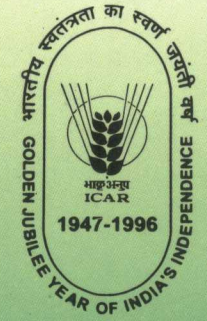
VISION-2020

CIBA
PERSPECTIVE PLAN



INDIAN COUNCIL OF AGRICULTURAL RESEARCH

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PERSPECTIVE PLAN

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FOREWORD

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

Aquaculture, on a global scale, has emerged as a significant fish producing sector, stepping in to make a major contribution to bridge the gap between demand and supply. It has been assumed that aquaculture should fill a gap of 62.4 million tonnes expected in the year 2025. It is a challenge both for the scientific community and for the aquaculturists to achieve the projected target through sustainable development.

Brackishwater culture in India is very recent. With a coastline of 8,129 km and vast brackishwater resources, there is immense potential for exploitation. In 1994-95, India produced 82,500 tonnes of shrimp by culture which contributed to earnings of about Rs.1500 crores as foreign exchange.

The Central Institute of Brackishwater Aquaculture was established by the Indian Council of Agricultural Research in 1987 to conduct research leading to development of techno-economically viable and sustainable culture systems. The Institute has made significant contributions to the development of production technologies for fish and shellfish culture and effective seed production.

Building up on the strengths and weaknesses of the existing base of the brackishwater culture sector and the R&D establishment, the Institute has prepared the Perspective Plan for the next 25 years. The document critically examines all the elements of production system in perspective and presents the research programme priorities in a time-frame.

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

May 6, 1997

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

PREFACE

The **Perspective Plan 1997-2020** of the Central Institute of Brackishwater Aquaculture, as presented in this document, is the final outcome of the two-year effort that was initiated in November 1994 at the Directors' Conference of the Indian Council of Agricultural Research. The Heads of Divisions / Units and Project Leaders at the Headquarters of the Institute at Chennai and the Officers-in-charge of the research Centres of the Institute at Kakdwip, Puri and Narakkal, besides the Administrative and Finance Wings of the Institute, drafted the Perspective Plan after detailed discussions with all their colleagues.

Following the guiding principles on Perspective Planning set by Dr.R.S.Paroda, Director General, ICAR, at the meeting of the ICAR Directors' Conference in July 1995, the draft Perspective Plan of the Institute was peer reviewed under the Chairmanship of Dr. P. V. Dehadrai, Deputy Director General (Fy), with external experts and Directors of the Fisheries Institutes of ICAR. The draft was revised based on the observations and recommendations of the above review.

Subsequently, the Perspective Plan of the Institute was further peer reviewed on 15th May 1996 at the Council under the Chairmanship of Dr. R. S. Paroda, Director General of ICAR and the specific observations and recommendations of the relevant aspects as reflected in the proceedings of the inter-divisional peer review meetings of the Perspective Plans of the ICAR Institutes, were incorporated in the Plan. The comments of the Research Advisory Committee of the Institute received during June 1996 have also been duly considered in finalising the Perspective Plan of the Institute. The present document would, thus, reflect the vision on the brackishwater aquaculture research requirements to meet the present and future challenges of the sector to be nationally and globally competitive, forward looking and visible for the next 25 years.

The Perspective Plan sets the theme for sustainable development of brackishwater aquaculture, identifies the issues involved and strategies to be adopted, and the R&D programmes to be undertaken with a time frame during the next 25 years to achieve the objectives and projections envisioned in the Perspective Plan. Periodic review, evaluation and mid-course corrections would become a necessary part of such long-term planning.

The Central Institute of Brackishwater Aquaculture is grateful to Dr.R.S.Paroda, Secretary to Government of India and Director General, ICAR, for his abiding interest and advice in the preparation of the Perspective Plan. Dr. P. V. Dehadrai, Deputy Director General (Fy), ICAR, has given his guidance at various stages of preparation of the document. The Peer Review Committee members and the Research Advisory Committee of the Institute have made substantial contributions to this effort. Our grateful thanks are due to them. I would like to record my appreciation and thanks to all my colleagues at the Institute for their devoted work during the two-year period in the preparation of this Perspective Plan.

Chennai
18th January, 1997.

(K. ALAGARSWAMI)
DIRECTOR, CIBA

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EXECUTIVE SUMMARY

The Central Institute of Brackishwater Aquaculture is one of the eight Institutes under the Fisheries Division of the Indian Council of Agricultural Research. It was established in 1987 to conduct research and provide technology support to the growing brackishwater aquaculture sector. The headquarters of the Institute is located at Madras and the Research Centres at Kakdwip (West Bengal), Puri (Orissa) and Narakkal (Kerala).

In the past eight years, the Institute has made significant progress in production technology for shrimp including seed, nutrition and feed development, diagnosis of fish and shellfish diseases and health management and shrimp farm environmental survey and impact assessment. The Institute has also made substantial progress in fish breeding and production besides opening up areas of reproductive and digestive physiology, enzyme kinetics, microbial fermentation, gene-probe based rapid diagnostic techniques, genetic selection etc. for multidisciplinary research. It has contributed to development of guidelines for brackishwater aquaculture at the national level. The Institute, despite several constraints of physical infrastructure, has established good laboratories with equipments and engaged in programme-mode research with 20 disciplines.

It is in the above background that the Perspective Plan of the Institute for the next 25 years has been prepared.

The **Mandate** will be towards supporting sustainable and responsible development of aquaculture in brackishwater systems in different agro-ecological-aquatic zones through eco-friendly, economically viable and socially acceptable culture technologies.

An analysis of **Impact Assessment** shows the rapid growth phase of brackishwater aquaculture since 1990 in area expansion, and increase in production, productivity and profitability of shrimp farming achieved by the sector which consists predominantly of small and marginal farmers. This phase was supported by indigenous technologies developed by the Institute, as well as by technologies adopted from outside by the corporate sector. During the last two years, the demand for indigenous technologies for solving the immediate problems of production has increased steeply due to disease outbreaks in shrimp farms.

The depiction of **Scenario** shows the vast potential of India along the 8,129 km long coastline for land-based brackishwater aquaculture; the compulsive need for rational utilisation of physical and biological resources with great diversity for increasing production from aquaculture to meet the seafood requirements for domestic consumption and for export and the long-term sustainability approach to the sector's development in future in view of socio-economic and environmental issues presently witnessed due to unplanned and unregulated development.

The **SWOT** analysis brings out the major aspects as follows: **Strengths** are (i) strong resource base of which only 10% is under utilisation; (ii) ever-increasing export markets for seafood; and (iii) well-planned and multidisciplinary research programmes with appropriate prioritisation on immediate problems and long-term prospective aspects of research. The **Weaknesses** are: (i) unplanned and

unregulated development of the sector; (ii) single commodity approach for higher profitability on the short-term by the industry; (iii) absence of proper extension network; and (iv) lack of critical mass support for R&D programmes. The **Threats** are: (i) socio-economic and environmental issues; (ii) absence of diversification of cropping system; (iii) disease outbreaks; and (iv) absence of quarantine and quality control system. The **Opportunities** are: (i) to improve upon culture production for the yet unexplored domestic market and expanding global market; and (ii) rational utilisation of diversity for sustainable development without affecting the capital resources.

The **Sectoral Perspective** shows a projected production potential of about 350,000 tonnes of shrimp, 250,000 tonnes of fishes, and 100,000 tonnes of other aquatic organisms including molluscs and seaweeds by 2020, as compared to the 82,500 tonnes level of shrimp in 1994-95. The export earnings from cultured shrimp and fishes are projected to reach an order of Rs 10,000 crores from the present level of about Rs 1,500 crores. Agro-ecological-aquatic zone approach would be essential for diversification and sustainable development.

The **Research Perspective** is towards intensification of present programmes and pro-active research on anticipated problems of the industry. Some of the other urgent issues are correct assessment of potential area through use of remote sensing data and GIS; diversification and cropping / farming systems approach; genetic improvement of stocks; pathogen-free and disease resistant broodstock; disease forecasting and health management; waste management through recycling, biofiltration and secondary aquaculture; post-harvest technology; quarantine and quality control system; and aggressive transfer of technology and information dissemination programme.

A **profile of the Institute** in terms of infrastructure development has been envisaged. Strengthening of existing divisions / sections and creation of new ones in a phased manner in the next 25 years has been planned. A reorganisation of the Institute has been suggested towards campus approach with the Headquarters for administration and common laboratories, library etc. at Chennai; major national facility of Experimental Station for fish and shellfish breeding, seed production and wet laboratories for genetics, physiology, nutrition and health at Muttukadu (near Chennai); major national facility for production technology, environmental management, etc. at the proposed new Research Centre at Polekurru in Andhra Pradesh; and the Eastern Regional Centre at Kakdwip for R&D programmes on traditional system. The West Coast developments in brackishwater aquaculture will be serviced through AICRP and networking programmes with the SAU system. **Programme Identification** with phasing on a time scale for the entire programme has been reflected in the PERT chart. Details of HRD requirements for training of scientists have been incorporated. Linkages have been spelt out with specific subject areas and institutions in India and abroad. The budget outlay for IX Plan has been proposed at Rs 3500 lakhs.

1. PREAMBLE

Fisheries development programmes in the world, during the last 100 years, had aimed at increasing production by improving the methods of *hunting* of fish. During the last 20 years, accent has been slowly shifting towards *farming* of fish. The global production of fish, shellfish and other aquatic organisms reached a peak of 104.6 million tonnes in 1989 and thereafter has shown a declining trend tending to stabilize at 100 million tonnes. The demand and supply gap is widening and farming of fish is being given a higher priority to bridge the gap. The situation in India is not far different from the global scenario.

India's fish production was 4.789 million tonnes in 1994-95. To meet the target of 11 kg/caput/annum fish availability for human consumption, India has to produce 6.367 million tonnes in 1996-97. The gap will continue to widen in future as increase from capture fisheries will not be substantial given the constraints of potential resources and their sustainable levels of exploitation. Therefore, aquaculture has been given a high priority in the recent Plan programmes of the Government (Union and States) and will be a thrust area in future.

Brackishwater aquaculture development in the country is hardly 10 years old, and it picked up momentum only during the last five years. Shrimp farming has been the only activity in view of its demand for export and, between 1990 and 1994, the growth has been rapid. Area under shrimp farming increased from 65,100 ha (this includes 52,000 ha under traditional system) to 100,700 ha and production from 35,500 tonnes to 83,000 tonnes during the above period. The sector has been supported by a number of shrimp seed hatcheries and feed mills, and ancillary industries. In 1994-95, cultured shrimp production contributed to about Rs 1,500 crores in foreign exchange, in a total of Rs 3,576 crores earned from the entire marine products exports.

The Central Institute of Brackishwater Aquaculture was established in 1987 by the ICAR to carry out research to provide R&D support to this sector. Since then, the Institute has made several strides in creating infrastructure, augmenting scientific and support cadre positions enlarging the disciplines, planning and execution of research programmes as per its mandate and for solving the immediate problems of the industry, initiating programmes in the conventional and the frontier areas of research for long-term sustainability of the industry and also a number of transfer of technology programmes.

It is in the above background, the PERSPECTIVE PLAN of the Institute for the next 25 years has been prepared. The possible lines of development and growth of the sector on a sustainable path have been considered in the projections made. Needless to state that periodic reviews and midcourse corrections will be applied as we go along. The Perspective Plan, however, is expected to have a reasonable validity as a reference document from now to year 2020.

2. MANDATE

- To conduct research towards supporting sustainable and responsible development of aquaculture in brackishwater systems in different agro-ecological regions.

- To develop eco-friendly and economically viable culture technologies towards greater productivity and production of fish, shellfish and other aquatic organisms in brackish water areas through a multi-disciplinary matrix approach to production and management.

- To provide policy support for environmental and natural resource management and socio-economic development related to brackishwater aquaculture activity.

- To develop a strong database and information management system.

- To undertake human resource development and transfer of technology programmes, and to provide consultancy service.

3. GROWTH

The Central Institute of Brackishwater Aquaculture (CIBA) was established in 1987 by transferring the Madras Research Centre, Kakdwip Research Centre and Puri Research Centre of the erstwhile Central Inland Fisheries Research Institute and the Narakkal Research Centre of the Central Marine Fisheries Research Institute. This was done under a re-organisation plan of Fisheries Institutes under ICAR for carrying out accentuated research and providing development support to a fast growing and expanding fisheries sector with diversification.

The Institute has been built up from a modest base of manpower and infrastructure to meet the challenges of a fast growing brackishwater aquaculture sector which has been rapidly gaining economic significance due to its export potential. It has made strident progress in every sphere of activity, despite several constraints and has emerged as a pioneer research organisation on brackishwater aquaculture looked towards by the farmers, industry, line departments of States, planners and policy makers for developmental, strategic and management support.

The Institute's permanent assets in 1987 consisted of an office-cum-laboratory building, experimental farm, residential quarters and guest house at Kakdwip Research Centre; and a semi-permanent office-cum-laboratory and experimental farm at Narakkal Research Centre. Since taking decision in 1989 that the headquarters of the Institute would be located at Chennai (Madras), efforts were directed at establishing permanent infrastructure facilities.

