CMFRI SPECIAL PUBLICATION

Number 67

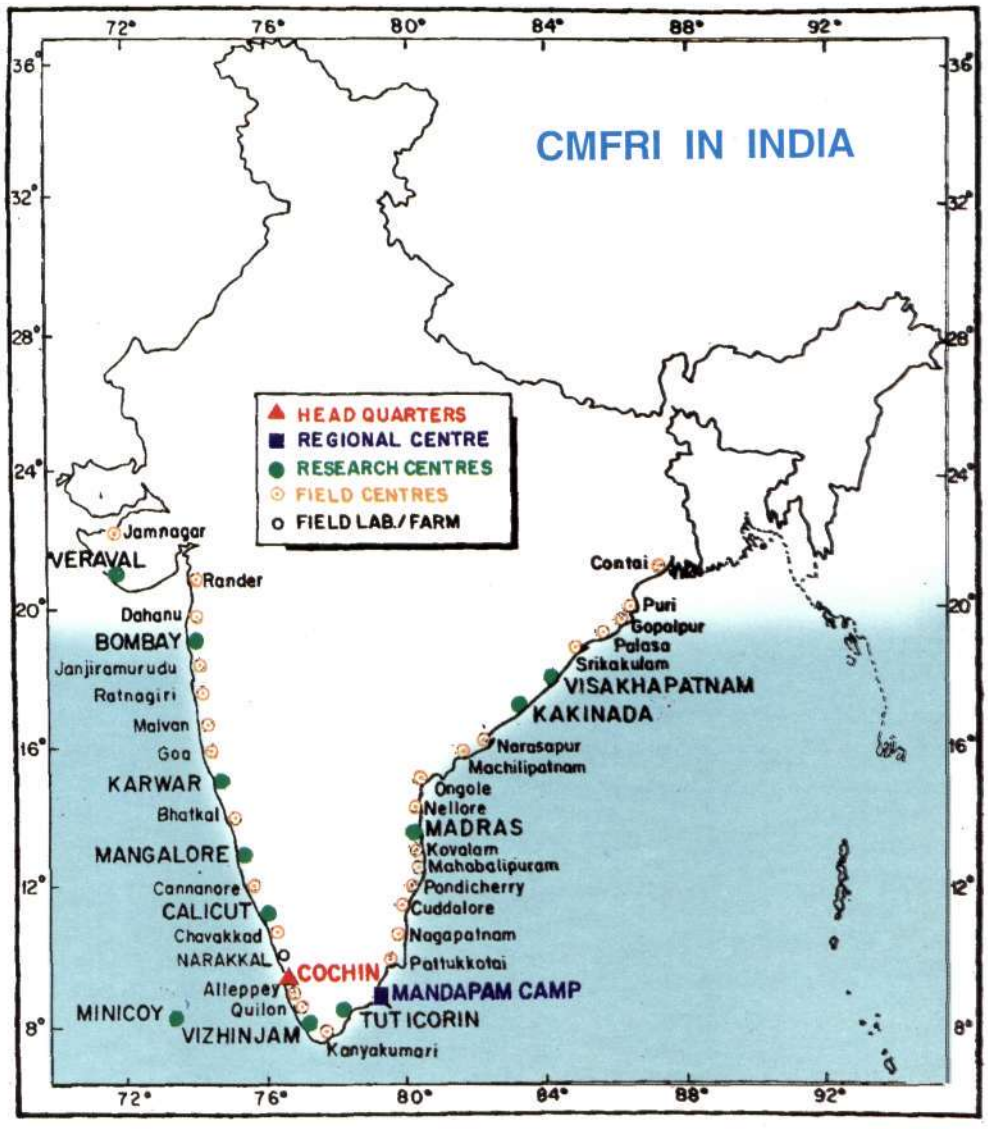
STATUS OF RESEARCH IN MARINE FISHERIES AND MARICULTURE

(Role of CMFRI)

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE

Indian Council of Agricultural Research

Post Bag No. 1603, Cochin - 682 014



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Dr.M.Devaraj
Director
Central Marine Fisheries Research Institute
Cochin - 682 014

Presented at the
175th Meeting of the Governing Body of
Indian Council of Agricultural Research Society,
at
CMFRI, Cochin
on
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Central Marine Fisheries Research Institute
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CONTENTS

BACKGROUND

Fisheries being a transferred subject (from the Centre to the States), the government of India did not take any direct interest till the early forties,except enacting the Indian Fisheries Act 1897. In the preindependence and the immediate postindependence years, the Fisheries Departments of the States were attending mainly to revenue collections. The Surgeon-Naturalists of the Marine Survey of India, the Zoological Survey of India and some universities were carrying out limited studies relating to species records and taxonomy of fishes and other aquatic fauna, and there was no organised fisheries research in the country. The lack of adequate supplies of fish during the Second World War, particularly to the defence personnel, made the then Government of India realise the need for taking direct interest in research and developmnet of fisheries in the country. The proposal for the establishment of a Central Fisheries Research Institute was first made in 1943 by the late Dr. Baini Prasad, the then Director, Zoological Survey of India, in his memorandum on the "Postwar Development of Indian Fisheries". This proposal which paved way for the establishment of a Central Fisheries Research Institute, was endorsed by the subcommittee of the Policy Committee on Agriculture and Fisheries in its 1945 report. Subsequently, on the basis of the "Memorandum on the proposed Fishery Research Institute" prepared 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 then 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 shifted to the ICAR.

India has a long coastline 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. The CMFRI is geared to meet these challenges by implementing suitable action plans for sustained marine fisheries and mariculture development.

In the context of rapidly growing human population and increasing protein malnutrition, food security assumes greater significance in the developing countries. Increasing urbanisation and related activities are fast leading to significant declines in the arable land areas, resulting in increased attention on the aquatic sources of food. Among these resources, marine fisheries play an important role in supplementing the protein food requirements and employment generation. Marine fisheries in India underwent a phenomenal change during the past half a century, from a predominantly sustenance avocation to that of an industry. The present situation warrants a close scrutiny of marine fisheries and mariculture research, the infrastructure, the human resource development and the social and economic conditions of the fisherfolk to meet the challenges of increasing the production to the required level effectively. In 1991,the Government of India launched the New Economic Policy (NEP), with competition, privatisation, liberalisation and globalisation as its main components. The NEP has its implications in the marine fisheries and mariculture sectors also in the context of increasing production by deepsea fishing, sustaining production from the presently exploited stocks, modernising the processing sector, generating additional employment, commercialising mariculture practices and further promotion of trade and exports. This policy also enables improving capabilities in the marine fisheries R&D and human resources development.

LIST OF FIGURES

MANDATE

1. Assessment and monitoring of the status of the exploited fish stocks in the Indian EEZ for the sustained growth of marine fisheries in relation to fishery independant and fishery dependant factors.

2. Development and transfer of seafarming technologies.

3. Evaluation of the technoeconomics and socioeconomics of marine fishery and seafarming operations.

4. Monitoring the health of the marine ecosystems.

5. Postgraduate education in marine fisheries and mariculture leading to M.F.Sc and Ph.D degrees. Skilled manpower development through training programmes, onfarm trials and village adoption.

ORGANISATION

The Institute's programmes are implemented through eight divisions, and besides the headquarters, 12 research centres and 28 field centres representing the major ecological provinces of the country (Plates I-VIII).

SCIENTIFIC DIVISIONS AND RESEARCH PROGRAMMES

Name of Division (1)	Fishery Resources studied/ Specialisation (2)	Research Programmes (3)
1. Fishery Resources Assessment	(i) Exploited Fisheries Resources: Assessment & Monitoring	(i) Fisheries statistics for estimation of catch, effort and cost & revenue (ii) Development of models & methods for fishery forecast (iii) Stock assessment
2. Pelagic Fisheries	(i) Capture fisheries of Sardines, Anchovies, Mackerel, Horse mackerel, Scad, Tuna, Seerfish, Ribbonfish, Bombay-duck and Hilsa shad	(i) Biology including Maturation, Spawning, Fecundity,Distribution Growth & Recruitment (ii) Monitoring catches (iii) Stock assessment
3. DemersalFisheries	(i) CaptureFisheriesof Elamobranchs, Perches, Catfishes, Threadfinbreams, Silverbellies, Croakers,Lizardfishes,Flatfishes, Threadfins, Pomfrets, Bull's eye, Goatfishes and Whitefish	(i) Biology including Distribution Maturation, Spawning, Fecundity, Food, Growth & Recruitment (ii) Monitoring of catches (iii) Stock assessment
	(ii) Mariculture of Groupers, Snappers, Breams and Ornamental fish	(iv) Breeding, Seed production and Growout

(Contd)

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	(ii) Mariculture of Groupers, Snappers, Breams and Ornamental fish	(iv) Breeding, Seed production and Growout

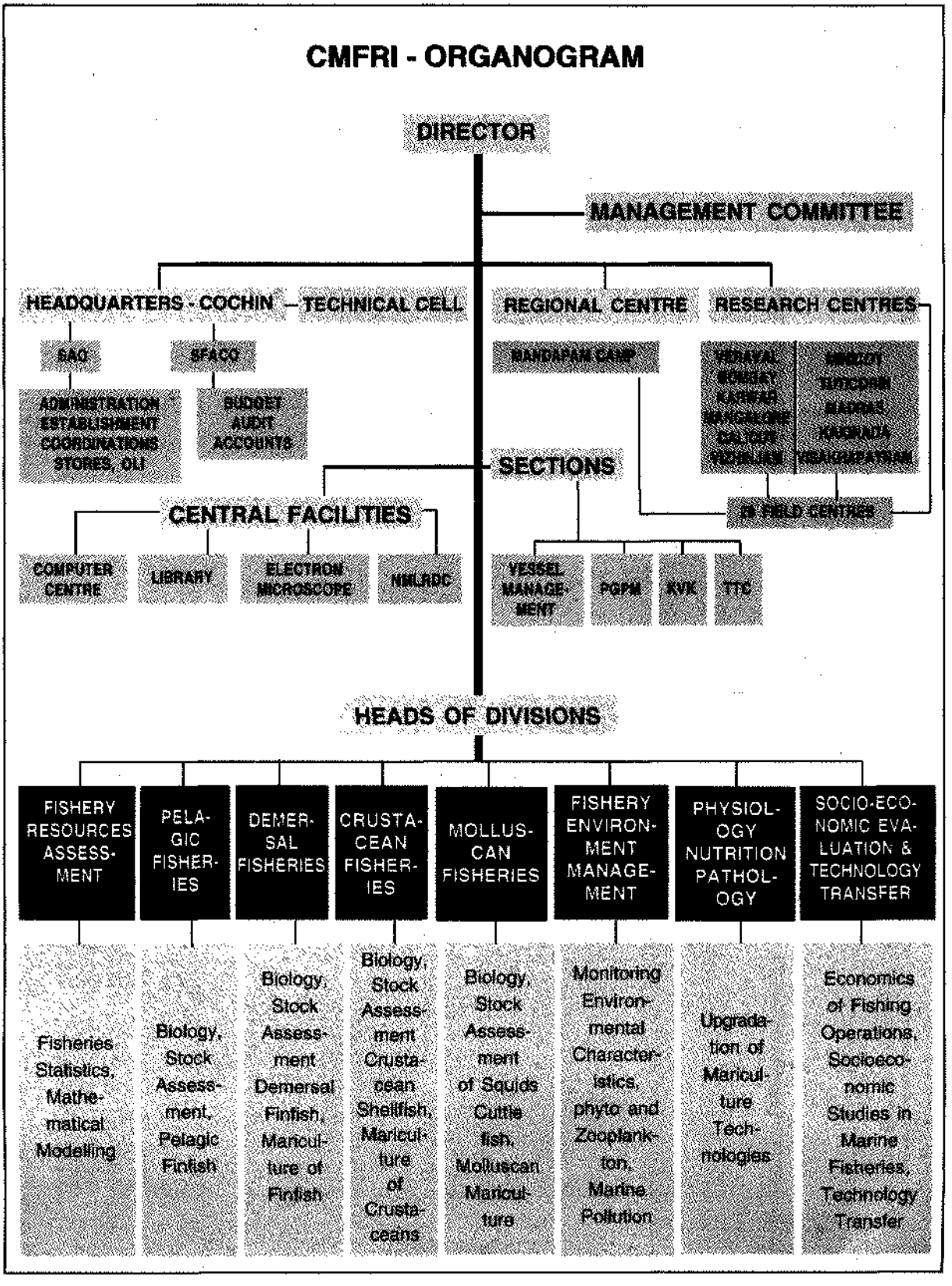
(Contd)

(1)	(2)	(3)
4. Crustacean Fishereis	(i) Capture fisheries of Penaeid prawns, Nonpenaeid prawns, Crabs, Lobsters and Stomatopods	(i) Biology including distribution, Spawning, Fecundity, Growth & Recruitment
		(ii) Monitoring of catches
		(iii) Stock assessment
	(ii) Mariculture of Penaeid prawns, Crabs and Lobsters	(iv) Breeding, Seed production, Fattening and culture
5. Molluscan Fisheries	(i) Capture fisheries of Squid, Cuttlefish, Gastropods, and Bivalves	(i) Biology including Distribution, Spawning, Fecundity, Growth & Recruitment
		(ii) Monitoring landings
		(iii) Stock Assessment
	(ii) Mariculture of	
	(a) Mussel, Clam, Edible oyster, Abalone, Cephalopods	(iv) Breeding, Seed production & Culture of edible molluscs
	(b) Pearl oyster	(v) Breeding, Seed production, Growout for Pearl culture
6. Fishery Environment Management	(i) Primary, secondary and tertiary production	(i) Plankton studies
	(ii) Oceanography	(ii) Hydrography (pH, salinity etc.),currents, nutrients, DO and Marine Meteorology
	(iii) Mariculture of Seaweed and Seacucumber	(iii) Seed production & Propagation and Growout
	(iv) Remote Sensing	(iv) Potential Fishing Zone, Seatruth data, Validation and Dissemination
7. Physiology, Nutrition, Pathology	(i) Biotechnology for Finfish and Shellfish Mariculture, Genetics	(i) Nutrition & Compounded feeds, Physiology and Endocrinology
		(ii) Microbiology, Pathology and Genetics
8. Socioeconomic Evaluation and Technology Transfer	(i) Marine Fisheries Economics	(i) Economics of fishing and mariculture operations
	(ii) Extension	and Extension, Village adoption, Technology Transfer

STRUCTURAL SETUP
HEADQUATERS, REGIONAL CENTRE AND RESEARCH CENTRES

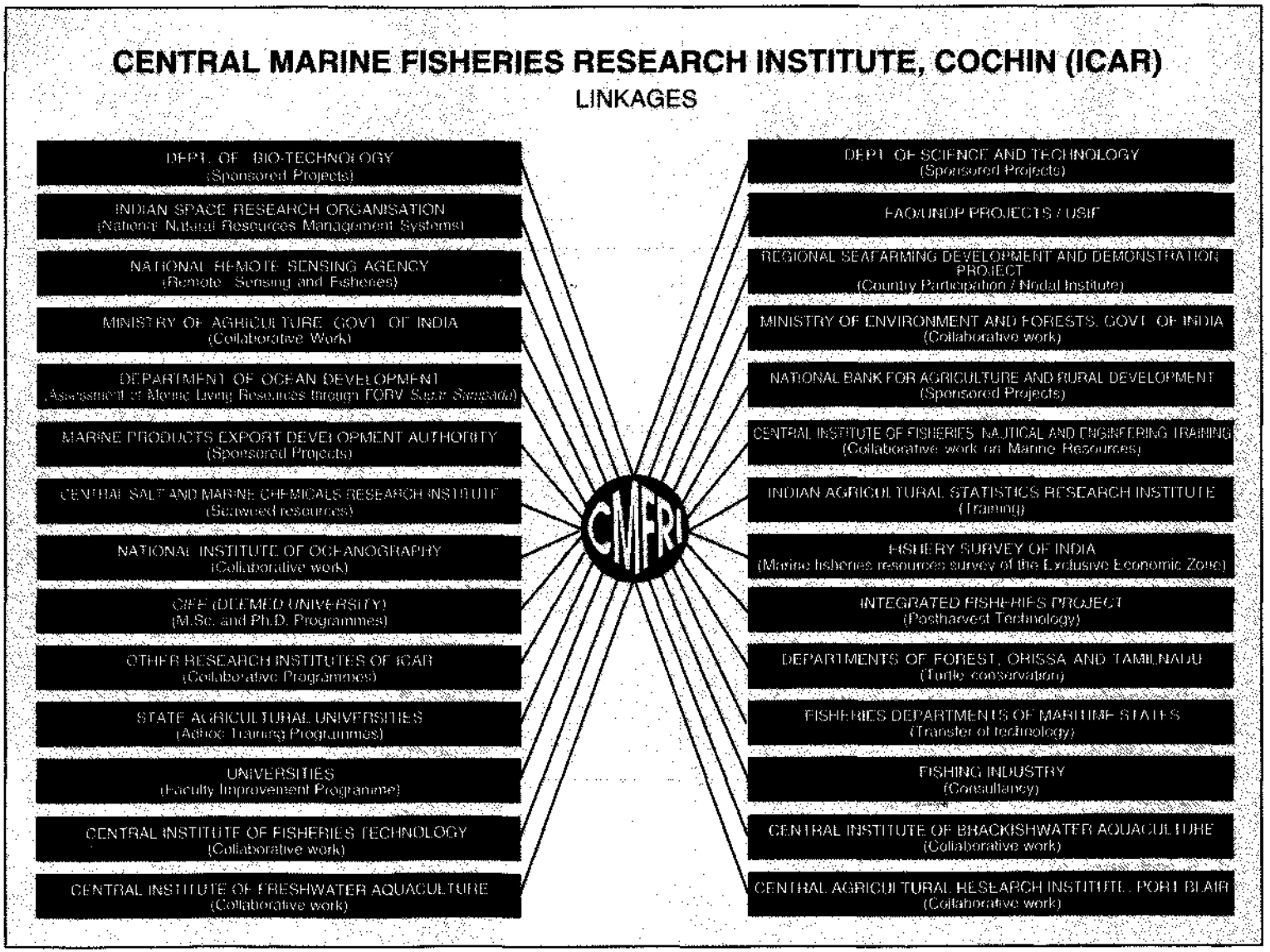
State/UT	Research Centre	No.of Field Centres	Laboratory Building Own/Rented	Farm	Hatchery and wet labs	Vessels
Gujarat	**Veraval**	2	Own Laboratory, Quarters under construction	3 acre land available	-	-
Maharashtra	**Bombay**	4	Rented Laboratory	40 ha marine farm, being transfered from Maharashtra Govt.	-	-
Karnatka	**Karwar**	1	Own Building	Being developed	Multipurpose wetlab	1(7.5m OAL)
	Mangalore	1	Rented Building	Land & farm area under negotiation with Karnataka Government		1(7.5m OAL)
Kerala	**Calicut**	1	Own Building Quarters under construction	3 acre farm -	Multipurpose hatchery Mussel hatchery	
	Cochin HQ (Fisheries Harbour Lab. TTC, KVK)	3	Own Building	9 acre farm	7000s.ft Multipurpose hatchery	(*Sagar Sampada* of DOD) 1(13.26m OAL)
	Vizhinjam	nil	Rented Building	1.7 ha. (proposed hatchery)	Aquarium	1 (13.26m OAL)
Lakshadweep	**Minicoy**	nil	Own Building	-	-	-
Tamil Nadu	**Tuticorin**	1	Partly owned Partly rented	4.0 ha. farm	Pearl oyster and edible bivalve hatcheries	1(13.26m OAL)
	Mandapam Camp (Regional Centre)	2	Own Laboratory and Quarters	3.8 ha farm 227 ha.lagoon Commercial pearl culture farm	Penaeid hatchery Aquarium	2(13.26m, 9.8m OAL)
	Madras	6	Mainly Rented building Partly owned		Onshore and multipurpose hatchery 1.5 acre farm	1(13.26m OAL)
Andhra Pradesh	**Kakinada**	2	Rented	-	-	-
	Visakhapatnam	5	Own Building	-	Multipurpose hatchery	1(13.26m OAL)
Total	13	28				9 Vessels

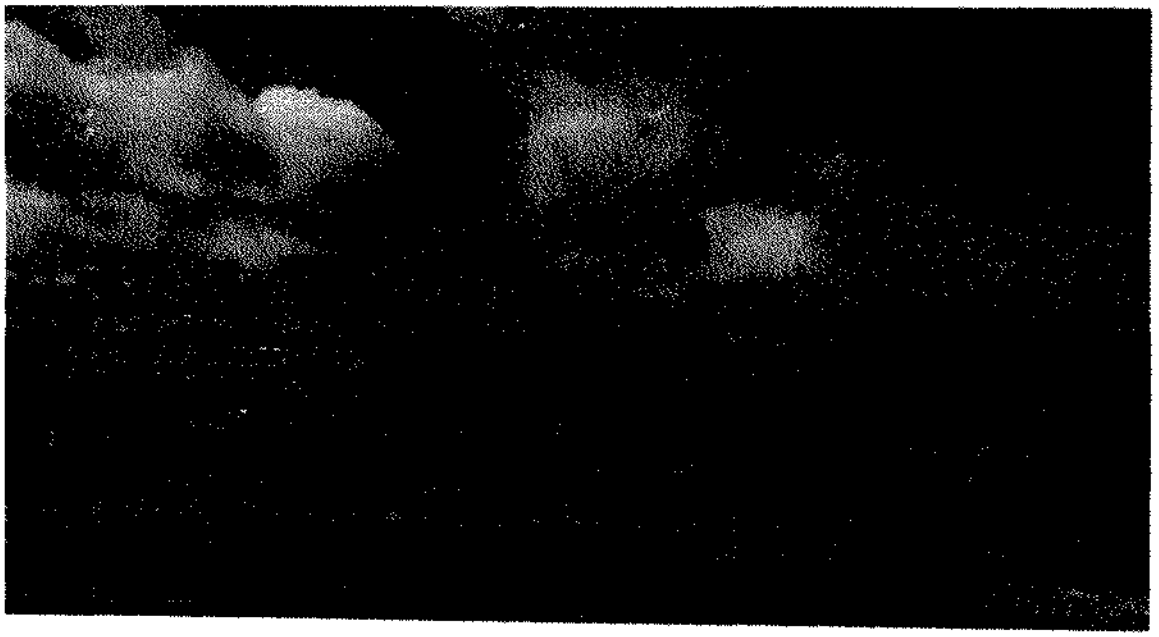
Own laboratories	=	in 9 centres	Farm area	=	55 ha	Hatcheries	=	7
Rented Buildings	=	in 4 centres	Land area	=	5 ha	Wetlab	=	2
Partly owned and partly rented	=	in 2 centres	Lagoons	=	227 ha	Hatcheries and Wetlab	=	3
						Aquaria	=	2


