## 1. Background information about the Centre

### Location

The Vizhinjam (Long: E. 76° 59'15", Lat: N. 8° 22' 30") Research Centre of CMFRI is located in the coastal village of Vizhinjam in Neyyattinkara Taluk of Thiruvananthapuram District of Kerala. The centre is about 18 km south of Thiruvananthapuram city and famous for the fishing harbor with a lighthouse and a blue beach sheltered on the coast of Arabian Sea. Vizhinjam is historically known for ancient civilizations and a rock cut temple. Archeological excavations revealed the existence of an ancient port. The history of Vizhinjam dates back to The Ay Dynasty. Before the Cheras established themselves as a major force in Kerala, it was ruled by the Ay dynasty sometime between 7th to 11th Century AD with Vizhinjam as the capital. The Ay kingdom extended between Nagercoil and Thiruvalla. When the kings of the Ay dynasty shifted their capital to Vizhinjam, they built a fort which is now considered to be the oldest fort in Kerala dating to the eighth or ninth century. Excavations carried out by noted archeologists have brought to light the evidences of ancient international maritime trade flourished from Vizhinjam with the Red Sea Coast during the early Christian era (Roman period). It would support the identification of the port with Balita or Blinca of the Greco-Roman records. A large number of sherds of the Torpedo Jar and Turquoise Glazed Pottery types indicated trade relations with the Persian Gulf region also. The East Asian trade connections were indicated by Chinese and Thai ceramics.

From the year 2010 onwards, Vizhinjam area has been included in the Thiruvananthapuram Corporation. From the fisheries point of view, Vizhinjam has attained the special significance on account of the periodic occurrence of larvae and juveniles of some of the important commercial species. The protected Bay enclosed by two rocky promontories protruding into the sea (*viz*., Mathilpuram on the western side and Kottapuram on the eastern side) is a special and a unique feature of the inshore fishing area of Vizhinjam, facilitating favourable conditions of year-round fishing activities. The pristine sea water with almost stable salinity and proximity to the Wadge bank are other added advanages offering high scope for potential fisheries - related research activities.

**Historical background of Vizhinjam Research Centre of CMFRI**

The fisheries research activities of the CMFRI at Vizhinjam were initiated as early as 1948 with a preliminary survey of the area. As a part of the research programme of the Central Marine Fisheries Research Station, it was decided in 1948 to conduct a survey of the Indian coastline to estimate the

marine fish landings and to find out the types of fish stocks available. A preliminary survey was found essential before embarking on the final programme. With this in view, Shri Gopalan Nayar conducted a preliminary survey in 1949 to ascertain the number of fishing villages, boats, nets and fishermen along the coastal strip extending from Cape Comorin in the south to Ponnani River in Malabar District in the north. Based on the data thus collected, the final design to estimate the landings was made. Initially five observation centres, Blangad in South Malabar, Narakkal and Malippuram in Trichur District, Wadi in Quilon District, and Vizhinjam in Trivandrum District, of the erstwhile Travancore-Cochin State, were selected. Though regular observations were taken at these centres in 1950, from the year 1951 onwards observations were restricted to two centres, Narakkal and Vizhinjam, and from January 1953 to August 1954 observations were confined to Vizhinjam alone. As Vizhinjam at that time itself was considered as a very important fishing centre and as data for five consecutive years were available it was decided to embody the observations in a reaserach paper by Gopalan Nayar in 1958 [Nayar, S Gopalan (1958) A preliminary account of the fisheries of Vizhinjam Indian Journal of Fisheries. 5 (1): pp. 32-55] as suggested by Dr. N. K. Panikkar, the then Chief Research Officer of the Central Marine Fisheries Research Station at Mandapam Camp. In the year 1951, a Survey Centre of CMFRI was started in Vizhinjam.

The survey Centre was subseqeuently upgraded to the status of a Research Unit with effect from 23-8-1965. The Research Unit was further promoted as a Research Sub-station with effect from 1-4-1969. With the addition of further research programmes and personnel over the years, the Vizhinjam centre has grown into the present day full-fledged Research Centre. The Centre has been carrying out pioneering research, contributing substantially to the knowledge about the marine fisheries of this region. Realizing the importance of this centre which was housed in rented buildings, the Government of Kerala had allotted 1.7 acres of sea front land area for VRC of CMFRI on 99 years lease to establish further and to construct permanent Office-cum-Laboratory building, Marine hatcheries and Marine Research Aquarium. For the permenatnt buildings the foundation stone was laid on 3rd September 2011 by Shri. Oommen Chandy, the Hon'ble Chief Minister of Kerala in the presence of Dr. Shashi Tharoor, Hon'ble Member of Parliament, Thiruvananthapuram and Dr. S. Ayyappan, Secretary, DARE and Director General, ICAR, New Delhi. On completion of the Office-cum-Laboratory building the centre was shifted to the new premises in April 2013.

**Present Organization and Structure**

During the review period 28 research projects under 7 Divisions were handled in Vizhinjam Research Centre of CMFRI. There were 8 Scientists, belonging to 7 Divisions carrying out research in

Vizhinjam. At present, 6 scientists belonging to 5 Divisions are carrying out research in this centre. The distribution of Scientists and Technical staff of different Divisions during the review period is given below:

| **Divisions** | **Scientific** | **Technical** | **No. of Projects** |
|---|---|---|---|
| 1. Fishery Resource Assessment Division | - | 1 | 2 |
| 2. Pelagic Fisheries Division | - | | 4 |
| 3. Demersal Fisheries Division | - | 2 | 3 |
| 4. Crustacean Fisheries Division | 1 | 2 | 1 |
| 5. Molluscan Fisheries Division | 1 | 1 | 2 |
| 6. Marine Biotechnology Division | 1 | 1 | 3 |
| 8. Mariculture Division | 2 | 2 | 3 |
| 9. Marine Biodiversity Division | 2 | | 7 |
| 10. SEETD Division | 1 | 1 | 5 |
| **Total** | **8** | **10** | **32** |

Present Organization and Structure *

| **Divisions** | **Scientific** | **Technical** | **Projects** |
|---|---|---|---|
| 1. Fishery Resource Assessment Division | | 1 | 2 |
| 2. Pelagic Fisheries Division | | - | 1 |
| 3. Demersal Fisheries Division | | 2 | 3 |
| 4. Crustacean Fisheries Division | 1 | 2 | 1 |
| 5. Molluscan Fisheries Division | 1 | 2 | 2 |
| 6. Marine Biotechnology Division | 1 | 2 | 1 |
| 7. Fishery Environment Management Division | - | - | - |
| 8. Mariculture Division | 1 | 1 | 1 |
| 9. Marine Biodiversity Division | 2 | | 3 |
| 10. SEETD Division | - | - | - |
| **Total** | **6** | **10** | **14** |

*Note: The supporting staff and motor driver are not attached to any particular Division.

## 2. Staff strength (year wise)

**List of Scientists of the Centre**

| Name | Designation | Period |
|---|---|---|
| Dr. Rani Mary George | Principal Scientist & Scientist-In-Charge | Till date |
| Dr. R. Sathiadhas | Principal Scientist | Retd. on February 2013: Joined as Emeritus Scientist on 1st January, 2014 |
| Dr. N. Ramachandran | Principal Scientist | Retd. on December 2013 |
| Dr. A. P. Lipton | Principal Scientist | Till date |
| Dr. M. K. Anil | Principal Scientist | Till date |
| Dr. B. Santhosh | Principal Scientist | Till date |
| Dr. S. Jasmine | Senior Scientist | Till date |
| Smt. K. N. Saleela | Scientist | Till date |

**Staff strength - Year wise**

| Staff | 2009-10 | 2010-11 | 2011-12 | 2012-13 | 2013-14 |
|---|---|---|---|---|---|
| Scientists | 7 | 8 | 8 | 8 | 7 |
| Technical Officers | 3 | 8 | 9 | 9 | 9 |
| Technical Assistants | 7 | 3 | 3 | 3 | 2 |
| Administrative staff | 4 | 5 | 6 | 4 | 4 |
| Skilled supporting staff | 10 | 9 | 8 | 8 | 4 |

**Staff strength as on March 2014**

| **Staff** | **Strength** |
|---|---|
| Scientists | 6 |
| Technical Officers | 9 |
| Technical Assistants | 2 |
| Administrative Staff | 3 |
| Skilled Support Staff | 4 |
| **Total** | **24** |

**3. Budget (Year wise)**

| BUDGET (amount in lakhs) | 2009-2010 | 2010-2011 | 2011-2012 | 2012-2013 | 2013-2014 |
|---|---|---|---|---|---|
| PLAN | | | | | |
| TA | 1.00 | 1.50 | 2.50 | 4.50 | 2.50 |
| Research &operational | 14.00 | 11.00 | 13.00 | 19.00 | 3.80 |
| Administrative Exp. | | 12.20 | 1.50 | 7.50 | 13.775 |

| BUDGET | 2009-2010 | 2010-2011 | 2011-2012 | 2012-2013 | 2013-2014 |
|---|---|---|---|---|---|
| NON-PLAN | | | | | |
| Estt. | 175 | 170.00 | 185.00 | 1207.00 | 207.00 |
| TA | .50 | 1.50 | 1.00 | 207.00 | 0.90 |
| Research & operational | 17.00 | 4.00 | 6.00 | 4.00 | 30.00 |
| Infrastructure, Communication, Repair& Maintenance exp./ others | | 13.13 | 18.00 | 14.75 | 25.50 |

## 4. Research programmes

**Research Projects during April 2009 to March 2014**

| | | |
|---|---|---|
| **Fishery Resource Assessment Division** | | |
| 1. | FRA/ASSESS/01 | Development of knowledge based information system for marine fisheries sustainability (2009-2014)<br><br>Shri. K.K. Suresh |
| 2. | FRA/ASSESS/02 | Decision support system for marine fisheries management (2012-2014)<br><br>Shri. K.K. Suresh |
| **Pelagic Fisheries Division** | | |
| 3. | PEL/IDP/01 | Management advisories for sustaining marine fisheries of Kerala & Lakshadweep<br><br>Dr.N. Ramachandran (2009-2012)<br>Dr. S. Jasmine (2009-2012)<br>Smt. K.N. Saleela (2009-2012) |
| 4. | PEL/IDP/03 | Strategies for sustaining tuna fishery along the coast of India<br><br>Dr. S. Jasmine (2009-2012) |
| 5. | FISHCMFRISIL20120030 0003 | Development of fishery management for sustaining marine fisheries of Kerala & Lakshadweep<br><br>Dr.N. Ramachandran (2012-2013)<br>Smt. K.N. Saleela (2009-2014)<br>Dr. B. Santhosh (2012-2014) |
| 6. | FISHCMFRISIL201200700007 | Development of strategies to sustain the stock and fishery of large pelagics of Kerala & Lakshadweep<br><br>Dr. S. Jasmine (2012-2014) |
| **Demersal Fisheries Division** | | |
| 7. | DEM/IDP/01 | Management advisories for sustaining marine fisheries of Tamil Nadu and Puducherry<br><br>Smt. K.N. Saleela (2009-2012) |
| 8. | FISHCMFRISIL201200800008 | Development of fishery management for sustaining marine fisheries of Tamil Nadu and Puducherry<br><br>Smt. K.N. Saleela (2009-2012) |
| 9. | FISHCMFRISIL201200500005 | Assessment of Elasmobranch resources in the Indian seas<br><br>Dr. B. Santhosh (2012-2014) |

| | | |
|---|---|---|
| **Crustacean Division** | | |
| 10. | FISHCMFRISIL201200900009 | GIS Based Resource Mapping of Distribution and abundance of Fin fishes and Shell fishes off Indian coast for Suggesting Operational based strategies for Fisheries management<br><br>Smt. K.N. Saleela (2012-2014) |
| **Molluscan Division** | | |
| 11. | FISHCMFRISIL201200900009 | Sustainable molluscan mariculture practices<br><br>Dr. M.K. Anil (2012-2014) |
| 12. | FISHCMFRISIL201201200012 | Development of fishery management plans (FMPs) for the bivalve fisheries of India<br><br>Dr. M.K. Anil (2012-2014) |
| **Marine Biotechnology Division** | | |
| 13. | PNP/BIOT/01 | Biotechnological applications in mariculture and conservation<br>Dr. A.P. Lipton (2009-2012) |
| 14. | MBTD/PATH/01 | Pathogen profiling, diagnostics and health management in maricultured fin fish and shell fish<br><br>Dr. A.P. Lipton (2009-12)<br>Dr. M.K. Anil (2009-2012)<br>Dr. B. Santhosh (2009-2012)<br>Smt. K.N. Saleela (2009-2012) |
| 15. | FISHCMFRISIL20120260026 | Health management in maricultured fin fish and shell fish for mariculture and aquaculture & bioprospecting from marine resources<br><br>Dr. A.P. Lipton (2012-2014)<br>Dr. M.K. Anil (2012-2014) |
| 16. | **FISHCMFRISIL2012O2700027** | Aquatic feed biotechnology for mariculture and aquariculture<br><br>Dr. M.K. Anil (2012-2014) |
| **Socio economic Evaluation and Technology Transfer Division** | | |
| 17. | SEETD/PMS/01 | A diagnostic study on dimensions, causes and ameliorative strategies of poverty and marginalization among the marine fisher folk of India<br><br>Dr. R. Sathiadhas (2009-2012) |
| 18. | SEE/PME/01 | Benefit Cost analysis of marine fishery business and Alternative investment options<br><br>Dr. R. Sathiadhas (2009-2012) |

| | | |
|---|---|---|
| 19. | FISHCMFRISIL201202300023 | Supply chain management of marine fisheries sector in India<br><br>Dr. R. Sathiadhas (2012-2014) |
| 20. | FISHCMFRISIL201202100021 | Economics of marine fisheries and sustainable management: Policy issues and interventions.<br><br>Dr. R. Sathiadhas (2012-2014) |
| 21. | FISHCMFRISIL201202200022 | Capacity development for ecosystem based responsible fisheries management in India, a co- learning action research<br><br>Dr. R. Sathiadhas (2012-2014) |
| **Marine Biodiversity Division** | | |
| 22. | MBD/RE/01 | Understanding the threatened coral reef Ecosystems of Southern India and Designing Interventions aimed at their restoration<br><br>Dr. Rani Mary George (2009 -2012)<br>Dr. S. Jasmine ((2009 -2012) |
| 23. | MBD/RE/04 | Species variation and biodiversity of the fishes of the family Lutjanidae of India<br><br>Dr. S. Jasmine ((2009 -2010) |
| 24. | MBD/RE/05 | Assessment of biodiversity and ecological changes in open sea cage<br><br>Dr. Rani Mary George (2009 -2012)<br>Dr. S. Jasmine ((2009 -2012)<br>Dr. M.K. Anil (2009-2012)<br>Dr. B. Santhosh (2009-2012) |
| 25. | MBD/RE/06 | Biodiversity evaluation of marine ecosystem of the south west coast of India<br><br>Dr. Rani Mary George (2011 -2012)<br>Dr. S. Jasmine ((2011 -2012) |
| 26. | FISHCMFRISIL201201500015 | Bioinventorying and biodiversity valuation of marine organisms in selected ecosystem along the Indian coast<br><br>Dr. Rani Mary George (2012-2014)<br>Dr. S. Jasmine ((2012-2014) |
| 27. | FISHCMFRISIL201201600016 | Investigations on vulnerable coral reef ecosystems of Indian waters with special emphasis on formulation of management measures for conservation<br><br>Dr. Rani Mary George (2012-2014)<br>Dr. S. Jasmine ((2012-2014) |

| | | |
|---|---|---|
| 28. | FISHCMFRISIL201201700017 | Assessment of the fishing impacts on biodiversity loss, with special reference to the threatened species, to formulate management options for their protection.<br><br>Dr. S. Jasmine ((2012-2014) |
| **Mariculture Division** | | |
| 29. | MD/IDP/02 | Development of diversified mariculture systems<br><br>Dr. M.K. Anil (2009 -2012) |
| 30. | MD/IDP/03 | Development of broodstock, captive breeding and seed production techniques for selected marine food fishes and ornamental fishes.<br><br>Dr. M.K. Anil (2009 -2012)<br>Dr. B. Santhosh (2009 -2012) |
| 31. | MD/IDP/04 | Innovations in sea cage farming and sustainable Capture Based Aquaculture<br><br>Dr. M.K. Anil (2009 -2012)<br>Dr. B. Santhosh (2009 -2012) |
| 32. | FISHCMFRISIL201202400024 | Development and standardization of seed production technologies for selected highvalue finfishes and shell fishes<br><br>Dr. B. Santhosh (2012-2014) |
| **Externally funded (sponsored) projects** | | |
| 33. | ICAR, New Delhi | ICAR Mega seed project<br>Dr.Rani Mary George<br>Dr. M.K. Anil (2009 -2015)<br>Dr. B. Santhosh (2009 -2012) |
| 34. | NFDB | Open sea cage-culture demonstration farms in India (NFDB)<br><br>Dr. Rani Mary George (2009 -2012)<br>Dr. A.P. Lipton<br>Dr. M.K. Anil (2009 -2012)<br>Dr. B. Santhosh (2009 -2012) |
| 35. | Ministry of Agriculture (Government of India) | Open sea floating cage culture demonstration farm for R&D in Marine finfish and shellfish production (MOA/1)<br><br>Dr. Rani Mary George (2009 -2012)<br>Dr. A.P. Lipton(2009 -2012)<br>Dr. M.K. Anil (2009 -2012)<br>Dr. S. Jasmine ((2009 -2012)<br>Smt. K.N. Saleela (2009-2012) |

| | | |
|---|---|---|
| 36. | ICAR, New Delhi | ICAR Outreach Project on Fish Feeds<br><br>Dr. M.K. Anil (2009 -2012) |
| **Consultancy projects** | | |
| 37. | DOT – Govt of Kerala | Impact assessment of multi-purpose reef at Howa Beach, Kovalam, Thiruvananthapuram on fishery resources of the area. For DOT, Govt. of Kerala.– Rs. 7 lakhs (2011)<br><br>Dr. M.K. Anil, PI<br>Dr. Rani Mary George<br>Dr. A.P. Lipton<br>Dr. B. Santhosh<br>Dr. S. Jasmine<br>Smt. K.N. Saleela |
| 38. | Asian Consultant Engineers, New Delhi | Baseline data collection and monitoring on environment and social impact assessment for the development of Vizhinjam port. For Asian Consultant Engineers, New Delhi – (Rs.30 lakhs) (2012)<br><br>Dr. M.K. Anil, PI<br>Dr. Rani Mary George<br>Dr. A.P. Lipton<br>Dr. B. Santhosh<br>Dr. S. Jasmine<br>Smt. K.N. Saleela |

## 5. Major achievements of Research

### Fishery Resource Assessment Division

**1. Development of knowledge based information system for marine fisheries sustainability**
**Code: FRA/ASSESS/01 Period: 2009-2014**

- Fishery Resource Assessment data were collected from the Thiruvananthapuram district and the coastal area of Thiruvananthapuram district is divided into two zones K-1(Kollamcode to Valiaveli) & K-2 (Pallithura to Kappil). The zones K-1 & K-2 extend about 80 km, in which 51 fish landing centres are located. The zone K-1 is bifurcated into K-1(A) and K-1(B). The K-1 A cover three centres of greater fishing activities (Puthiathura, Vizhinjam and Poonthura). Two fishing harbors-viz., Vizhinjam and the other under construction at Perumathura -Muthalapozhy**.**
- In Thiruvananthapuram coast, during the period 2009-2014, pelagic fishes dominated the catch followed by demersal and Molluscan groups. The major contributor was tuna followed by mackerel. The fishery showed a slightly declining trend. The prices showed a tremendous increase and for some fishes, it was more than 200%. Hence, though catch was less the importance of this sector remained unaffected due to the high price of the fishes.
- Many fishes which were considered as trash or low value like the balistids also become an important component of fishery as their price increased drastically. Many commercially important groups like prawns and cephalopods landed only in less quantity.

**2. Decision support system for marine fisheries management**
**Code: FRA/ASSESS/02 Period: 2012-2014**

- Evaluation of annual trends (spatial) in fishery abundance index and stock assessment of important fishery resources were undertaken.
- The fishery information/ forecast obtained from NRSA were communicated to the end users of this region. Conducted periodic fishery census and socio-economic surveys.

## Pelagic Fisheries Division

**1. Management advisories for sustaining marine fisheries of Kerala & Lakshadweep**
**Code: PEL/IDP/01 Period: April 2009 – March 2012**

**Resource: Tuna**

- An average quantity of 6244 t of tunas was caught off Vizhinjam during the period by the artisanal fishery. Tuna catch contributed almost 50% of the total fish landings at Vizhinjam. The catch and catch per unit effort of tunas in drift gill net though registered a slight decrease, in hooks & lines it had considerably increased to almost 10%. Drift gill nets landed 29.76% and hooks and lines contributed 70.24% of the total tuna catch. The peak tuna catch and catch rate in drift gill net were during monsoon, with maximum in July. In hooks and lines, the catch and catch rates were good throughout all the year except in September and maximum was during November. The peak tuna catch and catch rate in drift gill net were during June to September with maximum landing in July. In hooks and lines the catch and catch rates were good during November to January and also in April.
- During 2009-2010, in the total tuna catch landed by the two gears, the major share was *Auxis rochei* which formed 29.83% of the total tuna catch followed by *Euthynnus affinis* – 24.4%, *Sarda orientalis* – 17.17%, *Thunnus albacares* – 14.33%, *Katsuwonus pelamis* – 8.43% and *A. thazard*- 5.84%. The share in the by *Auxis rochei* increased to 59.4 % of the total tuna catch landed in the following year followed by *Euthynnus affinis* – 21.4%, *A. thazard* –11.3%. *Katsuwonus pelamis*– 1.3%, *Sarda orientalis* – 5.8%, and *Thunnus albacares* – 0.70%.
- During the year 2011-12, the major share in the coastal tuna fishery was contributed by *Auxis rochei* forming 69.3% of the total tuna catch followed by *Euthynnus affinis* – 15.32%, *Sarda orientalis – 9.76* %, and *A. thazard* – 5.38%. In drift gill nets, *Auxis rochei, Euthynnus affini,* and *A. thazard* were the major species which contributed 41.2 %, 22.5 % and 20.8 % respectively to the total tuna landing in this gear. The other species caught were *Sarda orientalis* (11.5%), *Katsuwonus pelamis* (2.6%) and *Thunnus albacares* (1.3%). In hooks and lines, *Auxis rochei* was the major species contributing 77.7% of the total tuna landed by this gear followed by, *E. affinis* (20.3%), *A. thazard* (1.9%), *Sarda orientalis* (0.2%) and *Thunnus albacares* (0.20%). *A. rochei* ranged in fork length from 15-36 cm with modes at 26 and 27 cm in drift net and from 20-29cm with a mode at 24cm in hooks and line. The size at first maturity for *A. rochei* was estimated at 23.6cm. *E. affinis* ranged in fork length from 24-54cm with a major mode at 38cm in the drift net catches. *A. thazard* ranged in fork length from 22-40cm with a major mode at 32cm in drift net. *K. pelamis* ranged in fork length from 34-68cm, *S. orientalis* ranged in fork length from 15-40cm and *T. albacares* ranged in fork length from 55-70cm in drift net.

**Resource: Crustaceans**

- In Vizhinjam, an estimated catch of 22 tonnes of penaeid shrimps were landed by trammel nets. When compared to the previous years, the catch and effort had increased by 19t and 4100 units respectively. An estimated 110.7t of shrimps and 22t of crabs were also landed by boat seines. When compared to the previous years, the effort expended as units was declined by 54.3% and landings of shrimps. Crab landings were increased by 96 t (362%) and 19 t (545%) respectively.
- At Mulloor, an estimated 721kg of spiny lobsters were caught by bottom set gillnets. The lobster landings by traps were estimated as 380kg at a cpu of 0.519kg at Vizhinjam. The lobster landing at Vizhinjam and Mulloor declined by 15% and 5.5% respectively during the period 2009.

**Resource: Cephalopods**

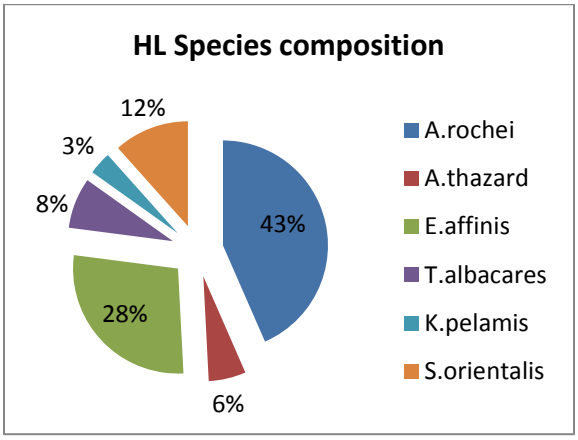
- The annual yield of cephalopods at Vizhinjam was 1436 tonnes showing an increase of 3.69%. About 76 % of the catch was obtained in boat seine and the rest in hook and line. Peak fishing season was July-October. Species included *S. pharaonis* (6.5%), *L. duvaucelii* (82.9%) and *D. singhalensis* (10.6%).
- *S. pharaonis* catch declined by 18% whereas the catch of *L. duvaucelii* increased by 4% and of *D. singhalensis* by 23%.
- The brown mussels' (*Perna indica*) landing was 492t with peak landing during September -October.
- The exploitation rate of *S. pharaonis, L. duvauceli, D. singhalensis* and *P. indica* were 0.69, 0.73, 0.03 and 0.47 respectively. The values of Lopt for these species were 25.3cm, 19cm, 16.7cm and 7.3cm.
- Estimated fishing mortality rate (F) of *L. duvaucelii* and *S. pharaonis* was more than $F_{0.1.}$

**2. Strategies for sustaining tuna fishery along the coast of India**
**Code: PEL/IDP/03 Period: April 2009 – March 2012**

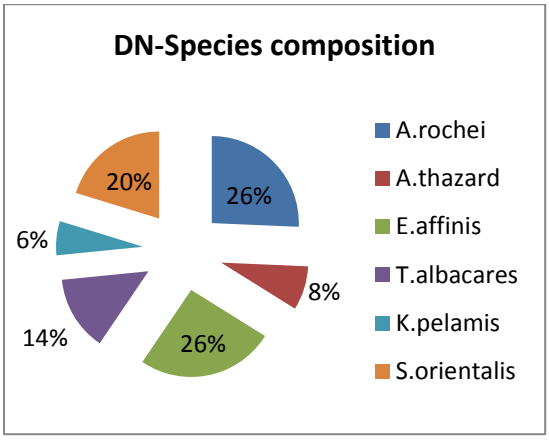
- Gear wise catch, effort and biological studies on commercially important oceanic tunas exploited by different gears along Vizhinjam and Thoothoor area was estimated for the period.
- The incidence of oceanic tunas in the traditional gears is seasonal and less in Vizhinjam. In Thoothoor, the fishery was seasonal and mainly landed by multiday long-liners as by catch along with sharks and snappers.
- In Vizhinjam coastal tunas constitute a major pelagic fish resource accounting for almost 50% of the total marine fish landings. Among this the coastal species, *A. rochei* and among the larger varieties *Euthynnus affinis* forms bulk of the total tuna landings. Tunas were exploited mainly by drift gill net and hook & line operated from motorized crafts. The annual catch during the reporting period

varied from an estimated total of 3803 tonnes in 2008 to a total of 7205 tonnes in 2010 forming a share percentage of 16 to 51.85% of the total fish landings in this traditional landing centre.

- Tuna fishery in Vizhinjam was constituted mainly by six species, major being the bullet tuna, *Auxis rochei* which is the only targeted fishery in this coast, *A. thazard, Euthynnus affinis, Sarda orientalis, Thunnus albacares* and *Katsuwonus pelamis.* The average CPUE varied from 359.5 kg to 625.7, in Drift gillnet cpue varied from 237 to 795kg and in hook & line it was from 338.2 to 480.5 kg.
- Among the larger tunas *Euthynnus affinis* – 23%*, Sarda orientalis* – 10.7%, *Thunnus albacares* –7.3% and *Katsuwonus pelamis*–3.4%. In drift gill nets, *E. affinis,* and were *Sarda orientalis* were the major species which contributed 25%, and 19.5% respectively to the total tuna landing in this gear. The other species caught were *T. albacares* (13.7%), and *K. pelamis* (6.4%) In hooks and lines *E. affinis* (20.7%) and *S. orientalis* (0.7%) contributed more among the larger tunas. Contribution by the other two species, *T. albacares* and *K. pelamis* in this gear total tuna catch was negligible only.
- The size range of the fishes in the catch were: *E. affinis*, 24-60cm, with the mode supporting the fishery in the 38-64cm size range; *K. pelamis*, 24-68cm, with modes in the 42-64cm size groups; *T. albacares*, 28-90 cm, with modes in the 42-86cm size groups; *S. orientalis*, 36-54cm, with modes in the 43-48cm size group; and *A. rochei*, 22-34cm, with modes in the 24-28cm size group. *E. affinis* ranged in fork length from 24-54cm with modes at 38-42cm in drift net . *K. pelamis* ranged in fork length from 34-68cm, *S. orientalis* ranged in fork length from 15-40 cm and *T. albacares* ranged in fork length from 55-70cm in drift net.




**HL: Hoook &Line Fishery**




**DN: Drift Net Fishery**

**3. Development of fishery management for sustaining marine fisheries of Kerala & Lakshadweep**
**Code: FISHCMFRISIL201200300003 Period: 2012-2014**

**Resource: Elasmobranchs**

- An estimated average of 703tonnes of elasmobranchs were landed in Thiruvananthapuram coast in the year 2012 and 2013 with an average cpue of 0.9kg and percentage of the total landing was 1.35.
- Rays are the most common groups landed followed by skates and sharks. In Vizhinjam landing centre, landings were highly irregular, while small landings were observed in Poovar and Panathura.
- Elasmobranchs were landed mainly by gill nets, hooks and line with a share percentage of 84.99% and 15.11% respectively. The fishery was confined in post-monsoon period mainly from August to December. In drift gillnets the cpue was maximum during August-September period (2.3kg) and minimum in December (0.04kg). Rays dominated the fishery with 95.6% of the total elasmobranch landings followed by skates (4.3%). Major species which contributed to the fishery included: *Mobula japonica*, followed by *Himantura* spp. and *Dasyatis* spp. *Rhinobatos* spp., *Carcharhinus* spp., *Alopias* sp. and *Chiloscyllium* spp.

*Himantura* spp.

*Rhinobatos obtusus*

**Resource: 2 Crustacean resources**

- From the Thiruvananthapuram coast, an estimated 20.8t of penaeid shrimps *Fenneropenaeus indicus* and 25.5t of crabs, *Portuns sanguinolentus* were landed by 2,15,980 numbers of gill nets. At Thiruvananthapuram district an estimated 2.6t of penaeid shrimps *Fenneropenaeus indicus* and 29t of non penaeid shrimp *Acetus indicus* were landed by 15,084 numbers of boat seines.An estimated 326kg of penaeid shrimps,108t of non penaeid shrimps and 52.7t of crabs were landed by 2,01,426 numbers of trammel nets at Thiruvananthapuram district. The penaeid shrimp fishery was represented by *Fenneropenaeus indicus* (95%), *Metapenaeus monoceros* (3.5%) and *Parapenaeopsis stylifera* (1.5%) in trammel nets.

- At Vizhinjam and Mulloor an estimated 265kg and 437kg of spiny lobsters were caught by traps and bottom set gill nets respectively during the year. The size of *F. indicus* in the commercial fishery was ranging from 130-170mm in respect of males and females. Sex- ratio was 2.2:1 by males and females in order. The size of *Panulirus homarus* exploited by traps at Vizhinjam was ranged from 90 - 210mm and 110 -230mm in respect of males and females. Sex ratio was 1:1 by males and females. Mean size was 137mm by males and 162mm by females. The size of *P. homarus* exploited by bottom set gill nets at Mulloor was ranging from 91-182mm and 120-225mm in males and females respectively. Sex ratio was 0.7: 1 in males and females. Mean size was 139mm by males and 182mm by females. The sizes of *Portunus sanguinolentus* in the commercial fishery ranged from 80 - 143mm and 82-125mm in respect of males and females. Sex- ratio was 1:1 by males and females in order. The size of *P. homarus* exploited by bottom set gill nets at Mulloor was ranging from 105 - 210mm and 120 - 225mm in males and females respectively. Sex ratio was 1: 1 in males and females. Mean size was 160mm by males and 185mm by females.

**Resource: Cephalopods**

- Studies was conducted on the fishery of cephalopods along Thiruvananthapuram coast. Time series data based on fishery samples collected from landing centres and on observations about catch and effort were generated and analysed. The gears used were hook and line operated from motorized crafts (OBHL), boat seine operated from motorized crafts (OBBS) and those operated from non motorized crafts (NM). Three species contributed to the fishery, viz., *Loligo duvauceli*, *Uroteuthis singhalensis* and *Sepia pharaonis*.
- Using the estimated parameters of growth and mortality, the average exploitation rate (u) of these species for the past two years was calculated. It was 0.63 for the cuttlefish *Sepia pharaonis,* 0.44 for the squid *Loligo duvauceli* and 0.57 for *Uroteuthis singhalensis*. The fishing mortality rate, F was 3.67, 2.41 and 3.86 respectively. The Fmax was 8.48, 10.89 and 6.21 respectively and the F0.1 was 2.15, 3.69 and 2.46. This indicates a low level of exploitation for *L. duvauceli*.

**3. Development of strategies to sustain the stock and fishery of large pelagics in Indian waters**
**Code: FISHCMFRISIL201200700007 Period: 2012-2013**

- In Vizhinjam, the group large pelagics constitute a considerable share to the total fishery accounting for 11.08% of the total marine fish landings during the period. The fishery of all these resources except the tuna *E.affinis*, were highly seasonal. The sail fish *Istiophorus platypterus*, *Xiphias gladius,* the larger tunas like*, Euthynnus affinis, Sarda orientalis, Katsuwonus pelamis, Thunnus albacares*, *T. tongol,* seer fishes such as *Scomberomorus commersoni* and *S. guttatus* and the dolphin fish,

*Coryphaena hippurus* and the belonids were exploited mainly by Hooks & line, drift gill nets and multiday units. The Barracudas was landed mainly by drift gill net followed by mechanized Hooks & line and Boat seine. Major share among the bill fishes landed was by *Istiophorus platypterus* followed by *Xiphias gladius* were landed mainly by multiday units.

- Among the tunas landed, major share contributed by *Euthynnus affinis* followed by *Sarda orientalis*, *Thunnus albacares and Katsuwonus pelamis*. The major share of the landing was by drift gill net, mechanized H&L and multiday units. *Scomberomorus guttatus* and *S. commersoni* landing was mainly by Drift gill net followed by multiday units. The size range of the *Scomberomorus guttatus* landed was from 452 - 667mm and S*. commersoni* from 450 - 670mm. The dolphin fish, *Coryphaena hippurus* ranged from 228 -1029mm in total length and landed mainly by multiday units, drift gill net followed by hook & line.
- The bulk of the fishery of Barracudas was mainly contributed by the smaller size groups of two species, *Sphyraena putnamae* and *S. obtusata*. *S. barracuda* was also observed in the landings in very negligible quantity. The major gear was boat seine net, drift gill net followed by H&L and multiday units. The landings comprised of *Sphyraena putnamae* from 245 - 333mm and *S. obtusata* from 210- 282mm size range. The belonidae fishery was contributed mainly by *Albennes hians* and *Tylosurus* spp. Morphometric and meristic characteristics of *Coryphaena hippurus, Istiophorous platypterus, Sphyraena putnamae, S. obtusata , Scomberomorus guttatus, S. commersoni, T. tonggol, Elagatis bipinnulata, S. orientalis, E. affinis, Scombroides lysan, S. tala* and *Albennes hians*, were collected for taxonomic studies. Biological studies have been carried out for all the above mentioned species.

**Size range (mm) observed in the fishery**

| ***Species*** | **Size(mm)** |
|---|---|
| *Istiophorus platypterus* | 1050 - 2020 |
| *Makaira* spp | 980- 2400 |
| *T. albacares* | 570-1320 |
| *K. pelamis* | 440-980 |
| *Scomberomorusguttatus* | 480-1050 |
| *S. commersoni* | 560-1250 |
| *Coryphaena hippurus* | 110-1180 |
| *Sphyraena putnamae* | 330-525 |
| *S. obtusata* | 144-205 |
| *Rachycentron canadum* | 560-780 |

*Istiophorus platypterus*

Landings of large pelagic fishes

*Xiphias gladius*

*Coryphaena hippurus*

**Demersal Fisheries Division**

**1. Management advisories for sustaining marine fisheries of Tamil Nadu and Puducherry**
**Project Code: DEM/IDP/01 Period: 2009-2012**

- The fishery and resource characteristics of lobsters carried out exclusively by artisanal sector were monitored from Colachel, Kadiapatanam and Chinnamuttom in Kanyakumari district. The resources are exploited by traps and bottom set gill nets engaged by catamaran and canoes operating within 20m depth. An estimated catch of 11.8t of spiny lobster *P. homarus* was caught by 8,605 numbers of bottom set gill nets at a cpu of 0.685kg at Colachel. July - December period was observed as good season for lobsters along the coast as about 80.0% of the catch was caught during this period. The average monthly units operated were ranged from a minimum of 67 during June to a maximum of 755 units during March. The spiny lobster fishery exhibited declining trend during 2009, contributing an estimated 5.3t and 4.1t during 2010. It declined further to 1.8t during 2011. An estimated 2.5t of spiny lobsters were caught by bottom set gill nets at a catch per unit of 1.161kg at Chinnamuttom.
- The fishery showed an increasing trend during 2010 contributing 1.8t from an initial production of 0.6t observed during 2009.The sizes of males and females of *P. homarus* in the fishery were ranged from 101 - 300mm and 95 - 300mm in order. Berried females observed during May and December. The size at 50% of males and females caught was estimated as 153mm and 163mm respectively.
- An estimated 4.5t of spiny lobsters were caught by traps at a catch rate of 0.970kg per unit Kadiapatanam. The annual catch per unit effort ranged from 0.885 kg in 2009 to a maximum of 1.032kg in September 2010. Peak season for the fishery were observed during September - December. The fishery was represented by three species *P. homarus*, (65.7%), *P. ornatus* (33.8%) including stray numbers of *P. versicolor* (0.5%).
- The fishery showed an increasing trend during 2010 contributing 2.7t from an initial production of 1.7t observed during 2009. The sizes of *P. homarus* males and females in the fishery were ranged from 95 to 300mm and 106 to 286mm in order. May and December period formed spawning season. The size at 50% of males and females captured at the centre was estimated as 150mm and 162mm respectively. An estimated 215kg of spiny lobsters were caught by bottom set gill nets at a catch per unit of 0.480kg at Kadiapatanam.The fishery was constituted by three species such as *P. homarus* (52%), *P. ornatus* (42.8%) and *P. versicolor* (5.2%).

**2. Development of fishery management plans for sustaining marine fisheries of Tamil Nadu and Puducherry**

**Code : FISHCMFRISIL201200800008 Period : 2012-2014**

- At Chinnamuttom, an estimated 4.5.9 t of spiny lobsters were caught by 6200 numbers of bottom set gill nets at a catch per unit of 0.859 kg. The fishery was represented by *Panulirus homarus* (94.3%), *P.ornatus* (3.4%) and *P.versicolor* (4.3%). The sizes of *P.homarus* in the commercial fishery at Chinnamuttom were represented by 92-190mm and 107-210mm by males and females. Mean size was 132mm by males and 139mm by females. The sex-ratio was 1.1: 1 by males and females.
- At Colachel, an estimated 6.8t of spiny lobsters were caught by 7,296 numbers of bottom set gill nets at a catch rate of 0.680kg. The sizes of *P. homarus* in the commercial fishery at Colachel were formed by 112-250mm males and 89-270mm females. The sex ratio was 0.9:1 by males and females. The mean size was 178mm by males and 182mm by females.

**3. Assessment of Elasmobranch resources in the Indian seas**

**Code: FISHCMFRISIL201200500005 Period: 2012-2013**

- Major landing centres included: Muttom, Colachel, Thoothoor and Vizhinjam. Rays were the most common groups landed followed by skates and sharks. In Thoothoor, the landings directly go to processing centres and in Vizhinjam and Muttom the landings were irregular. Small landings were noted in Tengapatnam, Poovar and Panathura. Major portion of the Colachel landings also brought to Thoothoor for processing. The average landings in Colachel, Thoothoor, Muttom and Vizhinjam were 0.9t/day, 0.5t/day, 0.1t/day and 0.09t/day respectively.
- In Colachel the catch was contributed by 77.7% rays, 21.4% skates and 7.1% sharks. In Thoothoor, the catch was contributed by 66.6% rays, 20.8% skates and 12.5% sharks. In Muttom, the catch was contributed by 87.3% rays, 7.9% skates and 4.7% sharks. In Vizhinjam the catch was contributed by 95.6% rays, 2.3% skates and 1.9% sharks.
- At colachel, the most dominant species of ray landed was *Himantura* spp. and dominated by *Himantura urnak, Himantura jenkinsii* and *Himantura gerrardi*. The second dominated group was *Dasyatis* spp. dominated by *Dasyatis kuhlii*. Rare landings of *Gymnura poecilura, Aetomylaeus nicolfii, Rhinoptera javanica, Aetobatus flagellum, Pastinachus* sp. and *Taeniura meyeni* were noted.
- Skates: Considering the weight, the dominant species is *Rhina ancylostoma* followed by *Rhinobatos obtusus* and *Rhinobatus* sp. considering the numbers *Rhinobatosobtusus* contribute almost 80% of the total skates landed. Sharks are not regularly landed unlike rays and skates. The species noted were: *Carcharhinus falciformis*, *Rhizoprionodon acutus, Scoliodon laticaudus, Chiloscyllium* spp.,

*Carcharhinus* spp., *Sphyrna mokarran*, *Rhizoprionodon acutus, Iago omanensis,* and *Galeocerdo cuvier*.

- At Muttom, major landings was *Himantura* spp. followed by *Mobula japonica, Manta birostris* and *Dasyatis* spp. *Rhinobatos* spp*., Scoliodon laticaudus, Chiloscyllium* spp., *Carcharhinus* spp. and *Sphyrna mokarran.*
- At Thoothoor, major landings are *Manta birostris* followed by *Himantura* spp. *Dasyatis* spp., *Rhina ancylostoma, Alopias* spp., *Scoliodon laticaudus, Carcharhinus* spp., *Sphyrna mokarran* and *Galeocerdo cuvier*.
- At Vizhinjam, major landings are *Mobula japonica* followed by *Himantura* spp. and *Dasyatis* spp. *Rhinobatos obtusus* and *Rhinobatus* spp.

*Rhina ancylostoma*

*Mobula japonica* and *Himantura uarnak*

*Rhinobatos* spp.

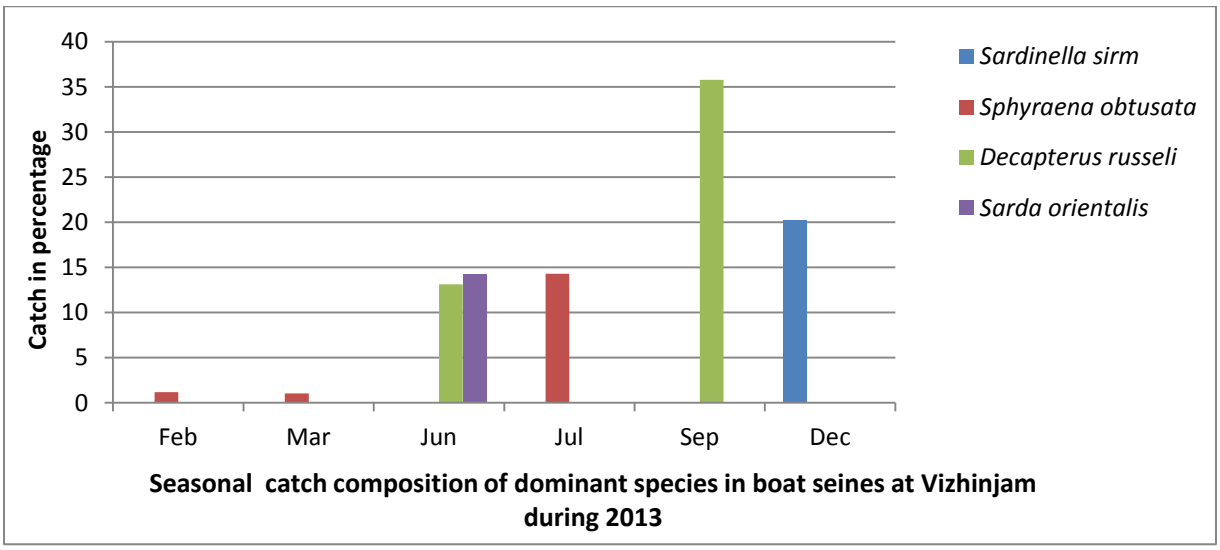
Tiger shark *Galeocerdo cuvieri*

## Crustacean Division

**1. GIS based resource mapping of distribution and abundance of fin fishes and shell fishes off Indian coast for suggesting operational based strategies for fisheries management**
**Code : FISHCMFRISIL201200900009 Period :2012-2013**

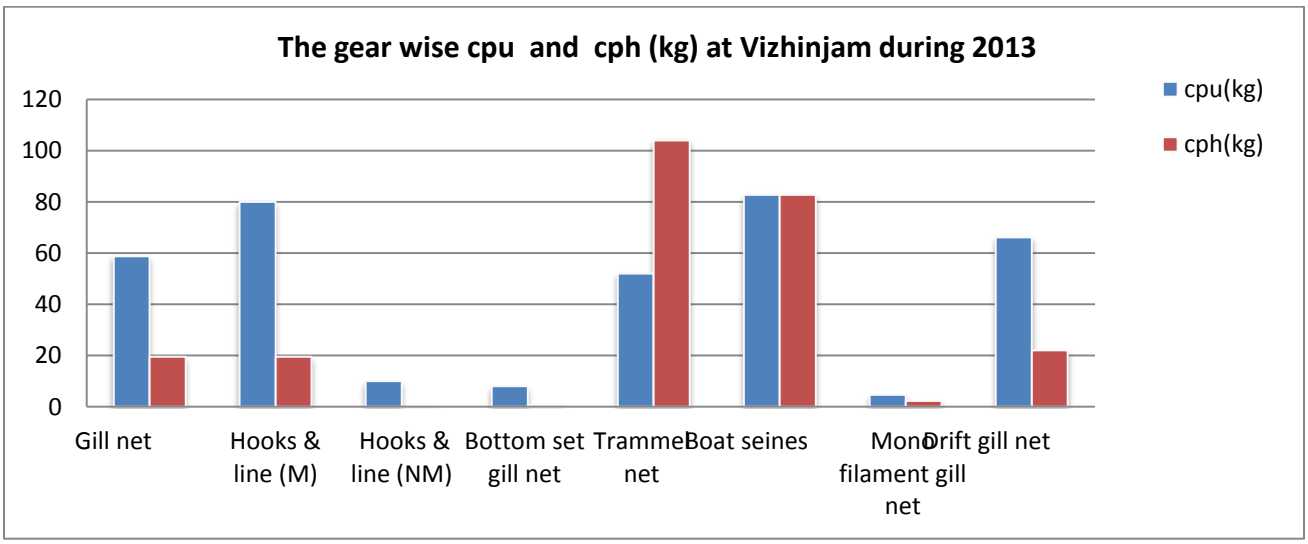
- Spatial and temporal distribution pattern of commercially important fishery resources were ascertained documenting data on catch, species composition, effort, area of fishing operation *etc* by different craft and gears operated at Thiruvananthapuram district of Kerala.
- The real time data being collected on GPS reading of fishing zones, landing centers, gear wise species composition, biological aspects, juvenile and spawner composition of commercial catch, cph and cpue, would give a picture of spatio- temporal resource distribution, species correlation graphs *etc.* on commercial fishing grounds by the end of the project which would be very much useful for fishery resource mapping, planning, policy making and sustainable exploitation of the fishery resources.
- In Thiruvananthapuram district, fishing is carried out only by traditional craft and gears. Data on fish landings from different gears was collected and estimated total catch, species composition, size frequency including biology of dominant species from Vizhinjam and Poovar. Inventorisation of all the fish landing centres (42 numbers) of Thiruvananthapuram district of Kerala was done. The fishing gears operated at Thiruvananthapuram district was Hooks and lines, hand lines, boat seines, shore seines, gillnets, drift gill nets, bottom set gill nets, trammel nets and lobster traps.
- The depth of operation of the gears operated from all the landing centers were ranged from 0.5m to a maximum of 60m. The distance of fishing operation from sea shore was observed as a maximum of 25km. The fishing season was recorded as whole year at Vizhinjam and January - May, September - October at other centres.
- The gill net fishery at Vizhinjam represented 51 species dominated by *Rastrelliger kanagurta* (67.3%) followed by *Decapterus macrellus* (9.5%), *Stolephorus indicus* (6.1%). The bottom set gill net fishery at Vizhinjam represented 32 species dominated by *Saurida tumbil* (18.2%) followed by *Pomadysis maculata* (17.32%). The hooks and line (NM) fishery at Vizhinjam represented 7 species dominated by *Lutjanus lutjanus* contributing 54.8%. The hooks and line (Mech) fishery at Vizhinjam represented 9 species dominated by *Auxis rochi* (65.4%) followed by *Decapterus russeli* contributing (19%). The trammel net fishery at Vizhinjam represented 4 species dominated by *Narcine timlei* (57.6%). The monofilament gill net/Thangoose net at Vizhinjam contributed 16species dominated by *Pomadysis maculatus* (33%) followed by *Saurida tumbil* (21.8%).

