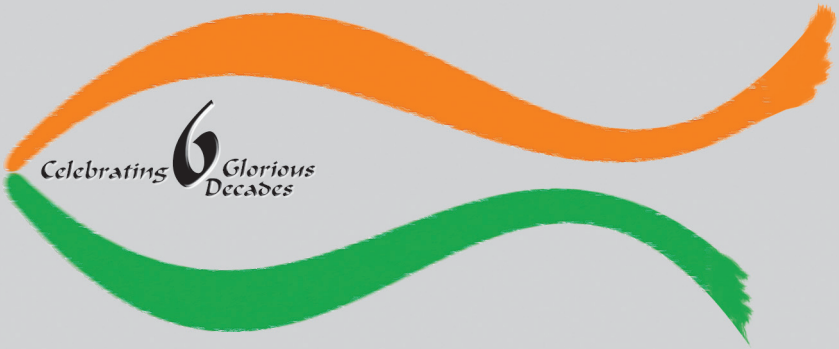
CMFRI
Research Highlights
2007-2008



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CMFRI Research Highlights 2007-2008

Central Marine Fisheries Research Institute
(Indian Council of Agricultural Research)
Kochi - 682 018, Kerala, India
www.cmfri.org.in

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CMFRI Research Highlights, 2007-2008

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Director's Foreword

The year 2007-08 has been a remarkable year for the Central Marine Fisheries Research Institute. The Institute celebrated its Diamond Jubilee with a series of outreach programmes commemorating its past and present achievements. This year my colleagues have striven to make significant and meaningful achievements in all areas that the Institute is mandated to work on. This publication highlights some of the significant achievements in the areas of marine capture fisheries, impact of climate change, deep-sea resources, data archaeology, marine environment, resource conservation, marine biodiversity, mariculture, socio-economics, technology transfer and marine biotechnology. More details on the results are provided in the forthcoming Annual Report. I hope this publication would be useful for the researchers, planners, students and others working for the well being of the fisheries sector.

Kochi
May 30, 2008

Dr. N.G.K. Pillai
Director

Marine Capture Fisheries

Marine fish landings of India during 2007

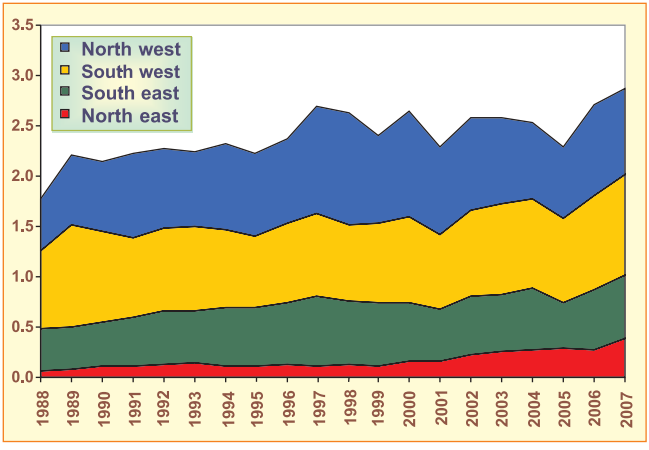
- The marine fish landings of India during the year 2007 has been estimated as 2.88 million tonnes showing an increase of about 1.7 lakh tonnes (6.3%) against the estimate of the previous year.
- The pelagic finfishes constituted 57%, demersal fishes 25%, crustaceans 14% and molluscs 4% of the total landings.
- The sector-wise contributions during the year 2007 were mechanized 68%, motorized 28% and the artisanal 4%.

Estimated landings of major species/groups

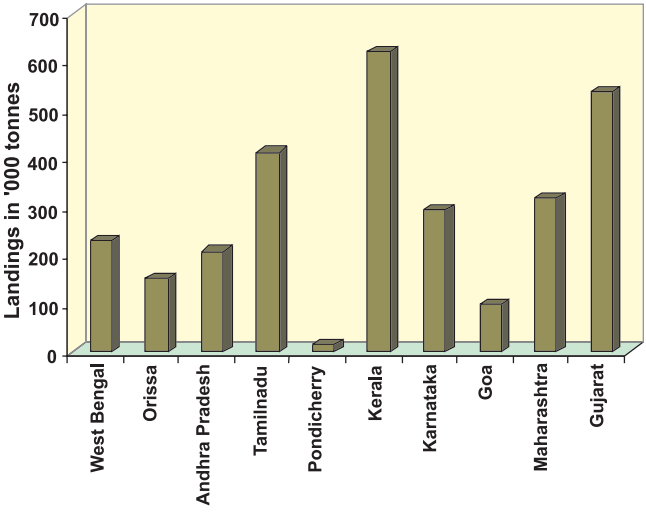
- Oil sardine landings were estimated as 4,97,264 t (26% increase compared to that of 2006)
- Penaeid prawn landings were 2,02,053 t (17.2% increase)
- Indian mackerel landings increased to 1,78,734 t (25.9% increase)
- Landings of croakers increased to 1,68,031 t (40.7% increase)
- Lesser sardines increased to 94,827 t (6.5% increase)
- Silverbellies landings increased to 69,856 t (8.1% increase)
- Other clupeid landings increased to 67,750 t (62.1% increase)
- Non-penaeid prawn landings decreased to 1,39,052 t (18.6% decrease)
- Ribbonfish landings decreased to 1,32,388 t (43.7% decrease)
- Bombay duck landings decreased to 1,12,721 t (4.9% decrease)
- Threadfin breams decreased to 94,221 t (15.4% decrease)
- Cephalopod landings decreased to 94,804 t (30.3% decrease)

The estimate of region-wise production showed that the north-east region, comprising West Bengal and Orissa

coasts contributed 13% to the total production. South-east region consisting of Andhra Pradesh, Tamil Nadu and Puducherry coasts contributed 22%. On the west coast, the north-west region comprising Maharashtra and Gujarat coasts contributed 30% of the total, whereas, the south-west region comprising Kerala, Karnataka and Goa coasts contributed to the maximum of 35%.



Regionwise Marine Fish Landings in India (in million tonnes)



State-wise landings in India, 2007

Marine Capture Fisheries

Marine fisheries of Kerala

- The estimated marine fish landings of Kerala during 2007 was 6.19 lakh t and compared to 2006, showed an increase of 5%. Landings were also higher than the annual average (1988-2005) catch of 5.74 lakh t. Compared to previous year, the contribution of pelagic resources to the total landings increased largely due to the record catches of oil sardine and the substantial increase in mackerel landings.
- Among finfishes, pelagic resources accounted for 73% and demersal 14%. Crustacean resources accounted for 9% while cephalopods formed 4%.
- Pelagic resources were mainly constituted by oil sardine (250,469 t), mackerel (68,062 t), carangids (39,875 t), tunas (25,009 t), ribbonfishes (11,431 t) and seerfishes (9,750 t). Demersal resources were dominated by threadfin breams (27,943 t) and soles (19,146 t). Among crustaceans, penaeid prawns were dominant (41,002 t). Cephalopods (mainly squids and cuttlefishes) contributed 23,391 t.
- The mechanized sector contributed 44%, motorized 54 % and the rest 2% was by the artisanal sector. In the mechanized / motorized sector, among various gears, ring seines contributed 50%, trawls 26%, gill nets and hooks & line 18% and other gears (such as boat seine, purse seine) 4%.
- Trawl landings (1.57 lakh t) were dominated by penaeid prawns, cephalopods, threadfin breams, ribbonfishes, lizardfishes, anchovies and elasmobranchs. Compared to last year, trawl landings declined by 35,000 t (18%) and its gear-wise contribution decreased by 7%. CPUE in multiday trawl nets was 40 Kg (AFH) and 1.02 t (units). CPUE in single day trawls was 33 kg (AFH) and 0.19 t (units).
- The Long Term Potential Yield (LTPY) and Average Long Term Yield (ALTY) of marine fish landings of Kerala was estimated as 6.63 lakh t while the current yield was 6.19 lakh t indicating scope for increase in landings.

