VISION 2030

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भारतीय कृषि अनुसंधान परिषद
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FOREWORD

The diverse challenges and constraints as growing population, increasing food, feed and fodder needs, natural resource degradation, climate change, new parasites, slow growth in farm income and new global trade regulations demand a paradigm shift in formulating and implementing the agricultural research programmes. The emerging scenario necessitates the institutions of ICAR to have perspective vision which could be translated through proactive, novel and innovative research approach based on cutting edge science. In this endeavour, all of the institutions of ICAR, have revised and prepared respective Vision-2030 documents highlighting the issues and strategies relevant for the next twenty years.

Marine fisheries serve as important sources of livelihood, food and nutritional security to the Indian population. The sector through its consistent performance in the export front and domestic market contributes to the country's GDP and has gained an important place in the Indian economy. However, with the natural harvest from the seas is showing signs of stagnation. The need of the hour is to revisit the marine production technologies in practice and the areas of future technological interactions to rejuvenate the rate of growth in marine fish production. The Central Marine Fisheries Research Institute (CMFRI), Kochi has visualized the future scenario and presented the research strategies and approach

It is expected that the analytical approach and forward looking concepts presented in the '*Vision 2030* document will prove useful for the researchers, policymakers, and stakeholders to address the future challenges for growth and development of the agricultural sector and ensure food and income security with a human touch.

(S. Ayyappan)

Dated the 22nd June, 2011
New Delhi

Preface

Fisheries sector in India has transformed from subsistence fishing to the status of a multi crore industry during the last six and a half decades. The share of marine fisheries in the total fish production is currently around 50% and is skewed around that level during the last few years. The fisheries sector has made valuable contributions to economic development of coastal areas and generating employment opportunities, especially in remote and marginal areas. Furthermore, fish export is the major contributor to foreign exchange earnings to the tune of Rs.10,000 crores during the past five years. However, the marine fisheries sector is presently facing problems like excess fishing capacity, low catch per unit effort, wide income disparities among the sectors of the fishing community and resultant socio economic conflicts. Poor implementation of the various fishery management measures suggested also adds to the present crisis.

Marine fisheries in India has been showing a slow pace of growth during the last one decade. Though the production from the seas was stagnating, the annual total marine fish landings exceeded three million tonnes. However, meeting the requirements of the growing population in the years to come is a big challenge. To meet this challenge, we have to look into the seas again as it is the only available alternate food production system, which offers immense potential like sea farming systems.

To harness the potential of sea farming / mariculture bio-secured facilities are to be developed on priority basis for brood stock management. Sea farming is an emerging field that requires massive investment to establish. A

National Fisheries Information Grid is required to be established in association with all related agencies to develop a GIS enabled comprehensive data base. Our research priorities focus on arriving at an economically sustainable marine fisheries management paradigm in the near future. This document CMFRI VISION 2030 comprehensively lists our goals, strategies and performance measures to achieve our mission in both marine capture fisheries and mariculture by 2030.

In the preparation of this document, all Scientists of the Institute as well as stake holders from different maritime states were consulted through a series of interaction meetings. I wish to avail this opportunity to express our sincere thanks to Dr.S.Ayyappan, Secretary DARE and Director General, ICAR who has been guiding us through frequent interactions and meetings. Our thanks are also due to Dr.B.Meenakumari, Deputy Director General (Fisheries), Dr.Madan Mohan, Assistant Director General (M.Fy.) and Shri.Anil Agarwal, Principal Scientist (Fisheries), Dr. E. Vivekanandan, Principal Scientist, Demersal Fisheries Division, Dr. E. V. Radhakrishnan, Head, Crustacean Fisheries Division, Dr. G. Gopakumar, Head, Mariculture Division, Dr. V. Kripa, Head, Fisheries Environment Management Division, Dr. J. Jayasankar, Dr. R. Jayabaskaran and Dr. V. Sreenivasa Raghavan for their help rendered in preparation of this document.

G. Syda Rao
(Director)

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Vision 2030

Central Marine Fisheries Research Institute: A Preamble

Introduction

The **Central Marine Fisheries Research Institute (CMFRI)**, one of the eight national fisheries institutes under ICAR, through its research and developmental activities in marine fisheries during the last six decades has played a vital role in sustaining the marine fish production through development and implementation of resource management strategies and policy advisories to the Govt. of India for fisheries governance. The Institute has been responsible for developing time series data base on marine fish production from the Exclusive Economic Zone (EEZ) of the country, their biology, distribution, abundance, fishery forecast, potential yield, stock assessment and in formulating management measures for sustainable production.

The Institute has successfully addressed issues of ecosystem health, biodiversity conservation and coastal pollution. The technologies developed for culture of finfishes, pearls, mussels, clams, crabs, lobsters, sea cucumber and seaweeds and other cultivable organisms in open seas have opened avenues for entrepreneurship development, increased production, employment generation, women empowerment, upliftment of the fisher folk and growth of the fishing industry. The credit for earning substantial foreign exchange through large-scale shrimp farming in the country is fully owing to the adoption of the hatchery technologies for shrimps developed by the Institute. The coastal mariculture development through green mussel farming is the outcome of CMFRI technology dissemination. The HRD and out-reach / extension programmes of the Institute have an enduring brand identity. The CMFRI, with the following mandate, has a vision to ensure equitability and sustainability of the resources.

Vision

- Sustainable marine fisheries through management interventions and enhanced coastal fish production through mariculture for improved coastal livelihood.