3.1 Infrastructure

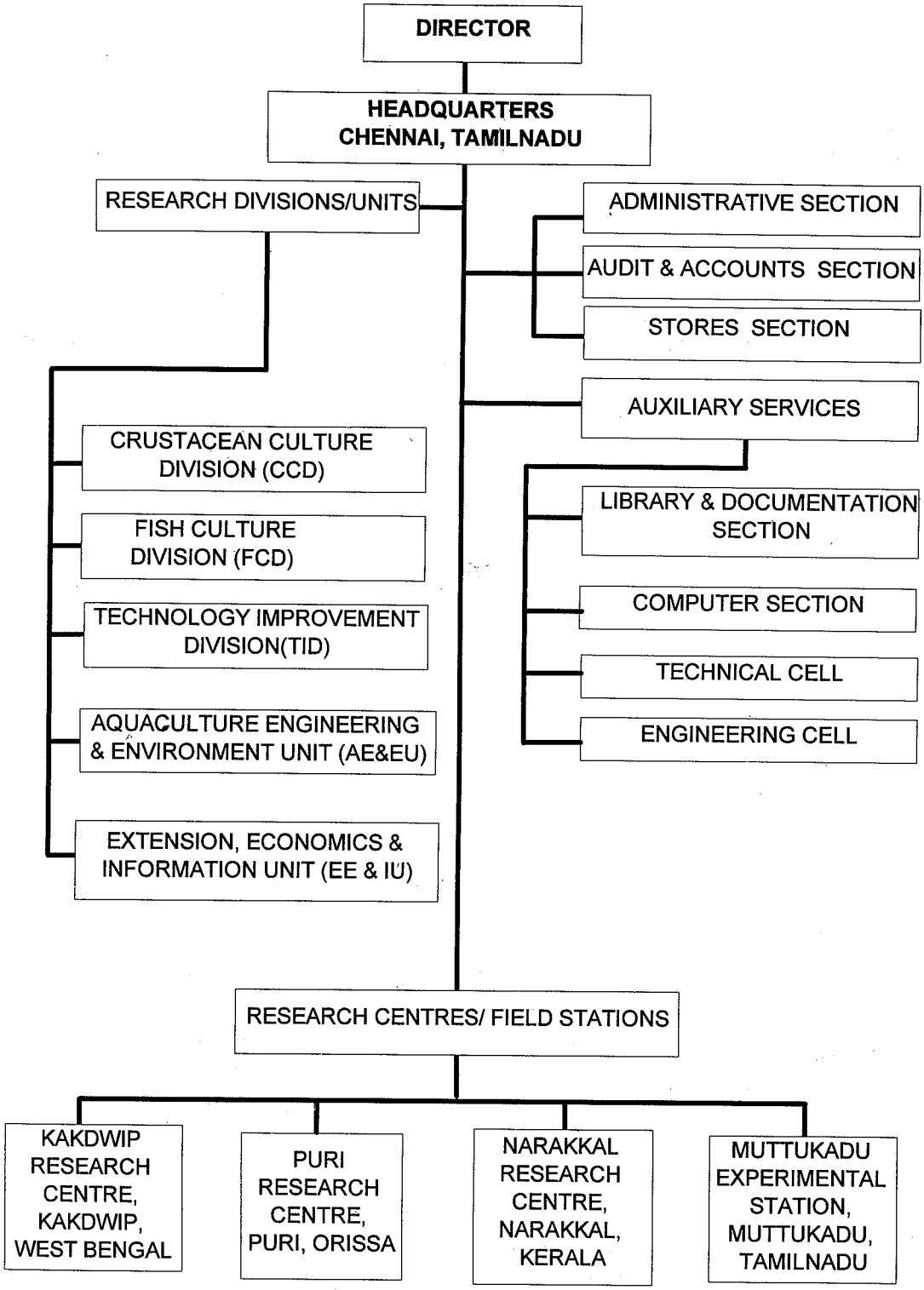
3.1.1 Laboratories

Pending construction of permanent laboratory-cum-administrative building at Chennai (Madras), laboratories have been established in a hired building. A Nutrition and Feed Laboratory has been fully equipped with sophisticated analytical and feed production equipments. A Central Instrumentation Laboratory has been created for research on biochemistry, biotechnology and genetics. The Pathology and Microbiology Laboratory is equipped for all types of bacteriological, mycological, histopathological and a good part of virological research. A general Chemistry Laboratory is provided for routine chemical analytical work required for different disciplines. A Computer Laboratory has been established for database work, routine scientific data analysis and rapid communication. Some amount of upgradation of Soil and Water Chemistry Laboratory has been carried out at Kakdwip Research Centre. Investment made on major laboratory equipments is of the order of Rs 1.75 crores which has been possible with the budget allocation of ICAR to the Institute and support received under externally funded schemes.

3.1.2 Library

As a new Institute, the library has been built up from an initial holding of 5 journals and 52 reference books. The library now has 940 reference books and subscribes for 33 international and

CENTRAL INSTITUTE OF BRACKISHWATER AQUACULTURE
Organisational Chart



33 Indian journals. It has exchange programmes with national and foreign institutions and several publications are added gratis.

3.1.3 Field

Another most significant area of growth has been the creation of working field facilities at Muttukadu, about 35 km from Chennai (Madras) where the Institute has a total area of 49.10 ha with a seafront which forms the ground for all its present technology development programmes. A part of the lagoon area is utilised for pen and cage culture and for captive shrimp and fish broodstock development. The major features of infrastructure development at this field station are mentioned under section 3.1.4 (Buildings.) The investment made on these facilities has been of the order of Rs 1.40 crores. The Institute has also planned to develop a 35 ha experimental farm complex at Polekurru, in Andhra Pradesh.

3.1.4 Buildings

Since the formation of CIBA, the following buildings were developed at the Muttukadu Experimental Station:

(i) Field laboratory building which houses facilities for research on Soil and Water Chemistry, Nutrition, Pollution and Biology, (ii) Shrimp Hatchery, Nursery and Effluent Treatment facility (iii) Wet laboratories for experimentation in Nutrition, Genetics and Disease Diagnostics (iv) Essential Staff Quarters (6 nos.) and (v) Fish Broodstock Holding Tanks and Fish Hatchery.

3.1.5 Vehicles

To the 4 old jeeps transferred to the Institute in 1987, one Ambassador car and one Mini Bus have been added during the last 9 years. Three of the old jeeps have been replaced with new ones.

3.2 Budget

(Rs. in lakhs)

Plan period	Plan	Non-plan	Others*	Total
VII Plan				
(1985-90) Actuals	93.50	130.76	.---	224.26
Rolling Plan				
(1990-91) Actuals	34.96	68.85	1.00 @	104.81
(1991-92) Actuals	49.26	71.85	0.35 @@	121.46
VIII Plan				
(1992-97)				
Budget outlay	900.00	590.00	113.66 ~~	

* Externally funded schemes

@ FAO - Other international funded scheme

@@ AP Cess I - Emeritus Scientist Scheme

~~ Different external sources funding (Department of Biotechnology, NARP, World Bank Project)

3.3 **Manpower** (Sanctioned strength)

Plan period	Scientific *	Technical	Administrative	Auxiliary	Supporting	Total
VII Plan (1985-90)	47	33	20	6	89	195
Rolling Plan (1990-92)	62	33	20	6	89	210
VIII Plan (1992-97)	65	33	26	9	89	222

* Excluding 1 RMP post of Director

The most significant aspect of growth in manpower is the diversification from a total 2 disciplines in 1987 to 20 disciplines at present required for matrix-driven research programmes on brackishwater aquaculture.

The cadre position of scientists at the Headquarters and Research Centres, including discipline-wise and grade-wise position, is shown in Annexures 1 & 2

4. SALIENT RESEARCH ACHIEVEMENTS

The research programmes of the Institute are carried out under five divisions *viz.,* Crustacean Culture Division, Fish Culture Division, Technology Improvement Division, Aquaculture Engineering and Environment Division and Extension, Economics and Information Division. About 15 major research programmes have been implemented under the Institute's budget.

Concurrently, the Institute has been able to propose and get a number of externally sponsored and funded research schemes falling within the purview of its mandate. These are:

- **FAO/Bay of Bengal Programme:** Development of water-stable shrimp feed for artisanal sector (1989-90).
- **FAO/Bay of Bengal Programme:** Study of shrimp fry by-catch in West Bengal (1990-91).
- **Department of Biotechnology, Govt. of India:** Quantitative requirements of amino acids and fatty acids for the prawn *Penaeus monodon* and use of additives in grow-out feeds for improving feed efficiency and growth promotion (1991-94).
- **Department of Biotechnology, Govt. of India:** Development of feed technology for semi-intensive and intensive shrimp farming (1992-96).
- **ICAR Cess Fund Scheme:** Impact of brackishwater aquaculture on environment (1992-95).
- **ICAR/IBRD/NARP:** Basic Research Sub-project on Aquaculture - Identification and characterisation of digestive and gut microbial enzymes in brackishwater fish and prawn and enzyme-mediated bioconversion of feed ingredients (1992-96).

Achievements

Production technology

- Higher production rate (1.2 t / ha / crop) of tiger shrimp in tidal fed extensive culture
- Semi-intensive culture of tiger shrimp (4-5 t / ha / crop) demonstration-collaboration with MPEDA
- Mono- and polyculture of fish grey mullets under tidal fed culture
- Pen/pond culture of milkfish
- Culture of seabass with forage fish in tidal fed ponds
- Backyard and small-scale hatchery technology for shrimp seed production
- Captive shrimp broodstock development under pond conditions
- *Artemia* biomass and cyst production in saltpan areas
- Broodstock development of seabass and grey mullets
- Pearlspot seed production and integrated fish-poultry production

Nutrition and Feed Development

- Database on available marine protein resources as raw material for shrimp feed production
- Quality evaluation of animal and plant products and by-products as raw material for shrimp and fish feed production
- Dietary requirements of shrimp *(P. monodon* and *P. indicus)*
- Balanced feed formulations for extensive and semi-intensive culture of shrimp
- Microparticulate feeds for shrimp larval and postlarval rearing
- Maturation diets for shrimp *P. monodon*
- Development of mineral and vitamin-mix as feed component
- Identification and incorporation of growth promoting substances and attractants in feed
- Bioconversion of feed ingredients for enhancement of digestibility
- Use of exogenous enzymes in feed preparation

Shrimp and fish diseases and health management

- Survey and monitoring of shrimp farms for disease occurrence and outbreaks, and database
- Development of conventional diagnostic techniques (clinical microbiology and histopathology) for bacterial, fungal, viral and parasitic diseases
- Immuno-diagnostic tests on bacterial diseases in shrimp
- Bacterial and parasitic (trematode) diseases in fish broodstock (seabass and grey mullet) and control
- Basic research on defence mechanism against diseases in shrimp
- Disease epizootics related to environmental degradation in shrimp ponds
- Basic research in development of rapid diagnostic techniques (DNA probes and PCR) for shrimp diseases
- Prevention of disease outbreaks through stock and environmental management

Shrimp and Fish Physiology and Genetics

- Digestive and gut microbial enzymes - identification and activity levels in shrimp *P. monodon* and fish *Mugil cephalus*
- Development of techniques for cryopreservation of milt of fishes *M. cephalus* and *Liza parsia*
- Construction of cDNA library for different fractions of RNA from thoracic ganglion of shrimp *P. monodon*
- Artificial insemination and *in vitro* fertilisation in shrimp *P. indicus*
- Initiation of genetic selection for growth characteristics in shrimp *P. monodon*

Shrimp farm environmental survey and impact assessment

- Environmental survey of shrimp culture sites and shrimp farms; database on soil and water quality
- Organic matter and nutrient loading in shrimp farms of extensive, semi-intensive and intensive types during initial, culture and harvest phases
- Standards evolved for brackishwater aquaculture farm effluents discharged into receiving coastal waters (sea / creek)
- Productivity management in brackishwater aquaculture through simulated yard experiments
- Assessment of environmental impact of brackishwater aquaculture and database on environmental management
- Technical assistance to Government of India and State Governments (Tamil Nadu and Andhra Pradesh) in evolving guidelines for sustainable development of brackishwater aquaculture and regulations

Economics and Extension

- Database on brackishwater aquacultural practices, production and economics
- Development of in-house software for data entry and retrieval
- Optimisation of input use and output for sustainable development - State-wise and system-wise analysis and report
- Conduct of training programmes in several technology areas
- Publication of extension literature for farmers on sound farming practices

5. IMPACT ASSESSMENT

5.1 Growth

Crop / Commodity

From a traditional type of activity, brackishwater aquaculture has grown into a respectable industry practised by small and marginal farmers as also by the corporate sector. Area under production has doubled from about 50,000 ha (traditional system) to 100,000 ha during the decade, much of that growth from about 70,000 ha to 100,000 ha took place between 1992-93 and 1994-95. Shrimp production increased from about 30,000 tonnes in 1989-90 to 83,000 tonnes in 1994-95. Contribution of cultured shrimp to exports reached 45% of the total shrimp exported in quantity and 60% of the foreign exchange earned due to shrimp. Although there has been a setback in production in 1995-96 (about 70,000 tonnes) due to several factors, it is considered a temporary phase. Concomitant with the above growth in commodity, there has been all round development in hatcheries for shrimp seed production, feed mills for shrimp feed, ancillary industries in aquaculture engineering, drugs and chemicals marketing, processing and export activities. Over 300,000 jobs have been generated in the main and supporting sectors.

Discipline / Area / Science

The above growth in brackishwater aquaculture has largely been due to research and development efforts of the Fisheries Research Institutes of the Indian Council of Agricultural Research and the Fisheries Division of the Department of Agriculture and Cooperation of the Union Ministry of Agriculture which are the nodal agencies of the country for the two areas respectively. Prior to the establishment of CIBA in 1987, the Central Inland Fisheries Research Institute (CIFRI) had carried out extensive studies on the fisheries resources, biology and ecology of the major estuarine systems of the Hooghly-Matlah, Mahanadi, Godavari and Krishna rivers and the brackishwater lakes of Chilka and Pulicat. These studies provided a wealth of information which forms the basis to aquaculture in these ecosystems. A major programme was undertaken by CIFRI during 1972-1985 for developing technologies for brackishwater farming in different agro-ecological regions under the All India Coordinated Research Project (AICRP) on Brackishwater Fish Farming. The project established the basic technology for fish and shrimp culture under tidal-fed, low-input (seed, feed and management) production system. The findings made an impact on the development of extensive shrimp farming in some areas of Orissa, Andhra Pradesh and Tamil Nadu.

The Central Marine Fisheries Research Institute (CMFRI) concentrated its efforts on development of technology for shrimp breeding and successfully bred a number of species under laboratory conditions. It made significant contributions to hatchery technology for the white shrimp *Penaeus indicus* seed production.

The new growth phase of shrimp culture for higher production, productivity and profitability commenced along with the establishment of CIBA. The technology and information needs for semi-intensive and intensive culture for production levels of about 4-5 t / ha / crop (4 months) became very demanding. A new Institute, without adequate infrastructure and trained manpower to start with, had to meet the challenges of this growth phase. Brackishwater aquaculture has been practised on empirical basis as a state-of-art, but the problems encountered proved the need for a deep and sound scientific basis. This needed a multidisciplinary approach.

The area of research has been expanded to include strategic research on production of seed and crop of a number of species of shrimp and finfish; nutrition and feed technology; fish and shrimp diseases, their etiology, prevention and control; pond ecology and productivity; environmental impact assessment and social science to mention the important areas. Simultaneously basic research in digestive and reproductive physiology, metabolism, enzyme systems, microbial fermentation and immune systems has been conducted.

