of undesirable products. Among various marine fish oils, sardine oil is one of the rich sources of PUFA (31.40%), especially 20:5n3 (17.62%). Since the oil is cheaply available as the byproduct of fish processing industry, we have targeted to concentrate 20:5n3 from this source. The present study therefore addresses to prepare EPA-concentrates particularly n3 PUFAs by a combination of *Bacillus circulans* lipase-catalysed enrichment of n3 PUFAs in triglycerides derived from clarified sardine oil, and further concentrating the PUFAs by amide complexation and chromatography. The *Bacillus circulans* bacterial colonies were originally isolated from seaweed *Turbinararia conoides* and were sub cultured for characterisation and extraction of lipolytic enzyme. The enzyme was purified 108.57-fold by precipitation and gel filtration on Sephadex G-100 with specific activity of 119.26 LU/mg. The enzyme was finally purified 178.39-fold using Amberlite XRD-5 (Cl^- form) anion exchange chromatography using an increasing NaCl-Triton X-100 gradient with a yield of 5.21% and a specific activity of 386.15 LU/mg. As a first step to prepare PUFA concentrates, stabilised sardine oil triglycerides were cleaned up on neutral alumina using *n*-hexane/diethyl ether as eluting solvent system (95:5, v/v). The refined sardine oil was found to contain PUFAs particularly 20:5n3 (17.62 $\pm$ 0.61%) and 22:6n3 (8.16 $\pm$ 0.96%) along with other n3 and n6 PUFAs like 18:3n3 (2.48 $\pm$ 0.53%), 18:2n6 (0.69 $\pm$ 0.12%), and 22:5n3 (1.09 $\pm$ 0.15%). The sardine oil triglycerides were hydrolysed

with lipases purified from *Bacillus circulans*, and the total fatty acid content of triglycerides at various time-interval of hydrolysis (1-6 h) was analyzed. The lipase-catalysed hydrolysis (500 LU) of triglycerides from refined sardine oil was performed in a reaction mixture of triglycerides (100 mL, 0.01% w/w *ter*-butylhydroquinone) in PIPES–NaOH buffer (5 mL of 0.1 M solution at pH 7.0) stabilized with Triton X-100 (0.5% v/v), and $CaCl_2$ (0.4 mL of 100 mM). The lipase produced the highest degree of hydrolysis for SFAs (47.19%) followed by MUFAs (25.90%) from their initial content after 3 h. The lipase was able to enrich sardine oil with 37.74 $\pm$ 1.98% EPA after 3 hours of hydrolysis of triglycerides, which was higher than that in the crude sardine oil. The total n3 PUFA increases with time up to 3 h of lipase-catalyzed hydrolysis (52.71% TFA), beyond which it plateaued down (51.09% TFA at 6 h) apparently due to the reduced selectivity of the lipase. However, with the increase of acyl chain length ($> C_{20}$), the hydrolytic susceptibility of the esteritic linkage of triglycerides towards the lipase was found to increase as evident from the 12.13% decrease of 22:6n3 in the triglyceride fraction after 3 hours of hydrolysis. The corresponding n6 fatty acids (18:2n6 and 20:4n6) exhibit a reduction in their content (49.28% and 46.15%, respectively from their initial content) (Fig. 1). Structure-bioactivity relationship analyses revealed that the lower hydrophobic constants of 18:3n3 and 20:5n3 (log P = 5.65 and 5.85, respectively) result in higher hydrolytic resistance towards lipase leading to their enrichment in the triglyceride fraction after lipase-catalyzed hydrolysis. Lipase catalyzed hydrolysis of sardine oil for 3 hours followed by amide complexation (at the urea fatty acid ratio of 4:1 w/v at 4°C) provided free fatty acids containing 51.29 $\pm$ 4.65% 20:5n3. The purified methyl ester of 20:5n3 from the urea concentrate was attained by repetitive flash chromatographic techniques on argentated neutral alumina. The product contains methyl esters 20:5n3 as 68.29 $\pm$ 2.15%, n6's are 2.61% and other fatty acid esters are <1% using *n*-hexane/EtOAc (9:4, v/v). The fatty acid 18:3n3 was found to be eluted with *n*-hexane/CH_2Cl_2 (7:2, v/v) with a final purity of 56.06 $\pm$ 3.18%. In conclusion, the results suggest that a combination of lipase- catalysed hydrolysis followed by urea fractionation and argentated chromatography may be a useful method to concentrate n3 PUFAs from sardine oil. New strains bacterial such as *Pseudomonas* sp. and *Bacillus* sp. are being explored for more effective and higher lipase activity in an attempt to prepare target PUFA concentrates.

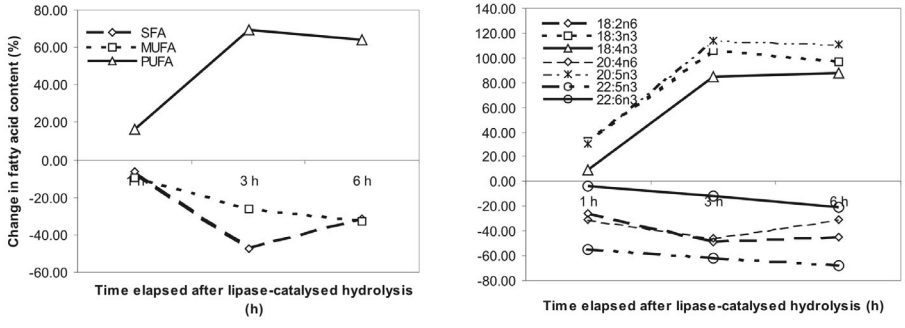

Fig.1. Change (%) in the fatty acids content in triglyceride fraction by *B. circulans* lipase catalyzed hydrolysis of sardine oil for different time intervals (1 to 6 h).

OPO 07 **MECOS 09**

SPONTANEOUS SPAWNING OF *EPINEPHELUS TAUVINA* (FORSSKAL) IN CAPTIVITY

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This paper describes the natural spawning of the greasy grouper Epinephelus *tauvina* in captivity in recirculating sea water system under controlled conditions. The broodstock was developed in the culture system by rearing the wild fingerlings of 90 to 200 mm length. Females matured within two years. *E. tauvina.* Being a protogynous hermaphrodite, male spawners were developed through hormonal sex inversion of females. Natural spawning occurred in almost all the months of the year. Each time the spawning occurred between 1600 to 2000 hrs and continued for three days. The same pair of male and female spawned continuously for 4-6 times in the same year. Single female released on an average of 50,000 eggs/kg body weight on each day of spawning. Spawning was mostly related to lunar cycle, coinciding with the last or first quarter of lunar cycle. Eggs were single, buoyant and non-adhesive. Fertilization rate obtained in the present study varied from 60 to 99%. Egg diameter ranged from 0.720 to 0.910 mm, with a single oil globule. The eggs hatched out in 22 – 23 hours. Hatching rate was observed to vary from 45% to 80%. The length of newly hatched larvae was 1.74mm.

OPO 08 **MECOS 09**

ANTIBIOTIC PRODUCTION BY MARINE FUNGI FROM THE SLOPE SEDIMENTS OF ARABIAN SEA

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Marine fungi are proven to be a rich and promising source of novel compounds. They grow in a unique extreme habitat and therefore have the capability to produce unusual metabolites. Marine fungi are recognized recently as one of the barely tapped sources for biologically active secondary metabolites. The present study deals with the antibacterial activity of marine fungi and the effect of different nutrients on antibiotic production.

Fungal cultures (181) were tested for antibacterial property against pathogens *viz., Vibrio harveyi, Vibrio alginolyticus, Vibrio parahaemolyticus, Vibrio cholerae, Staphylococcus aureus, Salmonella typhi, Psuedomonas aeruginosa, Micrococcus luteus, Aeromonas hydrophila* and *Escherichia coli*. Among the positive forms, 37% were *Pencillium* sp., 21% *Aspergillus* sp., 9.6% *Scopulariopsis* sp., 7.6% *Cephalosporium* sp., 1.92 % *Humicola* sp., 3.8 % *Phoma* sp., 7.6% *Gymnoascus* sp., 1.92% Chaetomium sp., 1.92% Trichoderma sp., 1.92% Zalerion sp. and 5.76% unidentified. Among the isolates, S9 (*Pencillium* sp.), S35 (*Aspergillus* sp), S111 (unidentified) and S 173 (*Pencillium* sp.) showed potential antibiotic activity. *Aspergillus* sp. (Fig. 1) was found to inhibit all the 10 pathogens tested. This isolate showed strong antibacterial activity towards all the test organisms.

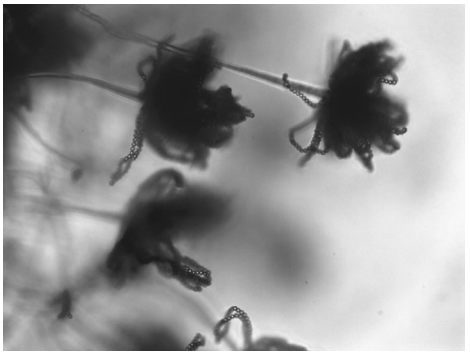

Fig. 1. Slide culture of S35 *Aspergillus* sp.400X

Solid state fermentation was done for the production of antibiotics and the effect of various additional nutrients on antibiotic production was examined. Antibiotic production was favored with the addition of corn steep liquor, pharmamedia, molasses and ammonium sulphate.

OPO 09 **MECOS 09**

AN EXPERIMENTAL POLYCULTURE OF PEARL OYSTER (*PINCTADA FUCATA*), SEAWEED (*KAPPAPHYCUS ALVAREZII*) AND ASIAN SEABASS (*LATES CALCARIFER*) IN CAGE OFF VISAKHAPATNAM

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Cage culture is an alternative sustainable practice for rearing fish and shellfish in polyculture along with seaweeds, which leads to increased profitability. At the open sea cage demonstration project site at Visakhapatnam, polyculture of the Asian

seabass *Lates calcarifer*, the seaweed *Kappaphycus alvarezii* and the marine pearl oyster *Pinctada fucata* was undertaken in a floating cage. The experiments were carried out in an offshore area near the Visakhapatnam Regional Centre of Central Marine Fisheries Research Institute, off Andhra Pradesh coast, India. Experimental circular grow-out cage of 15 m diameter and 6 m deep, with floating frames was used for the purpose. Fish fingerlings of 80-95 mm average length, which were reared and acclimatized in 5 tonne capacity FRP tanks at the mariculture hatchery of the Regional Centre, were transferred to the grow-out cage and reared at a suitable density. In order to test the use of available space in the outer ring of the floating cage, thalli of the seaweed *K. alvarezii* were grown in square plastic rope nets (2x2') tied with plastic rope to the HDPE outer ring of the cage. Simultaneously, epoxy coated iron boxes (2x2x0.5') with plastic net covering were used to grow the spat of *P. fucata* and attached to the outer ring of the cage. The spats which were produced and grown in the mariculture hatchery of the centre were used to stock in the boxes with an average initial Dorso-Ventral Measurement (DVM) OF 45 mm, AVM of 38 mm and cup width of 13 mm and with an average weight of 6.2 g. Only the seabass was fed with trash fish at different rates as per the biomass. No other management measures were undertaken for the oysters and the seaweeds. Growth of oysters, seaweeds and fish yield reached remarkable production rates with the increment of about 212.5%, in the case of fish; 23.7 % in AVM, 28.8% in DVM, 61.5% in cup width and 296.6% in weight in the case of oysters; and 456.7% in the case of seaweed during the culture period of 45 days. The oysters and seaweed were very healthy and no negative interferences could be observed in the polyculture of fish, oyster and seaweed in the same cage.

OPO 10 **MECOS 09**

MOLECULAR CLONING AND CHARACTERIZATION OF CDNA OF GONAD INHIBITING HORMONE (GIH) OF BLACK TIGER SHRIMP *PENAEUS MONODON* FROM INDIAN WATERS

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Aquaculture of tiger shrimp is one of the most important food production sectors in India and elsewhere. There are, however, serious constraints for development and sustainability of cultivation of black tiger shrimp *Penaeus monodon*. The sector solely depends on wild spawners for seed production. The only method to induce reproduction and spawning is the manipulation of Gonad Inhibiting Hormone (GIH) through surgical extirpation of eyestalk. It is obviously a physiologically destructive

and irreversible procedure. Further, with the emergence of several pathogens (e.g., White Spot Syndrome Virus, WSSV), this technique is often unsuccessful in commercial production systems. However, induced breeding is an integral component for successful commercial seed production as it is difficult to breed this species. Further success of a commercial hatchery operation largely depends on the predictability of seed stock production. At this juncture, the only option is to understand more about the regulatory mechanisms involved in the gonadal maturation and related molecular basis of GIH physiology. Thus, one can have better control over the induced breeding process through the manipulation of GIH using molecular tools.

Gonad-inhibiting hormone is a member of the neuropeptide family that is synthesized in neuroendocrine cells located in the eyestalk medulla terminalis ganglionic X-organ. This hormone family is known as the CMG (CHH/MIH/GIH) family. The CMG family of hormones can be divided into two types as reflected by their primary structure. The most abundant hormone in this family, crustacean hyperglycemic hormone (CHH), belongs to Type I, whereas the other two hormones, Molt Inhibiting Hormone (MIH) and Gonad Inhibiting Hormone (GIH), are categorized in Type II.

Although GIH is shown to inhibit gonad maturation in crustaceans, the detailed mechanism of its function is still unclear. In this study, we have used the crustacean GIH sequence information available in the GenBank for designing primers specific for GIH. Using these primers we were able to amplify a cDNA fragment of size 316 bp from the eyestalk cDNA of *Penaeus monodon*. The amplified product was cloned and sequenced. The sequence analysis showed that it contained the complete Gonad Inhibiting Hormone CDS (Coding Sequence) of 291 bp. The deduced amino acid sequence of GIH hormone consists of 96 amino acids that showed the characteristic of Type II CMG family neuropeptide and homologues to the GIH sequences of *Metapenaeus ensis* (61%), *Homarus americanus* (41%) and *Nephrops norvegicus* (43%).

Thus, the finding of target gene for GIH has turned out to be a major impetus for generating recombinant hormone which would serve as an effective tool for manipulating the reproductive cycle of the organism. The efficiency of antibodies produced against the GIH hormone or the double-stranded RNA to inhibit GIH function in shrimps can also be investigated. Therefore, the scope of GIH manipulation through these molecular techniques may serve as an alternative for the conventional eyestalk ablation for the effective induced maturation of shrimps in the hatchery.

OPO 11 **MECOS 09**

ACCLIMATION AND GROWTH OF HATCHERY PRODUCED FALSE CLOWN *AMPHIPRION OCELLARIS* TO SURROGATE ANEMONES

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Anemone fishes live unharmed among the tentacles of sea anemones. Among the tested natural sea anemones, *Heterctis magnifica*, *Stichodactyla gigantea* and *S. mertensii* were found suitable as host sea anemones, and for acclimation of hatchery produced *Amphiprion ocellaris*. Two hypotheses have been recently formulated regarding this acclimation. (i) The fish coat itself with anemone mucus to mask its chemical stimulation for cnida discharge. (ii) The fish is protected by some alteration in its own mucus coating. Surrogate anemones were used to test this alternative hypothesis. The hatchery produced *A. ocellaris* were allowed to associate with it prior to being reared with natural anemone *H. magnifica*. If the acclimation times are reduced significantly after exposure to artificial anemones, it is concluded that the fish does not need to coat itself with the anemone mucus to become protected. After rearing or in association with surrogate anemones, the acclimation time to natural anemones significantly reduced. The results of the present study evinced that the fish is responsible for manufacturing its own protection from the sea anemone's mucous during acclimation. The experiments were conducted to assess the growth of hatchery produced *A. ocellaris* seeds in association with natural anemones, surrogate anemones and without sea anemones. There was considerable difference in the growth of the juveniles reared with surrogate and natural anemones. Significant growth differences ($p < 0.01$) were noticed between anemone-associated juveniles (natural and surrogate) and without sea anemones. This difference could be attributed to social inhibition of growth of subordinate late-settlers by frequent attack from the dominant early-settlers.

OPO 12 MECOS 09

SEX CHANGE OF HATCHERY PRODUCED *AMPHIPRION OCELLARIS*: INFLUENCE OF MATING SYSTEM REMOVAL ON GONAD MATURATION AND NESTING SUCCESS

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The phenomenon of sex reversal is an intriguing component in the life history of anemone fishes. Influence of gonad maturation and nesting success in *Amphiprion ocellaris* through mating system removal were analyzed through four experiments. (i) Sex inversion of active male to female in the absence of active female showed that after 180 days of association, the active male fish converted to female. (ii) In the presence of a functional male, juveniles changed sex from male to female. After 16 to 20 weeks, the gonads of juvenile fish showed increased testicular tissue development and active spermatogenesis. The study revealed that developments in gonad are dependent on the sex of the associated adults and juveniles. (iii) In the presence of a functional female, the juvenile developed into a male. In this, the functional female was allowed to remain in an aquarium with one juvenile during 4 to 20 weeks without the presence of a functional male. Gonads of juvenile after 16 to 20 weeks had a well-developed testicular zone in which all steps of spermatogenesis (from spermatogonia to spermatozoa) were detected. (iv) Same age-group juveniles (total length (TL): 50 mm) from two different pairs were kept together in an aquarium for 6 months without the presence of adult fishes. At the end of the experiment, the spermatogenic activity in the largest fish (TL= 66 mm) was very abnormal in the small testicular area. Alteration of spermatocytes and spermatids, and mingling of different types of male germ cells were observed and they were numerous in the ovarian zone. In the ovarian part, in addition to oogonia, numerous oocytes were observed. In the small testicular zone of the second largest specimen (TL = 58 mm), the male germ cells were intact and active spermatogenesis was noted. They were similar to those recognized in the ovotestis of juveniles associated with a female. The specimen, ranking third in size (TL = 52 mm), had a very weak spermatogenic activity and looked like an immature gonad of a juvenile.

The observation of nesting success in the above four experimental groups showed that spawning occurred in the third group after 4 months of association, whereas nesting success was after 12 months in the first and second groups. In the fourth group, nesting success was after 20 to 24 months. The present study shows that in the absence or disappearance of adult female, the active male changes sex to female within a period of 25 weeks. The study also confirmed that the unusual aspects of sex reversal in *A. ocellaris* is from male to female (protandrous hermaphroditism) in which the largest and socially dominant fish in a particular anemone (or cluster of anemones) is generally the female, whose gonads are functional ovaries with

remnants of degenerate testicular tissues. The second largest fish in the same group is the active male that has functioning testis but also possess non-functioning or latent ovarian cells. If the dominant female dies or is experimentally removed from the "queue", the male not only changes sex but also grows at an accelerated rate and the new male grows faster to fill the size gap of the social group. This adaptation allows continuous reproduction, and this kind of social structure plays an important role on the sex changing mechanism.

OPO 13 **MECOS 09**

BIOACTIVE STUDIES ON *KAPPAPHYCUS ALVAREZII* AGAINST BACTERIAL PATHOGENS ISOLATED FROM INFECTED MARINE ORNAMENTAL FISHES

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In marine ornamental fish culture, diseases may badly affect the profitability. Diseases are mainly caused by virus, bacteria, fungi and protozoa. Viral and bacterial diseases are the most responsible factors for sudden mortality of fishes. Nowadays, using antibiotics to control the bacterial diseases is in practice, but extensive use of antibiotics might lead to the emergence of antibiotic resistant bacterial pathogens. Seaweed is a known source of iodine, an element necessary for thyroid function with deficiencies leading to goitre. It has been found that seaweeds may have curative properties for tuberculosis, arthritis, cold and influenza, worm infestations and even tumors. But the use of seaweed extracts in aquaculture, especially in ornamental fish culture, is limited.

In the present study, bacterial pathogens were isolated and identified from the infected marine ornamental fishes obtained from the hatchery and aquarium. Investigations on the potential activity of the seaweed, *Kappaphycus alvarezii* against the isolated pathogens were studied. Ethanol, methanol, chloroform and acetone extracts of *K. alvarezii* were screened for antibacterial activity and the minimal inhibitory concentration (MIC). Methanol and ethanol extracts of *K. alvarezii* showed maximum activity against 5 bacterial pathogens *viz*., *Aeromonas hydrophila, Pseudomonas aeruginosa, Vibrio alginolyticus, V. parahaemolyticus* and *Streptococcus* sp. The acetone extract had good activity against *Edwardsiella tarda*. The minimal inhibitory concentrations (MICs) of crude extracts were determined by broth dilution technique which ranged from 250 μg/ml to 800 μg/ml. The results indicated that *K. alvarezii* have a potential broad spectrum antibacterial activity.

Further, *in vivo* screening and purification studies were carried out to ascertain the antimicrobial potential of the seaweed.

OPO 14 **MECOS 09**

ISOLATION, CHARACTERIZATION AND BIOLOGICAL ACTIVITIES OF TOXIC COMPOUNDS FROM THE SEA ANEMONES *HETERACTICS MAGNIFICA* [QUOY AND GAIMARD, 1833] AND *STICODACTYLA MERTENSII* [BRANDT, 1835]

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Sea anemones are rich sources of biologically active substances. This work deals with the toxic proteins obtained from the sea anemones, *Heteractics magnifica* and *Stichodactyla mertensii*. To assess the toxic activity of the venom, crude toxin from the two anemones was extracted by two different methods after which the protein content was estimated. Several bioassays were carried out to evaluate the effect of crude toxins. *In vivo* toxicity assay was performed using the ocypod crab *Ocypoda macrocera*. The toxicity of the venom of the anemones, *H. magnifica* and *S. mertensii* increased with increasing concentrations. The extracts effected the death of the test animals within 5 minutes at a dosage of 5 mg/ml. Mortality was more pronounced in crabs challenged with *H. magnifica* acetone extract. Other changes like foaming, paralytic effect, colour changes and restlessness were also observed. Hemolytic activity was also tested for the two crude extracts against chick, goat and human blood erythrocytes. The activity was higher in the acetone extract of *H. magnifica* as compared to the acetone extract of *S. mertensii*. The minimal inhibitory concentration of the venom of both the anemones against two human pathogens, *Staphylococcus aureus* and *Salmonella typhi* was evaluated. Acetone extract of *H. magnifica* showed highest inhibition against *Staphylococcus aureus* (69.2%) and *Salmonella typhi* (63.2%). In *S. mertensii,* the acetone extracts showed 30% inhibition against *Staphylococcus aureus*. However, poor inhibition was observed against *Salmonella typhi*. The molecular weight of the bioactive proteins in both the extracts was determined by SDS-PAGE. Distinct bands were observed correspondingly in both *H. magnifica* and *S. mertensii* at 24.0 and 72.0 KDa in acetone precipitation extraction method.

OPO 15 **MECOS 09**

ISOLATION OF MULTIPLE ENZYME PRODUCING BACTERIA (*BACILLUS SUBTILIS*) FROM THE POLYCHAETE, *PERINEREIS CULTRIFERA*

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An attempt was made to isolate the multiple enzyme producing bacterial flora from the gastrointestinal tract of the polychaete *Perinereis cultrifera*. The bacteria *Bacillus subtilis* was identified and qualitatively screened on the basis of their extracellular enzyme producing ability. *Bacillus subtilis* was further quantitatively assayed for amylase, cellulase, lipase and protease activity and was found to produce 1026 IU/ml of amylase, 878 IU/ml of cellulose, 540 IU/ml of lipase and 824 IU/ml of protease. This study also indicates that these enzymes are a distinct microbial source of some digestive enzymes apart from endogenous sources in the gut of a polychaete. The findings of the present investigation would form baseline information for low-cost feed formulations in aquaculture incorporating the multiple enzyme producing bacterial isolate as a probiotic.

