SIGNIFICANT ACHIEVEMENTS IN THE LAST FIVE YEARS

FISHERY ENVIRONMENT MANAGEMENT DIVISION

The **Fishery Environment Management Division** (FEMD) is fundamentally involved in research on marine and coastal environment in relation to marine and coastal fisheries. The division also carries out environmental awareness programs, monitor environmental degradation, accomplishes ecosystem restoration and climate change mitigation programs through research by community based participatory approach, empower fisher folk through management advisories, mobilize citizens of our country for responsible living through adoption of green economy by conducting exhibitions, interactive meetings, trainings and campaigns.

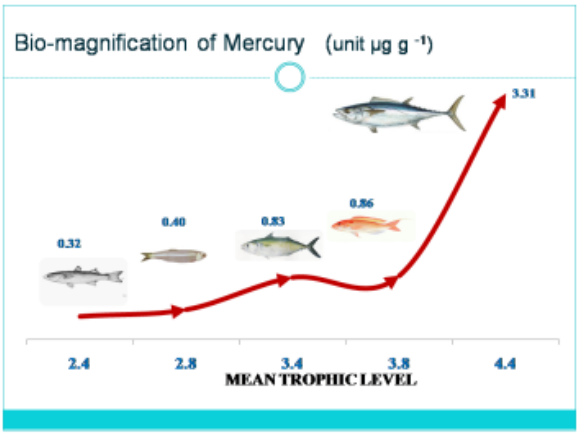
Project Code	FEM/RE/01
Project Title	Impact of anthropogenic activities on coastal marine environment and fisheries
Principal Investigator	P.Kaladharan

Impact of sewage disposal

- Low levels of dissolved oxygen were encountered at Threspuram coast (Tuticorin), which sometimes reached anoxic levels in July 2009. At Vishakaptnam, the site at the sewage outfall was found to be hypoxic (0.869 mg l^{-1}).
- Along Tuticorin at Threspuram, the CO_2 levels in seawater was high (42 mg l^{-1}) in September 2009. However, this elevated CO_2 levels did not affect the primary and secondary productivity of the area.
- Dissolved CO_2 at Kochi, Mangalore and Mandapam remained well below the detection levels.

Arsenic and Mercury in the ecosystem

- Concentration of Arsenic and Mercury in seawater and sediment collected from along both the Indian coasts were either below detectable level or showed very negligible levels within the permissible levels as per the stipulated standards.
    - Level of mercury and arsenic in selected finfishes, crustaceans and molluscs , sampled from Tuticorin, Chennai, Visakhapatnam, Mumbai, Mangalore, Calicut and Kochi were found to have concentrations within the permissible levels prescribed by the WHO.



Assessment of biomagnifications of arsenic and mercury in the south west coast

- Level of mercury and arsenic in 49 species of marine resources which are commonly found in the food chain in the southwest region were analyzed. All commonly occurring fishes which were fished from southwest coast (eg sardine, mackerel, anchovies, etc) were found to be safe for consumption.

- Mercury concentrations in mean trophic levels 2.4, 2.8, 3.4, 3.8 and 4.4 were estimated as 0.32,0.40. 0.83, 0.86 and 3.31 µg g^{-1} respectively.
- Though belonging to higher trophic level (4.0 to 4.5), species like *Epinephelus tauvina, Seriolina nigrofasciata, Saurida tumbil, Trichiurus lepturus, Saurida undosquamis Chirocentrus dorab, Sphyraena jello, Scomberomorus commerson Caranx sexfasciatus, Sphyraena barracuda* were found to have very low levels of Hg, all within permissible limit. Bioaccumulation of mercury in the liver was observed in 64.2 % of fishes. However, in the tissue of these species, the levels of mercury were below detectable level (BDL).Bioaccumulation of arsenic was observed only in 30% of the fishes. However, both in the tissue and in the liver, levels of arsenic were within permissible limits

Mangrove destruction

- It was estimated that 1.5 acres of mangroves, mainly *Avicenia officinalis* was destructed recently near Kadalundi. However, 50 ha of mangroves are now protected under the Kerala Forest Department and afforestation with Rhizophora saplings have been carried out at 15 ha area.

Dredging

- Due to dredging near Rameswaram, the silicate content in the Palk Bay showed an average of 6.55 ug l^{-1} and in the Gulf of Mannar recorded 6.6 ug l^{-1} as against only 4.33 ug l^{-1} in the reference site.

Impact of Industrial effluents

Maharashtra

- One significant observation was the low level of dissolved oxygen and moderately high level of Biological Oxygen Demand (BOD) and high levels of carbon dioxide in all the outfall locations. The impact of urbanization on the near shore regions is evident in the water quality as indicated by the low oxygen levels. However, high levels of nutrients were not observed.

Karnataka

- Though the dissolved oxygen content (DO) was lower than the optimal level in outfall locations, the BOD and Chlorophyll values indicated that ecosystem is not degraded. The nutrient levels were also not unusually high indicating that there is no threat to of eutrophication in the coastal region. However at the sites related to the river had high silicate content than the other marine sites.

Tamil Nadu

- The water quality near the municipal sewage discharge point at Threspuram, the barmouth region at Punnakayal and the fairly unpolluted region near Tharuvaikulam was monitored continuously during the period. Though the hydrographic parameters showed variations, the water quality at Threspuram was low with hypoxic condition. The pH was also low and the carbondioxde content in the water was high compared to the other two sites.

Kerala

- The mean values for all the parameters in all the four locations were within the normal range except for ammonia and dissolved oxygen at Irumpanam where, ammonia was high and dissolved oxygen was low. This station is near the industrial unit FACT- Fertilizers and Chemicals, Travancore (Ambalamukal) and there is frequent transport and unloading of liquid ammonia barrels at this point. In IFP Jetty (Kochi backwaters) which is subject to frequent anthropogenic activity, ammonia content was slightly above the permissible limit.

Andhra Pradesh

- In the coastal region of Vishakaptnam, five sites were regularly monitored *viz* Vishakapatnam Port /Fishing Harbour . Sewage outfall region, Mangamripeta, and coastal waters at 10 and 15 m depth. Among these sites water quality was found to be affected in the sewage outfall area where carbon dioxide level was high and dissolve oxygen low.

