VISION-2020

CMFRI

PERSPECTIVE PLAN

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

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Published by

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Research Institute
P. B. No. 1603,
Cochin - 682 014

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FOREWORD

Over the years, the Indian Agricultural Research System under the aegis of the Indian Council of Agricultural Research has served a very useful purpose. Nevertheless, in the fast changing global context, managing the change on a time scale, by converting weaknesses, if any, into opportunities to become internationally competitive is considered important. We need to be forward looking and visible with appropriate agricultural research policies in place supported by the cutting edge technologies in order to attain and sustain global advantages. It is in this background that the formulation of a perspective plan with a visionary approach for the next 25 years, is quite necessary. The clearly spelt out options and likely changes would enable the system to capitalize on our strength so that the threats, if any, are converted into opportunities.

The need for ensuring food and nutritional security to the rapidly growing human population is of paramount importance. About 780 million people in the Third World countries are living on food that does not help maintain a healthy life. Increasing urbanisation and expanding construction works are fast leading to a significant decline in the land area available for agriculture. This situation warrants a closer scrutiny to our food needs and formulation of appropriate strategies to tackle the current and emerging problems of food deficiency and malnutrition.

The marine fisheries scenario of the country is one of challenges: the production in the capture sector is stagnating around 2.3 million tonnes. The scope for increasing production by expanding fishing effort in the deep seas at the economically optimum levels is limited to about 0.6 million tonnes only although the total estimated potential for the Indian exclusive economic zone is about 4 million tonnes. Under these circumstances, the R&D should focus essentially on sustaining the production from capture fisheries at economically sustainable levels, and to step up efforts at consolidating the mariculture and seafarming technologies into package of practices for augmenting seafood production significantly. The Central Marine Fisheries Research Institute (CMFRI) established on February 3, 1947 has been carrying out research on these critically important areas serving the needs of the various governments and the marine fishing industry comprising the fisherfolk, the fishing enterprises and the trade. The Perspective Plan 2020 of CMFRI provides a vivid account of all areas of concerns in Indian marine fisheries and mariculture and the ways of addressing them so as to help the country register steady and sustained growth in this important sector.

In perspective plan formulation there was an overwhelming response to Council's initiative. The staff of the Policy and Planning Cell of the council deserves all appreciation for undertaking this onerous task right from designing of the necessary format and taking the plan formulation process to its logical conclusion. The various divisional heads at the ICAR Headquarters, Peer Review and RAC members made valuable contributions to the process of Plan formulation. The Director and scientists of the Institute have put in their collective wisdom in bringing out the document in its present form. It is hoped that the framework prepared would continue to be reviewed to accommodate changes in future so that the perceived vision continues to be close to the expected target. In the years to come, based on the long term perspective, it would be relevant to put implementable plan to action on five yearly basis to match with the on going planning system of the country.

March 5, 1997

(R.S. PARODA)
Secretary, DARE and
Director General, ICAR

PREFACE

The Central Marine Fisheries Research Institute is one of the eight research establishments in the network of central fisheries research institutes under the ICAR, devoted to research, education, training and transfer of technologies in support of the development of the fisheries sector in India. The CMFRI was established in 1947. During the period of nearly half a century of its existence with its Regional, Research and Field Centres situated all along the coast, manned by a dedicated band of scientists and technical staff, the Institute became one of the leading marine fisheries laboratories in the world and contributed in no small measure to the marine fisheries and mariculture development in the country.

Issues such as the rapidly increasing human population, increasing food needs, declining yields from the marine capture fisheries sector and growing imbalance in the social and economic status of different categories of resource users, led the CMFRI assess the present and future marine fish requirements of the country and the role it could play in addressing these issues effectively. The results of this exercise are dealt with in this Perspective Plan. This document has been prepared taking into consideration a large number of factors such as the marine fishery resource potential, growth of the marine fisheries sector, the knowledge base developed, mariculture resources, scientific and technical manpower, infrastructure and funding.

Copies of this Perspective Plan were submitted to the ICAR and circulated among the members of the Peer Group constituted by the ICAR. A presentation was made at the ICAR, New Delhi before the members of the Peer Group and senior officers of the ICAR on the 11th October 1996. The experts made certain constructive suggestions to improve the quality of the document; all these comments were taken into account and the document revised.

The Vision 2020 sets the goals, strategies and logistics to be implemented and achieved in marine fisheries and seafarming during 1996-2020. The CMFRI continues its efforts in achieving the targets set, and rededicates itself to the cause of research and development of marine fisheries, mariculture and the range of communities engaged in marine fish production, farming, trade and consumption.

This document is the result of deep involvement of a team of my colleagues in the CMFRI led by Dr. V.Sriramachandra Murty, Head, Division of Demersal Fisheries, who was given the prime responsibility of collecting and collating the information and writing the document. Dr. N.G.K. Pillai, Head, Division of Pelagic Fisheries, Shri K. Balan, Senior Scientist and Shri M. Srinath, Senior Scientist rendered active support in computerising the text, making the figures and checking the manuscripts.

I take this opportunity to express my sincere gratitude to Dr. R.S. Paroda, Director General, ICAR and Dr. P.V. Dehadrai, Deputy Director General (Fy), ICAR for their continued support in this endeavour.

Cochin
15-1-1997

M. DEVARAJ
DIRECTOR

EXECUTIVE SUMMARY

The Central Marine Fisheries Research Institute, Cochin was established in 1947 to carry out multidisciplinary research in marine capture and culture fisheries and to conduct education and training programmes in support of marine fisheries and mariculture development. Over the period of the last half a centruy, the Institute has grown in stature and size with 12 constituent research centres and 28 field centres along the coastline of the mainland and in the Lakshadweep. The present sanctioned staff strength is: Scientists 189(+1), Technical 396, Administrative 173, Auxiliary 53 and Supporting 303. The Eighth Plan budget of the Institute under Plan is Rs. 900 lakhs and Rs. 3466.68 lakhs under non-Plan. Very important infrastructure has been developed for both shorebased and onboard research in marine capture fisheries and seafarming.

The important achievements of the CMFRI include: development and implementation of a time-tested sampling scheme for the systematic collection of marine fisheries production statistics, development of a strong information base on the biological and fishery characteristics of all major exploited finfish and shellfish stocks, stock assessment and monitoring to furnish realistic estimates of stock size, fishing pressure, optimum yields and optimum fleet size for all the major exploited stocks, survey of the fisheries resources of the Andaman group of islands and the Lakshadweep islands and suggestions for marine fisheries development, database on fishery environmental characteristics, development of hatchery and growout technologies for shrimps, crabs, lobsters, pearl oyster, mussel, clam, edible oyster and seacucumber, development of pearl culture technology in the sea and onshore facilities, development of seaweed culture technology, searanching of shrimp and bivalves, education programmes for masters and doctoral degrees in mariculture, socioeconomics of fisherfolk and economics of fishing operations.

With a view to developing a comprehensive strategy to address the future challenges in the country's marine fisheries and mariculture sector, the CMFRI has prepared this Perspective Plan for the coming 25 years. In the process, we have critically looked at the mandate of the Institute, the nation's growth in marine fisheries, research capabilities, manpower needs, funding and achievements, and analysed the strengths, weaknesses, opportunities and threats of the sector. We have examined the national and international scenario in respect of marine fisheries and mariculture and the possible issues that may emerge in the ensuing years and the strategies to address them. Taking into account all the major areas of concerns, this Perspective Plan lays down the policy within which the various activities have to be carried out. Sixty research programmes in the following major areas are proposed and the needs of infrastructure, manpower and funds to implement the programmes are furnished.

1.	Fisheries database and modelling	3 projects
2.	Assessment and monitoring of the exploited stocks	10 projects
3.	Finfish mariculture	3 projects
4.	Crustacean mariculture	2 projects
5.	Molluscan mariculture	9 projects
6.	Seacucumber mariculture	1 project
7.	Mariculture systems	2 projects
8.	Seaweed mariculture	2 projects
9.	Mariculture biotechnology	16 projects
10.	Socioeconomics	5 projects
11.	Extension	4 projects
12.	Education	2 projects
13.	Deepsea and Antarctic resources	1 project

EXPLANATION TO THE ABBREVIATIONS

ARS	:	Agricultural Research Service
ASRB	:	Agricultural Scientists' Recruitment Board
BOBP	:	Bay of Bengal Programme
CIBA	:	Central Institute of Brackishwater Aquaculture
CICEF	:	Central Institute of Coastal Engineering for Fishery
CIFE	:	Central Institute of Fisheries Education
CIFNET	:	Central Institute of Fisheries Nautical Engineering and Training
CIFT	:	Central Institute of Fisheries Technology
CGIAR	:	Consultative Group on International Agricultural Research
CMFRI	:	Central Marine Fisheries Research Institute
COMAPS	:	Coastal Marine Pollution Studies
CSIR	:	Council of Scientific and Industrial Research
DAC	:	Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India
DANIDA	:	Danish International Development Agency
DARE	:	Department of Agricultural Research and Education, Ministry of Agriculture, Government of India
DBT	:	Department of Biotechnology
DOD	:	Department of Ocean Development
DOE&F	:	Department of Environment & Forests
DST	:	Department of Science and Technology
EEZ	:	Exclusive Economic Zone
FAO	:	Food and Agriculture Organisation of the United Nations
FSI	:	Fishery Survey of India
HRD	:	Human Resources Development
IASRI	:	Indian Agricultural Statistics Research Institute
ICAR	:	Indian Council of Agricultural Research
IFP	:	Integrated Fisheries Project

IFPRI : International Food Policy Research Institute

MARSIS : Marine Remote Sensing Information System

ME & F : Ministry of Environment and Forests

MFPI : Ministry of Food Processing Industries

MOA : Ministry of Agriculture

MPEDA : Marine Products Export Development Authority

MSAU : Maritime State Academic Universities

m t : Million tonnes

NABARD : National Bank for Agriculture and Rural Development

NBFGR : National Bureau of Fish Genetic Resources

NGO : Non Governmental Organisation

NIO : National Institute of Oceanography

NRSA : National Remote Sensing Agency

PFZ : Potential Fishing Zone

PGPM : Postgraduate Programme in Mariculture of CMFRI

SAC : Space Application Centre

SAU : State Agricultural University

SUFD : State and Union Territory Fisheries Departments

t : tonnes

ZSI : Zoological Survey of India

1. PREAMBLE

India is endowed with a long coastline of 8129 km, 0.5 million sq.km of continental shelf, 2.02 million sq.km of EEZ and a catchable annual marine fishery potential of 3.9 million tonnes. The Indian marine fisheries sector plays a very important role in supplying protein-rich food to the increasing population, employment generation and foreign exchange earning. India occupies the 7th position in world marine fish production and is one of the leading nations in marine fish export. Besides, the vast areas all along the coastline offer ideal sites for seafarming and coastal mariculture. The present marine fisheries scenario is characterised 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 large scale seafarming and coastal mariculture. This calls for a much stronger R&D base to be able to implement suitable action plans for sustained marine fisheries and 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 to Cochin in 1971. In 1967, the Administrative control of the CMFRI was transferred to the ICAR.

For its effective functioning, the CMFRI carries out its research activities through eight Divisions operating from the headquarters at Cochin, one Regional Centre at Mandapam Camp (Tamil Nadu) eleven Research Centres and 28 Field Centres located along the Indian coastline (Fig. 1). The regional problems and national priorities in marine fisheries and seafarming are attended to by these divisions and centres.

Main Functions of the CMFRI

- to assess and monitor India's marine capture fisheries potential and production
- to develop appropriate seafarming/mariculture technologies, test and transfer them to different target groups comprising fishermen, farmers and industries
- to conduct postgraduate teaching at Masters and Doctoral levels in mariculture to help develop the required human resources
- to provide training and consultancy services on various aspects of marine capture fisheries and seafarming.

Over the period of nearly 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 it 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 five decades of its existence, the CMFRI devoted most of its research attention towards the estimation of marine fisheries landings & effort, taxonomy

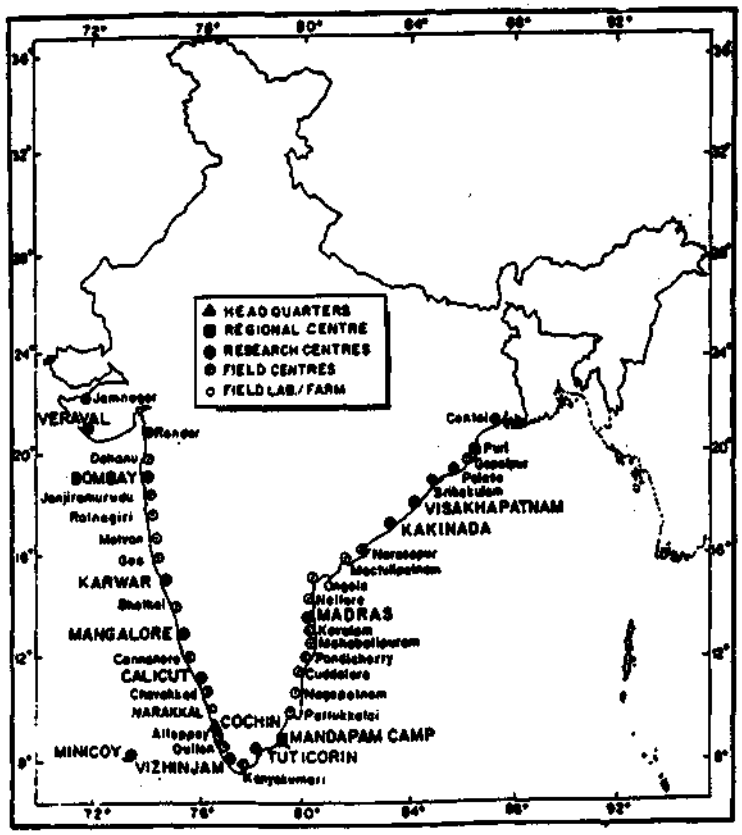
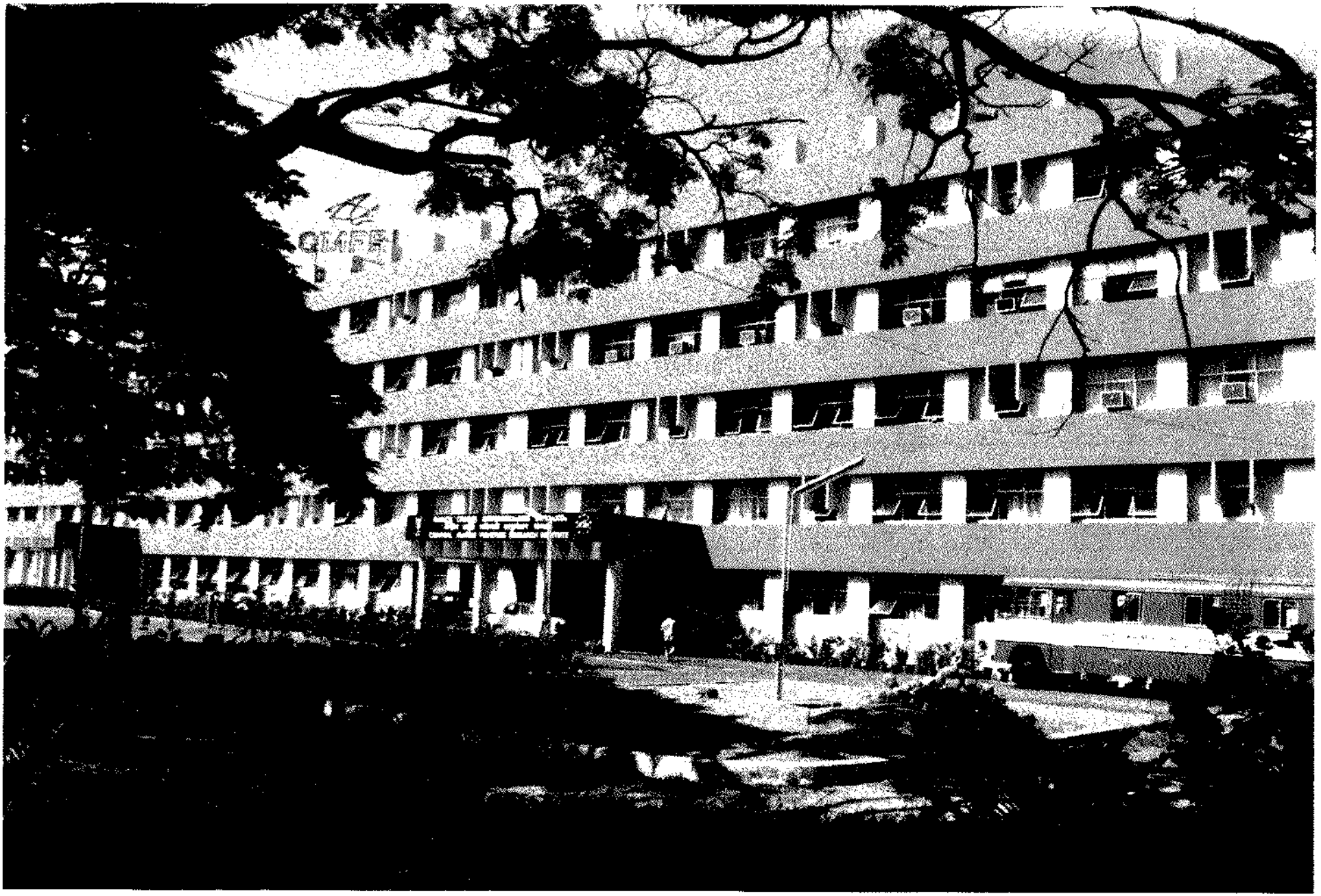


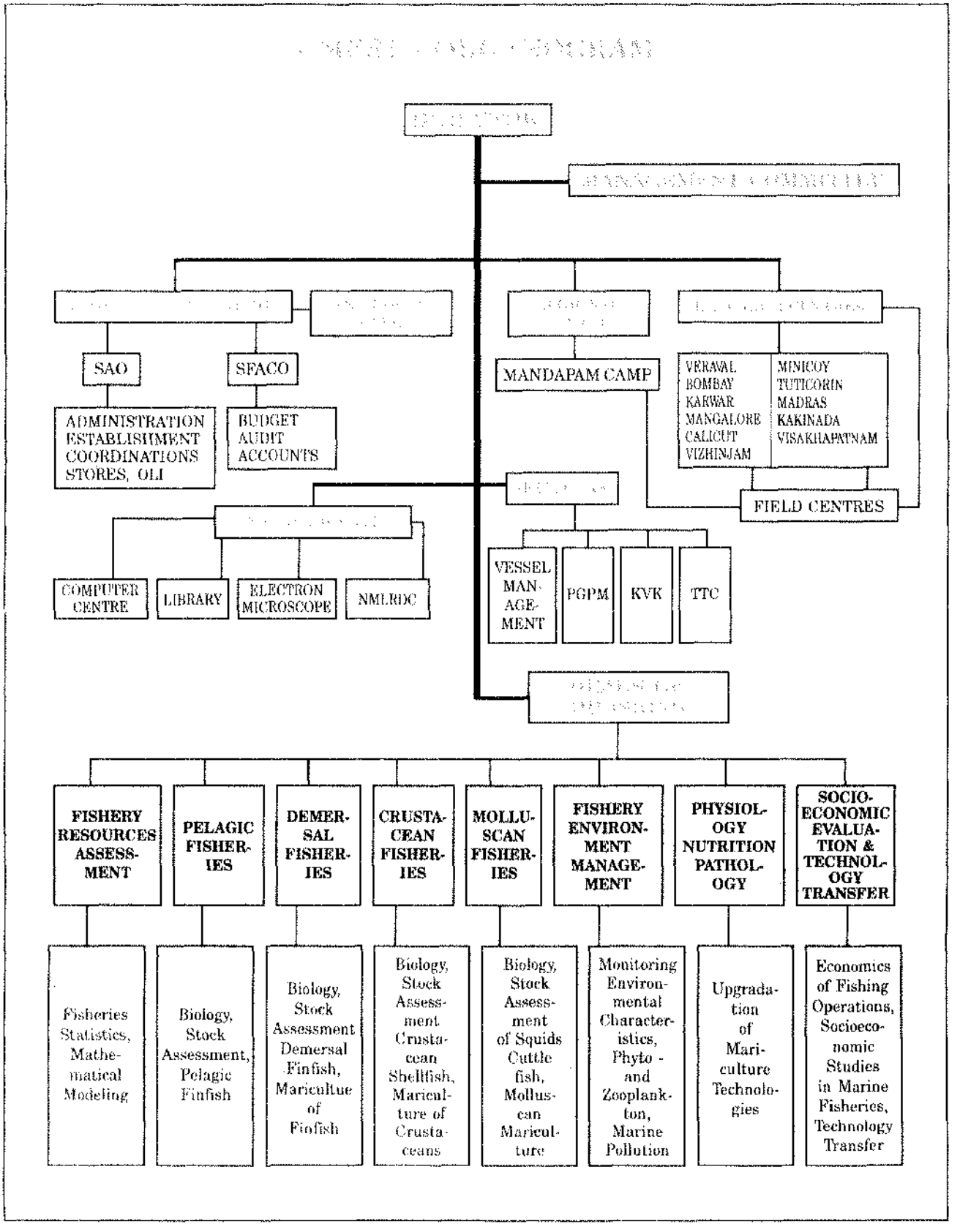
Fig. 1. Establishments of CMFRI along the Indian coast

of marine organisms and the bioeconomic 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, multigear, multispecies fishery of industrial status. During the beginning of the second half of this 50-year period i.e., by the early seventies, the CMFRI realised that capture fisheries production alone would not be able to cater to the needs of the growing population and it became very clear that there was need to supplement capture fisheries with production from coastal mariculture and seafarming. Consequently, a major part of the research effort began to be focussed on seafarming and coastal mariculture. Over the past quarter century, this effort has paid rich dividends in the form of viable technologies for hatchery production of seed and aquacrops through the farming of shrimp, edible oyster, mussel, clam and seaweed 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.

With the infrastructure and expertise built over half a century and looking at the future needs, the CMFRI proposes to play a much greater role in 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 suboptimal in certain cases) exploitation of stocks in inshore waters and the potential yield in the EEZ, the Institute realised the imperative need to intensify research in marine capture and culture fisheries including the frontier areas (biotechnology, genetic engineering, physiology, pathology, nutrition and endocrinology) 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 25 years. The impressive database developed, the achievements made and the current international and national marine fisheries scenarios, constitute the basis for the preparation of this Perspective Plan.



The Laboratory and administrative building of CMFRI Headquarters at Cochin


SAO
SFACO
ADMINISTRATION
ESTABLISHMENT
COORDINATIONS
STORES, OLI
BUDGET
AUDIT
ACCOUNTS
MANDAPAM CAMP
VERAVAL
BOMBAY
KARWAR
MANGALORE
CALICUT
VIZHINJAM
MINICOY
TUTICORIN
MADRAS
KAKINADA
VISAKHAPATNAM
FIELD CENTRES
COMPUTER CENTRE
LIBRARY
ELECTRON MICROSCOPE
NMLRDC
VESSEL MAN-AGE-MENT
PGPM
KVK
TTC
FISHERY RESOURCES ASSESS-MENT
PELAGIC FISHER-IES
DEMER-SAL FISHER-IES
CRUSTA-CEAN FISHER-IES
MOLLU-SCAN FISHER-IES
FISHERY ENVIRON-MENT MANAGE-MENT
PHYSIOL-OGY NUTRITION PATHOL-OGY
SOCIO-ECONOMIC EVALUA-TION & TECHNOL-OGY TRANSFER
Fisheries Statistics, Mathe-matical Modeling
Biology, Stock Assessment, Pelagic Finfish
Biology, Stock Assessment Demersal Finfish, Mariculture of Finfish
Biology, Stock Assess-ment Crusta-cean Shellfish, Mariicul-ture of Crusta-ceans
Biology, Stock Assess-ment of Squids Cuttle fish, Mollus-can Mariicul-ture
Monitoring Environ-mental Character-istics, Phyto - and Zooplank-ton, Marine Pollution
Upgrada-tion of Mari-culture Technolo-gies
Economics of Fishing Operations, Socioeco-nomic Studies in Marine Fisheries, Technology Transfer

2. MANDATE

- Assessment and monitoring of the status of exploited and unexploited fish stocks in the Indian EEZ, the contiguous international waters (for the mesopelagics) and the Southern Ocean (for Antarctic krill and fin-fish) in relation to fishery independant and fishery dependant factors; evaluation of the technoeconomics and socioeconomics of marine fishing operations.