Marine Capture Fisheries

Potential Yield estimates and landings of various resource groups in Kerala during 2007

Resource	LTPY (t)	ALTY (t)	Yield 2007
Oil Sardine	264372	236182	250469
Mackerel	128411	106250	68062
Penaeid prawns	71871	57894	41002
Seer fishes	10162	7862	9750
Cephalopods	43472	37658	23391
Tunas	32615	22671	25009
Silverbellies	6887	6176	6186
Elasmobranchs	6968	6136	2755
Lizard fishes	14126	13341	7741
Rock cods	9386	6822	3752
Snappers	2482	2066	1141
Threadfin breams	55078	45163	27943
Other perches	16488	13640	4716
Sciaenids	17720	15665	10363
Soles	27301	22802	19146
Total	**662890**	**624859**	**619255**

Ringseine - a mass harvesting gear being loaded in a mechanized inboard fishing craft

Marine Capture Fisheries

Marine fisheries of Lakshadweep

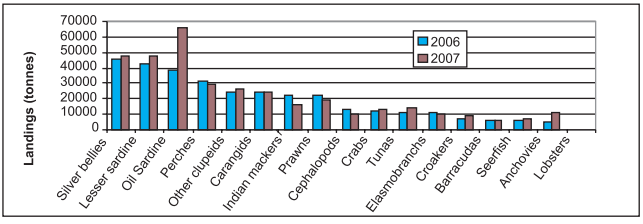
- The total fish catch from Minicoy, Androth and Agatti was estimated at 3283 t. Catch rate in the Pole and line fishery was 4.2 kg / hour followed by hand line (2.55 kg / hr), troll (2.28 kg / hr), encircling gill nets (2.08 kg / hr) and drift gill nets (1.28 kg / hr)
- Tunas (3144 t) formed 96% of the total fish landings. Minicoy accounted for 72% of the tuna landings followed by Agatti (25%) and Androth (3%). Compared to 2006, poor catch rates were observed in the pole and line fishery for tunas at Minicoy and Agatti.
- In pole and line fishery at Minicoy, skipjack (*Katsuwonus pelamis*) dominated (90%) followed by yellowfin (*Thunnus albacares*) (8%) and frigate tuna, *Auxis thazard* (2%). In troll, seerfish, *Acanthocybium solandri* (75%), sailfish, (*Istiophorus platypterus* (8%), yellowfin (7%) and skipjack (4%) occurred. Handline catches were constituted solely by yellowfin.
- At Agatti, in pole and line fishery, catches of skipjack dominated (97%) followed by the little tunny *Euthynnus affinis* (2%), frigate tuna (0.6%) and yellowfin (0.4%). In troll, yellowfin (45%), seerfish *A. solandri* (16%), skipjack (12%) and little tunny (5%) occurred. Handline catches were constituted by *Lethrinus* spp., *Lutjanus* spp., carangids and yellowfin.

Catch of flying fish and half beaks caught with encircling gill net at Androth Island

Marine Capture Fisheries

Marine fisheries of Tamil Nadu and Puducherry

- The estimated marine fish landings of Tamil Nadu was 4,12,066 t during 2007. The catch increased by 14.7% from that of 2006. Mechanized trawlers contributed 46% to the catch. The maximum landings was at Tuticorin and Ramanathapuram districts.
- Pelagics formed 53.9%, demersals 29.6%, crustaceans 8% and molluscs 2.7% of the total landings. The landings of pelagics increased by 21.6% while molluscs and crustaceans recorded a fall by 18.8% and 6.6% respectively. Among the pelagics, sardines dominated the landings (1,13,931 t) followed by carangids (24,698 t).
- Oil sardine landings increased substantially from 39,000 t in 2006 to 66,624 t and stood first in the landings.
- Among the demersals, silverbellies were dominant (47,887 t) followed by perches (29,135 t) and elasmobranchs (9,820 t). Molluscan catch was dominated by cephalopods (10,306 t), whereas prawns (19,041 t) and crabs (12,566 t) dominated the crustaceans landings.
- The estimated marine fish landings in Puducherry was 14,721 t, which was 18% higher than the previous year.

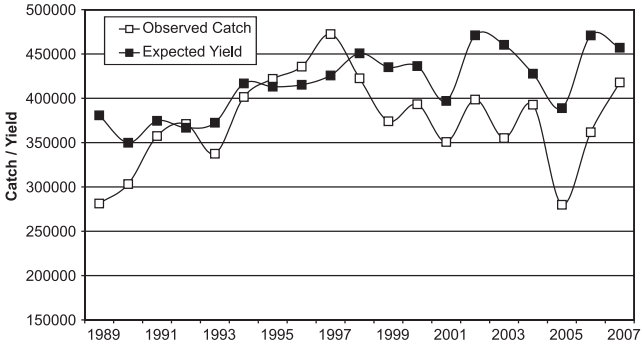


Landings of major marine fish groups in Tamil Nadu during 2006 and 2007

Potential Yield

Data on marine fish landings (t) and effort expended along Tamil Nadu during 1989 to 2007 was used to fit a non-equilibrium Schaefer's surplus production model using a genetic algorithm. From 1998 onwards, the estimated Potential Yield is higher than the catch, which indicates that the catch can be increased. This is because the small pelagics, especially the oil sardine has emerged as a major fishery and its biomass is continuously increasing over the years.

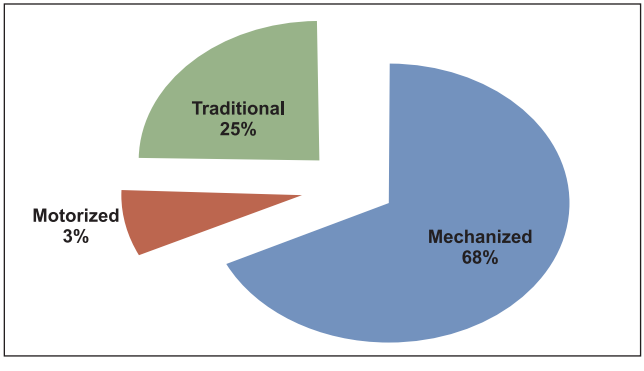
Marine Capture Fisheries



Surplus production model for Tamil Nadu

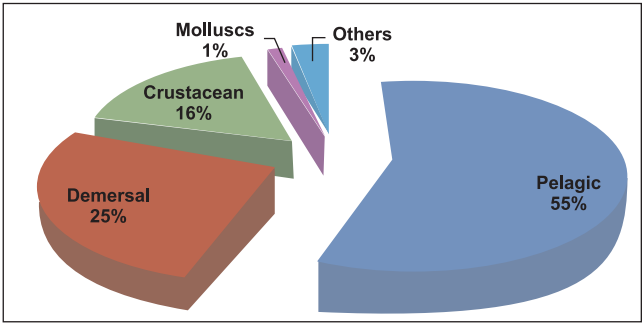
Marine fisheries of Andhra Pradesh

- An estimated 2,10,864 t of marine fish was landed off Andhra coast during 2007. Pelagic resources (55.2%) dominated the fishery followed by demersal (25.3%), crustacean (15.7%), molluscs (1.2%) and others (2.5%).
- The mechanized, motorized and the non-mechanized sectors contributed 67.7, 6.6 and 24.7 % respectively of the catch.
- The total marine fish landings of Andhra Pradesh decreased by 3.8% as compared to the previous year. The catch as well as effort expended for fishing increased for all mechanized gears and decreased for other sectors.



Sectoral contribution in Andhra Pradesh

Marine Capture Fisheries



Group-wise contribution to landings

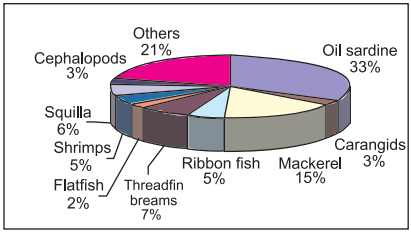
- The catches of sardines, mackerel, ribbonfish, nemipterids, lizardfish and goatfish decreased by 50, 48.8, 34.4, 5.3, 19.2 and 19.1% respectively, while seerfish, sciaenids, pomfrets and elasmobranchs increased by 64, 10.5, 61.3 and 1.9% respectively as compared to the previous year.
- The trawls were the major gear contributing 44.8% followed by gillnets (33.1%), seines (13.3%) and the hooks and line (7.0%).
- The major pelagic resources supporting the fishery of Andhra Pradesh were sardines (8.7%), seerfish (5.5 %), ribbonfish (5.1%), anchovies (5.1%) mackerel (3.0%) and tunas (1.0%).

Catch of yellowfin tuna from artisanal gear

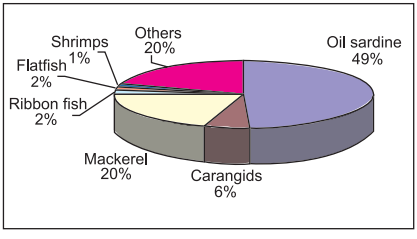
Marine Capture Fisheries

Marine fisheries of Karnataka and Goa

- In Karnataka, during 2007, the estimated monthly marine fish landings of the State varied between 2,068 t (June) and 46,555 t (October).
- The annual catch was 2,91,813 showing 21.1% increase as compared to that recorded in 2006 (2,40,888 t).
- Pelagics dominated the landings with 63.9%, followed by demersal finfish (20.4%), crustaceans (11.6%) and molluscs (3.5%).
- In Goa, the estimated marine fish landings was 97,160 t. showing 7.9% decrease as compared to 1,05,539 t recorded in 2006.
- Pelagics dominated the landings with 89.4%, followed by demersal finfish (9.0%), crustaceans (1.5%) and molluscs (0.2%).