OPO 16 **MECOS 09**

IMMUNOSTIMULANTS IN THE IMMUNE RESPONSE OF *PENAEUS MONODON* (FABRICIUS)

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Marine invertebrates lack an acquired, memory-type immunity based on T-lymphocyte subsets and clonally derived immunoglobulins. Instead they rely solely on innate immune mechanisms that include both humoral and cellular responses. Humoral immunity in marine invertebrates is characterized by antimicrobial agents present in the blood cells and plasma, along with reactions such as haemolymph coagulation or melanization. The cellular component of marine invertebrate immunity is mediated by haemocytes, motile cells that phagocytize microbes and secrete soluble antimicrobial and cytotoxic substances into the haemolymph. The immune system of shrimp is relatively primitive when compared to that of fish. In shrimp, non-specific immune system plays an important role in the defence mechanism. Non-specific

immune systems such as phagocytosis, encapsulation, nodule formation, cytotoxicity, lectins and prophenoloxidase (proPO) play an important role in the defence mechanism of shrimps. Immunostimulants increase resistance to infectious diseases, not by increased specific immune responses, but by improving the non-specific defence mechanisms. Therefore, in the absence of the memory component, the response is likely to be of short duration. Immunostimulants comprise a group of biological and synthetic compounds that enhance the non-specific defence mechanisms in animals.

The effectiveness of three immunostimulants *viz*., vitamin C, levamisole and chitin on the proPO activity of haemolymph, on the growth of juveniles of the tiger shrimp *Penaeus monodon* (Fabricius) was assessed by administering them orally to the shrimps. The levels of incorporation of three immunostimulants in shrimp feed were vitamin C at 50, 150 and 250 mg/kg; levamisole at 5, 50 and 100 mg/kg and chitin at 50, 100 and 200 mg/kg levels. Juveniles were fed with the experimental diets (9 immunostimulants + 1 control) for 6, 10 and 15 days under laboratory conditions. The proPO activity, as a measure of immune enhancement in shrimp was recorded in haemocytes and plasma of experimental juvenile shrimps. The administration of immunostimulants incorporated diets resulted in relatively better growth rates than the control. The challenge studies were carried out for 6, 10 and 15 days. Considering the cumulative effects of proPO activity in haemocytes and plasma along with the growth increment and survival rate, levamisole at 5 mg/kg level followed by chitin at 100 mg/kg and vitamin C at 150 mg/kg level were found to be effective immunostimulant doses for incorporation in shrimp feeds to enable immune enhancement in cultivable shrimps. The prophenoloxidase assay standardised in the study is an effective and simple tool for measuring the immune enhancement in penaeid shrimps. It would go a long way to identify more immunostimulants and their optimum dosages for sustaining shrimp aquaculture.

OPO 17 **MECOS 09**

ANTIBACTERIAL ACTIVITY OF MARINE ACTINOMYCETES AGAINST HUMAN PATHOGENS

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Discovery of novel bioactive secondary metabolites from marine organisms is gaining importance in recent years. Among the marine organisms, actinomycetes are considered as vital source for diverse bioactive compounds. The current work is focused on diversity of marine actinomycetes of Tamil Nadu coast, to identify novel secondary metabolites with diverse bioactivity. Twenty five deep sea sediments and

45 seawater samples were collected during the cruise programme organized by the National Institute of Ocean Technology (NIOT), Chennai on board research vessel *Sagar Purvi*. Isolation of marine actinomycetes was carried out in different media prepared in natural seawater. Eighty five different actinomycetes were isolated from deep sea sediments, but no actinomycetes were obtained from seawater samples. All the isolates were checked for their antibacterial activity against two human pathogenic bacteria, *Staphylococcus aureus* (Streptomycin resistant) and *Pseudomonas aeruginosa* as well as antibiotic susceptible bacterial strain of *Bacillus pumilus*. Culture filtrates, ethyl acetate extracts of culture filtrate and mycelial biomass of all the 85 isolates were used in the antibacterial activity. All the 85 isolates showed inhibitory activity against all the three test organisms. However, only 10 isolates were selected for further studies as they exhibited high antibacterial activity. Interestingly, nine out of 10 isolates were from estuarine sediments. It implies that the estuary is a different niche compared to the marine locations, in which, conditions are frequently changing due to seasons. Perhaps, these actinomycetes undergo tremendous pressure to exist in the environment. Therefore it is likely that they try to produce different secondary metabolites in order to protect themselves in the extreme environment.

OPP 01 **MECOS 09**

BIOTECHNOLOGICAL APPROACH IN ENVIRONMENTAL IMPACT ASSESSMENT OF COASTAL AQUACULTURE

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Fish are the key species in aquatic environment and their protection is very much important for both ecological and economic reasons, as they are the source of major nutrients.

Biotechnological tools involving genetic engineering and r-DNA technology have a great potential in assessment of adverse effects by environment pollutants on organisms like fish and shellfish. However, traditional processes like biochemical, toxicological, cytological, physiological, genetical methods cannot be overlooked in ascertaining the adverse effects on aquatic life.

Biomarkers have been used in field monitoring studies in order to recognize polluted sites. It can also be applied in culture assays in laboratory to evaluate the potential environmental impact of individual chemical or for identifying the presence of pollutants in samples from the environment.

OPP 02 **MECOS 09**

THE BIOACTIVE COMPOUNDS OF LATEX OF *CALOTROPIS GIGANTEA* ON ANTIMICROBIAL ACTIVITY IN DIFFERENT FISHES

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Residual pesticides in soil and crops are transported from agricultural fields to the marine, surface and ground waters. The leaves and stems of *Calotropis gigantea (l.)r.Br.* are used in agriculture for soil fertility and insecticidal activity. C*alotropis* species contains physiologically active components namely cardiac glycosides (cardenolides) - calotropin, uscharin, voruscharin (dihydrousacharin), calotoxin, calactin, uscharidin, gigantin, triterpenes, pentacyclic triterpenoids and flavonoid triglycosides. These compounds are highly toxic and have direct effect on the animal heart and central nervous system. Calotropagenin is the common glycone of all the glycosides. Calotropin, gigantin and uscharin show digitalis-like action on heart. Many members of Asclepiadacea family are toxic and glycosides are known to cause gastro-intestinal toxicosis, inhibiting cellular membrane ATPase enzyme system activity during early course of poisoning. The animals exhibit rapid breathing, convulsions and irregular heart activity. Cattle and horses consuming cardiac glycoside-containing plants are often found dead. Their postmortem scrutiny revealed hemorrhages, congestion, edema and cell degeneration of organs including multifocal myocardial degeneration and necrosis. The antimicrobial activities of cardiac glycosides in different fishes are discussed in detail.

OPP 03 **MECOS 09**

GROWTH RESPONSES OF *PENAEUS MONODON* UNDER SEMI-INTENSIVE AND TRADITIONAL CULTURE SYSTEMS

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The black tiger shrimp *Penaeus monodon* is widely cultured due to its advantages over other species in terms of size, growth rate, wide range of salinity tolerance and established markets. Feed is a major component of production cost in semi-intensive culture systems. The feeding strategy in commercial culture of shrimp could have a significant impact on pond water quality, growth, health and survival of the shrimp as well as efficiency of feed utilization.

The present study deals with the growth responses of *P. monodon* under two semi-intensive culture systems (Farm A and Farm B) and a traditional culture system (Farm C). Water exchange of 50% was done in two weeks in the first two farms but daily water exchange was carried out in the latter. In Farm A and B, two different commercial feeds (Feed A and Feed B) were given while no feed was given in Farm C. Feeding was done thrice daily in Farm A and Farm B. A daily ration of about 2 kg of feed was given in Farm A and 1.5 kg of feed was given in Farm B. The physico- chemical parameters of pond water and soil and the average growth rate of shrimps were estimated. *P. monodon* (PL 15) was stocked at the rate of 35,000/ ha in Farm A and Farm B and 18,000/ha in Farm C.

Under semi-intensive culture system, the production was 950 kg/ha/crop and 1150 kg/ha/crop in Farm A and Farm B respectively in 107 days. An average length of 13.5 cm and weight of 19 g was obtained in Farm A. In Farm B, an average length of 15 cm and weight of 23.8 g was obtained. In farm C, the production was 214.6 kg/ha/crop with an average length of 15-19 cm and weight of 25-50 g. The water quality parameters analysed showed that the nutrient load of Farm A was in higher limits when compared to that of Farm B and Farm C. This might be due to over feeding resulting in the dissolution of excess feed in the water column. The growth performance of *P. monodon* was satisfactory and there was no record of diseases during the study period. The production and biomass increase per day were not significantly influenced by the different feed. From the present study it was observed that apart from feed, better water quality management practices determines the growth rate in shrimps.

OPP 04 **MECOS 09**

OCCURRENCE OF THE INVASIVE MUSSEL *MUSCULISTA SENHOUSIA* IN THE COCHIN BACKWATERS

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The invasive mussel *Musculista senhousia* (Family: Mytilidae) has been reported from Cochin backwaters. This is the first detailed study on the distribution, taxonomy and habitat of the mussel in India. They form thick beds in the high saline areas of the backwaters during summer. Low salinity ranges are not conducive for the survival. A substratum with a mixture of sand, silt and clay is found to be suitable for dense growth. Though *M. senhousia* does not have much food value to man, it is used as poultry feed. They are collected and transported in huge quantities of 200 -300 kg per day in summer months.

Poultry farmers claim that this feed promotes better growth and egg laying in ducks. This offers scope for biochemical as well as bio-active studies.

OPP 05 **MECOS 09**

EVALUATION OF ANALGESIC AND ANTI-INFLAMMATORY ACTIVITY OF RAY FISH CARTILAGE

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Sharks, rays and skates are cartilaginous fishes belonging to subclass Elasmobranchii. Shark cartilage has been used for years in cancer treatments and for arthritis, diabetic retinopathy and psoriosis. While there has been much work on the pharmacological activity of shark cartilage, comparatively less research has been undertaken on ray fish cartilage. In the present investigation, an attempt was made to evaluate the analgesic and anti-inflammatory activity of crude hexane fraction of ray fish cartilage using animal models. The results suggest that ray fish cartilage is also a productive source of bioactive substances.

OPP 06 **MECOS 09**

ECOFRIENDLY FATTENING OF MUD CRAB: AN APPROACH OF AQUASILVICULTURE IN MANGROVE ENVIRONMENT OF ANDAMAN ISLANDS

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Aquasilviculture is an important practice used for sustainable development of coastal aquaculture to minimize the impact on mangrove area and maintain the carrying capacity of the environment. Commercially important species of mud crabs belonging to the genus *Scylla* (Portunidae) are strongly associated with the mangroves. Fattening and growout practices of all the four species of mud crabs *Scylla serrata, S. tranquebarica, S. olivacea* and *S. paramamosain* are widely practiced in the brackishwaters associated with mangroves. Andaman and Nicobar islands (A & N Islands) are suitable for both fattening and growout systems for mud crab aquaculture. During pre-tsunami period, two sites, namely, Lakshmipur in North Andaman and Bamboo Tickri in Middle Andaman were selected for crab fattening in Andaman district. Tide-fed earthen ponds prepared within mangrove stands and mangrove species like *Rhizophora mucronata, R. apiculata* and *Avicennia marina* were abundant inside the mound covering 60-80% of the total pond area to maintain the culture

system as aquasilviculture. Low cost moult crabs (water crabs) of > 500g were procured and stocked at a density of 0.5 kg/m^2. Suitable hideouts were provided to prevent cannibalism among crabs. The crabs were fed on trash fish and clam meat and survival rate of 85% was achieved with an average of 8% weight increment of total biomass stocked at both places within 30-35 days. The earthquake, which struck A & N Island on 26th December 2004, and the consequent tsunami have made large area of agricultural lands unsuitable for agriculture due to inundation. Similarly wider mangrove areas were degraded due to elevation and subsidence of land. In this paper, application of proper measures for aquasilviculture practices in mangroves as well as mangrove free environment with its economics and limitations are discussed. Further, proper utilization of newly inundated lands as well as its site dependent factors will also be presented.

OPP 07 **MECOS 09**

STUDIES ON BIOCHEMICAL COMPOSITION OF COPEPOD *OITHONA RIGIDA*, ROTIFER *BRACHIONUS PLICATILIS* AND BRANCHIOPOD *ARTEMIA* NAUPLII

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Marine copepods are considered to be nutritionally superior live feeds for commercially important cultivable species, as they are valuable source of protein, amino acids, lipid, fatty acids, carbohydrate and enzymes. Biochemical constituents of the laboratory cultured copepod *Oithona rigida* were compared with other traditional live feed organisms like rotifer *Brachionus plicatilis* and branchiopod *Artemia* nauplii. The copepod *O. rigida* showed greater variations in biochemical composition. The protein formed the major component in all the three live feed organisms. Protein, carbohydrate and lipid contents of *O. rigida* were 69.24, 11.44 and 15.36% respectively. *O. rigida* contained higher amino acid of 63.50% than *B. plicatilis* (56.22%) and *Artemia* nauplii (50.64%) in dry matter. The total fatty acid content of *O. rigida* was 98.05%, which is higher than *B. plicatilis* (82.01%) and *Artemia* nauplii (86.40%). Highly unsaturated fatty acids (HUFA) like Eicosapentanoic acid (7.81%) and Docosahaexanoic acid (9.49%) were rich in the copepod. The values (%) of polyunsaturated fatty acids (PUFA) such as linoleic acid, arachidonic acid and linolenic acid of copepod were 0.61, 1.81 and 0.59 respectively.

OPP 08 **MECOS 09**

ANTI-*RHIZOCTONIA* ACTIVITY OF *STREPTOMYCES LIENOMYCINI*, A MARINE ISOLATE

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Biocontrol potential of a marine actinomycete isolate (MNG-127), *Streptomyces lienomycini*, was evaluated using *Rhizoctonia solani* as the target pathogen. In dual culture assay, the actinomycete displayed strong inhibitory effect. Production of antifungal metabolites was favored under static culture conditions and was much better in yeast extract-malt extract and potato dextrose broth. Production was higher at pH 8 on 16th day of incubation. The active principle displayed better activity between pH 7 and 9. Heat treatment at 50-100ºC for 30 min at and 121ºC for 20 min did not affect the potency of the culture filtrate. The culture filtrate also showed wide spectrum activity. Partial purification of the culture filtrate resulted in four active fractions. Though all the fractions exhibited activity, the aqueous fraction was more active followed by benzene fraction.

The isolate grew well in almost all the media tested, produced grey aerial mycelium, cream colored basal mycelium and brown to yellowish brown reverse colour and produced brownish green diffusible pigment. Melanin production was noticed in ISP-7. Scanning electron microscopic analysis revealed presence of long chains of smooth walled spores. The organism was positive for urease, lipase, catalase, protease, phosphatase, cellulase and indole production. It neither reduced nitrate nor utilized citrate. Partial sequencing of 16S rRNA gene of the isolate was carried out at the MIDI Labs. Inc, USA. The sequence was deposited in GenBank (EMBL) database under accession no. EU 139307. Based on the 16S rRNA gene sequence homology, the isolate MNG-127 was identified as *Streptomyces lienomycini*. Survey of literature revealed that this is the first report on anti-*Rhizoctonia* activity of *Streptomyces lienomycini* from India.

OPP 09 **MECOS 09**

ANTIMICROBIAL PEPTIDES FROM MARINE FISHES

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The primary interference of fish with environment is through a mucous layer that covers their entire body. Marine fishes possess antimicrobial peptides as a part of their defense system, which are mainly present in the mucous layer indicating

that they eliminate the pathogenic bacteria before they enter the skin barrier. A number of á-helical antimicrobial peptides (AMP) such as pardaxins, misgurin, pleurocidins, parasin, oncorhyncin II and III, chrysophsin and HFIAPs have been isolated from different species of fishes. However, studies on the role of antimicrobial peptides in fishes are very limited. Various mechanisms developed by multicellular organisms in nonspecific immunity raise questions on the role of antibiotic peptide as a deterrent against infection. The present study provides a general introduction to the subject with special emphasis on the role of bioactive peptides in marine fishes. Their mode of action and defending mechanism of antimicrobial peptides are also discussed.

OPP 10 **MECOS 09**

EMPLOYMENT OPPORTUNITIES FOR WOMEN SELF-HELP GROUPS IN THE MARINE SECTOR IN ORISSA- ROLE OF BANK CREDIT

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The database on 228 Women Self-Help Groups (WSHGs) in Puri, Orissa undertaking various activities in the marine sector and having bank linkage during 2002-03 to 2007-08 was collected from an N.G.O PENCODE. The WSHGs earning their livelihood were from activities like making fish pickle, dry fish and fish trade. A total amount of Rs.82,38,000/- was sanctioned to the groups during the period from 2002-03 to 2007-08 with an amount of Rs.1,77,000/- in 2002-03 and Rs. 21,85,000/- in 2007-08 registering substantial increase. It is observed that the number of WSHGs linked with different banks had increased annually by 60% during 2002-03 to 2007-08 and the percentage of repayment till in November 2008 is more than 50% in the case of all the 228 WSHGs. Out of the 228 WSHGs, 3 WSHGs had repaid more than 90% of loan. The trend in the sanctioned loan and repayment by the groups indicate the generation of employment and incremental income of the group members and thus improving their socio-economic status.

The members of the three groups who repaid more than 90% of the loan were interviewed and the Monthly Per Capita Consumption Expenditure (MPCE) for 3 months from August to October 2008 was analyzed. It is observed that the MPCE for 3 months showed an increasing order of incremental income of the groups. The average MPCE of WSHGs with bank linkage is significantly higher than that of neighboring fishermen community without bank linkage. The monthly incremental income resulted in increasing the monthly expenditure under different consumption heads *viz.*, food, clothing, health, education, durable goods and miscellaneous expenses. The factors responsible for incremental income of the groups were analyzed using multivariate regression.

OPP 11 **MECOS 09**

LIVELIHOOD SECURITY AND ENTREPRENEUR OPPORTUNITIES IN COASTAL FISHERIES OF ANDHRA PRADESH

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Fisheries sector plays a vital role in meeting the food security of the country. The need for enhancing fisheries production either through capture or culture is to meet the basic demand for protein rich food. Andhra Pradesh with a long coastal stretch of 974 km goes long way in meeting the food production through capture fisheries. The total marine fish landings of India during the year 2007 has been estimated at 2.88 million tonnes showing an increase of about 1.7 lakh tonnes (6.3%) against the estimate of 2006. The total marine landings of Andhra Pradesh was estimated at 2,10,864 tonnes (2007). About 30% of the total marine fish landings are by-catches and low-value fishes. These can be converted into value added products not only to avoid wastage of valuable protein but also to open up employment opportunities and additional income to the rural fisher women.

Transfer of rural appropriate technology with special emphasize on women empowerment will be locally relevant, easily assimilable and economically viable so that transcribing the same will be easy for the beneficiaries.

The present paper focuses on the livelihood security among selfhelp groups of fisherwomen in the coastal area of Andhra Pradesh by generating employment through processing and value addition of cheap fishery resources.

OPP 12 **MECOS 09**

MARINE FUNGI AS SOURCE OF A GLUCOSIDASE ENZYME FOR BIOETHANOL PRODUCTION

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Ethanol blended petrol can reduce our dependency on fossil fuel import. With ever-increasing oil prices and shortage, the government of India has accepted a National biofuel policy to enhance the proportion of biofuels from 5% to 20%. In India, ethanol is produced from sugarcane. However, our dependency on monsoon for sugarcane production makes it an unreliable feedstock for alcohol production.

Enzymatic conversion of lignocellulosic biomass is projected to be the most important route for fuel generation for the future. Cellulose, the major component can be converted in to glucose by the synergistic action of three enzymes namely endoglucanase which produces nicks in cellulose exposing reducing and non reducing ends, cellobiohydrolase which acts on these fragments to release cellobiose and â glucosidase that cleaves cellobiose in to glucose. The glucose can be fermented using suitable yeast strains to produce ethanol. Most of the cellulose decomposers are deficient in â glucosidase enzyme and are subjected to product inhibition. With the vast stretch of coastal area remaining unexplored, the marine ecosystem offers great opportunity for isolating fungi capable of secreting considerable amounts of â glucosidase showing low product inhibition.

Sediments from coastal areas and brackishwaters were collected and fungi were isolated by serial dilution and pour plate method using mycological broth supplemented with 1.5 % NaCl. Of the 103 fungi isolated, 46 strains showed â glucosidase production. The strain SA 56, identified as *Aspergillus* sp. showing high production was selected for the present study. Parameters for maximum enzyme production were optimized. Non-cellulosic carbon sources like pectin, starch and xylose induced more enzyme production than cellulosic substrates. Among the carbon sources, pectin at a concentration of 1% showed maximum enzyme production. Fungus was capable of enzyme production both in acidic and alkaline range, while a temperature of 35° C was found to be the optimum. Addition of organic non defined nitrogen sources showed increased production, and beef extract was found to have profound effect on enzyme production. Acetone precipitation of the enzyme followed by native PAGE and zymogram using methyl umbelliferyl â D glucopyranoside revealed two distinct bands of activity. This strain with high production in acidic as well alkaline pH range makes it a potential strain for â glucosidase production, which can be subsequently employed for bioethanol production from cellulosic substrates.

OPP 13 **MECOS 09**

SEA-CAGE CULTURE OF BIGEYE TREVALLY *CARANX SEXFASCIATUS* QUOY & GAIMARD, 1825 IN VIZHINJAM BAY, SOUTHWEST COAST OF INDIA

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The potential for using suspended sea cages for farming bigeye trevally *Caranx sexfasciatus* was assessed in Vizhinjam Bay, southwest coast of India. The cage was stocked using wild caught juveniles of average total length of 81.7 mm and 7.8 g weight. The fishes were fed with anchovies at the rate of 5-7 % of body weight. They grew healthy and were harvested at the end of ten months rearing. They reached a size of 303 mm in average length and 563 g in average weight. Large

scale fouling of the cage was noticed during the rearing period. Regular cleaning of the cage was carried out during the rearing. The main organisms found fouling the cage were sponges, seaweeds, ascidians, barnacles, mussels and oysters. The results indicated that suspended sea-cage culture has considerable potential for the aquaculture of *C. sexfasciatus* juveniles but will require careful selection of sites and development of effective feeding arrangements**.**

OPP 14 **MECOS 09**

EFFECT OF DIETARY SALT ON SURVIVAL AND GROWTH OF ASIAN SEA BASS (*LATES CALCARIFER* BLOCH) FINGERLINGS REARED IN FRESHWATER

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The Asian sea bass (*Lates calcarifer* Bloch) is a diadromous fish of the family *Latidae,* order *Perciformes* that occurs in tropical and semi-tropical areas of the Indo-Pacific. It is a euryhaline fish of commercial importance as well as a sport fish. This species inhabits rivers and descends to estuaries and tidal flats to spawn. Several studies have reported that dietary salt influences the growth and survival in a number of fish species. Significantly better growth, survival and feed conversion ratio have been reported earlier in the postlarvae of Asian sea bass reared in freshwater and fed on 4% salt enriched diet. A recent study has shown that Asian sea bass juveniles reared in freshwater grew better with higher survival rate when fed salt rich diets higher than 4%. Based on the above findings, the present study was conducted for finding the more optimal dietary salt levels for the Asian sea bass fingerlings reared in freshwater.

The indoor experimental setup consisted of fifteen rectangular rearing tanks each of 100 l capacity. The tanks were grouped into five separate systems each consisting of three rearing tanks connected to one common water-cleaning unit. Dechlorinated freshwater was recirculated in each system at the rate of 3 l per minute. Thirty percent of the dechlorinated freshwater was replaced daily in each system to compensate for losses from evaporation and sludge removal.

Fingerlings (X= 3.3g; 108 days old) of Asian sea bass, produced by induced spawning (Maagan Michael Hatchery, Israel), were used for the 56-day experiment. Sixty-five fish were randomly stocked in each of the 15 rearing tanks.