- Development of suitable technologies for seafarming of finfish, shellfish, seaweeds and other cultivable marine organisms; evaluation of the technoeconomics and socioeconomics of mariculture operations; upgradation of technologies through R&D in frontier areas in Biotechnology, Nutrition, Pathology & Endocrinology

- Monitoring the health of the coastal ecosystems, particularly the endangered ecosystems in relation to artisanal fishing, mechanised fishing and marine pollution.

- Transfer of viable seafarming technologies through extension education, specialised trainings and consultancy services.

- Postgraduate education in marine fisheries and mariculture leading to M.F.Sc and Ph.D degrees; introduction of new subjects in frontier areas and establishment of another Deemed University in fisheries.

3. GROWTH

3.1. INFRASTRUCTURE

3.1.1. Laboratories

The laboratories at the Headquarters, the Regional Centre and the Research Centres are fairly equipped with the basic facilities (they include compound microscopes, binocular microscopes, binocular stereozoom microscopes, cameras with closeup lenses, electronic balances, refrigerators, deep freezers, ovens, incubators, spectrophotometers, calorimeters, pH meters, autoclaves and several other facilities to carry out research in the laboratories and to collect hydrographic data and plankton onboard the research vessels). Atomic absorption spectrophotometer, amino acid analyser and fully equipped radio isotope laboratory are the other major facilities at the Headquarters. A transmission-cum-scanning electron microscope has also been installed in the Institute at Cochin to tackle certain frontier areas of fisheries research.

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 60,000 volumes of 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 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 text books.

3.1.3. Field

A. **Marine fish farms**

Mandapam Camp: A marine fish farm developed in a 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 waterspread is available at the Tuticorin Research Centre.

Madras: A shellfish hatchery is functioning in an area of 1.5 acres at Kovalam near Madras

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

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.

Vizhinjam: 1.7 acres of land close to the Vizhinjam Bay for the construction of a marine hatchery complex for seafarming purposes.

B. **Wet Laboratories and hatcheries**: Onshore hatchery-cum-culture facilities have been developed at Visakhapatnam and Fisheries Harbour Laboratory at Cochin. Three bivalve hatcheries one each for pearl oyster, edible oyster and clam at Tuticorin and one shrimp hatchery at Mandapam are available. A mussel hatchery and a multipurpose marine hatchery for mariculture have recently been developed at the Calicut Research Centre.

3.1.4. Buildings

The Headquarters, the Regional Centre at Mandapam Camp and the Research Centres at Veraval, Karwar, Calicut, Minicoy, Tuticorin (partly at Karapad), Madras (partly at Kovalam) and Visakhapatnam are housed in the Institute's own buildings. The other Research Centres (Bombay, Mangalore, Vizhinjam, Tuticorin, Madras and Kakinada) are functioning in rented buildings only. The Institute has rented accommodation at the Cochin Fisheries Harbour premises for mariculture and wet laboratory work. Residential quarters and guest houses are available at Mandapam Camp and to a limited extent at Calicut. The construction of 32 residential quarters at Cochin is in progress.

3.1.5. Any other

Vessels: There are five vessels (*Cadalmin*) of 13.26 m OAL one each at Madras, Mandapam, Tuticorin and Vizhinjam research centres and headquarters, Cochin. These vessels carry out trawling and assist in the collection of hydrographic and plankton data from inshore waters. Besides, one vessel (9.8 m OAL) is available at Mandapam for fishing with other gears in the nearshore waters and for the collection of hydrographic data. Two smaller vessels (7.5 m OAL) are assisting in the collection of nearshore hydrographic data at Mangalore and Karwar Research Centres.

Vehicles: The Institute is adequately supported for its programmes of field work with 21 jeeps and a staff car at different Research Centres and Headquarters. For training purposes a minibus and for "on the spot analysis" of samples in the field, a Mobile Laboratory are available.

3.2 BUDGET

Plan	Period	Plan (Rupees in lakhs)	Non-plan	Total	Percentage increase over the previous 5-year plan
I	1951-1956	4.06	17.66	21.72	-
II	1956-1961	31.45	26.96	58.41	168.9
III	1961-1966	15.87	59.63	75.50	29.3
Annual	1966-1967	1.46	19.12	20.58	-
Annual	1967-1968	1.38	21.73	23.11	-
Annual	1968-1969	0.50	22.73	23.23	-
IV	1969-1974	48.51	133.13	181.64	140.6
V	1974-1979	419.93	255.83	675.76	272.0
Annual	1979-1980	105.79	91.66	197.45	-
VI	1980-1985	722.50	680.60	1403.10	107.6
VII	1985-1990	489.47	1679.87	2169.34	54.6
Annual	1990-1991	90.00	433.00	523.00	-
Annual	1991-1992	100.00	440.00	540.00	-
VIII	1992-1997	900.00	3466.68	4366.68	101.3
% Increase		+22067.5	+119530.1	+20004.4	

3.3. MANPOWER

Growth of Manpower

Plan period	Scientific	Technical	Administrative	Auxiliary	Supporting	Total
IV	206	183	95	-	213	697
V	255	364	141	-	262	1022
VI	229	460	176	15	291	1171
VII	200	445	172	39	296	1152
VIII (1994-95)	189+1	394	172	50	296	1102
% increase/ decrease	-7.76	+115.3	+81.1	+233.3	+39.0	+58.1

The present approved strength of Administrative, Auxiliary, Technical and Supporting staff

Category	Sanctioned	Filled
Administrative	173	165
Auxiliary	53	28
Technical	396	374
Supporting	303	293
Total	925	860

Approved Cadre Strength of Scientists, Disciplinewise and Stationwise

S. No.	Discipline	Hqrs.* Cochin			Visakha-patnam			Kaki-nada			Madras			Tuti-corin			Manda-pam			Vizhi-njam			Minicoy			Calicut			Manga-lore			Karwar			Bombay			Veraval			Total
		PS	SS	S	PS	SS	S	PS	SS	S	PS	SS	S	PS	SS	S	PS	SS	S	PS	SS	S	PS	SS	S	PS	SS	S	PS	SS	S	PS	SS	S	PS	SS	S	PS	SS	S	
1	Fish and Fishery Science	10	8	18	1	2	7	1	1	8	1	2	6	1	4	10	1	2	5	0	2	5	0	1	4	0	1	6	1	2	7	0	1	5	1	3	6	1	3	6	143
2	Agri. Statistics	0	1	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8
3	Agri Extension	0	2	5	-	-	-	-	-	-	-	-	-	-	-	-	0	1	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8
4	Agri. Economics	0	0	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
5	Animal/Fish Nutrition	0	0	1	-	-	-	-	-	-	0	1	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
6	Animal/Fish Genetics & breeding	0	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
7	Animal/Fish Pathology	1	0	0	-	-	-	-	-	-	-	-	-	-	-	-	0	0	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
8	Vet. Pathology	0	0	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
9	Vet. Parasitology	0	0	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
10	Microbiology	0	0	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
11	Biochemistry	0	0	1	-	-	-	-	-	-	-	-	-	-	-	-	0	0	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
12	Agri. Chemistry	0	0	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
13	Soil Conservation & Engg.	0	0	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
14	Soil Chemistry	0	0	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
15	Organic Chemistry	0	0	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
16	Economic Botany	0	0	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
17	Fish Processing Tech.	0	0	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
18	Computer Applications	0	0	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
19	Plant Physiology	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	0	0	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
20	Livestock Production & Management	0	0	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
21	Home Science	0	0	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
	Total	11	12	54	1	2	7	1	1	8	1	3	6	1	4	10	1	3	8	0	2	5	0	1	4	0	1	6	1	2	7	0	1	5	1	3	6	1	3	6	189

(* Includes 1 PS and 2 S of KVK, Narakkal)

Total: PS = 19; SS= 38; S = 132

PS : Principal Scientist; SS : Senior Scientist; S : Scientist

4. SALIENT RESEARCH ACHIEVEMENTS

4.1 CAPTURE FISHERIES

4.1.1. Yield and stock assessment

- Developed, standardised and implemented the Multistage Stratified Random Sampling Design for the estimation of marine fish production along the Indian coast. Districtwise, statewise, gearwise and specieswise production estimates are made by means of this design on a continuous basis from 1947 onwards.

- Quinquennial Frame Surveys have been made for the estimation of fisherfolk population, craft, gear and other details.

- Database on the distribution of a large number of exploited species of pelagic and demersal fishes, crustaceans and molluscs in space and time, their biological characteristics and yield was developed. This information is of vital importance in making stock assessment studies. Methods of estimating the vital statistics for stock assessment were developed.

- 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.

- Optimum mesh sizes and fishing efforts have been determined for all major fisheries. It has been shown that the codend mesh of trawls has to be increased to prevent overexploitation of target demersal stocks as the shrimps.

- 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.

- 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 (Figs. 2, 3, & 4).

- Potential fishing grounds were identified through onboard surveys in the EEZ. Surveys of fishery resources of Andaman and Nicobar islands and Lakshadweep islands were made and suggestions for development given. Survey of economically important seaweed resources completed and the standing stock of various species in the Gulf of Mannar, Palk Bay, Lakshadweep and A. & N. Islands estimated.

- Resources of sponges, corals and echinoderms which have great potential in 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.

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

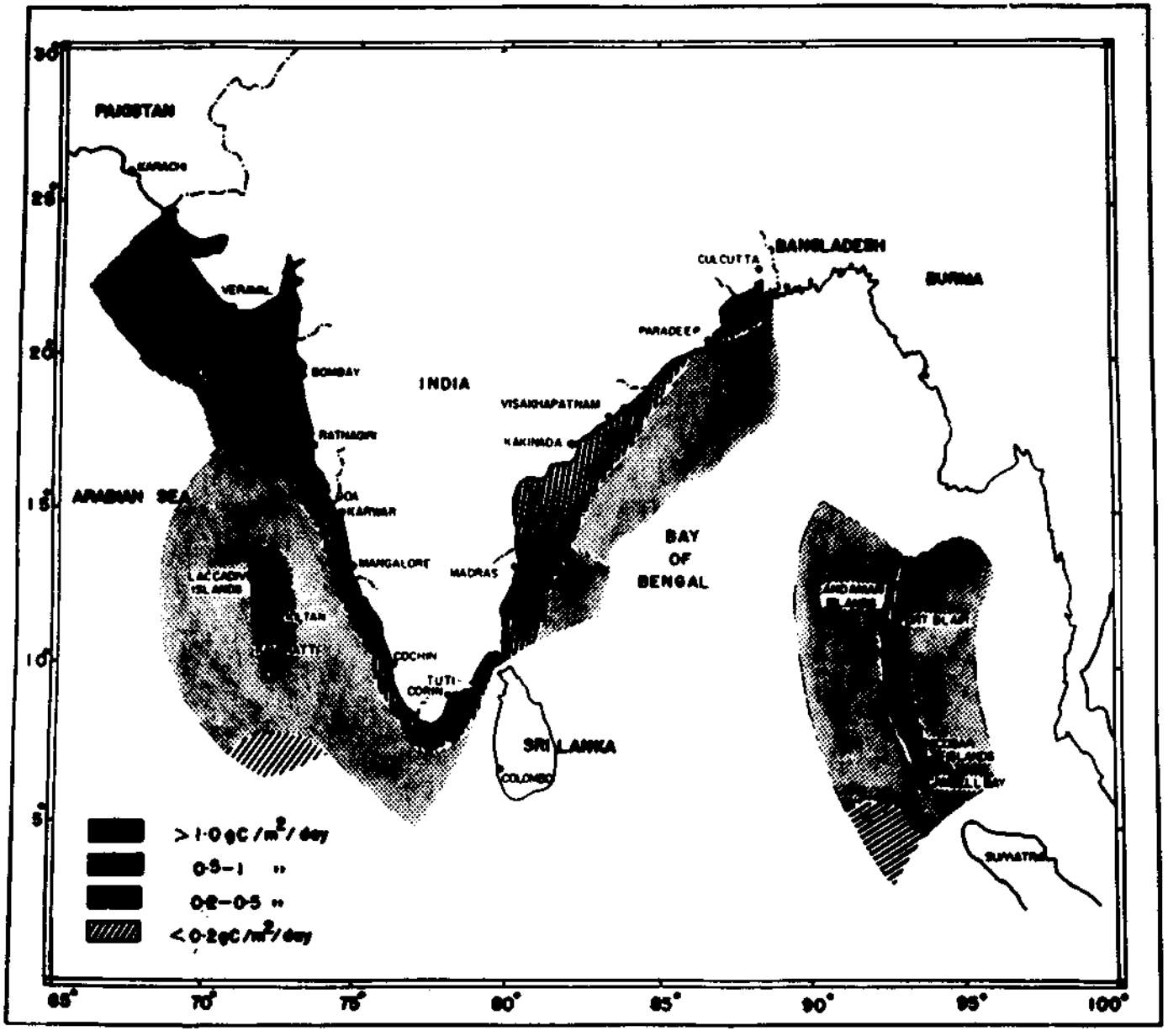


Fig. 2. General level of primary production in the exclusive economic zone of India (Source : Nair, P.V.R. and C.P. Gopinathan 1981, *J. Mar. biol. Ass. India*, 23: 48-54)

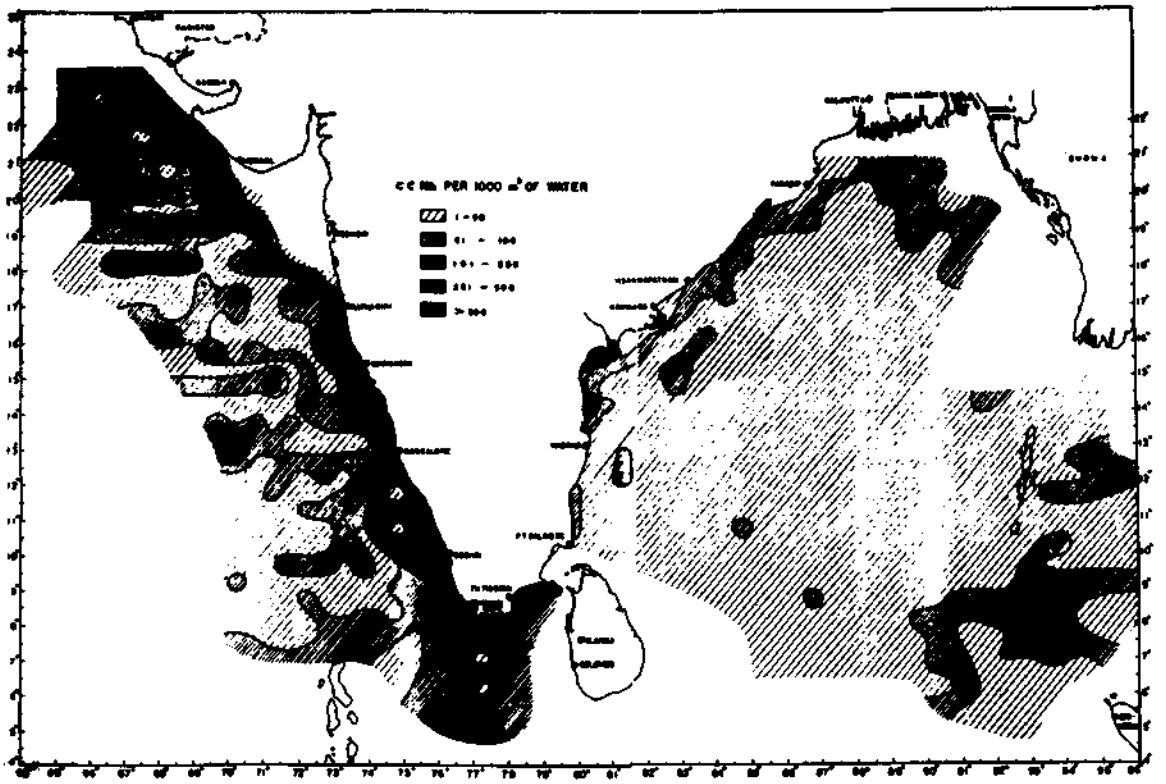


Fig. 3. Spatial distribution of zooplankton biomass

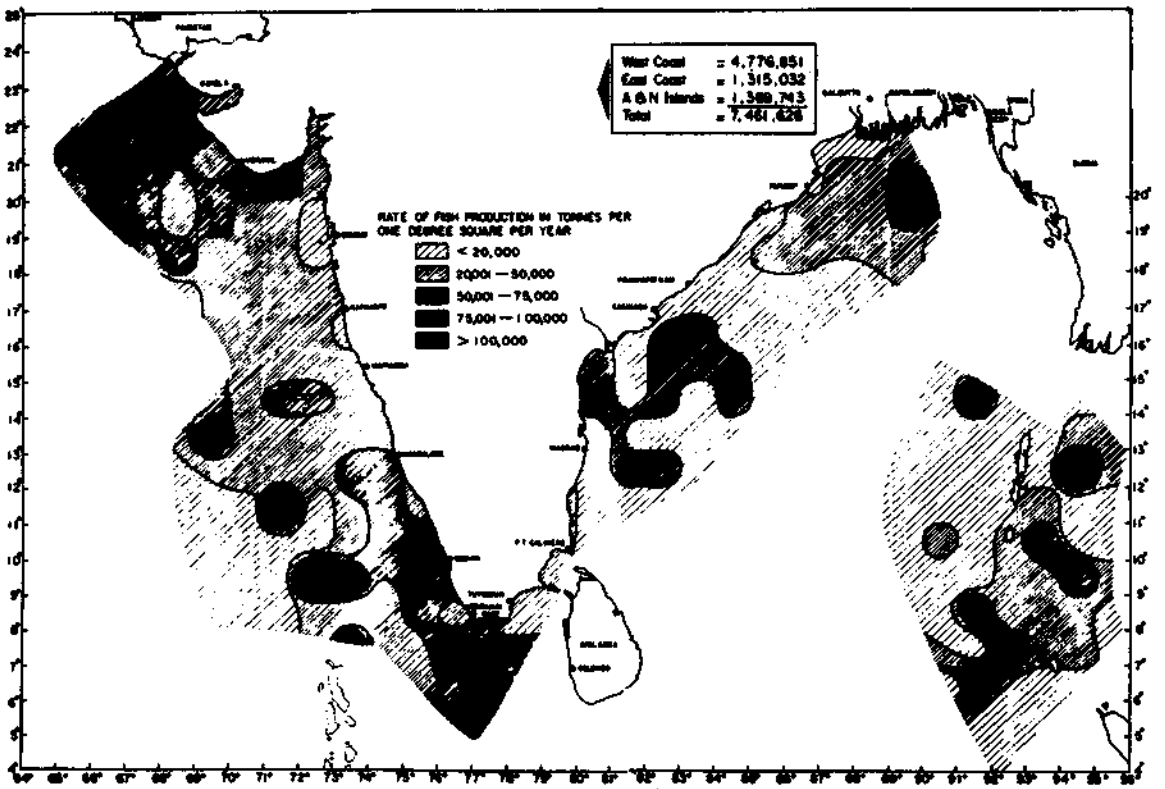


Fig. 4. Rate of fish production in the EEZ of India
(Source : Mathew, K.J. *et al.* 1990. *Proc. First workshop FORV Sagar Sampada,* Cochin, p 59-69)

KNOWLEDGEBASE DEVELOPED BY CMFRI ON THE PRESENT STATUS OF EXPLOITED MARINE FISH STOCKS*

(Data of 1985-89 period)

S. No	Species	Growth parameters		Annual mortality rates			Levels of exploitation	Region along the Indian coast
		Loc (cm)	K/yr	Z (Total)	M (Natural)	F (Fishing)		
	A. PELAGIC FISHERIES							
1	*Sardinella longiceps*	22.1	0.75	2.23	1.30	0.93	optimum	West coast
2	*S. gibbosa*	21.1	1.40	3.90	1.90	2.00	under	Goa-Karanataka
	"	19.7	1.20	6.80	2.10	4.70	under	Kerala
	"	19.1	1.50	6.30	2.10	4.20	optimum	Tamilnadu
	"	19.1	1.50	-	-	-	optimum	Andhra-Orissa
3	*Hilsa ilisha*	59.5	0.47	1.71	0.68	1.03	optimum	North east coast
4	*Encrassicolina devisi*	10.3	1.60	3.77	2.66	1.11	under	East coast
	"	10.3	1.60	3.07	2.61	0.46	under	West coast
5	*Stolephorus waitei*	13.5	1.20	3.95	2.04	1.91	under	East coast
	"	13.0	1.40	3.60	2.25	1.35	under	West coast
6	*Rastrelliger kanagurta*	31.5	0.60	2.92	1.00	1.92	optimum	West coast
	"	31.5	0.60	3.50	1.00	2.50	optimum	East coast
7	*Scomberomorus commersoni*	146.0	0.78	4.08	-	-	over	Kerala
	"	146.0	0.78	3.09	-	-	over	Tamilnadu
8	*Euthynnus affinis*	83.5	0.42	1.52	0.62	0.90	optimum	All India
9	*Thunnus tonggol*	94.0	0.48	1.47	0.66	0.81	optimum	All India
10	*Auxis thazard*	56.0	0.77	1.98	1.02	0.96	under	All India
11	*A. rochei*	37.0	0.64	2.74	1.02	1.72	optimum	All India
12	*Katsuwonus pelamis*	80.2	0.65	3.36	1.06	2.30	optimum	All India
13	*Megalaspis cordyla*	41.0	0.52	3.08	0.84	2.24	optimum	East coast
	"	52.5	0.80	5.12	1.04	4.08	optimum	Northwest coast
	"	39.4	0.60	2.85	0.93	1.92	optimum	Southwest coast
14	*Decapterus russelli*	22.1	0.71	2.83	1.35	1.48	optimum	East coast
	"	29.9	0.45	2.85	0.83	2.02	optimum	Northwest coast
	"	24.8	0.78	3.88	1.26	2.62	optimum	Southwest coast

S. No	Species		Growth parameters L∞ (cm)	K/yr	Annual mortality rates Z (Total)	M (Natural)	F (Fishing)	Levels of exploitation	Region along the Indian coast
15	*Caranx carangus*		44.4	0.65	4.51	0.95	3.56	over	Northeast coast
16	*Selaroides leptolepis*		20.2	0.82	4.88	1.35	3.53	over	Northeast coast
17	*Atropus atropus*		44.0	1.00	6.85	1.26	5.59	over	Southwest coast
18	*Alepes kalla*		17.1	0.83	3.08	1.40	1.68	under	Southwest coast
19	*A. djedaba*		32.6	0.61	5.15	0.99	4.16	over	Kerala
20	*A. mate*		34.0	0.85	3.53	1.22	2.31	optimum	Kerala
21	*Parastromateus argenteus*		39.0	0.70	5.40	1.20	4.20	over	Maharashtra
	"		36.0	0.69	5.10	1.00	4.10	over	Karanataka
22	*Formio niger*		56.0	0.73	4.20	0.89	3.31	over	Kerala
	"		55.0	0.69	6.45	1.03	5.42	over	Karanataka
23	*Trichiurus lepturus*		129.0	0.56	3.15	0.95	2.20	over	East coast
	"		129.7	0.50	3.77	1.07	2.70	over	West coast
24	*Harpodon nehereus*		42.6	0.52	1.44	0.55	0.89	optimum	Maharashtra
	"		41.0	0.75	2.54	1.54	1.00	optimum	Gujarat
	B. DEMERSAL FISHERIES								
25	*Nemipterus japonicus*		30.5-35.1	0.40-0.62	1.80-2.92	0.94-1.29	0.68-1.74	optimum	East coast
	"		32.0-35.0	0.43-0.70	1.95-3.39	0.99-1.37	0.77-2.19	optimum	West coast
26	*N. mesoprion*		22.3-26.7	0.46-0.84	2.01-5.37	1.12-1.67	0.63-3.90	optimum	East coast
	"		22.2-29.7	0.40-0.77	2.04-5.06	1.24-1.57	0.65-3.73	optimum	West coast
27	*Leiognathus bindus*		15.1-16.7	0.70-0.96	4.14-7.44	1.64-2.05	2.09-5.43	optimum	Southeast coast
28	*L. jonesi*		15.5-16.0	0.60-0.70	4.95-5.36	1.50-1.67	3.45-3.69	optimum	Southeast coast
29	*L. dussumieri*		16.2-17.5	0.80-1.20	5.46-6.70	1.76-2.35	3.70-4.30	optimum	Southeast coast
30	*Secutor insidiator*		12.0-13.8	0.85-1.30	4.36-8.72	1.99-2.59	2.33-6.13	optimum	Southeast coast
31	*Tachysurus tenuispinis*		56.0	0.8	2.01-3.70	0.78-1.56	0.45-2.92	over	West coast
32	*T. thalassinus*		75.5	0.4	2.32-2.93	0.36-0.72	1.64-2.57	over	West coast
33	*Otolithus cuvieri*		38.1-39.8	0.52-0.55	-	-	-	optimum	Northwest coast
34	*Johnius macrorhynus*		35.0	0.8	-	-	-	optimum	Northwest coast
35	*J. vogleri*		34.5	0.7	-	-	-	optimum	Northwest coast
36	*J. carutta*		28.1-29.3	0.51-0.56	-	-	-	optimum	Southeast coast
	C. CRUSTACEAN FISHERIES								
37	*Penaeus monodon*	Male	28.5	1.5	-	2.1	-	optimum	East coast
		Female	33.1	1.6	-	1.8	-	optimum	East coast
38	*P. indicus*	Male	20.0	2.0	-	2.0	-	over	East coast
		Female	23.0	2.0	-	2.0	-	over	East coast
39	*P. semisulcatus*	Male	21.0	1.7	-	1.7	-	over	Southeast coast
		Female	26.1	1.3	-	1.3	-	over	Southeast coast
40	*Metapenaeus monoceros*	Male	18.0	1.8	4.28-8.05	1.8	2.48-6.25	optimum	NE & NW coast
		Female	21.0	1.8	4.17-6.33	1.8	2.37-4.53	optimum	NE & NW coast
41	*M. dobsoni*	Male	13.9	2.4	16.5-25.3	2.3	14.2-22.9	over	SE & SW coast
		Female	14.5	2.8	16.2-20.5	2.3	13.9-18.7	over	SE & SW coast
42	*Acetes indicus*	Male	3.1	3.2	13.5	10.9	2.6	under	Northwest coast
		Female	4.0	3.2	10.6	8.2	2.4	under	Northwest coast
43	*Panulirus polyphagus*	Male	53.7	0.2	1.2	0.4	0.8	over	Northwest coast
		Female	44.3	0.2	1.1	0.3	0.7	over	Northwest coast

S. No	Species		Growth parameters Lœ (cm)	K/yr	Annual mortality rates Z (Total)	M (Natural)	F (Fishing)	Levels of exploitation	Region along the Indian coast
	D. MOLLUSCAN FISHERIES								
44	*Loligo duvauceli*	Male	22.0	0.9	1.70-4.76	1.35-2.70	0.35-1.46	optimum	East coast
		Female	20.5	1.3	2.64-5.40	1.95-3.90	0.69-1.50	optimum	West coast
45	*L. duvauceli*	Male	36.0	0.8	2.22-4.06	1.20-2.40	1.02-1.66	optimum	West coast
		Female	23.2	1.1	2.11-4.35	1.65-3.30	0.46-1.05	optimum	West coast
46	*Sepia pharaonis*	Male	27.0	0.9	1.74-2.93	1.08-1.80	0.66-1.13	optimum	East coast
		Female	23.0	1.0	1.82-3.02	1.23-2.05	0.59-0.97	optimum	East coast
		Male	32.0	0.7	1.68-2.95	1.41-2.35	0.27-0.60	under	West coast
		Female	29.6	0.8	1.64-2.86	1.50-2.50	0.14-0.36	under	West coast
47	*Sepia aculeata*	Male	20.3	0.9	1.84-3.47	1.35-2.25	0.49-1.22	optimum	East coast
		Female	20.3	0.9	1.84-3.47	1.35-2.25	0.49-1.22	optimum	East coast
		Male	20.6	1.1	1.82-2.22	1.65-2.75	0.17-0.47	under	West coast
		Female	20.5	1.0	1.62-2.87	1.50-2.50	0.12-0.37	under	West coast

* Extracted from a series of scientific papers published by CMFRI staff in the *Indian Journal of Fisheries*, Vols 39 (1-4) and 40 (1&2).