Catch composition in Karnataka



Catch composition in Goa

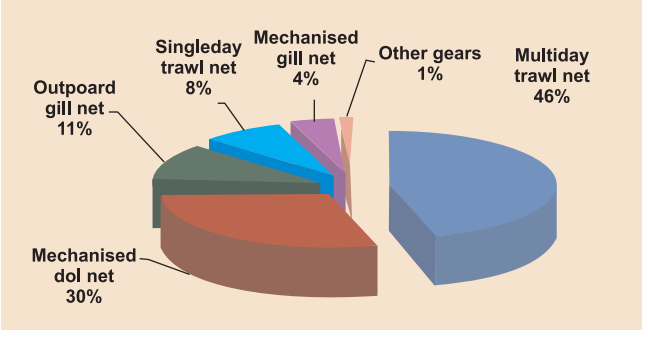
Status of exploitation ratio *(E)* of 25 major species in 2007

Below optimum level (2)	*Auxis thazard* (0.46), *Octopus membranaceous* (0.5)
Optimum level(6)	*Nemipterus japonicus* (0.58), *Metapenaeus dobsoni* (0.52), *Parapenaeopsis stylifera* (0.52), *Metapenaeus monoceros* (0.54), *Meretrix casta* (0.58), *Paphia malabarica* (0.56)
Above optimum level (17)	*Scomberomorus commerson* (0.73), *Euthynnus affinis* (0.65), *Trichiurus lepturus* (0.73), *Sardinella longiceps* (0.70), *Rastrelliger kanagurta* (0.73), *Stolephorus waitei* (0.65), *Enchrasicholina devisi* (0.63), *Decapterus russelli* (0.73), *Megalaspis cordyla* (0.66), *N. mesoprion* (0.64), *Lactarius lactarius* (0.70), *Cynoglossus macrostomus* (0.80), *Solenocera choprai* (0.62), *Portunus pelagicus* (0.67), *P. sanguinolentus* (0.71), *Loligo duvaucelli* (0.73), *Sepia pharaonis* (0.74).

Marine Capture Fisheries

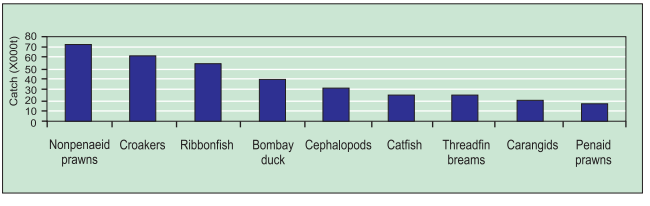
Marine Fisheries of Gujarat

- The estimated marine fish landings along Gujarat coast was 4.75 lakh t during 2007. The landings decreased by 6.5% compared to 2006. The pelagic landings were estimated as 1.66 lakh t forming 36% of the total production. The demersal resources contributed 35% (1.63 lakh t), followed by crustaceans 22% (1.01 lakh t) and cephalopods 7% (31,120 t).
- Multiday trawl operations aimed at exploitation of valuable target species with specific gears and in specific fishing grounds contributed 46 % to the total landings.



Contribution by different gears to the landing along Gujarat coast during 2007

- Ribbonfish (31%) and Bombay duck (24%) were the major contributors to the pelagic fishery.
- The major demersal resource was Sciaenids (37 % of demersal landings) represented mainly by *Otolithes cuvieri* and *Johnius glaucus*. Catfishes (15%) and threadfin breams (14%) were the other dominant groups.
- Non-penaeid prawns formed 70% of the crustacean landings and penaeid prawns formed 17% of the crustacean catch.



Catch of major resources in Gujarat during 2007

Marine Capture Fisheries

Marine fisheries of Maharashtra

- Estimated marine fish landings in Maharashtra was 3.19 lakh t during 2007, valued at Rs 1,262 crores. The catch recorded a marginal increase of 4.6% over the last year. Shrimp trawl was the major gear that contributed 1.57 lakh t (49.1%) followed by *dol* nets with 1.1 lakh t (33.1%), gill net 38,772 t (12.1%), purse seine 12,855 t (4.0%), hooks & lines 4,753 t (1.5%) and others 705 t (0.8%).
- Penaeid prawns (13.7%), non-penaeid prawns (12.3%), croakers (9.6%), sardines (9.4%) and Bombay duck (8.8%) formed the major components of the landings.
- The landing of 27,440 t of oil sardine was the most unprecedented, especially along the northern coast of the state. It is noteworthy that the oil sardines brought from 'dol' nets operated at Vasai appeared emaciated with large head and lean body. When compared to 2006, oil sardine and mackerel showed 5 fold and 2.4 fold increase in catch respectively.
- The catch of tuna and bill fishes, catfishes, Bombay duck, croakers and penaeid prawns showed 42, 19.5, 11.4, 9.4 and 8.5% increase respectively over 2006. However, catch of ribbonfish (-42.4%), threadfins (-27.6%), lizard fish (-21.4%), flat fishes (-18.9%), non-penaeid prawns (-16.9%) and eels (-9%) showed significant decline over the last year.

Trawl fishery

- Trawling effort (5.65 million h) declined by 11.6% while the catch decreased by 10% registering a marginal 2% decline in catch rate in the state. Reduction in trawling effort was mainly due to lower catch rates and consequent laying off many trawlers.

'*Dol*' net fishery

- Dol nets landed 1.05 lakh t of fish at a catch rate of 40.9 kg / h. Although the number of boat trips declined by 27% when compared to 2006, the catch improved by 15% and the catch rate increased by 37%.
- Major components of the 'dol' net fishery were non-penaeid prawns (32%), oil sardine (24.5%), Bombay duck (20%), croakers (6.2%), penaeid prawns (4.1%), golden anchovy (3.7%) and silver pomfret (2.8%). Landing of 25,762 t of oil sardine in '*dol*' nets was very unusual and mostly treated as trash for fish meal.

Impact of selective fishing of juveniles and by-catch and discards by trawlers

- An estimated 17,203 t of Low Value Bycatch (LVB) with a catch rate of 24.86 kg / hr trawlers was landed at Veraval during September to December. Thirty five genera / species of finfishes and six genera of crustaceans have been observed in the LVB. The value of LVB landed at Veraval during September to December is estimated to be Rs.34.4 million.
- At Mumbai, 1671 t of bycatch with a catch rate of 200 kg / hr was landed during January to December 2007, which formed 22% of the total catch. Seventy three species of finfishes and shellfishes constituted the LVB and considering the size at maturity, all were juveniles.
- At Mangalore, during September-December, an estimated 998 t of LVB was landed by multi-day (MDF) and 208 t by single day trawlers (SDF). MDF trawlers discarded 1255 t into the sea. An estimated 2953 t of of *Epinephelus diacanthus* and 98.5 % of seerfishes landed by trawlers were juveniles.
- At Calicut, an estimated 28,954 t of LVB was landed with a catch rate of 23.3 kg / h. sixty species / groups constituted the bycatch and 81% were low value fishes / shellfishes. An estimated 234 t of juveniles of high value commercial species were present in the bycatch, of which *Saurida tumbil, Epinephelus diacanthus, Johniopsis sina* and *Nemipterus mesoprion* were the major species.

Estimation of biological and economic loss

- At Pallithode-Chellanam, Kerala an estimated, 216 t of shrimps and fishes was landed by 'minitrawls' of which 87% (188 t) was constituted by shrimp. *Parapenaeopsis stylifera* (61%) and *Metapenaeus dobsoni* (78%) were the major shrimp species.
- On an average, 51% of *M. dobsoni* females landed were juveniles. If not caught and allowed to grow, it would have fetched Rs.45.3 lakhs instead of Rs.3.7 lakhs for the juveniles.
- If the shrimps would have been allowed to mature and spawn atleast once, the total egg production would have been 46,350 million, and the exploitation of juveniles has resulted in a massive biological loss to the fishery.

