National Initiative on Climate Resilient Agriculture (NICRA)

ANNUAL REPORT FOR THE PERIOD 2012 -13

1.	Name of the Institute	:	**Central Marine Fisheries Research Institute, Kochi**
2.	Component involved	:	**Strategic**
3.	Project title (if applicable)	:	Not applicable
4.	Major theme areas addressed/Activities taken up	:	*Assessment of spawning behavior of major fish species in marine environments with a view to harness the beneficial effects of temperature.*

Activities taken up

Capture Fisheries

To know the changes in distribution, catch and biological characteristics, especially spawning of ten major species of marine fish, shrimp and squid the data collected were co-related with time-series data on climatic and oceanographic parameters at centres of different latitudinal locations, namely, Veraval, Mumbai, Mangalore Kochi, Tuticorin, Chennai, Visakhapatnam, Paradip and Digha.

Assessed the vulnerability of coastal districts to climate change. Ocean acidification in different zones was studied and intervention to increase carbon sequestration by planting mangroves saplings was done.

Mariculture

In order to find out the response, especially of spawning, the hatching success and larval survival of cultivable species and live feed organisms to different seawater temperature, experiments were conducted on 1 species of copepod, 1 species of shrimp, 1 species of

sand lobster, 5 species of ornamental fish and 2 species of food fish.
Growth and multiplication of Rotifers at different temperatures with algal feeds Impact of temperature and salinity on the Cobia embryonic development and larviculture was assessed

Technology Demonstration
Empowering the coastal fishermen to harness positive impact of climate change by capture based aquaculture, Technology of sea cage farming of high-value fishes cobia and pompano, low-cost cage construction, mooring of cages in the sea; mussel and seaweed farming and integration of cage farming with pokkali farming were demonstrated to fishermen and other stakeholders.

5. Salient achievements (only technical achievements) : Please refer Annexure 1

6. Major theme areas/objectives

- To enhance the resilience of Indian fisheries to climatic variability and climate change through development and application of improved production and risk management technologies
- To demonstrate site-specific technology packages on farmers fields for adapting to current climate risks
- To enhance the capacity of scientists and other stakeholders in climate resilient agricultural research and its application.

7. Name of the Principal Investigator **Dr P.U. Zacharia**, CMFRI, Cochin

Cochin, 10-5-2013

Annexure 1: ***Salient achievements***

A. CAPTURE FISHERIES

1. Database development:

- Historical environmental data for the period 1960 – 2011 for the parameters SST, air temperature, specific humidity, relative humidity, scalar wind, vector wind, sea level pressure, chlorophyll, rainfall, particulate inorganic Carbon, upwelling index etc. was downloaded from various sources for southwest (Kochi & Mangalore), Southeast (Chennai) and Northeast (Visakhapatnam) coasts. The data is being tabulated.

- **Real-time monthly environmental data was generated** on Silicate, Nitrate, Orthophosphate, Ammonia, Chlorophyll, DO, pH, Temperature, TSS for southeast (Tuticorin), Southwest (Kochi) coasts.

- **Data on biological parameters ie.** Length frequency, maturity, ova-diameter, food, fecundity, ovary weight, gut condition, spawning characteristics of 9 species of marine finfish/shellfish from south east (Chennai), for the period 1990-2012 and all the commercial species of crustaceans, cephalopods and finfishes from southwest (Mangalore) coast digitised for database. The database is available at Chennai centre of CMFRI

- **Real-time monthly data on biological parameters** is being generated on all the parameters from seven centres for ten resources.

