CMFRI Perspective Plan

# VISION-2025

भाकृ अनुप
ICAR

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

केंद्रीय समुद्री मात्स्यिकी अनुसंधान संस्थान
CENTRAL MARINE FISHERIES RESEARCH INSTITUTE

# VISION - 2025

## CMFRI

## PERSPECTIVE PLAN


**CENTRAL MARINE FISHERIES RESEARCH INSTITUTE**

***Indian Council of Agricultural Research***

P.B. No. 1603, Marine Drive North Extension

Kochi - 682 018, Kerala, India

Published by

**Prof. Dr. Mohan Joseph Modayil**
Director
Central Marine Fisheries Research Institute
P.B. No. 1603
Kochi-682 018

Website : www.cmfri.org.in

# FOREWORD

Indian agriculture must continuously evolve to remain ever responsive to manage the change and to meet the growing and diversified needs of different stakeholders in the entire production to consumption chain. In order to capitalize on the opportunities and to convert weaknesses into opportunities, we at the ICAR attempted to visualize an alternate agricultural scenario from present to twenty years hence. In this endeavour, an in-depth analysis of the Strengths, Weaknesses, Opportunities and Threats (SWOT) was undertaken to place our research and technology development efforts in perspective so that we succeed in our pursuit of doing better than the best. Accordingly, the researchable issues are identified, strategies drawn and programmes indicated to have commensurate projects and relevant activities coinciding with the launch of the 11$^{th}$ Five Year Plan.

Fisheries and aquaculture have played vital role in food and nutritional security, employment and livelihood and contributed significantly to foreign exchange earning through export of sea food. Indian fisheries production registered an eight-fold increase during the last five decades, contribution to 6.4 million tonnes in 2005 which is about 4.4% of global fish production, 1.1% of India's GDP and 4.7% of agricultural GDP. The marine capture fisheries contribute to about 50% of total fish production in the country. However, open access nature of the fisheries and unplanned development of fishing have resulted in stagnation in yield as well as conflicts among stakeholders. Potentials of oceanic and deep sea fishing as well as large scale sea farming and coastal mariculture are not fully realized presently. There is need to focus on sustainability of capture fisheries as well as increasing production through diversification as well as mariculture of high value species.

Established in 1947, the Central Marine Fisheries Research Institute has been carrying out pioneering research in the area of marine capture fisheries and in recent years in production system research in the field of mariculture. The knowledge base developed by the Institute and recommendations have played vital role in policy formulation and fisheries governance in the country. The basic research carried out in breeding technologies of shrimp and finfish has opened up new avenues of fish production and export trade. Ensuring sustainability, promoting diversification, exploitation of oceanic resources, developing mariculture technologies and conserving endangered/threatened species and ecosystems are priorities for the Institute in its future research agenda.

It is expected that realizing the Vision embodied in the document would further ensure that the CMFRI, Kochi continues to fulfill its mandate to make Indian fisheries locally, regionally and globally competitive. The efforts and valuable inputs provided by my colleagues at the ICAR Headquarters and by the Director and his team at the Institute level for over an year to develop Vision 2025 deserve appreciation.

**(MANGALA RAI)**
**Secretary,** Department of Agricultural Research & Education
and
**Director General,** Indian Council of Agricultural Research
Dr. Rajendra Prasad Road, Krishi Bhawan, New Delhi 110001, India

New Delhi - 1
February 2007

# PREFACE

Marine fisheries in the world, including India, is currently passing through a crisis mainly due to stagnation in production, higher cost of operation and low profitability. The transformation of the marine fisheries in the country, over the last six decades, from a traditional livelihood avocation to a well-developed industrialized sector was phenomenal. However, the recent signs of stress and threats as seen in the fisheries sector calls for a rapid change from the existing open access system to a knowledge based management regime.

The Central Marine Fisheries Research Institute, established in 1947, is the largest among the eight fisheries research institutes under ICAR and mandated to carryout R&D activities in marine fisheries and mariculture. The Institute has built up a strong database on exploited stocks during the last 60 years and has evolved strategies to implement effective management regime to sustain production. The Institute, with its three regional and seven research centres, besides the headquarters has developed mariculture technologies for many marine finfishes, shellfishes and ornamental fishes.

Marine fisheries sector contributes to about 50% of the total fish production in the country and earns foreign exchange over Rs. 7500 crores annually through seafood export. However, the present scenario is characterized by stagnation in production and declining yields from traditional fishing grounds, increasing conflicts between different resource users and degradation of ecosystems, whereas the demand for seafood in domestic and export markets has been increasing.

The research in fisheries is focused on sustainability and conservation of coastal resources through development of management models, biodiversity and ecosystem conservation and consolidating the mariculture and seafarming technologies into package of practices for augmenting seafood production. Research on marine biotechnology is dovetailed with production system research. The Vision 2025 document sets the goals, strategies and logistics to be implemented and achieved in marine capture fisheries and mariculture by the year 2025. The CMFRI has a major role to play in ensuring the sustainability of the marine fishery resources and ushering in an era of responsible fisheries and mariculture in the Indian seas and it is expected that the Vision presented in this document would help accomplishment of these objectives.

This document was prepared mainly by the efforts of many scientists initially and subsequently revised by Dr. N.G.K. Pillai, Principal Scientist and Head of Pelagic Fisheries Division and me. I take this opportunity to thank Dr. Mangala Rai, Secretary DARE & Director General, ICAR who spared many days of his valuable time to interact and guide us in the preparation of the revised manuscript and Dr. S. Ayyappan, Deputy Director General (Fisheries) who was our inspiration to excel. Our thanks are due to Dr. A.D. Diwan, Assistant Director General (Marine Fisheries) and Shri Anil Agarwal, Principal Scientist (Fisheries) for all help rendered.

Cochin - 18
February 2007

**MOHAN JOSEPH MODAYIL**
**Director**

# CONTENTS

# EXECUTIVE SUMMARY

The revised Vision 2025 document outlines the institutional structure, mandate revised in tune with changing scenario, current status of the marine fisheries in the country, institutional infrastructure, scientific and technical manpower, significant achievements in research and development carried out by the Institute during the past, SWOT analysis, issues and concerns facing the marine fisheries and mariculture sectors, identification and prioritization of research priorities and a road map for research for the period up to year 2025 under the various identified thematic areas and defining of outputs and outcome.

The Central Marine Fisheries Research Institute (CMFRI) was established in 1947 to carry out multidisciplinary research in marine capture and culture fisheries and to develop the required human resource for research and development in the above areas through education and training. During the past 60 years, the Institute has grown in stature and size with 9 constituent research centres for addressing regional capture and culture fisheries research needs. The present sanctioned staff strength is Scientists 189+1, Technical 330, Administrative 152, Supporting 262 and Auxiliary 6. The X Plan budget is Rs. 2715 lakhs under Plan and Rs. 8810 lakhs under Non Plan. Recently developed infrastructure include two additional floors of laboratory and office space in the Headquarters, a modern multipurpose hatchery in the Mandapam Regional Centre, a lobster hatchery at Kovalam, Chennai, experimental marine aquarium at Calicut and Cochin, ornamental fish hatchery at Cochin, multipurpose research wet lab with running seawater at Visakhapatnam, new office cum laboratory building at Tuticorin, girls hostel at headquarters, a modern library with digital server, LAN, online access, computerized issue and return of books and a well developed ATIC ( under NATP) at Cochin.

The major achievements of CMFRI include development and implementation of a multistage stratified random sampling technique for assessing the marine fish landings, development of a strong information base on biology, systematics, population dynamics, fishery characteristics of all major stocks, stock assessment, fishing effort, yield, mortality, resource estimates of unexploited resources in the Andaman and Lakshadweep island ecosystems, biodiversity inventories on endangered and threatened species, database on fishery environmental characteristics, development of hatchery / grow out technologies for shrimp, swimming crab, mussels, oysters, pearl oysters, clams and seaweeds. Recently the Institute has developed for the first time in the world a tissue culture technology for marine pearls using *Pinctada fucata* and the earshell *Haliotis varia.* Another significant achievement was the world second development of the successful breeding technology for the sand lobster *Thenus orientalis.* The Institute also has developed pioneering breeding techniques for about a dozen species of marine ornamental fishes which are being commercialized. The technologies for sea cucumber and rock lobster breeding are nearing completion and would be ready for commercialization. A new initiative is the development of integrated sea farming of mussels and seaweeds in the coastal waters for additional income for farmers. The Institute has also ventured into the new and exciting area of open sea cage farming of finfish which is expected to open up a new avenue for marine fish farming in the country. The research works on biotechnology, fishery economics, livelihoods and transfer of technology are commendable. The institute also offers masters and doctoral degree courses in mariculture as part of the CIFE's educational programme.

The Perspective Plan presented in this document outlines the strategy for research by the Institute for the period up to year 2025 in the areas of marine capture fisheries and mariculture. In the face of the changing national and international marine capture fisheries and mariculture scenarios, the approach to resolve the researchable issues were categorized under three sections: basic research, strategic research and anticipatory research. Thematic areas and specific activities were identified in each of these areas and time frame outlined after prioritization. Under basic research, thematic areas outlined are mariculture technologies and marine resources. In these areas the specific programmes include biotechnology, biodiversity, fisheries environment. Under strategic research the thematic areas are marine resources, capture fisheries and mariculture. The specific

activities are in fishery environment, modeling and management, assessment and monitoring, extension and economics, hatchery technology, biotechnology, growout, pearl production and mariculture systems. Under anticipatory research, the thematic areas are capture fisheries, mariculture, fisheries management and socio-economics. The specific activities are conservation of fishery environment, trade and policy and biotechnology. This document projects altogether 68 specific research issues for the next 20 years, 7 in basic research, 49 in strategic research and 12 in anticipatory research.

It is expected that by meticulously following the research agenda outlined in this Vision 2025 document, marine capture fisheries and mariculture scenario will contribute much better and proactively result in furthering the cause of overall marine fisheries development in the country.

.....

# 1. PREAMBLE

India, endowed with a long coastline of 8,129 km, 0.5 million sq.km of continental shelf, 2.02 million sq.km of EEZ has a catchable marine fishery potential of 3.93 million t. The marine fisheries sector in the country plays a very prominent role in providing protein rich food to the increasing population, employment generation and foreign exchange earning. India occupies the fourth position in World marine fish production and is one of the leading nations in seafood export. Besides, the vast areas all along the coastline offer ideal sites for seafarming and coastal mariculture. The present marine fisheries scenario is characterized by declining yields from inshore waters, increasing conflicts among different resource users, increasing demand for fish food for domestic consumption and export and prospects for value addition, seafarming and coastal mariculture. This calls for a much stronger R&D base to be able to evolve suitable action plans for sustaining the marine fisheries and increasing production through diversification and through new initiatives of mariculture development.

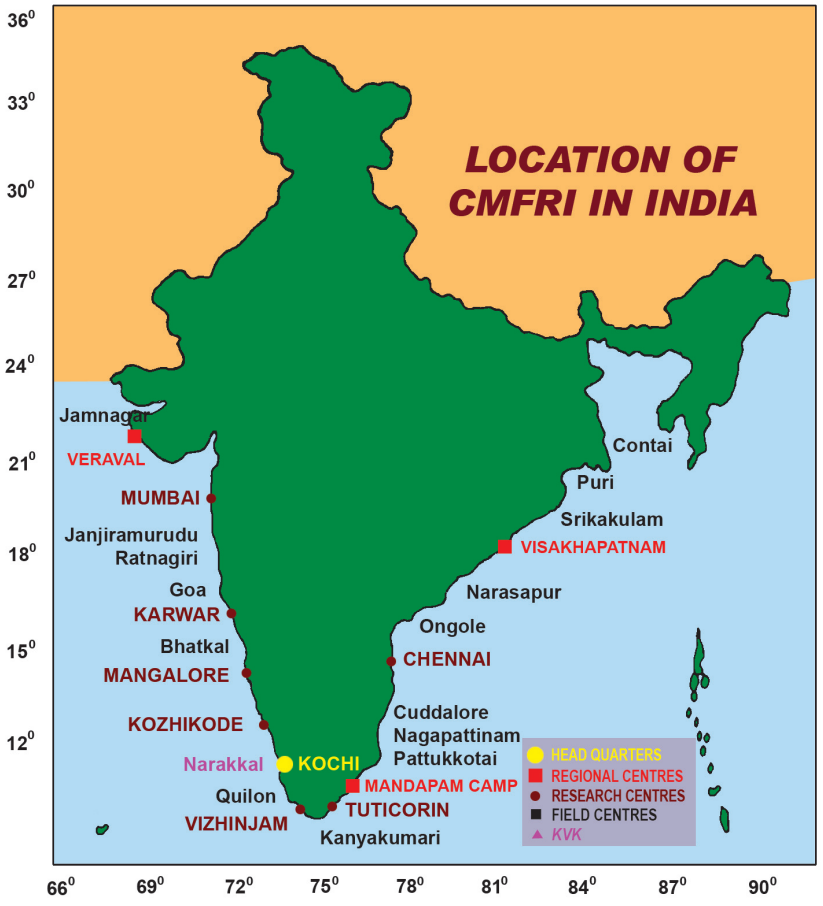
The proposal for establishing various Central Fisheries Research Institutes, under the Union Government, was first made in 1943. The Fish Subcommittee of the Policy Committee on Agriculture and Fisheries in its report in 1945 endorsed this proposal. Subsequently, on the basis of the 'Memorandum on the proposed Fishery Research Institute' submitted by Lt. Col. R.B. Seymour Sewell in 1946, the Central Marine Fisheries Research Institute (CMFRI) was established on the 3rd February 1947 by the Government of India under the Ministry of Food and Agriculture with headquarters at Madras which was shifted to Mandapam Camp in 1949 and thereafter to Cochin in 1971. In 1967, the administrative control of the CMFRI was transferred to the ICAR.

**ORGANIZATIONAL SET-UP**

The following ten Research Divisions carry out the research work at the Institute. (1) Fishery Resources Assessment Division, 2) Pelagic Fisheries Division, 3) Demersal Fisheries Division, 4) Crustacean Fisheries Division, 5) Molluscan Fisheries Division, 6) Fishery Environment Management Division, 7) Physiology, Nutrition & Pathology Division, 8) Mariculture Division, 9) Marine Biodiversity Division and 10) Socio-Economic Evaluation and Technology Transfer Division. The Director, with whom all administrative and financial powers regarding research and management of the Institute are vested, heads the Institute. He is assisted by a Senior Administrative Officer, Administrative Officer and Assistant Administrative Officers in matters relating to general administration and Sr. Finance & Accounts Officer and Assistant Finance & Accounts Officer for looking after the financial accounting and also internal audits of the Institute.

The Institute has Regional Centres at Mandapam Camp, Visakhapatnam and Veraval and Research Centres at Mumbai, Karwar, Mangalore, Calicut, Vizhinjam, Tuticorin and Chennai and 15 Field Centres (9 along east coast and 6 along west coast). Regional and Research Centres are also ably supported by sufficient administrative machinery. The Headquarters at Cochin coordinates the entire activity.

The Technical Cell monitors and streamlines all the intra-Council correspondences and with all the external agencies in all matters relating to scientific and technical aspects. There are two Project Monitoring and Evaluation Cells. The Priority Setting Monitoring & Evaluation Cell (PME Cell) manages and maintains database on in-house projects, effectively monitors the progress of the research projects and analyses the inputs and outputs and advices the Director as well as reports the progress of work periodically to the Council. The External Research Project Review Cell (ERPRC) monitors all externally funded projects of the Institute and all reports and project outputs.




## MANPOWER

The sanctioned staff strength and the shortfall (in parentheses) of the Institute as on 31.3.2006 is Scientist 189+1 (-67), Technical 331 (-3), Ministerial 153 (-4), Supporting 263 (-26) and Auxiliary 6.

Over the period of over half a century since its inception, the CMFRI grew significantly in its size and stature and built up a fairly adequate research infrastructure and recruited suitably qualified R&D staff. The Institute's multidisciplinary approach to research in marine capture and culture fisheries has won the recognition as a premier Institute comparable to any well-established laboratory in the U.K., the U.S.A., Canada, Germany, France and Japan. During the first half of the six decades of its existence, the CMFRI devoted most of its research attention towards the estimation of marine fisheries landings and effort, taxonomy of marine organisms and the bio-economic characteristics of the exploited stocks of finfish and shellfish. This research effort contributed significantly to marine fisheries development from a predominantly artisanal, sustenance fishery till the early sixties to that of a complex, multi-gear, multi-species fishery of industrial status. During the beginning of the second half of this 60-year period *i.e.*, by the early seventies, the CMFRI realized that capture fisheries production alone would not be sufficient to meet the nutritional requirements of the growing population. It became very clear that there was need to supplement capture fisheries with production from coastal mariculture and sea farming. Consequently, a major part of the R & D activities were focused on seafarming and coastal mariculture. The effort made over the past quarter century has paid rich dividends in the form of viable technologies for hatchery production of seed and aquacrops through the farming of shrimp, edible oyster, mussels, clams and pearl production through pearl oyster culture. Besides, development of human resources in mariculture was successfully carried out through a Centre of Advanced Studies which was later named as Postgraduate Programme in Mariculture, offering Masters and Doctoral courses in mariculture. Presently this programme is under CIFE (ICAR) Mumbai, a Deemed University.

With the infrastructure and expertise built over half a century in place and realizing its role, the CMFRI is committed to the cause of marine fisheries of the country. Taking note of the growing demand for seafood in the domestic and export markets, the near optimal (or sub-optimal in certain cases) exploitation of stocks in inshore waters and the potential yield from the EEZ, the Institute realized the imperative need to intensify research in marine capture and culture fisheries including the frontier areas (biotechnology and genetic engineering) of critical importance to increase and sustain production. It is with this background that the CMFRI prepared this document on the Perspective Plan for the ensuing 20 years. The impressive database created, the achievements made and the current international and national marine fisheries scenarios, the needs felt by the sector in the light of the National Agricultural Policy, constitute the basis for the preparation of this Perspective Plan.

.....

## 2. MANDATE

- To undertake basic, strategic and applied research in marine fisheries and mariculture.
- To monitor and assess the fisheries resources of the Exclusive Economic Zone (EEZ) and to understand the stock and its dynamics in relation to environment and human interventions.
- To develop and commercialize hatchery and production system technologies for finfish, shell fish and other commercial marine organisms in coastal and open seas.
- To build up database on marine biodiversity, carry out research on fragile marine ecosystems for their conservation and restoration.
- To undertake research on utilization of potentially beneficial marine organisms.
- To act as a repository of information on marine fishery resources with a systematic and analytical database for policy interventions and to carry out research on social and economic costs and benefits of marine fisheries.
- To conduct front line demonstrations and training to develop human resource for R&D in capture fisheries, mariculture.
- To create awareness and provide training and consultancy services.

