Significant achievements in the last five years

The Calicut Research Centre of Central Marine Fisheries Research Institute started functioning in 1947 as a sub-station of the Central Marine Fisheries Research Institute to monitor the important fisheries of the Malabar area. The Research Centre is functioning in its own building since October 1958. In more than six and a half decades, this centre has done significant contributed to fishery science and mariculture. A modern hatchery complex was built in 1.5 ha. plot owned by the Institute near the Centre in 1998. This hatchery has got facilities for maintaining brood stocks of crustaceans, molluscs and fishes, spawning and larval rearing, live feed culture etc.

At present the Centre is studying the fishery and resource characteristics of mackerel, sardines and ribbon fishes under the pelagic fisheries division. Biology and fishery of flatfishes, goatfishes, whitefishes, lizard fishes, polynemids, pomfrets, bull's eye and catfishes are being studied under Demersal Fisheries Division. Penaeid shrimps, lobsters and crab resources are being studied under Crustacean Fisheries Division. Mariculture Division is carrying out research projects on seed production, experimental farming, brood stock development and sea ranching of shrimp, marine crabs, lobsters, bivalves, gastropods and fin fish. Under Molluscan Fisheries Division investigations are being made on the resource characteristics of cephalopods, bivalves and gastropods. Under Fishery Environment Management Division the environmental parameters of the inshore waters are being collected for developing fishery forecast models.

The activities of this centre will be further diversified and intensified to meet the challenges of increasing production in the coming years from the capture and culture fisheries of the Malabar area by proper management and development measures and through coastal farming and open sea mariculture.

Facilities added during the last five years

1	Meeting hall	1
2	Garage	4
3	Visitors guest room	1
4	Wet laboratory	1
5	Video conference room	1

1. FEMD (Fishery Environment and Management Division)

1.1 Impact of Anthropogenic activities on coastal marine environment and fisheries (FEM/01)

- Nearly 185-210 dugout canoes are being engaged in sand mining from Kadalundi, Murad, Korapuzha and Azhikal estuaries causing destruction of eggs and larvae of fishery resources which might result in drastic reduction in the fish catch.
- Destruction of meobenthic organisms due to large scale sand mining in estuaries along the Malabar coast are 11.39 ± 2.41 g/m^2 /day wet weight &1270± 84 individuals/m^2/day during premonsoon, 1.25 ± 0.29 g/m^2 /day wet weight & 491 ± 33 individuals/m^2/day during the monsoon and 18.63 ± 4.51 g/m^2 /day wet weight & 6518 ± 120 individuals/m^2/day during post monsoon seasons.

- Coconut spikes suspended on long ropes employed to aggregate squid and cuttlefish by traditional fishers along the Malabar Coast pose serious problems to the trawlers during the off season and destruct the brooders.
- Mangroves are denuded mainly for house construction, agriculture or aquaculture. It is estimated that 1.5 acres of mangroves mainly *Avicenia officinalis* destructed recently near Kadalundi. However, 50 ha of mangroves are now protected under the Kerala Forest Dept and afforestation with *Rhizophora* saplings have been carried out at 15 ha area.
- It is estimated that the seaweed biomass occurring along the Indian coasts is capable of utilizing 9052 tonnes of CO_2/day against emission of 365 tonnes CO_2/day indicating strong sequestration of 8687 tonnes of CO_2/day by seaweeds. Hence large scale mariculture of seaweeds along the Indian continental shelf is recommended to sequester CO_2 further which can check global warming to larger extend.
- Wiping out of large areas of seagrass beds in the atolls of Agatti, Bnagarum and Kavaratti in the recent years is traced to the overexploitation of these beds by turtles whose population have been increased considerably.

1.4 Pollution and litter in the coastal and marine ecosystem and their impact

- Beypore beach was prone to more anthropogenic activities than other beaches in Calicut. Qty of plastics and other NBW showed 80% higher in Beypore than other beaches in Calicut.From Beypore beach, tar balls at the rate of 5gm/m^2 occurred during July 2012.
- Incidence of clearing mangrove patches along Chaliyar River (Cheruvannor), Kadalundi and Payangadi areas was observed during the months of July- Novemebr 2012 for aquaculture and house construction. BOD, TSS and dissolved CO_2 levels were higher in Beypore than in Konnad and Thikkodi areas however within the safe limits, indicating more anthropogenic pressure in Beypore.
- National status assessment on beach litter was carried out in the month of October 2013 along the Indian Peninsular coasts as well as the Laccadive Archipelago.In Kerala out of 54 beaches studied, mean quantity was 3.85 g/m^2 ranging from 0- 22.2 g/m^2. Three beaches registered nill. In one of the beaches daily cleaning debris twice a day being done by SHG. 28 beaches showed below 3 g/m^2 and four beaches showed more than 10 g/m^2. U.T of Lakshadweep Islands showed a mean of 7.71 g/m^2 and 4 inhabited Islands were monitored ranging from 2g/m^2- 11 g/m^2

- From the trawl grounds the mean quantity of plastic was 29g/haul, comprising mostly carry bags and covers of consumable goods obtained. It was observed that June month showed maximum quantity of plastic to the tune of 38g/haul and a minimum of 20 g/haul during February. Realizing the ill effects of indiscriminate use and discards of polythene carry bags, the fishermen of Azhikode south have taken a decision to avoid the use of polythene carry bags for transportation of their share of fish for daily consumption after their work. Instead of carry bags they carry 5 lit buckets.

1.5 Ecosystem process of critical marine habitats and development of protocols for restoration

- To quantify the link between the mangrove beds and fishery resources, fish samples caught using cast net (net open area 28.3 m^3) from Padanna river (less mangroves) and Kadalundi river (more mangroves) were estimated bimonthly which showed higher catch rate and more species composition from mangrove areas.

- Vertical growth rate studied monthly from Kadalundi mangrove areas showed 7 cm/ month for *Soneratia caseolaris* plants and that of *Rhizophora mucronata* plants at Dharmadom was detrmined to be 2.8 cm/ month during the reporting period.

- Drifting fruits of mangrove plant *Cerbera odollom* commonly known as suicide plant is known to harbour many zooplankters and juveniles of marine organisms. Upon analysis of some drifting fruit samples collected from Calicut and Aleppy coasts showed considerable numbers of Amphipods, crab larvae and polychaetes species.

- Net Primary Productivity (NPP) of Kadalundi area is estimated to 0.31 mgC/l/day and the vertical growth rate of sonneratia plants is 6-8 cm/month. However, the Rhizophora plants from Dharmadom area registered mean vertical growth rate of 2.5 cm /month with NPP of 0.789 mgC/l/day and a Gross primary productivity (GPP) of 0.404 mgC/l/day.
- Mangrove areas of Kadalundi showed catch rates varying from 97 gm/ net during July 2013 (Mean individual/ net was 35) to 195 gm/ net during April 2014 (Mean individual/ net was 17) indicating the presence of more juveniles of *Gerrus filamentatus* and mullets during July 2013.
- Seagrass beds of Minocy, Kiltan, Chetalt, Kavarathi and Agathi atolls of Lakshadweep Archipelago were monitored for their herbivory by green turtles and for any anthropogenic activities. Wet biomass of underground parts of the seagrass vegetation comprising rhizomes and roots were always higher than that of the shoots comprising leaves and leaf sheaths.
- The Kadalundi estuary has seagrass ecosystem formed of *Halophila beccarrii* in association with seaweeds, *Enteromorpha, Chaetomorpha* and sometimes the long thalloid *Gracilariopsis lemaneiformis*. The density of Halophila palnts ranged from nil during June- July to 420 g/m^2 during December-January. This seagrass bed harbour large quantities of benthic organisms such as *Cerithium*, Polycheate, Crab larvae, Tanaids(Crustacean), Isopod, Amphipod, Cray fish juvenile and eel juvenile

1.6 Sustainable molluscan mariculture practices

- Green mussel farming areas in Padanna estuary were monitored bimonthly. Diurnal observation on the oxygen levels carried out in the farming areas indicated autotrophic conditions before the introduction of mussel rafts (P/R= 1.109) as well as 20 days after the raft introduction (P/R = 1.167). However after 45 days turned heterotrophic. Phytoplankton scarcity was observed through reduction on Chl content and drop in primary productivity.
- Carrying capacity studies carried out in the mussel farming areas of Padanna Estuary indicated positive impact on the physical and ecological carrying capacity of this estuary.
- High density farming of mussels affects the oxygen budget of the system and turns it to heterotrophic (P/R= < 1) during the peak farming period marked by increase in TSS, PO_4, SiO_2, Chl *a* and BOD as well as decrease in light permeability, nitrite and net primary productivity. Due to the alteration of water flow by constructing bund resulted in eutrophication and hence mortality of farmed mussels to a great extent.

2. MD (Mariculture Division)

2.1 Innovations on sea cage farming and development of sustainable Capture Based Aquaculture (CBA) systems (MD/IDP/04)

Successful harvest of Red snapper at Calicut Beach pond.

The Malabar red snapper were stocked in the beach pond. The sizes range of the snapper introduced were 2.5 to 4.5 cm. The snapper fingerlings were brought from Moorad estuary on 4.6.2010. The snappers were reared for 8 months in the beach pond to determine the growth and suitability for

culture. Snapper were fed with trash fish and sardines which were readily accepted by the fish. The average length was 33.30 and the average weight 687.6 gm.

The culture experiment has shown that red snapper is a suitable species for culture along our coast. Further studies should be done on stocking density and feeding regimes on the growth and survival.

Culture of Red snapper *Lutjanus argentimaculatus* at Padanna backwaters, Kasargod, Kerala.

The culture of red snapper was initiated at Padanna in Kasargod district At Padanna the cage was fabricated using PVC pipes and nets of 7 feet x 4 feet dimension. The fishes used were caught using the Bamboo trap used for trapping. The total numbers of fishes stored was 47 numbers. The average size of the fish stocked was 18.5 cm. The average salinity was 27 ppt.

At Calicut:

Survey for the availability of finfish seed such as *Etroplus suratensis*, *Mugil cephalus* and *Lutjanus argentimaculatus* along Malabar Coast was carried out at Thikkodi, Elathur and Korapuzha.Site selection for small cages in less saline waters along Malabar Coast was carried out at Kozhapuzha and Elathur.Beach Pond was cleaned, water pumped and bird's net was placed for culture of *Etroplus suratensis* from October 2011. 5000 seeds of Pearl spot were introduced on 22.10.2011 for culture at Beach Pond of Beach Hatchery Complex of the Centre. Regular feeding and cleaning was carried out and growth was monitored and hydrological parameters estimated.
Broodstock of *Etroplus suratensis* (Pearl Spot) was developed.


Pearl Spot culture at Beach Pond of Beach Farm at Calicut.Red Snappers broodstaock development at the Beachfarm


Pearl Spot cultured at Thiruvangoor, CalicutHarvested Pearl Spots form low cost cages


Arreccanut wood pen (Inside view)Red Snappers broodstock at the beach farm

2.2 Innovations in Sea Cage farming and Coastal Mariculture (FISHCMFRISIL201202500025)

Culture of red snappers

The rearing of 150 numbers of red snappers under captivity in concrete ponds was carried out. Red snappers were collected from the Kodasserry, Atholi and Thiruvangoor of Calicut. The size of the fish in the concrete ponds varied from 150-310 mm in length and 200-700 gm in body weight. The salinity in the pond was maintained around 35 ppt by pumping sea water. The water depth in the pond was always maintained above 2.5'. The fishes were daily fed live Tilapia and also oil sardine at the rate of 10% of their body weight.

Culture of Red Snapper in the coastal pond of Beach Farm at CMFRI

The rearing of red snappers under captivity in concrete pond was continued in the Beach Farm at Calicut. Juveniles of the species found frequently in less saline waters were collected and stocked in the concrete pond in the beach farm. The snappers which were stocked initially had a size of 150-310 mm in length and 200-1300 gm in body weight and now it has grown to 240-460 mm in length and 550-2800 g in weight. The salinity in the pond was maintained around 35 ppt by pumping sea water on alternate days and wherever salinity was increased due to evaporation, then fresh water was pumped to the pond and thereby the salinity was maintained around 35ppt. The water depth in the pond was always maintained above 2.5'. The fishes were daily fed with also oil sardine at the rate of 8-10% of their body weight

Culture of Red Snapper in the natural pond

Red snappers can grow fast in less saline wasters from juvenile to sub adult stage. Brackish water ponds can be used for extensive red snapper culture. The ponds can be shallow, ranging from 60-150 cm, in order to maximize light penetration for benthic natural food production. Ponds having small area can be used for the culture. Productivity of extensive ponds relies on the supply of food which can be either natural or artificial and it can produce a good growth of the fish up to 1.1.5 kg in a year per fingerling stocked in the pond.

Thorayi Fish Farm near Atholi, Calicut was adopted for culture of red snapper through participatory approach. The area of the pond is 0.2 acre, which is having a depth of 2 m during high tide. Sluice gate is provided for exchange of water, which helps to maintain the optimum environmental condition for the survival of the fishes stocked in the pond. The pond was adopted in June 2013 and it was stocked with juveniles of red snappers in the rage of 150-250 mm in length and weighed 220- 950 g. The fishes were fed with low value fishes at the rate of 10% of the body weight daily in the morning. The environmental parameters were monitored every week and the salinity ranged between 6-8ppt in June and the DO ranged 4.5-5 ml/l and the pH was around 8.

Survey of coastal area for mariculture

Surveys were conducted in the Calicut area for finding out suitable culture site for food fishes in cage in less saline water for coastal mariculture. On survey severalideal sites were identified for cages culture and these areas are having excellent facility for water exchange, which is an important factor for growth and survival of the fishes.

Designing of low cost cages

Depth of the selected sites for coastal mariculture was between 2.0 and 2.5m. Rectangular cage of 2.5x1x1 m was designed and fabricated using sealed PVC pipes of 1.5" diameter and an outer covering of garden mesh net (Netlon) of 7 mm mesh used. In the bottom of PVC pipe of the cage sand was filled which acted as weight to hold the cage vertically. A feeding tray of $1m^2$ was suspended in the middle of the cage and it is attached to the upper part of the PVC frame of the cage using nylon threads. Lead weight is attached to the feeding tray to suspend it vertically. A bird net of 3x1.5x1.5m is also attached to the top of the cage to prevent birds picking fishes from the cage (Fig) Cost of the cage including the maturing and labour charges is approximately. Rs 3000/.

Cage culture of pearl spot in low-cost cages

The low cost cage designed was used for culture of pearl spot in the less saline waters of Moorad and Thiruvangoor in Calicut district. These two sites are ideal due to very good tidal flow of water and good salinity of 20-25 ppt after monsoon season. Ten cages each were installed at Moorad and Thiruvangoor estuarine areas. Each cages in Moorad is stocked with 150 young ones of Pearl spot of 25 mm in November. Feeding was done twice in a day during morning and evening at the rate of 10% biomass with formulated feed made of Coconut oil cake, Rice bran, Tapioca powder, Maida and common salt. The ingredients were mixed with boiled water and made into small balls and mixed with growth enhancers, and placed in the feeding tray. The salinity in the site ranged 20-25 ppt (October-December). The DO ranged between 5.2-6.8ml/L in these sites. Presence of ammonia and nitrates in the cage farming areas was almost negligible. Flow of water in the site were very good, which provided healthy environmental conditions for the growth of food fishes stocked in the cages which also helped to reduce the risk of occurrence of disease in the farming area.

Harvest of Pearl Spots from low cost cages

Pearl Spot (*Etroplus suratensis*), the State Fish of Kerala cultured in low cost cages at Thiruvangoor, Chemancherry Panchayat at Calicut District, Kerala was harvested on 30.01.2014. The culture was carried out at Madhav Fish farm of Mr. P.K. Venugopal, an innovative fish farmer. The fish was harvested after 8 months after introducing in the cages. Total ten numbers of cages each costing Rs. 2,500/- was introduced with 150 numbers of Pearl Spot. A total of 250 Kg was harvested and realized Rs. 90,000/-. Total cost of the operation including ten cages, cost of feed and cost of feed comes around Rs. 50,000/-. A profit of Rs. 40,000/- was received. The size of the fish at the time of harvest was 150 to 180mm in length and 110 to 180 gm in weight. This demonstration of Pearl Spot culture in low cost cages raised enthusiastic response from the farmers who are seen and attended the harvest mela. This low cost cages was designed and low cost feed was also developed for this demonstration programme.

Red snapper culture in Arreccanut wood pen

Culture of red snapper (*Lutjanus argentimaculatus*) was initiated with farmer's participation at Velur, Atholi, near Calicut. Arreccanut wood was used for making pen of 20 x 20 x 1.5 m and work of the pen was completed. Red snapper will be stocked by the end of April. The main idea behind the pen culture is popularisation of this culture method in the Calicut area and also for development of brood stock for breeding in the hatchery.

2.3 Development of bloodstock, captive breeding and seed production for selected marine food fishes and ornamental fisheriesMD/IDP/03. Development and Standardisation of seed production technologies of selected high value fin fishes and shellfishes (FISHCMFRISIL201202500024).

Pathological manifestations of the acanthocephalan, *Tenuiproboscis* sp. in the mangrove red snapper, *Lutjanus argentimaculatus*

The study describes the pathological manifestations of the acanthocephalan, *Tenuiproboscis* sp. in the mangrove red snapper, *Lutjanus argentimaculatus*. The fish collected from Calicut, Cochin and Kannur harboured the acanthocephalan parasite, *Tenuiproboscis* sp. with up to 100% prevalence. Heavy infections with the parasites were observed in the posterior region of the intestine, almost blocking the lumen. At the site of parasite attachment, the surface of the intestine appeared thickened and the mucosal epithelium showed compression and abrasion. Intestinal folds were eroded along with thickening of lamina propria. The presoma of the parasites pierced the mucosal epithelium, lamina propria, muscle layers and serosa, reaching the peritoneal cavity, surrounded by a tunnel with collagenous fibers and granulocytes. Inflammation, granular tissue formation, connective tissue proliferation and associated host immune reactions were evident. Though the worms substantially damaged the architecture of the intestinal tissues, no apparent ill effects on the general health/condition of the fish were observed. This is the first report of *Tenuiproboscis* sp. from *L. argentimaculatus*.

Development of Brood stock of Red snappers

Red snappers were collected from Kodasserry, Atholi and Thiruvangoor. 50 numbers Red snapper adults of an average of 1200 gm in body weight of stocked from October to December 2012 in the cemented pond of Beach Farm of CMFRI, Calicut after cleaning netting the whole pond. Sea water was pumped to the cemented pond and the depth was maintained above 2.5 metre. The salinity in the pond was maintained at 35 ppt. The fishes were daily fed live Tilapia and also oil sardine at the rate of 10% of their body weight.

Development of Brood stock of Red snappers at Beach farm, Calicut

Malabar Red Snapper (*Lutjanus argentimaculatus*) were collected from Kodasserry, Atholi and Thiruvangoor. Total 50 numbers of fish with an average of 1 Kg in body weight collected from these three sites in healthy condition were stocked in the silpoulin lined pond at Beach Farm of CMFRI, Calicut. Sea water was pumped and the depth was maintained above 2 metre. The salinity in the pond was maintained at 30 - 35 ppt. The fishes were daily fed twice with oil sardines, flat fishes at the rate of 10% of their body weight.

3. DFD (Demersal Fisheries Division)

3.1 Management advisories for sustaining Marine Fisheries of Kerala and Lakshadweep (PEL/IDP/01) (2009-12) .Development of fishery management plans for sustaining marine fisheries of Kerala and Lakshadweep FISHCMFRISIL201200300003 (2012-2014)

- Assessed the fishery of elasmobranchs, threadfinbreams, flatfishes, lizardfishes and sciaenids exploited by different gears in the Malabar region and a strong data base on catch, effort and species composition of these resources were prepared.
- Assessed the species composition of sharks and found that more deepwater and oceanic species has emerged in the fishery. *Alopius vulpinus, Carcharhinus leucas, C. brevipinna* and *C. amblyrhynchoides* has emerged as an important component of the long line fishery. 21 species of sharks, rays and skates represented the fishery of elasmobranchs. In threadfinbreams

Parascolopsis aspinosa was recorded in the fishery for the first time from this region and now it has emerged as an important resource.