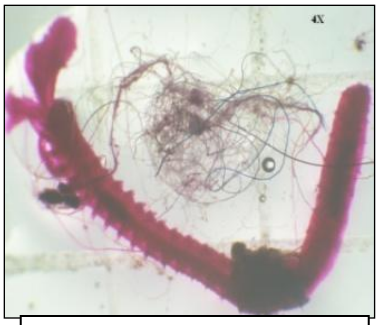
Marine litter – Coastal / Beach debris

- Occurrence of non bio-degradable material (NB-DM) in the coastal areas (Marine litter) and its presence in the fishing regions (Submerged marine debris) was assessed. The quantity of debris in the fishing area and the quantity deposited by ebbing tide in stake nets were also studied.
- **Tamil nadu (Gulf of Mannar region):** The quantity of non-biodegradable substances were highest at the harbor beach, Tuticorin ranged between 78.7 – 850 g m^{-2} with a mean of 313.6±63.3 g m^{-2} followed by Threspuram beach (256.1±42.2 g m^{-2}) and Tharuvaikulam beach (173.7±29.3 g m^{-2}). The relatively clean Mottaigopuram beach recorded the least value of 35.8 ±7.3 g m^{-2}.
- **Karnataka:** Plastics were monitored on three beaches Chitrapur, Panambur and Thaneerbhavi. Chitrapur had the highest rate of marine litter of 963.72g/m^2 followed by Thaneerbhavi with 541.25 g m^{-2} and Panambur with 97.57 g m^{-2}.
- **Kerala :** Occurrence of non-biodegradable waste in an unit area along Calicut beach was estimated at 0.295 g m^{-2} and along beaches of Kochi as 20 to 70 g m^{-2} . At Kochi, seasonal variation was observed in the occurrence of NB-DM in the coastal region. The peak was found to be during the pre monsoon period and the least during Post monsoon. Plastic was the major debris followed by rubber, glass and thermocol.

Impact of marine litter on fauna

- In Mangalore RC of CMFRI, during routine examination of gut of Mackerel and Oil Sardine from the trawl boat landings nylon thread pieces of length 1 to 4 mm were observed. Entangled nylon thread were also observed in the benthos samples.

Plastic strand found in twisted form in the gut of Mackerel



Polychaete larvae entangled with assorted plastic

Marine debris in fishing areas

- In the **trawl fishing area** off Mangalore (N 12° 48 ' 995" E 74° 42 ' 796"), the quantity of Non biodegradable material collected ranged between 0.32 and 0.82 gram per square meter. The marine debris in the fishing ground off Calicut ranged from nil to 117 g/ haul.
- **Stake net in the bar mouth region**: The quantity of marine debris accumulating in the stake net was estimated at 2 to 18 kg and consisted of tyre, bottles, metal plates, tin cans etc .
- The **Chinese dip nets** operated in the near shore coastal areas and it was estimated that the about 2 to 4 kg (per day) of non biodegradable material gets collected in the net.

Plastic in a fish catch at Mumbai

Project Code	FEM/RE/02
Project Title	Impact and yield study of environmental changes on the distribution shift in small pelagic along the Indian coast
Principal Investigator	P.K.Krishnakumar, K. Vijayakumaran, V. Kripa

Phytoplankton

- Phytoplankton density was highest off Veraval along west coast and off Chennai along east coast. In the GoM *Nitzschia longissima* (9.4%) and *Nitzschia sigma* (6.61%) were dominant while in Palk Bay, *Coscinodiscus excentricus* (6.88%) and *Coscinodiscus marginatus* (6.71%) were more. In near shore, off Mangalore, 64 species were prominent and *Thallasionema nitzschioides* (6.8%) and *Coscinodiscus lineatus* (4.8%) were more. In the off shore region 74 species were present and *Cyclotella striata* (6.3%) and *Nitzschai seriata* (5.4%) were the dominant species.

Zooplankton

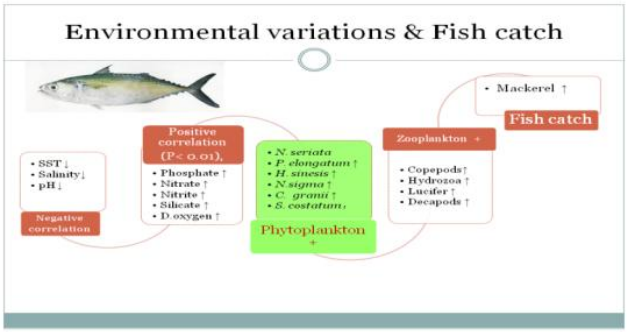
- Copepods formed the major group of zooplankton at Visakhapatnam (87.12%), Chennai (84.19%), Tuticorin (48.06%) , Veraval (95.52%) and Mangalore (88.4%). In Kerala, decapods were dominant forming 53% of the community followed by copepods (31.5%). In Visakhapatnam, fish eggs formed 2.99% of the zooplankton and among the different sampling sites, Tuticorin recorded the highest diversity index followed by Kochi.

Evaluation of dissolved nutrients in coastal waters, off Cochin

- The annual averages of total inorganic nitrogen (TIN) and dissolved phosphates were consistently lower after 1995, till 2010, indicating no negative impact .
- The annual average TIN ranged between 0.42 µg at l^{-1} and 2.36 µg at l^{-1} during 1996 to 2010 and the dissolved phosphate levels were generally lower than the levels (1.69 µg at l^{-1}) in 1995 except during 1999 (1.74 µg at l^{-1}) and 2002 (1.89 µg at l^{-1}).
- Dissolved silicate levels were found to increase during the last decade. The average annual silicate levels were lower than the levels in 1996 (12.031 µg at l^{-1}) only during 1997 (8.12 µg at l^{-1}) and 1998 (3.2 µg at l^{-1}). From 1998 onwards, the silicate levels increased and were highest in the year 2007 (35.04 µg at l^{-1}).

Fishery environment and fish catch

- The hydrological characteristics of the fishing area were studied in detail and 17 different environmental parameters were collected from the coastal fishing area. An attempt was made to analyse the relationship between abiotic factors, productivity and fish catch. Detailed analysis of the phytoplankton and zooplankton were also carried out. The results are given below.



- **Environmental variations and Mackerel catch**: Analysis of the hydrological parameters, the productivity factors and the catch by gears operating in the near-shore area off Kochi indicated that there is a negative correlation in SST ($p<0.01$), salinity ($p<0.05$) and pH ($p<0.05$) with mackerel catch. The mackerel catch showed positive correlation with DO ($p<0.01$), silicate ($p<0.01$),

phosphate ($p<0.01$), nitrate ($p<0.05$), nitrite ($p<0.05$), chl a ($p<0.01$) and chl b ($p<0.05$). The corresponding increase in phytoplankton such as *Nitzschia seriata, Pleurosigma elongatum, Hemiaulus sinensis, Nitzschia sigma, Coscinodiscus granii* and *Skeletonema costatum* leads to increase in copepods, hydrozoa, Lucifer and Decapods. Such a combination leads to increased catch of mackerel in near shore gears.