Experimental salt rich diets were prepared by adding salt to a commercial pelleted fish feed (protein 45%, lipid 14%, ash 2.4% and fiber 9.4%; Rannan Company, Israel). The pellet first ground and then repelleted after adding salt. The

salt was obtained by evaporation of the brine (53.7ppt, TDS) that was produced during desalination of brackish geothermal water from a deep well located in the Israeli Negev desert. Fish were fed *ad libitum* three times daily. Fish in system 1 were fed the control diet, in system 2 were fed 5% salt-rich diet, in system 3 were fed 6% salt-rich diet, in system 4 were fed 7% salt-rich diet and in system 5 were fed 8% salt-rich diet.

Samples (n = 30) from each experimental group were weighed every two weeks using a digital scale for monitoring growth performance. Survival and feed conversion ratio were monitored daily. The growth and survival data were analyzed using one-way ANOVA and Tukey's Multiple Range Test.

The highest growth ($p < 0.05$) and survival rate were achieved by fish fed 6% salt-rich diet followed by the fish fed 5% salt rich diet and the control diet. Of all the groups, fish fed 8% salt-rich diet showed the lowest growth and survival rate. The best specific growth rate (SGR), feed conversion ratio (FCR) and protein efficiency ratio (PER) were also observed in the groups fed 6% salt-rich diet (Table 1).

Table 1. Growth performances of Asian sea bass fingerlings reared in freshwater and fed salt rich diets for 8 weeks

	Control	5% salt	6% salt	7% salt	8% salt
Initial weight (g.)	3.3 ± 1.2	3.3 ± 1.2	3.3 ± 1.2	3.3 ± 1.2	3.3 ± 1.2
Final weight (g.)	20.1^{a} ± 2.5	21.0 ^{a} ± 1.7	22.5 ^{b} ± 1.4	16.3 ^{b} ± 1.6	14.64 ^{c} ± 1.7
Weight gain (g.)	16.8	17.7	19.2	13.0	11.3
Average weight gain (%)	509.0	537.5	582.7	396.3	343.6
Feed conversion ratio (FCR)	2.05	1.69	1.34	2.43	2.81
Protein efficiency ratio (PER)	1.083	1.307	1.653	0.911	0.790
Specific growth rate (SGR; % d^{-1})	0.868	0.914	0.982	0.664	0.551
Survival (%)	65.1	73.8	85.6	56.9	49.7

a, b, c and d denote significant differences at $p < 0.05$ level by one-way ANOVA and Tukey's Multiple Range Test

The results of the present study demonstrate that the growth of Asian sea bass fingerlings can be significantly improved by incorporating 6% salt in the diet. Earlier studies have suggested that dietary salt influences the growth by increasing the feed conversion ratio. No detrimental effects on the fish were recorded when feeding with the tested diets.

For rearing Asian sea bass in freshwater, it is recommended to supplement the fish diet with 6% salt in order to achieve better growth, survival and feed efficiency.

OPP 15 **MECOS 09**

SERINE PROTEASE ENZYME INHIBITOR FROM MARINE BACTERIA: IMPLICATIONS FOR INHIBITION OF MICROBIAL GROWTH

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Enzyme inhibitors have received increasing attention as useful tools, not only for the study of enzyme structures and reaction mechanisms but also for potential utilization in pharmacology, agriculture, food and detergent industries. A protease inhibitor impairs the enzyme responsible for the breakdown of protein thereby blocking its function. Proteolysis has emerged as an essential mechanism of major biological processes. Hence, specific and selective protease inhibitors are potential and powerful tools for inactivating target proteases in food spoilage as well as in pathogenic processes.

Microbes are preferred source of protease inhibitors in view of their rapid growth, limited space required for cultivation, and ready accessibility to genetic manipulation. Marine bacteria are one of the richest sources of bioactive compounds, and have only marginally been investigated. Thus it was desired to screen marine bacteria for protease inhibitors and evaluate the antimicrobial activity potential of the purified inhibitor.

The major objective is to screen marine bacteria for protease inhibitors and study their prospective applications in food and therapeutic industries. The isolates of marine bacteria from the marine environments of Cochin were screened for inhibitory activity against trypsin. It was observed that marine environments have potential microorganisms that could produce molecules that have inhibitory activity against trypsin. All the positive cultures that showed inhibition were further reconfirmed for production of inhibitor molecules using liquid assay and those having maximum inhibitory activity were selected for further study.

Selected bacterium was used for the production of extract in bulk to carry out isolation and purification of protease inhibitor employing standard protocols like salting out, dialysis, chromatography and electrophoretic methods. Again we have evaluated the antimicrobial potential of the purified inhibitor. The production optimization and property studies affecting the inhibitory activity are under study to check their applicability in different biotechnological processes.

OPP 16 **MECOS 09**

MESOPELAGIC ORGANISMS FROM THE DEEP SCATTERING LAYER OF CENTRAL ARABIAN SEA DURING THE SUMMER MONSOON

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Mesopelagic organisms were collected from the deep scattering layer (DSL) of central Arabian Sea (AS) during RV *Roger Revelle* cruise from August-September, 2007. The DSL was found between 200 and 500 m depth during the day and between the surface and 200 m during night. Out of 25 groups obtained from the DSL biocomposition, 7 were mesopelagic fishes and 18 were zooplankton. Among the mesopelagics, fishes, shrimps, leptocephalus, fish larvae and myctophids were the dominant groups, while chaetognaths, siphonophores, euphausiids and decapods dominated the zooplankton. Due to the variations in availability of light, food and oxygen concentration in the mesopelagic zone, these DSL organisms were found to exhibit diurnal vertical migration. The vertical profile of dissolved oxygen concentration showed significant variation with high concentration at surface (~200 μM) and high oxygen deficiency (20 μM) in the intermediate depths (100 - 500 m). Most of the organisms were recorded from the oxygen minimum zone (OMZ) in the depth range of 100 - 500 m during the day and in the oxygenated surface waters during the night.

OPP 17 **MECOS 09**

MARICULTURE OF *KAPPAPHYCUS ALVAREZII* ALONG MALABAR COAST, KERALA

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Kappa carrageenan producing red alga *Kappaphycus alvarezii* was cultured in Thikkodi near Kozhikode of Malabar coast, by adopting raft culture method in sub-tidal water pool to determine the viability of producing this seaweed commercially.

A series of culture experiments were carried out during the post-monsoon period 2006. A maximum of 30-fold increase in weight was obtained in 63 days and a minimum of 12.6-fold increase during January and February 2006. Hydrographical parameters such as temperature, salinity, dissolved oxygen, pH and nutrients such as nitrate, nitrite, phosphate and silicate were also estimated during the culture period.

During the post-monsoon period, due to availability of nutrient rich, less turbid water, this species showed very high growth. This study shows that *Kappaphycus alvarezii* is very fast growing species and can be grown successfully along the Malabar coast. Since the Malabar coast is free from industrial activities and pollution, it is a suitable area for farming the fast growing *Kappaphycus alvarezii*.

OPP 18 **MECOS 09**

THE IMPACT OF LATEX OF *CALOTROPIS GIGANTEAN* (LR) B.R ON POSTLARVAE OF *PENAEUS INDICUS*

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Viral infection, especially the monodon bacculo viral infection also called SEMBV (systemic ectodermal mesodermal and bacculo virus) infection, poses a great threat to the shrimp aquaculture. The postlarvae collected from the estuary, mangrove area and hatchery, and also the larvae collected from the hightide of Bay of Bengal are prone to be infected by SEMBV which is also known as white spot disease. This results in the mortality of postlarvae. The present work shows that incorporation of serum of latex of *Calotropis gigantean* (L.r) B.r along with the feed, gives better results as it reduces the mortality of PL 20. In histopathological findings, the intraocular bodies were seen in the hepatopancreas, which are indicative of the disease. The remedial measures to overcome the disease may be addition of serum which may include bioactive compounds, and protect the shrimp from white spot disease at the stage of PL-20. The methodology and significant findings are discussed in detail.

OPP 19 **MECOS 09**

FEEDING ELASTICITY OF PLANKTONIC COPEPOD *PSEUDODIAPTOMUS ANNANDALEI* (COPEPODA: CALANOIDA)

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Studies on feeding elasticity gives a clue in the energy transfer between trophic levels. Very few studies have been carried out on the feeding behavior and size selectivity in tropical waters. An experiment was conducted to understand the feeding elasticity of *Pseudodiaptomus annandalei,* a common pelagic calanoid copepod in Cochin backwaters. Phytoplankton of particle size ranging from 3-13 μm (*Skeletonema*

costatum, Chaetoceros sp., *Isochrysis galbana* and *Chlorella* sp.) were collected from the same site, cultured (mono and mixed) and used as food for conducting the experiment. Experiments with mono and mixed algal culture revealed that *P. annandalei* is showing selectivity of size range of 8-13 μm with preference to *Skeletonema costatum and Isochrysis galbana*. The maximum filtration rate was 1.5 ml. copepod^{-1}. h^{-1} and the ingestion rate was 3.5 μm x10^6 cells. copepod^{-1}. h^{-1}. The study showed that the filtration rate decreased steadily with increase in concentration of food while ingestion rate increased to the maximum and then decreased with increase in the concentration of food.

OPP 20 **MECOS 09**

ISOLATION, PURIFICATION AND PARTIAL CHARACTERISATION OF VIBRIOPHAGES FROM MANGROVE ECOSYSTEM

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Bacteriophages are viruses whose hosts are bacterial cells. Like all viruses, phages are metabolically inert in their extra-cellular form, reproducing only after infecting suitable host bacteria. Discovered over 80 years ago, they have played a key role in the development of modern biotechnology. Their defined host specificity facilitated their application in the typing and identification of a wide range of bacteria. While providing a valuable resource to the development of modern biotechnology, their ability to mobilize and transfer toxin genes in the environment is viewed with concern. Present study is on the vibriophages isolated from the marine system and its physiochemical characterization.

Environmental samples were collected from mangrove ecosystems of Kannamally track off Cochin. *Vibrios* strains isolated from the water samples on TCBS plates and characterized to species level using biochemical and molecular tools, were used as host for phage isolation. Enrichment technique was followed for the isolation of vibriophages. Induction by mitomycin C was used to study the lysogenic nature of phages. The filtrates were also tested for the presence of bacteriophages by diluting and plating onto lawns of vibrios by the soft agar overlay method. Phages from representative plaques were used for the production of high-titer stocks, which were used to study the genetic character, the morphology by EM and for the physiochemical analysis.

OPP 21 **MECOS 09**

DYNAMICS OF GROUP FORMATION, DECISION MAKING AND PERFORMANCE OF WOMEN SHGS AMONG FISHERS

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The SHG model in Kerala has evolved as an effective strategy for poverty alleviation, human development and social empowerment. Predominantly women oriented, it has played an important role in bringing about a change in the socioeconomic status of women leading to their empowerment and instilling in them a sense of self esteem. In Kerala, there are about two lakh women self-help groups. Most SHG-based programmes are implemented by the State in partnership with NGOs or by NGOs in association with donor agencies. SHGs besides being engaged in various economic activities also provide a forum for group learning and developing personal and professional skills paving way for empowerment.

This paper analyses the dynamics of group formation and decision making in the women SHGs in Chellanam village of Ernakulam district in Kerala. The role of the Chellanam-Kandakadavu Fishermen Welfare Development Cooperative Society, managed by persons belonging to the fishermen community, in catalyzing the movement is examined. The role of change agents has been critical in the successful operation of the groups. The groups are engaged in various economic activities and are supported by the Society through management of credit, regulating the activities and evaluating their performance. Change in the livelihood options of women of the fishermen community as a result of this movement was studied.

OPP 22 **MECOS 09**

ISOLATION OF A NOVEL PROTEASE GENE USING METAGENOMIC APPROACH

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Soil microorganisms serve as a valuable reservoir for many biomolecules. The rate of exploitation of these molecules is very low as majority of these organisms cannot be cultivated by conventional culture techniques. This problem can be solved by direct isolation and cloning of DNA from any environmental sample thereby

bypassing the need for culturing microorganisms. Metagenomics is the culture-independent genomic analysis of microbial communities which provides opportunities to fully explore and exploit the enormous genetic and metabolic diversity of soil microorganisms.

Sediment samples from mangroves of the Kannamali tract off Cochin were used for the study. DNA was isolated by a method which involves lysis with a high salt extraction buffer (1.5 M NaCl) and extended heating (2-3 hours) of the soil suspension in the presence of SDS, CTAB and proteinase K. The DNA obtained was purified using a commercially available kit. Shot gun cloning technique using Sau3A1 and BamH1 was used for cloning the metagenomic DNA into *E.coli* DH5á. The library containing 205 clones were screened for proteolytic activity by patching them on skimmed milk agar plate. The plasmids were isolated from the protease positive clones and double digested to pull out the insert DNA, which were ~5kb size. The clones were also screened for antibacterial property against a wide range of test organisms.

OPP 23 **MECOS 09**

CHARACTERISATION AND DIVERSITY OF POLYHYDROXYALKANOATES PRODUCING VIBRIOS INHABITING MARINE BENTHIC ENVIRONMENTS

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Benthic environments represent a largely untapped source for isolation of new microorganisms with potential to produce industrially useful compounds. *Vibrios* inhabiting benthic environments deserve special attention because they have been reported to be a dominant flora among the commensally heterotrophic bacteria in Cochin backwaters and nearshore areas of west coast of India. Bacteria under unbalanced growth conditions of carbon substrate in excess of other nutrients, like nitrogen, sulfur, phosphorus or oxygen are known to accumulate polyesters like polyhydroxyalkanoates (PHAs). These polyesters are biodegradable and biocompatible and thus useful for the development of non-petroleum based biodegradable plastics. Accumulation of reserve polymers such as polyhydroxyalkanoates (PHAs) increases survival in changing environments like benthic environments.

Sediment samples were collected from benthic environments in the Cochin backwaters, Mangalavanam mangroves and east coast of India. A total of 850 isolates were isolated and identified as genus *Vibrio* employing biochemical methods. More than 60% of these isolates were found to be potential producers of polyhydroxyalknoates in the preliminary screening and a total of 70 isolates were selected for further studies. These PHA producers were characterized to species level using HiVibrio identification kit. *Vibrios* were screened for extracellular hydrolytic enzymes like amylase, lipase,

caseinase, cellulase, xylanase, alginase, DNAse, phosphatase gelatinase and pectinase. Extracellular-hydrolytic enzyme profile was constructed and it showed that most of the isolates were potential producers of casienase, lipase, amylase, gelatinase and Dnase. The multiple antibiotic resistance pattern (MAR INDEX) of these isolates were also studied. From the results it was noticed that PHA producing *Vibrios* from the benthic environment are a markedly diverse group. The extracellular enzyme and antibiotic profile of the PHAs producers are indicative of the stressful environment in which the benthic *Vibrios* survive.

OPP 24 **MECOS 09**

EDIBLE OYSTER CULTURE – AN ALTERNATIVE LIVELIHOOD FOR POVERTY STRICKEN PEOPLE OF SUNDARBANS WETLAND

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In order to defray the poverty-stricken people from entering into the mangrove forest for cutting timbers, collecting honey or illegal poaching of wild animals, oyster culture was initiated in this mangrove dominated deltaic lobe at the apex of Bay of Bengal in 2006. Protein, lipid and glycogen content of oysters were analyzed on monthly basis for a period of two years along with simultaneous monitoring of hydrological parameters such as surface water temperature, salinity, pH, nitrate, phosphate and silicate. Phytopigment level of the ambient water was also analysed. The two-year study indicates significant positive relationship of oyster growth with phytopigment concentration, salinity, pH and water temperature.

Culture of edible oyster was undertaken during 2007 and 2008 at Uttar Chandanpiri under Namkhana block of South 24 Parganas district of West Bengal. Prior to initiation of the culture, a feasibility study was conducted to know the ambient water salinity, pH, water temperature and plankton density. The water quality showed a congenial environment (except extinction coefficient, which is an indicator of water turbidity) for the culture of edible oyster. Wild collection of natural spat from Frazergaunge fish landing station was done to initiate the programme. The first year could not see the success of the project as there was 90% mortality due to heavy downpour and subsequent lowering of salinity. The run-off from the adjacent landmasses increased the turbidity. The salinity in August, 2007 dropped to 2 ppt and the extinction coefficient raised up to 12 m^{-1} at the culture site. The results from the first year were taken into consideration and the second year of the project witnessed success with respect to weight gain and protein level of the oyster. A comparison of the cultured individuals was done with the natural population of the oyster in Frazergaunge. The weight gain was 316.67% in culture condition (initial

weight 6 g and final weight 25 g) and 233.33% in wild (initial weight 6 g and final weight 20 g) at the end of 6 months culture period (January to June 2008). The silt on the oyster shell was removed mechanically during culture at regular intervals to avoid gill closing by sediment. The protein content of the cultured oyster was higher (11.60%) than that of the oysters collected from wild (11.15%). The turbid water of Frazergaunge along with the stress posed by regular activities of fishing vessels and trawlers of the area may be one of the possible causes of deterioration of biochemical quality of oyster in the wild. The culture site situated in a shelter tide fed canal provides a congenial environment for the growth of oyster, which has been reflected through water quality of the site and protein content of oysters. Therefore, more research is required for standardization and establishment of oyster culture technique in and around coastal West Bengal. This will not only meet the protein deficiency of coastal population, but may also provide a source of income, if scientifically backed and proper scale-up is attempted. The culture of the species can also shoot out a spin-off industry as oyster shell can be a source of calcium for poultry and piggery sectors. This paper also highlights a comparative study of protein level and edibility value of the edible oyster (*Saccostrea cucullata*) between cultured and natural condition of Indian Sundarbans with respect to hydrobiological parameters.

OPP 25 **MECOS 09**

MEDICINAL VALUE AND ANTIMICROBIAL PROPERTIES OF INDIAN MANGROVES: SCOPE FOR DISEASE MANAGEMENT IN AQUACULTURE

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In India, 6,419 km^2 area is covered by mangrove forest. A total of 44 families comprising 71 genera and 112 spices of mangroves and mangrove associated plants are present along the Indian coast.

In popular Indian folklore medicine, the mangrove plants are reported to control asthma, elephantiasis, hemorrhage, jaundice, malaria, syphilis, tuberculosis and ulcers. The red mangrove *Rhizophora mangle* has anti-diabetic and anti-hyperglycemic property. The leaf extracts of *Acanthus ilicifoliusis* used to treat poison arrow wounds and snake bites. *A. ebracteatusis* used to treat kidney stones.

The phytochemical analysis of various mangrove plants indicates the presence of biologically active compounds including tannins, flavonoids, sterols, coumarins, glycosides and organic acids. Alkaloids and saponins are absent in most of the mangrove extracts, which means there is no toxicity.

The leaves of *Excoecaria agallocha* have antibacterial and antifungal activities. Gargles of mangrove bark can cure throat cancer. A polysaccharide extracted from the leaf of *Rhizophora apiculata* inhibits HIV-I and HIV-2. Hence it can be used to control AIDS in early stages. The leaf extract of *Finlaysonia obovata* exhibited antibacterial activity against the freshwater fish pathogens such as *Aeromonas hydrophila, Pseudomonas aeruginosa, Vibrio alginolyticus, Staphylococcus aureus, Escherichia coli* and *Edwardsiella tarda*.

Further research and development on the phytochemical constituents of mangrove plants and their structures are needed, not only for the discovery of new drugs for the emerging diseases causing viral pathogens in aquaculture like WSSV, YHV, IHNV, IPNV etc. and potent bacterial pathogens, but also for "deciphering" the value of folklore remedies.

Ecosystem Health - EH

EHO 01 – KEYNOTE ADDRESS MECOS 09

THE HEALTH OF THE MARINE ECOSYSTEMS – KEY TO SUSTAINABILITY OF BIODIVERSITY, ECOSYSTEM GOODS AND SERVICES

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This paper is based on existing published literature and reports on the subject combined with the author's knowledge, experience and familiarity with the Indian situation.

Of the eight ecosystems in the world, the ocean is by far the largest, encompassing approximately 70% of earth's biosphere and harbours a vast diversity of flora and fauna, serving as an important source of food, mineral resources, biomedical products and multifarious services. Once considered inexhaustible of the resources, the world's oceans have been stated to be stressed by natural (reversible) and human-induced (often irreversible) pressures leading to changes in the structure and organization of marine communities. These impacts, which are elaborated, have been reported to have resulted in reduction in fish and shellfish resources, reduction or loss of species of biomedical value, changes in species composition, functioning of the very ecosystems, and alteration of coastal habitats indirectly affecting the social, economic and cultural background of communities. The World Summit on Sustainable Development (WSSD) rightly recognized the current inadequate protection to oceans and coasts, and suggested creation of representative networks of Marine Protected Areas (MPAs) by the year 2012. In this context, the paper also refers to the study by 82 nations on Census of Marine Life which is progressing for the last ten years. The study is aiming to help protect life in the seas (from overfishing, pollution and climate change) and seeking to map the oceans from microbes to whales. The study has identified 5300 new species thus adding to the existing biodiversity although the sustainability of marine biodiversity is continuously threatened by human and natural phenomena.

Marine ecosystems spreading from the intertidal region to the abyss include a broad range of saltwater ecosystems such as the oceans, backwaters, lagoons, estuaries, seagrass beds, coral reefs, mangrove forests, mudflats, marshes and rocky, gravel and sandy shores. The paper details the key roles played by and the health of these sensitive and fragile ecosystems providing the countless ecological and economic benefits to humankind that justify their sustainable use.

The health of coastal marine ecosystems has been found to be affected to the extent of their annihilation due to overfishing leading to depletion of top predators and suspension feeders that filter microbes, which in turn result in opportunistic microbial explosions, toxic blooms, eutrophication and diseases affecting even human

beings. The role of harmful algal blooms (HABs), fungi, bacteria and viruses and the consequent chronic morbidity, mortality, disease epidemics, pathogens and invasive species which have been constantly increasing and drastically affecting the ecosystem health has been referred to.

Aquaculture chemicals and pesticides which are known to cause toxicity in the marine environment alter waste assimilation in coastal areas and destroy nursery areas of oceanic fisheries. Aquaculture also indirectly encourages fishing down the food chain (for fish feed organisms) thus not reducing demand on marine ecosystems. The usefulness of manatees, bottlenose dolphins and seabirds as good sentinels of marine ecosystem health has been mentioned.

Natural and anthropogenic changes affecting the health of large marine ecosystems (LMEs) which are estimated to produce nearly 95% of usable marine biomass are briefly dealt with. Overfishing which has substantial ecosystem effects has been identified as a single major cause of depleting ocean fish stocks. According to FAO, 25% of all known fish populations are already overfished and another 50% are considered completely exploited. Growing demand and industrial scale fishing, which intensified the exploitation of marine ecosystems and transformed natural conditions, have been found to be destroying global fish stocks, indicating the failure of management to achieve principal goal, sustainability. Excessive removal of top predators like the sharks and others which depend on lower trophic levels, vulnerable to overfishing and playing a crucial role in the balance and health of marine ecosystems, coupled with continued and competitive fishing at lower levels of the food chain would lead to wholesale collapse of marine ecosystems. However, marine ecosystems and marine fish stocks are considered resilient, given all the abuses they face. Effective fisheries regulations, cutting fishing activities by as much as 60% of the present level and adoption of conservation measures are expected to halt further declines.

The author is of the opinion that countries like India, where coastal fisheries are predominant, protection to coastal ocean ecosystems is of paramount importance for the sustainability of fisheries, since coastal habitats account for the highest marine biological productivity. It is felt that the Coastal Regulatory Zones (CRZs), the Coastal Management Pans (CMPs) and the proposals for the development of industrial corridors along the coastline are not in the interest of protecting marine ecosystems or the marine resources. It is the author's strong conviction that irrespective of any other consideration, all coastal areas, upto the highest high tide mark should be left free from all types of encroachments and activities and reserved for fishing and aquaculture activities to ensure the goods and services (listed in the paper) to the country. The paper also highlights certain critical areas concerning marine ecosystems and biodiversity for future research.