- Drift nets at Vizhinjam represented 16 species dominated by *Rastrelliger kanagurta* (49.6%) followed by *Auxis rochi* (32.5%). The Thangal vala fishery at Vizhinjam represented 5 species dominated by *Istiophorus spp* (44 %) followed by *Katsuvonus pelamis* (24%). The Boat seine fishery at Vizhinjam represented by 15 species dominated by *Sarda orientalis* and *Sardinella sirm*. The Long Line fishery at Vizhinjam represented by 6 species dominated by *Mene maculata* (57%) followed by *Katsuwonus pelamis* (38%).



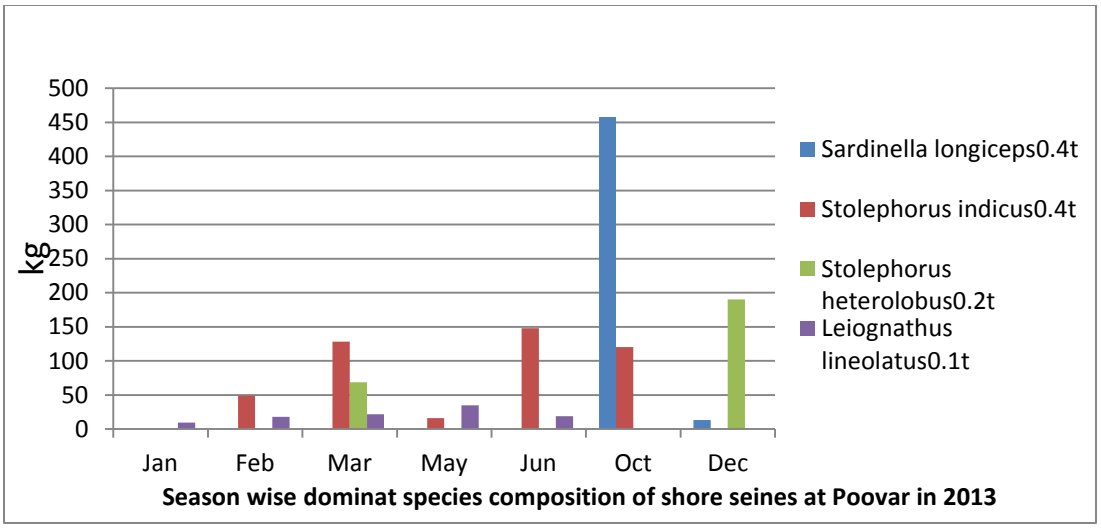

**Seasonal catch composition of dominant species in boat seines at Vizhinjam during 2013**

- The seasonal species composition of major species in boat seines at Vizhinjam showed though 15 species contributed to the fishery,their catch was low and only a single species, *S.obtusata* found available in the fishery during three months. Bulk of the catch was observed during monsoon period at Vizhinjam followed by post monsoon season.

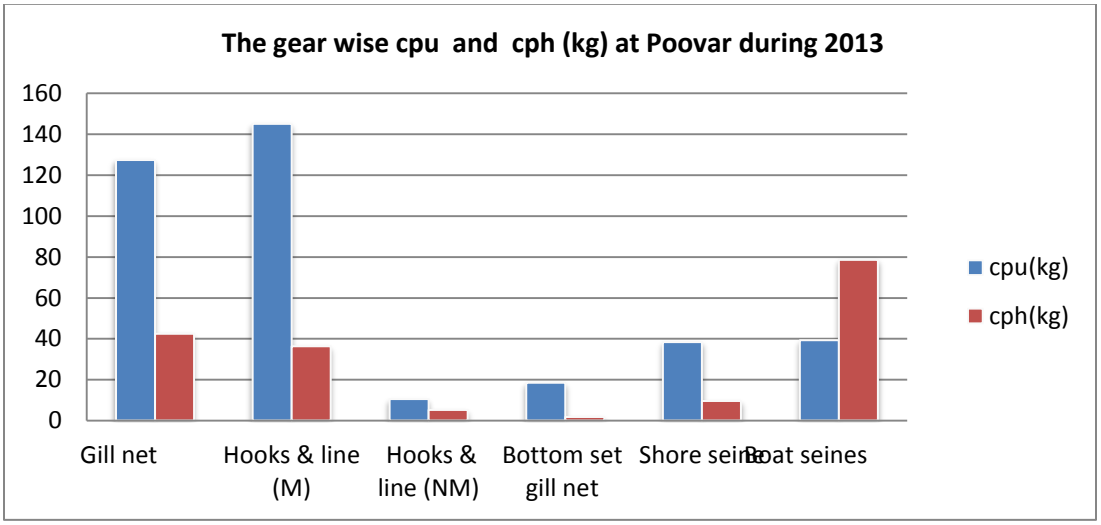


**Seasonal distribution of juveniles**

- At Vizhinjam, juveniles of *Leiognathus splendens, Siganus canaliculatus, Sphyraena obtusata, Gazza minuta, Ambassis urotaenia, Athryna boyeri and Pempheris moluca* were observed during February. Juveniles of *Apogon lineolatus, Secutor insidiator and Decapterus russeli* were observed during May and *Stolephorus indicus* were observed during June. The shore seine fishery at Poovar represented by 30 species. The seasonal species composition of dominant species and gear wise catch rates are given in the following figures.



**Season wise dominat species composition of shore seines at Poovar in 2013**



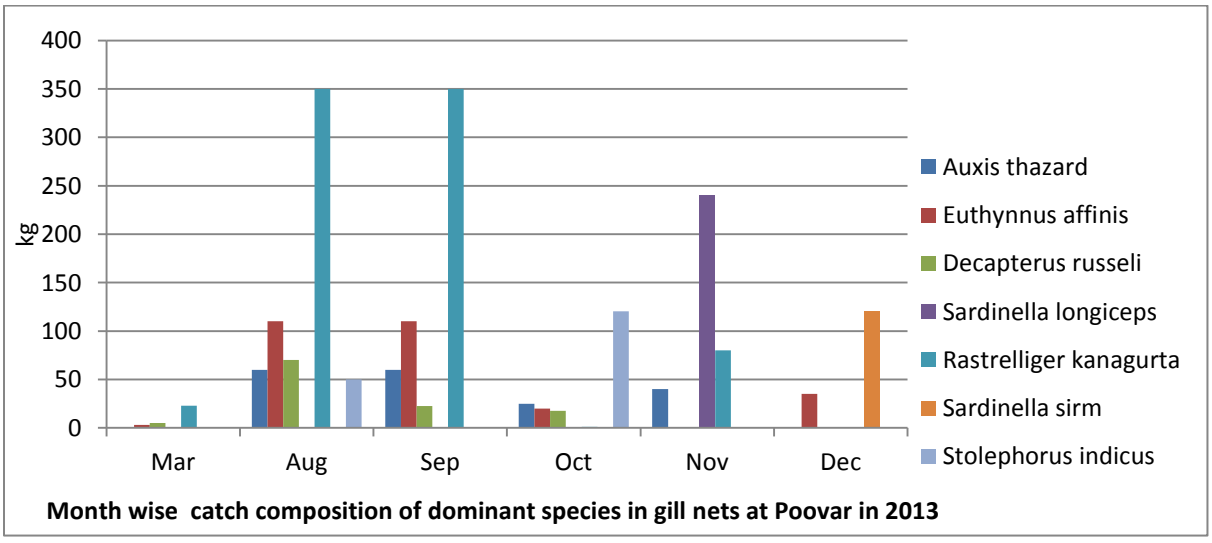

- The gill net fishery represented 15 species dominated by *Pomadysis maculata* (37.1%), followed by *Rastrelliger kanagurta* (34.6%) and *Caranx ignobilis* (10.4%). The bottom set gill net fishery at Poovar represented 23 species dominated by the skate, *Rhina ancylostoma* (66.3%) followed by *Saurida tumbil* (7.74%). The boat seine fishery at Poovar was represented by 13 species and dominated by *Sardinella sirm* (65.5%).

**Seasonal distribution of juvenile fishes off Poovar (Trivandrum coast)**

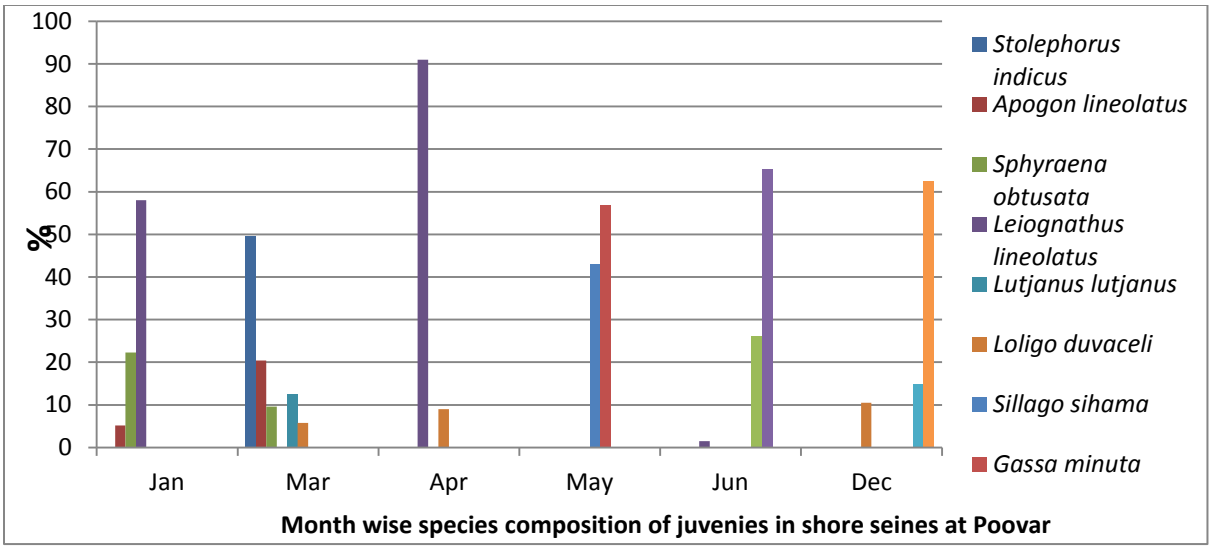
At Poovar, juveniles of *Auxis thazard, Leiognathus lineolatus, Siganus canaliculatus, Sphyraena obtusata, Decapterus russeli* and *Sphyraena bleaker were* observed during January. Juveniles of *Apogon lineolatus* were observed during January and March. Puffer fish and *Loligo duvaceli* were observed during March and juveniles of *Megalapsis cordyla* and *Thryssa setirostris* during June. When compared to Poovar, the species diversity was more at Vizhinjam. Exploitation of juveniles was observed very high level at Poovar. Among all the gears operated at Vizhinjam and Poovar, shore seines were traced most destructive gear operated at Thiruvananthapuram district on account of bulk catches of commercially highly important varities of finfishes such as *Auxis thazard, Sphyraena obtusata etc.* At Vizhinjam, boat seines recorded highest cpu of 82.7kg and at Poovar, hooks and lines (mechanized) recorded highest cpu of 145kg.

Shore seine fishing operation at Poovar

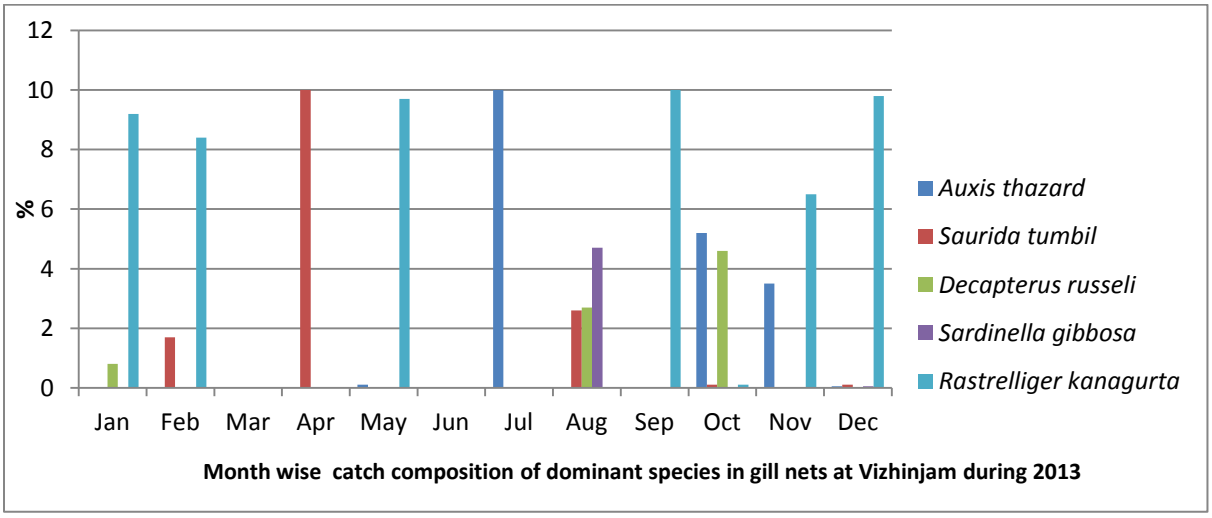
Catch in shore seine at Poovar



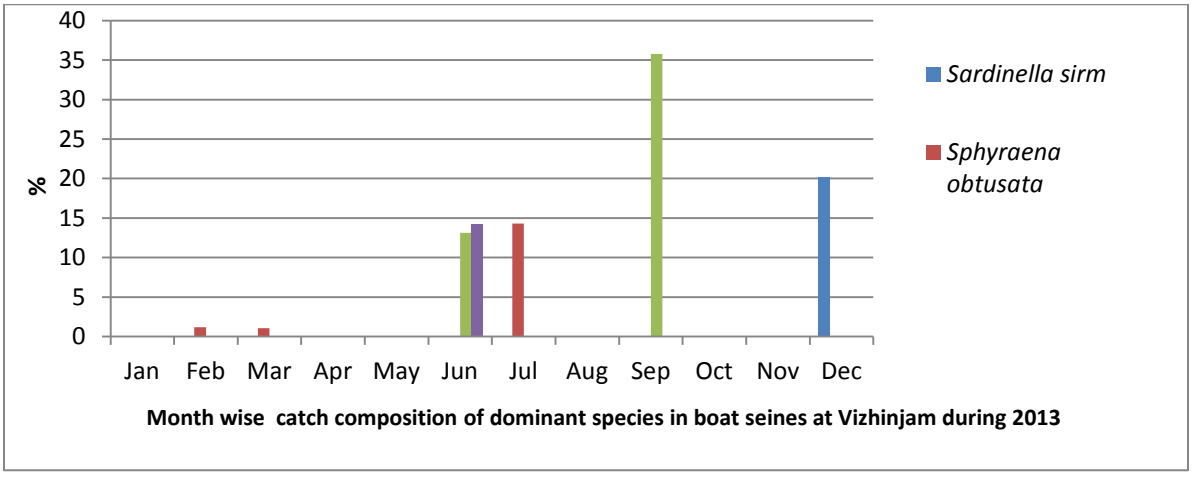

**Month wise catch composition of dominant species in gill nets at Poovar in 2013**




**Month wise species composition of juvenies in shore seines at Poovar**




**Month wise catch composition of dominant species in gill nets at Vizhinjam during 2013**




**Month wise catch composition of dominant species in boat seines at Vizhinjam during 2013**

## Molluscan Division

1. **Sustainable Molluscan mariculture practices**
   **Code: FISHCMFRISIL201200900009 Period: 2012-2014 &**
   **Molluscan mariculture: Project title: Sustainable molluscan mariculture practices (FISHCMFRISIL201201400014)**

- **Building up of stock of oysters for image pearl production studies:** More than 3000 oysters *Pinctada fucata* and 1025 numbers of *P. sugillata* were collated and stocked. The oysters were taken out every month and cleaned to prevent the accumulation of fouling organisms.
- **Development of techniques for production of image pearl nuclei using shell cement and acrylic polymers:** Quality image nucleus is a prerequisite for the production of quality image pearls. The thickness of the nucleus, thickness of the groves and lines which describe the image is important. An eight- step process involving making of metal templates, making of mould, hot and cold process of image nuclei making and grinding the nuclei to proper size was developed. The methodology was standardized for making images using acrylic polymer (DPI RR cold cure polymer resin) and shell powder.
- Developed techniques for production of image pearl nuclei using shell cement and acrylic polymer.
- During the period under study 600 image nuclei were produced and were implanted in 390 oysters of 50 to 75mm DVM. The implanted oysters were stocked in cages at the rate of 50numbers/ cage. Oysters were harvested 52 days after implantation and the rate of "A" quality image pearls ranged from 10 to 15%. Harvested oysters were also analysed to assess the variation in nacre secretion and quality in different seasons. An amount of Rs. 6000/- obtained through sale of image pearls was remitted to ICAR account.

Image pearl ornaments

**Submission of a Frontline demonstration project on designer pearl culture to the Department of Fisheries to the Government of Kerala:** As per the request from the Director of fisheries, Government of Kerala, for initiating and implementing a pilot project on pearl culture, field visits to various sites and existing hatcheries of state government were carried out. Based on the discussions and visits, a frontline demonstration project was prepared and submitted to the state government and it is in the final stages of approval.

**Image pearl implantation trials: I**mplantation trials to study the effect of area of implantation of nuclei on pearl production was conducted. About 400 image nuclei were produced and were implanted in 200 oysters of 55 to 80 mm DVM. The implanted oysters were stocked in cages at the rate of 50 numbers per cage. Oysters were harvested 52 days after implantation. Nacre coating ranged from 65.1 to 93.02 micron at various sites of implantation. Nucleus implanted close to the mantle edge gave darker shades and thicker coating. The region nearer to the body mass gave silvery coloration and the coating was thinner. Left valve gave more space for implantation that larger nucleus could be implanted.


Cleaning of oysters


50 mm DVM oysters


70 mm DVM oysters stock in cages

**Designer pearl exhibition**

A designer pearl exhibition was organized in conjunction with the National training on designer pearl production and the the exhibition was inaugurated by honorable minister for fisheries, Govt. of Kerala,

**2. Development of fishery management plans (FMPs) for the bivalve fisheries of India**
**Code: FISHCMFRISIL201201200012 Period: 2012-2013 & 2013-2014**

- The brown mussel *Perna indica* was exploited mainly along Kovalam-Pulinkudi coast. The annual catch was 656t and catch per effort was 41kg/man day. The peak fishing season was October-November.
- The estimated average L-opt for this species for the past two years, considered as a reference point for exploitation, was 7.4cm whereas the $L^{-}$ was 7.9cm.
- The fishing mortality rate, F, was 2.12 and the exploitation rate 0.57.

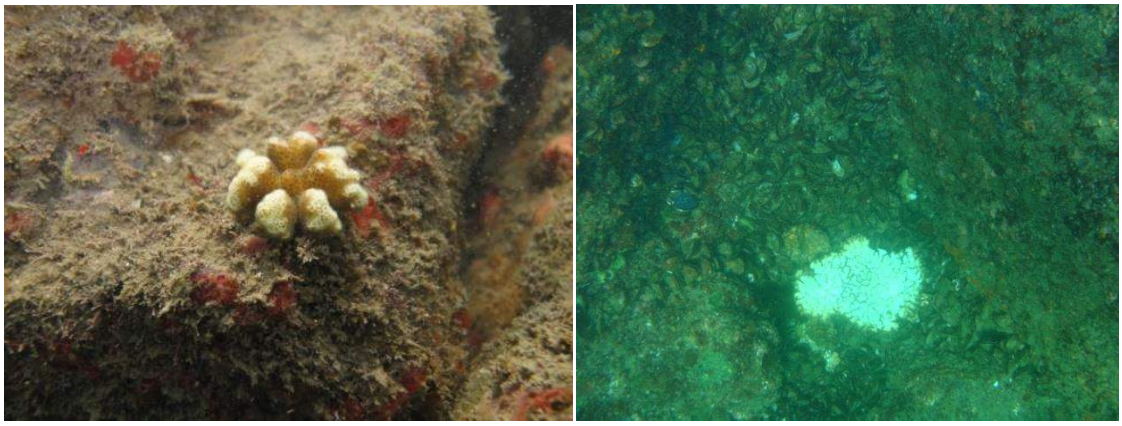
**Marine Biodiversity Division**

**1. Understanding the threatened coral reef Ecosystems of Southern India and Designing Interventions aimed at their restoration**

**Code: MBD/RE/01 Period: 2009-2012**

**Coral and sponge resource survey**

- Resource surveys were conducted along Kollam inshore waters following Line Intercept Transect method to collect information on the present status of coral cover and biodiversity. The reefs spread around Thankassery Harbour and Thirumullavaram waters were surveyed and the reefs were monitored regularly during the period and found to be the richest in species belonging to the family Pocilloporidae and Poritidae.
- The coral growth was patchy and sparsely distributed and the total coral cover was less as compared to reefs of south-west coast of India. A single species, *Porites lutea* was the single most dominant species in Thirumullavaram. However, *Pocillopra damicornis* and *Pocillopora verrucosa* and *Pocillopora meandrina* were recorded in the Thankassery harbour area.



Bleached *P. damicornis* Thankassery & Enayam

- This survey revealed that the reefs of Thankassery harbour area were live, partially bleached and had dead specimens of pocilloporids, whereas in Thirumullavaram waters, diseased corals were predominant and therefore these reefs could be termed 'fair' in condition as the live coral cover was less than 50%. Most of the massive corals in this area were covered with algae/seaweeds and sediments and therefore were either dead or affected by disease.

- Similar comprehensive survey conducted at Vizhinjam Bay to assess the reef condition revealed substantial growth in live coral colonies compared to the previous surveys conducted during two consequetive years.
- Coral diversity and growth, fish assemblages and sponges associated with patchy coral reefs around Muttom and Enayam in Tamil Nadu and Adimalathura to Thankassery in Kerala (South India) were re- investigated using Line intercept transect and visual census methods in 2012. The study revealed a decline in the existing coral cover due to encrustation by zooanthids and bleaching of corals in Enayam. The study also revealed reduction in coral growth in the Vizhinjam bay due to sedimentation and other anthropogenic activities in this area. But outside the bay, live coral colonies on the rocks were found to be in healthy condition including recruitment of several new species.

Zooanthid encrustation

- The corals collected from Tuticorin Harbour were identified and were represented by the following species; *Favia speciosa, Favia pallida, Goniastrea pectinata* ,*Goniastrea retiformis*, *Hydnophora microconos* and *Echinopora lamellosa.* Species status was prepared for the Tuticorin harbour by combining the earlier transects data.

**Reef fishes**

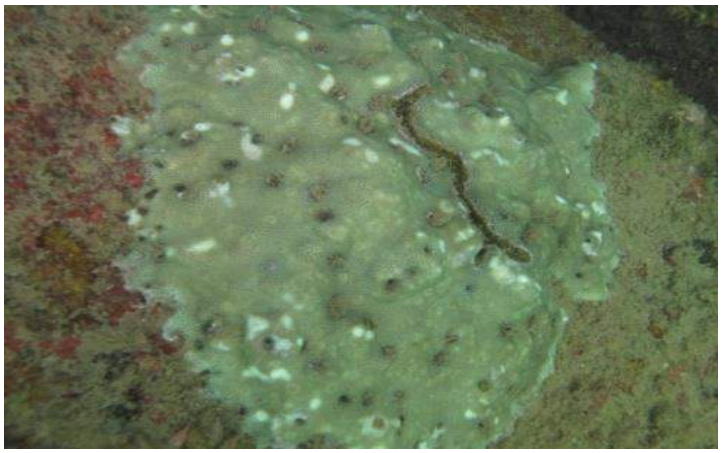
- Visual survey carried out from Muttom to Thankassery area, particularly on hard corals, sponges and associated fauna revealed a rich biodiversity along this coast. A rich assemblage of marine ornamental fishes was observed, especially in Thirumullavam temple point, Thankassery harbour, Paravoor, Odayam, Varkala, Vizhinjam, and Enayam.

- The Visual Census Method revealed a total of 47 species of reef fishes belonging to 30 genera, and 20 families along Enayam-Kollam waters in Southern India. Maximum species diversity was recorded at Thankassery (23 species), followed by Vizhinjam (20) and Varkala (20 species).
- Ornamental fishes collected in traps operated from Vizhinjam and also from the local landings were recorded. The coral reef fishes from traps in and around Vizhinjam waters were dominated by species belonging to families Chaetodontidae (Butterfly fish), Pomacentridae (Damsels) and Siganidae (Rabbit fish). However, Species belonging to families such as Balistidae (Trigger fish), Lutjanidae (Snapper), Acanthuridae (Surgeon fish) and Apogonidae (Cardinal fish) were also represented, but in sparse numbers.
- Major species recorded in the local landings were *Acanthurus mata*, *Abudefdef saxatilis, Sargocentron rubrum, Epinephelus malabaricus, E. tauvina, E. sonnerati, Apogon aureus ,Lutjanus lutjanus, Lutjanus fulvus, Siganus javus, Siganus canaliculatus, Sufflamen fraenatum ,Odonus niger, Parupenaeus indicus, Balistapus undulatus, Scarus sordidus, Abalistes stellatus etc.*

**Coral Diseases**

- From samples of ulcerative white spot syndrome affected corals (*Porites* sp.) collected from Vizhinjam Bay, unique pink translucent bacterial colonies were isolated on Marine broth (MB)agar. These organisms were found to be slow growing gram negative rods, difficult to grow on general purpose media. The strains were sent to IMTECH, Chandigargh for phenotypic characterization and were identified as *Sphingomonas* sp. Another strain (C144) isolated from *Pocillopora* sp. from Vizhinjam Bay, growing as orange red colonies (Gram positive cocci) on Nutrient agar plates (with 2.5% added NaCl), was identified as *Microbacterium arborescens*. *Vibrio* spp. were the predominant colonies ioslated from bleached *Pocillopora* sp. which are being identified to species level.
- A unique bacterial strain C29 was isolated from *Porites* sp. collected from Vizhinjam waters forming pink translucent bacterial colonies on Marine broth (MB) agar. These were the predominant colonies grown on direct plating of the coral tissue homogenate on MB agar plates. The strain was suspected belonging to *Sphingomonas* sp. based on phenotypic characteristics. Further, based on 16S rRNA gene sequencing and blast search, this strain was found to be a potential novel genus showing 95% similarity to *Fabibacter halotolerans* under the family Flexibacteraceae.
- Another orange pigmented strain C144 isolated from the branching coral *Pocillopora* sp. was identified as *Microbacterium arborescens* based on phenotypic characteristics. The strain is

characterized by its ability to produce strongly pigmented orange colonies and could be a potential source of carotenoid pigments.



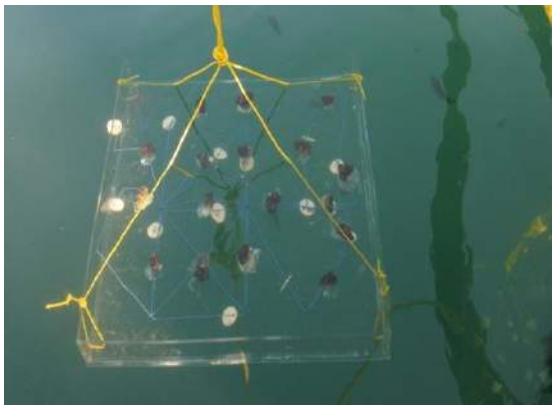
*Porites* ulcerative white spot syndrome at Vizhinjam bay

Pink line syndrome in *Porites lutea* from Thirumullavaram, Quilon

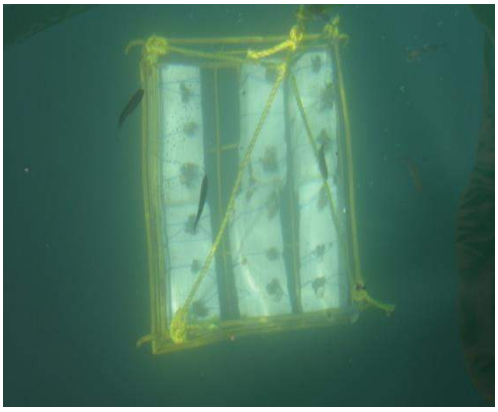
**Propagation studies**

- Preliminary studies were made to assess the suitability of various substrates for undertaking growth studies on corals in Vizhinjam Bay using *Pocillopora* spp. Based on the results,Experiments for growth studies of hard corals were initiated in 2010-11 period with the view to replenish the degraded coral beds in Vizhinjam Bay using the available coral, *Pocillopora* spp. suspended from a floating raft with different substrates such as plastic baskets, cement coated bricks and acrylic sheets.

Raft for suspension of corals



Corals attached to the Acrylic sheet



Corals attached o the cement coated bricks

Coral growth in Vizhinajm

Fouling in the acrylic sheet

- Although all the fragments were found completely attached to the substrates, the rate of attachment was faster in the cement coated bricks than the acrylic sheets. An average increase of 7.5 mm in length was noticed for *Pocillopora damicornis* within a period of three months.
- The growth increment for *Pocillopora* spp. in the natural habitat in the Vizhinjam waters was also recorded using Line Intercept Transect method and an average growth rate of 1.32cm/year was

noticed in Vizhinjam Bay with comparatively high rate of survival and growth for *Pocillopora damicornis*. In the first set of experiments, heavy fouling was noticed in the Acrylic sheet mainly by ascidians, oyster, and encrusting sponges after a period of one year. To avoid fouling, in the second series routine cleaning was carried out to remove the sediment and foulers.

**Sponges**

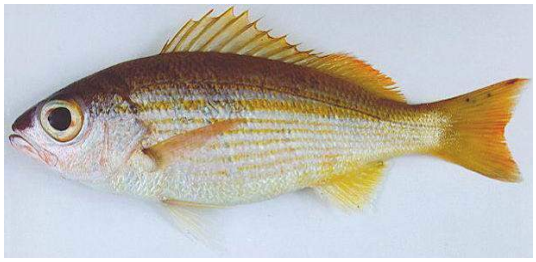
- Underwater surveys conducted in the shallow coastal waters extending from Enayam to Kollam, southern India revealed a total of 24 species of sponges which were identified during the study and belonged to 20 genera, 13 families and 6 orders. Maximum species diversity was recorded at Enayam (11 species), followed by an equal number of species at Vizhinjam and Adimalathura (10 species). A majority of sponge species at Enayam, Vizhinjam and Adimalathura were found to be associated with the mussel beds.

**2. Species variation and biodiversity of the fishes of the family Lutjanidae of India**

**Code: MBD/RE/04 Period: 2009-2011**

- Specimens collected from Vizhinjam and Enayam were identified upto species level. Morphometric and meristic measurements were taken and also information on distribution, synonyms, morphometric and meristic details were documented for all the 18 species recorded for the two years from this centre under the genera *Lutjanus, Aphaeurus, Aprion, Pinjalo, Lipocheilus* and *Pristipomoides.*
- Digitized species profile was prepared for the major species collected and they were *Aprion virescens, Aphaeurus rutilans*, *Lutjanus russelli, Lutjanus lutjanus, Lutjanus vitta, Lutjanus fulviflamma, Lutjanus bohar, Lutjanus decussatus, Lutjanus kasmira, Lutjanus biguttatus, Lutjanus fulvus, Lutjanus erythropterus, Lutjanus lemniscatus, Lipocheilus carnolabrum, Etelis carbunculus, Pristipomoides filamentosus* and *Pristipomoides sieboldi*.
- Although snappers seldom constitute the main focus of major commercial fisheries, they are an important component of the local artisanal catch. In Vizhinjam, Lutjanids contributed a minor share in the local fishery mainly by the gears hooks & line, drift net, boat seine etc. The seasonal fishery of Pristipomoides was the only genus which contribute to the total fishery in this centre.

**Lutjanid Species recorded from Vizhinjam**



*Lutjanus lutjanus*

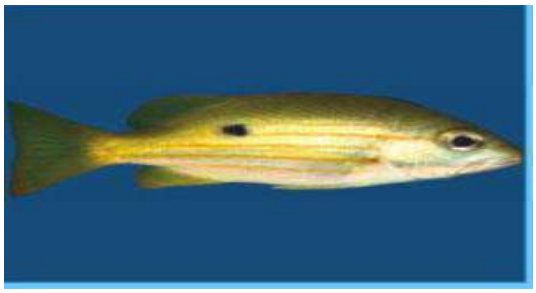

*Lutjanus vitta*

*Lutjanus quinquilineatus*

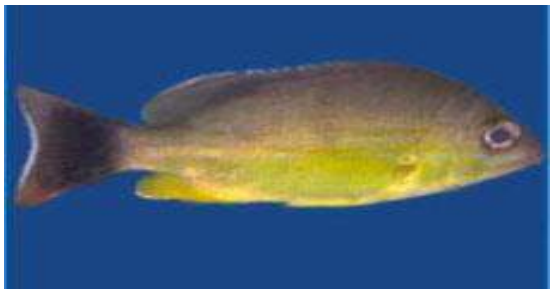

*Lutjanus bohar*

*Lutjanus lemniscatus*

*Lutjanus decussatus*

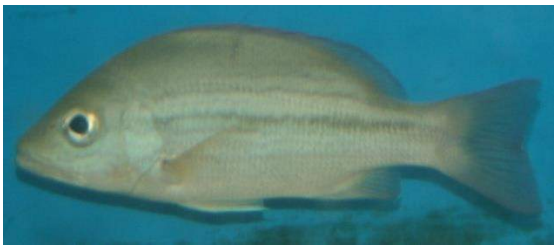


*Lutjanus fulviflamma*

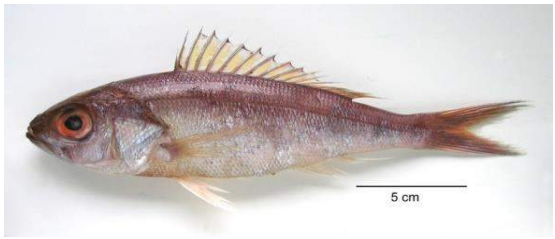


*Lutjanus fulvus*

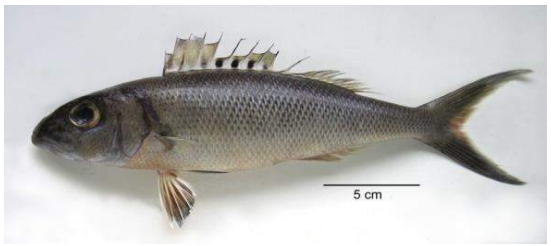
*Lutjanus erythropterus*



*Lutjanus biguttatus*



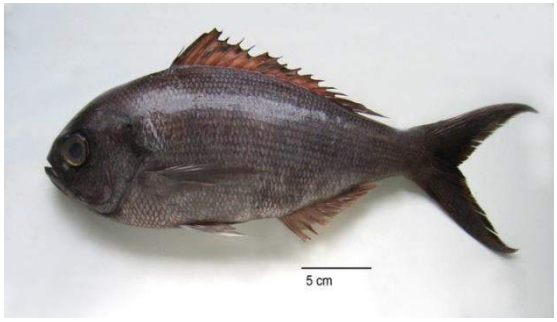

*Aphaeurus rutilans*




*Aprion virescens*

*Etelis carbunculus*

*Pinjalo pinjalo*




*Pristipomoides seiboldi*


*Lipocheilus carnolabrum*

**3. Assessment of biodiversity and ecological changes in open sea cage**

**Code: MBD/RE/05 Period: 2010-2012**

- At Vizhinjam, the analysis of water quality parameters indicated no significant changes between the cage and the control sites. The sediment was silty in the cage site and sandy in the reference site.
- Thirty two genera of phytoplankters were recorded from the study sites, comprising both the cage and reference sites. A total of 16 groups of zooplankters were recorded from the cage and reference sites. Macrobenthos were less abundant in the reference site than in the cage site. The macrobenthos in the cage site comprised mainly of amphipods, bivalve shells, gastropods, polychaetes, copepods, nematodes, sipunculids and algae. In the control site, bivalves were the dominant, while copepods were in meager.
- One of the important bottlenecks for the sea cage farming is the biofouling of net and cages. Knowledge on succession of fouling is important to adopt easy management strategies for net

exchange and net cleaning which is one of the most difficult tasks of sea cage farming. Hence, experimental panels were suspended and fowlers were regularly sampled and analysed for one year each in Chinnamuttom (Kanyakumari) and Vizhinjam. It is essential to know the succession of fouling communities for controlling their bio-fouling effectively. Barnacles, oysters, mussel, algae and sponges were the main foulers which causes maximum damage to the nets. Most of these were reproducing seasonally and thus knowledge about their community structure and succession pattern, can pave ways for management measures for controlling them at the early stages of their development.

- Experimental panels made of PVC pipes (15cm x 15cm) with 2cm mesh netting were suspended to study the fouling communities. Examination of panels revealed that the most common species of associates were sponges, colonial ascidians, solitary ascidians, and hydroids
- In both the areas, the fouling succession followed almost same pattern. In May-oyster spat, June-barnacles, July-mussel spat and August-miscellaneous species including sponges were found. From September onwards algae started appearing and in November and December algae completely dominated. It was also observed that the season of installation of the cage has significant impact on the ultimate dominance of the fouling species. The succession of foulers in this area started with oysters, followed by barnacles, mussels and algae. For most of the fin fish species a change of net during first week of August clears most of the foulers at least for the next 6-9 months.

Experimental panels in Chinnamuttom, Kanyakumari

PVC frame with experimental panels

Checking the panels in Vizhinjam

Fouled net block the movement of water

Barnacle spat (June)

Algae (November)

**5. Biodiversity evaluation of marine ecosystem of the south west coast of India**

**Code: MBD/RE/06 Period: 2011-2012**

- An inventory on seaweeds, sea grasses and hard corals recorded from south west coast of India especially from Kerala and Lakshadweep was prepared. Among the 118 species of sea weeds, majority belongs to the family Rhodomelaceae(13), followed by Caulerpaceae(10), Cladophoraceae(6), Ulvaceae(5), Dictyotaceae(5), Ceramiaceae(4), Cystocloniaceae(4), Valoniaceae(4), Sargassaceae(4), Codiaceae(3), Halimedaceae(3), Oscillatoriaceae(3) and Gracilariaceae (3). Following families were represented by two species each viz., Bryopsidaceae, Siphonocladaceae, Galaxauraceae, Solieriaceae, Lomenariaceae, Gelidiellaceae, Halymeniaceae and Spyridiaceae.
- The families Acrochaetiaceae, Anadyomenaceae, Galaxauraceae, Bonnemaisoniaceae, Dichotomosiphonaceae, Siphonocladaceae, Scytosiphonaceae, Gloiosiphonaceae, Champiaceae, Boodleaceae. Derbesiaceae, Dasyaceae, Ectocarpaceae, Gelidiaceae, Scytosiphonaceae, Anadyomenaceae, Udoteaceae, Sphacelariaceae and Phormidiaceae were represented by single

species only. Seagrasses represented two families. Among the six species recorded four species belong to the family Cymodaceaceae and three species represented the family Hydrocharitaceae.

- The hard coral fauna of Lakshadweep and Kerala coast, revealed a reported number of 195 species from the study area belonging to the class Anthozoa.
- The subclass Hexacorallia was represented by 15 families reported from this area. Among this, the family Acroporidae dominated with 55 species, followed by Faviidae with 34 species, Fungiidae with 19 species and Poriitidae with 18 species. 13 species were reported under the family Agaricidae, and 10 species under Pocilloporidae and Mussidae. The family Siderastridae contributed eight species, Pectinidae and Merulinidae added 7 and five species to the total coral fauna.
- The family Dendrophyllidae and Caryophillidae contributed 4 species each to the total fauna of hard corals reported from this region. Minor families such as Oculinidae(3), Astrocoeniidae(2) and Flabellidae(1) also represented in the coral fauna reported from the study area. The subclass Octocorallia was represented by 2 species, each under Tubiporidae and Helioporidae. Class Hydrozoa represented by 6 species under the order Anthoathecata, represented by Milleporidae(5) and Stylasteridae(1).

**5. Bioinventorying and biodiversity valuation of marine organisms in selected Ecosystem along the Indian coast**

**Code: FISHCMFRISIL201201500015 Period: 2012-2014**

- Inventory of 195 species of hard corals recorded from south-west coast of India and Lakshadweep based on published literature was compiled. Fin fishes were collected and identified from the commercial landings from Vizhinjam, by the major gears included gill nets, hooks & line, Shore seine, boat seine, trammel net etc., most of them being seasonal in their operation .
- Majority of the species were recorded from gill nets. Under the fin fishes a total of 160 species of fishes under 102 genera and 58 families were recorded from various gears during the study period.
- Among the recorded families, Carangidae dominated with 23 species followed by Scombridae(12), Clupeidae(10), Lutjanidae(10), Serranidae(9), Leiognathidae (8) and Engraulidae (6).

**List of Hard corals**

| Family | Genus | No. of species | Family | Genus | No. of species |
|---|---|---|---|---|---|
| Mussidae | *Acanthastrea* | 3 | | *Pectinia* | 3 |
| | *Australomussa* | 1 | | *Oxypora* | 2 |
| | *Cynarina* | 1 | Flabellidae | *Flabellum* | 1 |
| | *Lobophyllia* | 2 | Fungiidae | *Cycloseris* | 4 |
| | *Symphyllia* | 3 | | *Fungia* | 8 |
| Acroporidae | *Acropora* | 40 | | *Lithophyllon* | 1 |
| | *Astreopora* | 5 | | *Polyphillia* | 1 |
| | *Montipora* | 10 | | *Podabacia* | 2 |
| Poriitidae | *Alveopora* | 1 | | *Sandalolitha* | 1 |
| | *Goniopora* | 2 | | *Seriatopora* | 1 |
| | *Porites* | 15 | | *Herpolitha* | 1 |
| Siderastriidae | *Coscinaraea* | 2 | Oculinidae | *Galaxea* | 3 |
| | *Psammocora* | 6 | Agariciidae | *Gardineroseris* | 1 |
| Faviidae | *Cyphastrea* | 2 | | *Leptoseris* | 5 |
| | *Diploastrea* | 1 | | *Pavona* | 6 |
| | *Echinopora* | 3 | | *Pachyseris* | 1 |
| | *Favia* | 4 | Merulinidae | *Hydnophora* | 3 |
| | *Favites* | 5 | | *Merulina* | 2 |
| | *Goniastrea* | 5 | Pocillopridae | *Pocillopora* | 7 |
| | *Leptoria* | 1 | | *Stylophora* | 2 |
| | *Leptastrea* | 3 | | *Seriatopora* | 1 |
| | *Montastrea* | 2 | Astrocoeniidae | *Stylocoeniella* | 2 |
| | *Oulophyllia* | 2 | Dendrophyllidae | *Tubastrea* | 1 |
| | *Platygyra* | 6 | | *Turbinaria* | 3 |
| | *Plesiastrea* | 1 | Tubiporidae | *Tubipora* | 1 |
| Caryophillidae | *Euphyllia* | 3 | Helioporidae | *Heliopora* | 1 |
| | *Physogyra* | 1 | Milleporidae | *Millepora* | 5 |
| Pectinidae | *Echinophyllia* | 2 | Stylasteridae | *Distichopora* | 1 |

**List of sea weeds**

| Family | Genus | No. of species | Family | Genus | No. of species |
|---|---|---|---|---|---|
| Boodleaceae | *Cladophoropsis* | 1 | Dasyaceae | *Dictyurus* | 1 |
| Siphonocladaceae | *Boergesenia* | 1 | Gracilariaceae | *Gracilaria* | 3 |
| | *Dictyosphaeria* | 2 | Gelidiaceae | *Gelidium* | 1 |
| Valoniaceae | *Valonia* | 3 | Gelidiellaceae | *Gelidiella* | 2 |
| | *Valoniospsis* | 1 | Pterocadiaceae | *Pterocadia* | 1 |
| Anadyomenaceae | *Anadyomene* | 1 | Champiaceae | *Champia* | 1 |
| Cladophoraceae | *Chaetomorpha* | 4 | Lomenariaceae | *Gelidiopsis* | 2 |
| | *Cladophora* | 2 | Galaxauraceae | *Actinotrichia* | 1 |
| Anadyomenaceae | *Microdictyon* | 1 | | *Galaxaura* | 2 |
| Ulvaceae | *Enteromorpha* | 4 | Corallinaceae | *Amphiro* | 2 |
| | *Ulva* | 2 | | *Amphiroa* | 1 |
| Dichotomosiphonaceae | *Avrainvillea* | 1 | | *Cheilosporum* | 1 |
| Bryopsidaceae | *Bryopsis* | 2 | | *Jania* | 2 |
| Caulerpaceae | *Caulerpa* | 10 | | *Lophocladia* | 1 |
| Codiaceae | *Codium* | 3 | Bonnemaisoniaceae | *Asparagopsis* | 1 |
| Derbesiaceae | *Derbesia* | 1 | Gloiosiphonaceae | *Chondrococcus* | 1 |
| Halimedaceae | *Halimeda* | 4 | Acrochaetiaceae | *Acrochaatium* | 1 |
| Udoteaceae | *Penlcillus* | 1 | Sargassaceae | *Sargassum* | 2 |
| Spyridiaceae | *Spyridia* | 2 | | *Turbinaria* | 2 |
| Rhodomelaceae | *Acanthophora* | 2 | Sphacelariaceae | *Sphacelaria* | 1 |
| | *Chondria* | 2 | Ectocarpaceae | *Ectocarpus* | 1 |
| | *Herposiphonia* | 1 | Scytosiphonaceae | *Chnoospora* | 1 |
| | *Lauranica* | 7 | | *Hydroclathrus* | 1 |
| | *Leveillea* | 1 | | *Rosenvingea* | 1 |
| | *Lithothamnion* | 1 | Dictyotaceae | *Dictyopterls* | 1 |
| Halymeniaceae | *Halymenia* | 2 | | *Dictyota* | 2 |
| Gigartinaceae | *Gigartina* | 1 | | *Lobophora* | 1 |
| Cystocloniaceae | *Hynpea* | 4 | | *Padina* | 1 |
| Solieriaceae | *Sarconema* | 2 | Oscillatoriaceae | *Lyngbya* | 1 |
| Spyridiaceae | *Spyridia* | 2 | | *Oscillatoria* | 1 |
| Ceramiaceae | *Centroceras* | 2 | Phormidiaceae | *Phormidium* | 1 |
| | *Ceramium* | 3 | | | |

**6. Investigations on vulnerable coral reef ecosystems of Indian waters with special emphasis on formulation of management measures for conservation**

**Code: FISHCMFRISIL201201600016 Period: 2012-2014**

- The patchy coral cover and diversity was assessed using line intercept transect method in Grande Island, Goa in three locations: Site1. Lobster Avenue: GPS: 15°20.99' N and 73°46 .53'E, Site 2. Chow Point: GPS: 15°21.03' N and 73°47 .03'E, Site 3. Jetty: GPS: 15°21.18' N and 73°45 .96'E. Three Line transects of 20m each with duplicates were made in the three sites for recording the corals and other bio resources. In the first site, the coral cover was dominated mainly by *Turbinaria* spp., *Psammocora profundacella, Goniastrea retiformis, Plesiastrea versipora, Favites pentagona*, *Porites lobata ,Cyphastrea serailia, Porites lutea, Favia pallid, Favites complanata, Favia speciosa, Alveopora* sp. and *Dendrophyllia* sp. The estimated total coral cover was 54.2% of the surveyed transect area followed by sponges (8.55%) and dead corals with encrusting algae (1.8%).The rest of the area (34.45) was dominated by rocks and sea weeds ( *Padina* sp. and *Chaetomorpha* sp). In the second site, the estimated coral cover was 43.77% followed by sponges (10.84%) and the green algae (1.23%) of the total transect area. *Turbinaria* spp. dominated the coral fauna followed by *Goniastrea retiformis, Porites lobata, Psammocora profundacella ,Favia speciosa, Favites pentagona, Favia pallida, Porites lutea, Cyphastrea serailia, Pocillopora verrucosa* and *Pavona minuta.*The third site, little far from the first two adjoining sites, had comparatively less coral cover (29.98%) and 3% of sponge cover. In this site *Favites pentagona* was the dominant followed by *Goniastrea retiformis, Favia speciosa, Turbinaria mesenterina, Porites lutea* and *Porites lobata.*

**Coral cover (%) and Relative Abundance (RA) in Grande Island, Goa**

| **Species** | **S** I (%) | RA | **S** II (%) | RA | **S** III | **RA** |
|---|---|---|---|---|---|---|
| *Alveopora fenestrata* | 0.47 | UC | - | - | | - |
| *Cyphastrea serailia* | 3.32 | C | 1.25 | C | - | - |
| *Dendrophyllia* sp. | 0.24 | UC | - | - | | - |
| *Favia pallida* | 2.77 | C | 5.22 | C | - | - |
| *Favia speciosa* | 1.62 | C | 8.35 | C | 20.40 | A |
| *Favites complanata* | 2.21 | C | - | - | - | |
| *Favites pentagona* | 8.4 | C | 6.35 | C | 24.19 | A |
| *Goniastrea retiformis* | 4.19 | C | 10.38 | A | 22.02 | A |
| *Pavona minuta* | - | - | 0.45 | UC | - | |
| *Plesiastrea versipora* | 7.38 | C | - | - | - | |
| *Porites lutea* | 2.86 | C | 4.99 | C | 15.68 | A |
| *Porites lobata* | 6 | C | 10.21 | A | 2.54 | C |
| *Pocillopora verrucosa* | - | | 0.68 | - | - | |
| *Psammacorapro fundacella* | 10/08 | A | 9.78 | A | - | |
| *Turbinaria* spp. | 46.27 | D | 42.34 | D | 15.2 | A |

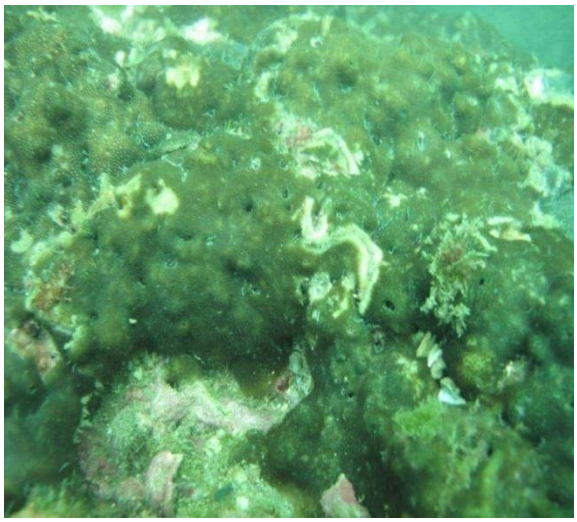
- Hydrographic parameters of the three sites were also recorded. The Site II was having more clear water and also well oxygenated and hence lush growth of seaweeds was noticed. Site I, where *Turbinaria* is the single dominant gnus, turbidity values were comparatively high than the other two sites.