# 3. GROWTH

## 3.1. INFRASTRUCTURE

### 3.1.1. Laboratories

The laboratories at the Headquarters, the Regional Centres and the Research Centres are fairly equipped with necessary basic facilities. Atomic absorption spectrophotometer, amino acid analyzer, gas chromatograph, HPLC, PCR thermocycler, gel documentation system and Twin-screw extruder are the other major facilities at the Headquarters. A transmission-cum-scanning electron microscope has also been installed at the Headquarters.

### 3.1.2. Library

The Institute has its central library at Cochin, while the Research Centres have sectoral libraries catering to their immediate needs. The central library has over 65,000 books, periodicals and reports. A total of 78 foreign and 41 Indian periodicals are subscribed, besides receiving 190 periodicals on exchange or complimentary basis. The central library has good documentation and reprographic facilities and on-line facility for accessing source of the major research journals dealing with fisheries research including mariculture. The library at the Regional Centre at Mandapam Camp possesses some of the rare and old publications on marine sciences and fisheries, besides a large number of periodicals (both Indian and Foreign) and textbooks.

### 3.1.3. Field

#### A. Marine fish farms

**Mandapam Camp:** A marine fish farm of 3.8 ha area and a lagoon of 227 ha are available for mariculture activities at the Regional Centre, Mandapam Camp.

**Tuticorin:** A marine fish farm having 2.5 ha water spread is available at the Tuticorin Research Centre.

**Narakkal:** The 4.0 ha KVK Campus at Narakkal has 4 ponds each of 0.1 ha, besides an open wild watershed of about 2.0 ha.

**Chennai:** A shellfish hatchery is functioning in an area of 1.5 acres at Kovalam near Chennai.

**Calicut:** An area of 1.22 ha which has been partly developed into a marine fish farm of 5 ponds, each of 0.25 ha is now being fully developed into a modern hatchery system of 5 broodstock ponds of various sizes and hatching & rearing facilities.

#### B. Wet-laboratories and hatcheries

Onshore hatchery-cum-culture facilities have been developed at Visakhapatnam and Calicut. Three bivalve hatcheries, one each for pearl oyster, edible oyster and clam at Tuticorin and one shrimp hatchery at Mandapam are available. A Marine Research Aquarium has also been commissioned at Calicut.

### 3.1.4. Buildings

The Headquarters, the Regional Centres at Mandapam Camp, Veraval and Visakhapatnam and the Research Centres at Mumbai, Karwar, Calicut, Tuticorin and Chennai are housed in the Institute's own buildings. The other Research Centres (Mangalore and Vizhinjam) are functioning in rented buildings. Residential quarters and guesthouses are available at Mandapam Camp. Residential accommodation to a limited extent is available at Cochin, Calicut and Visakhapatnam.

### 3.1.5. Any other

**Vessels:** There are two vessels (*Cadalmin*) of 13.26 m OAL one each at Cochin and Tuticorin and a smaller vessel at Mandapam. These vessels carry out trawling and assist in the collection of hydrographic and plankton data from inshore waters.

**Vehicles:** The Institute is adequately supported for its field programmes at different Research Centres and Headquarters with 23 jeeps, a mini lorry and a staff car. For training purposes a minibus is also available.

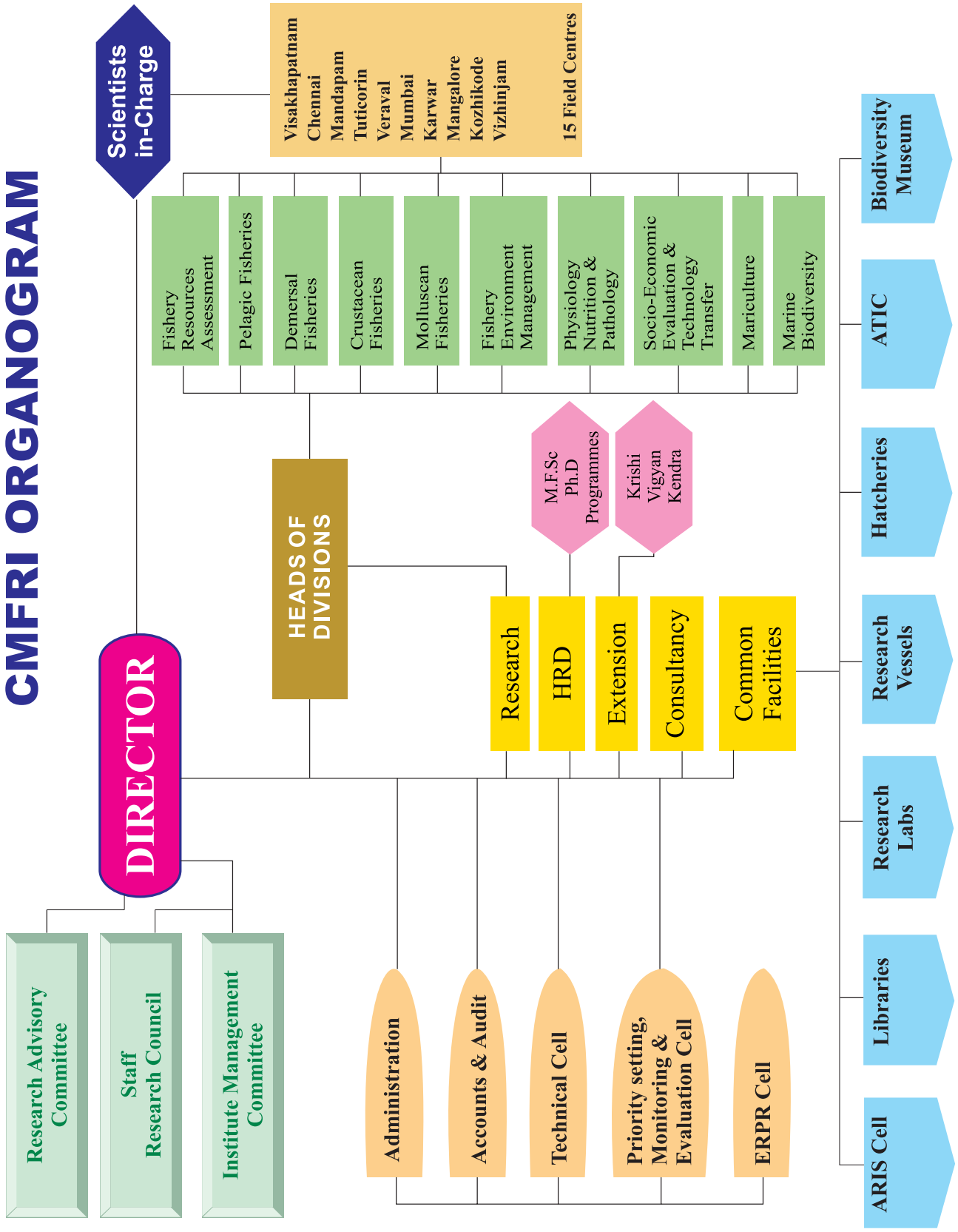
### 3.2. BUDGET (Rs. in lakhs)

| Plan | Period | Plan | Non-Plan | Total | Percentage increase over the previous 5-Year Plan |
|---|---|---|---|---|---|
| IX | 1997-2002 | 1784.85 | 6617.77 | 8404.62 | 92.5 |
| X | 2002-2007 | 2715.00 | 8810.00 | 11525.00 | 94.32 |
| Projected XI | 2007-2012 | 4500.00 | | | |

### 3.3. MANPOWER

| *Category* | *Staff Strength as on 31.03.2006 including KVK, Narakkal* | | |
|---|---|---|---|
| | *Sanctioned* | *Filled in* | *Vacant* |
| RMP | 1 | 1 | Nil |
| Scientific | 189 | 122 | 67 |
| Technical | 331 | 328 | 3 |
| Administrative | 153 | 149 | 4 |
| Supporting | 263 | 237 | 26 |
| Auxiliary | 6 | 6 | Nil |
| **Total** | **943** | **843** | **100** |

The sanctioned strength of Scientists (excluding Director) during the IX & X Plan is 189.


CMFRI ORGANOGRAM
DIRECTOR
Scientists in-Charge
Visakhapatnam
Chennai
Mandapam
Tuticorin
Veraval
Mumbai
Karwar
Mangalore
Kozhikode
Vizhinjam
15 Field Centres
Fishery Resources Assessment
Pelagic Fisheries
Demersal Fisheries
Crustacean Fisheries
Molluscan Fisheries
Fishery Environment Management
Physiology Nutrition & Pathology
Socio-Economic Evaluation & Technology Transfer
Mariculture
Marine Biodiversity
HEADS OF DIVISIONS
M.F.Sc Ph.D Programmes
Krishi Vigyan Kendra
Research
HRD
Extension
Consultancy
Common Facilities
Research Advisory Committee
Staff Research Council
Institute Management Committee
Administration
Accounts & Audit
Technical Cell
Priority setting, Monitoring & Evaluation Cell
ERPR Cell
Biodiversity Museum
ATIC
Hatcheries
Research Vessels
Research Labs
Libraries
ARIS Cell

# 4. SALIENT RESEARCH ACHIEVEMENTS

## 4.1. CAPTURE FISHERIES

- 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 Institute has developed and tested software for statistical analysis of marine fish landings. The marine fish production in the country was estimated as 0.5 million tonnes (mt) in 1950 and it rose to 2.7 million t in 1997 and declined to 2.59mt in 2002-03, increased to 2.58 mt in 2003-04 and further declined to 2.38 mt in 2004- 05. The Agricultural Research Information Service (ARIS) and the MFIS published every quarter by the Institute disseminate information on fisheries to user agencies. The country occupies an enviable position among the maritime countries of the world for possessing such time series data on exploited marine 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. The results of detailed analysis of data on marine fisheries resources and their exploitation in different maritime States have been brought out as a compendium for distribution to all national and state policy makers and administrators.

- 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.

- **Potential fishing grounds** were identified through onboard surveys in the Exclusive Economic Zone (EEZ) of the country including island territories and suggestions for the development given.

- Based on the 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 were 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.

- **Fluctuations in abundance of oil sardine** fishery based on analyses of time series data on rainfall, sea level and sun spot activity have been explained.

- The pattern of **migration of oil sardine** charted out indicating shoal movements of various size groups of fishes in space and time.

- A generalized **estimator for total mortality** was developed under finite exploitation phase.

- Quinquennial Frame Surveys were conducted for updating information on **fisherfolk population, craft, gear** and other details, which form a basis for Central and State policy makers.

- Database on distribution of a large number of exploited species of pelagic and demersal fishes,

crustaceans and molluscs in space and time, their **biological characteristics and yields** were developed. This information is of vital importance in making stock assessment studies.

- The stocks and their levels of exploitation in respect of different commercial fisheries of finfish and shellfish in the presently exploited grounds have been determined on the basis of effort and catch data, biological parameters and primary production. **Stock estimates of nearly 50 species of finfishes** have been published.

- **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.

- Charted out the primary and secondary production, distribution, availability and potential of **conventional and non-conventional resources** and environmental parameters in the EEZ and contiguous seas through vessel based surveys (R.V. *Varuna*, FORV *Sagar Sampada* and Fishing vessels of FSI and CIFNET)

- Institute has played a major role in assisting the Govt. of India in formulating a **Comprehensive Marine Fishing Policy** to be implemented in the coming years. Also communication tools meant for Responsible Fisheries Extension Module (RFEM) have been designed, validated and disseminated. Besides, the **FAO Code of Conduct for Responsible Fisheries** was translated to Malayalam and has been published as a book.

- The **potential yield estimates** of marine fisheries resources in India has been revalidated to 3.934 million t.

- The Institute has comprehensively studied the **highly migratory straddling stocks** of tunas and seerfishes and brought out a book entitled ***Management of Scombroid Fisheries*** containing policy guidelines for exploitation of these oceanic resources.

- **Status of exploited marine fishery resources.** This book is compendium of papers by experts on the status of 22 commercially important exploited finfishes and shellfishes, marine mammals, turtles and seaweeds and has suggested management measures containing policy guidelines for sustainable production.

- **Marine Ornamental Fish Resources of Lakshadweep.** This publication documented 165 species of ornamental fishes with information on the biology and stock of 40 of them from seas around the Union Territory of Lakshadweep. The scientist who worked on this won the most covetous ***Rafi Ahmed Kidwai Award***.

- **Resources of sponges, corals and echinoderms**, which have great potential in the pharmaceutical and industrial applications, have been assessed.

- The annual **standing stock of chanks** in the Gulf of Mannar was estimated as 2 million as against the present production of 1.26 million numbers.

- Determination of **genetic heterogeneity** in marine ornamental fishes like the clown fishes and damsels is another achievement. The population genetic profile of Indian mackerel, oil sardine and Indian white prawn has been worked out.

- Measures stipulated for conservation of **marine mammals, turtles and biodiversity.**

- **Inventorisation** of 270 marine fish species and 240 gorgonid species completed.

- By regularly monitoring the **marine pollution in coastal waters**, the hot spots of pollution and their effects on the marine ecosystem in general and the marine fisheries in particular were assessed through consultancy services.

- **Sea-truth data for the validation of potential fishing z**ones (PFZ) mapped by the NRSA on the basis of remote sensed sea surface temperature, helped to establish a **Marine Remote Sensing Information System** for the validation and dissemination of yield forecast maps to the user communities.

- **FADs and Artificial Reefs:** Observations on FADs in Lakshadweep indicated large scale aggregation/exploitation of juvenile tunas. 250m long and 50m wide artificial reefs were established off Thikkodi, Dharmadom and Muttom, Kannur district, Kerala with the involvement of local fishermen.

- **Socio-Economic analysis** of marine fisheries were carried out on a regular basis. About 56% of the marine fishermen households have ownership and some means of production and about 45% of them are in debt.

### 4.2. MARICULTURE

#### 4.2.1. Crustacean mariculture

- **The culture technologies for shrimp** developed by the Institute as far back in 1975 have led to development of farmed shrimp industry. The area under farming increased from 5000 ha in 1980-81 to 1,40,000 ha by 2000-01. The recent production of **97,096 t** was valued at **Rs. 3,545 crores in foreign exchange.** In total, fifteen species of commercially important shrimps were bred under captivity and their eggs and larvae reared successfully. Hatchery technology was developed and standardized for the Indian white prawn (*Penaeus indicus*) and the giant tiger prawn (*P.monodon*). Breeding, hatchery production and experimental farming of the green tiger prawn *P. semisulcatus* have been carried out with the objective of assessing the farming potential of this species as an alternative to *P. monodon.* 7.5 million hatchery produced post-larvae of *P. semisulcatus* were released in Palk Bay to study the impact of searanching on natural resource augmentation. These technologies were later taken up for research by Central Institute of Brackishwater Aquaculture (CIBA) when it was formed in 1986.

- **Hatchery technology for blue swimming crab:** A hatchery technology developed for seed production of the blue swimming crab (*Portunus pelagicus*) is undergoing refinement for commercial release of the package.

- **Maturation and breeding of lobster:** Developed and standardised the technology for maturation and breeding of the spiny lobster *Panulirus homarus* in captivity by environmental regulation and feed control.

- **Breakthrough - Hatchery production of sand lobsters:** Captive breeding and complete larval rearing of the scyllarid lobsters *Thenus orientalis* and *Scyllarus rugosus* have been successfully achieved for the first time in India. The Institute is gearing up to take a pilot project on the hatchery production and farming of *T. orientalis.*

- **Farming/fattening of lobsters:** A grow-out technology for farming of spiny lobsters in indoor grow-out system has been developed.

- **Consultancy service:** For setting up shrimp hatcheries was rendered to government (Kerala) and private (Andhra Pradesh) organisations. The indoor lobster grow-out technology is being transferred to Rajiv Gandhi Centre for Aquaculture under the Consultancy Service.

**4.2.2. Molluscan mariculture**

- The package of practices for culture of green mussel has been widely adopted. The farms set up at Padanna, Dharmadam, Thikodi, Chellanum, Vizhinjam, Mandapam, Chennai, Mangalore, Karwar and Ratnagiri by the Institute and many private entrepreneurs were highly successful in generating income and employment opportunities especially for women. The Aquaculture Development Agency in Kerala (ADAK) with scientific support from CMFRI has succeeded in extending mussel farming to other areas in coastal villages at Atholi, Chaliyar, Kannur, Beypore, Elathur, Padanna, Patuvam, Payyanur and Purangara. The production of farmed mussels in the state could be increased **from nil in 1996 to 1,250 tonnes in 2002 and 7,500 tonnes in 2005.** It is worth mentioning that the entire produce was from the small-scale farm units.

- The mussel farming technology was extended to farmers in Maharashtra through Konkan Krishi Vidyapeeth (KKV), Ratnagiri. More than 3 women SHGs were formed for implementing the programme. Economic analysis of the demonstration farm indicated that with an investment of **Rs. 25,000, an annual profit** ranging from **Rs.11,000-19,000 could be obtained from a unit area of 200 m$^2$**. Recently this technology has also been extended to shrimp farmers in Goa and fishers in coastal Karnataka.

- **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.

- Packages of practices for **edible oyster culture** were developed. The hatchery at Tuticorin produces millions of spat every year for supply to the farmers. The Institute has demonstration farms at Tuticorin and Kollam. The commercial oyster farms owned by self-help groups at Dalavapuram in Kollam and Kayamkulam are a success story of technology adoption. The annual production is presently over 800 tonnes.

- **Women empowerment:** At Kayamkulam and Ashtamudi lakes, oyster farming in estuaries by **Women Self Help Groups** with the financial aid and support from BFFDA has been successful. For the benefit of planners and state fisheries officials, a manual on oyster culture was prepared.

- Package of practices for **cultured marine pearl production** was developed and standardized.

- 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. Under the ICAR Revolving Fund project, nearly 40,000 nucleus-implanted oysters have been handed over to the **M.S. Swaminathan Research Foundation** for the farmers of Rameswaram Village in Tamil Nadu for the empowerment of fisherfolk.

- **Mabe pearls and make up pearls**: Mabe pearls and make up pearls from the flat oyster *Pinctada sugillata* produced.

- **Breakthrough in tissue culture:** A breakthrough has been achieved by developing a **tissue culture technology** for marine pearl production using the pearl oyster, *Pinctada fucata* and abalone *Haliotis varia* for the **first time in the world**.

- Developed the hatchery technology for cuttlefish, *Sepiella inermis.*

- Juveniles *of Sepia pharaonis,* an export variety cuttlefish were reared upto 10 mm size.

- **Sea Ranching:** Sea ranching of shrimp and molluscan seed at Mandapam, Tuticorin and Kollam also have been found to augment production leading to great economic benefits to the fishermen.