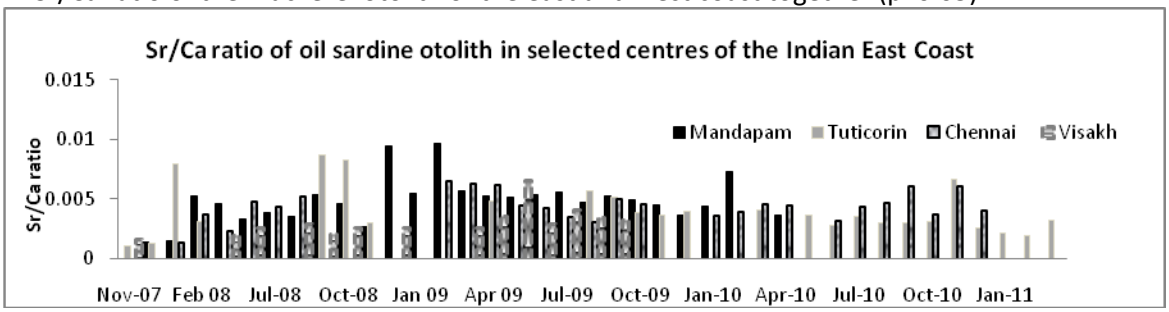
- Along Mangalore coast, Mackerel catch was found to be negatively correlated ($P< 0.05$) with SST. Along Mangalore coast, mackerel landings was found to be positively correlated with salinity and chlorophyll a ($p<0.01$) and negatively correlated with dissolved oxygen ($p<0.01$). During upwelling period the DO of bottom water is low. Mackerel catch showed positive correlation with silicate. As near shore the influence of the discharge of rivers brings in more silicate during monsoon.
- The oil sardine catch in the region off Kochi showed negative correlation (($p<0.05$) with pH and positive correlation with chl b ($p<0.01$). Oil sardine catch along Mangalore was negatively correlated with SST and silicate ($p<0.05$).
- *Stolephorus* (Anchovies) catch was positively correlated with chlorophyll a and nitrite ($p<0.01$) in the region off Mangalore.

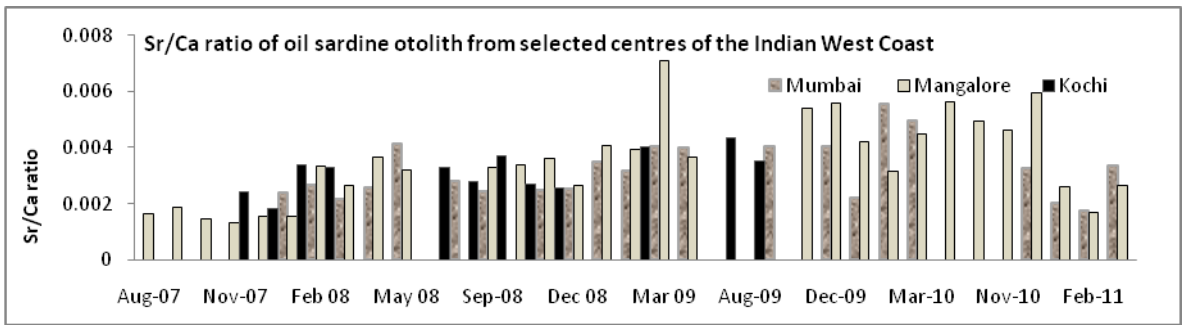
Algal Blooms and Zooplankton swarms in the fishing areas along the west coast

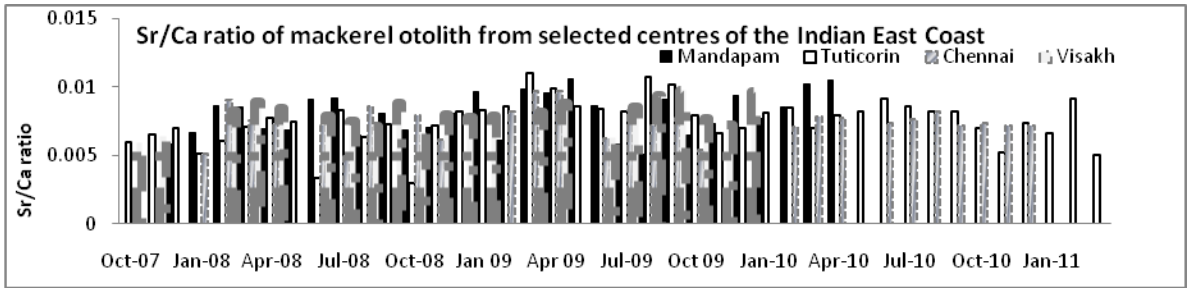
- Toxic bloom of *Chattonella marina* was observed during 27-9-2011 to 17-10-2011 at varying intensities along the entire Calicut coast. Dissolved oxygen levels in the bloom area were low (1.90 ml l^{-1}) in the morning hours but recovered (3.09 to 4.28 ml l^{-1}) after the noon hours. Mass mortality of fingerlings of Otolithes sp, Cynoglossus sp. and Liza sp and mole crab *Emerita asiatica* was observed in association with the bloom.
- A bloom of *Noctiluca scintillans* (Macartney) with a cell density of 10.5 lakh cells l^{-1} was observed along the Mangalore coast on 12.05.2011 from Mangalore bar mouth area to Sasihithlu spanning (15 km) and 2 km towards west rendering the sea surface a greenish tinge.

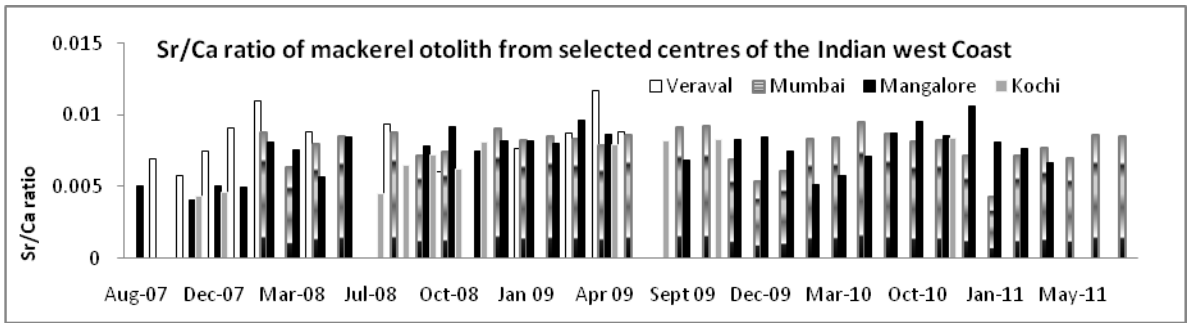
Otolith chemistry (Sr/Ca ratio) from different zones of the Indian Coast

- The results on variation in Sr/Ca ratio in otolith pairs of oil sardine and mackerel collected from Indian East Coast in different centres of CMFRI are plotted.
- Statistical analysis (ANOVA using SPSS version 16) showed significant difference between the Sr/Ca ratio of oil sardine otolith of the east coast and west coast ($p<0.01$). Significant difference was seen among the different locations of the east and west coast together ($p<0.05$). No significant difference was seen among the monthly variability of the Sr/Ca ratio of the oil sardine otolith of the East and west Coast together.
- ANOVA showed no significant difference between the Sr/Ca ratio of mackerel otolith of the east coast and west coast. No significant difference was seen among the different locations of the east and west coast together. But significant difference was seen among the monthly variability of the Sr/Ca ratio of the mackerel otolith of the east and west coast together ($p<0.05$).