4.1.2. Fishery prediction

— By collecting sea-truth data for the validation of potential fishing zones mapped by the NRSA on the basis of remote sensed sea surface temperature, helped establish a Marine Remote Sensing Information System for the validation and dissemination of yield forecast maps to the user communities (Fig.5).

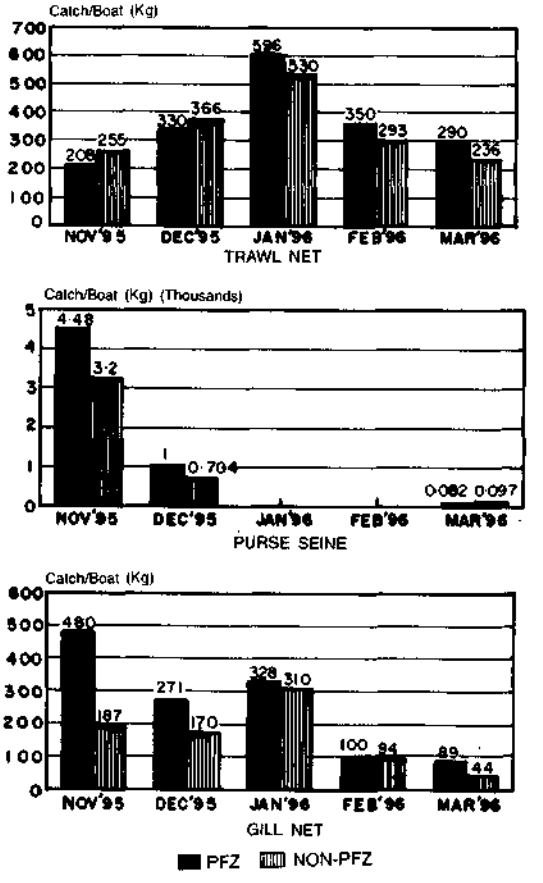


Fig. 5. PFZ Validation : Cochin Fisheries Harbour (Source : CMFRI)

— Developed fishery forecast models based on fishery-dependent and fishery-independent parameters (Fig. 6) for the Malabar upwelling zone.

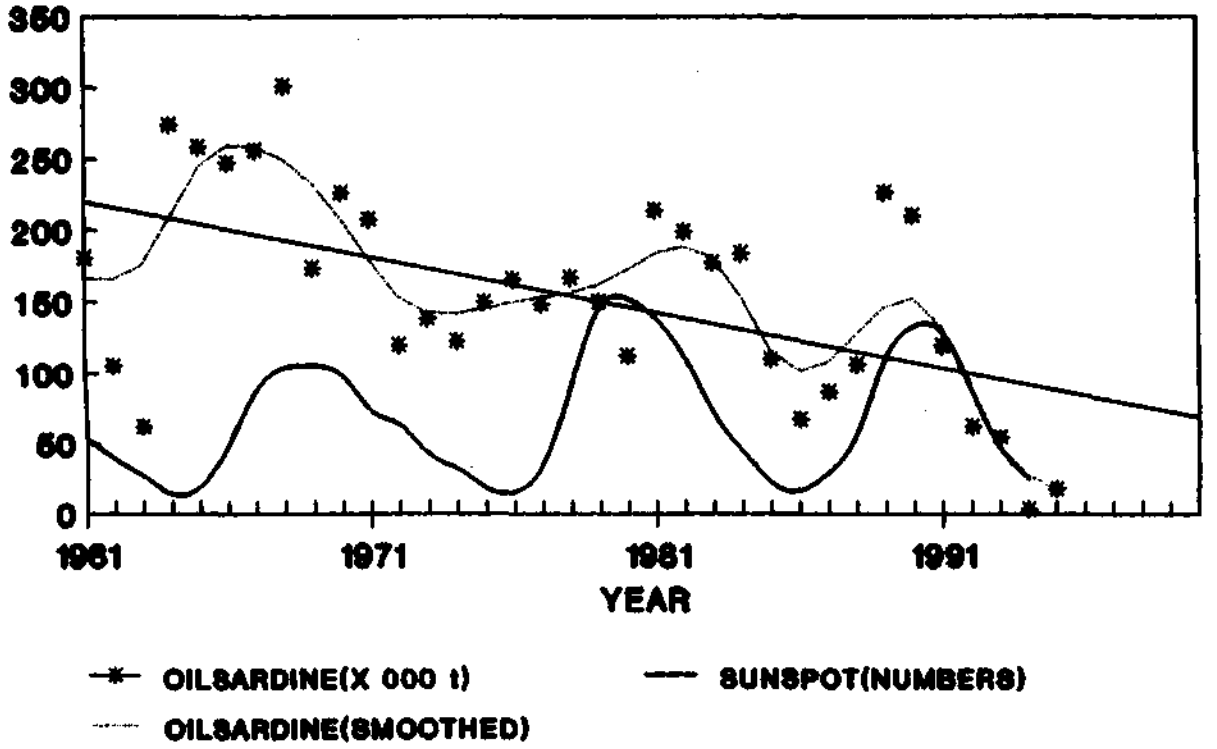


Fig. 6. Oil sardine landings and Sunspot activity (Kerala & Karnataka) (Source : CMFRI)

4.1.3. Economics of fishing

— About 56% of the marine fishermen households have ownership and some means of production and about 45% of them are in debts. Overcapitalisation in inshore fisheries and marginalisation of traditional fishing units are the major problems leading to conflicts between traditional and mechanised sectors.

— The fishermen's share in consumer's rupee ranged from 32% for low quality fish to 72% for high quality fish. The difference in wage rates for men and women doing the same job was found to be wide.

4.2 MARICULTURE

4.2.1. Crustacean mariculture

— 15 species of commercially important crustaceans were bred under captivity and their eggs and larvae reared successfully. Hatchery technology was developed and standardised for *Penaeus indicus, P. semisulcatus* and *P. monodon.*

— Consultancy service for setting up shrimp hatcheries was rendered to government (Kerala) and private (Andhra Pradesh) organisations.

— Indigenous shrimp feeds like the CMFRI 'Mahima' were found to give 25-50% higher performance in terms of growth, production and F.C.R. than the imported shrimp feeds. Inclusion of 30% mantis shrimp meal and 40% soya flour in shrimp feeds was found to improve the quality of shrimp feed substantially. Protein to energy (P/E) ratios in shrimp feeds were determined.

— The quantities of carotenoid pigments in the hepatopancreas of *Penaeus semisulcatus* were determined during different ecdysial stages in males and females.

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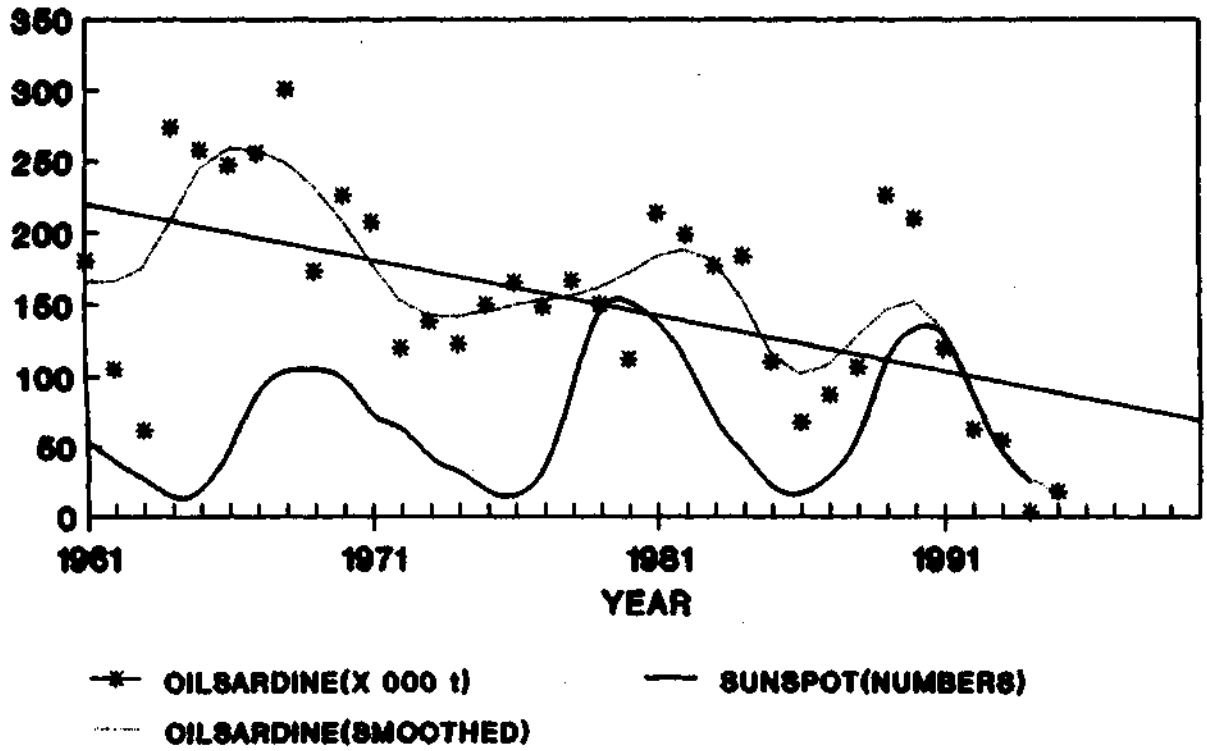

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— The capabilities of juvenile and adult *Penaeus indicus* and *P. monodon* to regulate osmolality concentration in the haemolymph were brought out.

— Phenol oxidase enzyme was found to play an important role in the hardening of the cuticle of penaeid prawns.

— The protein secretory patterns of the neuroendocrine centres of eyestalk, thoracic ganglia and brain in shrimps were quantified for the first time and it was shown that the thoracic ganglia of mature females secrete greater concentration of protein compared to eyestalk and brain. The eyestalk extract inhibits moulting.

— Electrophoretic studies in *Penaeus indicus, P. monodon* and *P. semisulcatus* revealed intraspecific enzyme/protein polymorphism at several loci in specimens from the east as well as the west coasts of India.

4.2.2. Molluscan mariculture

— Package of practices for cultured pearl production was developed and standardised.

— Package of practices for edible oyster culture was developed. The rack and tray method yields 130t/ha/year, the ren method 80t/ha/year and the stake method 20t/ha/year. Successfully completed pilot project on oyster culture and demonstrated the technology.

— Package of practices for the culture of green and brown mussel was developed. Production of 10 kg/metre rope/6 months was shown. Longline mussel culture was developed with the active involvement of fishermen and farms were set up at Padana, Dharmadam, Thikodi, Chellanam, Vizhinjam, Mandapam, Madras, Mangalore and Karwar by the Institute and many private parties.

— Package of clam culture practice was developed. In *Anadara granosa*, the production is 40t/ha/6 months and in *P. malabarica* 15-25t/ha/4-5 months.

— Hatchery technologies for mass production of the seed of 2 species of pearl oysters, one species of edible oyster, 2 mussel species and 5 clam species were developed and standardised.

— R&D support to States and Union Territories was given by supplying hatchery-raised seed of pearl oyster and edible oyster to Gujarat and Lakshadweep Administrations. Regular training programmes on pearl oyster seed production and pearl culture, edible oyster seed production and oyster culture and SCUBA diving were conducted.

— Optimum levels of salinity and temperature were determined as 30 ppt and 30°C respectively for *Meretrix casta* and 5 ppt and 27.1°C respectively for *Paphia malabarica*. The study opens up prospects of commercial clam farming in both brackishwater and marine farms, integrated with fish, shrimps, seacucumber and seaweeds.

— Tissue specific genetic variation was discovered in *Crassostrea madrasensis*. Genetic analysis of electrophoretic pattern of adductor muscle protein indicated the genetic similarity between the Cochin and Tuticorin populations.

4.2.3. Searanching

— Technology of searanching of shrimp and molluscan seed produced in the hatcheries was developed and tested at Tuticorin and Mandapam. A total of 10 million pearl oyster spat was searanched in the Gulf of Mannar in 17 batches during 1985-1990, 4.86 lakh clam spat searanched in Ashtamudi lake in 7 batches during 1993-1996.

— Searanching experiments on hatchery produced *P. semisulcatus* were carried out in Mandapam area. This programme helped in augmenting production in the coastal waters of Palk Bay.

— A few hundreds of baby seacucumber (*Holothuria scabra*) produced in the Tuticorin hatchery have been searanched in the Gulf of Mannar during 1995.

4.2.4. Seacucumber mariculture

Successfully bred seacucumber under captivity and developed hatchery technology for mass production of seed.

4.2.5. Seaweed mariculture

Culture of seaweeds in open coastal waters was undertaken successfully and its feasibility demonstrated in the Gulf of Mannar and the Minicoy lagoon.

4.2.6. Nutrition, Breeding, Pathology and Genetics

Nutrition

— Experimental studies on nutrition of milkfish showed that the fry could utilise gelatinised starch upto a level of 45% in the diet with relatively high survival, growth and feed efficiency.

Breeding

— In controlled breeding of *Mugil cephalus*, successful spawning was achieved (the fish spawned four million eggs; the fertilisation rate was 60% and hatching rate 12.5%) by (a) keeping the fish in healthy condition in an anti-shock cage treated with antibiotics, (b) transferring the maturing fish to seawater, and (c) by judicious administration of hormones after periodic ovarian biopsy.

— Cryopreservation of gametes at a temperature of -196°C using suitable cryoagents and extenders revealed that the 50-60% sperm motility remained unaltered for eight to ten months in *Liza parsia*, for one month in *Sillago sihama* and *Mugil cephalus*, for three months in *Gerres* species and for two months in *Penaeus indicus*.

Pathology

— Pathological changes occurring in the tissues of finfishes due to various chemical pollutants were studied in detail.

— Oxytetracycline was found to be effective in treating brownspot disease and blackgill disease in fishes.

— *Aeromonas hydrophila* was isolated from fishes infected with Epizootic Ulcerative Syndrome.

Genetics

— Species/tissue specific gel electrophoretic patterns of enzyme/protein indicated genetic polymorphism in the oil sardine stocks of the east as well as the west coasts of India. Characteristics of chromosomes were studied for genetically differentiating the heterogenous stocks of the species.

— Exposure of fish *(Lates calcarifer, Liza parsia)*, and clam *(Villorita cyprinoides)* to malathion results in changes in the morphology of the chromosomes in the form of chromosomal breaks and gaps. Sister chromatid exchanges were also observed in *Therapon sp., Oreochromis mossambicus* and *L.parsia*.

— Genetic variations in Indian mackerel collected from different centres indicate the existence of different genetic stocks.

4.2.7. Economics of Mariculture and Extension

— Entrepreneurship development was organised to promote the 'Mahima' shrimp feed and prawn farming. A group farming model was demonstrated successfully by involving 50 fishermen and women in an area of 100 acres which resulted in a reduction of 25% in the cost of production.

— Training, demonstration, exhibition and group meetings were organised on prawn culture, crab culture, mussel culture, pearl culture, oyster culture and seaweed culture. As a result, open sea mussel culture was adopted by fishermen at Andhakaranazhi, Adimalaithurai, Dharmadam and Padana. Ten fish farmers have taken up edible oyster culture at Dalawapuram near Quilon.

— Fishermen - Farmers - Industry - Institution Meets were conducted every month at the Headquarters and the research centres. More than 100 fishermen and officials from R&D agencies and government organisations attended these Meets. As a result, large number of fishermen and fish farmers have started adoption of the technologies.

— Innovative methods of selective farming in brackishwater canals of coconut groves were demonstrated.

— Consultancy services rendered on environmental impact of development projects to Cochin Port Trust, Tuticorin Port Trust and the mariculture industry in Andhra Pradesh and Tamil Nadu.

4.3. HUMAN RESOURCES DEVELOPMENT

4.3.1. Postgraduate Programme in Mariculture

Since its inception in 1979, the achievements of the postgraduate programme in mariculture have been quite impressive, as shown below:

— Twelve batches of students numbering 133 have been awarded M.Sc/M.F.Sc degrees in Mariculture.

— 43 candidates were awarded Ph.D degree on various aspects of Mariculture.

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

4.3.2. Trainers' Training Centre

Altogether 77 courses were conducted since its inception in 1983 and 655 candidates were trained in different areas of mariculture.

4.3.3. Krishi Vigyan Kendra

6,960 fishermen in 369 batches were trained in fisheries; 2,274 persons in 105 batches in Animal Science; 2317 persons in 138 batches in Home Science and 2,175 persons in 101 batches in Crop Science.

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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 till the forties.

- This situation changed drastically through the subsequent decades by the introduction and popularisation of mechanised fishing vessels using trawlnets and motorisation of indigenous craft.

- By the seventies, purseseines 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 development 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 motorised 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 increase the harvests from about 0.6 million tonnes in 1950 to 2.36 million tonnes in 1994, showing a growth of nearly 400% over a period of about 4 decades. This growth also resulted in the annual catch attaining the optimum levels and in the decrease in the per capita area per active fisherman and per boat in the fishing grounds and catch per unit effort, warranting effective management of the exploited stocks in the coastal waters upto the 50 m depth.

Change in per capita area in ha/boat (nonmechanised + mechanised) in the inshore areas (0-50 m) during successive periods

State	1961-62	1973-77	1980	1990
Gujarat	1453	1095	862	499
Maharashtra	257	251	205	108
Goa	3030	229	87	94
Karnataka	114	109	89	51
Kerala	59	57	44	40
Tamilnadu	78	74	52	53
Pondicherry	-	82	77	25
Andhra Pradesh	84	64	46	31
Orissa	528	317	147	96
West Bengal	1503	599	234	192

Change in percapita area in ha/boat (nonmechanised + mechanised) in the offshore shelf areas (50-200 m) during successive time periods

State	1961-62	1973-77	1980	1990
Gujarat	2214	1669	1314	760
Maharashtra	852	833	680	359
Goa	7070	534	204	220
Karnataka	244	233	190	109
Kerala	123	118	92	84
Tamilnadu	55	53	36	38
Pondicherry	-	55	51	17
Andhra Pradesh	69	53	38	25
Orissa	599	359	166	109
West Bengal	626	249	97	80
Lakshadweep	-	-	-	347
Andamans	-	-	-	3043

5.1.2. Coastal Mariculture and Seafarming

- 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 current decade. In the case of marine prawns an estimated 70,573 tonnes (1995-96) of penaeids are annually produced by coastal mariculture operations in an area of about 0.12 million ha.

- The technology of bivalve (mussel, edible oyster and clam) mariculture is poised for commercial growth particularly along the peninsular parts of the country.

- The pearl culture technology developed by the CMFRI is being increasingly adopted by the shrimp farmers for the production of cultured pearls in their onshore shrimp growouts.

- The seacucumber has been successfully bred under captivity and the hatchery technology developed.

- Seaweed culture is on the threshold of commercial operations.

- Though there are certain serious problems relating to disease, feed, seed and water quality in coastal mariculture, such problems are not uncommon in any cultivation sector. These problems are being solved by the farmers with the active support of government R&D institutions.

5.1.3. Infrastructure and economy

- There is a long coast of 8129 km in the country (Fig. 7) with a continental shelf of over 0.5 million sq km (Fig. 8) and an EEZ area of 2.02 million sq km.

- There are 3638 marine fishing villages in India and the catches are landed at 2251 traditional landing centres (Fig. 9).

- 6 major fishing harbours, 27 minor fishing harbours and 109 modernised landing centres are functioning along the coast.

– About 1.91 lakh nonmechanised craft, (including 32,000 motorised craft), 47,000 small mechanised craft and 180 large fishing vessels are presently engaged in fishing in the Indian seas.

