# Significant Achievements in the last 5 years

**1.** *Management advisories for sustaining marine fisheries in Maharashtra* **(CF/IDP/01)**

- This centre had estimated decadal compounded growth rate (CGR) of marine fish landings in Maharashtra from 1961 to 1990. Annual Increase at the rate of 3.2% was observed that slowed down to 0.41% during 1991-2000 showing negative growth rate (-4.7%) during the past decade (2001-2010). The contribution of the State to total marine fish landings of India also declined from 19.6% in 1971-80 to 12.6% during 2001-10. Despite average annual catch of 3.65 lakh t that contributes 15% to the total marine fish landings of the country, the marine fisheries sector in Maharashtra is facing crisis since late nineties. The total fish landings during 1961-2010 showed increasing trend from 1.53 lakh t to 4.5 lakh t and recorded a moderate decadal growth rate of 2.8% annually.

- During 2007-2011 the estimated marine fish landings averaged at 3.06 lakh t that contributed 9.3% to 3.29 million t of total marine fish landings of the country. The landings declined from 3.49 lakh t in 2008 to 2.4 lakh t in 2010. When compared to previous five yearly periods the landings declined from 3.62 lakh t to 3.06 lakh t by 15.5% and correspondingly the percentage contribution to the marine fish landings of the country declined from 12.3% to 9.3%.

- The present fishing fleet in Maharashtra is about 17,000 that comprise of 13,000 mechanized (75%), 1,563 motorized (9%) and the rest 2783 (16%) non-mechanized fishing crafts. The estimated landing by different fishing gears showed that almost the entire catch in was landed by mechanized boats (99%) and 1% by the non-mechanized crafts. The mechanized trawlers landed 47% of the total catch followed by *dol* netters (29%), purse seiners (11.9%), gill netters (11.3%), hooks and lines (0.3%) and non-mechanized boats landed 0.5%.

- The annual value of the marine fish landings in Maharashtra increased from Rs 1,259 crores in 2007 to 2,122 crores in 2011 despite of fluctuations in the annual landings

and the average price of fish per kg increased from Rs 39.3 in 2007 to Rs 66.8 in 2011 with the annual rate of 13.6%.

- Compounded annual growth rate (CGR) of landings showed that among 25 resources only 5 recorded positive CGR while the rest 20 showed negative values.

- Rapid assessment of commercially important stocks showed that 8% were abundant, 28% less abundant, 56% declining, 4% depleted and 4% in collapsed state. Similarly, stock assessment of 36 species of commercially important finfishes, elasmobranchs, crustaceans and cephalopods by analytical methods showed that 59.6% are over-exploited ($E>E_{max}$) the state.

- The fishing season that used to last for 8-10 month in the state, has shortened to 4-5 months resulting in idling of fishing crafts for 3-4 months. Majority of fishing boats carry out fishing from August to December and remain idle owing to decline in catch rates of prime varieties of fish, high operating costs and economically unviable operations from January to May. Declining catch rates of prime quality fishes, changing catch composition and shortening of fishing season (from earlier 8-9 months to less than 6 months) are clear indicators of overfishing in the state.

- The state had strong traditional fishing by '*dol*' nets, gill nets (*Dalda* nets), '*rampani*' and hooks and line fisheries until early 1980s that dominated the landings. But intensive shrimp trawling with multi-day fishing trips, rapid increase in purse seine fleet in the past 5 years and enhancement of overall fishing effort by more than three folds have been responsible for the declining catch rates.

- Increasing fishing pressure on the fish stocks, overcrowding of boats, industrial and domestic pollution in certain pockets around the coastal cities, habitat degradation and reduction of mangrove vegetation due to rapid urbanization together with vagaries of climate change have affected recruitment patterns of important species owing to which traditional fishers have been facing severe crisis. Besides non-availability of quality fishes, rising fuel costs, early cessation of fishing season and subsequently reduced profitability has led to idling of fishing boats.

- For management and conservation long term potential yield was estimated based on the maximum average landings. The estimated LTPY of Maharashtra is 5.18 lakh t comprising of 2.45 lakh t small pelagic, 19,000 t large pelagic and 2.54 lakh t demersal resources which formed the foundation for estimation of optimum fleet size.

By using the total marine fish production from mechanized boats the maximum sustainable yield (MSY) by Schaefer's model was estimated at 4.35 lakh tonnes. But it was estimated that the present fishing effort in the state has exceeded by 30%.

- Trawlers (43%), bag (*dol*) netters (31%), purse seiners and gill netters (23%) are the main crafts in the mechanized sector. It is widely known that bottom trawl which is used for catching shrimps, exploits 50-70% non-targeted bycatch. The bycatch comprises of low value smaller fishes and juveniles of commercially important fishes in addition to large quantity of non-edible benthic biota which is discarded in the sea. The shrimps constitute only 15-20% of the trawl catch but the rest especially non-edible biota and low value fish are component of bottom ecosystem. Thus, trawl is the most destructive among the fishing gears which inflicts damage to bottom ecology and habitat degradation. Similarly, purse seining being a mass harvesting fishing gear greatly affects the economy of traditional fishers by virtue of huge catches. In order to maintain sustainability it is pertinent to regulate both trawling as well as purse seine fleet in the state.

- In order to find out the optimum fleet size of trawlers and purse seiners, maximum sustainable yield (MSY) and corresponding trawling effort ($F_{msy}$) were estimated with long time series of data collected by CMFRI. Being a targeted resource for trawlers, the MSY for shrimps is 44,647 t and the optimum number of trawlers for the state is 2,778 against the present fleet of 5,613. Similarly for purse seines, mackerel is a target resource, but it exhibits 7-9 year cycles of abundance; considering the lowest biomass of mackerel during the cycle, the MSY was estimated at 29,547 t and the optimum fleet size of purse seiners in the state estimated to be 182 against the present fleet of 519 (including mini purse seiners). Both the fleets have developed overcapacity as result they are fished out the beyond the capacity of fish to reproduce and replace the exploited stocks. As per preceding analysis, this centre had suggested to regulate the fleet to 50% of the existing fleet of trawlers and purse seiners.