- Studied the recruitment of *Nemipterus mesoprion, N. japonicus, Cynoglossus macrostomus, Johnieops sina, Otolithus ruber* and many other demersal species into the fishery at the onset of trawling in July/August and assessed the impact of trawl ban on these resources.
- Studied the spawning season of *N. japonicus* and found a decrease in the spawning during the primary peak during April-May, but it increased during the cooler months in October-December during the secondary peak in spawning. This shift in the distribution of spawners is primarily attributed to ecological stress due to climate change and fishing pressure.
- Studied and prepared database on the age, growth, mortality parameters, size at recruitment, length at first capture, probability of capture, spawning stock biomass, recruitment size, fecundity, mean length, length at first maturity and many other parameters on *C. limbatus, N. mesoprion, N. japonicus, C. macrostomus, J. sina* and *O. ruber* to assess the impact of fishing on these resources and as an input for developing ecosystem based fisheries management models.
- Studied the trophodynamics of *N. mesoprion, N. japonicus, C. macrostomus, J. sina* and *O. ruber* exploited in Malabar region and assessed the food component up to species level and statistically analysed using Index of relative Importance. A strong data base on trophodynamics of these species was prepared.
- Studies made on elasmobranchs showed that the catch and catch rate are declining since 2004 and the stock assessment studies made on *C. limbatus* and *Sphyrna zygaena* showed that these two resources are under intensive fishing pressure and further increase in the effort will make only a negative impact. The spawning stock biomass in these two species is marginally above 20% of its stock at its unexploited level.
- Analysis of threadfinbreams catch and catch rate revealed that it has shown wide fluctuations during the past few years. The stock assessment studies made on *N. japonicus* and *N. mesoprion* has shown that these resources are heavily exploited. However, it was seen that the spawning stock biomass in these resource are more than 30% of the stock at its unexploited level, which a good indicator is showing the revival of the fishery in the coming year.
- Flatfish fishery of Malabar area is of considerable importance along the Malabar region and the success of its fishery determines the demersal fishery scenario of this region. Like many other resources Malabar sole also exhibited seasonal and annual fluctuations in the landings. The virtual population analysis showed that more than 40% of the spawning stock is at its unexploited level.
- An analysis of data of sciaenid resources has shown that the sciaenid catch in this region has registered a downward trend for the past few years. The catch rate also is stagnated, which indicates that the trawl catch of sciaenids from the present area of fishing has reached a level of stagnation. The exploitation ratio estimated for *J. sina* and *O. ruber* is also high, which shows that the intensity of fishing pressure on these resources is very high. However, in gillnet and ring seine the fishery has showed some improvement. The spawning stock biomass in *J. sina* and *O. ruber* formed a good percentage of the stock, which shows the reviving capacity of these resources in future.
- Suggested a number of management measures for sustaining the marine fishery of Kerala.
    a. Mandatory registration of all motorised and mechanised boats, review of registration and licensing every five years.
    b. Fixing the size and power of the boats in each sector by imposing upper limits for the length and horsepower of the boats.
    c. Restriction of multi-day fishing by fixing upper limit for absence from the shore
    d. Discourage further increase in the effort by restriction of licensing for new boat.

e. Closed fishing season is made compulsory for all mechanised and motorised boats.
f. Only non-motorised vessels to be allowed to operate during closed season.
g. Ban on catching and marketing of juvenile fishes.
h. Log book should be made mandatory for all fishing vessels.
i. The fishermen should be involved in the management of marine fishery resources.
j. Strengthening of data collecting system.

1. Resource studied : Fishery of elasmobranchs

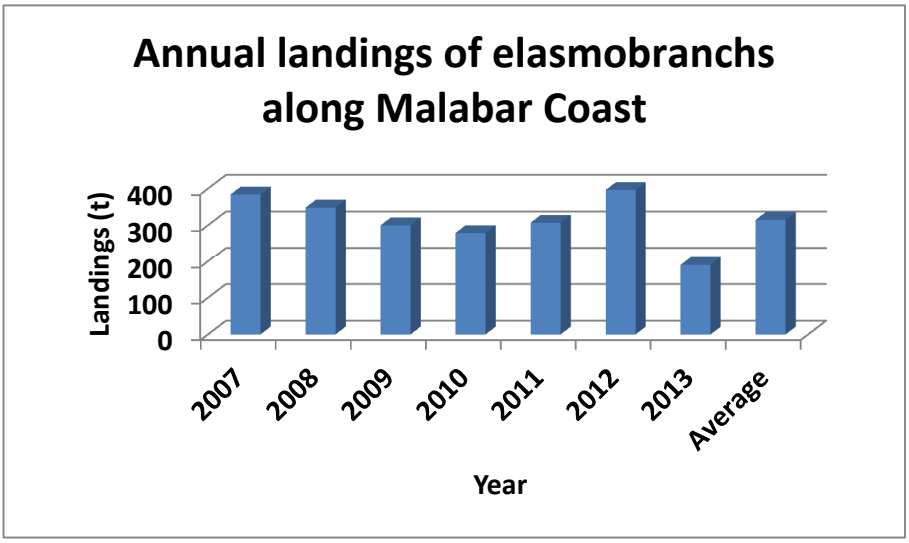
Elasmobranchs formed an incidental catch in many fisheries. They are generally caught in trawls, gillnets and longlines and are landed almost round the year accounting less than 1% of the annual catch. The catch fluctuated between 190 t in 2013 and 396 t in 2012 with an annual average of 315 t (0.4%). The contribution of trawls, gillnets, longlines and other gears were 43.1%, 31.3%, 21.1%, and 4.5% respectively. The catch has shown a declining trend, but towards the end of this period the fishery has improved marginally. The contribution of sharks, rays and skates were 70.8%, 24.2% and 5.0% respectively. Peak landings were noticed in January-May and during this period more than 60% of the elasmobranchs were landed.

Trawl fishery: Elasmobranchs are incidentally caught by commercial trawlers of OAL 32-68' operating in 15-140 m depth range at a distance of 6-50 km from the shore depending upon the season and availability of fish. More than 70% of the trawlers go for multiday fishing for 5-6 days and the rest for single day fishing. The cod end mesh size of trawl net ranged 15-18 mm. Trawl fishery in Malabar region is based at Ponnani, Beypore, Puthiappa, Chombala and Azheekal. Elasmobranchs in trawls formed less than 1% of the catch. Yearwise landing has shown a decreasing trend from 48 t in 2012 to 160 t in 2007 and the average for this period was 87 t. The catch rate of elasmobranchs in trawl was less than 1 kg/h.

***Gill net fishery*:** Gill net fishery was observed throughout the year based at Ponnani, Beypore, Chaliyam, Puthiappa, Vellayil, Elathur, Chombala, Quilandy and Azheekal in Malabar region. The fishery of elasmobranchs was observed in gill nets operated from mechanized, motorized and non-mechanised crafts. Most of the gill nets consisted of 80-180 mm mesh. Surface set gill nets, used to target large sharks, while the bottom set nets targeted small sharks and rays. The length of gillnets were highly variable and used to range from 1200 to 1800 m. In Malabar region the annual elasmobranch catches varied from 52 t (2011) to 164 t (2009) and the average catch for this period was 89 t. The elasmobranch catch has shown a declining trend from 2005 onwards although the effort was around 2 million units. This decline may be due to high fishing pressure on coastal sharks. The annual catch rates of elasmobranchs in gill net were around 1 kg/u**.** Bottom set and surface set gillnets were the primary gear employed in gill net fishery. Soak time ranged 8-12 hours. Sharks, skates and rays contributed 76.3%, 0.80 % and 22.9 % respectively. The annual effort of gill nets also has shown a reduction from 0.28 to 0.17 million fishing units and the annual average effort for the study period was 0.21 million fishing units. The catch rate also has shown a decline.

***Long line fishery*:** Introduction of multiday fishing by long liners by the migrating fishermen from Thuthur between Kanaykumari and Ratnagiri based at Azheekal enabled extension of fishing grounds in the entire south west coast. The fishery commences in November and extends up to May. About 400-800 hooks having the size number 2 are employed from each boat at a depth range of 100-200m and the units remain in the sea for nearly 5-15 days conducting long line fishery. Long line fishery is mainly based at Azheekal in Kannur and Elathur and Chaliyam in Calicut. The average long line contribution was 163 t (19.3 %) and it ranged between 19 t (2013) and 179 t (2008). The catch rate also has shown a decreasing trend from 0.7 kg/u in 2013 to 3.9 kg/u in 2007. Highest catch rate was

recorded in March and lowest in July and the average catch rate observed was 2.4 kg/u. The average contribution of sharks and rays in this gear was 97.3% and 2.7% respectively.



***Species composition*:** Information is available on the species composition of sharks in different gears. Among elasmobranchs, 24 species of sharks, 8 species of rays and 2 species of skates were recorded in the catch. The gear composition revealed that *C. limbatus* (42.6%) was the dominant species in sharks, followed by *C. melanopterus* (18.0%), *Sphyrna zygaena* (16.7%), *C. Sorrah* (8.6%), S. *lewini* (2.9%), *C. dussumieri* (2.2%) and *Scoliodon laticaudus* (2.1%). Gearwise contribution of different species showed that *C. limbatus*, *C. melanopterus*, *S. zygaena* were the most commonly seen species in all the gears. Besides the common species usually found in the catches, new species of sharks have emerged in the longline and trawl fishery. *Alopias vulpinus, C. longimanus, C. obscures, C. leucas, Echinorhinus brucus, Isurus oxyrinchus* and *Triaenodon obesus* started to appear in the fishery from 2005 onwards. In the beginning these species especially *A. vulpinus* were caught occasionally. Now the species is seen regularly in the longlines from September to May. Increase in the depth and area of fishing operation has resulted a change in the species composition of sharks.

Eight species of rays belonging to 5 genera were observed in the fishery. *Aetobatus narinari* (40.8%) was the most common species found in the gears total catch, followed by *Dasyatis uarnak* (18.3%), *Mobula* spp, (15.1%), *Gymnura micrura* (12.1%), *D. sephen* (6.2%), *G. poecilura* (3.48%) and *Rhinoptera javanica* (0.5%). *Rhynchobats djiddensis* and *Rhina ancylostoma* were the only two species of skates found in the fishery. They were occasionally found in the trawl catches.

Since *C. limbatus* was the most dominant species found in the fishery, further studies on biology and stock assessment were carried out on this species.

Size distribution: The catch of *C. limbatus* in trawl was supported with 60-152.1 cm with 90.2 cm as mean size. Major share, accounting 62.5% of the catch in number was supported by 91-120cm. The size of *C. limbatus* caught in gill net was relatively large, 62.1-162.8 cm, compared to those caught from trawl net. The size in this gear was supported by 120-140 cm. Size of fishes caught in long lines was relatively large, 94.8-238.2 cm with 13.50 cm mean size compared to those caught in gill net and trawl net. Fishery was sustained mainly by 120.0-180.0 cm representing 75.0% of the catch. The yearwise fluctuation in the mean size in all these gears has shown that the mean size has declined. The observations for the seven years show that there was a marginal decline in the size of *C. limbatus* observed in the trawl and long line fishery.

Length -weight relationship: A total of 1151 males in the range of 65.1-211.2 cm (2.6 - 76.8 kg weight) and 1100 females in the range of 75.8-238.2 cm (2.3-82.5 kg weight) were used for determining the length-weight relationship of *C. limbatus*. The relationship was estimated by the least square method and the regression equation for both the sexes was:

Female: $W= 0.00001472\ L^{2.8514}$ (r=0.9512)

Male: $W = 0.000015005\ L^{2.8215}$ (r=0.9665)

The analysis of covariance showed that there was no significant difference at 5% level between sexes and the common equation was:

$W = 0.00001486L^{2.80214}$ (r=0.9661)

***Sex ratio*:** The females of *C. limbatus* grow larger and live longer than the males. Thus the largest female measured during this study period was 238.8 cm and the male 211.2 cm. Month wise distributions of sex ratio of 2088 specimens of *C. limbatus* (average of seven years) is given in Fig.7. The overall male female ratio being 1: 1.59, females dominated males in almost all months. The chi-square test indicated that the differences noticed in the ratio were not significant at 5% level.

***Growth parameters*:** the growth and mortality parameters estimated using the raised length frequency corresponding to each month pooled over the years 2005 and 2011. The growth parameters estimated for *C. limbatus* were L_{00} = 302 cm and K = 0.45 by modal progression of cohorts over time. The growth of this species described by the equation $Lt= 302\ (1-e^{-(0.45)\ t-(-1.2)})$. This shows that the species grows fast during the early stages of its life. They attain 64.92, 89.6, 111.7, 131.5, 149.3, 165.2, 179.4, 192.2, 203.6 and 214.6 at the end of 1st to 10th years. The longevity of this species in Indian waters is estimated as 30 years. The minimum size of the fish in the catch was 1 year with 3-5 years as common age group constituting the fishery.

***Mortality parameters*:** Mortalityparameters estimated using catch curve method. According to this the estimatedZ ranged between $2.18y^{-1}$ (2009) and $3.88y^{-1}$ (2013). The natural mortality (M) was estimated using the Pauly's empirical formula (Pauly, 1980) for an average temperature for 28^{o} C was $0.54\ y^{-1}$.The value of natural mortality obtained by Pauly's method was deducted from the total mortality obtained from the catch curve method and fishing mortality (F) obtained ranged $1.64y^{-1}$ (2009) - $2.34\ y^{-1}$ (2013) and the average for this period was $1.94y^{-1.}$

***Status of the Stock*:** The length at first recruitment was taken as the smallest length in the length frequency distribution and the length at first capture was obtained as the mid length of the first peak in length frequency distribution. The length at first capture (Lc) and length at recruitment (Lr) of *C. limbatus* were taken as 94.5 cm and 62.2 cm respectively. The average exploitation ratio (E) is estimated as 0.77, which is higher than the optimum exploitation rate estimated by the Beverton and Holt's method. This means that the current level of exploitation ratio is higher than the MSY level

3.2 Resource damage assessment in marine fisheries: impact of selective fishing of juveniles, by catch and discards in trawl fisheries (CF/IDP/02) Study period 2007-08 to 2008-09

Highlights of the work

- Assessed the total catch, effort, bycatch, low value bycatch, discards and juvenile composition of 15 species of finfishes exploited by the commercial trawlers by sampling method developed by the Institute and through participatory approach involving stakeholders from 2007-08 to 20011-12.
- The historical data on trawl bycatch collected were analysed and found that the bycatch component of the trawl was nearly 75% of the total trawl catch. The low value bycatch formed more than 30% of the trawl catch and was composed of demersal fishes and shell fishes.

- The discarded portion of the catch estimated through participatory approach involving stakeholder ranged between 18.5% (2007) and 9.7% (2009).162 species of fishes and shell fishes were found in the discarded portion of the catch. Fin fishes comprising mainly low value and juvenile fishes were the main component of discards and it formed 84.15%. Among fin fishes 112 species were found in the discards. The contribution of crustaceans, molluscs and miscellaneous items were 14.3%, 1.2% and 0.3% respectively.
- Awareness created among the fishermen during the field visit has reduced the discards to less than 8% of the trawl catch. This will reduce destruction of non-target groups is detrimental to marine life as they occupy an important position in the food web and life supporting systems**.**

First record of *Aesopia cornuta, Mustelus mosis, Torpedo sinuspersici, Brotula multibarbata Chascanopsetta lugubris, Pseudanthias sp., Chelidoperca investigatoris, Roa jayakari, Hemipristis elongatus,Acanthocepola limbata, Antennarius indicus, Diodon hystrix Ruvepta pretious, Halieutaea stellata, Chascanopsetta lugubris*and *Ostichthys acanthorhinus* were recorded for the first time from Malabar region.

- Database on fish and selfish groups constituting the bycatch, percentage of juveniles of major groups contributing to the bycatch and biological and economic less due to exploitation of juveniles were prepared.

- Measures to describe the benefits of prohibiting harvesting of juvenile fishes, advisories for reducing bycatch and solutions for bycatch utilization were suggested.

Studies on the trawl fishery

The trawl catch estimated at Calicut during the period 2007-2011 ranged from 26452 t (2009) to 47184 t (2011). The trawl catch has shown a declining trend from 2007 to 2009. However, the catch has shown an increasing trend in 2010 with an estimated total catch of 34452 t by an effort of 0.76 million fishing hours and the increasing trend continued upto 2011. The effort expended by trawlers has shown an increasing trend up to 2006, thereafter the effort has shown a declining trend till 2009, but in 2010 the effort has increased to 0.81million fishing hours. Average annual effort expended by trawlers for this period was around one million fishing hours.

The studies made on the yearwise bycatch during the period 2007-2011 showed that bycatch formed 34138 t in 2007, which was declined to 20956 t in 2009. The bycatch landing showed

an increase from 28468 t in 2010 onwards and has reached 41052 t in 2011 t. Bycatch landing was highest in March (4291 t) and lowest in December (1778t). The bycatch rate ranged between 23.18kg/h (Jan) and 74.87 kg/h (August). Yearwise fluctuation in the bycatch rate has shown an increase from 27.83kg (2007) to 50.18.kg (2011) and the average catch rate for this period was 34.66 kg

Low value bycatch: The contribution of low value bycatch ranged from 9116 t (2009) to 14118 t (2007) and average for this period was 12241 t. The catch rate of low value bycatch ranged from 11.57 kg/h (2007 to 15.62 kg/hr (2008). The monthly contribution of low value bycatch ranged between 730 t (August) and 1716 t (May) and the catch rate ranged 10.86 kg (September) - 19.59kg (October).

Among low value bycatch landed during this year, scads (20.57%) contributed highest and its monthly contribution varied between 12.01% (2008) and 33.70% (2011). Lizard fishes (14.88%) were the second dominant low value bycatch present in the commercial fishery. Soles (14.23%) also were a dominant component of low value by catch. Thryssa (4.29%), sciaenids (4.75%), other carangids (3.55%), silverbellies (3.48%) and stomatopods (0.67%) were other dominant low value resources present in the bycatch.

***Trawl discards*:** The trawl discards varied between 1957 t (2011) and 6264t (2008) and the average discard landing estimated for this period was 3367 t. The discard rate was highest in November (570 t) and lowest in June (91 t). Analysis of data showed that the quantity of trawl discards has come down and now it is less than 9 % of the trawl catch in this region.

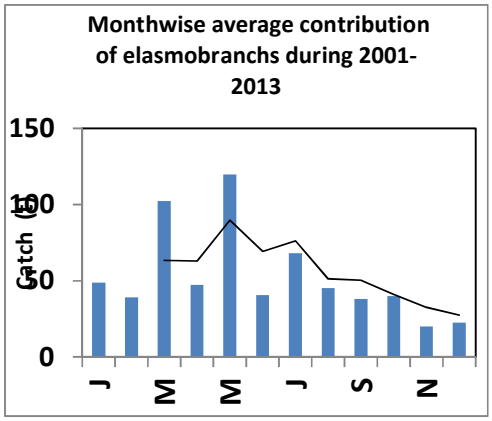
178 species of fishes and shell fishes were found in the discarded portion of the catch. Fin fishes comprising mainly low value and juvenile fishes were the main component of discards and it formed 63.15%. Higher contribution of fishes was noticed in February (86.18%) and lowest in November (29.2%). Among fin fishes 124 species were found in the discards. The contribution of crustaceans, molluscs and miscellaneous items were 22.35%, 7.28% and 7.22% respectively.