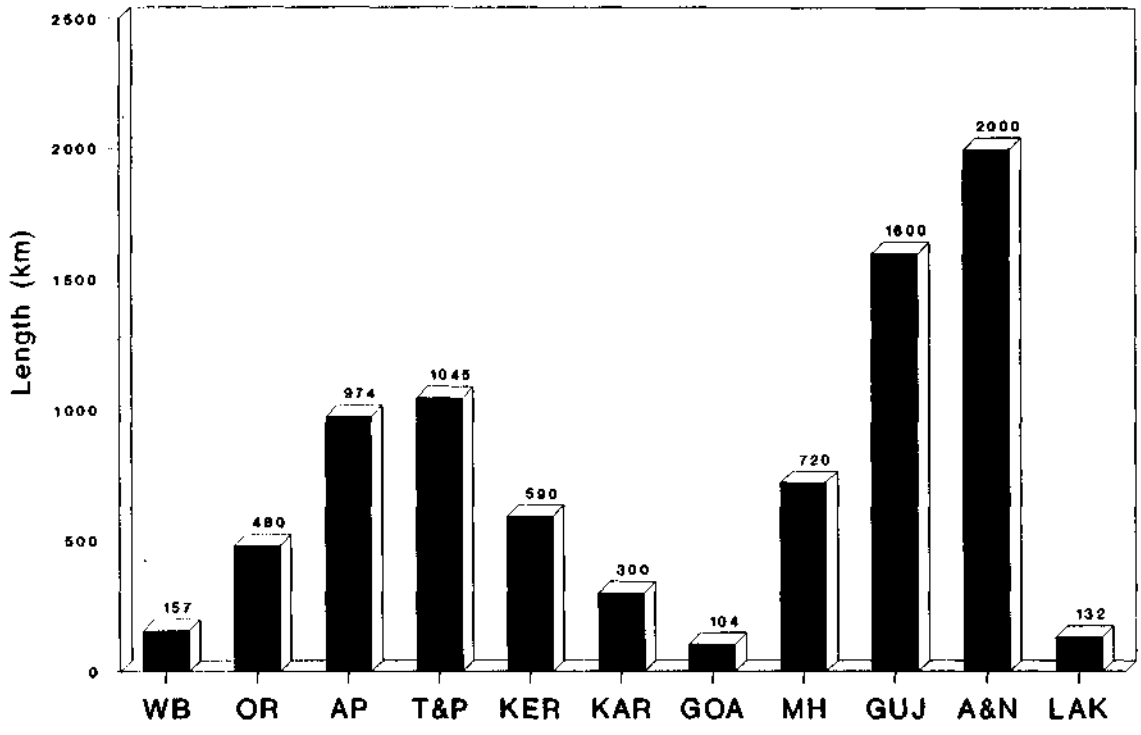

Fig. 7. Coast Lengths of maritime states and union territories (Source : DAC)

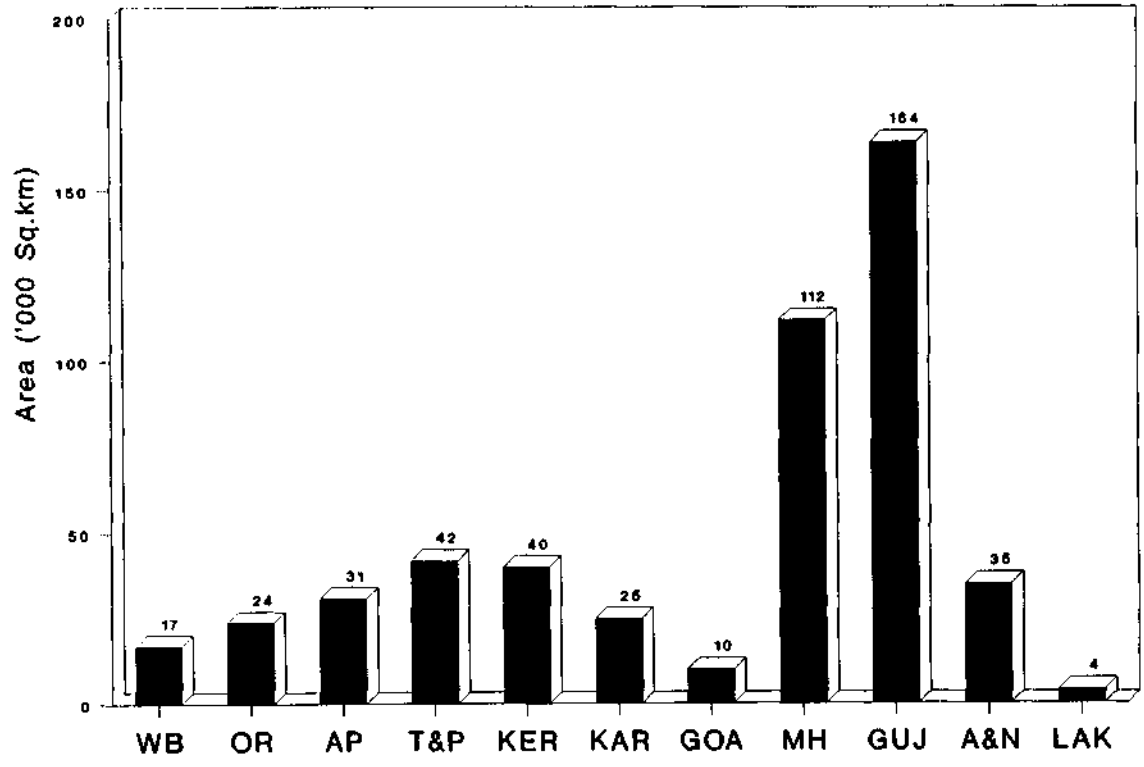

Fig. 8. Continental shelf area off different maritime states and UTs (Source : DAC)

– 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 6600 t capacity per day, 14 canning plants with 52.5 t capacity per day, 148 ice making plants with

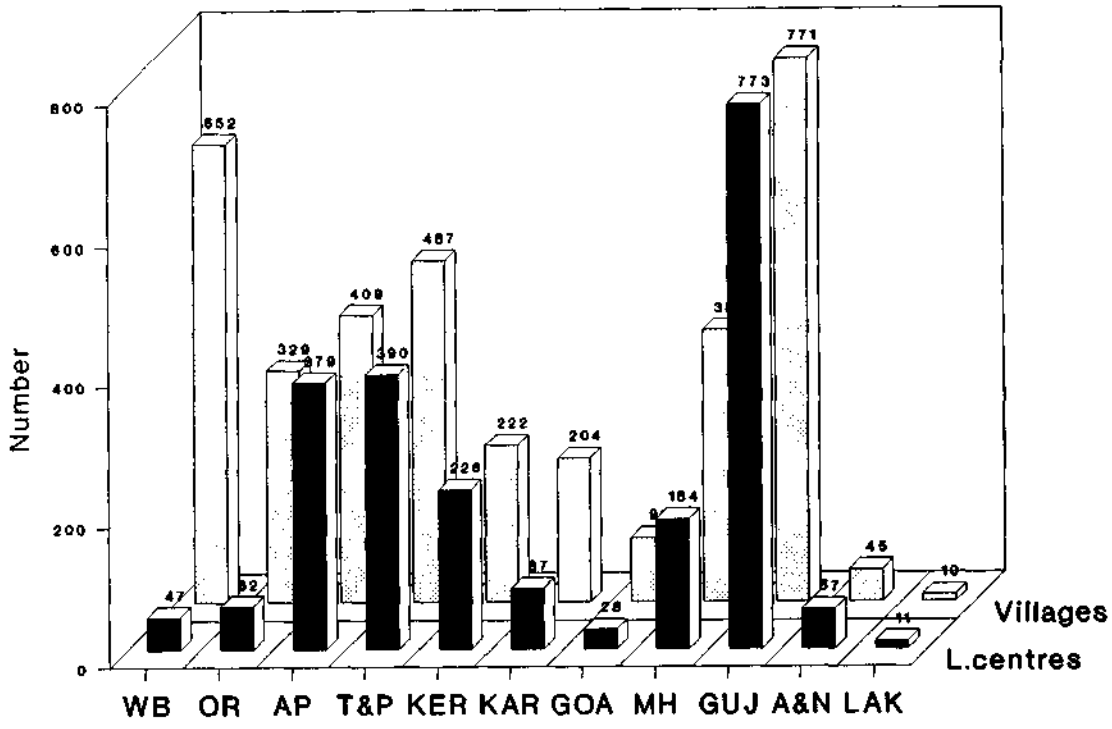

Fig. 9. Distribution of landing centres and fishing villages in different maritime states & union territories (Source : DAC)

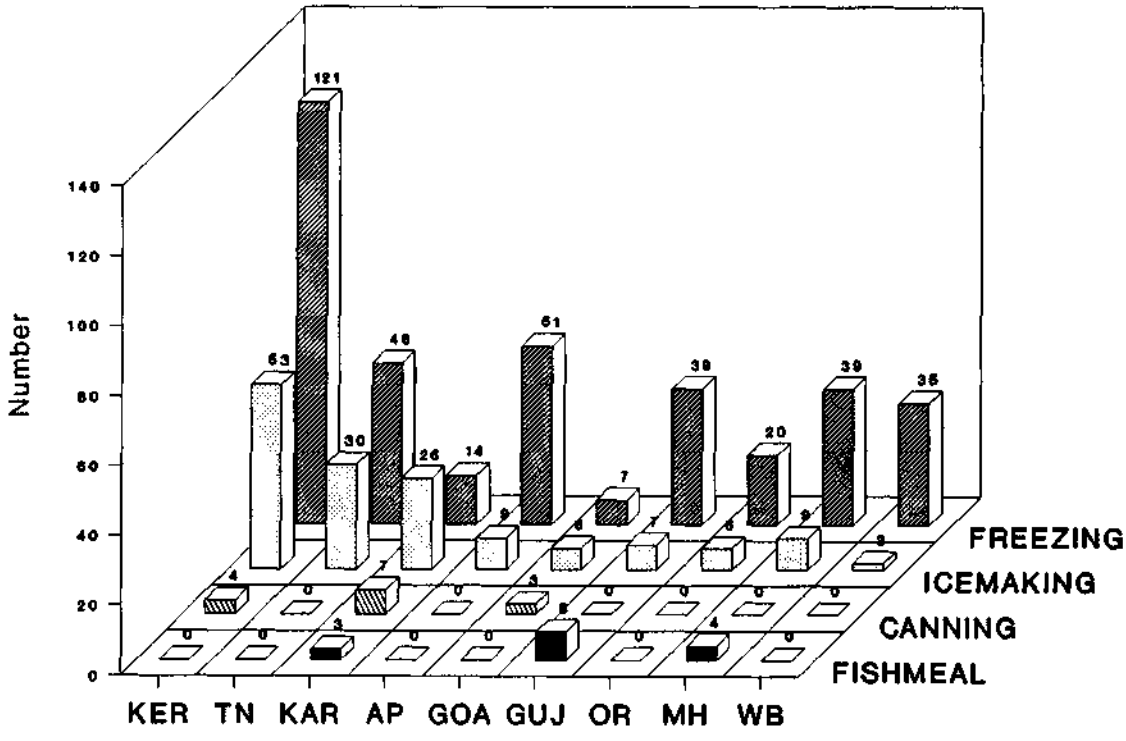

Fig. 10. Number of Freezing, Canning, Ice making and Fish meal plants in different maritime states (Source : MPEDA)

about 1800 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 2684 t (Figs. 10, 11, & 12).

– The number of fishermen engaged in active fishing in the small-scale fisheries sector alone increased from about 6 lakhs during 1980-81 to 10.25 lakhs during 1994-95.

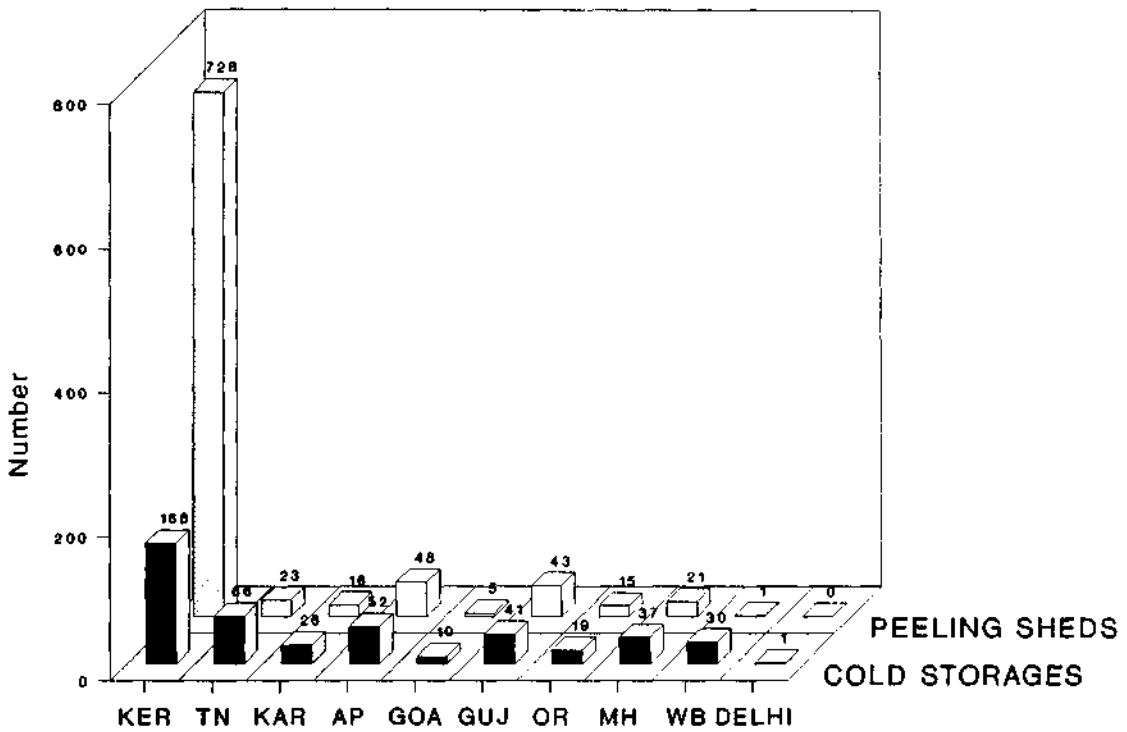

Fig. 11. Number of Cold Storage and Peeling Sheds in different states (Source : MPEDA)

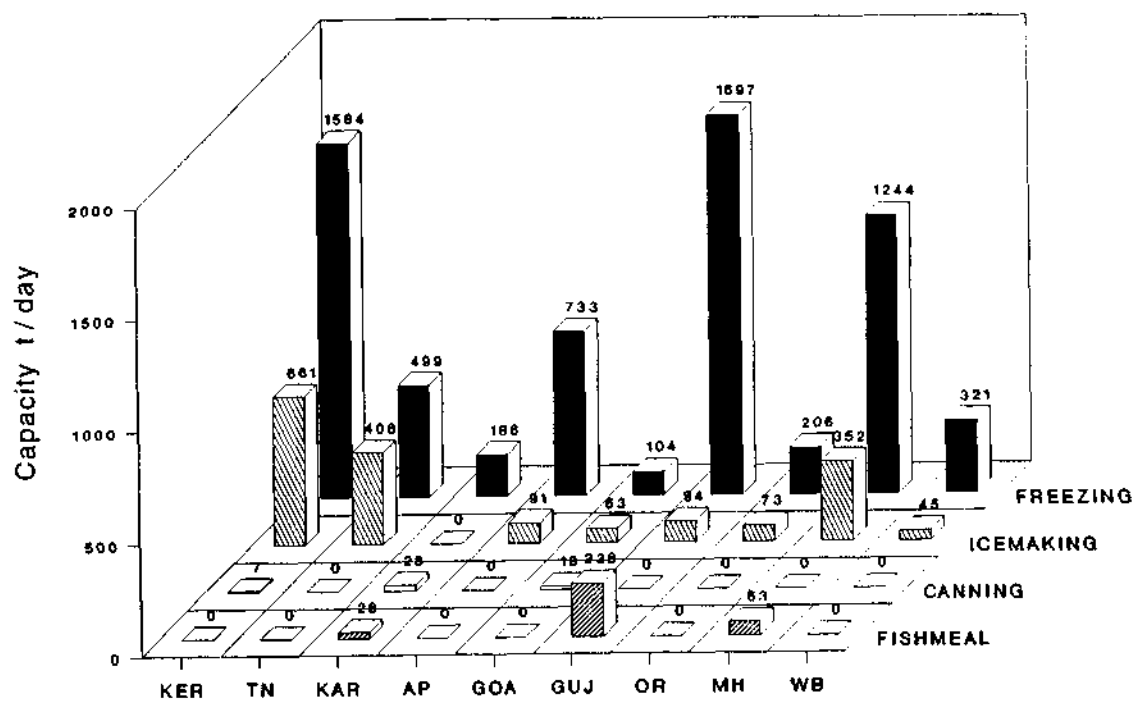

Fig. 12. Capacities of Freezing, Canning, Ice making and Fish meal plants in different maritime states (Source : MPEDA)

The employment generated in the harvest and postharvest 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 nonmechanised, motorised, small mechanised and large mechanised sectors at current price level is around Rs. 3,34,000 lakhs. The marine fish landings during 1994 earned an estimated gross income of Rs. 8,80,060 lakhs at the landing centre price level. The contribution of the fisheries (marine & inland) to the net domestic product increased

8 fold during 1980-81 - 1993-94while that of the agriculture sector increased only 4 fold duringthe same period.

— About 55 varieties of marine products are exported to different countries in Southeast Asia, Europe and USA. The total quantity of marine product exports increased from about 97,200 t in 1987-88 to 307,337 t in 1994-95 and the export value increased from Rs. 53,000 lakhs in 1987-88 to 3,57,500 lakhs in 1994-95 (Figs. 12, 13, 14, 15, 16). In

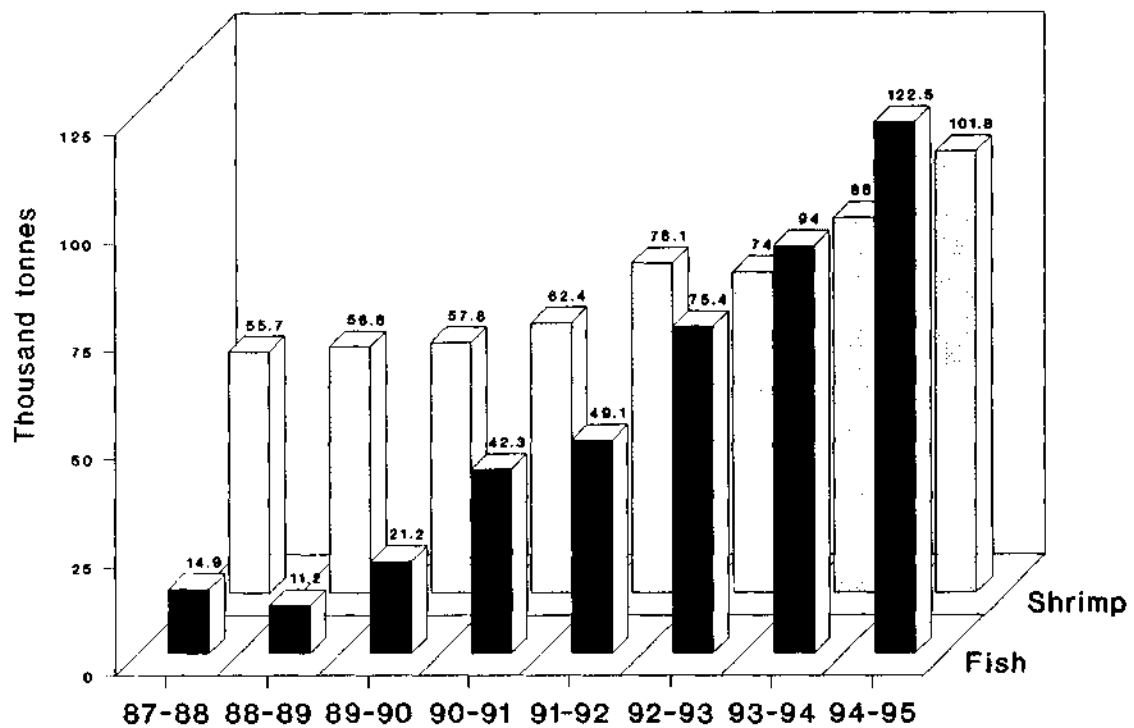

Fig. 13. Export of marine fish and shrimp: 1987-88 to 1994-95 (Source : MPEDA)

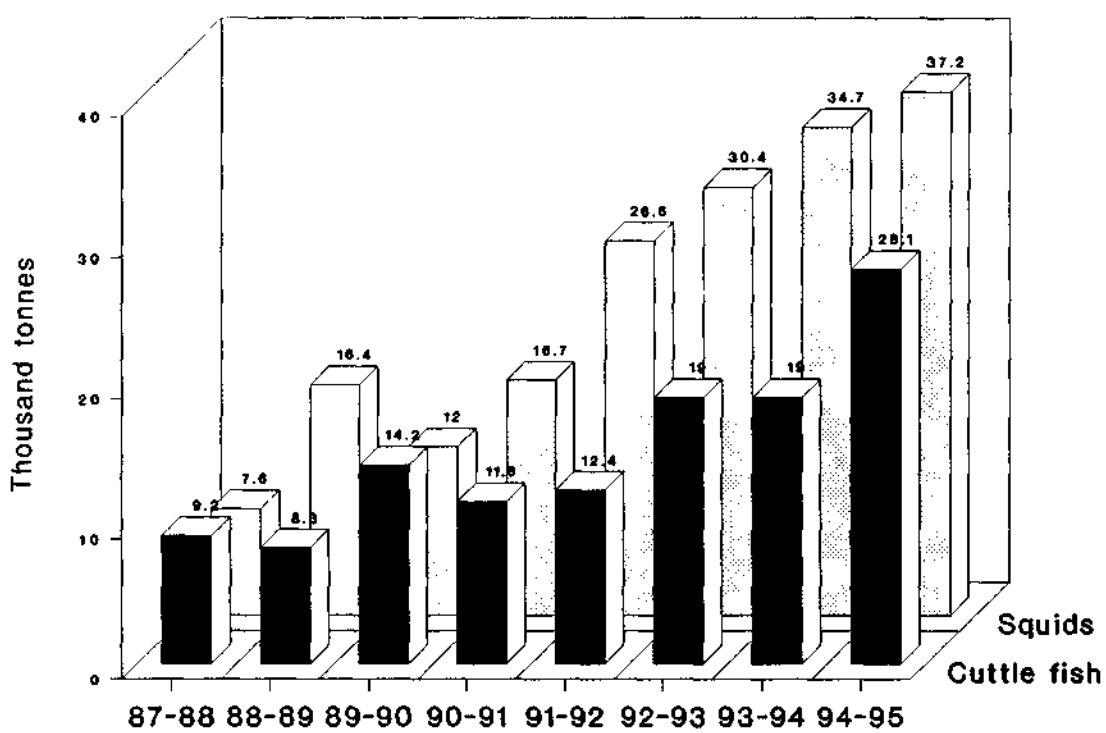

Fig. 14. Export of cuttle fish and squids: 1987-88 to 1994-95 (Source : MPEDA)

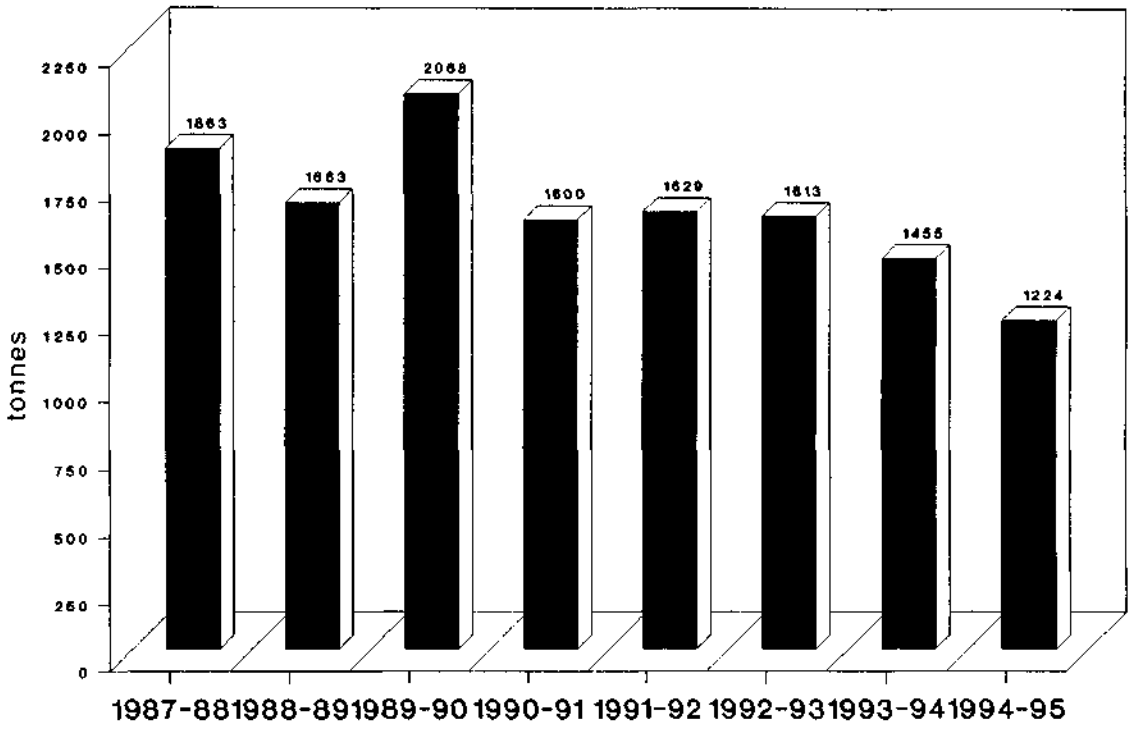

Fig. 15. Export of lobster : 1987-88 to 1994-95 (Source : MPEDA)

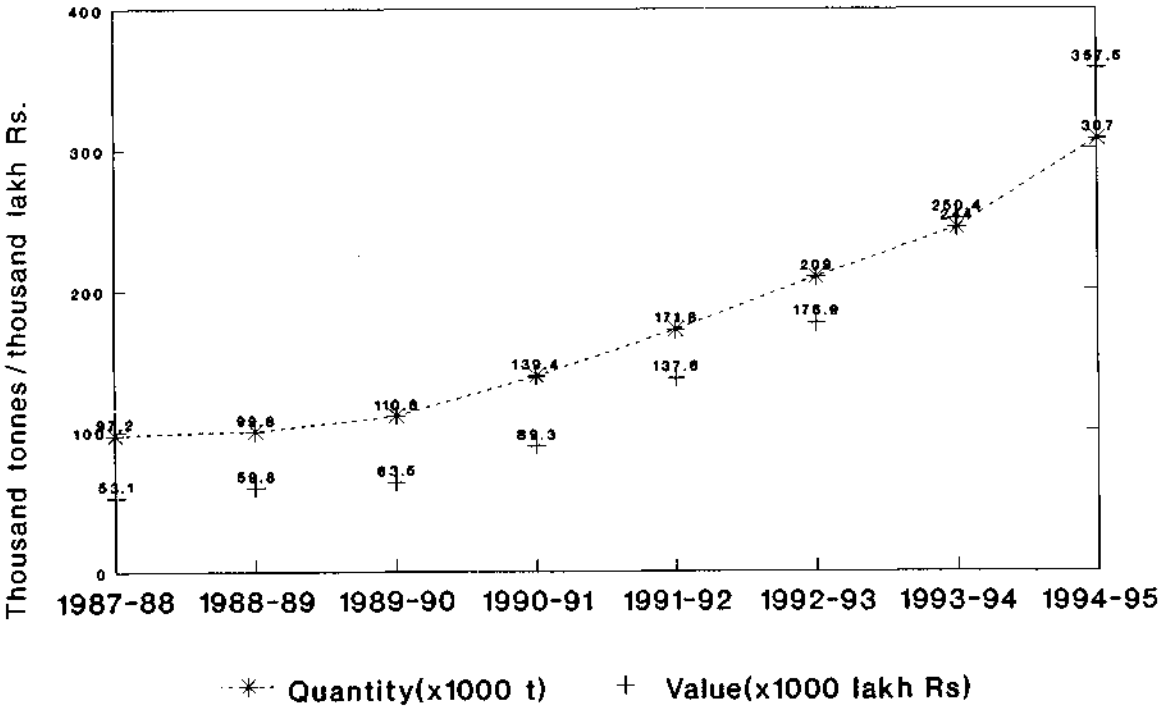

Fig. 16. Export of marine products — quantity and value (Source : MPEDA)

terms of the US dollar, the foreign exchange earning from marine products exports by India reached a record US $ 1,140 lakhs in 1994-95 compared to US $ 1,400 lakhs by Taiwan, US $ 1,600 lakhs each by Indonesia and South Korea, US $ 2,300 lakhs by China and US $ 4,300 lakhs by Thailand.

