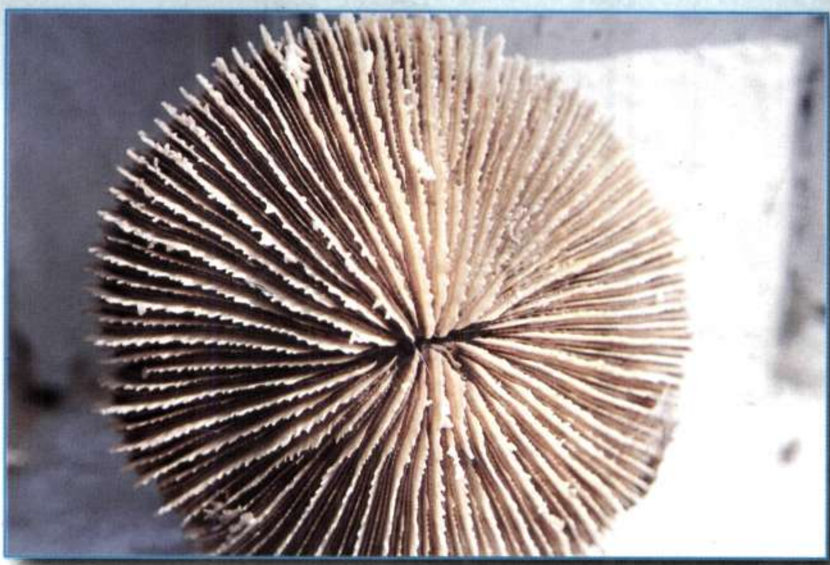
CMFRI SPECIAL PUBLICATION
NUMBER 65



REPORT OF THE SPECIAL SCIENTIFIC TEAM TO ANDAMAN AND NICOBAR ISLANDS TO GIVE RESEARCH SUPPORT TO THRUST AREAS IN FISHERIES

D.C.V. Easterson and S. Dharmaraj

Central Marine Fisheries Research Institute
(Indian Council of Agricultural Research)
P.B. No. 1603, Tatapuram P.O.
Cochin - 682 014
India

September 1996

भाकृअनुप
ICAR

CMFRI SPECIAL PUBLICATION
Number 65

REPORT OF THE SPECIAL SCIENTIFIC TEAM TO ANDAMAN AND NICOBAR ISLANDS TO GIVE RESEARCH SUPPORT TO THRUST AREAS IN FISHERIES

D.C.V. Easterson

and

S. Dharmaraj

ICAR

Central Marine Fisheries Research Institute

(Indian Council of Agricultural Research)

P.B. No. 1603, Tatapuram P.O.

Cochin - 682 014

India

September 1996

Published by : **Dr. M. Devaraj,**
Director,
Central Marine Fisheries Research Institute,
Cochin - 682 014.

Edited by : **Dr. K.J. Mathew,**
Senior Scientist,
and
Ms. Geetha Antony,
Technical Officer,
Central Marine Fisheries Research Institute,
Cochin - 682 014.

Citation : Easterson, D.C.V. and S. Dharmaraj 1996. Report of the special scientific team to Andaman and Nicobar Islands to give research support to thrust areas in fisheries. *CMFRI Spl. Publ.*, No. 65, 38 pp.

Front cover : Sea erosion and felled trees at Wandoor, Andamans.
Inset : *Fungia fungites*, a solitary coral common in Andamans.

Back cover : *Acrostichum aureum* — a mangrove associated fern.

Cover photos by : Mr. D.C.V. Easterson.

Price : Rs. 35.00

Printed in India at Modern Graphics, Malu's Complex, Elamkulam Road, Kaloor, Cochin - 682 017.

PREFACE

The Central Marine Fisheries Research Institute has the credit of being the first Institute to establish a Research Centre at Port Blair as early as 1960. However, this centre was subsequently merged with the newly formed Central Agricultural Research Institute (CARI) for Andaman and Nicobar Islands in 1978. Pioneering studies on fisheries biology, faunistics, capture fisheries, oceanogrphy, planktonology and secondary productivity were conducted and the results published by this centre.

The Andaman and Nicobar Islands, also know as the Bay Islands, are quite fascinating. Zoogeographically they belong to the subregion within the India-Indian region of the Oriental-Palaeotropic realm. Being geogrpahically nearer to the Wallace Line, the flora and fauna are unique, and the endemic elements associated with the peninsular relics confluence with the adjacent Indo-Chinese and Indo-Malayan subregions.

In 1978, the CMFRI sent two teams of Scientists to conduct large scale surveys for assessing the mariculture potential in the Andman and Nicobar Islands and their findings were published in the Bulletin No. 34 of the Institute. In 1989 at the behest of the ICAR and the CARI, a team of two Scientists, Mr. D.C.V. Easterson (Leader) and Mr. S. Dharmaraj was sent with six specific assignments. The report of this team which is now published in this document could be of great use in the planning and establishment of mariculture facilities in the Andman and Nicobar Islands.

I compliment the authors for this report and Dr. K.J. Mathew for editing it. I also thank Dr. A.K. Bandopadhyay, Director, CARI and Mr. K. Dorairaj and Mr. R. Soundararajan, Scientists, CARI for rendering valuable help to the team during the survey.

Dr. M. Devaraj,
Director,
Central Marine Fisheries
Research Institute.

CMFRI, Cochin-14,
30 September 1996.

CONTENTS

REPORT OF THE SPECIAL SCIENTIFIC TEAM TO ANDAMAN AND NICOBAR ISLANDS TO GIVE RESEARCH SUPPORT TO THRUST AREAS IN FISHERIES

I. Background

Realising the importance and urgent need for judicious exploitation and utilization of the marine living resources of the Andaman and Nicobar seas, the Director General, Indian Council of Agricultural Research (ICAR) as Chairman of the Central Co-ordinating Committee for Survery of Living Resources had recommended at the first meeting of the committee, held in May 1988 that the Central Marine Fisheries Research Institute (CMFRI) should depute its scientists to the Central Agricultural Research Institute for Andaman and Nicobar Islands (CARI), Port Blair on a fixed tenure basis to support the R & D thrust in fisheries in the region. Consequent to this, from 1-8 March 1989 the Director, CMFRI made a visit to the Andaman and Nicobar Islands to make an on-the-spot study of the potentials and possibilities for marine fisheries development in the Exclusive Economic Zone (EEZ) of the Bay Islands. Special attention was paid to the requirements of CARI in marine fisheries research. The Director also met and discussed with senior policy and decision makers in the Andaman and Nicobar Administration. As a result, two scientific teams with specific objectives were constituted. This is the report of the first team.

II. Team

The first scientific team from CMFRI to Andaman & Nicobar Islands visited during 14 April to 12 May 1989 to give research support to thrust areas of fisheries comprised of:

1. Shri D.C.V. Easterson, Team Leader
2. Shri S. Dharmaraj

Shri K. Dorairaj, and Shri R. Soundararajan, two scientists from Central Agricultural Research Institute for Andaman and Nicobar Islands (CARI), Port Blair also collaborated with the team.

III. Assignments

The team was entrusted with the following tasks:

i) To provide guidelines for the development of infrastructure facilities for the research programmes to be undertaken by CARI in collaboration with CMFRI.

ii) To take up follow-up studies on the indicative survey made earlier by CMFRI on the mariculture potential of Andaman and Nicobar Islands.

iii) To make an on-the-spot study of the specific sites identified for development of prawn and molluscan hatcheries. (In this connection as a first step it was suggested that the team should suggest ways of utilising the buildings of the existing fisheries training centre of the Fisheries Department for commencing the work of setting up hatchery, the adjacent area being allotted to CARI for development of hatchery. Hence the team was to give the necessary blue print separately for both the sites and indicate the layout of different structures, hatchery sheds, air and water circulation systems, algal culture facilities etc. including estimated costs).

iv) To make surveys for the natural population of pearl oysters, both black lip and *Pinctada fucata*, study the hydrological data collected by CARI and to identify site for setting up rafts for mother oysters.

v) To visit Viper Island which has been identified as the permanent site for CARI fisheries research centre and study

REPORT OF THE SPECIAL SCIENTIFIC TEAM TO ANDAMAN AND NICOBAR ISLANDS TO GIVE RESEARCH SUPPORT TO THRUST AREAS IN FISHERIES

I. Background

Realising the importance and urgent need for judicious exploitation and utilization of the marine living resources of the Andaman and Nicobar seas, the Director General, Indian Council of Agricultural Research (ICAR) as Chairman of the Central Co-ordinating Committee for Survery of Living Resources had recommended at the first meeting of the committee, held in May 1988 that the Central Marine Fisheries Research Institute (CMFRI) should depute its scientists to the Central Agricultural Research Institute for Andaman and Nicobar Islands (CARI), Port Blair on a fixed tenure basis to support the R & D thrust in fisheries in the region. Consequent to this, from 1-8 March 1989 the Director, CMFRI made a visit to the Andaman and Nicobar Islands to make an on-the-spot study of the potentials and possibilities for marine fisheries development in the Exclusive Economic Zone (EEZ) of the Bay Islands. Special attention was paid to the requirements of CARI in marine fisheries research. The Director also met and discussed with senior policy and decision makers in the Andaman and Nicobar Administration. As a result, two scientific teams with specific objectives were constituted. This is the report of the first team.

II. Team

The first scientific team from CMFRI to Andaman & Nicobar Islands visited during 14 April to 12 May 1989 to give research support to thrust areas of fisheries comprised of:

1. Shri D.C.V. Easterson, Team Leader
2. Shri S. Dharmaraj

Shri K. Dorairaj, and Shri R. Soundararajan, two scientists from Central Agricultural Research Institute for Andaman and Nicobar Islands (CARI), Port Blair also collaborated with the team.