Mission

- To develop information-based management system for changing over from open access to regulated regime in marine fisheries, augment coastal fish production through mariculture and sea ranching and restore critical marine habitats.

Focus: Mandate of the Institute (As approved by ICAR)

- To monitor the exploited and assess the under-exploited of the marine fisheries resources of the Exclusive Economic Zone (EEZ)
- To understand the fluctuations in abundance of marine fisheries resources in relation to change in the environment
- To develop suitable mariculture technologies for finfish, shellfish and other culturable organisms in open seas to supplement capture fishery production
- To act as a repository of information on marine fishery resources with a systematic data base
- To conduct transfer of technology, post-graduate and specialized training, education and extension-education programmes
- To provide consultancy services

Organizational setup

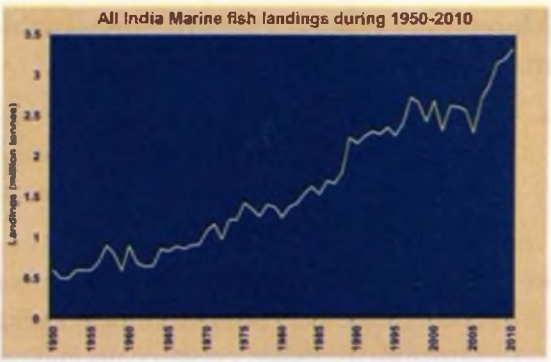
The Director is the Head of the Department (Institute). The Institute is having three Committees namely (1) Research Advisory Committee (RAC); (2) Institute Research Council (IRC); (3) Institute Management Committee (IMC) to guide the research and administration process through periodical meetings.

The Institute is having ten divisions to undertake multi-disciplinary research in Capture and Culture fisheries. The Institute has three regional centres at Mandapam (Year of establishment 1949), Visakhapatnam (1947, up graded to regional centre in 2001) and Veraval (1954 up graded to regional centre in 2002) and seven research centres at Mumbai (1947), Karwar (1948), Mangalore (1957), Calicut (1947), Vizhinjam (1951), Tuticorin (1948) and Chennai (1947) undertaking location specific research.

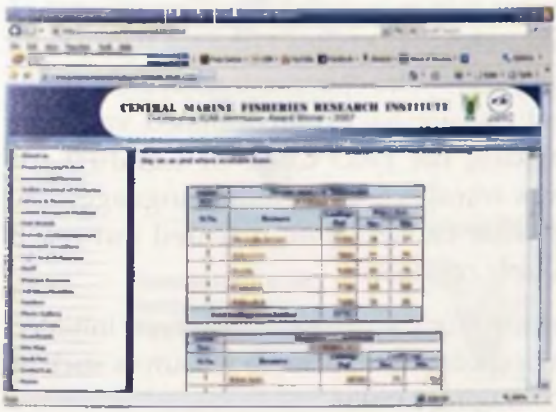
Research Achievements

Repository of Marine fish landings Data in India

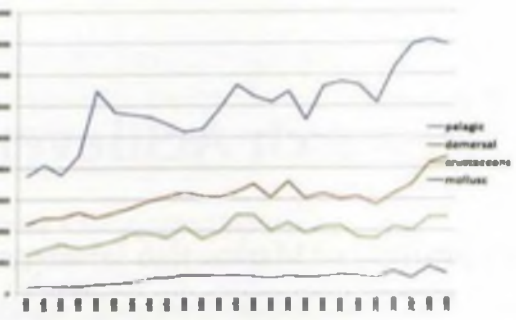
- The Institute has developed, standardized and implemented the Multistage Stratified Random Sampling Design to estimate marine fish production in India on a continuous basis from 1947 onwards. Built up time series data on season-wise, region-wise, gear-wise and species-wise marine fish production. The Institute is a repository of all data pertaining to marine fisheries of India.



- The marine fish landings data of CMFRI is all set to be declared as official statistics on fisheries by the Ministry of Agriculture (MoA), Government of India.
- **Fish Watch:** CMFRI has initiated a new system of field information dispensation on a near real time basis. As the first phase of this effort, the fish landing figures and the landing centre price range of important resources at six major fishing harbours of the country are being published as "Fish Watch" in CMFRI website. The landing figures are given in kg starting from 12.00 noon of the first calendar day to 12:00 noon of the subsequent day. These figures are updated at 16.00 hrs on working days.



- The Agricultural Research Information Service (ARIS) is disseminating and managing information on fisheries to user agencies. The country occupies an enviable position among the maritime countries of the world for processing such time series data on capture fishery resources.



- Optimum mesh size and fishing effort have been determined for all major fisheries such as the shrimps to prevent overexploitation of target demersal stocks.

Management Advisories for sustainable & responsible fisheries management

- The Institute has already advocated management advisories for the maritime States (relevant for the respective States) and the trawl ban enforcement for effective fisheries management of fisheries by the maritime States.
- Strategies for the conservation and management of overexploited, endangered and threatened stocks such as the marine turtles, marine mammals, finfishes, crustaceans and corals were devised. Based on the recommendations of CMFRI, the Ministry of Commerce, Government of India has issued orders specifying Minimum Legal Size (MLS) of four species of lobsters.
- Institute has played a major role in assisting the Government of India in formulating a comprehensive Marine Fisheries Policy to be implemented in the coming years. Also communication tools meant for Responsible Fisheries Extension have been designed, validated and disseminated. Besides, the FAO Code of Conduct for Responsible Fisheries was translated to regional languages like Malayalam and nation wide conservation-oriented out reach activities have been regularly conducted.
- The participatory management or co-management efforts initiated by the Institute in managing certain vulnerable resources such as lobster have yielded encouraging results.