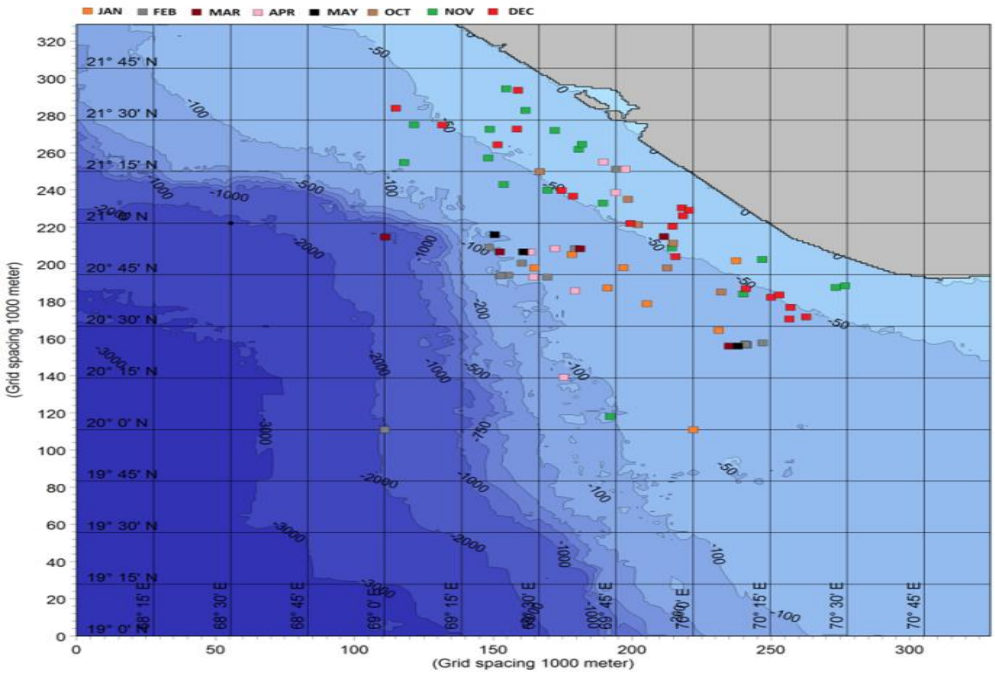
  Common species decided for each centre were Oil Sardine, Indian Mackerel, Threadfin breams, Skipjack tuna, *Metapenaeus monoceros* and *Loligo duvaucelli.*

Region specific species studied were

a. North West Coast: Bombay duck, Coilia, Ribbonfish & Silver Pomfret.
b. North East Coast: Ribbonfish, Lizard fish, Goat fishes & Yellowfin tuna
c. South West Coast: Yellowfin tuna, *Metapenaeus dobsoni,* Anchovy & *Lactarius lactarius,* Green mussel
d. South East Coast: Goat fishes, Mullet, Yellowfin tuna & Ribbonfish

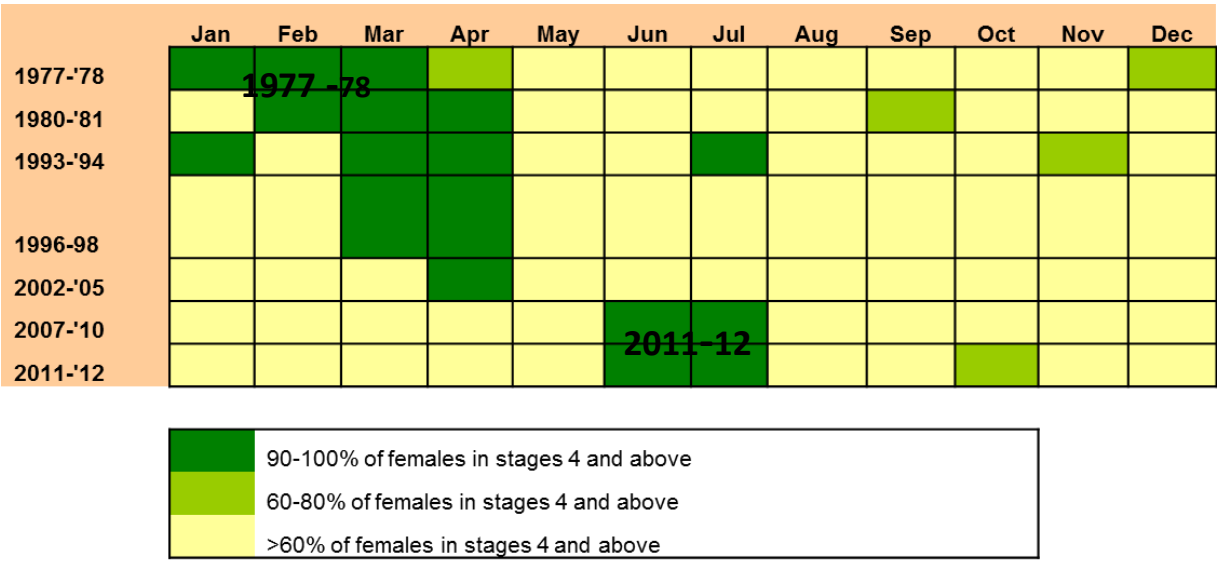
2. Geo-referencing of Skipjack tuna incidence points in multiday Gillnetters was done off Gujarat

Skipjack tuna is seen more abundantly in the inshore areas of 50m depth zone during the winter months of November, December and January where as it is near the 100m zone during the summer months of March to May.