EHO 02 MECOS 09

TROPHIC LEVEL AND MEAN TROPHIC INDEX OF FISH FAUNA ASSOCIATED WITH TRAWL BYCATCH OF KERALA, SOUTHWEST COAST OF INDIA

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Trophic level and mean trophic index describe a major aspect of complex interactions between fisheries and marine ecosystem and provide clues for measuring species replacement induced by fisheries. Trophic level changes are widely used in monitoring the sustainability of marine fisheries catches and in realizing the impact of fishing on marine ecosystems. Changes in demersal and pelagic ecosystem structure due to the removal of species through mobile fishing gears such as trawlers could be explained through the mean trophic level in fish catch. This paper records the diversity, trophic level and mean trophic index of fish fauna in the trawl by-catch landings of Kerala coast of India.

Fish samples from trawl by-catch landings along Kerala, southwest coast of India, were collected from various fishing harbours during 2004 to 2006. Each fish in the sample was identified up to species level and Information on trophic level of individual fish was gathered from FishBase. Diversity of fish fauna at each trophic level was calculated and Shannon diversity indices at various trophic levels were compared using t-test. The length class of fishes at each trophic level was also recorded. Mean trophic index of the by-catch was calculated by multiplying the by-catch of each species with their corresponding trophic level and then by taking the weighed mean that is,

$$MTI = \frac{\sum ij\ TLj\ Yij}{\sum Yij}$$

where, TLj is the trophic level of individual species j, Yij is the biomass of that species, Σij is the summation of TLj x Yij, and ΣYij is the total weight of all species.

Out of the 217 species of finfish recorded from the trawl by-catch of Kerala, 103 species (47%) belonged to the trophic level 3.5-3.99, 56 species (26%) to the trophic level 3.0-3.49, 40 species (18%) to the trophic level 4.0-4.49, 13 species (6%) to the trophic level 2.5-2.99 and five species (2%) to the trophic level 2.0-2.49 (Table 1). The diversity indices also recorded significantly higher values for the trophic level 3.5-3.99 and it was the lowest for the trophic level 2.0-2.49. In the trophic levels 2.0-2.49 and 2.5-2.99 however, the dominance index of fishes were higher (0.502 and 0.307 respectively) than the remaining trophic levels. This could be due to the presence of lower trophic level fishes such as *Sardinella longiceps* and

Leiognathus splendens as dominant fraction in the trawl bycatch throughout the period of study. In general, the dominant fraction of fish fauna (73%) of the trawl by-catch, represented by 159 species, was the mid-level carnivores in the trophic level 3.0-3.99.

Table 1. Diversity of fish fauna in the trawl by-catch of Kerala coast at different trophic levels

Diversity Indices	Trophic level				
	2.0-2.49	2.5-2.99	3.0-3.49	3.5-3.99	4.0-4.5
Number of species	5	13	56	103	40
Number of individuals	109	448	857	1159	612
Shannon diversity	0.801	1.490	2.899	3.660	2.823
Simpson	0.498	0.694	0.912	0.952	0.914
Dominance	0.502	0.307	0.088	0.048	0.086
Evenness	0.446	0.341	0.324	0.377	0.421
Fisher-alpha	1.082	2.504	13.420	27.310	9.588

The diversity of fish fauna in the trawl by-catch differed significantly at different trophic levels. Presence of a large number of mid-level carnivores in the trawl by-catch may indicate large-scale removal of top level predators from the ecosystem. As predatory fishes are selectively removed from the oceans, the trawlers may have to increasingly rely on species in the lower trophic level.

The mean trophic index of fish species in the trawl by-catch of southwest coast of India was 3.12, indicating higher biomass of low trophic level fishes in the trawl bycatch. A clear trend of higher diversity of high trophic level fishes and lower mean trophic index indicated the absence of sustainability of trawl fishing and the need for interventions to reduce the amount of by-catch. In all the trophic levels, fishes in smaller length groups dominated the landings, indicating that juveniles are landed in larger proportions in the trawl by-catch. The current features of trophic levels of trawl bycatch warrants policy interventions to reduce fishing pressure and to implement bycatch reduction devices in the trawlnets.

EHO 03 MECOS 09

SEASONAL ALGAL BLOOM AND WATER QUALITY STUDY IN THE COASTAL KERALA DURING SOUTHWEST MONSOON USING *IN SITU* AND SATELLITE DATA

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Algal blooms were observed using IRS-P4 (Oceansat-1) OCM data and *in situ* observations during September 2002 and 2003 in the coastal and shelf waters of Calicut (Kerala). The algal bloom features were observed in the total radiance, remote sensing reflectance, chlorophyll and diffuse attenuation coefficient images. The study was carried out with less-cloudy OCM passes during September 2002 (dates 1, 3, 13, 15, 19, 23 and 27) and September 2003 (dates 18, 20, 22, 24, 28 and 30). *In situ* observations indicated the dominance of dinoflagellate *Noctiluca* species in the 1st, 2nd and 3rd weeks of September 2002. In the south off Calicut, mass mortality of fishes was observed. Watercolour was found green due to the green micro algae *Hornelia marina*. The blooms extended untill 22nd September. Massive death of the green mussel *Perna viridis* was recorded during the 3rd week of September 2002. Fishes perished due to lack of oxygen in the water column due to algal bloom. Later, the water turned red in colour. The fishermen reported red water upto 35 kilometers from the shore and this has been reflected in the OCM derived chlorophyll images with dense algal bloom features. The red colour of water was due to the dinoflagellate *Noctiluca* spp, with very high chlorophyll concentration (20-50 mg/m^3). Oxygen deficiency due to the swarming of *Noctiluca* spp led to the mortality of fishes and marine fauna. Water currents moved dense blooms towards offshore and near the coast.

During September 2002, three blooms of high intensity were recorded. The successive blooms may be attributed to the delayed southwest monsoon and intermittent showers followed by bright sunshine. Additional features for the onset of bloom are upwelling, which continues till November, and enrichment of coastal waters due to the flushing of monsoonal rain. The oxygen concentration around Calicut ranged from 0.96 to 1.67 ml/l, which was much below the normal range of 4-5 ml/l. The water temperature range was 22.4-26^{0}C compared to the normal range of 28-30^{o}C, which is an indication of upwelling. pH ranged from 7.21 to 7.57. Nutrients such as nitrate, nitrite and phosphate recorded high values during the algal bloom period. The intensity of bloom in September 2003 was less compared to the bloom of September 2002. The bloom occurred in the 3rd week of September, but the death of fishes and mussels were not noticed. *H. marina* bloom was on 22 September 2003. Gross primary productivity was very high (13.104 gC/m^3/day), SST ~27.5^{0}C, salinity ~35.07 ppt, pH ~7.37 and DO ~3.46 ml/l. Decrease in dissolved

oxygen (~3.85 ml/l) and SST (25.5^{0}C), and increase in phosphate (0.171 μg atm/l) and nitrate (0.085 μg atm/l) were observed from the monthly data (April-September). During September 2002, the *in situ* chlorophyll concentration was 10-30 mg/m^3 and OCM derived chlorophyll ranged from 20 to 50 mg/m^3 on 13, 15, 19 and 27 September 2002. During September 8, 20, 22, 24 and 30 2003, indicated highly dense algal bloom patches (chl > 20 mg/m^3) were noticed. This indicates seasonal algal bloom around the Calicut coast, which spreads across the Kerala coast in the shelf waters up to 20-30 km from the coastline.

The OCM reflectance images indicated high reflectance (1-2%) in extreme blue and green channels at 490, 512 and 555 nm of OCM, which might be due to the reflectance of *H. marina*, which causes green tide. During September 2003, the OCM reflectance was highest in channel 5 (550 nm) of OCM on 20th September, followed by channel 3 and 4, 490 and 512 nm (0.5-1.5%) during 22-30th September 2003. The attenuation coefficient (Kd) has not shown much variation during September 2002 with a low range of 0.15-0.20 m^{-1}. It showed that the weather was sunny with better transparency. However, during September 2003, Kd indicated variation with high range of 0.7-0.85 m^{-1}. It indicated high Kd value and low transparency of water, partially cloudy weather resulting in algal bloom with high chlorophyll concentration. The *in situ* observed algal bloom around Calicut during September 2002 and 2003 has been well reflected in the respective OCM observed chlorophyll images with dense chlorophyll patches and stripes along the coast. The chlorophyll concentration from *in situ* data matches well with OCM derived chlorophyll. During bloom, the chlorophyll concentration ranged from 20 to 30 mg/m^3 from the *in situ* as well as satellite data. The spectral characteristics with respect to *in situ* radiometers and satellite hyper-spectral channels will be an important study for future. The *in situ* observations based on the measured water quality parameters and optical properties will be of interest from remote sensing based bio-optical algorithms and biodiversity study.

EHO 04 **MECOS 09**

DEGRADATION OF NATURAL BEDS OF OYSTER BY ANTHROPOGENIC ACTIVITIES AT ENNORE ESTUARY, CHENNAI

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Survey conducted during 1988 on the standing stock of edible oysters in Ennore estuary showed vast resources in 10 out of 16 stations and the potential yield was estimated as 18610 t. These resources were found in dense beds in the form of mounds. The richest bed was in Stations 5 and 7 stretching for about 2 km with a potential yield of 18000 t. The size of the oysters was large and constituted by more than one-year groups.

The survey conducted during 2008 has revealed the devastation of oysters and other sedentary organisms like mussels and clams in most of the areas in the estuary. There was a drastic decline in the stock of the edible oysters in stations 5, 7 and 8 due to overexploitation. In most of the beds the size of the oysters was found to have decreased. There was complete denudation of the stocks in stations 9,10, 12 and 14 even without any remnants of the old beds due to pollution. Contrary to the above, there was an increase in the density and growth of oysters in stations 3 and 4. In two stations (3 and 6), the oysters were larger in size than in 1988 due to non-exploitation of the resources.

The reasons for the decline in the standing stock of oysters in Ennore estuary is mainly due to the establishment of a number of industries along the estuary, discharge of thermal effluents and other activities such as overexploitation, discharge of sewage effluents, and dredging which lead to decline in the natural stocks.

EHO 05 **MECOS 09**

OPEN SEA FARMING OF *KAPPAPHYCUS ALVAREZII* OFF COCHIN AND ITS IMPACT ON ENVIRONMENT

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Kappaphycus alvarezii (Doty).ex. *P. silva* was successfully cultivated in the open sea off Narakkal, Cochin in floating rafts by introducing the seed material in fruit bags. The crop growth rate ranged from 3.97 to 10.87 g/day showing maximum growth on 75 days of culture period. The carrageenan content varied from 11.8 to 52.9%. The growth has direct impact on the environment. The total chlorophyll content in the water declined by 11 to 71%. Maximum decline was observed during the active period of growth. The dissolved oxygen concentration (DO) was found to be 32-37% less in the initial period of growth whereas during the peak period of growth the DO increased by 25-56%. Ammonia content declined gradually and maintained to be nil during peak period of growth. The decline ranged by 3-100%. Nitrate reduced by 41-58% but again increased at the end of the cultivation. Nitrite showed a reverse trend of nitrate with a peak value during 60-75 days of cultivation. Phosphate showed bimodal pattern with peak values on 45 and 75 days of cultivation. There was not much difference in silicate content but a decline of 10-28% was observed near the seaweed bed.

EHO 06 MECOS 09

OCCURRENCE AND BIOACCUMULATION OF TRACE ELEMENTS BY BENTHIC POLYCHAETES FROM SUNDERBAN MANGROVE WETLANDS, WEST BENGAL

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Polychaetes, the dominant component of soft-bottom macro-invertebrate communities, are diverse, abundant and ecologically significant functional components of coastal ecosystems. The present study is designed to report the community structure of benthic polychaetes along with their role in bioaccumulation of trace elements from seven sites of Sunderban Mangrove Wetland, having different environmental stresses. Polychaete assemblages, comprised of thirteen species belonging to six families, are characteristically different at seven sites of Sunderban. The pre-dominant polychaete fauna exhibited distinct and unique assemblages of two types such as *Dendronereides heteropoda* and *Dendronereis arborifera* at Ghushighata, a sewage-fed substratum and *Perinereis cultifera* and *Ganganereis sootai* at Gangasagar and Haribhanga, both at the direct influence of marine environment. The maximum density of *P. cultifera* (637 ind.m^{-2}) was encountered at Haribhanga, an offshore island in the Bay of Bengal. The dominance of two species (*Dendronereis arborifera* and *Mastobranchus indicus*) has been recorded almost throughout the year. The potential for accumulation of trace elements from the ambient medium are distinctly different in polychaetes showing species-specific and site-specific heterogeneity. *Ganganereis sootai* exhibits the potential role in accumulating seven elements (Al, Fe, Mn, Cr, Co, Ni, and Pd) in its body tissues. The bioaccumulation factors (BAF) for thirteen trace elements were calculated revealing the ability of *G. sootai* to accumulate As, Se, Cd, and Hg in several orders of magnitude higher than the background medium. The study demonstrates that the textural composition of the sediment, together with hydrodynamic and geochemical properties, may have an impact on the differences of the polychaete community in the seven study sites of Sundarban. An in-depth comparative study of polychaete community structure at multiple spatial scales is strongly recommended for future environmental impact assessment in this fragile environment.

EHO 07 **MECOS 09**

TOWARDS AN ECOSYSTEM APPROACH TO LONGLINE FISHERIES OF THE INDIAN EEZ: IMPACT ON SHARKS AND SEA TURTLES

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Over the past decade, there has been global concern over the bycatch of sea turtles and sharks from tuna fishing operations. The incidental mortality of these species due to longline fisheries has been held widely responsible for the declining populations and threatened status of several species. Many recent reports point the growing concern over the widespread decline of shark populations. All the shark species are at or near the apex of a trophic structure that supports them. The fishery induced depletion of sharks is made worse due to their characteristics such as slow growth, late maturity and low fecundity, all of which can make them extremely vulnerable even to the modest level of fishing. It is often suggested that sharks may function as keystone predators and that they might be essential to the maintenance and stability of food webs in the world oceans. Thus, the question of the consequences of shark exploitation extends from population to the domain of ecosystem issues. Addressing this significant issue is a prerequisite for a more comprehensive view of sharks and shark fisheries in an ecosystem context in the Indian EEZ.

Sea turtles have low reproductive capacity and long life span. Moreover, since they travel long distances especially for nesting, they are exposed to dangers of either entanglement or getting caught in fishing gears resulting in high mortality. In the past, research was focused on land–based threats, such as nesting habitat alteration and harvesting of adults and eggs. However, more recent research has recorded alarming levels of mortality in various fishing operations, including pelagic longline, drift-netting and pelagic trawling. Globally, large numbers of sea turtles are taken as bycatch by pelagic longline fishing and the longline bycatch rates have been identified as the main cause of their population decline.

In order to study the impact of tuna longline fishing on the population of these ecologically important species in the Indian waters, the results of exploratory longline surveys conducted by the FSI during April 2005-March 2008 is analysed and the results are furnished.

EHO 08 **MECOS 09**

ALGAL BLOOMS ALONG THE COASTAL WATERS OF SOUTHWEST INDIA DURING 2005-08

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Planktonic algae can proliferate into enormous concentrations of upto millions of cells per litre when sufficient conditions of light and nutrients are available and these natural phenomena are termed as blooms. Most of these blooms are extremely beneficial to the marine ecosystem as a primary source for food for various larvae of marine organisms. However, in some situations, algal blooms have a negative effect, causing severe economic losses to aquaculture, fisheries and tourism operations and having major environmental and human health impact by producing harmful or toxic effect to the ecosystem.

A study was carried out with the financial support of CMLRE under the Ministry of Earth Sciences, Govt. of India for monitoring and surveillance of algal blooms along the southwest coast of India, both from the coastal and estuarine stations during 2005-08. The study was conducted in seven stations starting from Vaadi, in the south (Kollam) 8^0 52 01′N, 76^0 34 26′E, to north Mahe estuary in the north, 11^0 42 18′N, 75^0 32 36′E along the southwest coast of India. Blooms of *Coscinodiscus* spp were observed during the monsoon 2006 off Kodikkal (Calicut; 11^0 28 43′ N, 75^0 36 10′E) and *Coscinodiscus* spp and *Pleurosigma* spp in Mahe (11^0 42 18′N, 75^0 32 36′E). During the monsoon 2007, a bloom of *Ceratium* spp. has been found off Punnapra (9^0 25 23′ N, 76^0 19 41′E). A detailed investigation was carried out on the taxonomy, abundance and ecology of these algal blooms. Hydrographic variables such as temperature, salinity, pH, dissolved oxygen (DO) and nutrients (nitrate, phosphate and silicate) were analysed employing standard techniques. Primary productivity, chlorophyll *a* and phytoplankton composition were also estimated.

Off Kodikkal, during the monsoon 2006, water discolouration due to the blooming of *Coscinodiscus asteromphalus* var. *centralis* was observed Fig. 1a), with a cell density of $7x10^6$. l^{-1}. Pennate diatoms such as *Pleurosigma acuminatum* and *P. falx* significantly contributed to the total biomass. Primary production was 5.6 $gC.m^{-3}.day^{-1}$, with a very high chlorophyll *a* (206.5 mg. m^{-3}) concentration. Surface temperature was within the normal range (28° C) but salinity (34 psu) was high. The concentration of nitrate (3.185 ìmol. l^{-1}) was found to be low and phosphate was relatively high (2.185 ìmol. l^{-1}). The reactive silicate (42.27 ìmol. l^{-1}), was very high. The dissolved oxygen concentration (6.9 mg. l^{-1}) was also high in the surface waters.

During the same period, in the Mahe estuary, discolouration of the surface water was observed. *Coscinodiscus asteromphalus* var. *centralis* was the dominant species with $4x10^6$ cells. l^{-1}. Other diatom species like *Pleurosigma acuminatum, P. aestuarii, P. angulatum* and *P. falx* also significantly contributed to the standing crop and the cell count of each species was around $3x10^4$ cells. l^{-1}. The hydrographic parameters of the bloom period were relatively low sea surface temperature (25º C) and high salinity (32 ppt). The pH was as 7.8 and the nitrate was 3.1ìmol. l^{-1}. However, phosphate was high with 5.11ìmol. l^{-1}. Silicate was comparatively high with 38.12ìmol. l^{-1}. Dissolved oxygen concentration was 5.2mg. l^{-1} in the surface waters. Primary production was 4.43gC. m^{-3}.day^{-1} and chlorophyll *a* concentration was 120.3 mg. m^{-3}.

Off Punnapra, a bloom of *Ceratium* spp imparted a slight brown colouration to the surface water during the monsoon 2007. The total standing crop of phytoplankton was $4x10^4$ cells. l^{-1}. The major components of the phytoplankton community were *Ceratium furca* (Fig. 1b; 8900 cells. l^{-1}), *Ceratium gibberum* (4435 cells. l^{-1}), *Ceratium horridium* (8150 cells. l^{-1}), *Ceratium symmetricum* (10600 cells. l^{-1}) and *Ceratium trichoceros* (9900 cells. l^{-1}). The diatoms *Coscinodiscus asteromphalus, Achnanthes hauckiana, Thalassionema nitzschioides* and *Pleurosigma angulatum* were found in low densities. Generally, *Ceratium* spp. may produce harmful effect due to the mechanical interruption in the gills of fishes with its epithecal and hypothecal horns. The surface water temperature was 27º C and salinity was 36 psu. pH was recorded as 7.7. Nitrate was 3.13 ìmol. l^{-1}. However, the phosphate was in a below detectable range. The silicate was higher and measured 54.5 ìmol. l^{-1}. High dissolved oxygen concentration (6.17 mg. l^{-1}) was found in the surface waters. Primary production was very low when compared to the normal values with only 0.32 gC. m^{-3}.day^{-1} and chlorophyll *a* concentration was 6.41 mg. m^{-3}.

All the bloom events did not prolong for more than a week. The DSP (Diarrhoeic Shellfish Poisoning) producing species such as *Dinophysis fortii, D. acuminuta, D. acuta, D. miles* and *Prorocentrum lima* were also recorded during the study, but in less concentration. There are reports that *Dinophysis* spp. can induce potent toxin even at low abundance of 200 cells. l^{-1}. The present investigation has recorded more than 250 cell. l^{-1} from various stations during the monsoon period. There were no reports of casualties that can probably be due to the absence of toxic strains with in these species.

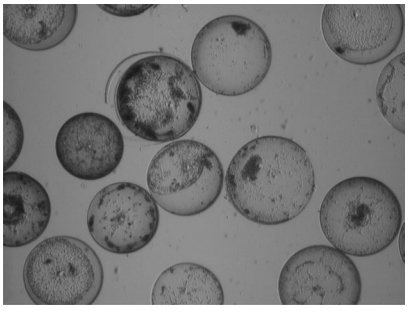

Fig. 1a. *Coscinodiscus asteromphalus* var. *centralis* (off Kodikkal; 11º 28 43′N, 75º 36 10′E)

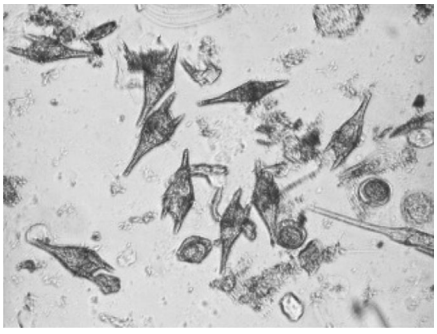

Fig. 1b. *Ceratium furca* (off Punnapra; 9⁰ 25 23′ N, 76⁰ 19 41′E)

EHO 09 **MECOS 09**

IMPACT OF TSUNAMI ON THE ECOLOGY AND DISTRIBUTION OF BRINE SHRIMPS (BRANCHIOPODA: ANOSTRACA) IN THE SALT PANS OF VEDARANYAM, TAMIL NADU, INDIA: A CASE STUDY

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Vedaranyam is 45 km south of Nagapattinam, Tamil Nadu, India (Lat. 08° 59' N, Long. 78° 50' E) and is known for large salt production units. The effect of 2004 tsunami on these salt pans (2500 acres) was the deposit of slush and black silt. One of the consequences of the devastation was the invasion of an exotic *Artemia* strain into these salt pans. The objective of the present study is to (1) find out the current status of the inhabiting strain, mode of reproduction and morphological characterization, and (2) compare with that of the pre-tsunami population.

An extensive survey along the salt pans (4 stations) in Vedaraniyam was carried out during the post-monsoon season of 2008. Biometric analyses were made for the diameter of hydrated cysts (HC), decapsulated cyst (DC) and instar-I naupliar size (N). Adult morphological parameters such as total length (TL), abdominal width (AW), eye diameter (ED), distance between compound eyes (DEC) and furca length (FL) were analyzed. The reproductive modes of the populations (sex ratio) were examined for at least 50 individuals per population per generation by rearing them for consecutive three generations under laboratory conditions. Data obtained on biometric and morphological traits of pre and post- tsunami populations were subjected to one-way ANOVA followed by Tukey –HDS test using the SPSS statistical software (version 10.0).