Table showing the hydrographic parameters in the sites

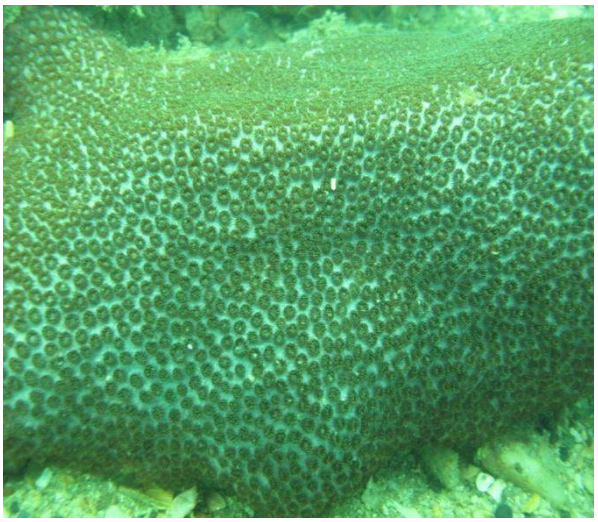
| Site | Depth (m) | Temp (ºC) | Salinity (ppt) | D. oxygen (mg/l) | Turbidity (ntu) | Silicate (mg/l) | $PO_4$ (mg/l) | Nitrate (mg/l) | Nitrite (mg/l) |
|---|---|---|---|---|---|---|---|---|---|
| Site I | 3-5 | 28 | 32 | 5.17 | 2.35 | 1.16 | 0.92 | 2.8 | 0.009 |
| Site II | 5.5 | 29 | 33 | 5.82 | 0.95 | 2.63 | 1.35 | 1.63 | BDL |
| Site III | 5 | 28.5 | 28 | 5.58 | 0.99 | 2.86 | 1.93 | 2.25 | 0.013 |

*Turbinaria* sp.

*Goniastrea retiformis*

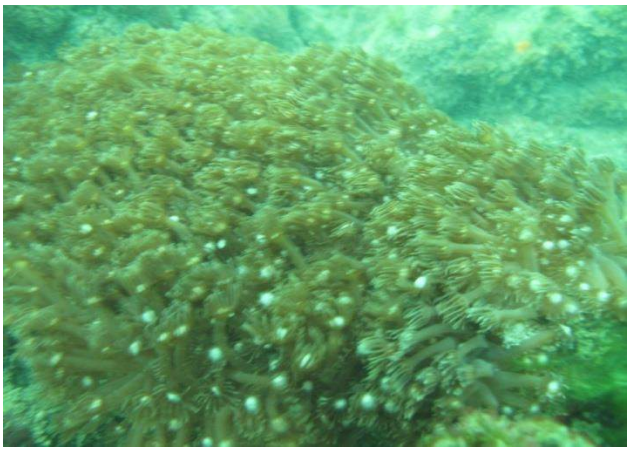


*Porites* spp.

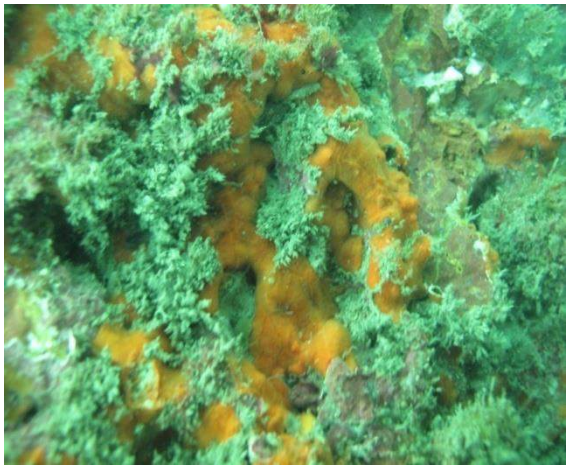


*Plesiastrea versipora*

*Tubastrea* sp.



*Alveopora* sp.

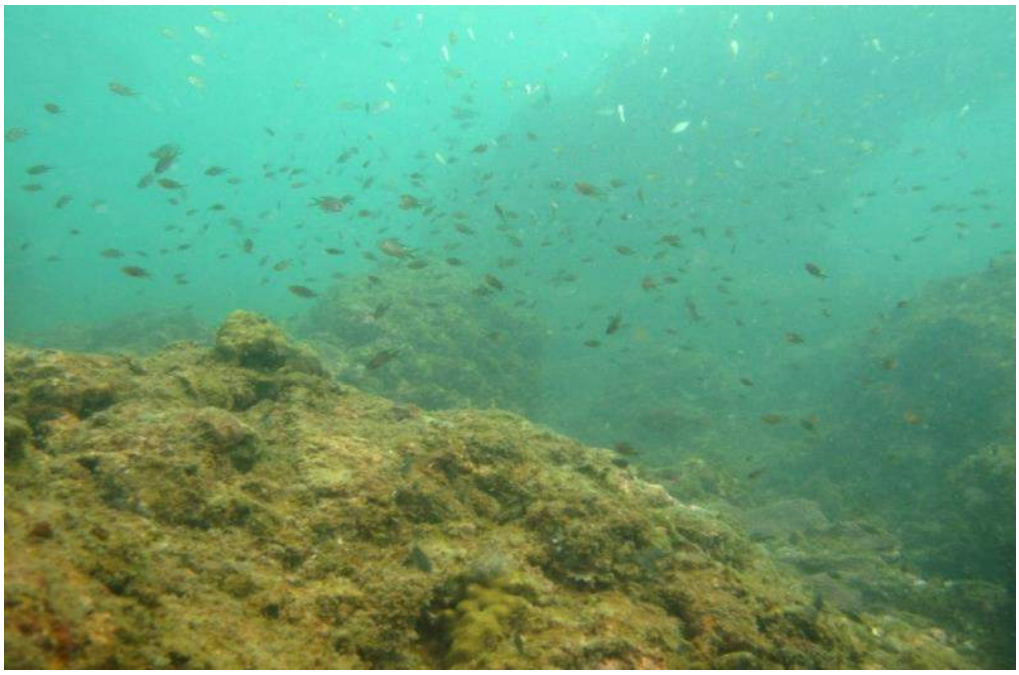


Encrusting sponge and algae

Sponge

**Reef fishes**

- In Grande island –Goa**,** abundance estimates for diurnally active coral fishes were evaluated using underwater visual census (UVC) technique by SCUBA diving. In the first site, *Lutjanus* spp. Dominated followed by *Chaetodon lunula, C. collare, Bodianus* sp., *Heniochus* spp., *Sargonentron* sp., *Gymnothorax* sp., *Epinephelus* sp., *Acanthurus* spp., *Plectorhyncus lineatus*, *Thalassoma lunare*, *Bodianus* sp., *Labroides dimidatus, Aballistes stellatus* etc*.*
- The *Pomacentrus* spp. dominated the reef fishes observed in the second site followed by *Chlorurus sordidus* and *Siganus canaliculatus.* Fishes belonging to the family Sparidae dominated the fishes recorded from the third site. *Acanthurus* spp*.* was abundant in this site followed by *Chaetodon* spp*., Ballistids,* Wrasses*, Sargocentron* sp*., Lutjanus* sp*., Scorpaenopsis* sp*., etc.* Holthurians and beautifully coloured nudibranchs were also observed in this site*.*

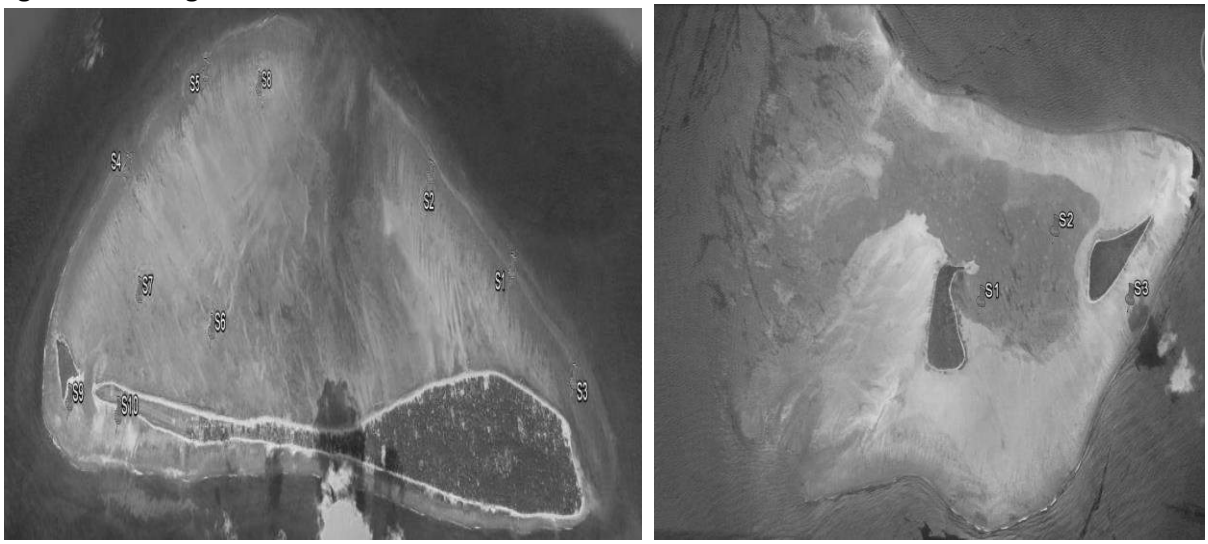


Damsel fishes

**Lakshadweep islands**

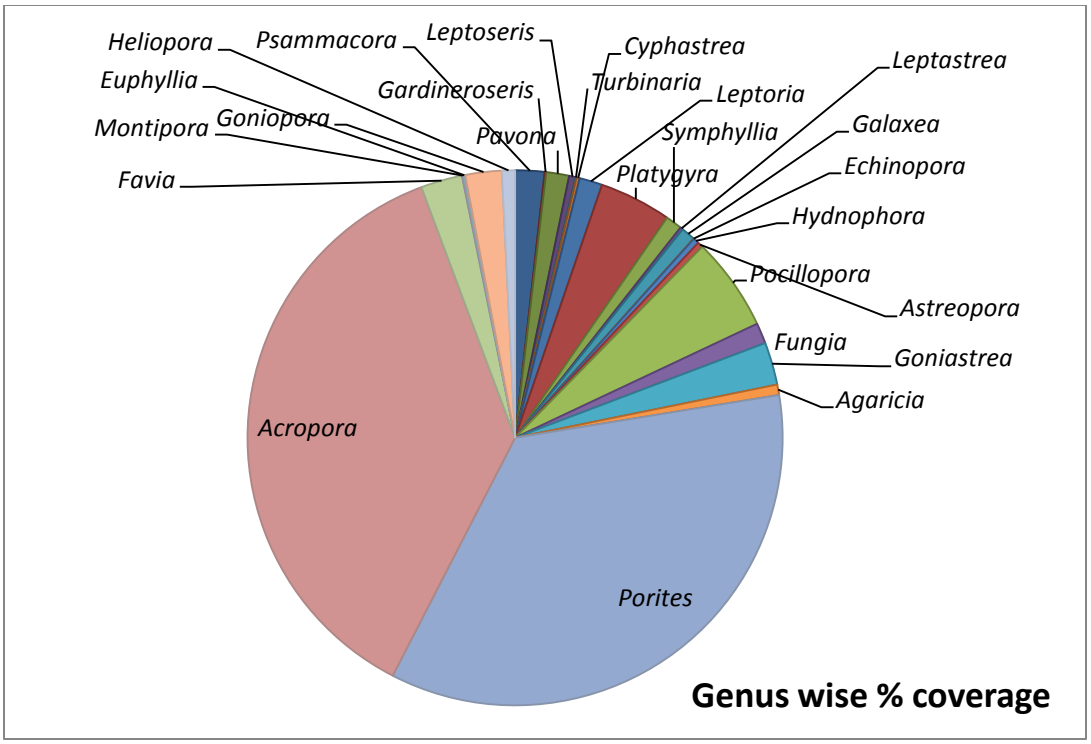
- The hard corals collected during the underwater surveys following Line Intercept Transect Method in Agathi and Bengaram islands of Lakshadweep during March, 2013 were identified and recorded on a GIS based platform.

**Agathi and Bengaram**




Map depicting Sampling sites of Agatti Lagoon ,Bengaram-TInnakkara Lagoon

,




Genus wise percentage coverage of hard corals of Agathi Island, Lakshadweep

- Line intercept transect method was adopted to describe coral community and composition. At Agathi, a total of 10 transects of 30 m each with three replicates set apart by 5 metres were placed parallel to the reef break at 1 to 3 m deep areas of lagoon. At Bengaram, two transects were set at the deeper areas between Bengaram and Tinnakkara islands and a single transect was made at the eastern part of Tinnakkara island. In Agathi islanda, total of 70 scleractinian species belonging to 25 genera were recorded during the survey. Genera *Acropora* (37%) and *Porites* (35%) showed maximum abundance in the transected areas followed by *Pocillopora* and *Platygyra (*4% each). The other genera recorded *were Psammacora, Gardineroseris, Pavona, Turbinaria, Cyphastrea, Leptoria, Leptastrea, Galaxea, Echinopora, Astreopora, Pocillopora, Goniastrea a*nd *Agaricia.* Bleaching was not noticed in any site in the surveyed areas, although sites with dead corals were noticed.
- In Bengaram, **mass coral spawning** was observed during the survey. The major release of eggs was noticed around *Psammacora, Acropora* and faviid colonies. The non-scleractanian corals were represented by *Millepora exesa* and *Heliopora coerulea.* Results of 'Relative Abundance Analysis' categorised 3 species as 'Abundant' namely, *Acropora formosa, Porites lobata* and *Porites lutea*; 20 as 'common' species, 34 'uncommon' species and 13 as 'rare' species. Coral Mortality indices showed lesser rate of mortality in the south eastern part of the atoll. In the lagoon which lies on the

western side of island, the southern most station ( S3) showed maximum mortality. As most of the sites had a MI value>0.33, they can be classified as near to ' sick'.

- The species *Porites lobata* and *Poritesl utea* inside lagoon (Station S6) supported a variety of *Acropora* spp.. Occurrence of algal growth on dead corals and fewer incidences of freshly bleached corals showed that the incidence which caused the mortality has not occurred in the recent past.
- A total of 40 species of corals were recorded from Bengaram atoll. Acroporids of selected areas were found dead and were covered with algae.

**Dominant hard coral species of Agathi and Bengaram**

*Porites lutea*

*Acropora palifera*

*Acropora formosa*

**Amini and Kadamat islands**

- In January-February 2014, Amini and Kadamat islands of Lakshadweep were surveyed and the biodiversity was assessed by Line Intercept Transect and Visual Census methods. The hard corals (55 and 72 species and from Amini and Kadamat islands), 26 species of molluscs (24 gastropods, 1 giant clam and 1 octopus), 20 species of sea weeds, 8 species of holothurians, 3 species of sea hares, 1 feather star, 5 species of brittle stars, 1 pin cushion star were recorded. Quantification of the coral fishes and hydrological analysis were also carried out. Incidence of disease, especially in *Porites* spp. was observed in both the islands, the incidence was more prevalent among the hard corals collected from Amini. Black-band disease, yellow band disease, white pox and pink line syndrome were noticed mostly in colonies belonging to the genera *Porites*.

**7. Assessment of the fishing impacts on biodiversity loss, with special reference to the threatened species, to formulate management options for their protection**

**Code : FISHCMFRISIL201201700017 Period : 2012-2014**

- A Pre-implementation rapid survey has been carried out for selecting the centres and gears for detailed study. A total of 24 centres, north and south of Vizhinjam were covered under this survey.
- The most common gears found to be operated along this shore were different types of gill nets, hook & line, shore seine, ring seine and trawl net. For detailed study two centres in the southern side and two centres in the southern side were selected.
- Muttom is one of the important fish landing centres in the southwest coast of India for artisanal fisheries. The most important damaging gear observed was Thathuvalai - Bottom set gill net mainly used for catching *Sillago* spp. Usually the fishing hours is 16 to 24 hrs. Another damaging gear was 'kelaichuvalai' which is also a sort of bottom set gill net with less number of sinkers and floats and fishing time is restricted to 4-6 hrs.
- The different types of bottom set gill nets along with the fish catch, remove sponges, gorgonids, antipatharians, star fishes and other echinoderms, sea weeds etc. in large quantities. Most of the local fishermen are aware of the destruction they cause while fishing. To minimize the loss, immediately after the removal of their required catch they clean the net in the sea itself, thus giving a chance to the other organisms like sea weeds and echinoderms to replenish. Moreover due to the seasonal nature of this type of fishing which extends for hardly 3 to 4 months, the destruction caused could be considered less compared to other gears.

Thathuvala

Antipatharians removed from the net

Kelaichuvalai

Sea weeds and gorgonids caught in Kelaichuvalai

Thathuvala before cleaning

Sponges collected from the thathuvala landings

- Colachel is an important fishing centre for traditional as well as mechanised fishery sectors. This is mainly a trawl net operating centre which is cephalopod oriented and the species of cuttlefish landed were *Sepia aculeata, S. pharaonis* and *Sepiella inermis* and those of squid were *Doryteuthis sibogae, Uroteuthis singhalensis* and *Loligo duvauceli.* Fin fishes such as *Saurida tumbil, S. undosqucunis* and *Synodus indicus, Nemipterus japonicus, N. bleekeri* and *Lagocephalus enermis* were also landed in good quantities. Heavy landing of sharks and rays were also observed in the trawl landings. *Rhynobatos* spp. observed in fairly good numbers in this centre.


Cephalopod landing in Coachal


Elasmobranch landing in Colachal

- Neerndakara and Sakthikulangara are the twin main fishing harbours situated on the mouth of Ashtamudi estuary which connects Ashtamudi Lake with the sea in the Kollam district. Mechanised boats were first introduced in this area in the mid-fifties under the auspices of the Indo-Norwegian Project and over the years there has been a spectacular growth in the fishing activities of this area mainly trawl net and ring –seines. The juveniles of finfishes especially, *Nemipterus* spp. and S*aurida* spp. and flat fishes landed along with the main catch. Large quantities of gastropods were also landed as a bycatch.


Juveniles of flat fishes *Epinephelus diacanthus*

*Fusinus* sp.

Gastropods

- Due to trawl ban in Neendakara and Colachal, the fishing activity got in full swing only by mid August.
- In Muttom apart from usual gill nets and Hooks & line fishery, a large mesh-sized bottom set gill net, 'ottakunduvala' was in operation. This gear removes huge quantities of live rocks along with large sized rare bivalves and gastropods like *Malleus malleus*, *Pinna bicolor, P. muricata, Lambis crocata*, star fishes such as *Protoreaster lincki* and cushion star, *Culcita novaeguineae*.
- Along with targeted species of rays *Plutosus* spp., Snappers, lethrinids etc. and fairly good number of big sized ornamental fishes also got caught in the net. As compared to other BSGN, the biodiversity loss in respect to scheduled fauna such as sponges, gorgonids etc. were almost nil in this gear.
- In Colachal, apart from the usual landings of Cephalopods, *Saurida* spp., *Nemipterus* spp., occasionally fairly good quantities of *Epinephelus diacanthus* and *Rhinobatos* spp. were also recorded during the period in the trawl landings.

Some of the protected species encountered in different fishing gears

| Place | Gear | Vulnerable / Threatened species encountered | Indian Wildlife (Protection) Act, 1972 |
|---|---|---|---|
| Colachel | Trawl | *Rhyncobatus djiddensis* | Schedule I, part II-A |
| Muttom | Bottom set gill net, *Thathuvalai* | Gorgonids | Schedule I, part IV-A |
| | | Sponges | Schedule III |
| | Bottom set gill net, *Kelaichuvalai* | Gorgonids | Schedule I, part IV-A |
| | | Sponges | Schedule III |

- The analysis of the bycatch revealed presence of fishes, mostly juveniles belonging to 36 families, major part by juveniles of Platycephalidae, Sauridae, Cynoglossidae, Bothidae, Soleidae, Trichiuridae, Nemipteridae, Mullidae, Lutjanidae, Leiognathidae and Fistulariidae. Other major contributors were Scorpaenidae, Serranidae, Tetraodontidae, Apogonidae Balistidae Anguillidae etc.
- Apart from the fin fish catch, Crabs, Gastropods, Bivalves and Echinoderms were also very common in the bycatch landings. The species composition was found to vary with seasons with more species diversity during the monsoon months. The major species of gastropods recorded during the study period were *Conus flavidus, Ficus subintermedius, Bursa subgranosa, Babylonia spirata, B. zeylonica, Murex nigrospinosus, Ficus ficus, Fusinus crassiplicatus, Fusinus colus, Tibia insulaechorab, Conus consor, Bursa spinosa, Tonna dolium, Turris crispa, Turitella duplicata, Canthurus* sp*., Amoria ellioti, Peristernia* sp. etc.

Bycatch in Sakthikulangara area

Juvenile landings in Neendakara

**Table showing the percentage composition of frequently occurring goups in bycatch**

| **Group** | **%** | **Group** | **%** |
|---|---|---|---|
| Shark | 0.937 | *Leiognathus* spp. | 1.237 |
| Rays | 5.7 | Clupeids | 1.945 |
| *Decapterus ruselli* | 4.554 | Sciaenids | 0.751 |
| Other Carangids | 0.442 | Mullidae | 3.004 |
| *Saurida* spp. | 10.6 | *Therapon* spp. | 0.221 |
| *Synodus* sp. | 1.061 | *Priacanthus* spp. | 1.043 |
| *Nemipterus* spp. | 10.34 | *Pomadassys* spp. | 2.386 |
| *Stolephorus* spp. | 0.177 | *Trichurus lepturus* | 1.238 |
| *Apogon* sp. | 0.725 | *Parapercis robinsoni* | 0.668 |
| Monocantidae | 3.271 | *Paracallinonymus costatus* | 0.247 |
| *Platytcephalus* spp. | 12.46 | Sea weed | 0.354 |
| *Cynoglossus* sp. | 4.067 | Sea snakes | 2.245 |
| Bothidae | 3.094 | Prawns | 1.856 |
| Soleidae | 0.353 | Crabs | 4.774 |
| Anguilliforms | 1.856 | *Thenus* sp. | 0.177 |
| *Dactyloptera peterseni* | 1.326 | *Squilla* | 0.353 |
| *Fistularia petimba* | 2.916 | Bivalves | 4.155 |
| *Arius* spp. | 0.398 | Octopus | 0.53 |
| *Ostracion cubicus* | 0.265 | Cuttle fishes | 0.265 |
| *Epinephelus diacanthus* | 4.065 | Squid | 0.177 |
| Other Serranids | 0.842 | Echinoderms | 0.955 |
| *Sillago sihama* | 0.407 | Miscellaneous | 2.4 |

## Marine Biotechnology Division

**1. Biotechnological applications in mariculture and conservation Code: PNP/BIOT/01**

- Emerging lobster disease was recorded for the first time from farmed lobsters along the Kanyakumari coast. The disease was termed as 'Tissue swelling disease' or 'neck out disease' Four distinct bacteria were isolated and characterized using molecular method and gene sequence of one viz., *Bacillus circulans* was deposited in GenBank (Acc No: JQ409560)

Typical symptoms of the new 'neck out disease condition' in farmed lobsters. Black burn type spots in the central telson as well as in the bordering pair of uropods on either side are noted. The mean size was 128.85±7.63mm and 65.24±6.64 g.

- Considering the potential uses of sponge – associated bacteria in marine biotechnology applications, suitable methodologies were standardized to isolate and culture potential strains of hetrotrophic bacteria from the sponge *Mycale mytilorum*. Two potential strains viz., *Bacillus subtilis* and *Bacillus boroniphilus* (Gen Bank Acc No: JQ409557 *B. subtilis* and JQ409558 *Bacillus boroniphilus*) were obtained.
- The positive impact of open sea cage farming demonstration by CMFRI was evaluated along the Kanyakumari coast in which farmers have started culturing lobsters in improvised smaller HDPE floating cages.

**2. Pathogen profiling, diagnostics and health management in maricultured fin fish and shell fish. Code: MBTD/PATH/01**
**[Sponge bioactivity and sponge culture scientific programme incorporated after SRC at Mandapam during May 2009]**

- Screened potent antimicrobials from the sponge, *Callyspongia subarmigera* (Ridley) against fish and shellfish pathogenic bacteria. The methanol extracts of *C. subarmigera* inhibited the fish and shellfish pathogenic bacteria such as *Vibrio alginolyticusV. pelagius*, *V. harveyi*, and *Pseudomonas aeruginosa* at 0.1% of the extract onwards.
- Screened novel probiotic bacteria from the mucus of marine batfish. Bacterial isolates obtained from the mucus of marine batfish exhibited mild antagonistic activity against *Vibrio alginolyticus*.
- Lobsters reared in captivity were monitored for infections along with the ambient hydrological conditions. The microbial load varied from 1.9 $X10^4$ to 2.9 $X10^5$ CFU/ml. No infections and mortality were recorded during the observation period
- Treatment of bacterial infections in sea bass reared in open sea cages**:** A few sea bass young ones reared in open sea floating cages off Vizhinjam showed symptoms such as erythemia and mild ulcerations all over body surface. The feed was top coated with a combination of chloramphenicol + Oxytetracycline (1:0.5 ratio) in gelatin and administered to the sea bass. Complete recovery was noted from the fourth day of treatment indicating the possibility of combating bacterial infections

**Aquaculture of Sponges, *Echinodictyum* gorgonoides (Dendy) and *Callyspongia subarmigera* (Ridley, 1884) together with their Bioactivity Profiles**

- Experiments were conducted to evaluate the growth and bioactivity performance of sponges cultured in open sea conditions. The sponge *Echinodictyum gorgonoides* was cultured in the *In vitro* conditions in which, the explants survived repeated harvests i.e. $70^{th}$ day of culturing. The extract of harvested sponge tissue (after 40 and 70 days) inhibited several fish & shellfish pathogenic bacteria.
- The extract of *Echinodictyum gorgonoides* in the second harvest (at $70^{th}$ day) had higher bactericidal activity than the first harvest. Freshly collected sponges *Echinodictyum gorgonoides*, *Callyspongia subarmigera* and *C. diffusa* were cultured in 'open sea conditions'. Among these, C*. subarmigera* survived with good growth; while *E. gorgonoides* and *C. diffusa* did not survive.
- The *Callyspongia subarmigera* survived under the open sea conditions had attained a biomass increase of 193.4% at the depth of 1 meter below the sea level after 40 days. The cultured and the fresh sponge extracts were screened for different antibacterial, mosquito larvicidal and brine shrimp cytotoxicity.
- The methanol extracts of cultured *E. gorgonoides* and *C. subarmigera* and its different concentrations exhibited antibacterial activity against *Pseudomonas aeruginosa, Vibrio harveyi, V. alginolyticus* and *V. pelagius.* In the Brine shrimp cytotoxicity test, the mortality rate was 10.0, 25.0 and 60.0 % in different concentrations of sponge extracts suggesting moderated cytotoxicity as

noted in the sponges in nature. Mosquito larvicidal activity was also noted in both the sponges after aquaculture.

**Purification of the extract of sponge, *Callyspongia diffussa* for chemical characterization**

- In TLC purification of *Callyspongia diffusa* extract, 3 compounds were separated (Non fluorescent compounds-2 and fluorescent compound-1) with Rf values of 0.464, 0.461 and 0.36 respectively.
- In Column chromatographic purification, high antibacterial activities were noted in the dichloromethane 40, 50, 60, 70, 80 and 90 percent fractions. Comparatively higher inhibition zone were obtained against pathogens *Staphlyococcus aureus, Pseudomonas aeruginosa*, *Proteus mirabilis, Bacillus subtilis, E. coli and Klebsiella* sp). In Lambda max (λ) for active principles of the methanolic crude extract of *C. diffusa,* only one clear peak noted with a maximum absorbance at 308nm.
- The FTIR results suggest the compound as "Unsaturated hydroxy aldehyde".

Baskets suspended in Vizhinjam Bay, Trivandrum coast for sponge culture

*Callyspongia subarmigera* cultured in Vizhinjam Bay

**Antibacterial activity of extract of *Callyspongia subarmigera* cultured in open sea conditions**

| Test Bacteria (fish pathogenic bacteria) | *Callyspongia* extract (%) | Zone of Inhibition (mm) | | |
|---|---|---|---|---|
| | | Fresh extract | Activity after 40 days of culture | Activity after 75 days of culture |
| *Pseudomonas aeruginosa* | 0.1<br>1.0 | 8<br>9 | 7<br>- | -<br>- |
| *Vibrio harveyi* | 0.1<br>1.0 | 7<br>7 | -<br>7 | 7<br>7 |
| *V. alginolyticus* | 0.1<br>1.0 | 7<br>8 | -<br>9 | 7<br>8 |
| *V. pelagius* | 0.1<br>1.0 | 11<br>19 | 8<br>14 | 7<br>8 |

- Results of sponge culture experiments and the data regarding bioactivity suggest that sponge species that produce bioactive compounds can be cultivated in 'open sea' conditions.

**<u>Disease investigations of species of ornamental fishes</u>:**

- Disease investigations of 2species of ornamental fishes such as *Amphiprion biaculatus, Amphiprion ocellaris* and spiny lobster *Panulirus homarus* maintained under captivity was carried out by studying water quality parameters, total bacterial load and biochemical tests of microbes isolated from rearing water and diseased organisms.
- Water quality parameters recorded from brood stock/larval rearing tanks of ornamental fin fishes showed salinity 34-35ppt, temperature 26 $^{0}$C to 28 $^{0}$C P$^{H}$ 7.7 to 8, dissolved oxygen 5.7ml/l to 6.8ml/l. The mean bacterial load ranged from $1.7x10^{-3}$ to $1.0x10^{-4}$ in *Amphiprion biaculatus* and $1.2x10^{-2}$ to $1x10^{-3}$ in *Amphiprion ocellaris* system.
- Water quality parameters recorded from lobster rearing tanks showed salinity 34-39 ppt, temperature 25.$^{40}$C to 29.9 $^{0}$ C, $^{PH}$ 7.2 to 8, dissolved oxygen 4.7ml/l to 6.8ml/l.The lobsters were observed in healthy condition during the period. *P.homarus* affected with brown shell disease observed at Chinnamuttom Lobster holding center was examined for pathogen profiling. Diseased lobsters exhibited external symptoms related to hypoxia stress including missing limbs mainly attributed to overcrowding, aggression and associated opportunistic bacterial infections. The total bacterial load estimated from different tissue sites of the diseased *P.homarus* were $3x10^{-2}$ from exoskeleton, $7x10^{-2}$ from gills, $6x10^{-4}$ from hepatopancreas and innumerable from muscle tissues.
- Pathogens such as *Vibrio* and *Pseudomonas* species were isolated from different tissue samples such as hepatopancreas, gills and muscles of diseased *P.homarus*.

**Influence of Probiotic bacteria in offering disease resistance among pearl oyster *Pinctada fucata* (Gould) larvae and spat**

- The probiotic bacterium used for the study was type culture of *Lactobacillus acidophilus* (MTCC * 447) acclimatized to saline water. *Lactobacillus acidophilus* had antagonistic activity against bacterial pathogens of pearl oyster, *Pinctada fucata* such as: *Vibrio alginolyticus*, *V. furnissi, V. fluvialis* and *V. splendidus*. *Vibrio furnissi* showed maximum zone of 25 mm after 24 h; while *V. alginolyticus* had 24 mm. A split dose of the probiotic provided daily thrice in the larval rearing system retained a sustainable density of it in the media throughout the rearing period.
- The effect of *L. acidophilus* on the survival and spat settlement was evaluated by feeding it with microalgal diet at 1:1, 2:1, 3:1 and 4:1 ratios. The 3:1 and 4:1 ratio produced significantly ($p<0.0001$) higher survival (51.4±1.9 and 48.5±1.6%) compared to the control group (9.5±1.8%).
- The spat settlement started from 19$^{th}$ day onwards in the 3:1 and 4:1 ratio fed group, while in the control it was only from the 27$^{th}$ day onwards.
- The pearl oyster spats reared using probiotics at 3:1 and 4:1 levels in the hatchery were transferred to sea farm with control group and the survival and growth were evaluated. The 3:1 and 4:1 feed group showed a significant AGR of 0.36 ($p<0.01$) and 0.35 ($p<0.05$) mm/day respectively in terms of DVM over the control (0.29 mm/day). In addition to the growth, the survival was also enhanced significantly in the probiotic treated groups.

**Isolation and characterization of biofilm bacteria from sea grass for bioactivity studies**

- A biofilm forming bacterial strain of *Bacillus pumilus* was isolated and characterized from the sea grass, *Halodule pinifolia* collected fresh from sea grass beds off Kanyakumari.
- Using standard 16s rRNA sequence analysis, the *Bacillus pumilus* isolated from the sea grass was closely related to *Bacillus stratospericus* (Acc. No: AJ831841).
- The sequence was deposited in GenBank Acc. No: EU880532.
- The growth response of *Bacillus pumilus* was very high in the medium containing sea grass *Halodule pinifolia* extract suggesting the links involved in colonization and biofilm forming requirements for the bacteria.

**Studies on Bacteriociocin production by *Lactobacillus sp***

- A new strain of *Lactobacillus* (MSUIS1 isolate) isolated using de Mann Rogosa Sharpe (MRS) medium was characterized **as** *Lactobacillus rhamnosus* by cell morphology, carbohydrate fermentation and

16s rRNA sequencing. The bacteriocin of the strain exhibited antimicrobial activity towards the human pathogenic bacteria *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Escherichia coli*, *Bacillus subtilis* and *Enterococcus faecalis*.

- Maximum bacteriocin activity of 1200 AU / ml was noted in MRS broth at 72h at an initial pH of 6.0 in $30^0$C. Increased bacteriocin production by *L. rhamnosus* was noted when MRS broth was supplemented with yeast extract (0.1 %), tween 80 (0.1%), $MgSO_4$ (0.02% to 0.04%) and dextrose (2.0 to 3.0%).

**Metagenomic approach in marine sponge *Callyspongia subarmigera* (Ridley, 1884) collected off southern coast of India**

- The sponge *Callyspongia subarmigera* obtained in the by catch was used to study the associated bacteria. Four different colony forming units of sponge-associated bacteria were isolated from *C. subarmigera.*
- The ECPs of sponge associated bacteria when tested for antibacterial activity showed similar activity as that of the extract from the sponge. An increased antibacterial activity of the ECPs was noted towards the fish pathogen *Vibrio harveyi* compared to the sponge extract.
- A dose dependent lethality of chikungunya mosquito larvae, *Aedes aegypti* larvae was recorded for the *C. subarmigera* extract*. Callyspongia subarmigera* extract exhibited better anticoagulant activity when compared to that of conventional anticoagulant tri sodium citrate.
- The sponge associated microbes exhibited protease product*ion.* Total DNA of *C. subarmigera* 950 bp was isolated and the 18srRNA gene amplified using specific primers. The phylogenetic tree depicted *Haliclona cinaria* as its closest relative with 87% homology.

**Metagenomic approach of the marine sponge *Echinodictyum gorgnoides* (Dendy)**

- The methanol extracts were further purified using Silica gel, chromatographed with three step elution and the fractions were used for detecting antibacterial activity. Bacteria such as *Vibrio harveyi, Bacillus subtilis* and *Staphylococcus aureus* were inhibited by *Echinodictyum gorgonoides* extract in both well and Disc diffusion methods. Cytotoxicity of Brine Shrimp (Artemia) nauplli was noted with 80.0% mortality at 10.0% of *E. gorgonoides* extract. The bioactive secondary metabolites from *Echinodictyum gorgonoides* were initially extracted with methanol and then condensed using rotatory evaporation.

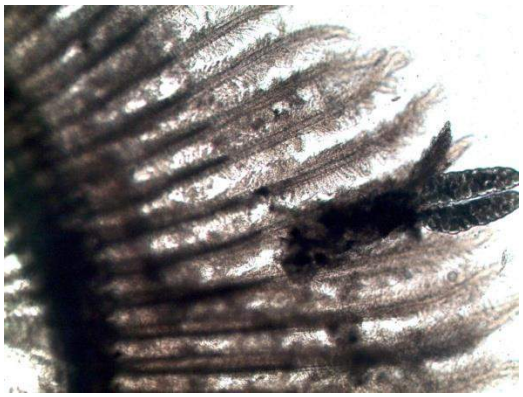
- The total DNA of *E. gorgonoides* was isolated and standardized using different annealing temperature. The ideal amplification was 54°C for 1.30mins using XTO5 Taq polymerase. The amplified products of 16SrRNA genes were eluted for the further studies. The potentially novel and diverse isolates would be useful resources for screening for bioactive natural products.

**Health status of fish seeds with special emphasis on parasitic infestations**:

- Though there were no external signs of infections on seeds of all mugilids collected, examination of few representatives revealed infections of copepods and monogenetic trematods. Two species of monogenean, *Ligophorus* sp.1 and sp.2, *Ergasilus rostralis*, *Dermoergasilus vericoleus* and *Nothobomolochus* sp. were found infecting the gills of fingerlings of mullets. *Ligophorus* spp., and *E. rostralis*, were found infecting all the three hosts. *D. varicoleus* were found to infect only *Liza* spp. and *Nothobomolochus* sp. was found infect only *V. seheli*.
- The fingerlings which could not withstand the normal collection and transportation stress were examined and sub samples of same number of healthy fingerlings also were examined after one week of stocking. Two major size groups examined were fry and fingerlings. The fry upto the size range 3-4.5cm were found free from infection and the mortality due to stress was also very low in this group. Infections were present mainly in the size group of 5-9cm.
- Nature of infection of parasites in all the species in two groups was analyzed and mortality with single species infection and multiple species infection also were analysed using statistical methods. The fingerlings which were severely infected at the time of collection were succumbed due to stress. Most of the fingerlings with multiple species infections also could not survive. Though it was a good sign that healthy fingerlings survived for final stocking, the fishes were carrying all the species of parasites to their culture system which could flare up later and can cause serious damage. The samples of fry (smallest size group) were devoid of any infection and these were easily transported with least mortality. So at least in case of mugilids seeds it is always ideal to collect and transport the smallest fry group and rear them in happa at the culture site itself to reduce parasitic infection and transportation stress.

Seeds stored in floating cage


*Nothobomolocus* sp. infecting fry of *Valamugil* sp.

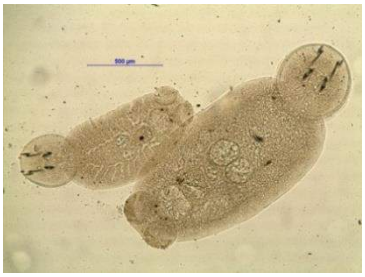


*Ergasilus* sp. infection in gill of fingerlings of *Liza macrolepis*

*Ligophorus* sp. infection in gills of *Valamugil* sp.

- There was mortality of *Seriolina nigrofasciata* in cages after few weeks of stocking. The mortality was due to the infection of a monogenean *(Benedenia* sp.*)* for which precautions should be taken at the time of stocking itself. Benedenia infection is very common in cage culture of yellowtails. In addition, 6 more species of parasites were collected and are in the process of identification. Biology and infections in *Lethrinus nebulosus* is also investigated in details. Seven species of parasites were collected and the identification process is continuing.

*Calydiscoides* sp. infecting *L. nebulosus*



*Benedenia* sp. from *Seriolina nigrofasciata*.

**Pathogen mapping and health managemaqnt of brood stock larvae and growout life stages of hatchery bred marine ornamental at Vizhinjam:**

- Continuous monitoring for any signs disease among the ornamental fishes viz., *Amphiprion ocellaris, A. seba* and Maroon clown *Premas biaculeatus* kept in the hatchery at Vizhinjam.
- An instance of Clown fish disease (Brooknellosis) in orange clown (*Amphiprion ocellaris*) was observed in the brood stock. The symptoms include thickening of the skin's mucus; so much so that the fish appears to have a rough white coating. This thickening of the mucus layer may become so severe in some individuals that mucus strands trail behind the fish as it swims. Often the scales are loosened in the infected area and may come away from the fish when it is caught in a net. Microscopical examination of skin and gills revealed the infection of ***Brooklynella*** *hostilis* (Protista, Ciliophora). 3-5 minutes in a freshwater bath dislodged most parasites and should be repeated for 3 days leaving one day in between the baths. Only few individuals were affected and timely management could prevent the spread of the disease.


*Brooklynella hostilis* infection and the parasite

**3. Health Management in selected Finfish and Shellfish for mariculture and aquaculture & bioprospecting from marine resources [Code: FISHCMFRISIL201202600026]**

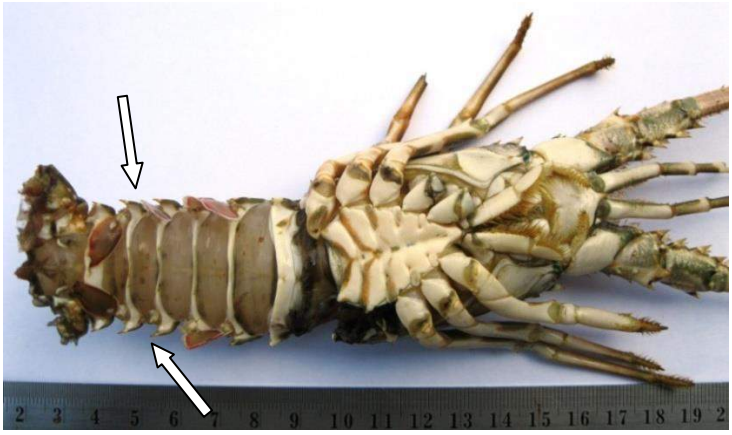
The health investigations, water quality and microbial investigations were carried out among lobsters, marine ornamental as well as other culturable species.

**Infections among Lobsters reared under captive rearing conditions:**

Lobsters reared in captivity were monitored for infections along with the ambient hydrological conditions. The microbial load varied from $1.42x10^4$ to $2.96x10^5$ CFU/ml (Table).

| Month | Temperature | pH | Salinity | Microbial load CFU/ml |
|---|---|---|---|---|
| January 2012 | 28.2±0.08 | 7.45±0.17 | 33.25±0.5 | $2.03x10^5$ |
| February | 29.68±0.87 | 7.35±0.31 | 33.75±1.26 | $1.42x10^4$ |
| March | 29.45±0.13 | 7.35±0.21 | 33±00 | $1.92x10^5$ |
| April | 30.05±0.13 | 7.2±0.37 | 34.5±0.58 | $3.47x10^4$ |
| May | 29.9±0.14 | 7.35±0.13 | 34±00 | $2.675x10^5$ |
| June | 29.7±0.52 | 7.36±0.15 | 34±00 | **$2.96x10^5$** |
| July | 29.77±0.61 | 7.37±0.22 | 33.5±0.58 | $2.22x10^5$ |
| August | 30.1±0.17 | 7.3±0.22 | 33.5±0.58 | $1.01x10^5$ |
| September | 31.17±1.30 | 7.1±0.24 | 33.75±0.5 | $1.14x10^5$ |
| October | 31.33±0.55 | 7.6±0.20 | 34.0±00 | $1.34x10^5$ |
| November | 30.4±0.35 | 7.55±0.13 | 33.75±0.5 | $6.3x10^4$ |
| December | 30.02±0.22 | 7.57±0.17 | 34±00 | $1.33x10^5$ |

- In the captive holding facility of KME Fisheries, Coastline Fisheries and Scannet Fisheries located in Chinnamuttom, near Kanyakumari, thoug The under-sized lobsters (less than 100.0g ABW size) stocked did not show any infections. However, slightly larger specimens (average length of 145mm and average weight of above 108g) stocked in RCC tanks had exhibited instances of mortality with the symptoms like tail erosions, necrosis, lesions and Loss of walking legs and blackening of joints and cepahlothorx region.



Tail erosion and blackening in *Panulius homarus* maintained in RCC tanks

**Water quality parameters in lobster rearing tanks**

| Water temperature ($^oC$ | pH | Salinity (ppt) | Dissolved oxygen (mg/l) | Microbial load (cfu/ml) |
|---|---|---|---|---|
| Coastline Fisheries (instance of mortality) | | | | |
| 28.9 | 7.8 | 35.0 | 8.17 | $5.9X10^7$ |
| KME Fisheries | | | | |
| 28.2 | 7.6 | 36.5 | 5.59 | $1.1\ X10^7$ |

- Water quality parameters in lobster rearing RCC tanks from Kanyakumari coast: A few lobsters stoked in floating cages off Arokyapuram (Kanyakumari) have developed swelling and fluid accumulation in the joining area below the end of carapace (behind the thorax) and prior to the beginning of abdominal segment. The water quality parameters were recorded together with the microbial load.

**Water quality parameters in lobster culture area along the Kanyakumari coast**

| Water temperature $^{o}$C) | pH | Salinity (ppt) | Dissolved oxygen (mg/l) | NH4 + (mg/l) | $H_2S$ (mg/l) | Microbial load (cfu/ml) |
|---|---|---|---|---|---|---|
| Inside the bay | | | | | | |
| 30.7 | 7.6 | 34.0 | 5.66 | ≤ 0.25 | 0.02-0.04 | $1.16X\ 10^{-6}$ |
| Outside the bay | | | | | | |
| 27.3 | 7.6 | 34.0 | 6.63 | ≤ 0.25 | 0.02-0.04 | $6.7X\ 10^{-5}$ |

- From the infected lobsters, 4 distinct colonies were isolated from different body parts like telson, walking leg and exposed muscle areas. In the deeply wounded area two distinct colonies were observed. The bacterial colonies were subjected to biochemical investigations and also exposed to antibiotics to detect the sensitivity pattern. The potent bacterial colonies and their sensitivity pattern are listed in Table 4. The bacteria are being characterized.

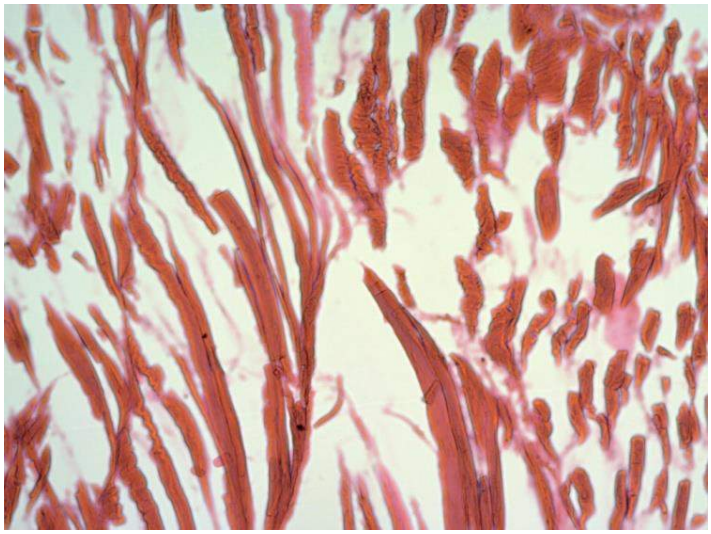
**Microbial types observed from lobsters and their antibiotic susceptibility pattern(zone in mm)**

| Antibiotic discs (mcg) used | Bacterial isolate from lobster and the zone diameter in mm | |
|---|---|---|
| | LTYKK (isolate from telson area) | LTRLKK (isolate from telson edge) |
| Cefotaxime CTX 30 | 30 | 24 |
| Azithromycin AZM 15 | 13 | 23 |
| Ampicillin AMP 10 | 11 | 12 |
| Cefadroxil CFR 30 | - | 14 |
| Ciprofloxacin CIP 5 | 17 | 23 |
| Clarithromycin CLR 15 | 14 | 19 |
| Penicillin-G P 10 | 10 | - |
| Cefixime CXM 30 | 15 | 20 |
| Erythromycin E 15 | 15 | 11 |
| Cefoperazone CPZ 75 | 15 | 11 |
| Amoxyclav AMC 30 | 11 | 12 |
| Cefaclor CF30 | 16 | 17 |

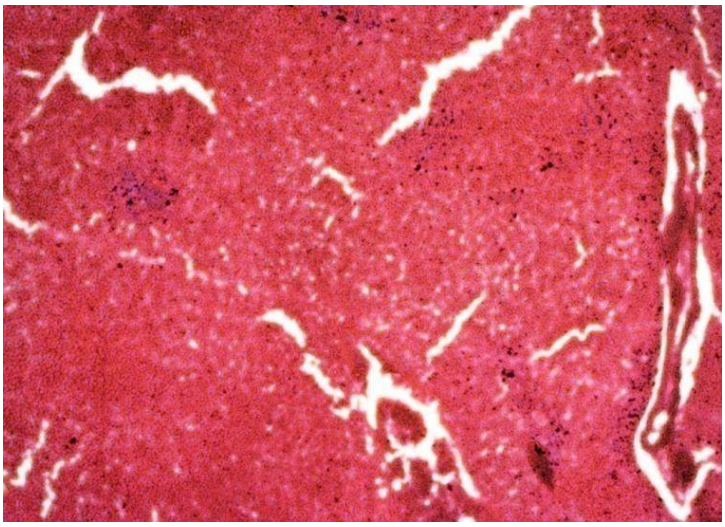
- **Infections among clown fishes bred and reared in captive conditions:**Bacteria were isolated from the moribund clown fishes viz., *Amphiprion nigripes* (43mm; 2.5g) and the maroon clown fish *Premnas biaculeatus* (30mm; 1.2g) from the marine ornamental fish hatchery / aquaria. The average water temperature was 30.7$^{o}$C, pH: 7.7 with a salinity of 34.0 ppt. The symptoms of the infected fish included: tail rot and erythemia on the ventral side (Plate 2) and infections on the caudal peduncle. In addition, gills were infected and the tail of most of fish had erosions. A unique 'w' shaped reddish patch was also noted among a few *A. nigripes.* The microbial load in the rearing water was very high with more than 1X10$^{6}$ CFU/ml. Initially two distinct bacteria were recorded. The total microbial load in the infected tissue and gills was 2.7X10$^{7}$ and 2.2X10$^{7}$ CFU/ g respectively. Seven different bacterial colonies (GS, GRC, GI, GGR, TD, TRYS and TIY) were scored for further evaluations.