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

- increased production by extending the area of operation to the underexploited and unexploited grounds,
- optimal and/or overexploitation of many prime fishery resources in the shelf waters upto the 50 m depth
- conflicts among different categories, particularly between the artisanal and mechanised groups of fishermen.
- the realisation that effective management of exploited stocks is necessary for sustaining production in the coastal waters
- the need for development and further improvement of mariculture technologies
- the need for promoting integrated growth of the marine fisheries sector and
- the imperative need for improving and expanding fisheries extension activities for effective and faster technology transfer.

5.1.4. Science

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

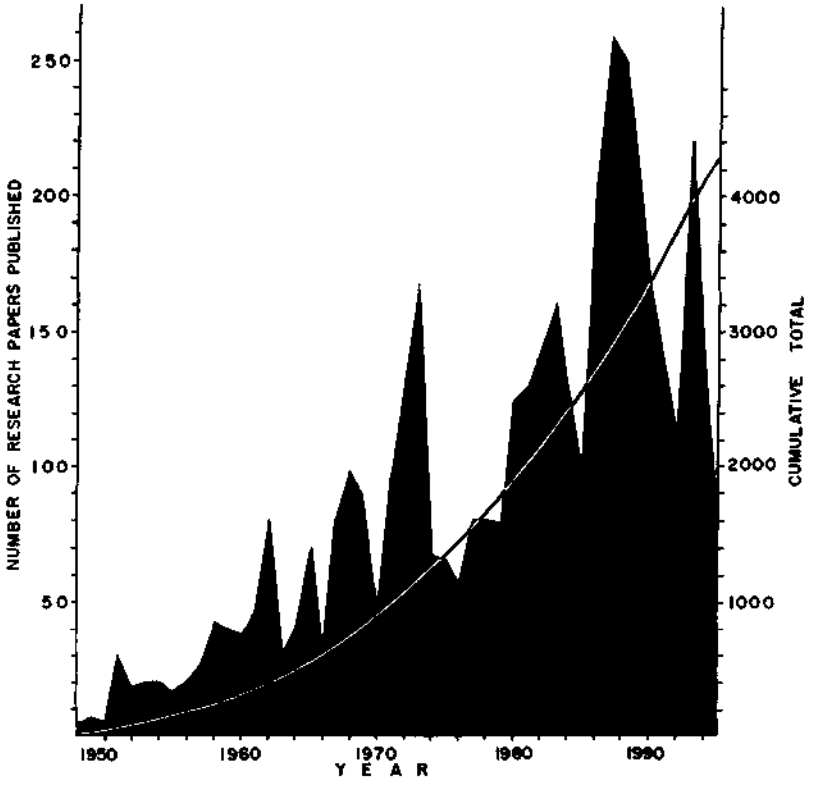

Fig. 17. Number of Research Papers Released from CMFRI every year from 1948 to 1995 and the cumulative total

The CMFRI has been paying special attention to the development of a comprehensive knowledge base for marine capture fisheries and mariculture since its inception in the year 1947. About 4300 scientific papers have been published so far both in Indian and foreign journals on the basis of research carried out in the CMFRI (Fig. 17) on various disciplines pertaining to the:

- taxonomy of different groups of finfish, shellfish, other marine invertebrates, microalgae, macroalgae, marine mammals and marine turtles
- spatial and temporal distribution of different species of finfish, shellfish and seaweeds of commercial importance
- distribution and abundance of different planktonic organisms in space and time
- oceanographic features of the Indian EEZ, particularly its upwelling areas, primary and secondary productivity, nutrients and pollution status
- the food preferences of the different exploited stocks
- spawning periodicities and spawning periods, spawning grounds and fecundity of a large number of marine fin-fish and shellfish stocks
- growth rate and age of a large number of commercial fin-fish and shellfish stocks
- population parameters, stock size, optimum yields and optimum effort for a number of major exploited fish stocks
- inedible living resources of commercial importance (e.g., to the chemical and drug industries) such as sponges, corals, gastropods and certain echinoderms
- controlled breeding, seed production and farming of cultivable marine organisms.
- mariculture, biotechnology, genetics, pathology, nutrition, physiology and endocrinology

The knowledgebase obtained, the human resources developed and the infrastructure established in marine fisheries R&D since independence have placed India in a prestigeous 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. 1,17,232 lakhs in the eighth 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 1.6 lakhs, motorized craft to 32,000 and that of the mechanised craft to about 47,000.
- The development in the processing and export sector led to the growth of the industry to 372 freezing plants with a daily capacity of 6575 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 2684 t.

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- The marine fish production reached the optimum level of about 2.3 m t and coastal aquaculture production to about 70,000 t. Of the total area of 1.2 million ha available for shrimp culture, 0.12 million ha is currently under active use.

- The earning from export of marine products has increased to an all-time high of Rs. 3575.3 crores in 1994-95.

The investment in the capital sector and the developments that have taken place so far, no doubt led to increased production, increased exports, increased 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 fisherman or per boat and optimum exploitation in the 0-50 m 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 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 Tamilnadu, Maharashtra and Gujarat are also carrying out research in marine fisheries and mariculture. The CMFRI published over 4300 scientific papers 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 national survey for estimation of marine fish landings, fishing effort and economics of fishing has been developed, improved and standardised 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 coast developed. This database has facilitated the estimation of marine fish landings and fishing effort specieswise, gearwise and districtwise 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 realising sustained production of fish from our EEZ dealt with under 5.2.1 above.

C. Research on the population characteristics and response of the fish stocks to exploitation, over the years, has 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 of trawls and other gears in order to ensure sustained production and returns dealt with under 5.2.1 above.

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

E. Interinstitutional 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 CMFRI and the FSI undertake regular validation of the PFZ maps by means of sea-truth data on seasurface 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 instant prediction of fisheries abundance and production prospects for the country's entire EEZ 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 ICAR, 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 CMFRI, several *ad hoc* research projects sponsored by the ICAR, 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. A large number of projects in the inland fisheries and aquaculture sectors are also being implemented by these agencies. Such a national facility provides immense opportunities for continuous technology upgradation. 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 have not been effectively transferred to the endusers due to weak fisheries extension.

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.

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G. The initiative taken to develop the human resources for the marine fisheries sector by the national and regional institutes including the ICAR, 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 CMFRI, several *ad hoc* research projects sponsored by the ICAR, 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. A large number of projects in the inland fisheries and aquaculture sectors are also being implemented by these agencies. Such a national facility provides immense opportunities for continuous technology upgradation. 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 have not been effectively transferred to the endusers due to weak fisheries extension.

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 delay or failure in the development of suitable indigenous feeds and feed technology for different commercially cultivable marine candidate species has been a serious lapse as a result of which the country imports nearly all its requirements of shrimp feeds for its semiintensive to intensive farms.

D. 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 Sasson Dock), 27 minor fishing harbours and 109 modern landing centres have been created for the current 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 2251 village landing centres where most of the 160,000 artisanal craft (belonging to 3638 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 13% to the total annual catch while the motorized sector contributes 19% and the mechanized sector 68%. Although mechanization has paid rich devidends, the problems of declining productivity in the artisanal sector have not been properly addressed. These problems could be resolved by mechanising (not motorizing) all the larger vessels of the artisanal sector as indicated below. There is a strong possibility of successfully fitting the artisanal craft of about 30' OAL from among the existing fleet with 26 HP inboard 'Yanmar' engines for offshore pelagic fishing for the larger pelagics like the sharks (following the BOBP-SRL model). This programme would, however, have to take care of the berthing facilities in as many fishing villages as possible.The best option in this regard is the establishment of floating type marina berths for all such prospective mechanized artisanal vessels requiring not more than 3 m (draft) depth for berthing. Fuel berths could be easily integrated with marina type floating quays. Such artisanal mechanised vessels could carry enough salt for curing the catches taken over a cruise duration of 12 to 15 days each just as the SRL (BOBP) vessels fishing from Mangalore for the same type of fishery. As there are fuel efficient offshore fishing vessels with a potential of Rs. 6 lakhs annual income and Rs. 2.5 lakhs net profit (fuel consumption only 3 l diesel/ hr as against 10 l/42'vessel with 110 hp engine), the country should hasten the development of this fleet from among the artisanal fleet. Without such a programme: (1) the existing production gap of about 0.8 m t of fish from the midshelf grounds (50 to 200 m depth) would be difficult to bridge, and (2) most of the fleet of 160,000 artisanal craft which spend hardly 20 days per year in fishing in some of the states (Andhra Pradesh, West Bengal, Karnataka, Maharashtra and Gujarat) would continue to remain idle together with the fishermen. Such a situation, if allowed to persist, is bound to aggravate the problems of unemployment, underemployment and economic waste. This R&D activity has to be taken up as a matter of utmost national priority.

The failure to integrate small scale mariculture/seafarming with small scale fishing ever since the mariculture packages were made available nearly 2 decades ago, has led to the aggravation of famine and deprivation during seasons of low catches from capture fisheries. The floating marina type berths provide good platforms for integrating sea fishing with seafarming.

Inshore artificial reefs have been limited to only Trivandrum and Kanyakumari districts (31 reefs) and Madras district (only 2 reefs). They need to be established throughout the country as in South Korea as an industry *per se*, and duly integrated with inshore seafarming to promote productivity and production in the artisanal sector.

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 recruitment overfishing of certain species. Another important issue in the trawl fishery is the large scale discards of finfish by shrimp 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 depthwise 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 not be carried out 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, UNDP-Pelagic Fisheries Project etc) effort over the last 50 years are now being used to develop forecasting 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 aquire 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 such as capture fisheries management, fisheries oceanography and aquaculture with particular reference to biotechnology, genetics, nutrition, physiology, pathology, and endocrinology in order to meet the growing demands for these cadres in all R&D and industrial aquaculture activities.

5.3.4. Deemed University in Fisheries

In the network of fisheries Institutes of ICAR, the CMFRI is the largest with regard to manpower and infrastructure; it also has 12 research centres along the country's coastline to attend to the research and development needs of different hydroclimatic regions. The Institute is recognised as one of the centres of excellence in marine fisheries and mariculture research in the world. It was in recognition of its excellence, the FAO/UNDP sanctioned the CAS in mariculture to the CMFRI in 1979. Therefore the Institute deserves to be given the status of a Deemed University, besides the CIFE under which all fisheries education under ICAR system has been brought. The status of marine fisheries and mariculture in the country deserves **establishment of another Deemed University which the CMFRI could fulfill.**

5.3.5. 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 utilised (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 will be able to carry out the research programmes in these 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.

5.3.6. 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 (IFP, CIFNET & CICEF), the DARE and the ICAR institutes, (2) the Ministry of Food Processing Industries and the FSI working under its control, (3) the Ministry of Science and Technology together with the DST, DOD, DBT and the CSIR Labs like the NIO and the Ministry of Commerce together with the MPEDA. At the state level, the SAU 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 independant 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 manufacture of food indigenously 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, breams and seabass. Action has been taken for pilot scale farming of these fishes and also the pampano in the Mandapam, Tuticorin and Narakkal marine fish farms of the CMFRI.

5.4.2. Capture Fisheries

A. **Mechanisation of artisanal boats**: The artisanal sector fishing vessels, remaining mostly idle today, need to be mechanized for offshore pelagic 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.

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B. **Regulations and 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 prevent growth overfishing. 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. The active involvement of the ICAR and the Ministries of Food Processing Industries, Agriculture and Commerce will greatly help in achieving the targets.

D. **Information technology and networks**: In order to keep pace with the developments taking place in the world in the areas of marine capture and culture fisheries research and development, increased use of computers and networks deserve much greater attention.

E. **Marine environment monitoring for fishery forecast and for ocean health**: Realising the importance of clearly elucidating the relationship between fishery independant factors and fish abundance, the CMFRI is giving greater emphasis for monitoring the various fishery oceanographic and meterological parameters including sunspot activity 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 flyash 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 sustained 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, genetics, nutrition, physiology, pathology and endocrinology) deserve to be accorded postgraduate status, following the system in vogue in agricultural and animal sciences. The CMFRI, with 189 scientists working in 8 need-based divisions at Cochin as well as 12 research centres along the country's coastline together with a large number of technical and other staff is the largest fisheries research institute in the country and possesses expertise in almost every field of Fishery Science. The Institute is in a better position than any other Institute to be accorded the status of a Deemed University in Fisheries. The already existing deemed university for fisheries (CIFE) under the ICAR need not be taken as a reason for according deemed university status to the CMFRI because:

- there is acute shortage of trained manpower in fisheries and in the coming years, it is likely to attain unmanageable levels if timely corrective measures are not taken, and

- the complexity of Indian fisheries, the value of the fish stocks, the size of the population living on the fisheries and the need to increase fish production to 7.2 m t by 2020 amply justify at least a second deemed university in fisheries under ICAR.

The deemed university at CMFRI can look after the manpower needs of the marine and brackishwater fisheries and mariculture sectors while the CIFE can continue with its historic role, similar to the functioning of the IVRI and NDRI as deemed universities in the animal sciences sector under the ICAR. The proposed deemed university status to the CMFRI will usher in a new era in the country's marine fisheries and mariculture sectors and help the country realise the full economic potential.

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 jeopardise 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 IASRI, the nodal agency to carry out HRD work in statistics and the ICAR will be requested to introduce "Fisheries Statistics and Fish Population Dynamics" as a specialisation for M.Sc. statistics programmes. The CMFRI would also introduce this discipline 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 manyfold in the coming years through the active involvement and participation of the fisheries departments, research institutions, universities, NGOs and the industry including the fisherfolk community.

6. SCENARIO (National *vis-a-vis* International)

According to the FAO, food insecurity in the developing world is a serious problem, with about 780 million people living on food that does not help maintain a healthy life. A recent (1994) study by M. Garcia of IFPRI 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 one of 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 tonnes in 1989 and declined to 84.25 million tonnes in 1993 (Fig 18); the indications are that this is likely to level off at 100 million tonnes by the year 2020.

Capture Fisheries International Scenario

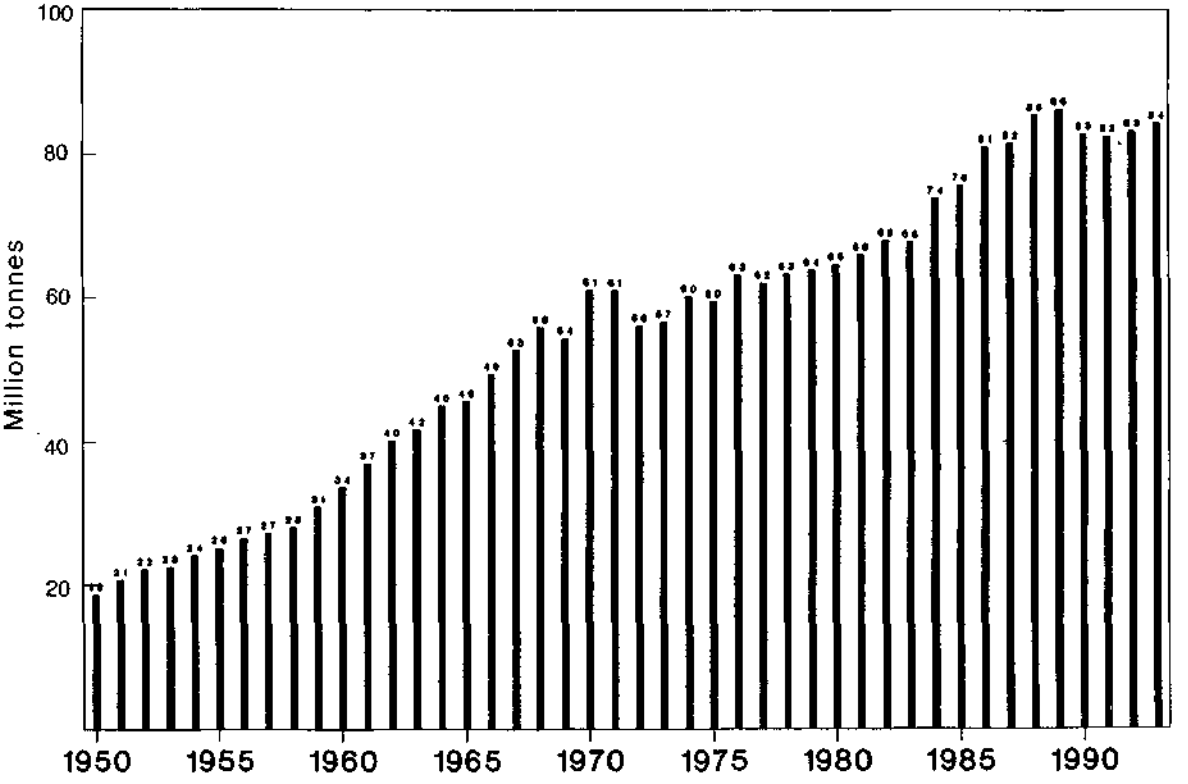


Fig. 18. World marine fish production during 1950-1993 (Source : FAO)

The marine capture fisheries scenario in India is not inconsistant with the world situation: with all the technological advancements, innovations and human resources and infrastructure development, the annual production reached the 2.3 million tonne mark in the beginning of the nineties and has been showing signs of levelling off immediately thereafter with the annual growth rates oscillating between about -5% and 5% during the past few years (Fig 19). Though the potential yield estimate of 3.9 m t from the Indian EEZ (including 1.7 million tonnes available in the outer continental shelf of which about 0.6 million tonnes is currently taken) throws hopes of increasing production from the outer continental shelf, the distressing feature is that most of the stocks

Capture Fisheries National Scenario

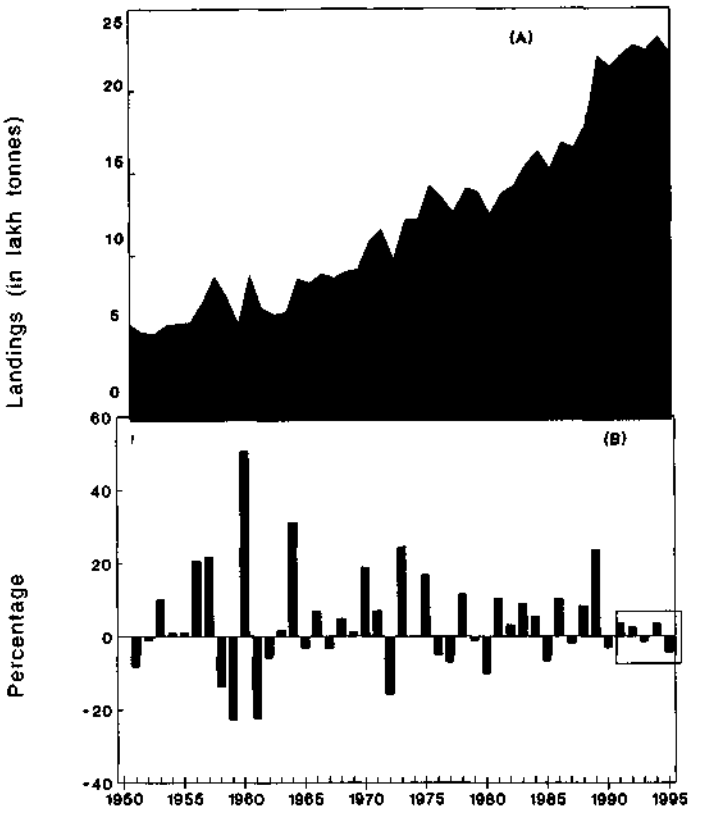


Fig. 19. A. Marine fish production in India during 1950-'95
B. Growth (percentage) of marine fish production from 1950 to 1995
(Source : CMFRI)

reported to be available for exploitation in this zone, are also distributed in the inshore region and are currently exploited from these grounds, suggesting the real potential of at least some of the resources to be less than what has been projected. This fact, together with the present socioeconomic conditions in the capture fisheries sector and the policy scenario, suggests that production from capture fisheries can, at best be increased by only 5 to 6 lakh tonnes comprising mainly the oceanic tunas, squids and some demersals like the threadfin breams, bull's eye and a few others.

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 (Fig. 20).

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 tonnes 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 marine products exports, availability of a large number of culture technologies and different hydroclimatic zones for coastal mariculture and seafarming, India is on the threshold of becoming a major player in world mariculture production.