### 4.2.3. Finfish culture

- The Institute has achieved broodstock development, maturation, sex reversal, spawning, fertilisation and hatching of groupers such as *Epinephelus tauvina* and *E. polyphekadion* that have of great demand in the export market.

- The institute has recently ventured into a pathbreaking new area "Open Sea Cage Mariculture" through a new R&D project fully funded by the Ministry of Agriculture. The project envisages installation of 4 open sea cages at Ratnagiri, Diu, Visakhapatnam and Palk Bay (Tamil Nadu). This project is expected to initiate a new era of open sea cage culture of finfish in India and will make a new beginning of increased production from marine farming and lead to an exciting and highly profitable industry of live fish trade.

### 4.2.4. Seaweed culture

- Culture of seaweeds in open coastal waters and its **feasibility demonstrated in the Gulf of Mannar**. Under the ICAR Revolving Fund a project on *Production of agar and sodium alginate from the seaweeds of Gulf of Mannar and Palk Bay* were carried out successfully. Recently the institute initiated a new activity of integrated mussel-seaweed mariculture in the Kasargod area where marine mussels and the seaweed *Kappaphycus* are grown together in coastal waters. This is an environment friendly technology which is making the mariculture operation much more profitable than earlier, resulting in additional income for the SHGs.

### 4.2.5. Seacucumber culture – a breakthrough

- For the first time in the world the Institute has made a **breakthrough in the seed production and larval rearing** of the seacucumber *Holothuria spinifera,* an item of high export demand.

### 4.2.6. Ornamental fish culture

- The Institute has developed technologies for broodstock development, **breeding and larval rearing of marine ornamental fishes such as the clownfish** (*Amphiprion sibae*) and the one spot damselfish *Chrysiptera unimaculata*. Second generation of seahorse (*Hippocampus kuda*) has been produced in captivity. Patent applications have been submitted for the ornamental fish breeding technology.

### 4.2.7. Nutrition, Breeding, Pathology and Genetics

*Feed Technology*

- A simple low cost shrimp feed (***MAHIMA***) was developed and facilitated setting up small scale industry units in central Kerala by 5 women groups. The Institute has also developed **bio-enriched feed for ornamental fishes** incorporating through fermented product and also formulated pellet feed, ***Scylla pushti*** for mud crab fattening which has become popular among farmers.

*Disease Management*

- **Cost effective and rapid duplex PCR kit** for detection of deadly virus of White spot syndrome in shrimps has been developed and the marketing rights transferred to M/S MICROL REMEDIES, Hyderabad. The aqua-clinic provides screening service to shrimp farmers and hatcheries to select virus free shrimp larvae for stocking at the competitive rates using the kit. The kit can be sold at about 30-50% cheaper than the similar PCR kits available in the country.

- **Genetic profile**

  The population genetic profile of Indian mackerel, oil sardine, skipjack tuna and the Indian white prawn has been worked out.

- **The plasmid DNA profile**, cellular protein and genomic DNA finger print of the bacterial pathogens causing major fish diseases have been worked out for rapid identification of the potential disease outbreaks.

- **Development of triploid strains in oyster:** In order to improve the quality of the edible oysters and to exploit the higher growth triploid strains have been produced through cytogenetic manipulation.

### 4.2.8. Environmental Impact Assessment

The Institute has submitted an Expert Technical Report on Assignment to work out applicability of **Precautionary Principle and Polluter Pays Principle** in coastal shrimp farming – to **Aquaculture Authority of India**. Marine pollution risk assessments along the Indian coasts and identification of hotspots is carried out particularly along Gujarat, Karnataka and Tamil Nadu coasts.

**4.2.9. Consultancy Service** (dovetailing research with industry): Over the years the Institute has been able to undertake over 71 consultancies generating an income above Rs.3.6 crores. Our clients include Multinationals, Central and State Government Departments, Public sector undertakings, Private sector and individual entrepreneurs from within the country and abroad. The consultancies services were provided under various disciplines within the mandated areas of the Institute led by concerned expert scientists and technical associates. The major areas where successful consultancies were taken up and the type of clientele during the last five years are as follows.

**Subject wise Consultancy Projects of the Institute**

| Major areas of consultancies offered | Amount (Rs.) |
|---|---|
| Environmental Impact Assessment | 2,57,85,177 |
| Marine aquarium/ Oceanarium projects | 24,73,000 |
| Training programmes | 10,18,179 |
| Mariculture | 18,99,760 |
| Marine catch data analysis | 2,81,774 |
| Under water/ Diving studies | 4,79,000 |
| Biodiversity studies | 12,40,000 |
| Socio economical Studies | 3,81,004 |
| Artificial reefs | 24,26,923 |
| Specimen identification | 1,30,704 |
| **Total (71 nos.)** | **3,61,15,521** |

**Client-wise Consultancy Projects of the Institute**

| Sl. No | Category | No of clients |
|---|---|---|
| 1 | International agencies | 3 |
| 2 | Government agencies | 15 |
| 3 | Public sector agencies | 9 |
| 4 | Private sector agencies | 22 |

### 4.2.10. Extension programmes carried out on

- Transfer of Technology (ToT) – various hatchery and culture technologies developed by the Institute
- Fishermen – Farmers- Industry – Institution Meets with participation of fishermen and officials from R&D agencies
- Women empowerment
- Lobster conservation programmes
- Alternate livelihood for women in the Gulf of Mannar through M.S. Swaminathan Foundation
- Community mariculture programmes for women self help groups
- Awareness programmes for conservation of juveniles
- Institute-Village-Linkage Programme
- Agriculture Technology Information Centre (ATIC)

### 4.2.11. Support to Government / Policy Issues

The CMFRI has been performing duties as the nodal agency for marine fisheries policies of the country. It has served/ is serving to help the following agencies in policy making.

- Revalidation of potential yield from EEZ (MoA)
- Marine Fishing Policy (MoA)
- Marine Products Export Development Authority (MoC)
- Exotic Species Committee (MoA)
- Biodiversity Committee Western Zone (MoEF)
- National Coastal Zone Regulation Authority (MoEF)
- Island CRZ Committee (MoEF)

- Kerala Coastal Zone Management Authority (GoK)
- Kerala Backwater CRZ Committee (MoEF)
- Kerala Biodiversity Council (GoK)
- Pearl Mariculture Policy (MoA)
- Mussel Farming Action Plan (GoK)
- Marine Mammal Conservation (MoEF)
- Tuna Advisory Committee (MoA)
- Coral Reef Ecosystem Conservation (MoA)
- Impact of Monsoonal Trawl Ban (MoA)
- Impact of Monsoonal Trawl Ban (GoK)

### 4.2.12. International Recognition

Important recognition for CMFRI from international agencies include the adoption of the methodology developed by CMFRI for stratified random sampling for catches estimation by FAO.

- Collaborative research project with the WorldFish Center, Penang, Malaysia
- Funding of projects by the IFS, Sweden
- Publication of Bivalve Farming, Success Stories by APAARI of FAO
- Conducting of international training programme on marine pearl culture sponsored by NACA
- Several scientists have worked as consultants to various countries in middle east and southeast Asia
- Conducted international symposia/workshops on:
  - scombroid fishes
  - crustacea
  - mollusca
  - corals and coral reefs
  - coastal aquaculture
  - endangered marine animals; marine parks
  - two workshops on scientific results of FORV *Sagar Sampada*

## 4.3. HUMAN RESOURCES DEVELOPMENT

### 4.3.1 Postgraduate Programme in Mariculture

Under the Postgraduate Programme in Mariculture, since its inception in 1979, organised M.F.Sc and Ph.D programmes. The degrees are awarded by CIFE, Mumbai and Cochin University of Science & Technology.

- Twenty one batches numbering 189 students have been awarded M.Sc/M.F.Sc. degrees in Mariculture.

- 100 candidates were awarded Ph.D degree in various aspects of Mariculture.

- All of the above candidates, trained and qualified in Mariculture were absorbed in R&D organizations, banks, fishing industry, mariculture industry, teaching assignments and research departments.

**4.3.2 Training Programmes**

- **TTC** and **KVK -** a large number of fishers, farmers (nearly 23,000) and officials have been trained in various areas of marine fisheries management, mariculture, home science, animal husbandry and agriculture during 1997-2003.

- KVK organised 1,194 training courses for 22,892 trainees 1997-2003.

- TTC imparted training to 1,847 trainees during 1985-2003.

- 6,960 fishermen in 369 batches were trained in fisheries; 2,274 persons in 105 batches in Animal Science; 2,317 persons in 138 batches in Home Science and 2,175 persons in 101 batches in Crop Sciences.

.....

# 5. IMPACT ASSESSMENT

## 5.1. GROWTH

### 5.1.1. Capture Fisheries

- Fishing in the Indian seas remained restricted to operations by only the artisanal gear and craft in the nearshore waters upto the sixties.
- This situation changed drastically through the subsequent decades by the introduction and popularization of mechanized fishing vessels using trawl nets and motorization of indigenous craft.
- By the seventies, purse seines were also introduced along the southwest coast.
- Increase in our knowledge on the distribution and abundance of fish stocks in different geographic regions and depth zones, led to greater investment in major infrastructure, which in turn resulted in the expansion of the fishing areas and increase in the production.
- With increasing demand for fish and with improved technologies the indigenous fishing craft has been progressively motorized to reach the fishing grounds quickly and to operate gears like the drift gillnets, trammel nets, hooks and lines, ringseines and mini trawls.
- All these developmental activities helped to increase the harvests from about 0.6 million tonnes in 1950 to 2.72 million t in 1997, showing a growth of nearly 400% over a period of about 5 decades. The production from capture fisheries hovers around 2.6 million t per annum warranting effective management of the exploited stocks.

### 5.1.2. Coastal Mariculture and Sea-farming

- The development of technologies for coastal mariculture and seafarming since the early seventies resulted in the rapid growth of this sector particularly from the beginning of the last decade. In the case of marine prawns an estimated 97,096 t of penaeids are annually produced by coastal mariculture operations in an area of about 0.145 million ha (Export value Rs.3,870 crores).
- The technology of bivalve (mussel, edible oyster and clam) mariculture is poised for commercial adoption particularly along the peninsular parts of the country. **Mussel culture** was developed with the active involvement of fishermen and farms were set up at Padanna, Dharmadam, Thikodi, Chellanum, Vizhinjam, Mandapam, Chennai, Mangalore and Karwar by the Institute and many private entrepreneurs. Mussel farming activities were further extended in Kerala with the backing of the Aquaculture Development Agency in Kerala (ADAK), which initiated a new programme on mussel farming with scientific support from CMFRI. The Institute has identified the sites suitable for mussel farming and imparted training to 340 fishers including 180 women in the coastal villages at Atholi, Chaliyar, Kannur, Beypore, Elathur, Padanna, Patuvam, Payyanur and Purangara. From these villages, the ADAK identified villagers and formed 15 groups and provided free materials for construction of farm such as bamboo poles, nylon rope and other necessary items for setting up mussel farms. The production of farmed mussels in the state could be increased **from nil in 1996 to 7,500 tonnes in 2005** is worth mentioning and the entire produce was from the small-scale farm units.
- The seacucumber (*Holothuria scabra* and *H. spinifera*) have been successfully bred under captivity and the hatchery technology developed.

### 5.1.3. Infrastructure and economy

- The country possesses a long coast of 8,129 km and a continental shelf of over 0.5 million sq.km and an EEZ area of 2.02 million sq km.

- There are 3639 marine fishing villages in India and the catches are landed at 2,251 landing centers.

- 6 major fishing harbours 27 minor fishing harbours and 109 modernized landing centers are functioning along the coast.

- About 1.91 lakh non-mechanized craft (including 32,000 motorized craft), 47,000 small mechanized craft and 180 large fishing vessels (presently decreased to 40) are presently engaged in fishing in the Indian seas.

- There are a large number of auxiliary small scale units in the marine fisheries processing sector in the country: a total of 372 freezing plants with 6,600 t capacity per day, 14 canning plants with 52.5 t capacity per day, 148 ice making plants with about 1,800 t capacity per day, 15 fish meal plants with about 330 t capacity per day, 450 cold storages with over 80,000 t capacity per day and 900 peeling sheds with a daily capacity of 2,684 t.

- The number of fishermen engaged in active fishing in the small-scale fisheries sector alone increased from about 6 lakhs during 1980-81 to over 10.25 lakhs.

- The employment generated in the harvest and post-harvest sectors of marine fisheries recorded phenomenal growth over the past few decades.

- The gross capital investment on fishing equipments such as the craft and the gear in the non-mechanised, motorised, small mechanised and large mechanised sectors at current price level is around Rs. 12,000 crores. The marine fish landings during 2005 earned an estimated gross income of over Rs 13,000 crores at the landing centre price level. The contribution of the fisheries (marine & inland) to the net domestic product increased 8 fold during 1980-81 – 1993-94.

- Over 55 varieties of marine products are exported to different countries in Southeast Asia, Europe and USA. The country now earns about Rs.7,500 crores in foreign exchange (2005-06).

The above growth of the marine fisheries sector has led to:

- increased production by expansion of fishing to distant waters to exploit the hitherto underexploited and unexploited resource

- optimal and /over exploitation of many prime fishery resources in the shelf waters upto the 50m depth

- conflicts among different sectors of fishermen

- the realization that responsible management practices are necessary to sustain productivity

- the need for development and further refinement of mariculture technologies

- the need for promoting integrated growth of the marine fisheries sector for effective and faster technology transfer

### 5.1.4. Science

Ever since independence, over the years, the country has registered a steady growth in its expertise in marine fisheries R&D. The education programmes received considerable attention during the last two and a half decades. 13 fisheries colleges under SAUs and a deemed university for fisheries (CIFE**)** under ICAR have been established during the period. The development resulted in the availability of trained manpower atleast partly in different subject areas to carry out fisheries R&D.

The CMFRI has been playing special attention to the development of a comprehensive knowledge base for marine capture fisheries and mariculture since its inception in the year 1947. About 5,700 scientific papers (apart from Bulletins, Marine Fisheries Information Service Series, Special publications, News letters, etc.) have been published so far both in Indian and foreign journals on the basis of multidisciplinary research carried out in the field of fisheries biology, fisheries oceanography, taxonomy, fish stock assessment, fish population dynamics, mariculture and breeding, nutrition, genetics, physiology and pathology.

The knowledge base obtained, the human resources developed and the infrastructure established in marine fisheries R&D since independence have placed India in a prestigious position among both the developing and the developed countries and help address the current and emerging problems of marine fisheries R&D of the country effectively in the ensuing years.

## 5.2. INPUT/OUTPUT ASSESSMENT

### 5.2.1. Input/output assessment in respect of Investment in the capital (development) sector

- The plan outlay for fisheries development in India grew from a modest Rs.513 lakhs in the First Five Year Plan to Rs. 765 crores in the X plan.

- The investment in the marine fisheries sector over all the Plan periods and the developmental activities in this sector led to the development of 6 major and 27 minor fishing harbours and 109 improved landing centres.

- The size of the artisanal fleet grew to 110,000 lakhs, motorized craft to 75,590 and that of the mechanised craft to about 58,910.

- The development in the processing and export sector led to the growth of the industry to 372 freezing plants with a daily capacity of 6,575 t, 14 canning plants with a daily capacity of 52.5 t, 148 ice making plants with a daily capacity of 1788.5 t, 15 fish meal plants with a daily capacity of 329 t, 450 cold storage plants with a capacity of 80,505 t and 900 peeling sheds with a daily capacity of 2,684 t.

- The marine fish production reached the optimum level of about 2.6 million t and coastal aquaculture production to about 1.25 lakh tonnes.

- The earning from export of marine products has increased to Rs. 7,500 crores in 2005-06.

The investment in the capital sector and the developments that have taken place so far, no doubt led to increase in production, exports, employment and to improved living conditions of the fisherfolk, but they have also led to certain economic imbalances and conflicts between those engaged in artisanal and mechanised sectors and between those engaged in coastal aquaculture and fishing sectors, reduction in the area available in the sea per active fishermen or per boat and optimum exploitation in the 0-50m inshore waters.

### 5.2.2. Input/output assessment in respect of investment in the research sector

**A.** There are about 190 Universities in India including the State Agricultural Universities, Open Universities, Deemed Universities and a large number of academic general Universities. Most of the Universities are engaged in some form of research in fisheries. The State Agricultural Universities along the maritime States of India are offering fulltime postgraduate and doctoral programmes in marine fisheries and carrying out research programmes on various aspects of marine fisheries and mariculture. Moreover, the CMFRI, CIFT, CIBA and CIFE under the ICAR are also contributing to research in marine/brackishwater fisheries and HRD in fisheries. The departments of fisheries in certain maritime states like Tamil Nadu, Maharashtra and Gujarat are also carrying out research in marine fisheries and mariculture. The CMFRI published over 5,700 scientific papers apart from bulletins, MFIS, Special publications, News letter, etc. in several areas of marine fisheries and mariculture. All these scientific inputs have significantly contributed to the knowledge and development of technologies for capture, processing, stock assessment to ensure sustained yields, culture of finfish and shellfish and several others in marine fisheries and mariculture and to human resources development.

**B.** The methodology for estimation of marine fish landings, fishing effort and economics of fishing has been developed, improved and standardized by the CMFRI by means of a 'Stratified, Multistage, Random Sampling Scheme' and a database for marine fisheries statistics from all along the country's coasts developed. This database has facilitated the estimation of marine fish landings and fishing effort specieswise, gearwise and district-wise on a quarterly, half yearly and annual basis since 1947. The output from this ongoing study forms the basis for the formulation of various marine fisheries development plans by the governments and the fishing industry, with the prime objective of realizing sustainable production of fish from our EEZ.

**C.** Research on the population characteristics and response of the fish stocks to exploitation, over the years, have led to the framing of appropriate management strategies by the administrators, planners and the industry for the optimum exploitation of the fisheries resources in the inshore waters, regulation of fishing effort by different gears and regulation of the codend mesh size of trawls and other gears in order to ensure sustainable production.

**D.** Shipboard surveys by the national Institutes (CMFRI, NIO, FSI, CIFT, CIFE, CIFNET, CMLRE and IFP) have brought to light the extent and location of under exploited and unexploited fishing grounds in the EEZ together with data on the availability and abundance of both conventional and non-conventional resources in the outer continental shelf which are not presently exploited.

**E.** Inter-Institutional collaboration among the premier national Institutions (NIO, SAC, CMFRI, C-MMACS, IOM, Anna University, ORSAC in the project on "Ocean Related Remote Sensing Programme" through the MARSIS has enabled quick dissemination of PFZ maps to the user community through the government and private agencies. Some of these premier Institutes including the CMFRl and the FSI undertake regular validation of the PFZ maps by means of sea-truth data on sea surface temperature, primary production and by monitoring the catches from the PFZ and non PFZ areas by the commercial fishermen. This system has paved the way for real time prediction of fisheries abundance and instant dissemination of this information to the user communities.