Human resource development was achieved through training of scientists in advanced research laboratories in India and abroad in specialised areas.

5.2 Input / Output Assessment

The inputs have been the research programmes in priority areas of brackishwater aquaculture with focus on technical programmes which are immediately relevant to the production sector. These were in the broad areas of shrimp seed production technology; shrimp broodstock development; fish broodstock development in captivity; production technology for shrimp and fish; feed formulation and feed production technology; fish and shrimp disease diagnosis and health management; shrimp farm environmental management and impact assessment; basic research on nutrition, enzyme kinetics, bioconversion of feed ingredients and immune system to support above areas of applied research; and database on brackishwater aquaculture practices and production. These efforts were in the right direction and in consonance with the needs for technologies and information.

The outputs from the above programmes have been the technology packages wherever the results have been conclusive to a satisfactory level. Such examples are the backyard and small scale hatchery technology for *Penaeus indicus* seed production; formulated feeds for extensive and semi-intensive culture of *P. monodon; Artemia* cyst production; disease diagnostic techniques through microbiology and histopathology and water and soil quality standards. These have been transferred to the industry and farmers through technical assistance, training, publications and extension literature. At Government policy level, the Institute has played a very significant role in development of guidelines for sustainable aquaculture, in developing standards for aquaculture effluents and in furnishing scientific facts and data on coastal environmental aspects related to brackishwater aquaculture.

Some of the researches are on the verge of yielding results shortly, e.g. technology for closing the life-cycle of shrimp *(P. monodon)* under captive conditions; pond / tank - reared broodstock development of fishes seabass and grey mullet and hatchery technology for fish seed production.

Certain other areas of research which have recently been initiated have to be continued, e.g. development of DNA probes for rapid diagnosis of bacterial and viral diseases; microbound larval diets; genetic selection; and microbial fermentation technology for feed quality improvement.

5.3 Short - comings

The Institute has worked under constraints of inadequate infrastructure of laboratories and field facilities. The inordinate procedural delays in getting lands from the State Governments have been a major hurdle in physical infrastructure development. Human resource development in specialised areas takes a long gestation period and opportunities in needed areas have been few. There has been imbalance in cadre strength and positions. There has been inadequate interaction with the industry and farmers and the demands of the sector could not be met satisfactorily. The State-level mechanism for extension in the Fisheries Departments has been very weak and could not absorb technologies and information available at the Institute, with some exceptions.

The shrimp culture industry itself was in a state of euphoria with liberal imports of feed, equipment etc. as also with joint ventures and franchise schemes allowing overseas consultants and technicians to establish themselves everywhere. This was short-lived as the problems cropped up due to unplanned and unregulated development and unsound technologies. The Institute has to step-in in a responsible manner as the industry has realised the mistakes made while pursuing unsustainable technology practices.

5.4 Lessons learnt, suggestions and options for future

- Speeding up and completion of infrastructure of Institute
- Provision of a balanced cadre strength and positions in all cadres
- Creation of opportunities for human resource development in identified areas of specialisation and work needs
- Improvement of mobility of scientists for field-oriented programmes considering the fact that monitoring of and providing services to brackishwater aquaculture has to be carried out along a long coastline of 8,129 km.
- Further strengthening of multidisciplinary research by discipline-specialists with fishery science orientation as in the case of agriculture and animal sciences to be developed by the SAU system and the Deemed University in Fisheries.
- Social and environmental issues related to land-based coastal aquaculture have received public attention. Future development of brackishwater aquaculture would depend entirely on sustainable technologies.
- Programmes on integrated coastal area development, master plan preparations and zonation with available tools of Remote Sensing and GIS should be taken up and support of the Institute should continue to be available to the planners in taking policy decisions.
- Research on diversification of species as candidates for culture, with accent on fish culture and polyculture, should receive high priority. This strategy would help control spread of epizootic diseases. Natural endowments of aquatic ecosystem and species shall be considered.

- Aquaculture cropping system research should be fostered.
- Research by the groups on physiology, nutrition, reproduction, genetics, biotechnology, pathology, health management and environment needs further strengthening with critical mass needs of manpower and their integration with production technology groups for effective multidisciplinary orientation.
- Research on quarantine system and quality control should be taken up.
- Aquaculture engineering research is presently weak and requires to be strengthened for providing cost effective and environment friendly designs for production systems.
- Social science, Economics and Extension research should be strengthened to provide an effective extension and information service to the farmers and industry.
- An increased interaction with farmers, NGOs and line departments and industry-sponsored research should be facilitated.

6. SCENARIO

6.1 Strengths

Resource base

India has vast potential for brackishwater aquaculture. In *physical* terms, the country has a long coastline of 8,129 km; a number of brackishwater lakes most important of which are the Chilka Lake, Vembanad Lake and Pulicat Lake; estuarine systems formed by the major rivers confluencing with the sea and an estimated potential area of 1.19 million ha amenable for brackishwater aquaculture. The coastal area of the country has 2.54 million ha of salt-affected soils which are unfit or only marginally fit for agriculture, excluding 0.57 million ha under mangroves.

Besides the coastal agro-ecological zones (Eastern and Western Coastal Plains and the Andaman and Nicobar and Lakshadweep Island zones), there are large tracts of salt-affected land in the hot, semi-arid eco-region of Northern Plain and Central Highlands in the States of Haryana, Rajasthan and Uttar Pradesh, with surface and sub-soil brackishwater. These resources are also to be considered for their aquaculture potential albeit cautiously in regard to environmental concern.

In *biological* terms, there are diverse species resources of crustaceans, fishes, molluscs and aquatic plants in different agro-ecological regions which are well suited for brackishwater aquaculture. The tropical / sub-tropical climate of the country provides a natural advantage of faster growth of the aquatic organisms. There are more than 10 species of shrimp, 8 species of finfish, 2 species of crab and a few species of seaweed in Indian waters. At present, farming of only two species of shrimp is done in India, the rest being available for taking up in future.

Production

Global data on aquaculture production demonstrate the increasing importance of culture operations and the share of cultured aquatic organisms reached 18.5% of the total world fisheries production in 1992. Asia provided 88.2% of the global volume of cultured aquatic organisms in that year. In the background of dwindling catches from capture fisheries, it has been assumed that aquaculture should fill in a gap of 19.6 million tonnes in 2000, 37.5 million tonnes in 2010, and 62.4 million tonnes in 2025, based on the predictions that (i) world population will reach 8.5 billion in 2025, (ii) production from capture fisheries will level off at 100 million tonnes, and (iii) demand for fish and seafood will have to stay at 19.1 kg / caput / year. During the past decade, it is encouraging to note that aquaculture was by far the fastest growing food production sub-sector in the world. Brackishwater aquaculture, though recent among aquaculture activities, has gained the greatest importance in view of significant production of shrimp for export from the developing to the developed countries.

In 1994, the world's cultured shrimp production was estimated at 733,000 tonnes and Asia contributed to 80% of this total. The major shrimp producers in Asia were: Thailand (225,000 tonnes), Indonesia (100,000 tonnes), India (70,000 tonnes), Vietnam (50,000 tonnes), China (35,000 tonnes),

Bangladesh (30,000 tonnes) and Taiwan (25,000 tonnes). In the Western Hemisphere, shrimp culture production was from Ecuador (100,000 tonnes), Mexico (12,000 tonnes), Colombia (10,000 tonnes) and Honduras (10,000 tonnes).

India is one of the major exporters of marine products. In 1994-95, India exported 3,07,368 tonnes of marine products fetching foreign exchange equivalent to Rs 3575.91 crores. Frozen shrimp which is the most important export item accounted for 70.73% of the foreign exchange with only 34.47% of total volume exported during 1993-94. In 1994-95, cultured shrimp contributed to more than 45% of quantity and 60% of the value of shrimp exports of India. The world demand for shrimp has ever been on the increase. Our major markets have traditionally been Japan and the USA, and the European Union countries have recently become customers for Indian marine products.

The per capita availability of fish in India is 8.11 kg / annum against 19.1 kg / caput / year projected global demand for fish and seafood. The increase in per capita availability of fish and seafood has to largely come from aquaculture.

Multidisciplinary research

Our research programmes are well founded on a multidisciplinary approach and in some of the important areas there has been anticipatory research which have become useful in time. Besides CIBA, a number of laboratories under SAU system and academic institutions have research programmes in related areas which can be brought under networking for achieving early results.

6.2 Weaknesses

- Unplanned, unregulated development of shrimp farms in the private sector and consequent social issues in certain areas and alleged environmental impacts in areas of over-concentration of farms. More than 80% of the activity is concentrated on the east coast. One single State (Andhra Pradesh) has about 50% of the total area.
- Most of the coastal areas do not have infrastructure facilities such as roads, electricity, communication and even drinking water is scarce. Farms have to function under extreme conditions.
- The industry has grown based on a single commodity (shrimp) and total export orientation and neglected the large potential for diversification and domestic market.
- There has been an overplay of expatriate consultants and technicians and unrestricted import of materials resulting in suppression of indigenous input supply and service sector as also skill development.
- Although an extension system (Brackishwater Fish Farmers Development Agencies) is in place, it has remained weak on technology front.
- The industry does not come forward to sponsor research projects. More than 85% of the land area under brackishwater aquaculture is stated to be with the small farmers.
- The science of aquaculture is itself very young and has to grapple with many interacting problems unique to the aquatic organisms and ecosystems.

6.3 Threats

» Social and environmental issues to be sorted out through informatics and technology interventions for sustainable development.

» Eco-planning and eco-restorative programmes which are not given importance today should be resorted to in future.

» Without diversification and alternation of crops, the industry based on single species and export orientation alone cannot be sustained.

» Post-GATT / WTO issues will have to be considered appropriately.

» Quarantine mechanism and quality control for aquaculture species and products are not available now.

» Major input supplies of seed and feed do not match the regional requirements. Feed would be a major constraint in view of its quality requirements for aquatic animals.

» Epizootic diseases have already appeared in the shrimp farms all along the coastline affecting production and economy and could pose threats from time to time unless preventive, control and management measures are adopted. Cooperative action by farmers is very essential.

» Although all-round research programmes have been initiated, some of them need time to deliver technology packages.

6.4 Opportunities

» India has a reputation in marine products export in the world market and has almost unlimited opportunities for improving its performance from the present US $ 1 billion to take a larger share of world market which is of the order of US $ 50 billion, through brackishwater aquaculture of shrimp, fish and other commodities.

» Cultured shrimp, in 1994-95, accounted for foreign exchange earnings of about Rs 1,500 crores, in the total of Rs 3,576 crores earned from marine products exports. While export earnings will continue to rise the contribution from cultured shrimp will increase substantially.

» Consumers are prepared to pay higher prices for seafood which is considered health food as compared to meat and poultry and hence market expansion is assured.

» The distinct coastal ecosystems and species resources provide great opportunities for diversification. Since land-based aquaculture production system works with brackishwater as well as seawater, product spectrum can be very large to include many conventional and non-conventional species to contribute to food security as well as exports.

» Although the tentative estimate of potential area is 1.20 million ha, considering the existence of over 3 million ha of salt-affected areas in the coastal zone, the potential would be much larger. The current area utilisation is only 0.10 million ha.

» Potential for fish production has hardly been touched and this is an area of abundant opportunity for raising production.

» CIBA, with a multi-disciplinary research base, has great opportunities and responsibility, to develop centres of Excellence in many areas such as Fish Health Management, Nutrition and Feed, Aquaculture Biotechnology and Environment Management, to serve the growing critical needs of the industry.

7. PERSPECTIVE

Sector Development

Brackishwater aquaculture has emerged as a major food production sector playing a very important role in India's marine products export trade. It can safely be assumed that the ever-increasing demand for shrimp in the international market will continue to maintain the trend.

The potential for fish culture in brackishwater systems has not been exploited at all. The industry has already realised the need for diversification for production of fishes, crabs, molluscs and seaweeds, besides taking up a larger number of species of shrimp. This is a healthy trend not only for enhancing production of these crops, but also for sustainable development of aquaculture through rotation of crops, polyculture and integrated farming.

By 2020, brackishwater aquaculture production is expected to reach about 350,000 tonnes of shrimps and 250,000 tonnes of fishes as shown below. Other non-conventional groups together would contribute to about 100,000 tonnes, molluscs and seaweeds being the major components.

Period	Area (ha)	Production rate (tonnes/ha)	Production (tonnes)	Shrimp : Fish Ratio	Production (tonnes) Shrimp	Fish
1990-91	65,100	0.545	35,000	1 : 0	---	---
1991-92	68,227	0.581	40,000	1 : 0	---	---
1992-93	70,700	0.665	47,000	1 : 0	---	---
1993-94	82,500	0.752	62,000	1 : 0	---	---
1994-95	100,700	0.824	83,000	1 : 0	---	---
1995-96	100,700	0.695	70,000	1 : 0	---	---
1996-97	100,000	0.800	80,000	1 : 0	---	---
Projections :						
2001-02	150,000	1.000	150,000	1 : 0.1	136,000	14,000
2002-07	200,000	1.250	250,000	1 : 0.2	208,000	42,000
2007-12	250,000	1.500	375,000	1 : 0.4	268,000	107,000
2012-17	300,000	1.750	525,000	1 : 0.6	328,000	197,000
2017-20	330,000	1.800	594,000 *	1 : 0.7	349,000	245,000

* Another 100,000 tonnes of molluscs, aquatic plants etc. is likely to be produced by the farmers through aquaculture.

Brackishwater aquaculture depends on a number of industries to supply inputs, support production and post-harvest technology and marketing (internal / export).

CIBA - profile

The role of CIBA will increasingly become science, technology and information intensive to serve the exacting demands of brackishwater aquaculture industry. It will also be called upon to set the directions, and sustain responsible development of aquaculture, responsible to the society and to the environment, besides to the production sector.

Towards this, the programmes of the Institute will have to be enlarged, strengthened and re-oriented from time to time to address current problems and carry out anticipatory and futuristic research. The profile of the Institute is envisaged as follows:

Infrastructure

Building up of modern laboratories and providing them with equipments and facilities for research on culture biology of various candidate species, genetics, physiology, nutrition, biochemistry, microbiology, pathology, virology, immunology, biotechnology, biodiversity, genetic engineering, vaccine production, quality assurance, quarantine, water technology, soil science, environment, pesticide, pollution, remote sensing applications, geographic information system, aquaculture engineering, social sciences, economics, data centre, extension and information technology and computer application.