III. Assignments

The team was entrusted with the following tasks:

i) To provide guidelines for the development of infrastructure facilities for the research programmes to be undertaken by CARI in collaboration with CMFRI.

ii) To take up follow-up studies on the indicative survey made earlier by CMFRI on the mariculture potential of Andaman and Nicobar Islands.

iii) To make an on-the-spot study of the specific sites identified for development of prawn and molluscan hatcheries. (In this connection as a first step it was suggested that the team should suggest ways of utilising the buildings of the existing fisheries training centre of the Fisheries Department for commencing the work of setting up hatchery, the adjacent area being allotted to CARI for development of hatchery. Hence the team was to give the necessary blue print separately for both the sites and indicate the layout of different structures, hatchery sheds, air and water circulation systems, algal culture facilities etc. including estimated costs).

iv) To make surveys for the natural population of pearl oysters, both black lip and *Pinctada fucata,* study the hydrological data collected by CARI and to identify site for setting up rafts for mother oysters.

v) To visit Viper Island which has been identified as the permanent site for CARI fisheries research centre and study

REPORT OF THE SPECIAL SCIENTIFIC TEAM TO ANDAMAN AND NICOBAR ISLANDS TO GIVE RESEARCH SUPPORT TO THRUST AREAS IN FISHERIES

I. Background

Realising the importance and urgent need for judicious exploitation and utilization of the marine living resources of the Andaman and Nicobar seas, the Director General, Indian Council of Agricultural Research (ICAR) as Chairman of the Central Coordinating Committee for Survery of Living Resources had recommended at the first meeting of the committee, held in May 1988 that the Central Marine Fisheries Research Institute (CMFRI) should depute its scientists to the Central Agricultural Research Institute for Andaman and Nicobar Islands (CARI), Port Blair on a fixed tenure basis to support the R & D thrust in fisheries in the region. Consequent to this, from 1-8 March 1989 the Director, CMFRI made a visit to the Andaman and Nicobar Islands to make an on-the-spot study of the potentials and possibilities for marine fisheries development in the Exclusive Economic Zone (EEZ) of the Bay Islands. Special attention was paid to the requirements of CARI in marine fisheries research. The Director also met and discussed with senior policy and decision makers in the Andaman and Nicobar Administration. As a result, two scientific teams with specific objectives were constituted. This is the report of the first team.

II. Team

The first scientific team from CMFRI to Andaman & Nicobar Islands visited during 14 April to 12 May 1989 to give research support to thrust areas of fisheries comprised of:

1. Shri D.C.V. Easterson, Team Leader
2. Shri S. Dharmaraj

Shri K. Dorairaj, and Shri R. Soundararajan, two scientists from Central Agricultural Research Institute for Andaman and Nicobar Islands (CARI), Port Blair also collaborated with the team.

III. Assignments

The team was entrusted with the following tasks:

i) To provide guidelines for the development of infrastructure facilities for the research programmes to be undertaken by CARI in collaboration with CMFRI.

ii) To take up follow-up studies on the indicative survey made earlier by CMFRI on the mariculture potential of Andaman and Nicobar Islands.

iii) To make an on-the-spot study of the specific sites identified for development of prawn and molluscan hatcheries. (In this connection as a first step it was suggested that the team should suggest ways of utilising the buildings of the existing fisheries training centre of the Fisheries Department for commencing the work of setting up hatchery, the adjacent area being allotted to CARI for development of hatchery. Hence the team was to give the necessary blue print separately for both the sites and indicate the layout of different structures, hatchery sheds, air and water circulation systems, algal culture facilities etc. including estimated costs).

iv) To make surveys for the natural population of pearl oysters, both black lip and *Pinctada fucata,* study the hydrological data collected by CARI and to identify site for setting up rafts for mother oysters.

v) To visit Viper Island which has been identified as the permanent site for CARI fisheries research centre and study

the land and water area for developing prawn culture, pearl culture and fin fish culture.

vi) To develop suitable strategies for overall development of marine fisheries through appropriate research support and identification of priorities for coastal and oceanic fisheries development.

Acknowledgements

We wish to thank Dr. P.S.B.R. James, former Director, CMFRI for having send them on this assignment and to Dr. A.K. Bandyopdhyay, Director, CARI for his full co-operation. Our thanks are due to Shri K. Dorairaj and Shri R. Soundararajan for their collaboration for useful discussions and for making necessary arrangements during our stay at Port Blair, to Dr. K. Palanisami for useful discussions and to Shri M.S. Muthu, Shri M. Kathirvel and Dr. K. Narayanan for discussions pertaining to shrimp hatchery and culture. We would like to record our thanks to Shri E.K. Ravindran, Director, A&N Department of Fisheries, Shri H.D. Birdi, Secretary, Fisheries and other officials of A & N Administration for their co-operation. We also thank Dr. K.A. Narasimham, Shri P. Muthiah and Dr. A.C.C. Victor for giving useful suggestions pertaining to this report. Our thanks are also due to Dr. C.S. Gopinadha Pillai, Dr. D.B. James and Shri G. Gopakumar members of the second team and to Shri F. Soosai, V. Rayan and to Shri N. Jesuraj, divers, for their co-operation and to Shri A.D. Gandhi for assistance in typing the MS.

The team has the following to report on each of the assignments entrusted with it.

1. Guide lines for the development of infrastructure facilities for research programmes to be undertaken by CARI in collaboration with CMFRI

A. *Expertise with CMFRI*

Presently the CMFRI has expertise in many fields of marine fishery research including mariculture which the CARI can make use of in its marine fishery oriented research programmes. This would facilitate faster implementation of results generated within ICAR. The team is of the opinion that the technical assistants of CARI need to be trained first in the various techniques connected with the research programmes envisaged by CARI. Thus CMFRI can offer training to technical staff of CARI. In selected fields scientists of CARI also can be trained by CMFRI. Secondly, CMFRI can offer consultancy regarding the transfer of technology and expertise to CARI. Thirdly since it will take some time for the construction of Marine Hill facility, scientists of CARI can be asked to go over to CMFRI and get themselves involved in developing suitable hatchery and culture techniques for A & N candidate species. This is similar to the present practice of producing mussel seeds at Tuticorin by scientists involved in mussel culture at Vizhinjam and Tuticorin.

We also suggest visit of scientists from CARI to Madras and Tuticorin Research Centres of CMFRI and study the infrastructure systems in operational set up. During their stay the CMFRI should provide the working facilities.

The CARI also can offer facilities for scientists of CMFRI in the joint investigations, while it would be the responsibility of CARI to manage and maintain the facilities connected with Marine Hill and Viper. Further the CARI can offer support facilities to research vessels like FORV *Sagar Sampada*.

B. *The trainings CMFRI can offer*

The trainings, CMFRI can offer to CARI personnel in terms of weeks are as follows:

1.	Fishery data collection	–	4
2.	Analyses of fish catch statistics	–	6
3.	Training in population dynamics (basics)	–	4
4.	Training in population dynamics (advanced)	–	6
5.	Collection of fishery biological data (Length-weight, gut contents, maturity etc. in fishes, crustaceans & molluscs)	–	4

6.	Collection and analyses of water samples (for salinity, dissolved oxygen and nutrients)	-	4
7.	Collection, preservation, identification and quantification of phytoplankton	-	2
8.	Collection, preservation, sorting, identification and quantification of zooplankton	-	2
9.	Collection of bottom samples and analyses of soil & fauna	-	3
10.	Identification of :- Fishes	-	2
	- Crustaceans	-	3
	- Sponges	-	2
	- Corals	-	2
	- Asteroidea and Ophiuroidea	-	2
	- Echinoids, crinoids and holothurians	-	3
	- Sea weeds	-	2
	- Marine algae	-	2
	- Flora of mangroves	-	1
	- Parasitic crustacea	-	2
11.	Maturation and induced breeding of prawns	-	3
12.	Prawn farming systems and farming	-	4
13.	Breeding and hatchery production of molluscan seed	-	3
14.	Culture of bivalves (oysters, pearl oysters, clam and mussel)	-	6
15.	Pearl oyster surgery and production of cultured pearls	-	4
16.	Fabrication and maintenance of open sea culture systems (nets, rafts, pens, spat collectors etc.)	-	6
17.	Fouling aspects and maintenance of open sea culture systems and cultured organisms	-	2
18.	Maintenance of sea water and aeration systems	-	1
19.	Nutritional bio-energetics methodology	-	3
20.	Estimation of proximate composition of diet ingredients and metabolic parameters	-	6
21.	Feed, feed formulation and feeding	-	4
22.	Monitoring of fish diseases	-	3
23.	Swimming and snorkeling	-	3
24.	Use of SCUBA and underwater data collection methodology	-	3
25.	Filling and maintenance of SCUBA	-	1
26.	Estimation of chlorophyll and primary production (dark & light bottle method and use of 14 C)	-	4
27.	Isolation and culture of dietary algae	-	2
28.	Culture of sea weeds	-	2
29.	Preparation and analyses of products from sea weeds (agar, algenic acid etc.)	-	2
30.	Bacteriological monitoring of sea water and cultured animal	-	3

2. Follow-up studies of the 1978 indicative survey

A. Pressure on ecosystem

The team visited Wandoor, Pongi Balu, Chidiyatapu, Burmanulla, Corbyn's Cove, Ross Island, North Bay, Panighat, Bamboo Flat, Viper Island, Chippighat area and the coastal area of Port Blair. A brief account of biogeography of Andaman and Nicobar Islands is given in Annexure 1 in order to highlight the speciality of these islands. Diving observations were conducted in the islands close to Wandoor, Pongi Balu and in the waters around Port Blair. Since one of the team members D.C.V. Easterson was in the second team of the 1978 survey, a comparison of status of near-shore fauna in 1978 and in 1989 was possible. It is well evident that the pressure on coastal zone is high all around the islands. This is mainly due to the higher population density and letting the islands open to the tourists. The coral reefs and mangroves close to human habitations have suffered physically very bad. Further the corals and other near-shore fauna have been too much exploited and are almost barren due to hand picking of available shell fishes for use in shell craft industry. Presently, shell craft industry is very much visible everywhere and is a booming business.

Close to the air port at Port Blair are the brown coloured barren hills which welcome the visitor on arrival. Scientists of CARI (Sigh and Gajja, 1987) have estimated the carrying capacity and ecological burden of Andamans. They have indicated that deforestation without proper aforestation has produced a lot of bare hills and much associated ill effects. In a map in their publication the barren hills have been indicated. Soil erosion caused by deforestation removes the fertile top soil thereby restricting plant growth and making the seawater turbid. The turbidity in turn reduces light penetration, which destroys the photosynthetic free living marine flora and the symbiotic zooxanthelle in *Tridacna* . The soil particles on settling cover up reefs and other acquatic benthic biota, thereby causing irreversible destruction and bottom topographical change. With the destruction of reefs sea erosion could set in. Sea erosion is very much evident at Wandoor and to a lesser level at Chidiyatapu.

The reefs at Corbyn's Cove, Burmanulla and Port Blair have been heavily affected by siltation. Siltation and pollution are the prime enemies of the ecosystem. There are many saw-mills and wood works now than before. The saw dust behaves like silt particles and being a slowly decaying organic matter, deoxygenate the water and in the process of decay releases noxious chemicals and tannins which are not easily broken down by microbes. Soft drink paper cartons, pieces of plastic, metal scraps, glass pieces and the like of the present age were observed among coral reefs and in mangroves not only around Port Blair, but also in sparsely populated places such as Burmanulla, Chidiyatapu and Wandoor. Thus the coastal ecosystem is under great stress.