Eco-system monitoring

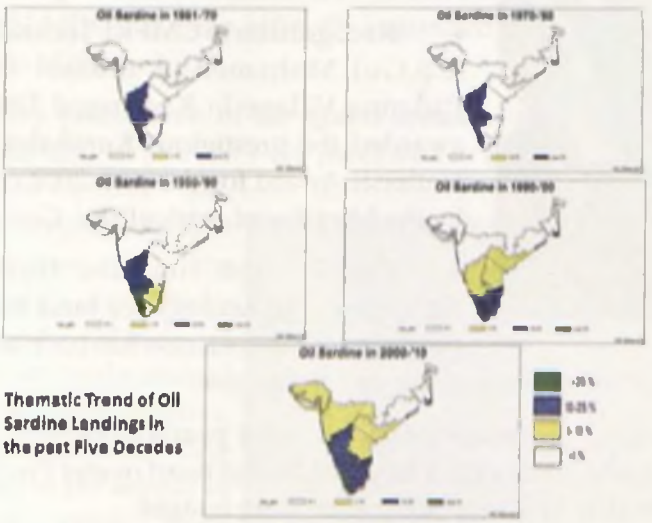
- Based on Survey of economically important seaweed resources the standing stock of various species in the Gulf of Mannar, Palk Bay (southeast coast), Lakshadweep and A & N Islands was estimated.
- Continuous monitoring of the oceanographic parameters and the estimation of primary and secondary production in the seas around India led to the charting of the abundance of the phytoplankton and zooplankton biomass and the projection of potential yields.
- Hot spots of pollution and their effects on the marine ecosystem in general and the marine fisheries in particular were assessed through consultancy services by regular monitoring of marine pollution in coastal waters.

Eco-path analysis for management

- Developed a Mass Balance Trophic Model of the Arabian Sea ecosystem of Karnataka. The model can forecast the impact of change in effort levels of different fleets on the different marine resources in the ecosystem.

Climate Change and Marine Fisheries

CMFRI has conducted pioneering research on the impact, adaptation and vulnerability of Indian marine fisheries to climate change. The increase in small pelagic abundance in the ecosystem of northwest coast has been attributed to the impact of climate change parameters like



Thematic Trend of Oil Sardine Landings in the past Five Decades

increase in sea water temperature and oceanographic factors. ECOPATH model with Ecosim simulation developed for northwest coast ecosystem showed that the biomass of oil sardine closely followed the change in fishing effort. The highest increase in biomass (more than 3-times) occurred in the small pelagic herbivores consisting of oil sardine. This shows that the biomass of small pelagic herbivores in the ecosystem is likely to increase in future (even under very high fishing pressure).

Looking into seas: Production enhancement through mariculture

- In order to augment coastal productivity **Artificial Reefs** (ARs) have been designed and installed in various locations.
- **Breakthrough in Hatchery production of sand lobsters:** Captive breeding and complete larval rearing of the commercially important scyllarid lobsters *Thenus orientalis* and *Petrarctus rugosus* have been successfully achieved for the first time in India.
- **Farming/fattening of lobsters:** Grow-out technologies for farming of spiny lobsters in indoor grow-out system and open sea cage farming have been developed.
- **The package of practices for culture of bivalves** (green mussel, edible oyster) and technology for marine pearl production developed and refined by the Institute have been widely adopted by mariculture farmers in Kerala, Karnataka, Goa, Tamil Nadu and Maharashtra.

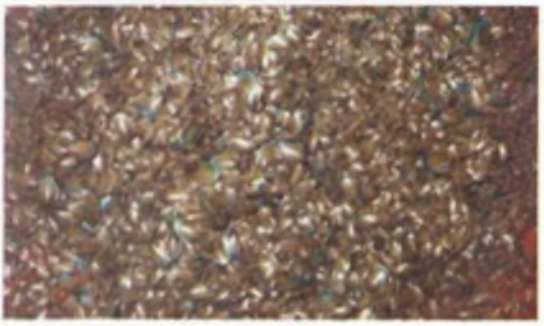
- **Recognition to CMFRI Technology:** Shri G.S.Gul Mohamed, a mussel farmer of Padanna Village in Kasaragod District was awarded the prestigious ***Karshaka Siromani*** National Award for the year 2002 constituted by the Ministry of Agriculture, Govt. of India.
- For the first time the Institute has developed a technology for **land based pearl production**. Also success has been achieved in production of large pearls of 5-8 mm size.
- **Technique for image pearls or mabe pearls** have been produced by the scientists of CMFRI in the Indian pearl oyster *Pinctada fucata* for the first time by placing miniature images.

- **Sea ranching** of shrimp and molluscan seed at Mandapam, Tuticorin and Kollam has been found to augment production leading to great economic benefits to the fishermen.
- **Culture of seaweeds in open coastal waters** and its feasibility has been demonstrated in the Gulf of Mannar.
- **Marine Ornamental fish culture:** The Institute was able to develop hatchery production methods for a dozen species of clownfishes and damselfishes such as *Amphiprion percula, A. ocellaris, Premnas biaculeatus, Dascyllus aruanus and Chrysiptera cyanea* which are in high demand in the international trade. The scaling up and commercialisation of these technologies can pave the way for the development of a hatchery produced marine ornamental fish trade in the country.