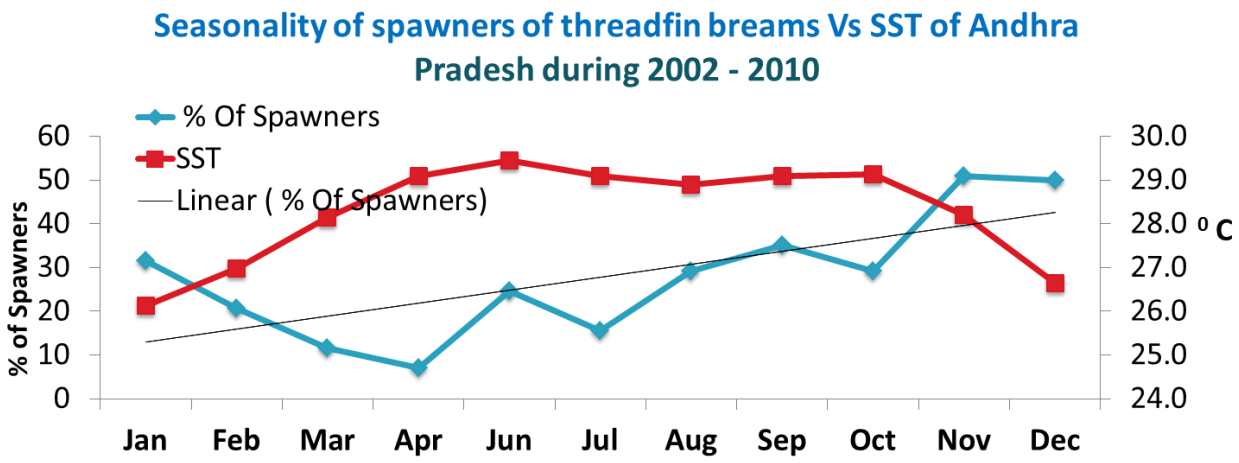


3. **Changes in Distribution, Abundance and Phenology of Marine Fish**

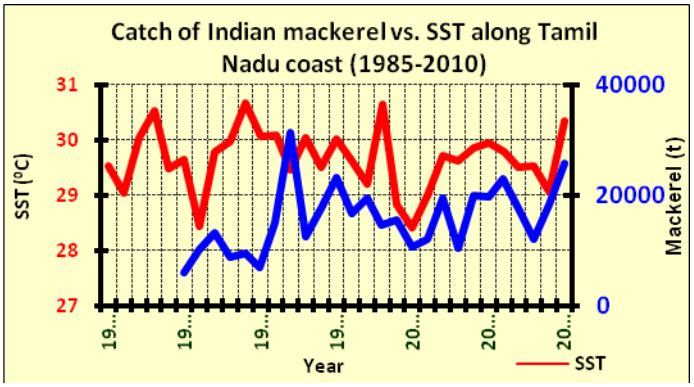
✶ **Significant changes were noticed** in the spawning months of *Sardinella longiceps* from January – March during 1977-78 to June - July in 2011-12 along SE coast. Spawning season shifted from January –April to June July.

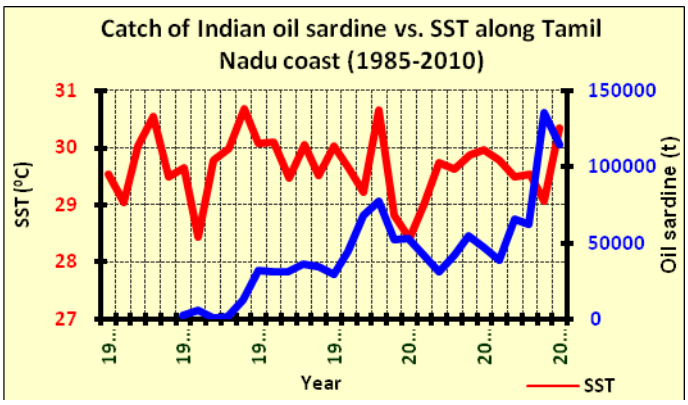


✶ The same feature was noticed in threadfin breams also. SST between 27.5 - 28.0°C may be the optimum for thread fin breams and when the SST exceeds 28.0°C, the fish shift the spawning activity to seasons when the temperature is around the preferred optima. Spawning season has shifted from September –October during 1990-99 to November – December during 2002-10.