CMFRI - ORGANOGRAM
DIRECTOR
MANAGEMENT COMMITTEE
HEADQUARTERS - COCHIN
TECHNICAL CELL
REGIONAL CENTRE
RESEARCH CENTRES
SAO
SFACO
ADMINISTRATION ESTABLISHMENT COORDINATIONS STORES, OLI
BUDGET AUDIT ACCOUNTS
MANDAPAM CAMP
VERAVAL MUMBAI KARWAR MANGALORE CALICUT VIZHINJAM
PORT BLAIR TUTICORIN MADRAS VISAKHAPATNAM
SECTIONS
CENTRAL FACILITIES
19 FIELD CENTRES
COMPUTER CENTRE
LIBRARY
ELECTRON MICROSCOPE
NMLRDC
VESSEL MANAGE-MENT
PGPM
KVK
TTC
HEADS OF DIVISIONS
FISHERY RESOURCES ASSESS-MENT
PELA-GIC FISHER-IES
DEMER-SAL FISHERIES
CRUSTA-CEAN FISHER-IES
MOLLUS-CAN FISHERIES
FISHERY ENVIRON-MENT MANAGE-MENT
PHYSIOL-OGY NUTRITION PATHOL-OGY
SOCIO-ECO-NOMIC EVA-LUATION & TECHNOLOGY TRANSFER
Fisheries Statistics, Mathe-matical Modelling
Biology, Stock Assess-ment, Pelagic Finfish
Biology, Stock Assess-ment Demersal Finfish, Mariculture of Finfish
Biology, Stock Assess-ment Crusta-cean Shellfish, Mariculture of Crusta-ceans
Biology, Stock Assess-ment of Squids Cuttle fish, Molluscan Mariculture
Monitoring Environ-mental Character-istics, phyto and Zooplank-ton, Marine Pollution
Upgrada-tion of Mariculture Tech-nologies
Economics of Fishing Operations, Socioeco-nomic Studies in Marine Fisheries, Technology Transfer

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE, COCHIN (ICAR)

LINKAGES



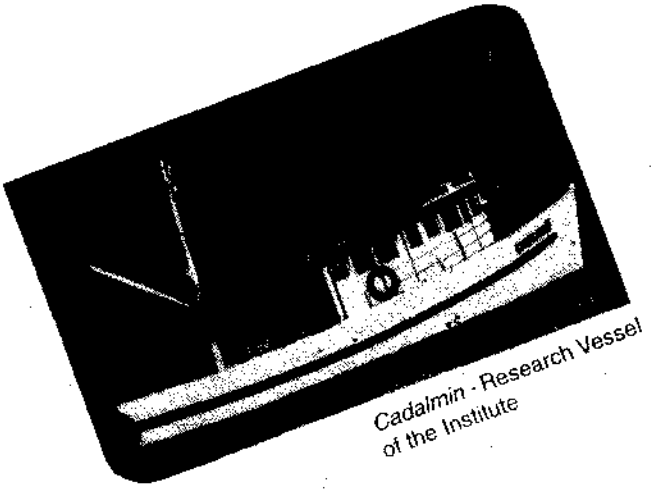


Administrative and Laboratory building of Headquarters at Cochin

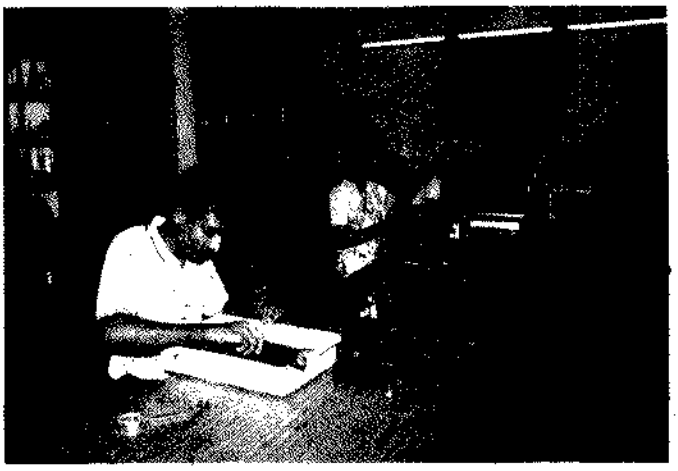
Mariculture facility of CMFRI at Fisheries harbour

PLATE I

Marine Remote Sensing Information System at Headquarters



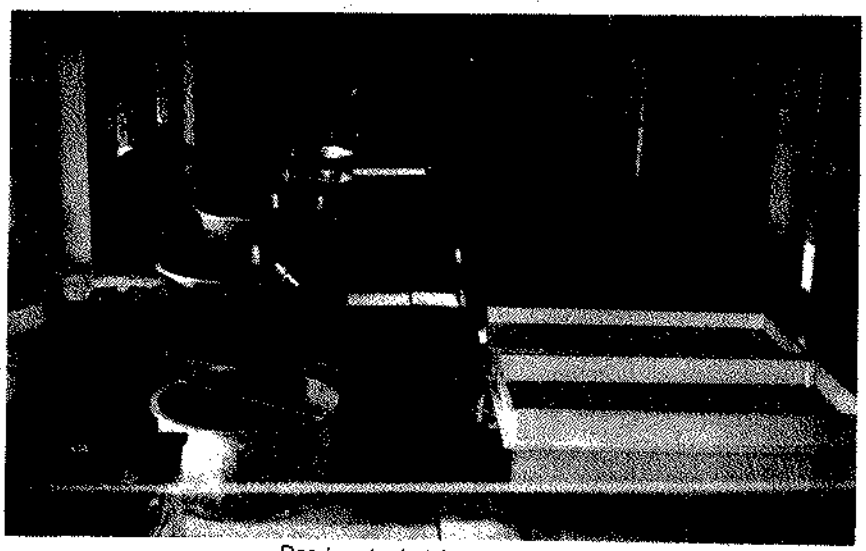
Cadalmin - Research Vessel of the Institute



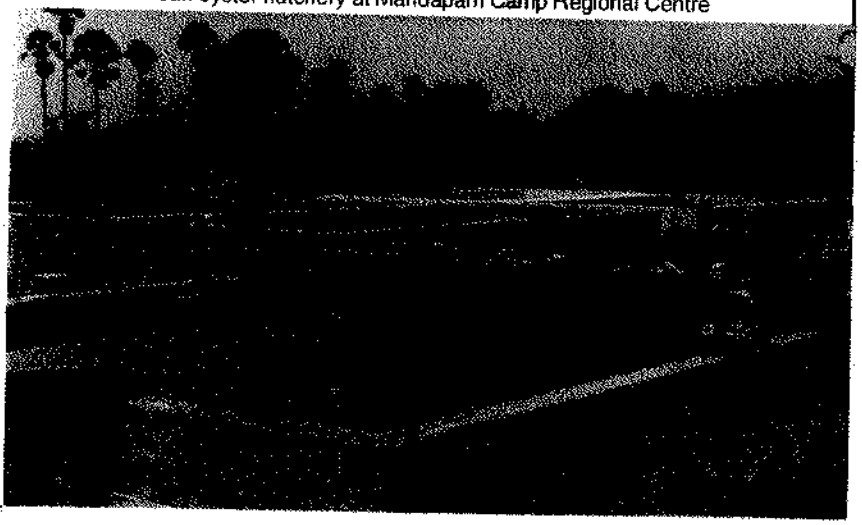
M. F. Sc. Mariculture laboratory at headquarters

PLATE II

Regional Centre at Mandapam Camp



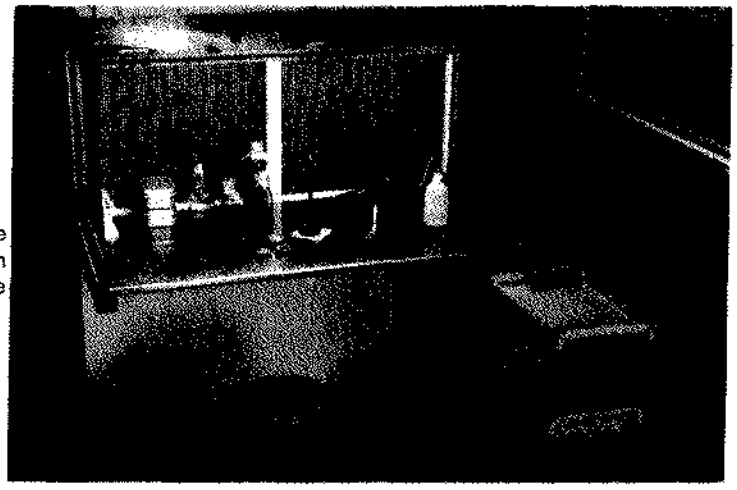
Pearl oyster hatchery at Mandapam Camp Regional Centre



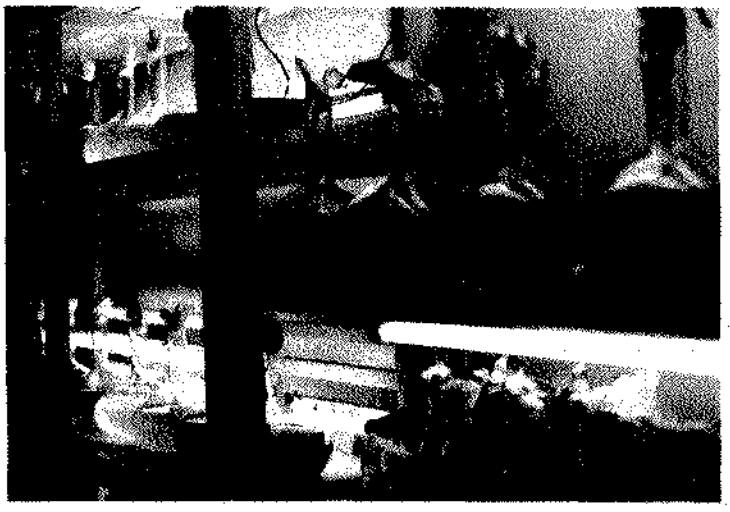
Onshore facility for pearl oyster farming at Mandapam Camp

PLATE III

Karapad laboratory complex at Tuticorin



Pearl oyster tissue - culture laboratory at Tuticorin Research Centre



Dietary microalgal mass culture laboratory at Karapad (Tuticorin)

PLATE IV

Bivalve hatchery at Karapad (Tuticorin)

Wet laboratory for nutrition studies at Karapad

Grouper culture pond at Tuticorin

PLATE V

Office- cum- laboratory of Calicut Research Centre

PLATE VI

Mariculture complex at Calicut being commissioned

Infrastructure

Laboratories: The laboratories at the Headquarters, the Regional Centre (one) and the Research Centres (eleven) are fairly well-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, radio isotope laboratory, tissue culture laboratory and a transmission-cum-scanning electron microscope are the other major facilities at the Headquarters.

Library: The Institute has its central library at Cochin, while the Research Centres have sectoral libraries catering to their immediate needs. The central library has over 65,000 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.

Budget

Plan	Period	Plan	Non-plan	Total (Rupees in lakhs)	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
Annual	1997-1998	260.00	728.00	988.00	-

Staff

The sanctioned staff strength of the Institute is 1115 consisiting of 190 Scientists (including the Director) and 396 Technical, 173 Administrative, 53 Auxilary and 303 Supporting staff. The cadrewise and discipline and centrewise Sceintist positions sanctioned are shown in the following statement.

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	P	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
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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

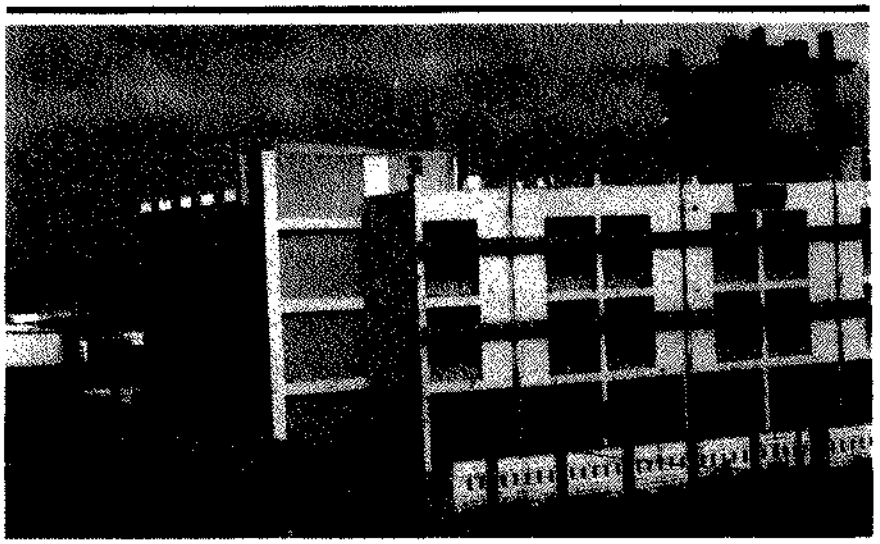
PS : Principal Scientist; SS · Senior Scientist; S : Scientist

Office and laboratory complex of Visakhapatnam Research Centre

Hydrography laboratory at Visakhapatnam

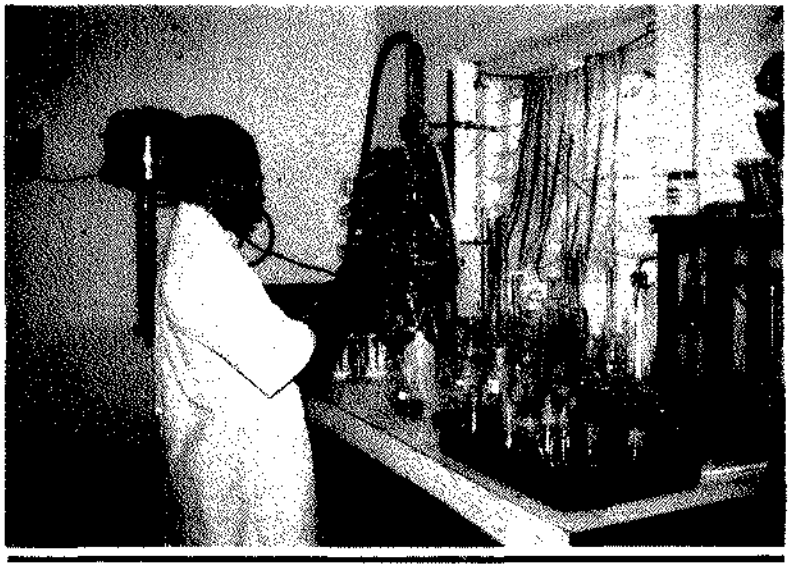
PLATE VIII

Hatchery laboratory complex at Visakhapatnam



Office - cum - laboratory building of Veraval Research Centre

Office - cum - laboratory building of Mangalore Research Centre



Hydrography laboratory at Mangalore Research Centre

PLATE VII

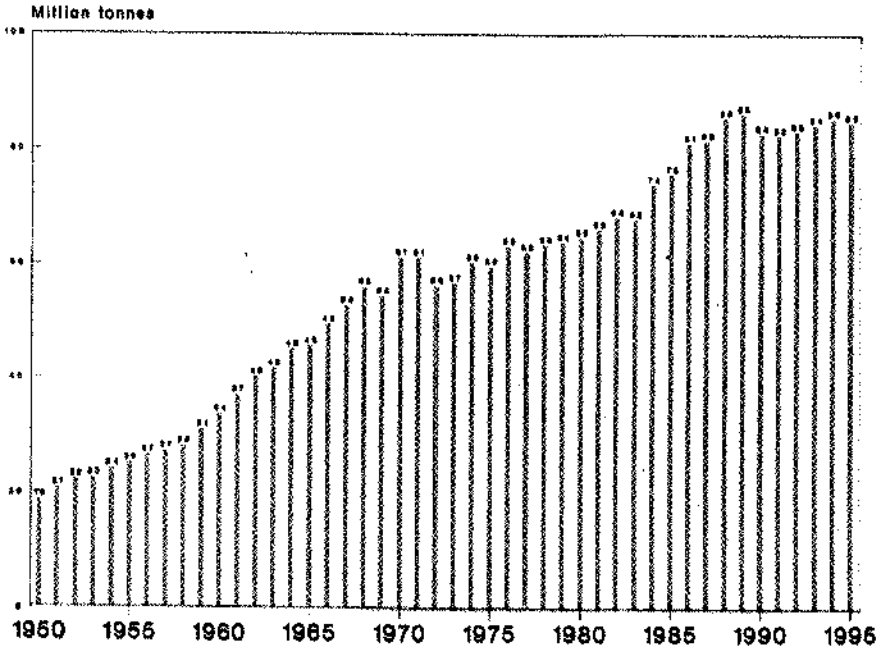


Fig : 1

Global marine fish production

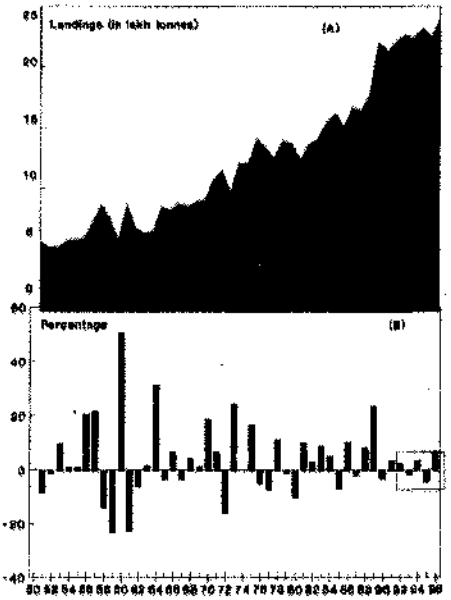


Fig : 2

A. Marine fish production in India during 1980-'96
B. Growth (percentage) of marine fish production from 1980 to 1996

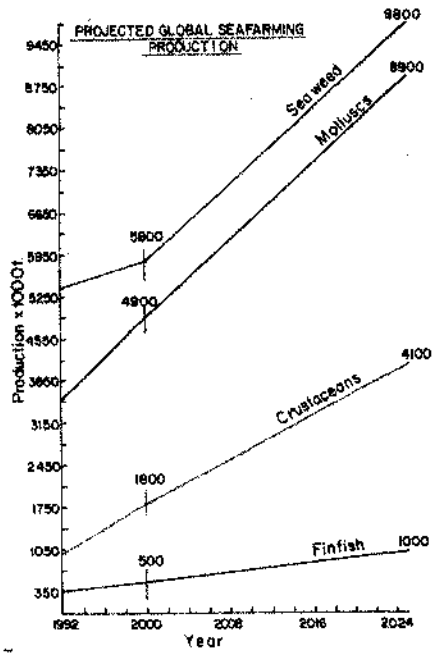
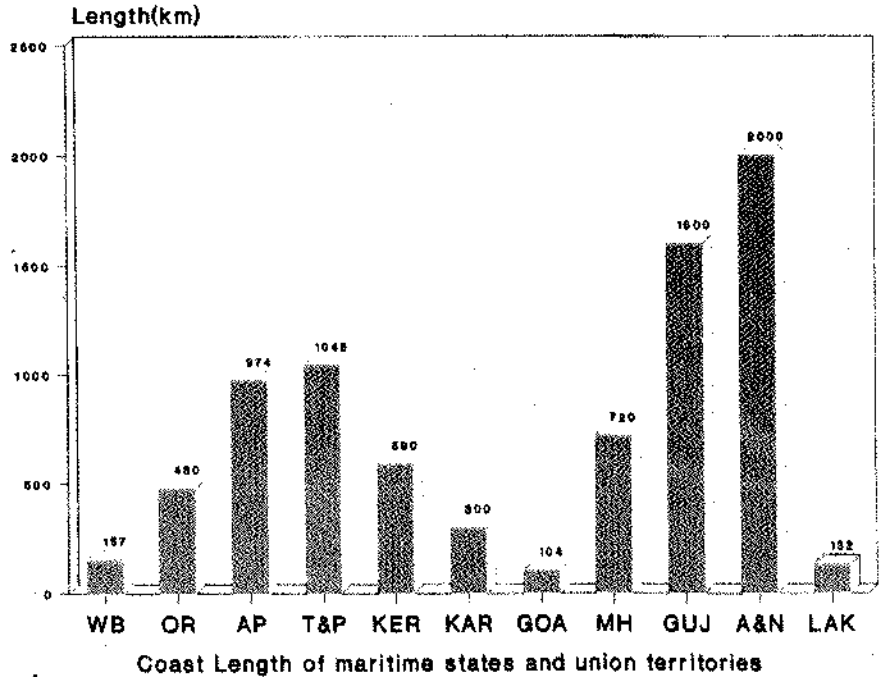


Fig : 3



Coast Length of maritime states and union territories

Fig : 4

STATUS OF MARINE FISHERIES AND MARICULTURE

National and Global Marine Fisheries and Mariculture Scenario

1. Global marine fish catch

It is estimated that about 780 million people in the developing world live on food that does not help maintain a healthy life. A recent study by M. Garcia of IFPRI (1994) reveals that the protein energy malnutrition is responsible for 56% of child deaths in 53 developing countries. If these trends continue, the cases of protein energy malnutrition will increase and the number of children affected is likely to be around 200 million by the year 2020. Fish is a good and cheap source of protein and will help combat protein malnutrition to a very large extent if production is increased and the supplies improved significantly. The present world marine fisheries scenario is that most fisheries are overexploited, resource management has not been considered seriously or where it is so considered, has failed to rerstrain the fishermen from exploiting the wild stocks beyond sustainable leves 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 (mt) in 1989, but declined to 84.7 mt in 1995 (Fig.1). The indications are that this is likely to level off at 100 million tonnes by the year 2020 AD.