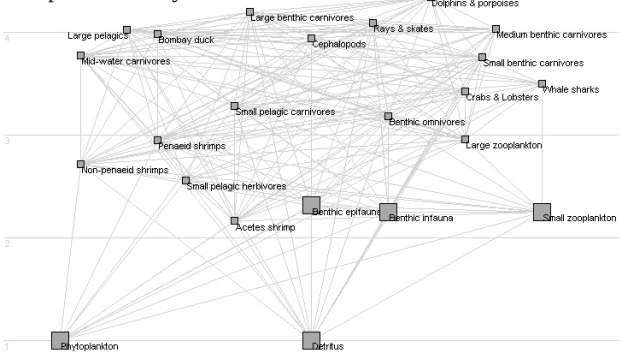
Marine Capture Fisheries

Trophic Modelling of Northwest Coast (NWC) Ecosystem developed

Mass balance was achieved for the NWC ecosystem model which had 23 ecological groups, of which 21 were consumers ranging from dolphins and porpoises to micro-zooplankton, one group was a primary producer, viz., phytoplankton and one was detritus. Separate single species groups created were Bombay duck, Whale shark and Acetes shrimp, considering their pivotal role in the NWC ecosystem.

The total system throughput, which is the sum of all flows, was estimated as 7492 t / km^2 / year, indicative of a system with medium turnover. The mean trophic level of the catch was estimated as 3.49 which is higher than that of the Karnataka and Southwest coast models and indicative of dominance of predatory animals in the ecosystem. Several ratios, such as; gross efficiency, total primary production / total respiration, total primary production / total biomass, total biomass / total throughput and net system production; indicate that the NWC ecosystem is immature and is in the process of achieving maturity. Both the connectance index and system omnivory index were relatively high indicating the high degree of biological and feeding interactions within the ecosystem and displays the web-like features of the ecosystem.

The flow diagram of the NWC ecosystem is shown below. Boxes representing organisms low in the food web are placed in the lower part of the graph, along with phytoplankton and detritus, while organisms high in the food web are placed higher. Flows from boxes are represented by lines.



Stock assessment of deep-sea fishes in the continental slope of Indian EEZ

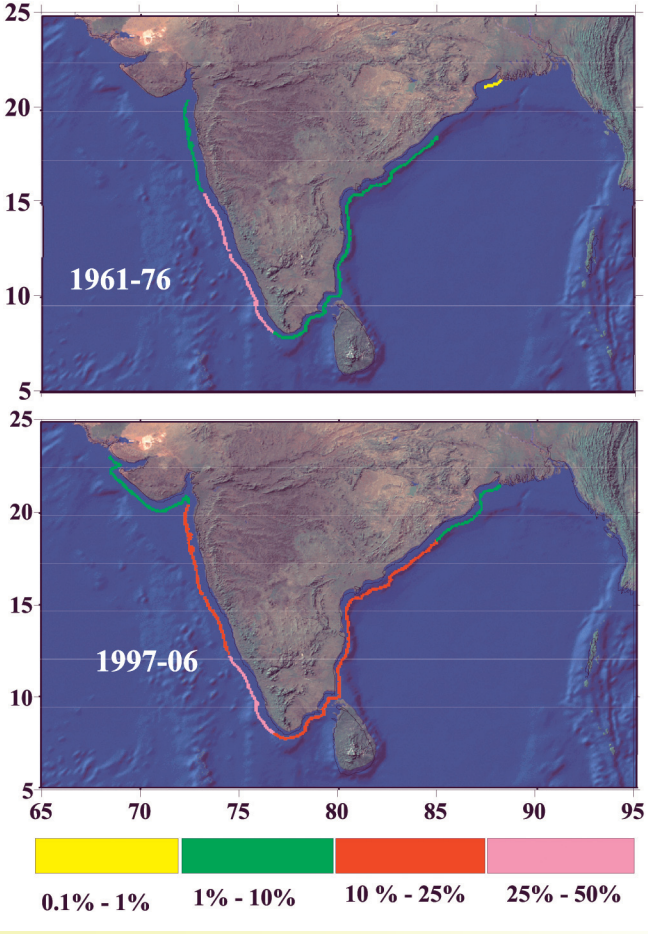
- The deep-sea demersal finfishes in the shelf edge off North Andaman were studied based on trawl survey at nine stations by FORV *Sagar Sampada* (Cruise No.252) during 2007. HSDT-CV and EXPO demersal trawl net were employed in continental shelf edge at depth ranging from 300 to 700 m.
- A total of 63 species of finfishes belonging to 53 genera, 42 families and 19 orders were recorded. The highest abundance was recorded at Station No. 8 with 25 species and lowest at Station No. 9 with 3 species.
- Shannon Weiner indices were high at Station 8 with a value of 2.51 and a low at station 1 with a value of 0.6. Simpson indices were high in Station 7 and a low in Station 1. Margalef Species Richness showed a maximum at Station 8 with a value of 3.88 and was low in station 9 with a value of 1.11. Species evenness indicated that they were evenly distributed at Stations 2 to 9 and uneven distribution was observed at Station 1.

Deep water sting ray Plesiobatis daviesi *from north Andaman water*

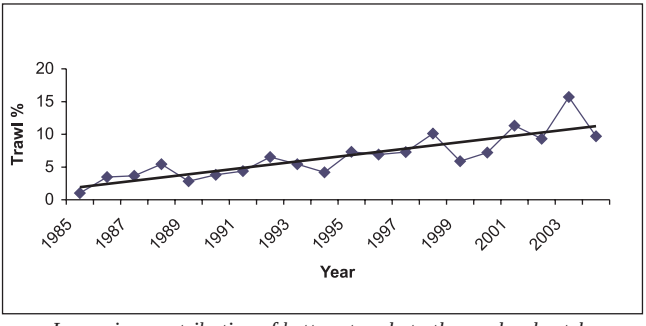
Impact of Climate Change

Adaptation of the Indian mackerel (*Rastrelliger kanagurta*) to climate change

The Indian mackerel *Rastrelliger kanagurta* is able to adapt to rise in sea surface temperature by extending its distribution towards northern latitudes, and by descending to depths. During 1961-76, the mackerel catch along the northwest coast of India contributed about 7.5% to the all India mackerel catch, which increased to 18% during 1997-06. Along the northeast coast, the mackerel catch contributed 0.4% to the all India mackerel catch during 1961-76, which increased to 1.7% during 1997-06. Mackerel was conventionally caught by surface drift



gillnets by artisanal fishermen. In recent years, however, the fish is increasingly getting caught in bottom trawl nets operated by large mechanized boats at about 50 m depth. In 1985, only 2% of the total mackerel catch was from bottom trawlers. In the last five years, about 10% of the mackerel catch is by the bottom trawlers. This shows that the fish descends down to deeper waters to overcome warmer surface waters.



Increasing contribution of bottom trawls to the mackerel catch

Carbon Footprint by marine fishing boats in India

The data collected on the diesel consumption of about 1332 mechanized boats and 631 motorized boats in the major fishing harbours along the east and west coasts of India revealed that the fossil fuel consumption is around 1200 million liters per year and CO_2 emission by the marine fishing sector is around 2.4 million t per year.

Vulnerability of coastal fishing villages to sea level rise

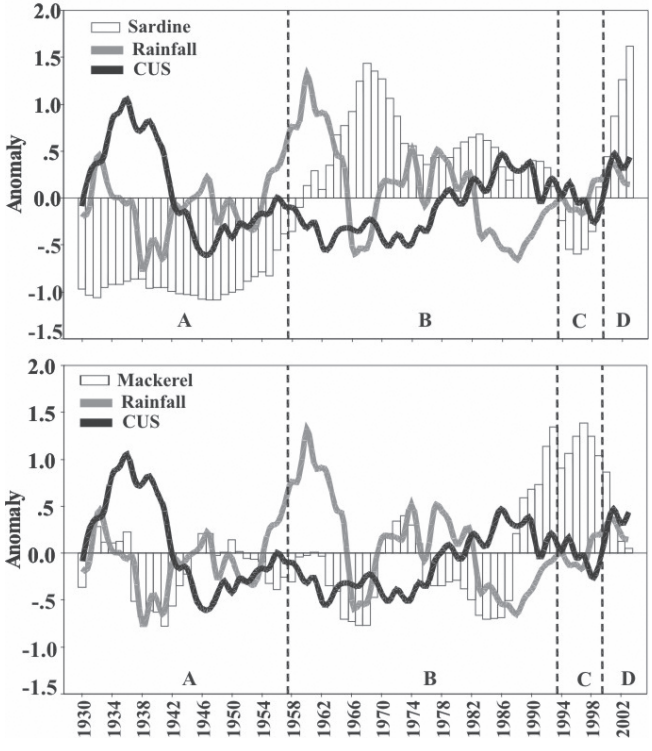
Many of the coastal fishing villages are vulnerable to sea level rise as they are located close to the seashore. To identify the most vulnerable villages, a survey on the distance from high-tide line (HTL) to each fishing village was undertaken.