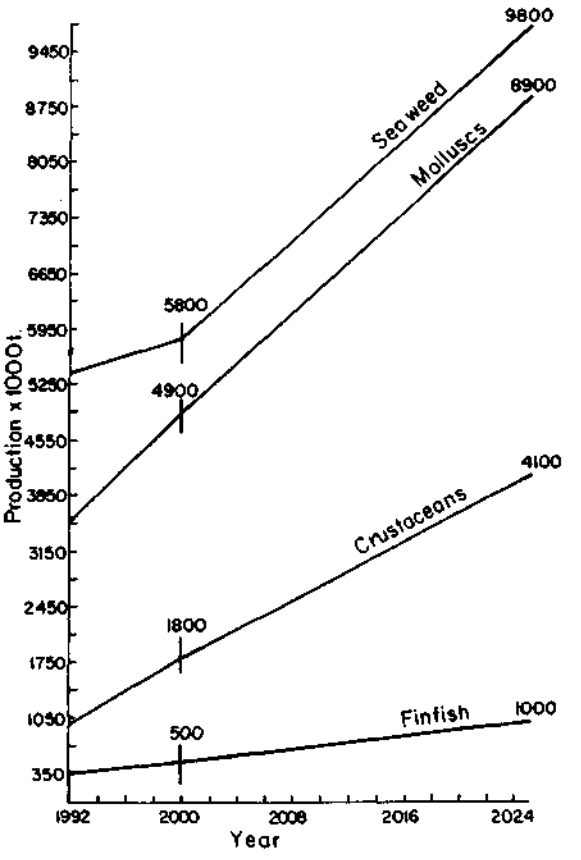


Fig. 20. Projected global seafarming production (Source : Aquaculture Magazine, 25th Annual Buyers' Guide 1996, p. 6-27)

Population and Fish Food Scenario

The human population of India by 2020 is expected to be 1.3 billion (World population projections, 2020; D.F. Nygaard, 1994; International Food Policy Research Institute, Washington) which is about 450 million larger 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 at least 50%, the total fish eating population in India by 2020 will be around 650 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 7.2 m t of which at least 4.3 m t has to be realised from the marine sector. This shows that the country needs to produce at least 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 0.6 m t of marine products will be required. Thus the total increase in marine fish production required to meet the demand by 2020 is around 2.6 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 2020 is one of great challenge and the options available are:

- managing the exploited stocks to realise sustained yields
- exploiting and monitoring the deepsea fishery resources
- increasing production substantially through seafarming and coastal mariculture, and
- addressing the socioeconomic, environmental and conservation needs

6.1. STRENGTHS

6.1.1. Database on fish yield and effort: The Indian EEZ is spread over an area of 2.02 million sq km offering vast scope for the exploitation of a large number of commercial finfish and shellfish species. A very strong database, comprising catch and effort statistics at district level, with gearwise, species/groupwise estimates, seasonal/annual variations in abundance, biological characteristics, mortality rates and yield per recruit of a large number of species of pelagic and demersal finfish, shrimp, crab, lobster, cuttlefish, squid, gastropod and bivalves, economics of fishing operations and socioeconomic conditions of fisherfolk, has been built up over the last fifty years by the CMFRI. These historic and new data generated on these aspects constitute the basis for carrying out the task of stock assessment and for suggesting from time to time the required management and conservation measures for the exploited stocks. The thrust in the marine capture fisheries research in the coming 25 years should be towards sustaining the yields from the presently exploited grounds and the socioeconomic benefits to the community and to the industry while paying attention to increasing production of unexploited or underexploited resources.

6.1.2. Database on fisheries oceanography: This database includes i) ocean currents, ii) primary and secondary productivity, iii) distribution and abundance of plankton, iv) nutrients, v) upwelling, vi) salinity, vii) dissolved oxygen, viii) temperature, ix) marine meteorology, x) ocean dynamics, xi) monsoons and xii) PFZ (from NRSA) built up by the CMFRI and also available with the other organisations in India. They are of great value in understanding the relationship between the fish stocks and the marine environment, and therefrom to make fishery forecasts.

6.1.3. Potential yield: The resource potential in the EEZ is estimated as 3.9 m t. In order to increase the harvest from the present 2.3 m t, additional effort will be deployed in the outer continental shelf (i.e., beyond 50 m depth) and the hitherto unexploited or underexploited stocks will be subjected to optimum exploitation. The CMFRI with its trained manpower is in a position to monitor the landings, carry out research on the exploited stocks and to render timely advice to the industry, the maritime state governments and the central government.

6.1.4. Fleet size: Along the country's long coastline of 8129 km bordering a continental shelf of 0.5 million sq.km, there are 3638 fishing villages and 2251 landing centres. The country's fishing fleet has shown phenomenal growth over the years: the number of traditional craft increased from about 91,000 in 1961 to around 1 91,000 (including 32000 motorised craft) in 1994 and mechanised units grew from around 7,000 in 1961 to 47,000 in 1994 (Fig.21). There are also about 180 large trawlers operating in the Indian EEZ. Berthing facilities for these fleets include 6 major harbours, 27 minor harbours and 109 improved landing centres. These resources, the infrastructure developed, large number of ancillary industries, the processing plants and the large human resource in the marine fisheries sector constitute the most favourable base for the sustained development of marine fisheries.

6.1.5. Human resources: In addition to a very large number of fishermen population available all along the Indian coastline, a large number of trained personnel in mechanised fishing, fish processing, net making and mending and marketing are available to undertake various vocations in marine fisheries. To look after the R&D activities, the SAUs, some universities in the maritime states, the CMFRI and the CIFE are engaged in education programmes to develop human resources at the graduate, postgraduate and doctoral levels in the country. These human resources add to the strength of Indian marine fisheries.

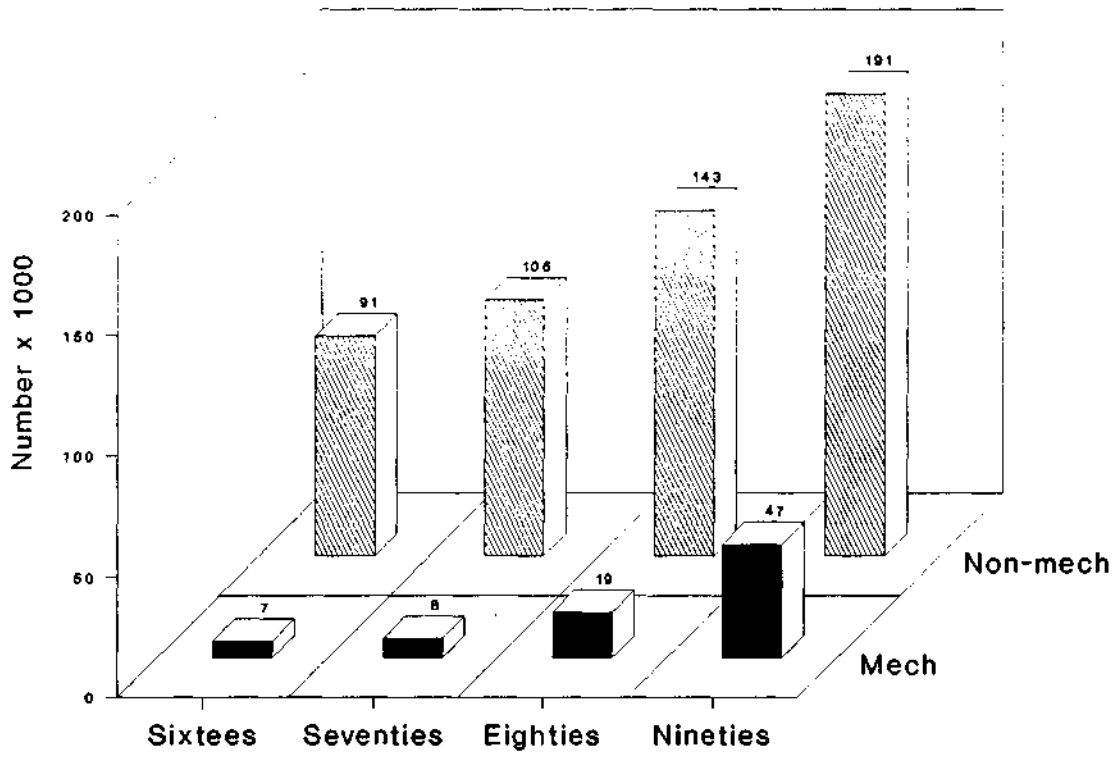


Fig. 21. Growth of mechanised and non-mechanised fishing fleet

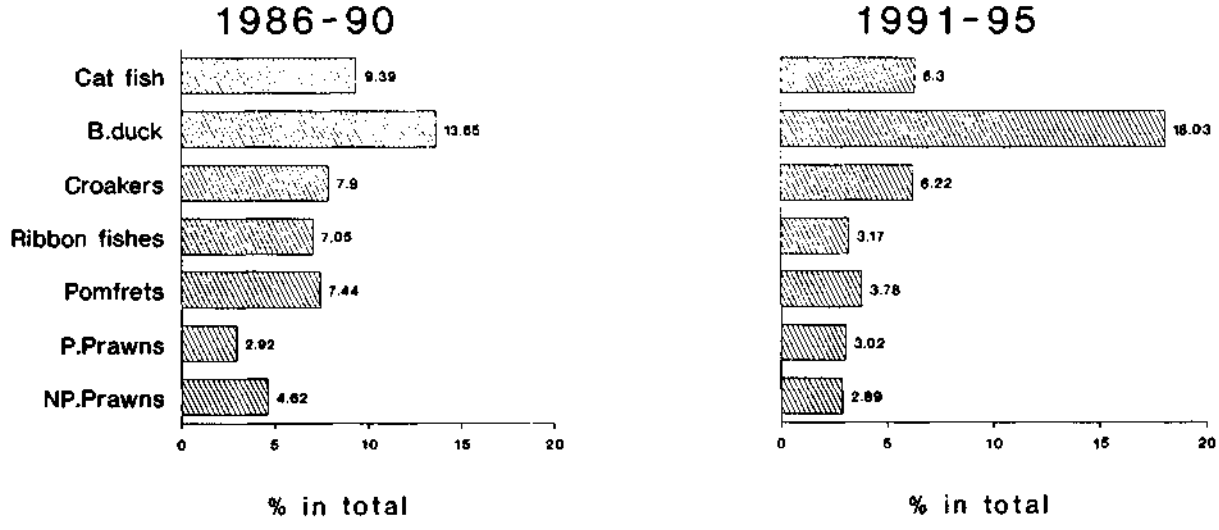
6.1.6. Characteristics of Indian Marine Fisheries:

A. Species Diversity: The Indian marine fisheries are multispecies and multigear in nature with fishing practices varying between different regions along the long Indian coast, depending on the nature of the fishing grounds and the distribution of the fisheries resources. Certain stocks such as the mackerel, oil sardine, lesser sardines, whitebait, ribbonfish, seerfish, coastal and oceanic tunas among the pelagic fisheries, croakers, threadfin breams, silverbellies, catfish, lizardfish and goatfish among the demersal fisheries, penaeid prawns, crabs, lobsters and stomatopods among the crustacean fisheries, squids and cuttlefish among the cephalopod fisheries are exploited all along the Indian coast. Among these, however, the mackerel and oil sardine are the most dominant along the west coast, the lesser sardines along the Tamilnadu and Andhra coasts and the silverbellies along the Tamilnadu coast.

Among the penaeid prawns, *Penaeus monodon* is of great fishery importance along the northeast coast, *P. semisulcatus* along the southeast coast (particularly in the Gulf of Mannar and Palk Bay), *Solenocera crassicornis* along the northwest coast, and *Parapenaeopsis stylifera* along the southwest coast; there are other penaeid prawns also which show such differential dominance. There is also difference in the distribution and abundance of crabs and lobsters between different regions along the country's coast.

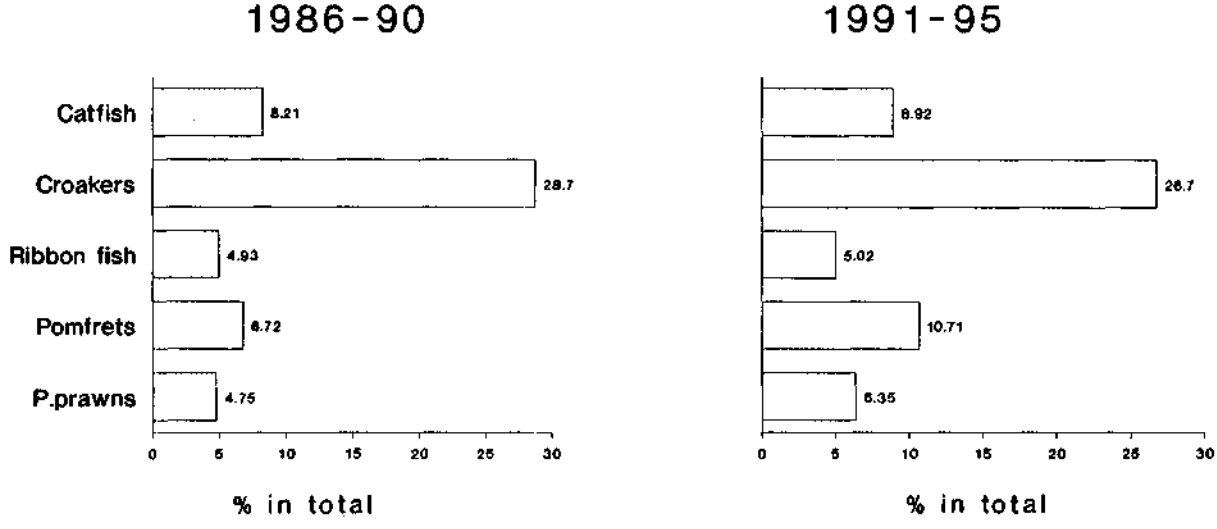
There are other large resources of regional importance: Tunas occur all along the Indian coast but are very abundant in the Lakshadweep sea. The Bombay duck is an important resource of India, but forms a major fishery only along the Gujarat and Maharashtra coasts and a minor fishery along certain pockets of Andhra, Orissa and West Bengal coasts. *Hilsa* is harvested along West Bengal. Perches (pigface breams, groupers and snappers) are a dominant resource in the Gulf of Mannar, Palk Bay, Wadge Bank and southwest and northwest coasts. Nonpenaeid prawns form a fishery to the tune of 80,000 t along the northwest coast and 8000 t along the Andhra coast (particularly off Kakinada) and do not either occur at all or if they occur, only in stray numbers along the other regions. Among the molluscs, the blood clam, windowpane

oyster and some gastropods form major fisheries resources off Kakinada along the east coast, mussels are abundant along Kerala and Tamil Nadu, while the chanks and edible oyster are predominant along Tamil Nadu and Kerala. There are a large number of such differences in the other marine fisheries also (Figs 22 to 29).



[Av. tot. ann. landing 27494 t] [Av. tot. ann. landing 74505 t]

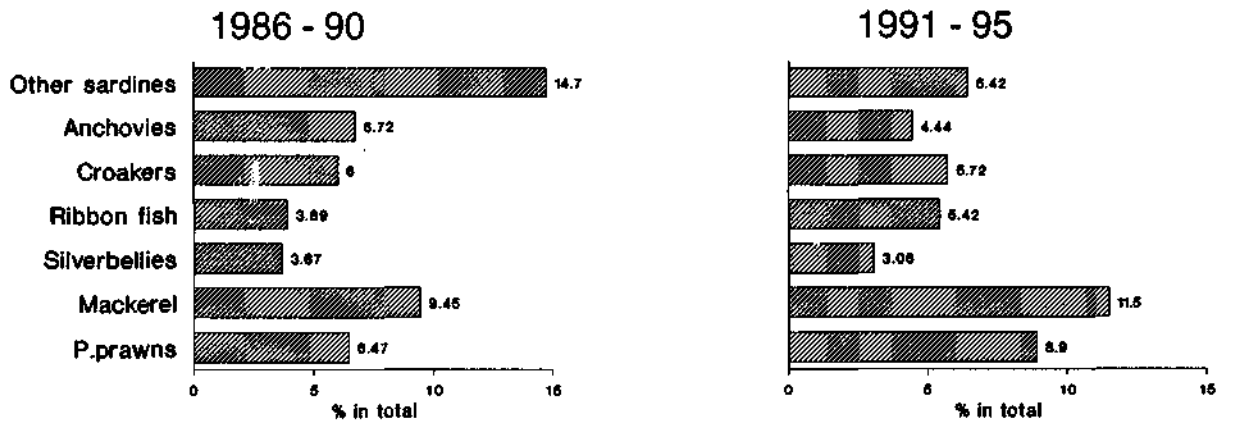
Fig. 22. Major Exploited Marine Fishery Resources in West Bengal (Source : CMFRI)



[Av. tot. ann. landing 54698 t] [Av. tot. ann. landing 49056 t]

Fig. 23. Major Exploited Marine Fishery Resources in Orissa (Source : CMFRI)

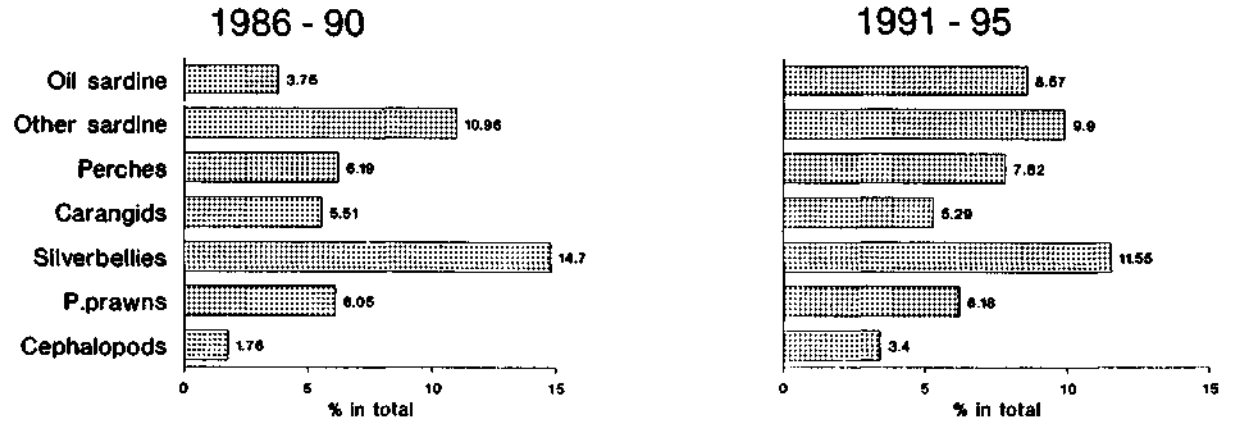
B. Gear Diversity: Among the different gears,the 'dolnet' (fixed bagnet) is operated in large numbers along Gujarat and Maharashtra, the ringseine along Kerala and Karnataka, the purseseine and mechanised gillnets only along Goa, Karnataka and Kerala, trawls operated by 37' and smaller vessels along the entire Indian coast, while the second generation large and minitrawls operated by 43' and still larger vessels of upto 56' are in use off Orissa, West Bengal, Andhra, Tamilnadu, Kerala, Karnataka, Goa, Maharashtra and Gujarat. Moreover, changes in the species composition of the



[Av. tot. ann. landing 131246 t]

[Av. tot. ann. landing 150907 t]

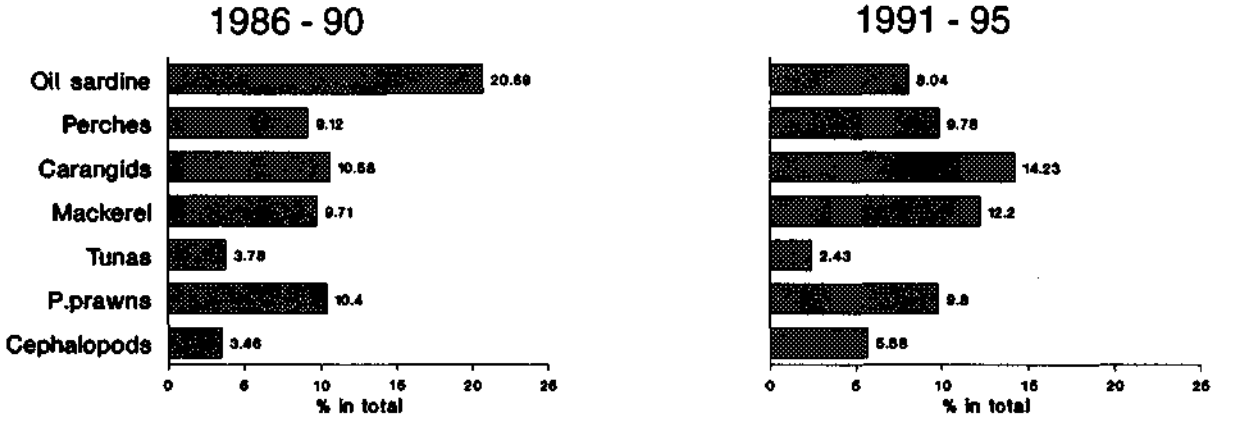
Fig. 24. Major Exploited Marine Fishery Resources in Andhra Pradesh (Source : CMFRI)



[Av. tot. ann. landing 285183 t]

[Av. tot. ann. landing 377916 t]

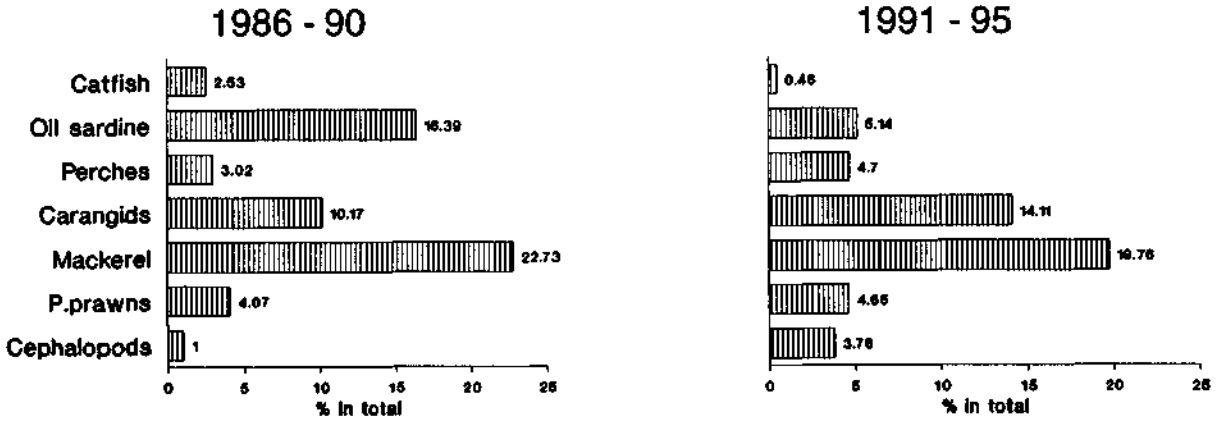
Fig. 25. Major Exploited Marine Fishery Resources in Tamilnadu & Pondicherry (Source : CMFRI)



[Av. tot. ann. landing 493060 t]

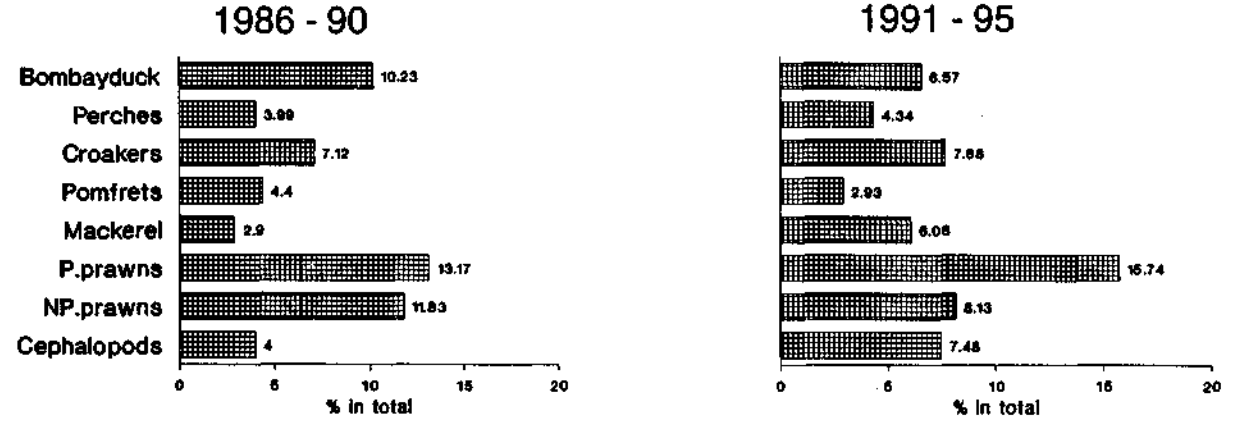
[Av. tot. ann. landing 559864 t]

Fig. 26. Major exploited Marine Fishery Resources in Kerala (Source : CMFRI)



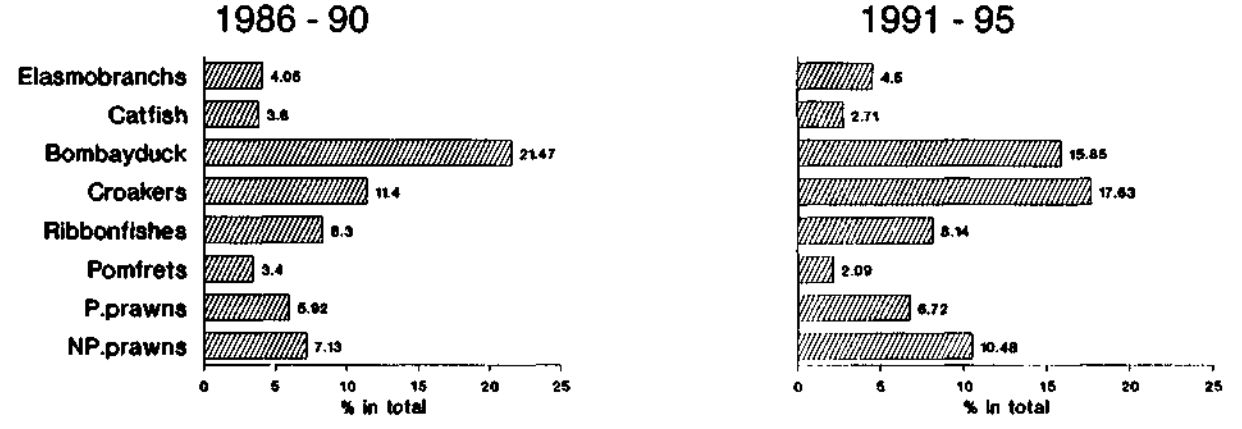
[Av. tot. ann. landing 289836 t] [Av. tot. ann. landing 230765 t]

Fig. 27. Major exploited Marine Fishery Resources in Karnataka & Goa (Source : CMFRI)



[Av. tot. ann. landing 324745 t] [Av. tot. ann. landing 337030 t]

Fig. 28. Major exploited Marine Fishery Resources in Maharashtra (Source : CMFRI)



[Av. tot. ann. landing 273097 t] [Av. tot. ann. landing 468967 t]

Fig. 29. Major exploited Marine Fishery Resources in Gujarat (Source : CMFRI)

catches are taking place all along the Indian coast almost continuously: for example the oil sardine which was restricted to the west coast is now forming a fishery of considerable magnitude along the east coast, particularly along Tamilnadu, Andhra and Orissa coasts.