Moribund clown fish with erythemic and necrotic lesions

- Severe necrotic areas and disarray of muscle fibres were noted in histological sections whereas in liver, iinfiltration of cells was noted.



Section of infected muscle of *A. nigripes (*100X magnification)

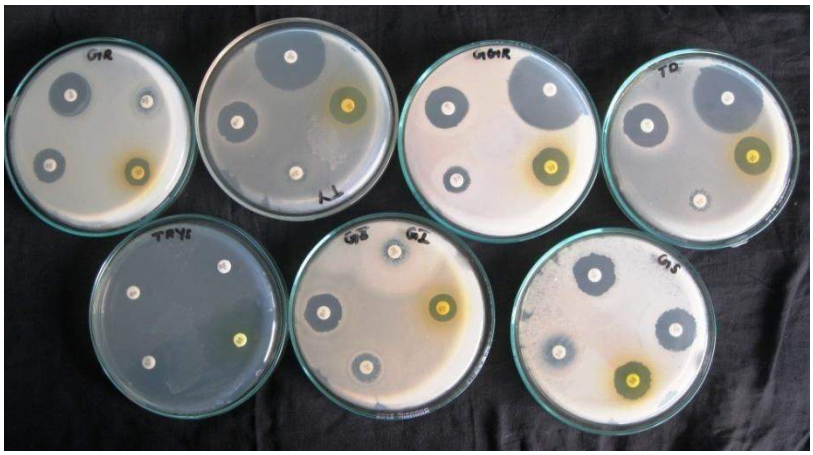


Section (100X magnification) of infected liver from *A. nigripes*

The antibiotic sensitivity pattern of the isolates was evaluated to provide immediate treatment. The isolate GI was proteolytic.

Susceptibility of clownfish bacterial isolates to different antibiotics

| Antibiotic | Content (mcg) | Zone (mm) |
|---|---|---|
| Co-Trimoxazole | 25 | 30 |
| Chloramphenicol | 30 | 29 |
| Nalidixic acid | 30 | 28 |
| Nitrofutrantoin | 300 | 22 |
| Erythromycin | 15 | 19 |
| Kanamycin | 30 | 20 |
| Ciprofloxacin | 5 | 22 |
| Gentamicin | 10 | 16 |
| Rifampicin | 5 | 14 |
| Streptomycin | 10 | 17 |
| Vancomycin | 30 | 14 |
| Tetracycline | 30 | 13 |
| Trimethoprim | 5 | 10 |
| Resistant | | |
| Penicillin | 10 | R |
| Ampicillin | 10 | R |
| Flucoinazole | 25 | R |
| Vibrio 0/129 | 10 | R |
| Methicillin | 5 | R |



Antibiotic sensitivity pattern of 7 isolates from clown fish

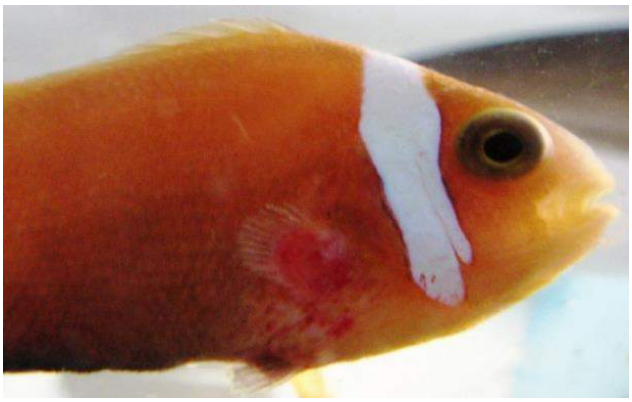
Protease activity of GI Isolate (skim milk agar)

- In addition, parasitic infections followed by secondary bacterial infection of *Amphiprion nigripes* were noted. After recording the morphological characteristics, the parasitic specimens were mounted in microscopic slide with D.P.X mountant (Plates 6 & 7). The parasite was tentatively identified as Capsalids (*Neobenedenia* sp.,) belonging to the Monogenan group.

Fish parasite (Capsalid - 50 X magnification) recorded from *Amphiprion nigripes*

Close up view of parasite showing anchors (100X)

- As a treatment protocol, benzalkonium chloride (0.001%) and buffered formalin (0.001%) was tried. The infected fish (average size: length: 55mm and weight: 3.7 g) exhibited the following abnormalities: red lesions on the pectoral fin, black colored patches on the middle portion of the ventral side, erosions in caudal fin and protrusion of scales



Moribund clown fish with red lesions on fin

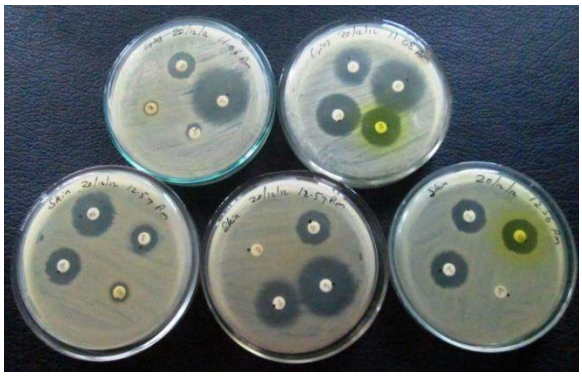
Clown fish showing scale protrusions

**Microbial infections in hatchery – reared 'silver sea bream', *Rhabdosargas sarba***

- Mortality of hatchery reared silver sea bream, *Rhabdosargas sarba* (average length: 159.47mm and average weight: 115.5g) was noted in the Vizhinjam fin fish rearing tanks (FRP) due to parasitic infestations followed by bacterial infections. Symptoms in infected fish included: high mucous secretion with unbalanced movements. An erythemic condition was observed at the base of all the fins (Plate 10). The microbial load in the rearing water was $4.6X10^{7}$CFU/ml indicating a higher ambient bacterial load.

- Initially, the anti-parasitic drug Vidac (as 50 mg tablets) was administrated followed by prasziquental (600mg). However due to severe secondary bacterial infection, total mortality of the reared fishes was recorded. From the moribund fishes, two discrete colonies with characteristic white and yellow colony colorations were retrieved in Zobell Marine agar. The antibiotic sensitivity pattern towards the common antibiotics is given in Table 6. Erythromycin and chloramphenicol were recorded to be effective against the white and yellow strains respectively.

Isolate (White colonies) from gills



Antibiotic sensitivity pattern of isolates from *Rhabdosargas sarba*

Antibiotic sensitivity of the bacterial colonies isolated from *Rhabdosargas sarba*

| Antibiotic disc | Content (mcg) | Zone (mm) | |
|---|---|---|---|
| | | Ys strain | Ws strain |
| Co-Trimoxazole | 25 | 21 | 23 |
| Chloramphenicol | 30 | 23 | 24 |
| Nitrofutrantoin | 300 | 17 | 21 |
| Erythromycin | 15 | 22 | 30 |
| Ciprofloxacin | 5 | 18 | 24 |
| Gentamicin | 10 | 16 | 15 |
| Streptomycin | 10 | 13 | 20 |
| Vancomycin | 30 | R | 16 |
| Tetracycline | 30 | 9 | 7 |
| Penicillin | 10 | 17 | 16 |
| Ampicillin | 10 | 17 | 18 |
| Methicillin | 5 | R | 10 |

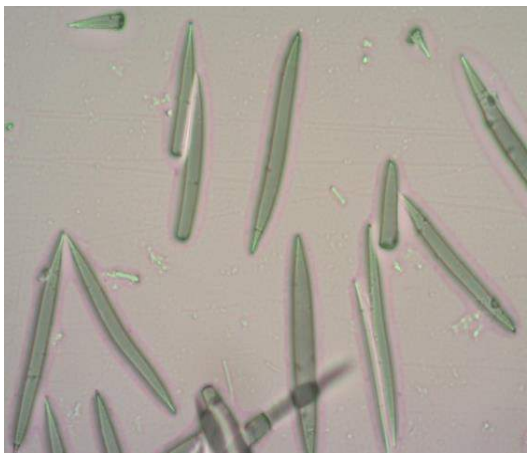
- The total coliform bacterial status of water in the bay of Vizhinjam was estimated

Total Coliform bacteria in Vizhinjam bay at different months during 2012

| Month | Water temperature ($^{o}$C) | PH | Salinity(ppt) | Average total coliforms (cfu/ml) |
|---|---|---|---|---|
| January 2012 | 32.5 ± 0.92 | 7.7 ±0.2 | 33 ±0 | $1.7x10^{4}$ |
| February | 32.6 ±1.27 | 7.7 ±0.14 | 33.35 ±0.35 | $1.8x10^{5}$ |
| March | 33.45 ±0.35 | 7.55 ±0.07 | 34.25 ±0.35 | $9.0x10^{3}$ |
| April | 33.4 ±0.14 | 7.55 ±0.07 | 34.0 ±0 | $9.0x10^{3}$ |
| May | 33.55 ±0.07 | 7.55 ±0.07 | 33.75 ±0.35 | $1.4x10^{4}$ |
| June | 31.85 ±2.05 | 7.45 ±0.07 | 33.5 ±0.71 | $1.3x10^{4}$ |
| July | 30.55 ±0.78 | 7.55 ±0.77 | 33.0 ±0 | $4.1x10^{3}$ |
| August | 31.25 ±0.07 | 7.35 ±0.77 | 33.0 ±0 | $5.9x10^{3}$ |
| September | 33.05 ±0.07 | 7.45±0.07 | 33.0±0 | $3x10^{3}$ |
| October | 32.7±0.14 | 7.45±0.07 | 33.5±0.71 | $2x10^{3}$ |
| November | 30.45±0.07 | 7.5±0.14 | 33.5±0.71 | $2.6x10^{3}$ |
| December | 30.65±0.92 | 7.55±0.07 | 33.5±0.71 | $3.1x10^{3}$ |

- **Isolation of Sponge-Associated microbes from the sponge *Callyspongia diffusa* and their characteristics:** From the randomly chosen *Callyspongia diffusa* tissue, (Plate 13&14) seven morphologically and culturally distinct bacterial isolates designated as: VCDB, VCDA, VCDW, VCDI, VCDY, VCDP, VCDPS were isolated and their cultural/biochemical characteristics are given in Table 8 & 9. The total number of bacterial colonies from the sponge interior surface was recorded to be 50.0% higher than the bacterial load from the ambient seawater. Among these, the black pigmented VCDB isolate exhibited higher bioactivity profile. It was interesting to note that VCDB isolate was a a true sponge- associated bacteria as this isolate was not recorded from the ambient sea water. The CFU of VCDB constituted 12.5% of total microbial load of $16\times10^{4}$ cfu/g.

Morphological features of *Callyspongia diffusa*



Spicules (400X) of *C. diffusa*

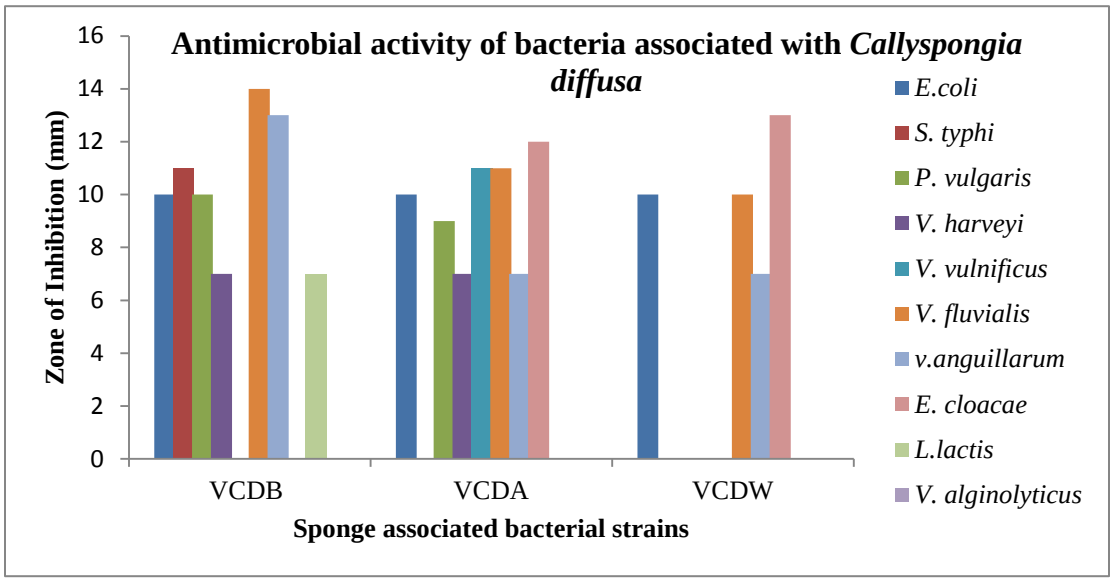
Cultural Characteristics of sponge-associated bacteria from *Callyspongia diffusa*

| Isolate | Cultural characters of sponge - associated bacteria | | | | |
|---|---|---|---|---|---|
| | Colony shape | Color | Form | Gram staining and shape | Motility |
| VCDB | Round | Creamy white with black pigmentation | Convex; mucoid | + rod | + |
| VCDA | Spreading | Creamy white | Rhizoid | + rod | - |
| VCDW | Round | White | Mucoid | + rod | - |
| VCDI | Round | White | Flattened | + cocci | - |
| VCDY | Round | Yellow | Raised; pin-headed | + rod | - |
| VCDP | Round | Pink | Small concentric ring | + rod | - |
| VCDPS | Spreading | Pink | Rhizoid | + rod | + |

The biochemical characters of isolates associated with *C. diffusa*

| Biochemical test | VCDB | VCDA | VCDI | VCDW | VCDY | VCDP | VCDPS |
|---|---|---|---|---|---|---|---|
| Glucose | - | + | - | - | + | - | - |
| Indole | + | - | - | - | - | - | - |
| Methyl red | - | - | - | + | + | + | - |
| Vogues Proskauer | - | - | - | + | + | + | - |
| Citrate | - | - | - | + | - | - | + |
| $H_2S$ | + | - | - | - | - | - | - |
| Starch hydrolysis | - | - | - | - | + | - | - |
| Catalase | + | + | - | + | - | - | - |
| Oxidase | + | - | + | + | - | - | + |

- **Screening of sponge-associated bacterial isolates for antimicrobial activity:** Experiments on the cell free supernatant of the associated bacteria showed that all the bacterial isolates except VCDI showed a significant antibacterial activity against all the tested human and fish pathogens. The VCDB isolate showed mild activity against *V. harveyi, V. anguillarum,Lactobacillus lactis, Proteus vulgaris* (MTCC 426) and *E. coli* (MTCC 40). Significant activity was exhibited against *Salmonella typhi* (MTCC 92), *V. fluvialis* and *Enterococcus cloacae*. VCDA exhibited a significant antibacterial activity of 12mm against *Enterococcus cloacae* and 11mm inhibition against *V. fluvialis* and *V.anguillarum* and mild activity of 7mm against *V. harveyi* and 9mm against *Proteus vulgaris* (Fig.1). The VCDB strain of bacteria was characterized as *Shewanella algae* (new isolate).

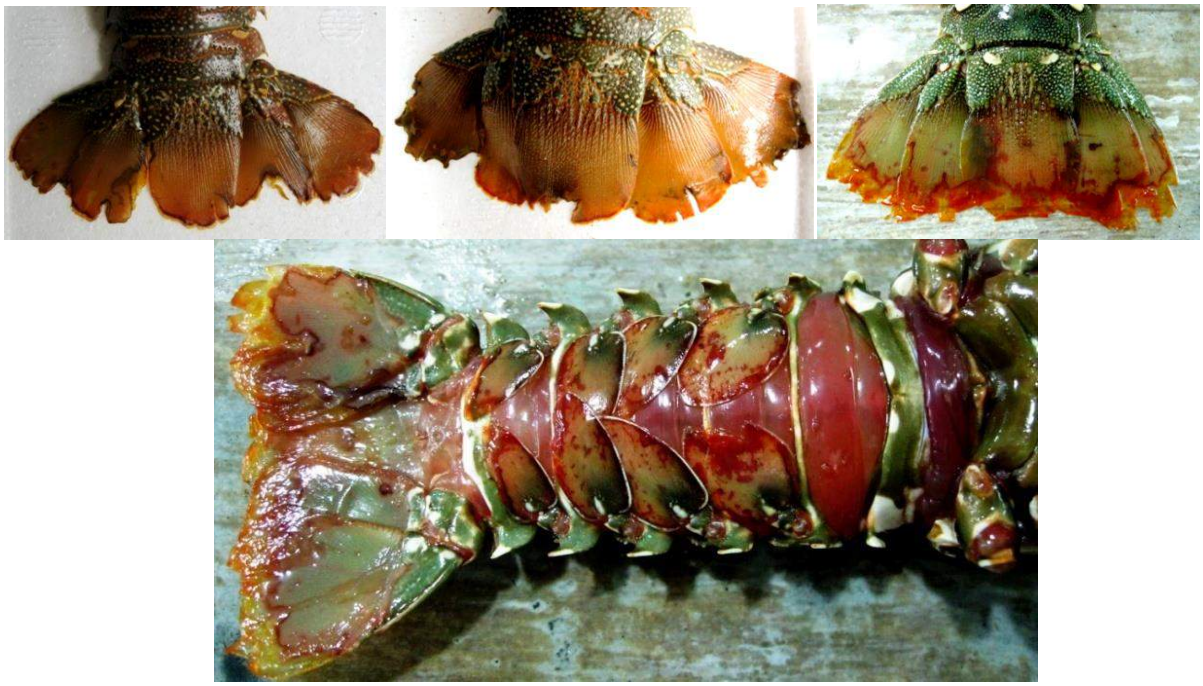



Antimicrobial activity of *Callyspongia diffusa* associated bacterial isolates

- **Antifungal potential of isolates from sponge tissue:** The experimental results on antifungal activity of bacterial strains from *Callyspongia diffusa* showed that only the ***Shewanella*** strain (VCDB) exhibited effective biocontrol potential against *Aspergillus niger, Aspergillus fumigatus, Saccharomyces cervicea* and *Colletotrichum gloeosporiodes*.

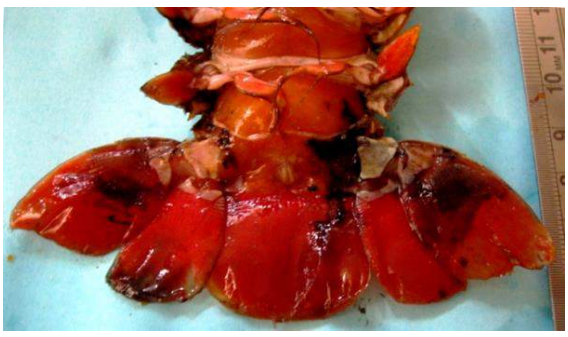
- **Infections in lobsters maintained in captive conditions before packing and exporting**: The health status of lobsters maintained in captive conditions before packing and exporting was monitored in different lobster holding facilities located around Kanyakumari. Infections in telson, appendages, inflammation in appendages and appearance of black spots in the abdomen were recorded as

common problems in the live lobsters (species such as: *Panuliurs homarus &P. versicolor*) maintained in the captive conditions. The average weight of such infected lobsters ranged from 200 to 350g. Bacterial examination in the infected lobsters revealed the association of 6 different isolates of which one exhibited high protease enzyme production. Results of antibiotic sensitivity revealed that chloramphenicol, tetracycline, erythromycin and ciprofloxacin in the decreasing order as effective inhibitory agents. During the sampling period, the microbial load in water varied from $4X10^6$ to $5.3X10^8$CFU/ml.

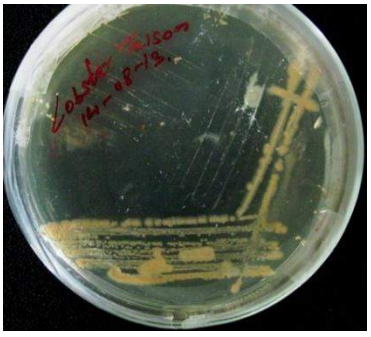


Telson rot conditions in live lobsters maintained in captive conditions for live export

**Infections in sand lobsters *Thenus orientalis* collected from natural grounds**:



Inflammation in telson in *Thenus orientalis*



Predominant bacterial isolate

- Sand lobsters,*Thenus orientalis* collected from natural habitat and kept for packing monitored for infections. Severe inflammation, redness and blackening of appendages in a few sand lobsters were noted during the month of August 2013. Microbiological analysis revealed the occurrence of 6 different bacterial forms. The predominant isolate colony was a spreading type in Zobell Marine agar which was examined for further detailed investigation.

- **Microbial infections in red spot emperor *Lethrinus lentnan* (Lacepede 1802) in the natural habitat:**Mass incursion of *Lethrinus lentnan* with skin lesions, fin erosions and scale loss along with a few specimens with blood oozing was recorded from the Kadiapatanam coast (along Kanyakumari coast) during September 2013. Several tonnes of *Lethrinus* species migrated in moribund conditions towards the shore and subsequently died. The average size was 258mm and 265g. The Dissolved Oxygen level was 4.4mg/litre; while the ammonia and nitrite content was 0.07mg/l and more than 3.0mg/l respectively. The microbial load in the ambient water was 3 $\times 10^7$. The $CO_2$ was 12.7mg/l. Though the salinity was 34.0ppt, the deep water temperature was very low as informed by the fisher folks. The drastic reduction in ambient temperature and water current velocity possibly would have debilitated and weakened the fish and subsequent infections by the bacterial pathogens.

Recently dead Lethrinid fishes

- **Infections among ornamental fishes in 'captive rearing' conditions:** Captive maintained emperor angel in the marine aquarium in moribund status was infested with ciliates and subsequent secondary infection by bacteria. The recently dead fish (Length and weight was 115 mm and 180 g

respectively) had fin erosion with exposed fin rays. Two predominant pathogenic isolates were obtained in Zobell marine agar.

Emperor angel with secondary bacterial infection and fin erosion

- **Dynamics of water quality and microbial conditions in the new marine research aquarium at Vizhinjam:**Studies on the dynamics of water quality conditions together with the microbial changes in the newly established marine research aquaria tanks were initiated. The average ammonia content on the initial day along with other parameters as well as microbial load was routinely monitored. The microbial load in the water was ranging from $4X10^5$ to $1.2X10^6$ CFU/ml in different tanks before the introduction of ornamental fishes. The salinity was 29 to 33 ppt; while the initial ammonia content was 0.018mg/l. The microbial load ranged from $2X10^4$ to $1.3X10^5$ CFU/ml (average $8.0X10^4$ CFU/ml) in different tanks after the rearing tanks were conditioned after one month.

- **Bioprospecting of marine microbes from the sponge and seaweeds:** The aqueous extract of the marine sponge *Callyspongia diffusa* was exerting antifouling activity towards the limpet, *Patella vulgata* which was evaluated through the 'Limpet Foot Adherence Assay' perfected in the laboratory. The sponge-specific bacterial extract from *Shewanella algae* also exhibited similar activity towards the limpets suggesting the lead antifouling compound/s from the sponge and its associated bacteria. The *Bacillus subtilis* VCDA strain recorded as a culturable co-inhabitant in the sponge *Callyspongia diffusa* and characterized by 16S rRNA sequencing displayed high protease and antibacterial activities.

*Callyspongia diffusa*

Limpet, *Patella vulgata*

- **Shrimp infections, management and harvest details:**Monitoring the diseases affecting the growth and production of *Penaeus vannamei* was accomplished in a private farm at Rajakkamangalam (Kanyakumari District). Observations revealed that the high stocking (90,000 PL) also helped the farmer to attain a production of 5763kg/ha during 90 days of culture. Black gill condition in the shrimps was noted after the shrimps have attained about 12g size (during 70 days of culture). The microbial load in water was $4.2X10^7$ CFU/ml and in soil it was $2.62X10^7$ CFU/g. Application of BKC reverted the black gill condition and the average growth attained by *P. vannamei* was 16.0g at the time of harvest.

Farm at Rajakkamangalam

*Penaeus vannamei* in check tray

- **Coliform bacterial monitoring in Vizhinjam Bay:** The occurrence of coliform bacteria in Vizhinjam bay was monitored periodically. The observations revealed that the coliform load of bacteria ranged from $1.2 \times 10^3$ (during June 2013) to $2 \times 10^6$ CFU/ml (in August 2013)

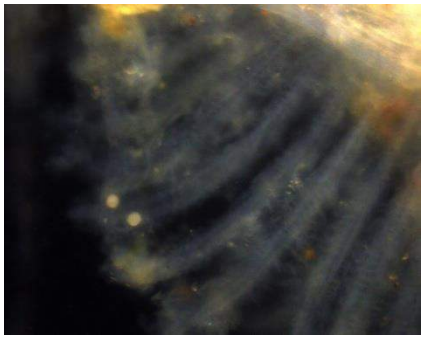
**4. Aquatic feed biotechnology for mariculture and aquariculture**
**Code FISHCMFRISIL 2012O2700027**

- Nutritional experiments were conducted using the seeds of *T. blochii* to evaluate the effect of different levels of protein and fat on growth. Seeds (4 to 5g and 84 to 102mm) collected from Kovalam bay were stocked in 10 tonne FRP tank with sea water and acclimatized to the lab conditions.
- Experiment was designed to examine different protein: fat combinations to arrive at an optimum one. Pellet feeds were made both low protein: low fat, low protein: high fat, high protein: low fat and high protein: high fat inorder to the optimum combination and to ascertain whether high fat really impacts the body composition.
- There are eight treatments of protein and fat 30:15, 40:12, 50:9, 50:9, 60:6, 30:6, 40:9, 50:12, and 50:12 200 L PVC tanks are for this purpose. Biochemical composition of initial and final samples was analyzed and results reported.

**Parasitic disease outbreak - cause identified and cured:**

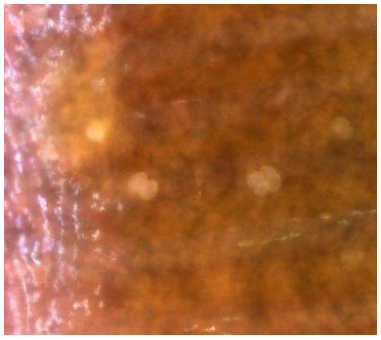
- Marine Velvet infestations caused by the protist dinoflagellate *Amyloodinium ocellatum* were noted in Pompano seed, Moorish idol and blue damsel.

Pompano infected by *A. ocellatum*



Trophont stage on gills

Trophont stage

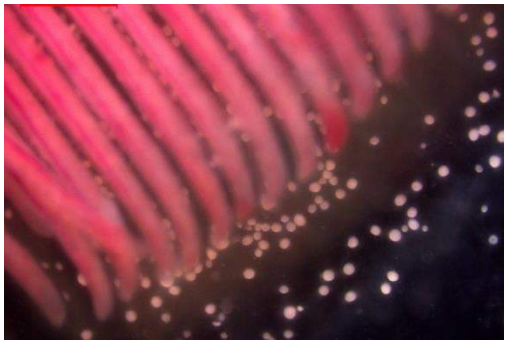


Tomont stage



Severely infected blue damsel Oodinium in damsel gill

- In blue damsel, the infested fish had also fin rot and discolouration. The infestation started from gills then progressed through skin with an initial sign of respiratory distress.

Infected Moorish idol Oodinium in Moorish idol gill

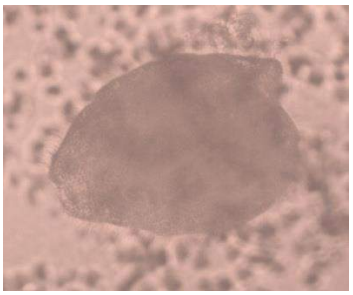
- Symptoms such as respiratory distress, loss of appetite, erratic swimming behavior, rapid gill movement with an excess mucous secretion were noted. The body surface irritation caused the pathogenic fish to scrapping the body and gill plates on the bottom substrate. Pathogenic fish swam alone from their group beneath the tank and after succumbed after suffocation. Treatment: 250mg Chloroquine diphosphate (Nivaquine-P) tablets with a dosage of 5mg/l for 10 days. On the 10$^{th}$day water was completely changed.

**Balantidiosis infection in Pompano brood stock**

- Symptoms: Discolouration or darkening of external body, external body surface of the fish appears as scratched-like pale white stripes due to scale drop, epithelial cells destroyed and thereby the parasite penetrates into the muscle tissues. Very weak in swimming & breathing. Extremely worse in external appearance with foul smell. Slowly eye becomes bulgy/exophthalmic. Fish swam without equilibrium.

Pompano affected by *B. coli*

Loss of epidermal layer



*B. coli*

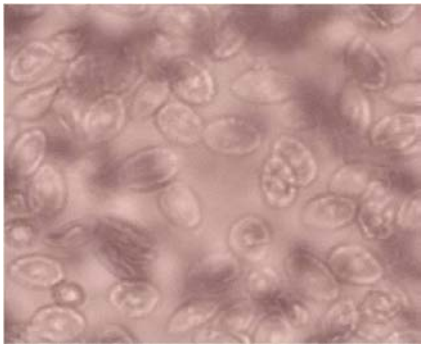
- Treatment**:** Fresh water dip resulted in majority of the parasite to come out of the host's body. It was followed by administration of Metronidazole at a concentration of 3g/1kg of feed for 10 days. An antibiotic dip was given to avoid secondary infections

**<u>Protozoan parasite -</u>** *<u>Chilodonella</u>* **<u>(seed Pompano)</u>**

- Infection in pompano seeds caused by ciliate protozoan *Chilodonella sp* was recorded. The parasite rapidly multiplied by conjugation and then spread to other fish causing serious and extensive damage. Mortality occurred due to fluid loss (dehydration) and secondary bacterial infections. Fish become lethargic with an excess secretion of mucus and death occurred within 12 hours.

Infected pompano seed


*Chilodonella* in gills

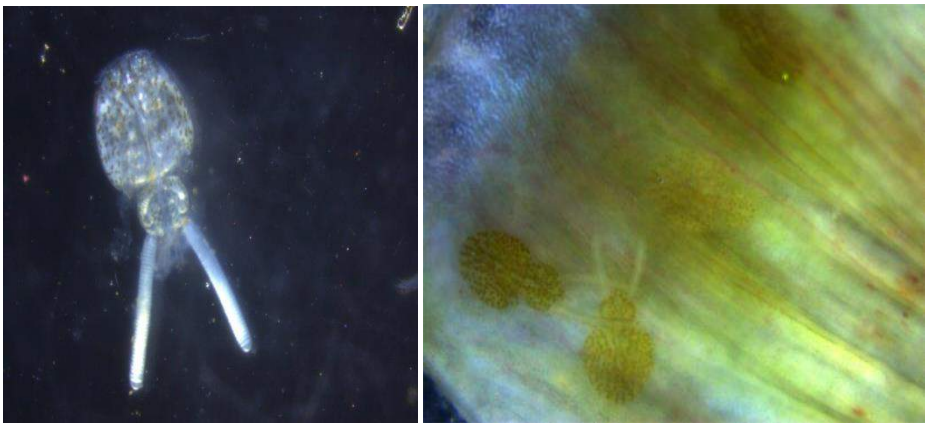


*Chilodonella* sp.

- Symptoms such as heavy breathing, rapid gill movement cloudy eyes and severe eye infection resulting in exophthalmic condition, excessive secretion of mucous and swimming in erratic manner; with an erratic manner were noted. Experiment was conducted on pathogenic gills with excess *Chilodonella* infection using various concentrations of 250ppt, 300ppt, 400ppt, 450 ppt and 500ppt of formaldehyde for 45min to 1hr. Results revealed that the formaldehyde treatment did not completely eradicate the parasite. A combination of Acriflavin–methylene blue powder was effective and eliminated as both with profuse aeration.

**Copepod parasites**:

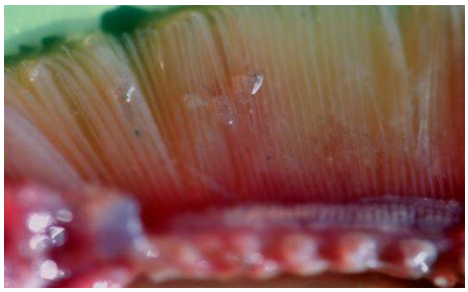
*Lepeophtheirus* spp.of the family caligidae was found to infecting marine fish and is found infecting the puffer fish *Arothron hispidus*. Parasites were seen attached to gills, fins as well as over the body surface.



*Lepeophtheirus* sp. from fins of puffer fish

**Caligid infection (Puffer fish, Bat fish and Koran angel):** Caligid was commonly associated with mortality of Koran fish in tanks and it was host specific. These parasites were easily visible (2-3 mm in length).

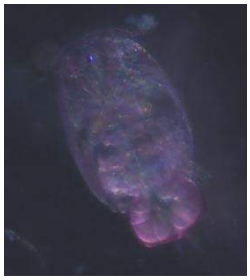
Bat fish infected by *Caligus* sp



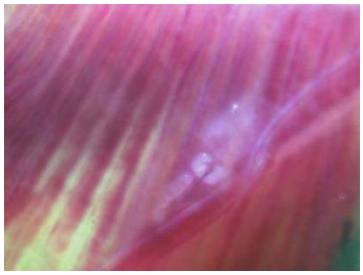
Caligus on Bat fish gills

Caligus

Koran angel infected by Copepod parasite

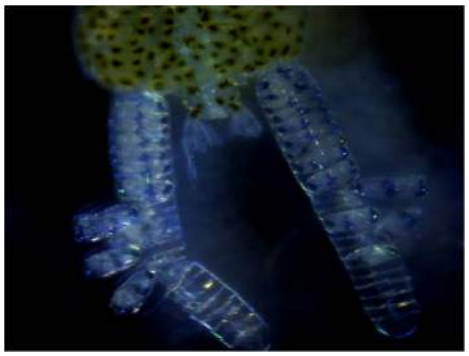


Parasite

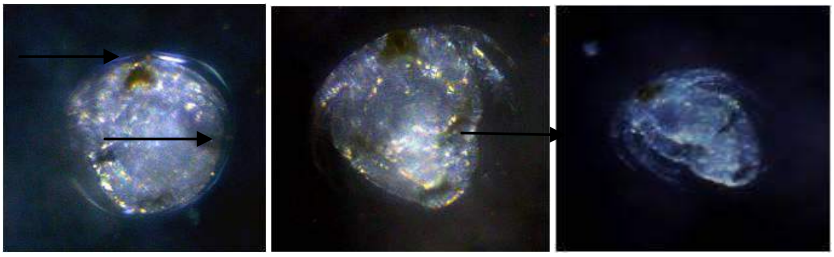


Parasite in Koran angel's gills

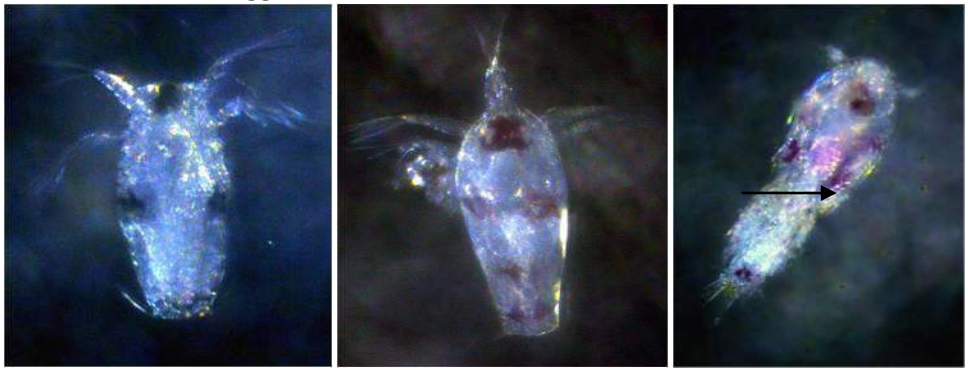
***Lepeophtheirus* sp.** The adult parasites of *Lepeophtheirus* sp. were found attached to the fins and in the body mucosa of the puffer fish *A. hispidus*. The egg hatched into free swimming nuaplii and passed through the free swimming and parasitic stages to attain infective adult.



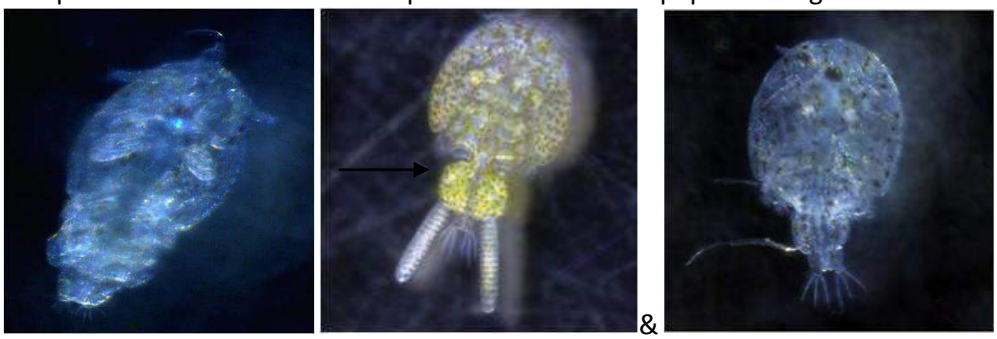
HATCHING



Inside egg case →



1Nauplius 2Nauplius Copepodite stage



Chalimus stage Adult female & Adult male

- Fresh water treatment was found to be the best method to eradicate the parasite. A bath treatment for 1 hr with 1 ppm of the organophosphorus compound Dichlorvos for 3-4 weeks was also effective.

***Hatschekia* sp. infection in (Blue damsel)**

- Blue damsels were prone for infestation by anchor worm (Family: Hatschekiidae & order Siphonostomatoida). The copepod parasite *Hatschekia* sp. was found attached using a 'holdfast', where it feeds on the gill – vascular tissue of the blue damsel fish. This resulted in severe heamorhhage of the attaching site. During the growth and its mature phase, this parasites feed on the host's blood causing injuries and muscle deterioration. Among them, females are the parasitic ones and embedded themselves into the hosts flesh. Reproductive potential was exhibited by the presence / development of two egg sacs on the exposed part of the parasite, hence Y/T- shaped appearance. This parasite could have been transmitted by means of contaminated and infected water, live foods and plants.

Blue Damsel – Anchor worm infected

Holdfast attachment


*Hatschekia* sp.

Female with eggs in the egg sac

Anterior anchors/ clawed antennae

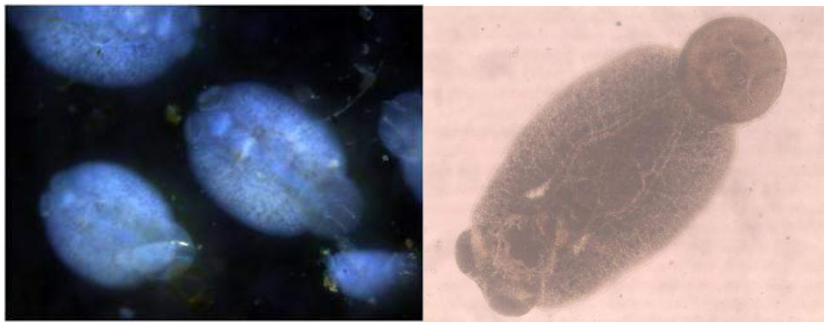
- The infected fish were transferred to quarantine tank in order to prevent the females from releasing eggs into the main tank. The wounds caused by the anchor worm on the attachment site were ugly and hard to heal. Treatment was given in the whole tank in order to kill the hatchlings. A prolonged

immersion treatment with Organophosphate repeating every 7 days for a period of 28 days was effective for the elimination of the parasite.

**Benedinia infection in (Butterfly, *A. oscillaris*):**

- The skin fluke *Benedinia spp.* was found attached on the butterfly fish of species *Chaetodon collare* by means of a well developed opisthohapter organ which had hooks, clamps, suckers or anchors for piercing and feeding on the host blood or tissues. Infection was also noted in *A. ocellaris*.

Butterfly affected by Benediniasis Parasite



Benedinian from *A. ocellaris*

- Fish infected by *Benedinia* have lost their normal shiny, wet appearance and turned into dull coloration.

Eroded eyes and damaged fins

- Freshwater baths, with formalin and malachite green was effective in the removal and destruction of the parasite. Repeated freshwater dip followed by Praziquantel 100mg/l bath for 5 minutes was effective.

**5. Aquatic feed biotechnology for mariculture and aquariculture**
**Code: FISHCMFRISIL 2012O2700027**

- Experiments were conducted using seeds of *T. blochii* to evaluate the effect of different levels of protein and fat on growth. Pompano seeds were collected from Kovalam and they were stocked in 10 tonne FRP tank with sea water and acclimatized to the lab condition. Around 100 fish seeds weighing about 4 to 5g with length ranging from 84 to 102mm were stocked in the tank.
- There are eight treatments of protein and fat 30:15, 40:12, 50:9, 50:9, 60:6, 30:6, 40:9, 50:12, and 50:12 200 L PVC tanks are for this purpose. Biochemical composition of initial and final samples was analyzed and results reported.

Experimental set up

## Mariculture Division Programmes

### 1. Innovations in sea cage farming and development of sustainable capture based aquaculture Code: MD/IDP/04

**Fish seed availability**

- Though the seeds of different species of fishes were available almost throughout the costal areas, throughout the year bulk collection was possible after the monsoon season (from August to May).
- A raft of size 15 x15ft with four compartments was fabricated for experimental rearing of seeds collected during survey**.**
- The project work also led to the development of multi-chambered, low cost, multipurpose wooden floating cages. Two net cage systems designed were with floating wooden frames of square/ rectangular shapes and sizes of 16 x 18ft. The first cage frame fabricated was of size 16 x18ft and the second one 16 x 16ft with 4 compartments each for attaching the net cages. The wooden frame was made using cheaper and hardy imported wood using planks of size 3 inch thickness and 2.5 inch width. There was a watch shed above the cage frame which can also be used for many other routine activities of the farm and for storage of items.
- Framework was designed with a catwalk, from which nets were suspended. This was sufficient to provide a stable and rigid platform to facilitate operation and maintenance. The frame work is shown below. The wall, floor and roof of the shed were made up of 6 mm marine plywood.

Full frame

FRP coated oil barrels

Tying the barrels

- Metal drums coated with fiberglass were used as floats due to their affordability and have a life span ranging from 3 to 5 years. The FRP coated barrels (16-18 numbers) were used for floating the framework. The cage was launched with help of a crane and dragged to the location of anchoring.

Launching of raft

Towing the cage unit to mooring site

- Anchoring was done with the help of concrete blocks having 2 to 2 hooks for attaching the rope (PP ropes and wire ropes). Four anchors weighing 50-60 kg each were used to moor the system. Iron anchors/Gabion boxes (a strong net cage) filled with rocks also could be used for anchoring. Each anchor was tied to the frame at four corners, and the rope length was usually two to three times the depth of the area.
- Monthly collections were made from coastal areas of Thiruvananthapuram District with specially designed drag nets with different mesh sizes using small hired boats.
- Operations in early hours of the day or in the evening especially before and after sunset yielded more fish seeds in the near shore areas.
- Mullet seeds were common in almost all seasons. Commonly available seeds include: *Mugil cephahalus*, *Liza* spp. *Valamugil seheli*, *Siganus canaliculatus*, *S. javus*, *Caranx* spp., *Therapon* sp., *Apogon* sp. and *Ambassis* sp. Juveniles of many important pelagic and demersal fishes were also available through shore seine operation.
- PVC framed hapas were used for transportation. Fish seeds were stocked and fed at regular intervals and maintained in the hapa with good survival rate till they are conditioned for transporting to grow-out areas. About 1000 mullet seed was collected stocked for about a week and 800 mullet seed of average size 5-7 cm were transported to Mandapam RC of CMFRI.
- About 2000 mullet seed was collected stocked for 15 days and 1500 mullet seed of average size 2-3.5 cm and were transported successfully to CMFRI Kochi for cage culture trials. In addition to this 3000 mullet seed were collected and maintained in the happas and transported the same to Kanyakumari.

*Liza* spp. fingerlings were found near the brim of the sand bar near Azhimalathura region

Mullet frys were shoaling (nearly 100 numbers) in near shore regions in Poovar and Thankassery

Ideal mode of operation to catch a definite shoal like that of Fig. 2

Near shore operation without seeing any shoal

Specially desined net for seed collection

Harvested small shoal

Seeds collected were stored temporarily in a polythene framed floating hapa

The framed hapa can also be used for transport of seeds to cage

Different netting materials were tried to prevent crab attack and fouling

Catching seed from happa for packing

Oxygen packing in raft itself

Seed being taken to shore for transporting to Kochi

- Developed techniques and new nets for collection of wild seed of *Sillago sihama,* Goldlined seabream *Rhabdosargus sarba* and pompano *Trachinotus blochii:* Three new nets were designed

and fabricated for the collection of fish seed. One net for the collection of seed of size above 15 mm was made using 10 kg net of mesh size 6 mm, length of 25 m and the breadth of 5 m. Floats were used at an interval of 60 cm and sinkers at an interval of 10 cm. The second type of net was made using mosquito net with a length 5m and breadth of 1.5 m. Third type of net was of 50 mm mesh size made of monofilament net used for collecting the seed of breams by putting bait of crushed mussel and surrounding the area.

- Seeds of *Sarda orientalis* (Striped bonito) and silver or white pomfret, *Pampus argenteus* were also collected. Information regarding the availability of shoals of these fishes was regularly obtained from the fishermen. Boat seiners were engaged to collect seed of these fishes. Seed of these fishes could be collected and transported live to the cages.

**2. Development of broodstock, captive breeding and seed production techniques for selected marine food-fishes and ornamental fishes Code: MD/IDP/03**

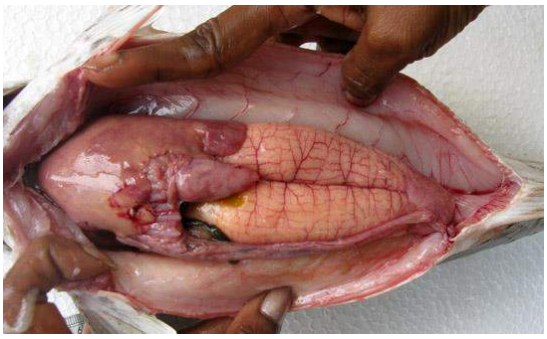
- The fishes which are available through angling could be easily collected in live condition for broodstock development. A survey was conducted randomly in the angling boats operated in vizhinajm area and evaluated the availability of fishes for live collection.
- **Very common fishes:** Spangled Emperor (*Lethrinus nebulosus*), Tomato grouper (*Cephalopholis sonnerati*) and Cobia (*Rachycentron canadum***)**
- **Common fishes:** Malabar trevally (*Caranx malabaricus)* Giant trevally (*Caranx ignobilis*) Bigeye trevally (*Caranx sexfaciatus)* Malabar grouper *(Epinephelus malabaricus)* Greasy grouper *(Epinephelus tauvina)* Brownspotted grouper *(Epinephelus chlorostigma)*
- **Rare fishes:** Two-spot red snapper *Lutjanus bohar* Mangrove red snapper *(Lutjanus argentimaculatus)* Smalltooth emperor (*Lethrinus microdon)* Blackbanded trevally *(Seriolina nigrofasciata)* and Goldlined seabream (*Rhabdosargus sarba*)
- **Collection conditioning and transportation of brood stock of cobia:** During the period under report more than 80 specimens of Cobia (*Racycentron canadum*) weighing 1 to 10 kg were collected and reared in cages attached to the raft moored in Vizhinjam Bay waters. Of which 42 numbers were successfully transported to Mandapam RC of CMFRI.

Brood stock of Cobia being transported

- **A new candidate species *Serriola nigrofasciata*** is taken up for studying the biology for evaluating feasibility of brood stock development and seed production.