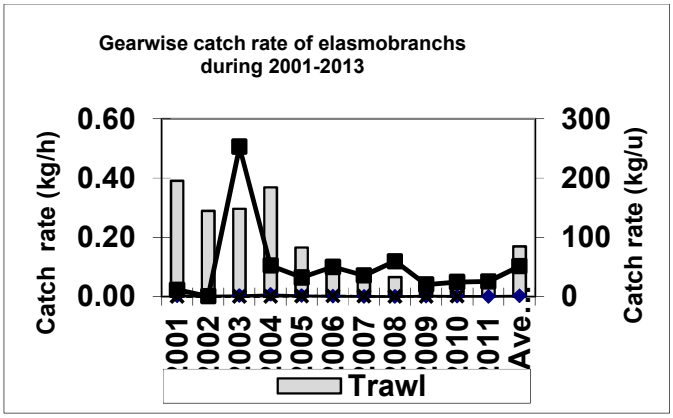
***Juvenile composition*:** The juvenile composition of 12 species such as *Leiognathus bindus* (32.2%), *Sphyraena obtusata* (21.8%), *Johnieops sina* (26.10%), *Epinephelus diacanthus* (95.50%), *Nemipterus japonicus* (34.50%), *N. mesoprion* (38.5%), *Otolithes ruber* (18.9%), *Platycephalus indicus* (42.1%), *Secutor insidiator* (40.41%), *Saurida tumbil* (24.21%), *S. undosquamis* (38.10%), *Priacanthus hamrur* (28.50%), and *Cynoglossus macrostomus* (24.9%) were studied .

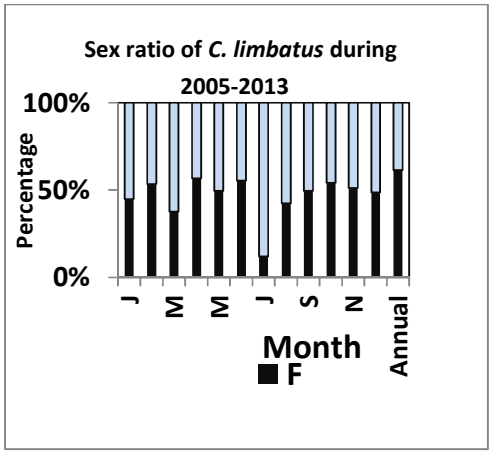
***Rare fishes found in the discards*:** *Mustelus mosis, Torpedo sinuspersici, Brotula multibarbata, Chascanopsetta lugubris, Pseudanthias sp., Chelidoperca investigatoris, Roa jayakari, Ruvettus pretiosus, Halieutaea stellata, Antennarius indicus, Diodon hystrix, Centriscus cristatus*and *Ostichthys acanthorhinus* were recorded from low value bycatch and it was the first report of these species from this region.

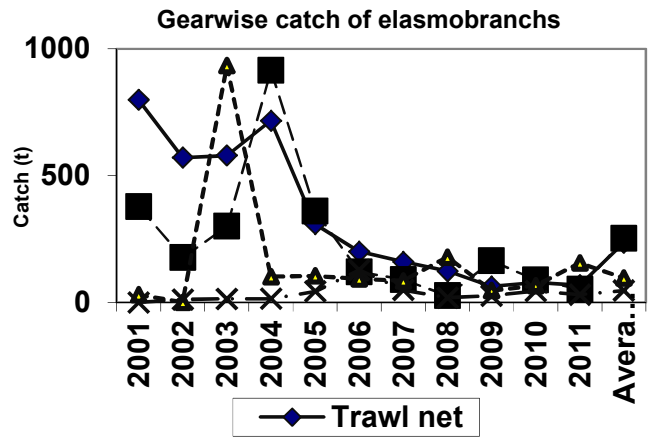
***Resource loss*:** The estimated resource losedue to juvenile fishing of some of the important demersal resources like *N. japonicus* (640 t), *N. mesoprion* (850 t), *O. ruber* (14 t), *C. macrostomus* (325 t) and *J. sina* (68 t) in 2010 was estimated.

***Economic loss*:** The economic loss due to the discarding of low value and juvenile fishes by trawlers at Calicut during this period is estimated as 6.6 crores in 2010 and in 2011 the economic loss due to the discarding of low value and juvenile fishes by trawlers at Calicut was declined to 3.4 crores.





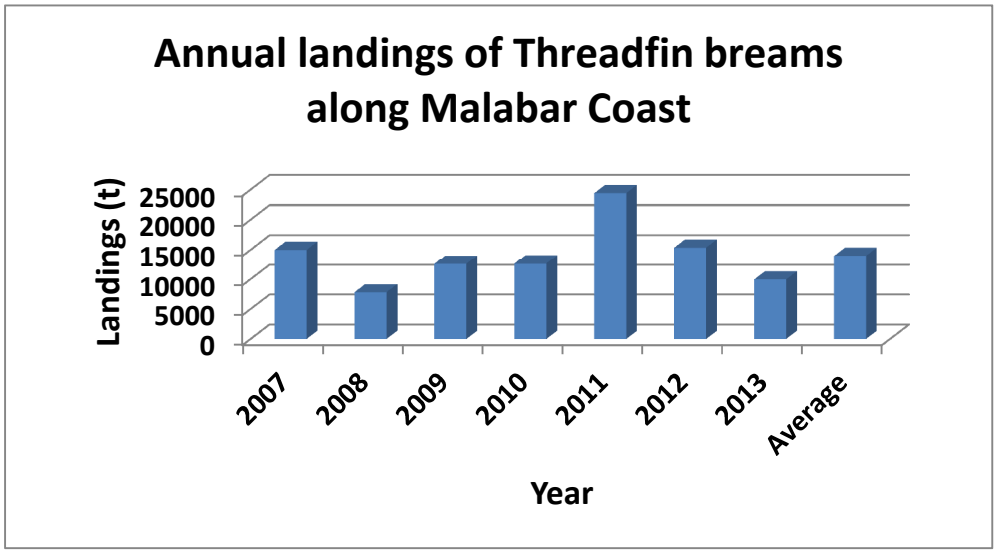




2. Resource studied: Threadfinbreams

Threadfinbreams catch ranged from 7811 t (2008) to 24404 t (2011) with an annual average of 13962 t. The contribution of to the total catch ranged between 3.35% (2008) and 7.46% (2011) and the average contribution to the total catch was 5.26%. Gearwise contribution of the catch showed that multiday trawlers operating in the deep sea has landed maximum quantity of Threadfinbreams forming 78.04% and the contribution by single day trawlers and other units were 0.74% and 21.21% respectively.

The catch rate of Threadfinbreams in multiday trawl units ranged between 5.19 kg/h (2008) and 17.21kg/hr (2011) and the average for this period was 8.84 kg/h. Monthly catch rate of Threadfinbreams was highest during August – September months, during this period more than 50% of the catch was landed.



Four species of nemipterids were observed in the fishery. The pooled data for five years showed that *N. mesoprion* (55.44%) is the most dominant species in the fishery, followed by *N. japonicus* (42.35%), *N. tolu* (1.84%) and *P. aspinosa* (0.39%). *N. mesoprion* and *N. japonicus* was the dominant species found in the fishery throughout the year. *N. tolu* was observed in marginal quantities, while *P. aspinosa* was found in the catches during post monsoon months.

Biology of *N. japonicus*

Size distribution: The size of *N. japonicus* in the fishery was observed and it was seen that the size in the fishery ranged between 32-348 mm. The mean size observed in the fishery ranged between 139.36 mm (2008) and 154.2 mm (2007) and the average mean size for this period was 141.2 mm. The common size range found in the fishery was 120-180 mm. The size has declined marginally in *N. japonicus*.

Food and feeding habits: Monthly average IRI of different food items in the stomachs of *N. japonicus* was studied. 36 food items were recorded in the stomach of *N. Japonicas* during this period. Crustaceans contributed highest with an IRI value of 58.13. Among crustaceans *M. dosbsoni* contributed highest with and IRI value of 30.49. Other crustaceans components present in the stomach was *Acetes* spp (23.03), deep sea prawns (2.66), squilla (0.45), crabs (1.29), *P. stylifera* (0.02) and prawn larvae (0.01) .

. Fishes with an IRI value of 29.82 was the second food items present in the stomach. The monthly IRI value of fishes ranged 0.7 (July) to 51.43 (April), The consumption of fishes were highest during March-May and October. The other fish food items present in the stomachs were *Stolephorus* spp (11.22), flatheads (5.01), *Bregmaceros maclellandii* (2.72), *N. mesoprion* (1.86), *D. russelli* (1.70), *Cynoglossus* spp. (1.28), fish larvae (0.61), *S.tumbil* (1.60), *N. japonicus* (0.46), *L. bindus* (1.03) *S. insidiator* (0.93) and *Trypauchen vagina* (0.03).

Molluscs: The molluscan components present in the stomach were cuttlefishes (0.85), octopus (3.22), and loligo (6.0). Monthwise IRI of molluscs indicates that loligo was the most commonly occurred food items in the stomach, the IRI values ranged between 0.54 (December) and 17.64 (November).

Other items: Other food items present in the stomach include medusa (0.01), detritus (0.19), jellyfish (0.09), Neeris (0.01), polychaetes (1.07) and worms (0.03).

Feeding condition: Fishes with empty stomachs dominated the catches (77.6%). The percentage of fishes with full, gorged, ¾ full, ½ full, ¼ full and trace were 6.8%, 0.1%, 1.28%, 5.3%, 6.2% and 2.7% respectively. Feeding intensity was high in the spent fishes.

Spawning season: Mature females occurred in the fishery form March onwards with increase in the number. But, mature and spent fishes were available in large numbers from August onwards and this continued upto December with gradual decrease in the number of mature and spent fishes in the fishery. There were two peaks in the spawning of this fish, the primary peak of shortest duration in April and a secondary peak of long duration from August-November. The occurrence of juveniles of this species in large numbers is noticed during November onwards.

***Sex ratio*:** The sex ratio between male and females pooled together for the study period showed that the males dominated female throughout the year and the annual sex ratio estimated for this species is 1:1.39, showing predominance of males in the catches. Monthly sex ratio also showed that males dominated the catches throughout the year.

***Size at first maturity*:** The percentage occurrence of females of *N. japonicus* is presented in figure 5 for assessing the size at first maturity of females. The pooled data indicate that the females up to 100 mm were all immature. The maturing females started to appear in the fishery from 100 mm size group onwards and 50 % of them were mature at 132 mm size. Therefore, it can be inferred that the size at first maturity of females of *N. japonicus* along the Malabar Coast is 132 mm.

The percentage occurrence of males in different stages of maturity are pooled and presented in figure 5. It would appear that males up to 90 mm were all immature. Maturing males appear in the fishery when they grow beyond 100 mm and attain maturity at 100 mm size. However, 50 % of the fishes were mature at 126 mm. Therefore, it can be concluded that the size at first maturity of males of *N. japonicus* is 126 mm.

Fecundity: The mature ovaries of *N. japonicus* contain mature and maturing ova. 110 specimens were examined for fecundity study. It has been found that the fecundity increases with the age. The fecundity estimation varied from 19876 (115 mm) to 67845 (258 m)**.**

Length- weight relationship*:* A total of 1523 male ranging from 114 to 272 mm total length and from 125 to 270 g weight and 1326 females ranging from 120 mm to 286 mm total length and from 26 to 272 g weight have been examined for this purpose. The relationship has been calculated separately for the sexes and the equations are:

Male: log W = - 3.9756+2.7818 Log L (r= 0.9725)

Female: Log W = - 4.1781+2.8212 Log L (r= 0.9603)

The differences between regression coefficients of the sexes have been tested by analysis of covariance and found that the differences are not significant at 5 % level. The data of sexes, therefore, have been calculated as

Pooled: Log W = - 4.0654+2.8049 Log L (r= 0.9674).

Biology of *N. mesoprion*

Food and feeding habits: The food composition of *N. mesopiron* was analysed using IRI and index value for each food component was worked out, it was seen that 38 food items were observed in the stomach. Crustaceans were the major food items present in the stomach forming an IRI value of 60.85. *Acetes* spp had the highest IRI value (29.29) followed by *M. dobsoni* (27.70), deep sea prawns (1.75), crabs (1.31), squilla (0.46), copepods (0.15),

prawn larvae (0.15*)* and *P. stylifera* (0.05) . . *Acetes* spp, *M. dobsoni* and squilla were the most commonly found crustacean component in the stomach of *N. mesoprion* throughout the year.

Among fishes 18 groups of fishes belonging to different species were recorded. *Stolephorus* spp. has the maximum IRI value of 21.19. The *Stolephorus* spp was found in the stomach throughout the year. The other fish components found in the stomach were silver bellies (2.19), *Bregmaceros* spp (1.96), *S. undosquamis* (1.87), *S. tumbil* (0.87), *D, russelli* (0.52), *N. mesoprion* (0.56), flatheads (0.31), larvae of eel (0.19), *Cynoglossus* spp. (0.13), *N. japonicus* (0.05), fish larvae (0.06) and eel (0.06).

Among molluscs four items were observed. The annual IRI value of all the, molluscan items was 5.77. The IRI value of cuttlefishes, loligo and octopus were 0.57, 4.55 and 0.64 respectively. Loligo was the dominant food item found in the stomach of *N. mesoprion*. Other molluscan components were found in the stomach occasionally.

Polychaetes (2.07), detritus (0.03), Neeris (0.32) and salpa (0.06) were the other major food items found in the stomachs of *N. mesoprion*.

Sex ratio: The sex ratio between male and female showed domination of females in the fishery (1:1.15). Monthwise sex ratio between male and female showed that males dominated over males during most of the months except February.

Size at first maturity: The study indicate that the *N. mesoprion* (females) up to 90 mm were all immature (Fig. 6) and mature fishes started entering the fishery from 90 mm onwards. It was found that 50 % of individuals were mature at 128 mm. Therefore, it can be stated that the size at first maturity of females of *N. mesoprion*along the Malabar coast is 128 mm. The size at first maturity of males was 121mm..

Spawning season: Mature females appeared in the fishery from February and its presence continued upto October. Occurrence of spent fishes in the fishery during April-May and August to October indicates that the *N. mesoprion* spawns in two peaks, one during April-May and the secondary peak in August-October.

Fecundity:The fecundity of 120 females in stage V and VI ovaries, ranging from 89 to 224 mm in length and weight between 28 and 270g was estimated. The fecundity ranged from 9958 to 67028 numbers of ova. The fecundity increased with increase in length and weight of the fish.

***Length- weight relationship*:**The length (mm) weight (g) relationship of *N. mesoprion* was calculated separately for males and females as

Male Log W= -4.08638 + 2.8770 Log L

Female Log W = -3.1485 + 2.5451 Log L

The regression coefficient of males and females was analysed using analysis of covariance. Since there was no significant difference between the regression coefficients of the sexes, the data on both sexes were pooled and a common equation was derived as follows.

Pooled Log W = -3.9620 + 2.8298 Log L

Population parameters of N. japonicus

The growth parameters such as L_{00} and K estimated for *N. japonicus* were 358 mm and 0.92 y^{-1} respectively. The total mortality (Z) ranged between 3.1 (2009) and 4.23 y^{-1} (2011) and the average for this period was 3.97y^{-1}. Fishing mortality ranged between 1.94y^{-1} (2009) and 2.64 y^{-1} (2013) and average fishing mortality for this period was 2.43y^{-1}. The Lopt and Tmax estimated for *N. japonicus* was 211 mm and 3.41 y^{-1} respectively. The length at capture (Lc) estimated using probabilities of capture was 120.1 mm.Recruitment takes place almost throughout the year with peak from May-September. Although the SSB has shown a declining trend from 4381 t (2007) to 1560 t (2010), the fishery has improved in 2011 to

highest level and the spawning stock biomass also has increased to 2626 t forming more than 35% of the stock at its unexploited level. The average SSB of *N. japonicus* for the study period was 3409 t.Exploitation ratio (E) obtained in the present study is 0.61, which is close to the E_{max} (0.65) obtained, this indicates that the *N. japonicus* resource along the Malabar coast is under intense fishing pressure and the resource is exploited near to optimum level .

Population parameters of *N. mesoprion*

The asymptotic length (L∞) and growth coefficient K in *N. mesoprion* were estimated as 299 mm and 0.79 y^{-1} respectively. *N. mesoprion* grows to 164, 238, 271 and 287 mm at the end of first, second, third and fourth years. The intensity of exploitation of *N. mesoprion* was measured in terms of exploitation ratio and yield per recruit. The length at first capture was estimated using the probability of capture as 105.5 mm and the length at recruitment was taken as the smallest fish observed in the catch as 52 mm The total mortality estimated for *N. mesoprion* ranged from 4.09y^{-1} (2012) to 5.12y^{-1} (2011) and the average for this period was 4.86y^{-1}. The fishing mortality was lowest in 2012 (2.64y^{-1}) and highest in 2009 (3.30y^{-1}) and the average for this period was 3.06y^{-1}. Natural mortality was 1.47y^{-1} during the study period. The Lopt and Tmax estimated for *N. mesoprion* was 178mm and 3.8y^{-1} respectively. the exploitation ratio estimated for this species seems to be very high during the study period and the average for this study period was 0.68. The spawning stock biomass in this species was shown an increasing trend from 1977 t (2009) to 4764 t (2008) but thereafter it has shown a declining trend upto 2010 and the average for this period was 2518 t,. However it was seen that towards the end of the study period the SSB has increased to 2093 t. The SSB estimated in this species is very high and hence the resource is having very good regeneration capacity.

The estimated mortality parameters and exploitation ratio of *N. mesoprion* from Malabar Coast

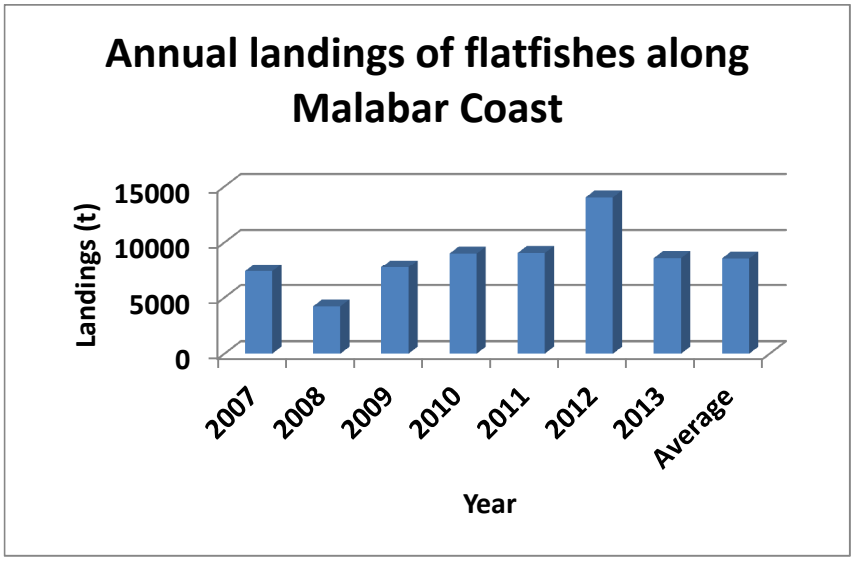
Year	Z y^{-1}	M y^{-1}	F y^{-1}	E	E max
2009	4.56	1.47	3.30	0.68	0.62
2010	4.56	1.47	3.09	0.67	**0.58**
2011	5.12	1.47	3.65	0.71	**0.58**
2012	4.09	1.47	2.62	0.64	**0.66**
2013	4.09	1.47	2.62	0.64	**0.66**
Average	4.86	1.47	3.06	0.668	0.62

The estimated mortality parameters and exploitation ratio of *N. japonicus* from Malabar Coast

Year	Z y^{-1}	M y^{-1}	F y^{-1}	E	E max
2009	3.1	1.64	1.94	0.62	0.67
2010	4.09	1.64	2.45	0.59	0.68
2011	4.23	1.64	2.59	0.61	0.56
2012	4.18	1.64	2.54	0.61	0.67
2013	4.28	1.64	2.64	0.61	0.68
Average	3.976	1.64	2.43	0.61	0.65

3. Resource Studied: Flatfishes

The average annual landing of flat fishes during the period was 8568 t, forming 5.8% of the trawl landings. The annual landing of flat fishes has shown a declining trend from 7355 t (2007) to 4212t (2008). The landing has shown a reviving trend in 2009 (7739 t) and has reached 14026 t (2012). Average catch of flatfish during the study period was 8568 t



Five species of flat fishes were landed during this period. *C. macrostomus* (93.40%) was the dominant species followed by *C. dubius* (5.64 %), *C. arel* (0.34 %), *P. erumei* (0.61 %) and *C. bilineatus* (0.01 %). The flatfish fishery of Malabar region was mainly supported by *C. macrostomus* and *C. dubius*.