**F.** Research input in mariculture has led to the establishment of a large number of commercial marine prawn/fish farms and hatcheries, particularly since 1990. The development of technologies for breeding, seed production and farming of edible oyster, mussels, clams and pearl oysters, and pearl culture have opened new avenues for mariculture production.

**G.** The initiative taken to develop the human resources for the marine fisheries sector by the national and regional Institutes including the lCAR, the SAUs and the State Fisheries Departments has considerably helped in meeting the trained manpower requirements of the R&D organisations and the industry.

**H.** The national expertise built up by India in marine fisheries and mariculture has paved the way to conducting various International Training Courses in India for the benefit of the international community. For example, the CMFRI undertook an International Pearl Culture Training Course to participants from 10 countries; it rendered the services of an expert as FAO consultant to develop seacucumber culture in the Maldives; provided faculty for FAO/DANIDA/ICAR Workshop on Fish Stock Assessment, and furnished national fish catch and effort data to the FAO for compiling world fish production.

**I.** With the expertise available in the national and regional research Institutes including the CMFRl, several *ad hoc* research projects sponsored by the lCAR, DST, DOD, DBT, DOEF, MPEDA, MOA and State Councils of S&T, several research problems in frontier areas of marine fisheries and mariculture are being investigated almost throughout the country (18 externally funded and 4 NATP projects). These projects have also been useful in HRD, in training young graduates and postgraduates in specialised areas, in reducing the burden on the research Institutes' regular budgets for developing facilities at the respective Institutes and in bringing out valuable information and technologies for marine fisheries and mariculture development and growth.

### 5.3. SHORTCOMINGS

#### 5.3.1.Mariculture

**A.** Although several production oriented mariculture technologies have been developed for several species of molluscs, sea cucumber and seaweeds, they are yet to be adopted on a commercial scale.

**B.** Development of hatchery technology for marine finfish seed production and sea farming has not received due attention mainly for want of proper infrastructure and expertise. However, this research gap is now being bridged through concerted effort in building the basic hatchery and growout complexes in all strategically located areas.

**C.** The prevention, diagnosis and cure of diseases in different culture systems have not received the required importance due to the existence of only very few well-equipped laboratories and expertise.

#### 5.3.2. Capture Fisheries

**A. Lack of berthing facilities and idling fleet:** Although, the track record of the country in marine fisheries infrastructure development has been quite impressive, only 6 major harbours (Roychowk, Paradeep, Visakhapatnam, Madras, Cochin and Sassoon Dock), 27 minor fishing harbours and 109 modern landing centres have been created for a fleet of 160,000 artisanal craft, 32,000 motorized craft and 47,000 mechanised craft. It is a paradox that only 109 modern landing centres have been built so far against a total of 2,251 village landing centres where most of the 160,000 artisanal craft (belonging to 3,638 fishing villages) are beached. The motorised craft are also beached by declamping the outboard engines just before beaching. Owing to the steady growth of the mechanized fleet since the 1960s, currently the artisanal sector contributes only less than 5% to the total annual catch while the motorized sector contributes 26% and the mechanized sector 69%. Although mechanization has paid rich dividends, the problems of declining productivity in the artisanal sector have not been properly addressed.

**B. Management - conspicuous by its absence**: Though several suggestions have been made by the concerned research Institutes on the adverse effects of indiscriminate exploitation in the fishing grounds at the appropriate times, the management in marine fisheries sector has never been satisfactory, leading to clashes between different resource users and overexploitation of certain premium stocks. The shrimp-oriented capture fishery development has been primarily responsible for the present situation of indiscriminate exploitation in the inshore grounds. In certain areas as in Kerala, Andhra Pradesh, Orissa and West Bengal, the exploitation of juvenile shrimps for domestic consumption has resulted in growth overfishing of certain species. Another important issue in the trawl fishery is the large scale discards of finfish by the multi day trawlers resulting in the wastage of precious protein food.

The emergence of ring-seines and minitrawls operated from motorised traditional craft, in conjunction with the growth of purse-seines and reduced mesh size at the bunt codend, along the southwest coast has further aggravated the problems of both growth overfishing and recruitment overfishing of the smaller pelagic and demersal stocks.

**C. Weak vessel-based fishing database**: Marine capture fisheries research demands data on regionwise, seasonwise and depth-wise catch, effort and cost of products and the population characteristics, particularly the changing stock sizes and the optimum yields from them for each species caught, discarded and landed on a continual basis. In the developed countries, much headway has been made in gathering such information and in utilising the same for research leading to better estimates of stock size and effective regulatory measures such as ban on fishing in particular areas and/or seasons, allocating particular regions/areas in the sea for different categories of resource users and for fixing catch quotas. In spite of repeated assertions by the national Institutes, particularly the CMFRI on the need for furnishing the fishing logs by all vessels belonging to the government and private sectors, together with all the data pertaining to each voyage, no headway has been made in this direction. This situation is primarily due to the lack of appreciation among the concerned on the value of this information as well as due to social and political reasons. There is also a lack of appreciation of the value of research in capture fisheries as the most important tool in fisheries management, sustained production and conservation.

**D. Lapses in national catch and effort database**: The collection of landing and effort statistics following the Stratified Multistage Random Sampling Scheme requires a minimum of 5% coverage in order to arrive at reasonably accurate estimates. However, about 2.5% sampling coverage could only be achieved for want of adequate funds and manpower, and apparently due to the lack of recognition of the importance of this work as an integral, inevitable part of research in capture fisheries. The quinquennial survey of fishermen population, landing centres, craft, gears and other capital infrastructure in marine fisheries is essential for the effective implementation of the sampling scheme for the collection of vital statistics in respect of marine fisheries. After 1980, this survey could be carried out only in 2005 due to paucity of funds. Instead, the statistics furnished by the State Fisheries Departments (not based on the requirements of an ideal methodology) are used for all practical purposes.

**E. Marine fishery forecast on real time basis:** The seasonal/periodic/cyclic changes and/or the special phenomena and events occurring in the marine environment play a very vital role in the availability and abundance of fish stocks. Though considerable information on the hydrography, plankton, ocean currents and upwelling is available, attempts to link these characteristics to actual fish abundance in space and time were not properly made due to the lack of effective coordination/ linkages between the different organisations under the Government of India, ICAR and CSIR and due to the lack of adequate vessel facilities and manpower with the national Institutes like the

CMFRI to carry out studies in the entire EEZ of the country on a real time basis. These studies play a key role in forecasting the abundance and availability of fish for the benefit of the fishing industry. Nevertheless, the historical data on oceanography, meteorology and fishery collected through national and international (International Indian Ocean Expedition, FAO/UNDP Pelagic Fisheries Project etc.) effort over the last 50 years are now being used to develop forecast models.

### 5.3.3. Manpower development

Upto about 1980, graduates and postgraduates, mainly in Zoology used to be recruited into the scientific and technical streams of the national research Institutes like the CMFRI and the development streams in the State Fisheries Departments as there were no undergraduate or postgraduate programmes in Fisheries Science in India till then. Over the years, the recruited personnel have been able to acquire adequate knowledge and carry out their assigned tasks. In view of the complex nature of Indian fisheries & aquaculture and of the tropical fish stocks, there is need for specially trained manpower to carry out the various R&D activities in marine capture fisheries and mariculture in the country. The CMFRI, CIFE and the Fisheries Colleges are offering B.F.Sc, M.F.Sc and Ph.D programmes in various disciplines of fisheries including mariculture since the early 1980s. However, there is an urgent need to introduce additional programmes in the frontier areas under marine biotechnology and fish genetics in order to meet the growing demands for these cadres in all R&D and industrial aquaculture activities.

### 5.3.4. ARS disciplines

The recruitment of scientists in the CMFRI through the ARS examination till date, took place mainly through a single discipline Fish and Fishery Science. The scientists thus recruited are carrying out research in all areas of marine fisheries and mariculture whereas considerable expertise in certain very important areas is available in the country which is not properly utilized (due to the lack of recruitment) resulting in poor progress in these areas. Persons with formal training in Oceanography (physical and chemical), Marine biology, Fishery biology, Aquaculture, Environmental sciences, Biotechnology, Bioinformatics, Information Technology, will be able to carry out the research programmes in these related areas more effectively than those without such training. There is a genuine feeling that Fishery Science, in contrast to Agriculture and Animal Sciences, in the ARS system of ICAR is stagnating with highly unbalanced recruitment policy resulting in the retarded growth of fisheries research, which is not justified, particularly when fisheries have to play a key role in protein food security and foreign exchange earning. There is need to introduce these new disciplines in to the institute through lateral entries so as to reposition our research at par with the best in the world.

### 5.3.5. Linkages and working groups

Marine fisheries (research, development and trade) are administered through four different central ministries: (1) the Ministry of Agriculture and its Institutes (FSI, lFP, CIFNET, CICEF, Aquaculture Authority and NFDB), the DARE and the ICAR Institutes, (2) the Ministry of Earth Science (CMLRE, NIOT), (3) the Ministry of Science and Technology together with the DST, DBT and the CSIR Labs like the NIO & CSMCRI and the Ministry of Commerce together with the MPEDA. At the state level, the SFD, Fisheries Colleges, some academic universities and the fisheries departments administer the R&D of the fisheries sector. Any set up like this, in the absence of any mandatory linkages, may cause hurdles/bottlenecks in the process of development besides often resulting in the duplication of effort. While such arrangement may be necessary for administrative convenience and quick disposal of matters, atleast all the activities related to marine fisheries should be brought under the control of one independent agency as for example “Marine Fisheries Research and Development Authority” to be wholly manned by scientists, while maintaining the present system of governance. There is a growing feeling that working scientists are often not involved in science policy making. For the effective flow of information

and knowledge, working groups from among the interested ministries and organisations should be constituted, defining their roles and responsibilities.

### 5.4. LESSONS LEARNT, SUGGESTIONS AND OPTIONS FOR THE FUTURE

#### 5.4.1. Mariculture

**A.** ***Improvement of mariculture technologies***: The outbreak of diseases in coastal shrimp culture systems during 1994 and 1995 has resulted in heavy mortality of the crops and hatchery seed. Lack of adequate feed formulations and dearth of feed manufacturing units led to large scale utilization of expensive imported feeds. There is urgent need to develop improved technologies for the production of good quality shrimp feed and marine fish/shrimp feed. In view of the shortage of animal protein like fish meal, its replacement with vegetable protein deserves consideration. Research on physiology, nutrition, pathology, genetics and endocrinology of cultivable species has not been given due importance.

**B.** ***Finfish breeding***: While the technology of breeding and seed production of molluscs and shrimps has been developed and standardised, the same for marine finfish is not yet available. In the context of increasing demand for certain species of finfish in both the domestic and export markets, there is urgent need to develop technologies in this direction. The CMFRI has taken action to establish the required hatchery and growout infrastructure for seed production of groupers, snappers and breams. Action has been taken for pilot scale farming of these fishes in the Mandapam, Tuticorin and Narakkal marine fish farms of the CMFRI.

#### 5.4.2. Capture Fisheries

**A.** ***Diversification of shrimp trawlers***: The mechanized shrimp trawlers, remaining idle today, need to be upgraded for oceanic tuna fishing (using 1000 m longlines and 800 m gillnets) and groundfish fishing (using lines). Floating marina type berths will have to be created off as many coastal fishing villages as possible in support of this programme.

**B.** ***Fisheries management***: The demand even for small prawns in the export market has resulted in the use of gears with small meshes, which also catch large quantities of young ones of other commercial species. Such indiscriminate fishing in the inshore waters needs to be curtailed so as to prevent growth overfishing. Undersized live lobsters are fished and exported though the Government has stipulated minimum legal size for export based on the scientific advice from CMFRI. The CMFRI will focus greater attention to this important aspect in its research and extension activities, and strongly take up this issue with the state governments, the fishing industry and the community in order to make the implementation of the prescribed measures of management more effective. The media as well as extension literature in local languages and video shows in villages will be used as tools to bring about changes in the attitude of the fisherfolk.

**C.** ***Marine fisheries database***: The nature of fishing and landings, the accessibility to the various landing centres along the coastline of the country and the restricted availability of funds, resulted in inadequate (2.5%) coverage of collection of fisheries statistics, which among other things, is a major requirement in carrying out the R&D activities in marine capture fisheries. The CMFRI endeavour in this regard is to increase the sampling coverage to at least 5%. In order to improve the quality of the database and to frame effective management measures, the CMFRI will initiate discussions with the fishermen, the boat owners and various private and government organisations to impress upon them the need to furnish fishing logs and data of each voyage to the CMFRI. In some countries, the marine fish landings and effort data are fully furnished to the governments/

concerned agencies in the form of log sheets and there is lot of saving on expenditure and more reliable data are obtained.

**D.** ***Marine environment monitoring for fishery forecast and for ocean health*****:** Realizing the importance of elucidating the relationship between fishery independent factors and fish abundance, the CMFRI is giving greater emphasis for monitoring the various fishery oceanographic and meteorological parameters and their impact on the availability and abundance of fish stocks in different regions for different periods. Based on these studies, fishery forecast models have been built and forecast of yields from various stocks along the Malabar coast has been made.

Untreated effluents from several industries and fly ash from coastal thermal power plants pose great threat to the marine life, particularly in the inshore waters and therefore to the mariculture systems. Pollution monitoring in the coastal waters is given priority attention in the CMFRI while at the national level the DOD has been implementing this programme through 10 national and state Institutions under the COMAPS programme.

### 5.4.3. Human resources development in marine capture fisheries and frontier areas in mariculture

Adequate attention has not been paid to the development of human resources in the area of marine capture fisheries research in general and in stock assessment in particular, mainly due to the belated realization of the importance of this study in tropical marine fisheries management. In order to ensure sustainable yields from the exploited stocks, manpower development in this area should receive greater attention. The CMFRI with its expertise can implement the programme at Masters and Doctoral levels. Similarly, frontier areas in mariculture (biotechnology, genetics, nutrition, physiology, pathology and endocrinology) deserve to be accorded postgraduate status, following the system in vogue in agricultural and animal sciences.

### 5.4.4. Introduction of new disciplines in ARS

The lack of adequate number of scientists (totally absent in certain areas) to carry out research in Oceanography, Marine Biology, Fishery Biology, Aquaculture and Fisheries Statistics coupled with increasing problems in these areas are threatening to jeopardize marine fisheries research in the country. The CMFRI would propose these disciplines to the ASRB and the ICAR for their consideration and recruitment. Some of the posts of “Fish and Fishery Science” discipline could be diverted to meet this recruitment needs. The CMFRI would also introduce these disciplines in their education programmes.

### 5.4.5. Technology transfer

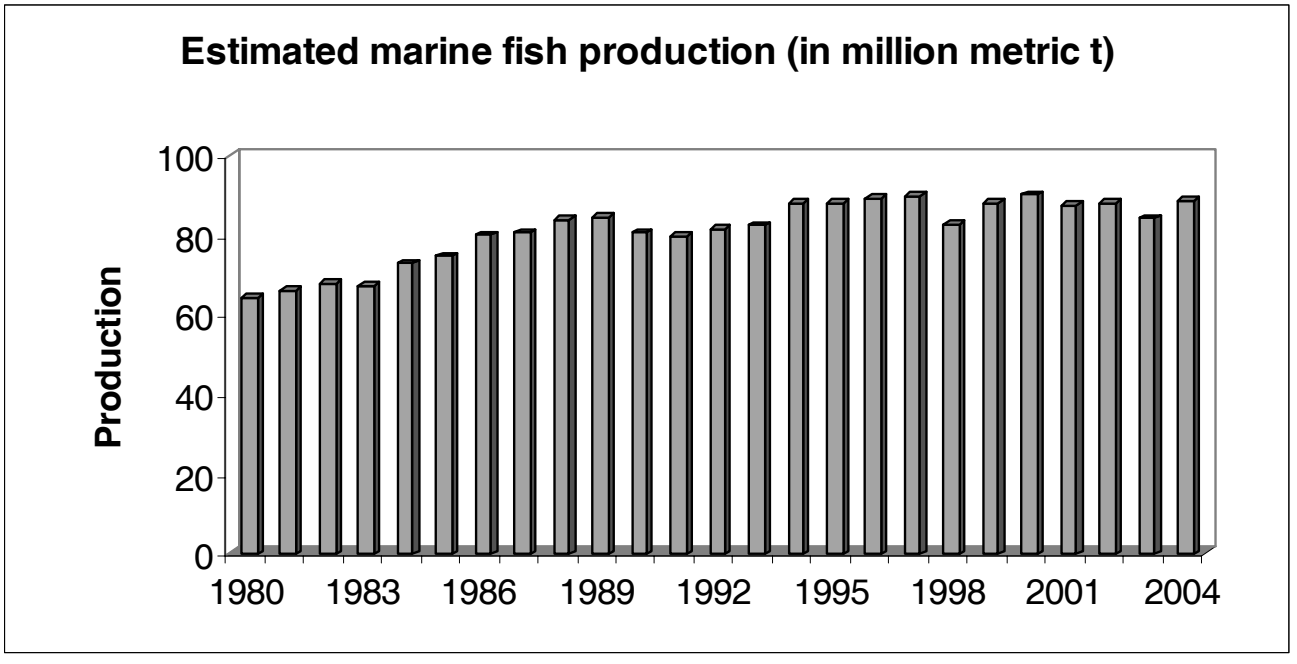
The results of research on both capture and culture fisheries and the technologies, which have emerged, have not been effectively transferred to the endusers. Fisheries extension needs to be expanded manifold in the coming years through the active involvement and participation of the fisheries departments, research Institutions, Universities, NGOs and the industry including the fisher folk community.

.....

# 6. SCENARIO (National *vis-à-vis* International)

**Capture Fisheries – International Scenario**

According to the FAO, food insecurity in the developing world is a serious problem, with about 7,800 million people living on food that does not help maintain a healthy life. A study by M. Garcia of IFPRI (1994) reveals that the protein energy malnutrition is responsible for 56% of child deaths in 53 developing countries. If these trends continue, the cases of protein energy malnutrition will increase and the number of children affected is likely to be around 200 million by 2020. Increased production and improved availability of fish food, which is a good and cheap source of protein, will help combat protein malnutrition to a very large extent. The present world marine fisheries scenario, however, is in a crisis. Most fisheries are overexploited. Resource management has not been considered seriously or where it is so considered, has failed to restrain the fishermen from exploiting the wild stocks beyond sustainable levels leading to increasing scarcity of fish and, conflicts between different economic or ethnic groups among those engaged in harvesting the wild stocks. The world marine capture fishery production peaked at 86.19 million t in 1989 and declined to 84.25 million t in 1993. The production during 2000 was 86.05 million t and the indications are that this is likely to level off at 100 million t by the year 2025.