- The database on Sr/Ca ratio otolith from different regions of the Indian coast does show significant spatial variability in the case of oil sardine and temporal variability in mackerel. The data can be further subjected to statistical Discriminant Analysis, making use of the data on size variability of the corresponding fishes from which the pair of otoliths have been collected, resulting in classification of discrimination in the stock of oil sardine and mackerel which are fishes found to be spreading towards other parts of the Indian coast, other than their natural historic distribution. The stock discrimination analysis can further be confirmed with DNA stock identification technique.

Investigation on Persistent Occurrence of PFZs along SE Arabian Sea

- A targeted study to understand the potential fishing areas and their ecological relevance was carried out for the fishing area off Kerala within (Latitude 7° to 13°N; longitude 74° to 77°30'E) 18 Zones (one degree grid).
- Based on depth, the grids were classified into three categories namely near-shore (NS; less than 50m); mid continental shelf (MS; 50 to 200m depth) and continental slope (CS; greater than 200m depth). 169 advisories released by INCOIS during the period 2003 to 2007 (5 years) were used for the analysis.

- These analyses clearly indicated that the near-shore (NS) regions of the Arabian Sea off Kerala with depths less than 50m occurred more (51% of the total observations) in the PFZ advisory maps than the mid continental shelf (MCS) region and the continental slope (CS).
- The northern regions of Kerala had persistent PFZ areas especially in the region between Calicut and Kannur. The relatively high river discharges in the area and presence of high nutrient content in the discharges because of high mangrove afforestation are likely causes for the persistent occurrence of PFZs in these regions.
- The coastal area between Beypore and Kannur (Lat 11° to 12°N; Long 75° to 75°50'E), was the most productive followed by Zone 9 (off Kochi-Alleppey, known for "mud banks" supporting good fisheries.)
- In the MS area, grids 4H (Lat 11°00' to 11°15') and 6E (Lat 10°45' to 11°00') lying between the same Long 75°30' to 75°45' (between Ponnani and Calicut) were the most frequent
- In the CS grids lying in the region north off Kochi and south off Beypore were most frequent.

Fifth Indian expedition to Southern Ocean

- Scientist of the FEM Division Dr.R. Jeyabaskaran participated in the 5th Indian Expedition to Southern Ocean during the period 25 January 2011- 10th March 2011. The main objective interpretation of oceanographic parameters related to the distribution, abundance and migratory patterns of marine mammals and megafauna along oceanic realms

Marine Mammals

- Opportunistic visual surveys for marine mammals were conducted onboard ORV Sagar Nidhi.
- A total of 45 days with average of 10 hrs of daily effort was spent for the opportunistic survey. Minke whale Balaenoptera bonaerensis and Killer whale Orcinus orca were the two confirmed species sighted in this cruise.

Sea Birds

- Five species of sea birds were encountered along the cruise track, wandering Albatross, black browed Albatross, light mantled sooty Albatross, giant Petrels and black Petrels.

Megafaunal Studies

- Samples were collected using Grab at three different locations. Deep sea coral fragments and gorgonids were collected from 789 metre depth at 32° S. The occurrence of coral fragment indicates the presence of cold water corals in the area.

Project Code	FEM/RE/03
Project Title	Development of fisheries ecosystem restoration plans for critical marine habitats in India
Principal Investigator	V. Kripa

Marine Habitat Restoration

- Mangroves form an important habitat in the coastal ecosystem and the area occupied by this critical habitat has been reduced in several maritime states during the last three to four decades. Though commendable work has been done in restoring the mangroves in certain regions of the east coast,

such intense and successful programs along the west coast are lacking. Hence during the year 2010, attempts were made to develop nursery protocols for selected species of mangroves and also to initiate planting of seedlings as a part of restoration protocol.

Kerala

- Nursery of three species of mangrove, *Rhizophora mucronata*, *Brugeira gymnorrhiza*, *B. cylindrica* was developed at Moothakunnam, Ernakulam district through a Community based Marine Ecosystem Restoration Programme (CMERP). Five groups of school children supported by teachers and one village youth group participated in the programme. 3000 nos of plantable size seedlings were developed.

- The survival rates where high for all the three species -*R.mucronata* (78.8%) *B. gymnorrhiza* (77.1 %) and *B. cylindrica* (87.7%). Survival percentage (80.9%) was highest in the nursery of village youth.

Planting of mangrove seedlings and initiation of ecofriendly aqua-farming practices

- The seedlings were planted in selected open areas in the northern part of Vembanad Lake and in a traditional shrimp culture pond near the bunds as eco-friendly aquafarming practice with the involvement of villagers. The ground area of planted was estimated as 900 m^2, with a spacing of 0.75 x 0.75 m in triangular pattern for planting.

- Net canopy photosynthesis for the planted mangroves was estimated as 0.029 g C hr^{-1} for *R. mucronata*, 0.026 g C hr^{-1} for *B. gymnorhiza* and 0.0091g C hr^{-1} for *B. cylindrica*.

Restoration experiments at Kochi

- Protocol for mangrove restoration (*Rhizophora mucronata*) was developed. It was found that soil plays a major role in the establishment of transplanted saplings of mangroves after the nursery stage. Soil with less than 11% of clay was indicated as not suitable for transplantation for restoration of mangroves. Mangrove saplings grown in the nursery were distributed to one school in North Paravur and a college at Vaikom.

Evaluation of early life history stages of fishes and shrimps in mangrove ecosystem

- Mangroves are recognized as the nursery ground for several species of fishes and shellfishes. The Quantitative Seed Sampling unit developed by CMFRI was fabricated and used for a survey to estimate the quantity of seed / early life history stage of fishes. The Ichthyoplankton survey indicated the quantity of seed (nos sqm^{-1}) of shrimp (*Fenneropenaeus indicus* : 22 to 162; *Metapenaeus dobsoni* 13 to 102; *M.affinis* 3 to 58); crab seed (4 to 8), finfish seed 5 to 287 mainly Ambassis sp, clupeids, gobiids, carangids etc .

Karnataka

- Survey was carried out in Nethravathi-Gurupura estuary to assess the mangrove status (degraded/ non-degraded). The following observations were made.

- Mangroves were destroyed mainly for construction of buildings, prawn farms and also as for wooden poles for displaying banners during festive season. Debris brought by Gurupura river and deposited in the intertidal regions also lead to the deterioration of mangrove habitat in Karnataka.

- The region near Nethravathi river is dominated by *Sonneratia caseolaris* followed by Rhizophora mucronata. Patches of *Acanthus ilicifolius, Avicinea alba* and *Kandelia candel* were also observed.