Length composition

The size of *C. macrostomus* in the fishery ranged between 22-178 mm. The yearwise fluctuation in the mean size showed that the mean size has declined from 110.6 mm (2007) to 94.71 mm (2009). The mean size has increased to 116.31 mm (2010), but towards the end of the study period the mean size has decreased to 104.41 mm.

Length -weight relationship

A total of 1374 specimens in the range 65-162 mm total length and 4-118 g weight were used for determining the length weight relationship of *C. macrostomus*. The length weight relationship was estimated by the least square method and the regression equation for both the sexes was:

Female: Log W= -4.22012 +2.9833 Log L (r= 0.9998)

Male: Log W = -2.44594 + 2.3267 + Log L (r = 0.9650)

The analysis of covariance showed that there was no significant difference at 5% level between sexes and the common equation was

Log W = -3.2706 +2.6317 Log L (r=0.9770)

Maturity and spawning

Monthly variation in the percentage composition of different stages of maturity in *C. macrostomus* showed that fishes in all stages of maturity were present in the fishery during most of the months. Availability of gravid and spent fishes in the fishery during most of the

months indicates that the spawning period of *C. macrostomus* is prolonged with two peaks. The average annual composition of different stages of maturity showed that immature fishes dominated the commercial catches and this was followed by maturing and spent fishes (Table 3). It was seen that a major share of the fishes examined were juveniles showing an indication of huge economic loss to the industry. Month wise sex ratio shows that females dominated the catch during most of the months. The annual sex ratio between male and female was found to be 1:5.23. The chi-square values indicated that the difference is significant at 5 % level.

Size at first maturity

The pooled data indicate that the females up to 70 mm were all immature. The maturing females started to appear in the fishery from 71 mm onwards and 50 % of them were mature at 102 mm size. Therefore, it can be stated that the size at first maturity of females of *C. macrostomus* along the Malabar Coast is 102 mm.

Food and feeding habits

Amphipods, copepods, diatoms, isopods, polychaetes, lamellibranchs were the chief constituent of the stomach of *C. macrostomus*. Diatoms were the first important food items present in the stomach with an IP value of 25.72%. The IP value ranged between 9.7% (April) and 42.2 % (January). The IP value of diatoms was found to be high whenever the volume of copepods in take was less. The diatoms were dominant food item observed in the diet . *Fragillaria oceanica*, *Cyclotella* spp, and *Coscinodiscus* spp were the diatoms found in the gut. Polycheates (24.38%) were the second dominant the food item of *C. macrostomus*. Its volume in the stomach was high during the post monsoon months. The monthwise abundance of polychaetes showed that it was mininmum in August (1.11%) and maximum is March (49.52%).

Copepods were the third dominant food item present with an IP value of 20.22%. IP values were highest in June (42.20%) and lowest in December (4.00%). Copepods were represented by *Calanus* spp.. *Prionospio pinnata* was the most frequent of these polychaetes and it was frequently noticed that the guts examined were gorged with individuals of this species. Amphipods and lamelllibranchs were found in the gut whenever polychaetes are poorly represented. The amphipods noticed were *Amphiscia* spp and *Chaeriphotis* spp. Among the lamellibranchs the species noticed were *Pholas spp*, *Nucula* spp and *Tellina caneolus.* Isopods, lamellibranchs and amphipods also formed the diet of *C. macrostomus* occasionally and their IP value were 15.4%, 4.1% and 9.8% respectively.

Feeding condition

The percentage occurrence of various distensions of stomach to the total number of stomachs was compared with the monthly intensity of feeding. . It was seen that the fishes with empty stomach formed 71.78% and this was followed by trace (10.16%), ¼ full (7.76%), ½ full (4.54%), ¾ full (2.51%) and full (3.25%). The occurrence of more number of fishes during most of the months indicates that feeding was poor.

Sex ratio

The average annual composition of different stages of maturity showed that immature fishes formed 45 % of the commercial catches. Females dominated the catch during most of the months. The sex distribution observed during different months reveal a very interesting feature, namely that the two sexes were not occurring in about the same proportions during

the entire period, but showed considerable fluctuations. Most of the months females were more in the commercial catch If we take the totals for the entire period still the females are found to be more in the fishery and the sex ratio for 2007 and 2011 was 1.83 .

Growth and mortality parameters

The values of L_{00} and K for *C. macrostomus* were estimated as 164.5 mm and 0.70 y^{-1} at an Rn value of 0.281**.**

The VBGE for *C. macrostomus* is

$Lt = 164.5\ (1-e^{-0.70\ (t-t_0)}$

The fish attained a size of 83, 124 and 146 mm at the end of 1st, 2nd and 3rd year respectively. Majority of the fishes were in the range of 80-120 mm indicating that major share of the landings of this species is juveniles of '0' and '1' year class from the present area of fishing. The estimated Z using the growth parameters was 3.01 y^{-1} (r = 0.96)and the instantaneous natural mortality (M) estimated using the Pauly's empirical formula (Pauly, 1980) for an average temperature of 28° C was 0.86 y^{-1}. The estimate of natural mortality obtained by Pauly's method was subtracted from the total mortality obtained from the catch curve and fishing mortality thus obtained was 2.15 y^{-1}.

Recruitment pattern

The recruitment pattern of *C. macrostomus* showed a distinct peak with maximum recruitment during April-August. Highest recruitment has taken place in May (18.63%) and lowest in January (0.55%). The recruitment during April-August alone was 74.5 %.

Length at first capture (Lc) and length at recruitment (Lr)

The length at first recruitment was taken as the smallest length in the length frequency distribution and the length at first capture was obtained by probability of capture analysis . The length at first capture (Lc) and length at recruitment (Lr) of *C. macrostomus* were taken as 38 mm and 95.63 mm respectively.

The current exploitation ratio (E) estimated is 0.71, which is less than the optimum exploitation ratio estimated by the Beverton and Holts method. This means that the current level of exploitation is below the MSY level.

Stock estimates

The average annual yield of *C. macrostomus along the Malabar* coast was 8568 t at an exploitation ratio (E) and exploitation rate (U) of 0.71 and 0.68 respectively. The average total and standing stocks were estimated as 10486 t and 3317 t respectively.

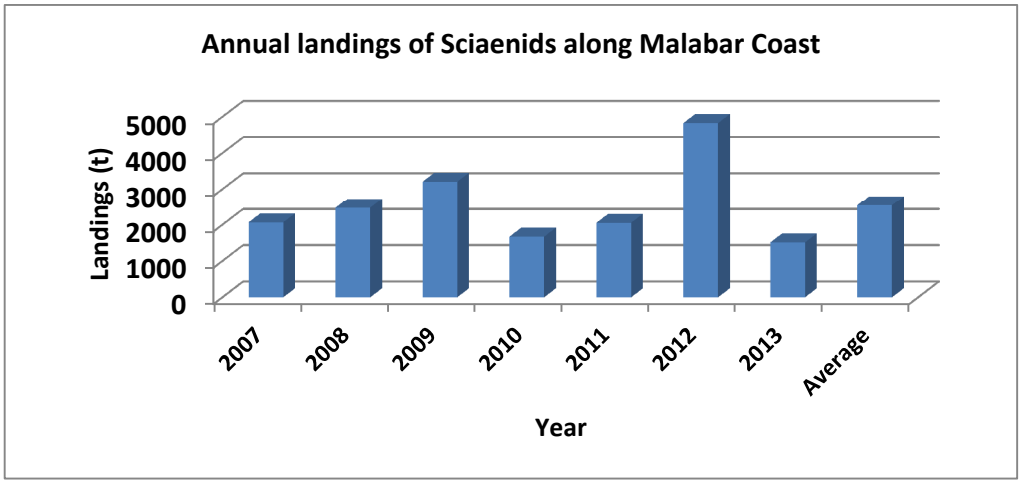
The value of 'M' to the extent of 1.91 y^{-1} gives an indication of higgh natural mortality for *C. macrostomus*. The fishing mortality F=2.08 y^{-1} is an indication of moderate fishing in the present depth of fishing of this species as also revealed by exploitation rate 0.52. The current exploitation rate from the present area of fishing is close to the optimum rate estimated. Thus for the benefit of the stock it is better if the efforts are confined at the present level only.

The estimated mortality parameters and exploitation ratio of *C. macrostomus* from Malabar coast

Year	Z y^{-1}	M y^{-1}	F y^{-1}	E	E max
2009	3.86	1.91	1.56	0.45	0.64
2010	4.39	1.91	2.48	0.56	0.79
2011	4.39	1.91	2.48	0.56	0.86
2012	3.86	1.91	1.95	0.51	0.89
2013	3.88	1.91	1.97	0.51	0.75
Average	4.076	1.91	2.08	0.52	0.79

4. Resource studied: Sciaenids

Fishery of sciaenids: The sciaenid catch ranged from 1669 t (2010) and 4826 t (2012) and the average sciaenids catch for this period was 2543 t. Gearwise contribution showed that trawls contributed 67.07% of the catch, followed by ring seines (21.41%), gill nets (6.48%), and the rest by other gears (5.04%). The contribution of sciaenids to the total catch was 0.92% of the total marine landing in the Malabar region. The annual catch rate of sciaenids in different gears showed that highest catch rate was recorded in ring seine (5.96kg/u). In trawl net catch rate was less than 1 kg/h, while in gill net catch rate of 0.66 kg/u was recorded. In other gears catch rate was (7.89 kg/u). Monthly average landings of sciaenids in trawl showed that the fishery was poor during most of the months. Month wise fluctuations in the fishery showed that highest catch and catch rate was recorded during the pre-monsoon and post monsoon months. Sciaenids were not a regular resource caught in ring seine; however the catch rate was high whenever sciaenids are caught in this gear. Small quantities of sciaenids are also caught in other gears such as hook and lines and other non-mechanised gears.



Species composition: 15 species belonging to four genera were recorded in the fishery. *Johnieops sina* was the dominant species found in all the gears with an annual average composition of 58.48%. Other species found in the fishery were *Otolithes ruber* (12.26%), *Otolithes cuvieri* (6.02%), *Johnius caruta* (2.16%), *J. macropterus* (5.62%), *Nibea soldado* (1.27%), *J. belangerii* (2.60%), *N. maculata* (0.52%), *J. glaucus* (6.93%), *J. aneus* (1.50%), *J. vogleri* (1.03%), *J. elongatus* (0.09%), *K. axillaris* (0.15%) and *P. macrophthalmus* (0.04%) . *J. sina* remained dominant species in trawl and ring seine, while *O. ruber* and *O. cuvieri* were the dominant species found in gillnet..

Biology of *J.sina*

Size distribution

The size of *J.sina* in the fishery ranged between 22-274 mm. The yearwise fluctuation in the mean size showed that the mean size has declined from 132.1 mm (2007) to 120.1 mm (2009), but towards the end of the study period the mean size has increased to 141.83 mm. The average mean size for this period was 132.47 mm.

Food and feeding habits

31 food items were found in the stomachs of *J. sina*. Fin fishes was the major food items present in the stomach and the IRI value of this items was 49.8. *Stolephorus* spp had highest IRI value of 24.74 dominated the stomach contents. This food element was found in the stomach throughout the period. Other important fish food items present in the stomach was *Bregmaceros mcclellandi* with an IRI vale of 11.23. *D. russelli* (7.10), *C.macrostomus* (3.08), *T. vagina* (1.05), *L. bindus* (0.54*), S. insidiator* (0.49), *N. mesoprion* (0.62), fish larvae (0.11), *S. tumbil* (0.05), ambasis (0.15), and *N. japonicus* (0.02) were other important food elements present in the stomach.

The second important food item present in the stomach was crustaceans and it has an IRI value of 39.96. *P. sylifera* (32.50) was the dominant crustacean component present in the stomach, this item was present in the stomach throughout the year. Other crustaceans present in the stomach were *Acetes* spp (3.33), deep sea prawns (0.05), mysids (0.22), copepods (0.21) and squilla (0.85).

Molluscs were the third food item present in the gut with an IRI value of 8.52. Among molluscs, cuttlefishes (1.09), squids (6.83) and octopus (0.59) were the different components present in the gut. Polychaetes (0.64), jelly fish (0.03), salpa (1.02) and detritus (0.03) were the other food items present in the gut.

Feeding condition

The occurrence of fishes with empty stomachs during most of the months indicates that the feeding intensity is poor in *J. sina*. The occurrence of fishes with heavily fed stomachs was noticed in higher numbers during February-April indicates that the intensity of feeding is higher during these months. In general poor feeding was observed in *J. sina* throughout the period of observation.

Spawning period: To determine the spawning period of *J. sina* only females were taken into account. Mature and spent fishes were also present in the fishery throughout the year. The presence of mature and spent fishes throughout the year indicates that the spawning in this species is prolonged with two peaks, the first peak is in August-October and the second peak is in March- April. The value of relative condition factor is high during September-November and, February -April which varied within the range of 0.94 to 0.98, indicating the earlier conclusion that this species has prolonged spawning season . The occurrence of spawning individuals in the fishery for a long period stood as the confirmatory evidence to the present spawning season. According to the findings from the above, it can be concluded that *J. sina* is a continuous breeder having two peak spawning seasons between August - October and March - April.

***Sex ratio*:** A total of 7253 specimens of *J. sina* were examined for analysing sex ratio. The sex ratio between male and female was found to be 1:1.14 showing a marginal domination of females in the fishery . It can be observed that the sex ratio was close to 1:1 during most of the months. The chi-square test conducted showed that the difference is not significant at 5% level.

***Fecundity*:** The fecundity of 124 females in stage V and VI ovaries, ranging from 114 to 229 mm in length and weight between 25 and 24 g was estimated. The fecundity ranged from 9253 to 50925 ova. The number of ova per gram ovary varied from 1895 to 9218 (Average-7210). The fecundity increased with increase in length and weight of the fish .

Size at first maturity: With a view to find the size at first maturity, the percentage composition of different stages of maturity was calculated for each 10 mm class intervals separately for the two sexes. The smallest mature specimen recorded was 98 mm for males and 102 mm females. The size at first maturity for male and female was 114 mm and 122 mm respectively.

Length -weight relationship: A total of 1151 males in the range of 66-208 mm (2-28 g weight) and 1100 females in the range of 62-218 mm (2-26 g weight) were used for determining the length-weight relationship of *J. sina*. The relationship was estimated by the least square method and the regression equation for both the sexes was:

Female: $W= 0.000047472\ L^{2.8514}$ (r=0.9512)

Male: $W = 0.000045005\ L^{2.8215}$ (r=0.9465)

The analysis of covariance showed that there was no significant difference at 5% level between sexes and the common equation was:

$W = 0.000046658L^{2.8313}$ (r=0.9494)

Biology of *O. ruber*

Size distribution

The size of *O. ruber* in the fishery ranged 72-344mm. The mean size has shown an increase from 175.4 (2008) to 189.2 (2009), but has declined marginally to 176.1 (2011). The mean size has not shown a decline during the study period.

Food and feeding habits of *O. ruber*

Twenty three food items were seen in the stomach of *O. ruber*. Crustaceans were the dominant food item found in the stomach of *O. ruber* (61.45). *Acetes* spp was the dominant crustacean component found in the stomach with an IRI value of 34.84. The IRI value ranged between 6.94 (April) and 75.56 (June). *P. stylifera* was the second dominant crustacean present in the stomach and its IRI value ranged between 1.99 (October) and 65.80 (April) and the annual IRI value was 25.14. Other crustaceans found in the stomach were crabs (0.75), *Solenocera* spp (0.02), squilla (0.67) and prawn larvae (0.03) .

Fin fishes were the second dominant food item found in the stomach with an IRI value of 36.17. *Stolephorus* spp was the most dominant fish found in the gut with IRI value of 18.72 and it ranged between 5.95 (January) and 29.85 (October). Other fishes present in the stomach were *D. russelli* (6.23), oil sardine (4.06), *Cynoglossus* spp (1.87), *N. mesoprion* (1.85), *B. mcclellandi* (0.76), *S. tumbil* (0.65), ambassis (0.28), ribbon fishes (0.23), *S. insidiator* (0.12), apogon (0.14), lesser sardines (0.02) and mackerel (0.01).

Molluscs had an IRI value of 2.37. Loligo (2.35) and Octopus (0.02) were the molluscan component found in the gut. Polychaeates also was found in the stomach in small quantities.

Feeding condition

Fishes with empty stomachs dominated the fishery forming 82.97%. The contribution of fishes with trace, 1/4 full, 1/2 full,3/4 full, full and gorged was 3.22%, 4.79%, 3.82%, 1.42%, 3.60% and 0.07% respectively .

Spawning season

Immature and maturing fishes were present in the fishery throughout the year. Mature and spent fishes started to appear in more numbers from September onwards and it continued upto May with peak during November and March and this is the spawning season of *O. ruber*. The occurrence of juveniles of this species in large numbers was noticed during December to March.

Sex ratio

The annual sex ratio between male and female showed that females dominated the caches during the study period and the annual sex ratio was 1:1.70. Month wise sex ratio between male and female showed that females dominated the catches during all the months except in April.

Size at first maturity

All the females examined were pooled for this study. All the individual below the size 112 mm did not show any indication of sex and those upto 130 mm were all immature. Maturing females started to appear in the fishery from 134 mm size onwards and 50% of them were mature at 152 mm size. Hence, it can be concluded that the size at first maturity of females of *O. ruber* is 152 mm and in male the size at first maturity was 148 mm .

Fecundity

The fecundity with regard to *O. ruber* was worked out to study the relationship between size of the fish and number of eggs produced. It was seen that the fecundity of 124 females ranging from 216 to 289 mm length and weight between 118 and 152 g was estimated. the fecundity ranged from 129492 to 168695. The number of ova per gram varied from 9454 to 12458 the fecundity increased with the increase in size of fish.

***Length weight relationship*:**

A total of 382 males in the range of 122-342 mm TL (20-385 g weight) and 522 females in the range of 131-358 mm TL (25-410 g weight) were used for determining the length weight relationship of *O. ruber*. The length weight relationship of both male and female *O. ruber* is described by the following regression equation:

Male : Log W = -4.3962 + 2.9809 Log L (r = 0.9396)

Female : Log W=-4.4541 + 2.9825 Log L (r = 0.8795)

The regression coefficients of the sexes have been tested by analysis of covariance and found that the differences are not significant at 5 % level. Therefore a pooled fit was derived as:

Log W=-4.4632 + 2.9801 Log L (r= 0.9036)

Stock assessment of *J. sina*

Stock assessment studies were made on *J.sina* and the growth parameters $L\infty$ and K were estimated as 348 mm and $0.45y^{-1}$ respectively. The natural mortality was estimated as $1.10y^{-1}$ by Pauly's empirical formula. The total mortality (Z) ranged between $3.65y^{-1}$(2010) and $4.40y^{-1}$ (2013) and the average for this period was $4.01y^{-1.}$ Fishing mortality parameters (F) was minimum in 2009 ($2.55\ y^{-1}$) and maximum in 2013 ($3.30\ y^{-1}$) and the average for this period was $2.84\ y^{-1}$. The exploitation ratio estimated in the present study ranged 0.65 (2009) - 0.75 (2013) and the average for the period was 0.66. Higher exploitation ratio indicates that the resource is heavily exploited. The spawning stock biomass and standing stock biomass of

J.sina was estimated for different years. The SSB formed more than 35% of the stock at its unexploited level, which is a good indicator showing the reviving capacity of the resource.