Infrastructure for experimental and pilot-scale production systems - captive broodstock (on-shore and off-shore); breeding; seed production; closing of life cycle in captivity; feed processing and production; health management; organic farming; integrated farming; culture production to market; waste recycling; biofiltration; industrial intensive production systems; effluent treatment and secondary aquaculture; computerised and probe-based monitoring and automation of production systems as required; and demonstration and training.

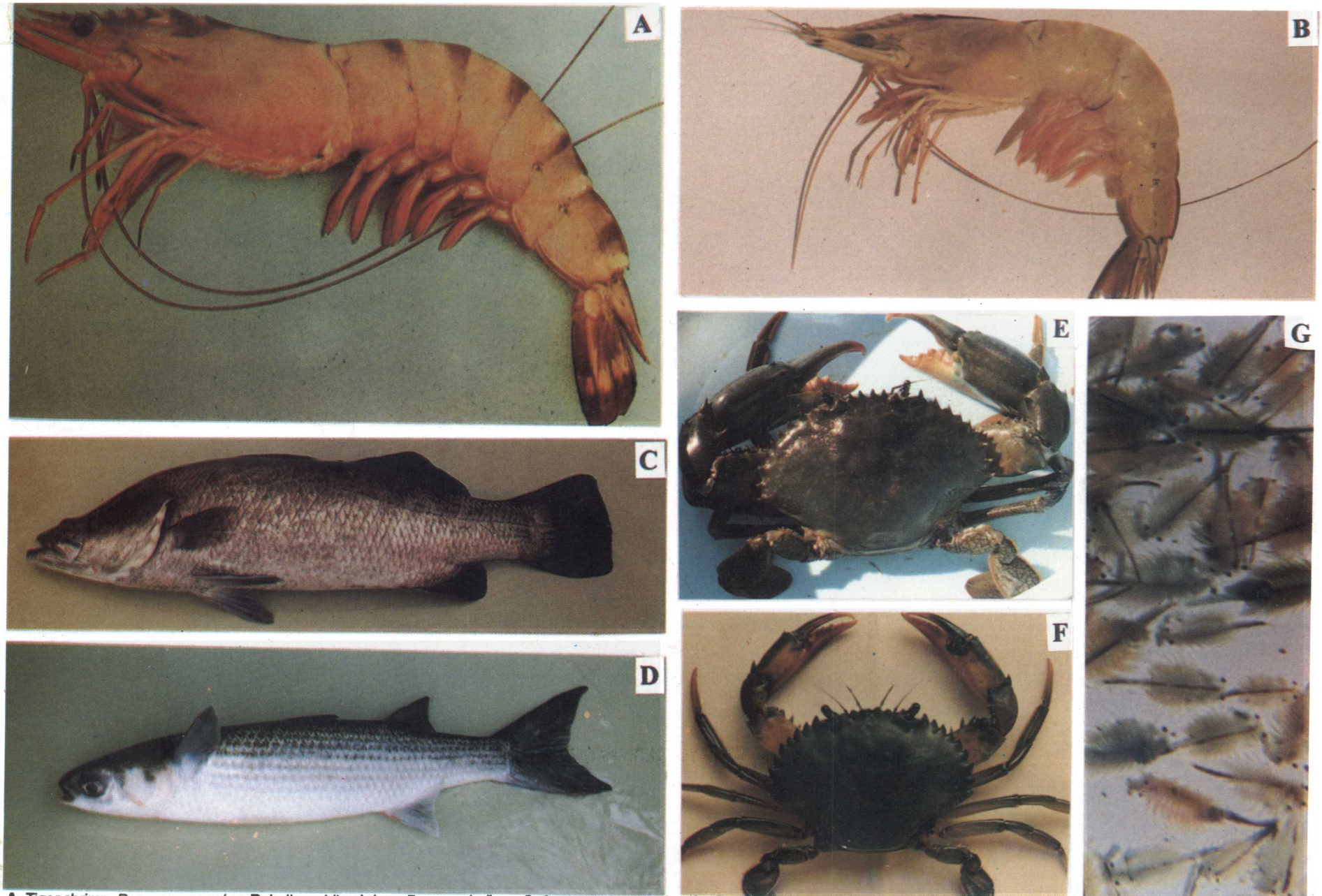
Research Divisions / Sections

The Institute will have the following Divisions by 2020. However, these Divisions will have to be created in a phased manner during the next 25 years. In the IX Plan, the new Division proposed is Quarantine and Quality Control Division only. The other sections / units will be strengthened to qualify for Divisional status in the future.

- Programme Implementation, Monitoring and Coordination
- Crustacean Production and Management
- Fish Production and Management
- Integrated Production and Management
- Physiology and Reproduction
- Nutrition and Feed Technology
- Fish and Shellfish Health Management
- Genetics and Breeding

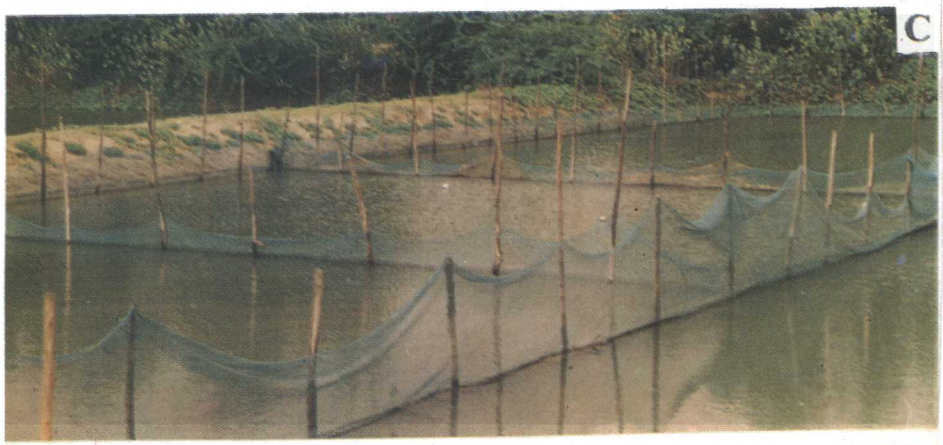
Technology Project (NATP), AHRDP, Krishi Vigyan Kendras (KVK), Trainers' Training Centres (TTC), Lab-to-Land Programme (LLP), National Demonstration Programmes and Training Programmes. The philosophy, programmes and accents are different among these, and the right types of programmes suited to brackishwater aquaculture which will be relevant and effective to its particular situation should be chosen.

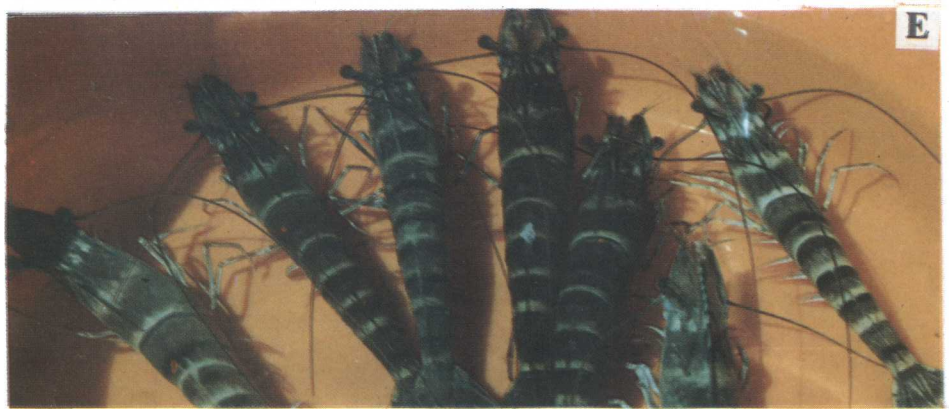
Given the spread of aquaculture along the over 8,000 km long coastline, it will be necessary to have Regional TOT Centres with infrastructure and manpower to draw and absorb technologies from the research system, to carry out adaptive research, to conduct demonstrations and to provide training and extension support to the development programmes in the States. It is important to involve NGOs in extension programmes.



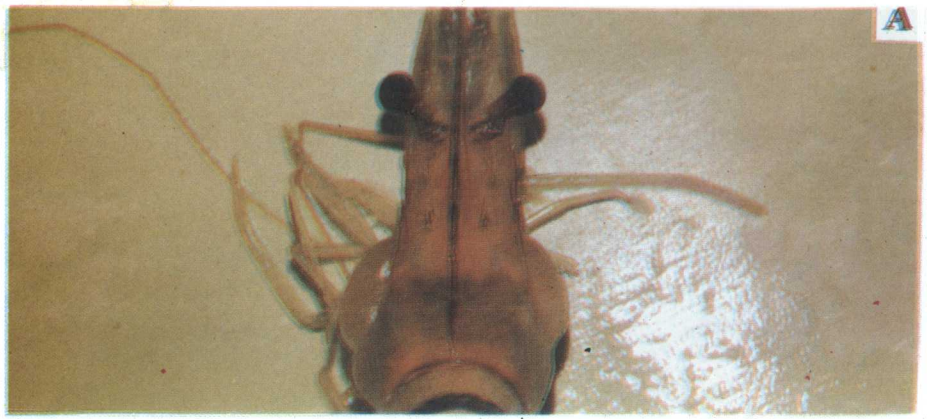
A. Tiger shrimp, *Penaeus monodon*. **B.** Indian white shrimp, *Penaeus indicus*. **C.** Seabass, *Lates calcarifer*. **D.** Grey mullet, *Mugil cephalus*. **E.** Larger species of mud crab, *Scylla tranquebarica*. **F.** Smaller species of mud crab, *Scylla serrata*. **G.** Brine shrimp, *Artemia* sp.

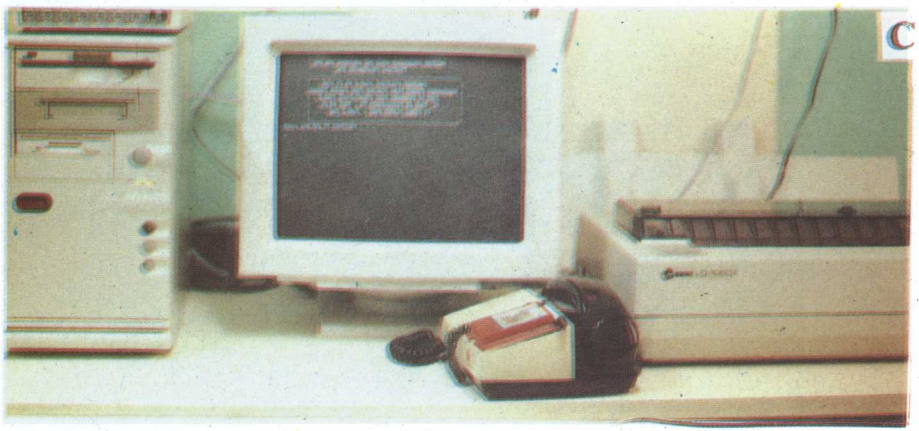
A. Laboratory building (Muttukadu). **B.** Shrimp hatchery complex (Muttukadu). **C.** Experimental tide-fed farm (Kakdwip), **D.** Fish broodstock holding facility (Muttukadu).
E. Staff quarters (Kakdwip). **F.** Staff quarters (Muttukadu).

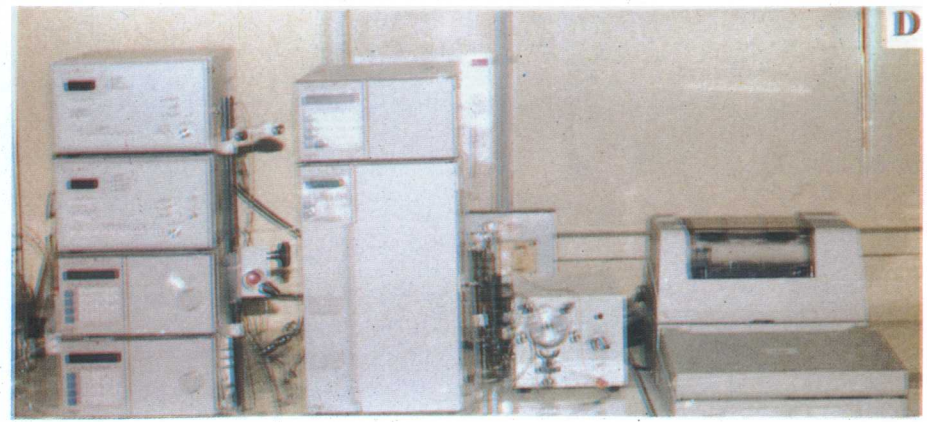




A. Narakkal Research Centre, Kerala. **B**. Experimental pond with windmill for pumping saline water (Muttukadu). **C**. Pen culture of mud crab, *Scylla tranquebarica* (Muttukadu), **D**. Pen culture of milk fish *Chanos Chanos* (Muttukadu). **E**. Broodstock of tiger shrimp *Penaeus monodon*. **F**. Induced maturation method for tiger shrimp.







A. Cultured tiger shrimp *Penaeus monodon* affected with bacterial septicaemia.
B. Cultured tiger shrimp with white spot disease.
C. Computer with E-mail facility.
D.'SHIMADZU' High Performance Liquid Chromatograph.
E. Institute developed feeds for Shrimp.
F. Training programme in shrimp hatchery technology.

8. ISSUES AND STRATEGIES

Some of the major issues and strategies are given below:

Fresh assessment of potential for brackishwater aquaculture at national level : Examination of Thematic Maps from Satellite Imageries; use of GIS and Ground Truth Data; establishment of Dedicated Centre on Remote Sensing Applications for brackishwater aquaculture development; Land use laws; Environmental and related Acts; Coastal Zone Management Plans of the States. On the basis of all the above aspects, make a fresh assessment of the potential for brackishwater / coastal aquaculture development.

Welfare of coastal communities : Social Sciences research; strategies with technologies for community-managed production programmes; Panchayat-managed programmes for lands under jurisdiction; Economic research on equity; Institute-Village Linkage Programme (IVLP) under Panchayati Raj and other public funded rural development programmes; development of working models; helping multiplier effect along coastal areas.

Eco-system based production programmes : Preparation of models of different coastal ecosystems with climatic and aquatic regimes and optimal production systems largely with local resources and species; testing and development of technology packages under All India Coordinated Research Projects (AICRP); Implementation of National Agricultural Technology Project (NATP) on coastal ecosystem - integration of aquaculture and plantation crops.