- Incursions by trawlers in '*dol*' net grounds for Bombayduck and targeting of silver pomfrets by '*dol*' netters in the nursery areas have created conflicts among trawlers, '*dol*' netters and gill netters in the northern districts, while similar conflict was noticed for mackerel amongst '*rampani*', purse seine and trawler operators in Ratnagiri and Sindhudurg districts. Since Bombayduck and silver pomfret are the economic strength of '*dol*' net and gill net fisheries, it is suggested to observe closure of '*dol*' net fishing

during February-March in the sea off Vasai, Uttan and Arnala. On account of poor availability of quality fish, the hooks and line fishery and '*rampani*' operations are on the verge of closing therefore, reduction of trawling effort and strict compliance with marine fisheries act (MFRA, 1981) for the operation of purse seines have been suggested for the sustenance of the traditional fisheries.

- The fishing operations by multi-day trawlers, purse seiners and large gill netters have been extended far in the sea up to 100 m depth zone (20-50 nautical miles), while jurisdiction of the Maharashtra Marine Fisheries Act (1981) is limited within territorial waters of 12 nautical miles. Regulation, management and conservation of marine fishery resources under the act have not been possible since majority of trawlers and purse seiners not only belonging to the Maharashtra but also from the neighbouring states carry out fishing beyond the territorial waters of the state. Therefore, it is suggested to enact a new legislation that will be applicable to Exclusive Economic Zone (200 nautical miles) of the country. Such an act with the premise of the 'Code of Conduct for Responsible Fisheries' should not only envisage community management of marine fisheries but also registration of all types of fishing vessels, catch certification and heavy penalty for the offenders with consensus of the stake holders and active fishers engaged in fishing. The Marine Fisheries (Regulation and Management) Act may prove useful in regulation of fleet size, mesh size, closed seasons, closed areas and also conservation practices in management of marine fishery resource.

**2. *Resource damage assessment in marine fisheries: impact of selective fishing of juveniles and by-catch and discards in trawl fisheries* (CF/IDP/02).**

- The low value bycatch (LVB) is mostly discarded by multi-day fishing trawlers, except the last day's haul, whereas single day fishing trawlers invariably bring the bycatch to the shore. An estimated 69.3 t of bycatch, with a catch rate of 3.6 kg h$^{-1}$ were landed at Versova, Mumbai forming 23% of total trawl landings during 2009-2010. 86 species of marine organisms constituted the bycatch (54 species of fishes, 11 species of crabs, 5 species of cephalopods, 2 species of stomatopods, 8 species of penaeids and 6 species of non-penaeid shrimps).

- In Versova, Mumbai an estimated 2,294 t of LVB (39% of total catch) was landed. Maximum bycatch was landed during April (45%) and the lowest during September

during year 2010-2011. In Versova, Mumbai, an estimated LVB landings of 4,567t were recorded, which formed about 29% of the total catch. Maximum catch was landed in January (44%) and minimum in October (21%). At Mumbai, 51 species of finfishes, 20 species of crustaceans and 11 species of molluscs were observed in LVB during year 2011-2012.

- Increase in cod end mesh size of trawl nets to 35 mm and popularization of bycatch reduction devises among trawl owners are management measures suggested for reduction of LVB catches in trawlers.

## 3. *Recruitment dynamics of penaeid prawns along Indian coast* (CF/IDP/03).

- The project was approved in August 2008 and the actual work commenced from September 2008. During the period, past 10 years of fishery and biological data on penaeid shrimps have been compiled and re-organized on calendar year basis from important observation centres at Mumbai (NFW and Versova), Mangalore (FH), Calicut (Puthiappa), Mandapam and Visakhapatanam.

- Despite the increasing fishing effort at all the centres the time seriesm of shrimps landings during 1997-2006 indicated declining trend at Mumbai and Mangalore and an increasing trend at Chennai and Visakhapatanam.Analysis of monthly length frequency distribution of important species was used for the estimation of von Bertalanffy growth parameters by ELEFAN and other methods.

- Month-wise spawning stock biomass of female shrimps shows decline due to increasing fishing mortality.

*Parapeneopsis stylifera*:

- Month-wise spawning stock biomass and recruitment number for 5 months were obtained by LCOHOR programme.
- Tested by 2 models: Beverton & Holt & Ricker's models.
- Ricker's model gave the best fit ($r2=0.84$).
- Suggests stock dependent control mechanism on the recruitment.

Correlation of monthly estimated number of recruits and the spawning stock biomass of *P. stylifera* (Mumbai) was attempted. The spawning stock biomass and the number of recruits arriving in the fishing grounds five months later were regressed. The

regression of recruits (in millions) and the spawning stock biomass by Ricker's model gave the best results. The 17 data points observed during 2002 and 2003 revealed that as the stock increased the recruitment (after 5 months) also increased, but with further increase in stock the recruitment declined exhibiting a dome shaped Ricker's relationship.

According to the model, recruitment increased initially, but decreased at high stock levels, which explains the stock dependent control mechanism on the recruitment.

Similar attempt was made for *M. monoceros* in Visakhapatanam waters which also showed better fit by Ricker's model.

During the yearb 2009-10, the data on the fishery and biological characteristics of penaeid prawns for the past 10 years were compiled and re-organized on calendar year basis from important centres at Mumbai, Kochi, Mangalore, Calicut and Visakhapatanam.

- With VBGF growth parameters, size at first maturity and analysis of monthly length frequency distribution of prawns, month-wise number of recruits and biomass of spawning stock (adult and mature females) was estimated by length cohort analysis (LCOHOR).

- The relationship between recruits and spawning stock was estimated considering the data on monthly basis and also the pulses of recruitment and spawning stock peaks with a time lag of 4-5 monthsbetween them.