There are about 2643 fishing villages along the Indian coast, of which 458 are within 100 m from the high tide line. The population in the 458 coastal fishing villages is around 1 million. The largest number of coastal fishing villages (about 200) within 100 m are in Kerala. The data on vulnerable fishing villages will be useful to sensitize the fishing communities on the perils of rising sea level, and to take up appropriate disaster management measures.

Data Archaeology

How environmental parameters influenced fluctuations in oil sardine and mackerel fishery during 1926–2005 along the southwest coast of India

Inter-annual fluctuations in oil sardine catches were very high when compared to mackerel. Significant inverse relationships were not observed between the catches of oil sardine and mackerel. Catches of both the species were not having any significant relationships with sunspot activity, ENSO or rainfall. Both the species were exploited by the same gear, from the same area and almost during the same period and hence, over exploitation may not be

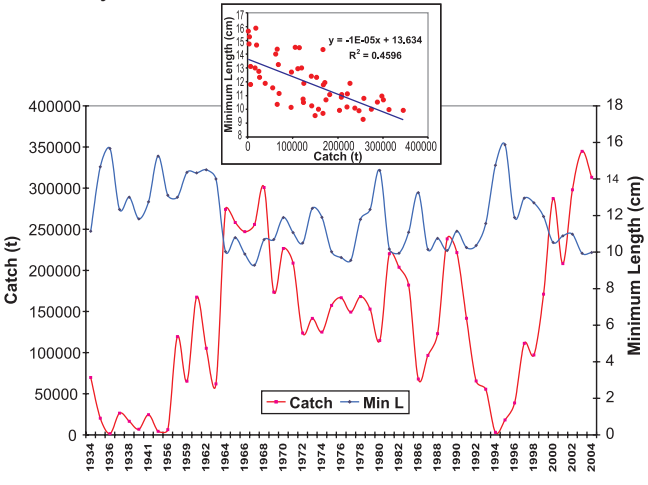


Six point moving average of anomalies of CUS (Coastal Upwelling Index) and rainfall plotted against anomalies of oil sardine landing (top panel) and Indian mackerel landing (bottom panel) along the west coast of India during 1926- 2005. A) mackerel dominated period during 1926-1956, B) sardine dominated period during 1957 - 1992, C) mackerel dominated period during 1993-1998 and D) sardine dominated period during 1999-2005

the reason for the collapse of oil sardine fishery during early 40s and in 1994. The spawning and recruitment period of oil sardine was overlapping with the major upwelling season of June to September along the Malabar Coast, while mackerel was having relatively extended spawning and recruitment period. Therefore during certain years, the unfavorable environmental conditions associated with intense upwelling might have affected the successful spawning and recruitment of oil sardine. The revival of oil sardine fishery in mid 50s and late 90s coincided with the heavy rainfall.

Use of Size-based Indicators (SBIs) for evaluating long-term trends in Indian Oil sardine (*Sardinella longiceps*) fishery

SBIs are a cost-effective tool to evaluate the effects of fishing on a population of fish, and have been used for several temperate water species such as cod and plaice. The results obtained are in contrast to what has been observed for temperate water stocks, where a decrease in mean length and maximum length can signify adverse fishing effects on the population. In the case of oil sardine ,L_{mean} was not a good predictor of stock health, probably because of the fast growth rate and the presence of multiple broods in the population. The L_{min} was however a reasonably good predictor of recruitment success and eventually a good fishery.

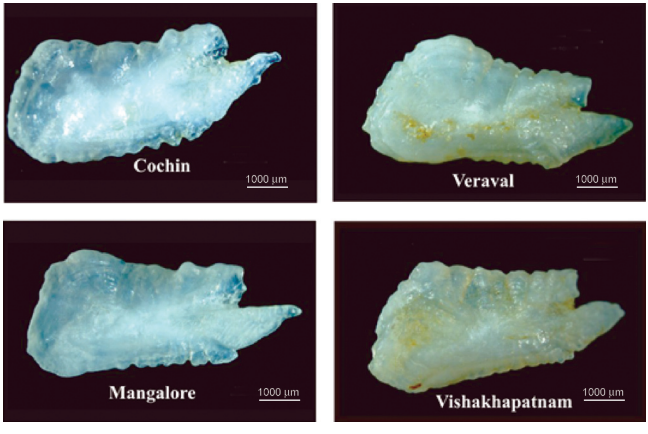


Striking inverse relationship between L_{min} and catch of oil sardine, inset shows scatter plot showing inverse relationship between L_{min} and catch

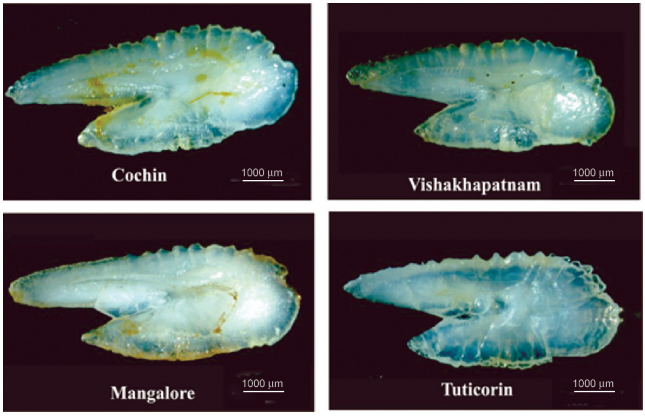
Impact of environmental changes on the distribution shift in small pelagics

Historically, the distribution of sardines and mackerels were restricted to the Malabar upwelling system along the southwest coast (8°–16° N latitude) of India. However, a clear cut distribution shifts in these two species were observed since 1989.

- The prey organisms of oil sardine and mackerel such as Diatoms (*Coscinodiscus* sp., *Rhizosolenia* sp., *Biddulphia* sp., *Thallasiothrix* sp., *Fragilaria* sp., *Pleurosigma* sp., *Nitzschia* sp., etc), dianoflagellates (*Ceratium* sp., *Dinophysis* sp., *Peridinium* sp., *Porocentrum* sp. etc.) and zooplankton (Copepods, Cladocera, Lucifer, Mysids, Sagitta, Ctenophores, Stomatopod larvae, Decapod larvae, Chaetognaths etc.) were observed both along the east and west coasts of India in substantial quantity.
- Truss analysis of mackerels showed that Veraval sample is morphometrically different from those at Visakapatanam and Mandapam.
- Otolith morphology of oil sardine from both the coasts was similar, while the mackerel otolith was having some morphological variations with sampling locations.
- Otolith of mackerel from Mangalore and Cochin having heavy river discharge were having low Sr : Ca ratio compared to the samples collected from Veraval and Chennai having very low river discharge into the sea.



Mackerel otolith

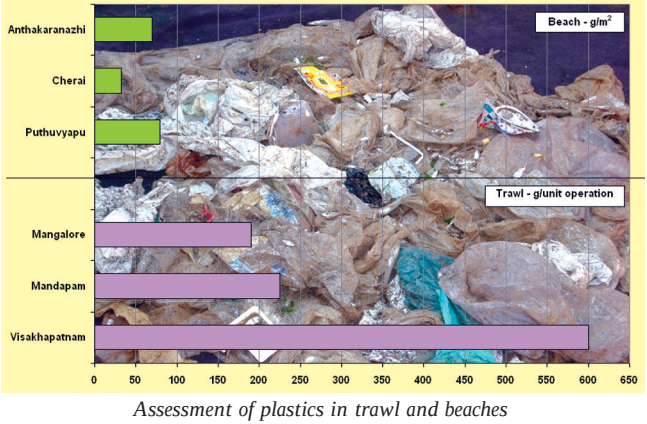


Oil sardine otolith

- Studies indicate that truss analysis and otolith chemistry is very useful in identifying fish stocks.

Plastics in fishing grounds and beaches

- A systematic survey was launched to assess the amount of plastics in the sea bottom (trawl) and on the beaches.
- Plastic materials weighing on an average of 190 – 500 g per operation containing mostly carry bags, sachets, drinking water covers, biscuit covers, plastic cups etc. were collected from shore seine nets and trawl nets along the coasts.