Stock assessment of *O. ruber*

In the case of *O. ruber* the L∞ and K values estimated was 462 mm ad $0.62y^{-1}$. The total mortality parameter (Z) estimated ranged between $3.76y^{-1}$ (2011) and $4.51y^{-1}$ (2009) and the average for this period was $3.36y^{-1}$. Fishing mortality parameter (F) estimated ranged between $2.59y^{-1}$ (2013) and $3.34y^{-1}$ (2009) and the average for this period was $2.31y^{-1}$. The exploitation ratio ranged between 0.68 (2010) and 0.74 (2009) and the average for the study period was 0.64. Maximum recruitment takes place during April- June. The spawning stock biomass, standing stock biomass and yield of *O. ruber* was estimated and the SSB ranged between 59 t (2010) and 162 t (2009) and the average for this period was 106 t. The average SSB formed more than 27% of the annual stock at its unexploited level.

The estimated mortality parameters and exploitation ratio of *J. sina* from Malabar coast

Year	Z y^{-1}	M y^{-1}	F y^{-1}	E	E max
2009	3.92	1.1.0	2.55	0.65	0.66
2010	3.65	1.1	2.55	0.7	0.68
2011	3.99	1.1	2.89	0.72	0.89
2012	4.04	1.1	2.94	0.72	0.66
2013	4.4	1.1	3.3	0.75	0.68
Average	4.01	1.1	2.846	0.71	0.73

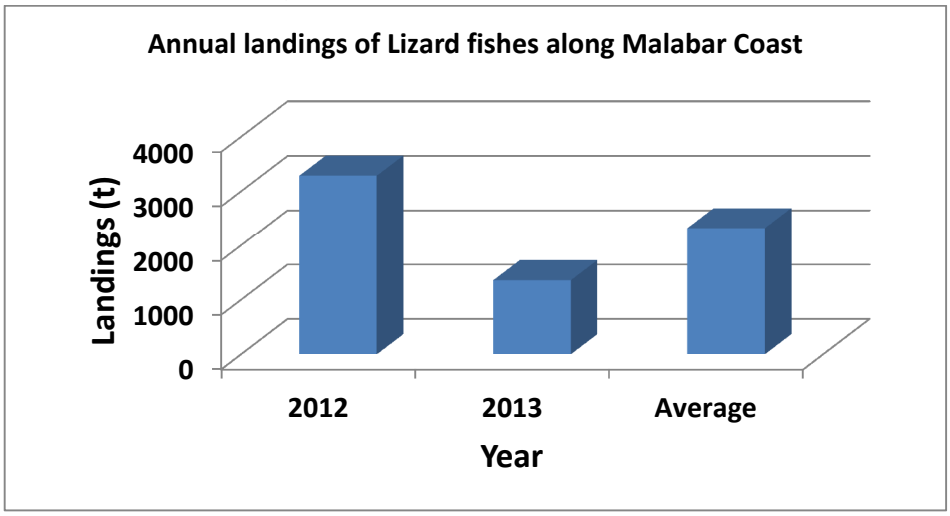
The estimated mortality parameters and exploitation ratio of *O.ruber* from Malabar coast

Year	Z y^{-1}	M y^{-1}	F y^{-1}	E	E max
2009	4.51	1.17	3.34	0.74	0.67
2010	3.76	1.17	2.59	0.68	0.71
2011	3.76	1.17	2.59	0.68	0.70
2012	3.88	1.17	2.71	0.69	0.72
2013	3.92	1.17	2.75	0.71	0.70
Average	3.36	1.17	2.31	0.64	0.70

Conclusion: The catch of sciaenids in trawl showed declining trend in trawls, while in gillnet and ring seine the fishery showed some improvement towards the end of the period. It was noticed that the total sciaenid landing along this region is registering a downward trend for the past so many years in trawl net and gill net units. The catch rate also is stagnated, which indicates that the catch of *J. sina* from the present area of operation has reached at a level of stagnation, hence further increase in the effort will make only a negative impact. The stock is exploited closely exploited to the optimum level at present. Hence, the effort may be maintained at the current level to sustain the fishery. The exploitation ratio estimated for *J. sina* and *O. ruber* is high which shows the intensity of fishing pressure on these resources. It was seen that although this resource is heavily exploited, the spawning stock biomass estimated for both the species are more than 30 % of the resource at its unexploited level which is a good indicator showing regeneration capacity of the resource.

5. Resource Studied: Lizardfishes

An estimated total of 1356t of lizard fishes were landed at Calicut region during the year 2013, the catch has shown a decline of 1930t against the previous year. The decline in the catch was mainly due to the decline in multiday trawl units 1195t against the previous year. The gearwise catch showed that multiday trawlers contributed 66..00% of the catch followed by other mechanised units (26.30%) , mini trawlers (1.90%) and out board gill net units (5.00%). The reduction in the catch was mainly due to reduction in the effort by multiday trawlers (35.03%), mini trawlers (33.05%) during the current year. Month wise fluctuation in the catch showed that peak catches were recorded during January- May. Catches were poor during September and November-December. The catch rate was poor in mechansied trawlers and gill units.

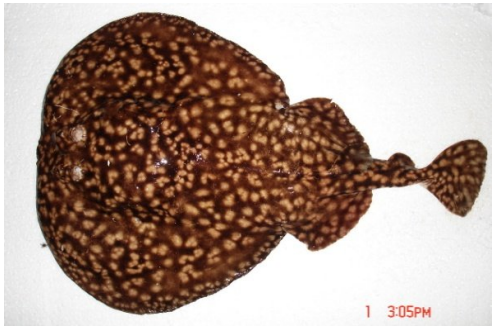


Species composition: *S. tumbil* (67.18%) *S. undosquamis* (21.28%) *S. gracilus* (7.53%) and *S. indicus* (4.03%) were the species of lizard fishes found in the fishery. *S. tumbil* was dominant species found in the fishery in this region.

Length frequency distributions: Length distribution of *S tumbil* in the fishery was studied. The length of this species in the fishery ranged 111-504mm with modes at 140-149mm,280-289mm and 320-329mm. The mean size observed in the fishery was 244.2mm

Maturity: Immature fishes (61.67%) dominated the catches during the period, followed by mature (19.46%) and spent (18.87%). Spent fishes were available more in number during October-December. The sex ratio between male and female was found to be 1:1.36 showing domination of females in the commercial catches.

***Gut content analysis*:** *Acetes* spp. *Nemipterus* spp. Mysids, *S. tumbil*, *Platycephalus* spp. *R. kanagurta,* penaeid prawns, loligo and *Stolephorus* spp. were the dominant food items found in the stomach.



Electric Ray, *Torpedo sinuspersici* landed at Beypore

Whale shark landed at Thalassery

N. mesoprion landed at Calicut

Sharks landed at Azheekal

Sharks landed at Azheekal

N. japonicus landed at Calicut

. Egg case of bamboo shark hatched at Calicut RC

14 day old young ones of bamboo shark

A view ofelasmobranchs landed at Azheekal

Faltfishes landed at Puthiappa

A view of young ones of *Carcharhinus leucas*

A view of sharks landed at Azheekal, Kannur

3.3 Assessment of Elasmobranch Resources In The Indian Seas(FISHCMFRISIL201200500005)

An estimated total 190t of elasmobranchs were landed at Calicut region in 2013 showing a decline of 51.9 % of in the catch against the same period of previous year. The main reason for decline in the catch in Calicut area was due to a shift in the operation base of a number of long line units from Azheekal to Cochin. A number of longline units operated based Azheekal has shifted their operational base to Cochin. The gear wise contribution has shown that highest catch was recorded by trawlers (69t) followed by gill nets (65 t) hook and line (18 t) and other mechanised gears (37 t). The decline in the catch was highest in hook and lines (132 t) and gill nets(73t). The catch rate was highest in hook and lines (6.8 kg/u) and in all other gear the catch rate was negligible .

Species composition: Among sharks 8 species were found in the fishery. *C. limbatus* (44.12%) was the dominant species followed by *C. sorrah* (20.61%), *S. zygaena* (18.40%) *S. lewini* (14.18%) and *R. oligolingus* (1.38%), *R. acutus* (0.73%), *A vulpinus* (0.22%) and others (0.36 %). Among rays, *A. narinari* (32.66%) *D. bleekeri* (28.3%) *D. uarnak* (26.37%) and *Mobula* spp. were the important species found in the fishery (Proforma P2).

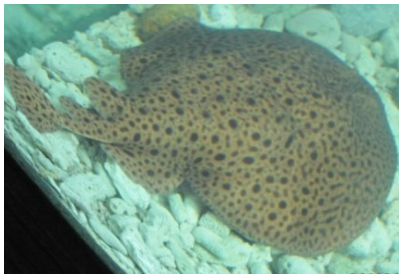
Biological observations: Studies were carried out on the size distribution of *C. limbatus* in the fishery. The size of the species in the fishery ranged 524-2174 mm and the dominant size group observed in the fishery was 1100-1600mm. The sex ratio between male and female was estimated to be 1:1.2.

Stock assessment: Studies were also made on the length based stock assessment of *C. limbatus* and the $L\infty$ and K value were estimated as 3240 mm and $0.43y^{-1}$ respectively. The natural mortality, fishing mortality and total mortality parameters were estimated as 0.54 y^{-1}, 2.34 y^{-1} and 3.88 y^{-1} respectively. The L_{opt} estimated for *C. limbatus* was 1144 mm. The spawning stock biomass (21 t), standing stock biomass (43 t) and yield (44 t) of *C. limbatus* in Calicut region was estimated.

Breeding and rearing of the marbled electric ray (*Torpedo marmorata*, Risso, 1810) in the Marine Research Aquarium at Calicut

The parents of electric rays were collected from Thikkodi area of Calicut in August, 2013 and were kept in a tank at the aquarium. Feeding was initiated with chopped mussel meat and later on fed with prawn meat and mussel meat daily in the morning. Water quality was maintained by water exchange and aeration. Rays require a temperature of 26-28° C in the aquarium and the salinity was maintained between 33-35 ppt. Ample number of hiding places such as dead corals and rocks were arranged in aquarium. Electric rays require sandy substrata in aquarium, as a coarse substrata can easily scratch their body.

As many as 8 young rays was spawned in the aquarium on 18.10.13, each about 115 mm in length, were swimming about in the tanks at the aquarium after spawning. The yolk attached with the juveniles lasted for 20 days. Feeding the young ones was stared with artemia nauplii from 15th day onwards but, none of them were not taking the feed. On 22nd day all the young ones died in the aquarium.



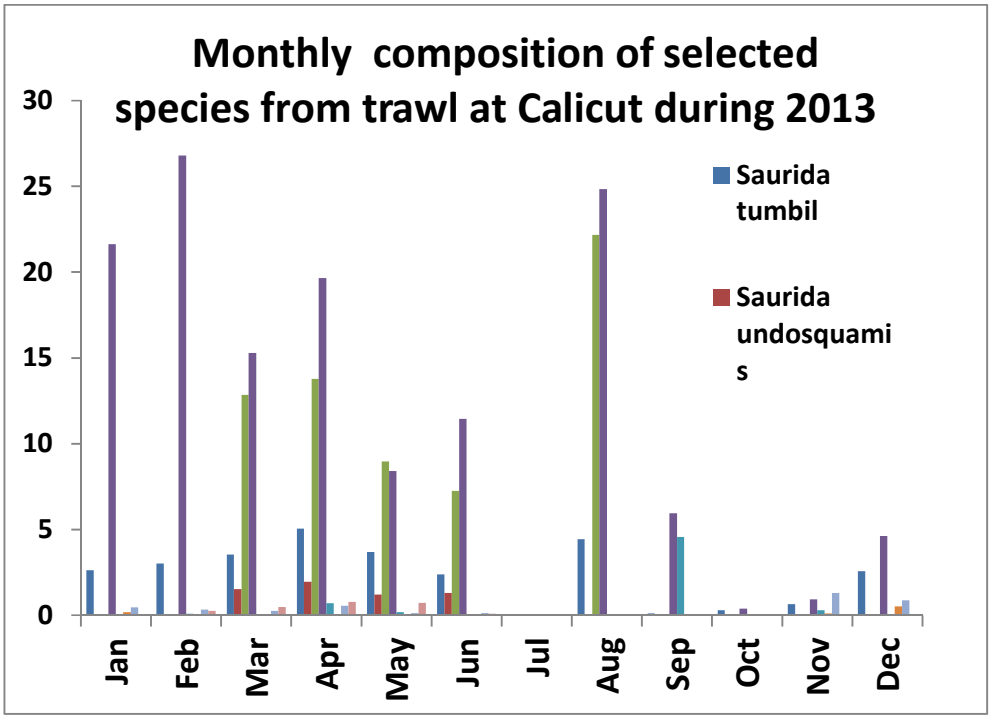
Adult electric ray reared

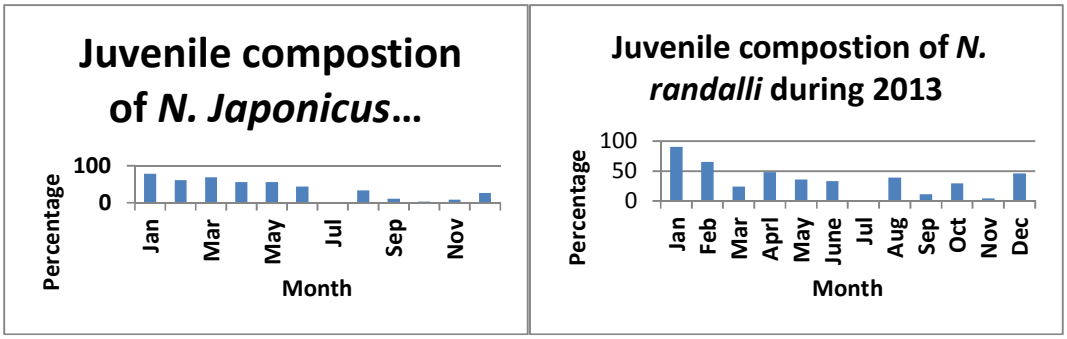
Juveniles of electric ray

3.4 GIS based resource mapping of distribution and abundance of finfishes and shellfishes off Indian coast (FISHCMFRISIL2012000900009)

Studies on the GIS based resource mapping of distribution and abundance of finfishes along the Calicut region was initiated from August, 2012. Initially landing centres in the Calicut region was surveyed and collected geographical information on the location of each landing centre. The data on GIS based information on catch, effort and species composition of a multiday trawler was collected twice a month based at Beypore in Calicut. Information on the distance travelled from landing centre, direction travelled and depth of operation were also collected. The depth of operation ranged 20-130m. The effort expended in each trip ranged 20-120 hrs depending upon the number of days of fishing during the period of study. The area of operation of the trawler was off Calicut between 11°.9.29.5844 N -75°.47.31.00E and 11°.11.37.4352 N- 75°.47.37.7788 E. The number of hauls during each trip ranged 12-42 depending upon the number of days of fishing operation during each trip.

The catches mostly consisted of threadfinbreams, scads, loligo, bulls eyes, ribbon fishes, lizards fishes, white baits etc. The monthwise composition of juveniles and spawners of five demersal resources were studied. Juveniles were highest during the period January-February in *N. japonicus* and *N. randalli*. In the case of *J.sina* juvenile composition was highest during March-May. In *O. ruber* highest composition of juveniles were recorded in March and May. While, in *C. macrostomus* juveniles were present in the catch in highest quantity in April. Spawners of four species were present during January-June. But in the case of *N. japonicus* spawners were available in the fishery during February -June only.





3.6 Assessment of myctophid resources of the Arabian Sea and development of harvest and post harvest technologies (2007-08-2009-10)
Highlights of the work

- Myctophids were collected from commercial deep-sea trawlers. Since these resources were having no economic value most of these catches were discarded in the sea at the time of catch. Among the myctophids, *Diaphus watasei* of the family Myctophidae and *Neoscopelus microchir* of Neoscopilidae were the dominant representatives found in the catch.

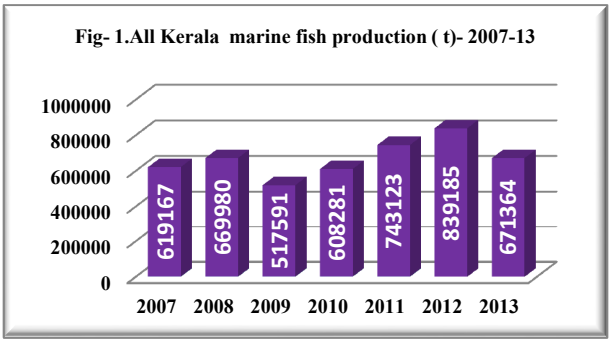
4. Pelagic Fisheries Division

4.1 Management advisories for sustaining marine fisheries of Kerala & Lakshadweep (PEL/IDP/01)(2009 – 2012). Development of Fishery Management Plans for Sustaining Marine Fisheries of Kerala & Lakshadweep (FISHCMFRISIL 201200300003)

General observations :

Total Kerala marine fish production trends from 2007 to 2013 is indicated in Fig – 1. Total catches after 2009 exhibited an upward trend and registered a record production of about 8.4 lakh tones in 2012 and subsequently declined to 6.7 lakh tones in 2013.

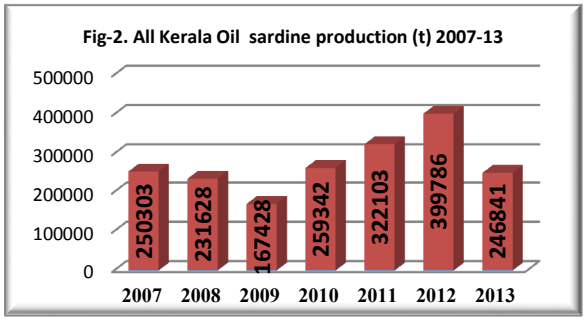
The resources monitored during the period were the oil sardines ,Indian mackerel , ribbon fishes and tunas, which together contributed about 64.6 % to the total Malabar landings .



Oil Sardine

General trend

The oil sardine production trends for the period 2007-13 is indicated in Fig- 2 . The sardine catch showed increasing trend from 2009 onwards reached the record 4 lakh tones in 2012 then declined to 2.5 lakh tones in 2013.



Gear wise composition

The most important gears which supported the oil sardine fishery were mechanized ring seines, trawl nets, gill nets ,mechanized combination gear units, non –mechanized units etc.. The *Sardinella longiceps* exploited at Malabar measured 40-215 mm in total length and the dominant groups were 109-130, 135-155, 170-184 mm in TL . The widest range 40-215 mm was observes in seine nets . The same for

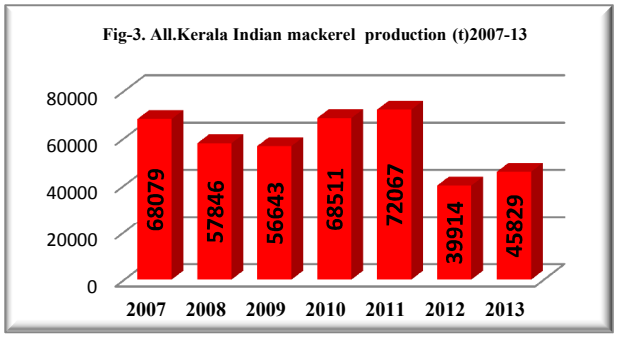
Bumper catchRing seine sizes

trawlers and gill netters were 135-180 mm and 170- 205 mm respectively . The juveniles and young ones were mainly landed by seine nets and the comparatively bigger ones and the adult fishes were landed by trawlers and gillnetters.

Indian mackerel

General trend

The Indian mackerel production trends for the period 2007-13 is indicated in Fig- 3 . The catch after 2009 showed increasing trend and reached maximum in 2011 subsiquently, declined 39914 t and then regitered 14.8 % (5915 t) increase during 2013. However, the increase recorded in 2013 was much below the average production for the 2007- 11 period .