- The monthly estimated number of recruits and the spawning stock biomass of P. stylifera revealed a dome shaped Ricker's relationship in the case of stock in Mumbai. The regression of monthly estimated number (R) of recruits (in millions) and the spawning stock biomass

- Ln(S/R) by Ricker's model gave the following parameters: a = 11.184 ± 0.418; b = 0.0279 ± 0.003 (r2 = 0.840).

- Similar attempt was made for *M. monoceros, P. stylifera* and *M. dobsoni* from Visakhapatanam, Calicut and Cochin waters which also showed better fit by Ricker's model.

# 4. *Application of trophic modeling in marine fisheries management* (MF/IDP/02).

- Using the constructed ECOPATH model of the Gulf of Mannar, a scenario was built in ECOSIM with increasing effort at the rate of 10% per year for a period of 10 years. The parameters monitored in this scenario were cumulative catch and biomass. It was observed that effort increase resulted in drastic reduction in the cumulative catch, and therefore effort control is very much necessary in the GOM ecosystem. The main group which would be affected are the small benthopelagics and small pelagics. Benthic crustaceans are relatively resistant to heavy fishing pressure in the GOM ecosystem.The cumulative biomass curve also shows a decline in biomass of all groups due to increased fishing effort.

- Under the porject trophic model of the Gulf of Mannar (GOM) had 32 ecological groups. Most groups were not predated upon and also were not fished in the ecosystem. Fishing mortality was highest for small and large reef fishes and medium benthic carnivores. In most exploited groups, predation was the main source of mortality. In order to understand the scale and magnitude of the predation taking place in the ecosystem, the GOM model was used to assess the predation strengths of all ecological groups.

- The predation strengths are primarily based on the qualitative and quantitative diet data scaled by biomass of different ecological groups.

- The analysis shows that the major predatory group, dolphins and predatory whales predates on a wide variety of pelagic and demersal carnivores and herbivores including pelagic crustaceans like swimming crabs.It is predated only by large pelagic carnivores during its very young stages.Similar is the case of turtles which also feed substantially on sea plants. In the case of phytoplankton, they are predated by a wide variety of organisms including other whales (baleen).

**5.** *Impact of anthropogenic activities on coastal marine environment and fisheries* **(FEM/01).**

- The impact of urban domestic sewage and other anthropogenic activities, environmental parameters such as $CO_2$, pH, SST, BOD, TSS, Salinity, $NH_3$, dissolved nutrients, primary productivity, chlorophyll pigments and quantity of plastics and other non degradable materials from 32 stations out of 8 coastal centers along the maritime states were monitored monthly from 2009 onwards.

- Results of six parameters collected from five selected locations from Mumbai and five locations from Ratnagiri were tabulated regularly. SST, Salinity, Dissolved oxygen, Turbidity, Biological Oxygen Demand, Total Suspended Solids, Total Viable Counts, Total Coliform and Nutrients have been analyzed. All results are maintained in common Registers.

**6.** *Impact and yield study of environmental changes on distribution shifts in small pelagic along the Indian coasts* **(FEM/02).**

- For the project, observations continued form the two stations off west coast of Mumbai at Apollobunder and Versova Nearshore. For small pelagic, samples were collected from landing form Mumbai and Ratnagiri. Analysis of seawater, phytoplankton, zooplankton samples from the inshore waters was undertaken. Monitoring of pelagic fishery (*R.kanagurta, Sardinella longiceps*) and collection of morphometric measurement for truss analysis and stomach content analysis was also undertaken to identify prey organisms.

- Truss and otolith data has also been recorded along with physico-chemical, biological and fishery data. All results are maintained in common registers.

**7.** *Innovation of Sea cage farming and development of sustainable capture based aquaculture (CBA) systems* **(MD/IDP/04).**

- Two 6 mt diameter HDPE cages were launched near Kalamb, District Thane September 2009 for capture based aquaculture of lobster, Panulirus polyphagus. Cages were drifted due to heavy wind action and wave action caused mortality of stocked lobsters. Wild seed resources were identified and quantified for collection of mangrove red snapper, Lutjanus argentimaculatus; sea bream, Acanthopagrus latus; Asian sea bass, Lates calcarifer. One 3 mt diameter HDPE seed cage was

launched at Killbandar, District Thane in 2010 and was stocked with Lutjanus argentimaculatus, accidentally cage was cut released in to open sea resulting loss of cage frame along with stocked fishes.

- During 2012, one low cost GI cage of 3 mt diameter was launched at Kalamb, District Thane. 200 nos of Panulirus polyphagus (average weight 51.59 ± 1.80 g) were stocked and reared for 117 days. Weight gain of 201.76% was recorded in harvested lobsters after rearing period of 117 days and specific growth rate of 0.41% g/day.

8. *Strategies for sustaining tuna fishery along the Indian coast (From 2010 onwards)* **(PEL/IDP/03)**

- In Maharashtra purse seine contributing the major tuna catch (2671 t) followed by gill net (1528 t), trawl net (422 t) and dol net (59 t).
- An estimated catch of 315.3 t of tuna was landed by trawler forming about 5.25 % of the total catch landed at New Ferry Warf. 50% of the total tuna catch was contributed by *E affinis* followed by *T.tonggol* (38%) and *A.thazard* (8.6%).
- An estimated catch of 147 t of tuna was landed by purse seine and 26 t was landed by trawler contributing 8.8% and 0.25% respectively of total catch landed at Sassoon dock. *E affinis* (44%) and *A.thazard* (44%) contributed the major catch.
- The length frequency data analysis shows that the *E.affinis, T.tonggol and A.thazard* landing in Mumbai has the length range of 300-660mm, 320-420mm and 220-420mm respectively.
- The price structure analysis shows that the market price is (Rs. 60-70/-) higher than the landing centre price which is Rs.45-50/- only.