Assessment of plastics in trawl and beaches

Marine Mammals of Indian EEZ and the Contiguous Seas – Recommendations for conservation

- Abundance estimates on dolphins, porpoise, dugong and whales have to be made over space and time.
- Fishermen need to be educated on the importance of marine mammals in the ecosystem. This will help reducing the incidental capture of marine mammals in fishing gears.
- The concentration of trace metals and organochlorine pesticides in marine mammal tissues of the Indian seas are mostly within the safe limits. However, continuous monitoring on pollutant concentration in the tissues of marine mammals is necessary.
- For validation of species identity, sex identification, and to check illegal trading, it is important to strengthen molecular techniques for marine mammals.
- The research and conservation efforts on dugong need to be intensified.
- Training should be conducted as a measure of capacity building to the officials of Forest and Wildlife Departments, Fisheries Departments and other stakeholders on different aspects of conservation.
- Ecotourism on marine mammals may be promoted along the coast between Cochin and Calicut, Mangalore and Goa, south of Kanyakumari and off Visakhapatnam based on the abundance of nearshore marine mammal populations.

Mammal Watch
CMFRI is advising promotion of eco-tourism in selected sites along the Indian coast

Tursiops aduncus
(off Calicut)

Benefit-cost analysis of marine fishery business enterprises and alternative investment options

- The lowest investment option in Kerala was found to be a thermocool - drift gillnet unit with an initial investment of Rs. 10,000 getting an average catch of about 18 kg and earning an average gross revenue of Rs. 320/trip during October-November 2007. Similarly, the highest investment option is a multi-day trawler with an average investment of Rs 24 lakhs, incurring an average operating expense of Rs.78,000/trip of five days duration, with an average catch of 2400 kg fetching an average gross revenue of Rs 1.07 lakh with net income of about Rs 29,500.
- The provisional estimate of value of marine fish landings at primary level increased from Rs. 13,287 crores during 2006 to 14,721 crores during 2007. The value of fish at last sales increased from Rs.22,236 crores during 2006 to Rs.24,934 crores in 2007

Poverty and marginalization among the marine fisherfolk of India: Causes and ameliorative strategies

- The locations selected were Anjuthengu, Kotture, Ambalappuzha, Thankassery in southern Kerala; Kasaba and Koyippady in Northern Kerala; Alamthala, Tuticorin (Tamilnadu), Bhimlipatanam (Andhra Pradesh), Dakshin Kannada (Karnataka).
- There was no significant difference between the BPL and APL families across the study locations when monthly per capita consumption expenditure (MPCE) alone was taken into account.
- The problem analysis based on RBQ values revealed that declining catch (0.9012) was ranked as the major problem across the study locations followed by lack of government support (0.8178), exploitation by middlemen (0.6178) and threat of AIDS (0.5564).
- A case study was conducted in Alamthala village in Tamilnadu to assess the socio-technological changes happened after the bench mark study period of 1982-83. The village has registered an amazing socioeconomic transformation. The literacy rate of the village has increased from 28.7% in 1982 to 97.22%, the percentage of huts has reduced from 31% to 0.01 %, the average family income increased nine fold, resistance to family planning

has reduced from 91% to 5% and the extent of motorization was 98%. There is perceptible shift in occupational pattern towards non-fishery related jobs.

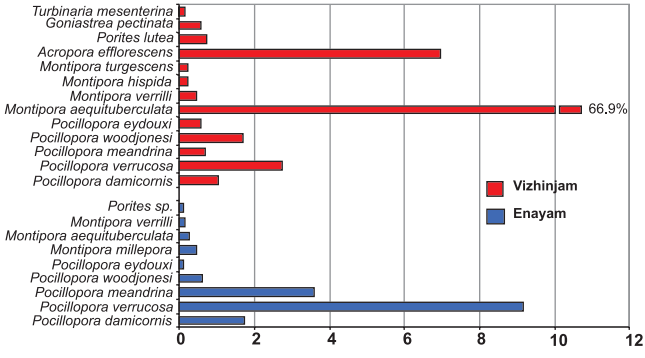
Alamthala village has only two catamaran units now compared to 100% such units in 1982-83

Economic evaluation of trawl fishing in Andhra Pradesh and Kerala

- Capital productivity ranged from 0.59 for Single day (SDF) trawling at Bhairavapalem to 0.73 at Visakhapatnam in Andhra Pradesh**.** In multi-day trawl fishing (MDF) (3-5 days), the capital productivity was most efficient at Kakinada with the lowest operating ratio of 0.49.
- At Kerala, the capital productivity for SDF trawling was comparatively less efficient than at Andhra Pradesh with the operating ratios of 0.87 and 0.75 at Neendakara and Beypore respectively. In multi-day trawl fishing (MDF) (3-5 days), the capital productivity varied marginally among the selected centres namely Cochin Fisheries Harbour, Munambam, Neendakara and Beypore, which ranged from 0.62 to 0.64.
- In Andhra Pradesh**,** the mean technical efficiency of SDF trawling worked out to 54 per cent and about 85 per cent of the fishing units were operating above the mean technical efficiency of 54 per cent. In case of MDF trawling, the mean technical efficiency worked out to 57 per cent and 92 per cent of the fishing units were operating above the mean efficiency level.

Status of hard corals at Vizhinjam and Enayam

- Underwater surveys conducted at Vizhinjam revealed a total coral cover area of about 16%. Nine species of hard corals were recorded with Pocilloporids forming the dominant group.
- Thirteen species of hard corals were collected and identified from Enayam. The total coral cover area was about 83% with the bleached and dead corals forming less than 1%. Enayam presented a generally healthy ecosystem.



Diversity and status (% cover) of hard corals at Vizhinjam and Enayam Reefs

World record of the rare female fairy basslet from the west coast of India

- Specimens of the rare fairy basslet, *Sacura boulengeri* (Heemstra, 1973), known otherwise as 'Boulenger's anthias' belonging to the subfamily Anthiinae (Family Serranidae) were collected from trawler/boat seine landings off Neendakara, Mumbai and Mangalore.

Female Sacura boulengeri

- This is the third record of the occurrence of this species worldwide as the specimens were known previously only from six adult males recorded from the Gulf of Oman (05 nos.) and off Sindh, Pakistan (01 no.). The adult specimen of *Sacura boulengeri*, collected from the trawl catches off Neendakara forms the first female specimen recorded globally.

Specific and infraspecific diversity of Carangids of the Indian seas

- Sixty-one species of fishes belonging to 20 genera of Carangidae were reported. Maximum species diversity and abundance was reported from Tuticorin (57), Kochi (45), Mandapam (45), and less from Mumbai (15), Karwar (27) and Vizhinjam (26) coasts of India.
- Species diversity was more in the genera *Carangoides* (17) and *Caranx* (10) when compared to *Decapterus* (5), *Trachinotus* (5), *Alepes* (4), *Scomberoides* (4), *Uraspis* (3), *Alectis* (2), *Seriola* (2) *Atropus*. Genera like *Elagatis*, *Gnathonodon*, *Megalaspis*, *Naucrates*, *Parastromateus*, *Selar*, *Seriolina* and *Ulua* are monotypic.
- Species such as *Caranx ignobilis*, *Caranx melampygus*, *Caranx sexfasciatus*, *Gnathanodon speciosus*, *Carangoides armatus*, *Carangoides ferdau* and *Carangoides gymnostethus* showed infraspecific variation in colour patterns. Ontogenetic changes in morphological characters were observed.

Gnathanodon speciosus
(TL: 42 cm)

Carangoides armatus
(TL: 31 cm)

Broodstock Development of Cobia, *Rachycentron canadum*

Fishes caught from commercial hooks and line fishing were transported to the hatchery at Mandapam in anaesthetized sea water (5 ml Aqui-S in 500 litres of seawater). The fishes were treated with 100 ppm formalin for one hour and kept in 5 t FRP tanks with filtered seawater for one day and stocked in outdoor concrete broodstock tanks.

Broodstock of cobia

Fishes were fed once in a day with lesser sardines (containing approximately 20% moisture) @ 5% of their body weight, after removal of gut and head. The feed was analysed for their fatty acid profile. It was observed that the ratio of DHA: EPA: ARA is approximately 1: 2: <1. The ideal ratio reported for marine finfish is 2: 1: 1 which implies that other species of low quality fish which can be used as feed for cobia has to be profiled for their fatty acid content and chosen as feed for maturation of these fishes in captivity.

Cleaner wrasses were introduced to check the external parasites. The total length ranged from 520 to 1240 mm and weight ranged from 0.9 to 13 kg. The size at maturity was around 900 mm, weighing around 5 kg.