2. Indian marine fish catch

With all the technological advancements, innovations and human resources and infrastructure development, the annual marine capture fishery production reached the level of 2.4 mt in 1996; during the past few years, the annual production has been oscillating between 2.2 and 2.4 mt (Fig.2). The potential yield estimate of 3.9 mt from the Indian EEZ (including 1.7 mt available in the outer continental shelf of which about 0.6 mt is currently taken), offers high hopes of increasing the production from the outer continental shelf. However, most of the stocks reported to be available for exploitation in the offshore zone, beyond the 50 m depth, are also distributed in the inshore region of less than 50 m depth and are currently exploited from these grounds. This observation suggests the real potential of at least some of the resources to be less than what has been projected. Such a scenario compounded with the present socioeconomic conditions in the capture fisheries sector, suggests that the production from the capture fisheries sector can, at best be increased by another 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.

3. Global mariculture situation

A recent report of the Consultative Group on International Agricultural Research (CGIAR) states: "within 15 years, fish farming and searanching 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 mt in 1992 to 26.9 mt in 2000 and to 51.8 mt in 2025. Marine finfish production by farming is expected to increase from 0.36 mt to 1.0 mt, crustaceans from 1.0 mt to 4.1 mt, molluscs from 3.5 mt to 8.9 mt and seaweeds from 5.4 mt to 9.8 mt (Fig.3).

4. Indian mariculture potential

India, as a leading country in Asia in aquaculture production, should be able to achieve atleast a production of 2 mt through mariculture by the year 2025, i.e., 3.9%

of the projected global aquaculture production of 51.8 mt. 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 could become a major player in world mariculture production.

5. India's fish supply-demand position

The human population in 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 mt of which at least 4.1 mt (marine fish poduction forms 56% of total fish production in India) has to be realised from the marine sector. This shows that the country needs to produce at least an additional 2 mt 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 mt 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 mt over and above the current annual production. However, the additional scope from the marine capture sector is only to the extent of another 0.5 to 0.6 mt suggesting that the required additional 2 mt should be produced through commercial mariculture operations.

Growth Profile of Indian Marine Fisheries

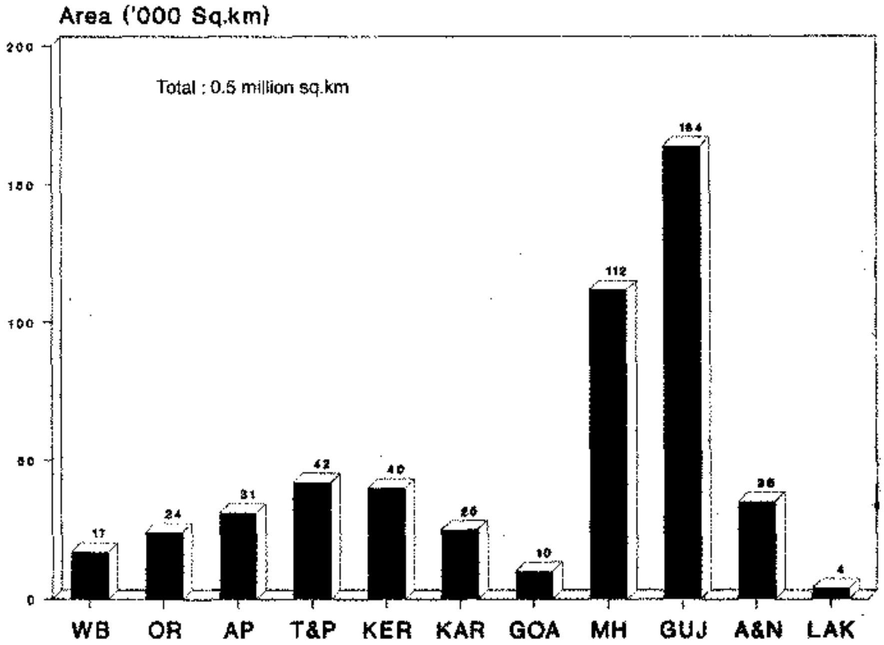
1. Infrastructure and economy

(i) Basic resources endowments: India has a long coast of 8129 km (Fig.4) with a continental shelf of over 0.5 million sq.km (Fig.5) and an EEZ area of 2.02 sq.km. There are 3638 fishing villages in India and the catches are landed at 2251 traditional landing centres (Fig.6). The plan outlay for fisheries development in India grew from a modest Rs 513 lakhs in the first five year plan to Rs 117,232 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.

(ii) Harvest & postharvest infrastructure: The fleet size has grown (Fig.7) to 1.91 lakh nonmechanised craft (including 32,000 motorised craft), 47,000 small mechanised craft and 180 large fishing vessels during 1996. There are a large number of auxiliary smallscale 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 about 1800 t capacity per day, 15 fishmeal 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 8, 9 and 10).

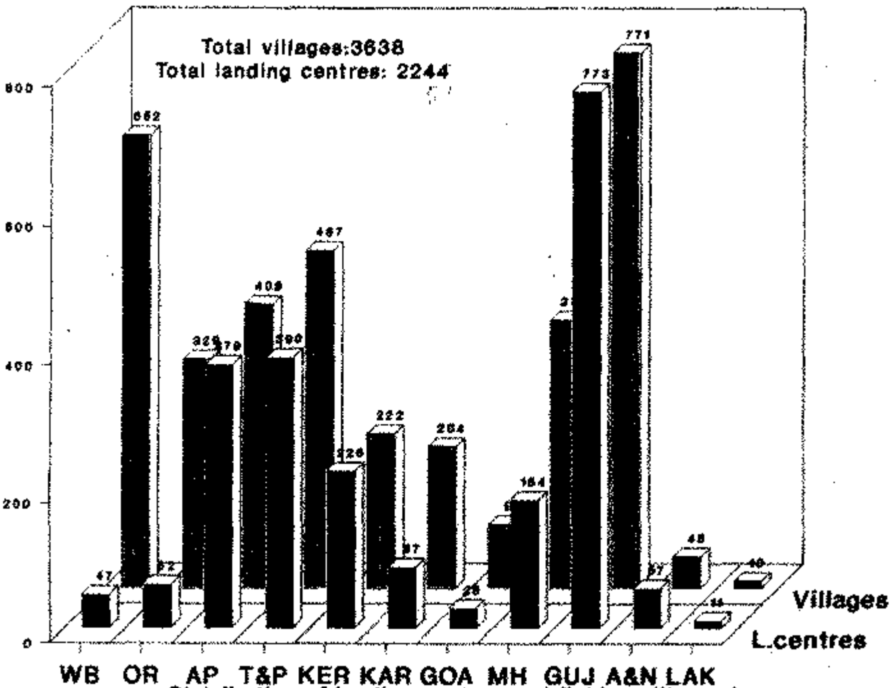
(iii) Human resources: The number of fishermen engaged in active fishing in the smallscale fisheries sector alone increased from about 6 lakhs during 1980-81 to 10.25 lakhs during 1994-95. The employment generated in the harvest and postharvest sectors of marine fisheries recorded phenomenal growth over the past few decades.

(iv) Investment and income: The gross capital investment on fishing equipments such as the craft and the gear in the nonmechanised, motorised, small mechanised and large mechanised



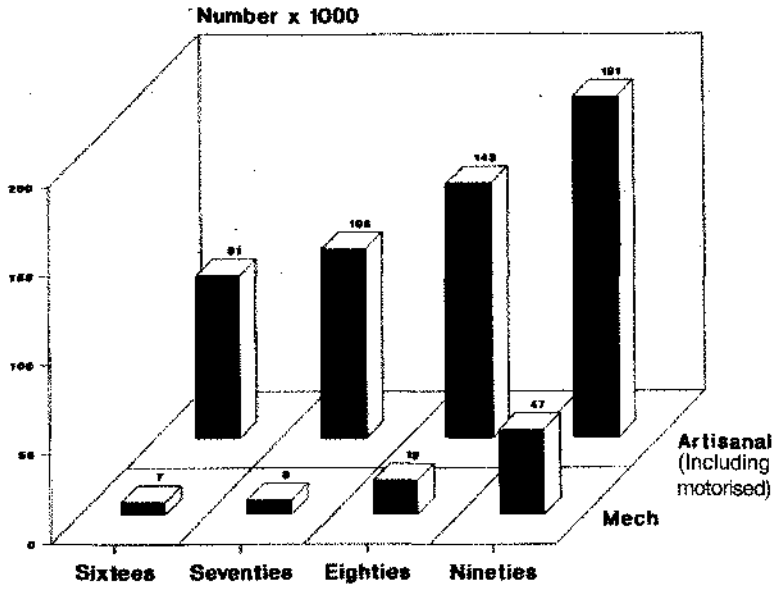
Continental shelf area

Fig : 5



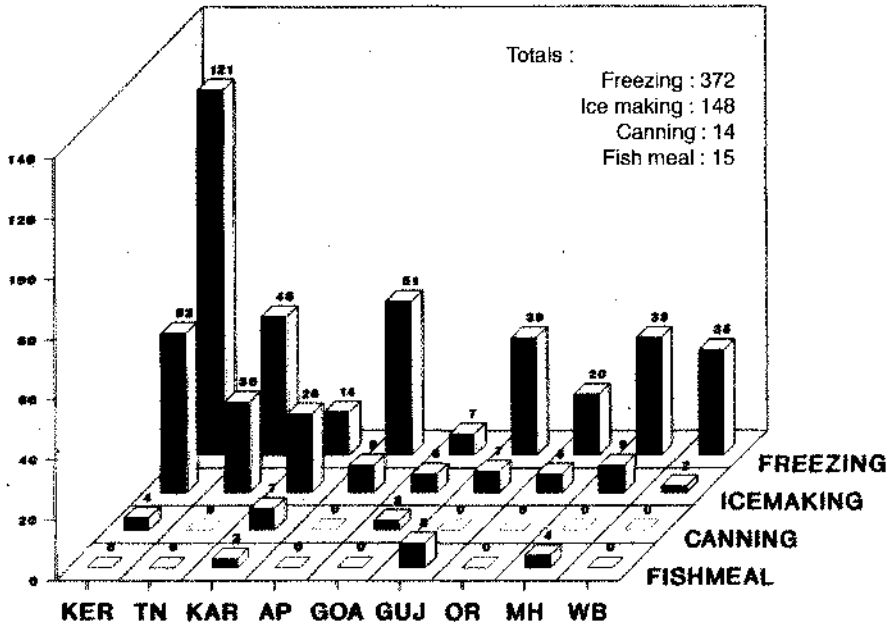
Distribution of landing centres and fishing villages in different maritime and union territoreis

Fig : 6



Growth of fishing fleet

Fig : 7



Number of Freezing, Canning, Ice making and Fish meal plants

Fig : 8

DEVELOPMENT THRUSTS IN THE MARINE FISHERIES SECTOR THROUGH THE PLAN PERIODS FROM 1951 TO 1996

Five-Year Plan period	*Duration*	*Major developments*	*Average annual catch/ culture production*
I	1951 to 1955	1. Exploratory surveys 2. Mechanisation of indigenous artisanal fishing craft	0.56 m t
II	1956 to 1960	3. Introduction of mechanised fishing vessels 4. Introduction of modern gear materials 5. Infrastructure for preservation, processing, storage and transportation	0.73 m t
III	1961 to 1965	1. Substantial increase in the use of synthetic gear meterials	0.73 mt
Three annual plans	1966 to 1968	2. Export trade	0.70 mt
IV	1969 to 1973	1. Imports of trawlers for deepsea fishing 2. Indigenous construction of deepsea trawlers 3. Fishing harbours at major & minor ports 4. Intensification of exploratory fishery surveys 5. Expansion of export trade	1.07 mt
V	1974 to 1978	1. Diversification of fishing, introduction of purseseining	1.33 mt
Annual	1979	2. Diversification of products 3. Motorization of artisanal craft	1.37 mt
VI	1980 to 1984	4. Further intensification of exploratory surveys in offshore grounds 5. Declaration of EEZ in 1977 6. MZI Act 1981 for regulation of foreign fishing vessels 7. Deepsea fishing through licensing and chartering	1.43 mt Shrimp culture
VII	1985 to 1989	1. New chartering policy of 1989	1.72 mt
Two annual plans	1990 to 1991	2. Development of deepsea fishing through joint venture 3. Substantial growth in motorised artisanal fleet of ringseiners 4. Coastal shrimp aquaculture	2.18 mt Commercial shrimp culture
VIII	1992 to 1996	1. Deepsea fishing by joint venture 2. Development of coastal aquaculture 3. Substantial growth in motorised artisanal fleet 4. Export trade changes from a resource-based to food engineering-based industry	2.23 mt (2.41 mt in 1996) Cultured Shrimp Production 60,000 to 100,000 t/year Shrimp culture in about 0.12 m ha.

sectors at the 1995 price level is around Rs 4,117 crores . The marine fish landings during 1995 earned an estimated gross income of Rs 7,230 crores at the landing centre price level. The contribution of the fisheries (marine & inland) sector to the net domestic product increased 8 fold during 1980-'81 to 1993-'94, while that of the agriculture sector increased only 4 fold during the same period.

(v) Exports: About 55 categories 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 3,78,199 t in 1996-'97 and the export value increased from Rs 53,000 lakhs in 1987-'88 to Rs 4,12,136 lakhs in 1996-'97 (Figs 11,12,13 and 14). In terms of the US dollar, the foreign exchange earning from marine products exports by India reached US $ 1,153 million in 1996-97 compared to US $ 1,400 million by Taiwan, US $ 1,600 million each by Indonesia and South Korea, US $ 2,300 million by China and US $ 4,300 million by Thailand.

2. Capture fisheries

(i) Induction of modern harvesting technologies: Fishing in the Indian seas which remained restricted to operations by only the artisanal gear and craft in the nearshore waters till the forties, changed drastically through the subsequent decades by the introduction and popularisation of mechanised fishing vessels using trawls and motorisation of indigenous craft. By the seventies, purseseines were also introduced along the southwest coast. 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, trammelnets, hooks and lines, ringseines and minitrawls.

Increase in the knowledge of 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.

(ii) Growth in production: All these development activities helped increase the harvests from about 0.6 million tonnes in 1950 to 2.41 million tonnes in 1996, showing an average annual growth of 6.4% over a period of about 4 decades. The annual growth rate during the different decades commencing from 1950, declined from 6.5% during 1950-'60 to 2.3% during 1960-'70; it increased to 4.3% during 1970-'80 and to 4.8% during 1980-'90, but declined to 4.0% during 1990-'96 (only six years). This fall in the growth rate is reflected in the annual catch attaining the optimum levels in the inshore fishing grounds of about 0.18 X 10^6 sq.km area extending upto a depth of 50 m. The substantial increase in the fishing effort over these 4 decades resulted in the decrease in the per capita area per active fisherman and per boat in the inshore fishing grounds, and also in the catch per unit effort.

The consistent growth of the sector up till now (1996) could be attributed to a comprehensive investment programme in the capital sector in the harvesting and postharvest areas, which facilitated significant and progressive expansion of the areas of operation into the underexploited and unexploited grounds and optimal and/or overexploitation of many prime fish stocks in the inshore shelf waters upto about 50 m depth. However, it also resulted in conflicts among different categories of fishermen, particularly between the artisanal and mechanised groups. Such a critical situation warrants effective management of the exploited stocks in the coastal waters upto the 50 m depth for sustaining the current production and to augment it further by focussing attention on the offshore sector and on seafarming and coastal mariculture.

Oil sardine - one of the most dominant pelagic fish resources of India

Pole and line fishing for tuna in Lakshadweep sea

PLATE IX

Tuna catch at Cochin

Important demersal finfish resources of India

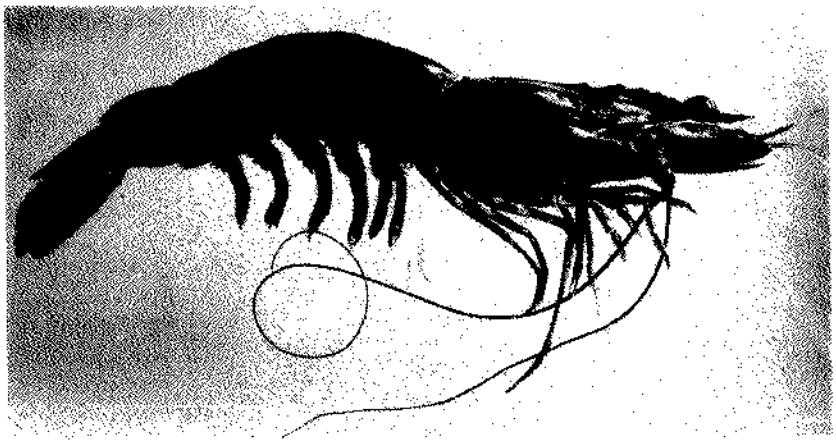
Lizard fish

Catfish

Threadfin breams

White fish

PLATE X



Important species in the marine shrimp fisheries of India

Penaeus monodon
(Triger prawn)

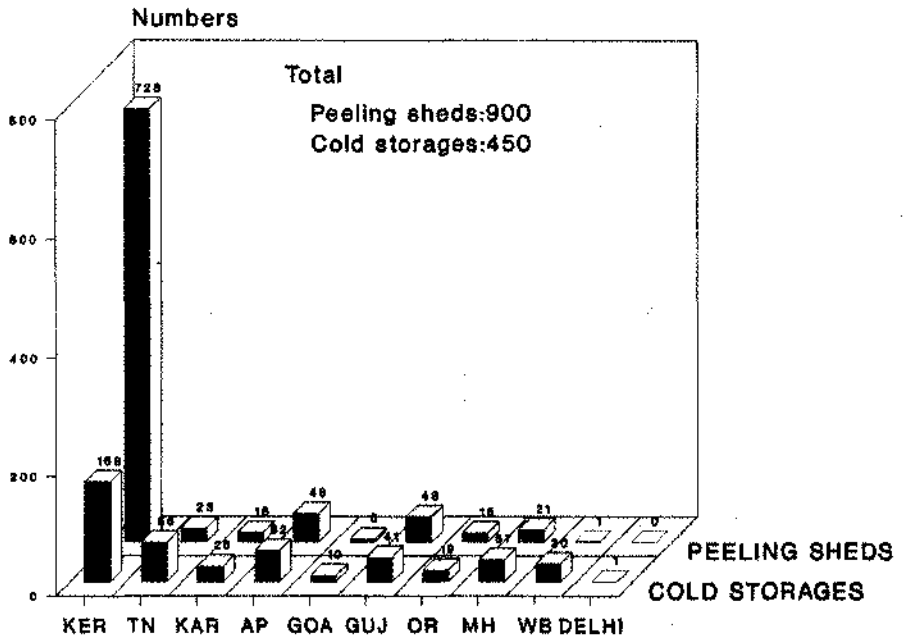
P. semisulcatus (Flower)

P. indicus (Indian White prawn)

Metapenaeus monoceros (Brown prawn)