Significant differences ($p < 0.01$) were recorded in the biometric analysis of the cyst as well as the biomass. The post-tsunami population was found to be bisexual against a pre-tsunami parthenogenetic population. The current population was found to differ from the earlier parthenogenetic population in almost all the traits considered in this study. The diameter of hydrated cysts of pre-tsunami population measured around 284.6 $\pm$ 0.70 μm compared to the post-tsunami population with 235.0 $\pm$ 1.13 μm. The instar-I naupliar size measured were 627.5 $\pm$ 0.17 μm and 570.0 $\pm$ 0.70 μm for pre-tsunami and post-tsunami populations respectively. The results of the present investigation are: (1) the biometric characters have discriminated between the two populations and showed that the pre- and post-tsunami populations are very different from each other (Fig. 1 and 2), (2) a bisexual population of *Artemia* sp. is available in Vedaranyam currently, and (3) no parthenogenetic strain could be traced from the location in the post-tsunami scenario.

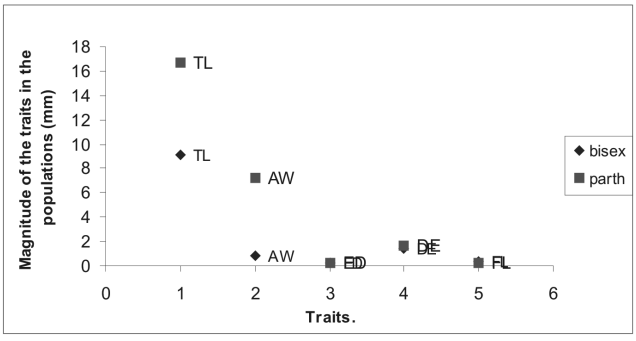

Fig. 1. Comparison of biometric traits for bisexual and parthenogenetic populations; TL: Total Length; AW: Abdominal Width; ED: Eye Diameter; DE: Distance between Compound Eyes ; and FL: Furca Length.

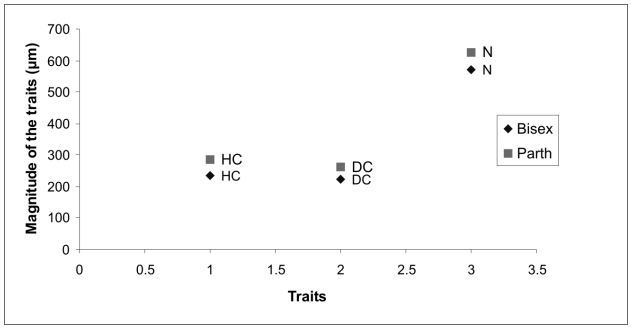

Fig. 2. Comparison of morphometric traits for the cysts and nauplii of bisexual and parthenogenetic population; HC: Hydrated Cyst Diameter; DC: Decapsulated Cyst Diameter; N: Naupliar size

Thus, the present study reports the phenomenon of post-tsunami ecological invasion of a bisexual foreign strain of *Artemia* sp. in these salt pans that has excluded the native parthenogenetic strain from this site leading to the ecological extinction

of the native Vedaranyam strain, over a short time period. However, owing to its smaller size, the present bisexual strain might be of aquaculture interest, which is a subject for further study.

EHO 10 **MECOS 09**

BLOOM OF *NOCTILUCA SCINTILLANS* IN GULF OF MANNAR, SOUTHEAST COAST OF INDIA

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Gulf of Mannar, which extends from Rameswaram to Kanyakumari, has a chain of 21 islands (area of each island 0.95 to 130 ha) along the 140 km stretch between Tuticorin and Rameswaram (Lat 8° 55′- 9° 15′ N and Long 78° 0′- 79° 16′E). The coastal waters have fringing coral reefs and patch reefs rising from shallower areas of sea shore. Fringing reefs are located mostly at a distance of 50-100 m from the islands and are narrow. Patch reefs arise from depths of 5 to 9 m and are 1-2 km in length with width up to 50 m. The Gulf of Mannar Marine Biosphere Reserve is India's first Marine National Park. The biosphere includes coral reefs, seagrasses and mangroves. This ecosystem supports wide spectra of flora and fauna of taxonomic and economic importance.

From 2.10.08 to 12.10.08 an intense bloom of *Noctiluca scintillans* (Macartney) was observed for the first time in the coastal areas of Gulf of Mannar near Appa Island, Thalaiyari Island and Valai Island. The bloom later intensified into a dense bloom in Muthupettai area and spread from Kilakarai to Pamban. The bloom resulted in very low oxygen levels which led to loss of biodiversity in the most densely affected region, resulting in the death of organisms in the higher as well as lower trophic levels.

The coastal water appeared dark green. Microscopic examination of the water samples revealed the presence of *Noctiluca scintillans*. The organism is bioluminescent, inflated and sub-spherical. The size of the organism ranged from 400-1200 microns. Though the species is colourless, the presence of photosynthetic green endosymbionts makes the water green. As the depth of the water where the bloom occurred was very shallow (0-6m) and the wind velocity less, the bloom intensified. The current was in clockwise direction in the Gulf with water flow nearly still just before the change of season from the southwest monsoon to northeast monsoon. The high temperature, salinity and low pH aided the spread of the bloom to adjacent waters off Muthupettai. During the intense period of the bloom, the cell concentration of *Noctiluca scintillans* was around 13.5 lakh cells /l, the dissolved oxygen level was below detectable level and the total suspended solids was 510 mg/l, thereby increasing the turbidity and penetration of light to the bottom. This resulted in the biodiversity

loss in the intensely affected area from Valai Island to Muthupettai coast. The dead animals noticed ashore in the islands and shores of Muthupetai, Periappatinam, Pudumadam were rabbitfishes, moray eels, goatfishes, serranids, carangids, silverbellies, barracudas, halfbeaks, seabass, flathead, surgeonfishes, threadfin breams, snappers, breams, silverbiddies, theraponids, anchovies, lesser sardines, *Psammorperca* sp., lizardfishes; endangered animals such as seaturtles, seahorses etc; ornamental fishes like chaetodontids, parrotfishes, damselfishes, squirrelfishes, clownfishes, sea snakes, molluscs (cuttlefishes, squids, *Trochus* sp., *Cypraea* sp, clams (*Cardium* sp, *Donax* sp. etc), crabs (*Portunus pelagicus*, *Charybdis natator*), jellyfishes, sea anemones, sea cucumbers and polychaetes. Underwater observations immediately after the bloom showed that the corals were bleached and there were no associated reef fishes in the severely affected Valai Island. During the waning phase of the bloom, the surface water temperature was 29.5° C, salinity 34.2 ppt, dissolved oxygen 4.86 ml/l, phosphate 50 μg at/l and ammonia 85 μg at/l. Further investigations indicated the resilience of the ecosystem to recover from the sudden natural damage.

EHO 11 **MECOS 09**

TEMPORAL PATTERNS IN BIODIVERSITY AND HEALTH STATUS OF PALK BAY REEF CORALS

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A detailed study aimed at identifying the changes in biodiversity, live coral cover as well as health status of the Palk Bay reef corals was carried out over a period of 4 years. The live coral cover was measured using Line Intercept Transect method at fixed sites in the reefs of Palk Bay in 2008 in order to study and make comparisons with the surveys conducted in 2004. Substantial decrease in live coral cover was observed over the four years as it decreased from 44.0% to 13.6% and from 37.8% to 12.9% in Velapertumunai and Kathuvallimunai Reefs respectively. *Acropora hyacinthus* and *Favites abdita* were the abundant species in Velapertumunai Reef with relative abundance values of 12.13 and 10.85 respectively. However, in Kathuvallimunai Reef, *Acropora lamarcki* was found to be the most abundant species with a relative abundance value of 12.68. All other species belonged either to common or uncommon species status. Alterations in community structure were also noticed in both the reefs. However, the biodiversity indices showed an increasing trend in both the reefs, which is an indication of recruitment taking place. Studies on the disease prevalence in hard corals indicated more incidences of diseases in massive corals as compared to branching corals. Disease conditions such as brown band disease, porites ulcerative syndrome, white pox syndrome and pink line syndrome/ porites pinking were observed.

EHO 12 **MECOS 09**

EFFECTS OF BOTTOM TRAWLING ON THE ECOLOGICAL INTEGRITY OF MACROBENTHOS OFF VERAVAL COAST, GUJARAT

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The present communication is on the impact of bottom trawling on the macrobenthic fauna off Veraval coast, which is the largest trawler port of India. Experimental bottom trawling was conducted from *MFV Sagarkripa* at five transects of water depths 15-20 m, 21-25 m, 26-30 m, 31-35 m and 36-40 m in commercial trawling grounds for 12 months in a span of 15 months (September 2005 to November 2006) excluding the trawl ban period (June to August). The groups of fauna present were polychaetes, gastropods, bivalves, scaphopods, amphipods, isopods, copepods, cumaceans, ostracods, shrimps, crabs, squilla, balanids, foraminiferans, octocorals, sipunculids, nemerteans, pogonophores, pterobranchia, brittle stars and teleost fishes. A total of 81 species of polychaetes belonging to Errantia (36 species) and Sedentaria (45 species) were identified. The molluscs were represented by 15 species of gastropods, 13 species of bivalves and one species of scaphopod. One octocoral genus was also identified. The abundance and biomass of the fauna were recorded. The total numerical density of macrofauna increased after trawling, exposing them from their natural habitat. The numerical density of macrofauna increased after trawl ban period showing that the trawl ban is giving some respite to the fauna for rejuvenation. The biodiversity indices were found to be significantly different before and after experimental trawling at 15-20 m depth and 21-25 m depth. The Abundance Biomass Curve and w-statistic of the total macrofauna showed that the fauna of the area were moderately or grossly stressed. It was also possible to delineate the impact on the fauna by multidimensional-scaling (MDS) plots. The present study confirms the deleterious effects of bottom trawlers on macrobenthos off Veraval. Cataloguing the biodiversity of macrobenthos, identification of indicator species and updating the new data generated will aid in taking up steps towards conservation of macrobenthos. Suggestions are made for the promotion of ecofriendly gears and for conducting studies on appropriate un-trawled control sites for comparative assessment.

EHO 13 MECOS 09

IMPACT OF NUTRIENT POLLUTION IN ADYAR ESTUARY, CHENNAI, EAST COAST OF INDIA

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Over the years due to anthropogenic causes like widespread industrialization, developmental activities, population pressure etc., the marine ecosystem of Chennai is getting polluted. The water quality problems of the Adyar estuary are mainly associated with the wastes from discharge along the banks from settlements. The environmental status of Adyar River suggests that, this perennial river is subjected to pollution from a typical metropolis through wastes from dense human settlements along its coast. Each pollutant has its own effect on water and the environment. In the present investigation, samples were collected at four points, the first at the estuary, second at the downstream, third at the midstream and fourth at the upstream. The samples were analyzed for physical, chemical and biological parameters. *In situ* measurements of physicochemical parameters revealed the deterioration of water quality. It was obvious that, intake point 1, 2 and 3 was probably subjected to chronic stress that is very severe in the vicinity of municipal sewage and storm drain outlets. One potential stress that was measured concurrently with sampling is hypoxia resulting from eutrophication. In the study area, the level of DO remained just above 0. A reduction in DO concentration is one of the most important direct effects of nutrient over-enrichment. The nitrite in all the sites ranged from 0.062 $\pm$ 0.002 to 2.57 $\pm$ 0.08 μmol/l; nitrate from 3.919 $\pm$ 0.18 to 22.133 $\pm$ 1.912 μmol/l; inorganic phosphate from 6.031 $\pm$ 0.1 to 19.26 $\pm$ 2.5 μmol/l; total phosphorus content from 3.838 $\pm$ 0.4 to 15.009 $\pm$ 1.02 μmol/l; and inorganic silicate from 1.47 $\pm$ 0.1 to 8.092 $\pm$ 0.5 μmol/l. Overall, the nutrient concentrations were high in the study area due to industrialization and developmental activities. The result of the present study advocates treatment of the sewage wastes prior to discharging so as to avoid severe organic pollution and change in the biodiversity of the prime ecosystem.

EHO 14 MECOS 09

ASSIMILATIVE CAPACITY OF INSHORE AREAS OF COCHIN WITH REFERENCE TO THE CONTAMINANTS FROM UPSTREAM EFFLUENTS

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Assimilative capacity of inshore waters of Cochin coast was assessed for three years (April, 2003 to October, 2006) based on the hydrography, photosynthetic pigments and primary production, dissolved nutrients and dissolved heavy metals collected from the source to the sink.

Reduction in pH during the monsoon months was conspicuous in the estuary as well as in the sea. In the two backwaters selected, the pH was higher during monsoon than that in the post-monsoon season. Considerable increase in BOD levels during monsoon period over the non-monsoon periods was observed in the estuary (1.67 mg/l), sea (1.67 mg/l) and river (1.89 mg/l) compared to that of the backwaters. The estuary recorded the maximum gross primary productivity (GPP: 0.35 mgC/l/d) as well as net primary productivity (NPP: 0.28 mgC/l/d) and the river registered minimum GPP (0.09 mgC/l/d) and NPP (0.08 mgC/l/d). Heavy metals such as Zn and Cd recorded higher levels in the river (Zn: 115 μg/l and Cd: 2.33 μg/l) than in the estuary (29.48 μg/l and 0.47 μg/l respectively) and sea (23.2 μg/l and 0.53 μg/l respectively). Copper registered highest value (2.03 μg/l) in the estuary followed by the backwaters (1.92 μg/l) and sea (1.46 μg/l). Unlike other metals, Pb concentration was higher in the sea (3.17 μg/l) than in the estuary (2.69 μg/l) and backwaters (2.68 μg/l).

Assimilative indices for Cochin estuary and the inshore waters of Cochin were worked out and a scale of safe, desirable, cautionable or critical state was attributed to the estuary and inshore waters with regard to different parameters based on the score. The results revealed that in the estuary TSS and Cadmium have reached critical levels and Cu and Pb have reached cautionable levels. In the Cochin inshore waters, Cd and Pb have attained cautionable levels.

EHO 15 MECOS 09

EFFECT OF HEAVY METALS ON THE HATCHING OF EGGS OF THE BANANA SHRIMP *PENAEUS MERGUIENSIS*

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The embryonic and larval forms of marine invertebrates are highly sensitive to pollutants and studies on the younger life stages are imperative to determine the safe levels of various contaminants in the sea. A study was conducted on the hatching rate of *Penaeus merguiensis* eggs on exposure to different concentrations of four heavy metals *viz*., mercury, copper, cadmium and zinc.

The study was conducted at the School of Ocean Sciences, Karwar, India and the backyard shrimp hatchery operated in this Institute served as a source for the experimental eggs. The eggs released by the same spawner were used to carry out each set of experiment. The experiments were conducted in seawater having a salinity of 33.0 ppt and a pH of 8.0.

In all the tested heavy metals, hatching was more pronounced during the initial period of exposure at lower concentrations. However, with increase in concentration, a considerable delay in hatching was observed. Hatching of 10, 8, 14 and 15% was recorded in the highest tested concentrations of Cu (0.07 ppm), Hg (0.015 ppm), Zn (1.75 ppm) and Cd (0.35 ppm) respectively. The 24-hour LC_{50} value of Cu on eggs was 0.038 ppm while that of Hg, Zn and Cd were 0.0055, 0.85 and 0.17 ppm respectively. The hatching rate of *P. merguiensis* eggs was found to be considerably affected on exposure to heavy metals, although they were found to be less susceptible when compared to the first larval stage *i.e*., nauplius larvae. Mercury was found to be the most toxic among the tested heavy metals and the order of toxicity of the tested metals on eggs was Hg > Cu > Cd > Zn.

EHO 16 MECOS 09

PHYSICO-CHEMICAL CHARACTERISTICS OF THE SEAGRASS ENVIRONMENTS OF ANDAMAN AND NICOBAR GROUP OF ISLANDS

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The Andaman and Nicobar groups of islands are known for high biodiversity, pristine beaches and rich coastal ecosystems. Physicochemical parameters are important parameters influencing the distribution of marine organisms. Considering the importance of seagrasses in the coastal ecosystem, hydrographical investigations were carried out in 17 stations in the seagrass areas of Andaman group of islands during November-December, 2007. Temperature, pH, dissolved oxygen and salinity of seagrass areas showed only minor variation between the stations. However, nitrite, nitrate, reactive silicate, phosphate and particulate organic carbon showed notable variation; nitrite concentration ranged between 0.521 and 0.95 μM, nitrate between 1.676 and 6.1 μM, reactive silicate from 6.07 to 14.686 μM, phosphate from 1.8 to 4.62 μM and particulate organic carbon between 1.375 and 6.408 mgC/l. The sediment characters showed the following significant variations; pH varied between 8.1 and 8.6, the electrical conductivity between 2.1 and 4.1 dSm^{-1}, soil nitrogen (N) between 22 and 52 kg/acre, phosphorous (P) from 10 to 15kg/acre and potassium (K) between 55 and 73kg/acre. The composition of sediment texture in all the stations showed higher sand composition followed by silt and clay. The various physicochemical parameters were within the optimum range of a typical tropical marine environment and the ranges are very congenial for seagrass growth. However, the nutrient levels were low when compared to the seagrass meadows of the mainland. Occurrence of coral reefs and seagrasses in the same area might be one of the reasons for the low nutrient level in this part of Bay of Bengal. The elements like nitrogen, phosphorous and potassium are essential for the growth of plants. The present study recorded adequate amount of these elements in the seagrass areas when compared to non-seagrass areas. This indicates re-mineralization process in the seagrass areas.

EHO 17 **MECOS 09**

BIOACCUMULATION OF HEAVY METALS IN THE BIVALVE COLLECTED FROM SUNDERBAN WETLAND

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The coastal environment of West Bengal is recognized as the most diversified and productive ecosystem of India. It faces organic and inorganic pollution coming from domestic sewage, agricultural and industrial effluents which lead to serious impacts on its biota. Organisms which are sensitive to the ambient environment are used as bioindicators in monitoring pollution. The present paper aims at providing information on concentration level of heavy metals (Zn, Cu, and Pb) in the tissues of a bivalve (*Saccostrea cocullata*) collected from the Sunderban mangrove wetland. Highest concentration of these heavy metals was observed in the surface water during monsoon. This period is characterized by low salinity and pH of the ambient water. A unique relationship was observed between sediment and surface water with respect to these heavy metal levels and an overall common trend in bioaccumulation of these heavy metals was observed with the following decreasing order: Zn > Cu > Pb with few exceptions. A high degree of organ specificity was evident in the bivalve, where gill and mantle exhibited higher metal accumulation due to their ion exchange property of the mucous layer covering these organs. A continuous monitoring programme is recommended in order to clarify the present state of heavy metal pollution in the coastal areas of West Bengal and to establish the studied organisms as indicator species for bioaccumulation of heavy metals.

EHO 18 **MECOS 09**

DIVERSITY OF EGGS AND LARVAE OF BONY FISHES ALONG THE SOUTHWEST COAST OF INDIA

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Eggs and larvae of marine bony fishes were collected, identified and documented during an extended period of more than 30 years. Eggs and larvae were collected by plankton net and post larvae were obtained from the distal end contents of seine nets operated off Thengapattinam and Vizhinjam along Kanyakumari and Thiruvananthapuram Districts of Tamil Nadu and Kerala states, respectively. The study revealed that the nearshore waters are the breeding and nursery grounds of almost

all commercial, ornamental and sport fishes of importance. During October to April every year, larval fish assemblage in abundance is a unique phenomenon of the coast. The characteristics of few eggs and larvae of important species are figured and described. Postlarvae of 72 bony fish families represented by 243 species were collected and identified during this study. Lutjanidae ranked first comprising 32 species, followed by Serranidae (26 species), Carangidae (19 species), Engraulidae (19 species), Sciaenidae (9 species), Pomacentridae and Platycephalidae by 8 species each, Bothidae and Leiognathidae by 7 species each, Sphyraenidae, Siganidae and Tunnidae represented by 5 species each. All the other families were represented by < 5 species each. A traditional fishery, known as 'NONNAVU', existed for postlarve of fishes together with cephalopods and crustaceans. The significance of ecosystem diversity as spawning, breeding and nursery grounds is discussed with respect to the abundance of young fish assemblage. There is a need to protect the areas of spawning and nursery as Marine Protected Area.

EHP 01 **MECOS 09**

TRENDS IN THE ABUNDANCE INDICES OF LARGE PELAGICS IN THE EXPLORATORY LONGLINE SURVEYS: AN INDICATION OF OVEREXPLOITATION IN THE INDIAN OCEAN

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In recent years, there have been growing concerns on the status of tunas, sharks and other large pelagic predators in the world oceans including the Indian Ocean. There has been a rapid increase in the fishing effort especially in view of a large fishery developed on purse-seine fishing using Fish Aggregation Devices (FADs) mainly by the French and Spanish fleets operating in the Western Indian Ocean. These drifting man-made objects are usually tracked by satellite and radio for the information on fish aggregated under and around them, which increases the ability of large purse-seine vessels to capture fishes including large quantities of small juvenile fishes. It is feared that this will have a negative effect if excessive fishing using FADs is continued. Simultaneously, the Indian Ocean Coastal States are also strongly committed to increase their direct stake in fishing for tropical tuna species (skipjack, yellowfin and bigeye tunas). This warrants the necessity to monitor the stock status of these commercially important oceanic fishes for maintaining healthy stocks and for their sustainable exploitation. Abundance indices of the large pelagics caught during the exploratory longline surveys conducted by the Fishery Survey of India (FSI) in the Arabian Sea, Bay of Bengal and Andaman and Nicobar waters for the last 30 years were analysed for examining the trends in the abundance indices of these valuable resources. The study shows a declining trend in the abundance of these resources particularly after the mid-nineties when the purse seining for tunas was increased in the Western Indian Ocean. Further, it calls for immediate management measures for maintaining healthy stocks of these resources in the Indian Ocean.

EHP 02 **MECOS 09**

INDUCTION OF PERIPHERAL ERYTHROCYTIC NUCLEAR LESIONS IN THE ASIAN CICHLID, *ETROPLUS SURATENSIS* (BLOCH) BY CADMIUM

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Cadmium, a widespread, non-essential water-soluble heavy metal, accumulates and causes damage to kidney and blood cells in higher vertebrates including aquatic organisms. A cytotoxic study on cadmium by scoring of nuclear lesions (micronucleus and nuclear anomaly) was conducted in a common euryhaline species, *Etroplus suratensis*. A linear increasing trend in cell damage and nuclear lesions was registered with an increase in dosage and exposure time. Significant variation ($p < 0.01$) between the doses (0.0, 0.5, 1.0 and 2.0 ppm) was observed both in micronucleus and nuclear anomaly and hence in the induction of total nuclear lesions. Similarly, significant variation between the time of exposure (24, 48, 72 and 96 hours) was recorded for nuclear anomaly ($p < 0.01$) and total nuclear lesions ($p < 0.05$). But for micronucleus production, homogenous effect of time was noted. The Critical Difference (C.D.) analysis showed variation between the dosages in the order of 0.0-2.0, 0.5-2.0, 0.0-1.0 and 0.5-1.0 ppm and between the time 24 - 96 hrs for the generation of nuclear lesions. In the rest of the combinations of time and dose, no significant variation was observed.

EHP 03 **MECOS 09**

STUDIES ON POPULATION STRUCTURE, BURROWING NATURE AND TOXICITY OF HEAVY METALS TO *DONAX* SPP. FROM GULF OF MANNAR AND PALK BAY COAST

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Bivalves of the genus *Donax*, which frequent sandy beach intertidal zones, often rank high among dominant beach macrofauna along the Gulf of Mannar and Palk Bay coast. Two species, *Donax faba* and *Donax cuneatus* were sampled during all the months in 2008 for population distribution. The study investigated the effect of grain size on the burrowing performance of these two species in the laboratory to elucidate the influence of grain size on the longshore distribution of *Donax* populations. Toxicity of chosen heavy metals such as copper, cadmium, lead and

manganese to the *Donax* spp. was also studied. The study revealed high abundance of *Donax faba* and *Donax cuneatus* along the Palk Bay coast when compared to that of the Gulf of Mannar coast. The burial times of both *D. faba* and *D. cuneatus* were positively correlated with shell length. Burrowing performance of both species was influenced by grain size. Fastest burrowing times were measured in the fine and medium sediments (125-500 ìm) but increased towards the very fine (90-125 ìm) and coarse extremes (500-2000 ìm). Toxicity test was done for 96 hour period under continuous flow-through setup to determine the lethal concentration (LC50) to the *Donax* spp. in Field lab, Centre for Marine and Coastal studies, Pudhumadam. The toxicity test indicated that *D. cuneatus* was very sensitive to heavy metals when compared to *D. faba*. Among the heavy metals, copper was found to be more toxic when compared to cadmium, lead and manganese.