Mangrove nursery at Mangalore

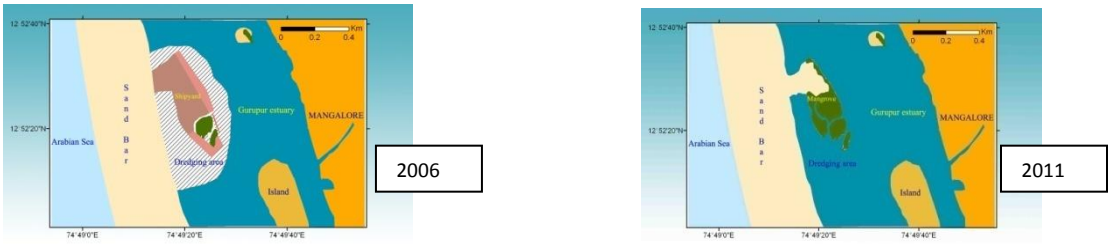
Restoration trial in Karnataka

- An experiment was initiated at Kuduroli for restoration of mangroves in Gurupura estuary. Gastropods, fish eggs and jelly fish were observed in abundance in the area. 50 seedlings of *Rhizophora mucronata* were planted in Bamboo of 1 feet long . The seedlings were collected from the wild and transferred to the bamboo and then transplanted along with bamboo for protection at the selected site.

Extent of clam and mangrove habitat loss in Karnataka

- The Gurupur estuary along the southern part of Karnataka is an important bivalve fishing centre. Since 2007-2008, dredging activities in Bengre for reclamation of sand bar and mangrove areas has resulted in the destruction of bivalve beds and mangroves. A survey was conducted to estimate the extent of habitat loss due to anthropogenic activities.

- The historic extent of clam bed in 2006 was estimated as 2,03,266 m^2 and mangrove as 53,250 m^2. The present study revealed total destruction of bivalve habitat in the dredging area. The existing mangrove coverage is about 13,479 m^2 (25.3%) area, which shows that 39,770 m^2 of mangrove habitat or 74.7% historic coverage is destroyed. This estuarine habitat loss is mainly due to the continuous dredging and reclamation activities in the area.



Impact of dredging on clam and mangrove habitats in Gurupur

Effect of Oil spill on Mangrove at Mumbai

- The Cargo Vessel MV Rak grounded on Mumbai coast causing oil spill along Juhu-Versova beach from Sunday 7th August 2011onwards. About 100 metric tons of oil had been spilled into the sea. The field survey by MRC of CMFRI, Mumbai indicated impacts at Juhu, Versova Bandra and Mahim where patches of oil on the sand were observed. The cross section of the sea water that has been affected by the oil spill was 9 x 1 km. Mangroves of Bandra, Juhu in Greater Bombay

The mangrove habitats along Mumbai which were affected by the oil spill in August 2011

district was found with oil smeared on them. On subsequent observation at Bandra bandstand on 17th August 2011, no traces of oil on mangrove area, debris were noticed.

Project Code	FISHCMFRISIL201201800018
Project Title	Ecosystem processes of critical marine habitats and development of protocols for restoration
Principal Investigator	V. Kripa

Habitat Restoration Programmes

- Areas suitable for clam restoration were selected in Karnataka based on the salinity and sediment characteristics in natural beds of *Meretrix casta* and three pens of 2x2m were erected. The growth rate and survival of clam in the estuarine net pen were monitored.

Experiments on Mangrove Restoration

- **Karnataka:** Three sites, (i) Kudroli where mangroves are planted after partial degradation of natural ecosystem (ii) Thaneerbhavi – non mangrove site (iii) Mulki – natural mangrove site, were monitored for water quality and growth at monthly intervals
- **Kerala (North):** Hydrography and growth of mangrove saplings in two restoration areas viz Kadalundi and Dharmadom along Malabar coast was studied. Net Primary Productivity (NPP) of Kadalundi area was estimated to 0.31 mg C l^{-1} day^{-1} and the vertical growth rate of *Sonneratia* was found to be 6-8 cm $month^{-1}$. The *Rhizophora* plants from Dharmadom area registered mean vertical growth rate of 2.5 cm $month^{-1}$ with NPP of 0.789 mg C l^{-1} day-^{1} and a Gross primary productivity(GPP) of 0.404 mg C l^{-1} day^{-1}.
- **Kerala (Central zone)** : Bio-pouches made of leaves were used for nursery rearing of propagules involving students. The saplings of *R. mucronata* planted in September 2010 had grown above 150 cm and had developed 5 to 7 prop roots. The occurrence of fish and shrimp juveniles in the mangrove area was also assessed.

Evaluation of ecosystem services (VL)

- Vembanad Lake related to fisheries and aquaculture was gathered. The main activities were shrimp farming (prawn filtration and semi-intensive) fish farming , paddy cum prawn culture, oyster farming, shrimp hatcheries, fish breeding units, aquarium fish breeding, fixed net operations, other traditional fishing gear operations and clam fishing.
- The Water Quality Index (WQI; as per USPEA grading method) of VL and the coastal waters during 2008-2013 indicated that the western industrial area of V L was consistently 'poor' and central part covering harbour and backwaters region was 'fair'.
- The inshore regions were found not affected and were found to be of "good" water quality index.
- Both the fisheries and aquaculture activities depend on the water quality of VL and it is evident that the brackish water region is not healthy and the services are negatively impacted.

Mud bank of Alappuzha district, Kerala

- Environmental Variables of mud bank: Bottom water had lower temperature (25.3 deg C) than SST (26 deg C) in the mud bank region. Higher salinity of the bottom water and low oxygen (4.06 mg l^{-1}) content than surface water (7.83 mg l^{-1}) and higher nutrients indicate up-welled water. The very high level of TSS surface and bottom water of the mud bank region compared to the non mud bank region is also characteristic.

Plankton community

- The zooplankton diversity in mud bank was low. Lucifer and Fish eggs dominated followed by Cladocerans. Zooplankton biomass was more (0.42) in the mud bank region than the non mud bank area. The phytoplankton community consisted of 24 main species and was dominated by *Chaetoceros* (27%) followed by *Peridinium depressum* (10%), *Coscinodiscus gigantium* (8%), *Nitszschia seriata* and *Fragilaria* sp (6% each). The density was 2.2 lakh cells l^{-1}. In the non mud bank area, the community structure was only slightly different and the density was 1.62 lakh cells l^{-1}.

Benthos

- The benthic biomass was very high in the mud bank area (1.29 g m-3) than non mud bank area (0.002 g m^{-3}). Polychaetes (62%) contributed by Eunicids and *Sternaspis scutata* and bivalve spat (38%) formed the benthic community.

Gut content of sardine and anchovies

- The food of anchovies consisted mainly of zooplankton (Copepods, Tintinnids, Lucifer and Siphonophores), benthos (bivalves and Polychaetes), small fishes and shrimps. Food of sardine consisted mainly of phytoplankton (especially *Nitzchia, Fragelaria, Thalassiosira* and *Dinophysis*) and Copepods and Tintinnids.