The team is of the opinion that it is high time to take stock of pollution and damage to the coastal ecosystem in the Andaman waters especially close to human habitations and in Port Blair. Policy decisions with fore-sight for over 20-25 years need to be charted out, especially pertaining to (1) the problem of waste and sewage disposal and (2) developmental activities like colonisation, industries, shipping, aquaculture, tourism, water sport etc. and suitable remedial measures planned in advance and enforced.

B. Identification of candidate species for mariculture

The team after careful study, suggest the following candidate species for culture:

Crustaceans	:	*Penaeus merguiensis* *P. monodon* *P. semisulcatus* *Metapenaeus dobsoni* *M. ensis*
Molluscs	:	*Pinctada margaritifera* *P. fucata* (spat to be brought from Tuticorin) *Pteria penguin* *Crassostrea madrasensis* *C. cucullata* *Perna viridis* *Trochus niloticus* *Tridacna crocea* and related species
Echinoderms	:	*Holothuria scabra* *H. atra* *Actinopyga mauritiana* *A. echinites* *A. miliaris* *Triprieustes gratilla* *Echinometra mathaei*

C. Development of infrastructure

This aspect has been covered in detail separately in the following pages of this report. Though there are many sites outside Port Blair, considering the available facilities for the stay of scientists and amenities such as school, hospital, bank, transportation, communication, supply of electric power and water we have taken areas around Port Blair only into consideration (Fig. 1). Development of facilities at Marine Hill and Viper Island have been discussed in detail. For keeping the open sea grow-out systems, areas close to Marine Hill, Ross Island facing Aberdeen, entrance of North Bay, Panighat and north of Dundas Point are found suitable. For culture organisms, poaching and predation by fishes seem to be the natural adversaries. We also recommend reserving North Bay area in full along with the hills and the adjacent area in S. Andaman north to Viper for the future aquacultural developments.

3. Plan for temporary prawn hatchery at FTC and permanent marine research hatchery facility at Marine Hill

CARI has its prawn farm in integration with coconut farm at Chippighat. This farm has two major impediments viz., highly acidic soil and getting freshwater logged for nearly 9 months in a year. Inspite of these, the scientists of CARI have produced limited number of prawn seeds during the short favourable period using fibreglass tanks and have distributed them through

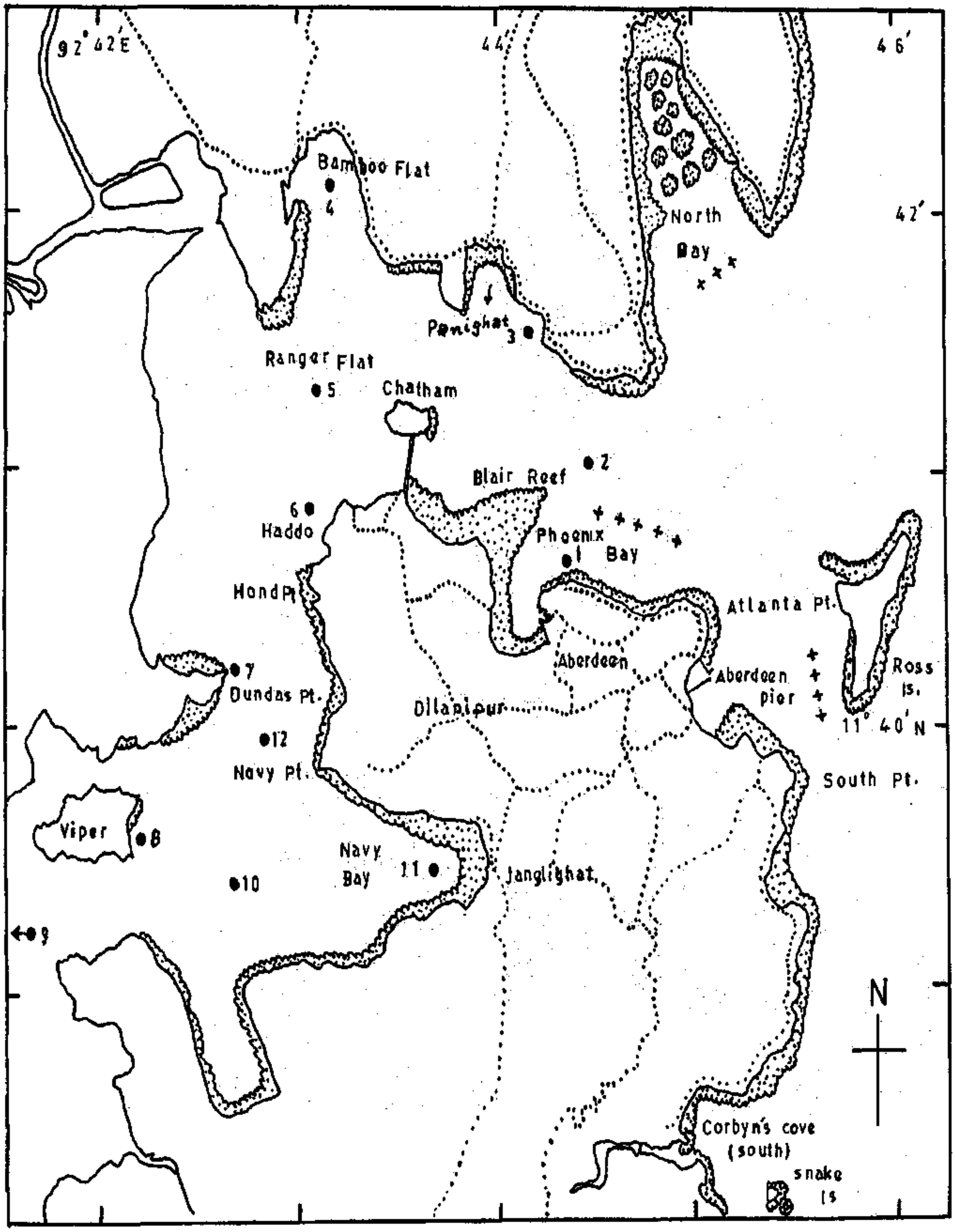


Fig. 1. Port Blair and its surrounding areas.

Hydrological data collected by CARI at 12 centres (•) around Port Blair. (+ + + +) proposed sites for pearl culture farm.

A & N Department of Fisheries. Seeds produced being insufficient, CARI after a long search for suitable site close to quality sea water source, presently obtained 1.5 ha in two pieces at the northern slope of the Marine Hill on either side of Fisheries Training Centre (FTC) of A & N Department of Fisheries. Since CARI's hatchery at this new site will take some time to take shape, as a temporary arrangement the FTC campus was intended to be used as prawn hatchery.

The present team was assigned the job of setting up the above said hatchery at FTC with all necessary amenities making use of tanks available at CARI's Chippighat farm and other necessary equipments and accessories being purchased by CARI. The next team of scientists from CMFRI shall produce prawn seeds making use of the hatchery set up by this team.

The team visited the Fisheries Training Centre at Marine Hill facing Phoenix Bay on the Foreshore Road. The FTC is within a campus of about 3 ha on the seaward slope and is roughly rectangular in shape, the longer sides being parallel to the sea.

Close to the Foreshore Road on the eastern half lies the FTC building with 2 rooms, each of about 6 × 4 m in size on either side and four rooms of ca. 3 × 2.5 m in between them. A verandah of about 1.5 m is present along the whole length on the seaward side of the building. There are 2 residential quarters situated uphill, behind. There is open space on all sides except in the eastern side.

The team is of the opinion that though the FTC building cannot accommodate all the infrastructures, it can accommodate live feed culture, spawning tanks and larval rearing tanks. Three sheds need to be put up for maintaining brood stock, air compressor, stand-by generator and sea water pumps. In 12 cycles 2.5 million shrimp larvae could be produced herein. The arrangement of the tanks planned, is as follows.

A. Space and tanks required

Prawn hatchery	Tanks	Space required
Maturation	1 No. of 10 t	5.50 × 5.50 m
Spawning (dark)	3 Nos. of 3 t	5.25 × 5.25 m
Larval rearing	6 Nos. of 1 t	5.50 × 4.00 m
Post larval rearing	6 Nos. of 1.5 t	7.00 × 5.00 m
Formula feed preparation		3.00 × 3.00 m
Dietary algal culture: Pure culture (air conditioned)		4.00 × 3.00 m
Mass culture in bright sun light		6.00 × 6.00 m
Sea water reservoir		5.00 × 5.00 m
Generator and air compressor		5.00 × 4.00 m
Total area		$216.81 m^2$

B. Allocation of space in the training centre building

Room	1.	One maturation and two larval rearing tanks
"	2.	Two larval rearing tanks
"	3.	Formula feed preparation
"	4 & 5.	Five algal culture (pure & mass)
"	6.	One spawning and two larval rearing tanks

Post larval rearing and support facilities need to be set up at sheds, (which need to be put up) out side the present building.

C. Sheds and facilities required

1. 7 × 7 m post larval rearing
2. 5 × 5 m sea water reservoir
3. 5 × 4 m
   a. Generator 4 KV portable
   b. Air compressor 1 HP with pressure tank (single phase)
   c. Sea water pump 1 HP (single phase) with gun metal impeller, flexible hose and foot valve
   d. Watchman

The list of tanks, equipments and chemicals required have been given in detail in Annexure - 2.

D. Why temporary prawn hatchery could not be set up at FTC ?

The availability of FTC for setting up a temporary shrimp hatchery seems to have bottle necks. The Director, CMFRI was made to understand (CMFRI Director's report, item 2 (i)) through the discussions with the various high level officials in A & N Administration that FTC being not in active use, will be kept at CARI/CMFRI's disposal for setting up a temporary prawn hatchery. Here we may set up the necessary systems to facilitate the next team of scientists from CMFRI to produce shrimp seeds for distribution to shrimp farmers by A & N Fisheries through CARI, after meeting CARI's limited requirements in their on-going programmes. However, the team was informed that FTC was in active use and hence the facility will not be made available. It was also informed that training being an ongoing programme could not be disturbed and there was no other building to shift the training classes. But it may be pointed out that FTC is not the only building available at their disposal; there are a few more buildings with space available at Port Blair itself to which they can shift the training programme if they wanted so. Lecture hall need not be close to sea, while the marine hatchery need to be close to good quality sea water source, as is the present FTC.