Diversification of production : Development of technologies for production of seed and production for market of different species of shrimps, other crustaceans, fishes, seaweeds and others of economic value which could be cultured under land-based pond systems; polyculture of shrimp / fishes / seaweeds; alternation of crops; production for export; production for domestic market to enhance nutritional security.

Environmental issues : Aquaculture zonation; site selection criteria; farm designs to avoid / minimise seepage and salinisation; waste management; microbial biodegradation; secondary aquaculture technology; pollution control; independent and common effluent treatment technology.

Disease epizootics : Rapid diagnostics; screening of broodstock and seed; screening and treatment technology for intake water; pond hygiene; pond management; disease control; methods for safe disposal of diseased / dead organisms; surveillance and monitoring systems; development of early warning system based on shrimp / fish health and water quality trends; cooperative action; vaccine development; enhancement of immunity.

Quarantine and quality control : Development of mechanism and protocols for a quarantine system for aquatic animals and plants; development of quality standards under Bureau of Indian Standards (BIS) for aquaculture (broodstock, seed, feed, effluent water etc.); certification for quality and quarantine purposes.

Feed problems in aquaculture : Indigenisation of feed production; increased use of agro-animal waste and by-products; feed additives packages; improved feed processing and production technology.

Seed Production : Establishment of on-shore and off-shore broodstock development facilities; control and management of reproduction; integrated hatcheries for shrimp / prawn / fish / crab seed production; establishment of seed banks; quality control of seed; seed certification.

Farming technology : Optimisation of water use for different culture systems; water quality criteria and management in culture systems; soil productivity improvement; silt control measures; screening and treatment of intake water; optimisation of stocking density; feed quality and management; natural productivity management; waste load control; sediment control and disposal; biofiltration; organic farming technology.

Aquatic weeds : Measures for prevention, control and eradication of harmful aquatic weeds in ponds.

Use of chemicals and drugs : Codification of prohibited and permissible chemicals and drugs for use in aquaculture; appropriate delivery systems; codes of practices.

Biodiversity conservation : Baseline data; periodic monitoring; impact assessment and restorative measures; *in situ* conservation of genetic material.

Energy use optimisation : Saving of non-renewable energy sources (electricity, petroleum products) by optimising operations; use of non-conventional energy sources (solar and wind energy).

Global warming and sea-level rise : Baseline data; modelling; anticipatory research on likely impact on eco-system, resources and production systems; alternate strategies.

Post harvest operations : Towards quality assurance through phyto-sanitary control measures in production system, product and preservation.

9. PROGRAMMES

9.1 Time frame

» Fresh assessment of potential and suitable areas for brackishwater aquaculture through use of Remote Sensing Data and GIS and with reference to legal provisions on land use and integrated coastal area development (CAD) plans.
Time scale : 1997 - 98 to 2001 - 02

» Using the above technique, periodic monitoring of changes, if any, in coastal ecosystem due to brackishwater aquaculture and preparation of restorative / remedial action plans wherever necessary.
Time scale : 2002 - Periodic; quinquennial

» With reference to the natural endowments of land, water and biological resources in different agro-eco-aquatic regions, suggest crops, cropping systems and management practices for sustainable development of brackishwater aquaculture.
Time scale : 1997 - 98 to 2001 - 02; thereafter innovations and fine-tuning

» To carry out periodic environmental impact assessment (EIA) and social impact assessment (SIA) for corrective action to ensure environmental sustainability and social equity of brackishwater aquaculture.
Time scale : Periodic; every 3 years

» Biodiversity and its conservation through periodic monitoring and preparation of plans for *in situ* and ex situ conservation of germ plasm.
Time scale : 1997 - 98 to 2006 - 07

» Technologies for captive broodstock development of all aquaculture candidate species of crustaceans and fishes to ensure availability of spawners for breeding and seed production.
Time scale : 1997 - 98 to 2001 - 02

» Development and introduction of innovative measures for seed production in hatchery systems for crustaceans and fishes; programmes on decentralisation of seed production with reference to areas to be served.
Time scale : 1997 - 98 to 2001 - 02

» To scientifically define principles and practices of brackishwater aquaculture production systems (crustaceans, fishes, molluscs) through well designed experiments on species, their combination, stocking densities, feeding and other management practices and to develop packages of sustainable practices for extensive, semi-intensive and intensive production systems.
Time scale : 1997 - 98 to 2019 - 20; continuing programme

» To enlarge the database on nutritional requirements of shrimp and fish (larval, juvenile and adult phases) through experimentation, develop feed formulations using indigenously available marine and land-based animal / plant resources and by-products and to reinforce such diets with feed additives towards production of nutritionally balanced practical diets for aquaculture.
Time scale : 1997 - 98 to 2006 - 07

» To scale up feed processing and production technology for adoption in commercial feed plants.
Time scale : 1997 - 98 to 2006 - 07

- To enhance natural productivity of plankton and benthos in culture ponds through appropriate and scientific application of biofertilisers, organic manures and chemical fertilisers with reference to soil and water quality parameters and production targets.
  Time scale : 1997 - 98 to 2006 - 07
- To carefully assess water quality, volume and exchange requirements for culture and also the externalities (intake and drainage) and bring about desired levels of equilibrium of the system.
  Time scale : 1997 - 98 to 2006 - 07
- To survey and monitor fish and shellfish diseases, investigate aetiology and causative biotic and abiotic factors, and to develop health management practices.
  Time scale : 1997 - 98 to 2019 - 20; continuing programme
- To develop genetic probe-based rapid diagnostic techniques for microbial diseases and vaccines for prophylactic applications.
  Time scale : 1997 - 98 to 2019 - 20; continuing programme
- Scientific application of probiotics, bioenzymes, bioaugmentors, immunostimulants, and other phyto-sanitary measures in culture ponds to improve quality of the production system and produce.
  Time scale : 1997 - 98 to 2019 - 20; continuing programme
- To combat pollution problems, set standards and achieve desired levels of quality of effluent through scientific management and secondary aquaculture for utilisation of excess nutrients and organic matter.
  Time scale : 1997 - 98 to 2006 - 07
- To establish an Aquatic Animal Quarantine and Quality Control System for certification of seed, adults, feed and other major inputs.
  Time scale : 1997 - 98 to 2019 - 20; continuing programme
- To develop codes of practices for use of chemicals and drugs, including antibiotics, in aquaculture to ensure product quality acceptable as per international standards; monitoring.
  Time scale : 1997 - 98 to 2019 - 20; continuing programme
- To examine issues under Post-GATT Agreement and IPR Regime and take up appropriate research from time to time to safeguard India's interests in international trade of aquaculture products.
  Time scale : 1997 - 98 to 2019 - 20; continuing programme
- Programme on brackishwater aquaculture economics to determine efficacy of systems and procedures; market economics; socio-economics; contributions to national economy; policy guidelines for planning and investment.
  Time scale : 1997 - 98 to 2019 - 20; continuing programme
- Aquaculture engineering programmes on eco-friendly farm designs and operations, materials and structures, energy saving devices and use of renewable energy sources.
  Time scale : 1997 - 98 to 2006 - 07
- Development of a National Data Centre on Brackishwater Aquaculture and effective dissemination of information.
  Time scale : 1997 - 98 to 2019 - 20; continuing programme
- Education and extension programmes for Human Resource Development and Transfer of Technology.
  Time scale : 1997 - 98 to 2019 - 20; continuing programme

Note : The programme activities and priority setting are given in the PERT chart.

PERT chart of Programme Activities and Priority Setting

S.No.	Activity	1997-98 - 2001-02	2002-03 - 2006-07	2007-08 - 2011-12	2012-13 - 2016-17	2017-18- 2019-20
1.	Fish broodstock development, breeding and seed production - seabass, grey mullets, groupers, seabream, milkfish, snappers, other species (in future)	>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>				
2.	Shrimp broodstock development, breeding and seed production - penaeids and metapenaeids	>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>				
3.	Fish and shellfish production systems and development of code of management practices for sustainable aquaculture	>>				
4.	Fish and shellfish health monitoring, disease diagnosis, prophylactic and control measures	>>				
5.	Improvement of feed quality through use of probiotics, permissible growth promoting substances, immunostimulants and organic additives for fish and shellfish culture systems	>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>				
6.	Scaling up of feed processing and production technology	>>>>>>>>>>>>>>>>>>>>				
7.	Replacement / substitution of marine protein resources in feed formulation with land based agricultural and animal products and by-products and with reference to EAA requirements	>>>>>>>>>>				
8.	Development of maturation diets for fish and shellfish with requirements of Essential Fatty Acids and vitamins/minerals	>>>>>>>>>>>>>>>>>>>>				
9.	Development of microbound larval and postlarval diets for crustaceans	>>>>>>>>>>				
10.	Digestive physiology of fish and shellfish and improvement of feed quality through exogenous and microbial enzymes (fermented)	>>>>>>>>>>>>>>>>>>>>				

(Contd.)

PERT chart (Contd.)

S.No.	Activity	1997-98 - 2001-02	2002-03 - 2006-07	2007-08 - 2011-12	2012-13 - 2016-17	2017-18- 2019-20
11.	Shrimp and fish farm and hatchery effluent quality monitoring, treatment systems for reducing pollution load and secondary aquaculture	>>>>>>>>>>>>>>>>>>>>				
12.	Comprehensive survey of brackishwater aquaculture for impacts on society (SIA) environment (EIA) genetic biodiversity and public health and contributions to technical improvements and public policy for sustainable and progressive aquaculture (periodic assessment)	>>>>>>>>>		>>>>>>> >>		>>>>>>
13.	Assessment of carrying capacity of environment / eco-system / zones / sites and optimisation of brackishwater aquaculture development (case studies)	>>>>>>>>>>>>>>>>>>>>				
14.	Water quality, treatment, biofiltration, recycling and exchange requirements in culture systems for optimisation of water use; development of water technology for brackishwater aquaculture	>>				
15.	Pond soil quality, productivity and microbial activity and use of sanitizers and bio-augmentors for improving pond bottom quality during culture and between culture	>>				
16.	Pond dynamics and bioenergetics for synergetic production system	>>>>>>>>>>>>>>>>>>>>				
17.	Economically viable and ecofriendly polyculture technologies with shrimp, fish, molluscs and seaweeds	>>>>>>>>>>>>>>>>>>>				
18.	Establishment of a Remote Sensing Cell and GIS facility for assessment of potential and suitable area for brackishwater aquaculture, monitoring environmental impact and planning eco-restorative measures (collaboration with NRSA/SAC)	>>				

(Contd.)

PERT chart (Contd.)

S.No.	Activity	1997-98 - 2001-02	2002-03 - 2006-07	2007-08 - 2011-12	2012-13 - 2016-17	2017-18- 2019-20
19.	Development and upgradation of rapid disease diagnostic techniques such as ELISA, dot-blot immunoassays, PCR and nucleic acid probes	>>>>>>>>	>>>>>>>>	>>>>>>>>	>>>>>>>>	>>>>>>>>
20.	Immune systems in fish and shellfish and development of immunostimulants	>>>>>>>>	>>>>>>>>			
21.	Development of vaccines against diseases and their field testing for prophylactic action in aquaculture fish and shellfish		>>>>>>>>	>>>>>>>>	>>>>>>>>	>>>>>>>>
22.	Development of specific pathogen-free and disease-resistant strains of fish and shellfish and their propagation		>>>>>>>>	>>>>>>>>	>>>>>>>>	>>>>>>>>
23.	Reproduction management through physiological / endocrine control, feed manipulation and environmental control for development of broodstock and spawners round the year	>>>>>>>>	>>>>>>>>	>>>>>>>>		
24.	Genetic characterisation of candidate species, selection and breeding for improvement of growth, disease resistance, meat quality and colour (partly in collaboration with NBFGR)	>>>>>>>>	>>>>>>>>	>>>>>>>>	>>>>>>>>	>>>>>>>>
25.	Ploidy manipulation for production of triploids, desirable mono-sex fishes		>>>>>>>>	>>>>>>>>		
26.	Genetic engineering for introduction of novel genes for production of transgenic fish / shellfish (partly in collaboration with NBFGR)		>>>>>>>>	>>>>>>>>	>>>>>>>>	>>>>>>>>
27.	*In situ* and *ex situ* conservation of germ plasm of brackishwater aquaculture organisms (collaboration with NBFGR)	>>>>>>>>	>>>>>>>>	>>>>>>>>	>>>>>>>>	>>>>>>>>

(Contd.)

PERT chart (Contd.)

S.No.	Activity	1997-98 - 2001-02	2002-03 - 2006-07	2007-08 - 2011-12	2012-13 - 2016-17	2017-18- 2019-20
28.	Establishment of a Quarantine and Quality Control facility for development of procedures and standards and implementation of certification requirements (partly in collaboration with NBFGR)	>>>>>>>>>>	>>>>>>>>>>	>>>>>>>>>>	>>>>>>>>>>	>>>>>>>>>>
29.	Development of Code of Practices for permissible use of drugs and chemicals in aquaculture	>>>>>>>>>>	>>>>>>>>>>	>>>>>>>>>>	>>>>>>>>>>	>>>>>>>>>>
30.	Use of renewable energy sources in coastal aquaculture and optimisation of energy use in production systems	>>>>>>>>>>	>>>>>>>>>>			
31.	Standardisation of engineering designs, structures and processes in brackishwater aquaculture farms and hatcheries; feed processing and production; and feed dispensers	>>>>>>>>>>	>>>>>>>>>>	>>>>>>>>>>		
32.	Social and economic survey of brackishwater aquaculture; role of women; macro and microlevel economic analysis and appraisal of production systems; evaluation of economics of in-house technologies contributions to policy planning	>>>>>>>>>>	>>>>>>>>>>	>>>>>>>>>>	>>>>>>>>>>	>>>>>>>>>>
33.	Anticipatory research on possible impacts of sea level rise on coastal aquaculture and programmes for such contingency		>>>>>>>>>>	>>>>>>>>>>		
34.	Participation in post-graduate education / research programmes of CIFE (Deemed University)	>>>>>>>>>>	>>>>>>>>>>	>>>>>>>>>>	>>>>>>>>>>	>>>>>>>>>>
35.	Participation in NATP programme of ICAR on coastal ecosystem	>>>>>>>>>>	>>>>>>>>>>			
36.	Transfer of Technology / Extension / training programmes; informatics; publications	>>>>>>>>>>	>>>>>>>>>>	>>>>>>>>>>	>>>>>>>>>>	>>>>>>>>>>
37.	Consultancy programme and revenue generation	>>>>>>>>>>	>>>>>>>>>>	>>>>>>>>>>	>>>>>>>>>>	>>>>>>>>>>
38.	National Data Centre on Brackishwater Aquaculture	>>>>>>>>>>	>>>>>>>>>>	>>>>>>>>>>	>>>>>>>>>>	>>>>>>>>>>

9.2 Funds

The Institute's programmes are largely funded by the ICAR through plan funds. Additional funding requirements are met through sponsored projects. A summary of the Budget Estimate for the first five years (IX Plan) is given below:

IX Plan Budget

Recurring	Rs.(in lakhs)
Pay & Allowances	250.00
Travelling Allowance	50.00
Contingencies	400.00
Human Resource Development*	70.00
Total (A)	770.00

* Human Resource Development budget outlay is Rs 70.00 lakhs.