Ecology of sea grass and mangrove ecosystems

Gulf of Mannar

- GPP and NPP were higher in the mangrove beds. The mean values were 3.7 ±2.8 mg C $l^{-1}day^{-1}$; 3.1 ±2.4 mg C l^{-1} day^{-1} and 5.6±1.4 mg C l^{-1} day^{-1}; 4.8±1.8 mg C l^{-1} day^{-1} for GPP and NPP in the sea grass beds and mangrove swarms respectively. High positive correlation was noticed between GPP and NPP ($p<0.05$) .

- The chlorophyll concentration was higher in the mangrove bed (mean 6.18 ±1.9 µg l^{-1}). In sea grass bed, chlorophyll ranged between 0.24-2.9 µg l^{-1} (mean of 1.34±0.27µg l^{-1}). Positive correlation noticed between chlorophyll and nitrate and silicate concentration ($p<0.001$).

- Nutrients were unusually higher in the mangrove beds with the highest mean of 1.52±0.4 µgl^{-1}; 9.6 ±5.8 µg l^{-1}; 39.9±7.02 and 19.02±3.7 µg l^{-1} for nitrite, phosphate, silicate and nitrate respectively . In sea grass beds, the nutrients ranged between 0.02—0.8 µg l^{-1} for nitrite, 1.4-4.8 µgl^{-1} for phosphate, 7.4-36.7 µgl^{-1} for silicate and 0-7.6 µg l^{-1} for nitrate respectively.

Survey of Muthupettai mangroves

- *Avicennia marina* the dominant mangrove species in Muthupettai covers about 95% of vegetation.
- Diatoms dominated phytoplankton followed by dinoflagellates, chlorophyceans and cyanophyceans. Among the zooplankton, copepods dominated and other groups are tintinnids and rotifers.

- With traditional canal fishing , 30 species of finfishes are caught in the region. Lagoon also found rich in prawns and crabs.
- The underwater exploration revealed three types of sea grass beds (i) Coral reef associated, as in Mandapam (ii) Mangrove associated, as in Adirampattinam, Mallipattinam and Sethupavachatramarea and (iii) Shallow sandy bottom as found in Thondi, Kottaipattinam and Jegathapattinam area. They were important fishing grounds for shrimps, crabs and also formed breeding grounds especially for egg laying of squids.

Squid egg mass in the sea grass habitat

- Traditional fishing *viz*. stake net (*adappu valai)*, squid fishing (*Kanava maaru*), shore gill net (*Nandu valai*) and single trawl net (*Oththai madi*) are used in this area. Sea grass community structure and ecology assessed and the avian fauna associated were also studied in detail.

Sediment characteristics and sea grass productivity in Gulf of Mannar

- Sea grass bed constituted mainly by fine sand (66.8%) followed by clay (11.3%); silt (5.85%) and coarse sand (3.4%). The mangrove ecosystem, had fine sand and coarse sand almost equal, 25.7% and 25.9% respectively followed by clay (19.01%).
- The sea grass population mainly constituted *Halodule uninervis* and *Halophila ovalis.* The productivity of *Halodule uninervis* varied between 46 g.m^{-2} in July to 380 g m^{-2} in May with (mean 119.7±27.8 g.m^{-2}) and of *Halophila ovalis* varied between 52 g m^{-2} during September to 280 g m^{-2} during October (mean 110.8±18.5 g m^{-2}).

Sea Grass bed of Lakshadweeps Islands

- Density and composition of sea-grass from of Minicoy, Kiltan, Chetalt, Kavarathi and Agathi atolls of Lakshadweep islands assessed. Minicoy atoll had average biomass of 500 g m^{-2} wet weight of underground parts (rhizomes and roots) but had only 96 g m^{-2} of leaves indicating the canopy loss (leaf biomass) owing to herbivory by green turtles. Distribution of *Cymodocea* and *Syringodium* in Minicoy lagoon once dominant was only negligible.

Sea grass beds of North Kerala

- The Kadalundi estuary had *Halophila beccarrii* in association with seaweeds, *Enteromorpha, Chaetomorpha* and *Gracilariopsis lemaneiformis*. The density of Halophila palnts ranged from nil during June-July to 420 g/m^2 during December-January. They harbour considerable benthos *viz*. Cerithium, Polycheate, Crab larvae, Tanaids (Crustacean), Isopod, Amphipod, Cray fish juvenile and eel juvenile.

Habitat dependent species – sea birds and coastal birds

Tamil Nadu – Gulf of Mannar

- The diversity and population of avian fauna were higher in the calm sea. The fauna comprised of medium to larger birds *viz*. painted stork, grey heron, little egret, great egret, terek sand piper, lesser crested tern etc.,
- In the salt pan area, medium to smaller sized birds *viz*. Eurasian oyster catcher, curlew sand piper, grey heron etc., were seen. Curlew sand piper dominated during November and December (18.3±4.9 during high tide and 8.9 ±2.1 during low tide). Oyster catcher dominated secondly, during April, May, June September and December (10.7±2.3 during high tide and 8.8±2.1 during low tide).

Karnataka

- Along Karnataka coast a total of 41 species of sea and coastal birds were identified and photographed from Ullal, Someshwar, Bunder, Bengre, Kudroli, Hegemadikodi, Mulki, Kapu, Uppunda and Murudeshwar during the period from Oct 2012 till Dec 13.

Kerala

- A detailed study was done in the Purakkad region of Alapuzha district where more than 2000 birds were observed to be associated with the fishery. An analysis dissolved inorganic nitrogen (DIN) and dissolved inorganic phosphorous (DIP) from beach sediments where the birds perched regularly was done and this was compared with an area where there were no birds.

- Dissolved inorganic nitrogen (DIN) and dissolved inorganic phosphorus (DIP) were derived from the above analytical results.
- The DIN from bird area sediment was 4 times more than that of non bird area sediment.
- The DIP from bird area sediment was 16 times more than that of non bird area sediment.

Investigations on biology of coastal birds

- A coastal bird experiment unit (CBEU) to study the feeding behavior and links between environment and coastal birds was set up in Cochin backwaters. The structure is a modified floating hapa with a double layered frame; lower made of PVC pipe and upper with wooden pole. The release of the DIN and DIP from the droppings in the CBEU to the coastal water was 0.076 and 0.120 µg g^{-1} respectively. The release of DIN and DIP were 1.3 times excess of those of background coastal water.

Observations on migratory coastal birds

- In the traditional shrimp farms of Chellanam in VL, the water ducks, were seen during January 2013 to March 2013. These were found to feed on the fruits of weeds and other fauna and using mangrove habitats.