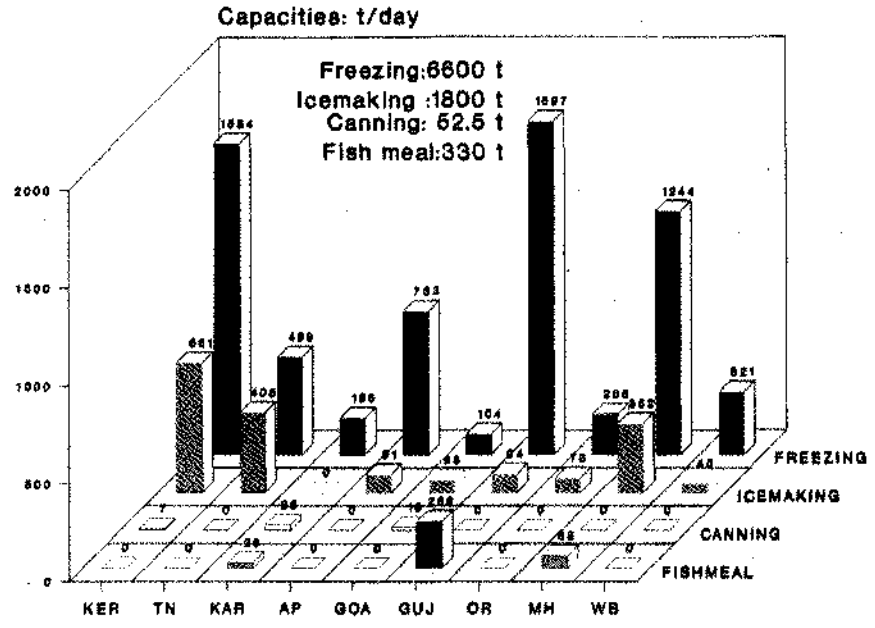
Trachypenaeus curvirostris

PLATE XI



Number of Cold Storage and
Peeling Sheds

Fig : 9



Capacities (t/day) of Freezing Canning
Ice making and Fish meal plants

Fig : 10

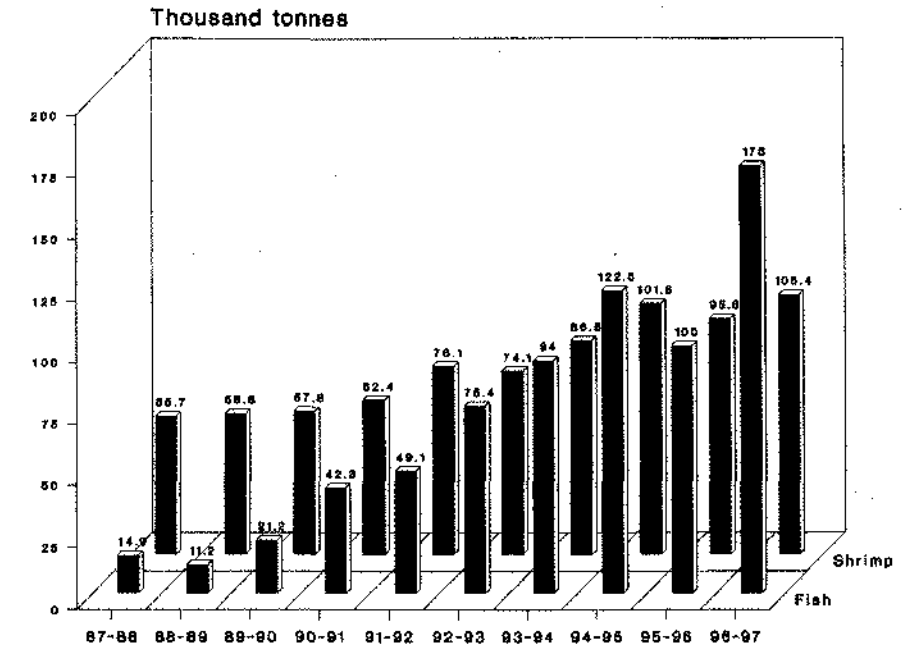


Fig : 11 Export of marine fish and shrimp

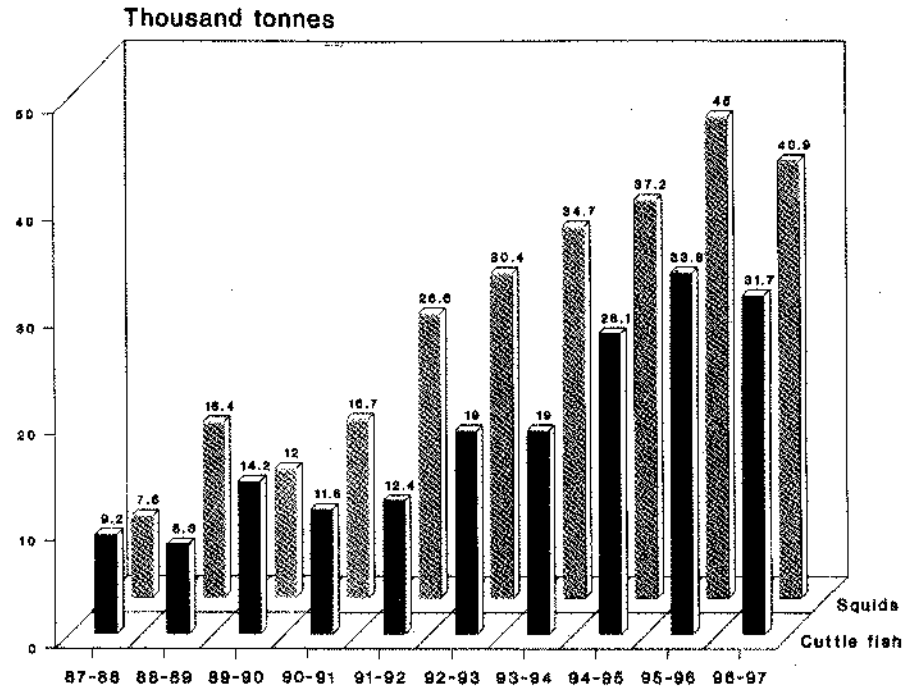


Fig :12 Export of cuttle fish and squid

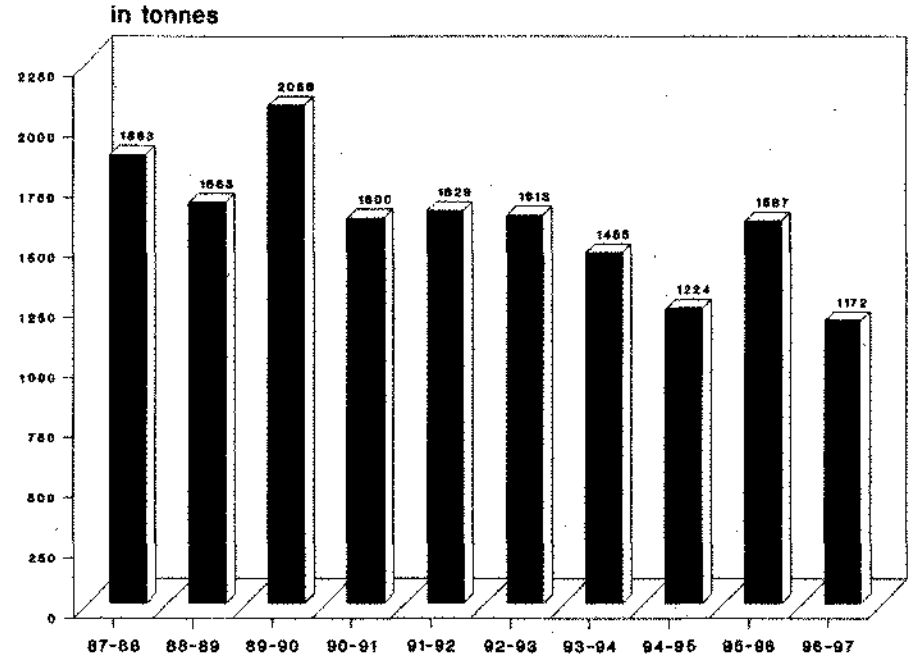


Fig : 13 Exprot of lobster

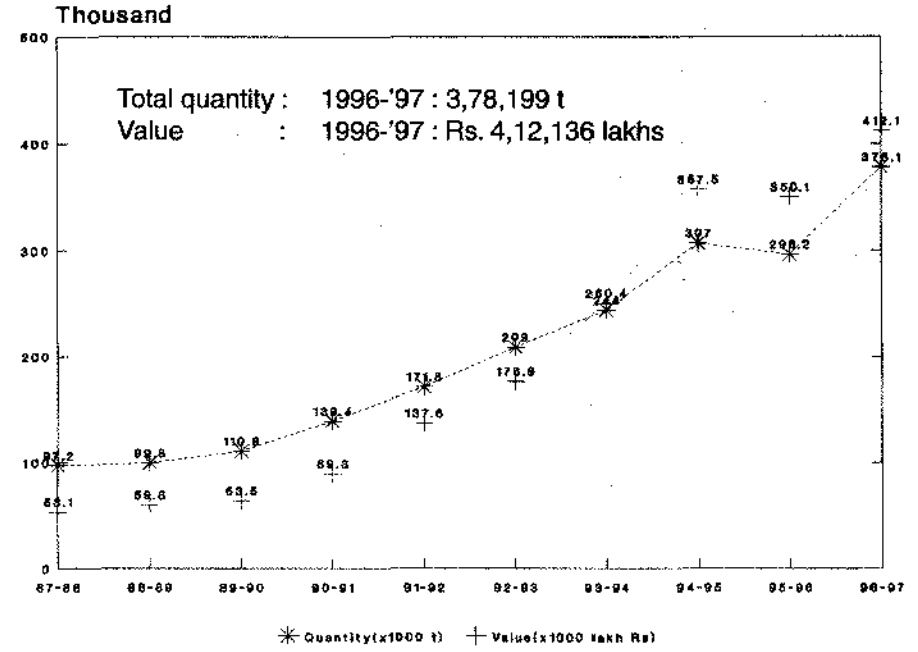
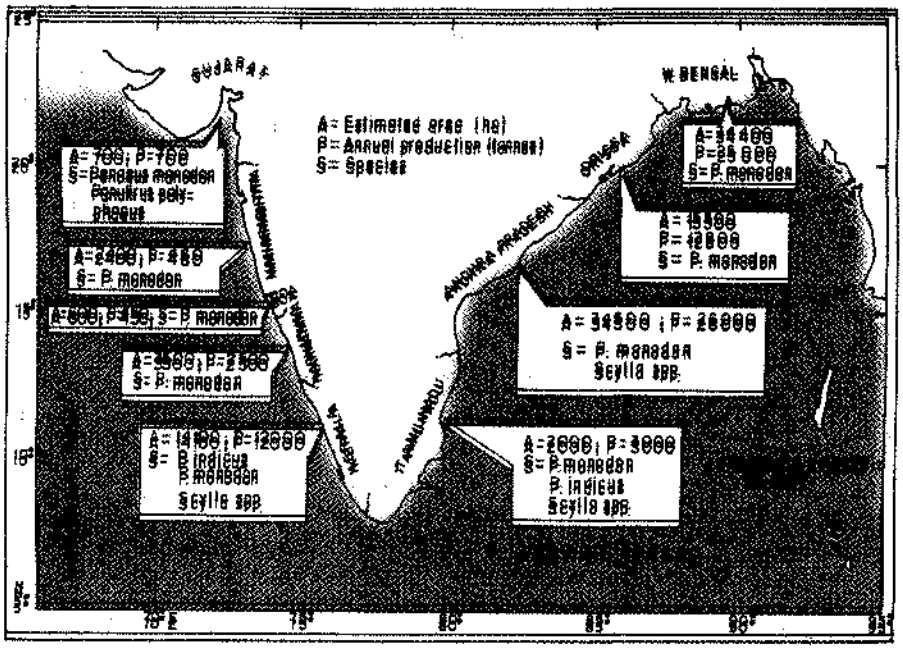
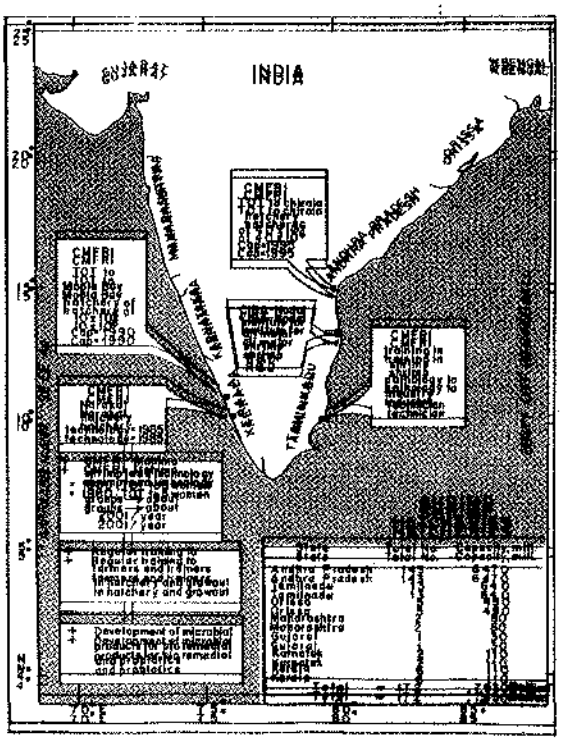


Fig : 14 Marine Fishery Exports from India
(Quantity and Value)



Cultivated areas and annual production of Crustaceans in different maritime states of india (1994-'95)

Fig : 15



Shrimp hatcheries and CMFRI's contributions

Fig : 16

3. Coastal mariculture and seafarming

(i) Shrimp farming : The development of technologies for coastal mariculture and seafarming since the early seventies resulted in the rapid growth of this sector particularly from the beginning of the current decade. In the case of marine prawns an estimated 70,573 tonnes of penaeids were produced from coastal shrimp aquaculture during 1995-'96 and about 100,000 tonnes during 1996-'97 from an area of about 0.12 million ha. The shrimp hatchery sector grew rapidly to over 170 with an annual production capacity of over 10 billion seed (Fig. 15 and 16). 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.

(ii) Pearl culture: The pearl culture technology developed by the CMFRI is being adopted for commercial production; about 20 kg of pearls valued at about Rs 14.2 million have been produced.

4. Growth in the research sector

The fisheries research Institutes under the ICAR are contributing to research in marine/ brackishwater/inland fisheries and HRD in fisheries R & D. The departments of fisheries in certain maritime states likeTamilnadu, Maharashtra and Gujarat are also carrying out research in marine fisheries and mariculture. All these scientific inputs have significantly contributed to the knowledge and development of technologies for marine fisheries and mariculture and to human resources development. There are about 190 Universities in India including the State Agricultural Universities (29), 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 eleven Fisheries Colleges under the State Agricultural Universities are offering B.F.Sc. programmes, while 4 of them are offering postgraduate and doctoral programmes in marine fisheries and carrying out research on various aspects of marine fisheries and mariculture.

CMFRI NETWORK ALONG THE INDIAN COAST FOR APPROPRIATE R & D RESPONSE MATCHING WITH THE CHARACTERISTICS OF INDIAN MARINE FISHERIES AND MARICULTURE

1. 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:

(1) the mackerel, oil sardine, lesser sardines, whitebaits, ribbonfishes, seerfishes, coastal tunas and oceanic tunas among the pelagic fisheries (Plate IX),

(2) the croakers, threadfin breams, silverbellies, catfishes, lizardfishes, flatfishes and goatfishes among the demersal fisheries (Plate X),

(3) the penaeid prawns, crabs, lobsters and stomatopods among the crustacean fisheries (Plate XI & XII),

(4) the squids, cuttlefishes, mussels, clams and edible oyster among the molluscan fisheries (Plate XII),

(2) A total of 1570 species of finfishes are known from the Indian seas which form about 62.8% of the total number of fish species (both inland and marine together) known from the country.

(3) The research and development needs of:

(i) the vast, varied, complex and multispecies marine fishery resources of India,

(ii) the complex socioeconomic, cultural and traditional characteristics and ethos of marine fisherfolk,

(iii) the seafarming and coastal mariculture opportunities along the different hydroclimatic regions of the country, and

(iv) the marine fisheries and mariculture extension responsibilities,

are adequately addressed through the CMFRI network of regional, research and field centres located in the various sections of the coastal agroecosystems of India. These centres are faily well-equipped with all necessary infrastructure, funds and authority.

ACCOMPLISHMENTS OF CMFRI

I. Assessment and Forecasting of Marine Fish Production

(i) Application of Stratified-Multistage-Random Sampling Design for the estimation of marine fish production, effort, cost and income, districtwise, statewise, gearwise and specieswise from 1947 onwards; estimation of marine fisherfolk population, craft, gear and socioeconomics. Annual appraisal of the status of marine fisheries is made for each state.

(ii) Fishery prediction through (a) seatruth data for the validation of potential fishing zone maps from satellite imageries of sea surface temperature; (b) cyclic events brought about by climatic and oceanographic phenomena including sunspot activity, upwelling intensity, sealevels etc. and (c) fishery dependent factors.

(iii) In order to sustain the current levels of production from the inshore grounds through a realistic regime of management, the CMFRI made a detailed assessment of the optimum size of the fleet in the mechanized, motorized and artisanal sectors based on the analysis of time-series data on catch and effort for the period 1986 to 1996 using the surplus production model. It has been found that the currently exploited fishing grounds could sustain exploitation by 20,928 mechanised, 12,832 motorised and 31,059 artisanal boats only,as against the currently operating fleet size which is much larger than the optimum and hence, a large number of them remaining idle.

OPTIMUM AND THE EXISTING FLEET SIZE (IN NUMBER)

Fleet	Existing	Optimum	% Excess	% Contribution to total catch in 1996-'97
Mechanised	46918	20928	55.0	67.0
Motorised	31726	12832	60.0	20.0
Nonmechanised	159481	31059	81.0	13.0
Total catch : 2.41 m t (1996-'97)				

CURRENT STATUS OF FLEET SIZE IN MARITIME STATES

STATE	EXISTING			OPTIMUM			DIFFERENCE (SURPLUS)		
	MECHANISED	MOTORISED	NONMECHANISED	MECHANISED	MOTORISED	NONMECHANISED	MECHANISED	MOTORISED	NONMECHANISED
WEST BENGAL	1880	270	4091	369	372	391	1511	-102	3700
ORISSA	1665	2453	7796	1534	148	1584	131	2305	6212
ANDHRA PRADESH	8991	3269	54000	1156	816	8481	7755	2453	45519
TAMILNADU & PONDICHERRY	8783	5705	32637	5819	1338	13922	2964	4367	18715
KERALA	4206	12913	27873	3401	6750	5159	805	6163	22714
KARNATAKA	3655	1189	11952	1452	430	328	2203	759	11624
GOA	850	900	1100	611	274	74	239	626	1026
MAHARASHTRA	7930	286	9702	3333	583	395	4597	-297	9307
GUJARAT	8365	4283	8370	3253	2121	725	5112	2162	7645
ANDAMANS	230	160	1180	NA	NA	NA	NA	NA	NA
LAKSHADWEEP	443	298	780	NA	NA	NA	NA	NA	NA
TOTAL	46918	31726	159481	20603	11895	31059	25317	18436	126462

NA: Not available

ESTIMATES OF MAXIMUM SUSTAINABLE YIELDS (MSY) AND CATCH (t) OF PELAGIC AND DEMERSAL FISHERIES RESOURCES IN THE MARITIME STATES

STATE	MSY		1996 CATCH	
	PELAGIC	DEMERSAL	PELAGIC	DEMERSAL
WEST BENGAL	58281	20013	42081	33229
ORISSA	25737	25803	26081	27510
ANDHRA PRADESH	104425	58281	100890	61972
TAMILNADU	207090	193201	219783	215890
PONDICHERRY	11902	2189	17226	2778
KERALA	346477	226186	339984	232071
KARNATAKA	96300	62569	105053	64015
GOA	49566	24642	35187	15785
MAHARASHTRA	137124	193507	123260	215888
GUJARAT	194296	343041	202991	299171
TOTAL	1231198	1149432	1212536	1168309

II. Assessment of the Health of the Exploited Marine Fish Stocks

(i) Bioeconomic database on the exploited pelagic, demersal, crustacean and molluscan stocks developed, stock assessment of about 50 major exploited species stocks made and management measures suggested.

(ii) Assessment and conservation of endangered and threatened stocks such as the marine turtles, marine mammals, finfishes, crustaceans and coral reefs.

(iii) Mapping potential fishing grounds through 120 onboard cruises and surveys by FORV *Sagar Sampada* in the EEZ including Andaman & Nicobar and Lakshadweep islands.

(iv) Mapping economically important seaweed resources and assessment of their standing crop in the Gulf of Mannar, Palk Bay, Andaman & Nicobar and Lakshadweep islands (Fig. 35, 36).

(v) Determination of the stock sizes and mapping of gastropods and bivalves in the Kakinada Bay (Andhra Pradesh), Vembanad lake (Kerala), Mulki estuary (Karnataka) and the Gulf of Mannar for optimum exploitation.

(vi) Determination and mapping of the standing crops of sponges, corals and echinoderms to provide data relating to their pharmaceutical and industrial applications.

(vii) Determination and mapping of marine ornamental fish resources of Lakshadweep and their stock size to assess their commercial potential; damsel fish, wrasses, surgeon fish, butterfly fish, squirrel fish, trigger fish, goat fish constitute the bulk of this resource (Plate XIII).

(viii) Regular monitoring of coastal pollution for mapping hot-spots of pollution, and assessment of impact on the marine ecosystem and marine fisheries.

(ix) The Government of India is encouraging installation of artificial reefs (ARs) to help artisanal fishermen increase their earnings. To demonstrate the value of ARs in increasing productivity and production, the Institute installed two ARs off Vizhinjam in 1996. The feedback is encouraging.

III Assessment of Fishery Oceanographic Features

(i) Monitoring the oceanographic parameters, primary, secondary and tertiary production; charting of phytoplankton, zooplankton and fish biomass potential maps (Fig. 37, 38, 39).

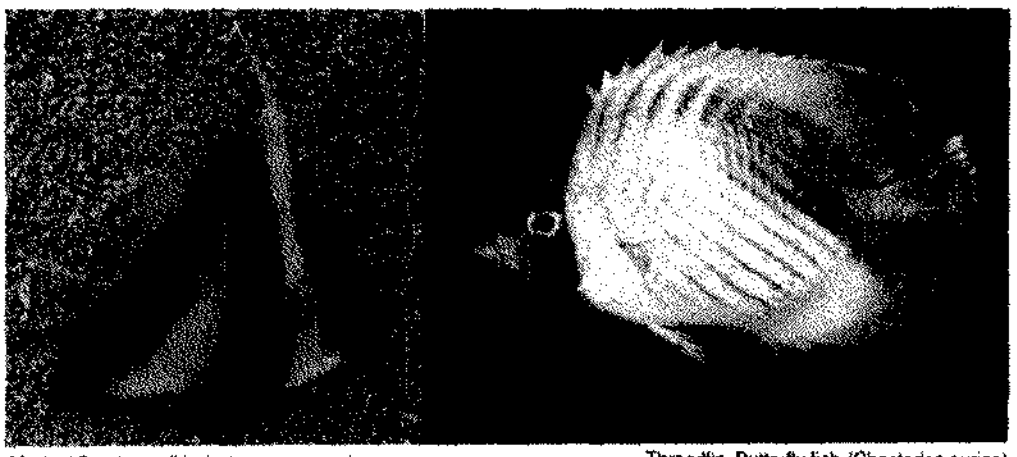
IV Mariculture Technology Development and Transfer

1. Shrimps, crabs and lobsters

(i) 15 species of commercially important shrimps have been bred under captivity and their eggs and larvae reared successfully. Hatchery technology has been developed and standardised for *Penaeus indicus, P. semisulcatus* and *P. monodon*. Consultancies for setting up shrimp hatcheries have been rendered to government (Kerala) and private (Andhra Pradesh) organisations. *Penaeus semisulcatus* has been shown to be a suitable candidate species for farming in coastal ponds in Tamilnadu. Broodstock of this species has been developed in the growout system. Indigenous CMFRI *Mahima* shrimp feed has been developed. With this feed, there has been25 to 50% higher performance in growth, production and F.C.R. than the imported shrimp feeds. Inclusion of 30% mantis shrimp meal and 40% soya flour in shrimp feeds has been found to improve the quality of shrimp feed substantially.

(ii) Phenol oxidase enzyme was found to play an important role in the hardening of the cuticle of penaeid prawns. The thoracic ganglia of mature female shrimps secrete greater concentration of protein compared to the eyestalk and brain. Intraspecific enzyme/protein polymorphism has been found at several loci in *P. monodon* and *P. semisulcatus* from the east as well as the west coasts of India.