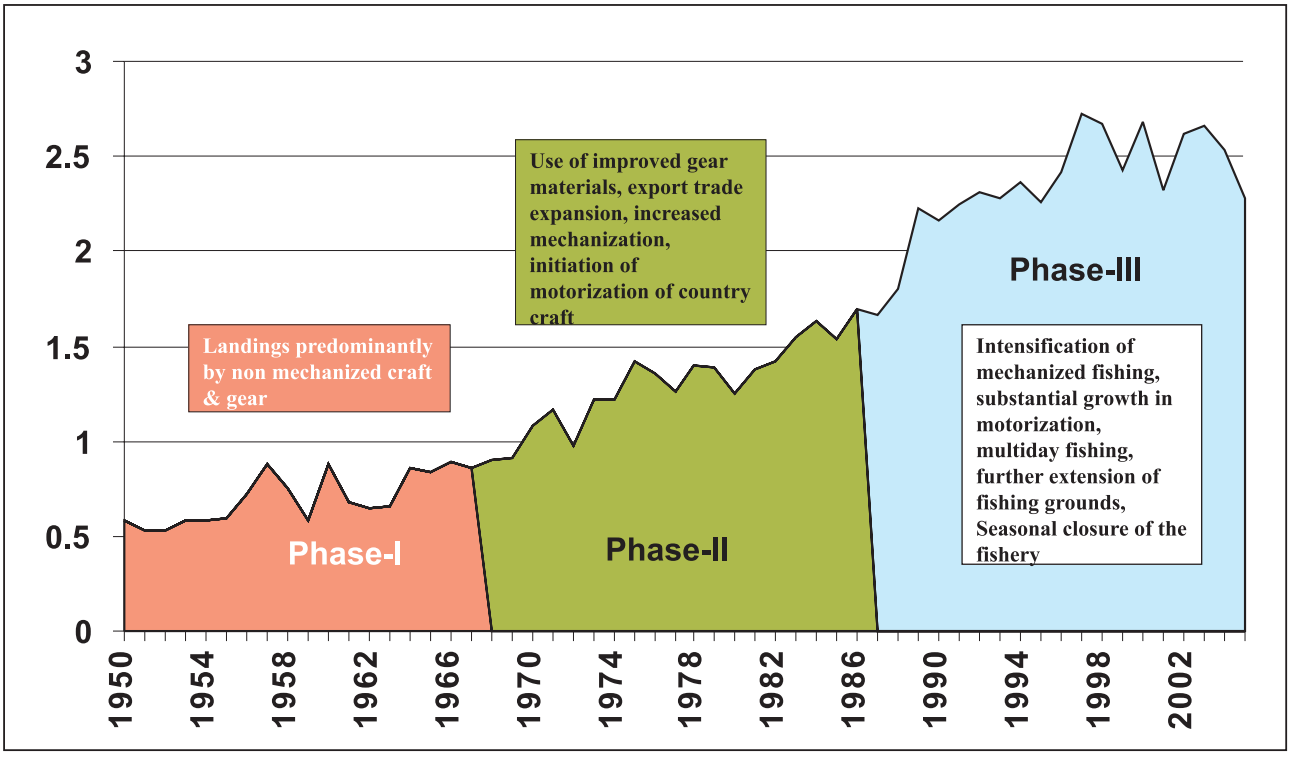



**Capture Fisheries – National Scenario**

The marine capture fisheries scenario in India is not inconsistent with the world situation. With all the technological advancements, innovations and human resource availability and infrastructure development, the annual production reached the 2.3 million t mark in the beginning of the nineties, which showed signs of leveling off immediately thereafter. The annual growth rates were oscillating between -5% and 5% during the past few years. In recent years the production is stagnating around 2.7 million t. The potential yield estimate of 3.9 m t from the Indian EEZ (including 1.7 million t available in the outer continental shelf of which about 0.6 million t is currently taken) offers scope for increasing production from the outer continental shelf. However, it is distressing to note that most of the stocks reported to be available for exploitation in this zone are also distributed in the inshore areas. They are currently exploited from these grounds, suggesting the real potential of atleast some of the resources to be less than what has been projected. This fact, together with the prevailing socioeconomic conditions

in the capture fisheries sector and the policy scenario, suggests that production from capture fisheries could at best be increased by only 5 to 6 lakh tonnes comprising mainly the oceanic tunas, squids and some demersal groups like the threadfin breams, bulls eye and a few others.

**Estimated marine fish landings (million tonnes) in India over different growth phases (1950-2005)**




**Mariculture – International Scenario**

A recent report of the Consultative Group on International Agricultural Research states: 'Within 15 years, fish farming and sea ranching could provide nearly 40% of all fish for the human diet and more than half of the value of global fish catch'. According to a report of the FAO, the world aquaculture production is projected to increase by 2.69 times by 2025, growing from 19.3 m t in 1992 to 26.9 m t in 2000 and to 51.8 m t in 2025. Marine finfish production by farming is expected to increase from 0.36 m t to 1.0 m t, crustaceans from 1.0 m t to 4.1 m t, molluscs from 3.5 m t to 8.9 m t and seaweeds from 5.4 m t to 9.8 m t.

**Mariculture – National Scenario**

With these optimistic projections, India, as a leading country in Asia in aquaculture production, should be able to achieve atleast a production of 2 million t through mariculture by the year 2025, i.e., 3.9% of the projected global aquaculture production of 51.8 m t. Besides, with the improvement in the domestic marketing, diversification of culture technologies and different hydro-climatic zones for the coastal mariculture and seafarming, India is on the threshold of becoming a major player in world mariculture production.

**Population and Fish Food Scenario**

The human population of India by 2025 is expected to be 1.35 billion (World population projections, 2020: D.F. Nygaard, 1994: International Food Policy Research Institute, Washington) which is about

450 million higher than the present. The proportion of fish-eating people in India grew from 27.7% in 1987-88 to 39.7% in 1996-97. Assuming that this proportion will increase to atleast 50%, the total fish eating population in India by 2025 will be around 675 million. Considering the per capita nutritional requirement of fish of 11 kg/year, the total quantity of fish required for domestic consumption will be around 7.4 m t of which at least 4.4 m t has to be realized from the marine sector. This shows that the country needs to produce atleast an additional 2 m t of marine fish for meeting the domestic requirements alone. Besides, in order to meet the increased demand for export and foreign exchange earning, a total of 0.7 m t of marine products will be required. Thus the total increase in marine fish production required to meet the demand by 2025 is around 2.7 m t over and above the current annual production (capture and culture) of about 3 m t. However, the additional scope from the marine capture sector is only to the extent of another 0.5 to 0.6 m t.

Thus, the marine fish vision for 2025 is one of great challenges and the options available are:

- managing the exploited stocks to realize sustainable yields
- harvesting the oceanic and deep-sea fishery resources
- increasing production substantially through seafarming and coastal mariculture, and
- addressing the socio-economic, environmental and conservation needs

## 6.1 STRENGTHS

| | |
|---|---|
| **Sectoral potential** | ➢ The marine fisheries sector is one of the significant contributors to the national economy, food security and livelihood<br>➢ The Indian EEZ has the potential to yield 3.93 million t annually, out of which about 2.7 mt is being harvested annually in the recent years.<br>➢ The sector strives to sustain the livelihood of more than 6 million fisherfolk inhabiting about 3600 fishing villages, of which nearly 1.3 million are actively engaged in fishing, landing their catch in about 1400 landing centers using about 49,000 mechanized, 51,000 motorised and about 77,000 traditional craft.<br>➢ The first sale value realized at the landing centre amounts to about Rs. 14,000 crore annually and export earnings are around Rs. 7,500 crore annually.<br>➢ The Indian EEZ has a wealth of rich marine biodiversity with more than 200 species contributing to the fishery.<br>➢ The rich biodiversity offers great potential for mariculture for food security and livelihood for the coastal rural folk and investment opportunities to entrepreneurs. |

| | |
|---|---|
| **Pioneering advantage** | ➢ One of the oldest research organizations dedicated to marine fisheries research and development in the country<br>➢ Pioneered innovative and need-based research in marine fisheries and mariculture. |
| **Human resources – Core competency** | ➢ Research work in the Institute is manned presently by about 130 scientists whose core competencies are in the multi disciplinary areas of marine fisheries and mariculture.<br>➢ This core group is proficiently supported by an able team of technical assistants and administrative staff. |
| **Wide research network** | ➢ The Institute is multi-locational with its headquarters in Cochin and having 3 regional, 7 research and 15 field centres located along the Indian coastline which enables the Institute to address location specific problems in marine fisheries and mariculture.<br>➢ The Institute has also close linkages for research and capacity building, with reputed R&D organizations within and outside the country. |
| **Infrastructure** | ➢ The Institute has modern laboratories and hatcheries which are well equipped with the state of the art facilities to carry out research in multi-disciplinary areas like fishery biology, marine ecology, hydrography, biodiversity, statistics, marine biotechnology, economics, extension and mariculture.<br>➢ The Institute headquarters and its regional and research centres are housed in secure permanent buildings with provision for staff quarters in many places. |
| **Information advantage** | ➢ Since its inception the Institute has created and maintained a strong database on the various aspects of marine fisheries including biology and production. The data are collected through scientifically designed data collection and acquisition systems.<br>➢ The Institute is thus a repository of all data pertaining to marine fisheries of India.<br>➢ The information emanating or drawn from the Institute's database forms the basis for the R&D activities in the marine fisheries sector of the country and for formulation of national and regional fisheries policies.<br>➢ The Institute has also built up a database on distribution of a large number of exploited species of pelagic and demersal fishes, crustaceans and molluscs in space and time, their biological characteristics and yields. This information is of vital importance in making stock assessment studies. |

| | |
|---|---|
| **Resource monitoring andstock assessment** | ➢ The network of research/regional and field centres has enabled the Institute build up an efficient resource monitoring system to study and explain the dynamics of the exploited marine fishery resources and add information to the resource database<br>➢ Carried out stock assessment of more than 50 species of exploited stocks and estimated various biological parameters including rate of exploitation, standing stock size and the maximum sustainable yield and the optimum rate of fishing.<br>➢ Methods of estimating the vital parameters for stock assessment of tropical marine fish stocks were also developed.<br>➢ The Institute is providing expertise and data for making potential yield estimates of marine fish stocks of the country. Based on new information generated continuously by the Institute these estimates are revalidated periodically. |
| **Mariculture technologies** | ➢ The Institute introduced the concept of mariculture in the Indian sub-continent and over the years it has been able to develop nearly a dozen mariculture technologies.<br>➢ Most of these have been transferred to fishers and entrepreneurs and are under continuous process of refinement and upgradation. |
| **Economics and Extension** | ➢ The Institute has carried out extensive economic analysis of marine fisheries including evaluation of worth of the marine fish landings, economics of different craft-gear combinations, price spread and market dynamics.<br>➢ Dissemination of information on marine fisheries and mariculture is done through various extension activities including industry-farmer meets, village level meetings, training programmes, symposia and exhibitions.<br>➢ Established Agricultural Technology Information Centre (ATIC) as a single window delivery system for the end users. |
| **Revenue generation through consultancies** | ➢ The expertise developed by the Institute in critical areas over the years has been used by the various private, public sector, NGO and governmental agencies in the form of consultancies.<br>➢ During the last 5 years more than Rs.180 lakhs was realized from about 50 consultancies. |
| **Human Resource Development to meet the country's requirement for fishery professionals** | ➢ The Institute conducts Masters (M.F.Sc) and Doctoral (Ph.D) programme in mariculture under its education programme.<br>➢ The Institute also carried out specialized national and international training programmes in marine fisheries research and mariculture. |

| | |
|---|---|
| **Focused vision and proactive management plan** | ➢ Emerging scenario in the national and global context is closely followed and necessary changes in approach, prioritization and delivery are planned.<br>➢ Besides, the Institute follows principles of an informed management action plan with a focus on Management by Objectives (MBO) and Management of Change (MOC).<br>➢ Managing change through organizational cultures and mental modes as well as through people are priorities of the Institute. |

## 6.2 WEAKNESSES

| | |
|---|---|
| **Inadequate staff strength** | ➢ Although the Institute has a sanctioned scientific staff strength of 190, there are only 122 scientists in position. This has affected the pace of research work in certain critical areas of marine fisheries and mariculture, for example, oceanography, bioinformatics and remote sensing. |
| **Gaps in coverage** | ➢ The database on estimated marine fish production in the country which is continuously updated by the Institute through a year-round monitoring programme has a coverage of only 3% as against the recommended 5%.<br>➢ Besides, for several maritime regions of the country like the Gulf of Kutch, Lakshadweep and Andaman and Nicobar Islands, the Institute is constrained to depend on secondary data sources. |
| **Lack of control over national fish stocks** | ➢ Studies made by the Institute have resulted in several recommendations for sustainable marine fish production in different maritime states. However, most of these recommendations are not effectively put to use by the governments through regulations and legislations. This precludes validation of the recommendations made for adaptive fisheries management.<br>➢ There is no effective control and surveillance for marine fish stocks of the country. |
| **Hydrographic data** | ➢ In order to make predictive assessments of marine fish stocks, fishery independent factors including oceanographic data need to be collected and correlated. Over the years the Institute's capability to monitor hydrographic parameters in the seas in relation to fisheries has diminished due to de-commissioning of research vessels without replacement. |
| **Edible finfish mariculture** | ➢ The Institute has not been able to make a commercial model for edible finfish mariculture technologies, while many countries in the Southeast Asia have reported remarkable achievements with the establishment of commercial finfish farms and increase in production. Adequate funding are needed for this. |

| | |
|---|---|
| **Lack of national policy for leasing open access water bodies** | ➢ The lack of a leasing/licensing policy is preventing extensive adoption of mariculture technologies developed by the Institute by entrepreneurs. |

## 6.3 OPPORTUNITIES

| | |
|---|---|
| **CMFRI in a statutory role** | ➢ Similar to International marine fisheries research Institutes elsewhere in the world, the CMFRI has also been mandated to monitor the exploited marine fish stocks in the country and make policy advice to regulate the fishery within sustainable limits. But unlike many of these International Institutions which have regulatory, controlling and statutory authority over stakeholders, the CMFRI's role is limited to offering advice to maritime states which is very often overlooked. The research carried out by CMFRI would become more meaningful and valuable if a statutory role is assigned to CMFRI. |
| **Ecosystem Based Fisheries Management** | ➢ The problems of excess capacity, overfishing, detrimental impacts of fishing on the ecosystem and detrimental impacts of contaminants on the fisheries ecosystems are emerging issues for research throughout the world and the solution proposed by International fisheries experts is a fundamental change in fisheries governance through a new approach called Ecosystem Based Fisheries Management (EBFM). The CMFRI is poised for reorienting its fisheries research following this ecosystem concept. |
| **International collaborative research** | ➢ Under the WTO regime higher level of International collaboration and linkages in research are possible. The CMFRI would opt for such collaborative research, which in turn would help to upgrade the technical competency of the scientific staff. The ICAR on its part should ease the administrative requirements to enable such collaborative research. |
| **Extension of mariculture technologies** | ➢ In recent years, the mariculture technologies developed by the Institute has found new takers in some of the maritime states resulting in increase in mariculture production from nil in 1996 to 8300 tonnes in 2005. These technologies need to be outreached to fishers in other maritime states so that the pace in production increase can be accelerated. |
| **Pipeline mariculture technologies** | ➢ Mariculture technologies need to be developed for species having pharmacological importance. Development of new drugs from marine organisms belonging to lower invertebrate phyla is an emerging area and mariculture technologies for farming of these species will support this nascent industry. |
| **Socio-economic status of fishers** | ➢ Socio-economic status of fishers and their implications and impact in formulation of marine fisheries policy is an area in which more attention will be paid. |

| | |
|---|---|
| **Conservation of stocks through passive methods** | ➢ Conservation of vulnerable marine fish stocks and preservation of biodiversity by identification of marine protected areas (MPAs) in heavily fished and ecologically damaged zones. |

## 6.4 THREATS

| | |
|---|---|
| **Inadequate recruitment of scientists** | ➢ With the average age of workforce in scientific category being above 50 years and with no immediate plans for replenishing the dwindling scientific strength with younger scientists, the threat of senescence in scientific research looms large. |
| **Lack of informed management** | ➢ The Institute's recommendations on management of marine fish stocks are not made into regulations and policies by the implementing agencies. |
| **Destructive gears** | ➢ Many of the gears operated by marine fisheries like trawl, ringseine, *mini trawl*, *dol* net etc. have been documented as posing a threat to the regeneration capacities of resources. |
| **Pollution** | ➢ With increase in industrialization in coastal areas, the health of the seas around India have come under threat of pollution. Initial studies indicate certain hot-spots around our coasts having levels of pollutants above safe levels. |
| **Biodiversity destruction** | ➢ With the increase in discards from multiday trawl operation, there is increasing evidence that many non-commercial groups are facing wanton destruction causing loss to biodiversity. |
| **Stock depletion** | ➢ Due to excessive fishing pressure (recruitment overfishing) on certain stocks for e.g., catfish – stock depletion have taken place along certain regions of the Indian coast |
| **Over capacity** | ➢ In most maritime states fishing fleets have increased in number beyond economic viability and in some cases, it has begun to affect stock sizes deleteriously. |

.....

## 7. PERSPECTIVE

### National goals and targets

The anticipated national growth rate for the XI Plan period is 8.5% against the current growth rate of 7%. The fisheries sector has contributed 1.1 % of the national GDP and 4.7% of the agricultural GDP. In order to ensure a positive growth in the sector, there is need to shift the focus from increasing production to increasing profitability. This paradigm shift in the outlook can result in ensuring sustainability of the resource, resilience of the stock and overall benefits to the sector. Thus, the outlook for future should be to reduce the present overcapacity in the fisheries, better management of the resource through enforcing present and emerging regulatory measures and changing over from a raw material provider of fish to provider of value added fishery products both for domestic and international markets. There is also need to look for alternate sources of protein for the animal feed industry by changing over from the present fish meal to a plant based protein source. The increased pressure on the fishery resources especially on the low value pelagics for the preparation of animal feed thus can be reduced by the altered approach. Further, reduction in bycatch and discards should be a major objective in the resource utilization agenda.

Marine fisheries throughout the world are passing through a critical phase. A recent study by Boris Worm and others (2006) has warned that at the present rate of biodiversity loss and fishing practices, the sea food supply from the oceans will cease by year 2048. However, if appropriate interventions are taken, the trend can be reversed. Indian marine fisheries is also passing through a crisis due to its over capacity and open access nature. Most marine fish stocks are optimally or slightly over exploited. Some stocks have almost disappeared. Marine capture fisheries is essentially a natural resource exploitation and unless the natural resources are carefully managed using scientifically developed management models based on scientific data gathered, sustainability and resource resilience will be uncertain. The problems facing the marine fisheries sector and the need for effective management interventions have been flagged by the Institute through its many publications in the past.