EHP 04 **MECOS 09**

ESTIMATION OF VIRAL ABUNDANCE IN THE COCHIN BACKWATERS BY EPIFLUORESCENT MICROSCOPY

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Viruses are the most common and diverse biological entities in the ocean. They are 20-200 nm long consisting of genetic material (DNA/RNA) surrounded by a protein coat. Viruses play an important role in marine and estuarine ecosystems. They convert macronutrients (nitrogen and phosphorus) and micronutrients (iron) to particulate and dissolved forms which can be easily utilized by actively growing phytoplankton and bacteria and thus recycle nutritional elements. They are important agents of mortality of bacteria and regulate the bacterial community. Viral lysis of organisms can alter the pathways of carbon cycling. To understand the viral and bacterial density in Cochin backwaters, viruses and bacteria were counted by epifluorescent microscopy using SYBR Green stain. Viral abundances of 10^7 per litre and bacterial abundance of 10^6 per litre were determined. Counts of viruses were higher than total bacteria by one order of magnitude suggesting that viruses are much abundant in the Cochin backwaters.

EHP 05 **MECOS 09**

THREATENED SPECIES IN THE MARINE ECOSYSTEM OF YEMEN

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The Republic of Yemen lies in the southwestern corner of the Arabian Peninsula, with a coastline of approximately 2200 km. The marine ecosystem bordering Yemen is inhabited by a large number of flora and fauna, many of them being economically important species. The marine resources have been used in a sustainable manner by the local inhabitants for hundreds of years. However, the rapidly growing population and their developmental activities threaten the sustainability of these resources and have put tremendous pressure on the existence of many marine species. The threatened marine organisms include several aquatic species in mangroves; corals, crustaceans, molluscs, sea cucumbers, sea turtles, seabirds, fishes and marine mammals. The major threats are due to overexploitation, habitat destruction, oil pollution, tourism, natural predators and climate change. Efforts to conserve many of the declining species are discussed in the paper.

EHP 06 **MECOS 09**

STUDY ON THE MEIOFAUNA OF EARTHQUAKE AFFECTED INTERTIDAL AREA OF PORT BLAIR, ANDAMAN ISLAND

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This article presents results of the investigation on the distribution of meiofauna of the intertidal area of the earthquake affected regions around Port Blair. The 26th December 2004 earthquake caused subsidence of land by about 0.97 m that converted the freshwater environment into a nearshore environment. Meiofaunal distribution in the region provides an opportunity to understand the adaptation of these species in the new environment.

The study was carried out at five different sites such as Station-A (Dollygunj), Station-B (Shiphighat), Station-C (Carbyns Cove), Station-D (Wandoor) and Station-E (Chidiyatappu). These study area covers the Andaman Sea (A,B&C) and Bay of Bengal (D&E) marine waters. The samples were collected in the site between low water mark to the high water line during the low tide. Forty three species of meiofauna were

identified, which fall under nine phyla. The investigation showed comparatively higher diversity of animals in the areas of Station-A (14), Station-B (10) and Station-C (10) intertidal environments, compared to other two stations. The results indicated that the new subsidence along the Bay of Bengal side exhibited less concentration of animals than in the Andaman Sea side. This may be due to the rich species diversity of the Andaman Sea than the Bay of Bengal or that the fresh nearshore environment might be providing an opportunity for a rapid proliferation of these meiofaunal species because of less competition and high nutrients released from the decaying coconut and arecanut plantations after the earthquake. Further, the occurrence of marine phyla (Gnathostomulida and Gastrotricha) in the high diversity stations such as A, B and C suggested that the freshwater environment was converted into a nearshore environment.

EHP 07 **MECOS 09**

LEAD CONCENTRATION IN EDIBLE FISHES FROM SOUTHERN IRAN

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In 2006, 24 fish samples of the oriental sole (*Euryglossa orientalis*) and deep flounder (*Psettodes erumei*) were collected from two regions in Bandar-Abbas (BA) and Bandar-Lengeh (BL), the fishing grounds north of Hormoz Strait (Persian Gulf). Using the ROPME method (MOOPAM) for chemical digestion, lead (Pb) concentration was measured with a non-flame atomic absorption spectrophotometer. The average concentration of Pb in the edible muscle of deep-flounder was 0.27 $\pm$ 0.09 and 0.15 $\pm$ 0.09 $\mu g.g^{-1}$ respectively in BA and BL. In the oriental sole, the concentrations were 0.15 $\pm$ 0.04 and 0.14 $\pm$ 0.08 $\mu g.g^{-1}$ respectively. The average concentration of Pb in the liver of the deep-flounder in Bandar-Abbas and Bandar-Lengeh was 0.37 $\pm$ 0.14 and 0.23 $\pm$ 0.09 $\mu g.g^{-1}$ respectively, and in the oriental sole was 0.20 $\pm$ 0.03 and 0.19 $\pm$ 0.1 $\mu g.g^{-1}$ respectively.

EHP 08 **MECOS 09**

DISTRIBUTION OF BACTERIOPLANKTON IN THE INDIAN OCEAN SECTOR OF SOUTHERN OCEAN

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Southern Ocean is the fourth largest ocean in the world with a total area of 20.327 million sq km. The multidisciplinary scientific expedition to the Southern Ocean (Pilot Expedition to the Southern Ocean-PESO) onboard *ORV Sagar Kanya* conducted during the summer of 2004 collected various physical, chemical and biological data/samples. This expedition is the first Indian attempt to understand the distribution of bacterioplankton in the Southern Ocean. In the present study, we identified the distribution pattern of bacterioplankton in water samples collected from the Indian sector of Southern Ocean between latitude 27°14′00′′ and longitude 50°32′00"E to latitude 44°59′55"N and longitude 57°29′55"E. Total (culturable) Heterotrophic Bacterial (THB) count was maximum ($107x10^4$/CFU/ml) in water samples collected from 200 m depth and the lowest ($15.1x10^3$/CFU/ml) was at 3730 m depth. Surface water samples showed higher total heterotrophic bacterial population than that of deeper water samples. Of the 250 cultures isolated from various water samples, 9.2% were positive rods, 58.4% negative rods, 27.6% positive cocci and 4.8% negative cocci. The important groups isolated were *Pseudomonas, Aeromonas, Vibrio, Acinetobacter, Micrococcus, Staphylococcus, Flavobacterium, Chromobacterium, Moraxella, Bacillus, Planococcus,* Coryneforms and Enterobacteriaceae. Twenty percent of the isolates belonged to the genus *Pseudomonas*. The next dominant genus was *Vibrio* (17%) followed by *Acinetobacter, Micrococcus* and *Aeromonas* (Fig. 1). Extracellular enzyme production showed that 94% were lipolytic, 40% gelatinolytic and 32% amylolytic. Of the various genera capable of producing lipase, *Pseudomonas* was found to be the dominant (21%) followed by *Vibrio* (16%). Gelatinase production was found to be remarkable among the isolates from deeper part of the Southern Ocean compared to those from 200 m depth.

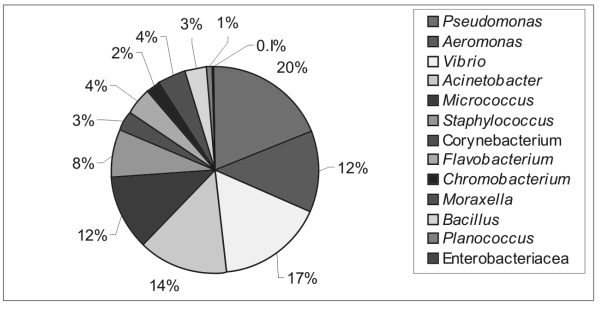

Fig. 1. Generic Composition of THB isolated from various stations in the Southern Ocean

EHP 09 **MECOS 09**

HYDROGRAPHY AND HEAVY METALS IN UPPANAR ESTUARY, NAGAPATINAM COAST, INDIA

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The present work was carried out on the hydrography and distribution of heavy metals (Cu, Zn, Cd and Hg) in two stations of Uppanar estuary. Atmospheric and surface water temperature showed maximum values during summer and minimum during monsoon season. Dissolved oxygen concentration was high during the monsoon and low during the summer at both the stations. Distribution of dissolved nutrients also exhibited considerable seasonal and spatial variations with high values during the monsoon due to the flooding and land runoff. The silicate concentration was found to be higher than the other nutrients. Heavy metal concentration was high during summer and post-monsoon seasons. During monsoon, prolongation of turbidity and heavy load of metals washed down from the land to the sea resulted in higher accumulation of heavy metals.

EHP 10 **MECOS 09**

DESTRUCTION OF SPAWNS IN SUNDARBANS DAMAGING COASTAL MANGROVE ECOSYSTEM

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The Sundarbans, situated at one of the largest delta-face offered by Bhagirathi-Hooghly river systems in India, is declared as World Heritage Site for the largest mangrove forest and the only mangrove- tiger land on earth. A great floral and faunal biodiversity are mingled together in a closely-knit matrix of mangrove food web in the Sundarbans. Extensive broadbase of energy-fixers is formed by huge reserve of phytoplankton in the estuarine waters and detritus in the dense mangrove vegetation with Royal Bengal Tigers occupying the pinnacle. If any of these components is affected by human intervention, the entire food pyramid will collapse in the long run.

With increasing population, local fishermen and multinational companies have converted low lying paddy fields and coastal swamps of Sundarbans into extensive

bheries, *i.e.*, artificial enclosure of saline water taken from tidal influx for large scale commercial prawn culture. Coastal Sundarbans is a great potential source of seedlings of the prawns *Penaeus monodon* and *Fenneropenaeus indicus* for the *bheris*. As there is no hatchery or seed bank, a large number of poor females and children collect prawn seeds indiscriminately from daily tides by using mosquito-nets. After sorting out the economically valuable prawn seedlings, they destroy millions of other ecologically valuable juveniles of other organisms (Tables 1 and 2).

Table 1. Maximum catch of seed (numbers/ net hour) during peak months of availability

Fish landing station	Species	1986	1987	1988	1989	1990	1991	1992
FRESERGANJ	*Penaeus monodon*	175	184	126	2332	2208	480	82
	Fenneropenaeus indicus	336	514	1680	6224	704	538	185
CANNING	*Penaeus monodon*	158	184	35	24	32	17	12
	Fenneropenaeus indicus	127	215	-	11	-	-	45

Source : De, D.K. and Sinha, M. 1997. *Indian J. Fish*, April-June, 1997.

Table 2. Destruction of seeds in the estuaries of Sundarbans

Hooghly	Matla	Saptamukhi	Thakuran	Bidya	Jhilla	
Destruction of seeds in millions	930.0	568.8	7775.0	233.4	196.2	160.0
No. of seed collectors	46,000	24,050	30,000	18,000	14,000	11,000

Source : Bhaumik, U. *et* al., 2004. *Environ & Ecol*, 22(4), 796-803, CIFRI, India.

Over-collection has reduced the by-catch of prawn seedlings from 14.4% (1970-'71) to 8.1% (1989-'90) in the total catch. This practice seems to be responsible for the disappearance of *Chandana hilsa*, sea-conch and *Chiruni*, which were last recorded 25 years back, and endangering *Pangas* shark in the coastal Sundarbans. It may narrow down the broad base of the mangrove food pyramid.

EHP 11 **MECOS 09**

FATE OF PLASTIC IN THE MARINE ENVIRONMENT AND THEIR POSSIBLE EFFECT ON MARINE BIOTA

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Three fourth of the earth's surface is covered by water which forms one of the key assets to any coastal nation. This marine environment is also host to most of the living species on the earth. This environment, thought to be resilient to any amount of human impact, has become the ultimate storehouse of our wastes. All sorts of pollutants, metals, pesticides, chemicals, organic wastes, dyes, fertilizers, sewage etc, have been observed in the coastal oceans. DDT has been reported even in the polar bears in the Arctic and eggs of penguins in the Antarctic regions. Plastics have been the latest material in marine pollution. Most research has been focused on the effect plastics exert on the living organisms like ghost fishing due to derelict gear, entanglement of marine birds, mammals and other organisms; and ingestion problems in turtles and whales.

Some of the little known aspects of plastic degradation in the marine environment is the formation of 'mermaid tears' or microscopic particles of plastic. These microscopic particles are formed by the long term exposure of plastic to weathering and other physical processes in the marine environment. Plastics are not biodegradable and they simply break down physically and can exist in environment for hundreds of years. These fragments can accumulate toxins and other substances in the water and enter the food chain. Ultimately they can result in biomagnification of hydrophobic chemicals such as PCBs and other polymer additives which largely accumulate on the sea surface. About 1% of the world's plastic is recycled and the US recycles about 2% of the plastic. The rest are left in landfills and other disposal sites and may remain unaffected for centuries. In this article, effort has been taken to review the status of plastic pollution and their possible consequences on marine life. Little information is available regarding the status of such research in India. However, the onus on measures to curb plastic does exist. It is in the hands of the government and research institutions to initiate and inculcate safe disposal means in the people. The other way will be to develop research towards suitable alternatives to plastics. Further research is also needed to understand the fate of plastics in the marine environment and the possible impact on the marine biota. Addressing the problem of plastic debris in the oceans is a difficult task, and a variety of approaches are urgently required. Some of the ways to mitigate the problem are discussed.

EHP 12 **MECOS 09**

POST-TSUNAMI IMPACT ON COPEPOD DIVERSITY IN MUTTUKADU BACKWATERS NEAR CHENNAI

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Microzooplankton are more common than macrozooplankton. An attempt was made to correlate the water quality and plankton distribution soon after tsunami 2004 in the Muttukadu backwaters near Chennai.

Salinity fluctuation had a marked effect on the planktonic population. The salinity during January 2005 ranged between 46.0 ppt and 49.5 ppt. In contrast, the lowest range of salinity (0.3 - 0.8 ppt) was recorded during December 2005. Among the copepods, calanoids were represented by only 3 genera, cyclopoids by 7 genera and harpacticoids by two. There was an increase in the zooplankton population from October 2005.

EHP 13 **MECOS 09**

BIOACCUMULATION OF HEAVY METALS IN SOME COMMERCIAL FISHES OF THE PERSIAN GULF, IRAN

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Six samples of deep flounder *(Psettodes erumei*) and oriental sole (*Euryglossa orientalis)* were collected in Bandar-Abbas and Bandar-Lengeh during April to June 2006. The samples were analyzed for As, Cd, Co, Cr, Cu,Fe, Hg, Mn, Ni, Pb and Zn by Inductively Coupled Plasma Atomic Emission Spectrometer (Perkin Elmer Optical Emission Spectrometer, Optima 2000 DV). Metal accumulation follows the order Fe > Zn > Mn > Cu > As >Pb > Hg > Cr > Co > Cd in the oriental sole and Cu >Fe > Zn > Mn > Hg > Ni > Pb > Cr > Cd >Co in the deep flounder.

EHP 14 MECOS 09

DIVERSITY OF POSTLARVAE OF LUTJANIDAE ALONG THE SOUTHWEST COAST OF INDIA

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The snapper family, Lutjanidae is a common and commercially important group of fishes. From Western Indian Ocean, 44 species belonging to 14 genera are reported to occur. Every year, during October to April, larval fish assemblage is a unique phenomenon of the coast. Several species of lutjanid postlarvae occur in the shore seine as incidental catch. The postlarvae of lutjanids are transparent with a short conspicuous opaque abdominal cavity. Postlarvae of the following 34 species belonging to 6 genera collected from shore seine at Vizhinjam and Thengapattinam fishing villages of southwest coast are described and illustrated: *Aprion viresens* (9.22 mm BL), *Lipocheilus carnolabrum* (11.8 mm BL), *Lutjanus lutjanus* (15.74 mm BL), *Lutjanus lemniscatus* (12.17 mm BL), *Lutjanus bengalensis* (11-79 mm BL), *Lutjanus lunulatus* (11.2 mm BL), *Lutjanus quinquelineatus* (18.21 mm BL), *Lutjanus madras* (14.1 mm BL), *Lutjanus coeruleolineatus* (11.05 mm BL), *Lutjanus gibbus* (9.28 mm BL), *Lutjanus erythropterus* (16.48 mm BL), *Lutjanus monostigmus* (16.26 mm BL), *Lutjanus revulatus* (16.79 mm BL), *Lutjanus johni* (8.5 mm BL), *Lutjanus duodecemlineatus* (11.32 mm BL), *Lutjanus malabaricus* (14.62 mm BL), *Lutjanus bohar* (11.25 mm BL), *Lutjanus fulvifilamus* (12.95 mm BL), *Lutjanus kasmira* (17.2 mm BL), *Lutjanus russelli* (19.17 mm BL), *Lutjanus biguttatus* (11.49 mm BL), *Lutjanus lineolatus* (25.37 mm BL), *Lutjanus argentimaculatus* (15.32 mm BL), *Lutjanus sangunensis* (12.31 mm BL), *Lutjanus sebae* (5.84 mm BL), *Lutjanus vittus* (17.8 mm BL), *Lutjanus ehranbergii* (15.1 mm BL), *Lutjanus guilcheri* (10.30 mm BL), *Lutjanus fulvus* (18.57 mm BL), *Tropidinius zonatus* (16.84 mm BL), *Etelis marshi* (11.58 mm BL), *Pinjalo pinjalo* (12.11 mm BL), *Pristipomoides multidens* (11.6mm BL) and *Pristipomoides filamentosus* (13.08 mm BL).

Lutjanids, like most marine fishes experience a pelagic dispersal phase at the beginning of their life cycle in the form of countless larvae and postlarvae. They return to their parent environment after transformation to juvenile fish. During the pelagic phase, they are fragile and more sensitive to the environment. During certain seasons, postlarvae of lutjanids occur in large quantity. It can be used as potential seeds for the ecofriendly mariculture. Environmentally safe process of exploitation and sustainable management are of great importance. The significant diversity of the snapper postlarvae proposes the feasibility of culture prospects benefiting the community to a great extend.

EHP 15 **MECOS 09**

EGGS, LARVAE AND JUVENILES OF TRICHIURID FISHES *TRICHIURUS LEPTURUS* (LINNAEUS, 1758), *LEPTURACANTHUS SAVALA* (CUVIER, 1827), *EUPLEUROGRAMMUS GLOSSODON* (BLEEKER, 1860) FROM THE INSHORE WATERS OF SOUTHWEST COAST OF INDIA

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Eggs, larvae and juveniles of the ribbonfishes *Trichiurus lepturus*, *Lepturacanthus savala*, and a postlarva of *Eupleurogrammus glossodon*, collected from the inshore waters of the southwest coast of India are described and illustrated. Eggs and larvae were collected by plankton net and postlarvae and juveniles were from the discards of the boatseines operated off Vizhinjam and Thengapattanam. Eggs are fairly large, spherical with single oil globule and narrow perivitelline space. Unlike the prolarval and larval phase, the postlarval phase is most significant and highly protracted followed by transformation of general body form and structure that changed the postlarva as a true replica of its parents. Change of body shape is due to the progressive increase in the size of head, gut and caudal. Development of fin elements, ossification of vertebral column, loss of transparency and deposit of silvery guanine in the body surface followed by characteristic pigmentation on head, trunk and tail are the features of postlarval phase. Fin structure consists of dorsal, pectoral and anal. Caudal and pelvic are absent.

Fertilized eggs of *Trichiurus lepturus* are large ranging from 1.58 to 1.65 mm diameter with a single, large oil globule and narrow perivitelline space. Three yolk sac larvae measuring 2.04, 2.2, 3.6 mm Notochord Length (NL) and two larvae of 4.7 and 4.9 mm NL were used in this study. Postlarval phase is highly significant and protracted. Seven stages ranging from 6.63 mm NL to 135 mm NL are described and illustrated. Teeth first appeared at 15.12 mm NL. The dorsal fin consists of 3 distinct anterior spines followed by 131 to 136 soft rays. The dorsal spine is serrated. Pectoral fin is very small. The anal fin consists of two anterior large spines followed by 103 to 107 anal spinules which exhibited characteristic transitory spinnation. The full compliment of 171 vertebrae plus urostyle occurs at 136 mm NL. Melanophores present at the larval phase are indistinct and faded away easily. Chromatophores are large and distinct on head and dorso-lateral sides of the body. The chromatophores present on the tail are species specific.

Fertilized eggs of *Lepturacanthus savala* are larger, ranging from 1.95 to 1.97 mm diameter with single oil globule and narrow perivitelline space. Two prolarvae of 2.18 mm and 2.93 mm and single larvae of 4.59 mm NL were used for the study. The postlarval phase is highly significant and protracted. Seven stages ranging from 5.6 mm to 135 mm NL are described and illustrated. Teeth were noticed as small

conical buds at 20.31 mm NL. Alimentary canal is large during early stages and recorded 59.1% at 16.3 mm NL. First appearance of three anteriormost dorsal spines were noticed at 5.63 mm NL, and at 7.67 mm NL, the characteristic IV dorsal spines appeared followed by 8 feeble soft rays. At 135 mm NL, full compliments of (IV + 123) dorsal fin elements established. Pectoral fins are small, rays are indistinct to enumerate. Anal fin consists of two large anterior spines followed by 93 anal spinules which exhibited characteristic transitory spinnation. Full compliment of 175 vertebrae plus urostyle was accomplished at 135 mm NL. Chromatophores are comparatively less at head and the dorso-lateral aspect. Chromatophores are seen till to the base of last dorsal fin rays. No chromatophores are present on tail.

The meristic and morphometric characters of postlarva of *Eupleurogrammus glossodon* measuring 74.56 mm NL is documented with figures.

EHP 16 **MECOS 09**

BIOAVAILABILITY OF HEAVY METALS IN WATER, SEDIMENTS AND FISH SPECIES FROM KAATTUPPALLI ISLAND, SOUTHEAST COAST OF INDIA

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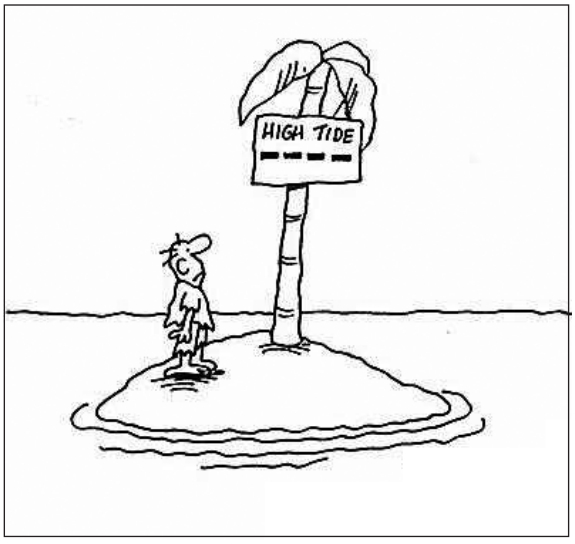
Preliminary attempts were made to study the impact of industrial effluents on heavy metal accumulation in water, sediment and biota off Kaattuppalli Island. The study area is situated in the vicinity of a petrochemical industry, a desalination plant and a sewage outlet which makes the ecosystem stressful. The present study documents the accumulations of heavy metals (Cu, Zn, Pb, Cd, Mn, and Fe) in the water, sediments as well as in different organs of the fish *Chanos chanos*, confined to Kaattuppalli Island. The results clearly indicated that the heavy metals were present in the order of Zn > Fe > Cu > Mn > Pb > Cd in the fish. Accumulations of metals in the water and sediment were in the order of Cu > Cd > Pb > Fe > Zn and Fe > Mn > Cu > Zn > Pb > Cd respectively. The metal accumulation was prominent in the reproductive tissues (ovary) of the chosen fish. This may be due to the impact of effluent discharge via food chains. Besides, these toxic heavy metals cause oxidative stress in fish and impair the nutritive value of edible fish.