## Institutional Projects 2012-2014

1. **Project Title:** *Remote sensing assisted biodynamic forecasting paradigm for Indian marine fishery resources* **(FISHCMFRISIL201200200002).**

- Grids for fishing trip have been selected with the help of fisherman at Ratnagiri.
- Trawling has been conducted at a depth of 40m and water samples were collected from 10m, 20m and 30m depth.

- GPS location of each trips were recorded and species composition was investigated.

- Water quality parameters like temperature, salinity, turbidity, total dissolved solids, resistivity, conductivity, pH and chlorophyll were estimated.

2. **Project Title***: Assessment of Elasmobranch Resources in the Indian Seas"* **(FISHCMFRISIL201200500005).**

- Major species of sharks contributing to the total catch of elamobranch resource were *Scoliodon laticaudus, Rhizoprionodon oligolinx, R. acutus, Carcharhinus sorrah, Carcharhinus limbatus, L.temmincki* and *Sphyrna lewini* in Maharashtra.

- Major species of rays contributing to the total catch of elasmobranch resource were *Himantura alcockii* and *Himantura imbricata* in Maharashtra.

- Major species of skates contributing to the total catch of elasmobranch resource were *Rhynchobatus djiddensis*, *Rhinobatos granulatus* and *Rhinobatos annandalei.*

- About 3.5 t catch of *Rhizoprionodon oligolinx* landed by the bottom gill net (Magar Jal), mesh size ranging from 100-120 mm in March at Satpati, Mumbai.

- Sting ray attack was reported during Ganesh idol immersion at Girgaon – Chowpathy beach, Mumbai on 10th September, 2013.

- Among Sharks, *Carcharhinus leucas* and *Chiloscyllium arabicum* were reported for the first time in New Ferry Wharf and Sassoon dock, Mumbai in the month of January and March respectively.

- Among Rays, *Dasyatis microps* reported for the first time in the west coast of India, collected from Sassoon dock, Mumbai in the month of April.

- Pregnant females of *Rhinobatos annandalei* observed in September at New Ferry Wharf in the trawl net, which was operated at 40-45 m depth towards South Gujarat.

- The surplus catch of *Scoliodon laticaudus* was preserved by using the traditional method of salt curing at Satpati, Mumbai for export.

3. **Project Title**: *Development of biological indictors for large pelagics to evolve fishery management plans* (**FISHCMFRISIL201200700007**).

- Taxonomy and biology of large pelagic species of barracuda sail fish, dolphin fish, tunas, seerfish and cobia.

- Morphometric and meristic data of 3 species barracudas (*Sphyraena putnamae, S.jello* and *S. sphyraena*) were collected and biology of *Spyraena putnamae* was carried out.

- Sassoon dock landing centre observed unusual landing of full beak, *Ablennis hians* by purse seine in the month of October.

- Morphometric data of dolphin fishes *Coryphaena hippurus* were collected. The diet comprised of fin fishes and cephalopods.

- Biological studies of sail fish, *Istiophorus platypterus* were carried out by collecting the guts from Crowford fish market (CST market). The gut content showed that the fish fed most of the small pelagic fishes like mackerel, sardines and anchovies. Cephalopods were also observed rarely.

- Tuna fishery is mainly contributed by *Euthynnus affinis* followed by *Auxis thazard* and *Thunnus tonggol.* Detailed morphometric data and biological data were collected.

- Data were collected for the meristic and morphometric characters of Cobia, *Rachycentron canadum* . Biological studies were carried out in the lab.


4. **Project Title***: GIS based resource mapping of distribution and abundance of finfishes and shellfishes off Indian coast for suggesting operational based strategies for fisheries managements* (**FISHCMFRISIL201200900009**).


- Samples were collected from single day dol netter which operated at a depth of 10 m & 24 m and multiday dol netters that operated at 45-50 m depth.

- Single day drift gill net samples with GPS location were collected from Worli beach where the nets were operated at 10-15m depth.

- The juvenile percentage and spawner percentage of single day and multiday dolenetters and gillnetters were estimated for the top 5 species.

- Single day gillnet catch was dominated by the presence of *Escualosa thoracata followed by Hyporamphus limbatus, strongylura leiura, Sardinella fimbriata, Lepturacanthus savala.*

- Single day gillnet caught 100% spawners of *E. thoracata* and *L. Savala* thorugh out the year. *S.fimbriata* caught by gillnet was juveniles except the month of December. Juveniles of *H.limbatus* were appeared only in April-May and October only. Juveniles of *S.leiura* was present from August-October.

- Multiday dol net fishery was contributed by H.*nehereus, Hilsa toli, Pampus argenteus, Scomberomorus guttatus and Thryssa mystax.*

- *H.nehereus* spawners appeared in the catch from May – October and 100% juveniles were there during November and December

- *100% Spwners* of *H.toli* were observed in February and March months. During April and May the catch was contributed by juveniles of *H.toli*.

**5. Project Title:** *Development of fishery management plans for sustaining marine fisheries of Maharashtra* **(FISHCMFRISIL201201000010).**

- Due to increasing number of purse seine in Maharashtra, the catch of pelagic fishes has been increased. Many trawlers were converted into purse seine because of raising operational expenses.

- Sassoon dock landing centre observed unusual landing of full beak, *Ablennis hians* by purse seine in the month of October. The species contributing to the needle fish fishery are *Ablennes hians* (44%), *Tylosurusacus melanotus* (28%), *Strongylura leiura*(11%), *S. strongylura* (10%) and *T.crocodulus* (7%).

- Gill net fishery contributes *Escualosa thoracata* and two species of half beak namely *Hyporhamphus limbatus* and *Rhyncoramphus malabaricus.*

- Biology of 16 pelagic fishes was carried which includes Bombay duck, *Coilia*, Sardine, Mackerel, shads, wolf herring, Ribbon fish, two species of seer fishes, 4 species of tuna, cobia, barracuda, sail fish and dolphin fish. Biological investigations were reported for tuna, cobia, barracuda, sail fish and dolphin fish.