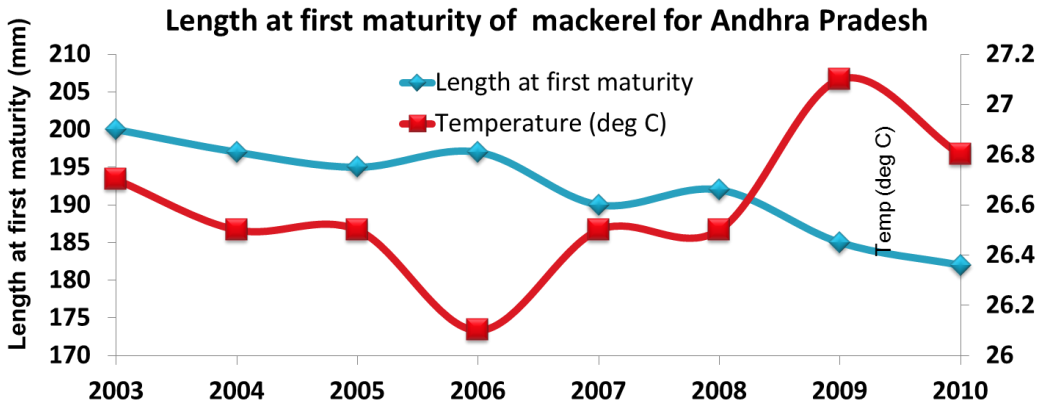
- **Catches of oil sardine, mackerel and lesser sardines** show **increasing trend** over past 20 years, corresponding with the **increasing trend in SST along Tamilnadu coast**



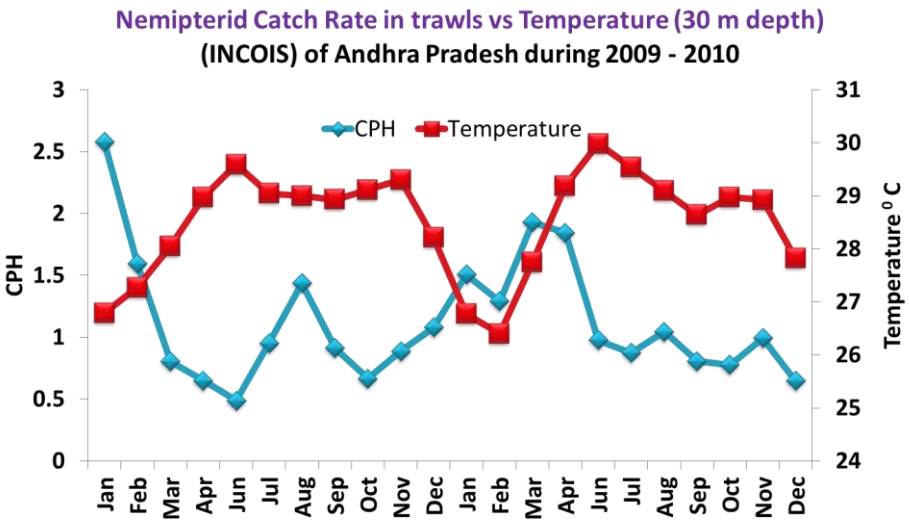


- In general, low value, small sized, short-lived species with quick turnover of generations such as oil sardine and mackerel are able to adapt to seawater warming by extending their distributional boundaries to northern latitudes. About 20% of fish in the Indian seas fall under this category.

- The mackerel, being a tropical fish, are expanding the boundary of distribution to depths as they are able to advantageously make use of increasing temperature in the sub-surface waters. Hence catches in the bottom trawl are increasing. Off Vishakapatnam, the length at first maturity is also seen to decrease as the temperature increases.



- The nemipterid catch rate in trawls was plotted against temperature from 30 m depth (based on INCOIS data) at Vishakapatnam during 2009-10. Negative correlation between water temperature at 30 m and Threadfin bream catch rates was observed, possibly as a result of vertical migration of fish.