Hatchery produced *Amphiprion ocellaris*

Hatchery produced *A. percula*

- **Launching of CMFRI Trademark-'Cadalmin':** A trademark entitled 'CADALMIN' has been officially registered for the products and services of the Institute.
- **Hatchery production of the green mussel *Perna viridis*:** Nearly one lakh spat of *P.viridis* were produced in the marine hatchery at Regional Centre, Visakhapatnam. This is the first time in India, where large scale spat production in the hatchery has been achieved. This is significant to the mussel farming industry, since farmers are now looking forward to the supply of mussel seed from



hatchery to meet the increasing demand of seed for the expanding farming activities especially in northern and central Kerala.

- **Mariculture through open sea cage farming**

Open sea culture of finfishes and lobsters was initiated at Veraval, Mumbai, Karwar, Mangalore, Cochin, Kanyakumari, Chennai, Kakinada, Visakhapatnam, Srikakulam and Balasore. Very good success was achieved for farming of sea bass at Balasore and for lobster at Vizhinjam. Other experiments with mullets and polyculture are also encouraging.

Hatchery produced *Amphiprion ocellaris*

Farming of spiny lobster, a most sought after species of shellfish in the international market, was carried out in open sea cages and successfully harvested in February 2010 at Mandapam and

Open sea cage farm, Karwar, Karnataka, 2010

Kanyakumari for the first time in the southern coast of the State of Tamil Nadu. The cost of production per crop was Rs.95,000 including Rs.67,000 as the operational expenses, which included the cost of juveniles, feed, labour and others. The crop of lobsters could be sold for Rs.2.40 lakh, realizing a net income of Rs.1.46 lakh. It had been proved that cage farming of spiny lobsters could pave the way for the development of commercial level farming ventures in the region through self-help groups.

- **The harvest of the integrated fish farming in cage under** the NFDB sponsored project was carried out by CMFRI at Moothakunnam near Cochin during June 2010. The seedlings of mullet (*Mugil cephalus*), sea bass (*Lates calcarifer*) and the pearlspot (*Etroplus spp.*) with an average weight of 40-60 g were stocked in 6m dia HDPE cage. The fishes attained 300-600 gm in weight during a period of six months.

- **CMFRI achieved record growth rate for sea bass at Karwar** The Asian sea bass *Lates calcarifer* stocked in the cage under the project "Open sea cage farming of finfishes/shell fishes" in the marine cage farm of CMFRI at Karwar achieved a record growth rate with a high FCR which is considered as one of the best FCR obtained anywhere in the world for sea bass culture.

- **Cobia seed production and farming**

Cobia (*Rachycentron canadum*) has emerged as a potential global species for marine aquaculture mainly due to its fast growth rate and good meat quality. At Mandapam Regional centre of CMFRI a major breakthrough in breeding, seed production and farming of cobia was achieved. Successful broodstock development of cobia was obtained in sea cages for the first time in India by feeding with suitable broodstock

Spawners of Cobia

Late fingerlings

diets. Methods for induced breeding were also developed and successful spawning and larval production was achieved. The larval rearing protocols were developed and successful fingerling production was obtained. Nursery rearing was carried out and trials on sea cage farming of cobia were done. The fishes attained an average weight of 2.5 kg in six months and 7.3 kg in twelve months. This indicates that cobia is a lucrative species for sea cage farming in India and the standardisation of fingerling production can lead to large scale sea cage farming of cobia in our country.

Cage cultured Cobia

Nutraceuticals

Cadalmin™ Green Mussel extract (GMe) The Cadalmin™ Green Mussel extract (GMe) was launched in March 2010. The product contains 100% natural marine bioactive anti-inflammatory ingredients extracted from green mussel. GMe is an effective green alternative to synthetic non-steroidal anti-inflammatory drugs (NSAIDs) to combat joint pain/ arthritis and inflammatory diseases in humans.

Cadalmin™ Varna-Ornamental Marine Fish Feed

Cadalmin™ Varna is a scientifically evaluated slow sinking marine ornamental fish feed.

Constituents : 38% protein, 9% fat, 39% carbohydrates, 7% ash (minerals) and less than 2% fiber. Contents are marine protein, soy protein, wheat flour, oil vitamins, minerals, colour imparting nutrients like carotenoids from natural sources, immune promoters, probionts and antioxidants.

Availability : In particle size: 0.25mm, 0.75 mm and 1 mm

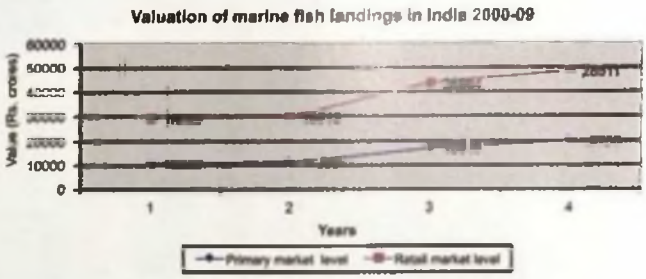
- **National Marine Fisheries census-2010:** CMFRI has been entrusted the task of conducting National Marine Fisheries Census by DAHDEF, Ministry of Agriculture since 2005. We have successfully completed the second census during 2010.
- **E-prints@cmfri:** CMFRI has established Open Access Institutional Repository, Eprints@CMFRI, for its research publications. Eprints@CMFRI is an open access digital collection containing the research output of CMFRI scientists. About 9,000 publications have been uploaded and gained global visibility.