- Different food items were identified, upto generic or species level, from sardine gut depending on the state of digestion. Sardine feed mainly on Copepod sp. and *Coscinodiscus sp., Dynophysis Sp., Pleurosigma sp., Lampriscus sp.,Peridinium* and other phytoplanktons. 100% Juveniles were obtained during the month of December

- Mature and ripe females (stage V and VI) of mackerel were present during August to November and February to May. In month of August, 10% maturing and 90% were matured. *Copepods, Ostracods, Coscinodiscus sp., Foramnifera sp., Acetes sp*. etc were found in the gut of mackerel.

- Mature and ripe females of *H.nehereus* were present during month of October to December and February to May. Major food items were *Solenocera sp. N.tenuipes* , B.duck , Acetes sp. and Loligo sp.

- The gut of *Coiliadussumieri* mainly contained Acetes sp. and Copepod sp. were the dominant food items. Mature and ripe females were present during month of October to December. The male to female ratio 1:0.5.

- Mature and ripe females of *T.lepturus* were present during month of October to December and February to May. The major food items comprises of Cephalopods, *Thryssa sp.,*ribbon fishes and *Acetes* sp.

- Biology of 24 demersal fishes belong to Nemipterids, Catfishes, Elasmobranchs, Pomfrets, Lizard fishes, Polynemids, Sciaenids, Groupers and Goat fishes from New Ferry Wharf, Sassoon dock, Vasai, Satpati and Naigaon, Maharashtra were carried out.

- Among Sciaenid's catch, 35% of Koth juveniles (*O. biauritus*) length ranging from 110 to 480 mm landed by trawl net during September to December at Sassoon dock and New Ferry Wharf, Mumbai.

- The *Paranibea semiluctuosa* catch observed in the month of September, which was rare in earlier years.

- About 2.0 t of *Otolithes ruber* and *Otolithes curvieri* were landed by purse seine at Ratnagiri.

- Among threadfin breams, 60% of the catch contributed by *N. japonicus* in trawl net followed by *N. randalli* and *N. bipunctatus*. Large quantity of juveniles of *N. japonicus* and *N. randalli* observed in the month of October-December.

- The largest *N.japonicus* specimen measuring 385 mm recorded in the month December from the fish landing centre, New Ferry Wharf, Mumbai.

- 80% juveniles of *E. diacanthus* landed by trawl net during November to December at Sassoon dock and New Ferry Wharf, Mumbai.

- Unprecedented catch of *Arius caelatus* (85 t) *Arius dussumieri* (175 t) in purse seine landed at Sassoon dock, Mumbai in the month of March.

- About 3.5 t catch of *Rhizoprionodon oligolinx* landed by the bottom gill net (Magar Jal), mesh size ranging from 100-120 mm in March at Satpati, Mumbai.

- Sting ray attack was reported during Ganesh idol immersion at Girgaon – Chowpathy beach, Mumbai on 10th September, 2013.

- Among Sharks, *Carcharhinus leucas* and *Chiloscyllium arabicum* were reported for the first time in New Ferry Wharf and Sassoon dock, Mumbai in the month of January and March respectively.

- Among Rays, *Dasyatis microps* for the first time in the west coast of India collected from Sassoon dock, Mumbai in the month of April.

- Pregnant females of *Rhinobatos annandalei* observed in September at New Ferry Wharf in the trawl net, which was operated at 40-45 m depth towards South Gujarat.

- Major species of sharks contributing to the total catch of elamobranch resource were *Scoliodon laticaudus, Rhizoprionodon oligolinx, R. acutus, Carcharhinus sorrah, Carcharhinus limbatus, L.temmincki* and *Sphyrna lewini* in Maharashtra.

- Major species of rays contributing to the total catch of elasmobranch resource were *Himantura alcockii* and *Himantura imbricata* in Maharashtra.

- Major species of skates contributing to the total catch of elasmobranch resource were *Rhynchobatus djiddensis*, *Rhinobatos granulatus* and *Rhinobatos annandalei.*

- *Among Polynemids, Eleutheronema tetradactylum* contributed about 70% of the catch in the multiday dol net at Vasai, *P. heptadactylus* contributed about 85% of the catch in the trawl at New Ferry Wharf, *P. indicus* contributed about 80% of the catch in bottom gillnet at Satpati, Mumbai.

- The landing of *P. argenteus* juveniles ranging from 30 to100 mm advanced in September in the multiday dol net at Vasai when compared to February month in previous years where as juveniles of *F. niger* size ranging from 100 to120 mm landed in the month of October.

- Collection of environmental data on benthos of samples primary and secondary production from PFZ and adjacent grounds along the coast from 5 locations.

- Surface water and benthos samples were collected once every month for 6 months off the coast ofRatnagiriat 4 different stations.

- Water samples were tested for 18 different environmental parameters including biotic and abiotic factors.

- A total of 24 benthos samples were collected and 432 environmental observations were made along the coast. Monthly environmental data were also collected at seven other locations, Apollo Bunder (AB),Versova Near shore(VN), Versova creek

(VC),Mahim creek(MC), Mahim Near shore (MN),Gorai creek(GC) andJuhu Reference(JR)in Mumbai for 6 months from Oct 2013 to Mar 2104 to obtain 756 observations.

- For study of parameters' influence on recruitment abundance and biomass of fishery resources regular environmental observations are being made off Ratnagiri and Mumbai locations and regular record is maintained in common registers.

**6**. **Project Title:** *Development of fishery management plans (FMPs) for the bivalve fisheries of India* **(FISHCMFRISIL201201200012).**

- In the project, three creeks were studied were Shirgoan creek, Sakhartar creek and Bhayte creek were studied first. Later three more creeks were surveyed - Rajapuri creek, Kuda creek and Mirya creek. The species composition at all these three creeks differs according to the topography and other factors. Bivalves are mostly handpicked and by hand operated dredge net locally known as 'Kurund'. They are also collected from the intertidal part of the creek and sea during low tide. Generally women are engaged in hand picking of clams. Oyster clusters have been observed on rocky beds, which were smaller in size and are regularly exploited by chisel and hammer.