Important ornamental fishes of Lakshadweep



Masked Coachman *(Heniochus monoceros)*

Threadfin Butterfly fish *(Chaetodon auriga)*

Powderblue Surgeonfish *(Acanthurus leucosternon)*

Moorish idol *(Zanclus canescens)*

Zebra humbug *(Dascylus aruanus)*

Blackbar triggerfish *(Rhineacanthus aculeatus)*

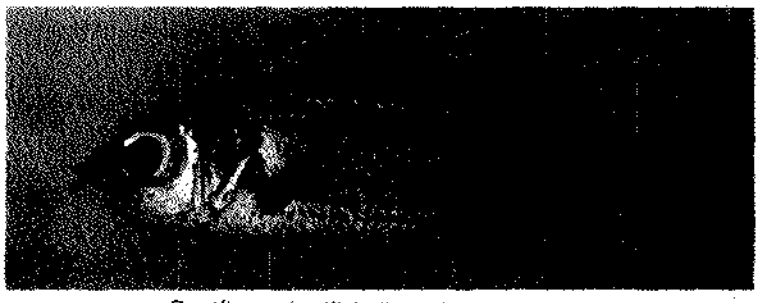
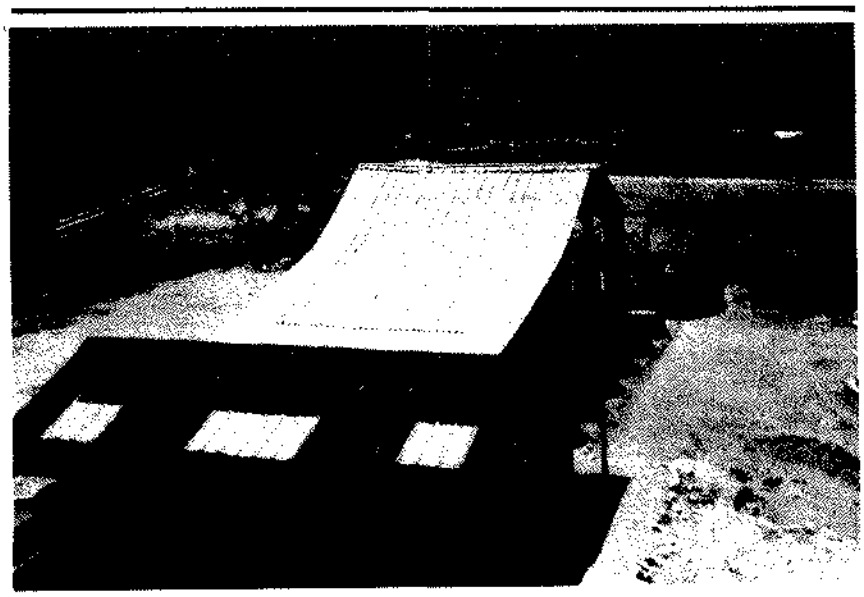
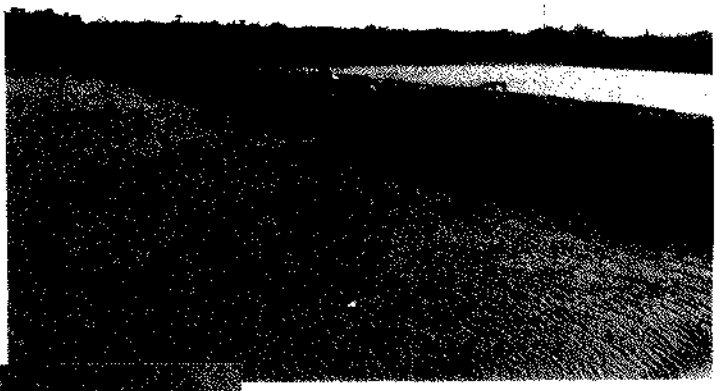


Plate XIII

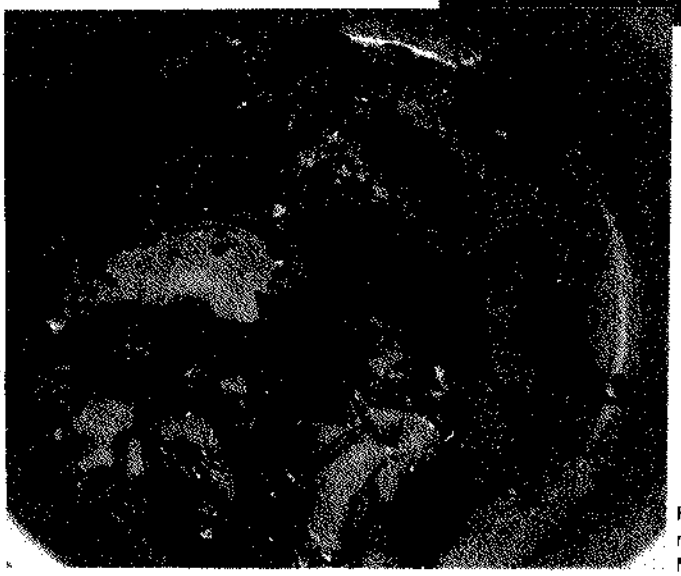
Spotfin squirrelfish *(Neoniphon sammara)*



Crustacean culture facility at Mandapam Camp



Ponds for culture of *Penaeus semisulcatus* at Mandapam Camp



F_1 generation of *Portunus pelagicus* raised to broodstock level at Mandapam Camp

PLATE XIV

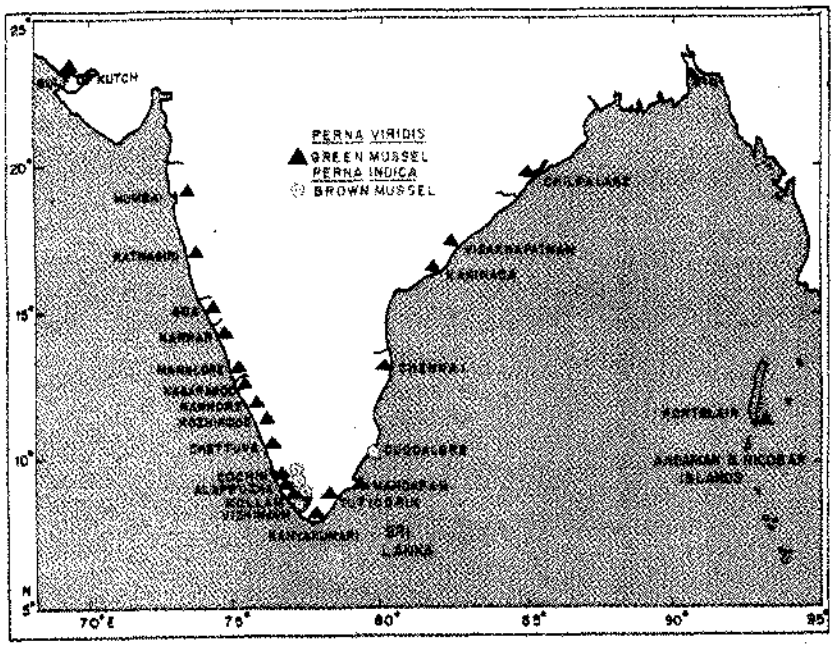


Fig : 33 Distribution of green and brown mussel in India and areas suitable for farming

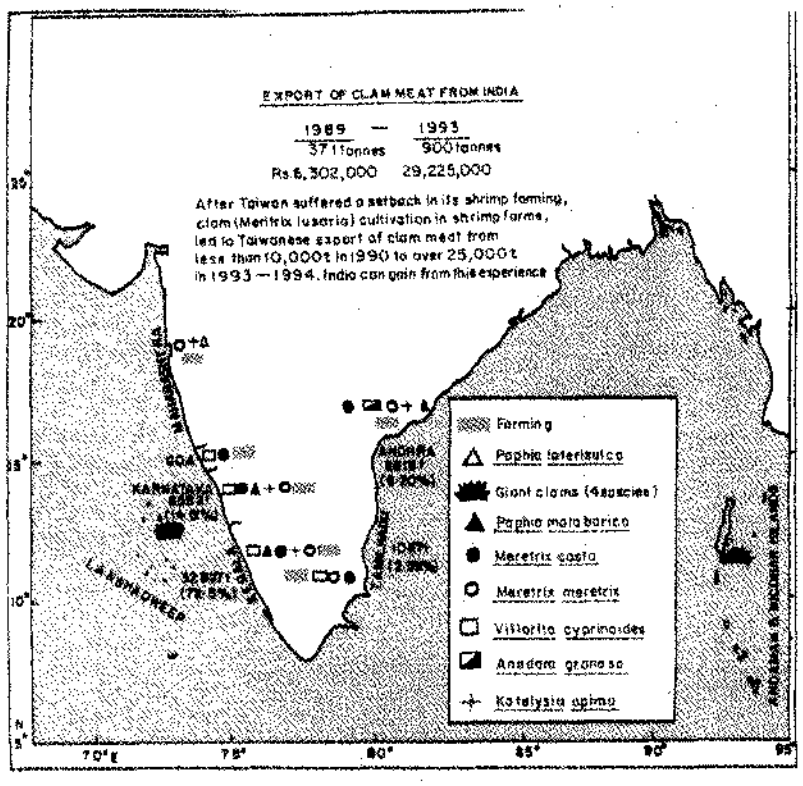


Fig : 34 Distribution of calms in India and farming areas

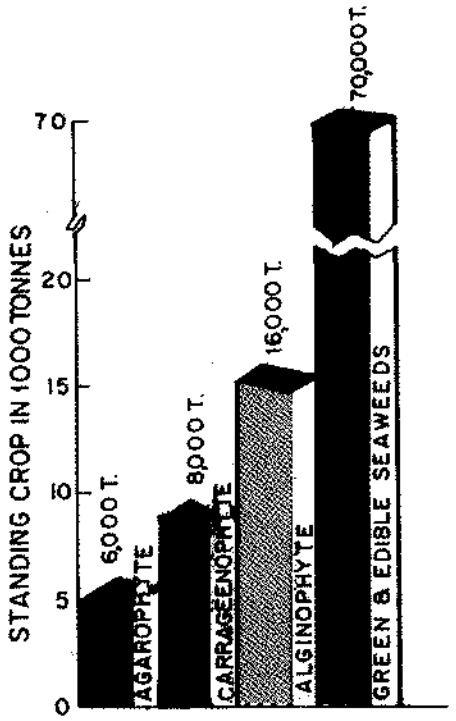


Fig : 35 Seaweed resources

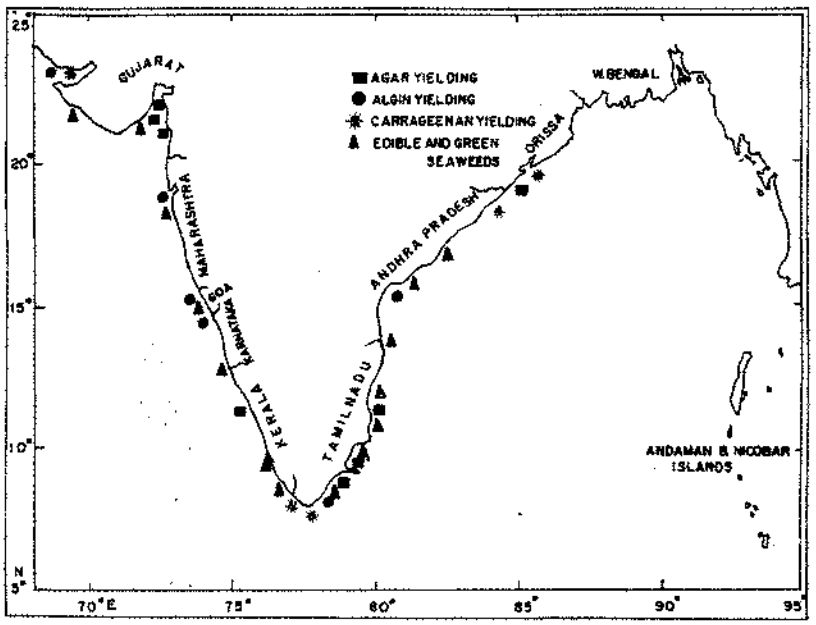


Fig : 36 Distribution and abundance of various seaweed resources along the Indian coastline

(iii) Disease problems in aquaculture can be controlled with the application of various biotechnological methods. Colonies of spore-forms of seven species of *Bacillus* of probiotic value, most often observed in the aquatic environments, have been identified. All of them can be mass-cultured and used in the manufacture of commercial probiotic products

COMMERCIAL PROBIOTIC PRODUCTS AND IMMUNOSTIMULANTS USED BY THE AQUACULTURE INDUSTRY

Probiotics	Manufacturers/ country	Price (Rs)	Quantity
1. DMS 1000 series	ARDA-TEK,Australia	3,000	5 litres
2. Synerbac	-do-	-do-	-do-
3. Wunapuo-15	Team Aqua Corporation, Thailand	6,000	25 kg
4. Biostart™ Bio-brews	USA	5,000	5 litres
5. Aqua bacta aid products	Water Quality Sciences International Inc.,	- USA	-
6. Aquakalgon+	Wockhardt Ltd (India) in collaboration with Techniques et Biochimie Appliques (TBA), Paris	-	-
7. Aqua buck up	Ecomax, India	5,000	5 kg
8. Spec™bac	Proposed by CMFRI	5,000	5 kg
9. Immustim (purified Beta 1,3-D-glucan)	Immu Dyne Inc.,USA	-	-
10. Aquastim	College of Fisheries, Mangalore, India.	-	-

(iv) Fattening of mudcrabs on commercial scale has been standardised. Hatchery techonlogy for the marine crab *Portunus pelagicus* has been standardised (Plate XIV).

ACHIEVEMENTS OF CMFRI IN BREEDING AND SEED PRODUCTION OF CRABS

Species	Year	Results
Mud crab *Scylla serrata*	1983	Incubation period, egg hatching and complete metamorphosis studied for the first time in India.
-do-	1983-84	Egg hatching and early development upto crab stage studied under controlled conditions at Tuticorin. A maximumof 15% survivalatcrab stage obtained.
Scylla tranque-barica & S.serrata	1994-95	Complete larval development of both species studied for the first time in India. Experimental seed production trials yielded 20 to 25% survival for both species.
Swimming crab *Portunus pelagicus*	1996	Larval rearing and seed production successfully carried out at Mandapam with a survival rate of 80 to 85% upto zoea-V stage and lesser survival rates for successive stages.

(v) A standard technology comprising a flowthrough system (Fig. 40) has been developed for lobster fattening. While the lobsters have been sucessfully bred and the phyllosoma larvae developed upto the 7th stage, hatchery techology for sed production is yet to emerge.

2. *Molluscs* (Plate XV-XVII)

(i) Packages of practices for cultured pearl production in seafarms and in onshore systems have been standardised (Fig. 41, 42, 43).

DEVELOPMENT OF PEARL CULTURE TECHNOLOGY BY THE CMFRI

I.	First pearl production in India:	July, 1973	Tuticorin Gulf of Mannar by CMFRI	
II.	First hatchery production of pearl oyster in India:	August, 1981	Molluscan shellfish hatchery CMFRI, Tuticorin	
III.	Development of land-based pearl culture technology	1995	Kakinada, Visakhapatnam, Madras, Mandapam	
IV.	Successful location testing for pearl roduction	1976	Vizhinjam Bay , Kerala	
		1985	Manadpam, Tamil Nadu	
		1986	Lakshadweep	
		1987	Gujarat	
		1994	Calicut, Andhakaranazhi (Cochin)	
V.	Number of pearls produced by CMFRI through investment of Rs 810,500 at Tuticorin		No. of pearl oysters harvested	No. of pearls obtained
	(See Fig. 41 & 42)	1973-78	605	428
		1978-83	768	443
		1983-88	3576	1390
		1988-95	6365	2171
		1995-96	7583	2666
	Number of pearls sold	1994-96	1173 for Rs. 1,28,668	
		(180.72 g)		
VI	Technology transfer experiments at Valinokkam, Gulf of Mannar	1-7-1991 to 11-8-1992		
	Total expenditure	Rs.	36,312	
	Total pearls produced		1,849	
	Pearls given to farmers as wage		250	
	Balance pearls sold		1,599	
	Revenue earned	Rs	73,134	

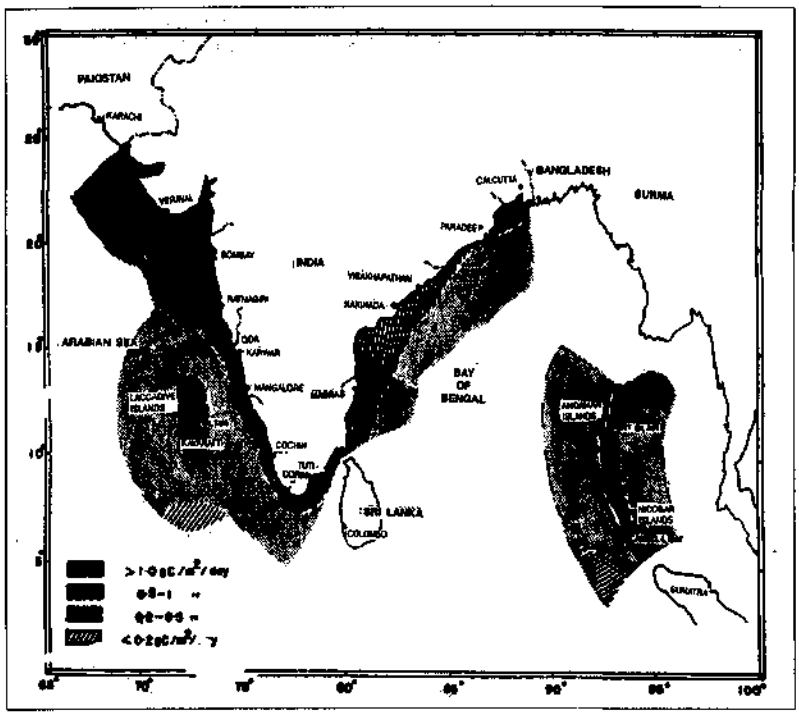


Fig : 37 General level o' primary production in the exclusive economic zone of the Indian seas.

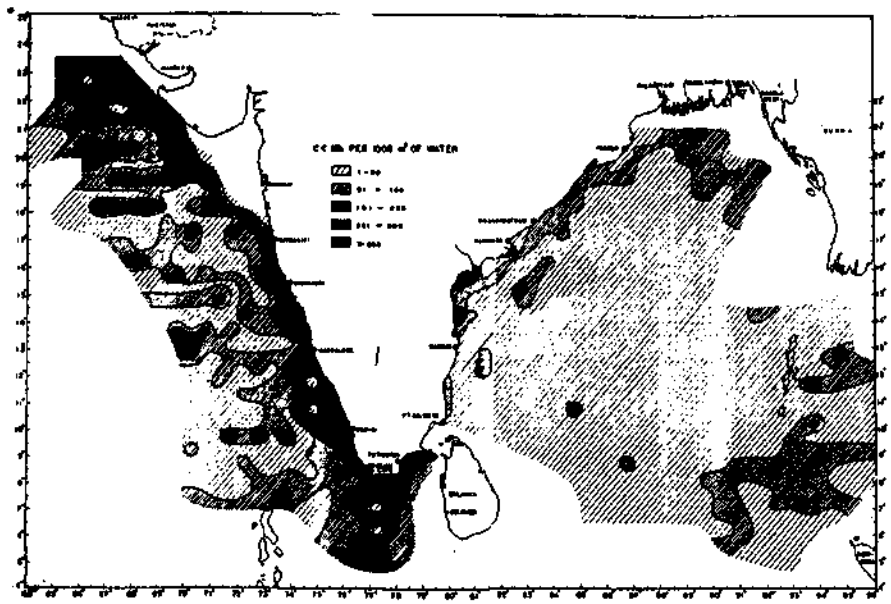


Fig : 38 Spatial distribution of zooplankton biomass.

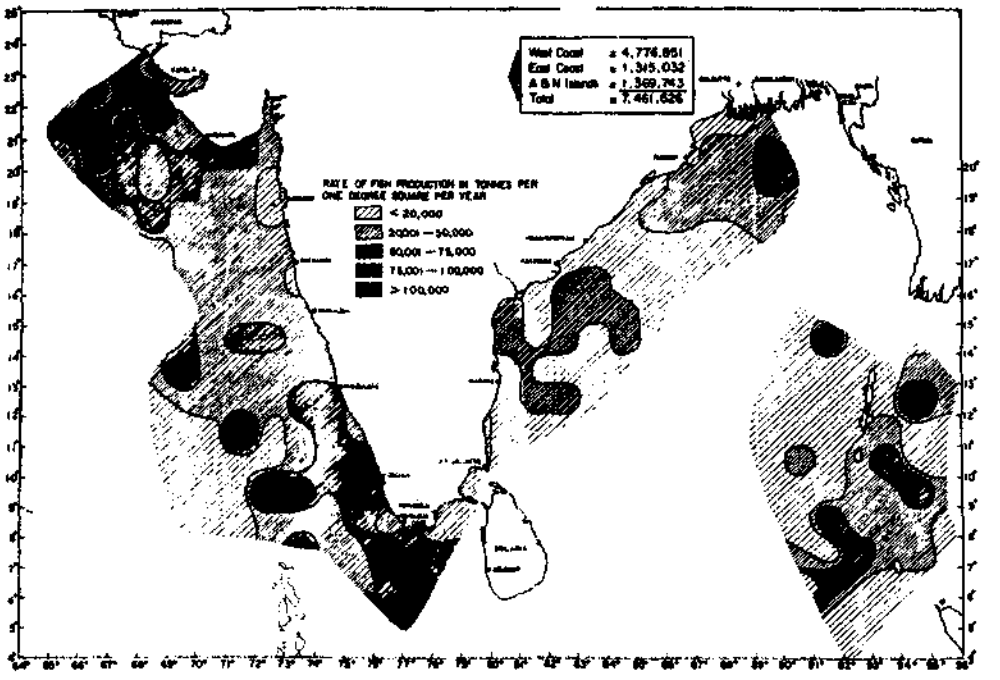


Fig : 39 Rate of fish production in the EEZ of India.