Climate Change - CC

CCO 01 MECOS 09

IMPACTS OF CLIMATE CHANGE ON MARINE ECOSYSTEMS AND FISHERIES

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Marine ecosystems have always been affected by changes in climate at timescales from decades to millions of years. Since the industrial revolution in the 19th century the increase in greenhouse gases has caused an accelerating rise in global temperature whose effects on marine biota can now be detected. The rising level of CO_2 and consequent acidification of the oceans is having an impact on metabolism and calcification in many organisms, with damage to vulnerable ecosystems, such as coral reefs, already occurring. The pH of the oceans is already lower now than it has been for the past 600,000 years.

We depend on the oceans and coastal seas for many ecosystem services (supporting, provisioning, regulating and cultural) and there is real cause for concern that these services will be damaged and degraded by climate change. Can we identify areas and ecosystems that are particularly vulnerable? How soon could climate have an impact on marine ecosystem services? How great is the impact likely to be under different scenarios of climate change? Do we have monitoring systems in place which will warn of impending changes and provide information which can be used to respond? Are there ways in which we can adapt to climate change and mitigate? The effects of climate change can be detected at individual, population and ecosystem level. We require better understanding of the processes which act at all these levels, from experimental and field work in order to provide credible responses to the questions posed above. Most of the studies of long term changes and climate impact to date have come from temperate parts of the Atlantic and Pacific and there is a great need for matching information from tropical areas, particularly in the Indian Ocean.

Climate change is not the only pressure which humans impose on the marine environment and in the short term it is probably not the one with the greatest impact. Fishing, habitat degradation, pollution and species introductions also have many undesirable consequences and they also interact with each other. In coastal and inland waters, there are also effects of changes in land use, coastal defence, damming, flood control and alteration of waterways.

Climate change can act directly on productivity of commercial fish species by altering growth, reproduction and other aspects of life history either positively or negatively. It can also act indirectly by enhancing or suppressing prey, predators and pests, with consequences for the structure and resilience of the whole ecosystem. The processes and pathways by which biological production is transferred through

marine food-chains are longer and more complex than in terrestrial agriculture and the scope for experiments and research is far less. Fisheries production depends on net primary production (NPP) and the transfer of this production through the food chain to human consumption. Future NPP may increase in some high latitude regions due to warming and decreased ice cover, but the dynamics in low latitude regions are governed by different processes, and production may decline due to reduced vertical mixing of the water column and hence reduced recycling of nutrients. Recent changes in distribution and productivity of a number of fish species can be ascribed with high confidence to regional climate variability, such as ENSO. The effects of fishing and of climate interact, because fishing reduces the age, size and geographic diversity of populations and the biodiversity of marine ecosystems, making both more sensitive to additional stresses, such as climate change.

The frequency and intensity of extreme climate events is likely to have a major impact on future fisheries production in both inland and marine systems. Reducing fishing mortality in the majority of fisheries, which are currently fully exploited or overexploited, is the principal feasible means of reducing the impacts of climate change.

CCO 02 **MECOS 09**

IS ARABIAN SEA RESPONDING TO GLOBAL WARMING AND UNDERGOING A CLIMATE SHIFT?

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Human induced global warming and climate change is a reality, which is happening at a much alarming pace than was expected. Response of the ocean to human-induced changes is different between ocean basins and it is presently unclear how the Arabian Sea is responding. In this presentation, we show that the impact of global warming on the Arabian Sea is the disruption of the natural decadal cycle in the sea surface temperature (SST) after 1995, followed by a secular increase in temperature. This increase in temperature is associated with a 5-fold increase in the development of most intense cyclones (>100 kmph) in the Arabian Sea (May-June) during the past 12 years after 1995 (1995-2007), compared to the previous 25 years (1970-1994). Concurrent with these events, there are progressively warmer winters, decreased monsoon rainfall, both occurring over India and an increase in the phytoplankton biomass in the Arabian Sea during fall and winter, all of which are linked. We further show that the warmer winters cause a reduction in the annual wheat yield while decreased rainfall results in the decline of vegetation, increase in aridity and increased occurrence of heat spells over India. We attribute the

synchronous increase in the phytoplankton biomass to iron-fertilization during fall and winter by enhanced dust-delivery from the surrounding landmass under increased aridity. Further, the increased phytoplankton biomass is tightly coupled to the higher fish (oil sardine) catch in the eastern and western Arabian Sea after 1995. These results have implication to the food and water security of the region.

CCO 03 **MECOS 09**

IMPACT OF EXTREME CLIMATIC EVENTS ON BRACKISHWATER AQUACULTURE

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Aquatic food supply in the next 20 to 30 years has to be met by aquaculture only, as most capture fisheries are either fully exploited or have been overfished. During this period, impacts of climate change are expected to increase and affect fisheries. In India, fisheries and aquaculture contribute over 1% to the national GDP and 5.34% to agriculture and allied activities. Brackishwater aquaculture in India is dominated by shrimp farming. Floods, droughts and cyclones are the main extreme climatic events in tropical Asia and any increase in the intensity and/or frequency of these may damage brackishwater aquaculture.

The east coast of India is subject to frequent cyclonic storms and occasional tidal waves, which cause loss of aquaculture stock and damage to aquaculture facilities. Studies conducted by Central Institute of Brackishwater Aquaculture (CIBA) on the impact of extreme climate events such as cyclones/floods/tsunamis/drought revealed the extent of damage that these events could cause. Cyclonic storms in May 1990 and November 1991 in coastal districts of Andhra Pradesh affected the economics of shrimp aquaculture. In Krishna District, the shrimp stocks had been harvested and damage was confined only to physical structures. In East Godavari District, the farms were inundated almost one meter above bund level and the damage included erosion of bunds, heavy siltation and damage to electrical installations, sluices, shutters and screens. Communications were cut off and feed stocks were lost. In Nellore District, with the breaching of 202 irrigation tanks, large-scale inundation of the entire watershed area was experienced and all the shrimp farms were submerged. The tsunami of 2004 caused either partial or complete damage to shrimp hatcheries and farms. The recent cyclone *Nisha* and the resultant flooding in November 2008 destroyed 1000 acres of shrimp farms in coastal Tamil Nadu. As per preliminary assessment, more than 1500 tonnes of mature shrimp were washed away and infrastructures including farm equipment were damaged accounting for a total loss of around 326 million rupees. Changes in pond water quality, introduction

of disease into aquaculture facilities along with the flooded water resulted in yield reduction and crop losses.

The term "coastal squeeze" describes the progressive loss and inundation of coastal habitats and natural features located between coastal defenses and rising sea levels. The total flood-prone area in India is about 40 million ha. Coastal ecosystems such as mangroves and salt marshes are essential for maintaining wild fish stocks, as well as supplying seed to aquaculture. Mangroves defend the shore from storm surges that can damage shrimp ponds and other farm infrastructure. Mangroves in Nagapattinam District, Tamil Nadu protected the shrimp farms and livelihood during tsunami 2004. The sea level rise and the subsequent inundation could cause the negative impacts on aquaculture. Loss of land due to inundation leads to reduced area available for aquaculture. Seawater intrusion into freshwater aquifers is an increasing problem with rising sea level. In certain geographical locations, seawater inundation may have positive impacts for aquaculture. Increased areas are suitable for brackishwater culture of high-value species such as shrimp and mud crab. Survey by CIBA revealed that around 829 ha of seawater inundated agriculture areas in Andaman and Nicobar Islands are now suitable for brackishwater aquaculture.

Drought has a profound effect on the shrimp farming. Approximately 40–45% of brackishwater area and 60% of freshwater area were affected by severe drought in Krishna District, Andhra Pradesh in 2002. The lack of rains during summer months leads to an increase in the salinity of the creeks beyond the tolerable limits of the cultured organisms. The drop in culture area was attributed to lack of freshwater and rise in salinity in the drains. Rise in water salinity to more than 50-60 ppt led to poor performance of shrimp seed in the initial culture days. Fall in freshwater culture of *penaeus monodon* was also due to drop in freshwater availability for culture. Since drought is expected to affect the availability of freshwater and the flow in river, it is essential to forecast the water availability for aquaculture.

Socioeconomic resilience is the capability of a society to prevent or cope with the impacts of extreme climate events and sea-level rise, including technical, institutional, economic, and cultural ability. The list of mitigation practices for individual agricultural systems and settings can also be applicable to aquaculture. Institutional responses such as constructing artificial flood defenses and maintaining natural ones can provide significant protection. However, poor communities in exposed areas are unlikely to be able to build substantial defenses. In locations where floods are common, short culture periods and minimal capital investment in aquaculture help reduce stock loss. It is essential that there is concerted research effort to understand the likely impact of extreme climate events and develop adaptive measures. More focused studies are required on the assessment of aquaculture related vulnerability through geographical information systems (GIS) based decision support models and planning for uncertainty to take care of extreme weather events.

CCO 04 MECOS 09

OPTIONS ON FISHERIES AND AQUACULTURE FOR COPING WITH CLIMATE CHANGE IN INDIA

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Fisheries and aquaculture have very important roles for food supply, food security and income generation in India. About 2 million people work directly in the sector in this region, producing around 6 million tonnes annually. Due to several reasons, production from fisheries is stagnant during the last ten years, and aquaculture is not expanding as anticipated. Climate change is projected to exacerbate this situation. Warming of water has impact on fish diversity, distribution, abundance and phenology, which will have, in turn, effects on the ecosystem structure and function. Acidification of water will have effects on calciferous animals. Increased incidence of extreme events such as storms, floods and drought will affect the safety and efficiency of fishing operations, flow of rivers, area covered by wetlands and water availability and will have severe impacts on fisheries and aquaculture. Sea level rise will have effects on the coastal profile and livelihoods of communities. The potential outcome for fisheries may be decrease in production and value of coastal and inland fisheries, and decline in the economic returns from fishing operations. The potential outcome for aquaculture may be higher capital, operating and insurance costs, loss of fish stocks, damage to facilities, conflict with other water users, reduced production capacity and increased per unit production costs.

Table 1. Options for coping with climate change in fisheries and aquaculture (gathered from different sources)

Concerns	Adaptive mechanisms
Uncertainties in fish availability and supply	i) Develop knowledge base for climate change and fisheries and aquaculture; ii) Predict medium and long term probabilistic production; iii) Predict specific fisheries and aquaculture systems; iv) Assess the adaptation capacity, resilience and vulnerability of marine and freshwater production systems; v) Adjust fishing fleet and infrastructure capacity; vi) Consider the synergy between climate change and factors such as fishing, water availability, energy and agriculture
New challenges for risk assessment	i) Consider increasing frequency of extreme weather events; ii) Consider past management practices to evolve robust adaptation systems; iii) Identify and address the vulnerability of specific communities; consider gender and equity issues

Complexities of climate change interactions into governance of frameworks to meet food security objectives	i) Recognition of climate-related processes, and their interaction with others; ii) Action plans at national level based on (a) Code of Conduct for Responsible Fisheries; (b) Integrated ecosystem-based fisheries and aquaculture management plans, (c) framework for expansion of aquaculture; (d) linkage among cross-sectoral policy frameworks such as insurance, agriculture, rural development and trade; iii) Action at regional level by (a) strengthening regional organizations and place climate change agenda as a priority; (b) addressing transboundary resource use; (c) evolving common platforms and sharing the best practices; iv) Action plan at international level by (a) linking with mitigation activities (b) enhancing co-operation and partnerships; (c) applying international fishery agreements
Fisheries and aquaculture are weak sector; may become more vulnerable in conflicts with other sectors	i) Action plans should involve not only fisheries institutions/ departments, but also those for national development planning and finance; ii) Sharing and exchange of information with other sectors; iii) Existing management plans for fisheries and aquaculture need to be reviewed in the context of climate change.
Financing climate change adaptation and mitigation measures	i) Fishermen, fish farmers, processors, traders and exporters should ensure self protection through financial mechanisms; ii) Improving equity and economic access such as microcredit should be linked to adaptation responses; iii) Investment on infrastructure, such as construction of fishing harbour, should consider climate change; iv) Financial allocation in national budget for risk reduction and prevention practices such as early warning systems and disaster recovery programmes and for relocation of villages from low lying areas; v) Fiscal insensitive for reducing the sector's carbon footprint and other mitigation and adaptation options.

Despite the uncertainties and potential negative impacts of climate change on fisheries and aquaculture, there are opportunities to reduce the potential vulnerability to climate-related impacts (Table 1). The following measures could contribute to coping with climate change: (i) evaluating the adaptive capacity of important fish groups; (ii) identifying adaptive fishing and post-harvest practices to sustain fish production and quality; (iii) supporting energy efficient fishing craft and gear; (iv) identifying new land-use system for aquaculture; (v) identifying new candidate species and developing hatchery and grow-out technologies; (vi) cultivating aquatic algae, which have positive response to climate change, for food and pharmaceutical purposes and for production of biodiesel; (vii) investigating the potential fish diseases in the natural and aquaculture systems; (viii) increasing climate literacy among the fishing and farming communities; (ix) establishing Weather Watch Groups; and (x) evolving decision support systems for fisheries and aquaculture in the region. It is also important to recognize the synergies between adaptive and mitigation options related to climate change and non-climatic factors such as responsible fisheries, and ecofriendly aquaculture.

CCO 05 MECOS 09

RESPONSE OF OIL SARDINE OF KERALA WITH SPECIAL REFERENCE TO EXTREME OCEANOGRAPHIC EVENTS

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Distribution of Sea Surface Temperature (SST) and response of oil sardine off southwest coast of India during extreme oceanographic events such as El Niño, La Niña and IOD (Indian Ocean Dipole) during the period 1991 to 2000 were studied. The monthly concentrations of chlorophyll pigments were also studied during 1997 to 2000. Satellite derived oceanographic data (AVHRR- SST and SeaWiFS - Chlorophyll) have shown that coastal upwelling occurs during the summer monsoon period, that resulted in high nutrient concentrations and biological productivity along this coast. Changes in the hydrographical factors and biological processes occurring in this region during different months appeared to be influenced by the pattern of upwelling along the northern and southern parts of westcoast of India. The extreme oceanographic events associated with cold La Niña (1999-2000), which preceded the 1997-1998 El Niño along with a positive IOD, was responsible for the collapse of the pelagic fishery in 1998. Significant positive correlation was observed between El Niño Southern Oscillation (ENSO) events and SST from the study area. From the AVHRR-SST figures, there is a clear evidence of ENSO's influence on the inter-annual SST variability of the tropical Indian Ocean. From October 1997 to June 1998, which was a major El Niño event, there was an unusual increase in SST when compared with other years. Variations in chlorophyll *a* concentration were also observed. A decrease in SST occurred during the La Niña event. Indian Ocean Dipole (IOD), an oscillatory mode of coupled ocean atmosphere variability, causes climatic extremes throughout the tropical Indian Ocean. Temperature is a dominant factor influencing the distribution and migration of the oil sardine. The co-occurrence of positive IOD and El Niño caused a decrease in oil sardine landings along the southwest coast of India. During 1994, a drastic decrease occurred in oil sardine landings along Kerala. Another decrease in oil sardine landings was also noted during 1998. During the negative IOD year 1996 and La Niña year 1999, there was an increase in the landings than the previous years. During 1991-2000, the El Niño and IOD events occurred frequently and during that period, there was a tremendous decrease in oil sardine landings of Kerala. When correlating the oil sardine landings with SST Dipole Mode Index (SST DMI), it can be seen that there is a negative correlation of landings with positive IOD events and a positive correlation with negative IOD events. Correlations are more when both the events (positive IOD and El Nino) happen within the same year. In 1994 and 1998, which were El Niño years with a positive DMI, there was a decrease in annual pelagic fish landings along the southwest coast of India.

CCO 06 MECOS 09

CLIMATE CHANGE ON OCEAN, COASTAL ECOSYSTEM AND SMALL ISLANDS — A DEVELOPMENTAL APPROACH

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Global warming due to greenhouse gas concentration and climate change is widespread over the earth. The rise in temperature over the last one hundred years reveals an average linear trend of 0.74°C (0.5 – 0.92°C) increase in global temperature. This paper reviews the present understanding of the impacts of climate change on ocean and coastal ecosystems with emphasis on small island ecosystem's hydrological regimes. The possible adaptation and mitigation measures are also discussed.

As per the reports of UNEP, the observed rise in sea level (SLR) due to climate change is more than the predicted SLR. The observed SLR is 3.1 mm per year whereas the predicted SLR is 2.9 mm per year. The countries that are most vulnerable due to sea level rise are in Asia, *viz*., China, India, Bangladesh, Vietnam and Indonesia. During the coming decade more than 24% of the coral reef will be affected due to SLR in Asia. Wetlands and mangroves are also declining rapidly by 50-90% in most regions in the past four decades. It is projected that one meter SLR will inundate 800 – 1000 sq. km land in Asia adversely affecting more than 100 million people and an economic loss of more than 400 billion US $.

The oceans have large resilience threshold to bear with the impact of climate change. It will be quite impossible to recover the ocean ecosystem once the threshold limit is exceeded. On a large scale, the changes in the ocean take place slowly, and take long time periods. The report published by the UNEP in 2008 indicates that the signal from the altered pH is a result of high carbon dioxide dissolved in seawater from the atmosphere. Ocean acts as a natural reservoir for carbon dioxide. The uptake of carbon dioxide since the year 1750 had decreased the average pH of ocean water by 0.1. The continued increase in carbon dioxide can alter the ocean pH within a short period — an effect greater than anything experienced in the past 300 million years. The continued increase of carbon dioxide in the atmosphere may lead to more acidification of oceans. This may reduce biocalcification of shells, bones and skeletons of most marine organisms. Studies had suggested that by the year 2100, around 75% of all cold water corals will live in calcium carbonate under-saturated waters. There will be severe consequence to marine ecosystem due to ocean acidification and may affect marine food chains from carbonate based plankton upto higher levels. Studies have inferred that carbon dioxide released by anthropogenic activities in the last 50-100 years has so far penetrated to 3000 meter water depth of the world oceans.

Climate change will affect the strength of currents, physical and chemical aspects of ocean, and invariably the fisheries. It will affect the productivity of world oceans, *i.e.*, the world's largest producers of food. It has been reported that productivity of ocean water may increase in certain regimes in the initial stages of global warming. The global warming may cause significant changes in species distribution and ecosystem biodiversity and regional changes in the abundance of various fish species. This will alter our present understanding of fish shoals/abundance and capabilities/ techniques to locate fish shoals. This will be a catastrophe to nations those depend on fish as the prime protein source. Marine biodiversity is essential for providing food, drug and technology to the world community. The value of the marine biodiversity outweighs that of land. The reduction of biodiversity is associated with exponential reductions of ecosystem functions. The reduction of marine diversity due to climate change will have serious consequences in the life supporting systems of earth.

Climate change will be vulnerable to islands, especially small islands. Due to climate change, small islands will be affected by global sea level rise. This will aggregate coastal inundation, erosion, hydrological system and coastal agriculture. Shrinking freshwater source, coral bleaching, climate change impact on fisheries and ocean acidification are threats that will undermine food security and livelihood of islands more so of small islands. India has 1175 islands and islets; 667 in the Bay of Bengal and 508 including Lakshadweep islands in the Lakshadweep sea. The Lakshadweep islands are of *atoll* formation of coral islands consisting of 36 islands. The largest islands have an area of 4.8 sq. km and the smallest is within 0.1 sq. km. The Lakshadweep islands have the characteristics of very small low islands. These islands have a flat topography with a minimum surface runoff. The impact of climate change on the hydrological system of a few islands of Lakshadweep, *viz*., Kavarathi, Agatti and Bengaram atolls, had been reported. The distance between the surface soil and water table of these islands are very small. It is estimated that 11.6% of freshwater resource of Kavarathi Island will be contaminated for 20 cm rise in sea level. During the year 2030, the water consumption of the projected population will be 108% more than the water consumption today. The impact of sea level rise will cause considerable shore line recession at Kavarathi Island. The available information suggests shoreline recession of 8.2 m, 30.8, and 6.38 m in the east, south and north side of Kavarathi Island respectively. It is reported that 26.9% of freshwater of Agatti Island will be contaminated for a sea level rise of 50 cm. The studies had suggested that 5.99 % of the present freshwater resource of Bengaram Island will be contaminated due to SLR of 50 cm.

Climate change will have deep social impact. It requires multifaceted adaptive and mitigation efforts. The adaptation and mitigation efforts are to be focused through reduction of greenhouse gas emissions, integrating climate adaptation methods into existing planning, economic development, environment protection measures and in decision making. The impact of climate change is to be classified into potential near-term impacts and that of far reaching ones. The baseline for risk based adaptation due to climate change is to be facilitated region-wise depending on the resilience of the regional ecosystem and community. The climate change is to be incorporated to all the future planning. The integrity, effectiveness and longevity of a project is

to be ascertained with the climate change. The adaptation is to be evaluated for cost-effectiveness, extreme events and longevity. An adaptation guidance manual is to be formulated based on the regional ecosystem and stakeholders. The above manual is to be incorporated in all the future projects.

CCO 07 **MECOS 09**

CARBON CREDITS FOR THE SEAWEED WEALTH OF INDIAN COAST: OBSERVATION AND PROJECTION

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Quantitative estimates were made on the capacity of sequestering CO_2, the major green house gas dissolved in excess of ambient levels, by the marine plankton *Nannochloropsis salina* and *Isochrysis galbana* as well as the seaweeds *Gracilaria corticata, Sargassum polycystum* and *Ulva lactuca*. The green seaweed *U. lactuca* registered 100 % utilization of CO_2 towards carbon fixation from the ambient water upto an anomalous level of 15 mg. l^{-1}; beyond that level, the CO_2 utilization declined to 60%. The marine microalgae *N. salina* and *I. galbana* were able to utilize 27.7% of the dissolved CO_2, when the anomalous level was 15 mg. l^{-1}. The gross primary productivity of these algae was not affected by increase in CO_2 levels. Preliminary estimates indicate that the standing stock of seaweeds in the Indian seas is capable of utilizing 9052 t $CO_2.d^{-1}$ against emission of 365 t $CO_2.d^{-1}$, showing a net carbon credit of 8,687 $t.d^{-1}$.

CCO 08 **MECOS 09**

THE POTENTIAL IMPACT OF CLIMATE CHANGE ON BIOLOGY AND FISHERY OF SHRIMPS IN INDIAN WATERS

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The speculation that climate change will have tremendous impact on tropical marine ecosystems and sustainable fish production has gained momentum in exploring how these changes influence fish catch and also the consequences on the economy. With a gross estimated annual value of Rs.14,271 crores for marine fish landings at primary level, the fishing industry is a significant industry in India. Shrimps (0.3 million tonnes) contribute 11.8% to the total marine fish production (2.88 million

tonnes) and is a major export earner and the fluctuations in landing will have a major bearing on the seafood export from the country. Lobsters though form only 0.004% of total edible crustacean landings, fetch the highest unit price. From an ecosystem perspective, shrimp is an important component serving as a major prey for many demersal fishes and changes in reproductive patterns and distribution due to warmer ocean temperature will have potential impact on food web dynamics. The extremely fast growth rate of individuals, high fecundity, short life span and rapid turnover of population have helped the shrimps to quickly respond to environmental or ecosystem changes. While the predicted increase in seawater temperature in Arabian Sea is 0.12°C per decade, the response of shrimp populations, especially the deepsea shrimps and lobsters to climate change is likely to be extremely complex. The functional implications of abiotic and biotic effects of climate change on individual, species, population and ultimately on the shrimp fishery is discussed.