- Premilinary estimate of bivalve resources of Maharashtra indicated that 70-80% production came from Ratnagiri district.

- Percentage wise bivalve landings have been monitored.

- Clam landings by hand picking and dredge were found to be dominated by the species *M. meritrix* (38.3%), followed by *K. opima* (23.9%), *P. malabarica* (19.1%), *P. erosa* (4.8%), *M. casta* (4.8%), *G. diverticum* (4.3%) and other bivalves (4.8%). Oysters were collected by hand picking and they were dominated by *S. cucullata* (78.7%), *P. placenta* (17.1%) and *Crassostrea spp* (4.2%). Mussels were dominated by a single species *P. viridis* which were handpicked.

- The shell length of the dominant commercial species which occurred in the fishery were *M. meritrix* (15-25 mm), followed by *K. opima* (15-20 mm), *P. malabarica* (40-60 mm), *P. erosa* (30-70 mm), *M. casta* (20-30 mm), *G. diverticum* (30-40 mm), *S. cucullata* (30-45 mm), *P. placenta* (60-190 mm), *Crassostrea spp* (30-90 mm) and *P. viridis* (40-80 mm.

**7. Project Title:** *Bioinventorying and biodiversity valuation of marine organisms in selected marine ecosystems along the Indian coast* (**FISHCMFRISIL 201201500015**)

- Deep sea Resources reported along the Indian Coast were compiled and recorded in digitized format.

- Stomatopod resources of Arabian sea, Indian Ocean and Bay of Bengal were collected from the secondary sources were compiled and recorded in digitized format.

**8. Project Title**: *Investigations on vulnerable coral reef ecosystems of Indian waters with emphasis on formulation of management measures for conservation* (**FISHCMFRISIL201201600016**).

- Three Line transects of 30 m each with duplicates were made in the three sites of Grande Island, Goa and the corals and other bioresources along the transects were recorded.

- In the first site - **Lobster Avenue**, the average sea surface temperature and salinity was $29^{o}C$ and 32 ppt respectively. The entire transect area consists of 75.56% live coral, 5.0% bleached coral, 12.5% dead corals with algae and rest 6.94% is contributed by sand, stones and seaweeds (*Padina* spp.). The 75.56% live coral cover consists of hard coral species belongs to six families namely Poritidae (9.11%), Merulinidae (19.13%), Faviidae (4.53%), Agariciidae (1.13%), Psammocoridae (2.64%) and Dendrophyllidae (39.76%). The linear scale of live coral cover was 75.56 % which is above 75% indicates the health status of live coral cover in site I is excellent. Coral mortality index is 0.188 which is less than 0.33 CMI revealed that site I coral cover is very healthy. The relative abundance of live corals in the site I is dominated by Dendrophyllids (52.62) followed by Merulinids (25.32), Poritids (12.06), Favids (6.0), Psammocorids (3.5) and Agariciids (1.5).

- In the second site - **Chow Point**, the average sea surface temperature and salinity was $28^{o}C$ and 32 ppt respectively. The entire transect area consists of 62.35% live coral, 21.5% dead corals with algae and rest 16.15% is contributed by sand, stones and boulders. The 62.35% live coral cover consists of hard coral species belongs to four families namely Dendrophyllidae (28.44%), Poritidae (22.79%), Merulinidae (7.74%), and Faviidae (3.37%). The linear scale of live coral cover was 62.35% which

is fall between 50-75% indicates the health status of live coral cover in site II is good. Coral mortality index is 0.256 which is less than 0.33 CMI revealed that site II coral cover is very healthy. The relative abundance of live corals in the site II is dominated by Dendrophyllids (45.62) followed by Poritids (36.55), Merulinids (12.42), and Favids (5.41).

- In the third site - **Jetty**, the average sea surface temperature and salinity was $27.5^{o}C$ and 28 ppt respectively. The entire transect area consists of live coral 21.5%, dead corals with algae 35.62% and rest 16.15% is contributed by sand, seaweeds (*Caulerpa* spp., *Sargassum* sp., *Padina* sp.) and boulders. The 21.5% live coral cover consists of hard coral species belongs to four families namely Dendrophyllidae (14.02%), Poritidae (2.26%), Merulinidae (1.15%), and Faviidae (0.78%) and soft coral – Gorgonids (3.27%). The linear scale of live coral cover was 21.5% which is <25% indicates the health status of live coral cover in site III is poor. Coral mortality index is 0.623 which is above 0.33 CMI revealed that site III coral cover is weak. The relative abundance of live corals in the site III is dominated by Dendrophyllids (65.23) followed by Gorgonids (15.25), Poritids (10.52), Merulinids (5.37), and Favids (3.63).

9. **Project Title**: *Assessment of fishing impacts on biodiversity loss, with special reference to the threatened species, to formulate management options for their protection* **(FISHCMFRISIL201201700017).**

- Documented the technical characteristics of fishing gears (trawlnet and Dolnet) and fishing practices that have a negative effect on the biological diversity.

- Forthnightly catch and bycatch samples from trawlnet and dolnet were quantified and prepared database on the endangered/threatened/vulnerable groups encountered during the study period.

- Fishing season starts in the middle of September every year and ends in late May or early June as when monsoon begins.

- The most vulnerable groups in the trawlnet are the juveniles of commercially important species that are being caught as bycatch in both the gears.

- In trawlnet, a total of 115 species with Teleost consists of 73 species from 33 families, Elasmobranch contains 6 species from 5 families, cephalopods contains 7 species

from 4 families, stomatopods contains 6 species from 1 family, molluscs contains 23 species from 13 families as bycatch from crustacean trawlers.