Marine Mammal survey and sighting

Karnataka

- Most of the Indo-pacific humpback dolphins were sited near shore while the spinner dolphin is sited away from shore of greater than 50 m depth.
- Indo-pacific humpback dolphins located in 6 to 15 m depth. Fish shoals of oil sardine and mackerel observed near shore indicating dolphins driving the fishes towards shore.
- Finless porpoise *Neophocaena phocaenoides* (7no:s) (family Phocaenidae) was incidentally caught in purse seine off Mangalore during March 2013 of length 1-1.35m. One of the females had a young male porpoise of size 46.5 cm.
- A baleen whale was found stranded (N 13° 03.643', E 74° 46.737') on 13.9.13 in the Sasihitlu beach of Karnataka.

Underwater Exploration of Dugong (*Dugong dugon*) Habitats in Palk Bay

- Underwater explorative survey was done in Palk Bay during the period 18th to 29th September using video transects method.
- About eight species of sea grasses such as *Cymodocea serrulata, Enhalus acoroides, Syringodium isoetifolium, Halophila ovalis, Halophila beccarii, Halodule pinifolia* and *Halodule uninervis* observed during the survey. Among these, fresh dugong feeding scars were observed in *Cymodcea serrulata* and *Syringodium isotifolium* beds in Sethupavachatram and Manamelkudi area. Fishers from these villages opined that dugongs which are locally called "*avolia"* or "*Kadal pani* are frequently seen in this area.

Project Code	FISHCMFRISIL20120190009
Project Title	Pollution and litter in the coastal and marine ecosystem and their impact
Principal Investigator	Dr. P. Kaladharan

Water Quality Grading of Coastal Waters

Grading of important coastal areas of different maritime states based on water quality

- The hydrologic variations of the inshore waters have been studied during the period under report. Based on the USEPA (2004) guidelines, the sea water quality index (SWQI) was worked out for selected coastal areas of different maritime states.
- In Kerala, water quality index, was Poor in the west industrial belt but was found to be Fair in East Industrial belt of Vembanad Lake and IFP harbor while it was graded as Good in the inshore fishing area and upstream river region.
- Unlike other states, where coastal waters adjacent to areas of high anthropogenic activities had one or more parameters graded as good, in the Mumbai region there was not even a parameter which was graded as good. The WQI was poor in all the sites.
- The coastal waters especially the Fishing harbor area and sewage outfall area was monitored and the WQI was rated as poor in Visakhapatanam.

Impact assessment of thermal power plant and port activities in Gulf of Mannar

- During the period under report, impact of anthropogenic activities of the coal fired thermal power plant effluents like fly ash containing slurry and hot water discharge and the impact of handling hazardous chemicals through loading and unloading activities at the major port on the Tuticorin coastal water ecosystem were studied. The mean values of water quality parameters indicated very high levels of productivity, ammonia, CO_2 and dissolved nutrients but very low dissolved oxygen.

Assessment of marine litter and its impacts on habitats and fauna

- The impacts of human activities especially those related to non-biodegradable wastes (NBW) were studied in different locations.

Occurrence of micro plastics in surface waters

- It is understood that micro plastics of size less than 5mm and 5 to 10 mm which occur along with the plankton can easily enter the food chain. An attempt was made to record the occurrence of micro plastics in plankton. Among the 21 zooplankton samples analysed, micro plastics of size less than 5mm were observed in 10% of samples while plastics of size 5 to 10mm were observed in 14% of samples in the coastal waters upto 30m depth off Kochi.

Assessment of marine litter density in different states

- A rapid survey covering the entire state coastline to assess the quantity of litter in various beaches was carried out in Kerala, Karnataka, Tamil Nadu and Andhra Pradesh. In Lakshadweep Islands, Gujarat and Maharashtra part of the states coastline was covered. Among the states covered, low densities of less than 10 g m^{-2} were observed in Kerala, Lakshadweep, South Tamil Nadu and Andhra Pradesh). Beach cleaning was observed only in less than 10% of the beaches. The state wise summary is given below.

- In Kerala 54 beaches surveyed, average litter density was 3.85 g m^{-2} ranging from 0- 22.2 g m^{-2}. Three beaches were completely clean without any litter. In one of the beaches daily cleaning the beaches twice a day by local self help groups.
- In Karnataka average litter density was 178 g m^{-2} ranging from 3 – 1240 g m^{-2} Total of 33 beaches studied, Uttara Kannada beaches had low levels while Mulky, Katpadimattu, Byndoor beaches had very high litter. In South Tamil Nadu, 14 beaches were surveyed, and the average was 2.94 g m^{-2} ranging from 0.18 – 9.79 g m^{-2} .In Andhra Pradesh, the Average litter density was 3.5 g m^{-2} . Covered 18 beaches and the litter density ranged from 0.4 – 9.06 g m^{-2}.
- In the Lakshadweep Islands the mean litter density was 7.71 g m^{-2} in the 4 inhabited Islands the litter density ranged from 2- 11 g m^{-2}
- Apart from this, monthly assessment of selected beaches in different maritime states was done as a part of this project, and awareness programs conducted. As an impact of monitoring and awareness campaigns in and around Mangalore by CMFRI and other organizations, positive changes in the management of beaches of Mangalore as well as the adjoining estuarine areas have been brought out. Beach cleaning activities have been taken up at Thanneerbhavi and Panambur beaches. Thus there was a reduction in quantity of marine litter in 2012 compared to that in 2011.

Incidence of ghost fishing in southeastern Arabian Sea

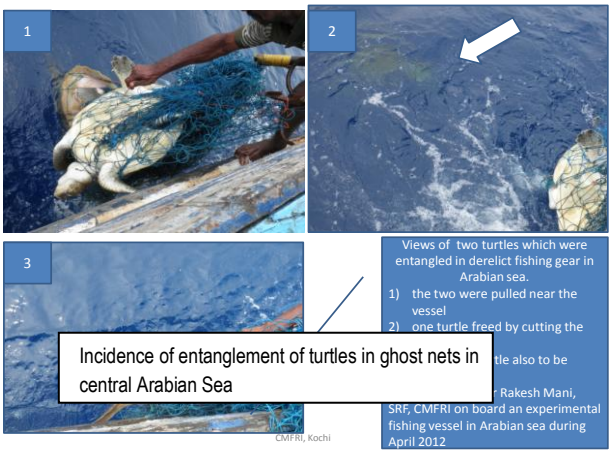
'***Ghost nets' in coastal waters of Kerala – Is the fishing area becoming a dumping ground***?

- On 25th of February 2013 a huge abandoned fishing net in the fishing area was washed ashore on the beach of a fishing village, Edavanakadu in Vypin Island, Kerala. Discarded fishing nets or "Ghost nets" are damaged nets which cannot be used for fishing operations which are thrown by fishermen in fishing area. Sometimes these partly torn nets drift on the surface or column waters and at times they get entangled on submerged objects or rocks and sway in the aquatic environment.

- This is the first report of a ghost net being washed ashore in the coastal area of southwest coast of India. This indicates that the threat to marine fauna due to uncontrolled anthropogenic activities is on the rise and that there is an urgent need to create awareness among fishers to be more responsible in discarding damaged nets.
- **Potential Impacts** : This incident exposes the fact that danger is lurking in the coastal waters of Kerala which has resident populations of several dophins. Also there are chances of such ghost nets getting entangled in the propeller of boats.