4. Impact of environmental parameters on fish catch was studied at Vishakapatnam and West Bengal

The impact of environmental parameters on fish catch was studied by fitting a generalized linear model to oil sardine catch rates in gillnets in Andhra Pradesh and environmental parameters. The best fit model with significant predictors was as follows:

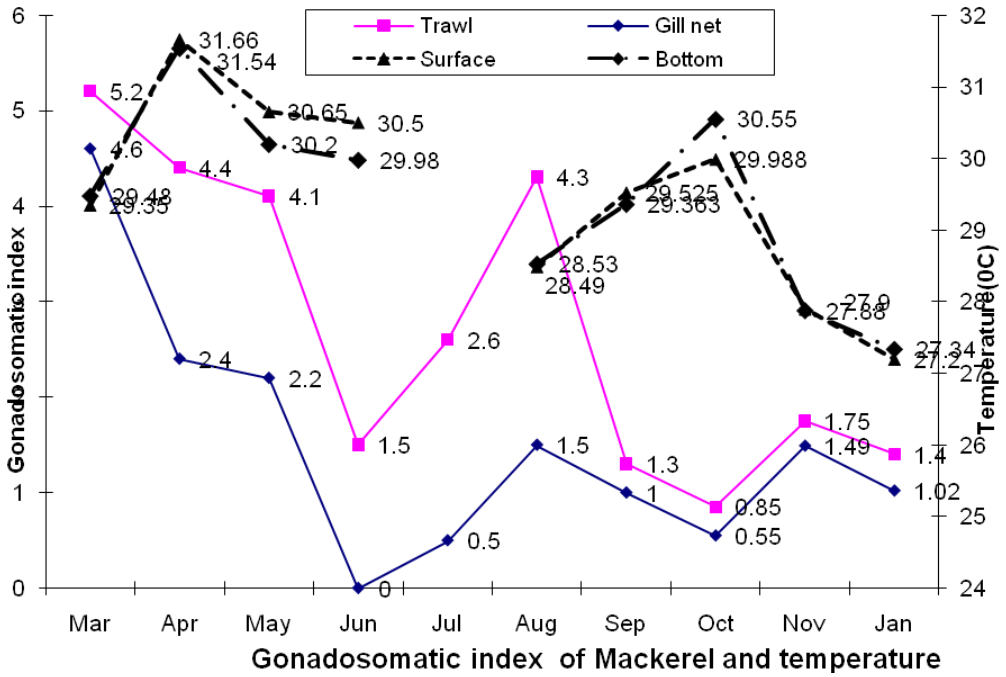
Catch rate of oil sardine = Intercept + factor (Year) + Chlorophyll a + CDOM + POC

The model indicates that CDOM and Chlorophyll a positively impact oil sardine catch rates and Particulate Organic Carbon negatively impacts oil sardine catch rates. None of the other predictors were significantly impacting oil sardine catch rates for this particular dataset. At West Bengal, it was seen that Sea surface temperature and particulate organic carbon positively impacts total fish landings while wind velocity, chlorophyll a and colour dissolved organic material negatively impacts the total catch

Total fish catch data of west Bengal (1998 – 2010) was fitted with climatic variables like SST, wind velocity, POC, CHL a and CDOM using Multiple Regression Analysis Best Fit Model (for total fish catch with Climatic Parameters. From the relationship it could be inferred that Sea surface temperature (SST) and particulate organic carbon positively impacts total fish landings while wind velocity, chlorophyll a and colour dissolved organic material negatively impacts the total catch

5.Relationship between SST and biological parameters of mackerel studied at Tuticorin

Studies on the biology of mackerel *Rastrelliger kanagurta* showed that only mature fishes belonging to stage VIIa or VII were present in most of the months. The sex ratio shows that female dominated in all the months except in July and August and the domination was found significant in March to May and September and the male domination in July was also found significant. In trawl net sample, males dominated in the catches from April to July and from October to November. The ratio was found significant from April to June. Studies on correlation of gonado-somatic index and temperature using SPSS showed that the correlation was not significant at 5 % level. The correlation between relative fecundity and temperature also showed that the correlation was not significant at 5 % level.