Non-recurring	
Equipments	250.00
Works	1830.00
Land	Nil
Vehicles	50.00
Library Books	50.00
Others	50.00
Total (B)	2230.00
AICRP** (C)	500.00
Total (A+B+C)	3500.00 lakhs

** The Institute has proposed an All-India Coordinated Research Project on Sustainable Shrimp Farming, with a budget outlay of Rs 500 lakhs.

9.3 Linkage, Coordination and Execution Arrangements

The implementation of various programmes requires the establishment of linkages with both governmental and other agencies as shown below:

Institution/Department	Areas for Linkage
National	
ICAR Fisheries Institutes	
NBFGR	Genetic resources; germ plasm conservation; biodiversity; quarantine system

Contd.

Linkages - (Contd.)

Institution/Department	Areas for Linkage
CMFRI	Coastal aquaculture
CIFA	Pond production systems; nutrition; disease diagnostics; monitoring and health management
CICFRI	Disease diagnostics; monitoring and health management
CIFE	Education; students' research
CIFT	Feed technology
ICAR Other Institutions	
NBSS & LUP	Coastal zone land use planning
CPCRI	Coastal ecosystem - Farming system - plantation crops
CSSRI	Coastal saline areas - wetlands - programme
IVRI	Vaccines
SAU System	
Fisheries Colleges of TNVASU, APAU, UAS, KKV (at Tuticorin, Nellore, Mangalore, Ratnagiri and others)	All India Coordinated Research Project on Sustainable Brackishwater Aquaculture
CSIR Laboratories	
NIO, Goa	Mangrove ecology, biodiversity, conservation
CFTRI, Mysore	Single cell proteins; spray-dried larval feeds
Other Organisations	
National Instt. of Immunology, New Delhi	Immune systems; immunodiagnostics; immunostimulants
National Instt. of Nutrition, Hyderabad	Nutrition in Fish / Shellfish
National Instt. of Virology, Pune	Cell culture; viral diseases
Centre for Cellular and Molecular Biology, Hyderabad	Genome mapping; Finger printing; Molecular diagnostic probes
Space Application Centre, Ahmedabad	Thematic maps; coastal zone management
Central / State Ministries and Departments	
Union Ministry of Agriculture, Dept. of Agri. & Coop., Fisheries Division, New Delhi	Policy, Planning, guidelines, programme support, central schemes

Contd.

Linkages - (Contd.)

Institution/Department	Areas for Linkage
Marine Products Export Development Authority, Kochi	Development; training, Farmers' Meets
Central Instt. of Coastal Engg. for Fishery, Bangalore	Aquaculture engineering, Farm designs
Dept. of Biotechnology, New Delhi	Mission-mode programmes on Aquaculture Biotechnology
Dept of Ocean Development Govt. of India, New Delhi	Coastal zone planning management; pollution
International	
Network of Aquaculture Centers in Asia Pacific, Bangkok	Sustainable brackishwater aquaculture; environmental management
Aquatic Animal Health Research Institute, Dept. of Fisheries, Bangkok	Health management
National Institute of Coastal Aquaculture; Songkhla, Thailand	Breeding of fish; cage culture
South East Asian Fisheries Development Centre, Iloilo, Philippines	Broodstock development and breeding
INRA, France	Reproductive physiology, nutrition and feed technology
IFREMER / COFREPECHE, France	Fish breeding and seed production; cage culture
Ocean Institute, Hawaii	Specific pathogen-free shrimp stocks; hatchery for grey mullet
Institute of Aquaculture, Stirling, U.K.	Fish pathology; Application of drugs in aquaculture
Dept. of Fisheries & Allied Aquaculture, Auburn University, Alabama, USA	Aquaculture environment; Soil & Water quality management
Dept of Veterinary Science, University of Arizona, Tucson, USA	Rapid Diagnostic techniques for fish/shrimp diseases
International Centre for Living Aquatic Resources Management (ICLARM), Manila, Philippines	Genetic selection; progeny testing

Executing arrangements

The linkage programmes between CIBA and other ICAR Fisheries Institutes will be executed through inter-institutional collaborative programmes.

The linkages with other ICAR Institutes will be through training of scientists in the area of specialisation and participation in NATP and other such programmes on collaborating arrangements.

The coordination with SAU system will be through All India Coordinated Research Projects and also by interfacing the Institute with the College/Faculty of Fisheries for identified research / educational programmes.

The linkage with CSIR and other laboratories will be for advanced specialisations through training of scientists.

The international linkages will be strongly established with some of the organisations listed above such as NACA, SEAFDEC, ICLARM, INRA, IFREMER, NICA and OI and with others for Human Resource Development programmes. Executing arrangements will be through ICAR / DARE with funding support with Institute's budget in highly critical and immediately needed areas of research and external assistance such as FAO, UNDP, UNEP, ADB, NACA, TCDC, TOKTEN etc. in other areas listed.

9.4 Critical Inputs

- Infrastructure development - early completion of ongoing programmes and taking up additional programmes in the IX Plan and thereafter.
- Establishment of laboratories with complete facilities for research, quarantine and quality control responsibilities.
- Staffing in all cadres as per ICAR norms.
- Human Resource Development through rigorous and periodic training of scientists, technicians and other support staff with proper motivation.
- External support in training of scientists in highly specialised areas such as genetics, biotechnology, immunology, vaccine development etc.
- Promotive policy and programmes for sustainable brackishwater aquaculture at the Central and State levels and essential regulations.
- Industry - Institution linkages in R&D areas
- Networking of R&D in aquatic animal health management, feed, seed, diversification, pollution control and extension services to the industry and farmers.
- Extensive information and communication system to the industry and farmers.

9.4.1 Funds

Refer Section 9.2.

9.4.2 Manpower

The sanctioned staff strength of the Institute is as follows:

Research Management post	1
Scientific	65
Technical	40
Administrative	26
Supporting	91
Auxiliary	-
Total	223

The discipline-wise and centre-wise break up of the scientific posts is shown in the Annexures.

The ratio norms of the Council in respect of different categories are: Scientific - 1.0; Technical - 1.5; Administrative - 0.5 and Supporting - 2.0. According to the above, the number of posts are as follows:

Number of posts in different categories

Category	As per norms	Sanctioned strength	Shortfall
Research Management post	--	1	--
Scientific	65	65	--
Technical	98	33	65
Administrative	33	26	7
Supporting	130	89	41
Auxiliary	9	9	--
Total	335	223	113

Proposed additional posts:

Scientific : The cadre strength of Principal Scientists is only four. The Institute has 5 Divisions and it is proposed to add a Quarantine and Quality Control Division during the IX Plan. Subsequently, the composite Division of Technology Improvement Division will have to be trifurcated into Nutrition & Feed Technology Division; Fish Health Management Division; and Physiology and Genetics Division. So also the Division of Environment and Engineering will have to be bifurcated into Aquaculture Environment Division and Aquaculture Engineering Division. Thus the Divisional framework of the Institute during the IX Plan will be as follows:

Present VIII Plan	*IX Plan*
Crustacean Culture Division (CCD)	CCD
Fish Culture Division (FCD)	FCD
Technology Improvement Division (TID)	TID
Aquaculture Engineering & Environment Division (AEED)	AEED
Economics, Extension & Information Division (EEID)	EEID
	Quarantine & Quality Control Division (New Division)

The scientific positions required for the Institute are projected as follows:

Number of posts in Scientific category

Category	Existing VIII Plan	Additional post proposed IX Plan	After IX Plan* By 2020
Principal Scientist	4	5	18
Senior Scientist	14	6	30
Scientist	47	4	52
Total	65	15	100

* It is envisaged that the total cadre strength of scientists of the Institute will grow progressively upto year 2020 and reach 100 as the ultimate strength.

The IX Plan scientific cadre strength proposed is as follows:

Principal Scientists / Heads of Divisions : CIBA is a multidisciplinary Institute with 20 disciplines. At present there are only 4 posts of Principal Scientists, leaving a very large gap in Divisional / Project level management. The imbalance should be set right in the IX Plan and 5 additional posts are proposed. This would give two Heads of Divisions and three Principal Scientists.

Senior Scientists : The distribution of discipline-wise cadre strength would show that many of the disciplines are covered only at scientist level without a supervisory senior scientist. Teams cannot be built up without a Team Leader of a senior position. Hence additional 6 posts are proposed.

Scientist : Marginal increase of 4 posts only are proposed to work in Quarantine and Quality Control Division proposed during IX Plan for the field level programme. Senior / Principal Scientists of cognate disciplines will also be involved in the work of the new Division.

Number of posts in Technical and other categories in relation to scientists

Category	Existing VIII Plan	IX Plan	After IX Plan By 2020
Research Management post	1	--	--
Scientific	65	15	100
Technical	40	41	150
Administrative	26	14	100
Supporting	91	30	200
Auxillary	--	--	--
Total	223	100	550

It has been shown earlier that presently the strength in the above categories is much below the stipulated norms of ICAR, creating a lot of strain on the Institute to provide even the minimum services to the scientific programmes, sometimes reaching breakdown point. The position is proposed to be improved to some extent during the IX Plan with additional posts. The ratio between scientists and other categories according to the proposal will be Scientific - 1.0; Technical - 1.5; Administrative - 0.5; Supporting - 2.0. Auxiliary posts will be adjusted in Supporting Staff strength.

9.4.3 Human Resource Development

The important R&D areas for HRD of scientists at the Institute are identified below, along with a list of laboratories where such programmes may be organised.

i) Management of reproduction in fishes and shrimp

» SEAFDEC, Iloilo City, Philippines

» Dept. of Fisheries, Govt. of Thailand, Bangkok (several laboratories in Thailand)

» INRA, France

» COFREPECHE / IFREMER, France

» Oceanic Institute, Univ. of Hawaii, USA

ii) Microencapulation of larval diets

» School of Ocean Science, Univ. College of North Wales, Menai Bridge, U.K.

» Faculty of Fisheries, Univ. of Kagoshima, Kagoshima, Japan

iii) Nutrition & feed development for carnivorous fishes

» National Taiwan College of Marine Sciences & Technology, Dept. of Aquaculture, Keelung, Taiwan

» SEAFDEC, Iloilo, Philippines

» Asian Institute of Technology, Bangkok

iv) Production and use of probiotics

» Altech, Inc., Biotechnology Centre, Nicholasville, Kentucky, USA

» Lab de Nutrition, IFREMER, Brest, France

v) Fish / Shrimp disease diagnosis and health management

» Gulf Coast Research Laboratory, Ocean Springs, Mississippi, USA

» Laboratoire de Pathologie Comparee, Montpellier, Cedex 5, France

» Aquatic Animal Health Research Institute, Dept. of Fisheries, Govt. of Thailand, Bangkok

» Dept. of Veterinary Microbiology & Parasitology, College of Veterinary Medicine, Texas A&M University, Texas, USA

» Aquatic Pathology Section, Dept. of Vety. Science, Univ. of Arizona, USA

» University of Hawaii, Hawaii, USA

vi) Aquaculture environment management

» Auburn University, Dept. of Fisheries and Allied Aquaculture, Alabama, USA

» Asian Institute of Technology, Bangkok

» Wetland Biogeochemistry Institute, Louisiana State University, Baton Rouge, Louisiana, USA

» IFREMER, France

vii) Genetic selection of SPF stocks

» Oceanic Institute, Univ. of Hawaii, USA

» ICLARM, Manila, Philippines

9.5 Risk Analysis

* Sectoral risks are likely to be:

» Socio-economic problems

» Occasional natural calamities

» Threat to environmental security

» Pollution problems

» Disease outbreaks

» Fluctuations in external markets

» Limiting factors of seed and feed

» Feed raw material short supply

» Anticipated sea level rise

* Technical issues to be addressed to by research for minimising / eliminating risks:

» Production and management technologies for sustainable brackishwater aquaculture

» Diversification of species and economic viability of such production systems

» Cropping patterns - rotation of crops / polyculture / integrated farming

» Seed production technologies for various species

» Indigenisation of feed production and increasing efficacy of feed by quality improvement

» Soil and water quality management

» Fish and shellfish health management

» Minimising waste organic / nutrient load in pond systems through better management and quality inputs

» Environmental management plans

9.6 Output and expected situation

Through implementation of the Perspective Plan in a phased manner, CIBA will develop the capacity and competitive edge in the global research scenario to solve most of the problems of brackishwater aquaculture production system in the country and also provide such services to other developing countries.

» Technology and services delivery system will be established as a business activity derived from R&D results.

» IPR and Patent issues will receive attention and the Institute will strive towards achieving eminence in this field.

» The sector will receive maximum R&D support for a smooth, progressive and sustainable growth in achieving the targets.

» The sector will contribute to progressively increasing earnings of foreign exchange and will be a major contributor to marine products exports.

» Domestic supplies of fish and shellfish would increase considerably thereby contributing to India's food security.

10. PROJECT REVIEW, REPORTING AND EVALUATION ARRANGEMENTS

The present system provides for such reporting and reviews through the organisation of Projects and Divisions at the Institute level. The supervisory, evaluating and advisory structure has been recently organised under Staff Research Council and Research Advisory Committee. The Institute also has the Management Committee to advise and assist in the management of the Institute with delegated administrative and financial powers. The Director as Chairman or Member of Committees draws suggestions, advice, recommendations and decisions from these Committees as per the terms of reference in managing the research programmes and administration.

The Quinquennial Review Team has been given wide terms of reference and all matters concerning the Institute are reviewed and their Report is considered by the Council for necessary action.