Patents

During the last five years from 2005-06 to 2009-10, the Institute has

- Sealed three patents,
- Obtained two provisional patents, submitted four provisional patent application
- Filed one global patent under the Patent Corporation Treaty.
- Received one complete patent and filed examination request

Fisheries management - the Human Dimension



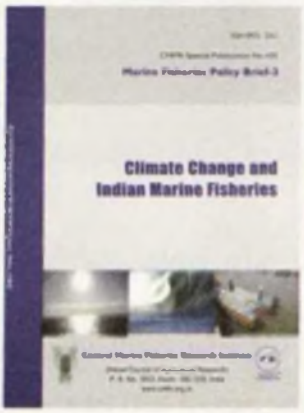
A diachronic database on cost & earnings of different fishing methods and socio economics status of marine fisheres across the maritime states of India is maintained. This enables to analyze the different parametes like economic efficiency, maximum economic yield, resource rent, income, LFPR, poverty indices and behavioural dynamics to guide policy formulations.

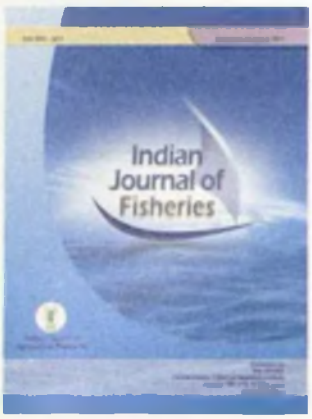
Consultancy services

CMFRI is providing consultancy services in areas like resource assessment and conservation, resource augmentation, environmental and socio-economic impact assessment, fisheries management, mariculture and molecular taxonomy. The Institute has earned Rs. 2.13 crores through consultancy services during 2010-11.

Publication of Journal

Indian Journal of Fisheries, an important journal of ICAR, managed by CMFRI has been made open access and online for better global visibility and to serve the scientific community in a better way.

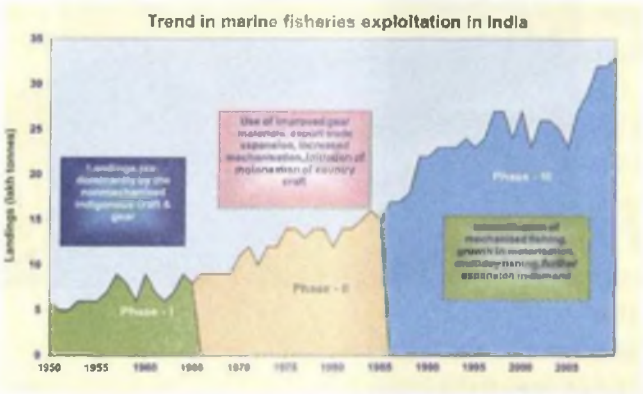




Looking ahead... Vision 2030

Fisheries sector is an integral part of the Indian economy with its consistent contribution to the country's GDP and its potential to provide the livelihood and nutritional security to about 40 million population. The fish production in India has gradually increased from about 0.52 million tonnes in the 1950 to 7.85 million tonnes in 2009-10 comprising 2.98 million tonnes (38%) from marine fisheries and 4.87 million tonnes (62%) from inland fisheries.

The projected yield of marine fish landings in India for 2030 is about 5.0 million tonnes. We can expect the harvest from inshore (up to 12 nautical mile) at 1.6 million tonnes and offshore (from 12 nautical miles to 200 nautical miles) at 3.2 million tonnes. The demand for fish in the next decade is expected to increase due to the awareness of the people on the nutritive value of fish. The existing per capita availability of fish is 6.5 kg and is expected to reach 9.0 kg by 2030. Sustainability of marine fish landings at the projected level is a major concern (though not as severe as the global scenario) and there exists limited scope to increase the capture harvest in future. Taking the optimistic estimate, we will have a marine fish production of 5.0 million tonnes only by 2030, which will be less than the projected requirement and the gap has to be filled by production through seafarming.



The demand in the export front is also on the increase especially with the diversification of our export basket by including fin fish also. The sector is also facing severe constraints in achieving our goal –*Fish*

for All- like indiscriminate harvest of certain stocks, irrationally increasing fleet size and declining catch per unit effort and social conflicts among the fishers in capture fisheries. The culture fisheries sector also faces challenges like, lack of adequate seed & package of practices for marine mariculture, hatcheries for seedlings of identified species, low cost indigenous feed & vaccines for diseases and high cost of production.

There is no doubt that the mainstay of marine fisheries will continue to be the capture fisheries sector. In future it will become mandatory to shift from an open access to a regulated regime which in turn demands the establishment of a scientifically informed marine fisheries management system. In the Indian context, management regulations are possible only by considering the socio-economic conditions as well as the intricacies of the multi species tropical ecosystem. There is a need to develop such stock assessment tools that are more sophisticated but sensitive not only to the tropical bio-social reality being manifested both in the inshore and off shore sectors but also the looming effect of climate change.

It is also a fact that the major portion of Indian marine fisheries is contributed by the artisanal sector. Providing alternate options of production of fish for the coastal fishermen will be the prime requirement. The orientation of research needs to be on production technologies. A concerted effort by the Institute on development of viable farming methods by taking into account the environmental considerations, biotechnological interventions, biodiversity implications and socio-economics is needed with a vision of enhancing coastal production through sea-farming.

The Institute has identified appropriate strategies to overcome these constraints and achieve our goal. The fundamental tenet that guides the envisaged vision is *"Better Science for Better Fisheries"*. A networked constituency of informed stakeholders holds the key for future

developments in the sector. The chapter gives an overview of the various approaches towards this goal.