6. LCA-Life Cycle Assessment studies done

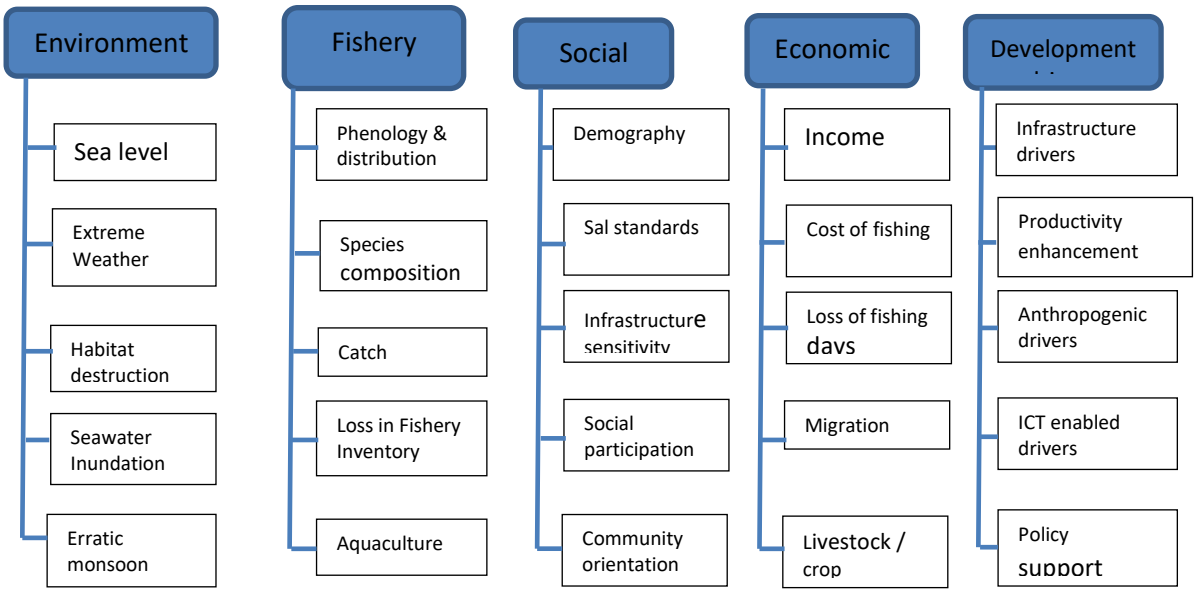
- Mapping of carbon dioxide consumption and emission from boat building, net fabrication, fish catch, processing, ice plants, transportation to final fish consumption was done at various fishing harbours along southwest (Mangalore), Southeast (Tuticorin), Northwest (Veraval) and Northeast (Vishakapatnam). Results point that per kg of fish produced carbon emitted ranged from 1.03 and 1.433.

Region	Total CO_2 (t)	Total C (t)	Kg C/ kg fish	Kg CO_2/ kg fish
Veraval				1.030
Visakhapatnam	93146	25336	0.390	1.433
Tuticorin	61828			1.278

7. IDLAM-Assessment of vulnerability of coastal districts to climate change done

The objectives of the IDLAAM plan was to develop a methodological framework for assessing the coastal vulnerability of fisher households, to assess perception of fishermen on causal factors of climate change, to analyze perception of fishers on different effects of climate change to develop a bottom up approach in climate change mitigation and adaptations. Based on the Patnaik and Narayan model coastal district vulnerability index was derived for different coastal districts of Kerala and it was found that Alappuzha had the highest vulnerability followed by Kozhikode and Thiruvananthapuram. In Alapuzha district 318 fisher households were selected from three fishing villages *viz*, Arthungal ,Thumbolyand Chethy,

Vulnerability of the fishing villages in Alappuzha district was done using PARS methodology. Of the three taluks assessed, Karthikappally (69.94), Ambalappuzha (64.31) and Cherthala (75.91) were found to be most vulnerable.



The study clearly indicates the level of awareness is low which indicate that the fishers couldn't correlate environmental changes consequent to climate change to their livelihood. The fishers were prone to loss in fishing days and erratic monsoon. There is need to improve on the awareness of the fishers knowledge to climate change by involving them in the disaster preparedness and planning process. Thus s a bottom up approach involving the primary stakeholders along with the community will adequately position them to climate change adaptation and mitigation by augmenting their traditional knowledge. The alternative avocations available across the different fishing villages need to be strengthened in order to negate the different risks and uncertainties of climate change and in ensuring a climate change informed fishers in the future.

8. Empowering the coastal fishermen to harness positive impact of climate change

In **Karnataka**, invasion of saltwater in estuarine areas due to sea level rise and limited freshwater availability caused livelihood issues for fishermen due to non availability of estuarine fishes. **Red snapper** was identified as the most suitable and fast growing species for Karnataka waters (under Capture Based Aquaculture) and a cage of 5mx2.5mx2m cage produced 500 kg of red snapper in 10 months with an average weight of 900g (range 650-1.200g) in 2013.

9. Ocean acidification : near-shore areas more vulnerable

Increased carbon dioxide in the atmosphere mainly due to anthropogenic activities has been found to lower the pH of seawater, a phenomenon known as ocean acidification. An analysis of the instances of low pH values of surface waters in three depth zones viz 10m, 20m and 30m during the period 2005 to 2012 has indicated that in the year 2012, ph of surface water at 10m depth zone was low for a considerably longer period (21% of the total recorded observations) than in the previous years (Table). Land run off is also known to affect the pH values.