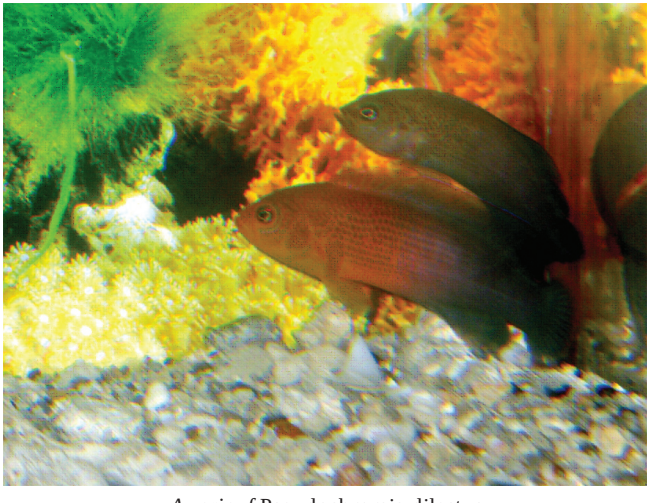
Larviculture of damselfishes

- The impact of greenwater and live feeds (copepods) on the larviculture of *Dascyllus trimaculatus* (Three spot damsel), *D. aruanus* (Humbug damsel) and *Pomacentrus caeruleus* (Blue damsel) were studied.

- The three species of damselfishes studied were with altritial type of larvae and the mouth gape of newly hatched larva ranged from 150 – 200 µ. Trials on feeding with the available strain of the rotifer *Brachionus rotundiformis* as starter feed were not successful. The co-culturing of the selected two species of copepods *viz. Pseudodiaptomus serricaudatus* and *Euterpina acutifrons* in greenwater along with larvae yielded positive results. The small size of the first naupliar stages of the copepods employed and the availability of different sizes of nauplii during the initial phase of larviculture had initiated and sustained the first exogenous feeding of the larvae. The initial stages of nauplii noted in the larviculture system measured from 60–80 µ, which is suited for the first feeding of the larvae.

Successful captive breeding of Redhead dottyback *Pseudochromis dilectus*

The redhead dottyback *Pseudochromis dilectus* was successfully bred under captive condition in the Marine Hatchery at CMFRI, Kochi. This species is much valued for the aquarium trade as they are hardy, small, colourful, adapt quickly to the life in aquaria and compatible with other species.



A pair of Pseudochromis dilectus

Microscopic view of egg mass interconnected with fine threads

Newly hatched larva

Farmed mussel production

- There was a 22% decrease in farmed mussel production mainly due to lower production in Kasargod and Malappuram districts of Kerala. An increase in the number of open sea farms (8 farms) was observed especially in Ernakulam district.

Details on the regional production of mussel during the period 2006-07 and 2007-08

	Rack 2005-06	Rack 2006-07	On-bottom 2005-06	On-bottom 2006-07	Total 2005-06	Total 2006-07
Kasargod	7496	5845	0	0	7496	5845
Kozhikode	211	95	511	623	722	718
Kannur	0	0	825	883	825	883
Malappuram	399	24	558	346	957	370
Thrissur	5	8	0	0	5	8
Ernakulam	25	40	0	2	25	42
Kollam	4	26	26	2	30	28
Total	**8140**	**6038**	**1920**	**1856**	**10060**	**7894**

Estimation of carrying capacity of bivalve farming area

- The carrying capacity of Sattar Island in central Kerala with respect to mussel farming was estimated as 52 t and currently 12 farms produce nearly 24 t of mussel annually from this area. There is scope to double the number of farms in Sattar Island without adversely affecting the environment.

Impact of oyster farming – development of ancillary industries in villages

- The oyster production during the period 2005-06 was estimated as 1500 t which is worth Rs. 7.1 million. The

average productivity has been estimated as 70 kg shell-on oyster per square meter.

- As a direct outcome of this industry, wooden poles valued at Rs 15.7 lakhs (30345 nos.) have been used. However, this has a durability of two to three years.
- Nylon rope valued at Rs.3.6 lakhs (2975 kg) and empty oyster shell worth Rs 1.5 lakhs (14,87,500 nos.) have also been used. Nylon rope and oyster shells were used for only one crop.
- Additional labour was also generated for oyster farming. It was estimated that 1487 labour days (worth Rs. 1.94 lakhs) were created for making ren and 1252 days (worth Rs. 17.85 lakhs) for heat shucking of oysters. These were carried out mostly by the family members or members of the Self Help Group and hence can be considered as family labour or group labour.
- For construction of farms, 1190 labour days (worth Rs 2.975 lakhs) have been expended.

Monoculture of *Hypnea valentiae* at Navibunder, Gujarat

- Seed material of *Hypnea valentiae* collected from the intertidal areas of Diu (Union Territory) were acclimatized in the tanks at CMFRI, Veraval. A two-meter square raft was constructed using bamboo pole and vegetative fragments of the plants with known weight placed in the 2 mm nylon hooks, which was inserted in the 3mm nylon rope that tied to the bamboo poles. Ten nylon ropes with 100 g seed material in each rope was introduced in the raft in the less saline waters of Navibunder in the post monsoon periods.
- A maximum of 5.2 fold increase in yield in 50 days was obtained during post monsoon period of December and January by adopting raft culture method.

High density grow out of sand lobsters

- A semi-enclosed intensive system with substrate bed trickling filter, for high density growout of the sand lobster *Thenus orientalis* was successfully developed and tested at the Kovalam Field Laboratory. Cement tanks of 12.5 sq.m floor space and 0.5 m depth were used.
- *T. orientalis* seed of 20 mm CL, 40 mm TL and 5 g approximate weight were stocked in two tanks. The seeds

stocked were nearly 70-80 days old and part of the stock was supplied from the hatchery while the rest was collected from the wild. The growout period was 250 days. The stocking densities were as high as 30 (tank I) and 35 (tank II) per sq.m.

- The production was 2.5-3 kg per sq. m (equivalent to 20-30 tonnes per hectare) with a survival rate of 90-91%. More than 60% of the lobsters harvested had attained commercial marketable size.
- The growth rates and the cumulative period point indicate the fact that the species can be raised to commercial sizes in less than a year, from the seed stage.

Harvested sand lobsters

Spawning, hatching and larval rearing of *Charybdis feriatus*

C. feriatus has spawned and hatched in captive condition. The weight of egg mass varied between 16-32.5 g. The embryonic development was completed between 9 and 11 days. The zoeal phase was complete within a period of 22-26 days and the larvae passed through 6 zoeal stages (Zoea - 1 to Zoea -VI) and one megalopa stage.

Developing eggs

Zoea

Evaluation of ornamental fish feeds developed by CMFRI

Two marine ornamental fish feeds viz., CMFRIOFF35 and CMFRIOFF45 developed at CMFRI were compared for their performance with two ornamental fish feeds procured from the market in *Amphiprion sebae* (the sebae clown)

Proximate composition and cost of ornamental fish feeds procured from the market and marine ornamental fish feeds formulated at CMFRI

Trade name	Aquadene	Tokyu	CMFRI OFF35	CMFRI OFF45
Country	Malaysia	Japan	India	India
CP	35	45	36	47
EE	5	6	5	5
CF	5	5	1	1
NFE	41	31	51	38
Ash	16	10	6	9
Cost INR kg^{-1}	500	300	190	210

CP= Crude protein, EE = Ether extract, CF = Crude fibre, NFE = Nitrogen free extract

- Nutritional evaluation revealed superiority in the performance of the indigenously developed formulated feeds at CMFRI. These results suggest the possibility for the development and marketing of indigenously developed feed for marine ornamentals fishes in India.

Comparative nutritional performance of *Amphiprion sebae* fed market-procured and CMFRI developed feeds

	AQ35	AD45	CMFRI OFF35	CMFRI OFF45
Initial weight mg	264.22	284.33	240.56	221.67
Initial length mm	24.00	23.83	22.22	22.17
Wt. Gain mg	461.28	452.92	514.69	514.08
Length gain mm	9.00	9.83	14.78	11.33
SGR % day^{-1}	1.60	1.51	1.82	1.90
CF	2.02	1.93	1.49	1.96
AGR mg day^{-1}	7.32	7.19	8.17	8.16
RGR %	174.58	159.29	213.96	231.92
Survival %	11.11	33.33	33.33	33.33

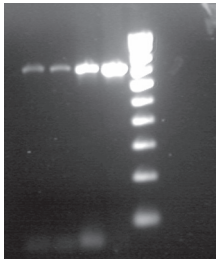
SGR – Specific growth rate, CF – Condition factor wt. mg/length mm^3
AGR – Absolute growth rate, RGR – Relative growth rate

Development of DNA barcode in Marine Catfish

Development of DNA barcode in Marine catfish *Tachysurus maculatus* and *Tachysurus thalassinus*, an important fishery resource of Indian seas facing threat to its very existence due to over-exploitation and damage of eggs were initiated.