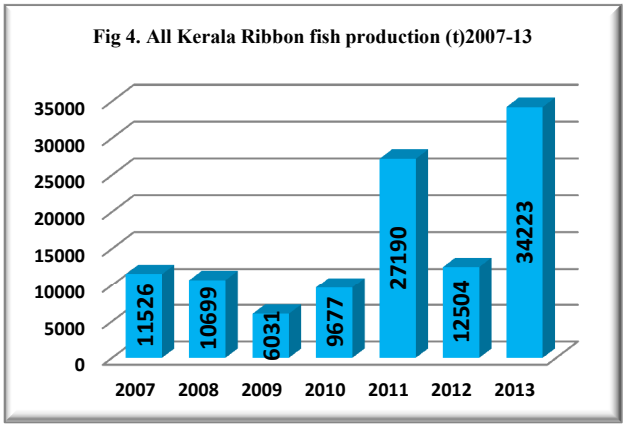
Gear wise composition

The most important gears which supported the Indian mackerel fishery were mechanized ring seines, trawl nets, gill nets ,mechanized purse seines, mechanized combination gear units, hooks & line etc.. The *Rastrelliger kanagurta* exploited at Malabar measured 47- 298 mm in total length and the same weighed 0.9-234.9 gram in total weight . Juveniles were encountered maximum in May / June and December- January months and were mainly landed by seine nets . The fishes in the spent recovery stages were encountered maximum in the trawl catches. The fishes in the oozing stages were observed maximum in the gill net catches .The regular target fishing of the same would be detrimental for the stock sustenance in the long run .

Ribbon fish

General trend

The ribbon fish production trends for the period 2007-13 is indicated in Fig-4.The catches were highly erratic and 2013 recorded the maximum which was 3 times more compared to 2012. . The 2013 spurt could be due to the unusual high aggregation of the feeding stock which was chasing the *Acetes* species along the southern districts during the post-monsoon months.



Gear wise composition

The most important gears which supported the ribbon fish fishery were trawl nets ,mechanized combination gear units, gill nets ,hooks & line etc.. There exists a very wide difference in the prices for the hooks & line caught fishes and trawl net caught fishes . The hooks & line caught fishes always fetch comparatively very high rate on account of their better quality and the size of the individual fishes . They are mainly purchased for the export purpose.

Hook & line catch

Species composition

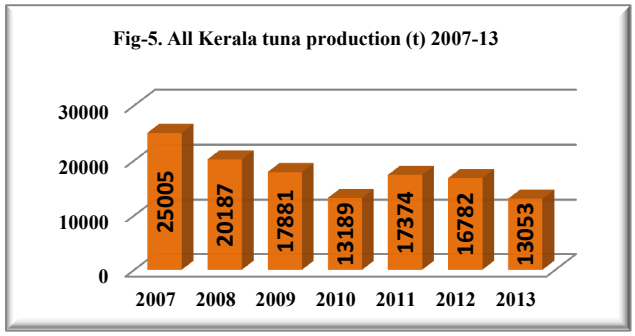
The fishery was supported by *Trichiurus lepturus* at commercial level and the same accounted for more than 98.5 % . *Eupleurogramus muticus* accounted for nearly 1.5 % . *Lepturacanthus savala* was also encountered in stray numbers.

The *Trichiurus lepturus* exploited at Malabar measured 69 - 942 mm in total length and weighed 0.21 – 764 gram in total weight . The juveniles measuring as small as 69mm in total length and 0.21 gram total weight were observed in considerable numbers in the catches in May 2013 .This indicates that a spawning has taken place in April .

Tunas

General trend

The tuna production trends for the period 2007-13 is indicated in Fig-5. Except for the comparatively better landigs in 2011 & 2012 the all Kerala tuna production has been exhibiting a gradual decline from 2007 onwards .



Gear wise composition

The most important gears which supported the tuna fishery were mechanized combination

gear units ,hooks & line, gill nets, trawl nets , etc.. Mechanized purse seines ,mechanized ring seines and non- mechanized units also landed tunas in small quantities.

Species composition

The tuna fishery at Malabar was supported by seven species. The bulk of the landing was contributed by *Euthynnus affinis* (65.3 %) followed by *Auxis thazard* (14.7 %) ,*Thunnus tonggol* (9.8 %) , *T.albacares* 6.9 %) , *A. rocheii* (2.1 %) *Katsuwonus pelamis* (0.9 %) and *Sarda orientalis* (0.3 %) . (Fig .6).

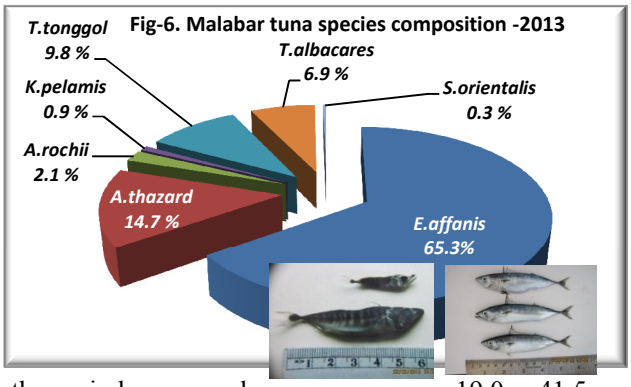


Fig-6. Malabar tuna species composition -2013

Size distribution

Euthynnus affinis exploited at Malabar during the period measured 11.2 - 68.0 cm in fork length and weighed 17.2 –5230 gramsin total weight. *Auxis thazard* exploited at Malabar during the period measured 19.0 - 41.5 cm in fork length and weighed 75.0 – 1350 grams in total weight.*A. rocheii* exploited at Malabar during the period measured 18.0 - 30.0 cm in fork length and weighed 150 – 280 grams in total weight.*Thunnus tonggol* exploited at Malabar during the period measured 28.0- 63.0 cm in fork length and weighed 323 –2540 grams in total weight.*K.pelamis* exploited at Malabar during the period measured 31.0 - 63.5 cm in fork length and weighed 600– 4100 grams in total weight. *Thunnus albacares* exploited at Malabar during the period measured 29.6 - 45.5cm in fork length and weighed 330 –1440 grams in total weight

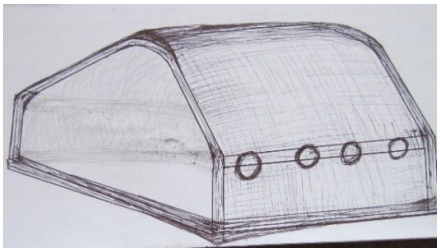
Management Plans

- The fishers are considered to be among the most back ward classes. Hence, special packages like that of "Kuttanad package" should be formulated and implemented for the overall development of the coastal areas and the coastal people .
- A committee may be constituted to study and recommend suitable modification / improvements in the existing KMFR Acts as well as to formulate fresh regulations where ever necessary.
- Alternative lively hood options may be provided to the unemployed fisher youth in the form of capture based and hatchery based culture practices, promote eco- tourism like Mammal watch, Sport fishing, Adventure tourism, Under water diving tourism etc. at selected specifically developed areas like Velliyankallu, Dharmadam Thuruth and other rocky areas and Islets. The programmes can be included under the Panchayath schemes and the preferences may be given to the unemployed youths staying along the coasts near the respective villages.
- The exploitation of "Low Value By Catches"(mostly juveniles of different varieties) to be reduced by the adoption and practicing of suitable " Excluder Devices" .
- Areas , gears and seasonal bans are necessary to conserve spawners / breeders. Because, a seasonal target fishing for varieties like mackerel, cat fish, cuttle fish etc. exist at some areas . Conduct specific focused studies to identify the grounds, seasons, the gears etc. and impose seasonal bans on the gears targeting the resource. The identified grounds may be declared as Marine Protected Areas.
- 5 surface FADs may be deployed for the augmentation of the production of the large pelagic fishes . An additional 10,000 tons of high value large pelagic fishes like tunas, bill fishes, dolphin fishes, rainbow runners, queen fishes etc. can be expected form 5 FADs if deployed and managed properly. The following locations would be ideal for the deployment .

FAD locations :

	Latitude	Longitude	Distance (NM)	Steaming (hrs)
1.	74o 55'/56'	11o 11'/12'	48-50	4.5 - 5.0
2.	74o 33'/34'	11o 11'/12'	70 - 71	6.0 - 6.5
3.	75o 25'/26'	10o 32'/33'	31 - 32	2.5 - 3.0
4.	75o 40'/42'	09o 27'/28'	38 - 40	3.5 - 4.0
5.	75o 50'/52'	08o 52'/54'	41 - 42	4.0 - 4.5

- The Ferro cement "Artificial KallumakakaiPaars" cum AFHs may be deployed for theenhancement of the production of Mussel as well as other resources like Lobsters, Carangids, groupers, snappers, ornamental fishes etc. 5-8 % increase in the production of mussel, other high value demersal fin fishes and spiny lobster can be achieved by the extensive deployment of the structures in the suitable locations along the coast. Also, mussel seeds from the new structures can be utilized for the mussel farming. The design given below will be a suitable one .



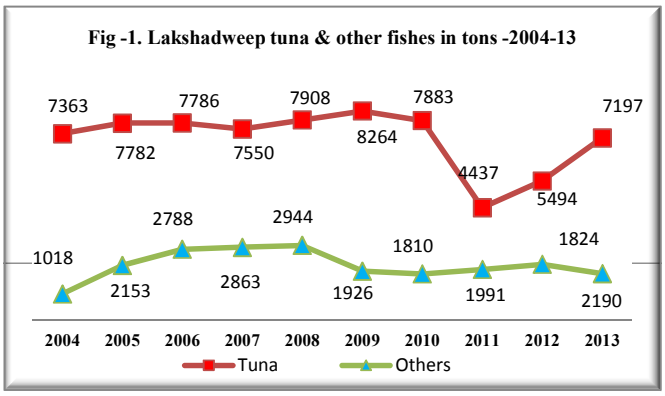
The AKPs cum AFHs may be deployed, adjacent to the existing Kallumakai Paars (Mussel beds) like Calicut South beach paar (Mukahdar) , Nandi Paar, DharmadamPaar, VizhinjamPaar, Kadalundy etc. The programs may be implemented by the local Panchayaths in consultation with local fishermen of the respective villages who are already engaged in the mussel picking /fishing.

- The complexity of managing the marine wealth, due to the open free access nature of fishing, the migratory behavior of the resources and the absence of a single manager cum coordinator make the situation chaotic. The resources being targeted are migratory and shared by many states and different stake holders. Hence, drawing the practical solutions for the problems by any one stake holder may not be a realistic one.

4.2 Strategies for sustaining tuna fisheries along the coast of India (PEL/IDP/03). (2010–2012). Development of strategies to sustain the stock and fishery of large pelagics in Indian waters (FISHCMFRISIL 201200700007).(2012 – 2014).

LAKSHADWEEP TUNA

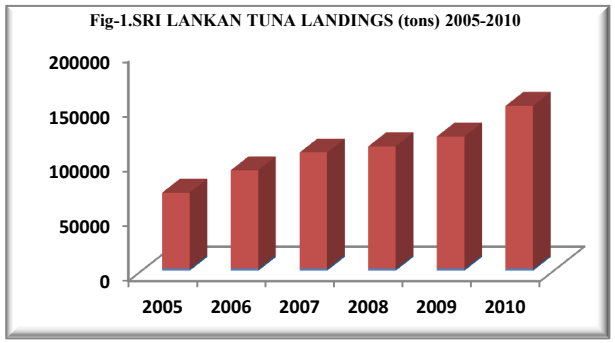
General observations: The total fish catch and estimated tuna production trends during 2004 – 2013 are given in Fig – 1 . The tuna, particularly skip jack, catches drastically declined after 2010 and the tuna in general (5493.6 t to 7196.9 t) and skip jack in particular (2483.6 t to 3684.8 t) recorded comparatively considerable increase throughout Lakshadweep in 2013. This was mainly due to the comparatively better aggregations of skip jack shoals at islands like Minicoy, Andrott, Kalpeni etc. However, at Agatti the tuna fishery though recorded comparatively very good improvements in 2013 has not yet exhibited the real recovery levels. The comparatively increased landings in 2013 too was far below the annual average production levels of 1980s & 1990s . Further, the surface skip jack shoals tends to aggregate more around Androth , Kalpeni axis in recent years ? In 2013 , during October- December months there was an unusual high aggregation of surface skip jack shoals along with small prawns (*Acets sp* ?) concentrated within 22-25 Km radius off Kalpeni / Cheriyam Islands. The aggregation yielded about 125.8 t during November – December months. Apart from the local Kalpeni units , the P& L units from Agatti ,Kavaratti & Andrott Islands also temporarily migrated to Kalpeni Island and exploited the resource during the period . The Pablo boats , OBM units & the country crafts landed about 99.2 t (78.9 %) , 15.2 t (12.1 %) and 11.4 t (9.0 %) respectively. The skip jack tunas of average 2 Kg sizes constituted > 90 % of the landings .Subsequently , the medium & big sized (15-30 Kg sizes) yellow fin tunas also landed at Kalpeni in considerable numbers .

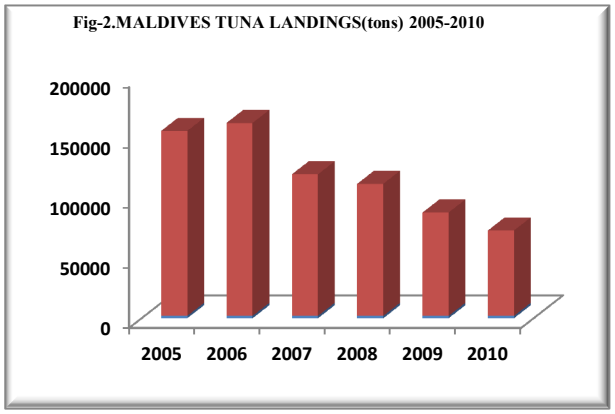


OBSERVATIONS ON THE DECLINING TRENDS

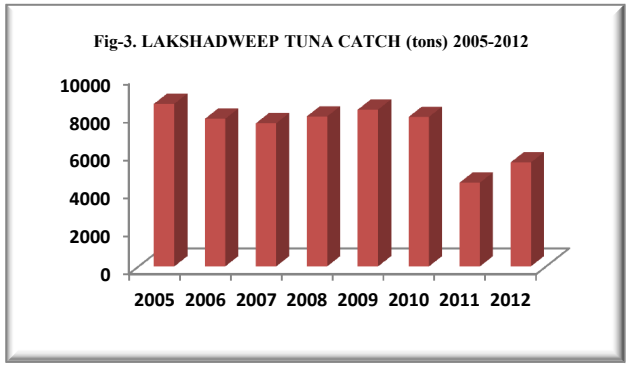
The back born/main stay of Lakshadweep fisheries was the exploitation of 2 &3 year class surface skipjack tunas and small yellow fin tunas caught by Pole and Line method. The tuna pole and lining by the Minicoyans, initially with the traditional *Massodies*, got established in all the islands through the introduction and popularization of the specially designed low draught Pablo boats. Consequently, the tuna production also increased tremendously from the few hundred tons in the 60s to about 10000 tons in the middle/ late 90s. Subsequently declined and stagnated around 7250 in the recent years. During the same periods large number of multiday (deep sea) vessels from the mainland bases and many LOP vessels were regularly conducting the fishing operations in the Lakshadweep waters. Further, the Ethiopian piracy problem in the recent years has forced many tuna fishing fleets to shift their operations from the Mascaren Plateau of the coast of Africa to the areas around Laccadive-Chagos ridges and the Andaman ridges. Also , the reports indicates a large scale FAD based tuna fishing including theindustrial purse seining in the international waters adjacent to the Laccadive-Chagos ridge which is the gate way and the migratory path of the juveniles and sub adults. Apart from these, the peculiar behavioral tendency of the juveniles and the sub adults to aggregate more around drifting floats/logs is also capitalized on with the help of the technical and technological advancements like drifting

FADs and purse seining with the support of helicopter tracking/scouting etc. for the exploitation/harvesting. No doubt, can reap the benefits within the shortest period. However, the big gain to one nation will be a great loss particularly to the adjacent nations who are patiently/eagerly waiting for the arrival of the shoals/resources into their waters. The effect of interaction between two adjacent fisheries arising out of high competition between the adjacent nations targeting a common resource normally adversely impacts on the resource/stock. The competition and struggle for exploitation leads to aggression and usually assumes destructive propositions with the adoption of unethical fishing practices. As per the IOTC catch estimate for Sri Lanka and Maldives, the Sri Lankan tuna catches were very nominal and the Maldivian catches were very high till 2000-02 periods.





The Lakshadweep catches were also comparatively very good during the period .But, in recent years the ,Sri Lankan catches were found to be sharply increasing, from 0.7 - 0.8 lakh tones to 1.4-1.5 Lakh tones (Fig - 1). Where as that of Maldives has tumbled, from 1.5 - 1.6 lakh tones to 0.7-0.8 lakh tones (Fig -2). The Lakshadweep tuna production tremendously increased from few hundred tons in the 60s to around 10,000 tones till the late 90s . Probably, during the initial period , the shoals were able to migrate freely for the spawning , feeding etc and very good numbers of the shoals were reaching Lakshadweep waters also without being caught en route. Subsequently, as the fishing en route increased and also due to the effect of interaction between two adjacent fisheries, the catches declined to around 7250 tons (Fig -3)during the decade. Large scale industrial fishing in the tuna migratory paths in the adjacent international waters and poaching in our own waters were also reported during these periods . Bulk of the catches (being migratory stock shared by many adjoining nations including Lakshadweep) by these vessels must be from the Lakshadweep potential estimates and might have affected the Lakshadweep production during the period.



The highly migratory tuna potential estimated for Lakshadweep varied between 50,000 t to 90,000 t . The annual average landings during 90s were about 10,000t which declined to 7700 t and has further marginally declined to 7250 t during 2007-11 period . The decline in 2010-12 period , particularly at Northern Islands were very conspicuous and were indeed alarming. The declining trends exhibited by

Lakshadweep from the late 90s could most probably be due to the culmination of the different factors like the impact of intensive multi gear fishing operations conducted by the mainland deep sea vessels and the LOP vessels, effect of interaction between two adjacent fisheries, the erratic environmental conditions and the consequent horizontal and vertical migrations, seasonality and duration of the stay in a particular area/ ground for spawning and feeding purposes , fishing methods employed for their exploitation ,quality and quantity exploited from a particular ground etc. The *Mas* prices , which was the main attraction for the adoption of the single species fishery , has not been increasing proportionally with the price increase for other commodities. In fact , of late, it has collapsed from ` 500-600 to 350 – 400 / Kg. This could be due to the increased tuna production in Sri Lanka. Because, Sri Lanka was the main market for the Lakshadweep *Mas* and after the self sufficiency (due to the increased landings there) , the imports were curtailed and the prices in the exporting country collapsed due to the reduction in the demand . The prices fell sharply to ` 175/ Kg. during 2008-09 period and Lakshadweep administration declared a support price of ` 240 /Kg due to the agitation organized by the Lakshadweep fishermen. The reason for the collapse was attributed to the poor demand from Sri Lanka. This also indicates the exploitation /landings in Sri Lanka was quite high during the recent years .

Management plans

- Collection of species wise, gear wise catch and effort data (scientific) of all the important groups including live baits form all Islands including Suheli Island.
- Development of basic infrastructures, storages ,ice factories etc. in all the major fishing centers.
- Free ration to Agatti fishers, who are economically disabled due to the collapse of P&L fishery, as an immediate relief and rehabilitation measure. Simultaneously, they may be encouraged to adopt alternative fishing practices through special incentives and credit facilities.
- Deployment and promotion of combination vessels and dory fishing at *Paar* and Bank grounds. Special packages & incentives for the promotion of the same.
- Diversification of fishing efforts to less labour intensive and fuel efficient fishing practices.
- Efficient and effective catch disposable techniques, including issuing the permits to main land entrepreneurs to procure the catches, for the sale of the highly perishable fresh fishes.
- Organizing and promoting fish and fisheries based eco-tourism packages as an alternative lively hood option for the youths and the unemployed.
- Deployment, maintenance and proper utilization of FADs/AFHs for surface tunas as well as reef fishes .
- Introduce and popularize the fish fattening/fish culture in the lagoons and open sea for the employment generation and the catch enhancement.