Facilitating a scientifically informed marine fisheries management system

Healthy stocks make a fishery sustainable. The meaningful delivery of the mandated duty of monitoring the status of exploitation of fish stocks in the Indian EEZ revolves around the accuracy of catch statistics collected and the subsequent analysis using sophisticated stock assessment models developed by the institute. The institute is maintaining a uniquely huge bio-statistical database which is constantly used to come out with region specific marine policy advisories. However, the spatio-temporal dissonance of the existing data management system *vis-a- vis* the geographical spread of the Indian EEZ needs to be reduced in order to augment the predictive power of the models. Participatory approaches involving the stakeholders in the stock assessment process will be resorted as a way out. Another approach here is to broaden the biological database through independent oceanic explorative studies in the whole of Indian EEZ. We aim to improve our capacity in formulating and disseminating regional marine fisheries management plans premised on the ecosystem approach and sensitive to tropical bio-ecological and socio-political realities. Priority will be given to the establishment of a National Fisheries Grid-GIS Platform for Marine Fisheries Management which will strengthen the National Marine Fisheries Information System.

Marine environmental health assessment and impact of climate change on marine Fisheries

Climate change is one of the most significant threats to fisheries habitats and biodiversity, which has a significant impact on dominant producer biota such as phytoplankton and zooplankton. Reduction of plankton productivity will reflect in food web productivity including fisheries yield. Many studies have pointed out how the environment and its variability can influence recruitment and fish distribution. Marine organisms are well adapted to short term climate variability but not to longer term rapid shifts in mean climate and increased frequency or intensity of extreme events as predicted under the current climate change scenarios. The small pelagics such as the oil sardine and Indian mackerel have extended their distributional boundary to northern and eastern latitudes contributing to fisheries in the last two decades.

Sea surface temperature has increased by 0.2 to 0.3°C along the Indian coast in the last 45 years, and is projected to increase by 2.0 to 3.5°C by 2099. The projected sea level rise is 30 cm in 50 years. These alterations will be manifested in:- i) Change in trophic relationship ii) Shift in recruitment patterns of marine flora and fauna iii) Changes in species composition iv) Changes in habitats v) Changes in structure, dynamics and distribution of communities. Climate change threats to small scale fisheries are very high while adaptive capacity is very low. Among the six marine fisheries regions in the Indian EEZ, it appears that the impact on southeast coast fisheries is faster than other regions. The mitigation and adaptation to climate change requires research to identify environmental effects associated with fishing and aquaculture activities; and identify potential pressures and threats to fish and their habitat. To ensure that fishing grounds are ecologically healthy as well as economically productive under the predicted impacts, CMFRI has prioritized the following research areas to study the impact of climate change on marine fisheries: 1) Research on impacts of increasing acidity of the oceans and their effects on fishes 2) Assessing the ecological health of fisheries ecosystems using satellite technology, 3) Identifying the adaptive fishing and post-harvest practices to sustain fish production and quality, 4) Cultivating aquatic algae, which have positive response to climate change, for food and pharmaceutical purposes and for production of bio-diesel, 5) Studies on integrated ecosystem based fisheries management using large scale biogeochemical ecological models, 6) Research on changes in the abundance and distribution of exploited fishes and 7) Development of Bio-safety protocols for sea farming fishes. The development and implementation of sustainable fish and fish habitat management strategies will be done based on these research priorities.

Development of harvesting strategies for oceanic natural resources like tuna, large pelagics and squids

Large pelagic fishes play an important role in the marine ecosystem. They are efficiently harvested by the purseseines and the ringseines. Environmental changes as well as fishing activities can have multiple effects on the availability and abundance of large pelagics. It is necessary to determine various biological reference points for realizing long-term sustainable yields. A thorough study of all aspects of the operation of the gears (including socio-economics) will enable policy makers, managers and the implementing authorities to decide on the right

management options to be suggested to put an end to the present conflicts among the fisher folk engaged in different harvesting methods.

Scaling up sea farming

One of the best ways to meet the likely demand - supply gap in marine fish production is to upscale mariculture technologies especially open sea cage farming based on carrying capacity assessments. Focused research efforts will be attempted to tap the potential of the Indian EEZ as an alternative production system. The specific corollary activities include brood stock development and seed production of marine finfish, formulating eco-friendly low cost feeds for marine finfish culture and vertical integration for high value fishes including marine ornamentals. Commercialisation of sea cage farming practices at selected locations of Indian coast demands proactive marine leasing policies. Necessary inputs will be generated to enable the government to take suitable decisions like subsidised frontline demonstrations and coastal innovation clusters in this regard.

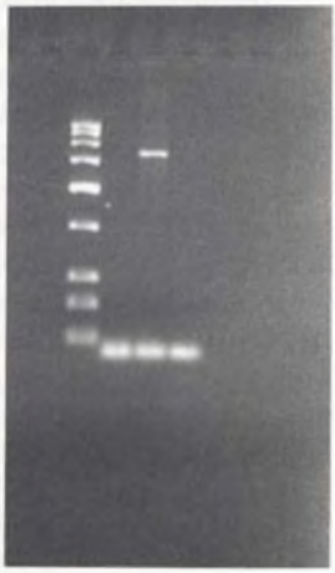
Brood stock development and seed production of marine finfish

There is limited production of seeds of high value species desired by the farmers. Cheaper and biosecure broodstock is the prime requirement. Application of extensive larval rearing technology has to be tried for desired species to reduce cost of production. The quality of seed stock has to be ensured by evolving certification for seed stock. The quality and management of broodstock and the impacts of domestication of hatchery broodstock have to be ascertained. If the broodstock development and larval production is practised in recirculation systems, it is possible to have control on the environment in which the broodstock and larvae are produced. Sustainable production of bio-secure seeds of suitable groups like cobia, pompano, snappers and groupers all through the year employing photo-thermal conditioning is possible only by recirculation systems and this proposed facility is unique and first of its kind in India. The steady supply of fertilised eggs to the hatcheries can lead to the production of sufficient fingerlings for farming to achieve a moderate production target of five lakh tonnes of farmed marine finfish annually.