Marine fisheries is an important player in the national GDP, not from its primary share in fish production which is as per CMFRI's estimates is currently to the extent of Rs. 13,000 crores annually at the landing site price. At the secondary level, the income from the fish caught and the extent of employment, nutritional, livelihood and entrepreneurial security is several hundred folds higher. The export earnings from marine products are an example. Currently it is over Rs. 7500 crores annually, which is much above the agricultural exports. The investment in the marine fish capture sector in various types of boats and gear is over Rs. 12,000 crores. The investments in the post harvest handling, chilling, processing, value addition through products and byproducts, storage, transportation, marketing sector run to several thousands of crores of rupees, providing investment, business and employment opportunities. The financial sector has a major stake in marine fisheries as an industrial investment opportunity. Therefore, sustainability and overall development of marine fisheries is a major financial concern in a developing country like India and set back in marine fisheries will lead to compounded setbacks and negative impacts in the economic growth of the country.

All these are possible only through policy interventions, which must anchor on scientific management practices developed through research and field-testing. India has many international commitments such as those in the Convention on Biological Diversity (CBD), FAO Code of Conduct for Responsible Fisheries, UNCED, WSSD, UNFSA, International organizations / Instruments such as IOTC, ICES, WWF, Reykjavik Declaration. India is also committed to rollback its marine fish stock position to the levels of 1985 by year 2010.

Thus, CMFRI has a major responsibility in developing the basic tools in marine fisheries and biodiversity management for ensuring sustained development, exploitation, nutritional and livelihood securities of

the people dependent on marine fisheries. These challenging but paramount roles are envisioned to be addressed as below:

**Ensuring sustainability through management interventions**

Sustainability is the basis of any natural resource targeted for commercial exploitation and marine fisheries in that respect pose many challenges in view of its widespread, migratory behaviour of the fish stocks and fish shoals, differential dynamics of fish stocks and varying nature of its vulnerability and accessibility to many types of fishing craft and gear. Resolving the sustainability concerns are yet a difficult task as the resources are invisible and direct estimates of the stock size is impossible. Thus a lot of primary data and application of specifically designed models are to be used in designing approaches for ensuring sustainability. Such management interventions call for generation of primary data on the fishing effort, catch or yield of various species from the different types of craft/gear and its seasonalities, species compositions and ratios, data on lengths, maturities, recruitment sizes, measures of natural and fishing mortalities and other elements of population dynamics in such measures that they help in forecasting short and long term fluctuations. Thus, research must focus on generating these information on a continuing basis from all over the coast ensuring coverage of all major marine fisheries and major landing centres. The analysis of such massive data by developing appropriate computer programmes leading to models would enable fishery planners and advisors develop national and regional strategies for change over from an open access to a regulated regime for ensuring sustainability. The research in CMFRI will have this vision in developing appropriate research projects on a national basis for long-term trend and predictive models. These initiatives will not only help India manage its marine fisheries in information and knowledge based platform, but also place the country at par with most developed countries who are able to manage their fishery in a scientific manner. These outputs will also help India confirm to the international commitments made as part of India's endorsement of compliance to the FAO Code of Conduct for Responsible Fisheries (CCRF). Thus, the basic research on stock, fishing effort, landings, trends, population analysis, and modeling is vital for future of India's marine fisheries and its management. The Institute is geared to address this issue through its basic and strategic research on marine fish stocks through its research efforts outlined in this document.

**Reducing losses, juvenile fishing and bycatch**

Since substantial marine fish catch from the Indian seas is through nonselective gears such as trawls and purse seines, a large quantity of low value fish are caught as bycatch. Use of small meshed nets result in capture of large quantities of juvenile fish. Depending on many factors, these catches are either discarded at sea or brought to land and quite often downgraded to fishmeal for the animal feed sector or as manure. Thus, there is blatant abuse and wastage of marine fishery resources by the fishing sector along the entire coastline. Such loss to the fish stocks gradually leads to destruction of the stock as juveniles are caught and destroyed, thus affecting the recruitment of fish into the fishery. In addition, handling and storage loss of captured fish is another major concern as research studies have shown that there are quantities, quality and value losses to the tune of several million Rupees in the post harvest sector in India. Thus, reducing losses, capture of juveniles and bycatch reduction are all priorities for the sector and continued research by analysis of field data only will yield the up-to-date status of the issue and its impact on the fish stock. The Institute will be addressing these issues through its strategic research on the impacts of fishing on the fish stocks and the results will feed in to development of strategies and actions for reduction of bycatches and juvenile fishing. Suitable research areas have been identified and incorporated into the Vision document to achieve these objectives.

**Increasing production through diversification and capture of oceanic tuna and deep sea resources**

In tune with the national objective of increasing fish production, the capture fisheries focus has to shift from inshore waters to the open ocean and deep seas for capture of hitherto unexploited varieties and

stocks of fish. Diversification of the present fishing effort in to oceanic and deep sea fishing will throw up new challenges to research on emerging fishery resources and their dynamics for designing of appropriate strategies for management. Studies on identification of new stocks, their distribution, abundance, stock size and dynamics, resource resilience are all important topics of research as many of these species like the tunas are straddling and migratory species which are also shared resources in international waters. There is great need and scope for carrying out work on these resources by India for strategic reasons in the international fishery scenario. These issues will be addressed by the Institute so as to develop not only a thorough understanding of the resources, but also to develop resource intelligence which are vital for future stakes on these shared resources.

**Restoration of critical habitats**

Anthropogenic activities both planned and unplanned have had compounded impacts on the marine environment and most critical habitats such as mangroves, coral reefs, tidal flats, estuaries are presently threatened. It is vital to protect these habitats and rebuild the threatened ecosystems in order to provide opportunities for the coastal fish species recover from the impacts of fishing. Indian coasts also offer very special habitats for endangered marine species such as marine turtles, dolphins, seahorses, sea cucumbers, corals, sea cows, sea grass beds etc. Since these critical habitats are continuously under pressure due to human activities, which are mostly detrimental, research has to focus on assessing the impacts and designing ways and means for restoration of the threatened ecosystems. The Institute will be designing appropriate research programmes for carrying out research in to the habitat conservation and biodiversity issues, which will lead to conservation of endangered species and recovery of damaged habitats.

**Increasing coastal productivity**

One of the major concerns of marine fisheries is to increase the coastal productivity in terms of fish yield. This is of importance for the livelihood security of coastal fishers who are mostly poor and solely depend on the seas for food and employment. Since the coastal fisheries are badly impacted by the fishing activities, increasing coastal productivity will also help them to improve their livelihoods through capture of fish. There are well known methods like Fish Aggregating Devices (FADs) and Artificial Reefs, which can help, rebuild depleted coastal fish stocks. However, the impact of the FADs on the food web and selective removal of certain fish species from the ecosystem have to be investigated and modeled to prevent significant changes in the trophic structures and species interrelationships. The Institute will carry out research on ecosystem analysis and modeling in such critical habitats and results generated will be used for effective and ecofriendly interventions for management of the habitats.

**Sea ranching and building up stock resilience**

Coastal resources are depleted and there is need for restoration of such overexploited species. Sea ranching is one well-established method for rebuilding depleting stocks. Earlier work by the Institute has demonstrated the efficacy of sea ranching with respect to species such as the sacred chank, pearl oysters, shrimp *Penaeus semisulcatus* etc. Sea ranching of threatened species such as sea turtles, sea cucumbers, sea horses and other molluscs like *Tridacna, Trochus* and transplantation of corals are important for rebuilding of lost stocks. Along with sea ranching activities, research must also be carried out to assess the impacts of the sea ranching on the stock recovery as well as identification and characterization of possible negative impacts of sea ranching on the wild stocks such as possible genetic contamination. The Vision document envisages such research efforts for ensuring a healthy and resilient fish stock in the coastal region. These studies are expected to result on a long-term basis better resource health and resource size.

**Mariculture in coastal waters, breeding technology and commercialization of trade of high value species**

One of the most promising areas the world over which is attracting R&D efforts is farming of fish in open seas. The sector has been registering a substantial growth and trade of farmed fish especially in live condition has been turning into a billion dollar industry. In India, mariculture has been limited to only land based farming of shrimps, coastal culture of marine mussels, edible oysters, pearl oysters, seaweeds and some small scale grow out of milk fish, crabs, the seed of which are caught from the wild. There has not been any true mariculture of finfish from hatchery produced finfish seed in India. In the context of India not allowing introduction of exotic fish species for mariculture and lack of quarantine facilities and legal mechanisms for import of finfish seed from other countries, there is urgent need for developing appropriate breeding and larval rearing technologies for culturable marine finfish as well as techniques for grow out in open seas. Multidisciplinary efforts in genetics, induced breeding, physiology, reproductive biology, water quality management, live feed culture, nutrition, health management, husbandry practices are all topics for concerted research. Major Indian species must be researched for sea farming, including its economics and profitability in Indian and export markets. Therefore, concerted research efforts need to be focused on potential Indian species of marine fish. India will be able to make an impact in this area as a result of continued research efforts with the commissioning of the new multipurpose hatchery being constructed at Mandapam Regional Centre of CMFRI. Already substantial progress has been made in the breeding of marine ornamentals. Renewed research efforts are planned for breeding of groupers, rabbitfish (*Siganus*), *Cobia*, breams and other perches, which are of high value in India. Further work will have to address the breeding of pomfrets, seerfishes and fattening of tunas. Open sea cage farming must also be undertaken with adequate research on potential mariculture sites, stocking, feeding and nutrition, management and husbandry, economics, transportation and live fish transport. All these areas need research attention and the Institute is poised to address these systematically over the next two decades as defined in the Vision document.

**Marine biotechnology**

A very potential and emerging area is marine biotechnology dealing with several research areas of potential applications like molecular markers, gene mapping, selective breeding and hybridization, biomolecules, marine microbes, seaweeds, marine pigments and drugs from the seas. Since this is a relatively less researched area in our country, there is great potential for research and development in India. However, lack of modern facilities, equipments and manpower are serious constraints. These can be resolved only through collaborative research and development with other organizations and the Vision document has addressed these research topics adequately.

**Impacts of climate changes, anthropogenic activities on marine fishery resources**

Global warming has been causing rapid changes in the climate as also in increasing the sea levels. Coral bleaching due to increased temperatures, loss of mangroves and critical coastal habitats like tidal flats due to sea level rise are all major areas of concern not only from the biodiversity angle, but also from ecosystem resilience and population biology. Many anthropogenic activities in the coastal zone negatively impact the coastal habitats and coastal fisheries. These are to be researched to understand their primary and compounded impacts. Short and long term impacts as well as modeling the impacts are to be addressed through research agenda. The social, environmental, ecological and economic and biodiversity related costs of climate changes are to be understood and modeled. Research must focus on the impacts on marine fisheries on a long-term basis. The Vision document has considered these aspects while planning the research agenda for the next two decades.

**Enhancing coastal livelihoods and nutritional security**

There are 3.52 million coastal fishers living near the coastal areas of India. The recent Marine Fisheries Census of India conducted by CMFRI has shown that among the active fishermen of 3.52 million, 717,999 engaged in full time activities followed by 117,628 part time and 53,901 occasional fishermen. In spite of mechanization and great strides in fish capture, most of the fishers along the Indian coasts live in abject poverty. Harvesting, processing and sale of fish have been traditionally the livelihoods of the coastal fisher folks. Mechanization and automation as well as the change over from fresh fish to processed and value added fish products coupled with ever increasing demand for fish meal have resulted in decreased livelihood and nutritional security of the coastal people. Thus, on the one hand fisheries is gaining a status of developed industry, on the other the economical and social status of the fishermen have been declining drastically. Over the past decade the fisher women along the coastal fishing villages have been drastically marginalized owing to lack of fish processing opportunities on which they have been depending for decades. Increased demand for fish meal from the animal food industry sector has deprived them from gaining access to low value pelagic fish which has been the main stay of their livelihood activity. Thus the impact of the changing fishery scenario must be addressed through research not only for benchmarking but also for planning alternate livelihoods and avocations for them. Research will also have to address the benefits and costs both social and economical, of the various developmental activities along the coasts. Impact of natural and manmade disasters also must be analyzed. Further, both biodiversity destruction and conservation have negative impacts on the living standards of the coastal fishers. Thus socio-economic investigation and analysis of alternate livelihood options form important topics of marine fisheries research. Our vision for future should address these issues through appropriate research projects with a view to optimizing the livelihood profiles of the coastal fishers.

**Creating awareness in co-management, environmental degradation, conservation, coping with disasters**

Fisheries management is mostly the management of fishing effort. This can be achieved only through management of the fishing folks and fishing craft and gear. In the past, many developed countries have tried and failed in management of fisheries through traditional directive and advisory mechanisms. As a result, co-management and participatory management have evolved as alternate approaches to fisheries management. This approach is beneficial to certain extent in many developing tropical countries. There is need for research-based interventions to motivate coastal fishers into a regime of participatory management. Awareness and participation are key in the decision making process and research based information will play key role in educating stakeholders in the process of participatory planning and intervention. Similarly research based information on environmental degradation and conservation are vital for sustainability of fisheries resources. Along the coastal belt, disaster management and coping strategies are also equally important in the marine fishery sector.

The contribution of CMFRI in technology generation, dissemination and adoption is substantial and the role of the Institute is crucial in the coming years to increase and sustain marine fish production from the capture and culture fisheries. Also the additional social benefits accrued from marine fisheries are immensely very high in the secondary sector of post harvest operations and marketing. If we are able to address the issues flagged in the Vision document, it could be expected that these along with a paradigm shift in the management approach will pave the way to a resilient and growing fishery sector in the next two decades.

.....

## 8. ISSUES AND STRATEGIES

The important issues in the **Vision 2025** and the strategies for their implementation by the CMFRI are spelt out below:

| Issues | Strategies |
|---|---|
| **I. Capture Fisheries** | |
| Improving data base for an efficient informed management regime | Increasing sampling coverage for assessment of exploited stocks and updating the frame through census of fisher populations, fishing implements and infrastructure |
| Discards | Develop methodologies to estimate the quantity of discards. This could be done through participatory approach involving stakeholders |
| Sustaining fish production from the presently exploited grounds | 1. Periodic assessment of status of the exploited stocks<br>2. Formulation of reference points for Indian marine fisheries management<br>3. Formulate regulations and policies for precautionary management and conservation<br>4. Apply ecosystem based fisheries management principles and building trophic models of all major Indian marine ecosystems |
| Real time advisories on potential fishing zones | Collection of satellite data from NRSA, interpretation and dissemination. |
| Fishery forecasting | 1. Use of different predictive models using landings and also in conjunction with the environmental and biological characteristics of the exploited stocks<br>2. Simulation of biomass and yield changes with different effort scenarios by applying the trophic modelling concept |
| Impact of fishing on marine biodiversity | 1. Assessment of biodiversity loss in Indian marine ecosystems<br>2. Identification of marine protected areas to conserve marine biodiversity |
| Conservation and sustainable utilization of coral ecosystems | Research in marine biodiversity and species assemblages. Framing of procedures for the preservation of marine biodiversity |

| | |
|---|---|
| Stock improvement | Evaluation of the impact of sea ranching on the wild stocks and the ecosystem |
| Excess fishing capacity | Research efforts to focus on developing socio-economic and other management incentives |
| Juvenile catches | Promote precautionary approach and Code of Conduct for Responsible Fisheries |
| Marginalization of artisanal fishers open access system | Research on the effects and efficacy of through forms of rights-based approaches and other management regimes. Research in the role of communities including fisher community based regulations |
| Global warming/Climatic variability | 1. Assessment of short term and long term effects of climatic variables in the dynamics of exploited stocks<br>2. Develop fishery model that incorporate environment variables |
| **II. Seafarming** | |
| Marine finfish and shellfish farming technologies including hatchery systems | By developing technologies for the farming of finfishes like groupers, snappers, breams, pompano and ornamental fishes; crustaceans like lobsters and crabs and molluscs like abalones and other pearl forming gastropods |
| Seaweed farming | Further improvements in farming techniques for increased production |
| Ensuring increase in national mariculture production | By dissemination of the technology to maritime states in north west and north east coasts |
| Production of cost-effective grow-out feeds for marine fish and shellfish. | By minimizing fishmeal content and animal protein in grow-out feeds |
| Production of high quality broodstock | By formulation of diets enriched with essential HUFAs, carotenoids, immunostimulants, and vitamins |
| Control of diseases in mariculture system | By isolation, culture and identification of viral and microbial pathogens, strengthening of referral laboratory, resolving the humoral and cellular factors of immune response and development of vaccines, probiotics and immunostimulants |

| | |
|---|---|
| Early identification of microbial pathogens for proactive disease control | Molecular genetic characterization of microbial pathogens and development of molecular immuno diagnostic techniques |
| Genomic information of marine shellfish commercial importance for developing genetically improved brood stock | Functional genome analysis of marine of shellfish with special reference to pearl production and disease resistant factors |
| Identification of marine bio-molecules as eco-friendly additives for management of health and nutrition | By isolation and characterization of bio-molecules from marine invertebrates, algae and microbes |
| Synchronization of reproduction in protogynous hermaphrodite, grouper | By studying the molecular mechanism of sex-reversal in grouper |
| Imparting salt-tolerance to crops growing in saline conditions | By isolation of salt tolerance genes from marine halophytes and production of transgenic plants |
| Unambiguous identification of marine mammals from Indian EEZ and contiguous seas | By molecular techniques |
| Availability of quality fish seed throughout the year for mariculture | Cryopreservation of gametes, in vitro fertilization and hatchery production of fish seeds |
| Cost-effective live-fish transportation | By optimising stocking density, anesthesia, and environmental conditions |
| **III. Socio-economics** | |
| Database on livelihood and assessing various socioeconomic indicators of fisherfolk to form an input for marine fisheries management | Analysis of different socioeconomic indicators and issues through participatory methods like RRA, PRA etc. and bringing out location-specific needs of fisherfolk pertaining to livelihood options |
| Sectoral optimum harvesting strategies, economic efficiency of factors of production | 1. Economic evaluation studies in capture and culture fisheries and marketing research<br>2. Assessment of environmental loss and economic impact with cost-benefit analysis |
| Impact of WTO and other global trade in production, equitable distribution and promotion of internal and external trade vis-a-vis the existing policies on marine fisheries | Conducting strategic policy research as policies per the changing scenario |

| | |
|---|---|
| **IV. Extension** | |
| Resource conservation and community based management with due recognition of the Code of Conduct for Responsible Fisheries by fisherfolk | Developing and utilizing different strategies for community participation |
| Adoption of mariculture technologies and impact assessment | TOT through front line demonstrations and development of linkages with grass root level organizations/Institutions for further promotion and proliferation of viable technologies |
| **V. Education** | |
| M.F.Sc and Ph.D degree programmes | Strengthening mariculture education programmes, introduction of 8 new subjects in frontier areas of marine fisheries and seafarming, establishment of fisheries university |

.....