- Rare species landed in trawlnet are *Colletteichthys dussumieri* (Valenciennes, 1837); *Antennarius striatus* (Shaw, 1794); *Torpedo marmorata* Risso, 1810**;** Galeocerdo cuvier (Peron & Le Sueur, 1822); *Rhynchobatus djiddensis* (Forsskal, 1775); *Oratosquillina perpensa* (Kemp, 1911) and *Oratosquilla kempi* (Schmitt, 1931).

- Based on the data of Length-at-first maturity, we calculated the juveniles percentage caught in the gear as bycatch. It was found that teleosts with 15 species has 69% of their catch consists of juveniles; elasmobranch with 45% of their catch consists of juveniles and cephalopods with 25% of their catch consists of juveniles

## 10. Project Title: *Ecosystem process of critical marine habitats and development of protocols for restoration* (FISHCMFRISIL201201800018).

- For Detailed study of Abiotic and Biotic factors (Nutrients and productivity etc.) ecosystem processes of selected habitats of Maharashtra surface water samples are being regularly collected every month at two stations *i.e*. Apollo Bunder and Versova Near shore. A total of 18 parameters, including 13 Abiotic and 5 biotic factors are tested at each location along with recording of seasonal occurrence of ELH (Early Life History) of different species of fishes in critical habitats. All records are maintained in common registers. Studies on identification of major resources and their links with the habitats of Maharashtra are also being persued. Cage culture related resources and their links are being identified at different habitats like Trombay, Mahul and Raigad. Identification and estimation of areas, maps etc is in progress for restoration along the coast of Maharashtra by adopting participatory approach. Cage culture, Seaweed culture, fishery and allied activities are encouraged and carried out in Alibaug, Sasawane and Shrivardhan, Bharadkhol, Turumbadi, Adgaon, Bagh Mandala, Poladpur, Dighi, Dahanu, Satpati, Jhai, Arnala locations.

## 11. Project Title: *Pollution and litter in the coastal and marine ecosystem and their impact* (FISHCMFRISIL201201900019).

Regular collection of monthly data on metal levels in water sediment and tissue samples from minimum three different sites is undertaken for 18 parameters, including 3 Biotic and 15 Abiotic factors along with the estimation of marine litters on beaches, mangrove flats and fishing grounds. This is substantiated with the collection of spatial and temporal data on impacts of location specific anthropogenic activities on marine ecosystem. Record is maintained in common registers. Organization of public awareness programmes to enlighten about adverse impacts of

anthropogenic interventions on coastal and marine ecosystem is a regular feature of the centre.

12. **Project Title:** *Innovations in Sea cage farming & Coastal mariculture (FISHCMFRISIL201200700025)*

- Survey and identification of cage culture sites in Malwan in Sindhudurg district had been done.

- Survey and identification of the seed resources for open sea cage culture (Lobsters, Snappers, Breams, Pompano and groupers) in Malwan in Sindhudurg district has been carried out.

- Mini cage farm in Malwan in Sindhudurg district has been developed

- Pompano seed from Mandapam had been released into the cages

- Conducting feeding experiments involving the fishermen community in Malwan in Sindhudurg district

- Regular monitoring of cage

13. *Tribal Sub Plan Scheme*

- Under Tribal Sub Plan Scheme (2013-14) Mumbai Research centre of CMFRI had undertaken open sea cage culture activities as an alternate livelihood option for socio-economic upliftment of *Mahadev Koli,* a tribal community recognised as Scheduled Tribe under Sr. No. 29 of the constitution (Scheduled Tribes) order 1950.

- For the year 2013-14 the centre had identified a tribal fisherman society belonging to the Hindu *Mahadev koli   i.e*., Adiwashi Macchimar Vividh Karyakari Sahakari Society Ltd., Danda Koliwada, Shrivardan in Raigad district of Maharashtra. The selected members of the society were trained at Mumbai research Centre of CMFRI and the technology of open sea cage culture developed by the CMFRI was transferred.

- With the intervention of the open sea cage culture technology the society is now empowered with expertise in the sea cage farming sector and are capable of doing captured based aquaculture in cages independently.

## Externally Funded Projects:

1. **Project Title:** *"State of diversity of commercially important seaweed along the West coast of India" NFBSFARA*

   - A survey of the West Coast of India was carried out to identify the availability and distribution of commercially important seaweed along the West coast of India. Sites accessible for the survey were selected using satellite imaging products such as Google Maps and Geographical illustration. A survey of Gujarat, Maharashtra, Goa, Karnataka and Kerala has been completed and water quality testing has been carried out at all surveyed locations. Sites for sample collection were selected and finalized based on the actual survey of each state. In **Gujarat,** eight sites were surveyed and four sites were selected for seaweed collection, viz. Jhaleshwer, Bhidbhanjan, Okha and Dwraka. Twenty four sites were surveyed in **Maharashtra**, out of which 12 sites were selected for seaweed collection, viz. Arnala, VelasAadgaon, Harihareshwar, Shekhadi, Ladghar, Panchnadi, Kolthare, Palshet, Vaigani, Purangad, Malvan and Redi. In **Goa,** 13 locations were surveyed and 5 sites were selected for sample collection viz. Morjim, Vagatore, Dona Paula, Anjuna and Cola. Nine locations were visited in **Karnataka** and 5 sites finalized for collection of seaweed biodiversity, viz. Bhatkal, Sirur, Surathkal, Ullal and Someshwar. In **Kerala,** 17 sites were surveyed and 4 sites selected for seaweed sample collection, Bekal Fort, Trikanna Temple, Kovalam and Kollam. All Physical (pH, Salinity, DO), biological (Phytoplankton, chlorophyll) and chemical parameters (Silicate, Sulphate, Total nitrogen, Phosphate, Nitrate, Nitrite, Ammonia) have been analysed at selected sites during the year 2013.
   - The investigation and study focused on 4 seaweed genera namely, *Porphyra, Ulva, Sargassum and Kappaphycus* is completed. Out of these, genus *Kappaphycus* isnot indigenous. Based on the survey, water analysis and suitable geographical conditions, sites suitable for cultivation of commercially important seaweeds were identified viz. Adgaon, Shrivardhan, Velas (Dist. Ratnagiri), Kelshi, Palshet, Vetye, Kiranpani (Maharashtra State), Terekhol, Shiroda, Satarda, Keri (Goa State). Out of these sites, *Kappaphycus*and*Gracillaria* cultivation was carried out at 4 sites, Palshet, Ladghar, Terekhol and Redi using Floating-raft and Monoline-rope method.