A & N Fisheries require freshwater fish seed and prawn larvae only. Molluscan culture which needs high cost inputs like rafts etc. is also labour intensive, and therefore is not practised at present. Above all there are only two marine fishery scientists with CARI and they cannot concentrate on molluscan and crustacean hatcheries at the same time. In view of the above facts, presently the team is not suggesting for starting molluscan hatchery. This can be taken up once the Marine Hill facility becomes operational. However, the list of materials required for pearl oyster culture is given in Annexure-4.

E. CARI'S *marine research hatchery at Marine Hill*

The land (Survey No. 1951/P) allotted to CARI for the construction of marine hatchery research facility is of two irregularly shaped pieces viz., 0.7 ha eastern sector and a 0.8 ha western sector. Both sectors are present in the northern slope of Marine Hill, facing Phoenix Bay in the Port Blair Inland Sea. (Fig. 1 & 3) In between these lie A&N Fishery Department's Fishery Training Centre (Survey No. 1951/1&2). At the base of the slope lies the Foreshore Road. Towards the seaward side of the road is a masonry break wall of about 5 m height. The drop of the wall is steep and no beach is presented during high tide and at low tide a rocky stretch of about 2-3 m is exposed. The Foreshore Road ends with the western sector against the compound wall of the ship repair yard and in the east leads to Gymkhana Ground. On the southern side of the plots i.e., on the top and on the southern slope of Marine Hill is another motorable road - Marine Hill Road- which leads to the Aberdeen Bazar of Port Blair. Thus on two sides of the plots, good roads exist. The lay out of the plots is given in Figure 3.

F. *Eastern sector*

In the eastern sector main laboratory, parking space, culture tank systems, water treatment and storage, support facilities such as water pumps, air blowers, electricity generator, fabrication, maintenance and repair sheds have been proposed. Reference is invited to the sketches given in Figures 4-10, which are self explanatory and have been drawn to the scale of 5 mm = 2 m.

The slopy terrain being highly uneven, in the western half, four levelled terracing and three (I, II & IV) levelling in the eastern half are suggested (Fig. 4). The main laboratory building is to have a ground floor (Fig. 5) first floor (Fig. 6), and two cellars (Fig. 7, 8). The main building is to be on top of the slope i.e., on the first terrace. The length of the building is to be in east-west direction, thereby providing sufficient sunlight to the mass culture of dietary algae throughout day time. The entrance of the building is to face south and is to be connected with Marine Hill Road by a road. The part of the

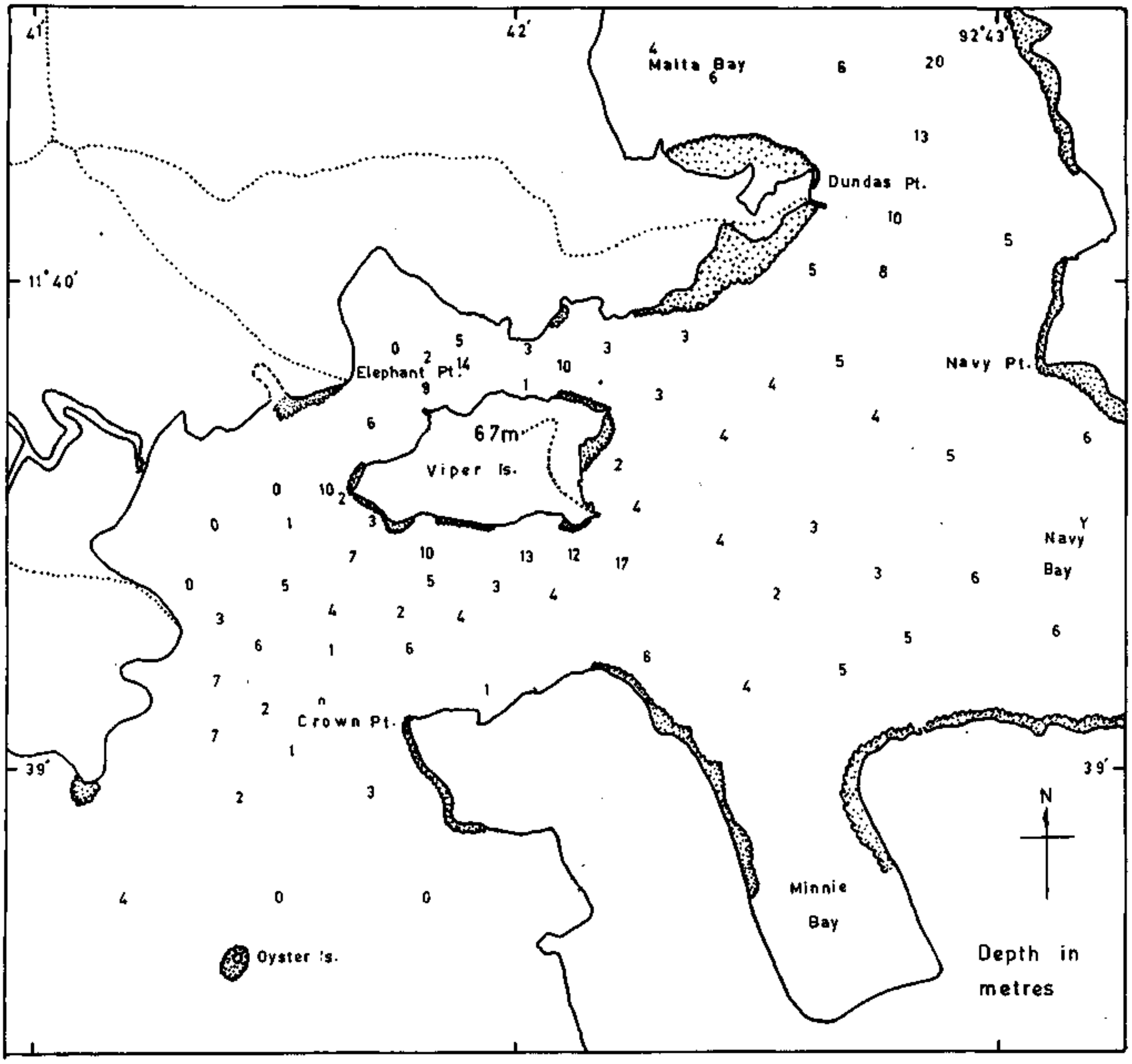


Fig. 2. Viper Island and surrounding areas.

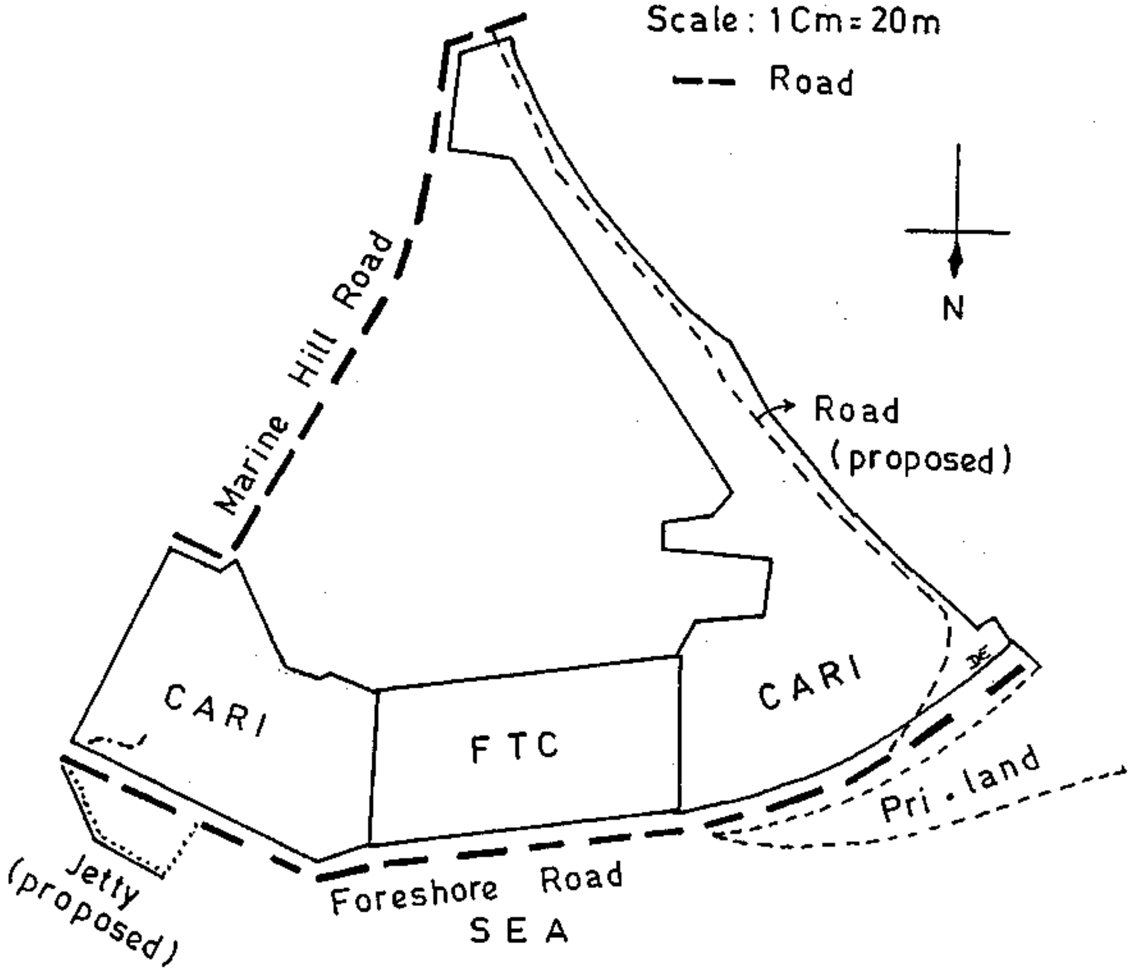


Fig. 3. Lay out plan of the site allotted to CARI.