Low pH values can lead to dissolution of the thin exoskeleton of several zooplankton including larval forms of shrimps, molluscs and fishes. This can lead to low food availability (secondary productivity) of the early life stages and also low survival rates of commercially important species, which in turn can affect the fish catch.

Among the three depth zones, low pH values were recorded only in the surface waters at 10m depth zone (Fig1; Table 1) indicating the influence of coastal landmass and anthropogenic activities.pH was always greater than 7 in the regions away from the shore.

Table . Details of instances when pH was less than 6 in the surface waters in the region off Kochi					
Year	No.ofreal time observations	No.of instances when pH was less than 6			Months when pH was less than 6
		10m	20m	30m	
2005	7	1	0	0	June
2006	7	1	0	0	September
2007	3	0	0	0	nil
2008	4	1	0	0	September
2009	4	1	0	0	September
2010	6	1	0	0	September
2011	8	1	0	0	December
2012	10	3	0	0	May, September, November

10. Mangrove cover in Allepey district : Intervention to increase carbon sequestration by planting mangroves saplings.

The district had low mangrove vegetation. Four species of mangroves, *Rhizophora mucronata*, *Acanthus ilicifolius* , *Excoecariaagallocha and Acrostichumaureum*were found in the brackish water ecosystem near Thuravoor. Though patchy in distribution, there were full gown mangrove trees. Six-month old saplings of *R.mucronta* from the nursery of CMFRI at Muthakunnam were planted in this ecosystem to develop the mangrove cover.Studies have shown that the Carbon sequestration rate 6 months, 5 and 10 years old *R. mucronata* are 0.1564 t C ha^{-1} yr^{-1}, 0.3134 t C ha^{-1} yr^{-1}.and 6.6302 t C ha^{-1} yr^{-1}, respectively. An attempt is made to increase the mangrove cover of the district.

Different mangrove species in the brackish water ecosystem of Thuravoor of Alleppy district

B. MARICULTURE

i) Growth and multiplication of Rotifers at different temperatures with algal feeds:

To assess the growth and multiplication of rotifers at different temperatures and with varying algal feeds experiments were conducted. About 50 numbers of rotifers /ml were introduced in each 30 ml test tubes containing known densities of algae *Chlorella* sp. and *Nannochloropsis* sp. The growth and multiplication of rotifers were assessed at 24 and 48 hours intervals. It was found that at 35 ºC, the rotifers have multiplied to 230 numbers per ml at 48 hours when maintained along with *Chlorella* sp. as feed. Similarly, rotifers maintained at 35 ºC with *Nannochloropsis* sp. as feed has multiplied to a maximum of 360 numbers per ml at 48 hours.

ii) **Impact of temperature and salinity on the Cobia embryonic development and larviculture**

- About 3000 nos. of fertilized cobia eggs were stocked in each 10 liter tanks with mild aeration containing seawater with salinities of 25, 28, 31, 34, 37, and 40 ppt. It was found that 78.89% of the fertilized cobia eggs hatched at 31 ppt salinity and a very poor hatching percentage of 15.18% was noticed in low salinity of 25ppt. The ambient temperature was 29.0 to 30.5°C Experiments were carried out to ascertain the survival of cobia larvae at different temperature regimes. It was observed that 93.33% of survival was noticed in the ambient temperature, whereas at 35°C all the larvae died within 24 hours. Poor survival of 26.67% was noticed in 34ºC. When the temperature was maintained at 34°C, the cobia larvae were deformed and showed retarded growth and movement.
- Experiments were carried out to ascertain the growth in terms of length and weight of cobia larvae at different temperature regimes. It was observed that faster growth of 6.47 mm was noticed in the cobia larvae maintained at 32°C at 40th dph, whereas at 34ºC all the cobia larvae had shown retarded growth.
- In **sand lobsters** reared at 36 -37 ppt salinity & 8-8.2 water pH with minimum light exposure, the incubation period was found to decrease from 39 - 41 days at 25-27°C to 32-35 days at 28-30°C.

- Highest hatching percentage of hatching of ***Cobia*** eggs was obtained at 31°C, while the lowest hatching percentage was in 34°C. Larval deformity was noticed in Cobia when temperature exceeded 32°C.

- In *Amphiprion nigripes and Amphiprion frenatus,* the rate of hatching increased when water temperature was increase d from 29°C to 30°C. However, mortality of eggs was noticed after 30°C.