2. **Project Title:** *"Strategies to Enhance Adaptive Capacity to Climate Change in Vulnerable Regions" NAIP*

- As part of the NAIP project, several achievements were recorded by the Mumbai Research Center of CMFRI. Three hundred and thirty mKRISHI®and mKRISHI®Fisheries Mobile handsets have been earmarked for beneficiaries and stakeholders who can relay advisory information to the community in selected villages. Mobile signal testing in sea have been carried out by CMFRI with TCS followed by a critical gap analysis and needs of the fishers. Expansion of mobile signal in deep sea was tested off different locations along the coast of Raigad. Field validation of the efficiency of the mKRISHI® Fisheries Service technology has been done by undertaking several validation cruises off the coast of Maharashtra. Eight GI open sea cage culture cages were launched at different locations in underprivileged as well as tribal villages of the project area (Raigad district) and lobster crop have been harvested successfully in 2013 and 2014 along the coast of Sasawane and Bharadkhol villages. The MRC has strengthened linkages with partner organizations, district administration and disaster management authority of the district and established, equipped & maintained five Rural Resource Centers (RRCs) for agricultural and fisheries clusters to provide fishers/farmers a common platform for updating their knowledge and skills. NGO/SHG/Society chairmen and representatives in all villages have been sensitized for GPRS activation and numerous service workshops cum training programs for use of mKRISHI®and mKRISHI®Fisheries have been organized for agriculture and fisheries clusters. Propagation of other interventions such as SRT, Wheeled ice boxes with pulling handles and ice boxes with lifting mechanism, GPS devices and Improved Agriculture, Aquaculture and Allied practices have been successfully achieved as part of the project.

- Three interventions of the NAIP project, viz., SRT, Open Sea Cage Culture and mKRISHI® Fisheries were identified by ICAR for media filming. GEF-World Bank learning mission, PwC, Inspire, Comfed and many other national and international reviewers have lauded the overall implementation of the sub-project in more than seven significant interventions. As a distinction in ICAR, the mKRISHI® fisheries mobile technology is being rolled out from private sector, TCS to fishers through Public-Private-Partnership (PPP) mode. In a rare event, through PPP mode,

mKRISHI® fisheries mobile technology was released for public on 6th March 2014 in Raigad district by CMFRI with TTSL and TCS and will be expanded later into other districts of Maharashtra and also in other states. Post completion of the project in June 2014, Implementation Completion Mission of WB-GEF-ICAR has recommended the project for next phase through a concept note.

3. **Project Title***: National Initiative on Climate resilient Agriculture" NICRA*

- Different food items were identified, upto generic or species level, from sardine gut depending on the state of digestion. Sardine feed mainly on Copepod sp. and Coscinodiscus sp., Dynophysis Sp., Pleurosigma sp., Lampriscus sp., Peridinium and other phytoplanktons. 100% Juveniles were obtained during the month of December

- Mature and ripe females (stage V and VI) of mackerel were present during August to November and February to May. In month of August, 10% maturing and 90% were matured. Copepods, Ostracods, Coscinodiscus sp., Foramnifera sp., Acetes sp. etc were found in the gut of mackerel.

- Mature and ripe females *of H.nehereus* were present during month of October to December and February to May. Major food items were Solenocera sp. *N.tenuipes*, *B.duck*, *Acetes* sp. and *Loligo* sp.

- The gut of Coiliadussumieri mainly contained Acetes sp. and Copepod sp. were the dominant food items. Mature and ripe females were present during month of October to December. The male to female ratio 1:0.5.

- Mature and ripe females of T.lepturus were present during month of October to December and February to May. The major food items comprises of Cephalopods, *Thryssa* sp.,ribbon fishes and *Acetes* sp.

- Mature and ripe females (stage V and VI) were present during November to March. In month of November and January, 56 % were matured. Sex ratio of *Pampus argentius* collected from Mumbai was 1:1.3 and the standard length range was 95-222mm. Major food item was Acetes sp.

- Matured Nemipterus japonicus were observed from August- November. The major food items were *Solenicera* sp., Crabs, Acetes sp., squids and fishes.

- The sex ratio of *Loligo duvaceli* was 1:0.6. Mature females were present almost all the months. The major food items were fish, prawns and cephalopods.

- Detailed study on M.monoceros showed that the major food item were Foraminiferans, Cephalopod, Prawns, Decapod, Fishes and Gastropods. Mature and ripe females (stage III and IV) were present during August and December

- The general trend of the mackerel fishery in total landings of Maharashtra shows that the catch is in fluctuating state over the period (1991-2010).

- The polynomial trend line fitted to the data explicitily exhibits the cyclic periodicity of the species.

- The catch from 1991 was correlated with the Sea surface temperature (SST) of Maharashtra which shows a negative correlation (-0.43428).

- The size at first maturity by Pradan and Rao,1958 was 22.4cm in West coast of India. The Lm value started decreasing after that and reached up to 18.38cm in 2012.

- Lm was correlated with the temperature which shows a strong negative correlation (-0.61) which indicates the spawning is taking place early in the life cycle

- CPUE from 2000 onwards shows strong negative correlation with chlorophyll a (-0.56458)

- The decadal analysis of Lm and SST of *Metapenaeus monoceros* from 1996-2005 showed a positive correlation with SST (0.52)

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