The climate change may impact directly on the physiology and morphology of individuals and indirectly due to changes in water chemistry and productivity. Ectothermic organisms generally acclimate and survive over wide temperature ranges. Their metabolism is dependent on temperature changes and critical biological processes including development, growth and reproduction are temperature dependent. Elevated levels of ocean temperature are likely to result in faster embryonic development, smaller larvae, faster growth rate, increased metabolism, early attainment of sexual maturity, lower fecundity and lower biomass production of shrimps. Increased temperature will lead to faster moulting but lower increment in weight due to increased cost of metabolism and thus offsetting the overall advantage of higher temperature. Seawater temperature and fecundity are inversely related and the impact of increased temperature on fecundity will be more evident in deepwater shrimps. In *Pandalus borealis,* 26% reduction in fecundity was associated with an increase from 4° to 6.25°C in temperature. For coastal shrimps such as *Metapenaeus dobsoni* along the Mangalore coast, 28% reduction in fecundity over a period of 20 years has been noticed due to reduction in size at first maturity. However, it may not be easier to associate the reduction in size at maturity to temperature increase alone for a tropical species, as reduction in size at maturity can also occur in species which are under heavy exploitation.

Shifts in the range and distribution of species, migration and the structure and dynamics of communities are predicted to occur due to environmental changes associated with climate change. Studies show correlation of magnitude of rainfall and shrimp fishery and while increased rainfall has been related to improved fishery for *Fenneropenaeus indicus* along the Chennai coast, movement of the deep water shrimp *Solenocera crassicornis* to inshore areas during periods of decreased rainfall and consequent higher salinity has been reported from Mumbai. The impact of climate change will be different for different species and it is likely that some changes may be beneficial to mankind whereas failure of fishery for some species will trigger economic losses and negative effects on ecosystem function. Research and management strategies based on observed and predicted changes in environmental conditions due to climate are to be developed to mitigate the challenges posed by global warming.

RELATIONSHIP BETWEEN CLIMATIC VARIABLES, AND OIL SARDINE AND INDIAN MACKEREL LANDINGS IN KERALA: A MULTIVARIATE MODELLING INQUIRY

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An attempt was made to understand the relationship between two important fish stocks of Kerala, *viz*., the oil sardine *Sardinella longiceps* and the Indian mackerel *Rastrelliger kanagurta,* and nine important climatic parameters *viz.,* Sea Surface Temperature (SST), Sea-level Pressure (SP), Relative Humidity (RH), Total Cloudiness (TC), Zonal Wind (U), Meridional Wind (V), Scalar Wind (W), Multivariate El-Nino Southern Oscillation Index (MEI) and Southern Oscillation Index (SOI). For the investigation, annual data from 1962 to 2007 were collected from International Comprehensive Ocean-Atmosphere Data Set (ICOADS). The data on annual commercial landings of oil sardine and Indian mackerel were collected from Central Marine Fisheries research Institute, Cochin. Principal Components Analysis (PCA) was employed to identify the principal factors.

A scatter plot indicated perfect correlation between MEI and SOI as perceived but other relationships were far from being linear (Fig. 1).

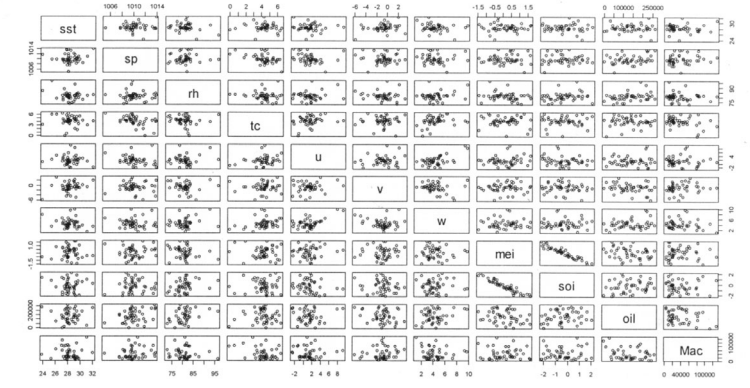

Fig. 1. Multiple scatter plot of the nine climatic variables and fish catch off Kerala

The nine climatic variables proved to be tough to be orthogonally recast into less number of PCs. PCA performed on scaled variables indicated that at least the first five PCs are important as they jointly explain 80% of variability.

The plot of oil sardine landings versus the first principal component scores presents a scattered picture, which clearly indicates the requirement of more PCs for a potentially good explanation of the landings.

The bi-plots created by tracing the original factors in the PC framework clearly sustained the findings of the analysis. The SOI and MEI were falling in the same axis albeit in opposite directions (Fig. 2). But SST, TC and SP were independent from each other's influence while explaining the performance of fish landings. The landings of oil sardine seems to be more influenced by SOI and RH whereas the pattern followed by the mackerel, which is quite deviant from that of the oil sardine, seems to be more in sync with SST and surface pressure. As the U-V-W components trace similar path only one occupies a place of prominence. This clearly suggests a five variate explanation for the performance of the two resources.

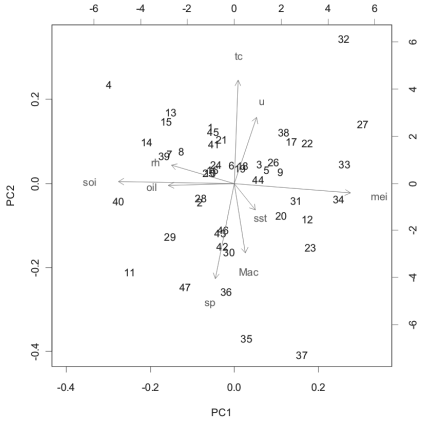

Fig 2. Bi-plot of the major climatic components against the PC axes

A multiple regression fit for the mackerel based on the first five PCs indicated a fit with 0.8089 with positive coefficient for the first PC and negative ones for the rest. A closer look at the rotation coefficients of PCs reveals that following: (i) The first five PCs are almost of equal influence with PC1 and PC2 explaining almost same proportion of variance (25%). (ii) PC1 has positive and higher magnitude loadings for SST and SP, whereas wind velocity components and relative humidity had negative loadings. The MEI and SOI had less bearing. Hence, this component may be considered as one made of those factors which are in the immediate proximity of these pelagic resources.

The analysis, while highlighting the complexity of the influence of various climatic variables, shows that the annual values indicate only the overall trend and mean performance. Moreover, the fish catch, to a large extent, are influenced by fishing intensity and technological advancements in fishing practices. An ideal way to find out the relationship between the climatic variables and fish catch would be to (i) use data of more frequent periodicity (monthly or quarterly) for an understanding of seasonal fluctuations, (ii) include other relevant factors such as rainfall, upwelling index and chlorophyll concentration, and (ii) de-trend the historical developments in fishing practices.

CCO 10 MECOS 09

TEMPORAL CHANGES IN THE CLIMATIC AND OCEANOGRAPHIC VARIABLES OFF KERALA

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To understand the temporal changes in the climatic and oceanographic variables off Kerala, monthly average data on Sea Surface Temperature (SST), Relative Humidity (RH), Total Cloudiness (TC), Zonal Wind (U), Meridional Wind (V), Scalar Wind (W), Multivariate El-Nino Southern Oscillation Index (MEI), Southern Oscillation Index (SOI), Coastal Upwelling Index (CUI) and Chlorophyll Concentration (chl) were gathered. Data on the first eight variables were collected from the International Comprehensive Ocean-Atmosphere Data Set (ICOADS) for the years 1961 – 2007; on CUI from NOAA the years 1981 – 2008; and on chl from SeaWiFS for the years 1997-2008. The data were gathered for three nearshore locations in the southern, central and northern parts off Kerala, averaged, and plotted to find out the (i) annual trend of each variable; (ii) number of decadal anomalous months, and (iii) monthly pattern in the parameters.

Annual trend in the variables: (a) The trendline of annual values of SST, V, TC and chl did not change over the timescale. However, the SST showed peaks at an interval of about ten years (1969-70, 1980, 1987-88, 1997-98, 2007). The value of V increased in the last ten years. The annual average chl concentration remained at around 1.3 mg/m^3. (b) The trendline of W and MEI substantially increased from 4 m/s in 1961 to 5 m/s in 2007, and from – 0.75 in 1961 to 0.5 in 2007, respectively. (c) The trendline of U, RH, SOI and CUI substantially decreased during 1961 - 2007; U from 2.0 m/s to 1.6 m/s, RH from 38% to 21%, SOI from 0 to – 1, and CUI from 420 to 300. The annual CUI, which sharply decreased from 1988 to 1999, however, increased thereafter until 2008.

Decadal number of anomalous months (Table 1): The number of anomalous months was identified from the monthly deviations from the respective mean values of SST, U, V, W and MEI over the 48-year period. A month was identified as anomalous if the anomaly was – 1 and below; or + 1 and above the mean value. The decadal number of anomalous months increased with regard to SST, U and SOI. For example, only 16% of the months were SST anomalous during 1961-1970, but 44% during 2001-2007. During the 48 years, the anomalies of SOI (189 anomalous months) and MEI (179 months) were very high, indicating the anomalies of the MEI components, *viz*., SST, surface air temperature, U, V and TC.

Table 1. Number of decadal anomalous months with regard to climatic and oceanographic variables off Kerala during 1961 – 2007

Decade	SST	U	V	W	SOI	MEI
1961-1970	19	24	28	35	29	35
1971-1980	29	30	35	28	49	50
1981-1990	22	31	26	29	40	40
1991-2000	35	35	35	40	51	47
2001-2007*	37	31	17	30	20	7
Total	142	151	141	162	189	179

* data for 7 years only

Monthly pattern (Table 2): In spite of the changes in the annual trend and increase in anomalies, monthly patterns were discernible for all the parameters. As expected, two distinct peaks, one during the summer (February – May) and the other during the southwest monsoon (June – September) were evident. Except SST, the peaks of all the forcing were during monsoon months and low values during summer months.

Table 2. Seasonal settings of climatic and oceanographic variables off Kerala (the values are average for the years 1967 – 2007 for SST, U, V, W and RH; for 1961 - 1999 for TC; for 1981 – 2008 for CUI; and for 1997-2008 for chl)

Parameter	Summer (Feb-May)	Monsoon (June-Sep)	Post-monsoon (Oct-Jan)
SST (^{o}C)	29.3	27.7	28.4
U (m/s)	1.6	4.1	- 0.1
V (m/s)	- 1.5	0.3	- 1.0
W (m/s)	4.0	5.6	4.0
TC (okta)	3.6	6.0	3.8
RH (%)	22.0	28.3	21.1
MEI	0.12	0.20	0.11
CUI	274.6	792.3	- 105.0
Chl (mg/m^3)	0.05	3.0	0.7

The analysis indicates the following temporal changes in the climatic and oceanographic variables off Kerala: (i) In spite of the changes in the variables over the years, the chlorophyll concentration has not shown conspicuous changes. (ii) The anomalies of some of the variables are increasing. (iii) If the changing annual trend and anomalies affect the well-defined seasonal oceanographic settings, it is possible that the biological processes may be affected in the future.

CCP 01 MECOS 09

GENETIC MANIPULATION TO COMBAT CLIMATE CHANGE

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The aquatic environment will respond to climate change in ways that are as equally significant as the responses of the terrestrial and atmospheric environments. Climate change will increase uncertainties in the supply of fish from capture and culture. Such uncertainty will impose new challenges for risk assessment in the aquaculture sector. Genetic manipulation of stocks may be able to offset the restrictions due to temperature rise. The present paper attempts to open up discussion on genetic manipulation by which it may be able to produce species better adapted to temperature increase and to cope with new pests and diseases that may arrive with warmer waters.

A major adaptive response will be the breeding of eurythermal species of aquatic organisms by utilizing genetic resources that may be better adapted to new climatic and atmospheric conditions. Collections of such genetic resources maintained in germ-plasm banks may be screened to find sources of resistance to changing diseases and insects, as well as tolerances to heat and water stress and better compatibility to new aquaculture technologies. Genetic manipulation may also help to exploit the beneficial effects of CO_2 enhancement on seaweed growth and water use. Manipulation of gene encoding for specific enzyme tolerating higher temperature is considered to be one of promising approachs. Gene transfer techniques offer new possibilities to alter the expression of heat shock genes in organisms by interference with the processes of transcription and translation.

Approved genetically manipulated organisms with some form of biological or genetic marker permitting the surveillance of foods is a requirement to label genetically modified food.

From this cursory examination of the onset of climate change and its impact on the aquaculture industry, one could deduce that the biggest need for mitigation is information and knowledge to allow for advanced planning. The industry should be able to adapt to changing conditions by technological and biological advances. Increased opportunities may present themselves to the industry with a warmer climate.

CCP 02 **MECOS 09**

SEA SURFACE TEMPERATURE CHANGES AND DISTRIBUTION SHIFTS OF INDIAN MACKEREL *RASTRELLIGER KANAGURTA*

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Climate change is believed to change the latitudinal, altitudinal and temporal distribution of a population and a trend in the northward displacement of marine organisms. Historically, the distribution of sardines and mackerels were restricted to the Malabar upwelling system along the southwest coast (8° – 16° N) of India. However, recently sardine and mackerel stocks started appearing along the northwest and southeast coasts of India respectively.

The annual mean nearshore SST along the southwest (8 °-14 ° N lat.) and northwest (16 ° -22 ° N lat.) coast of India during 1994 – 2004 is given in Fig. 1. An increasing trend in SST was observed in both the regions during 1994 – 2004. Generally, the SST was 0.85 °C higher in SW compared to NW. The strongest *El Nino* of 20th century was observed during 1997-98 and the related increase in SST was also recorded along the west coast of India. During the *El Nino* event, the maximum SST increase was noticed along the SW coast (0.56 °C) compared to the NW coast (0.42 °C). The SST showed an increasing trend all along the west coast and it was more significant along the SW coast when compared to the NW coast. The strongest *El Nino* event caused large-scale distribution shift of mackerel in 1997 towards the higher latitude, probably due to their preference for relatively cooler SST. Out of the total landings of mackerel by different gears, bulk was from gill-netters forming 60.6% of the total.

The mackerel catch was positively related to this difference in temperature (R^2 = 0.31). The distribution shift was more prominent during the *El Nino* years.

CCP 03 MECOS 09

EFFECT OF TEMPERATURE AND NUTRIENTS ON GROWTH OF MARINE ALGAE

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Temperature and irradiance are known greatly to influence phytoplankton species succession. Carbon-di-oxide is a major limiting factor dependant on water temperature. In equilibrium with air, the partial pressure of CO_2 in seawater is 0.03% of atmospheric pressure. This decreases rapidly as an inverse function of pH. For a given pH, the total amount of CO_2 decreases by about 1% for a temperature rise of 1°C. Thus, most of the responses elicited from the phytoplankton occur directly in relation to thermal changes and indirectly in relation to changes in the content of dissolved gases influenced by temperature variations. Seven marine phytoplankton species (*Chaetoceros calcitrans, Chlorella salina, Tetraselmis chuii, Isochrysis galbana, Dicrateria inornata, Pavlova lutheri* and *Nanochloropsis* sp.) were grown in monospecies and multispecies enriched static cultures in the laboratory at different temperatures under controlled conditions, with and without the addition of nutrients, to assess their response in terms of cell density and multiplication rate.

All experiments were run in sterile glass flasks capped with sterile cotton plugs and aluminum foil. Fluorescent lamps were used to provide ambient lighting in tandem with the natural photoperiodicity. Two sets of experiments at upper and lower limits of normal laboratory temperature (24ºC and 29ºC) were conducted. Each species was inoculated once and the growth and cell division patterns were continuously observed. Nutrients were added only once, at the time of inoculation in experiments without additional nutrient supplementation. Biomass, organic carbon levels, chlorophyll a and b content, nitrate, phosphate, pH and absorbance at different spectral wavelengths were recorded at each observation. For all the experiments, irradiance was maintained constant at 2 cal/cm^2/min by employing fluorescent tubes (photoperiod 12 h L**:**12 h D).

Monospecies static culture at various temperatures indicated that cell density and biomass were directly proportional to temperature elevations up to 32°C, beyond which cell death occured. The cell density of *I. Galbana*, *C. salina* and *Nanochloropsis* spp. increased to 250-300 x 104 cells/ml at 24°C in 8 to 9 days while at 29-30°C (all other parameters being constant), the cell density increased to 300-350 x 104 cells/ml in the same period of time (Fig. 1). All the species except *T. chuii* showed faster multiplication rates in the first 5 to 7 days of culture at higher temperature and the initial multiplication rates were faster with no additional nitrate additions. However, the rate of deterioration of the culture was also faster. In closed chamber culture tests, the cell densities peaked on the 3rd day and, simultaneous with decrease

in silicate and phosphate levels, the cell densities decreased, while nitrite and nitrate levels increased.

Multispecies static culture at 24 °C and 29 °C, with varying levels of nutrients revealed that as nitrate and other nutrients declined *C. salina* and *I. galbana* dominate at 29 °C while *C. salina* and *P. lutheri* dominate at 24 °C. When nutrients were added, *C. calcitrans, I. galbana* and *P. lutheri* dominate at 29 °C, while *C. calcitrans, D. inomata* and *I. galbana* dominate at 24 °C.

At 24 °C, *C. calcitrans* dominated in cell density in the first 6 to 7 days of culture, but eventually fell back to the last rank in abundance in the assemblage tested. *D. inomata* ranked second in both acceleration and deceleration. *C. salina*, which showed the slowest multiplication rate in the initial period, plateaued at the 7^{th}-8^{th} day of culture and thereafter dominated the assemblage in cell density, until further addition of nutrients. Throughout the sequence, the levels of phosphate and silicate were reducing, but the level of nitrate increased from the 7^{th} day onwards, probably due to degradation.

At 29 °C *Nanochloropsis* spp., *T. chuii*, *P. lutheri* and *D. inomata* maintained their proportionate density while *C. calcitrans* predominated initially. *P. lutheri* took over in the final phase. *C. calcitrans* reached maximum cell density of >600 cells/ml on the 6^{th} day itself while the other algae plateaued (800-400 cells/ml) in 6 to 9 days of culture and descended rapidly by the 10^{th} day, yielding high levels of ammonia and nitrate.

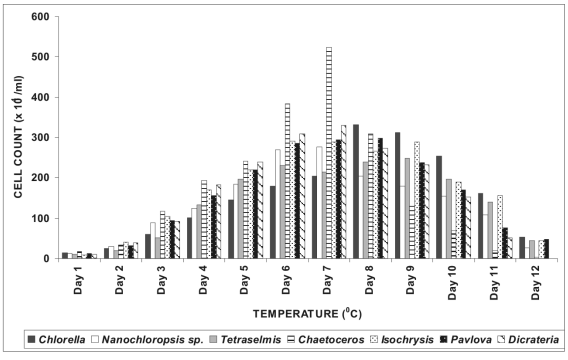

Fig. 1. Progress of algal dominance over time at 24°C

The cell density, growth, motility, dispersion and nutrient profiles at varying temperatures were estimated along a temperature gradient prevalent in large tanks holding mass cultures of the microalgae. An immersion heater set at 30-32ºC placed at one point in the tank effected temperature dispersion. The depth of the water column was maintained at 30 cm and the tanks were kept isolated and protected with side screens and light screens to avoid external influences. The trend indicated dependency of algal growth and performance on the ambient temperature than on the light source and intensity of light. Partial correlation matrix was derived nullifying the impact of select dependent parameters and thus the dispersion of the motile cells in the thermal gradient was correlated.

CCP 04 **MECOS 09**

GLOBAL WARMING, CLIMATE CHANGES AND CORAL REEF BLEACHING

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Increasing greenhouse gases and effects of global warming are serious concerns about the natural environments and ecosystems. Many scenarios have been established about the effects of global warming on biotic and abiotic components of different ecosystems. For example rising sea levels because of the heat capacity of water and melting of ices and glaciers in the poles and the land, increasing mean temperature of atmosphere, degradation of ozone layer and increasing UV absorption by the earth are dangerous for coral life. Because of the importance of corals for primary and secondary production in the sea, it is disadvantageous for other life forms in marine environments. Bleaching of coral reefs occur because of increasing water temperature, turbidity, decreasing water salinity (by glacier melting) and increasing incoming UV radiation. In this paper, we review the short-term and long-term ecological impacts of coral bleaching on reef ecosystems.

CCP 05 **MECOS 09**

MINIMIZING THE GLOBAL WARMING EFFECTS ON MARINE ENVIRONMENT

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Greenhouse gases and global warming cause changes in marine environments. Ozone layer damages caused by greenhouse gases permit the incoming UV radiation to increase. UV, with its high energy breaks down the links of the organic molecules in the living organisms and causes damages to phytoplankton and decreases the productivity of the oceans. For stopping the ozone layer degradation and the effects of global warming on marine environment, the following activities are suggested: decreasing CFC release, treatment of factory gas emission, decreasing the activities with burning fossil fuels, increasing the recovery of materials like the plastics, stopping the degradation of forests by human activities and activities for increasing the Albedo (earth's capacity for radiation reflection) by using white color in buildings and street

surfaces. Prevention of marine ecosystem degradation by human activities such as degradation of coral reefs also may be helpful for protecting the marine environment against global warming.

CCP 06 **MECOS 09**

THE CORAL REEF ECOSYSTEMS IN INDIAN WATERS: STATUS, DIVERSITY AND THREATS

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Coral reefs are among the most biologically diverse and economically important ecosystems on the planet. They provide a number of services to human societies through fisheries production, coastal protection and tourism opportunities as well as source of many raw materials and valuable drugs.

Coral reefs are similar to tropical rain forests in diversity and distribution. Barring a cold water coral belt in North Atlantic, the distribution of coral reefs is in the tropical region within the 30^{o} latitude of the equator, where the seawater temperature ranges between 16 and 30 ^{o}C. Though coral reefs cover only an insignificant portion of the ocean area (>0.2%), they support nearly 25% of the marine species. The major coral reef formations in India are restricted to the Gulf of Mannar, Palk Bay, Gulf of Kutch, Andaman and Nicobar Islands and Lakshadweep Islands.

Globally, coral reefs have deteriorated significantly in the last decade and the trend is true for India. Each area, particularly the Gulf of Mannar, faces specific problems resulting from anthropogenic influences such as high fishing pressure (trawls), high sedimentation from poor upland and coastal agriculture practices, and high levels of pollution. Furthermore, the reefs of Lakshadweep and Andaman and Nicobar Islands are considered the most polluted in the Indian Ocean because the seas around them serve as major routes for oil tankers.

Apart from these, the first signal of climate change affecting the coral reefs occurred during 1997-98 ENSO. This bleaching event affected the coral reefs to various extents, with Andaman and Nicobar Islands suffering the greatest mortality of coral (up to 80%) followed by the Lakshadweep (43% - 87%) and the reefs of the Gulf of Mannar (an average of 60%). The corals of the Gulf of Kutch were less affected (< 30 %), which could be due to a greater tolerance of higher sea temperatures resulting from their occurrence in the extreme arid conditions in the northwest India.

This trend will persist in the future as per the expert reviews provided by the IPCC. This paper advances this understanding by analyzing the comprehensive IUCN

2008 Red List of Threatened Species database of the conservation status and distribution of Indian coral reefs in the context of climate change and severe weather threats. The approach helps to determine the relative risk and identify those species that are facing a higher risk of extinction.

This study provides a framework for better understanding of the changes that have begun in coral reef ecosystems, highlighting the need for a comprehensive and objective approach for evaluating the conservation status of coral species. This would provoke proactive thinking and responses to initiate policy changes for future protection and management of coral reefs.

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