*S. nigrofasciata*


Testis of *S. nigrofasciata*

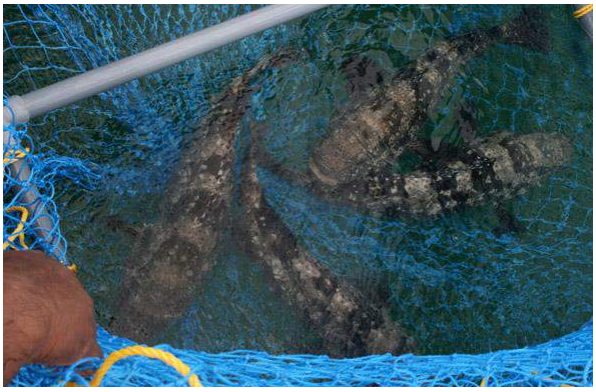

Mature ovary of *S. nigrofasciata*

- **Net cage***:* Net cages were made using synthetic HDPE nets and polythene fibres reinforced at the corners with nylon or PP ropes. The nets were kept stretched vertically with weights at the bottom of the cage and fastened at the top by rope to the framework with provision to be stretched with rectangular, round or square steel or PVC pipes depending on the shape of the cage. Since there is enough space for standing, net exchange and all operations were comparatively easier.

Net cage

Cages stretched by outer PVC frame

- **Utility of Cage culture system:** Cages were primarily used for farming of fish which include nursery rearing of seed. Fishes like seabass, groupers and cobia were reared. This is also being used for fish trap operation and also for suspending oysters and corals for various studies.

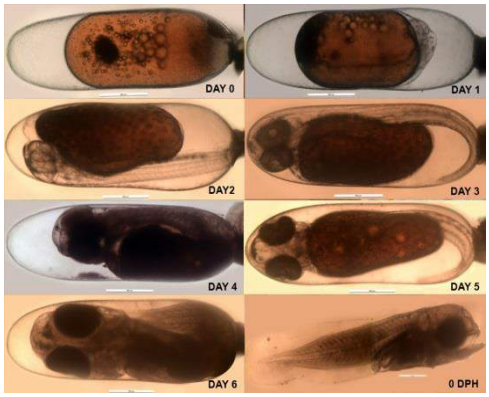


Grouper brood stock in cage

Cobia brood stock in cage

- Refined the Broodstock development and mass scale seed production technologies of 6 species of ornamental fishes *Amphiprion ocellaris*, true Percula Clownfish *A. percula,* sebae clown *A. seba* and Spinecheek anemonefish *Premnas biaculeatus, A. frenatus* and *A. nigripes* and also demonstrated the technologies developed to needy farmers. Brood stock of *Amphiprion nigripes* was developed

and seeds were produced for the first time. The fecundity ranged from 400 to 600. Survival of the larvae ranged between 60 to 80% during the first 30 days.



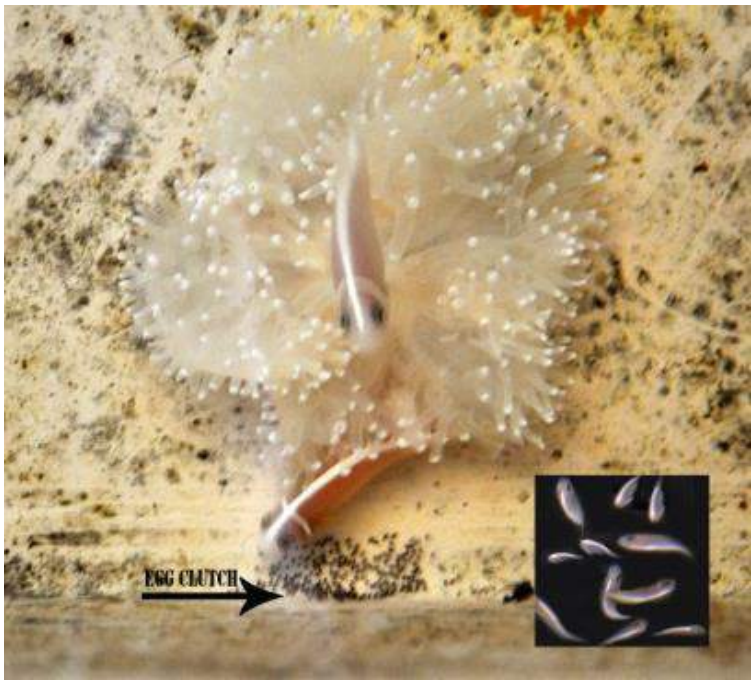
Development stages of eggs & larva


Advanced incubation-silvery eggs


Juveniles 40th day


4 month old juveniles in anemone

- Successful breeding and seed production of Pink Skunk Clownfish (*Amphiprion peridarion)* was achieved for the first time. Pink Skunk Clownfish *Amphiprion peridarion* is a highly sought after species in the international market. Fecundity was ranging from 75 to 150. This is reported as one of the difficult marine ornamental fishes to breed.




Pink anemone-fish *Amphiprion perideraion*

- **Culture of copepods as live feed: C**ontinuous culture and maintenance of copepods such as *Acrocalanus gibber, Temora turbinata, Pseudiaptomus serricaudatus* and *Acartia spinicauda* was achieved. Large scale cultures were undertaken in polythene buckets of 10 l capacity. For adults an intensity of 800-1000/l and for naupliar stages 2000-2500/l was attained. The copepod culture were fed with a combination of *Isochrysis galbana* and *Nannochloropsis* sp.
- Protocols was developed for feeding, rearing, isolation, cleaning, and maintaining culture without any contamination. Mass culture was initiated in 2000l Syntex tanks. Most promising results were obtained for *Temora turbinata* and *Pseudiaptomus serricaudatus.*

*T. turbinate* female

male

Feeding the copepods in mass culture tanks

3. **Development and standardization of seed production technologies for selected highvalue finfishes and shellfishes Code: FISHCMFRISIL201202400024**

- **Broodstocks of goldlined seabream-*Rhabdosargus sabra*:** Initiated the collection and biological studies. Fishes rarely available in the Enayam, Muttom and Thengapattanam areas were collected.
- Those fishes collected by hook and line methods did not survive. *R. sabra* has 4-5 rows of large molar teeth in upper jaw and 2-4 rows in lower jaw which are generally used for chewing. The hooks usually found penetrated deep and because of the strong teeth, it is very difficult to remove the hook in live condition. Fishes less than 1kg or below 30cm in total length were mostly males. Fishes above 30cm showed ovarian development. Mussels are the preferred food of this species. The fish become mature in the first year itself. Fish grow to a size of 25-30cm (0.3-0.5kg) in the first year and in the second year fish reaches a size of 35-45cm (0.8-1.5kg). First year all fishes will be male and from second year onwards most of them will become females. Fishes 30-35cm showed partial ovarian development with non-functional testis.
- Initiated the collection and biological studies of Spangled Emperor fish (*Lethrinus nebulosus).* Fishes were collected mainly from Enayam, Muttom and Vizhinjam areas. *L. nebulosus* were collected by hook and line method and brought to the cages using tanks fitted in boats. Four fishes are being reared in the cages. This is protogynus hermaphrodite species.

*Rhabdosargus sarb*

*A*cclimatisation in indoor conditions

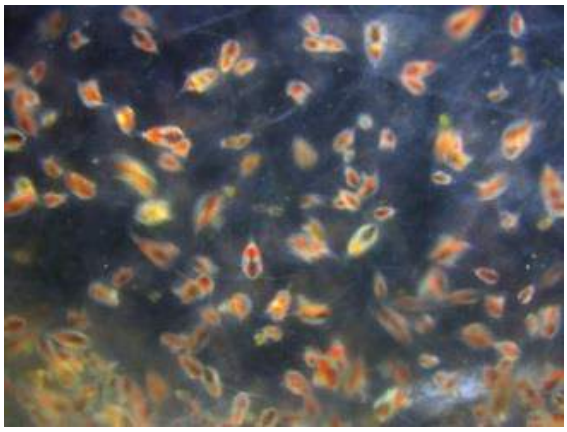
- Initiated the broodstock development of blue streake cleaner wrasse in the confined conditions. Twenty five fishes are being maintained in different conditions and studies are initiated for the development of broodstock.

Bluestreak cleaner wrasse pair

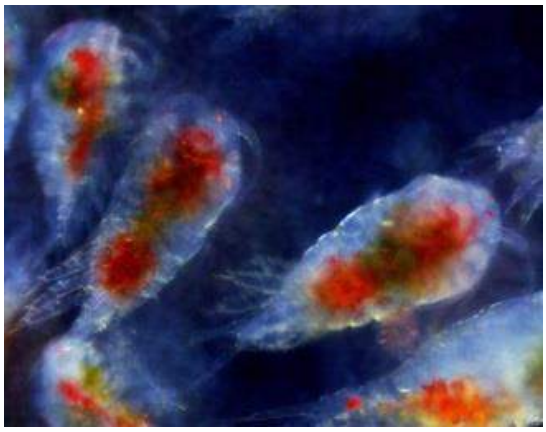
**Culture of copepods for larval feeding**

- Mass production of Calanoid copepod *Temora turbinata* has been standardised. For adults an intensity of 1000/l and for naupliar stages 2000-2500/l was achieved. The culture was mainly fed with a combination of *Isochrysis galbana* and *Nannochloropsis* sp. Protocols for feeding, rearing, isolation, cleaning and maintenance of pure culture were developed and standardized.
- Adults and naupliar stages of *T.turbinata* were highly pigmented and the slow moving copepods became easily vulnerable to predation than most of the calanoids.
- *T. turbinata* has no egg sacs or brood pouches. Eggs were scattered in the bottom. Bottom water was siphoned out daily and sieved using 100µ sieves. The filtrate can be removed, water aerated and kept in ideal condition. Pure and identical nauplii can be harvested by filtering surface water through a 50 µ sieve.

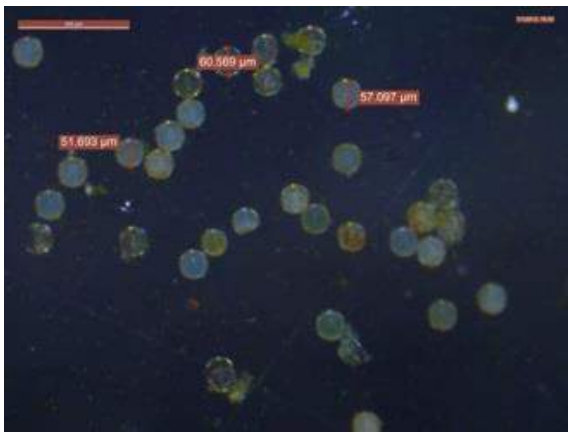
- Trials were being undertaken for producing resting eggs. Initial trials using higher and lower temperatures and salinities could not give promising results. Egg hatching can be delayed by keeping the eggs in 4°C. The success rate was reduced to 50% in 7days duration.
- Maintaining continuous culture of a promising another species of copepod *Pseudodiaptomus serricaudatus* was also achieved. Mass culture of *P. serricaudatus* was initiated in tanks of 1000l capacity. For adults an intensity of 600-800/l was obtained. Protocols for feeding, rearing, isolation, cleaning and maintenance of pure culture.
- Larval production trials were conducted using copepod (*Temora turbinata*) naupliar stages as feed for larvae of *Amphiprion frenatus* against the traditional practice of rotifer and artemia – nauplii combination. A 30 day trials gave 24.5% better survival, better growth and brighter colouration in copepod fed larvae.



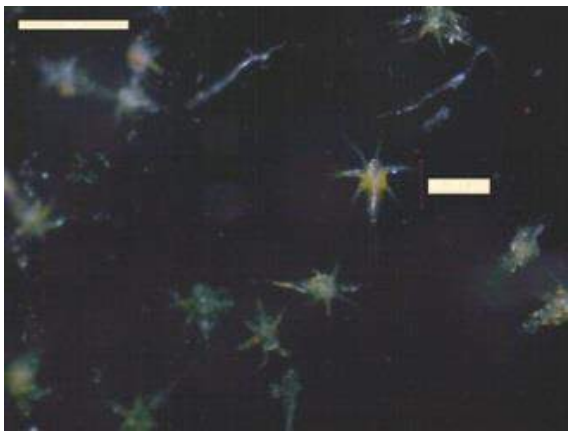
*Temora turbinata* (live)



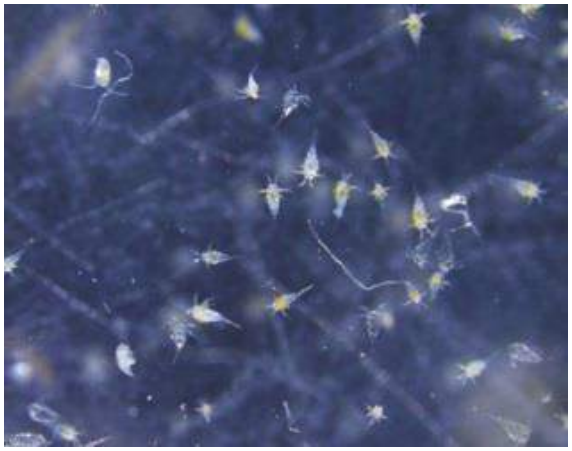
Pigmentation (rich in PUFA)



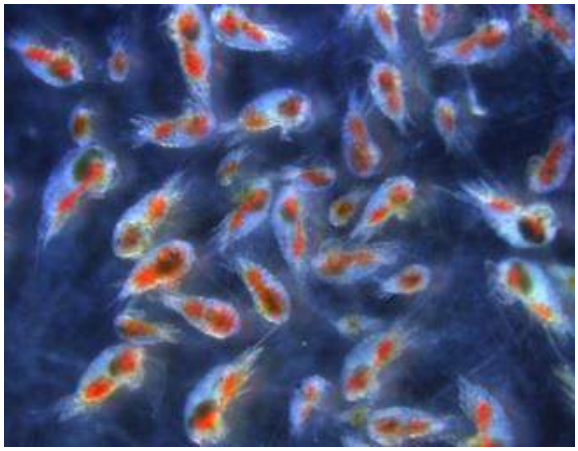

Eggs



Nauplii (24hr after hatching)

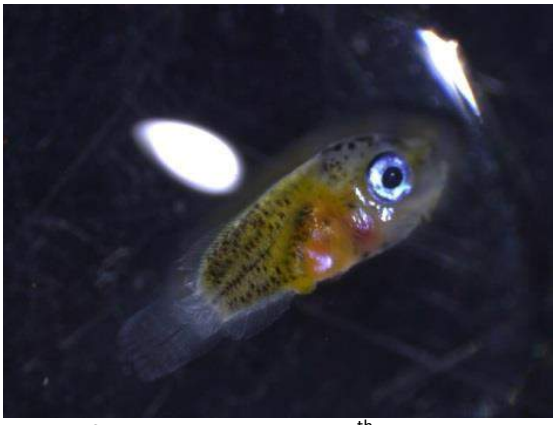


Nauplii (5days old)



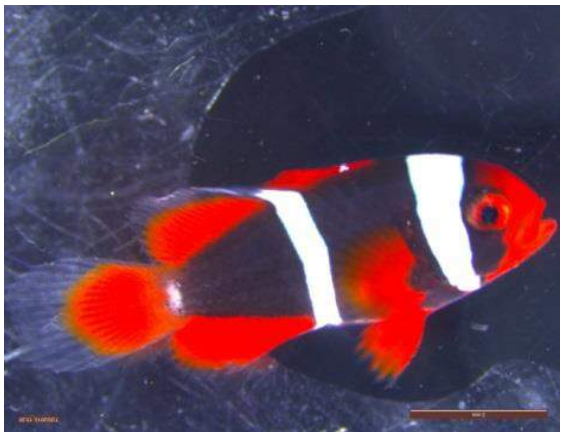
Adults

Larvae control on 8th day

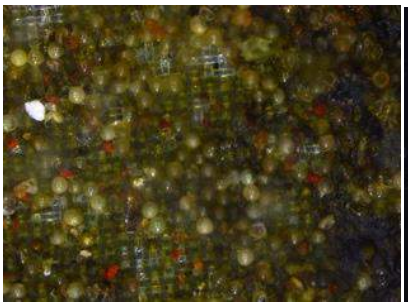
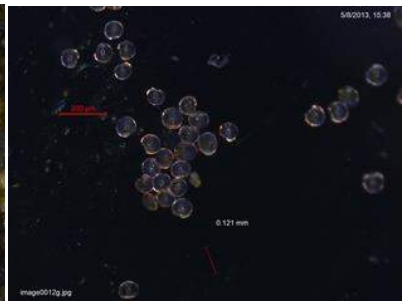


Larvae fed with copepod on 8th day

Larvae on 30th day (Control)



Larvae fed with copepod on 30th day



Dried eggs of *T. turbinata* Stored eggs in cool temperature *Pseudodiaptomus serricaudatus*

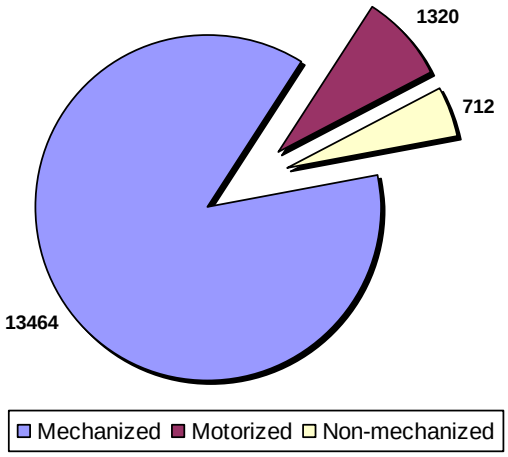
- Broodstocks of 7 species (*Amphiprion sebae*, *A. ocellaris, A. percula, A. frenatus, A. peridarion, A. nigripes* and *Premnas biaculeatus)* of ornamental fishes were maintained in hatchery for seed production. Breeding technologies developed were disseminated to needy farmers and entrepreneurs during several occasions through HRD programmes.

## SEETT Division

**2010-11**

- The gross revenue from the marine fish landings during 2009-10 at the point of first sales (landing centre) was estimated as Rs.19,753 crores, registering an increase of 14% over the previous year.
- The gross revenue from the marine fish landings at the point of last sales (retail market) was estimated at Rs.28,511 crores, with 14.35% increase over the previous year.
- The unit price of marine fish at the landing centre and retail market was Rs.61.88/kg and Rs.90.13/kg respectively.
- The gross private investment on fishing equipment in India (2009-10) was estimated at Rs.15,496 crores**,** out of which the investment on mechanised crafts was Rs.13,464 crores (87% of the total investment), followed by the motorized crafts with Rs.1,320 crores (8.5%) and the non-mechanized crafts with Rs.711.6 crores (4.5%).

**Gross Private Investment in Fishing Equipment in India, 2009-10 (Rs. in crores)**




- The per capita investment per active fishermen during 2009-10 was worked out as Rs.3,11,799 in the mechanized sector, Rs.32,870 in the motorized sector and Rs.17,205 in non-mechanized sector.

**Market structure and price behaviour**

- The marketing efficiency analysis of fish marketing in the different markets indicated that the price spread varied across the species and its size. In the case of small size the producers share of the consumers rupee was highest for Rock cods (85.37%) followed by Pomfrets(79.81 %),Catfishes (77.18%) and lowest for Clupeids (47.78), Cephalopods other than Sepia (49.18%), Rays (55.71%) and Sharks (55.71%).

- Analysis of fish price behaviour at landing centre and wholesale markets in Tamilnadu showed that the average minimum price was recorded for oil sardines at Rs.25 per kg and the maximum for seer fish at Rs.325 per kg. The price variation for different sizes was clearly observed in the study. At retail level, the minimum price was recorded for oil sardines at Rs.35 per kg and the maximum price was recorded for seer fish at Rs.450 per kg.
- Size wise variation at the landing centre price was highest for seer fish, pomfrets, penaeid prawns, non penaeid prawns and sharks. The difference between small and large sized seer fish in the landing centre was Rs. 50 per kg. In whole sale market, highest price was recorded for seer fish (Rs.325 per kg followed by penaeid prawns (Rs. 310 per kg).
- Size wise variation in retail market was highest for seer fish (Rs.400 tor small fish Rs.450 for large size fish per kg) followed by penaeid prawns (Rs. 30 per kg).

- The fishermen share in the consumer rupee was high for varieties like Non penaeid prawns (97.14%), pomfrets (96.42%) and penaeid prawns (90.32 %) indicating an efficient marketing system existing for these premium varieties. In the case of oil sardine, mackerel and silver bellies, fishermen earned nearly 85% of the consumer rupee.

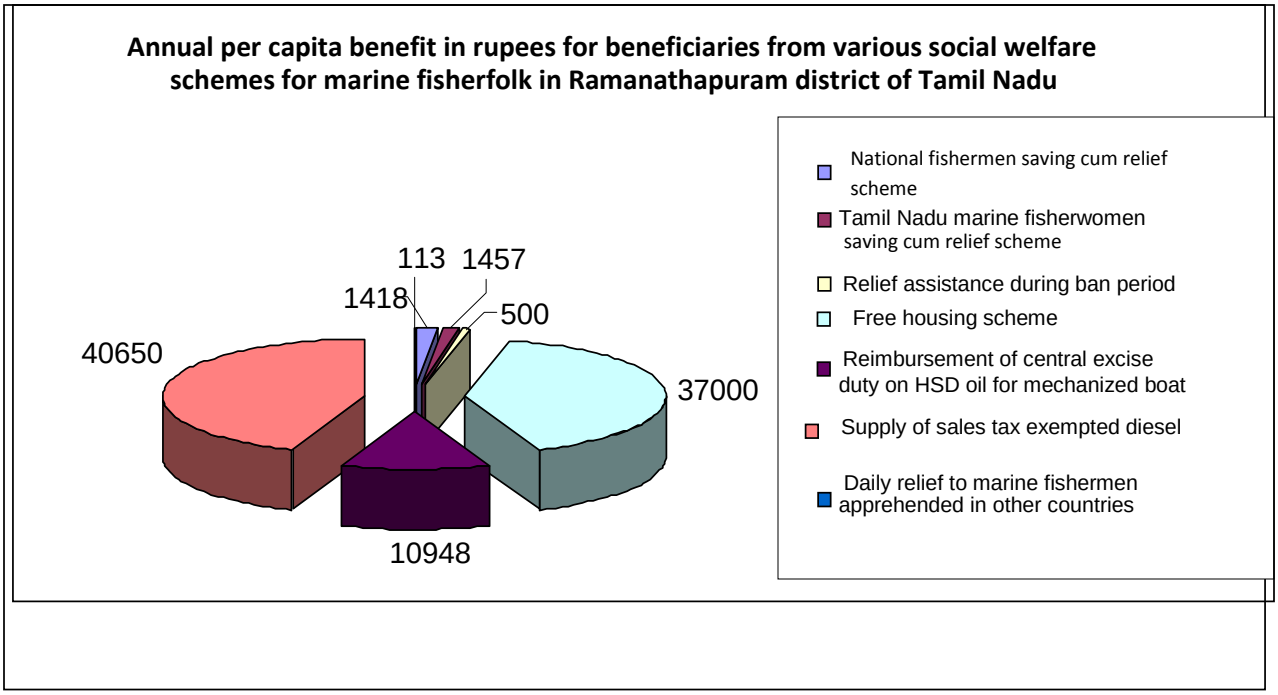
**Total Factor Productivity**

**Assessment of literacy, income and health status of fishers in India**

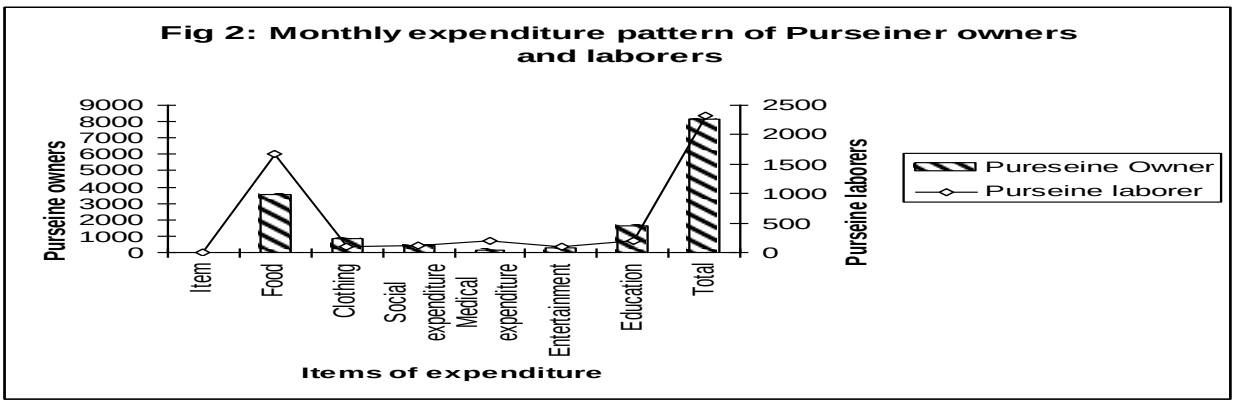
- The literacy ratio analysis of the selected marine fishers in the coastal states of Kerala, Tamil Nadu and Puduchery indicated that the literacy rate was highest in Kerala followed by Puduchery and Tamil Nadu at 87.2, 80.1 and 77.3 per cent respectively. The analysis on the access to educational institutions indicated that the primary schools were invariably accessed at less than a kilometer and high schools and colleges within a range of 1-3 km and 3-8 km respectively. The professional colleges were located a distance of 7 to 15 km in the selected states.
- The health status of the respondent household across the selected fisher families in Kerala, Tamil Nadu and Puduchery revealed that there wasn't any case of discontinuation of the vaccination regime for children/ infants.In addition there wasn't any mortality of mother or child during child birth which all indicated the high level of awareness of health
- The income analysis across the selected states indicated that the respondents involvement in non fisheries activities were found to be significant (25 per cent of the total selected fishers) on account of low level of income,seasonality of fishing operations. The level of indebtedness of the fishers across the states indicated that the indebtedness was reported high in Puducherry (77.14 %) followed by Tamil Nadu (54.28 % ) and low in Kerala ( 42.40 %).

**Fisheries governance, livelihoods, gender and welfare:**

- The data collection using the PPAR approach, which was designed and validated in 2008-09, was continued in Kerala, Tamil Nadu and Karnataka. The diachronic data obtained would yield multidimensional indices of poverty at the end of the project.
- The dimensions and extent of social security nets covered by the maritime states was characterized. Fuel subsidy lies on the top of the various welfare schemes offered by the State (Refer figure for a case in Tamilnadu). A similar trend has been observed in other states also.




- Access to means of production is one factor that determines the intra-sectoral inequality. Significant difference was observed in the monthly per capita expenditure (MCPE) in Karnataka varied between the owners and labourers significantly.




- While analyzing the various components of the social security net among the maritime states under study it was observed that the State of Kerala is unique in the case of provision of old age pension to fishermen above 60 years.The scheme was intiated in 1987-88 under the Kerala Fishermen Welfare Fund Board and a amount of Rs 49.85 crores (with a per capita dividend of Rs 2343) was disbursed as pension to 2,12,746 people (consisting of fishermen, widows and allied workers who are members of the Board) during 2006-11.

**Rural indebtedness and microfinance**

- Situational analysis was done through PLA in the selected potential maritime locations in the selected zones. The extent of coastal rural indebtedness and other parameters with was assessed with a pre-tested and standardized data collecting protocol.
- In South West zone, comprising Kasargod, Calicut and Ernakulam districts of Kerala the average indebtedness of fisheries households in mechanised sector of non members of Micro Finance Institutions (MFI) was Rs 95,000/- and that of members was Rs 48,000 /-. In motorised sector, the indebtedness of non-members is Rs 2,65,000 /- and that of MFI members was Rs 54,000 /-. But in the traditional sector MFI members' indebtedness was Rs 50,000 /- and that of nonmembers was Rs 20,000 /- which indicated the necessity of strengthening the MFI ventures in the traditional sector. It was also observed that the MFI member fisherfolk have a repayment capacity to the tune of 38 %.
- The level of indebtedness got reduced to the tune of 75 % after joining MFI and their repayment capacity improved to the extent of 65 % in mechanised sector. But in motorised/ non motorised sector level of indebtedness increased to the tune of 65 % after joining MFI, but in the mean time the their repayment capacity also got improved to the extent of 53 %.

**2011-12: RESOURCE MANAGEMENT, ECONOMIC SUSTAINABILITY AND SOCIO-ECONOMICS**

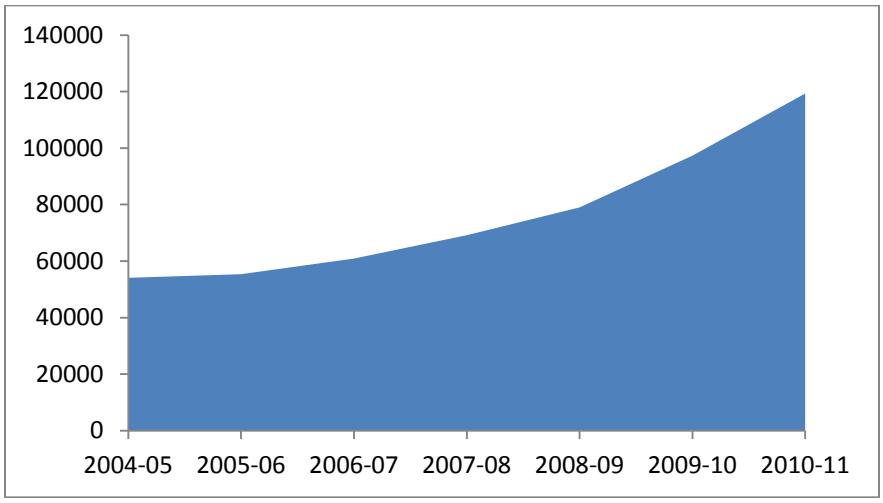
**Valuation of landings**: During 2011 the valuation of marine fish landings at the landing centre level (point of first sales) was estimated at Rs.24,372 crores and that of the retail centres (point of last sales) was found to be Rs.38,152 crores The average fishermen share in the consumer's rupee was found to be 63.88 %.

**Total factor Productivity Analysis**

- The total factor productivity growth in marine fisheries in India was worked out for the period 2000-2010 using the quantities and shares of labour and fuel as input variables and the quantities and shares in the total revenue of 12 resource groups. The output index showed a positive growth of 3.4 % during the period 2000-10.
- Analysis of shares of different resources in the gross revenue earned during the period 2000 to 2010 showed that share of crustaceans in the gross revenue increased from 38.68 % in 2000 to 40.69 % in 2010. The share of clupeids declined from 11.44 % in 2000 to 10.80 % in 2010. The share of cephalopods increased from 6.53 % to 9.77 % and the share of seer fishes declined from 5.6 % to 4.25 %. The share of mackerels, carangids, pomfrets and other pelagics remained the same during 2000-10 period.

**Fuel consumption in the marine fishing sector**

- The annual diesel consumption in Kerala has shown a continuous increase over the years with multiday fishing operations and use of chinese engines with very high capacity (up to 440 hp) and high diesel consumption. The diesel consumption increased from 54 million litres in 2004-05 to 119 million liters in 2010-11.




Growth in diesel consumption in Kerala

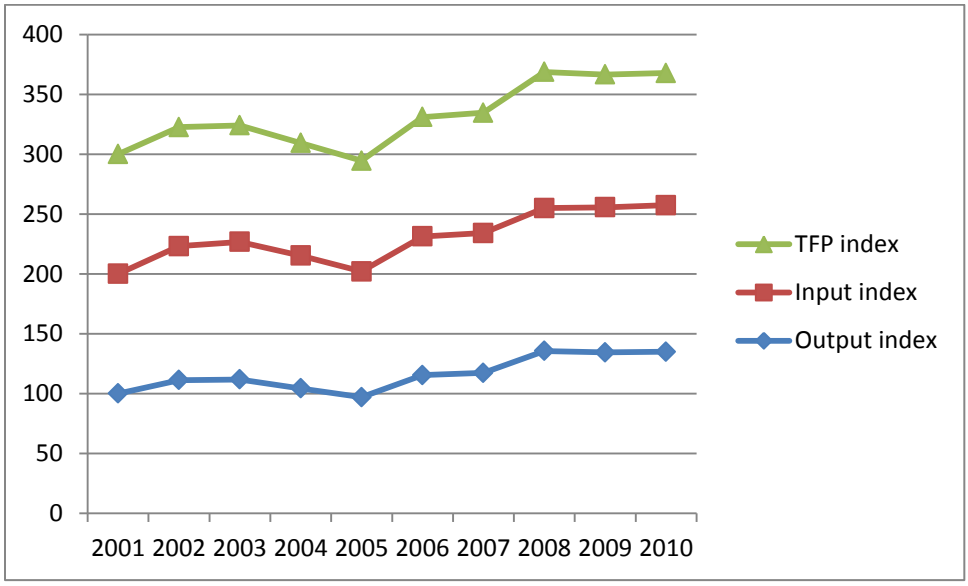
## Labour use in the marine fishing sector:

- The labour employed in the marine fishing sector was almost stagnant at 100 million days. In the mechanized sector the labour days increased from 57.31 mn in 2000 to 81.48 mn in 2009 and then declined to 71.71 million days in 2010. The labour employed in the motorized sector declined from 25.62 million days to 22.95 million days and in the non- mechanized sector the labour employed drastically reduced from 11.95 million days to 4.59 million days.

**State wise total factor productivity index**

- The state wise analysis of total factor productivity growth showed that the TFP growth was positive in the east coast ( 8.16 per cent), whereas it was negative in the west coast (-0.17 per cent) during 2000-10 period. The negative total factor productivity growth in the west coast was due to the negative output index growth rates in the major producing states of Kerala and Maharashtra. The reduction in the landings of the high value resources like shrimps in these states in the past decade might have contributed to the negative output index growth rates.

- At All India level the input index showed a positive growth of 1.7 per cent and the total factor productivity growth showed a positive growth of 1.7 percent. The positive total factor productivity growth showed the economic sustainability of the production system.




Growth in input, output and TFP indices

**2012-13: Resource management, economic sustainability and socioeconomics**

- The estimated value of marine fish landings at landing centre level was worked out at Rs.24,890 crores in 2012 an increase of 2.13 per cent year 2011. The unit price per kg of fish at landing centre was Rs.74.17 an increase of 10.57 per cent. At the retail level, the estimated value was Rs.38,562 crores registering an increase of 1.07 per cent over the year 2011. The unit price at the retail market level was Rs.111.92 an increase of 6.88 per cent compared to last year.
- The economic performance of various fishing methods were worked out for Kerala. For a single day trawl operation in Puthiyappa in the coastal district of Kozhikode, the average operating cost worked out to be Rs.18,504 per unit with an average gross return of Rs.34,648. The average capital productivity ratio worked out to be 0.53.
- For a multi-day trawl operation (less than six days) in Beypore in the coastal district of Kozhikode, the average operating cost worked out to be Rs.1,16,963 per unit with an average gross return of Rs.1,90,307. The average capital productivity ratio worked out to be 0.61. For a multi-day trawl operation (less than six days) in Puthiayapa in the coastal district of Kozhikode, the average operating cost worked out to be Rs.1,18,133 per unit with an average gross return of Rs.1,76,318. The average capital productivity ratio worked out to be 0.67.

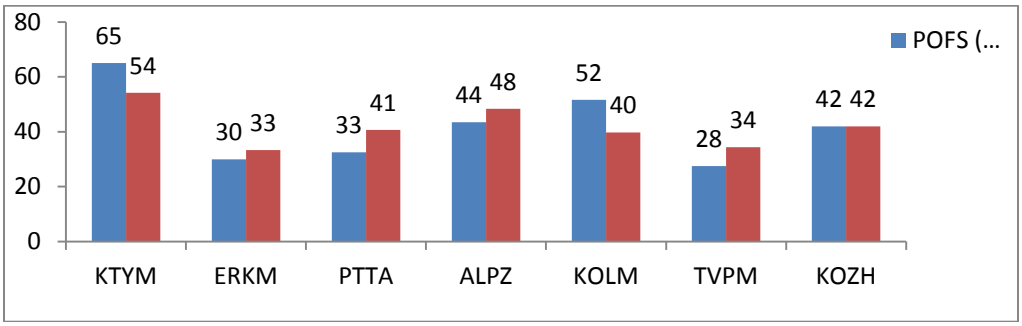
- For a multi-day trawl operation in Munambam Fisheries Harbour for more than six days in the coastal district of Ernakulam, the average operating cost was worked out to be Rs.1,16,963 per unit with an average gross return of Rs.1,90,307. The average capital productivity ratio was 0.61.
- For a multi-day trawl operation of 2-5 days in Cochin Fisheries Harbour in the coastal district of Ernakulam, the average operating cost was worked out to be Rs.75,009 per unit with an average gross return of Rs.1,05,225. The average capital productivity ratio worked out to be 0.71. For a multi-day trawl operation of 2-5 days in Cochin Fisheries Harbour in the coastal district of Ernakulam, the average operating cost worked out to be Rs.84,598 per unit with an average gross return of Rs.1,36,080. The average capital productivity ratio was 0.62.
- For multi day gill netter operations in Munambam fishing harbour of Ernakulam district the average operating cost worked out to be Rs.2,69,462 per unit with an average gross return of Rs. 4,20,000. The average capital productivity ratio worked out to be 0.61.

**Economic indicators for mechanized trawlers in Kerala**

| Economic indicators | Single day trawling | Multi-day trawling (< 6days) | Multi-day trawling (> 6 days) |
|---|---|---|---|
| Total Operating Cost | 18,504 | 95,986 | 1,06,565 |
| Gross Revenue | 34,648 | 1,47,766 | 1,67,568 |
| Net income | 16,144 | 51,780 | 61,004 |
| Operating ratio | 0.53 | 0.66 | 0.64 |

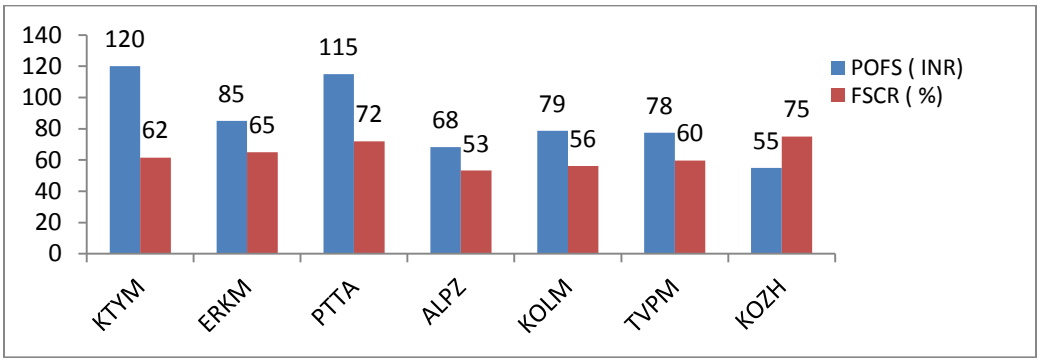
- The comparison of prices at the point of First Sales (landing centre prices) and the point of Last Sales (retail prices) and the Fishermen share of Consumers' Rupee for the major commercially important traded species across the different districts of Thiruvananthapuram (TVPM) , Kollam (KOLM), Pathanamthitta(PTTA), Alappuzha (ALPZ), Ernakulam(ERKM) and Kozhikode(KOZH) are given below:

(i) Pelagics- Oil Sardines



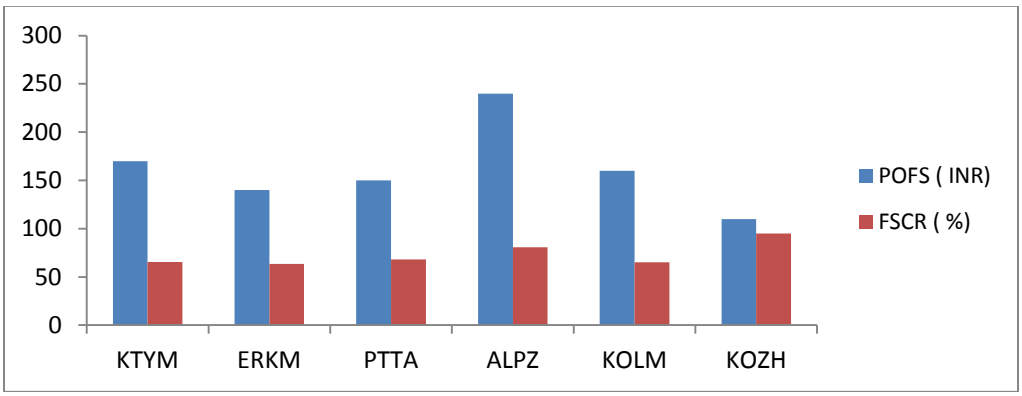

Comparison of prices at the point of First Sales and Fishermen share of Consumers' Rupee across different districts for Oil Sardine .

ii) Pelagics- Indian Mackerels



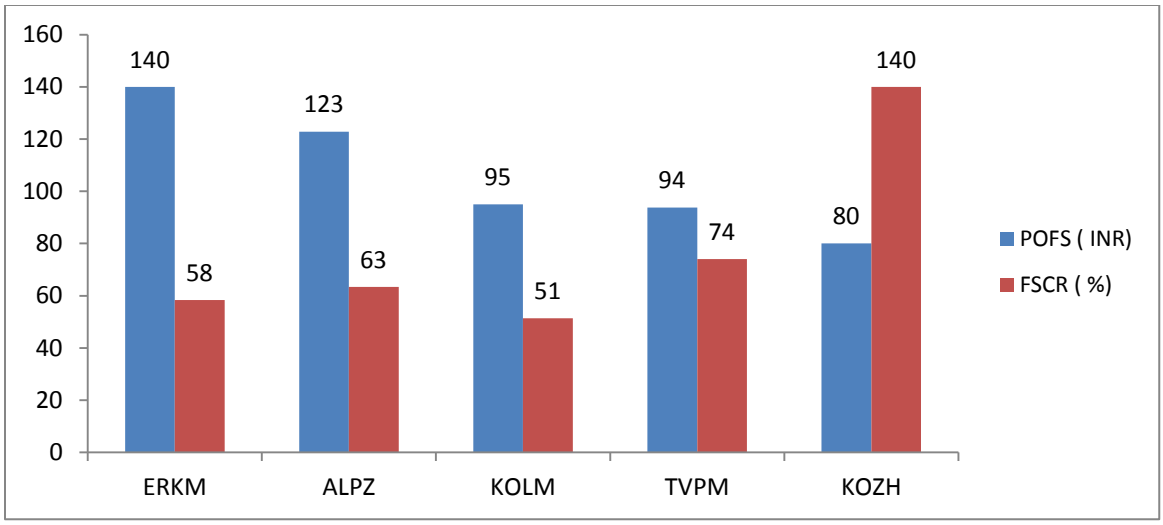

Comparison of prices at the point of First Sales and fishermen's share of Consumers' Rupee across different districts for Indian Mackerel.

(iii) Demersals - Black Pomfrets



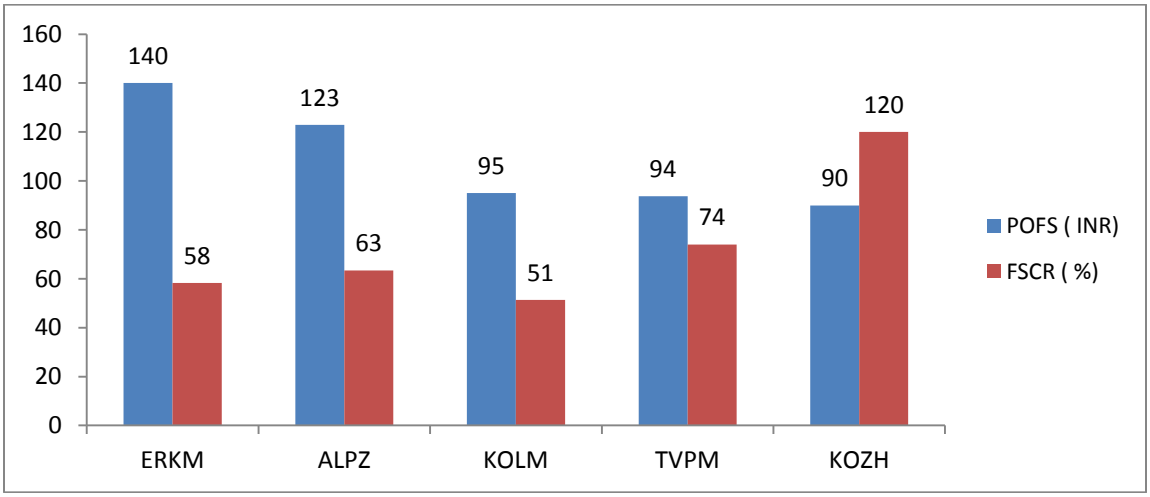

Comparison of prices at the point of First Sales and fishermen's share of Consumers' Rupee across different districts for Black Pomfrets.

(iv). Crustaceans – Indian white shrimps




Comparison of prices at the point of First Sales and Fishermen's share of Consumers' Rupee across different districts for Indian white shrimp

(v) Molluscans - Indian squids




Comparison of prices at the point of First Sales and Fishermen share of Consumers' Rupee across different districts for Indian squids.

**External Projects**

**ICAR Mega seed project**

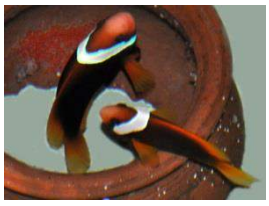
- Refinement of broodstock and mass scale seed production technologies of 7 species of ornamental fishes and also demonstration of the technologies were developed later to the needy farmers.


*A. sebae*


*A. ocellaris*

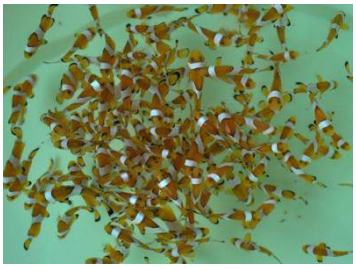

*A. percula*


*P. biaculeatus*


*A. frenatus*


*A. peridarion*


*A. nigripes*



Seed of clown fishes

Seed of following ornamental species were produced in large scale for distribution:

1. *Amphiprion ocellaris,*
2. *Amphiprion peridarion,*
3. *Amphiprion clarki*
4. *Amphiprion percula,*
5. *Amphiprion sebae,*
6. *Premnas biaculeatus,*
7. *Amphiprion tricinctus*
8. *Pomacentrus caeruleus*

**1. Open sea cage-culture demonstration farms in India (NFDB)**

- With the active participation of fishermen, two demonstrtions were successfully carried out for lobster culture in open sea cages at Chinnamuttom area of Kanyakumari. Methods including the selection of site, design and fabrication of the frame, outer and inner nets, mooring, safety devices to withstand the rough sea conditions, lobster seed collection, transportation, feeding, net exchange, other daily maintenance etc. were undertaken in participatory mode.
- Two demonstrations were undertaken for lobster culture with local fishermen at Kanyakumari in circular HDPE cages. The first cage was harvested on 8th December. Average size was 190.2g with a survival of 72.5%. 172kg lobsters were harvested from first cage. The second cage was harvested on 27th December and the average size was 178.5g with a survival of 69%. 130kg of lobsters were harvested.

Handing over cage to team

Harvesting

Harvest to the shore

Harvested lobsters

- **Sea Cage Farming seabass *Lates calcarifer* (Blotch) in sea-cages:** Technology was standardized and demonstrated for farming of sea bass *Lates calcarifer* in floating sea cage by rearing them in a large HDPE floating cage moored at Vizhinjam Bay. Technology for the culture of seabass include site selection, seed transportation, acclimatization, nursery rearing of seed, grading of seabass in nursery, design and fabrication of the frame, outer and inner net cages, techniques for safe seed

collection, transportation, feeding, net exchange, other daily maintenance activities, assessment of water quality parameters, disease management and harvesting were demonstrated.

Shoaling juveniles in hapa

Hand grading

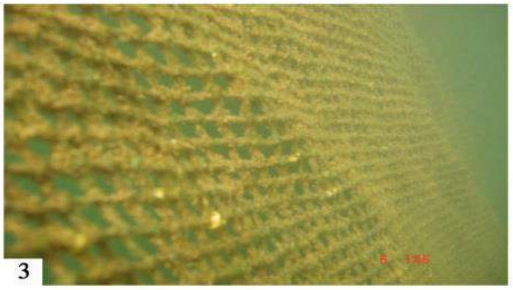
Shooters

Harvest

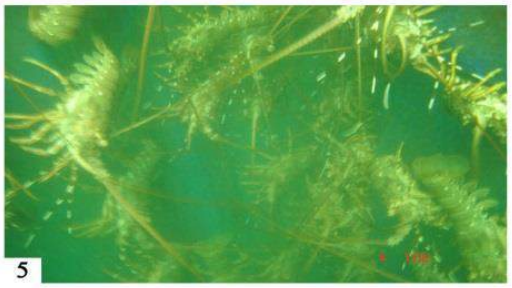
**2. Open sea floating cage culture demonstration farm for R&D in Marine finfish and shellfish production (MOA/1)**

- Technology for the culture of spiny lobster (*Panulirus homarus*) in sea-cages was successfully demonstrated **for the first time in India.** Design, fabrication of the frame, outer and inner net cages, techniques for safe mooring with safety devices like shock absorbers to withstand the rough sea conditions like high waves, winds and under water currents, ballast for keeping the net in stable shape, lobster seed collection, transportation, feeding, net exchange, other daily maintenances and observations, assessment of water quality parameters, disease management and harvest were demonstrated in participatory mode.
- Technology for the farming of spiny lobster *Panulirus homarus* in open sea cages including site selection, design and fabrication of the frame, outer and inner net cages, techniques for safe mooring with safety devices to withstand the rough sea conditions, high waves, winds and under water currents. Lobster seed collection, transportation, feeding, net exchange, other daily maintenance activities like diving observations, assessment of water quality parameters, disease management and harvesting were demonstrated.