Feed biotechnology, fish health & bio-prospecting, genetics and genomics with reference to mariculture

a) Fish Nutrition and feed biotechnology

The nutrition and aquatic feed biotechnology for mariculture and aquariculture is one of the important areas in aquaculture nutrition and required to be addressed from two angles. *viz.*, scientific research output in terms of pure and applied research and product development drawing heavily from the research output. Focused research is envisaged with the candidate species for cage culture such as, cobia, groupers, snappers and crustaceans like the blue swimmer crab and sand lobster. Indigenization of technologies for scaling up of laboratory scale production of feeds is an area where private partnerships are to be encouraged. It is essential to build capacity for process optimization and product development of fish feeds using state-of-the art technologies leading to the initiation of nutrigenomics.



b) Fish health and bioprospecting

Diseases in the aquatic rearing systems and the related mortalities caused by pathogens are the major limiting factors in the development of economically viable and sustainable aquaculture technologies and mariculture is no exception. Development of health management packages for the targeted candidate species is of prime importance in formulating viable technology packages for these species. Potential of exploring the bioactive secondary metabolites from microbial sources and other marine organisms such as sponges, molluscs, seaweeds etc., is a highly promising one. It is very important to explore and exploit the possibilities in marine bioprospecting, through building culture collections of bioactive microbes, marine organisms and algae for biologically active substances produced by this biota enabling the creation of novel health management components such as pathogenomics, probiotics and to establish a national facility for preservation of bioactive microbes for their ex situ conservation and future biotechnological exploitation and development of novel products.

c) Genetics and genomics research

The main focus will be on applications of genetics, genomics and biotechnology in mariculture and fishery resources management thus envisaging to develop molecular markers of finfish and shellfish of commercial and mariculture importance. It is hoped to realise marker assisted selective breeding for developing superior brood stock, sustainable mariculture through biotechnological interventions and gene mining from marine organisms, their characterization and gene banking.

Bio-inventorying and biodiversity evaluation of marine ecosystem

Marine biodiversity provides various ecosystem services including food, protection against coastal erosion, recycling of pollutants, climate regulation, and recreation. So far 15,042 marine species have been reported from coastal marine areas of India. These the diversity of fishes are well documented by CMFRI. The potential coastal and marine biodiversity occurring in the country could be several times higher than these estimates and several smaller groups are neglected and spatial coverage is still poor. The coral reef ecosystem and oceanic areas are the potential sites of new discoveries.

A decline in marine biodiversity will have a far reaching impact on society and the economy, including reduced resilience and resistance to change, declining marine environmental health and water quality. The economic valuation of bio diversity has the potential to play a fundamental role in this process. Valuing ecosystem services allows the translation of ecological importance into a representative monetary value that can be incorporated into decision support systems, which will be given utmost priority.

Economic sustainability and management issues in Marine Fisheries

Marine fishery sector in India has transformed from subsistence living to the status of an industry during the last six decades. The sector has witnessed growth in all components of the sector namely craft-gear combinations, processing and post-harvest facilities including infrastructure at landing centre and at market yards. The secondary and tertiary sectors depending on the fishing industry for their livelihood like providing ice and good water in the landing centre, cleaning and cutting the fishes in the markets, sorting and grading the catch in the landing centres and markets have also developed. Many fishery business

enterprises like ice plants, processing/grading centres have also come up. Despite the developments in the sector, the benefits of these developments have not trickled down to the grass root level of the industry. There is lack of information available on the investment and returns or benefits from these enterprises. Priority will be given in assessing the social cost benefit impacts and the economic performance of fishing units to evolve suitable policy options for optimal resource use. Suitable strategies for sustainable management of the marine fisheries will also be advocated based on these studies.

Fisheries governance, trade, livelihoods and gender issues

The marine fisheries sector play an important role in ensuring food and nutritional security of the growing population. Looking at the emerging global scenario there are concerns that fish may soon attain the status of a niche commodity threatening nutritional security of the poor. We need to constantly monitor the emerging value chain dynamics, globally as well as regionally, so as to retain the competitiveness without hampering the concerns on gender sensitive and equitable distribution of ecosystem services. Research support in provision of market intelligence, capacity building for establishing stakeholder platforms oriented towards responsible fisheries management and market- lead social engineering interventions will be given priority.

Capacity building for research excellence

With ASEAN in place, the emerging marine fisheries scenario in the South east asian region has become a testing ground for conducting research on the multi-species, tropical fishery, where CMFRI has a significant role to play. This includes well planned internal & external capacity building programmes. This can be achieved through conducting international training programmes on stock assessments, marine fisheries expeditions and well planned HRD initiatives through exchange programmes with National and International organizations.

Strategy and Framework

The vision statements given below indicate the strategy which would be adopted to guide our mission in both marine capture fisheries and mariculture.