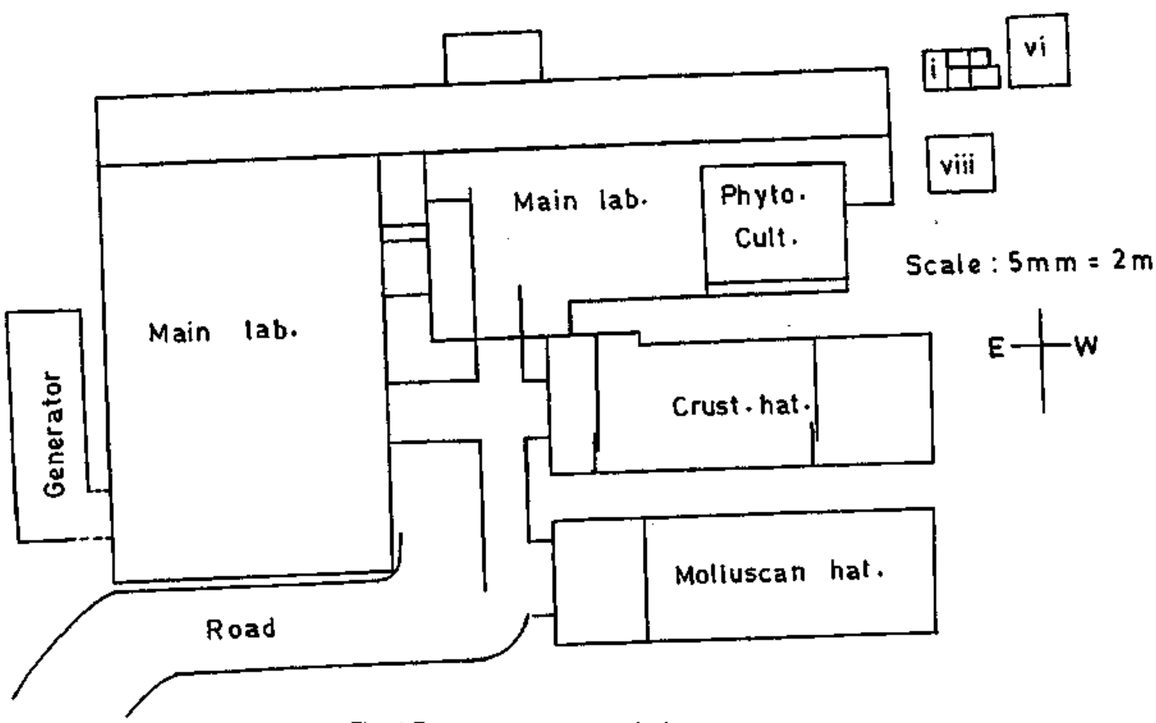


Fig. 4 Eastern sector - ground plan.

Explanation for Figures 5-10

1. Room for head of office
2. Rest and records room for head of office
3. Room for PA to head of office
4. Sitting room for visitors
5. Training and lecture hall (Cupboards for keeping audio-visual aids to be provided)
6. Scientist's and visiting scientist's room

6a. Technical assistant's room

6b. Room for telephone and intercom exchange equipments

7. Dark room for photographer
8. Toilets (gents and ladies)

9a. Water analysis

9b & c. Biochemistry-bioactive compunds, enzymes etc.,

9d. Chromatography & separation

9e. Balances & instruments which do not require air conditioning

10. Analytical instruments
11. Space allotted for walk - in cold room
12. Store for chemicals, glassware and spares
13. Verandah, passage

13a. Passage with roof

14. Space for compressor and gas cylinders for the instruments
15. Mariculture museum
16. Dietary algal culture, with translucent roofing

16a. Translucent roof of lab. no. 16.

17a &c. Algal culture - batch with glass panelled door

17b. Nutrients & CO_2 store

17d. Algal culture - stock with glass panelled door.

18. Algal culture lab. and CO_2 source
19. Sea water sterilisation for algal culture
20. Reception
21. Stairs
22. Lounge /corridor
23. Parking space for 4 wheelers
24. Parking space for 2 wheelers
25. Dept. vehicle driver's room
26. Portico
27. Sit-out/balcony (with terrace garden boundary)

27a. Passage for maintenance work

27b. Passage for maintaining translucent roofing

27c. Tiled flooring - open space for keeping live feed culture tanks

27d. This wall need to be short and the roofing on this side sloping

28. Open space for meteorological recording

29. a&b. Live feed stock culture

30. Research microscope
31. Microtechnique
32. Pathology
33. Genetics & electrophoresis
34. Glass room

35a. Feed preparation

35b. Feed ingredients store

35c. Feed store

36. General store
37. Molluscan biology
38. Recreation room
39. Crustacean biology
40. Coral reefs and mangroves study
41. In-house library
42. Temperature & light controlled wet laboratory
43. Temperature controlled wet laboratory
44. Crustacean - spawning (wet laboratory)
45. Crustacean - breeding (wet laboratory)
46. Field lab
47. Crustacean - larval rearing (wet laboratory) with 1:1 opaque and translucent roofing
48. Crustacean - rearing post larvae and growout (wet laboratory) with 1:1 opaque and translucent roofing
49. Molluscan hatchery (wet laboratory) with translucent roofing
50. Electricity generator room
51. Air blowers & air compressor room
52. Fabrication of cages, racks etc.
53. Mariculture system maintenance
54. Motorable road
55. Space for keeping dinghy

F. Fuel store

G1& G2. Stand-by and spare generator

R. Rolling shutter

S. Sliding door

SCUBA - Air compressor system for SCUBA

SP - Switch panel

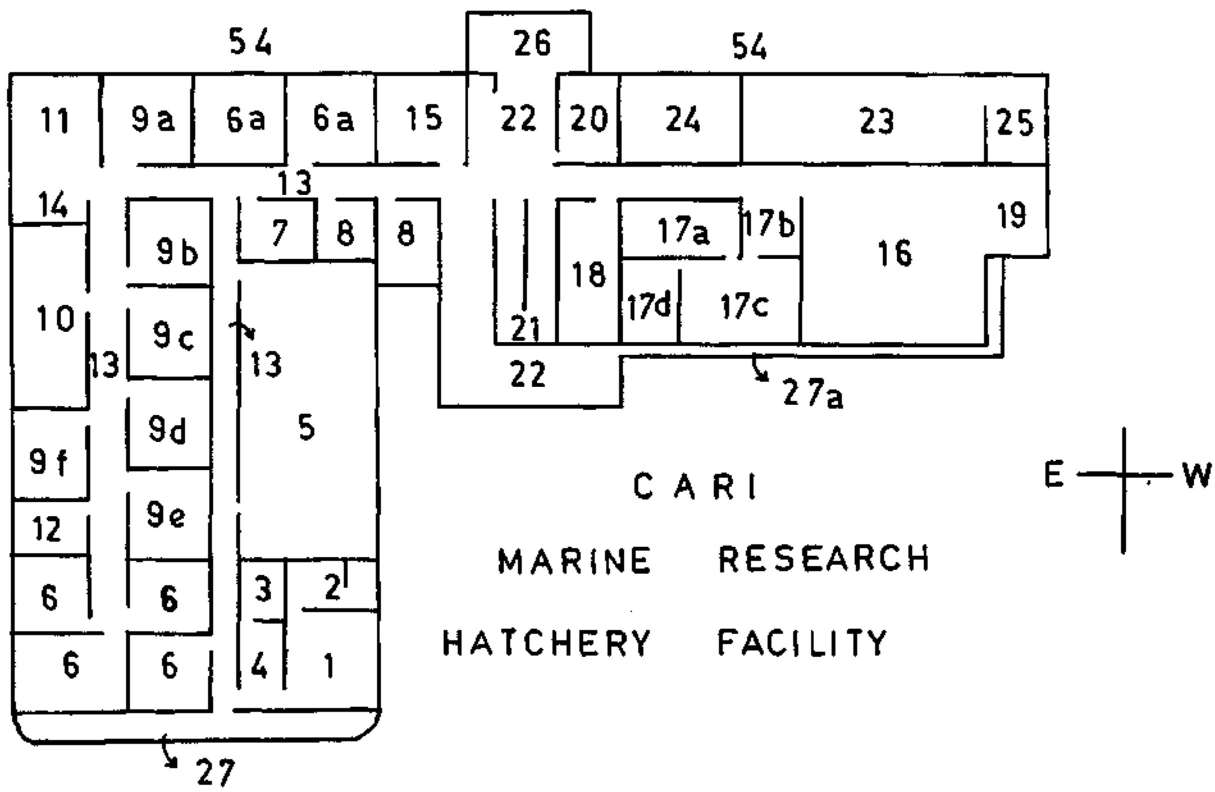


Fig. 5. Ground floor.

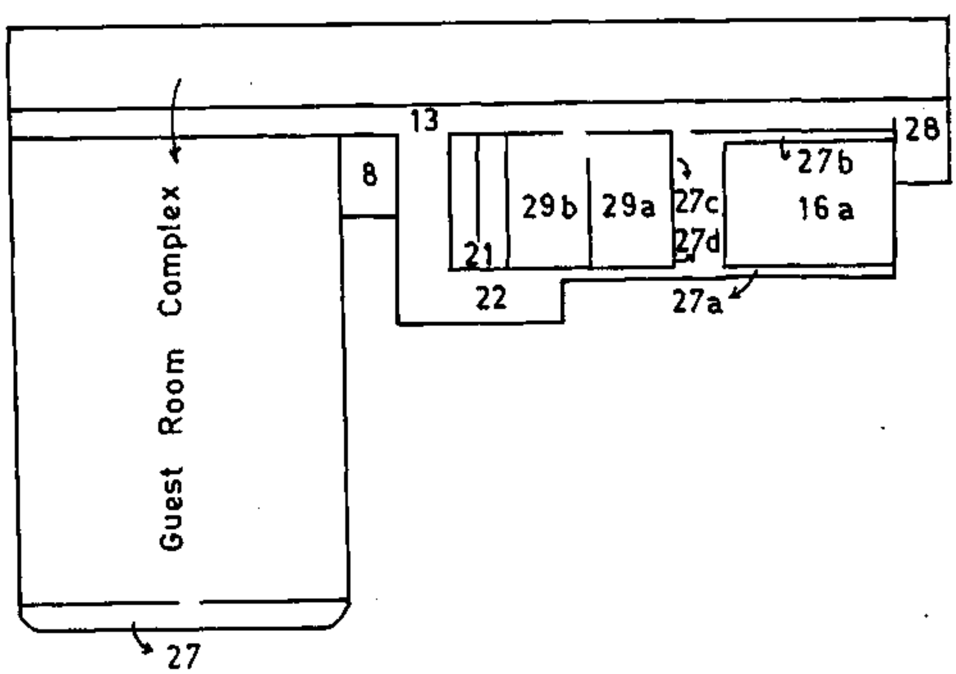


Fig. 6. Frst floor.