Within the Ministry of Agriculture, there is a coordination committee of DARE / ICAR and DAC. Similarly ICAR / DBT discussions deal with matters of common interest.The recommendations of these Committees are received at the Institute for necessary action.

11. RESOURCE GENERATION

The Institute does not at present have much of infrastructure facilities for production research on fish and shellfish which can contribute substantially to resource generation. The hatchery facility has now been established. Farm facilities will be established shortly. Revolving Fund Scheme will be taken up during IX Plan. With this background, the Institute proposes the following avenues of resource generation with tentative targets.

RESOURCE GENERATION (10 TO 30% OF IX PLAN OUTLAY OF INSTITUTE)

Details of Resource Generation		Anticipated earning during IX Plan (Rs in lakhs)		
		1997-98	1998-2002	Total
(i)	Number and different items of consultancy Environment & Disease -5 Nutrition & Feed - 3 Shrimp hatchery - 2	9.0	50.0	59.0
(ii)	Research contracts and agencies with which contracts are anticipated	4.0	20.0	24.0
iii)	Royalties	-	-	-
(iv)	Testing fees anticipated	3.0	15.0	18.0
(v)	Training charges foreseen	4.0	40.0	44.0
(vi)	Other items	5.0	25.0	30.0
	Total	25.0	150.0	175.0

(Base Year 1996-97 - Rs 10.00 lakhs from all sources)

ANNEXURE 1

A. Cadre Position at CIBA, Headquarters and Research Centres

S.No.	Hqrs/RCs	Revised Cadre Strength			
		Scientist	Senior Scientist	Principal Scientist	Total
1	CIBA Headquarters, Chennai (Madras)	34	11	4	49
2	Kakdwip Research Centre	7	1	0	8
3	Puri Research Centre	3	1	0	4
4	Narakkal Research Centre	3	1	0	4
	Total	47	14	4	65

B. **Cadre Position at CIBA, Headquarters, Chennai (Madras)

Sl.No.	Discipline	Revised Cadre Strength			
		Scientist	Senior Scientist	Principal Scientist	Total
1.	Fish and Fishery Science	7	2	2	11
2.	Animal / Fish Nutrition	2	1	1	4
3.	Animal / Fish Gen. and Breeding	2	1	0	3
4.	Animal / Fish Physiology	2	1	0	3
5.	Microbiology (Agri.)	1	0	0	1
6.	Biotechnology (Ani. Sci.)	2	1	0	3
7.	Biochemistry (Ani. Sci.)	1	1	0	2
8.	Agricultural Chemistry	2	0	0	2
9.	Organic Chemistry	1	0	0	1
10.	Veterinary Pathology	0	0	1	1
11.	Veterinary Microbiology	3	1	0	4
12.	Vet. Parasitology	1	0	0	1
13.	Soil Cons. & Engg.	1	0	0	1
14.	Soil Science - Soil Chemistry / Fertility / Microbiology	2	0	0	2
15.	Agril. Extension	2	1	0	3
16.	Agril. Statistics	1	0	0	1
17.	Agril. Economics	2	0	0	2
18.	Agril. Structure and Process Engg.	0	1	0	1
19.	Computer Application in Agri.	1	1	0	2
20.	Fish Processing Technology	1	0	0	1
	TOTAL	34	11	4	49

** When proposed Research Centre in Andhra Pradesh is established deployment will be done from strength at Headquarters.

ANNEXURE 2

C. Cadre position at Kakdiwp Research Centre of CIBA, West Bengal

Sl.No.	Discipline	Revised Cadre Strength			
		Scientist	Senior Scientist	Principal Scientist	Total
1.	Fish and Fishery Science	2	1	0	3
2.	Animal/Fish Nutrition	1	0	0	1
3.	Veterinary Microbiology	1	0	0	1
4.	Agricultural Chemistry	1	0	0	1
5.	Veterinary Pathology	1	0	0	1
6.	Agril. Extension	1	0	0	1
TOTAL		7	1	0	8

D. Cadre position at Puri Research Centre of CIBA, Orissa

Sl.No.	Discipline	Revised Cadre Strength			
		Scientist	Senior Scientist	Principal Scientist	Total
1.	Fish and Fishery Science	1	1	0	2
2.	Animal/Fish Gen. and Breeding	1	0	0	1
3.	Veterinary Microbiology	1	0	0	1
TOTAL		3	1	0	4

E. Cadre position at Narakkal Research Centre of CIBA, Kerala

Sl.No.	Discipline	Revised Cadre Strength			
		Scientist	Senior Scientist	Principal Scientist	Total
1.	Fish and Fishery Science	1	1	0	2
2.	Animal/Fish Nutrition	1	0	0	1
3.	Animal/Fish Gen. and Breeding	1	0	0	1
TOTAL		3	1	0	4

ANNEXURE 3

WORLD AQUACULTURE PRODUCTION

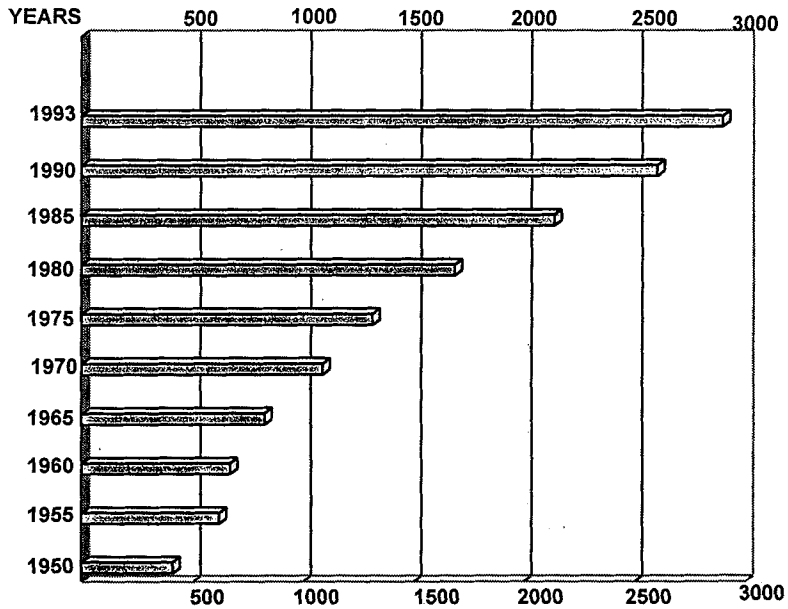
Environment		1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Fish and shellfish	Q	6937140	7724340	8811795	10149794	11202430	11713008	12410117	13150445	14390190	16285135
	V	9475408	10579407	13536613	17679874	20572151	21710802	24097527	25539239	27708391	29259161
Freshwater culture	Q	4154206	4652312	5374268	6177137	6774128	7187655	7612768	8036033	8879648	10062271
	V	5658449	6179077	7562332	9195552	10287941	11050123	12288975	12052600	13057770	13773981
Brackishwater culture	Q	605936	661353	773440	996195	1108839	1149178	1305191	1425272	1413950	1350121
	V	1403189	1690939	2276094	3803072	4694301	4866279	5334525	6271429	6569674	6197852
Mariculture	Q	2176998	2410675	2664087	2976462	3319463	3376175	3492158	3689140	4096592	4872743
	V	2413770	2709391	3698187	4681250	558909	5794400	6474027	7215210	8080947	9287328
All aquatic organisms	Q	10459113	11230255	12289950	13250776	14634262	15208230	15768241	17355685	19826354	22626168
	V	13093001	14167914	17514667	21416056	25027667	25954251	28268842	30723363	33610598	35708493
Freshwater culture	Q	4160287	4657100	5377530	6180426	6776936	7189300	7614130	8037417	8880621	10063314
	V	5728271	6229706	7595762	9227307	10312573	11064972	12300325	12063998	13063004	13778034
Brackishwater culture	Q	615972	671325	782648	1001674	1115415	1157825	1315743	1434513	1429984	1363045
	V	1412822	1700226	2285906	3807505	4701187	4868072	5335541	6272542	6575058	6202116
Mariculture	Q	5682854	5901830	6129772	6068676	6741911	6861105	6838368	7883755	9515749	11199809
	V	5951908	6237982	7632999	8381244	10013907	10021207	10632976	12386823	13972536	15728343

Q = MT V = US $ '000

Source : FADSTAT TS 1995

ANNEXURE 4

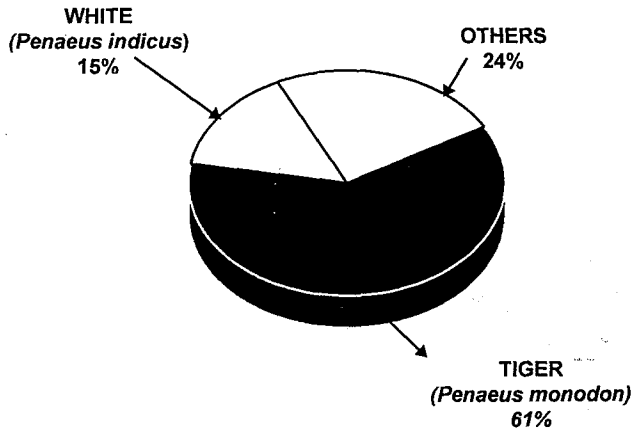
World Shrimp Production
1950 - 1993 ('000 Mt)



Source: FAOSTAT TS 1995

ANNEXURE 5

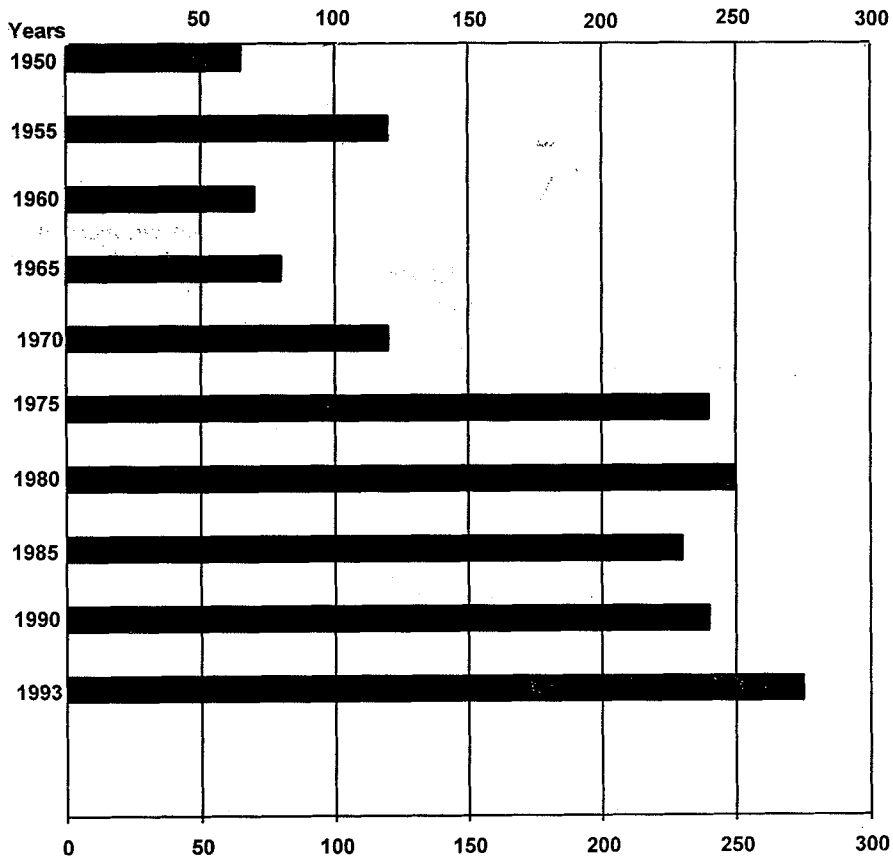
World Farmed Shrimp Production Species-wise 1994



Source: World Shrimp Farming 1994.

ANNEXURE 6

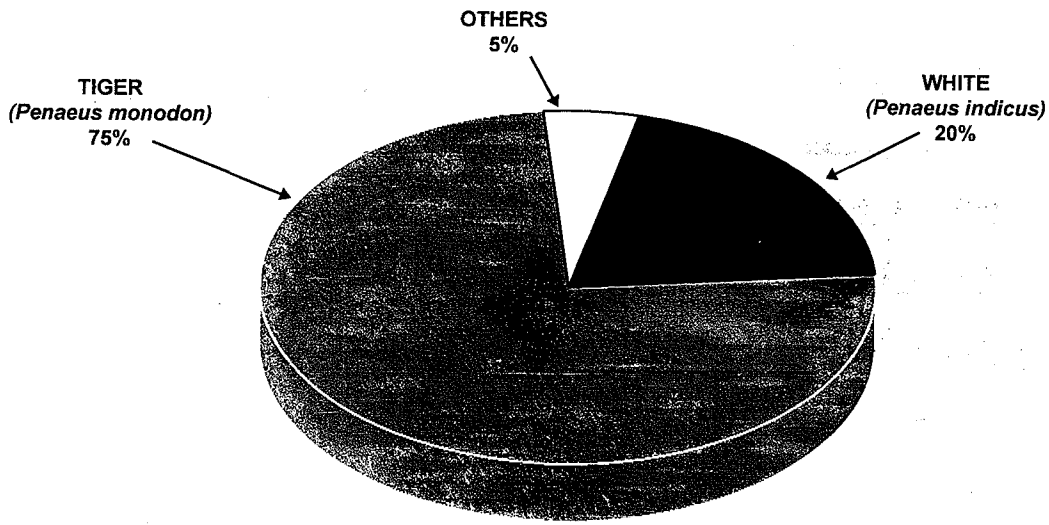
Indian Shrimp Production
1950 - 1993 ('000 MT)