- In *Trachinotus blochii***,** 34°C was favourable for reducing hatching duration and success, larval metamorphosis and growth, and juvenile growth. However, larval and juvenile success was very low at 34°C. Pompano culture was experimented in inland pond with no salinity; growth was found to be very slow and 250 g was achieved in 8 months.

C. TECHNOLOGY DEMONSTRATION

- Low cost cage development was done at Karwar. 6 meter square and circular cages using GI pipes, floated on HDPE barrels were fabricated. At Karwar, demonstration of low cost cage

technology, all weather mooring system and efficient net exchange technology, were conducted.Mussel and sea weed (*Kappaphycus alvarezi*) culture was also demonstrated off Karwar.

- Farming trial of Cobia at Rajulalanka, West Godavari District, Andhra Pradesh Cobia farming trials in sea cages at Mandapam Demonstration of cage farming of cobia by participatory mode with M/s. Vitality Aquaculture Pvt. Ltd. at Tuticorin and demonstration of cage farming of cobia by participatory mode with a fishermen group of the adjoining village, Marakayarpatinam was varied out

Pond culture demonstration and harvest of Pompano,

- The growth performance, survival and production of silver pompano, *Trachinotus blochii* were evaluated in a brackishwater pond farm. A total of 3,400 numbers of fingerlings of silver pompano (30.59 ± 0.24 mm mean length and 2.00 ± 0.04 grams mean weight) were stocked into a one acre pond having salinity of 8 ppt. The salinity gradually raised to 24 ppt during the farming period due to high saline intake water.

Photo: *Harvested Pomapno from ponds*

- Demonstration of cage and pond farming of Grouper was conducted at Visakhapatnam.

- 10 meter diameter GI cage which can be assembled and dismantled anywhere has been designed. The stocking capacity of this cage is 30000 fishes, almost three times that of a 6m dia GI cage.

Photo of 10 m GI cage which can be assembled at any place

Successful demonstration of profitable paddy-finfish integrated farming was conducted in pokkali fields in Kerala

Most of the Pokkali fields are kept fallow due to less profitability. To demonstrate that farming can be made profitable by integrating with fish farming four farmers from Pizhala, Ezhikkara and KadamakkudyPokkali regions were selected. Farming initiated in June, seeding was done in July; Mullet (@ 3000 per farm) and pearl spot fingerlings (@ 250 no.s per cages – 2 x 2 x 1.5 m) collected from wild stocked in cages in July; Pokkkali was harvested in October; fingerlings were released into farms in November; monitoring of water quality parameters from November. Harvesting mela was arranged on 10th April 2013. A profit of Rs. 83,000/- was obtained per hectare after the first year.

Harvested karimeen from cages in pokkali fields

Publications/patents

1. A.P. Dineshbabu, Prathibha Rohit, Geetha Sasikumar, Sujitha Thomas, P.U.Zacharia,2012. Hand book of suggested methodologies for studies in fishery biology of finfishes and shellfishes of Indian waters. Compiled for the biological studies under the project, National Initiative on Climate Resilient Agriculture (NICRA).

2. Sujitha Thomas, A.P. Dineshbabu, Swathilekshmi P.S. & P.U. Zacharia
   Sea level rise due to global warming and the impact on coastal fishers: Capture based aquaculture (CBA), a method to deal with climate change related salinity intrusions in coastal waters.

3. Sujitha Thomas, Anulekshmi Chellappan and Bala L. Mhadgut, 2012. Indigenous Technical Knowledge of Coastal Fisher Folks of Maharashtra, National Seminar on Traditional Knowledge and Management Systems in fisheries held at Kochi from 30-31 Oct 2012.

4. Shyam. S. Salim, V. Kripa, P.U. Zacharia, Anjana Mohan, Manju Rani and T. Ambrose, 2012. Assessing Climate Change Vulnerability of Coastal Livelihoods: A conceptual framework for marine fisheries sector, Paper presented in National Symposium on Climate Change and Indian Agriculture: Slicing down the uncertainties, 22-23 January, 2013, Organised by CRIDA, Hyderabad.

5. Sreenath, K.R, Soniakumari, M.P. Makwana, K. M. Koya, G. Dash. S. Sen. S.K Mojjada, P. Shiju and P.U Zacharia.2012. Impact of climate change on the Bombay duck *Harpodon nehereus* (Ham.) abundance along Gujarat coast of India. Paper Submitted.