(1): A view of open sea cage launched in Vizhinjam Bay (2): Lobsters before release in the cage (3): Underwater view of the inner net of the cage (4): Underwater view of outer net with ascidians (5):Underwater view of the lobsters of cage (6): Harvest of spiny lobsters (7): Bulk harvest of lobsters from cage (8): Berried Lobster from cage

Shri. K.P. Rajendran, Revenue Minister of Kerala inaugurating the cage harvest

Cage installed off Kanyakumari

Lobsters being handed over to the team member

Harvest at Kanyakumari

Harvested lobsters in basket

**3. ICAR Outreach Project on Fish Feeds**

- The major activities were: Refinement of the livefeed enrichment product developed through comprehensive evaluations; Development and evaluation of functional feeds for mariculture and aquariculture; Establishment of an aquatic microfeed production facility for larviculture and aquariculture.

- The nutritional enrichment experiments with rotifers were conducted in duplicate at a final volume of 10 liters. Cultures of the rotifers were maintained and fed with *Saccharomyces cerevisiae* (Baker's yeast) constantly checked for water quality; Initial mean rotifer density at start of the (10 L) culture was $5\times10^{-4}$ cells /l. Biomass was harvested at intervals in every replicate from the start of experiment. Initial microalgal cell densities inoculated were $1.2x10^{6}$ cells /l.
- Development of live feed enrichment emulsions and their evaluation. Sardine oil enriched through biochemical and microbiological procedures were used to formulate enrichment emulsions which contained grossly, 90% PUFA enriched fish oil and 10% lecithin extracted from fish roe from seer fish Scomberomorus guttatus was based on standard techniques. Seer fish roe, sourced from the local fish market @ Rs.80/ kgwas profiled for its fatty acid composition. Other than the stability and emulsification ability imparted by lecithin, tocopherol acetate (Vitamin E) at 0.5% was also included as a stabilizer. Two types of emulsions have been developed EPA rich and DHA rich.

## 6. Publications

| **Items** | **Year-wise** | | | | | **Total** |
|---|---|---|---|---|---|---|
| | **2009** | **2010** | **2011** | **2012** | **2013-2014** | |
| Peer Reviewed | 15 | 08 | 22 | 30 | 05 | 80 |
| Technical/Popular articles | - | 10 | 26 | 05 | 10 | 51 |
| Teaching Materials | | | | | | |
| Training Programme | - | 13 | 03 | 02 | 04 | 22 |
| Folders/Pamplets | - | 12 | - | - | - | 12 |
| Books | 1 | - | - | 1 | 1 | 03 |
| Genbank submissions | - | 05 | 14 | 16 | 01 | 36 |
| Scientific DVDs prepared | | 02 | 01 | 02 | 05 | 10 |
| Liasion with other Department | 01 | 02 | - | 16 | 01 | 20 |
| Contribution made in compilation/documentation | | | | | | |

**1. Peer reviewed publications of the Centre in 2009**

Annie, S.S, **Lipton, A.P** and R. Paul Raj. 2009. Antibacterial activity of marine sponge extracts towards fish pathogenic bacteria. *Israeli Journal of Aquaculture – Bamidgeh***,** 60 (3): 170-174

Chakraborty, K., **Lipton, A.P**., Paul Raj, R and K.K. Vijayan. 2010. Antibacterial labdane diterpenoids of *Ulva fasciata* Delile from southwestern coast of the Indian Peninsula .*Food Chemistry*, 119: 1399 –1408.

Huxley, V.A.J and **A.P. Lipton** 2009. Growth, biochemical and metabolism response of shrimp *Penaeus monodaon* (Fab.) with processed prawn head waste.*The Asian Journal of Animal Science.* Vol.4 (2): 161-166.

Huxley, V.A.J and **A.P. Lipton** 2009.Enhancement of phagocytosis, agglutinin and bactericidins in the hemolymph of the spiny lobster, *Panulirus homarus* by immunostimulants. *The Asian Journal of Animal Science*, 4 (2): 161-166.

Huxley, V.A.J and **A.P. Lipton** 2009Immunomodulatory effect of *Sargassum wightii* on *Penaeus monodaon* (Fab.)*The Asian Journal of Animal Science*, 4 (2): 192-196.

Jonsy Christobel and **A. P. Lipton**, 2010Influence of aqueous extract of macro alga *Hypnea musciformis* Lamour and *Codium tomentosum* (Huds) Stackhouse at different growth phases of micro algae *Chlorella marina* (Chlorophyta). Paper published. *In:* Proceedings of the National Seminar on 'Role of environmental changes in the lower group biodiversity with special reference to algal diversity'. (Feb. 9&10, 2010, WCC, Nagercoil): p. 336 -344.

Kiran, G.S, Anto Thomas, T., Selvin, J., Sabarathnam, B and **A.P. Lipton**. 2009. Optimization and characterization of a new lipopeptide biosurfactant produced by marine *Brevibacterium aureum* MSA 13 in solid state culture. *Bioresource Technology*, 101 (7): 2389-2396.

**Lipton, A.P**., (As co-author). 2009. Mutagenetic Study on Chitinase Producing Chi-a gene from *Chromobacterium* sp. Strain C-61 expressed in *Escherichia coli* XL-1 Blue. *International Journal of Biotechnology & Biochemistry*. Volume-5, Issue-1:

**Lipton, A.P**., (As co-author). 2009.Antimicrobial potential and seasonality of red algae collected from southwest coast of India tested against shrimp, human and phytopathogens. *Annals of Microbiology* 59 (2):

**Lipton, A.P**., Pramitha V.S and J. Jean Jose, 2009. Marine Secondary Metabolites (MSM) from Macro Algae Enhance Bacterial Clearance in Hemolymph of *Penaeus monodon Israeli Journal of Aquaculture – Bamidgeh***,** 61 (1): 42-47

Prema Kumari, **Lipton, A.P.** and Chandran, M. 2009.Influence of bittern on magnesium demanding horticulture crops *Journal of Theoretical and Experimental Biology*, 5 (1&2): 1-5.

Prema Kumari, P., Maniyan, C.G., **Lipton, A.P**., Chandran, M and Esai Selvan, K. 2009. Radioactivity associated with common salt and estimation of ingestion dose the general public. *Current Science*, 97 (5): 685-688.

**S. Jasmine, Rani Mary George**, Mary, K. Manisseri and **Jose Kingsly**, 2009**.** Hard coral diversity along South-west coast of India. *Journal of Marine Biological Association of India*, 51(2): 189-193.

**Santhosh, B** and Radhakrishnan, S. 2009. Host specificity of metazoan parasites infecting mullets of Kerala, India. *Indian Journal of Fisheries,* 56(4): 293-296

Selvin, J., Ninawe, A.S., Kiran, G.S and **Lipton, A.P.** 2010. Sponge-microbial interactions: Ecological implications and bioprospecting avenues. *Critical Reviews in Microbiology*, 36(1): 82–90

Thangaraj, M and **Lipton**, **A.P.** 2009. Distribution Pattern of Seahorses (Genus: Hippocampus) in Southern Coasts of India. In: "*National Symposium on Recent Advances in Biodiversity of Indian Subcontinent*". 2009 at Port Blair, Andaman and Nicobar Islands. p. 52

**In 2010**

**Anil, M.K. , B. Santhosh, S. Jasmine, K. N. Saleela, Rani Mary George**, **H. Jose Kingsly, C. Unnikrishnan, G. Hanumantha Rao** and G. Syda Rao. 2010. Growth performance of the seabass *Lates calcarifer* (Blotch) in sea cage at Vizhinjam Bay along the south-west coast of India. *Indian Journal of Fisheries,* 57(4): 65-69

**Rani Mary George**, T. S. Naomi and Miriam Paul Sreeram 2010. First record of the one-stripe anthias *Pseudanthias fasciatus* (Kamohara,1954) (Perciformes: Serranidae: Anthiinae) from Indian waters *Journal of Marine Biological Association of India,* 52 (1): 70 – 74.

Sandhya Sukumaran and **Rani Mary George**. 2010. Community structure and spatial patterns in biodiversity of hard corals in selected islands of Gulf of Mannar Biosphere Reserve, India*. Asian Fisheries Science*, 23: 9-24.

Syda Rao, G., Rani **Mary George, M.K.Anil, K.N. Saleela, S. Jasmine**, G. Hanumantha Rao and H. Jose Kingsly. 2010. Cage culture of the spiny lobster *Panulirus homarus* (Linnaeus) at Vizhinjam, Trivandrum along the south-west coast of India. *Indian.J.Fish*., 57(1):23-29.

M. Thangaraj and **A. P. Lipton** -2010. Genetic identity of three Indian populations of the seahorse, *Hippocampus trimaculatus*. *Advances in Biological Research*. 4 (1): 37-41.

Chakraborty, K., **Lipton, A.P**., Paul Raj, R and Rekha D. Chakraborty. 2010. Guaiane sesquiterpenes from seaweed *Ulva fasciata* Delile and their antibacterial properties. *European Journal of Medicinal Chemistry*. 45 (6): 2237-2244.

Selvin, J., Ninawe, A.S., Kiran, G.S and **A.P. Lipton**. 2010. Sponge-microbial interactions: Ecological implications and bioprospecting avenues. *Critical Reviews in Microbiology*, 36(1): 82–90.

Chakraborty, K., **Lipton, A.P**., Paul Raj, R and K.K. Vijayan. 2010. Antibacterial labdane diterpenoids of *Ulva fasciata* Delile from southwestern coast of the Indian Peninsula. *Food Chemistry*. 119: 1399 –1408.

**In 2011**

**Lipton, A.P,** H. Jose Kingsly, A. Udayakumar, M.S. Aishwarya and A.R. Sarika, 2011. Polymicrobial skin lesions in red spot emperor, *Lethrinus lentjan* (Lacepede 1802) during mass incursion towards shore along Kanyakumari coast, South India. *Indian Journal of Fisheries.* 58 (3): 129-13.

Pramitha, V.S and **A. P. Lipton**, 2011. Growth responses of *Chlorella salina* and *Isochrysis galbana* influenced by marine macroalgal extracts. *Indian Journal of Fisheries.* 58(4): 95-99.

Sarika, A.R, **A.P. Lipton**, M.S. Aishwarya, Christobel, J.G and R.S. Dhivya, 2011. Isolation, Identification and antibacterial activity of bacteriocin producing lactic acid bacteria from marine environment. *The Ecoscan (An international quarterly journal of Environmental Sciences): Special Issue*. 1: 149-153.

Dhivya R.S., **A.P. Lipton**, Sarika, A.R, M.S Aishwarya and Sreeya G. Nair, 2011. Physiological responses of brown mussel (*Perna indica*) towards alternations in marine temperature. *The Ecoscan (An international quarterly journal of Environmental Sciences): Special Issue*. 1: 281-286.

Kavitha, P, **A.P. Lipton,** A.R. Sarika and M.S. Aishwarya, 2011. Growth characteristics and Halocin Production by a new isolate, *Haloferax volcanii* KPS1 from Kovalam Solar Saltern (India). *Research Journal of Biological Sciences.* 6. (5): 257-262.

Sarika, A. R., **A. P. Lipton**, M.S. Aishwarya and R. S. Dhivya, 2011. Efficacy of Bacteriocin of *Enterococcus faecalis* CD1 as a Biopreservative for High Value Marine Fish Reef Cod (*Epinephelus diacanthus*) under Different Storage Conditions. *Journal of Microbiology and Biotechnology Research*.1 (4), 18-24.

Christobel, J.G, **A. P. Lipton,** M.S. Aishwarya, A.R. Sarika and A. Udayakumar, 2011. Antibacterial activity of aqueous extract from selected macroalgae of southwest coast of India. *Seaweed Res. Utiln***.,** 33 (1&2): 67-75.

Thangaraj, M and **A. P. Lipton**, 2011. Morphological characterization of four selected seahorse species (Genus: *Hippocampus)* from India. *Annals of Biological Research.* 2 (4):159-167.

Medo Merina, **A.P. Lipton** and S.G. Wesley, 2011. Isolation, characterization and growth response of biofilm forming bacteria *Bacillus pumilis* from the sea grass*, Halodule pinifolia* off Kanyakumari coast. *Indian Journal of Marine Sciences*. 43 (3): 443-448.

Thangaraj, M. V. Prem, T. Ramesh and **A.P. Lipton**, 2011**.** RAPD fingerprinting and demonstration of genetic variation in three pathogens isolated from mangrove environment. *Asian Journal of Biotechnology*.3 (3): 269 – 274.

Thangaraj, M and **A.P. Lipton**, 2011. Assessment of genetic variation in closely related sea horse species (Genus: *Hippocampus*) using mtDNA marker. *Indian Journal of Biotechnology.* 10: 140-142.

Prema Kumari, P, C.G. Maniyan, **A.P Lipton** and M. Chandran, 2011. Study on radioactivity associated with common salt production process of two salt works in Tuticorin District, Tamil Nadu, India. *Asian Journal of Chemistry*. 23 (8): 3695 -3698.

Prema Kumari, P, Leema Rose and **A.P Lipton**, 2011. Radio activity associated with Gypsum leaching process during the production of common salt. *Oriental Journal of Chemistry*. 27 (4): 1717-1721.

Selvin, J, Manilal, A, Sujith, S, Kiran, G.S and **A.P. Lipton**, 2011. Efficacy of marine green alga*, Ulva fasciata* extract on the management of shrimp bacterial disease. *Lat.Am. J. Aquatic Res.* 39 (2): 197-204.

Sandhya Sukumaran, **Rani Mary George**, Vinod, K, Sobhana, K.S., Naomi, T. S and Mary. K. Manisseri, 2011. **Temporal patterns in biodiversity and health status of reef corals of Palk Bay.** *Indian Journal of Fisheries*, 58 (1) 73-77.

Sarika, A. R., **A. P. Lipton**, M.S. Aishwarya and R. S. Dhivya. 2011. Efficacy of Bacteriocin of *Enterococcus faecalis* CD1 as a Biopreservative for High Value Marine Fish Reef Cod (*Epinephelus diacanthus*) under Different Storage Conditions. *Journal of Microbiology and Biotechnology Research*, 1(4), 18-24.

Sarika, A.R, **A.P. Lipton**, M.S AishwaryaChristobel, J.G and R.S. Dhivya, 2011. Isolation, Identification and antibacterial activity of bacteriocin producing lactic acid bacteria from marine environment. *The Ecoscan (An international quarterly journal of Environmental Sciences): Special Issue*. 1: 149-153.

Selvin, J, Manilal, A, Sujith, S, Kiran, G.S and **A.P. Lipton, 2011.** Efficacy of marine green alga*, Ulva fasciata* extract on the management of shrimp bacterial disease. *Latin American Journal of Aquatic Research,* 39 (2): 197-204.

Sujitha Thomas, Miriam Paul Sreeram, Kakati, V S , Mary. K. Manisseri, and **Rani Mary George,** 2011. **Coral fish diversity in Netrani waters off Murudeshwar Karnataka, South India.** *Indian Journal of Fisheries*, 58 (1): 45-51.

Thangaraj, M and **A.P. Lipton, 2011.** Assessment of genetic variation in closely related sea horse species (Genus: Hippocampus) using mtDNA marker. *Indian Journal of Biotechnology.* 10: 140-142.

Thangaraj, M, and **A. P. Lipton, 2011.** Morphological characterization of four selected seahorse species (Genus: *Hippocampus)* from India. *Annals of Biological Research.* 2 (4):159-167.

Thangaraj, M. V. Prem, T. Ramesh and **A.P. Lipton, 2011.** RAPD fingerprinting and demonstration of genetic variation in three pathogens isolated from mangrove environment. *Asian Journal of Biotechnology*, 3 (3): 269 – 274

**In 2012**

Abdussamad, E.M., G. Syda Rao, Said Koya, K. P. and Rohit Prathibha, Joshi, K. K. Sivadas, M. Kuriakose Somy, Ghosh Shubhadeep, **Jasmine, S**., Chellappan Anulekshmi and Koya Mohammed, 2012. Indian tuna fishery - production trend during yesteryears and scope for the future. *Indian Journal of Fisheries*, 59(3):1-13.

**Anil, M. K., Santhosh., B**, Prasad, B. O. and **Rani Mary George**, 2012. Broodstock development and breeding of black-finned anemone fish *Amphiprion nigripes* Regan, 1908 under captive conditions. *Indian Journal of Fisheries*, 59 (1): 77-82.

Annie Selva Sonia G and **A. P. Lipton**, 2012. Mosquito Larvicidal Activity of Marine Sponge Metabolites. *Global Journal of Pharmacology,* 6(1): 01-03.

Annie Selva Sonia G and **A. P. Lipton**, 2012. Pathogenicity and antibiotic susceptibility of *Vibrio* species isolated from the captive-reared tropical marine ornamental blue damsel *Pomacentrus caeruleus* (Quoy and Gaimard, 1825). *Indian Journal of Geomarine Sciences,* 41(4): 348-354.

Isaac Dhinakaran, D and **A. P. Lipton**, 2012. Antifungal and Cytotoxic Activities of Some Marine Sponges Collected from the South East Coast of India. *Journal of Applied Pharmaceutical Science*, 02 (01): 52-55.

Isaac Dhinakaran, D and **A. P. Lipton**, 2012. Antimicrobial Potential of the Marine Sponge *Sigmadocia pumila* from the South Eastern Region of India. *World Journal of Fish and Marine Sciences*, 4 (4): 344-348. ISSN 2078-4589

Isaac Dhinakaran, D. and **A. P. Lipton**, 2012. Evaluation of bioactivity in Marine Sponge *Sigmadocia pumila* collected from the South Eastern Region of India. *Journal of Microbiology and Biotechnology Research*, 2 (5): 651-656.

Isaac Dhinakaran, D. and **A. P. Lipton**, 2012. Screening of marine sponge-associated bacteria from *Echinodictyum gorgonoides* and its bioactivity. *African Journal of Biotechnology,* 11 (88): 15469-15476.

Jose, J. J., **A. P. Lipton**, Lincy Alex, P. Udayakumar, B. R. Rajesh, M. T. P. Miranda, 2012. Observation on marine copepod – Appendicularian naturally changing concentrations along southwest coast of India. *Notulae Scientia Biologicae*, 4(4): 20-26.

K. K. Joshi, R. Narayanakumar, **Rani Mary George**, Molly Varghese, **S. Jasmine**, K. R. Srinath, S. Saravanan, Somy Kuriakose and Geetha Antony, 2012. Biodiversity valuation of marine ecosystem of the south-west coast of India with special reference to Kerala coast. In: Abstracts of *First National Biodiversity Congress* NBC 2012, p. 48.

Molly Varghese, K. K. Joshi, **Rani Mary George**, V. J. Thomas and P.M. Geetha, 2012. "Bioinventory of Phytoplankters from south-west of India" .In: Abstracts of *First National Biodiversity Congress* NBC 2012, p. 48.

Parimala Celia and **A. P. Lipton**, 2012. In vivo studies on the therapeutic values of marine macroalgae against the fish pathogen *Aeromonas hydrophila. Ecology and Fisheries.*5(1): 65-74.

Pramitha, V. S. and **A. P. Lipton**, 2012. Selective cytotoxicity of macroalgal extracts *to Artemia salina* (Brine shrimp). *Seaweed Research and Utilization*, 34(1&2): 100-107.

**Rani Mary George,** 2012. Marine fishery development and climatic change. In: 8$^{th}$ *Kerala Environment Congress* (KEC, 2012) August 16 – 18, Rajiv Gandhi Centre for Biotechnology, Trivandrum. p. 167 – 174.

Remya Madhavan, Prabir K. Bandyopadhyay **& B. Santhosh**, 2012. Two new species of *Thelohanellus* Kudo, 1933 (Cnidaria: Mixosporea) from minor carps (*Labeo* spp. and *Cirrhinus reba*) of Tripura state, India. *Protistology,* **7 (4):** 203–208.

Sarika, A. R., **A. P. Lipton**, M. S. Aishwarya and R. S. Dhivya, 2012. Isolation of a Bacteriocin-Producing *Lactococcus lactis* and Application of Its Bacteriocin to Manage Spoilage Bacteria in High-Value Marine Fish Under Different Storage Temperatures. *Appled Biochemistry and Biotechnology,* 167(5): 1280-1289.

Sarika, A. R., **A. P. Lipton**, M. S. Aishwarya, R. S. Dhivya and G. Johnsy Christobel, 2012. Assessment of bacteriocin production by *Lactococcus lactis* PSY2 isolated from marine Perch fish. *Journal of Research in Science*, 1: 94-97.

Sarika, A. R., **A. P. Lipton** and M. S. Aishwarya, 2012. Comparative Assessment of Bacteriocin Production in Free and Immobilized *Lactobacillus plantarum* MTCC B1746 and *Lactococcus lactis* MTCC B440. *Journal of Applied Sciences Research*, 8(4): 2197-2202.

Selvin Pitchaikani, J. and **A. P. Lipton**, 2012. Impact of environment variables on pelagic fish landings: Special emphasis on Indian oil sardine off Tiruchendur coast, Gulf of Mannar. *Journal of Oceanography and Marine Science*, 3(3): 56-67.

Sivadas, M., Abdussamad, E. M., **Jasmine, S.**, Rohit, Prathibha, Said Koya, K.P., Shubhadeep Ghosh, Joshi, K.K., Dhokia, K., Prakasan, D. and Bineesh, KK. 2012. Assessment of the fishery and stock of striped bonito, *Sarda orientalis* (Temminck and Schlegel, 1844) along Kerala coast with a general description of its fishery from Indian coast*. Indian Journal of Fisheries*, 59 (2): 57-61.

Sreeya G. Nair and **A.P. Lipton**, 2012. Physiological responses of the Cyprinid, *Puntius ticto* Hamilton Acclimated to Different Temperatures. *Journal of Theoretical and Experimental Biology*. 8 (3 & 4): 133-139.

Thangaraj, M., **A. P. Lipton**, L. John and A. Gopalakrishnan. 2012. Genetic diversity of three spotted seahorse, *Hippocampus trimaculatus* in India using four microsatellite loci. *Notulac Scintica Biologicae,* 4 (4): 07-13.

Thangaraj, M., **A.P. Lipton** and T.T. Ajithkumar, 2012. Interrelationship among reproductive traits in Indian seahorse, *Hippocampus kuda. Asian Journal of Biological Sciences,* 5(5): 263-267.

Vinod, K., **Rani Mary George**, Thomas, P. A. and Manisseri, Mary K. 2012. *Semperella megaloxea* sp. nov. (Family: Pheronematidae): A new hexactinellid sponge from Andaman waters, India. *Indian Journal of Fisheries*, 59 (1): 33-36.

**Lipton**, **A.P** and M. Thangaraj. 2013. Distribution Pattern of Seahorse Species (Genus: *Hippocampus*) in Tamilnadu and Kerala Coasts of India. *Not Sci Biol*. 5(1): 20-24.

Aishwarya, M. S., **A. P. Lipton** and Sarika, A. R. 2013. Phylogenetic appraisal of the drug-bearing marine sponge *Callyspongia subarmigera* (Ridley 1884) from South India. *Indian Journal of Geomarine Sciences.* 42(1): 139-145.

Pramitha, V.S and **A.P. Lipton**. 2013. **Antibiotic potentials of red macroalgae Hypnea musciformis (Wulfen) Lamouroux and Hypnea valentiae (Turner) Montagne.** *Seaweed Research and Utilization, 35 (1 & 2). pp. 95-107.*

Manilal, A. Selvin, J, Kiran,G.S, Sujith, S, Feby, F.A.S and **A.P. Lipton**. 2013. Micro-algal lethality potentials of marine organisms collected from the Indian littoral. *Thalassas*. 29 (2): 59-65.

**Jasmine, S.** Prathibha Rohit, E. M. Abdussamad, K. P. Said Koya, K. K. Joshi, S. Kemparaju, D. Prakasan, M. N. K. Elayathu and Manju Sebastine. 2013. Biology and fishery of the bullet tuna, *Auxis rochei* (Risso, 1810) in Indian waters. *Indian Journal of Fisheries,* 60(2): 13-20.

Remya Madhavan, Probir K. Bandyopadhyay and **B. Santhosh,** 2013. Observations on the histopathological changes caused by myxosporidian infections in minor carps. *Journal of Parasitic Diseases,* 37: 185-188

Remya Madhavan, Prabir K. Bandyopadhyay & **B. Santhosh,** 2013 Observations on two new species of *Myxobolus* Butschli, 1882 from minor carps of Tripura, India *Journal of Parasitic Diseases* **37(1**): 56-61.

**In 2013- 2014**

K. Vinod, **Rani Mary George**, P.A. Thomas, Mary K. Manisseri and G. Shylaja 2014. Diversity and distribution of shallow water sponges (Porifera) in the coastal waters from Enayam to Kollam, south-west coast of India. *Indian Journal of Fisheries*, (accepted)

Rachanamol, R.S, **A. P. Lipton**, V. Thankamani, A. R. Sarika and J. Selvin, 2014. Molecular characterization and bioactivity profile of the tropical sponge-associated bacterium *Shewanella algae* VCDB. Helgoland Marine Research ©Springer-Verlag Berlin Heidelberg and AWI 2014. DOI 10.1007/s10152-014-0386-3. Published on line: March 5, 2014.

Isaac Dhinakaran, D and **A.P. Lipton**, 2014. Studies on the bioactivity of *Holothuria atra* extracts collected from the South east coast of India. *International Journal of Biology and Biological Sciences*. 3(1): 6-11.

**Lipton, A.P** and M. Thangaraj. 2014. Courtship behaviour, brood characteristics and embryo development in three spotted seahorse, *Hippocampus trimaculatus* (Leach, 1814). *Int. Res. J. Biological Sci.,* 3(1): 6-10. ISSN: 2278-3202.

**Lipton, A.P** and V. S. Pramitha. 2014. A simple and reliable assay to detect immunosuppressant activity in macroalgae. *International Journal of Pharmaceutical, chemical and Biological Sciences*. 4(1): 139-144.

2. **Presentation In Conference / Symposia/ Other Fora/ Abstracts Published**

Aishwarya, M. S. **A.P. Lipton**, Sarika, A. R., Dhivya, R. S. and Sreeya, G. Nair, 2011. Sponge-bacteria

association: Observations on antibiotic potentials of new bacterial strains isolated from *Callyspongia subarmigera* (Ridley, 1884). National Conference on Explorations of Natural Bioactive compounds from the Marine resources (BIOACTIVA'11 Feb. 10-11). (Best Paper Award)

Aishwarya, M.S **A. P. Lipton** Sarika, A. R., Dhivya, R. S. and Christobel, J. G. 2011. Isolation and evaluation of antagonistic property of *Bacillus amyloliquefaciens* collected from the marine sponge *Callyspongia subarmigera.* Abstract. In. *ibid. p.154.*

**Anil, M. K., B. Santhosh,** B.O. Prasad, **K.N. Saleela** and C. Unnikrishnan, 2011. Larval rearing of scarlet skunk cleaner shrimp, *Lysmata amboinensis* and fire shrimp, *Lysmata debelius*. In Gopalakrishnan, A.*et*. *al*. (Eds.), Renaissance in Fisheries: Outlook and strategies – Book of Abstracts, 9th Indian Fisheries Forum, CMFRI, Kochi and Asian Fisheries Society, Indian Branch, 2011, Chennai, India, 117 pp

**Anil, M.K., B. Santhosh,, S. Jasmine**, S. Reenamole, C. Unnikrishnan and A. Anukumar. 2010. Techniques for mass production of two species of clown fish: Clown anemonefish *Amphiprion ocellaris* Cuvier, 1830 and Spinecheek anemonefish *Premnas biaculeatus* (Bloch, 1790). In: *National Seminar Proceedings :Technology and trade prospects in Ornamental Aquaculture*, S. Felix (Ed.) Fisheries Research and Extension Centre, Tamil Nadu Veterinary and Animal Sciences University , Chennai. p.121-129.

**Anil, M.K., S. Jasmine, B. Santhosh, G., Rani Mary George**, B. Raju. , C. Unnikrishnan, and H. Jose Kingsly, 2010. Availability of marine ornamental fishes along vizhinjam coast, southern Kerala. In: *National Seminar Proceedings :Technology and trade prospects in Ornamental Aquaculture*, S. Felix (Ed.) Fisheries Research and Extension Centre, Tamil Nadu Veterinary and Animal Sciences University , Chennai. p.108-119.

**B. Santhosh, M.K. Anil**, K. Vinod, **A.P. Lipton, Rani Mary George, S. Jasmine**, H. Jose Kingsley , C.Unnikrishnan and A. Udayakumar. 2011 Community 'Structure and succession of foulers on cages in open sea cage farming of lobsters at Chinnamuttom, Kanyakumari.' p. 17. In: Gopalakrishnan, A. *et al.* (Eds.), *Renaissance in Fisheries: Outlook and strategies - Book of Abstracts.* 9th Indian Fisheries Forum, Central Marine Fisheries Research Institute, Kochi and Asian Fisheries Society, Indian Branch, 19-23 December 2011, Chennai, India, 381pp.

Baburaj Anu, Narayanan Subash, Nisha Unni, **M.K.Anil and Rani Mary George**. 2011 "Laser-induced fluorescence imaging: A potential tool for early detection of coral bleaching" p.248. In: Gopalakrishnan, A. *et al.* (Eds.), *Renaissance in Fisheries: Outlook and strategies - Book of Abstracts.* 9th Indian Fisheries Forum, Central Marine Fisheries Research Institute, Kochi and Asian Fisheries Society, Indian Branch, 19-23 December 2011, Chennai, India, 381pp.

Christobel, J.G., **A.P. Lipton**, Aishwarya, M. S. and Sarika, A. R,2011. Growth promoting activity of the aqueous extracts of marine red alga *Gracillaria corticata* towards microalga *Chlorella marina* used as live feed in fin fish and shell fish hatcheries. Abstract. In. *ibid. p..*

Dhivya, R. S., **A. P. Lipton** Sarika, A. R., Sreeya, G. Nair and Aishwarya, M. S.,2011. The effect of

temperature on the physiological responses of brown mussel (*Perna indica*) collected from Kadiapatnam coast, Tamil Nadu. National Seminar on Bioresources Conservation Management (NSBCM 2011 - Nagercoil March 30-31). P.21.

Dhivya, R. S., **A. P. Lipton**, A. R. Sarika, M.S. Aishwarya and Sreeya, G. Nair, 2011. Physiological responses of Brown Mussel (*Perna indica*) towards alternations in Marine Temperature. Abstract. In. *ibid. p.23.*

**Dr. Rani Mary George** attended 2nd Governing body of National Institute of Fisheries Administration and Management( NIFAM) at Hon'ble Fisheries Minister's Chamber, Secrateriat at 3.30 p.m at Trivandrum on 16/10/12

**Dr. Rani Mary George** attended and delivered presidential address on 12/10/12 in the training program on ''Recent advances on seafarming : Prospects for better livelihood options along the coasts of India' at Kanyakumari

**Dr. Rani Mary George** attended Workshop on inception of new project- Assessment of the fishing impacts in biodiversity loss, with special reference to the threatened species, to formulate management options for their protection (FISHCMFRISIL2012 017 00017) on 21st and 22nd September, 2011 Chennai and delivered lectures on marine biodiversity and coral taxonomy

**Dr. Rani Mary George** delivered lectures on live feed for the Training on Marine Ornamental Fish Breeding and Aquarium keeping 16/12/12 – 20/12/12

E. M. Abdussamad, Prathibha Rohit, K. P. Said Koya, K. K. Joshi, M. Sivadas, Somy kuriakose, Shubhadeep Ghosh, **S. Jasmine**, Anulekshmi chellappan, Mohammed Koya and G. Syda Rao. 2011 'Status and potential of tuna fisheries in Indian Waters' . In: Gopalakrishnan, A *et al.* (Eds.), *Renaissance in Fisheries: Outlook and strategies - Book of Abstracts.* . 9th Fisheries Society, Indian Branch, 19-23 December 2011, Chennai, India, 381pp. p.8.

G. Syda Rao, E. M. Abdussamad, Prathibha Rohit, K. P. Said Koya, K. K. Joshi, M. Sivadas, Shubhadeep Ghosh, **S. Jasmine**, D. Prakasan, M.N.K. Elayathu, K. Rammohan, Manju Sebastine and N. Beni. 2011. Fishery, Biology and population characteristics of Yellowfin Tuna ( Thunnus albacares ) exploited from the Indian EEZ. In: Gopalakrishnan, A. *et al.* (Eds.), *Renaissance in Fisheries: Outlook and strategies - Book of Abstracts.* 9th Indian Fisheries Forum, Central Marine Fisheries Research Institute, Kochi and Asian Fisheries Society, Indian Branch, 19-23 December 2011, Chennai, India, 381pp. p.8.

Jean Jose, **A. P. Lipton**, P. Udayakumar, B. R. Rajesh and K. Narendra Babu,2011. Observation on marine copepod – Appendicularian naturally charging concentrations at Mangalore, India. Abstract. In. *ibid. p.90.*

K. S. Sobhana, Githa Ann George, Sheethal Mary Sunny, S. Sreedevi, **M. K. Ani**l, **B. Santhosh**, C. Kalidas**,** K. K. Surendran and P. U. Zacharia**,** 2011. Establishment of five new cell lines from the

cobia, Rachycentron canadum (Linnaeus, 1766), In **:** Book of Abstracts, Eighth Symposium on Diseases in Asian Aquaculture 2011, Mangalore, 21st – 25th November, 2011, PP-C21.

K. S. Sobhana, Githa Ann George, Sheethal Mary Sunny, S. Sreedevi, K. K. Surendran, **M. K. Anil** and C. Kalidas, 2011. Establishment of cell lines from various tissues of the honeycomb grouper, *Epinephelus merra* (Bloch, 1793), In **:** Book of Abstracts, Ninth IFF Symposium on Renaissance in fisheries : Outlook and strategies 2011, Chennai,19– 23rd December,2011, NH-P41 .

K.Vinod, **Rani Mary George** and Mary. K. Manissery . 2011 'The shallow water marine sponges (Porifera) in the coastal waters from Enayam to Kollam, southern India" p.349. In: Gopalakrishnan, A. *et al.* (Eds.), *Renaissance in Fisheries: Outlook and strategies - Book of Abstracts.* 9th Indian Fisheries Forum, Central Marine Fisheries Research Institute, Kochi and Asian Fisheries Society, Indian Branch, 19-23 December 2011, Chennai, India, 381pp.

Kavitha, P and **A. P. Lipton, 2011.** Genetic studies on the genes responsible for halocin production and strain improvement using mutation studies (Physical – UV and chemical – ethyl methyl sulfonate – EMS). International conference on climate change, forest resource and environment (ICCFRE-2011.Dec. 9-11). p. 164.

**Santosh, B**. **Lipton, A.P.,** *et al, 2011.* Community structure and succession of foulers on cages in open sea cage farming of lobsters at Chinnamuttom, Kanyakumari. Abstract. In. *ibid. 257-258.*

**Lipton, A.P,** Annie Selva Sonia. P. Rajendran, Prabitha Mary and J. Selvin, 2011. Bioactivity profile and biotechnological significance of tropical marine sponge *Echinodictyum gorgonoides* (Dendy) entangled in fishing nets off Kanyakumari, South India. Abstract. In. 9th Indian Fisheries Forum (December 19-23, 2011). Sup. abstracts. p9.

M. Sivadas, E. M. Abdussamad, **S. Jasmine**, Prathibha Rohit, K. P. Said Koya, Shubhadeep Ghosh, K. K. Joshi, H. K. Dhokia, D. Prakasan and K. K. Bineesh. 2011. Assessment of the fishery and stock of Striped Bonito, *Sarda orientalis* (Temminck and Schlegel,1844) along Indian coast.' In: Gopalakrishnan, A. *et al.* (Eds.), *Renaissance in Fisheries: Outlook and strategies - Book of Abstracts.* 9th Indian Fisheries Forum, Central Marine Fisheries Research Institute, Kochi and Asian Fisheries Society, Indian Branch, 19-23 December 2011, Chennai, India, 381pp. p.9

P. Rajendran, **A.P. Lipton**, S.G. P. Vincent, and P. Vijaya-raghavan, 2011. Isolation and optimization of alkaline protease from marine bacteria associated with sponge *Echinodictyum gorgonoides* (Dendy). Abstract. In. *ibid.*

**Rani Mary George** 2012 delivered keynote address on "Marine Biodiversity Conservation with special emphasis to corals . In : International Biodiversity Day celebrations on May 22nd org. by Kerala State Biodiversity Board, Museum Hall, Trivandrum

**Rani Mary George** 2012. Marine Fishery Development and Climatic change. In: 8th Kerala Environment Congress (KEC,2012) August 16 – 18, Rajiv Gandhi Centre for Biotechnology, Trivandrum.

**S. Jasmine, Rani Mary George,** Mary. K. Manisseri, **M.K. Anil, B. Santhosh**, Jose Kingsley, P. Hilary, V.P. Benzeger and C. Unnikrishnan. 2011 'Observations on the preliminary growth studies on hard corals carried out in Vizhinjam bay, Southern kerala.' P. 348 In: Gopalakrishnan, A. *et al.* (Eds.), *Renaissance in Fisheries: Outlook and strategies - Book of Abstracts.* 9th Indian Fisheries Forum, Central Marine Fisheries Research Institute, Kochi and Asian Fisheries Society, Indian Branch, 19-23 December 2011, Chennai, India, 381pp.

Sarika, A. R., **A.P. Lipton**, Aishwarya, M. S., Dhivya, R. S., Nisha, R. S. and Sreeya, G. Nair, 2011. Efficacy of bacteriocin of *Lactobacillus brevis* BF1 as a biopreservative for high value marine fish reef cod (*Epinephelus diacanthus*) under different storage conditions. 23rd Kerala Science Congress, CESS, Trivandrum. Jan. 29-31- 2011. Abstrct. p.209.

Sarika, A. R., **A. P. Lipton**, M. S. Aishwarya, G. J. Christobel and R. S. Dhivya, 2011. Isolation, Identification and Antibacterial activity of bacteriocin producing Lactic Acid Bacteria from Marine Environment . Abstract. In. *ibid.* p. 156.

Sarika, A. R., **A. P. Lipton**, M.S. Aishwarya and R. S. Dhivya, 2011. Isolation of a bacteriocin producing *Lactococcus lactis* and application of its bacteriocin to manage spoilage bacterial problems in high value marine fish under different storage temperatures. International conference on New Horizons in Biotechnology & 8th annual convention of the Biotech Research Society of India, NIIST, Trivandrum. 2011, Nov.21-24 Abstrct. p. 9 ol

Sarika, A. R., **A. P. Lipton**, M.S. Aishwarya, R. S. Dhivya and G. Johnsy Christobel, 2011. Assessment of bacteriocin production by *Lactococcus lactis* PSY2 isolated from marine Perch fish. National Conference on Emerging Trends in Arts and Science, NMCC, Marthandam.2011, Oct. 7-8.Abstrct. p.76.

Syda Rao, G., **Rani Mary George, M.K.Anil, K.N. Saleela, S. Jasmine**, G. Hanumantha Rao, H. Jose Kingsly, C. Unnikrishnan, P. Hillay, V.P. Benzeger B.Raju, A. Udayakumar and **B. Santhosh**. 2010 Sea-cage farming of spiny lobster *Panulirus homarus* (Linnaeus) along south-west coast of India. In: International conference on recent advances in lobster biology aquaculture and management, RABLAM 2010, 5-8 January Chennai India, Book Of Abstracts: No. 42, page 81.

**B. Santhosh,** Anil, M. K., K.K. Vijayan, Gopakumar,G., C. Unnikrishnan, Udayakumar,A. and B.O. Prasad, 2011, Parasitic infections in broodstock of clown fishes in Vizhinjam. In Gopalakrishnan, A.*et*. *al*. (Eds.), Renaissance in Fisheries: Outlook and strategies – Book of Abstracts, 9th Indian Fisheries Forum, 193 p.

**B. Santhosh,** Anil, M. K., Rani Mary George, Jasmine, S., Udayakumar, A. Jose Kingsley, H. Raju, B. and Anukumar. A. 2010. Sea lice infection in *Arothron* spp. in marine aquarium, Vizhinjam, Thiruvannathapuram, Kerala, In: Book of abstracts, *National Symposium on Parasite Taxonomy, Biodiversity and Fish Health: Environmental impact*. Organised by Department of Zoology, Andhra University, Visakhapatnam. 69p.

**Santhosh, B.**, Singh, N. P., Ngachan, S. V. Remya Madhavan, Abraham, K. M., Das, S. K & Laskar, K., 2010. *Neoergasilus longispinosus* the most successful copepod parasite of fresh water fishes of Tripura. In: Book of Abstracts. *National Symposium on Parasite Taxonomy, Biodiversity and Fish Health: Environmental impact*. Organised by Department of Zoology, Andhra University, Visakhapatnam. 70p.

**B. Santhosh**, M. K. Anil, K.K. Vijayan, G. Gopakumar, K. N. Saleela, C. Unnikrishnan, A. Udayakumar, H. Jose Kingsley, A. Anukumar, S. Vinod, R. Mary Rinju and B. O. Prasad., 2013. Case studies on diseases of brood stocks of clown fishes in the National Seminar on Emerging Trends in Indian Aquaculture Dept. of Aquatic Biology and Fisheries, University of Kerala, Thiruvananthapuram, 28-30 March

**B. Santhosh**, M. K. Anil, G. Gopakumar, Rani Mary George, S. Jasmine, K. N. Saleela, C. Unnikrishnan, S. Vinod, R. Mary Rinju and B. O. Prasad. 2013. Mass production trials of three species of calanoid copepods suitable for feeding fish larvae in the National Seminar on Emerging Trends in Indian Aquaculture Dept. of Aquatic Biology and Fisheries, University of Kerala, Thiruvananthapuram, 28-30 March.

**Santhosh**, B., M. K. Anil**,** Syda Rao, G. Gopakumar, K.N Saleela, C. Unnikrishnan, P. Hillary, V.P. Benziger and K.M. Abraham. 2010. Nature of parasitic infections in fish seed for capture based aquaculture; A case study of Mugilids from Kerala, In: National Symposium on Parasitic taxonomy, biodiversity and fish health: Environmental impact, Book of Abstracts: Dept. of Zoology, Andhra University, Visakapatanam, March12-13,SIII OP 33. P. 60

**Santhosh, B.**, Singh, N. P., Ngachan, S. V. Remya Madhavan, Abraham, K. M., Das, S. K & Laskar, K., 2010. An analysis of nature and spread of parasites in Tripura, a land locked state of India, through the introduction of Indian major carps and Chinese carps In: *National Symposium on Parasite Taxonomy, Biodiversity and Fish Health: Environmental impact*. Organised by Department of Zoology, Andhra University, Visakhapatnam. Abstract No.SIII OP34 61p.

**Santhosh**, B. N P. Singh, M C. Nandeesha, M. Sankaran, M. Datta and K J. Joseph 2010. Integration of Tuber crops with Aquaculture in Tripura. In: National Seminar on Food security and Climate change in India organized by Indian Society of Roots Crops and Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala from 20-22$^{nd}$ January 2011. PTH19 185p.

**B. Santhosh**, M. K. Anil, K.K. Vijayan, G. Gopakumar, K. N. Saleela, C. Unnikrishnan, A. Udayakumar, H. Jose Kingsley, A. Anukumar, S. Vinod, R. Mary Rinju and B. O. Prasad., 2013. Case studies on diseases of brood stocks of clown fishes in the National Seminar on Emerging Trends in Indian Aquaculture Dept. of Aquatic Biology and Fisheries, University of Kerala, Thiruvananthapuram, 28-30 March.

**B. Santhosh**, M. K. Anil, G. Gopakumar, Rani Mary George, S. Jasmine, K. N. Saleela, C. Unnikrishnan, S. Vinod, R. Mary Rinju and B. O. Prasad. 2013. Mass production trials of three species of calanoid copepods suitable for feeding fish larvae in the National Seminar on Emerging Trends in Indian Aquaculture Dept. of Aquatic Biology and Fisheries, University of Kerala, Thiruvananthapuram, 28-30 March.

**B. Santhosh,** N. P. Singh, M. Datta, S. V. Ngachan, S. K. Das and K. Laskar, 2013**.** Aquaculture using Self Recruiting Fishes- an option for traditional aquaculture for tribals in Tripura in the National Seminar on Emerging Trends in Indian Aquaculture Dept. of Aquatic Biology and Fisheries, University of Kerala, Thiruvananthapuram, 28-30 March

Anil, M. K., **B. Santhosh**, B.O. Prasad, S. Jasmine and Rani Mary George, 2010. Occurrence, species composition and abundance of Chaetodontid fishes along Vizhinjam coast, Thiruvananthapuram, Kerala. In: First Indian Biodiversity Congress IBC 2010, **National Seminar**, Book of Abstracts, University of Kerala, Thiruvananthapuram, 28-30 December 2010, P. 15. (Page 234 )

Anil, M.K., **B. Santhosh**, S. Jasmine, S. Reenamol, C. Unnikrishnan and A. Anukumar. 2010. Techniques for mass production of two species of clown fish: Clown anemone fish *Amphiprion ocellaris* Cuvier, 1830 and Spine cheek anemone fish *Premnas biaculeatus* (Bloch, 1790). In: *National Seminar Proceedings :Technology and Trade Prospects in Ornamental Aquaculture*, S. Felix (Ed.) Fisheries Research and Extension Centre, Tamil Nadu Veterinary and Animal Sciences University , Chennai. 121-129. (Page 232 )

**Santhosh, B**. and M. K. Anil, 2013. Zooplankton for marine fish larval feed. In: Course Manual. Customised training in Mariculture for Maldivian Officials. Imelda Joseph and Edwin Joseph (Eds.) organised by CMFRI and the Commonwealth Secretariat, Published by the CMFRI, Kochi, p.89-96.

Anil, M. K., K. Sunil Mohamed, V. Kripa, **B Santhosh,** K.T. Thomas, P. Hillary, V.A Leslie, and C. Unnikrishnan 2014. Technology of designer pearl production In: Course manual: Marine designer pearl production - Science and Technology (M.K Anil, Ed.). Central Marine Fisheries Research Institute, Vizhinjam, February 19-28, 2014, p. 49-53.

Jasmine S., Anil, M.K., **B. Santhosh**, Saleela K.N., Jose Kingsly H, Raju B, Sugi V.V. and Mary Rinju R, 2014. Occurrence, species composition and feeding behavior of wrasses along Vizhinjam coast, Thiruvananthapuram, Kerala. In: Book of Abstracts - Ornamentals Kerala 2014:International seminar on ornamental fish breeding, farming and trade. 26-27 January 2014, p.75.

Saleela K.N., Anil, M.K. and **B. Santhosh** 2014. Potential of tropical lobsters as a candidate species for marine aquarium. In: Book of Abstracts - Ornamentals Kerala 2014: International seminar on ornamental fish breeding, farming and trade. 26-27 January 2014, p.40.

**Santhosh B**., M. K. Anil, K. N. Saleela, S. Jasmine, K.K. Vijayan, G. Gopakumar, C. Unnikrishnan, A. Udayakumar, H. Jose Kingsley and R. Mary Rinju. Common parasitic disease problems in marine aquarium fishes. In: In: Book of Abstracts - Ornamentals Kerala 2014: International seminar on ornamental fish breeding, farming and trade. 26-27 January 2014.

**Chapters in Trainig Manuals**

**Staff of VRC of CMFRI have contributed more than 100 chapters are their in training manuals of CMFRI and other Institutes**

## 3. Training / Refresher Course/ Summer/ Winter Institutes/ Seminars/ Conference / Symposia/ Workshop Attended Within India and on Deputation abroad:

**National level training program in designer pearl production**

A three day training program on the '*Image pearl production*' is scheduled from 19th to 21st February, 2014 at V.R.C. of CMFRI, and steps were taken for conducting the program. Already 20 participants from various maritime states and UT of Lakshadweep were selected for participating in the training program. A new manual is being prepared for the programme. The program targets Scientists, Technical staff/students/Teachers from universities/Research Institutes and officials.

National Training (CMFRI- HRD) on Marine Ornamental Fish keeping and breeding -26th to 30th March 2013. (5 days). Dr. M. K. Anil, Course Coordinator- (for twenty officials and 4 entrepreneurs)

Training workshop on Taxonomy of Brachyuran Crabs, organized by Department of Aquatic Biology & Fisheries during 9-01-2013 to 11-01-2013 at Kariyavattom,Thiruvananthapuram,Kerala. Participated in the programme on Integrated Scientific Project Management for Women Scientists/ technologists from 18-22 November 2013 at Centre for organization Development, Hyderabad.

**Anil, M. K**., **B. Santhosh and N. Ramachandran**, 2011. Advanced Techniques in marine ornamental fish keeping and breeding, Central Marine Fisheries Research Institute, Vizhinjam, 2nd November -1st December, 128 pp.

**Anil, M.K., B. Santhosh and N. Ramachandran**. 2010 Marine ornamental fish keeping and breeding . Central Marine Fisheries Research Institute, Vizhinjam, July 15-24, 2010, 120pp.

**Santhosh, B. and Anil, M.K**. 2011.Sea cage farming of seabass and lobsters. Training manual, Central Marine Fisheries Research Institute, Vizhinjam, 124pp.