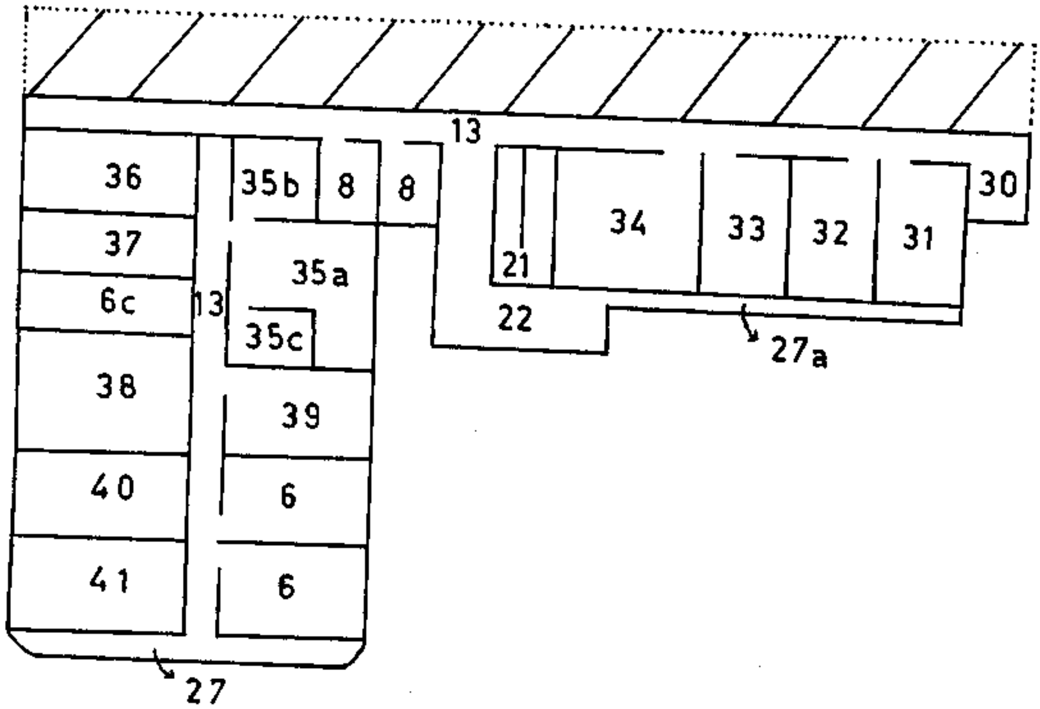


Fig. 7. I Cellar.

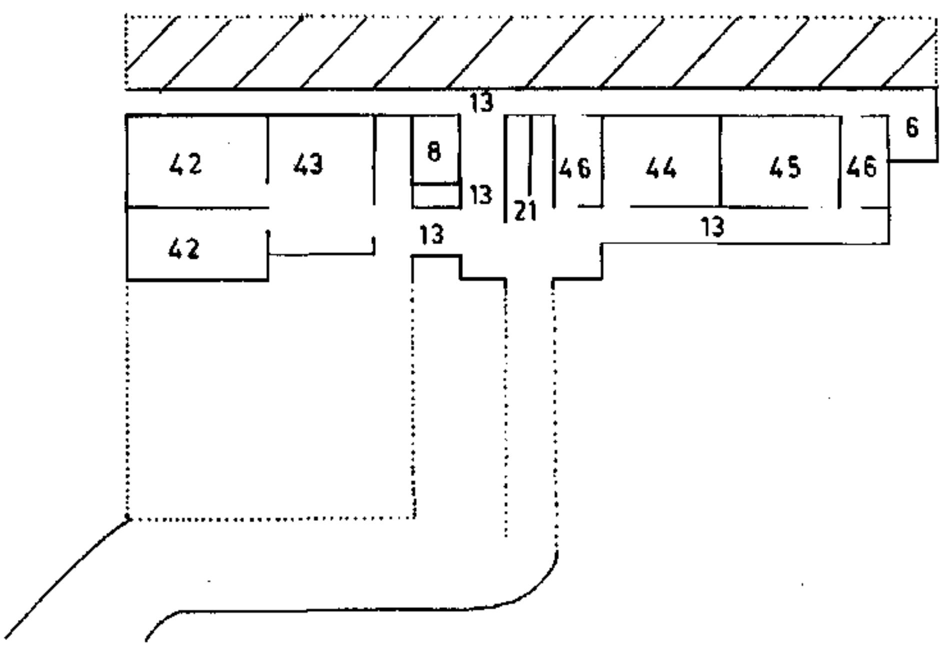


Fig. 8. II Cellar.

building on the first terrace is ground floor and the part which lies below on the second terrace is first and second cellars. Actually only a lengthwise portion of the ground floor is to stand on the first terrace and the rest is to project northwards on beams and pillars.

The freshwater sump, freshwater overhead tank and sea water treatment systems are to be constructed west of the building (Fig. 4) on the top of the hill. Freshwater sump is to be constructed north of sea water systems and over the sump the overhead tank for freshwater can be constructed. The sea water system would consist of four sedimentation tanks, one filter bed and a sump as given in the sketches (Fig. 11). The sea water is to be pumped into the first sedimentation tank from where it is to flow by gravity. All the sedimentation tanks are to be separated into two halves vertically by baffles. The baffles need to extend upto 20 cm above the bottom. The inlet and outlet are to be at the same height, each in separate halves and to be 20 cm from top of the tank. The inlet points are to have either conical or long ducted sprinklers with plenty of holes. To each of the tanks close to the bottom a drain with outer control valve need to be given for the purpose of periodical draining out of sediments. All the sedimentation tanks need to have covers for protection from sunlight and rain.

The filter bed would consist of the following. At the bottom leaving 30 cm space for water, 'Netlon' screen of about 0.25 cm mesh is spread on supports. On it a two shell thick layer of oyster shells is spread. Over it for 20 cm, 1 cm sized gravels is spread. On top of these 20 cm, 0.5 cm sized charcoal and above that sand is spread for about 20 cm thick. Close to bottom, a drain (5 cm dia.) for bad water has to be fitted and at a level of 8 cm from the bottom an outlet for purified water is given. The outlet pipe is connected with the sump through a flexible hose. This hose need to be pulled out before cleaning and changing the filter bed materials. The drains for bad water and purified water are to be at different sides. The bottom slope need to be given towards bad-water drain.

The stone chips available at Andaman are soft and leachy and hence not fit for use in filter bed. Therefore quality stone chips sufficient for two changes need to be brought from main land. The filter bed materials after each use are to be cleaned by jet of clean water and dried well. The pipes and other plumbing materials for sea water may be of PVC or other non-corrosive material.

The laboratory building all around should have tall glass panelled windows with rust proof (anodised aluminium) fittings. At the top of these windows provision has to be given for fitting venetian blinds if so desired later. The flooring in live feed culture, algal culture and in all wet laboratories should be of seawater-resistant, non-slippery material with sufficient gradient and drains. The algal mass culture room and wet laboratories in terraces III & IV need to have dust proof air vents and wall mounted exhaust fans with shutters.

Electrical fittings should be of good quality copper-wire. Metal clad fittings are recommended in wet labs. The use of aluminium wire for wiring is not recommended. The electricity supply to the instruments is to be highly stabilised.

For the mass dietary algal culture room (16) and molluscan hatchery (49), translucent roofing has to be given. Further, in algal mass culture room in order to keep algal growth progressing during cloudy days sufficient fluorescent lamps or day light lamps are to be provided. In the first floor (Fig. 6) provision has to be given for walking space (27 a & b) for carrying out maintenance work on the translucent roofing. The height of the western wall of the live feed culture laboratory (27d) (first floor) can be a little short, to the extent possible so that the shadow of it may not fall on the translucent roofing. The lights meant to provide illumination to the algae need to be connected through time-switch set to maintain 12 hr photoperiodicity. Since the chokes (ballast) of these lamps liberate a lot of heat, they are to be kept outside the room and well ventilated. Instead of the usual ballast, the recently introduced electronic chokes being long lasting and non-heating are preferred.

The laboratory work platform may be of 75 cm height and 75 cm breadth. The space below can be partitioned and fitted with sliding doors and used as shelves for keeping chemicals and gadgets. The shelf may be less broader (about 55 cm) than the platform, whereby offering leg space while working.

At the time of construction itself provision for fume exhaust motor and vents for fume cupboards are to be given in the instrument and chemistry rooms.

In the verandah close to instrument room (0.75 m broad) space (14) is to be given for keeping air compressor for AAS and gas cylinders meant far AAS, GLC, HPLC and bomb calorimeter.

The flooring in the instrument room can be of 'Marblex' or similar material, which is not only a non conductor for electricity, but also soft and hence glassware if accidentally dropped would not break.

In the first floor, space has been given for guest rooms for VIP's and visiting scientists along with space for kitchen, dining and laundry. The only research facility suggested in the first floor is for the culture of live feed organisms (29). Sea water into this laboratory has to be pumped using a miniature non-corrosive pump.

In the cellars (Fig. 7 & 8) since the Southern portion is earth filled, laboratories have been suggested in the northern portion whereby the cellars will have open space only for three (east, north & west) sides. The first cellar is the one immediately below ground floor and the second cellar is the one just below it. The second cellar will be on the second terrace. A central passage (13a) connecting the main building with the lower terraces, with light blue coloured translucent roofing (13a) is suggested for trouble free movement during rain. The arrangement of laboratories in the first cellar is given in the sketch (Fig. 7). In the second cellar (Fig. 8) on the eastern side two temperature and light controllable wet laboratories (42) have been suggested. Along with these, provision has been given for a temperature controllable (air conditioned) wet laboratory (43). (Desired temperature above ambient can be set by the use of Si-cased heaters, thermometer switch and relay. Desired quantum and duration of light conditions can be obtained through the use of time switches and the number of illuminating units). These provisions have been given with a view to making studies on breeding and culture of benthic fauna like *Tridacna*, corals, gorgonids, echinoderms etc. On the western side provision has been given for crustacean maturation (45) and spawning (44) laboratories, which require reduced light conditions. All these laboratories, in the second cellar being either with or without reduced number of windows need to be provided with forced air circulation.