The distribution and abundance of marine fisheries resources and the practices of exploitation warrant close monitoring. Research on the biology of the exploited stocks and the fishery environment has to be carried out on a regular basis consistantly, to enable timely advice on maximum sustainable yield, conservation needs and regulation measures.

C. **Mariculture Diversity:** Similarly, there are vast differences in the availability and suitability of the areas which could be developed for coastal mariculture and seafarming and in the candidate species available for farming. Finfish (seabass, pampano, groupers, red snappers and breams) are suitable for farming along the southwest and southeast coasts, seacucumber along the coast of Tamilnadu and Lakshadweep, pearl oyster along the Tamilnadu (Mandapam & Tuticorin), Andhra (Kakinada) and Gujarat coasts, edible oyster in Andhra, Tamilnadu, Kerala, Karnataka, and Gujarat, mussel in Andhra, Tamilnadu, Kerala, Karnataka, Goa and northern Maharashtra. The Kakinada bay and the nearby areas are rich in windowpane oyster and blood clam. Besides, a large number of artificial reefs and fish aggregating devices have been established along the Vizhinjam coast which require to be monitored regularly.

Commercial shrimp hatcheries and growouts have come up all along the Indian coast. The coastal shrimp aquaculture industry has now embarked on a major plan of diversification with the integration of seabass, groupers, breams, sea cucumber, seaweed, pearl oyster, clams, edible oyster and mussels in commercial shrimp farms and hatcheries. The problems and prospects of diverse mariculture operations need to be addressed through timely consultancy services from the regional research centres of CMFRI.

D. **Marine Biodiversity:** Corals, sponges and sea cucumbers are very abundant in the Gulf of Mannar, Palk Bay, Wadge Bank, coasts of Gujarat and Kerala and in the Lakshadweep islands and there is pressing need for research in marine biodiversity and its conservation.

6.1.7. CMFRI network of regional, research and field centres and other national & state institutes: The research and development needs of these varied and multiple marine fishery resources of the country, of the differing socioeconomic, cultural and traditional characteristics, the ethos of marine fisherfolk, the seafarming and coastal mariculture opportunities along the different hydroclimatic regions of the country and the marine fisheries and mariculture extension responsibilities can be adequately addressed only through the various regional research centres situated close to all these activities of critical importance to the country. Fortunately the CMFRI has established research centres along the coasts of most of the maritime States and Lakshadweep and field centres in all the maritime states. These centres are manned by the required manpower and equipped with all necessary infrastructure, funds and authority.

The country has a large number of R&D organisations which have involvement in marine fisheries science. The NIO at Goa carries out investigations on physical, chemical and biological oceanography. The CIFT is involved in the development of suitable designs of marine fishing craft and gear and processing technologies. The CIBA is catering to the R&D needs of the fast growing brackishwater aquaculture sector. The CIFE, a deemed University under the ICAR, undertakes human resources

development for fisheries R&D. The NBFGR is responsible for, among others, carrying out studies on threatened, endangered and vulnerable species, identification of genetic stocks and genetic upgradation. A large number of fisheries colleges, some of the traditional universities, State Fisheries Departments and the IITs at Madras and Kharagpur are also engaged in fisheries manpower development and research activities. The ZSI conducts periodic marine biodiversity surveys, which are regularly documented and circulated. All these organisations contribute to the process of sustainable development of Indian marine fisheries.

6.1.8. Expertise: The CMFRI has well-qualified and trained R&D staff in the areas of fisheries statistics, fisheries biology, stock assessment, physical and biological oceanography, coastal mariculture and seafarming including husbandry practices, genetics, nutrition, physiology, pathology and endocrinology, fisheries economics and extension.

6.1.9. Facilities: The CMFRI has all essential equipments and facilities such as computers, electron microscope, research vessels, hatcheries (principally meant for molluscs and crustaceans), marine aquaria and all essential laboratory equipments both at the headquarters and the research centres. The Institute has one of the biggest libraries devoted to fisheries, mariculture and aquatic sciences in the world (60,000 volumes of books and periodicals), subscribes to 78 foreign journals and 41 Indian journals and receives 190 journals on exchange/complimentary basis.

6.1.10. Education: The CMFRI with its PGPM (M.F.Sc and Ph.D programmes) devotes a great deal of attention to education and research in mariculture through the faculty members, many of whom were trained abroad in important areas of mariculture.

6.2. WEAKNESSES

6.2.1. Fish stock assessment expertise: Stock assessment of exploited stocks and fisheries regulations through scientific advice have not been given the required thrust until very recently. Consequently, the manpower development in this area and development of models and methods to carry out the task, did not take place in the manner commensurate with the needs. There is a tendency in India to believe that research in capture fisheries leads only to an advice for increasing production and there is lack of appreciation for sustaining fishery yields through scientific advice. The current earning from marine fish (at the landing centres) is estimated to be around Rs. 8,80,060 lakhs and over three million people are dependant on sea fishing, both directly and indirectly. Obviously,the resources need to be harvested on a sustainable basis.

6.2.2. Fishery environment and fish distribution: Though the CMFRI is carrying out research in fishery environment for nearly half a century and vast information base has been developed, utilisation of the same to predict changes in the availability and abundance of fish stocks and the yields therefrom has not been adequate.

6.2.3. Data on fishing: The nonavailability of proper data to the CMFRI on the actual areas of fishing, the catch, the discards and the effort through log sheets from different vessels operating in the Indian EEZ continues to be a serious lacuna in making realistic stock assessment studies.

6.2.4. Linkages: Several organisations in the country are engaged in research in marine fisheries and oceanography. Absence of obligatory linkages between them in the form of working groups is causing hindrance to the sustained flow of information and knowledge and effective utilisation of the same in the development process.

6.2.5. Funds: The Plan funds allotted by the ICAR to the CMFRI are inadequate considering the size of the Institute and its research and education activities. In the agri-exports from the country, the value of fish and fish products is the highest accounting for 29% of the total agri-exports during 1994-95. However the share of fisheries (Rs 6,500 lakhs) from the ICAR budget (of Rs 130,000 lakhs) in the VIII Plan was only 5.0%. Among the fisheries research institutes under the ICAR, the CMFRI is the largest in regard to staff size, research programmes and infrastructure. However, the allocation of funds to CMFRI is not commensurate with its requirements. The allocation of Plan funds to the CMFRI in comparison to other fisheries institutes is far too less than required; besides the inadequate allocation under T.A. is also adversely affecting the field programmes of the Institute. For marine fisheries research, extensive travel to different landing centres situated all along the coast is essential. The poor allocation under T.A. does not permit sampling coverage of 5% for catch and effort statistics which are essential for research in and management of the exploited stocks besides being very useful to the governments and the industry. If this trend of inadequate allocation continues, it is feared that the research programmes in the capture fisheries sector through the CMFRI will be adversely affected particularly at a time when marine fisheries R&D has to play a key role in food security and sustaining the production from the exploited stocks.

6.2.6. Infrastructure for mariculture research: Infrastructure facilities for seafarming and coastal mariculture research in different hydroclimatic zones (where the CMFRI has research establishments) using different candidate species along the Indian coast have not been properly developed or strengthened.

6.2.7. Fisheries extension: The virtual absence of research in fisheries extension is one of the national weaknesses prevalent in all Institutions including the CMFRI.

6.2.8. Idling fleet: Though the fleet size has grown to a very considerable extent, the entire fleet is not in operation regularly and a large number of them is idling for various reasons. Such idling capacity together with the lack of adequate incentives, infrastructure and trained manpower to invest in deepsea fishing and carry out fishing operations, has become an inherent weakness in our marine fisheries development.

6.2.9. Policy: Lack of suitable policy on small scale seafarming has become a bottleneck in popularising seafarming and coastal mariculture among the small scale fishermen.

6.2.10. Manpower

a. **Personnel policy**: The CMFRI has a sanctioned scientist strength of: Principal Scientist 19, Senior Scientist 38 and Scientist 132. Against this, the present strength of these categories is 15, 88 and 61 respectively. This imbalance is the result of absence of suitable personnel policy and promotion for scientists at the national level. The stagnation for over a decade, in certain cadres of Scientists, has a demoralising effect on the performance of the involved personnel. A suitable policy of periodic assessment of the work done and promotion to the next higher grades in respect of administrative staff is also lacking.

b. **Disciplines under ARS**: The fisheries research institutes under the ICAR recruit scientists through the ARS examination, mainly under two disciplines: Fish and Fishery Science and Fish Processing Technology. This policy and lack of recruitment through lateral entry resulted in the total absence of specialists in certain important areas such as fisheries oceanography, mariculture, nutrition, pathology, physiology, biotechnology, fish behaviour and biodiversity conservation.

6.3. THREATS

A. The present situation of near-optimal exploitation of marine fisheries resources, the open access nature of marine fisheries together with shrimp-oriented exploitation, increased demand for seafood and the overemphasis on the protection of the artisanal marine fisheries sector is fast leading to overexploitation/depletion of resources. If effective regulatory measures are not enforced, the situation is bound to worsen with depleted stocks and conflicts between different competing interest groups.

B. Marine fisheries and seafarming research and development have to be necessarily holistic in approach, with due consideration not only to the biological and fishery characteristics, but also to the environmental, economic and social aspects. There should also be proper linkages between the various R&D establishments functioning under the central and the state governments, industry, trade, community and NGOs. Lack of such a holistic approach and linkages at present may, in the long run, prove counterproductive. Due to the lack of strong database (which can be developed only with the active collaboration and cooperation among the various R&D agencies) on the social and economic aspects of marine fisheries, it has become extremely difficult to diagnose and identify the present ills of marine capture fisheries, coastal aquaculture and seafarming. The limited database suggests gross underutilization of the existing fishing fleets, processing plants, fisherfolk labour and coastal seafarming sites. These indications are suggestive of an impending crisis in the marine fisheries sector.

C. Lack of certain fisheries disciplines in the ARS and the consequent absence of trained scientific manpower in emerging and frontier areas like biotechnology, genetic engineering, molecular biology, nutrition, pathology, physiology, endocrinology and fisheries oceanography is hampering steady progress in the upgradation of seafarming technologies. Induction of scientists from Animal Husbandry and Agriculture Sciences into fisheries R&D sector is not providing lasting solution to this problem.

D. Cyclone-prone tracts along the West Bengal, Orissa and Andhra coasts and growing incidences of diseases in coastal shrimp farms pose considerable threats to the fishing fleets, farms and households.

E. The research centres of national fisheries institutes like the CMFRI have been established with the specific purpose of addressing the research needs of the respective hydroclimatic regions in the country, besides assisting in the overall national programmes. Nonavailability of scientific personnel from many of these different regions coupled with inadequate budget allocation for improving the facilities in each of these centres and recommendations, often made with inadequate justification, to close some of these centres pose serious threats in the fulfillment of the regional needs and aspirations of the marine fisheries and mariculture sectors.

6.4. OPPORTUNITIES

The country's marine fish requirement by the year 2020 is estimated to be around 5 million tonnes. In this context, opportunities exist for:

- intensifying research in marine capture fisheries, multispecies stock assessment, assessment of regional stocks, influence of the ocean environment on the availability and abundance of fish stocks and to render advice on sustaining fish yields over the long term. This situation affords challenging opportunities to the country, as a large number of species of finfish and shellfish are currently exploited and a large number

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of new or non-conventional fisheries resources will be caught when exploitation is extended to the entire EEZ of the country.

- assessing the oceanic fisheries resources such as the tunas, squids and sharks and evaluating the commercial viability for investment in the oceanic sector.

- utilising vast areas of lagoons, bays and coastal areas which exibit differences in their characteristics between different regions and which are suitable for the mariculture of different candidate species

- incorporating a large number of additional candidate species of finfish, shellfish, seaweeds and marine invertebrates of pharmaceutical value into coastal mariculture and seafarming R&D.

- producing pearl by large scale environment-friendly culture of pearl oyster in onshore captive systems and in the open sea

- carrying out research in breeding and hatchery production of finfish seed

- improving the wild stocks that are under heavy pressure of exploitation, by improved methods of seed production and searanching

- developing disease-resistant strains of the presently cultivated species and for studying the pathological characteristics of the cultivated species in the context of disease threats in culture systems

- conducting research following biotechnological approaches in the areas of nutrition, physiology, pathology, genetics and tissue culture which offer immense potential for increasing the production of the cultivated stocks.

- developing a strong database on aquaculture engineering in the design and construction of onshore farms and seafarms.

7. PERSPECTIVE

In consideration of (i) the national and international scenarios in marine fisheries, (ii) the SWOT with respect to the nation's marine fisheries sector, the CMFRI and the other national marine fisheries related R&D organisations, (iii) the increasing human population, together with the growing problem of protein energy malnutrition, (iv) the international trade scenario in marine products, and (v) the vast coastal, aquatic and human resources available to India, the country should intensify its effort to augment productivity and production in the marine fisheries sector on a sustained basis. Towards this, the marine fisheries and seafarming perspectives for the country and the role of the CMFRI in this task for the next 25 years upto 2020 AD are:

- constant monitoring of the status and health of the exploited marine fish stocks
- development of programmes and procedures for the prevention of exploitation of marine fish stocks beyond sustainable levels
- framing of action plans for enabling the recovery of overexploited stocks to optimum levels
- constant interaction with the small scale and industrial fisheries sectors and the state fisheries departments to emphasise on them the imperative need to reduce fishing pressure in the heavily exploited inshore grounds
- development of deepsea fishing programmes and procedures to help the sector obtain an additional production of about 1 million tonnes
- greater thrust to the development and improvement of seafarming and coastal mariculture technologies to help the sector achieve an additional 2.0 million tonne production
- training programmes and procedures for minimising conflicts between the different sections of the marine capture fisheries sector and between the coastal mariculture and fishing sectors
- training programmes and procedures for the rehabilitation of the dislocated and/or surplus fishermen into alternative, but allied occupations such as seafarming, coastal mariculture, fish processing and product making
- assisting the industry in the utilisation of bycatches into value added products, mainly for local markets (jointly with the CIFT, IFP and fisheries development corporations)
- human resources development for the R&D organisations and the industries engaged in marine capture fisheries and mariculture

In this endeavour, the CMFRI would implement about 60 research projects in the coming 25 years in the areas of marine capture fisheries and seafarming.

8. ISSUES AND STRATEGIES

The important issues in the **Vision 2020** and the strategies for their implementation by the CMFRI are spelt out below:

	ISSUES	STRATEGIES
	I. CAPTURE FISHERIES	
i)	Improving capture fisheries database to improve the quality and dependability of the results of stock assessments and economic performance of the fishing fleets	Increasing sampling coverage, frame survey and access to fishing logs from commercial and governmental fishing vessels
ii)	Sustaining fish production from the presently exploited grounds	Multispecies stock assessment, further development and improvement in mathematical models and methods. Constant dissemination of results to the user communities, industries and governments
iii)	Remote sensing for mapping potential fishing zones	Collection of satellite data from NRSA, interpretation and dissemination. Collection of sea-truth and actual fishing data from PFZ and non-PFZ areas
iv)	Fishery forecasting	Use of different models such as ARIMA, studies on environmental characteristics in relation to the availability, abundance and biological characteristics of the exploited stocks. Development of forecast models and dissemination of forecast results to the user communities, industries and governments
v)	Development of island fisheries (A&N islands & Lakshadweep)	Assessment of the oceanic fisheries resources of the island ecosystems and their commercial viability
vi)	Conservation and sustainable utilisation of coral ecosystems	Research in marine biodiversity and species assemblages. Framing of procedures for the preservation of marine bio-diversity
vii)	Stock improvement	Evaluation of the impact of searanching on the wild stocks and the ecosystem
viii)	Development of oceanic fisheries	Onboard surveys and techno-economic studies on the exploitation of oceanic tunas and squids

	II. SEAFARMING	
ix)	Marine finfish and shellfish hatcheries, seed production and growouts	Breeding of cultivable marine crabs, lobsters, molluscs and marine finfish species such as groupers, red snapper, breams, pampano, seabass and ornamental fishes and development of hatchery and growout technologies
x)	Seaweed cultivation	Further improvements in the farming techniques using biotechnological tools
xi)	Genetics of cultivable species	Development of polyploidy for better growth performance in growout systems, development of disease resistant varieties
xii)	Disease problems in culture systems	Development of vaccines for viral and bacterial diseases. Impact assessment of nutrient toxins on finfish and shellfish crops
xiii)	Finfish and shellfish nutrition	Diet development and improvement for all major cultured species
	III. SOCIOECONOMICS	
xiv)	Socioeconomic and technoeconomic assessment	Socioeconomic survey of different sectors in marine fisheries and mariculture operations. Technoeconomic assessment of marine fisheries and their contribution to GNP
xv)	Marketing and labour	Studies on market structure, supply-demand analysis and price behaviour. Economic analysis of capacity utilisation of fishing and processing infrastructure, labour utilisation and HRD in marine fisheries
	IV. EXTENSION	
xvi)	Marine fisheries and mariculture extension	Empowerment of rural communities, modelling and evaluation of extension methods for marine fisheries and seafarming development
	V. EDUCATION	
xvii)	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.
	VI. MESOPELAGIC AND SOUTHERN OCEAN CELL	
xviii)	Assessment and monitoring of mesopelagics, Antarctic krill and other resources	Establishment of mesopelagic and Southern Ocean cell at CMFRI and development of linkage with the proposed Antarctic Cell of DOD

9. PROGRAMME IDENTIFICATION (R&D)

Current landings from the inshore regions are showing signs of levelling off around 2.3 million tonnes which is close to the estimated potential yield. There has been vast growth in the infrastructure for marine capture fisheries and decline in the area available per active fisherman and per boat. The possible regulations should consider the available infrastructure, manpower, the economy and ofcourse 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 1.7 million tonnes in the outer continental shelf in the EEZ will enable additional harvests to the extent of around 1 million tonnes and possibly new or underexploited resources will be harvested. This future development would require continuous monitoring and generation of data on exploitation.

The required increase in marine finfish and shellfish production to meet the domestic food requirements and the demand of the export trade can be obtained mainly through increasing production by coastal mariculture and seafarming. While some technologies are developed and transferred, there is still vast scope for improving these technologies and making the target groups adopt the same profitably. 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 socio-techno-economic aspects of marine capture and culture fisheries and the needs of technology transfer have also to be addressed.

The outer border 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 m 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 DOD. Interinstitutional collaboration needs to be developed to motivate the industry for pilot scale fishing as well as product development and marketing.

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

9.1. SETTING PROGRAMMES ON A TIME SCALE

Programmes & Projects	Timeframe					Infrastructure (cost - Rs in lakhs)	Manpower (cost - Rs in lakhs)	Funding
	1996-2000	2001-2005	2006-2010	2011-2015	2016-2020			
I. CAPTURE FISHERIES							**S T RS I**	
I.A. **Fisheries database and Modelling (3 Projects)**								
I.A.1. Capture fishery database for the assessment & management of the exploited marine fishery resources.	Database : I.A.1					Fax, pagers, Internet, E-mail. (Rs. 25) Upgrading/re-placing the hardware (Rs.25)	18 152 - - (Rs. 4907)	ICAR
I.A.2. Development of models and methodologies for fish stock assessment	Model development : I.A.2					Digitiser, Scanner (Rs.10)	8 - - - (Rs. 121)	ICAR
I.A.3. Updating of sampling frame	Updating sampling : I.A.3					-	3 - - 10 (Rs. 51)	OTHERS
						Subtotal for IA : (Rs. 60) + (Rs. 5079) = (Rs. 5139) Annual average = (Rs. 206)		
I.B. **Assessment and monitoring of the exploited stocks (10 Projects)**								
I.B.1. Single species modelling & forecasting biological and fishery characteristics of the exploited pelagic and demersal finfish, crustacean & molluscan shellfish stocks	Single species modelling and forecasting : I.B.1					Small research vessels of 15 m OAL -10 vessels (Rs. 250)	84 148 80 - (Rs. 6275)	ICAR

Programmes & Projects	Timeframe					Infrastructure (cost - Rs in lakhs)	Manpower (cost - Rs in lakhs)	Funding
	1996-2000	2001-2005	2006-2010	2011-2015	2016-2020		S T RS I	
I.B.2. Multispecies modelling and forecasting	Multispecies modelling & forecasting : I.B.2					-	34 32 - - (Rs. 1100)	ICAR
I.B.3. Assessment, charting and mapping of mesopelagic stocks in the DSL of the Indian EEZ		Mesopelagics : I.B.3				Large research vessels of 40m OAL 4 (Rs. 4000)	14 46 - - (Rs. 326)	ICAR & DOD
I.B.4. Marine biodiversity management & conservation (with particular reference to Island ecosystems and coastal zone			Biodiversity : I.B.4			Equipments /lab (Rs. 50)	15 - 15 - (Rs. 100)	Others
I.B.5. Introduction, testing, upgradation & commercialisation of artificial reef structures				Artificial reefs : I.B.5		Vessels & lab facilities	22 22 22 - (Rs. 619)	Others
I.B.6. Mark recovery studies				Mark recovery : I.B.6		Vessels	3 6 6 - (Rs. 300)	Others
I.B.7. Acoustic surveys and test fishing for the assessment of underexploited & unexploited stocks in the EEZ				Acoustics & test fishing : I.B.7		Vehicles and shore laboratories (Rs.40 + Rs.30)	20 2 - - (Rs. 900)	ICAR

Programmes & Projects	Timeframe					Infrastructure (cost - Rs in lakhs)	Manpower (cost - Rs in lakhs)	Funding
	1996-2000	2001-2005	2006-2010	2011-2015	2016-2020		S T RS I	
	Environmental influence & fishery prediction : I.B.8							
I.B.8. Monitoring fishery environment characteristics (primary & secondary productivity, physical & chemical oceanography and pollution in inshore & offshore waters with reference to availability and abundance of fish stocks & fishery prediction						Vessels	31 31 20 - (Rs. 1619)	ICAR & DOD
	PFZ : I.B.9							
I.B.9. Remote sensing and validation of PFZ forecasts (through monitoring fish catches)						Equipments and data tapes (Rs. 200)	20 20 - - (Rs. 112)	ICAR
	Trawling impact on benthos : I.B.10							
I.B.10. Monitoring variations in the benthos & benthic production *vis a vis* bottom trawling (environmental impact assessment of trawling)						(Rs. 5)	- - - -	ICAR
						Subtotal for IB (10 projects) : (Rs. 4575) + (Rs. 11351) = (Rs. 15926) Annual average = (Rs. 637)		
						Total for I (Capture fisheries) : (Rs. 4635) + (Rs. 16430) = (Rs. 21065) Annual average = (Rs. 843)		