Source: FAOSTAT TS 1995

ANNEXURE 7

India's Cultured Shrimp Production Species-wise - 1994



Source: World Shrimp Farming 1994

ANNEXURE 8

State-Wise Details of Shrimp Farming in India

State	Estimated Potential Area(ha)		1990-91	1991-92	1992-93	1993-94	1994-95	1995-96
West Bengal	4,05,000	A	33,815	33,918	34,050	34,150	34,400	34,660
		P	12,500	13,800	16,300	16,500	25,000	23,445
Orissa	31,600	A	7,075	7,417	7,760	8,150	8,500	11,000
		P	4,100	3,800	4,300	3,300	4,800	6,000
Andhra Pradesh	1,50,000	A	6,000	8,100	9,500	19,500	34,500	50,000
		P	7,350	9,700	12,800	26,000	34,000	27,140
Tamil Nadu	56,000	A	250	480	530	1,050	2,000	2,879
		P	450	700	1,100	2,000	3,000	1,092
Pondicherry	800	A	Neg.	Neg.	Neg.	Neg.	Neg.	37
		P	Neg.	Neg.	Neg.	Neg.	Neg	10
Kerala	65,000	A	13,000	13,145	13,400	13,860	14,100	14,657
		P	8,925	9,500	9,750	11,500	12,000	9,000
Karnataka	8,000	A	2,500	2,542	2,570	2,600	3,500	3,500
		P	1,000	1,100	1,15000	1,500	2,500	2,050
Goa	18,500	A	525	525	550	575	600	650
		P	245	300	350	400	450	550
Maharashtra	80,000	A	1,800	1,869	1,980	2,180	2,400	716
		P	800	930	1,050	300	400	740
Gujarat	3,76,000	A	125	231	360	475	700	884
		P	125	170	200	500	700	546
Total	11,90,900	A	65,100	68,227	70,700	82,540	1,00,700	1,18,983
		P	35,500	40,000	47,000	62,000	82,850	70,573

A = Area under culture in ha

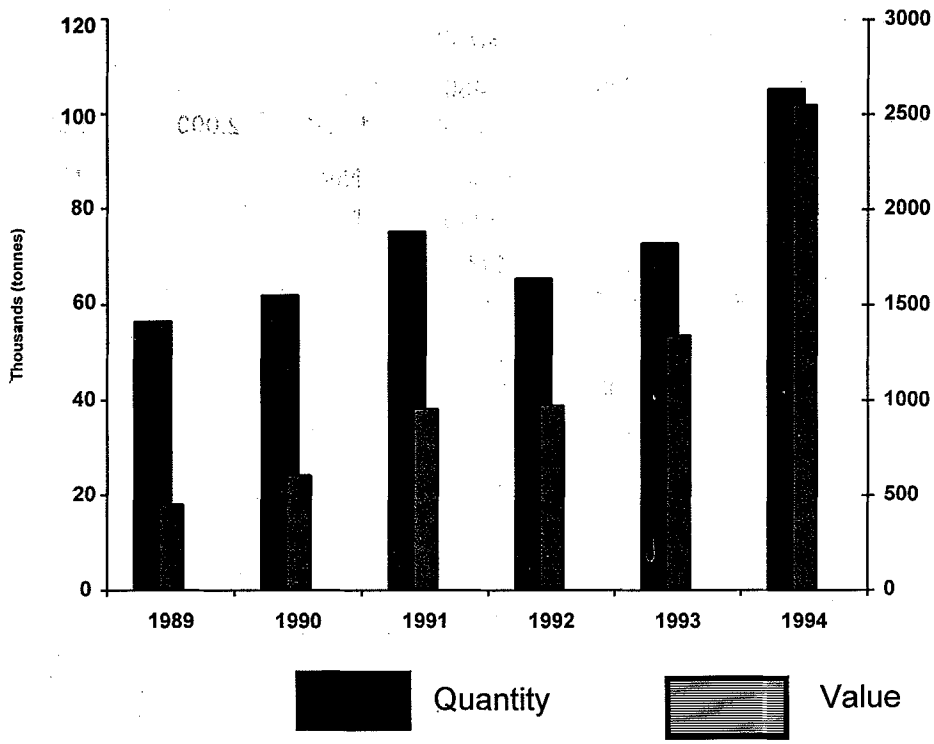
P = Estimated production in MT

Neg. = Negligible

Source: MPEDA, Kochi.

ANNEXURE 9

Shrimp Exports from India
1989 - 1994



Source: MPEDA, Kochi

ANNEXURE - 10

Hatchery shrimp seed production in India.

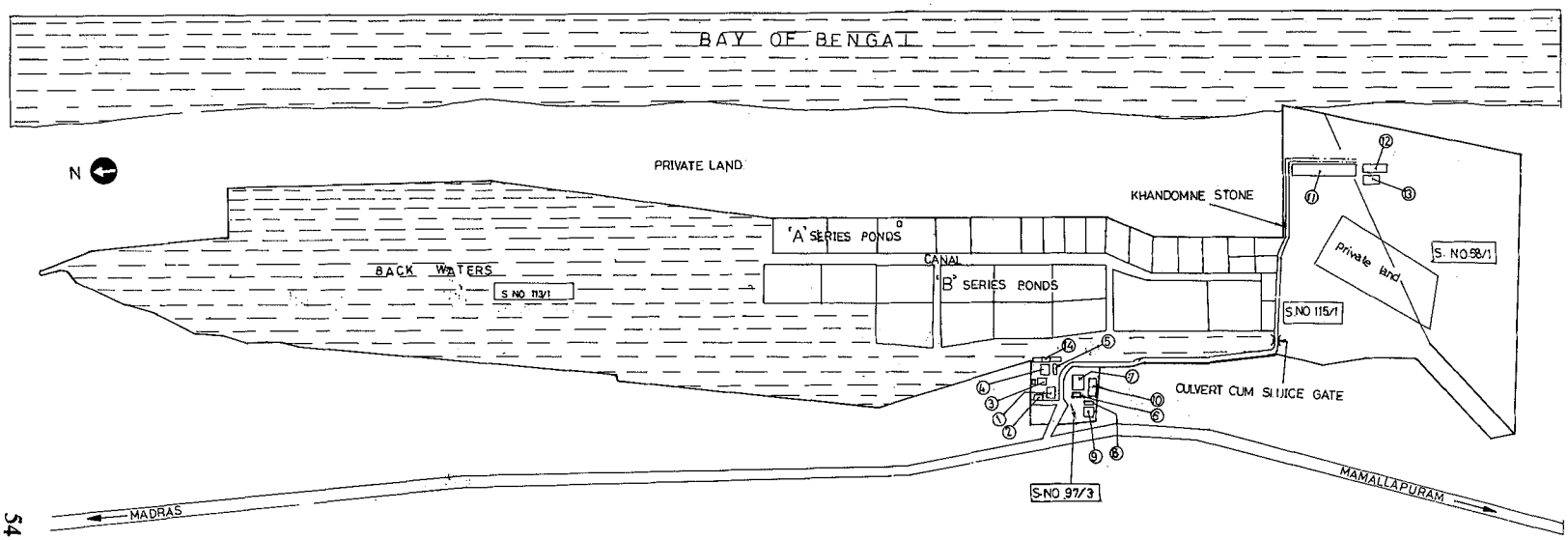
Year	Number of Hatcheries	Capacity (in billion)	Estimated production (in billion)
1989-90	13	0.20	0.08
1990-91	16	0.30	0.10
1991-92	16	0.30	0.15
1992-93	18	0.70	0.35
1993-94	36	2.16	1.00
1994-95	70	3.89	12.50
1995-96	175	10.00	7.50

Source : MPEDA, Kochi.

Details of Brackishwater Fish Farmers' Development Agencies

State	BFDA's sanctioned	Area covered (in ha)	Farmers trained (no.)
Andhra Pradesh	6	260	--
Gujarat	3	304	158
Karnataka	2	33	488
Kerala	6	442	674
Maharashtra	4	107	--
Orissa	7	9,652	4,538
West Bengal	3	728	1,000
Tamil Nadu	5	109	100
Goa	1	44	--
A & N Islands	1	--	--
Total	38	11,679	6,958

Source : Ministry of Agriculture, Govt. Of India, New Delhi.



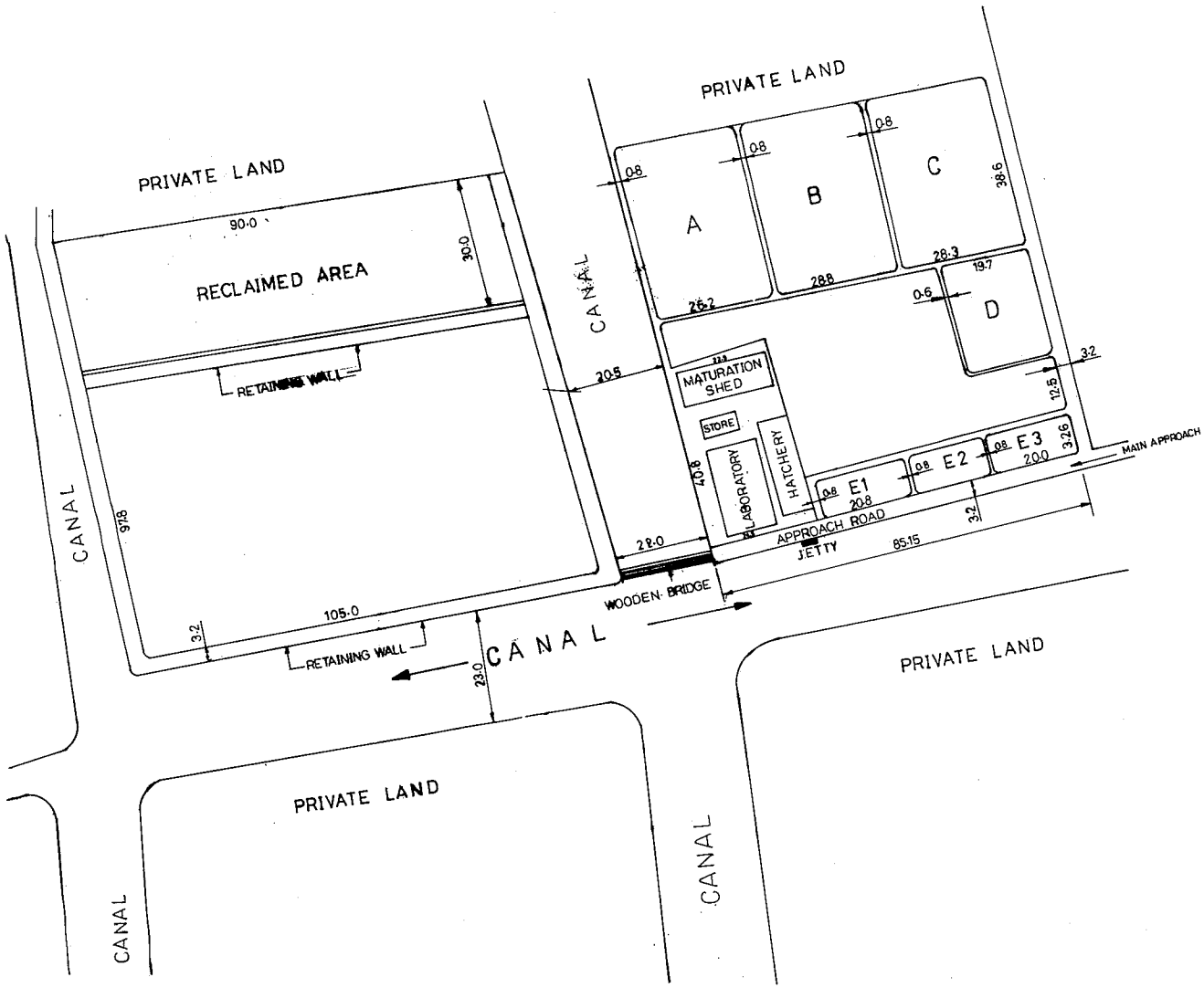
Lay-out of Farm-cum-hatchery complex at Muttukadu Experimental Station

REFERENCE

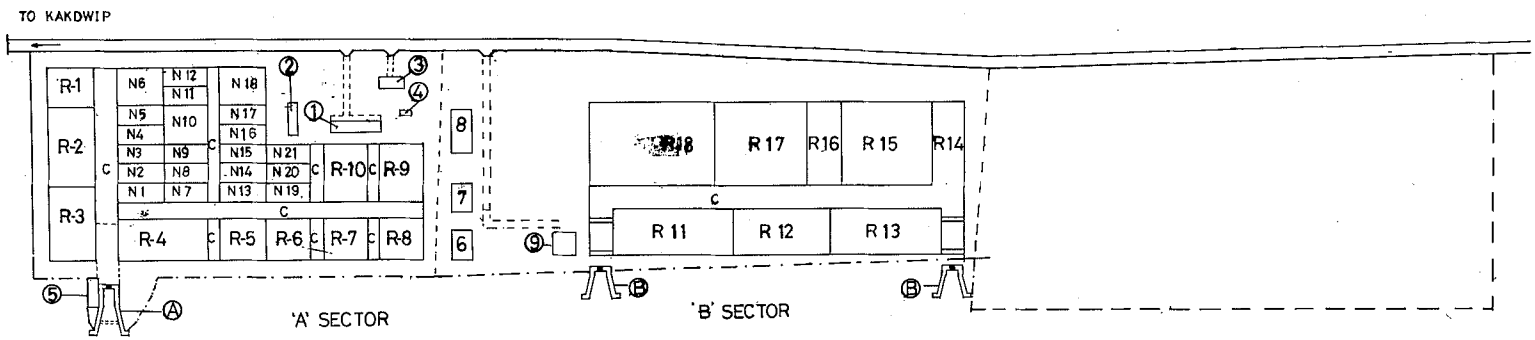
1. FARM-CUM- LAB BUILDING
2. OLD OFFICE BUILDING
3. FEED MILL
4. WET LAB
5. DBT-I
6. DBT-II
7. NUTRITION BUILDING (UNDER CONSTRUCTION)
8. MICROBIOLOGY AND PATHOLOGY
9. TYPE I QUARTERS
10. TYPE II QUARTERS (UNDER CONSTRUCTION)
11. SHRIMP HATCHERY
12. FISH BROOD STOCK TANK
13. FISH HATCHERY
14. NURSERY PONDS

TOTAL EXTENT - 49.5 Ha

Lay-out of Farm-cum-hatchery at Narakkal Research Centre



Lay-out of Farm-cum-residential quarters at Kakdwip Research Centre



REFERENCE

1. MAIN LABORATORY BUILDING
2. OLD QUARTERS
3. GUEST HOUSE
4. GENERATOR ROOM
5. HATCHERY BUILDING - A
6. TYPE-I QUARTERS
7. TYPE-II QUARTERS
8. TYPE-III QUARTERS
9. HATCHERY BUILDING - B

A-SLUICE GATE IN A-SECTOR
B-SLUICE GATE IN B SECTOR
R-REARING PONDS
N-NURSERY PONDS
C-CANALS

TOTAL EXTENT - 14 Ha