**Lipton, A.P., B. Santhosh, H. Jose Kingsly and A. Udayakumar, 2012.** Course manual, Recent advances in sea farming: Prospects for livelihood options along the coasts of India. 10-12 October 2012.76pp

**Anil, M.K., B. Santhosh**, C. Unnikrishnan,, S. Reenamole, and A. Anukumar. 2010. Broodstock development, breeding and larval rearing of clown fishes. *In* : Course Manual: Marine ornamental fish keeping and breeding (Ed. Anil, M.K., B. Santhosh and N. Ramachandran ). Central Marine Fisheries Research Institute, Vizhinjam, July 15-24, 2010, pp. 74-80.

**Anil, M.K., B. Santhosh**, C. Unnikrishnan,H. Jose Kingsly, P. Hillay, V.P. Benzeger, A. Udayakumar and K.T. Thomas. 2010. Design, construction, anchoring and utilization of multipurpose wooden sea-cage at Vizhinjam Bay. *In*: Course manual: Sea Cage Farming (Eds. Santhosh, B., M.K.Anil and G., Rani Mary

George**.**). Central Marine Fisheries Research Institute, Vizhinjam, October 27- November 2nd, 2010, pp. 54-59.

**Anil, M.K., B. Santhosh, S. Jasmine, K.N. Saleela, G., Rani Mary George**, H. Jose Kingsly, C. Unnikrishnan, and G. Hanumantha Rao. 2010. Growth, survival and performance of Seabass in sea cages at Vizhinjam. *In*: Course manual: Sea Cage Farming (Eds. Santhosh, B., M.K.Anil and Rani Mary George**..**) Central Marine Fisheries Research Institute, Vizhinjam, October 27- November 2nd, 2010, pp. 64-68.

**Anil, M.K., G., Rani Mary George, S. Jasmine, and B. Santhosh**, 2010. Algal culture techniques for larval rearing of ornamental fishes. In DBT Sponsored Refresher course: Innovative and Viable Biotechnological Techniques for Ornamental Aquaculture System Management. (November 10th to December 3rd, 2010) Course Manual, S. Felix (Ed.) Fisheries Research and Extension Centre, Tamil Nadu Veterinary and Animal Sciences University , Chennai. 198-208.

**Anil, M.K., K.N. Saleela,** H. Jose Kingsly, A. Udayakumar, and K.T. Thomas. 2010. Setting up and maintenance of reef aquariums. *In* : Course Manual: Marine ornamental fish keeping and breeding (Eds. Anil, M.K., B. Santhosh and N. Ramachandran). Central Marine Fisheries Research Institute, Vizhinjam, July 15-24, 2010, pp. 68-73.

**Anil, M.K., S. Jasmine, B. Santhosh, G., Rani Mary George**, Raju. B, C. Unnikrishnan. and H. Jose Kingsly, 2010. Marine Ornamental Fish Biodiversity of Kerala coast, In DBT Sponsored Refresher course Innovative and Viable Biotechnological Techniques for Ornamental Aquaculture System Management. (November 10th to December 3rd,2010) course manual S. Felix (Ed.) Fisheries Research and Extension Centre, Tamil Nadu Veterinary and Animal Sciences University , Chennai. 35-45.

**Anil, M.K., S. Jasmine, G., Rani Mary George**, B. RAJU, P. Hillary, and V.P. Benzeger. 2010. Common marine ornamental fishes of India. *In* : Course Manual: Marine ornamental fish keeping and breeding (Eds. Anil, M.K., B. Santhosh and N. Ramachandran ). Central Marine Fisheries Research Institute, Vizhinjam, July 15-24, 2010, pp. 5-13.

**B. Santhosh, M.K.Anil**, B.O. Prasad, C. Unnikrishnan,, A. Udayakumar and H. Jose Kingsly. 2010. Parasites of marine ornamental fishes and methods for control and treatment. *In* : Course Manual: Marine ornamental fish keeping and breeding (Eds. Anil, M.K., B. Santhosh and N. Ramachandran). Central Marine Fisheries Research Institute, Vizhinjam, July 15-24, 2010, pp. 101-112.

Grace Mathew , **M.K.Anil**, and H. Jose Kingsly. 2010. Broodstock development and breeding of some ornamental groupers from the near shore reef areas. *In* : Course Manual: Marine ornamental fish keeping and breeding (Eds. Anil, M.K., B. Santhosh and N. Ramachandran). Central Marine Fisheries Research Institute, Vizhinjam, July 15-24, 2010, pp. 89-94.

**Lipton A.P**., A. Udayakumar, Sreeya G. Nair, R.S. Rachna Mol, A.R. Sarika & J. Jean Jose. 2012. Practical notes on microbial diseases of ornamental fishes. In. CMFRI-HRD Training: 'Marine ornamental fish keeping & rearing' (held at Vizhinjam on 19-10-2012). 10pp.

**Lipton, A.P.,** 2011. Diagnosis and Treatment of microbial diseases of marine ornamental fishes. In. Course Manual: Advanced Techniques in Marine Ornamental Fish Keeping and Breeding (Ed. Anil, M.K., *et al*.) CMFRI. Vizhinjam. November 2011. pp. 96-101.

**Santhosh, B., M.K.Anil and G., Rani Mary George**. 2010 Sea Cage Farming . Central Marine Fisheries Research Institute, Vizhinjam, October 27- November 2nd, 2010, 150pp.

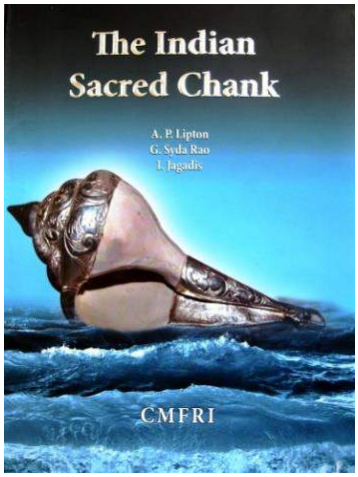
**Santhosh, B., M.K.Anil**, B.O. Prasad, C. Unnikrishnan, A. Udayakumar and H. Jose Kingsly. 2010. Fish health management in cage culture- parasitic diseases and control measures. *In*: Course manual: Sea Cage Farming (Eds. Santhosh, B., M.K.Anil and Rani Mary George**.**). Central Marine Fisheries Research Institute, Vizhinjam, October 27- November 2nd, 2010, pp. 119-137.

Syda Rao, G., **Rani Mary George, M.K.Anil, K.N. Saleela, S. Jasmine, B. Santhosh**, G. Hanumantha Rao, H. Jose Kingsly, C. Unnikrishnan, P. Hillay, V.P. Benzeger, A. Udayakumar and B. Raju. 2010. Sea cage farming of Lobster, *Panulirus homarus* at Vizhinjam. *In*: Course manual: Sea Cage Farming (Eds. Santhosh, B., M.K.Anil and Rani Mary George.). Central Marine Fisheries Research Institute, Vizhinjam, October 27- November 2nd, 2010, pp. 69-73.

**4. Books and pamphlets Published**

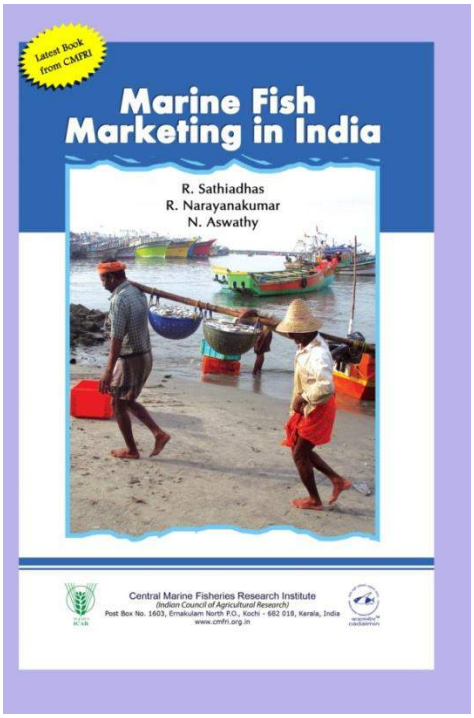
**1. A.P. Lipton**, G. Syda Rao and I. Jagadis. 2013. **The Indian Sacred Chank. CMFRI. 250pp.**

The CMFRI book "The Indian Sacred Chank" authored by A.P. Lipton, G. Syda Rao and I. Jagadis was released by Hon. Union Minister of Agriculture Shri. Sharad Pawar on 16th July 2013 on the occasion of the 85th ICAR Foundation Day at New Delhi.


**Book release by Hon. Union Minister of Agriculture Shri. Sharad Pawar**

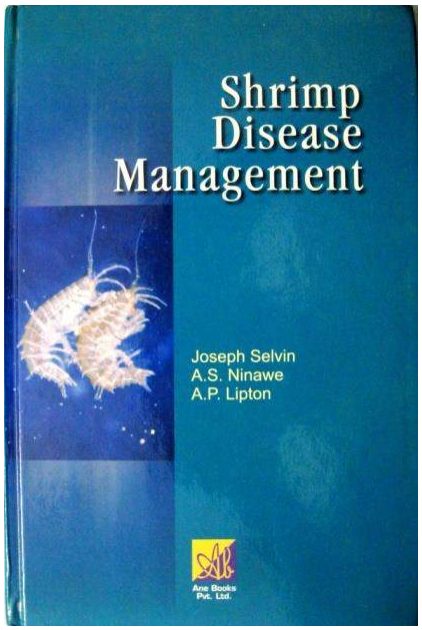
**2. Dr. Sathiadhas et al., 2012 Marine Fish Marketing in India. CMFRI Publication**




3. Joseph Selvin, A. S. Ninawe and **A.P. Lipton**. 2009

**SHRIMP DISEASE MANAGEMENT – Prospective approaches**

Ane Books Pvt. Ltd., New Delhi. 285pp.



**Folders/ pamphlets published**:

**A.P. Lipton**, Jose Kingsly and James, 2010. Pamphlet In Tamil: "***Kadalil midavai koondugalil meen valarpu***" (English: 'fish culture in sea in floating cages'). Published by: Dr. G. Syda Rao, Director, CMFRI, Cochin. CMFRI Pamphlet No: 11/2009

Manisseri, Mary K and Antony, Geetha and **George, Rani Mary** and Nair, Rekha J and Joshi, K K and Geetha, P M (2012) **Marine Biodiversity Museum (A Designated National Repository) Catalogue.** CMFRI Special Publication, 107 . Central Marine Fisheries Research Institute, Kochi, pp. 1-222.

Joshi, K K and Nair, Rekha J and Abdussamad, E M and Thomas, Sujitha and Kakati, V S and **Jasmine, S** and Varghese, Molly and Sreeram, Miriam Paul and Sukumaran, Sandhya and **George, Rani Mary** and Manisseri, Mary K (2011) **Carangids of India - A Monograph.**Central Marine Fisheries Research Institute, Kochi.

**Santhosh, B.,** N. P. Singh, M. Datta and S. V. Ngchan, 2010. Pond fish culture. Technical Bullettin Publication no. 10.ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra, West Tripura. 58pp.

**Santhosh, B.,** N. P. Singh, M. Datta and S. V. Ngchan, 2010.Use of self recruiting native fishes for extra income from composite fish culture. Technical Bullettin Publication no. 15. ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra, West Tripura. 62pp.

**Santhosh, B.,** N. P. Singh, K.K. Satpathi and S. V. Ngchan, 2010. Need a fish doctor? Publication no. 8. **(Pamphlet)**ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra, West Tripura. 6pp.

**Santhosh, B**., N. P. Singh, K.K. Satpathi and S. V. Ngchan, 2010. Worried about farmyard manure for your pond? Publication no. 9 **(Pamphlet)** ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra, West Tripura. 6pp

Datta, M. , N. P. Singh, **B. Santhosh,** K.K. Satpathi and S. V. Ngchan, 2010. Development of Agro-forestry based farming system model for sustainable land management in Dhalai district of Tripura. Publication No. 5.**(Folder)** ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra, West Tripura. 6pp.

Datta, M., N. P. Singh, **B. Santhosh**, K.K. Satpathi and S. V. Ngchan, 2010. Tripurar Dhalai anchale jhumer sub vyvahar kolpe krishi banayen vridhik mishro kamarer ek prayas. Publication No. 6. **(Folder in Bangali)** ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra, West Tripura. 6pp.

**Santhosh, B.,** N. P. Singh, K.K. Satpathi and S. V. Ngchan, 2010. Need a fish doctor? Publication no. 8. **(Pamphlet)**ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra, West Tripura. 6pp.

**Santhosh, B**., N. P. Singh, K.K. Satpathi and S. V. Ngchan, 2010. Worried about farmyard manure for your pond? Publication no. 9 **(Pamphlet)** ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra, West Tripura. 6pp

Datta, M. , N. P. Singh, **B. Santhosh,** K.K. Satpathi and S. V. Ngchan, 2010. Development of Agro-forestry based farming system model for sustainable land management in Dhalai district

of Tripura. Publication No. 5.**(Folder)** ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra, West Tripura. 6pp.

Datta, M., N. P. Singh, **B. Santhosh**, K.K. Satpathi and S. V. Ngchan, 2010. Tripurar Dhalai anchale jhumer sub vyvahar kolpe krishi banayen vridhik mishro kamarer ek prayas. Publication No. 6. **(Folder in Bangali)** ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra, West Tripura. 6pp.

**5. Technical and Popular article**

**Jasmine, S and Rani Mary George**, and Mary. K. Manisseri. (2011) **प्रवाल झाडियों पर अध्ययन.** जैवविविधता – *विशेष प्रकाशन* , 106 . pp. 38-41.

K. Vinod, **Rani Mary George** and Mary K. Manisseri 2010. Preliminary studies on the growth in captivity of *Spirastrella inconstans* (Dendy) collected from the intertidal region of Palk Bay, south-east coast of India *Mar. Fish. Infor. Serv*. *T &E. Ser*.,No.202: 4-6.

**Lipton, A.P.** 2012 'Atma' scheme – exposure visit of lobster farmers to Vizhinjam research centre of C.M.F.R.I. *Cadalmin*: CMFRI News Letter. 132: 19.

**Lipton, A.P**. 2012. CMFRI's HRD Training Programme on "Recent advances in sea farming" conducted at Kanyakumari. *Cadalmin*. CMFRI News Letter. 135:16-17.

**Lipton, A.P**. 2012. Sea Farming Training Programme at Kanyakumari. *Cadalmin*: CMFRI News Letter. 132: 20.

**Lipton, A.P**. 2012. Visit of 224 fishermen to Vizhinjam RC under the capacity building Extension Education to marine fishermen. *Cadalmin*. CMFRI News Letter. 134: 19.

**Lipton, A.P**. A. Udayakumar, A.R. Sarika, M.S. Aishwarya and H. Jose Kingsly. 2012. A new and fatal 'neck out disease' recorded among lobsters farmed in small floating sea cages off Kanyakumari coast*. Cadalmin*: CMFRI News Letter. 133: 11.

**Saleela,** K.N**, M. K. Anil,** S. Jasmine, B. Raju, 2011. Unusual landings of *Aluterus monoceros* (Linnaeus, 1758) along Vizhinjam coast. *Mar. Fish. Infor. Serv.*, *T & E Ser.* No.207: 30-31.

Sujitha Thomas., Miriam Paul Sreeram., Kakati, V S, **Rani Mary George** and Mary. K. Manisseri, (2011) **ग्रानडे द्वीप, गोवा के आसपास के प्रावाल खंडों पर जैवविविधता अध्ययन.** *जैवविविधता – विशेष प्रकाशन* , 106 . pp. 32-34.

T. S. Naomi, Mary. K. Manisseri and **Rani Mary George**. 2011. New distributional range of the soft coral *Cladiella australis* in the Palk Bay Sea. *Cadalmin*, *CMFRI News Letter*, 2011. No.128, p. 3

T. S. Naomi, Miriam Paul Sreeram, **Rani Mary George**, Sijo Paul, N. K. Sanil, Rekha J. Nair and P. M. Geetha 2010. New distributional record of the insular shelf beauty *Symphysanodon typus* Bleeker, 1878 (Family: Symphysanodontidae) from Indian waters *Mar. Fish. Infor. Serv*. *T &E. Ser*., No.204:10-13

T. S. Naomi**., Rani Mary George**, Miriam Paul Sreeram, N. K. Sanil, K. Balachandran, V. J. Thomas and P. M Geetha. 2012. Finfish diversity in the trawl fisheries of southern Kerala *Mar. Fish. Infor. Serv*. *T &E. Ser*.,No.207: 11-21

Udayakumar, A., H. Jose Kingsly, V. Viswanathan, Rachana Mol, R.S and **A. P. Lipton.** 2012. Unusual and Heavy landings of rays and skates in Muttom fishing harbour in Kanyakumari District, Tamil Nadu during June-July 2012. *Cadalmin*. CMFRI News Letter. 134: 14.

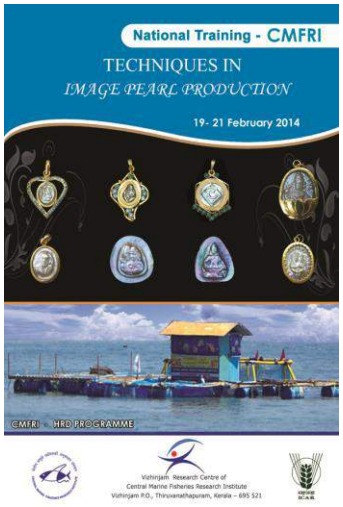
Success story of lobster culture at Vizhinjam and Kanyakumari. Open sea cage farming of spiny lobster by CMFRI- A success story. *CMFRI Newsletter* No.121:3-5. 2012

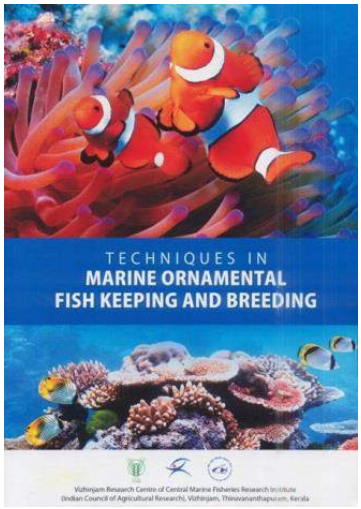
Anil, M. K., **B. Santhosh**, C. Unnikrishnan, B. Raju, A. Udayakumar, H. Jose Kingsly, P. Hillary, and V. P. Benzeger, 2010. Vizhinjam Marine Aquarium: Heaven for Marine Ornamentals. *Fishing Chimes*, 30: 50-53. (Pages 173-176 )

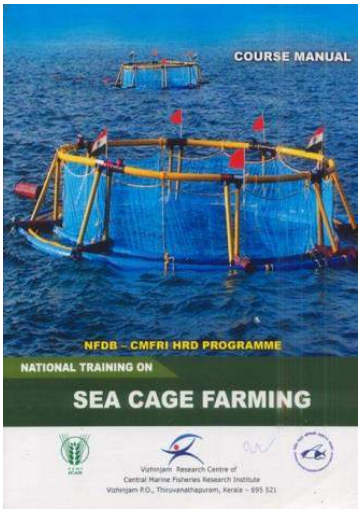
**S.Jasmine**, K. R. Sreenath, L. Ranjth and **H. Jose Kingsly** (2013) **Mass spawning of Scleractinian corals in the Lakshadweep Archipelago.** *CMFRI Newsletter* (136). p. 6.

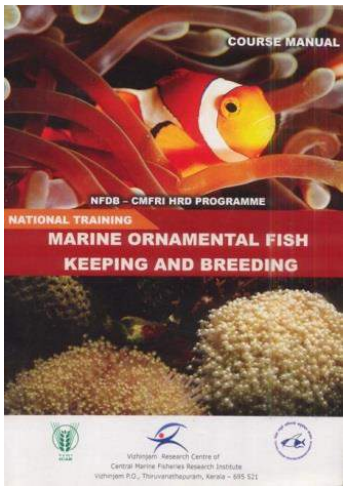
**M. K. Anil, Rani Mary George** and **S. Jasmine** 2014. Álgal culture techniques for larval rearing of pearl oysters' In: Manual on *Marine Designer Pearl Production –Science and Technology*, 29-41

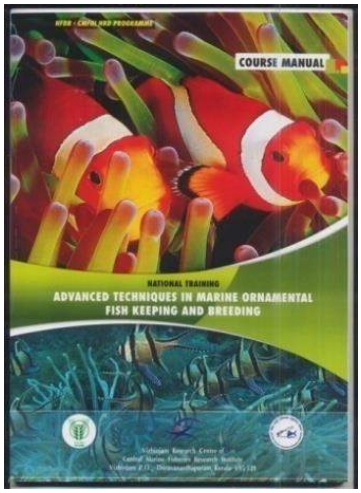
**Training Manuals**

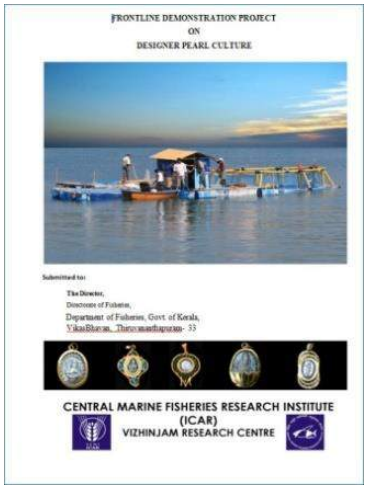


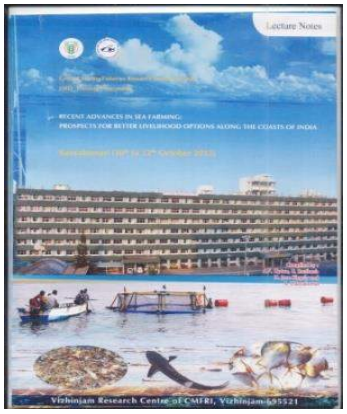



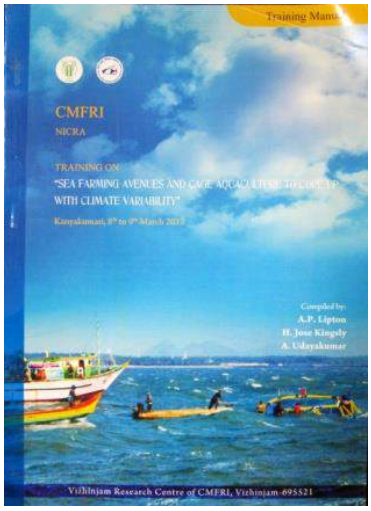




**1. GenBank submission:** **Total: 36 submitted**

**GenBank submissions/accession numbers in 2010:** 5

1. Sarika, A.R., **Lipton, A.P**. and Aishwarya, M.S. 2010. 2009. *Enterococcus faecalis* strain CD1 16S ribosomal RNA gene, partial sequence. (Accession: GQ483456 -1522 bp DNA linear BCT 13-SEP-2009).
2. Huxley,V.A.J., **Lipton, A.P**., Ramesh,R., John,J. and Innocent,B.X. 2010. *Paratelpusha hydrodromous* prophenol oxidase gene, partial cds. TITLE: The isolation and characterization of proPO activating gene in field crab *Paratelphusa hydrodromous.* Accession GU258542 (311 bp DNA linear 11-JAN-2010).
3. Huxley,V.A.J., **Lipton, A.P**., Ramesh,R., John,J. and Innocent,B.X. 2010. *Paratelpusha hydrodromous* mannose-binding lectin gene, partial sequence. PCR amplification of the partial sequence of the mannose-binding lectin gene GU258543 (727 bp DNA linear INV 11-JAN-2010).
4. Medo, M.R., **Lipton, A.P** and Aishwarya, M.S. 2010. *Vibrio alginolyticus* isolated from sea grass, *Syringodium isoetifollium* (16S ribosomal RNA gene, partial sequence). Accession No: HM045516 (bases 1 to 1517)
5. Authors: Medo, M.R., **Lipton, A.P**. and Godwin, W.S. 2010. *Bacillus pumilus* isolated from sea grass, *Halodule pinifolia.* Accession No: HM006706 (bases 1 to 1430)

**GenBank submissions/accession numbers in 2011**: 14 sequences deposited

1. A. R. Sarika, **A. P. Lipton** and M. S. Aishwarya. 2011. Fish pathogenic *Enterobacter cloaceae* MSU1 (isolated from diseased marine perch) 16S ribosomal RNA gene, partial sequence (1422 bp) submitted to GenBank with the accession number HQ888762.
2. Sreeya, **A. P. Lipton** and M. S. Aishwarya. 2011. Fish pathogenic *Pseudomonas aeruginosa* strain PSA1 (isolated from *Etroplus maculatus*) 16S ribosomal RNA gene, partial sequence (1403 bp) submitted to GenBank with the accession number **JF703671**.
3. A. R. Sarika, **A. P. Lipton** and M. S. Aishwarya. 2011. Bacteriocin producing *Lactococcus lactis* PSY2 (isolated from scales of marine perch fish) 16S ribosomal RNA gene, partial sequence (1074 bp) submitted to GenBank with the accession number JF703669.
4. M. S. Aishwarya, **A. P. Lipton** and A. R. Sarika. 2011. Bioactively efficient strain *Serratia rubidaea* CSP (isolated from marine sponge *Callyspongia subarmigera* collected off the coast of South-east India) 16S ribosomal RNA gene, partial sequence (735 bp) submitted to GenBank with accession number JF873082.
5. M. S. Aishwarya, **A. P. Lipton** and A. R. Sarika. 2011. Bioactively efficient strain *Bacillus amyloliquefaciens* CSG (isolated from marine sponge *Callyspongia subarmigera* collected off the coast of South-east India) 16S ribosomal RNA gene, partial sequence (737 bp) submitted to GenBank with accession number JF873083.
6. M. S. Aishwarya, **A. P. Lipton** and A. R. Sarika. 2011. Bioactively efficient strain *Arthrobacter* sp. CSY (isolated from marine sponge *Callyspongia subarmigera* collected off the coast of South-east India) 16S ribosomal RNA gene, partial sequence (707 bp) submitted to GenBank with accession number JF873084.
7. **Lipton, A.P**., Rao, G.S., Udayakumar, A and Aishwarya, M.S. 2011. Sequence from bacteria *Bacillus circulans* isolated from infected lobsters (*Panulirus homarus*) farmed in floating sea cages at KanyaKumari, Tamil Nadu. India. 16S ribosomal RNA gene, partial sequence (1457 bp) submitted to GenBank with accession number JQ409560.
8. Lipton, A.N., **Lipton, A.P** and Aishwarya, M.S. 2011. Sequence from bacteria *Bacillus subtilis* strain VZS1 associated with marine sponge, *Mycale mytilorum* (Annandale) with special reference to

protease production - 16S ribosomal RNA gene, partial sequence (530 bp) submitted to GenBank with accession number JQ409557.

9. Lipton, A.N., **Lipton, A.P** and Aishwarya, M.S. 2011. Sequence from bacteria *Bacillus boroniphilus* strain VZW 4 associated with marine sponge, *Mycale mytilorum* (Annandale) with special reference to protease production. Accession No: JQ409558**.**
10. Aishwarya, M.S., **Lipton, A.P**., Jijith,S.S. and Sarika, A.R. 2011. *Callyspongia subarmigera* cytochrome c oxidase subunit 1 gene, partial cds; mitochondrial. Accession Number: JQ 409559.
11. Parimala,M.C., **Lipton,A. P**. Deeja,R.M. and Suriya,R.K. 2011
    *Alcaligenes faecalis* subsp. *faecalis* strain AE1 16S ribosomal RNA gene, partial sequence.Isolated as seaweed-associated bacterial strain (Bacteria; Proteobacteria; Betaproteobacteria; Burkholderiales;Alcaligenaceae; Alcaligenes.
    GenBank: Accession HQ727664 (bases 1 to 1381)
12. Parimala Celia,M., **Lipton,A. P** and Athselal Bony,A. 2011
    *Klebsiella sp*. SW4 16S ribosomal RNA gene, partial sequence**.** Klebsiella sp. SW4 16S ribosomal RNA gene, partial sequence1489 bp DNA (Bacteria; Proteobacteria; Gammaproteobacteria; Enterobacteriales; Enterobacteriaceae; Klebsiella).
    GenBank: JF815403.1 (bases 1 to 1489)
13. Parimala Celia,M. and **Lipton,A. P**, 2011.
    *Alcaligenes faecalis* strain SW-3 16S ribosomal RNA gene, partial sequence
    GenBank: JF815402.1 (bases 1 to 1396)
    Alcaligenes faecalis strain SW-3 16S ribosomal RNA gene, partial
    sequence. )Bacteria; Proteobacteria; Betaproteobacteria; Burkholderiales;
    Alcaligenaceae; Alcaligenes).
14. Parimala,M.C., **Lipton,A. P**. and Suriya,R.K. 2011.
    *Halomonas venusta* strain DSM4743 16S ribosomal RNA gene, partial sequence GenBank: HQ727663.1 (1340 bp DNA)
    Source: endosymbionts associated with the seaweed *Hypnea musciformis* (Bacteria; Proteobacteria; Gammaproteobacteria; Oceanospirillales; Halomonadaceae; Halomonas).

**GenBank Submissions in 2012**: 16 accessions*

*Authors for 1 to 13 sequences: Jean Jose. J, M. Thangaraj, **A. P. Lipton** and Lincy Alex

*Authors for 14 to 16 sequences: Issac Dhinakaran, D and **A.P. Lipton**

13 sequences: Submission date: 5/11/2012 & GenBank accession No. assigned date: 7/11/2012

| Sl. No | Species | Sampling area | GenBank Acc. no. |
|---|---|---|---|
| 28S rDNA sequence details of *Oithona similis* from Arabian Sea | | | |
| 1 | *Oithona similis* | Calicut | KC136272 |
| 2 | *Oithona similis* | Calicut | KC136273 |
| 3 | *Oithona similis* | Calicut | KC136274 |
| 4 | *Oithona similis* | Cochin | KC136275 |
| 5 | *Oithona similis* | Cochin | KC136276 |
| 6 | *Oithona similis* | Cochin | KC136277 |

| | | | |
|---|---|---|---|
| 7 | *Oithona similis* | Neendakara | KC136278 |
| 8 | *Oithona similis* | Neendakara | KC136279 |
| 9 | *Oithona similis* | Neendakara | KC136280 |
| 10 | *Oithona similis* | Neendakara | KC136281 |
| 11 | *Oithona similis* | Vizhinjam | KC136282 |
| 12 | *Oithona similis* | Vizhinjam | KC136283 |
| 13 | *Oithona similis* | Vizhinjam | KC136284 |
| 28S rDNA sequence details of marine macroalgae collected from Rastagod region of Kanyakumari* | | | |
| 14 | *Ulva reticulata* (rbcl) | Rastagod region of Kanyakumari | JQ772534 |
| 15 | *Valoniopsis pachynema* | Rastagod region of Kanyakumari | JQ772535 |
| 16 | *Amphiroa zonata* (rbcl) | Rastagod region of Kanyakumari | JQ772536 |

**GenBank Submissions in 2013: 1**

bacterial isolate from Marine Sponge host: *Callyspongia diffusa*

GenBank submission: 1402 bp; Accession KC623651 (DNA linear BCT 01-MAY-2013)

*Shewanella algae* isolate A28728 16S ribosomal RNA gene, partial sequence.

Bacteria; Proteobacteria; Gammaproteobacteria; Alteromonadales; Shewanellaceae; Shewanella.

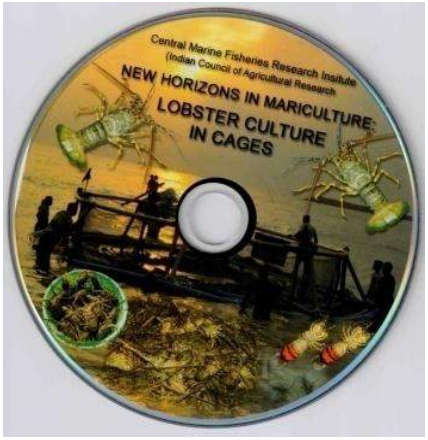
Authors Mol, R., Lipton,A.P., Thankamani,V. and Sarika, A.R.

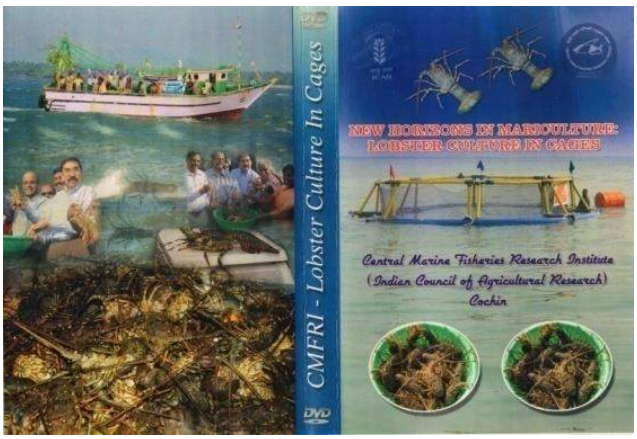
BankIt1717554 Seq KJ789102

**Contribution made in compilation/documentation: DVD's produced/edited: 10**

1. Syda Rao, G and **A.P. Lipton,** 2010.
   **DVD on 'New Horizons in Mariculture: Lobster culture in Cages'**.

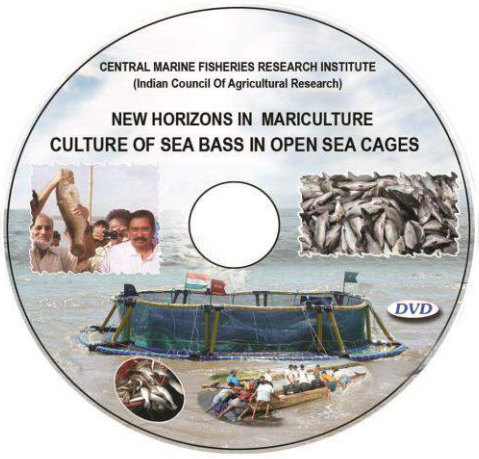
   The DVD was released by Dr. S. Ayyappan, Director General of ICAR, New Delhi on 23-5-2010.



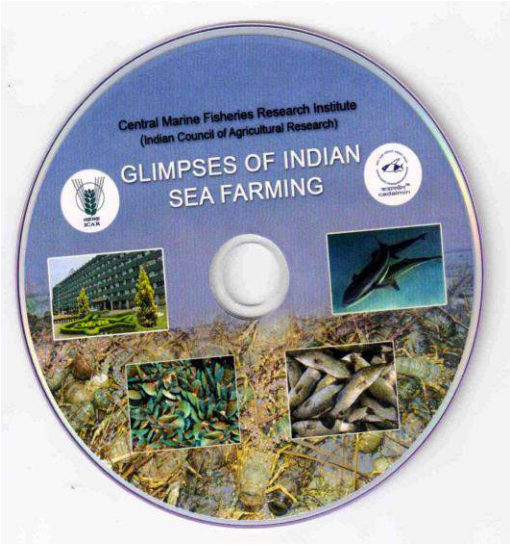
2. Syda Rao, G and **A.P. Lipton,** 2010.
**DVD on 'New Horizons in Mariculture: Culture of sea bass in open sea cages'**.

The DVD was released by Dr. Krishniah, Chief Executive, National Fisheries Development Board (NFDB) during the inaugural function of the 'National Workshop on Cage Farming' at Karwar on 18-7-2010.




1. Syda Rao, G and **A.P. Lipton,** 2011

CMFRI film on 'Glimpses of Indian sea farming'




- CMFRI's film in DVD on "Glimpses of Indian sea farming" (April 2011) was released during the inaugural session of the International Seminar organized by the NACA-CMFRI on 'Emerging issues in

Asian Aquaculture'. The film was released by Prof. Sena deSilva, Director General, NACA, Bangkok and the first copy was received by Dr. (Smt.). B. Meenakumari, Deputy Director General (Fisheries), ICAR, New Delhi. The film provided information on the achievements made by the scientists of CMFR Institute on the sea farming of invertebrates (crustaceans, mollusks), sea weeds, ornamental fishes and food fishes. CMFR Institute's new venture of sea farming through open sea floating cages and capture based aquaculture are highlighted in the film. The efforts made by the scientists in the successful breeding, nursery rearing and raising of F1 generation of cobia for the first time in the country and the future goals are depicted in the film.

2. Syda Rao, G and **A.P. Lipton,** 2012. CMFRI film on 'Cadalmin™ Green Algal extract (GAe)'
(Film produced by Dr. G. Syda Rao and Dr. A.P. Lipton with the technology developed by Dr. Kajal Chakraborty)

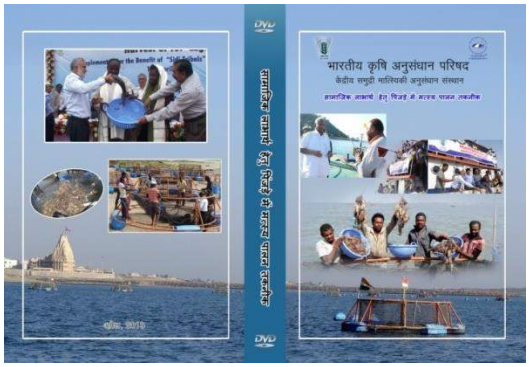
The CMFRI's film (as DVD) on Cadalmin™ Green Algal extract (Cadalmin™ GAe) was released at the 83rd Annual General Meeting of the ICAR Society on 6-3-2012 by Dr. Charan Das Mahant, Honourable Minister of State for Agriculture and Food Processing Industries, Govt. of India on at National Agricultural Science Complex. The function was presided by Shri Sharad Pawar, Honourable Union Minister of Agriculture and Food Processing Industries in the presence of Dr. S. Ayyappan, Secretary, DARE and Director General, ICAR. Agriculture and Animal Husbandry Ministers representing the different States, Members of the Governing Body of the ICAR and representatives from international organizations participated in the function. DVDs of the film were also distributed to the participants who visited the exhibition "Innovative Technologies go Commercial" organized by ICAR, New Delhi at the same venue.


English and Hindi versions of DVD cover for the Cadalmin™ GAe film

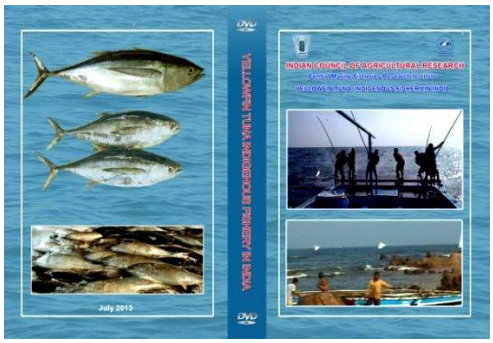
**DVD Editing during 2013**: 5 (By Dr. A.P. Lipton)

1. DVD on Cage Farming Technology for Community Development (English) – April 2013

2. DVD on Cage Farming Technology for Community Development (Hindi) – April 2013
3. DVD on Commercial Sea Cage Farming for Tribals under the Tribal Sub Plan: "Successful cage farming by Sidi Tribals of India" (English and Hindi) – April 2013
4. DVD on "Yellowfin tuna: Indigenous fishery in India" CMFRI – July 2013







**New Publications**

- A catalogue of the 1614 specimens available in the CMFRI Museum has been prepared with the assigned accession numbers. The catalogue was prepared as per the guidelines given by International Code of Zoological Nomenclature (ICZN). The index is given familywise and specieswise. The catalogue was published as CMFRI Special Publication No. 107, 58 pp.
- **Poster on Seaweeds, Seagrasses and Ornamental fishes**

A multicolour poster displaying 62 species of seaweeds and 6 species of seagrasses has been prepared. The seaweeds include 19 species of green algae, 29 species of red algae and 14 species of brown algae. The multicolour poster, double demy size (56x 87 cm), was printed on art paper (220 gsm). The copies of the poster will be sold through the ATIC.



**Patents filed**

**Patent**:

As co – inventor: 5 Scientists from Vizhinajam RC of CMFRI
In Dr. G. Syda Rao *et al*
'**A device for breeding and culturing marine fish in open sea**'

1. **National Marine Census** successfully completed for Thiruvananthapuram and Kollam Districts of Kerala (**Shri. K.K. Suresh, Shri. Jose Kingsley, Shri. A. Udayakumar, Dr. B. Santhosh and Dr. Rani Mary George)**

**Ph D. awarded**

1. Smt. S. Jasmine got Ph.D. awarded in 2011 from MS University, Thirunelveli, on Studies on copepods of the marine and brackishwater areas of southern Kerala. Dr. Rani Mary George (Scientist- In-Charge) was the Co-guide.

2. Smt. Remya Madhavan got awarded the Ph. D. degree in 2010 from Kalayani University, West Bengal. Title of the work: Studies on the parasites of minor carps of Tripura state. Dr. B. Santhosh, Co-guide.

Ph. D awarded under the supervision of Dr. A.P. Lipton:

Total: 12 Ph. Ds awarded during the review period (2009 to 2014)

2009-10 3 in MS University

1. Shri S.K. Subhash (Reg. No: 1751) for the thesis on "Studies on disease resistance among pearl oyster *Pinctada fucata* (Gould) larvae and spat by probiotic bacteria"
2. Shri Viswanathan (Reg. No: 1297) for the thesis entitled, "Probiotics use and their effects on selected freshwater air breathing fish, *Channa* sp."
3. Smt. Prema Kumari on salt bittern aspects.

2010-11 1. University of Kerala (Smt. V.S Pramitha, for the thesis entitled, "Bioactivity profile of extracts of selected marine macroalgae with emphasis on medicinal potentials".

2011-12 2 in M.S. university

Smt. Medo Merina (Reg. No: 3022) for the thesis on "Sea grass ecology, microbial association and bioactivity profiles with special reference to *Halodule pinifolia* (Miki) Hartog and *Syringodium isoetifolium* (Asch.) Dandy, occurring along the South Indian coast".

Smt. A.R. Sarika, on the topic "Studies on Novel Strains of Bacteriocin producing Lactic Acid Bacteria, optimization of culture conditions and Efficacy of Biopreservation".

2012-13 3 in M.S. University:

Smt. Aruna Devi on plant bioactivity profiles

Smt. Sreeya G. Nair on "pathophysiology of freshwater ornamental fishes infected by microbial agents".

Shri. D. Issac Dhinakaran, for the topic on antitumor and antiviral activities exhibited by marine bioactive compounds from marine invertebrates to the Manonmaniam Sundaranar University during January 2013.

2013-13 Shri. Jean Jose on “Zooplankton diversity in relation to Hydro Chemical Fluctuation along the Southwest Coast of India, with Special Reference to Morphology, Molecular Biology and Culture of *Oithona Similis* (Claus, 1866) (Crustacea: Copepoda: Cyclopoidae)” .
Smt. Johnsy Christobel on bioactivity and bioadsorption efficacy of chosen marine macroalgae with special reference to their influence on growth responses and biochemical contents of microalgae.

Smt. Dhivya, R.S on “Distribution pattern of different species of mussels occurring along south west coast of India, their species-specific characteristics including physiological responses and natural assemblages of macro fauna”.

## 7. Awards/Honours

2. **Dr. Rani Mary George and Dr. B. Santhosh serving as Editor and sub-Editor of Indian Journal of Fisheries respectively were partly instrumental for obtaining the international rating of this top rated Journal of ICAR.**

3. **Best poster: Anil, M. K., B. Santhosh, B.O. Prasad, K.N. Saleela and C. Unnikrishnan**, 2011. Larval rearing of scarlet skunk cleaner shrimp, *Lysmata amboinensis* and fire shrimp, *Lysmata debelius*. In Gopalakrishnan, A.*et*. *al*. (Eds.), Renaissance in Fisheries: Outlook and strategies – Book of Abstracts, 9th Indian Fisheries Forum, CMFRI, Kochi and Asian Fisheries Society, Indian Branch, 2011, Chennai, India, 117 pp.

4. **Best paper: B. Santhosh, M. K. Anil, K.K. Vijayan, G. Gopakumar, K. N. Saleela, C. Unnikrishnan, A. Udayakumar, H. Jose Kingsley, A. Anukumar, S. Vinod, R. Mary Rinju and B. O. Prasad**., 2013. Case studies on diseases of brood stocks of clown fishes in the National Seminar on Emerging Trends in Indian Aquaculture Dept. of Aquatic Biology and Fisheries, University of Kerala, Thiruvananthapuram, 28-30 March.

5. **Best paper: B. Santhosh, M. K. Anil, G. Gopakumar, Rani Mary George, S. Jasmine, K. N. Saleela, C. Unnikrishnan, S. Vinod, R. Mary Rinju and B. O. Prasad.** 2013. Mass production trials of three species of calanoid copepods suitable for feeding fish larvae in the National Seminar on Emerging Trends in Indian Aquaculture Dept. of Aquatic Biology and Fisheries, University of Kerala, Thiruvananthapuram, 28-30 March.

6. Aishwarya, M. S.**A.P. Lipton**, Sarika, A. R., Dhivya, R. S. and Sreeya, G. Nair, 2011. Sponge-bacteria association: Observations on antibiotic potentials of new bacterial strains isolated from *Callyspongia subarmigera* (Ridley, 1884). National Conference on Explorations of Natural Bioactive compounds from the Marine resources (BIOACTIVA'11 Feb. 10-11).

7. Appreciation letter received from the Deputy Director General (Fisheries) ICAR, Krishi Bhavan, New Delhi for floating cage culture work at Kanyakumari through the Vizhinjam Research Centre of CMFRI (Dr. A.P. Lipton).

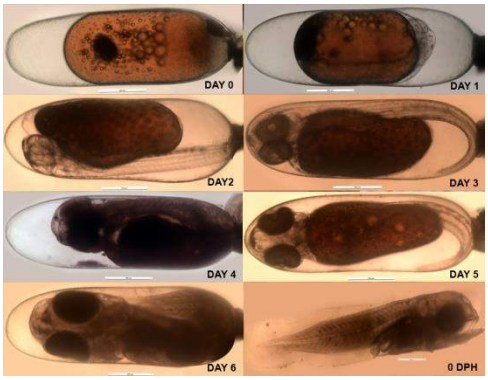
8. **CITE Alerts** (Elsevier): One publication by A.P. Lipton has been cited in a journal published by Elsevier.

## 8. Production, process, technologies developed with credited scientists

**Technologies developed**:

**1. Technology for breeding and seed production of Blackfinned anemone fish– *Amphiprion nigripes***

- Considering the high demand for the ornamental Blackfinned anemone fish– *Amphiprion nigripes,* a viable technology for commercial production of black-finned anemone fish *A. nigripes* was developed. Fecundity of this species ranged from 350-450 per spawning. Continuous spawning was chieved at 12 to 16 days interval. Incubation period was 6 to 7 days. Larval stages could be fed with rotifer *Brachionus plicatilis*, *Artemia* nauplii and particulate feeds at appropriate stages using green-water system. Juveniles with average size of 15 mm could be produced in 40 days with an average survival rate of 72 %. Marketable size of 25 mm or more could be achieved in less than 120 days.



Development stages of eggs & larva


Advanced incubation-silvery eggs

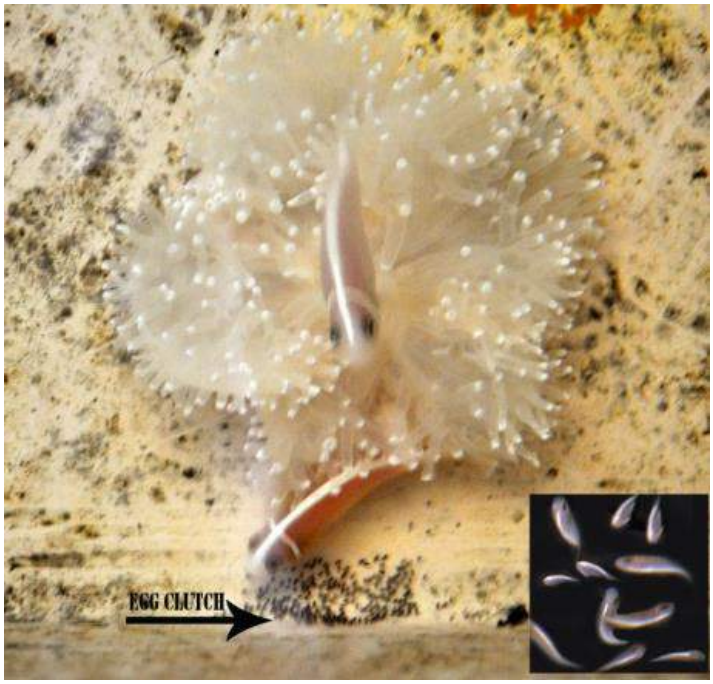

Juveniles 40th day


4 month old juveniles in anemone

Ref: Anil, M. K., B. Santhosh**,** B.O. Prasad, Rani Mary George, 2011. Broodstock Development and Breeding of Blackfinned Anemone fish *Amphiprion nigripes* Regan, 1908 under Captive Condition. *Indian J. Fish.,* 59:

**2. Technology for breeding and seed production of Pink Skunk Clownfish *Amphiprion peridarion***

- Internationally sought after tropical ornamental Pink Skunk Clownfish *Amphiprion peridarion,* was successfully bred under captivity at Vizhinjam RC of CMFRI for the first time in India. Its fecundity ranges from 75 to 150. This is reported as one of the difficult marine ornamental fishes to breed. Characteristic dorsal white line appeared in 15 to 20 days time. Several batches of this species were produced and a viable technology for commercial production of Skunk clown was developed. Some of the seeds were sold through the mega seed project of ICAR.




Pink anemone-fish *Amphiprion peridarion*

**3. Refinement of broodstock and mass production technologies of 7 species of ornamental fishes including demonstration of the technologies to the needy farmers.**

- Four national training programs were conducted for dissemination of this technology.