5. Moluscan Fisheries Division

5.1 Health Management in selected finfish and shellfish for mariculture and aquariculture & bioprospecting from marine resources <u>FISHCMFRISIL201202600026</u>

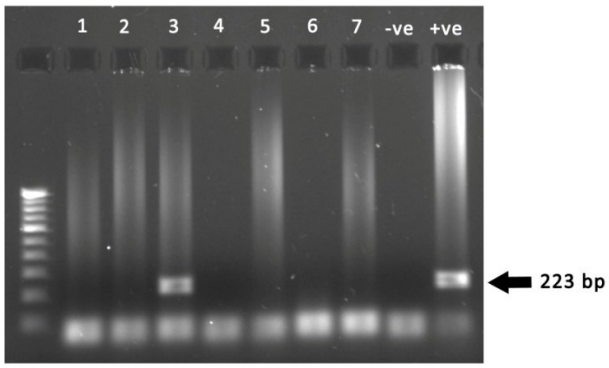
Screening of bivalves for *Perkinsus* infections:

Bivalves were collected from various regions along the south west and south east coasts of India and screened for the presence of *Perkinsus* spp. infections. Disease diagnosis

was made using qualitative methods and screening techniques like RFTM culture assay, histopathology preparations, PCR etc. Tissue samples (gills & mantle) were excised and subjected to Ray's Fluid Thioglycollate Medium (RFTM) culture, stained with Lugol's iodine and examined. For more specific and confirmatory diagnosis, PCR technique was used after DNA isolation. Genus specific primers of *Perkinsus* were used for amplifying the sample DNA. Low level infections with *Perkinsus* were detected using the newly developed nested PCR which ensures increased sensitivity and specificity.

Samples of bivalves were collected from various locations in Maharashtra. *Perna viridis* collected from Versova and *Meretrix meretrix* collected from New ferry wharf were negative for *Perkinsus* infection, while *C. madrasensis* collected from Sasoon dock was positive.

Epidemiological study of *Perkinsus* spp. in bivalves from Gujarat was carried out. Samples of *C. madrasensis* were collected from Miyani, Navibandar and Porbandar, while samples of *Saccostrea cucullata* and *Pinctada fucata* were collected from Sikka. The study revealed the presence of *Perkinsus* spp. in samples of *S. cucullata* collected from Sikka. The samples of *C. madrasensis* collected from Miyani, Navibandar and Porbandar were negative for *Perkinsus* infection.



Gel image of the Second step PCR for *Perkinsus* spp.

5.2. Sustainable molluscan mariculture practices - FISHCMFRISIL201201400014

Status: Principal Investigator

REPORT OF THE FIELD SURVEY TO DETERMINE AREAS SUITABLE FOR BIVALVE FARMING IN THE STATE OF MAHARASHTRA

Konkan coastal stretch of Maharashtra is endowed with large number of west flowing rivers formingproductive estuaries and creeks fringed by mangrove vegetation. The indented coastline stretchingacross the districts of Raigad, Ratnagiri and Sindhudurg are marked by the presence of narrow creeksoffering sheltered areas for aquaculture activities. Considering the potential for expanding bivalve farming in the State of Maharashtra, surveys for selecting suitable sites for farming were conductedfrom 5th to 8th October, 2013 covering coastal areas of Mumbai, Raigad, Ratnagiri and Sindhudurg.

Bivalve Resources: The numerous estuaries and backwaters present along the coastline of Maharashtra State abound in bivalve wealth and the main species that contribute to the fishery areclams such as *Meretrix meretrix*, *Marcia opima*, *Paphia malabarica*; oysters such as *Saccostrea cucullata*, *Crassostrea gryphoides* and the green mussel *Perna viridis*.

Ranade (1964) who investigated the bivalve resources of the state in more detail estimated that outof the total number of 70 creeks along the state's coastline from Thana to Ratnagiri District, 34 wereproductive, where about 3,600 persons were engaged in clam fishing. M. meretrix and M. opimaalone contributed nearly 70% of the total production, the rest being accounted by Paphia sp.,Marcia sp. and Donax cuneatus. The most productive areas lie in Kalbadevi estuary and Bhatia creekof Ratnagiri District, which accounted for more than half the total production for the state. Taxkarlicreek, south of Malwan, was another important

clam producing centre where M. meretrix wasparticularly abundant. Mumbai, Ratnagiri and Malvan are the important marketing centres for clams. Oyster fishing was reported in Alibag, Ratnagiri, Jaitapur and Malvan. In Purnagad creek near Ratnagiri the oysters were found attached to the rocks at a depth of 4 to 5 fathoms. The oyster fishing season was from December to May. Jaitapur was more important than Purnagad in oyster trade as the oysters from the area were sent to Mumbai for big hotels. Though oysters are foundand sometimes collected in Malvan they are not of any significance as clams are available in plentyand cheap.

Proposing a new conceptual value chain on rock oysters – The KONKAN MINI

Along Konkan coast, natural populations of*Saccostrea cucullata* are widespread in marine intertidal and estuarine areas, cemented to rocky/hard habitats. This oyster forms part of the foulingcommunity and they are found attached on harbourpilings and underwater structures. *Saccostrea cucullata*, distributed in the Indo-Pacific region isfarmed commercially in Malaysia, Thailand,Philippines and Australia. The commercial size ofexploitation of *S. cucullata* is 40-60 mm in shell heightalong the India coast. Compared to the edible oysters under genus *Crassostrea*, the shell valves of *Saccostrea cucullata* have crenulated margins. Due to the relatively lighter shell valves this specieshas reasonably higher percentage edibility or meat weight as a ratio of total weight as compared to *Crassostrea madrasensis*. They also have better flavour as they are always in salty marine waters.Considering these aspects, the species appears to be an appropriate candidate for rearing in areasidentified for oyster farming along the Konkan coast.In the recent past, a new value chain on live oysters (*Crassostrea madrasensis*) has been developedin and around Kochi by CMFRI under the NAIP scheme (Mohamed and Kripa, 2013). The oystersproduced by women SHGs in Ernakulam district are depurated and sold to high-end restaurants andhotels in live condition. The value appreciation is to the tune 7-10 times the existing market price.To build consumer confidence a portable depuration unit for high-end restaurants has also beendesigned (Mohamed et al. 2011).Considering the rock oyster populations in Maharashtra and the high local demand for oysters(locally called *kalwa*) both in Maharashtra and Goa, there is immense scope to develop a new valuechain on live rock oysters with the possible brand name of KONKAN MINI OYSTERS. The following factors may be considered for its development.

- Currently, we have farming technique for *Crassostrea madrasensis* which is commercially practiced (FAO estimate for 2011 production by farming is 4500 tonnes). But, we do not have techniques for *Saccostrea cucullata*. However, since the principles are the same, the *C. madrasensis* technique can be easily adapted during the demo period.
- Live oyster consumption requires depuration before consumption. These have to be developed with the help of MPEDA or UNDP project in Sindhudurg.
- Goa is a market that can be immediately tapped, and from thence, Mumbai and the Middle East can be targeted, again with the help of MPEDA.
- Packaging the small (mini) oysters in tray packing (half dozen in a thermocol tray) has to bedeveloped. The brand name KONKAN MINI OYSTERS has to be marketed with the help of MPEDA.

Mortality of the mussels from Edayilakadu area was reported by the Deputy Director of Fisheries (Kasaragod dist) on 16.1.14. To get the details of the mortality, the samples were collected from the affected as well as from neighbouring healthy areas to ascertain the possibilities of outbreak of any diseases.

Mussel farming at Edayalekkadu, Padanna backwaters.

The area of the mussel farming in Edayilakkadu was calculated as 0.75 km² and the perimeter as 5422 meters. The bridge in the northern area measures about 320 meters and it is constructed by filling the backwaters and called the Edayalekkadu bund. This restricts the flow of water into the southern area. The total number of the mussel farms during 2014 were 150 racks. Last year (2013), the number of farms were 123 (100 individual + 23 kudumbashree units).

Pathological investigations:

The mussel samples collected from Padanna from where mortalities were reported in 16 January 2014 were examined for the presence of all major OIE listed pathogens in molluscs using molecular diagnostic techniques. PCR was carried for *Perkinsus, Bonamia, Marteilia* and Osterid Herpes virus, the important pathogens of bivalve molluscs using their respective OIE suggested primers. All the samples examined were negative for the above pathogens.

Histopathological analysis showed that the tissue samples were normal. Very mild degenerative changes were observed in the digestive tissues of two samples examined and this cannot be related to any disease condition.

Environmental studies:

On 19.1.14, the **dissolved oxygen** in four locations of the Edayalikkadu farm area was estimated by Winkler method and the values were as follows:

1. 3.29 mg/L 2. 3.30 mg/L 3.3.28 mg/L 4.3.19 mg/L

Later, environmental studies were conducted from the major mussel farming areas of the Padanna backwaters including the Edayilakkadu area. The station were as follows:

1. Ori
2. Mavilakadapuram
3. Ori thekkepuram
4. Vadakkekadu
5. Thekkekadu bund
6. Edayilekadu
7. Edayilekadu
8. Valiyaparamba
9. Ayitti

The phosphate content of the Edayilakkadu area is 0.40mg/L compared to the range of 0.10 to 0.25 mg/L in rest of the areas under observations. The depth of Edayilakkadu area was also lower compared to other areas at 154cm. The BOD values are at 3.367 mg/L. The western side of Edayalikkadu and Thekkekadu area also showed higher BOD values at 4.483 and 3.945 mg/L respectively.

From Thekkekadu bund and further south, transparency is less, but higher TSS and BOD is recorded. The pH remained alkalineat the surface, (more than bottom) whereas at the bottom water it was less than 8. Although Chlorophyll a values are better, NPP is comparatively lower. Though the depth is shallow, the parameters show considerable difference indicating separate layers with no proper mixing and low flow rate of water. The inference is that due to eutrophication, as evidenced by the blooming of BGA (filamentous forms, *Lyngbia* sp) and higher BOD, mortality might have occurred.

The construction of the Edayilakkadu bund restricts the flow of water current and this has resulted in accumulation of waste and subsequent eutrophication. This areas showed the presence of the blue-green filamentous algae, *Lyngbya* sp. Sample of mud taken from the

bottom of the Edayilakkadu area showed complete mortality of the clam, *Villorita cyprinoides*.
South of Edayilakkadu area the other bund is at Udumbanthala-Madakkal road. However no mussel culture is practiced inside the area.

Carrying Capacity:

In mussel farming , the growth of mussels is limited by suspended food sources. Food is renewed by water exchange and primary production. Apart from phytoplankton, mussels feed on other organic particles which they filter from the water column. The portion of the un ingested material is expelled as mucous bound deposits of organic and inorganic material as pseudo faeces which settle on the floor below the mussel farms. Growth rates of mussels can vary substantially among different localities and years. Most of this variation is associated with variability in phytoplankton abundance. The carrying capacity depicts the relationship between the size of a population and change in the resources on which it depends and it presumes that there is an optimal population size that can be supported by the resource.
Empirical evidence suggests that the number of farms in the area is double that which can be scientifically accommodated there.

Estimated Loss: Based on current prices, the value of the loss due to crop mortality is Rs. 3.96 crores.

Cause of mortality:

The Edayilakaad Bund has blocked the free flow of the water into the Edayilakaad portion of the estuary leading to decreased water currents and insufficient flushing of water masses. There has been build-up of nutrients like phosphates (PO_4) in the Edayilakaad area because of lack of circulation. This has led to eutrophication which resulted in the blooming of the blue green filamentous algae. The resulting higher BOD and lower value of dissolved oxygen and lower Net Primary Production (NPP) has put physiological stress on mussels. This has been confirmed by the heavy pigmentation (due to higher carotenoid content) in young seed mussels. The situation became worse as the number of units increased this year and water body could not take the additional carrying capacity.
All these reasons, individually and collectively led to stress for the mussels which resulted in mortality.

Suggested improvements:

- The mussels being filter feeders, need appropriate phytoplankton for feeding..
- The construction of bund poses a problem not only in reducing the flow of food material for the mussels but also causes eutrophication of the water body.
- A proper pillar bridge should be made at Edayilakkadu and at Udumbanthala-Madakkal road.
- As these projects take long time for implementation as an interim measure, the method followed at Thekkekadu Bund road can be followed. Here cement pipes are kept in the middle of the bund for allowing flow of water.
- Though not a very efficient way of circulation, but this definitely is better than completely blocking the flow into Edayilakkad entirely.
- Based on the carrying capacity of the Edayilakkadu area, the number of mussel farms should be restricted to 75 from the next farming season onwards.

Training in bivalve farming

1. Training on '*Edible oyster and green mussel farming'* was jointly organized by CMFRI, MPEDA and NETFISH at Ratnagiri on 7th October 2013 for 40 participants.HRD programme on '*Molluscan Farming'* Demonstration was jointly organized with MPEDA,

Mumbai, and CMFRI from 12th to 14th December 2013 at Ratnagiri for 25 farmers. Demonstration racks were fabricated using bamboo poles at 2-3 m water depth for mussel farming.

Bivalve farming training at Kalbhadevi, Ratnagiri

2. Conducted training for 60 fisherwomen on mussel farming for the Kudumbashree units (SHG) of the Balathurithi area under the Vallikunnu Grama Panchayat on 16 November 2013.All the SHG's were assured subsidy for the culture of mussels in the backwaters of Kadalundi estuary.

Mussel farming training at Balaathurithi, Malappuram district

5.3. Development of Fishery Management Plans (FMPs) for the bivalve fisheries of India: (Project Code-FISHCMFRISIL201201200012)

Local self governance of Green mussel resource in Malabar area:

The green mussel (*Perna viridis*) fishery of Malabar area has of late seen a shift in the resource management. The shift started first at Elathur mussel landing centers which is one of the most important landing centers. The increase in the unit price of the mussel was one of the important reasons for this change in attitude. The fishers also felt that the reason for the lean period was the harvest of mussel seeds for mussel farming in the backwaters. So there was a conflict of interest here. A resolution was taken by the fishers that no seed harvesting will be allowed. Any seed accidentally brought was to be thrown back to the sea. This led the mussel farmers to find alternate source for their requirement of seed. They had to depend on areas where no fishery exists but seeds were available in areas of south Kerala (Quilon district) and Karnataka.

About 476 boats, canoe and catamarans are involved in the mussel fishery of Malabar area. The mussel beds are either laterite or granite formations. The granite areas are easier for picking the mussels during diving as there are few crevasses. The crafts used are either canoe, boats or catamarans. The canoes with sail are used usually by 1-2 persons, the boats have 3-18 persons and the catamarans are operated by single persons (Table 1).

The first change came at Elathur during August 2012. The mussel pickers formed a union with 315 members. 5-6 members were selected from each area. The areas were 1.Harbour area 2. Elathur thodu 3. Aayyapan thaya area and 5. Panni bazaar area. Totally there are 29 members in the coordination committee. Subsequently most of the mussel landing centers in Malabar area had their own committees similar to the one followed at Elathur.

Rationale for fixations of quota

The mussel pickers were of the view in order to get work for more number of days in a year a quota is essential. The pickers believe that the mussel seeds harvested by the mussel farmers reduce their stock for harvest and do not allow any removal of the seeds.

Fixation of quota for fishers.

The quota varies from different landing centers as the number of pickers and also the quantity available also varies. The quota is fixed based on the recommendations of committee which they arrive at by discussion with the mussel pickers' rough assessment of the stock available. At Thikkodi and Chombala the quota is 25 Kg per person. The quota fixed for Elathur, Chaliyam and Mahe is 30 kg per person. The quota is the highest at 60 Kg per person in the landing centres of Thalasseri and Koduvalli. At Kadalazhi and Kollam there are no fixed quotas as yet.

Implementation of the regulations

The implementation of regulations varies from landing centres. At Elathur violation is seriously viewed and action is taken by auctioning the excess mussel picked. So far the committee has just over a Lakh rupees income from the auctioning of excess catch. In all the centres the excess catch is taken by the committee in the landing centres and auctioned. Among the centres, Elathur and Thikkodi were the centres were the implementation of regulations were followed very strictly. The other centres varied in compliance. At Thalai, Thalasseri,Koduvalli and Moodadi upto 5% variation in the quota was tolerated. At Chaliyan, Mahe and Chombala the quota was more lax and 10% to 25% variations were tolerated.

Change in cost of mussel

Due to the quota system introduced by last year, the cost of mussels has gone up considerably. Table 2 and Table 3 compare the landing during 2012 and 2008 of the post monsoon fishery. Even though the cpue have come down, the increase in cost of mussel offsets this disadvantage.

This is the first time that the mussel fishery of Malabar is showing local self governance rather than a state centre decision making.

Conditions declared by the Coordination committee for sustaining the mussel fishery for the mussel pickers.

- Picking of mussel seed for sale or culture is strictly prohibited.
- The time for mussel picking is from 0530 hrs to 1300 hrs.
- The quantity of mussel to be picked would be a box (recommended by the committee) full of mussel.
- The mussel for personal use by the mussel pickers will be restricted to a container given by the committee.
- For the sale of mussels at Puthiappa harbor, the boat with mussel should be measured at the Harbour prior to the sale.
- Those found violating the rules and regulations of the committee, the whole catch of mussels of the day would be taken by the committee.
- The quantity of mussels taken by the pickers would be verified by the authorized person by the committee.
- All the workers should cooperate by following the above mentioned rules and regulation of the coordination committee.

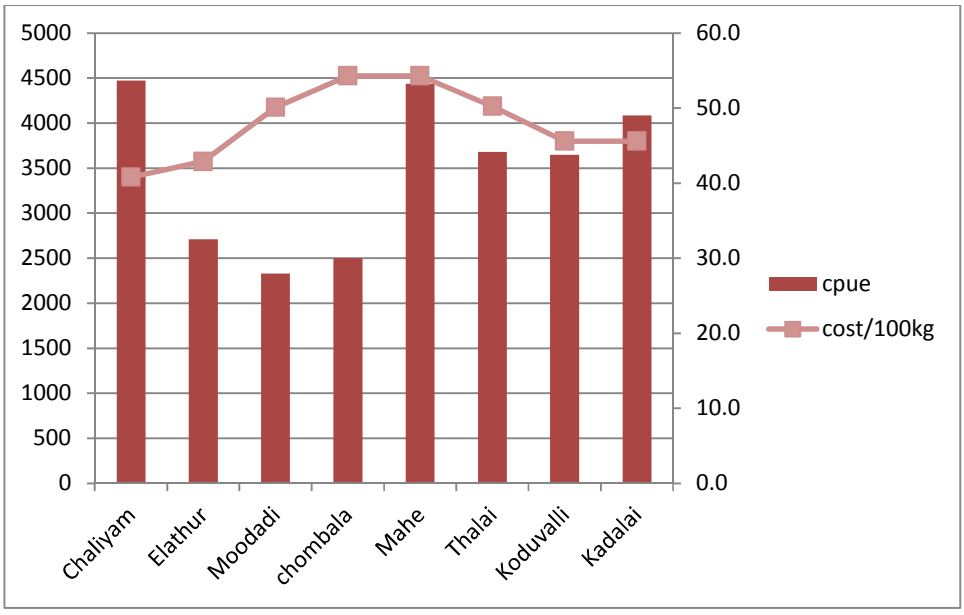


Table 2. Cpue and cost of 100 kg of *Perna viridis* at the landing centres in 2012.