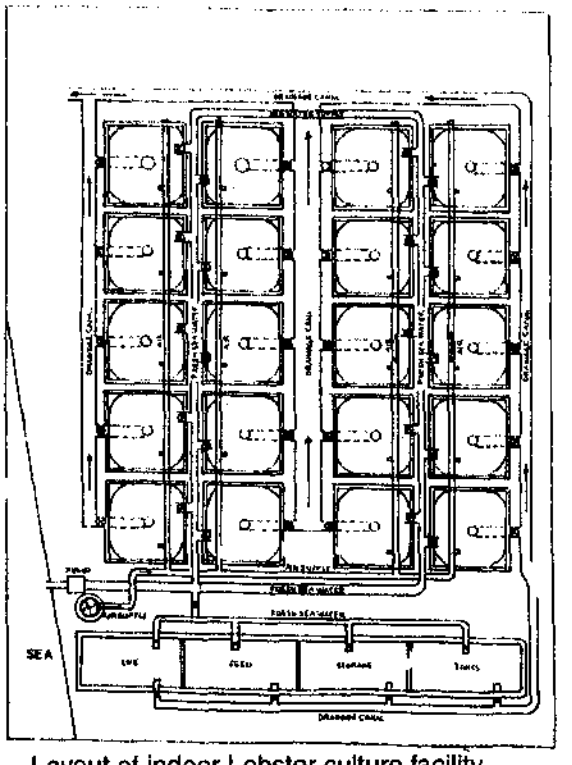


Fig : 40 Layout of indoor Lobster culture facility developed for the industry by the CMFRI

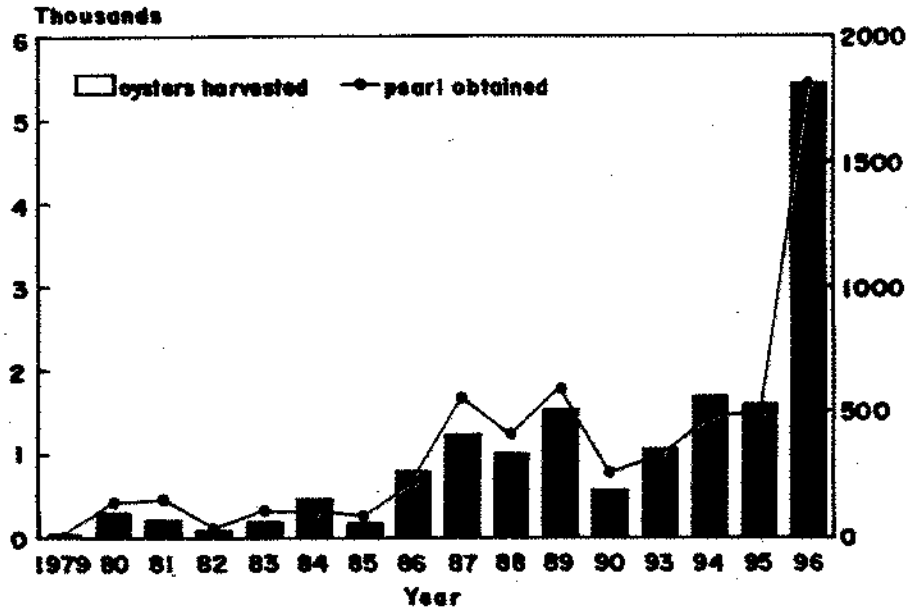


Fig : 41 Pearl production in CMFRI farm at Tuticorin

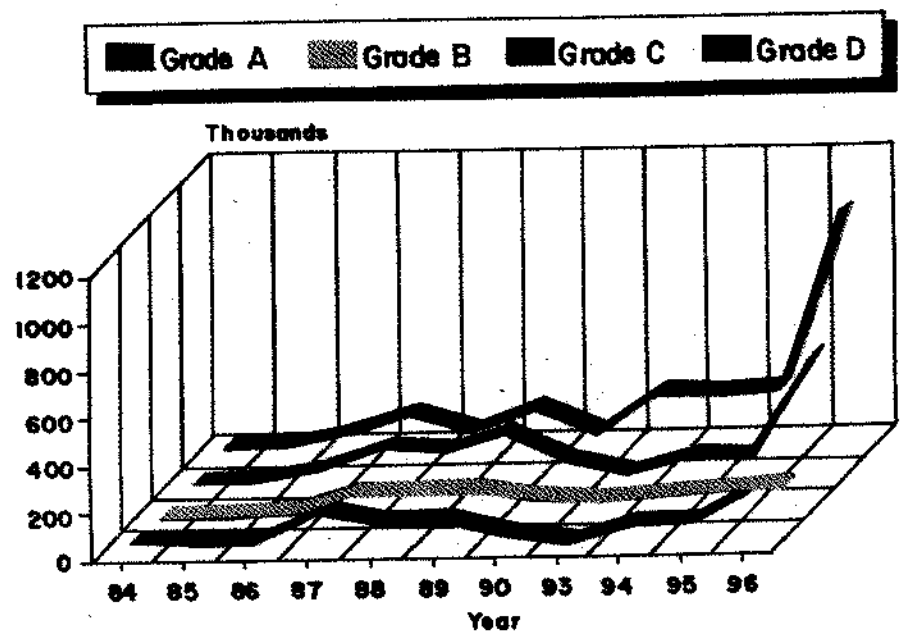


Fig : 42 Grade-wise production of pearls

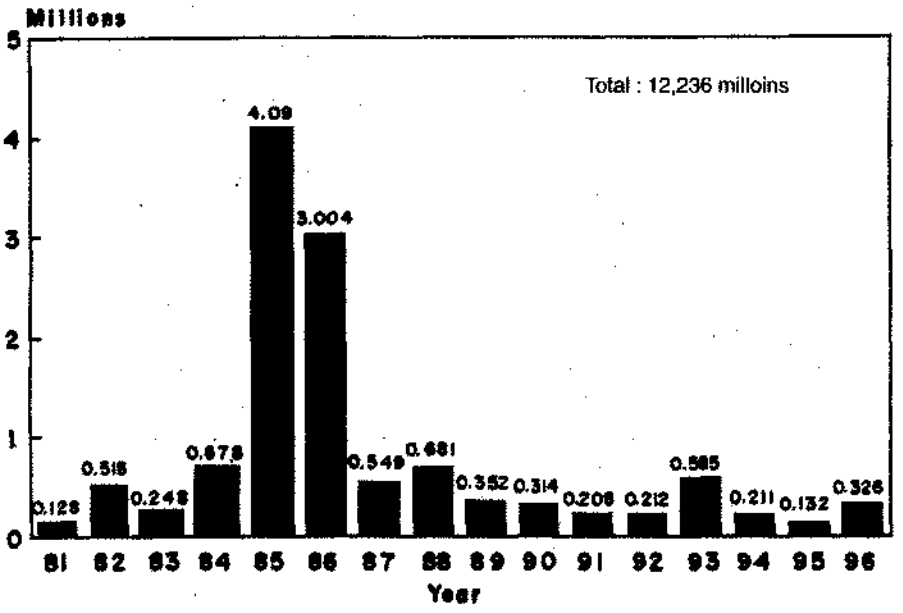


Fig : 43 Pearl Oyster spat produced at CMFRI hatchery

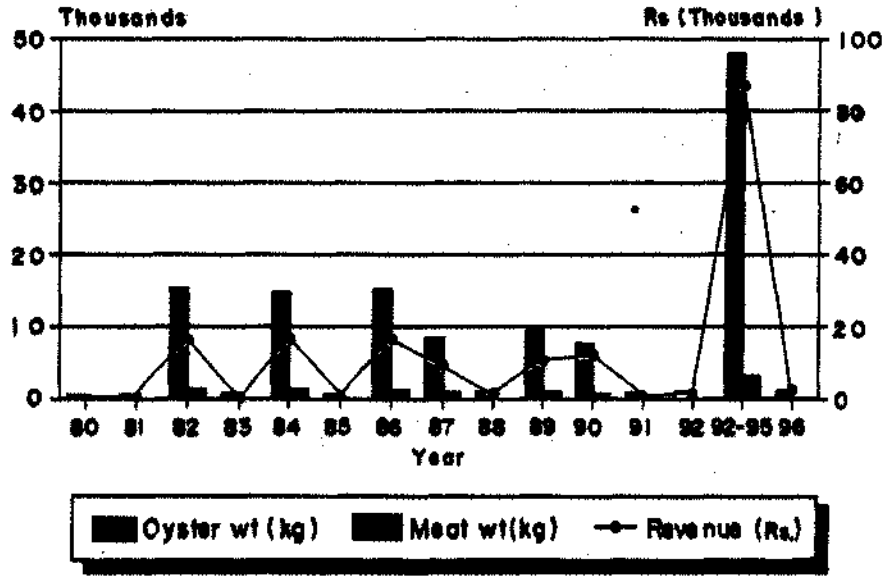


Fig : 44 Oyster production iand revenue earned by CMFRI at Tuticorin (1979-'95) and Dalavapuram (1994-'95)

VII Establishment of Tamilnadu Pearls Ltd

Duration	:	4 years
Total expenditure	:	Rs 6.9 million
Pearls produced	:	13 kg
Pearls sold	:	4 kg for Rs 0.782 million

VIII MoU signed for Transfer of Technology and Consultancy

1) NCC Blue water -Chandanada- A.P.
2) Gem Holiday, Resorts Ltd- Madras.
3) Balaji Bio-tech Ltd - Nellore, A.P.
4) M/S Sterling Shrimpex (P) Ltd, Chirala, A.P.
5) Mr. Jagadeswara Rao, Visakhapatnam, A.P.
6) Smt. V.Sarala , Visakhapatnam, A.P.
7) Ms/. Aqua Prime International, Nellore, A.P.

IX Sponsored Projects

1. DOD Funded Porject:-

Year of allocation	:	1995
Amount	:	Rs 2.5 million
Location	:	Mandapam Camp

2. ICAR Revolving Fund

Year of allocation	:	1996
Amount	:	Rs 3.0 million
Period of operation	:	8 years

3. Dept. of Biotechnology

Period of operation	:	May, 1994 to May, 1997
Project	:	Tissue cultured marine pearls
Amount	:	Rs 2.207 million

(ii) Package of practices for edible oyster culture has been 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 (Fig. 44, 45).

DEVELOPMENT OF EDIBLE OYSTER CULTURE TECHNOLOGY IN THE SHELLFISH HATCHERY & GROWOUT FACILITY OF CMFRI AT TUTICORIN AND TECHNOLOGY TRANSFER TO OTHER LOCATIONS

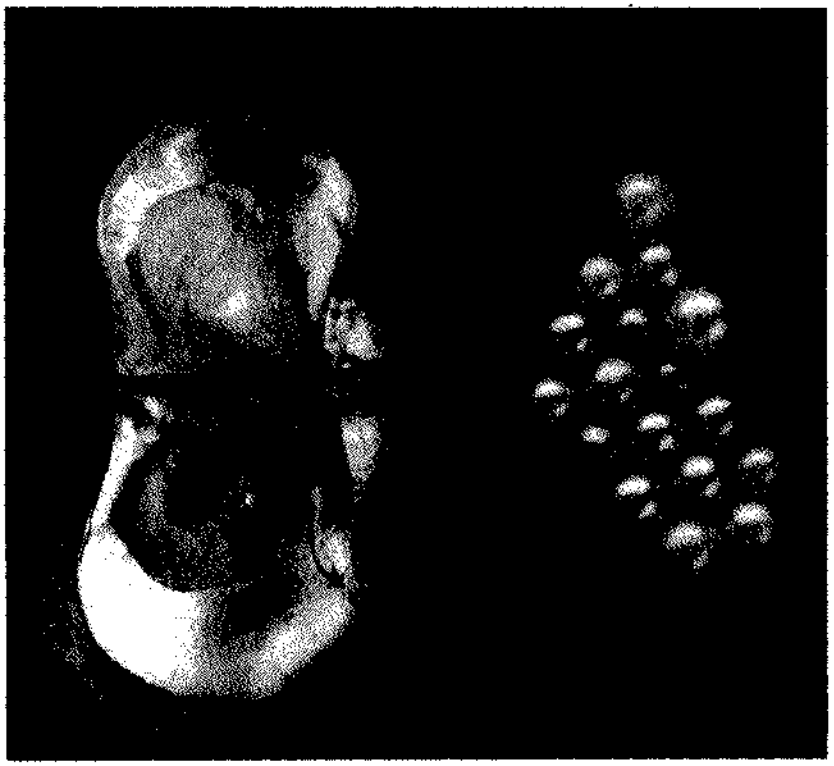
I.	Development of growout technology:	1977	CMFRI, Tuticorin-Molluscan shellfish hatchery
II.	Development of hatchery technology:	1982	- do -
III.	Oyster production:	1979-96	Total weight: 1,23,341 kg
			Meat weight: 8,369 kg
			Revenue: Rs 2,00,504
IV.	Spat production:	1982-96	14.52 million

V.	Lab-to-Land programme in oyster farming:	1979	12 t shell-on oyster produced in farmers' holdings, Revenue earned: Rs 8587.50
VI.	Sponsored Project by NABARD for Rs 8,58,200 for technology transfer	1992-95	Harvest: 47,756 kg (shellon) Meat weight: 2,946 kg Revenue earned: Rs 95,339
VII.	Site selection experiments	1993-94	Ashtamudi estuary, Kerala Munambam " Korapuzha " Dharmadam " Karwar, Karnataka
VIII.	Demonstration farms	1994-96	Dalavapuram - 0.2 ha Chetuvai - 0.03 ha Narakkal - 0.02 ha Dharmadam - 0.04 ha - good spat production from wild - good growth rate and 8-10% meat yield within 6-7 months - Yield in Rack-and-string: 80 t/ha
IX.	Private farms adopting CMFRI technology	1995-96	7 farms at Dalavapuram (0.03 to 0.2 ha) 1 farm at Munambam (0.04 ha) 1 farm at Padanna (0.04 ha)
X.	Mixed farming trials	1995-96	- oyster seed for farming from wild was used. - seed from Dalavapuram transported to Munambam, Narakkal, Chettuvai,Dharmadam, Padanna and Lakshadweep. - good survival and growth of transplanted seed at Dharmadam and Padanna. - green mussel grown in edible oyster racks. - good growth rates and survival from December to May. - 2.5 t of mussels harvested from Padanne, 1 t from Dharmadam in May, 1996 and sold @ of Rs 14/kg shellon. - About 20 private farms supported by IRDP-TRYSEM established in north Kerala in late 1996.

Pearl oyster (*Pinctada fucata*)

Spat

Adults

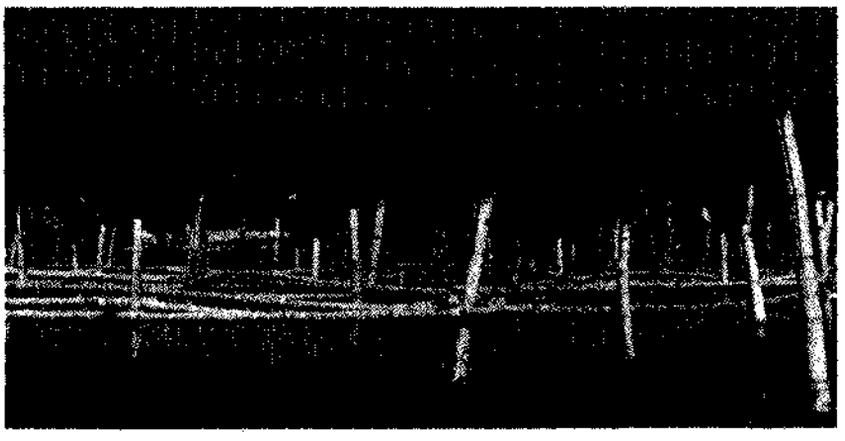


Oyster with pearl

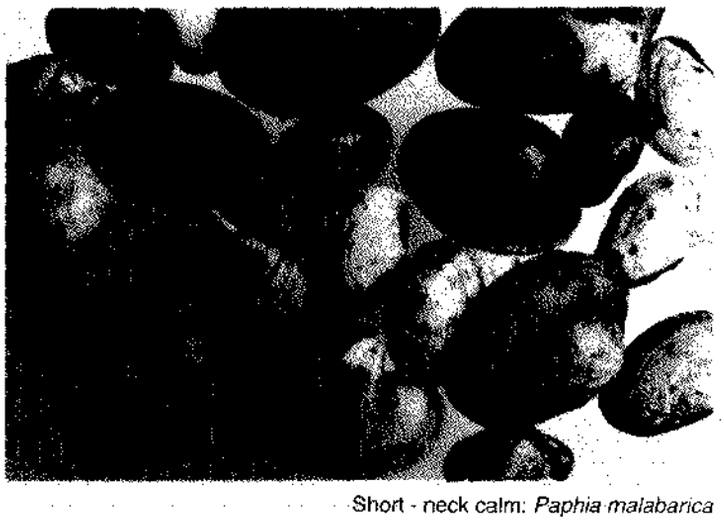
Pearls produced by CMFRI at Cochin.

PLATE XV

Edible oyster *(Crassostrea madrasensis)*



Edible oyster farm at Dalavapuram : strings released for spat collection



Short - neck calm: *Paphia malabarica*

PLATE XVI

(iii) Package of practices for the culture of green and brown mussel has been developed. Production of 10 kg/metre rope/6 months has been shown. Longline mussel culture has been developed with the active involvement of fisherfolk and, farms have been set up at Padana, Dharmadam, Thikodi, Chellanam, Vizhinjam, Mandapam, Madras, Mangalore and Karwar by the Institute and private parties.

PRODUCTION RATES ACHIEVED IN MUSSEL CULTURE BY DIFFERENT METHODS IN VARIOUS CENTRES BY CMFRI

Species	Place	Production rate	Duration	Raft	Long-line	Rack
Perna viridis	Calicut (opensea)	4.4-12.3 kg/ m/rope	5 months	+	-	-
"	Karwar (bay)	7.6-10 kg/m/ rope	5-6 months	+	-	-
"	Goa (NIO) (bay)	6 kg/m/rope	6 months	+	-	-
"	Ratnagiri (opensea)	7 kg/3 m rope	6 months	+	-	-
Perna indica	Kovalam (opensea)	6.6 kg/m rope	4 months	+	-	-
P. viridis	Vizhinjam (bay)	10 kg/m rope	7 months	+	-	-
P. viridis / P. indica	Andhaka-ranazhi (opensea)	10 kg/m rope	6 months	-	+.	-
P. viridis	Padana	10 kg/m rope	6 months	-	-	+
P.viridis	Dharmadam	10 kg/m rope	5 months	-	-	+

PROGRESSIVE DEVELOPMENT OF MUSSEL CULTURE TECHNOLOGY BY CMFRI

I	Culture technology	1973	Vizhinjam Bay - Brown mussel
		1974	Calicut - Green mussel
II	Hatchery technology	1984	Vizhinjam - Brown mussel
		1985	Madras - Green mussel
III	Lab-to-land programme	1979	Calicut-Pilot scale culture
IV	Farming experiments	1976-82	Raft culture - Madras, Karwar, Goa, Ratnagiri, Tuticorin, Andamans
	Longline		Visakhapatnam, Kakinada, Andakaranazhi (Cochin) and Karwar.
			1.5 t harvested in January 1996; sold @ Rs 14/kg
		1995-96	Rack culture - Dharmadam and Padanna (in estuaries)
V	Production rate achieved:		10 kg/m string/six months
VI	Sponsorship for hatchery	1994-97	by DBT

(iv) Package of clam culture practice has been developed. In *Anadara granosa*, the production attained 40t/ha/6 months and in *P. malabarica* 15 to 25t/ha/4 to 5 months.

(v) Hatchery technologies for mass production of the seed of 2 species of pearl oysters (Fig. 43), one species of edible oyster (Fig. 45), 2 mussel species and 5 clam species (Fig. 46) have been standardised.

(vi) R&D support has been extended 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 are conducted.

(vii) Optimum salinity and temperature requirements have been determined as 30 ppt and 30°C respectively for *Meretrix casta* and 5 ppt and 27.1°C respectively for *Paphia malabarica* opening up prospects of commercial clam farming in both brackishwater and marine farms, integrated with fish, shrimps, seacucumber and seaweeds.

(viii) Tissue specific genetic variation has been discovered in *Crassostrea madrasensis*. Genetic similarity between the populations at Cochin and Tuticorin has been established.

(ix) Tissue-cultured pearl is fast emerging as a commercial proposition in the Institute's laboratory at Tuticorin.

PROGRESSIVE DEVELOPMENT OF CLAM CULTURE TECHNOLOGY BY CMFRI

I.	Farming technology	1978	*Anadara granosa* - Kakinada	0.39 t/100 m²/5 months = 39 t/ha 2.6 t/625 2.6 t/625 m²/5.5 months = 41.6 t/ha 6.1 t/0.16 ha/7 months = 38.1 t/ha Survival rate: 88.6%
II.	Hatchery technology	1987	in Tuticorin shellfish hatchery *Villorita cyprinoides* and *Meretrix casta*	
III.	Pilot scale seed production	1987 1988 1988-96 (35000 to 1.54 million seed/year)	for *Meretrix meretrix* at Tuticorin shellfish hatchery for *Anadara granosa* and *Meretrix casta* -do- for *Paphia malabarica* -do-	
IV	Sea ranching of *Paphia malabarica*	1988-1996		Ashtamudi, Madras, Tuticorin, Munambam, Pondichery Production at Ashtamudi: 1.425 kg to 5.93 kg/m²/3.5 to 7.5 months Survival rate: 7.05 - 17.64%
V	Sponsored project Hatchery and ranching - 1993-95 MPEDA			Amount = Rs 0.362 million Seed produced: 1.54 million Places where sea ranched: Ashtamudi, Munambam & Ayiramthengu 1994-97 DBT Amount = Rs 0.8 million Seed produced: about 1 million

3. Seacucumber

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

4. Seaweed

(i) Culture of seaweeds in open coastal waters has been undertaken successfully and the commercial feasibility demonstrated in the Gulf of Mannar and the Minicoy lagoon (Fig 47, 48).