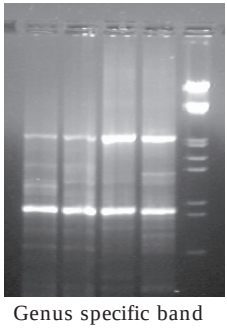
Mitochondrial DNA sequence coding for the Cytochrome C oxydase subunit 1 (*cox1*) gene forms the primary barcode for unambiguous species identification. Hence the PCR amplification of *cox-1* was optimised using the following two primer pairs specific for *Cox-1*.

F1- 5' TCA ACC AAC CAC AAA GAC ATT GGC AC 3'
F2- 5' TCG ACT AAT CAT AAA GAT ATC GGC AC 3'
R1- 5' TAG ACT TCT GGG TGG CCA AAG AAT CA 3'
R2- 5' ACT TCA GGG TGA CCG AAG AAT CAG AA 3'



Primer combination of F1- R2 was found to amplify a 700 pb gene segment.The PCR amplified *Cox*-1 gene segments on sequencing revealed the nucleotide positions of a contiguous region of 435 bases out of the 700 bp segments that was amplified.

The sequence data were aligned using BIOEDIT sequence alignment editor for estimating genetic homology and constructing phylogenetic tree (Neighbor Joining 'NJ' and Maximum Parsimony 'MP') using MEGA 3.1. Molecular genetic profiling of marine catfish through arbitrary primed PCR amplification of genomic DNA was also carried out. From an array of arbitrary primers tested, three selected for generating AP- PCR pattern were OPBH -01, OPBH - 02 and OPBH - 03. A genus specific band of 900 bp size was found to be amplified by OPBH- 01 which could be used as a genus diagnostic marker.



Genus specific band

Marine Biotechnology

Development of cell culture systems from *Epinephelus malabaricus*

Seven successful cell culture systems have been developed from tissues such as heart, gill, spleen and caudal peduncle of the grouper, *E. malabaricus* and are being passaged for developing cell lines of the respective tissues. Details of the cell culture systems developed and the number of passages till date are given in the table.

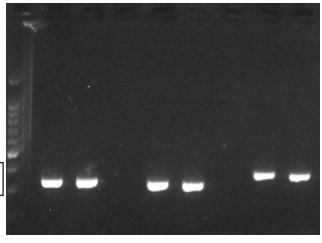
SLNo	Code	Tissue of origin	No. of passages
1.	EM2G Ex	Gill explant	24
2.	EM3G Ex (Fb)	Gill explant	22
3.	EM3G Ex (Ep)	Gill explant	22
4.	EM4Sp Ex	Spleen explant	14
5.	EM2Cp Ex	Caudal peduncle explant	13
6.	EM2H Ex	Heart explant	8
7.	EM2H Tr	Tryspinised heart tissue	7

Enrichment of Eicosapentanoic Acid Concentrates from Sardine Oil by bacterial (*Bacillus circulans*) lipase isolated from seaweed *Turbinaria* sp.

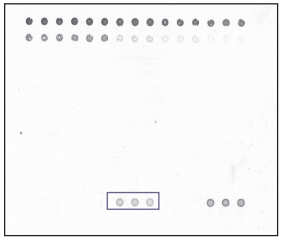
- An extra cellular lipase purified from *Bacillus circulans* from seaweed *Turbinaria* sp. was used to enrich EPA from sardine oil. The enzyme was purified 178-fold by a plurality of chromatographic techniques with an yield of 5.21% and a specific activity of 386.15 LU / mg.
- This lipase was able to enrich sardine oil with 37.74 ± 1.98% EPA after 3 h of hydrolysis of triglycerides. The purified lipase produced the highest degree of hydrolysis for SFAs (83.7%) followed by MUFAs (69.1%) and PUFAs from their initial content after 3 h. Lipase catalyzed hydrolysis of sardine oil for 3 hours followed by amide complexation provided free fatty acids containing 51.29% EPA.
- The individual fatty acids were determined as fatty acid methyl esters (FAME) by chromatography. Gas liquid chromatography of the EPA methyl ester revealed the single peak of eicosapentaenoic acid with a retention time of 9.34 $\pm$ 0.49 minute in a fast GC-mode (separation time 14.4 minutes). The results suggest that the lipase purified from ***Bacillus circulans*** may be a useful biocatalyst for concentrating EPA from marine fish oils.

DNA microarray technology for detection of viral pathogens

A demo DNA microarray (Biochip) has been developed through a combined multiplex PCR and DNA microarray technology for the detection of three economically important viral pathogens affecting shrimps and carps (white spot syndrome virus (WSSV), monodon baculovirus (MBV) affecting shrimp and Koi Herpes virus affecting freshwater carps). Screening of the field samples using the low density microarray (Diagnostic viral DNA chip), showed, high sensitivity, specificity, and the whole process was completed within 6 h. The results demonstrated the possibility for the development of a single DNA microarray (Biochip) for the detection of all the reported viral pathogens of finfish and shellfish.



Multiplex PCR with MBV, WSSV and KHV



Low density microarray with MBV

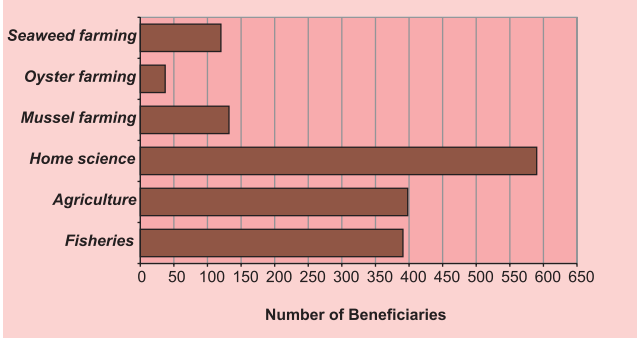
Market sample of spinner dolphin identified through the application of molecular taxonomy

A market sample of a marine mammal which was chopped into several pieces by the time it could be examined was observed. Nothing was left for the identification of the species based on morphology. The skin tissue was preserved in 70% ethanol and genomic DNA was extracted. Based on the techniques standardized in the laboratory, PCR, sequencing and sequence analysis were carried out. MtDNA control region and cytochrome b sequences were deposited in GenBank (www.ncbi.nlm.nih.gov/) under the accession numbers EU204618 and EU204619. Phylogenetic reconstruction in *DNA Surveillance* (www.cebl.auckland.ac.nz:9000/) has unambiguously recognized the species as spinner dolphin (*Stenella longirostris*), proving the application of molecular taxonomy in the species identification. With the help of conventional taxonomy, such a feat would never have been possible.

Technology Transfer

Trasfer of Technologies / Farmer Welfare Program

Training was imparted to coastal villagers through different development agencies. The details are given in the following table



Summary of Training Conducted during 2007-08

Mahila meet on cooking energy saving organized by KVK

Important Publications

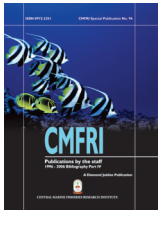
Mohan Joseph Modayil and N.G.K. Pillai (Eds.) 2007. Status and Perspectives in Marine Fisheries Research in India, Central Marine Fisheries Research Institute, Kochi, 404 pp.

Raje, S.G., S. Sivakami, G. Mohanraj, P. P. Manoj Kumar, A. Raju and K.K. Joshi. 2007. An atlas on the elasmobranch fishery resources of India. CMFRI Spl. Publ. No. 95, 253 pp.

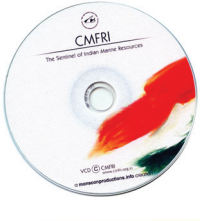
Rani Mary George and Sandhya Sukumaran 2007. A systematic appraisal of hard corals (Family Acroporidae) from the Gulf of Mannar Biosphere Reserve, South-East India. CMFRI Bulletin No. 50, 118pp.

Vijayan K.K., P. Jayasankar and P. Vijayagopal (Eds.) 2008. Indian Fisheries: A Progressive Outlook. CMFRI, Kochi, 203pp

Pillai N.G.K. and J.V. Mallia 2007. Bibliography on Tunas. CMFRI Spl. Publ. No. 92, 325 pp.



CMFRI Publications by the staff 1996 - 2006. Bibliography Part IV, 2008. V.E. Joseph, V. Mohan and R. Manjeesh (Eds.), CMFRI Spl. Publ. No. 96, 214 pp.



CMFRI - The Sentinel of Indian Marine Resources. DVD / VCD, 7 min. © CMFRI 2008.

Marine Mammal Atlas. CMFRI, CMLRE, MoES, 2007, VCD 30 min. © CMFRI 2007.

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