Observations on impacts of plastics and discarded fishing net in oceanic regions

- Through observations in the oceanic ecosystem when cruises where undertaken for studying other oceanic resources, the impacts by ghost nets were recorded.

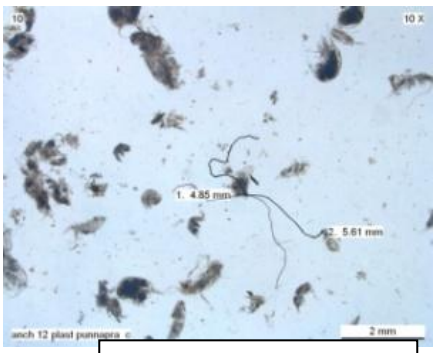


Micro plastics in Gulf of Mannar

- A proportionate decrease in the biomass of micro plastics with respect to depth was observed. However, there was not

much variation in the size range of micro plastics with respect to depth.

- The density was comparatively higher at 5 m depth and varied between 2.5 Nos. ml^{-1} during September to 6.5 $nos.ml^{-1}$ during Jun'13. The size of the particles varied between a minimum of 0.006mm a maximum of 0.164 mm at 20 m depth.



Microplastics in anchovy gut

Micro plastics in the food chain

- During the mud bank period, of the 16 nos of anchovies (average 9.06 cm, average weight 6.6 g) analysed in August 2013, 6 nos were found to have micro plastics of length ranging from 1.14 mm to 2.5 mm. The main food items were phytoplankton, zooplankton (Lucifer, copepod, tintinnids) bivalves and prawn (nekton). In December, when there was no mud bank, oil sardine collected from the same area, had micro plastics in the gut. Also, mud was observed in the gill region of these fishes.

Mussel Watch program in Vembanad Lake

- Mussels are known to be good indicators of pollution in the environment because of their filtration capacity. To study the gradation or level of heavy metals (Cu, Zn, Pd, Ni, Mn, Hg and As), pesticides and also the bacterial load (TPC and E.coli) in the environment and the fauna, an experiment was conducted from December 2012 to June 2013. The Cu and Zn content in water and tissue were below permissible level. The growth and survival of mussels was similar in the marine zone but very poor southern sites where there was no good water flow
- The content of lead (Pb), cadmium (Cd), copper(Cu) and zinc (Zn) in water samples of selected locations of Vembanad Lake (VL) at Moothakunnam, Munambam, Cherai , Njarakkal, IFP Jetty and Chellanam showed seasonal variations. The Pb and Cd were found not detected during March – May but detected in June but were below permissible level of 50 ppb and 10 ppb as per the stipulated limit of USEPA, 1986. In all stations TPC and *E.coli* showed an increasing trend from February to June. The increase in microbial load was coincident with fresh water influx.

Project Code	Funded by MoES - INCOIS
Project Title	Eco-biological investigations on major pelagic fishes and ecological modeling of the epipelagic habitat off Kerala and Lakshadweep
Principal Investigator	V. Kripa

Occurrence of main spawning biomass of major fishes and their relative occurrence in PFZ area

- **Spawning stock of Sardine**: During the period August to February, fully mature sardine were not observed and the advisories are not a threat to sardine fishery sustainability. The peak spawning period was during June and July and during this period there is no advisory and the trawl ban period also is during this period

- **Spawning stock of anchovy** : Anchovies were fully mature during Nov –Dec in the fishery between Kollam and Kannur and after that also mature fishes formed less than 20% of the fish caught in the fishery. More over their occurrence in the PFZ area was low and hence the advisories are not a threat to sustainability of the stock.
- **Spawning stock of mackerel**: In July 2013, fully mature mackerel formed 100% of the exploited stock in Zone 3, 4 and 5 and since the advisories were not released during this period, the chance of overexploitation of spawning stock during its **peak spawning period** is non-existent**.**

Validation of advisories in Lakshadweep waters.

- The tuna advisories were validated through catch observation of landings at Minicoy, Agathi and Androth. Cheriyakara was the island which most frequently occurred as a PFZ area (19 times; 11% of the pooled PFZs) followed by Minicoy (17 times; 10% of the pooled data)
- Validation was also done through special experimental cruises (5 nos) and fishing in February 2014.

Project Code	Funded by MoES - CMLRE
Project Title	Towards Developing Model For Prediction Of Recruitment Success In Major Indian Marine Fish Stocks
Principal Investigator	V. Kripa

- The project was initiated in 2012 and the work progressed as planned. The main spawning period of sardine mackerel and anchovy was assessed by routine biological sampling and the occurrence of eggs and larvae were checked by plankton analysis. It was observed that the average number of eggs per $1000m^3$ at 5, 10, 20 and 30m depth zone off Kochi were 51.8,96.3, 4.6, and 4.60 respectively. Larvae of sardine and mackerel were observed during in all depth zones. The weekly variation in gondosomatic index indicated that Sardine spawn by June and anchovies by November.

Project Code	Funded by NFBSFARA
Project Title	State of diversity of commercially important seaweed along the West coast of India
Principal Investigator	V.V.Singh


One month old Raft culture at Palshet


Sea weed culture in wooden rafts Terekhol

- Based on the survey, water analysis and suitable geographical conditions, sites suitable for cultivation of commercially important seaweeds were identified *viz*.Adgaon, Shrivardhan, Velas (Dist. Ratnagiri), Kelshi, Palshet, Vetye, Kiranpani (Maharashtra State), Terekhol, Shiroda, Satarda, Keri (Goa State). Out of these sites,Kappaphycus and Gracillaria cultivation was carried out at 4 sites, Palshet, Ladghar,Terekhol andRediusing Floating-raft and Monoline-rope method.

Project Code	Funded by NAIP- World Bank - GEF
Project Title	The Strategies to enhance adaptive capacity to climate change in vulnerable regions
Principal Investigator	V.V.Singh

- Two hundred and twenty six mKRISHI® and mKRISHI® Fisheries Mobile handsets have been distributed to beneficiaries who can relay advisory information to the community in selected villages.Field validation of the efficiency of the mKRISHI® Fisheries Service technology has been done by undertaking several validation cruises off the coast of Maharashtra.
- Eight GI open sea cage culture cages were launched at different locations in under-privileged as well as tribal villages of the project area (Raigad district) and lobster crop have been harvested successfully in 2013 and 2014 along the coast of Sasawane and Bharadkhol villages.Propagation of other interventions such as SRT, Wheeled ice boxes with pulling handles and ice boxes with lifting mechanism, GPS devices and Improved Agriculture, Aquaculture and Allied practices have been successfully achieved as part of the project. Three interventions of the NAIP project, *viz*., SRT, Open Sea Cage Culture and mKRISHI® Fisheries were identified by ICAR for media filming.