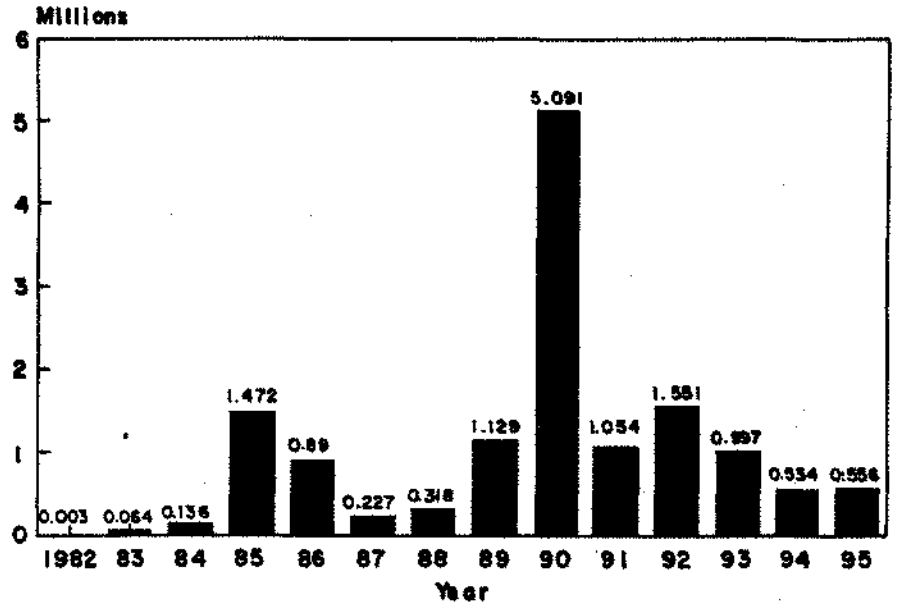


Fig : 45 Edible oyster spat produced at the CMFRI Tuticorin hatchery

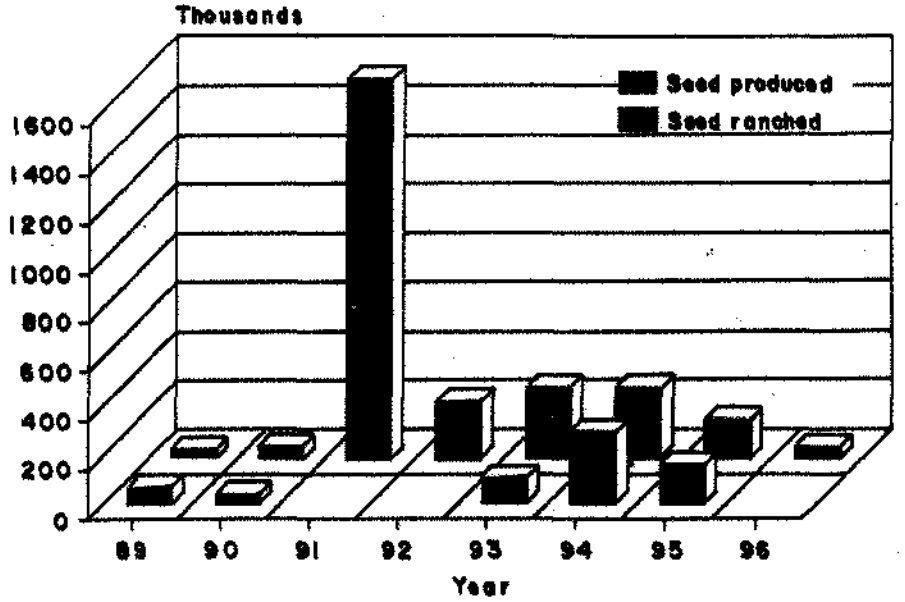


Fig : 46 Production of *Paphia malabarica* seed in CMFRI hatchery

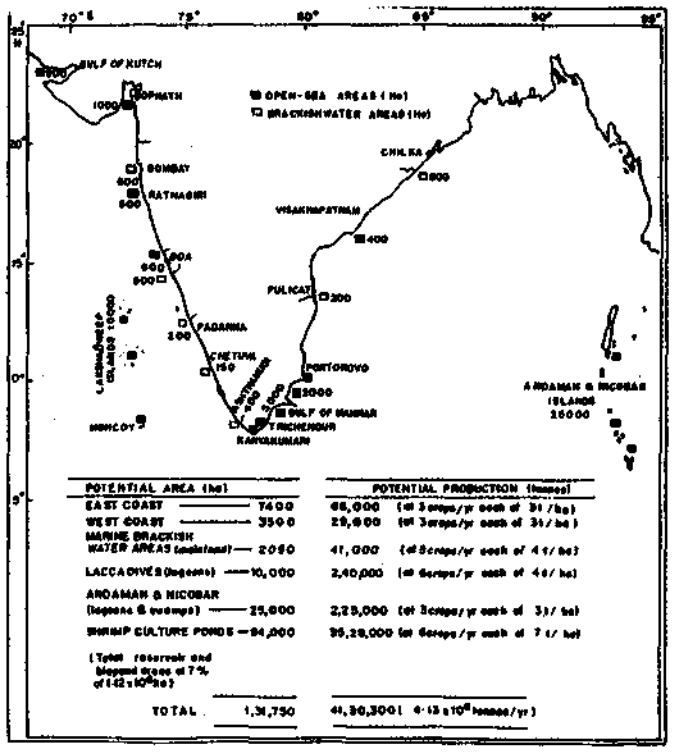


Fig : 47 Potential areas of seaweed aquaculture along the Indian EEZ

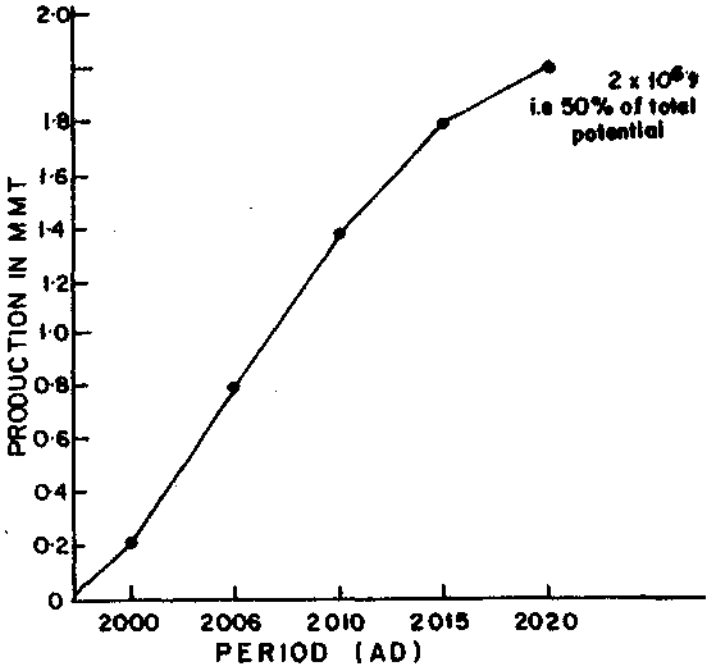


Fig : 48 Projected Indian mariculture production of seaweeds

Mussel - seeded ropes ready for deployment at Padana (Kasargode)

Mussel ropes harvested from CMFRI demonstration farm at Chettuva

Mussel harvested from Chettuva farm being sorted and shucked for meat extraction

PLATE XVII

Concrete module of the artificial reef set by CMFRI along Vizhinjam coast

Artificial reef installed by CMFRI along the Vizhinjam coast

PLATE XVIII

5. *Finfish*

(i) Nutrition study on the milkfiish indicates that the fry could utilise gelatinised starch upto a level of 45% in the diet with relatively high survival, growth and feed efficiency.

(ii) Successful spawning of *Mugil cephalus* yielded four million eggs, with 60% fertilisation and 12.5% hatching.

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

(iv) 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.

(v) The exposure of *Lates calcarifer* and *Liza parsia* to malathion, changes the morphology of the chromosomes with breaks and gaps. Sister chromatid exchanges have been observed in *Therapon sp.*, *Oreochromis mossambicus* and *L.parsia*.

(vi) Transport of live groupers and their culture in growout system has been carried out. The grouper has been successfully spawned in captivity, and the hatchery technology is being developed, following the success achieved by CIBA, Chennai on seabass.

MARINE FISH CULTURE EXPERIMENTS CARRIED OUT BY THE CMFRI

Place	Culture System	Methods	Species	Growth rate(mm)	Survival (%)	Production (kg/ha/yr)
Krusadi	Monoculture	Pond	*C.chanos*	230-240/yr	-	-
	Monoculture	Pond	*C.chanos*	240-250/yr	-	-
Mandapam	Monoculture	Pond	*C.chanos*	300/yr	9-11	212-455
Veppalodai	Polyculture	Pond	*C.chanos*	333/yr	50	192
Tuticorin	Polyculture	Pond	*C.chanos*	300-378/yr	5	324
			L.macrolepis	211-240/yr	67	630
			S.serrata	130-175/yr	26	690
Mandapam	Monoculture	Tank	*A.bicolor*	23/month	98	2.2 kg/sqm/
			A.bicolor			5 months
Mandapam	Monoculture	Cage	*S.canaliculatus*	8.5/month	-	
			S.javus	6.2/month	60	-
			E.tauvina	19/month	73	-
			S.sihama	10/month	-	-
Mandapam	Polyculture	Pond	*V.seheli*	15.8-24.6/month	-	-
			L.macrolepis	13/month	-	-
			C.chanos	16.8-30/month	-	-
			P.indicus	9.4/month	-	-
			S.sihama	11.4/month	-	-
Mandapam	Polyculture	Pen	*Mugil* sp.	18/month	-	-
			C.chanos	50/month		
Tuticorin	Monoculture	Pond	*C.chanos*	44/month	318-857	-
Mandapam	Monoculture	Cage	*E.tauvina*	16.3mm/month	-	-
Chennai (CIBA)	Seed production		*L.calcarifer*	-		2 million seed produced

6. Searanching

(i) Technology of searanching of shrimp and molluscan seed produced in the hatcheries has been developed and tested at Tuticorin, Mandapam and Dalavapuram (Quilon). Searanching of *P. semisulcatus* in the Mandapam area helped in augmenting shrimp production in the inshore waters of Palk Bay. A total of 10 million pearl oyster spat was searanched in the Gulf of Mannar in 17 batches during 1985 and 1990 and 4.86 lakh clam spat searanched in Ashtamudi lake in 7 batches during 1993-1996. About 80 million D-shaped larvae of *Pinctada margaritifera* was released in the Gulf of Mannar during May, 1996.

SOME SEARANCHING RESULTS: GLOBAL & INDIAN EXPERIENCE

Country	Location	Species	No.of seed ranched	Year	Results
1. Japan	Komance-Ko-Lagoon	Kuruma shrimp	700 million	-	2.4 tonnes increase in production of kuruma shrimp
	-do-	Seabream Flounder	16 million 19 million	-	Substantial increase in the wild stock
	16 national and 43 local aqua-culture centres	80 coastal species	-	-	-
2. U.S.A.	Hawaii	Striped mullets	Pilot scale	1970s	100% increase in wild stock
	Texas	Red drum	Pilot scale	1970s	Significant increase in wild stock
	Hawaii	Threadfin	Pilot scale	1970s	Significant increase in wild stock
3. -	Bohai sea Yellow sea	Penaeid shrimps	Large scale	1980s	Recapture rate 4 to 13.6%; searanched seed account for > 90% of catch
4. India (CMFRI)	Palk Bay	*Penaeus semisulcatus*	6 million	1990-94	Increased yield
	Gulf of Mannar	*Pinctada fucata*	10 million	1985 & 1990	Significant increase in adult pearl oyster
	(Pearl banks)	*P.margaritifera*	80 million larvae	1996	in the natural beds
	Ashtamudi estuarine lake	Clams	0.486 million	1993-96	Fairly good increase in production in Kerala

PROPOSED SEARANCHING PROGRAMME FOR THE VIZHINJAM BAY AND THE CONTIGUOUS GULF OF MANNAR-WADGE BANK -MINICOY LAGOON - COCHIN COAST UNDER THE INDIA - AUSTRALIA NEW HORIZON PROGRAMME IN SCIENCE & TECHNOLOGY

Location		Species	No. of seed to be ranched in 5 years (in millions)
1. Vizhinjam	(i)	Shrimp (*P.stylifera, M.dobsoni,P.indicus*)	8
	(ii)	Pearl oyster (*P.fucata*)	160
	(iii)	Grouper (*E.tauvina*)	16
2. Mandapam	(i)	Shrimp (*P.indicus, P.semisulcatus*)	24
	(ii)	Pearl oyster (*P.fucata*)	160
	(iii)	Seacucumber (*H.scabra*)	10
	(iv)	Grouper (*E.tauvina*)	18
3. Tuticorin	(i)	Shrimp (*P.indicus, P.semisulcatus*)	36
	(ii)	Pearl oyster (*P.fucata*)	180
	(iii)	Sea cucumber (*H.scabra*)	8
	(iv)	Grouper (*E.tauvina*)	16
4. Quilon	(i)	Shrimp (*P.stylifera, M.dobsoni,P.indicus*)	330
5. Alleppey	(i)	Shrimp (*P.stylifera, M.dobsoni, P.indicus*)	172
6. Cochin	(i)	Shrimp (*P.stylifera, M.dobsoni, P.indicus*)	330
7. Minicoy	(i)	Pearl oyster (*P.fucata*)	20
	(ii)	Seacucumber (*H.scabra*)	2

Total: Shrimp = 900 ; Pearl oyster = 520 ; Seacucumber = 20 ; Grouper = 50

All Total = 1490 million

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

V. Assessment and Monitoring of the Socioeconomic Health of the Marine Fishing and Mariculture Industries

(i) About 56% of the marine fishermen households have ownership on some means of production. About 45% of them are in debts. Overcapitalisation of the industry and marginalisation of the artisanal sector has led to conflicts between traditional and mechanised sectors. The fishermen's share in the consumer's rupee ranges 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. About 0.7 million fisherfolk work as labourers. The annual income of a labourer working in mechanised boats is Rs 34,200, motorised boats Rs 15,200 and artisanal boats Rs 8000.

(ii) In recent years, a number of medium trawlers (OAL:>14 m) have been inducted to facilitate multiday fishing and exploitation in un- and underexploited regions. These trawlers are estimated (CMFRI) to realise a greater profit ratio than the hitherto operating smaller trawlers (OAL:< 14 m). For example, the ratio of actual cost of fishing and actual value realised (AC:AV) by the trawlers engaged in daily fishing off Chennai was 1:1.4 in 1995; this ratio for the trawlers engaged in multiday fishing was 1:1.9.

ECONOMIC PERFORMANCE OF SMALL TRAWLERS (32-36') ENGAGED IN DAILY TRAWLING AND LARGE TRAWLERS (42-46') ENGAGED IN MULTIDAY TRAWLING FROM MADRAS FISHERIES HARBOUR

Economic parameters	Daily trawler 1985	Daily trawler 1995	Multiday trawler 1995
Initial ivestment (Rs in lakhs)	3.00	6.00	10.00
Fixed cost (Rs in lakhs)	0.90	1.80	3.00
Annual operating cost (Rs in lakhs)	3.16	6.40	8.27
Total cost (Rs in lakhs)	4.06	8.20	11.27
Annual effort (Fishing hours)	1800	2198	1425
Fishing cost/h (Rs.)	226	375	791
Total cost of fishing (Rs in lakhs)	4.07	8.24	11.27
Annual catch (t)	102.2	75.9	72.6
Annual value of catch (Rs in lakhs)	7.6	11.3	21.2

(iii) The total investment cost of fishing by the marine fisheries sector in the country has been estimated (CMFRI) as Rs 4,117 crores at the 1995 price value and the fixed and annual operating costs as Rs 4,528 crores. The estimated total value of the marine landings (Rs 7,230 crores) thus shows a fairy good profit ratio for the fishing industry as a whole.

CAPITAL INVESTMENTS, FIXED COST AND ANNUAL OPERATING COSTS (RS IN CRORES) OF THE INDIAN MARINE FISHING FLEET DURING 1995

Fishing Fleet	Investment	Fixed cost	Operating cost Fuel	Labour	Others	Total	Total cost	Fishing cost (Rs/kg)
I. Mechanised sector								
1. Medium trawlers (14-17 m OAL)	850	255	222	233	107	562	817	22.56
2. Small trawlers (10-13 m OAL)	1500	450	625	410	245	1280	1730	22.56
3. Dolnetters	30	9	6	12	4	22	31	2.95
4 Purseseiners	90	27	14	17	11	42	69	4.42
5. Pablo & plank built boats	434	109	105	242	50	397	506	32.65
6. Others	20	6	3	6	2	11	17	3.40
	2924	856	975	920	419	2314	3170	19.87
II. Motorised sector								
1. Canoes	375	75	47	187	78	312	387	12.29
2. Catamarans	31	9	4	21	9	34	43	10.75
	406	84	51	208	87	346	430	12.11
III. Artisanal sector								
1. Canoes	83	22	-	43	19	62	84	33.60
2. Catamarans	335	84	-	314	133	447	531	32.18
3. Plankbuilt boats	369	92	-	155	66	221	313	33.65
	787	198	-	512	218	730	928	32.79
All fleet	4117	1138	1026	1640	724	3390	4528	20.28

(iv) Entrepreneurship development has been 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 the 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 has been adopted by fishermen at Andhakaranazhi, Adimalaithurai, Dharmadam and Padana. Ten fish farmers have taken up edible oyster culture at Dalavapuram near Quilon.

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

VI. Human Resources Development

(i) **Postgraduate Programme in Mariculture**: Since its inception in 1979, the achievements of the postgraduate programme in mariculture have been quite impressive, as shown below.

- Fourteen batches of students numbering 133 have been awarded M.Sc/M.F.Sc degrees in Mariculture.
- 50 candidates were awarded Ph.D degree on various aspects of Mariculture. Besides, 8 candidates have submitted their theses and are awaiting the award of the degree.
- All the above candidates have been absorbed in R&D organisations, banks, fishing industry, mariculture industry, teaching and research organisations.

(ii) **Trainers' Training Centre**: 77 courses have been conducted since its inception in 1983 and 655 candidates have been trained in different areas of mariculture.

(iii) **Krishi Vigyan Kendra**: 6,960 fishermen in 369 batches have been trained in Fisheries; 2,274 persons in 105 batches in Animal Sciences; 2317 persons in 138 batches in Home Science; and 2,175 persons in 101 batches in Crop Sciences.

VII. Knowledgebase in Marine Fisheries and Mariculture Science and Technology

The CMFRI has been paying special attention to the development of a comprehensive knowledgebase for marine capture fisheries and mariculture since its inception in the year 1947. About 4400 scientific papers have been published so far both in Indian and foreign journals on the basis of research carried out in the CMFRI in various disciplines, majority of which are of immense scientific value.

VIII. Consultancies and R&D Support during 1996-97

S.No	*Name of the Entrepreneur*	*Location & activity*	*Amount(Rs)*
1.	M/s N.C.C. Bluewater Products Ltd.	Chandanada(A.P.) Pearl Culture	84,000

S.No	Name of the Entrepreneur	Location & activity	Amount(Rs)
2.	M/s Balaji Bio-Tech Ltd., Nellore	Thupilipalem Pearl Culture	1,66,250
3.	M/s Aqua Prime International (India) Ltd.	Nellore Pearl Culture	2,01,350
4.	M/s Gem Holiday Resorts Ltd.	Madras Pearl Culture	4,30,750
5.	M/s Sterling Shrimpex (P) Ltd.	Chirala (A.P.) Pearl Culture	
6.	M/s Kalinga Aquatics Ltd.	Bhubaneswar (Orissa) Crab Farming	
7.	M/s Pink Gold British Exports Ltd. Crab Farming	Raigarh (Maharashtra)	1,94,000
8.	M/s Mangalore Refineries & Petrochemicals	Mangalore Pollution Monitoring	3,60,000
9.	M/s Kudremukh Iron Ore Co. Ltd. (KIOCL)	Mangalore Pollution Monitoring	3,80,000
10.	M/s Master Pearls Ltd.	Hyderabad Pearl Culture	6,71,250
11.	MPEDA	Cochin Lobster fattening	5,82,400

IX. Village Adoption and Farmers' Meets

1. Village adoption

A society by name *Matsyamahilavedi*, was organised by the Institute exclusively for women at Chellanam village to serve as the platform for the coordination of programmes in the village.

a. Smallscale industry for prawn feed production: The technology of *Mahima* shrimp feed production was transferred to a group of five women in the Chellanam village and enabled them start a smallscale industry. A group loan of Rs 25,000 was arranged avilable to them through Corporation Bank under the refinance scheme of NABARD.

b.Introduction of poultry units: Twenty units of poultry consisting of 20 birds each were set up in the fishermen households with the finance obtained from the Innerwheel Club of Cochin.

c. Fishing net making: Organised 30 women for generation of selfemployment through net making by utilising the grant-in-aid of Rs 1.4 lakhs provided by the *Matsyamahilavedi* by the Central Social Welfare Board under its Socio-Economic Programme.

d. Awareness campaign for fisherwomen: A week-long awareness campaign to educate the women on the need for selfemployment, enterprise building and management, leadership development, group action and development programmes of the government was organised for 40 women with the help of the Workers' Education Centre (Department of Labour).

e. Involving women in prawn farming: A one day seminar and a one week training on prawn farming were specially organised for women. Demonstrations were conducted on the technology of prawn farmingin a 10-cent canal and a 1-acre farm owned by fisherwomen under which they were trained in seed identification, feeding and other management practices.

f. Group farming: This concept was demonstrated for the first time in Chellanam village among a group of 50 prawn farmers, in 96 acres of ponds.

g. Environment Awareness Programme: Environment awareness campaign was conducted in two centres in Chellanam which was sponsored by the State Department of Environment. The objective of the programme was to educate the villagers on the need for the protection of environment and their role in it.

h. Programmes for the development of SC/ST: The following projects funded by the District Administration under the Special Central Assistance to the Special Component Plan, 1996-97. The beneficiaries were sponsored by the SC\ST societies at Chellanam, Kandakkadavu and Valappu villages in Ernakulam District and a total number of 100 families are covered.

2. Fishermen-Farmers-Industry-Institution meets

To supplement the information gnerated from field visits, to have a better understanding of the various issues of marine fisheries and mariculture, to develop effective interaction with marine fishermen, fish farmers and the industry, to assess the impact of technologies transferred by the Institute and to offer quick and viable options to the concerned,the Institute has been organising Fishermen-Farmers-Industry-Institution meets regularly at the headquarters and the Research Centres. These meets, which are attended by officials of development agencies also, have benefitted a large number of fisherfolk. The subjects dealt with under this are shown below.

S.No.	*Subject*
1.	Mussel farming
2.	Fisheries management for sustainable development
3.	Mudcrab farming
4.	Fish diseases
5.	Pearl culture
6.	*Mahima* feed
7.	Edible oyster farming
8.	Artificial fish-habitats
9.	Mini shrimp hatchery
10.	Fisheries management and shrimp farming
11.	Clam farming
12.	Integrated mariculture
13.	Assessment of CMFRI's seafarming programme
14.	Seaweed culture
15.	Ornamental fish culture

16. Problems and prospects of smallscale marine fisheries of Kerala
17. Futurology in marine fisheries
18. Labour situation in marine fisheries of Kerala
19. Credit and Savings Schemes
20. Seafarming technologies
21. Oyster and finfish culture
22. Fisheries awareness camp
23. Fish culture

Assessment of Contributions

1. Database on fish production: The database on marine fish landings, fishing effort and economics of fishing continues to form the basis for the formulation of various marine fisheries development plans by the governments and the fishing industry.