Programmes & Projects	Timeframe					Infrastructure (cost - Rs in lakhs)	Manpower (cost - Rs in lakhs)	Funding
	1996-2000	2001-2005	2006-2010	2011-2015	2016-2020		S T RS I	
II. **MARICULTURE TECHNOLOGIES**								
II.A. **Finfish Mariculture (3 projects)**								
II.A.1. Induced breeding, seed production and hatchery development for seabass, groupers, breams, snappers, pampano and tuna livebait	Finfish hatchery : II.A.1					Vessels & lab facilities	6 12 12 - (Rs. 137)	Others
II.A.2. Development of technologies for pond, pen & cage culture of seabass, groupers, breams, snappers, pampano and tuna livebait		Finfish growout : II.A.2				-do-	18 36 12 - (Rs. 803)	Others
II.A.3. Induced breeding, seed production & growout technologies for ornamental fishes		Ornamental fish : II.A.3				-do-	3 12 12 - (Rs. 230)	Others
						Subtotal for II.A (3 projects) : (Rs. 1170) Annual average = (Rs. 47)		
II.B. **Crustacean Mariculture (2 projects)**								
II.B.1. Development, standardisation, demonstration and propagation of hatchery technology for important marine shrimps, lobsters and crabs	Crustacean hatchery : II.B.1					Crustacean hatcheries (Rs. 350)	25 43 10 - (Rs. 833)	ICAR

Programmes & Projects	Timeframe					Infrastructure (cost - Rs in lakhs)	Manpower (cost - Rs in lakhs)	Funding
	1996-2000	2001-2005	2006-2010	2011-2015	2016-2020		S T RS I	
II.B.2. Development and standardisation of techniques of sea ranching of commercial crustaceans	Crustacean ranching : II.B.2					(Rs. 340)	10 26 - - (Rs. 576)	ICAR
						Subtotal for II.B (2 projects) : (Rs. 690) + (Rs. 1409) = (Rs. 2099) Annual average = (Rs. 84)		
II.C. **Molluscan Mariculture (9 projects)**								
II.C.1. Onshore pearl culture technology for *P. fucata*	Pearl culture : II.C.1					Onshore tanks, microalgae production facility at 4 centres (Rs. 100)	8 16 8 - (Rs. 166)	ICAR
II.C.2. Hatchery technology for *P. margaritifera* and *P. maxima*	Pearl oyster hatchery : II.C.2					Establishment of hatcheries, demonstration farms (Rs. 60)	12 12 12 - Rs. 186	Others
II.C.3. Onshore culture of clams, edible oysters and mussels	Edible bivalve culture : II.C.3					Farms (Rs. 300)	12 10 6 - (Rs. 172)	Others
II.C.4. Hatchery, growout and pearl culture technologies for abalones	Abalone culture : II.C.4					Hatchery, grow-out ponds, demonstration farms (Rs. 70)	11 18 12 - (Rs. 250)	ICAR

Programmes & Projects	Timeframe					Infrastructure (cost - Rs in lakhs)	Manpower (cost - Rs in lakhs)	Funding
	1996-2000	2001-2005	2006-2010	2011-2015	2016-2020		S T RS I	
II.C.5. Hatchery, culture and sea-ranching technologies for cephalopods	Cephalopod culture : II.C.5					Hatchery, race-way tanks & farms (Rs. 100)	8 12 12 - (Rs.190)	ICAR
II.C.6. Hatchery, growout and sea-ranching technologies for *Trochus, Turbo,* and *Tridacna*	*Trochus, Turbo, Tridacna* hatchery : II.C.6					3 Hatcheries (Rs. 95)	17 36 20 - (Rs.295)	Others
II.C.7. Mantle tissue culture technology and *in vitro* production of pearls in pearl oyster	Tissue culture - pearls : II.C.7					Tissue culture labs (Rs. 72)	16 26 30 - (Rs. 231)	Others
II.C.8. Hybridisation in pearl oysters, clams, mussels and edible oysters				Hybrid bivalves : II.C.8		Hatchery & growout (Rs. 40)	10 12 20 - (Rs. 310)	ICAR
II.C.9. Polyploid edible oysters, clams and mussels			Polyploid bivalves : II.C.9			Hatchery & growout (Rs.10)	10 20 30 - (Rs. 380)	ICAR
						Subtotal for II.C (9 projects) : (Rs. 847) + (Rs. 2180) = (Rs. 3027) Annual average = (Rs. 121)		

Programmes & Projects	Timeframe					Infrastructure (cost - Rs in lakhs)	Manpower (cost - Rs in lakhs)				Funding
	1996-2000	2001-2005	2006-2010	2011-2015	2016-2020		S	T	RS	I	
II.D. **Seacucumber Mariculture (1 project)**											
II.D.1. Hatchery and growout technology for seacucumber	Seacucumber mariculture : II.D.1					Hatchery & growout (Rs. 30)	40	60	-	-	ICAR (Rs. 560)
						Subtotal for II.D (1 project) : (Rs. 30) + (Rs. 560) = (Rs. 590) Annual average = (Rs. 24)					
II.E. **Mariculture Systems (2 projects)**											
II.E.1. Site selection, EIA & water quality management in mariculture systems and artificial reefs	Water quality & EIA : II.E.1					Equipments & labs (Rs. 50)	6	6	-	-	ICAR (Rs. 352)
II.E.2. Live feed technology for hatchery systems	Live feed : II.E.2					Culture facilities, glasswares & chemicals (Rs. 45)	7	7	-	-	ICAR (Rs. 171)
						Subtotal for II.E (2 projects) : (Rs. 95) + (Rs. 523) = (Rs. 618) Annual average = (Rs. 25)					

Programmes & Projects	Timeframe					Infrastructure (cost - Rs in lakhs)	Manpower (cost - Rs in lakhs)	Funding
	1996-2000	2001-2005	2006-2010	2011-2015	2016-2020		S T RS I	
II.F. **Seaweed Mariculture (2 projects)**								
II.F.1. Culture of important seaweeds	Seaweed culture : II.F.1					Farms (Rs. 25)	2 2 - -	ICAR
II.F.2. Genetic improvement of seaweeds and microorganisms	Genetic improvement of seaweeds : II.F.2					Farms & labs (Rs. 50)	6 6 3 - (Rs. 274)	Others
						Subtotal for II.F (2 projects) : (Rs. 75) + (Rs. 274) = (Rs. 349) Annual average = (Rs. 14)		
II.G. **Mariculture Biotechnology (16 projects)**								
II.G.1. Diagnostics in finfish and shellfish	Diagnostics : II.G.1					Equipments (Rs. 495)	20 24 14 20 (Rs. 692)	ICAR/ Others
II.G.2. Cell and tissue culture of neuroendocrine organs of shrimps	Neuroendocrine cell & tissue culture : II.G.2					Equipments (Rs. 70)	4 2 2 2 (Rs. 100)	ICAR/ Others
II.G.3. Cryopreservation of gametes & *In-vitro* fertilization of groupers	Cryopreservation : II.G.3					Equipments (Rs. 70)	4 2 2 2 (Rs. 100)	ICAR/ Others
II.G.4. Bioactive substances from corals, sponges, echinoderms, tunicates and marine microbes using bio-technological tools	Bioactive substances : II.G.4					Equipments (Rs. 535)	26 14 6 14 (Rs. 629)	ICAR/ Others

Programmes & Projects	Timeframe					Infrastructure (cost - Rs in lakhs)	Manpower (cost - Rs in lakhs)	Funding
	1996-2000	2001-2005	2006-2010	2011-2015	2016-2020		S T RS I	
II.G.5. Effect of environmental parameters on the digestive and metabolic enzyme profile in groupers, pampano, breams, snappers & molluscs	Enzyme profile : II.G.5					Equipments (Rs. 60)	8 6 - 4 (Rs. 75)	ICAR
II.G.6. Reproductive physiology, sex reversal, induced maturation and spawning in groupers, snappers, breams & pampano; role of biogenic amines in the maturation of shrimps	Reproductive physiology : II.G.6					Equipments (Rs. 100)	6 3 - 3 (Rs. 136)	ICAR/ Others
II.G.7. Cytochemical & biochemical genetic/DNA techniques & Image analysis for assessing genetic isolation	Assessment of genetic isolation : II.G.7					Equipments (Rs. 200)	5 4 - 10 (Rs. 238)	Others
II.G.8. Induction of polyploidy in finfish, crustaceans and molluscans	Polyploidy : II.G.8					Equipments (Rs. 25)	3 1 1 2 (Rs. 42)	Others
II.G.9. Selective breeding of finfish & shellfish for foundation stocks.			Selective breeding : II.G.9			Equipments (Rs. 100)	5 3 15 10 (Rs. 350)	ICAR

Programmes & Projects	Timeframe 1996-2000 | 2001-2005 | 2006-2010 | 2011-2015 | 2016-2020	Infrastructure (cost - Rs in lakhs)	Manpower (cost - Rs in lakhs) S T RS I	Funding
II.G.10. Development of cytochemical and biochemical genetic model species for monitoring marine pollution.	Genetic model species : II.G.10	Equipments (Rs. 50)	3 2 - 10 (Rs. 262)	ICAR
II.G.11. Enzymology and ultrastructure of inflammatory reactions in marine animals.	Inflammation : II.G.11	Equipments (Rs. 60)	4 3 - 1 (Rs. 38)	ICAR
II.G.12. Role of nutrient toxins in finfish & shellfish health.	Nutrient toxins : II.G.12	Equipments (Rs. 60)	3 2 - 1 (Rs. 28)	ICAR
II.G.13. Ultrastructure and histochemistry of leucocytes.	Leucocytes : II.G.13	Equipments (Rs. 75)	3 2 - - (Rs. 32)	ICAR
II.G.14. Immune system in finfish/ shellfish: pollutant effect on host pathogen interaction; host defence and pathogenecity.	Pollutant effect and Immune system : II.G.14	Equipments (Rs. 205)	8 7 - 4 (Rs. 236)	ICAR
II.G.15. Development of vaccines for bacterial, viral diseases of finfish & shellfish.	Vaccine development : II.G.15	Equipments (Rs. 120)	4 4 3 3 (Rs. 159)	ICAR/ Others

Programmes & Projects	Timeframe					Infrastructure (cost - Rs in lakhs)	Manpower (cost - Rs in lakhs)	Funding
	1996-2000	2001-2005	2006-2010	2011-2015	2016-2020			
							S T RS I	
	Nutrition and feed : II.G.16							
II.G.16.Nutrition & feed technology for finfish and shellfish.						Equipments (Rs. 300)	20 16 16 8 (Rs. 534)	ICAR/ Others
						Subtotal for II.G (16 projects) : (Rs. 2525) + (Rs. 3643) = (Rs. 6168) Annual average = (Rs. 247)		
						Total for II (Mariculture technology): (Rs. 4262) + (Rs. 9759) = (Rs. 14021) Annual average = (Rs. 561)		
III. **ECONOMICS & EXTENSION**								
III.A. **Socioeconomics (5 Projects)**								
	Socioeconomic studies : III.A.1							
III.A.1.Socioeconomic impact of coastal aquaculture; socioeconomic indices in GIS; coastal zone management.						Computers & Extension literature (Rs. 20)	8 11 8 - (Rs. 203)	ICAR/ Others
	Cost benefit analysis : III.A.3							
III.A.2.Cost-benefit analysis of major fishing harbours and economic evaluation of capture fisheries.						Computers & Extension literature (Rs. 15)	9 13 13 - (Rs. 394)	ICAR/ Others
	Technoeconomic assessment : III.A.3							
III.A.3.Techno-economic assessment of marine fishery and its contribution to GNP. Economic anaysis of deepsea fishing.						Computer & Extension literature (Rs. 5)	4 6 4 - (Rs. 148)	Others

Programmes & Projects	Timeframe					Infrastructure (cost - Rs in lakhs)	Manpower (cost - Rs in lakhs)				Funding
	1996-2000	2001-2005	2006-2010	2011-2015	2016-2020		S	T	RS	I	
III.A.4. Market structure, supply-demand and price behaviour of marine fisheries; capacity utilisation in post-harvest infrastructure.			Market structure, price behaviour : III.A.4			Computer & Extension literature (Rs. 10)	6	11	15	- (Rs. 209)	Others
III.A.5. Economic analysis of labour utilisation and HRD in marine fisheries.		Labour utilisation : III.A.5				Computer & Extension literature (Rs. 25)	1	2	10	- (Rs. 85)	Others
						Subtotal for III.A (5 projects) : (Rs. 75) + (Rs. 1039) = (Rs. 1114) Annual average = (Rs. 45)					
III.B. **Extension (4 Projects)**											
III.B.1. Empowerment of marine fisherfolk through transfer of technology; integration of small scale mariculture with small scale fisheries.			Technology transfer, empowerment : III.B.1			Extension literature (Rs. 11)	15	20	-	- (Rs. 281)	ICAR
III.B.2. Entrepreneurship development and empowerment of marine fisherfolk through extension education.			Entrepreneurship development : III.B.2			-	2	2	-	- (Rs. 19)	ICAR

Programmes & Projects	Timeframe					Infrastructure (cost - Rs in lakhs)	Manpower (cost - Rs in lakhs)	Funding
	1996-2000	2001-2005	2006-2010	2011-2015	2016-2020		S T RS I	
	Role of women : III.B.3							
III.B.3. Behaviour of fisherfolk with reference to role of women; diffusion and adoption of mariculture technologies.						Extension literature	4 6 5 - (Rs. 40)	ICAR/ Others
	Modelling & evaluation of fiheries extension methods : III.B.4							
III.B.4. Communication techniques in fishery extension; modelling and evaluation of fisheries extension methods. Extension of mariculture technologies to all hinterland states in their saline soil areas.						Extension literature (Rs. 75)	8 6 4 - (Rs. 243)	ICAR/ Others
						Subtotal for III.B (4 projects) : (Rs. 86) + (Rs. 583) = (Rs. 669) Annual average = (Rs. 27)		
						Total for III (Economics): (Rs. 161) + (Rs. 1662) = (Rs. 1783) Annual average = (Rs. 71)		
IV. EDUCATION (2 Projects)								
	M.F.Sc. and Ph.D programmes : IV.1							
IV.1. PG Education: M.F.Sc.and Ph.D degree programmes in Mariculture and in 8 new subjects **						A students hostel at Cochin, 100-room capacity (Rs. 300). A demonstration farm at Cochin (Rs. 100).	* 50 25 160 - (Rs. 5625)	ICAR

Programmes & Projects	Timeframe					Infrastructure (cost - Rs in lakhs)	Manpower (cost - Rs in lakhs)	Funding
	1996-2000	2001-2005	2006-2010	2011-2015	2016-2020		S T RS I	
						A multispecies hatchery at Cochin (Rs. 200).		
						Land and separate teaching and research blocks (Rs. 1500).		ICAR
						Equipments, vehicles & laboratory facilities including a research vessel (Rs.1500).		
			Academic programme upgradation : IV.2					
IV.2. Creation of Deemed University for Fisheries.						Land and office building (Rs. 500).	2 40 - (Rs. 1365)	ICAR
						Staff quarters, Guest House, recreation facilities etc. (Rs.500).		
						Total for IV (Education): (Rs. 4500) + (Rs. 6990) = (Rs. 11490) Annual average = (Rs. 460)		
						Grand total : (Rs. 13558) + (Rs. 34801) = (Rs. 48359) Annual average = (Rs. 1934)		

S - Scientist T - Technical Staff RS - Research Scholars I - Investigators
(Each scientist will have about 3 projects. The Scientist : Technician ratio is about 1:1.5)

* For mariculture teaching, the existing CMFRI scientists are serving as faculty

** The 8 subjects include: Marine Capture Fisheries Development and Management, Mariculture Production and Management, Mariculture Engineering, Mariculture Genetics, Mariculture Nutrition, Mariculture Pathology, Mariculture Hatchery & Seed Technology and Marine Biotechnology.

9.2. FUNDING NEEDS OF THE PROGRAMMES

The funds needed for the various R&D programmes need to be met largely by the ICAR. 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 11 sponsored R&D projects with a total budget of Rs. 130.5329 lakhs.

The requirements of funds for infrastructure/equipments and salaries for various programmes are indicated against each of the programmes listed under 9.1 (Setting of programmes on a time scale).

9.3 LINKAGES, COORDINATIONS AND EXECUTION 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 12 Research Centres headed by Officers-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

All the research programmes are carried out though these 8 research divisions and the 12 Research Centres together with their field centres totalling 28. 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 Officer-in-Charge of the Research Centre. The programmes are screened by the Research Coordination and Management Unit of the Institute and the Research Advisory Committee and the progress is evaluated by the Staff Research Council.

The implementation of the various programmes requires the establishment of linkages with both governmental and other agencies. The linkages established in the major areas are given hereunder and in Fig. 30.

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The implementation of the various programmes requires the establishment of linkages with both governmental and other agencies. The linkages established in the major areas are given hereunder and in Fig. 30.

Linkages

Area of Study	Organisations
Assessment of marine living resources	DOD, NRSA, DAC, FSI, SUFD, CIFNET, FAO
Fisheries Oceanography	DOD, NIO
Biodiversity	ME&F, ZSI & SUFD
Mariculture and searanching	DOD, ME&F, DBT, MPEDA,SAUs, SUFD, NGOs, CIBA, NBFGR, CIFA and FAO.
Basic disciplines including Physiology, nutrition, Pathology and genetics	DBT, SAUs, CSIR labs, other ICAR labs, MSAU and FAO
Socioeconomics and Bio-economics	DAC, SUFD, NGOs, FAO
Technology transfer	SUFD, NGOs, Cooperatives NABARD
Post graduate Education & Training	CIFE, SAUs, Traditional Universities, IASRI, SUFD, NGOs, FAO.

9.4. CRITICAL INPUTS

9.4.1 Funding

The Institute programmes are funded by the ICAR through the plan funds and cess fund schemes. Additional funds are generated through sponsored projects from the DST, DOD, DBT, MOA, ME&F, MPEDA and through consultancies.

9.4.2. Manpower

The manpower requirements of Scientists, Technical staff, Senior Research Fellows and others are indicated under 9.1. For the next 5 years in addition to the existing staff, additional posts proposed are Scientists 25, Technical staff 50 and Ministerial staff 20.

9.4.3 Any other

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

b) Data in log sheets from all mechanised vessels, both governmental and private, need to be furnished to the National Marine Living Resources Data Centre (NMLRDC) of the CMFRI.

c) Funds as per the proposals made

d) Staff as per the proposals made

Linkages

Area of Study	Organisations
Assessment of marine living resources	DOD, NRSA, DAC, FSI, SUFD, CIFNET, FAO
Fisheries Oceanography	DOD, NIO
Biodiversity	ME&F, ZSI & SUFD
Mariculture and searanching	DOD, ME&F, DBT, MPEDA,SAUs, SUFD, NGOs, CIBA, NBFGR, CIFA and FAO.
Basic disciplines including Physiology, nutrition, Pathology and genetics	DBT, SAUs, CSIR labs, other ICAR labs, MSAU and FAO
Socioeconomics and Bio-economics	DAC, SUFD, NGOs, FAO
Technology transfer	SUFD, NGOs, Cooperatives NABARD
Post graduate Education & Training	CIFE, SAUs, Traditional Universities, IASRI, SUFD, NGOs, FAO.

9.4. CRITICAL INPUTS

9.4.1 Funding

The Institute programmes are funded by the ICAR through the plan funds and cess fund schemes. Additional funds are generated through sponsored projects from the DST, DOD, DBT, MOA, ME&F, MPEDA and through consultancies.

9.4.2. Manpower

The manpower requirements of Scientists, Technical staff, Senior Research Fellows and others are indicated under 9.1. For the next 5 years in addition to the existing staff, additional posts proposed are Scientists 25, Technical staff 50 and Ministerial staff 20.

9.4.3 Any other

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

b) Data in log sheets from all mechanised vessels, both governmental and private, need to be furnished to the National Marine Living Resources Data Centre (NMLRDC) of the CMFRI.

c) Funds as per the proposals made

d) Staff as per the proposals made

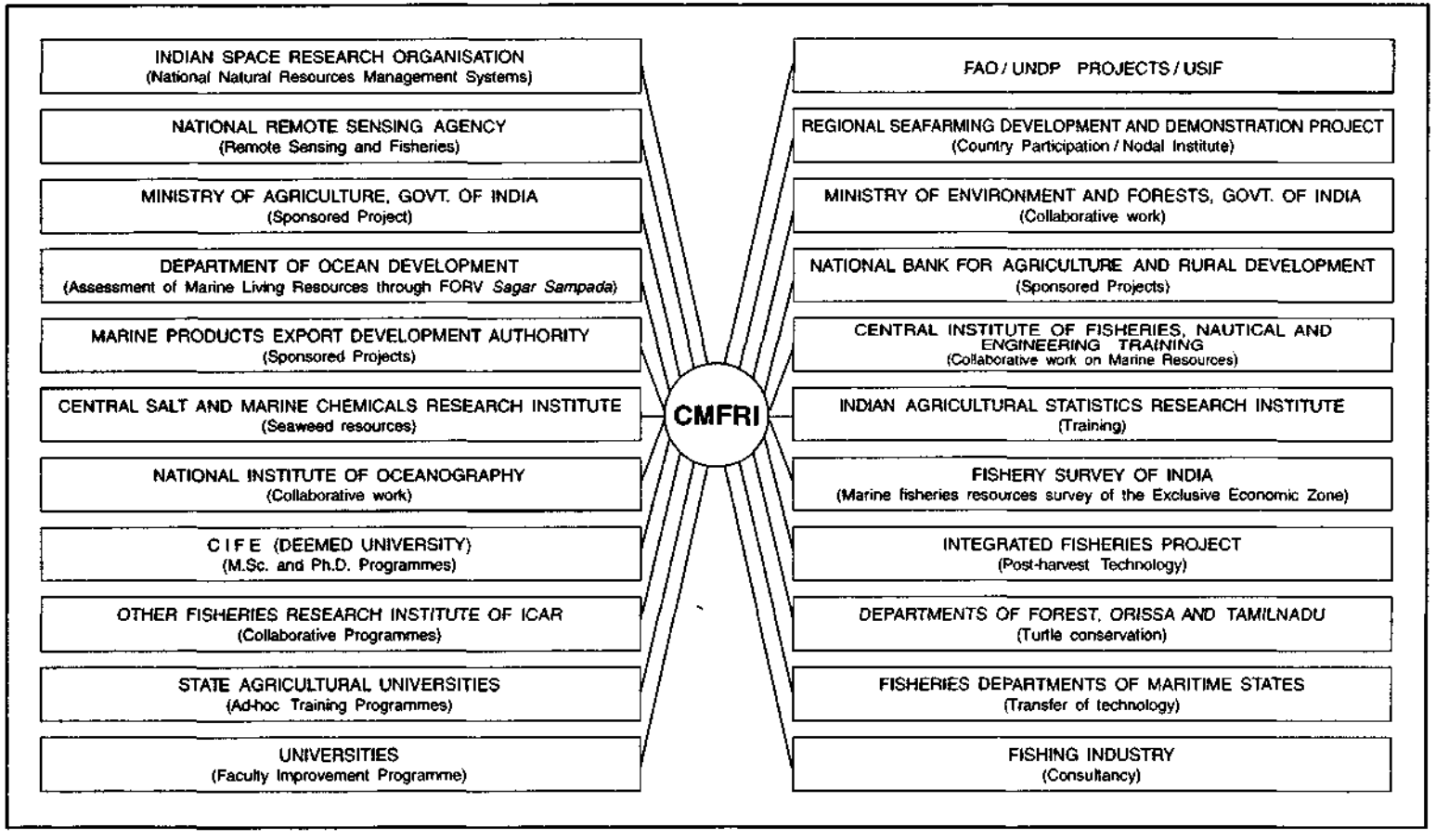

Fig. 30. Linkages of CMFRI with other organisations

9.5 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 wide 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, particularly the juveniles of several commercial species, thereby affecting recruitment. Several mariculture farms may become useless due to increasing coastal pollution.

Outbreak of diseases, pollution and calamities like cyclones 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 jeopardised the industry very much.

9.6 OUTPUT AND EXPECTED SITUATION

1. Sustained production from the EEZ at 3.9 million tonnes.
2. Decline in protein energy malnutrition
3. Increased exports of marine products
4. Mariculturte taking the form of an industry, the production reaching 2 million tonnes.
5. Stock improvement by searanching
6. New research programmes in frontier areas of seafarming
7. Increased employment and income

10. PROJECT REVIEW, REPORTING AND EVALUATION ARRANGEMENTS

The Research Coordination and Management Unit of the Institute scrutinises 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 projects are approved by the Management Committee of the Institute. 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.

11. RESOURCE GENERATION

The resources required by the Institute for implementing the Perspective Plan will be provided largely by the ICAR. The Institute shall approach agencies such as the DBT, DOD, ME&F and the MPEDA and various international donors for funding some of the R&D projects. Already a total of 25 R & D projects with a total budget of Rs.704 lakhs to be operated during the next 5 years have been submitted to various funding agencies. Additional resources will be generated through consultancy services and by sale of the technologies and products. Public marine aquaria being developed by the Institute in all its research centres, have very substantial income generating potential.