## 9. PROGRAMME AND PROJECTS ON TIME SCALE FOR FUND REQUIREMENT

The annual marine fish production in India is showing signs of leveling off around 2.7 million t which is close to the estimated potential yield in the presently fished grounds. There has been remarkable growth in the infrastructure for marine capture fisheries and decline in the area available per active fishermen and per boat. The possible regulations should consider the available infrastructure, manpower, the economy and of course the status of the exploited stocks, in order to ensure that none of these is adversely affected. All these very clearly suggest the need for sustaining the yields from the presently exploited grounds, which in its turn means that mission-oriented, multidisciplinary research in marine capture fisheries needs to be strengthened.

The potential yield of 1.2 million t in the outer continental shelf in the EEZ will enable additional harvests to the extent of around 1 million t and possibly new or unexploited resources will be harvested. This future development would require continuous monitoring and generation of data on exploitation. The stocks of all the species presently exploited have to be brought to the level existed in the 1990s through conservation measures adopting responsible management practices. While technologies are developed and transferred, there is still vast scope for improving and refining them further to suit changing scenario. There is also urgent need to develop breeding and farming technologies of marine finfish including ornamental fish, to develop hatchery and growout technologies for various shellfish species which have not been considered hitherto, to develop and improve seaweed production technologies and to monitor the diseases and to suggest prevention/cure in the culture systems. Besides, the socioeconomic aspects of marine capture and culture fisheries and the need of technology transfer have also to be addressed.

The outer boarder of the Indian EEZ and the contiguous waters in the Arabian Sea are known to be rich in mesopelagic fish; the stock size is estimated (US GLOBEC) to be around 1 million t. The Antarctic krill and other resources are identified and exploratory fishing conducted. The FORV *Sagar Sampada* has to be involved in further explorations of these resources. In order to formalise these efforts, the CMFRI proposes to establish the mesopelagic and Antarctic Cell to work in collaboration with the proposed Antarctic Cell of Ministry of Earth Science. Inter-Institutional collaboration needs to be developed to motivate the industry for pilot scale fishing as well as product development and marketing.

**Thrust areas**

**Marine Capture Fisheries**

- Policy advisories for fisheries management
- Short-term and long-term forecasts of fishery yields
- Impact of gears on fished stocks
- Trophic modelling of major marine ecosystems
- Simulation of fishery yields and biomass under various scenarios
- Application of remote sensing for fisheries forecasts on a GIS platform
- Tag-recovery studies on straddling and migratory stocks

- Impact adaptation and vulnerability of Indian marine fisheries to climate change
- Impact of fisheries on biodiversity and quantification of biodiversity loss
- Estimation of biomass of DSL and mesopelagics of the Indian seas
- Creation of a marine biodiversity registry of the country
- Rebuilding of vulnerable and overexploited stocks to 1985 level by 2015

**Mariculture**

- Development/standardization of hatchery and farming technologies for potential marine shrimp species, lobsters, brachyuran crabs, king crabs and molluscs leading to commercialization
- Development of technologies for seed production and farming of high value species like grouper, snapper, bream, pompano, cobias and tunas
- Open Sea Cage farming of carnivorous marine fishes
- Development of appropriate technologies for at least a dozen species of marine ornamental fishes of international commercial value and demand
- Development/standardization of technologies for sea ranching of commercially important crustaceans, molluscs and sea cucumbers to augment natural stocks
- Development of farming technologies for marine organisms of pharmaceutical importance
- Consolidation and transfer of mariculture technologies of pearl oyster, edible oyster, clam, mussel, chank, seacucumber, seaweed, shrimp and finfishes, and their integration with artisanal capture fisheries
- Development of blacklip pearl oyster farming technology and production of black pearls
- Organic farming protocols for marine organisms

**Marine Biotechnology**

- Genetic improvement of marine cultivated species through selective breeding and hybridization
- Endocrinology and reproductive physiology of cultivable marine organisms
- Bioinformatics and gene library of existing and emerging marine pathogens
- Bioconversion of raw material to enrich feed ingredients and reduce antinutrients
- Bioprospecting for secondary metabolites from marine invertebrates, algae and microbes for use in disease management.
- Molecular taxonomy of marine organisms to develop PCR based identification tools

In consideration of all these issues, the CMFRI proposes to implement the research and development projects as outlined in 9.1.

## 9.1. PROGRAMMES AND PROJECTS

| Major theme | Thematic area | Specific activities | Time frame | | | |
|---|---|---|---|---|---|---|
| | | | 2006 -2010 | 2011 -2015 | 2016- 2020 | 2021- 2025 |
| **A. BASIC RESEARCH** | | | | | | |
| Mariculture technologies | Biotechnology | Selective breeding and hybridisation in pearl oysters, clams, mussels and edible oysters | | | | |
| | | Defence mechanisms, immune modulation, pathological, processes and disease management | | | | |
| | | Bioinformatics and gene library of existing and emerging pathogens | | | | |
| | | Development of fish and shellfish cell lines for virological studies | | | | |
| | | Molecular taxonomy of marine organisms | | | | |
| | | Endocrinology and reproductive physiology | | | | |
| Marine Resources | Biodiversity, Fishery Environment | Inventorization, documentation and creation of database on marine biodiversity | | | | |
| **B. STRATEGIC RESEARCH** | | | | | | |
| Marine Resources | Fishery Environment | Fishery related marine environment characteristics, physical, chemical and biological oceanographic factors analysis | | | | |
| | | Remote sensing and identification of potential fishing zones (PFZ) | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | Marine health, Impact analysis, identification of Hot spots and effects on marine ecosystems | | | | |
| Capture Fisheries | Modelling and management | Simulation modelling for development of management game for an informed fisheries management for policy makers | | | | |
| | Assessment and monitoring of the exploited stocks | Single and multi species dynamics including the fishery and biological characteristics of the exploited pelagic and demersal finfish, crustacean & molluscan shellfish stocks | | | | |
| | | Development of GIS based marine fisheries resource database | | | | |
| | | Capture fishery modelling for management of the exploited marine fishery resources and strategies to rebuild fish stocks to 1985 levels by 2015 | | | | |
| | | Assessment of sedentary stocks in the coastal waters | | | | |
| | | Multispecies analysis for ecosystem based fisheries management | | | | |
| | | Mark recovery studies on migratory and straddling stocks | | | | |
| | | Impact Assessment of non-selective gears on the fish stock | | | | |
| | | Biological and economic impact assessment of discards and by-catch in different fleets | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | Conservation and ecofriendly management of coral reef ecosystems of India | | | | |
| | | Conservation strategies for endangered marine mammals, turtles and sea birds | | | | |
| | | Genetic stock delineation of threatened commercial species | | | | |
| | Extension and Economics | Responsible fisheries and community based resource management | | | | |
| | | Development of Fishery Development Index (FDI) through integration of socio-economic and livelihood analysis | | | | |
| | | Factor productivity and cost benefit analysis of fishing units | | | | |
| | | Policy issues, price behaviour and market intelligence | | | | |
| Mariculture | Hatchery technology | Development, standardisation, demonstration and propagation of hatchery technology for important marine lobsters and crabs | | | | |
| | | Hatchery, growout and pearl production technologies for abalones | | | | |
| | | Refinement of hatchery and growout technology for seacucumber | | | | |
| | | Induced breeding, seed production and hatchery development for groupers, rabbit fish, snappers and tuna livebait | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | Grow out in open sea, pen & cage culture of groupers, rabbitfish, snappers | | | | |
| | | Induced breeding, seed production & growout technologies for marine ornamentals | | | | |
| | | Hatchery and culture technologies for Cephalopods | | | | |
| | | Hatchery and sea ranching technologies for *Trochus, Turbo* and *Tridacna* | | | | |
| | | Integrated mariculture | | | | |
| | Biotechnology | Bioconversion of raw materials to enrich feed ingredients and reduce antinutrients | | | | |
| | | Identification of microbial strains (bacteria, fungi and yeast) suitable for bioconversion and enzyme production | | | | |
| | | Bio-enrichment of live feeds (Artemia, rotifer, copepods) with HUFA, amino acids and vitamins | | | | |
| | | Development of nutrient enriched diets for broodstock of fish and crustaceans | | | | |
| | | Development of cost effective grow-out feeds | | | | |
| | | Development of polyclonal and monoclonal antibody based diagnostic methods against specific bacterial and viral pathogens | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | Bio-prospecting for secondary metabolites from marine invertebrates, algae and microbes for use in disease management | | | | |
| | | Development and evaluation of probiotics immuno stimulants, vaccines and herbal extracts for health management | | | | |
| | | Development of a referral facility for major microbial and parasitic pathogens and their antigens for ready reference and a national diagnostic facility for diseases | | | | |
| | | Development of a referral facility for beneficial microbes | | | | |
| | | Molecular genetic profiling of microbial pathogens and development of diagnostic techniques | | | | |
| | | Selective breeding and genetic improvement of slipper lobsters | | | | |
| | | Hormonal profile of cultivable crustaceans, isolation, characterization and purification of growth hormones | | | | |
| | | Genetic improvement and transgenics | | | | |
| | | Cryopreservation of marine fish and shellfish gametes | | | | |
| | Growout | Growout upgradation of onshore pearl culture technology | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | Extension of bivalve mariculture technology to other maritime states through training programmes and demo farms and development of export markets | | | | |
| | Pearl production | Refinement of technology for production of Mabe and Make-up pearls | | | | |
| | | Black pearl production in A&N Islands | | | | |
| | Mariculture systems | GIS based potential mariculture site selection, Mapping of sites, along Indian coasts | | | | |
| | | High density algal cultures - mass production - algal pastes - zooplankton and novel organisms cultures and inert feeds for marine larviculture | | | | |
| | | Development of cost-effective technology for transportation of live ornamental/food fishes, crustaceans and molluscs | | | | |
| | Growout | Technology for culture of important seaweeds | | | | |
| | Extension & Economics | Evaluation, transfer and impact assessment of mariculture technologies through front-line extension research | | | | |
| **C. ANTICIPATORY RESEARCH** | | | | | | |
| | Mariculture | Stem cell research | | | | |
| | | Functional genome analysis and cloning of pearl forming genes | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | Functional genome analysis and cloning of disease resistance factors | | | | |
| | Conservation of fisheries environment | Identification and characterization of Marine Protected Areas (MPAs) for conservation of marine fisheries resources | | | | |
| | | Impacts, adaptation and vulnerability of Indian marine fisheries to climate change | | | | |
| Capture Fisheries | Trade and Policy | Impact of WTO and GATT regime on marine Fisheries and trade policy of India | | | | |
| Mariculture Systems | Policy | Investment, costs, earnings and HRD predictions in marine fisheries | | | | |
| | | Policy and regulations for leasing of water bodies for mariculture | | | | |
| | Biotechnology | Cloning, isolation and characterization of salt-tolerant genes | | | | |
| Fisheries Management | | Evolving adaptive fisheries management policies | | | | |
| | | Impact of policy changes and fisheries predictions | | | | |
| Socio-economics | | Marginalization of fisherfolk consequent to change in marine fisheries scenario | | | | |

## ACHIEVABLE OUTPUTS

2006-2010

### Capture Fisheries

1. A computer based management game for simulation of fishery yields suitable for policy makers and fishery managers
2. Policy guideline on gear regulations based on impact of non-selective gears on fish stocks
3. Policy on conservation of coral reefs, marine mammals and sea birds
4. Policy document on marine fish price structure and price movement
5. An interactive national marine fisheries database on GIS platform
6. Species-wise biological database of commercially exploited marine fish stocks and key biological reference points
7. Cost-benefit ratios of fishing units
8. Correlation of sea-truth data with remote sensed PFZs

### Mariculture

1. Open-sea cage mariculture technology
2. Complete technology package for farming of sea cucumber
3. Technology on onshore pearl culture, mabe and make-up pearls and black pearl production
4. Technology for hatchery seed production of palinurid lobsters
5. Technology on farming of lobsters, crab and seaweeds
6. Policy for leasing of open access water bodies for mariculture

### Marine Biotechnology

1. Bioenrichment protocols for marine live feeds
2. Genetically improved variety of slipper lobster
3. Complete hormonal profile of cultivable crustaceans

2011-2015

### Capture Fisheries

1. Trophic models of major marine ecosystems of the country
2. Comprehensive Fishery Development Index (FDI) based on integration of socio-economic and livelihood analysis

3. Demarcation of Marine Protected Areas (MPAs) for conservation of marine fish stocks
4. Quantified discard profile in different fleets

**Mariculture**

1. Technology offer for farming and pearl production in abalones
2. GIS maps of potential mariculture sites in all maritime States
3. Technology for cost-effective transportation of cultivable marine organisms

**Marine Biotechnology**

1. Technology for bioconversion of nutritional raw materials
2. Enriched diets for broodstock of fish and crustaceans
3. Characterization of pearl forming genes from pearl oyster

2016-2020

**Capture Fisheries**

1. Complete assessment of sedentary stocks in coastal waters with regulatory measures
2. Life history pattern of all commercial marine fish stocks and identification of sensitive biological reference points for major stocks
3. Scenarios of climate change on Indian marine fisheries for 2030, 2050 and 2080
4. Document on oceanographic parameters affecting marine fisheries

**Mariculture**

1. Induced breeding and hatchery seed production protocols for carnivorous fishes like tunas and cobia
2. Ecofriendly integrated (seaweed, molluscs, fish, crustacean) mariculture technology practices
3. An annual mariculture production of 1.0 million t through extension of mariculture practices

**Marine Biotechnology**

1. MAB based diagnostic method for viral and bacterial pathogens
2. Commercial scale production techniques for extraction of secondary metabolites from marine organisms for use in health management
3. Molecular genetic profile of marine pathogens and a national referral laboratory for disease diagnosis.

2021-2025

**Capture Fisheries**

1. Complete inventory of marine biodiversity of the country
2. Maps indicating migratory routes of straddling stocks and sharing of fishery yields between neighbouring countries
3. Mitigation measures for sustaining Indian marine fisheries under changing climate scenarios
4. Ensure sustainability and enhancing marine fish production for livelihood security and for meeting the animal protein demand of the country

**Mariculture**

1. Technologies for hatchery and searanching for *Trochus*, *Turbo* and *Tridacna*
2. Complete hatchery technology for seed production of groupers, snappers, cephalopods and marine ornamentals
3. Extension of integrated mariculture technologies to all maritime states

**Marine Biotechnology**

1. Production of pearl using stem cell technology
2. Species identification using molecular tools such as biochip
3. DNA based diagnostic kits
4. Production of transgenic marine ornamental fishes
5. Development of microbial products through marine bioprospecting

**9.2. FUNDING NEEDS OF THE PROGRAMMES**

The funds needed for the various R&D programmes are to be met largely by the ICAR as well as from the funding agencies. The Institute would supplement these funds from external sources through sponsored projects and also through the income generated by consultancy services. Currently the Institute is operating 21 sponsored R&D projects with a total budget of Rs. 1120.48 lakhs. The 9 ongoing consultancy projects have an outlay of Rs. 1,15,99,359.00.

To meet the R&D requirements as envisaged in this document, direct ICAR funding to the tune of Rs. 80 crores under Plan would be needed for the XI Plan period and Rs. 100 crores for the XII Plan period. Non plan funding will continue to increase in view of the increase in salaries, costs of operation and other commitments and are expected to be double of the present for the XI Plan period.

.....

## 10. LINKAGE, COORDINATION AND EXECUTIVE ARRANGEMENTS

The Director of the Institute is vested with all administrative and financial powers regarding the research programmes and the management of the Institute. He is assisted by the Senior Administrative Officer, Senior Finance and Accounts Officer and a retinue of administrative, accounts and supporting staff. The CMFRI has 3 Regional Centres and 7 Research Centres headed by Scientists-in-Charge who coordinate the activities with the headquarters and oversee the work carried out at each of the Research Centres. The Heads of the Research Divisions shown below are stationed at the Headquarters.

1. Fishery Resources Assessment Division
2. Pelagic Fisheries Division
3. Demersal Fisheries Division
4. Crustacean Fisheries Division
5. Molluscan Fisheries Division
6. Fishery Environment Management Division
7. Physiology, Nutrition and Pathology Division
8. Socio-Economic Evaluation & Technology Transfer Division
9. Mariculture Division
10. Marine Biodiversity Division

All the research programmes are carried out through these 10 research Divisions and the Regional/ Research Centres together with their field centres totaling 15. Each research project is led by a Principal Investigator who in turn is assisted by a group of scientists and technical staff. The progress of work is monitored by the Principal Investigator and the Head of Division in addition to the Scientists-in-Charge of the Research Centre. The programmes are screened by the PME Cell of the Institute and the Research Advisory Committee and the projects approved by SRC.

The implementation of the various programmes requires the establishment of linkages with both governmental and other agencies. The linkages with various agencies are given below:

**LINKAGES**

| Areas | Organizations |
|---|---|
| Assessment of marine living resources | DAHD & F, DAC, CMLRE, FSI, CARI, SAUs and SFDs, WorldFish Center, IOTC |
| Fisheries modeling | IASRI, MAACS, WorldFish Center |
| Mark recovery studies on migratory stocks | MoES, FSI |
| Fisheries Oceanography | MoES |
| Biodiversity | MoE&F, SAUs, ZSI and SFDs, |
| Basic disciplines including Physiology, Nutrition, Pathology and Genetics | DBT, SAUs, CIBA and DST |
| Socio-economics and Bio-economics | DAC, SAUs, SFDs, IGIDR, NCAP and NGOs |
| Technology transfer | SAUs, SFDs, NGOs, NABARD and NFDB |
| Post graduate education and Training | CIFE, SAUs, Traditional Universities, IASRI, SFDs and NGOs |
| Mariculture | DBT, MPEDA, NFDB, SAUs, SFDs, CIBA, NBFGR, CARI and NGOs |

.....

## 11. CRITICAL INPUTS

### Funding

The Institute programmes are funded by the ICAR through the plan funds and cess funds schemes. Additional funds are generated through sponsored projects from the MoES, MoE&F, DAHD & F, DST, NFDB, DBT, MPEDA and through consultancies.

### Manpower

All the vacant posts should be filled up and the full sanctioned strength in position by 2006-07. Details of sanctioned, filled and vacant posts are given in section 3.3. (Manpower).