2. 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. The 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.

3. Stock Assessment: 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.

4. 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.

5. Potential yield: The annual resource potential in the EEZ is estimated to be 3.9 million tonnes (m t). In order to increase the harvest from the present 2.4 m t, additional effort will be deployed in the outer continental shelf (i.e., beyond the 50 m depth) and the hitherto unexploited or underexploited stocks will be subjected to optimum exploitation. The CMFRI with its trained manpower and the neetwork of research centres 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.

16. Problems and prospects of smallscale marine fisheries of Kerala
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6. Charting fishing grounds: Shipboard surveys by the institute brought to light the extent and location of the underexploited and unexploited fishing grounds in the EEZ together with rich data on the availability and abundance of both conventional and nonconventional resources in the outer continental shelf which are not presently exploited.

7. 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.

8. Remote sensing: Collaboration with the premier national institutions (NIO, SAC, NRSA) in the project on "Ocean Related Remote Sensing Programme" through the "Marine Remote Sensing Information System" (MARSIS) has enabled quick dissemination of potential fishing zone (PFZ) maps to the user community through the government and private agencies. The CMFRI's system of undertaking regular validation of the PFZ maps by means of seatruth data on seasurface temperature, primary production and by monitoring the catches from the PFZ and non PFZ areas by the commercial fishermen, 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.

9. Mariculture techonlogies: 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 seacucumbers and pearl oysters and pearl culture has opened up new avenues for mariculture production. In recognition of the Institute's strengths and capabilities, the ICLARM, Manila has identified the CMFRI as a member in a network of International institutions for the assessment and monitoring of the demersal fish stocks of the south Asian and southeast Asian regions. The south Australian Research and Development Institute (SARDI) has identified the CMFRI as the nodal agency in the country for a project on stock enhancement through searanching.

10. International recognition : The expertise built up by the CMFRI 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 estimating world fish production.

11. Human resource development: The initiatives taken to develop the human resources for the marine fisheries sector has considerably helped in meeting the trained manpower requirements of the R&D organisations and the industry.

12. Sponsored research: With the expertise available in 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 studied almost throughout the country. Such a national facility provides immense opportunities for continuous technology upgradation. The 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 its facilities and infrastructure, and in bringing out valuable information and technologies for marine fisheries and mariculture development and growth.

13. Fishery science: The CMFRI has been publishing almost continuously a large number 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 fisheries, stock assessment to ensure sustained yields and mariculture of finfish and shellfish, and to human resources development.

14. 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 hatchery and husbandry practices, genetics, nutrition, physiology, pathology and endocrinology, fisheries economics and extension.

Future Needs

I. Mariculture

1. Improvement of mariculture technologies: The outbreak of diseases in coastal shrimp culture systems since 1994 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 needs to be given due importance. Upgradation of hatchery technologies of marine prawns, crabs, lobsters, seacucumber, pearl oyster, edible oyster, clam and mussel; upgradation of pearl culture technology, and culture technologies of bivalves, crustaceans and seaweeds.

2. Potential for inland saline aquaculture : Marine fish and prawn culture in saline soil ecosystems in Haryana carried out by the CIFE, indicates considerable potential for aquaculture in all the hinterland salt affected areas (Fig. 49) of about 8.5 million ha. The saline-alkali soils in arid and semiarid areas in India are considered to be unfit for agriculture due to the presence of soluble salts in these soils. In the attempts made to use these soils for the culture of marine fish and prawns, the ground saline aquifer was tapped through tubewells. In order to step, up this activity, there is need to establish Brackishwater Fish Farmers' Development Agencies (BFDAs) throughout the salt-affected states. It is also necessary to create Sea Farmers' Development Agencies (SFDAs) in all the maritime states.

CULTURE OF FISH AND PRAWNS IN THE SULTANPUR (HARYANA) SALINE AQUACULTURE FARM DURING 1984-85

Species	Duration (months)	Rate of stocking No/ha	Stocking size Mean length (mm)	Stocking size Mean weight (g)	Harvest size Mean length (mm)	Harvest size Mean weight (g)	Production (kg/ha/yr)
P.monodon	10	40,000	20	0.06	200	72.5	1450
M.cephalus	10	10,000	25	1.00	400	525.5	3150
C.chanos	10	10,000	25	1.00	415	520.0	3370
E.suratensis	10	15,000	30	1.75	150	140.0	2170

13. Fishery science: The CMFRI has been publishing almost continuously a large number 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 fisheries, stock assessment to ensure sustained yields and mariculture of finfish and shellfish, and to human resources development.

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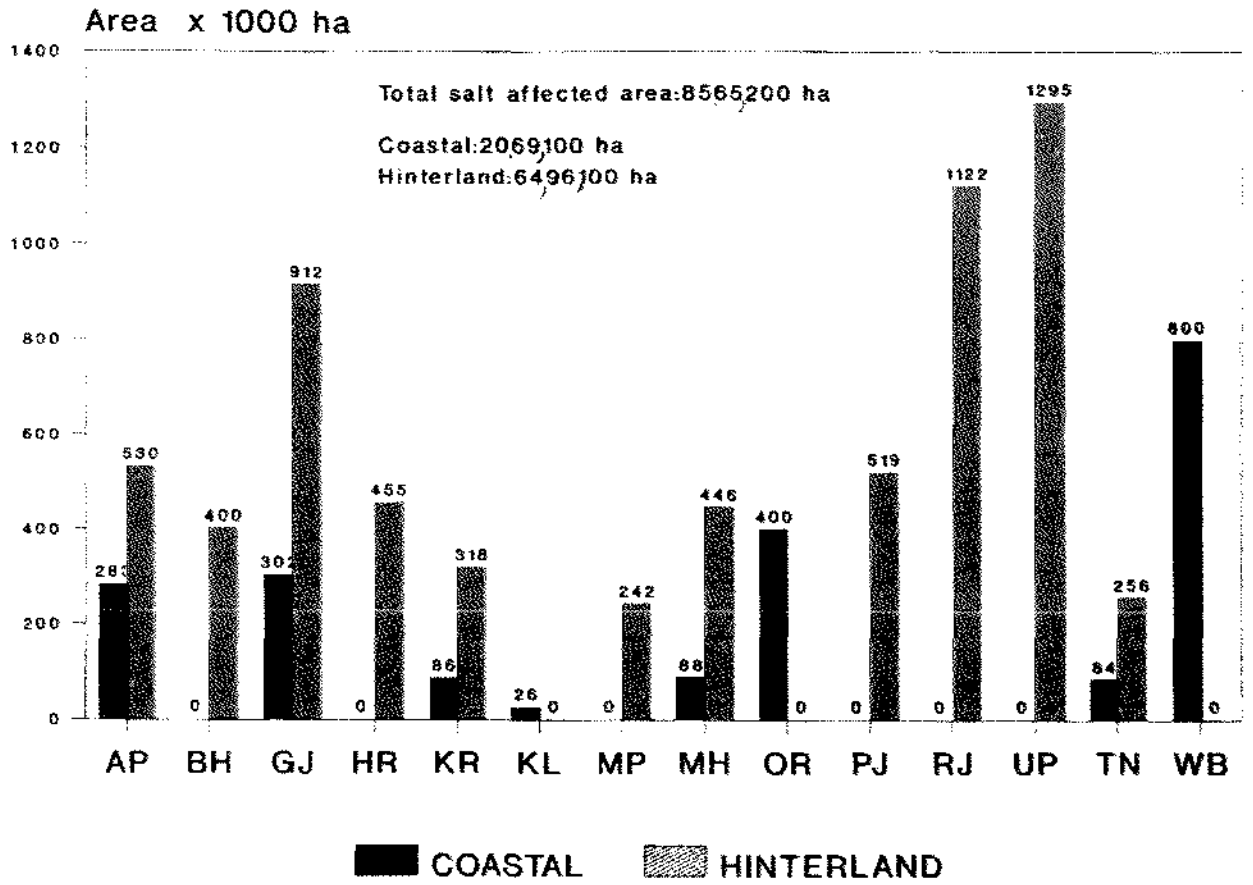


Fig : 49

Salt affected soils in India

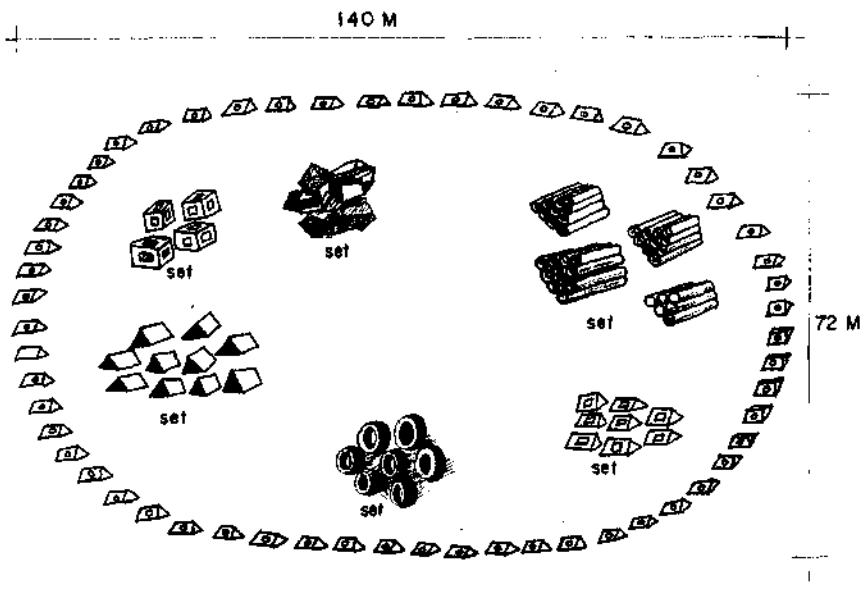


Fig : 50 An ideal Artificial Reef Complex Design of 10000 M^2 Area

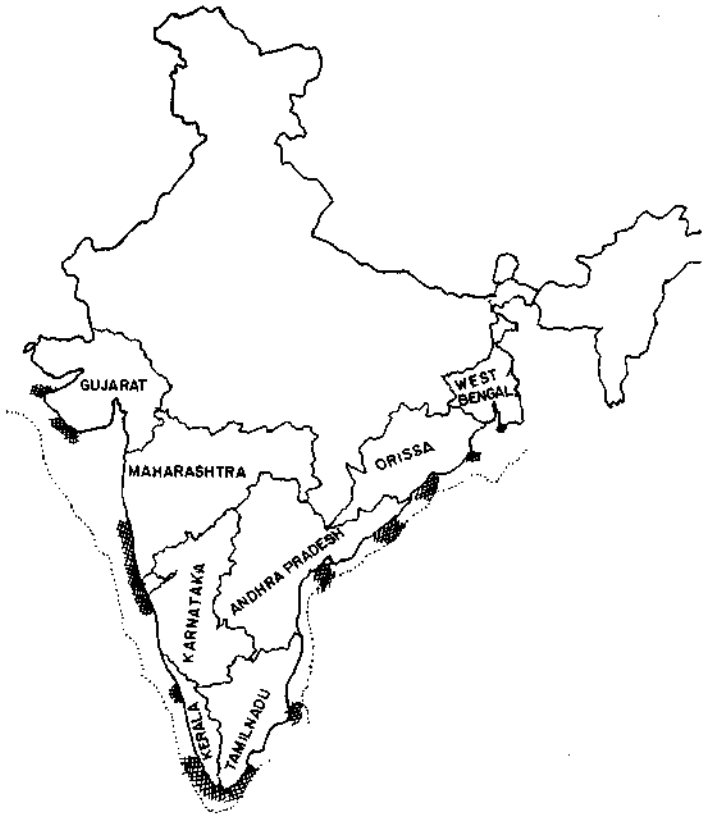


Fig : 51 Potrential areas identified for the development of artificial reefs

SALT-AFFECTED SOILS IN DIFFERENT STATES OF INDIA (AREA IN '000 HA), BRACKISHWATER FISH FARMERS' DEVELOPMENT AGENCIES (BFDAS) SANCTIONED AND PROPOSED FOR HINTERLAND SALINE AQUACULTURE AND, SEA FARMERS' DEVELOPMENT AGENCIES (SFDAS) PROPOSED

State	Coastal	Hinterland	Total	BFDAs		SFDAs
				Already sanctioned	Now proposed	Now proposed
Andhra Pradesh	283.3	530.0	813.3	6	10	10
Bihar	-	400.0	400.0	-	8	-
Gujarat	302.3	912.1	1214.4	3	9	10
Haryana	-	455.0	455.0	-	8	-
Karnataka	86.0	318.0	404.0	2	7	2
Kerala	26.0	-	26.0	6	0	9
Madhyapradesh	-	242.0	242.0	-	4	-
Maharashtra& Goa	88.0	446.0	534.0	5	10	5
Orissa	400.0	-	400.0	7	0	4
Punjab	-	519.5	519.5	-	10	-
Rajasthan	-	1122.0	1122.0	-	2	-
Tamil Nadu	83.5	256.5	340.0	5	8	9
Uttar Pradesh	-	1295.0	1295.0	-	10	-
West Bengal	800.0	-	800.0	3	0	2
Total	2069.1	6496.1	8565.2	37	86	51

*3. **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 pompano in the Mandapam,Tuticorin and Calicut marine fish farms of the CMFRI.

II. Capture fisheries

*1. **Regulations and fisheries management:*** The demand for even small prawns in the export market has resulted in the use of gears with small meshes, which also catch large quantities of youngones of other commercial species. Such indiscriminate fishing in the inshore waters has led to serious problems of effective management. The CMFRI will focus greater attention on 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.

2. Artificial reefs (Fig 50 & 51) (Plate XVIII) :

NUMBER OF ARTIFICIAL REEFS REQUIRED TO BE INSTALLED OFF COASTS OF MARITIME STATES FOR INCREASING PRODUCTIVITY AND PRODUCTION AND THE FINANCIAL REQUIREMENT

State	No.of reefs proposed	Cost* (Rs in lakhs)
Gujarat	10	100
Maharashtra	6	60
Goa	4	40
Karnataka	4	40
Kerala	16	160
Tamilnadu	16	160
Andhra Pradesh	12	120
Orissa	8	80
West Bengal	1	10
Total	77	770

* Cost is estimated for a reef of 10,000 sq.m. area consisting of 200 to 250 ferrocement modules of 1.5 m x 1.5 m.

3. 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 considerable saving on expenditure and more reliable data are obtained. The active involvement of the ICAR and the Ministries of Agriculture and Commerce will greatly help in achieving the targets.

4. 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 deserves much greater attention.

5. 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 meteorological 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.

6. Need for the establishment of a School of Taxonomy in the CMFRI: The ability to address the needs of biodiversity conservation and protection largely depends on the knowledge of taxonomy of the flora and the fauna constituting the biodiversity, the species interactions

and assemblages and ecology. Lack of encouragement to basic research in general and taxonomy in particular in recent years has resulted in the lack of expertise even in the major marine organisms like finfish, leave alone other organisms like coelenterates, sponges, echinoderms and others. There is urgent need to establish Schools of Taxonomy in fisheries research institutes not only to carry out research on the various aspects of biodiversity but also to develop the required HRD. While the Ministry of Environment & Forests, government of India, is attempting to launch a national project on biodiversity through the cooperation of national Institutions like CMFRI, the ICAR should seriously consider sanctioning a SCHOOL OF TAXONOMY with Division status at the CMFRI, inview of the fact that the institute possesses the required expertise currently which will not be available after about five years (due to superannuation of the experts). The expertise in most other organisations on important organisms constituting biodiversity has almost been reduced to none. Besides the expertise, the CMFRI is in the advantageous position of implementing such a programme because of its field-oriented programmes. Expertise in taxonomy *is* also required at CMFRI for its teaching and research programmes. Therefore, the ICAR needs to consider according the required status for the important area of research in CMFRI, on a priority basis, before it is too late.

III. Human resources development

In order to ensure sustained yields from the exploited stocks, research in stock assessment needs to be strengthened; in this connection, manpower development in the area of stock assessment should receive greater attention. Similarly, frontier areas in mariculture (biotechnology, genetics, nutrition, physiology, pathology and endocrinology) deserve to be introduced at postgraduate and doctoral levels. The CMFRI with 189 scientists working in 8 need-based divisions at Headquarters as well as the Research centres along the country's coastline together with a large number of technical and other staff can implement these programmes under another Deemed University of Fisheries of ICAR. The complexity of Indian fisheries, the value of the fish stocks, the size of the population living on fisheries and the need to increase fish production to 7.2 m t by 2020 and the acute shortage of trained manpower for fisheries R & D warrant immediate action for enlarging the scope of fisheries education in the country through this initiatve.

IV. Introduction of new disciplines in ARS

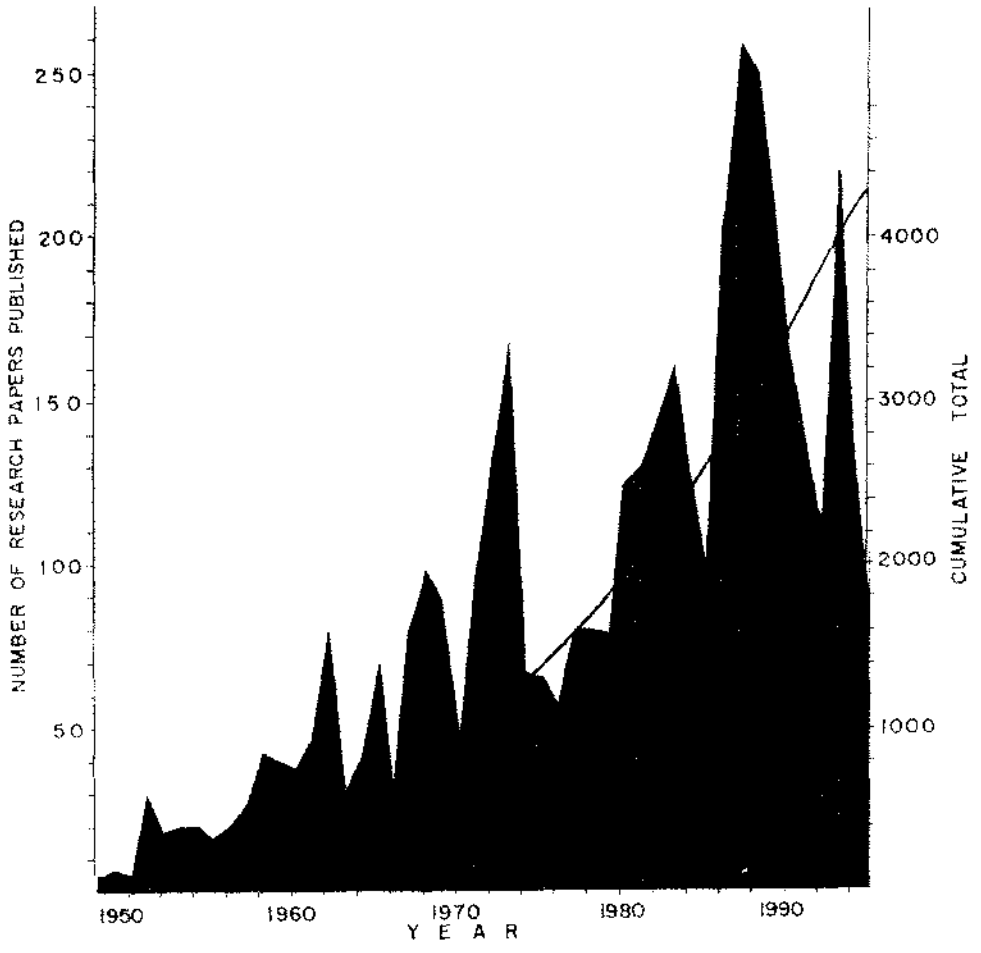
The lack of adequate number of scientists to carry out research in Oceanography, Marine Biology, Aquaculture and Fisheries Statistics and the lack of these disciplines under the ICAR system of recruitment suggest the need to correct this imbalance.

V. Technology transfer

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.

VI. Strong interinstitutional linkages and working groups

Linkages of the CMFRI with the CIFT, CIBA, NBFGR & CIFE under the ICAR; the NIO,CCMB, NII etc. of the CSIR and the Fisheries Colleges of the SAUs need to be strengthened through constitution of working groups. There must be constant interaction with the Departments of Fisheries and Fishermen Associations for speedier adoption of technologies of seafishing and seafarming and feedback.



Number of Research Papers Released from CMFRI every year from 1948 to 1995 and the cumulative annual growth.

SUMMARY

Marine Fisheries and mariculture sectors occupy a very important position in India's economy. The country is blessed with a long coast line of 8129 km., a vast exclusive economic zone (2.02 sq.km.), a potential yield of 3.9 million tonnes per year and an impressive infrastructure for harvest and postharvest operations. The annual marine fish landings have reached 2.41 million tonnes in 1996 valued at about Rs 7,230 crores against a fixed and operating cost of Rs 4,528 crores. The exports of marine fishery products reached 378,199 t valued at Rs 4,121 crores in 1996-97. Organised research in marine fisheries and mariculture started in 1947 with the establishment of the CMFRI. During this fifty-year period, a large database on marine capture fishery statistics, biology of exploited stocks, fishery environmental characteristics and economics has been built up. The database thus developed has been forming the basis for various marine fisheries development activities in the country.

Since the late seventies, the institute has been involved in the development of technologies for hatchery seed production and culture of marine shrimps, bivalves, seacucumber and seaweeds. Realising the importance of mariculture in increasing the total marine fish production progressively to about 5.0 million tonnes through the next five 5-year plans, the CMFRI has been taking appropriate steps over the past few years, to implement a programme of infrastructure development for mariculture research, technology transfer and training. Towards this objective, the institute is also carrying out education programmes leading to masters and doctoral degrees in mariculture for the past two decades, and training trainers as well as the farmers and fishermen in various seafishing and seafarming technologies for proper development, thus contributing to the HRD needs of the marine fisheries and mariculture sectors.