Vision Statements

By 2030

1. Marine fish stocks are plentiful and optimally harvested

- New stock assessment and bio-economic models amenable to tropical reality
- Transition to ecosystem based approaches in fisheries management
- Compliance to sustainable harvest strategies and habitat protection measures aimed at sustained stocks and sustained livelihoods
- Bio-inventorying and biodiversity evaluation of marine ecosystem
- Higher ecosystem resilience against biodiversity loss
- Marine environmental health assessment
- Equitable distribution of ecosystem services
- Robust knowledge base on impact of climate change on marine fisheries
- National Fisheries Grid-GIS Platform-Application of GIS in Marine Fisheries Management. Collaborative proposal with the national and regional organizations involved in fisheries research and management

2. Scientifically informed fisheries management system in place

- Formulation and dissemination of regional marine fisheries management plans.
- Development of harvesting strategies for oceanic natural resources like tuna, large pelagics and squids

- Development of Operational strategies for by-catch management
- Better ways of accessing the research output and feeding it into policy (higher dissemination capacity to enable decision makers)
- Greater functional and collaborative linkages between research, management and stakeholders
- Better availability of data through electronic gadgets and participatory approaches
- More knowledge-platforms for continuous dialogue and reconciliation between research system and fisheries administration
- Satellite based vessel monitoring system
- National marine fisheries expedition covering Indian EEZ and Central Indian Ocean

3. Indian EEZ as a source of alternative food production system through mariculture

- Development & scaling up of viable mariculture technologies especially open sea cage farming based on carrying capacity assessments
- Brood stock development and seed production of marine finfish.
- Formulating eco-friendly low cost feeds for marine finfish culture
- Vertical integration for high value fishes including marine ornamentals
- Feed biotechnology, fish health & bioprospecting, genetics and genomics with reference to mariculture
- Establishment of a National broodstock Centre with Recirculation Aquaculture System (RAS) and with photothermal control for high value finfishes such as cobia, grouper and pompano.
- Development of state-of-the-art hatcheries with automation and recirculation facility for seed production of selected finfish and shellfish.
- International collaboration for establishing the state-of-the-art infrastructure for seed production and farming of finfish and shellfish and for training on latest production technologies suited for our conditions.

- Commercialisation of sea cage farming practices at selected locations of Indian coast.
- Development of cobia aquaculture in the country.

4. **Capacity building of the stakeholders enabling them to participate in research and policy making; and consumers who can exercise choice over sustainable production**

- Monitor the behavioural responds of stakeholders to changing management regimes.
- Fisheries governance, trade, gender and alternate livelihood options (ALO)
- Participatory marine fisheries management
- Combining Informal and formal research
- Institutionalization of certification schemes
- Strengthened socioeconomic research and out-reach activities
- Provision of fisheries market intelligence
- Better use of ICT in dissemination of policy inputs

5. **Developing CMFRI as a Southeast Asian knowledge leader in multi - species tropical fisheries management and tropical mariculture**

- Enhanced capacity and competence to deal peculiarities of tropical fishery
- Leadership role in regional fish stock assessment & fisheries management
- Conduct international training programmes to improve regional capacity
- Assessment of marine fishery resources of the country and strengthening of the National Marine Fisheries Information System

Annexure

Strategy and framework

Goal	Approach	Performance Measure
Scientifically informed fisheries management system	Assessment of marine fishery resources of the country and strengthening of the National Marine Fisheries Information System	GIS based resource distribution and abundance mapping over space and time
	Development of sustainable harvesting strategies	Fishery sustainability index
	Knowledge base on the impact of climate change	Adaptability and vulnerability indices and mitigation strategies
	Bio-inventorying and biodiversity evaluation of marine ecosystem	Development of GIS based data base of marine finfish, shell fish sponges and soft coral species
	Ecosystem monitoring	Observations for estimation of pollution levels in different eco-zones
		Promoting bio-specified concept in villages for mangrove conservation
		Environmental impact parameters in hydrographic and benthic ecosystems
		Ecosystem indicators
		Estimation of carbon sequestration potential of Indian seaweed species
	Development of Operational strategies for by-catch management	Estimates of by-catch in trawl fishery and economic loss due to by-catches and exploitation of juvenile fishes
		Strategies for better utilization of by-catch

Goal	Approach	Performance Measure
	Assessment of recruitment dynamics of commercially important fishes and shell fishes	Estimation of spawning stock biomass of fishes and shell fishes that gives maximum recruitment
	Capacity building in stock assessment, and taxonomy	Training of scientists and technical personnel
	Formulation and dissemination of regional marine fisheries management plans	Assess the status of exploited stocks
		Assessing the ecological impact of fishing innovations
		Estimating the potential yield and optimum fleet-size-State-wise
		Assessment of stock size of oceanic tuna species
		Monitor the behaviour and response of fishermen to changing management regimes
Productivity and production enhancement	Open sea cage farming Better Management Practices for Aquaculture	Standardization of Technologies for Integrated Multitrophic aquaculture - Species
	Artificial reefs	Establishment of Mariculture technology park
	Seed production of marine finfish & shell fish species	Establishment of a National broodstock Centre with Recirculation Aquaculture System (RAS) and with photothermal control for high value finfishes such as cobia, grouper and pompano.
	Feed biotechnology, fish health & bioprospecting, genetics and genomics with reference to mariculture	Development of bio-products from marine resources
		Fish nutrition, fish genetics and fish health indicators