### Infrastructure

There is need for creating the much needed infrastructure at many of the centres. There are no own laboratory and office buildings for CMFRI at Mangalore and Vizhinjam. There is need for establishing one new Research Centre in Orissa and one in West Bengal which are currently not receiving any research attention. The Institute needs fully equipped research vessels, atleast 4 numbers, two in the east coast and two in the west coast. There is no Guest House facility at the Headquarters. The Electron Microscope needs replacement. The Mandapam Regional Centre which is over 60 years old needs renovation. Hatchery facilities at Calicut and Kovalam needs strengthening. A farmers hostel, an auditorium and a training hall are required at the Headquarters.

### Any other

a) Establishment of obligatory linkages with R&D organizations and constitution of **working groups** are essential.

b) Data on exploited fishery resources in log sheets from all mechanized vessels, both governmental and private, need to be furnished to the ARIS Cell.

.....

## 12. RISK ANALYSIS

As is the case with other biological production systems, marine fish production is risk prone and several factors have to be considered in risk analysis.

The availability and abundance of various fish stocks in time and space are related to recruitment, growth, natural & fishing mortalities and the fisheries oceanographic factors which show inter annual variations. As such, stock assessment and forecasting the abundance of the fishery resources is beset with difficulties due to interaction of both biotic and abiotic factors.

Increasing pollution of the coastal waters poses threat to the health of the fish stock particularly the juveniles of several commercial species, thereby affecting recruitment.

Outbreak of diseases, pollution and calamities like cyclones, tsunamis and floods can cause total loss of mariculture production in coastal farms and seafarms and destruction of fishing fleets and fishermen households. The recent outbreak of diseases in prawn farms almost throughout the country jeopardized the industry very much.

.....

## 13. PROJECT REVIEW, REPORTING AND EVALUATION ARRANGEMENTS

The PME Cell of the Institute scrutinizes the research proposals while the Research Advisory Committee and the Staff Research Council of the Institute review the progress attained in each research project.

The progress of the various programmes is reported through periodic reports on each project and reviewed by the SRC. The progress of work done by the Institute as a whole is reviewed by the Quinquennial Review Team of the Institute, appointed by the ICAR from time to time.

.....

## 14. RESOURCE GENERATION

The resources required for carrying out the mandated activities described in the perspective will be generated by the Institute through four sources. (1) From the R&D funds allocated in the Plan EFC allocations for every plan period. (2). From major national R&D initiatives such as the world bank funded NAIP, R&D funding initiatives from the National Fisheries Development Board, national projects from the special initiatives of Ministries such as MoEF, Earth Sciences etc. (3) From externally funded research projects from agencies such as the DBT, DST, MoA, MPEDA and various International donors (4) From public-private partnership in emerging areas with scope of commercialization such as marine ornamental fish breeding and export, open sea cage culture of finfish, breeding and farming of high value species such as lobsters, sea cucumbers, tissue culture of pearls, biotechnology, drugs from marine organisms etc.

Already a total of 26 R&D projects with a total budget of Rs. 750.76 lakhs to be operated during the next 5 years have been submitted to various Agencies. Additional funding through NAIP and NFDB to the tune of Rs. 35 crores for the XI plan period are being sought. Past experiences have shown that external funding for research is readily available, the major constraint is the dearth of the scientific staff as many vacancies are yet to be filled. Additional resources will be generated through consultancy services, entrance fee to marine aquaria and by sale of the technologies and products. The current annual consultancies cross over Rs. 100 lakhs and the revenue generation is currently Rs. 110 lakhs from various sources.

**Revenue generation during IX$^{th}$ & X$^{th}$ Plan period and projected for XI$^{th}$ Plan**

| Plan | Rs. in lakhs | Remarks |
|---|---|---|
| IX | 229,51,625 | |
| X | 498,19,018 | (upto 30-11-2006) |
| XI | 625,00,000 | Projected |

.....

## 15. OUTPUT OF THE R&D PROGRAMMES UNDERTAKEN

The R&D efforts undertaken by Central Marine Fisheries Research Institute will result in enabling a planned growth of marine fisheries and coastal aquaculture in India. Although the financial and economic impacts of research projects at micro level on multi-species, multi-input open access marine fisheries cannot be quantified, the macro level impacts will be long term and will be visible only through macro-analysis at periodic intervals. Already the macro impacts of several policy interventions by the Govt. of India and maritime state governments are showing positive impacts on the coastal marine fisheries scenario in the recent past. The advisories and inputs provided by the CMFRI have been incorporated in many Governmental documents such as the Marine Fishing Policy, Coastal Aquaculture Bill, Fisheries Development Board, CRZ rules, Marine Fisheries Census, MoEF guidelines for conservation of endangered species such as corals, turtles, seacucumbers, sharks, molluscs, etc.

The marine fish production increased from about 0.6 million t in the fifties to the maximum level of 2.7 million t during the IX Plan period recording a positive growth rate in our successive Five-Year Plans. The projected marine fish production is about 3 million t at the end of X Plan with the intensification of deep-sea and economic fishing focusing on oceanic tunas. However, this can be achieved only if appropriate management interventions are in place in all coastal states. The gross revenue generated from marine fisheries at first sales is currently estimated at about Rs.13,000 crores which is expected to increase at 5% annually. The additional revenue likely to be generated will be Rs.1,250 crores at constant prices and Rs. 4,160 crores at varying prices. The private capital investment towards fishing equipments is about Rs.5,000 crores. Thus the capital turn–over ratio in marine fisheries works out to be 1:2.5.

Diversified coastal aquaculture offers immense scope for further development. Currently hardly 1.57 lakh ha is utilized as against the potential area of 1.2 million ha mainly for shrimp oriented land based aquaculture. The current aquaculture shrimp production is about 1.02 lakh tonnes with an average production of 600 kg/ha /year. The average productivity of farmed shrimp has reduced from 800 kg/ ha/year in 1994-95 to 600 kg /ha/year in 2001-02 mainly due to white spot disease incidence. Hence, there is an urgent need for promotion of research oriented towards development of disease resistant breeds and disease control by the Institute. With the development of disease resistant broods and improved feed, the average production of farmed shrimp could be increased from the current level of 600 kg/ha/year to 1,000 kg/ ha/year by 2006-2007. With the projected area under shrimp culture alone to the tune of 2 lakh ha and production of 4 lakh tonnes, the benefit accrued in terms of additional revenue generated by coastal shrimp aquaculture alone will be Rs.8,000 crores by the end of the X Five Year Plan.

The CMFRI had carried out pioneering work in mariculture of edible oysters and marine mussels. These technologies have been commercialized and adopted by hundreds of SHGs all along the west coast of India, resulting in remarkable production of edible meat through culture. Technologies for mariculture of clams and gastropods are fast picking up. Bivalve mariculture is fast spreading in Kerala, Tamilnadu, Karnataka, Goa, Maharashtra and Andaman and Nicobar Islands. By the adoption of different mariculture techniques for molluscs, 800 tonnes of edible oysters, 8,000 tonnes of mussels, 10,500 tonnes of clams and 30 tonnes of gastropods could be additionally produced by end of X Plan.

The CMFRI has ventured for the first time pioneering R&D in open sea cage mariculture with funding support of Rs. 250 lakhs from the Ministry of Agriculture. The NFDB has earmarked Rs. 40 crores for this activity. The CMFRI is installing four open sea cage farms in Ratnagiri, Diu, Visakhapatnam and Palk Bay as demonstration- cum- development project for mariculture of finfish. The increase in price and the availability of finfish and crab culture technologies will bring under integrated mariculture

will result in production of about 1.5 lakh tonnes, fetching an additional revenue of Rs. 600 crores. Thus in the coastal aquaculture alone, the total additional revenue generated will be about Rs.3200 crores per annum at the end of the next five years.

The contribution of CMFRI in technology generation, dissemination and adoption is substantial and the role of CMFRI is highly significant in generating an additional revenue of Rs. 1,250 crores in marine fisheries and Rs. 3,200 crores in coastal aquaculture by the end of XI Plan. Also the additional social benefit accrued from marine fisheries is immensely very high in the secondary sector of marketing and post- harvest operations. Since the rate of return for the R&D investments in marine fisheries is far higher than agriculture (40-60%), there is need for much higher research investments in marine fisheries and mariculture.

**Anticipated outputs in Capture fisheries**

- Stock assessment of the multispecies fisheries
- Development of interactive management models for all maritime states
- National frame survey of marine fisheries every five years
- Guidelines on fishing effort regulations and mesh sizes
- Fixing of exploitable resource quotas for various resources
- Ensuring sustainability through management interventions and community awareness
- Stock enhancement of depleted finfish and shellfish stock through establishment of Artificial Reefs, FADs and searanching

**Anticipated outputs in Mariculture**

- Upgradation of hatchery technology for marine crab
- Growout of swimming crabs, sand lobsters, sea cucumbers
- Development of hatchery technology for lobsters
- Organic farming of the alternate species *P.semisulcatus*
- Extension of mussel mariculture to other states: Karnataka, Goa and Maharashtra
- GIS platform map of potential mariculture sites along the Indian coasts
- EIA of mariculture in coastal farming sites
- Coping with EU standards through depuration and post harvest handling of farmed bivalves
- Technology for tissue culture of pearls.
- Integrated farming of seaweeds with mussels
- Formulation of semi floating diets for marine ornamentals using fermented oilcakes

- Patenting of breeding technologies for a dozen species of marine ornamentals
- Production of Mabe pearls in *Pinctada fucata* and commercialization of the technology
- Production of black pearl in the Andaman waters
- Packaging and transport of marine live fish
- National referral collection of bacterial pathogens
- Cost effective molecular diagnostic kits for marine fish diseases
- Hatchery seed production technology for Rabbit fish, Grouper, Breams, Cobia
- Installation of Open Sea mariculture in floating cages along Indian coasts heralding a new revolution in sea farming

**W T O issues**

It is important that India addresses the challenges arising out of the WTO and other global pressures in marine fisheries. Appropriate strategies to address these issues will be included in research projects proposed to be undertaken by this Institute. These measures will address the following major areas:

- Issues of by catch and discards at sea and their impact on the livelihood of coastal fishers
- Improving the livelihood of coastal fishers through alternate income activities and lesser dependence on subsidies/threatened natural ecosystems
- Development of indigenous technology for production of broodstock of fish and shellfish to prevent import of GMO from abroad in the mariculture sector
- Development of breeding technology for alternate species of mariculture such as *Penaeus semisulcatus*, *Portunus pelagicus* and Palinurid lobsters
- Development of GMO in marine ornamental fishes in order to prevent abuse of indigenous germplasm by other countries
- Patenting of hatchery technologies for marine ornamental fishes
- Development of molecular diagnostic kits for disease monitoring
- Addressing IPR issues in Marine Biodiversity and documentation of indigenous species with protection rights
- Pearl production through tissue culture and establishing a local lead in this field.

.....

## 16. OUTCOME OF THE R & D PROGRAMMES UNDERTAKEN

It must be well reckoned that outcomes in natural resource management and interventions will start yielding anticipated results only on long term basis. This is true in the case of marine fisheries also. It must also be reckoned that research may not always lead to or result in governmental interventions in the national and federal contexts. Such uncertainities will result in not achieving the anticipated objectives. Thus, outcomes / impacts will have to be viewed in this context. Past experiences have shown that not all recommendations are converted to policies and interventions by the implementing agencies because of various other considerations. There is also dichotomy in the approaches by the governmental agencies which obstructs planned management considerations. Because of these reasons, outcomes will be impacted to a large extent by the effectiveness of the implementation of the regulatory regimes enforced by the maritime states. Changing over from the present open access to a regulated regime with an ultimate objective of achieving a user rights regime will be the key for ensuring sustainability and future growth of the capture fisheries sector.

Mariculture development in India has been tardy and low key in the past mainly due to the abundant supply of fish from capture and also because of the low or almost nil investment in technology generation. Except for shrimp mariculture, no attention was given in the past. Mussel and oyster culture developed as livelihood alternates in the coastal villages with low technological inputs. For the first time in history, a full fledged multipurpose marine fish hatchery is being readied at the Mandapam Regional Centre of CMFRI. This will be the first step for initiating a development agenda for mariculture in India. The results fom the technologies developed through research in this hatchery, coupled with the outputs from the smaller hatcheries in Tuticorin, Cochin, Calicut, Kovalam and Visakhapatnam will result in generating the locally relevant technologies for Indian species of marine finfish. Once assured seed supply in place, the newly developed national seed facility at the Headquarters of CMFRI at Cochin will be able to provide seed of finfish, crabs, lobsters and planting materials for seaweeds for use by farmers. This will lead to a quantum jump in the marine fish production through mariculture. It is anticipated that 100,000 tonnes of fish will be produced through mariculture in the next 10 years using these new technologies and practices. This will improve considerably the coastal livelihoods of the fish farmers and result in achieving the goal of a slow but steady blue revolution in the coastal regions of the country.

The research outputs are expected to yield the following outcomes:

- Increased fish production through mariculture
- Sustainable mariculture / seafarming
- Stock enhancement of depleted finfish and shellfish stock
- Conservation of endangered, threatened and vulnerable marine living resources
- Availability of fish and fishery products to the consumers at reasonable price
- Increased per capita consumption of fish
- Ensuring nutritional security
- Increased employment opportunities

- Ensuring livelihood securities
- Effecting the poverty eradication and empowerment of women fisherfolk
- Upliftment of socio-economic status of fishers and fish farmers
- Increased foreign exchange earnings through export of high value / live fish
- Bridging gap between generation of technology and uptake
- Increased awareness among the fisherman on responsible fishing practices
- Addressing WTO challenges
- Increased trained manpower in frontier areas
- Announcement of better marine policy

Further outcomes from the proposed programmes are expected to yield the following key outcomes important form the national context.

- Monitoring and documenting the current annual fish production from the EEZ and developing database for further analysis and advisories including policy interventions.
- Development of informed management regime and a regulated marine fisheries
- Policy frame work for marine capture fisheries, deep sea fisheries, island fisheries, coastal mariculture, environmental security, common property resource utilization, sustainability issues, food safety and WTO commitments for India.

.....

## 17. EXPLANATION TO ABBREVIATIONS

| | |
|---|---|
| APAARI | Asia Pacific Association of Agricultural Research Institutions |
| ARS | Agricultural Research Service |
| ASRB | Agricultural Scientists Recruitment Board |
| ATIC | Agricultural Technology Information Centre |
| BFSc | Bachelor of Fisheries Science |
| CARI | Central Agricultural Research Institute |
| CBD | Convention on Biological Diversity |
| CCRF | Code of Conduct for Responsible Fisheries |
| CFD | Crustacean Fisheries Division |
| CIBA | Central Institute of Brackishwater Aquaculture |
| CICEF | Central Institute of Coastal Engineering for Fisheries |
| CIFE | Central Institute of Fisheries Education |
| CIFNET | Central Institute of Fisheries Nautical & Engineering Training |
| CIFT | Central Institute of Fisheries Technology |
| CMFRI | Central Marine Fisheries Research Institute |
| CMLRE | Centre for Marine Living Resources and Ecology |
| C-MMACS | Centre for Mathematical Modelling and Computer Simulation |
| COMAPS | Coastal Ocean Monitoring and Prediction System |
| CRZ | Coastal Regulation Zone |
| CSIR | Council of Scientific and Industrial Research |
| CSMCRI | Central Salt and Marine Chemicals Research Institute |
| DAC | Department of Agriculture & Co-operation |
| DANIDA | Danish International Development Agency |
| DBT | Department of Biotechnology |
| DFD | Demersal Fisheries Division |
| DOD | Department of Ocean Development |
| DoEF | Department of Environment & Forest |
| DST | Department of Science & Technology |
| EAF | Ecosystem Approach to Fisheries |
| EBFM | Ecosystem Based Fisheries Management |
| EEZ | Exclusive Economic Zone |
| EFC | Expenditure Finance Committee |
| EIA | Environmental Impact Assessment |
| EU | European Union |
| FAD | Fish Aggregating Device |
| FAO | Food and Agriculture Organization |
| FEMD | Fishery Environment & Management Division |
| FORV | Fishery Oceanographic Research Vessel |
| FRAD | Fishery Resources Assessment Division |
| FSI | Fishery Survey of India |
| GDP | Gross Domestic Product |
| GMO | Genetically Modified Organism |
| GoK | Government of Kerala |
| HRD | Human Resource Development |
| IASRI | Indian Agricultural Statistics Research Institute |

| | |
|---|---|
| ICAR | Indian Council of Agricultural Research |
| ICES | International Council for the Exploration of the Sea |
| IFP | Integrated Fisheries Project |
| IFS | International Foundation for Science |
| IOM | Institute for Ocean Management |
| IOTC | Indian Ocean Tuna Commission |
| IPR | Intellectual Property Rights |
| KVK | Krishi Vigyan Kendra |
| MARSIS | Marine Satellite Information Services |
| MBD | Marine Biodiversity Division |
| MD | Mariculture Division |
| MFD | Molluscan Fisheries Division |
| MFSc. | Master of Marine Fisheries Science |
| MoA | Ministry of Agriculture |
| MoE | Ministry of Earth Sciences |
| MoEF | Ministry of Environment & Forests |
| MPEDA | Marine Products Export Development Authority |
| NABARD | National Bank for Agriculture and Rural Development |
| NACA | Network of Aquaculture Centres in Asia-Pacific |
| NAIP | National Agricultural Innovation Project |
| NATP | National Agricultural Technology Project |
| NBFGR | National Bureau of Fish Genetic Resources |
| NFDB | National Fisheries Development Board |
| NGO | Non Governmental Organisation |
| NIO | National Institute of Oceanography |
| NIOT | National Institute of Ocean Technology |
| ORSAC | Orissa Remote Sensing Application Centre |
| PFD | Pelagic Fisheries Division |
| PFZ | Potential Fishing Zone |
| Ph.D. | Doctor of Philosophy |
| PNPD | Physiology, Nutrition & Pathology Division |
| R & D | Research & Development |
| SAC | Space Applications Centre |
| SAD | State Agriculture Department |
| S & T | Science & Technology |
| SAU | State Agricultural University |
| SEETTD | Socio Economic Evaluation & Technology Transfer Division |
| SFD | State Fisheries Department |
| SHG | Self Help Groups |
| ToT | Transfer of Technology |
| TTC | Trainers' Training Centre |
| UNCED | United Nations Conference on Environment and Development |
| UNFSA | United Nations Fish Stocks Agreement |
| WSSD | World Summit on Sustainable Development |
| WTO | World Trade Organisation |
| WWF | World Wildlife Fund |

.....

**CENTRAL MARINE FISHERIES RESEARCH INSTITUTE**

P.B. No. 1603, Marine Drive North Extension
Kochi - 682 018, Kerala, India
Tel: +91-484-2394867, Fax: +91-484-2394909
website : www.cmfri.org.in
e-mail: mdcmfri@md2.vsnl.net.in