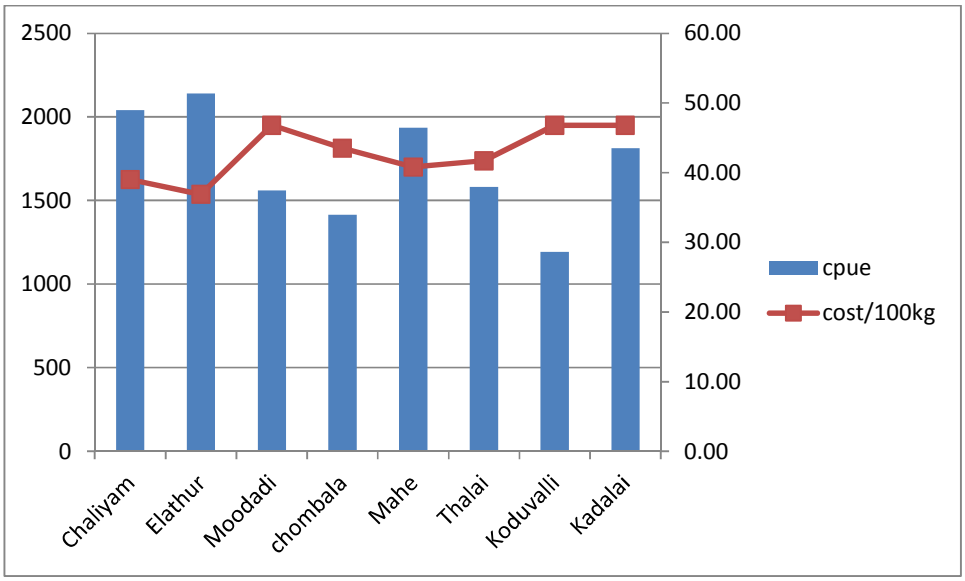


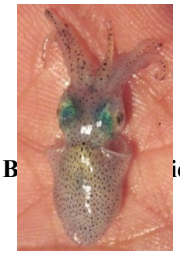
Table 3. Cpue and cost of 100 kg of *Perna viridis* at the landing centres in 2008.

6. External Funded projects

6.1 NAIP. "Utilization Strategy for Oceanic Squids (Cephalopoda) in Arabian Sea": A Value Chain Approach".



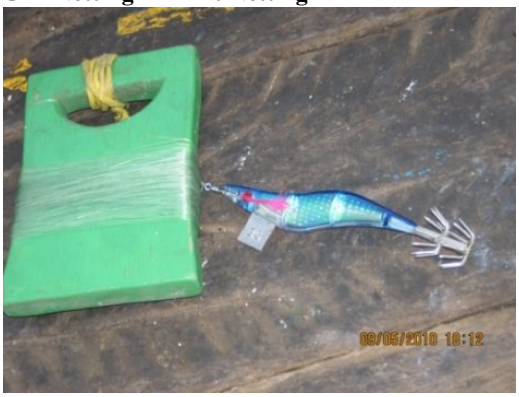

Squid jigging by MFV TitanicAdult & baby squids




B id i Diamo

Trained the local fishermen (Agatti) in December 2011 & January 2012 in gill netting ,Lift netting and hand jigging operations for catching squids .

Gill Netting **Lift Netting**



Hand jig **Squid with Hand jig**

- This value chain project is unlike other schemes operating under CN2 of NAIP. The uniqueness is due to the fact that there is no current PCS for the commodity (oceanic squids) which is targeted in the project. Therefore, establishing a baseline was difficult, particularly as envisaged in the example reports provided by NAIP. The base-line survey to find out the most likely short-term impact of implementing the project on the seafood processing sector (industry) as well as in domestic markets was designed and carried out during June-August, 2009.
- A commercial fishing trawler *MV Titanic*, of >20 m Overall Length was modified forcommercial squid jigging operations. Five mechanical squid jigging machines withpulling power 90-100 kg were installed. An accessory generator and aerial lightingsystem comprising of 18, 1.5 Kw halogen lamps were set for lighting.
- The conventional Pablo boats used for pole and line fishing for skipjack tunas wasmodified into a squid fishing boat with lights. The lights were powered by a 25 KVApetrol start and kerosene run generator. Four incandescent lights of 500 W each wereused for attracting squids. Pablo boat with Overall Length 8 m from Agatti Island wasleased for conversion.
- Exploratory surveys (58 stations) using the converted squid jigger *MV Titanic* andFSI vessel *MV Varshini,* were undertaken in the oceanic waters from 8°N to 17°Nlatitudes and 64°E to 76°E longitudes (Eastern and Central Arabian Sea) during 2010-13.
- The modified squid jigger carried out trial fishing techniques 1) Squid jigging 2)Hand jigging 3) Scoop netting 4) Gill netting 5) Purse-seining 6) Trammel netting.

- It was established that purse seining and gillnetting with light attraction from converted 20m LOA commercial fishing boats are the most efficient gears forexploiting oceanic squids in the Arabian Sea.
- Three lat/long grids 13°N/71°E, 11°N/72°E and 10°N/71°E had the maximum biomass of oceanic squids among the 58 stations covered. The average biomass was4.2 t/km2 and the maximum was 92.8 t/km2.
- The total biomass was estimated as 2.52 million tonnes and the annual fishable biomass (MSY) was estimated as 0.63 million tonnes.
- Maximum abundances were related to areas with low SST (28.0-28.6°C), low chlorophyll (<0.4 mg/m3), lower salinity (30.4-33.8 PSU) and high pH and dissolved oxygen values.
- Biological investigations revealed that the S. oualaniensis is a highly carnivorous and cannibalistic animal with fast and differential (between sexes and life stages) growthrate. The animal is an *r*-strategist with seasonal breeding and feeding migrations andvulnerability to fishing pressure is likely to be medium.
    - The techno-economic feasibility analysis showed that one-boat mini PS operations for 3 months would have a capital productivity ratio of 0.41 and a rate of return on investment of 87%.
    - The detailed biochemical composition of fresh, blanched and dried oceanic squid was analyzed and the potential human health benefits due to high selenium content were determined.
    - Three IQF ready-to-cook and 3 ready-to-eat products were developed, branded and test marketed successfully. A novel squid ink based sauce was developed which was transferred to a private entrepreneur under a MoU.

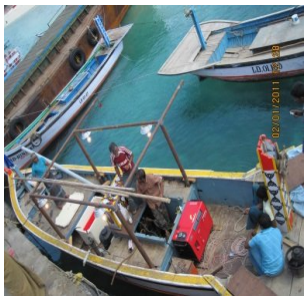
6.2 NAIP. A value chain on Oceanic Tuna Fisheries in Lakshadweep sea.(2009 - 2014).

- Generated month wise gear wise (8 gears) species wise fish landing data from Minicoy, Agatti and Androtт estimated and analyzed.
- Prepared and submitted the "Manual for the estimation of marine fish landings of Lakshadweep Islands – Methodology & Instructions", in May – 2009.
- Tested 4 baits viz., Clupeids, Ceasionids, Exocoetids, Lutjanids etc. by the modified Pablo boats and 4 baits viz Ribbon fishes, Scads, Bull's eyes, Squids etc. by the modified trawlers in the long lining operations.

Pablo long lining

- Trained the 6 skilled workers and 3 SRFs in the Lakshadweep fish landing data collection methodology
- Participated in fishing trips (long lining) onboard converted commercial trawlers MFV Ohom & MFV Cosmos from 16 to 27 October 2010 . Three different types of baits were tested during the cruise .





Line setting by MFV.Ohom **Modified Pablo boat**

- Conducted the Impact Assessment Survey between 22-30 January 2014 .
- Attended the meeting of NAIP - CPI & National Coordinator with theHon. Administrator and Department Heads of Lakshadweep Administration at Kavaratti on 13th November – 2013.
- The project completed and the completion report has been finalized .

6.3 Studies on Marine mammals of Indian EEZ and the Contiguous seas (2009 - 2012).

- Surveys were undertaken in the Malabar area and stranding of dolphins, whales and porpoises were recorded. A database on marine mammals was prepared. Surveys were carried out onboard FORV Sagar Sampada to assess marine mammals diversity and their distribution in oceanic waters of Indian seas and Indian Ocean.
- Unusual sightings of whales *Balaenoptera musculus* (P) between Doddra Head and Veligna region between the latitude 5 0.49 N and 5 0.50 N and longitude 80 0 21 E and 81 0 .05 E in the international shipping channel off Sri Lanka on 29.1.09. A total of 135 whales were recorded during the present cruise.
- First confirmed sighting of *Indopacetus pacificus* (Longman's beaked whale) from the southern Bay of Bengal was an important observation during the period.
- As a Co-Principal Investigator in this project funded by Ministry of Earth Science. Participated in the FORV Sagar Sampada Cruise: 261 and 269 in 2009 from Cochin-Port Blair-Cochin and Mangalore to Cochin. The main objective of the participation in the cruise onboard FORV Sagar Sampada from Cochin - Port Blair and Port Blair - Cochin were sightings and photo-identification of whales, dolphins, dugongs and porpoises and recording of hydrographical and meteorological data from the region of cetacean sightings. The salient finding of the participation in the cruise is as given below.
- A total of 35 sightings of dolphins and whales were recorded during the cruise. Altogether 135 whales and 176 dolphins were sighted in an area between 5°48 N to 13°45'N latitude and 76.05° E to 94°.43 E longitudes during the present cruise. Onboard observations of cetaceans is a difficult task since it has to be done based on occasional appearance of certain body parts as well as spouts from blowholes in case of whales. A detailed description of the features of sighted animals was also recorded for future reference.
- 40% of the sighted cetaceans could be unmistakably "identified", 37% falls in category of "possible" while 23% were "unidentified". Photos of animals were taken wherever possible foridentification up to genus or species level. 45% of the sighted cetaceans were whales while remaining were dolphins. The species that were identified in the cruise were (identified and possible) *Delphinus* sp. (Common dolphin), *Stenella longirostris* (Spinner dolphin), *Balaenoptera musculus* (blue whale) *Sousa chinensis* (Indopacific humpbacked dolphin) and *Balaenoptera* sp.

An important observation made during this cruise was the first sighting of Longman's beaked whale *Indopacetus pacificus* from southern Bay of Bengal. Most of these observations except the sighting of *B. musculus* and *S. chinenesis* were made in the offshore waters.

- Another important observation made during this period was unusual sightings of whales *Balaenoptera musculus* (P) between Doddra Head and Veligna region between the latitude 5 0.49 N and 5 0.50 N and longitude 80 0 21 E and 81 0 .05 E in the international shipping channel off Sri Lanka. The sightings of whales started around 1420 hrs and it was continued up to 1815 hrs in the evening. The whales were moving in small groups of 2-14. They were moving opposite to the ship's course, depth of the sea was about 1500 m, and the sea surface temperature was 28.6-28.70C. A total of 135 whales were recorded during the present cruise. The sightings of whales were also video recorded. Porpoises and dugongs were not sighted during the present cruise.
- Besides the above occasional stranding of marine mammals from the Malabar region was reported.

Balaenoptera musculus sighted off Sri Lanka

- Conducted surveys (total 15 trips) at Minicoy ,Kavaratti ,Pitti ,Agatti,Androtti & Kalpeni waters on board hired Pablo boats ,Departmental boats (Fisheries) and commercial passenger liners . Recorded lat. long. positions and taken photographs and video graphs of the sightings .
- Attended 4 days Marine Mammal Stranding Workshop jointly organized by the CMFRI ,NOAA(USA) & Indo US Science and Technology Forum at CMFRI ,Kochin from 20.01.2010 to 23.01.2010.
- Sighting observation carried out regularly off Calicut,Puthiyappa and Baypore and taken photo and video graphs .
- Observed the rare beaked whale stranded at South Beach ,Calicut in January 2010. Recorded the morphometric measurements , taken photographs and & photographs submitted to the Principle Investigator.
- Conducted sighting surveys onboard converted trawlers MFV Titanic , MFV Ohom & MFV Cosmos from 16 to 27 October 2010 in Lakshadweep waters . Recorded lat. long. positions and taken photographs and video graphs of the sightings .

Dolphins sighted off Kalpeni & Agatti Islands

- Conducted sighting surveys from Quilon to Cannanore off Kerala onboard MFV Titanic & MFV Lavanika from 17 to 21 April 2010 .Recorded lat. long. positions and taken photo and video graphs of the sightings .
- Stranding observations were carried out regularly and reported .

Hump back dolphin at Thikkodi **Finless porpoise at Calicut**

- Conducted sighting surveys onboard Pablo boats off Agatti ,Bangaram, Kalpitti Islands from 7-12 Dec-2011 & 17-24 Jan-2012 , off Beypore /Androth on 19.04.2011 and off Androth/Kalpeni on 24.04.2011.. Recorded lat. long. positions and taken photographs and video graphs of the sightings .

At 11^0 05' 766 "
74^0 03' 890" (Apl-11)

At 10^0 53' 610"
72^0 12' 234"(Dec-11)

Stranding observations were carried out regularly and the stranding were recorded and reported .

Hump back dolphin at South beach Calicut Hump back dolphin near Lions Park, Calicut

- Attended the International Colloquium on Marine Mammals (CIMCAR) at Kochin on 26-27 August 2011.
- The project completed and the completion report has been finalized

Sousa chinensis sighted off Cochin

Indopacetus pacificus sighted in the Bay of Bengal

6.4 Demonstration and transfer of technology of marine pearl culture (*Pinctada fucata*)" (2009 - 2012).

- The conventional bamboo raft of 4 X4 m with 5 PVC barrel floats fabricated & deployed at about 1 Km off the helipad in Kalpeni / Cheriyam lagoon in December 2009.
- Transported 900 spats with average 6.6 mm DVM in Oxygen filled plastic bags . The mortality in 24 hrs transportation was < 2 % only .The growth observed in after 2 months was 17 mm ie .5.2 mm growth / month .
- Organized one training programme for 12 days for 29 educated youths of Kalepeni Island (Lakshadweep) from 02.01.10 to 13.01.2010 .The training included all the aspects of pearl culture such as raft fabrication and deployment ,spat collectors , pouch and cage fabrication ,image making , graft preparation ,Mabe and spherical nucleus implantation , conditioning the implanted oysters , oyster cleaning and growth measurement studies etc. Consequent on the success of the training and the enthusiasm generated among the youths , the Department of Fisheries wide the Notice F.No. 56/1/2009- FY dated 30.01.2010 as announced financial assistance and subsidies to the SHGs and youths who are willing to take up pearl culture .
- Organized one training programme for 12 days for 29 educated youths of Kalepeni Island (Lakshadweep) from 02.01.10 to 13.01.2010 .The training included all the aspects of pearl culture such as raft fabrication and deployment ,spat collectors , pouch and cage fabrication ,image making , graft preparation ,*Mabe* and spherical nucleus implantation , conditioning the implanted oysters , oyster cleaning and growth measurement studies etc. Consequent on the success of the training and the enthusiasm generated among the youths , the Department of Fisheries wide the Notice F.No. 56/1/2009- FY dated 30.01.2010 as announced financial assistance and subsidies to the SHGs and youths who are willing to take up pearl culture .

Chairperson VDP Inaugurating the training **The Raft in Kalpeni / Cheriyam Lagoon**

Image preparation **Graft preparation & implantation**

- Harvested the *Mabe* pearls (implanted by the trainees) in July 2010. The quality of the pearls were poor due to the over coating . This was mainly due to the delay in harvesting the pearls. The gestation period allowed was 180 days .Inexperience of the trainees in handling the oysters also caused heavy post implantation mortality .

- Transported 320 nos of nucleus implanted & 94 nos of non implanted oysters by dry method from Tuticorin to Kochin to Kalpeni Island from 04 to 07 December 2010. 22.2 % of implanted & 7.4 % of non implanted ones only survived .Where as by wet method the survival was 71.6 % and the same was found to be better for longer duration transportation

- The growth ,fouling and spat settlement studies were carried out on a monthly basis .The growth studies on the spat already available was found to be not very encouraging . The growth during the period was < 4mm /month against the initial good growths of 5.2mm/month .The fouling (Foulers grown on the oyster and cages) was less compared to the Minicoy lagoon . However, there was heavy fouling with filamentous algae Chaetomorpha spp carried along with the current and the wind on the anchor ropes and the cages . No spat settlement was observed during the year . 94 nos of medium sized oysters from the spats grown were selected and Mabe implantation conducted on 11-13 December 2010.
- Regular growth, fouling ,mortality and spat settlement studies were carried out during second week of every month . The growth in both the adult as well as spats were not very encouraging . Average mortality was 6.4 % after the initial high mortality .The fouling (settled and grown) was also comparatively very low . However, the filamentous algae Chaetomorpha spp carried along with the current and the wind got entangled on the cages in very thick concentrations and caused restricted water flow and might have effected the growth of the oysters . Very low spat settlement was observed in January /February months

  Harvested the Mabe pearls on 23-24 April 2011. 57.8% of the 90 implanted oysters only had Mabe pearls. 28.2% died and 14.0% rejected the images . The quality of the Mabe pearls in 52 nos obtained were very poor .


Mabe pearls produced at Laccadives

Fouling on cages

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- The Self Help Group viz "Manakkam" established as the result of the project will carry out the future pearl culture works.
- The project completed and the completion report has been finalized .

6.5Assessment of Myctophid resources in the Arabian sea and development of harvest & post harvest technologies" . (2009 - 2012).

- Conducted 2 surveys on board Pablo boats in Lakshadweep waters in 7-12 Dec 2011 & 17-24 Jan 2012.Collected & preserved Myctophids .The cruise report with lat.long positions along with samples submitted to the PI for further necessary actions.

Mytophids collected off Agatti Island

6.7. Eco- biological investigations on major pelagic fishes & ecological modeling of epipelagic habitat off Kerala & Lakshadweep "

- Monitored Lakshadweep tuna fisheries and the PFZ forecasts for Lakshadweep.
- Attended the Methodology Workshop on 22rd October 2013 and presented the paper "Lakshadweep tuna fisheries – Problems & management strategies".
- Participated in the Ocean State Forecast for Lakshadweep Launch Workshop at Agatti on 29th January 2014.
- Conducted PFZ & hydrographic survey using Pablo boats at Andrott in February 2014.

6.8. National Surveillance Programme for Aquatic Animal Diseases (NSPAAD) :NSPAAD 4001-445

Collection of baseline data of farms: A total of 6 districts were identified within the state of Kerala for regular screening of bivalves for listed diseases. Ten farms from each district were

to be identified and fixed for the purpose. This work was initiated in Ernakulum district. A meeting was organized with the 10 bivalve farmers from Moothakunnam, Puthenvelikkara and Cherayi areas during Jan 2014. Discussions revealed that most of the farmers in these areas are have been practicing bivalve farming for more than 6 years. Presently, most of the farming operations are managed by separate Self Help Groups (SHGs)/Kudumbasrees. Base line data/information from the farmers was collected in the prescribed format.

Location (GPS position) of the farms selected for surveillance in Ernakulam district

State	District	Place	GPS co-ordinates	No of farms
Kerala	Ernakulam	Moothakunnam	N 10° 11' 08" ; E 76° 11' 22"	6
		Puthenvelikkara	N 10° 12' 02" ; E 76° 13' 05"	2
		Cherayi	N 10° 08' 54" ; E 76° 11' 56"	2

Publications

i) **In peer-reviewed journals: 40**
ii) **Technical and popular articles: 37**
iii) **Presentation in seminars/symposia: 26**

Workshops conducted

Conducted aCapacity building workshop on vulnerable/ threatened Marine Ecosystems organized by this Centre during29-10--12 to 31-10-12 .This workshop was attended by 20 participants and eight resource persons. Officials from the Forest Department and the Fisheries Department of Kerala State Government and Researchers from Calicut University attended this capacitybuilding workshop.

Training on green mussel farming

NFDB sponsored training on mussel farming was conducted from 10-19 January 2010 at Calicut RC of CMFRI. Participants from Gujarat, Maharashtra, Kerala and Tamil Nadu participated in the training. A manual was prepared for the training.Raft culture training was conducted at Kadalundi.

Mussel farming training at Kadalundi

The trainees who attended the training on green mussel farming

Recognition / Awards won:

Dr.P.K.Asokan, V.G.Surendranathan and M.P.Sivadasan were members of the PILLAY AQUACULTURE AWARD for the year 2011. The award is for the work entitled DEVELOPMENT OF BIVALVE FARMING FOR INCOME GENERATION IN COASTAL KERALA.