On the western side in the third terrace (Fig. 9) crustacean larval development (47) and growout facility (48) and in the fourth terrace (Fig. 10) molluscan hatchery and pearl oyster surgery facilities have been provided. The roofing in wet labs (47 & 48) should be of 1:1 translucent and opaque sheets and in molluscan hatchery completely translucent. The field laboratory area need to have RCC roof. On the eastern side, in view of the low profile of the hill, only one terrace of larger area at the elevation corresponding to the fourth on the western side has been proposed (Fig. 10). Herein a road (54) extending from Foreshore Road upto machine rooms, to which heavy

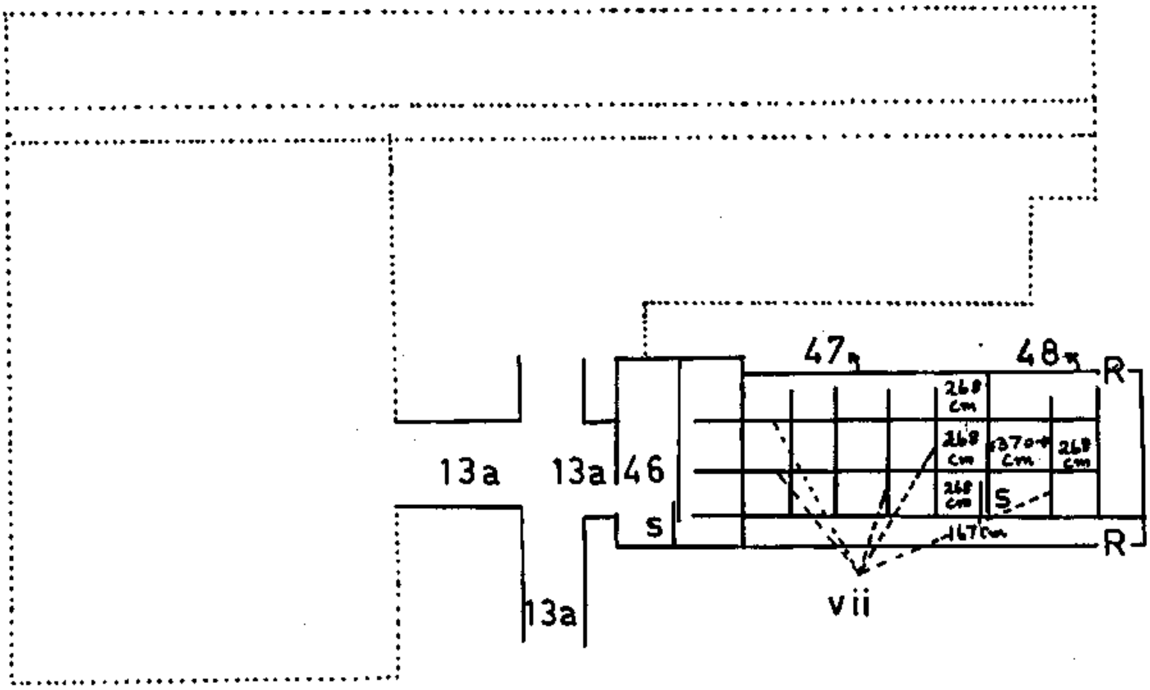


Fig. 9. III Terrace

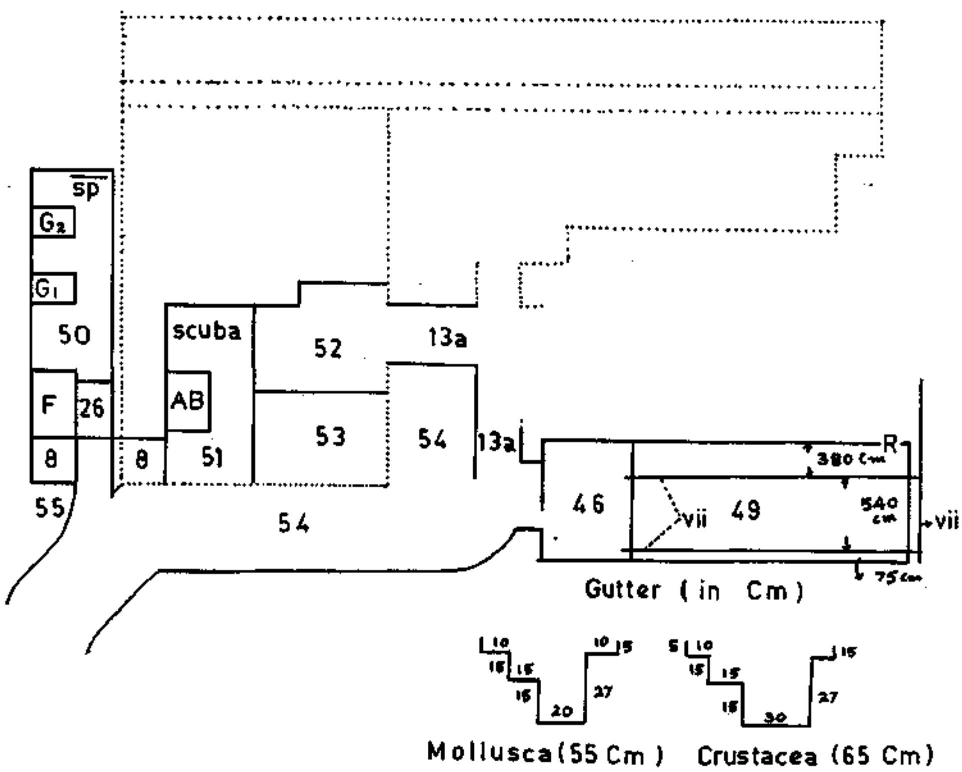


Fig. 10. IV Terrace.

materials are to be transported has been suggested. In addition generator (stand by (Gl) & spare (G2) (50)); Air blower (4 nos) and Air compressor for SCUBA (one) (51); service yard for air blowers and SCUBA (53); net cage, and raft fabrication and maintenance yard (52) have been suggested as given in Annexure-5.

The team is of the view that the office (sitting) rooms for the scientists (6) and technical staff (6a) be provided with built-in wooden almirahs at the entrance . The laboratory sinks need to be acid and alkali proof.

In order to save space, the southern wall of the molluscan hatchery (49) can be constructed to serve the dual purpose of retaining wall between the third and fourth terraces. Herein the height of the building should be such that rain water from the third terrace does not spill into the laboratory. Further, the roof of the field lab (46) adjacent to molluscan and crustacean (49 & 47) hatcheries can be concreted whereby this roof area can be used to keep additional open mass algal culture tanks and cage & raft materials. The approach to the roof may be given from the previous terrace.

Gutters (vii) in the wet laboratories are to be provided as shown in Fig. 10. The wider gutters (65-cm) are recommended in crustacean wet laboratories and small (55 cm) in molluscan wet laboratory. Space for tanks between the gutters is shown in the sketch. The seawater pipe (15 cm dia.) line can be accommodated in the gutter itself along the space provided for it.

It is also suggested that when the drainage from the western and eastern sectors is let out, care should be taken not to pollute the sea water intake point.

Though it is ideal that the I floor, ground floor and I cellar are air conditioned, the rooms 1, 6c, 9b, 9c, 10, 17a, 17c, 17d, 29a, 30, 31, 42 and 43 are to be air conditioned. The rooms 9a, 9d, 9e, 9f, 5 and 37 also can be considered for air conditioning.

In the ground floor in order to control dust in the verandah, between rooms 9a & 9b and between 20 & 18, glass panelled swing doors for the full breadth of the verandah have to be given.

In the future if tissue culture laboratory is considered herein, it can be ideally located in the southwestern part of the first floor i.e., opposite to the translucent roofed laboratory.

The equipments required for pearl culture and molluscan hatchery are given in Annexure 4. The equipments suggested for FTC (Annexure 2)are good for prawn hatchery. List of major equipments required for the marine research hatchery facility at Marine Hill is given in Annexure 5.

G. *Western sector*

Considering the distance between Marine Hill and Garacharma, heavy rains, condition of the roads, land slides and difficulties in getting contact through phone etc., atleast a few of the scientific and technical personnel connected with the hatchery should stay nearby so that whenever emergency arises especially during outside office hours attention of the scientific personnel will be available on short notice. In this regard construction of a few residential flats in the western sector is suggested. In the left out space a garden can be established. A new road is proposed between Marine Hill Road and Foreshore Road through the western sector close to the compound wall (Fig. 3).

In the area below the Japanese command bunker four large grow-out cement tanks may be constructed as per the design (Figs. 12-14). Sketches for tanks suitable for sand burrowing prawns (Fig. 12) and for non-burrowing prawns and fishes (Fig. 13) are given. The tanks may be circular, square or rectangular. The corners of the last mentioned two type of tanks need to be smothly rounded. The diameter of the tanks can be either 3 m or more. Along with the respective increase in size, the size of the pipes also need to be increased. For a 3 m

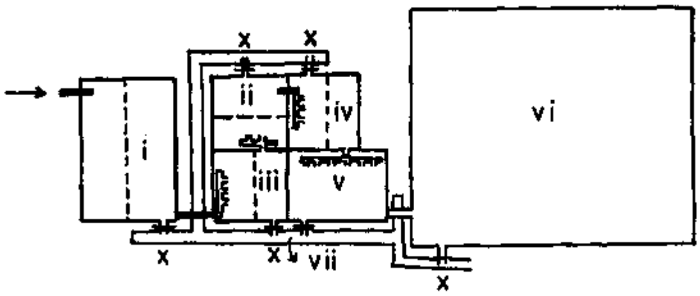


Fig. 11. Seawater system.

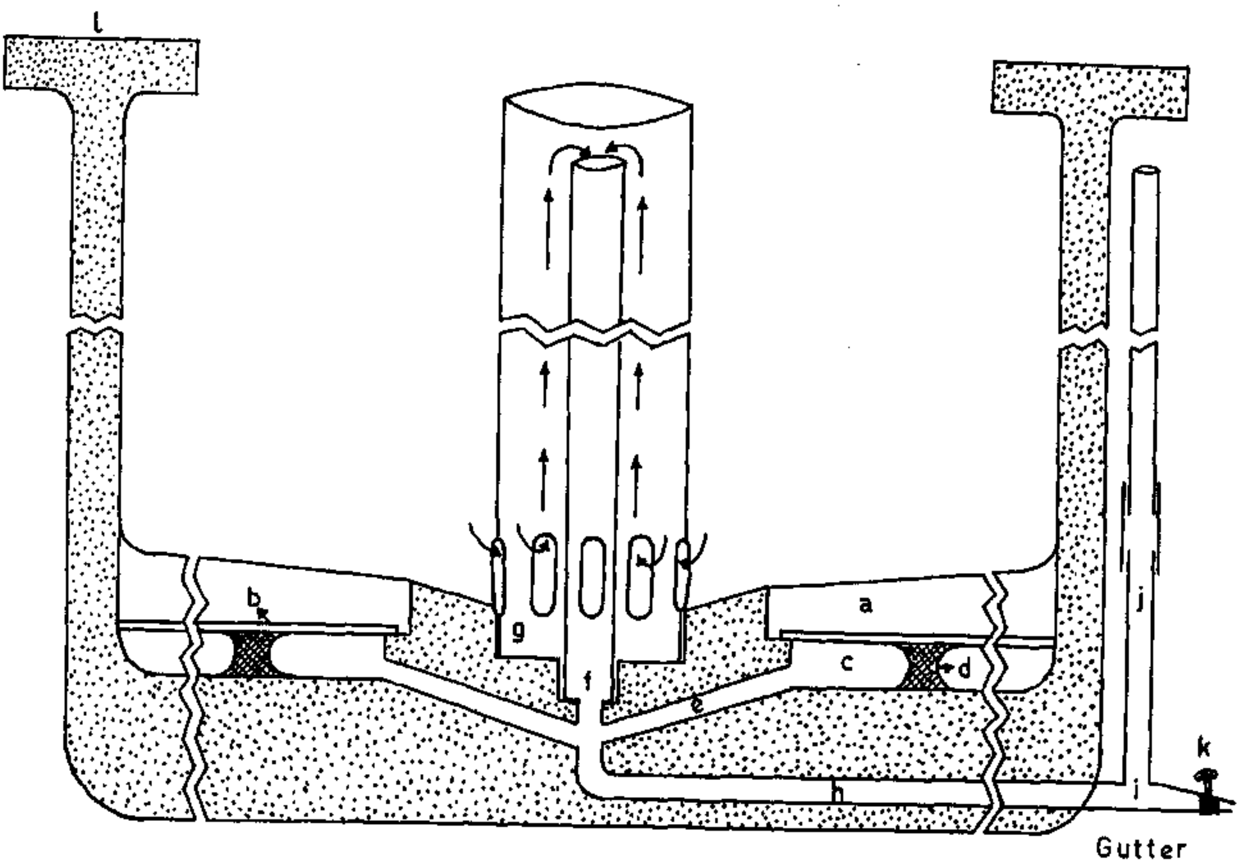


Fig. 12. Cement tank designed for burrowing type of prawns.