*A. sebae*

*A. ocellaris*

*A. percula*

*P. biaculeatus*

*A. frenatus*

*A. peridarion*

*A. nigripes*

Seeds of clown fishes

**4. Techniques for production of image pearl nuclei**

- Quality image nucleus is the basic prerequisite for the production of quality image pearls. The thickness of the nucleus, thickness of the groves and lines which describe the image is important. An eight- step process involving making of metal templates, making of mould, hot and cold process of image nuclei making, grinding the nuclei to proper size was developed. The methodology was standardized for making images using acrylic polymer (DPI RR cold cure polymer resin) and shell powder. Quality image pearl nuclei were produced using this method and used for implantation.

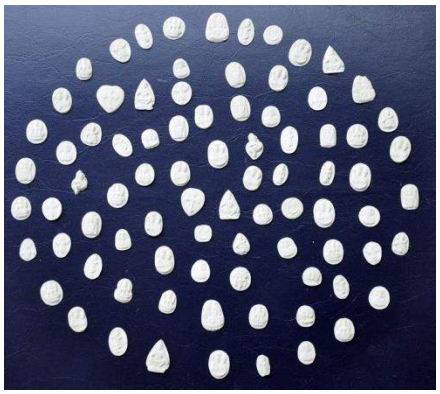


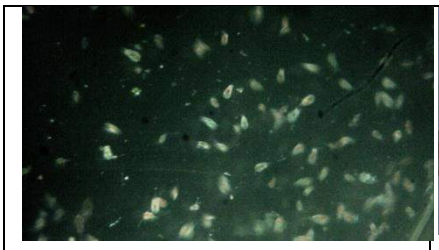
Image nuclei produced

Image pearl ornaments

**5. Technology for mass culture of the calanoid copepod, *Temora turbinata* and its nauplii for use in marine finfish hatchery**

- Of the several species of copepods investigated, *Temora turbinata* was found the most promising candidate for culture as it had several advantages compared to other popular species reported by several researchers. *T. turbinata* adults and naupliar stages, intensity of 800-1000 numbers/l and intensity of 2000-2500 numbers /l respectively could be achieved by adopting the standardized techniques. A combination of *Isochrysis galbana* and *Nannochloropsis* sp. with mild aeration was prerequisites. Fecundity ranged from 20-30eggs/female/day. *T. turbinata* has six naupliar stages and 5 copepodite stages and took 17-18 days to become adult. Adults survived for 38 days. The species is

found hardy and has comparatively good tolerance to salinity and temperature. Protocols for feeding, rearing, isolation, cleaning, and maintaining cultures without any contamination were also developed. Adults and naupliar stages of this species are highly pigmented indicating scope for predation for fishes, including the weak fish larvae. The egg sacs are absent and the scatter in the bottom. Bottom water can be siphoned out daily and sieved using 100µ sieves, filtrate can be removed and the water aerated and kept in ideal condition. Pure and identical nauplii can be harvested by filtering surface water through a 50 µ sieve.

<table>
<tr>
<td>  <br>T. turbinata live in tank</td>
<td>  <br>Eggs and shells</td>
<td>  <br>Female</td>
<td>  <br>Male</td>
</tr>
<tr>
<td>  <br>Algal culture & Buckets for nauplii collection</td>
<td>  <br>Naupleus 1st stage</td>
<td>  <br>Feeding the tanks</td>
<td>  <br>Seives prepared with different mesh sizes</td>
</tr>
</table>

6. **Development of multi-chambered, low cost, multipurpose wooden floating cages**

- Net cage systems were designed using floating wooden frames of square/ rectangular shapes and sizes of 16 X 18 feet. The first cage frame fabricated was of size 16 X 18 feet and the second one 16 X 16 feet with 4 compartments each for attaching the net cages. The wooden frame was made using cheaper and hardy imported wood using planks of size 3 inch thickness and 2.5 inch width. There was a watch shed above the cage frame which can also be used for many other routine activities of the farm and for storage of items.
- Framework is designed with a catwalk, from which nets are suspended. It is large enough to provide a stable and rigid platform to facilitate operation and maintenance. The full frame work is shown below. The wall, floor and roof of the shed are made up of 6 mm marine plywood.


Full frame


Launching of raft


Towing the cage unit to mooring site

Floats: Metal drums coated with fiberglass were used as floats. The FRP coated barrels ( 16-18 numbers) were used for floating the framework. The cage was launched with help of a crane and dragged to the location of anchoring. Anchoring was done with the help of concrete blocks having 2-2 hooks for attaching the rope (PP ropes and wire ropes). Four anchors weighing 50-60 kg each are used to moor the system. Iron anchors/Gabion boxes (a strong net cage) filled with rocks also can be used for anchoring. Each anchor is tied to the frame at four corners, and the rope length is usually two to three times the depth of the area.

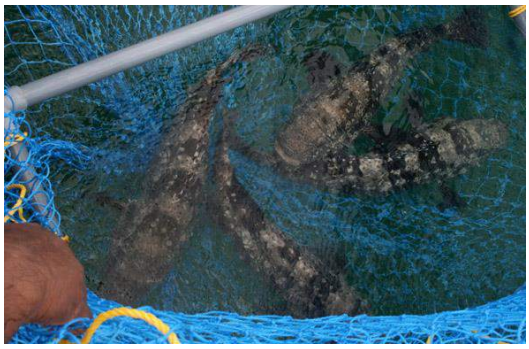
**Net cage***:* The net cage was made up of synthetic nylon nets or polythene fibres reinforced at the corners with nylon or PP ropes. The nets are kept stretched vertically with weights at the bottom of the cage and fastened at the top by rope to the framework. Since there is enough space for standing, net exchange and all operations are comparatively easy.

Net cage

Cages stretched by outer PVC frame

**Utility of Cage culture system**

Cages were primarily used for farming of fish which include nursery rearing of seed. Fishes like seabass, groupers and cobia were reared. This system was also used for keeping seed & ornamental fish stock collected from the wild and for suspending oysters for pearl production.



Grouper brood stock in cage

Cobia brood stock in cage

Seeds from wild conditions can be collected and stocked in hapas attached to cages and then packed and transported to different destinations.

Wild seed stocking, packing and transportation from the cage system

Acclimatization of seed Seabass fingerlings in happa Pearl oyster in box cages

**7. Technology for the culture of spiny lobster *Panulirus homarus* (Linnaeus) in sea-cages**

Technology for the farming of spiny lobster *Panulirus homarus* in open sea cages was developed and demonstrated for the first time in India in Vizhinjam. Technology for the culture of lobsters include site selection, design and fabrication of the frame, outer and inner net cages, techniques for safe mooring with safety devices to withstand the rough sea conditions, high waves, winds and under water currents. Lobster seed collection, transportation, feeding, net exchange, other daily maintenance activities, assessment of water quality parameters, disease management and harvesting were also standardized.

Two demonstrations were undertaken for lobster culture with local fishermen at Kanyakumari in circular HDPE cages. The first trial was harvested on 8$^{th}$ December 2011. Average size was 190.2g with a survival of 72.5%. 172kg lobsters were harvested from the first cage. The second trial was harvested on 27$^{th}$ December 2011 and the average size was 178.5g with a survival of 69%. 130kg of lobsters were harvested.

Lobster farming in cages-Chinnamuttam, Kanyakumari

**8. Technology for the culture of seabass *Lates calcarifer* (Blotch) in sea-cages**

Technology was standardized and demonstrated for farming of sea bass *Lates calcarifer* in floating sea cage by rearing them in a large HDPE floating cage moored at Vizhinjam Bay. Technology for the culture of seabass include site selection, seed transportation, acclimatization, nursery rearing of seed, grading of seabass in nursery, design and fabrication of the frame, outer and inner net cages,

transportation, feeding, net exchange, other daily maintenance activities, assessment of water quality parameters, disease management and harvesting.


Shoaling juveniles in hapa


Hand grading


Shooters


Harvest

9. **Development and demonstration of culture technology of big-eye trevally *Caranx sexfasciatus* in sea-cages**

This technology includes collection of seed of *Caranx sexfasciatus* from the wild using specially designed shore seine. Wooden raft was used for attaching the cage. Technology also include site selection, seed transportation, design and fabrication of net cages, feeding, net exchange, other daily maintenance activities, assessment of water quality parameters, disease management and harvesting. The cage was stocked with fingerlings of ***C. sexfasciatus*** **of average size** 81.7 mm (TL) and 7.8 g weight. They reached a size of 303 mm in average length and 563 g in average weight in 10 months with survival rate was 84%.


Harvested fishes

**10. Innovative technology for long distance transportation of large broodstock/live fishes like cobia (*Rachycentron canadum*)**

Technologies were developed for the transportation of large brood stock fishes in 5 ton HDPE tanks, using air supplied from blower operating with help of a portable generator. Oxygen cylinders and battery operated aerators were also kept as stand by. Methodology include conditioning of fishes, capture of fishes from cages, transferring them to the tanks under anesthesia using isoeuginol, managing the stress level, control of temperature in the tank during transportation and maintenance of water quality parameters during the transit. In four trials 42 fishes were successfully transported from VIzhinjam to Mandapam RC of CMFRI.


Brood stock of Cobia being transported

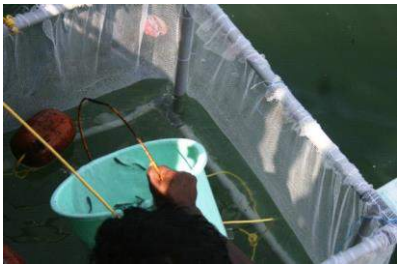
**11. Technology for collection, stocking and transport of commercially important wild seeds of mullets, *Sillago sihama,* sea breams and pompano.**

Different types of nets and collection methods were standardised for the collection of fish seed. One net for the collection of seed of size above 15 mm was made using 10 kg net of mesh size 6 mm, length of 25 m and the breadth of 5 m. Floats were used at an interval of 60 cm and sinkers at an interval of 10 cm. The second type of net was made using mosquito net with a length 5m and breadth of 1.5 m. Third type of net was of 50 mm mesh size made of monofilament net used for collecting the seed of breams by using crushed mussel as bait and enclosing the area using net. PVC framed hapas of different size and shapes were also designed for storing and transportation of collected live seeds without injuries/ damages.

Seed collection using different nets



Seed of pompano **(***Trachinotus blochii*), *Rhabdosargus sarba*, *Sillago sihama* and mullets


Mullet frys collected Framed hapa for storage Transportation of seeds

**12. Technology for identification and treatment of parasitic infections in marine ornamentals**

**1. Brooklynellosis (clownfish disease)**

**Causative agent**- *Brooklynella hostilis* in clown fishes

**Symptoms**-Thickening of the skin's mucus; fish appears to have a rough white coating.

**Treatment**- Freshwater dip for 2 minutes or 100 ppm formalin for 3 minutes in alternate days for 5 days.

Clown fish infected

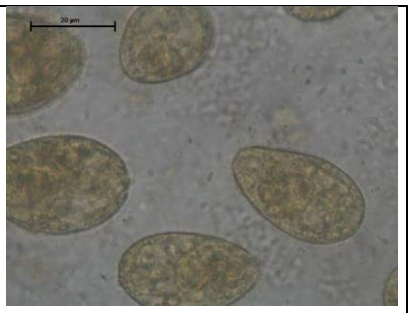
*Brooklynella hostilis*

*B. hostilis* side view

2. **Uronema infection:** The susceptibility patterns of fishes ascertained. *Amphiprion polymnus, A. perideraion, A. clarki* and *A. bicinctus* were more susceptible.
   Causative agent: *Uronema* spp.

**Symptoms:** grayish spots on the body surface and gills, loss of appetite, lethargic, abnormal swimming behavior, darkened body, hemorrhages on the body surface and exophthalmic, opaque or hemorrhagic eyes, respiratory distress

**Treatment:** Add 3 g copper sulphate and 2 g citric acid in 750 ml for stock solution; 1ml of the stock in 100ml water in 1:100 ratio with water; Bath treatment for 3-5 days.

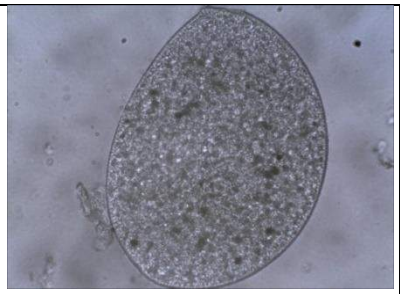
| | | |
|---|---|---|
|  |  |  |
| Infected fish | *Uronema* sp. | *Uronema* sp. |

3. **Marine white spot:** All species are susceptible.

**Causative agent-** *Cryptocaryon* sp.

**Symptoms**- whitish or grayish spots on the body surface and gills, loss of appetite, lethargic, abnormal swimming behavior, darkened body, hemorrhages on the body surface and exophthalmic, opaque or hemorrhagic, eyes, respiratory distress and rubbing their bodies against objects

**Treatment**: Copper sulphate bath: Add 3 g copper sulphate and 2 g citric acid in 750 ml for stock solution of 1 mg/ml, 1ml of the same in 100 ml water bath for 3-5 days

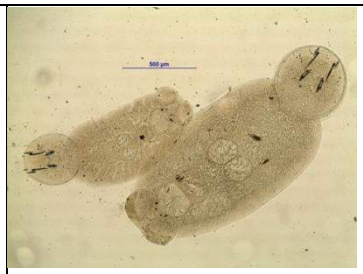
| | | |
|---|---|---|
|  |  |  |
| Infected fishes | *Cryptocaryon* sp | *Cryptocaryon* sp |

**4. Benedeniosis**

All species are susceptible and noticed several times in wild caught brood stocks of food fishes and ornamental fishes.

**Causative agent**: *Neobenedenea* sp.

**Symptoms:** Loss of scales, reddish patches, margins of fins damaged, weakness and mortality. **Treatment:** Freshwater dip followed by Praziquantel 100mg/l bath for 5minutes

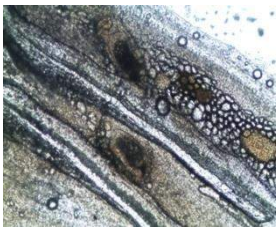
| | | |
|---|---|---|
|  <br>Infected fishes |  <br>*Neobenedenea* sp. larva and subadult |  <br>*Neobenedenea* sp. adult |

**5. Metacercareal infections**

**Common causative agent** is *Prosorhyncus* spp.

**Symptoms:** Weakness and mortality.

**Treatment**: Praziquantel 2mg/l bath for 30 minutes followed by giving feed prepared by using Praziquantel 500mg/kg for 10 days.

| | | |
|---|---|---|
|  <br>  <br>Infected fishes |  <br>Cysts between fin rays |  <br>Parasite emerged from cyst |

**9. Infrastructure and physical facilities planned and developed during the period under review commensurate with the mandate**.

- Compound walls for the two sites completed.
- Construction of the Office cum Laboratory.
- Construction of Research Aquarium, hatchery, live feed and quarantine units.

1. Office cum laboratory building 480.48 sq.m

Office cum laboratory building

**Conference Hall**

**Library**

**Instrumentation Room**

**Microbiology Laboratory**

**Marine Biotechnology Laboratory**

**Video conferencing facility**

Marine Aquarium – 200 sq m

Circular tank in the marine aquarium

Quarantine, algal culture and fishery biology laboratory


**Cage farm**

**INSTRUMENTS PROCURED DURING THE PERIOD**

**Microscopes - 3nos**

**Spectrophotometer - 1**

**Generator -1**

**Blower - 3**

**Storage tanks -2**

**Gravity filter - 1**

**10. Human resource development efforts for different categories of staff.**

**Training and workshops attended by the Scientists**

Smt. Saleela. K.N participated in Workshop on Prawn taxonomy; Recent advances and revision of nomenclature during 14-02-2011 to 19-02-2011 at CMFRI, HQ,Kochi.

Smt. Saleela.K.N attended workshop on Natural resource management and human development paradigms in climate change perspective-Adaptive strategy options for Kerala , organized by Environment Department and Kerala State Planning Board at Mascot Hotel, Thiruvananthapuram during 14 -12-2010 to 16-12-2010.

Smt. Saleela.K.N attended Training workshop on Taxonomy of Brachyuran Crabs, organized by Department of Aquatic Biology & Fisheries during 9-01-2013 to 11-01-2013 at Kariyavattom, Thiruvananthapuram, Kerala.

Smt. Saleela.K.N attended Fishery Assessment Methodology Workshop (FAM) during 17-10-2013 to 19-10-2013 at Chennai Research Centre of CMFRI

Smt. Saleela.K.N attended Fishery Assessment Methodology workshop at CMFRI, HQ,Kochi on 28.11.2013 and 29.11.2013.

Dr. M.K Anil Attended MDP workshop on PME of Agricultural Research Projects. From 19$^{th}$ - 23$^{rd}$ November 2013 at NAARM, Hyderabd.

Dr. M.K Anil attended the workshop cum training on Advances in Tuna Long lining organized by CIFT on 1$^{st}$ October 2013 at Seaweed Hotel, Vizhinjam.

Dr. M.K Anil attended one day workshop squid aging, CMFRI, Kochi – 25$^{th}$ June 2012.

Dr. B. Santhosh attended a workshop on PERMISNET and PMS organised by CMFRI Kochi on 16-3-2012.

Dr. B. Santhosh attended a workshop on Technological advancement in seed production of marine finfish with special reference to Cobia on 28th March 2011 at Mandapam Regional Centre of CMFRI, Mandapam, Tamil Nadu an presented a paper.

Dr. B. Santhosh attended a training on creative writing in Agriculture, organised by Indian Institute of Mass Communication, New Delhi, from 3-7 November 2009.

Dr. B. Santhosh attended a training on data analysis using SAS organized by NARS at CTCRI, Trivandrum from 3-9th March 2011.

Dr. B. Santhosh attended a training on e publication organized by CMFRI Kochi from 17-18 May 2012.

Dr. B. Santhosh attended a workshop on Assessment of Elasmobranch resources of Indian seas organized by Demersal Fisheries Division of CMFRI, 11-13 December 2012.

Dr. B. Santhosh attended the training on DNA barcoding of aquatic organisms: a tool for molecular taxonomy from February 5th -14th, 2014 organised by National Bureau of Fish genetic Resources, Lucknow at NBFGR, Lucknow.

Dr. B. Santhosh participated in the International workshop on Status of good practices and lessons learnt in aquaculture in the SAARC region from 5th June to 7th June, organised by CMFRI and SAARC Coastal Zone Management Centre, Maldives at CMFRI, Kochi.

Dr. B. Santhosh participated the workshop cum training on Advances in Tuna Long lining organized by CIFT, Kochi on 1st October, 2013 at Seaweed Hotel, Vizhinjam, Thiruvananthapuram.

Dr. B. Santhosh participated in the Brainstorming session on species prioritization of Mariculture Division from 4th to 5th November 2013 organised by Mariculture Division, CMFRI at Mandapam Regional Centre of CMFRI, Mandapam.

Dr. B. Santhosh participated in the Methodology Workshop related to the project Development of Fishery Management plans for Sustaining Marine fisheries of Kerala and Lakshadweep from 28-29th November 2013 organised by CMFRI at CMFRI, Kochi.

Dr. B. Santhosh participated in the First National Mission Meeting on Conservation of Sharks organized by SIFFS on 25th March 2014 at Animation Centre, Kovalam.

Dr. B. Santhosh attended the Training on Mariculture conducted by Mandapam Regional Centre of CMFRI, Mandapam from 13th to 23rd August, 2013.

Dr. B. Santhosh attended the User's conference on services rendered by Meteorological Centre, Thiruvananthapuram for the users of Kerala and Lakshadweep on 24th March, 2014 at Government Guest House, Thycaud, Thiruvananthapuram. Organized by India Meteorological Department, Ministry of Earth Science, Government of India, Meteorological Centre, Thiruvananthapuram.

Dr. B. Santhosh attended National Symposium on Parasitic taxonomy, biodiversity and fish health: Environmental impact, Dept. of Zoology, Andhra University, Visakapatanam, March12-13

Dr. B. Santhosh attended National Seminar on Food security and Climate change in India organized by Indian Society of Roots Crops and Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala from 20-22nd January 2011.

Dr. B. Santhosh attended National Seminar, First Indian Biodiversity Congress IBC 2010, University of Kerala, Thiruvananthapuram, 28-30 December 2010.

Dr. B. Santhosh attended 9th Indian Fisheries Forum, Renaissance in Fisheries: Outlook and strategies, CMFRI, Kochi and Asian Fisheries Society, Indian Branch, on 19-23 December, 2011, Chennai, India.

Dr. B. Santhosh attended Attended the workshop on Technological advancement in seed production of marine finfish with special reference to Cobia on 28th March 2011 at Mandapam Regional Centre of CMFRI, Mandapam, Tamil Nadu an presented a paper.

Dr. B. Santhosh attended National Seminar on Emerging Trends in Indian Aquaculture, Dept. of Aquatic Biology and Fisheries, University of Kerala, Thiruvananthapuram, 28-30 March 2013.

**Technical Officials**

Jose Kingsly H, Sofware training "Photoshop, Coral draw and Page maker" 10 days -2011.

Jose Kingsly H, Marine fin fish breeding and hatchery production of cobia and pompano and ornamental fish- 10 days -2011.

Raju B. Marine fin fish breeding and hatchery production of cobia and pompano and ornamental fish- 10 days -2011.

Unnikrishnan C. Attended the workshop cum training on Advances in Tuna Long lining organized by CIFT on 1st October 2013 at Seaweed Hotel, Vizhinjam.

Unnikrishnan C First National Mission Meeting on Conservation of Sharks organized by SIFFS on 25th March 2014 at Animation Centre, Kovalam.

Unnikrishnan C Fshery Assesment Methodology (FAM) workshop organized at Madras Research Centre of CMFRI from 17-19th October 2013

Unnikrishnan C Training on Mariculture conducted by Mandapam Regional Centre of CMFRI, Mandapam from 13th to 23rd August 2013.

Unnikrishnan C Attended the foundation stone laying ceremony of broodstock multiplication centre of RGCA (MPEDA) at Ganapathipuram, Kanyakumari district on 28th February 2014.

Unnikrishnan C attended Training workshop on Taxonomy of Brachyuran Crabs, organized by Department of Aquatic Biology & Fisheries during 9-01-2013 to 11-01-2013 at Kariyavattom,Thiruvananthapuram,Kerala.

Shri. K.K. Suresh had participated inthe Workshop cum training in Connection with the marine fishery census 2010, At CMFRI, Cochin from 23/11/2009 to 25/11/2009

Shri. K.K. Suresh attended the workshop cum training in Connection with the marine fishery census 2010, at CMFRI, Cochin, on 15th &16th March2010

Shri. K.K. Suresh attended Hindi workshop cum training conducted on 31st August 2010.

Shri. K.K. Suresh participated the Training cum workshop on "Data collection related to spawning behaviour of marine fish species to change in temperature" conducted at CMFRI, Headquarters from 24th to 26th March 2011 2012

Shri. K.K. Suresh participated the Training programme "Introduction to fish biology and taxonomy of demersal finfishes" Organized by Demersal Fisheries Division of CMFRI, Kochi. From 23 to25 February 2012

Shri. K.K. Suresh participated the Five day Training programme on "Taxonomy of exploited marine fisheries resources" conducted at Mangalore Research Centre of CMFRI, Mangalore from 26th to 30th August 2013. Received training on Field level identification of fishes, Cephalopods, shell fish and Prawns.

Shri. K.K. Suresh participated the Workshop cum training on advances in tuna longlinig 1st October 2013, Vizhinjam, Kerala Conducted by CIFT, Kochi.

Shri. K.K. Suresh participated the Pre-Census workshop in connection with National Marine Fisheries Census -2015; conducted at Mangalore Research Centre of CMFRI, Mangalore from 16th to 18th January 2014.

**Administrative staffs**

Smt. Latha K. Attended the Software training in "MS Access" for 8 days during February 2012.

**Official language implementation**

- Conducted Hindi week celebrations every year in this centre.
- Attended all the TOLIC committee meetings.
- Annual and trimonthly reports were prepared and submitted regularly
- Deputed Administrative staff for the 5 day condensed Translation training course conducted by TOLIC from 19-7-2010 to 23-7-2010
- One day training on Installation and usage of Hindi Leap software and also on Hindi translation was arranged on 31/8/2010 by Dr. Samraj and Shri. C. Krishnan, Hindi Officers from Divisional office, Southern Railway, Thiruvananthapuram.
- Conducted workshop on Hindi noting and drafting on 1/9/11 for all the staff members. The classes were conducted by Smt. Maqbool Khan, Hindi officer, Survey Of India, Thiruvananthapuram.
- A training on Hindi usage in daily official functioning and net learning was conducted for the scientific, Technical and administrative staff on 6/3/13 by Shri. Somashekharan Nair, Head , PGA, LPSA, Valiyamala
- Arranged Hindi Pragya, Praveen and Prabhodh classes for the technical and administrative staff.
- Deputed administrative staff for the training given by TOLIC, Thiruvananthapuram on 26/2/14.

**11. Budgets/Finances**

**Allocations to various heads**

| **Head** | **Year** | | | | |
|---|---|---|---|---|---|
| | **2009-10** | **2010-11** | **2011-12** | **2012-13** | **2013-14** |
| **PLAN**<br>TA | 1.00 | 1.50 | 2.50 | 4.50 | 2.50 |
| Research and operational | 14.00 | 11.00 | 13.00 | 19.00 | 3.80 |
| Administrative exp. | | 12.20 | 1.50 | 7.50 | 13.775 |
| **Total** | **15.0** | **24.7** | **17.0** | **31.0** | **20.075** |
| **NON PLAN** Estt. | 175 | 170.00 | 185.00 | 207.00 | 207.00 |
| TA | 0.50 | 1.50 | 1.00 | 1.00 | 0.90 |

| | | | | | |
|---|---|---|---|---|---|
| Research and operational | 17.00 | 4.00 | 6.00 | 4.00 | 30.00 |
| Administrative exp. | | 13.13 | 18.00 | 14.75 | 25.50 |
| **Total** | **192.5** | **188.63** | **210** | **226.75** | **263.4** |

**Revenue generation**

| **Source** | **Year** | | | | |
|---|---|---|---|---|---|
| | **2009-10** | **2010-11** | **2011-12** | **2012-13** | **2013-14** |
| Marine Aquarium (entry tickets) | 14,18370 | 15,59110 | 15,25925 | 13,69185 | 6,27090 |
| Seed/algae/other sample sales | - | 1,74850 | 1,05850 | 92820 | 17340 |
| **Total** | **14,18370** | **17,33960** | **16,31775** | **14,62005** | **6,44430** |

**12. S.W.O.T. Analysis of the Centre**

**S.W.O.T. Analysis**

**Strengths**

- Highly competent Scientific and Technical staffs with Ph.D.
- Modern laboratories & equipments
- Reputation
- Nearness to sea and availability of unpolluted seawater
- Experience in managing and implementing Research /Consultancy projects
- Nearness to many research Institutions such as NIIST,CESS, RCC, VSSC
- Transportation and communication facilities
- Opportunity to work in collaboration with state government agencies due to the proximity to capital city and University of Kerala.
- Marine Research Aquarium and Hatchery with a collection of more than 100 species of marine organisms and experienced staff handling these organisms.
- Review Process

**Weaknesses**

- Reduction of staff strength due to superannuation
- Non availability of full-fledged hatchery
- Lack of vehicles

- Lack motorized vessel for sea based work
- Lack of training hall and trainees hostel

**Opportunities**

- Growing demand for seafood and marine ornamental fishes and invertebrates
- Growing demand for conservation and management of the fishery resources
- Growing need for employment generation
- New Technology Developments- fish breeding, seed production, farming, development of new live feed
- Research opportunities in specialised areas of marine biotechnology
- Collaborations with state government programs and industry in developing pilot scale pearl and sea life projects
- Collaborations with institutes of higher learning (national & international)

**Threats**

- Pollution and global warming threats
- Change in Technology
- Declining availability of skilled workers

**Management**

**13. Frequency of staff meetings**

Monthly meetings were conducted regularly with all the staff of the centre in the first week of every month. Minutes of the meeting was prepared and circulated among all the staff members and a copy was send to the Director regularly. Smt. K. N. Saleela was the nodel officer for conducting monthly meetings.

Whenever, the Director/ADG/DDG/DG or any important person from ICAR/SAU/State/ Central Government or other similar organisations, eminent scientists from India and elsewhere visited, special meetings also were conducted.

Special meetings also were organized in connection with the Independence Day, Republic Day, Foundation day and Fish Farmers day. Special meetings also were conducted for making arrangements for all training programmes, visit of any important persons, any important functions, Official language implementation programmes, harvest melas and other important programmes.

Scientific or management meetings (with the Scientist-in-Charge and all scientists) were conducted on weekly basis exclusively for scientific discussions, monitoring of progress for all ongoing programmes, during the visit of the Director/ADG/DDG/DG or any important person from ICAR/SAU/State/ Central Government or other similar organisations, eminent scientists etc. Meetings like Centre SRC, IRC and

video conferencing with the Head Quarters and other centres were also conducted regularly for scientific, administrative and financial matters.

Monthly meetings were also conducted by staff welfare club for organizing various activities. Special meetings were also conducted by the club in connection with joining/retirement/transfer of an employee and also in connection with all major festivals of regional and national importance.

**Staff Amenities**

**14. Facilities available for staff including housing in campus, travel office, education facilities for children, etc.**

The centre has just shifted to its permanent establishments. Staff housing and other facilities will be taken care in future. Special programmes used to be organized for appreciating the children for their meritorious performance in state and national examinations. Staff welfare activities are regularly organized by the employee's recreation club.

**15. Participation of scientific staff in National and International Conferences (give details and problems and suggestions for the future)**

Support for participation of scientific staff for National and International Conferences held within India is within the power of the Scientist-in-Charge. All the staff applied for any such programmes were supported with appropriate travel grants and sanctions were given on the spot itself. All circulars in connection with various national or international programmes were circulated among staffs without any delay. Permission for attending any conference abroad was given by the Director.

The only problem in connection with participation of scientific staff for International Conferences is the insufficient travel support obtained from the Institute.

**A suggestion in this connection is that all the scientists should be given at least one chance in five years with full travel & other supports for participation for an International Conferences held outside India.**

**16. Sports, recreational research and vocational health facilities to the staff**

A very active staff welfare club is operating here. They are regularly organizing sports and recreational programmes for the staff and their families. A team of staff regularly participate for all ICAR sports events at Institute level and national level. Almost all important hospitals in Kerala are approved for providing treatment to the staff and their families now. All the staffs and their families are being benefitted by this facility.

**Linkage**

**17. Collaboration with others**

**a. Local institutions in the area (educational, research and infrastructural facilities)**

VRC of CMFRI has a live collection of more than 100 species of marine organisms in hatchery and marine research aquarium. Department of Aquatic Biology and Fisheries, and almost all colleges under University of Kerala, several colleges and departments under Mahatma Gandhi University, Calicut University, Cochin University of Science and Technology, Kannur University, Manonmanium Sundaranar University, Bharathiyar University and Bharatidasan University used to get benefitted in several ways and maintaining a strong linkage with them in several ongoing programmes. Trainings on ornamental fish culture, sea cage farming and pearl culture were given to several staff of these Institutions. Several researchers got their specimens identified and good suggestions and short trainings.

Several students have utilized the hatchery and marine research aquarium for their project works from school levels, graduate, postgraduate, M. Phil and Ph. D. levels. Live feed, hatchery bred fishes and invertebrates were provided to them and clarified their queries regarding maintenance of these organisms. The centre with its proximity to an important fishing harbour, sandy and rocky beaches assisted various organisations for their collections, oxygen packing and also provided facility for all emergency works to them in various occasions. The centre served as an important destination for study/ training trips of students, scholars and traninees from colleges, government organisations, NGOs from all maritime states of India. Hundreds of such groups visits here every year and interacted with the scientists. This centre has provided support to these organisations in various ways for assisting syllabus preparation, setting question papers, conducting practical examinations, evaluating thesis, viva voce and open defense.

The centre has close association with Department of Fisheries, Government of Kerala and Tamil Nadu, Department of Forests and Wildlife and Department of Science and Technology of Government of Kerala for organizing various scientific programmes, surveys exhibitions and training programmes.

State Agriculture Management and Extension Training Institute (SAMETI, Government of Kerala) has a close association with our centre and VRC of CMFRI is regularly assisting them for their training and extension programmes.

**b. National institutes and Agricultural Universities**

The centre is maintaining a strong linkage with National Institute for Interdisciplinary Science and Technology (NIIST former RRL), Central Tuber Crops Research institute, Central Institute of Fisheries Technology, Kerala Agriculture University, Kerala University of Fisheries and Ocean Studies, Centre for Earth Science, Rajive Gandhi Centre for Aquaculture, Marine Product Export Development Authority, VRC of CMFRI has provided several species of cultured marine organisms or suggestions for the maintenance of organisms for these Institutions. Some of our scientists are closely associated with several ongoing programmes of these organisations. Several researchers from these Institutes got their specimens identified and good suggestions and short trainings.

**c. International institutions**

Several eminent Scientists from various international organisations visited this centre and marine research aquarium here and interacted with scientists. Training classes were given to Maldivian officials on live feed culture.

**d. Extension and development agencies**

More than 10 nos of national trainings were conducted during this period. Fishery officials of all maritime states were got trained here for various aspects of ornamental fish culture, live feed culture, cage culture, pearl culture, mabe pearl culture and fish diseases control. Officials from other ICAR institutes, KVKs, FFDAs, SIFFS, NGOs progressive farmers and entrepreneurs from all maritime states including Lakshadweep and North eastern states also were trained during several occasions here. The centre is also providing extended support through e mails and phone calls to all these people for clarifying their queries and also giving timely suggestions.

The centre has always worked closely in association with National Fisheries Development Board, Hyderabad. NFDB is supporting the HRD training programmes, apart from sending groups of trainees to VRC of CMFRI for training.

The centre is working in close association with MATSYFED, FFDA, Fisheries Department, Government of Kerala and Tamil Nadu in several ongoing projects and programmes of these organizations and also for our projects especially related to FRAD programmes and Mariculture activities.

**e. Research-Extension linkages. Comment on the usefulness of extension activities and such collaboration and suggestions for further improvement.**

The centre has research and extension linkages mainly with MATSYFED and FFDA- Fisheries Departments of and also with all maritime states of India especially Government of Kerala and Tamil Nadu and Lakshadweep. There are several ongoing projects in association with these organizations and also getting assistance and feedback for our projects especially related to FRA division, Demersal Fisheries division, Biodiversity division and Mariculture activities. All these programmes gave excellent feed backs and support was further provided through e mails, phone calls and visits in person. Cage culture activities especially in Tamil Nadu, Kerala and Andhra coast is a proof of the earnest efforts made towards sea farming. Trained persons from several organisations like MATSYAFED and Lakshadweep administration have made hatcheries and started producing marine ornamental fishes commercially.

The centre has few important suggestions with this respect. The centre is badly in need of a farmers training hostel, a specialized extension scientist, technical staff and supporting staff to support the extension activities of the centre. We have a severe scarcity of vehicles for transportation. Our main activities are mostly related to sea water and often we have to carry live or dead fishes to long distance, the hired vehicles used to disagree for transporting these items. We need atleast two more vehicles for the centre.

**Liaison with other Departments**

- **Rani Mary George** 2012 delivered keynote address on "Marine Biodiversity Conservation with special emphasis to corals. In : International Biodiversity Day celebrations on May 22nd org. by Kerala State Biodiversity Board, Museum Hall, Trivandrum
- **Rani Mary George** 2012. Marine Fishery Development and Climatic change. In: 8th Kerala Environment Congress (KEC, 2012) August 16 – 18, Rajiv Gandhi Centre for Biotechnology, Trivandrum.
- **Lipton, A.P**. 2012. Lead Talk on: 'Marine Biotechnology: Significance of Microbes'. Talk delivered to the PG students of Microbiology during the inauguration of the Vision Seminar Series 2012 of the Biochemistry & Industrial Microbiology Association at S.N. College, Kollam on 2-2-2012.
- **Lipton, A.P**. 2012. 'Experiences of lobster farming in floating sea cages along Kanyakumari District, Tamil Nadu'. In: ATMA Scheme - Exposure visit" of fish farmers from Kollam District, Kerala on 4-2-2012.
- **Lipton, A.P**. 2012. Lead Talk on: 'Prospects of Sea Farming' in Tamil. *In: 'Collector - Fishermen meet'* at District Collector's office, Nagercoil on 24-2-12.
- **Lipton, A.P**. 2012. Felicitation Talk on: 'Marine Biotechnology' in the National Seminar on Spectra of Biotechnology – NSSB- conducted at Udaya School of Engineering, Vellamodi, Kanyakumari on 2-3-2012.
- **Lipton, A.P**. 2012. Livelihood options in Fisheries. Kanykumari District Collector's office, Nagercoil on 26-3-12.
- **Lipton, A.P**. 2012. 'Marine environment: Problems and possible options'. OISCA-Nagercoil on 23-7-2012.
- **Lipton, A.P.** 2012. 'Sea Farming: Success Stories' (In Tamil). Talk delivered on 27-07-2012 to the first batch of 179 fishermen during their visit to Vizhinjam under the National Agricultural Development Programme (NADP)'s capacity building "Extension Education to marine fishermen" implemented by the Government of Tamil Nadu.
- **Lipton, A.P**. 2012. 'Marine Fisheries: Resources and Alternative Options'. Talk delivered on 7-8-2012. In. Identification of Alternative Resources in Agriculture and Marine Sectors. Skill Promotion Network – India (SPiN India). Held at Kanyakumari on 7-8-2012.

- **Lipton, A.P.** 2012. 'Sea Farming: Success Stories' (In Tamil). Talk delivered on 7-9-2012 to the second batch of 45 fishermen during their visit to Vizhinjam under the National Agricultural Development

Programme (NADP)'s capacity building "Extension Education to marine fishermen" implemented by the Govt. of Tamil Nadu.

Fishermen being explained about the scope of sea farming during their visit

- **Lipton, A.P**. 2012. Endowment Lecture on: 'Recent Advances in Sea Farming in India'. Second 'Ganapathia Pillai endowment lecture' jointly organized by the Scott Alumni Association and the Department of Zoology & Research Centre, Scott Christian College (autonomous), Nagercoil on 5-10-2012.
- **Lipton, A.P**. 2012. Successful demonstration of Maricultue of Lobsters in open sea floating cages off Kanyakumari coast. CMFRI-HRD training at Kanyakumari on 10-10-2012.
- **Lipton, A.P**. Sreeya G. Nair, A. Udayakumar, R.S. Rachna Mol, A.R. Sarika & J. Jean Jose. 2012. 'Microbial diseases of marine ornamental fishes: Prevention and cure'. In. CMFRI-HRD Training: 'Marine ornamental fish keeping & rearing' (held at Vizhinjam on 17-10-2012).19pp.
- **Dr. B. Santhosh**, worked as a resource person for **NFDB sponsored Training Program on "Marine ornamental fish culture" at Regional centre of CMFRI, Mandapam Camp from 12$^{th}$ - 21st October, 2009**".
- **Dr. B. Santhosh**, worked as a resource person **for Matsyafed Training program for officers from Madhya Pradesh Fisheries Federation from 22-26 November, 2010, Thiruvananthapuram, Kerala.**
- **Dr. B. Santhosh**, worked as a resource person for three day Training programme on Ornamental Fish Culture from 15$^{th}$ to 17$^{th}$ November 2012 at State Agriculture Management & Extension Training Institute (SAMETI)
- **Dr. B. Santhosh**, C**haired one session** in the National Symposium on Parasitic taxonomy, biodiversity and fish health: Environmental impact. Organised by the Dept. of Zoology, Andhra University, Visakhapatnam, 12-13 March, 2010

- **Dr. B. Santhosh Co Chaired one session** in the National Seminar on Emerging Trends in Indian Aquaculture, Dept. of Aquatic Biology and Fisheries, University of Kerala, Thiruvananthapuram, 28-30 March, 2013
- **Dr. B. Santhosh** served as an external expert for DPC (5 times) and selection committee member (2 times) for T1 & T3 in Central Tuber Crops Research Institute (CTCRI), Sreekaryam, Trivandrum, 2012
- **Dr. B. Santhosh** served as External Examiner for, M. Sc., M. Phil & Ph. D. Courses and evaluated dissertations and theses of students. Department of Aquatic Biology and Fisheries, University of Kerala, Thiruvananthapuram.
- **Dr. B. Santhosh** served as External Expert for the Ph D. and progress assessment for SRFs in National Institute for Interdisciplinary Science and Technology (CSIR), Thiruvananthapuram
- **Dr. B. Santhosh** served as a Judge for all Aqua shows organized by Matsyafed during this period.

**18. Training programmes: 12 trainings conducted**

1. NFDB-CMFRI National Training on Marine Ornamental Fish Keeping and Breeding from 15-24th July, 2010 at Vizhinjam Research Centre of CMFRI -10 days Dr. M. K. Anil Course Coordinator (For twenty officials and 5 entrepreneurs)


2. NFDB-CMFRI National Training program on Sea cage Farming of Seabass and lobsters from 27th October to 2nd November 2010 at Vizhinjam Research Centre of CMFRI-7 days. Dr. B. Santhosh Course Coordinator (for twenty officials and 8 progressive farmers from Andhra Pradesh)

3. NFDB-CMFRI National Training on Advanced Techniques in Marine Ornamental Fish Breeding and Keeping from 22nd to November -1st December 2011 at Vizhinjam Research Centre of CMFRI -10 days Dr. M. K. Anil Course Coordinator (for twenty officials six entrepreneurs)

4. Conducted self-financed training on ornamental fish breeding at the centre organized by CMFRI at Vizhinjam Research Centre of CMFRI, Vizhinjam from 3-8 August, 2011 (6days) Dr. M. K. Anil Course Coordinator (for 10 progressive farmers)


5. Conducted self-financed training on ornamental fish breeding at the centre organized by CMFRI at Vizhinjam Research Centre of CMFRI, Vizhinjam from 16-20 October 2012 (5days) Dr. M. K. Anil Course Coordinator (for 12 progressive farmers)


6. National Training (NFDB/CMFRI) on Pearl culture-2012. Dr. M. K. Anil, Course Coordinator- (for twenty officials and 4 entrepreneurs)


7. National Training (CMFRI- HRD) on Marine Ornamental Fish keeping and breeding -26th to 30th March 2013. (5 days). Dr. M. K. Anil, Course Coordinator- (for twenty officials and 4 entrepreneurs)


8. National Training (NFDB/CMFRI) on Techniques in marine designer pearl production Pearl culture- 19th to 23rd March 2013. (5days) Dr. M. K. Anil, Course Coordinator- (for twenty officials and 4 entrepreneurs)



9. National level training program (3days) in Image pearl production organised from 19th to 21st February 2014 Dr. M. K. Anil, Course Coordinator- (for twenty officials, 4 entrepreneurs and four farmers)


10. ATMA scheme – Exposure visit and training: Organized the 'ATMA scheme – Exposure visit and training' of fish farmers from Kollam District, Kerala was organised on 4-2-2012 at Vizhinjam Research Centre of CMFRI. A group of 29 farmers from different coastal parts of Kollam District have participated in the exposure visit.



11. NICRA HRD Training at Kanyakumari- (2 days; 8th & 9th March 2012): Title: 'Training programme on Sea Farming and Cage Aquaculture to cope up with climate variability' Dr. A.P. Lipton, Course Coordinator- (twenty five trainees- officials, entrepreneurs and four farmers)

12. CMFRI - HRD Training at Kanyakumari (Three days- 10 to 12th October, 2012): Title: 'Recent advances in sea farming: Prospects for better livelihood options along the coasts of India' (30 participants including fisheries officers of Government of Tamil Nadu, coastal youths, fisher folks, research scholars and entrepreneurs. Dr. A.P. Lipton (Course Coordinator)

Sea farming orientation lecture during CMFRI-HRD sea farming training at Kanyakumari

- A one day Hindi Workshop was conducted on 1-9-2011
- One training programm for scientist on plankton and benthos identification and analysis conducted from 8-12th August 2011
- Two month training imparted for ARS probationers of MBD Division

**Impact of Trainings:**

All these training programmes gave excellent feed backs and we are continuing our support through e mails phone calls and visits in person. Cage culture activities especially in Tamil Nadu, Kerala and Andhra coast is a proof of our efforts. Trained persons from several organisations like MATSYAFED and Lakshadweep administration made hatcheries and started producing marine ornamental fishes

commercially. Government of Kerala has taken mabe pearl production as an important venture and started an exclusive project in Kollam and Vizhinjam.

**Impact of open sea cage farming demonstrations**

The impact of open sea cage farming demonstrations by CMFR Institute along the Kanyakumari coast was evaluated. A few of the trained farmers have started culturing lobsters in improvised and modified smaller HDPE floating devices and obtained profits. In Arokayapuram coast, smaller units are being used to condition the lobsters before stocking. Depending on the availability and collections, baby lobsters are stocked inside the rearing unit for two to three days. On an average, about 150 smaller sized lobsters are stoked in the conditioning unit.

Floating conditioning units for maintaining the baby /under-sized lobsters and baby lobsters inside the unit being conditioned prior to stocking in the floating farming cage

Lobster Farmer inspecting the growth and health status of lobsters reared in his improvised cage

A farmer with his smaller holding cage

Innovative cage designed by farmer in the shape of boat for rearing lobsters at Manakudi, Kanyakumari. The cage was coated with polyurethane foam for better durability and floating

**Exhibitions**

Participated in the Aquashow-2009 for 10 days at Trivandrum from 18/12/09 to 27/12/09 and Aquashow - 2011 at Trivandrum from 5/01/11 to 15/01/11 bagged the trophy for the best Marine Stall in both the occasion

CMFRI stalls bagged the prize CMFRI Stall and trophy being received by Dr. M.K Anil from Hon. Mayor, Jayan Babu


National exhibition (Fish Fest) organised by the State Fisheries Department for 5days from 24th February 2011 to 28th February 2011 at Trivandrum.


First Indian Biodiversity Congress, IBG 2010, from 28-30 December 2010 at Trivandrum.


Aqua show 2010-11 from 7th to 16th January 2011 at Trivandrum.


Forest Fest organised by the Kerala Forest Department from 6-10th February 2011 at Kanakakunnu, Trivandrum.

Participated in the Aquashow-2009 for 10 days at Trivandrum from 18/12/09 to 27/12/09 and bagged the trophy for the best Marine Stall**.**

Participated in the Aquashow - 2011 at Trivandrum from 5/01/11 to 15/01/11and the stall bagged the trophy for the best Marine Stall


Trophy being received by Dr. M.K Anil from Smt. P. K. Sreemathi Teacher, Minister for Health and Social Welfare, Govt. of Kerala.

**Designer pearl exhibition**

A designer pearl exhibition was organized in conjunction with the National training on designer pearl production and the the exhibition was inaugurated by Honourable Minister for Fisheries, Government of of Kerala, Shri. K Babu on 19th March 2013.

Designer pearl exhibition

**19. Consultancies**

1. **<u>Designing and fixing of Marine Fish Aquarium at National Agricultural Science Museum, NASC Complex, New Delhi</u>**

Tank set up at National Agricultural Science Museum, NASC Complex, New Delhi
Size 6 ft x 2 ft x 2 ft with all accessories like canister filter, protein skimmer, chiller, heater and lights of different Kelvin ratings from 6000- 20,000. Fishes stocked were clown fishes, damsel fishes, yellow tang and fire goby.

2. **Consultancy:** Dr. M.K Anil **PI of 2 projects (Total Rs. 38 lakhs) and reports have been submitted**

1. **<u>Impact assessment of multi-purpose reef at Howa Beach, Kovalam, Thiruvananthapuram on fishery resources of the area. For DOT, Govt. of Kerala. –(Dr. M.K Anil PI) – Rs. 7 lakhs</u>**

Final report of the consultancy project presented in a meeting of Department of tourism at Government Secretariat, Trivandrum.

Under water studies

3. **Baseline data collection and monitoring on environment and social impact assessment for the development of Vizhinjam port. For Asian Consultant Engineers, New Delhi – (**Dr. M.K Anil **PI) Rs.30 lakhs**

Chemical and biological oceanographic studies including monitoring of fishery in the impact area


**Revenue generation during the period: 3.67lakhs (from Hatchery and seed sales)**

**Hatchery and live feed units,** R&D **Marine Aquarium**

Hatchery has broodstock of 10 species of clown fishes and several other species of other ornamental fishes. We also have three sections of live feed units including 3 species of algae, rotifer and copepods. This research and development aquarium at Vizhinjam has unique collection of more than 100 species of ornamental fishes, 50 species of invertebrates, several species of corals, soft corals, sponges and seaweeds are being maintained here. The aquarium has 35 glass aquaria and two concrete tanks containing marine organisms and is supported by a hatchery for the breeding of ornamental fishes and other animals and a live feed production unit. The aquarium is open to public and attracted more than 10,000 visitors every year. (Dr. M. K. Anil, Scientist-in-charge).

**Marine Aquarium**

This research and development (R&D) aquarium at Vizhinjam had unique collection of more than 100 species of ornamental fishes, 50 species of invertebrates, several species of corals, soft corals, sponges and seaweeds are being maintained here. The aquarium has 35 glass aquaria and two concrete tanks containing marine organisms and is supported by a hatchery for the breeding of ornamental fishes and other animals and a live feed production unit. The aquarium is open to public and attracted more than 10,000 visitors every year. Major attractions include reef aquariums, several rare marine fishes and invertebrates and turtles. This aquarium has helped many students and scholars for studying the biology and behavior of hundreds of indigenous marine animals.

Students queuing up to visit the Marine Aquarium