diameter tank, the central pipe (f) in the outlet should have a minimum outer diameter of 10 cm, the outer pipe(g) 30 cm and the waste drain pipe (h) of 8 cm. The slope at the bottom must be 3%. All the edges should be rounded in order to avoid leakage and growth of unwanted micro-organisms. Since prawns restrict themselves mainly to bottom, the available bottom area determines the carrying capacity of the tank. Therefore the height of water column need not be large and just enough to maintain sufficient dissolved oxygen tension and soluble wastes in low concentration. For shrimps 1.5 m water column is sufficient and therefore the height of the tank need to be 1.75 to 2.30m. For free swimming animals the water column must be higher and the tank should be covered by a netting.

In the middle of the tank provision is given for two pipes, one inside the other. The inner pipe(f) is the actual drain pipe. The height of this pipe may be maintained at the desired water level. The outer pipe(g) must be taller than the inner one and should have large holes close to the bottom of the tank. The slope at the bottom is given in such a way that it converges towards the orifice of the outlet. The out-going water enters through the bottom holes of the outer pipe and leaves the tank through the top of the inner pipe, whereby the waste laden oxygen deficient bottom water is drained out. The post-larvae or juveniles are to be reared in this tank. The two pipes are replaced by a simple perforated pipe or a ring of netting. The water column may be increased or decreased by adjusting the drain pipe (j) provided outside the tank. The drain pipe (h) which emerges from the centre of the tank to outside must be of hard stoneware rather than PVC and should have sufficient downward gradient. The arrangements of 'T' joint(i), control valve (k) are given in Fig. 12 & 13.

To grow burrowing prawns like *Penaeus japonicus, P. semisulcatus* and *P. canaliculatus* (while *P. indicus, P. monodon* and *P. merguiensis* are non-burrowing) a perforated or narrow slited sheeting (b) is kept on supports (d) at the bottom as shown in the diagram of the tank. Clean sand (a) is kept over this for about 10 cm thickness. The chamber (c) below the sheet is sloped to drain percolated water into the drain pipe (e). This system gives good survival and better growth of prawns. The gutters need to have ditches in order to retain sand.

The top of the tank (Fig. 14) wall should have about 60 cm flange as foot path (l). In case of larger tanks (over 3 m dia.) the foot path, at one point may be extended (m) like a tongue upto the centre of the tank. The inlet seawater pipe (n) with valve (o) is attached on to one side of the path. The size of the orifice for the water jets (p&q) should be in increasing order from the centre to the wall. This type of arrangement of water jets creates a circular water movement.

Coating the inner side of the cement tank with light blue coloured epoxy resin without thinner is suggested. Since majority of the thinners are toxic, their use is not recommended.

H. Jetty

In carrying out open-sea culture, culture systems like cages, rafts, floats, anchors, biological materials like seeds and cultured products and materials required for diving operation need to be loaded and unloaded for transportation to and from culture and study sites through mechanised vessels and barges. Therefore construction of a jetty opposite to the hatchery in the eastern sector (Fig. 3) starting from the breakwall of the Foreshore Road is suggested. The jetty should be atleast 20-25 m in length. A crane having lifting capacity of 2.5-3 tonnes is needed near the jetty. The artificial bay formed because of the construction of the jetty can be enclosed with a two ply of 'Netlon' netting of 1 cm mesh on all sides except where the break wall is present. The netting need to be from 0.5 m above high tide mark to the bottom, held down by

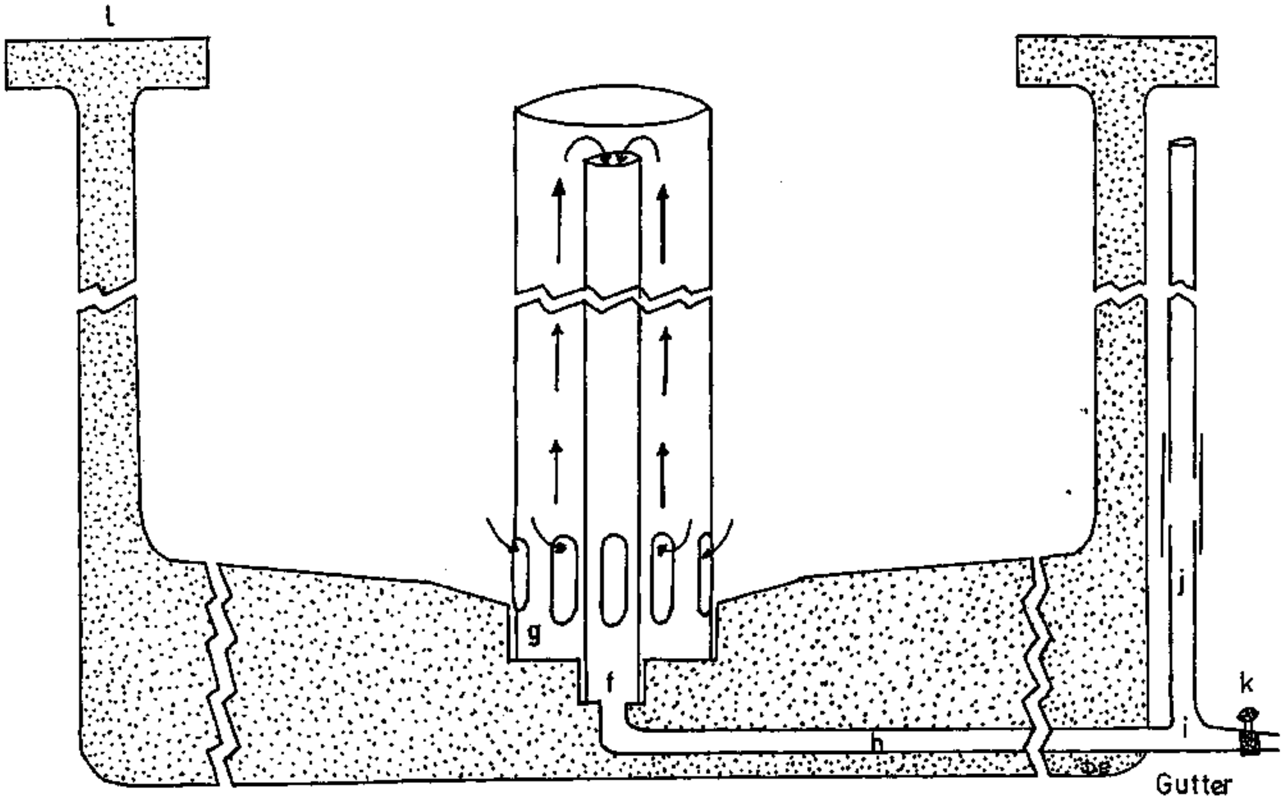


Fig. 13. Cement tank designed for non-borrowing type of prawns(Digramatic).

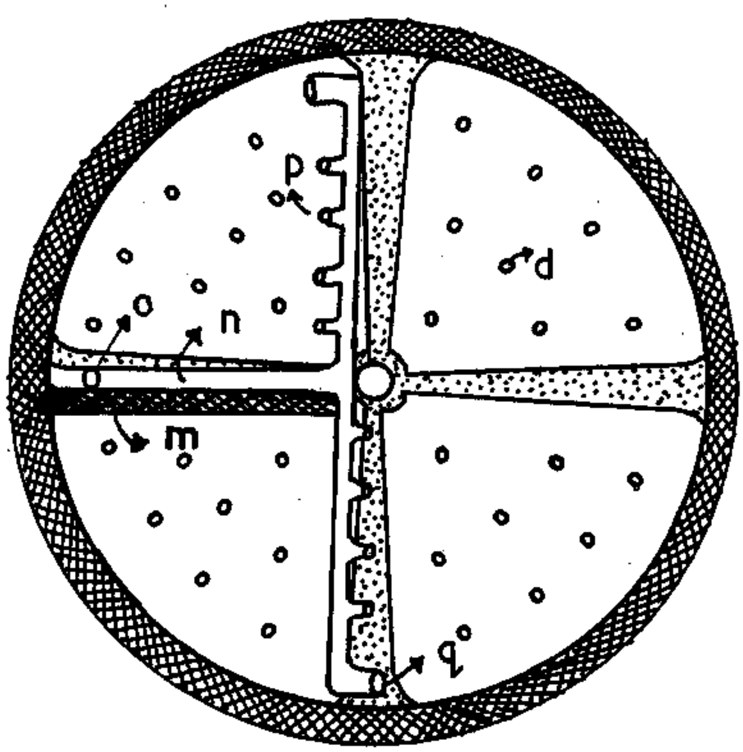


Fig. 14. Aerial view of Cement tank for burrowing type of prawns.

weights. Within this enclosure spat, molluscan brood-stock and pearl oysters before and after surgery (for a shorter duration) can be kept protected from predatory organisms.

Because of the limited space available for CARI at Marine Hill, expansion of breeding research covering most of the A & N candidate species will not be possible. Therefore in view of the larger interest of development of mariculture in A & N waters the team is of the opinion that at a later period the present FTC campus may be brought along with the CARI campus of Marine Hill.

I. Sea water quality at Phoenix Bay

Phoenix Bay is located in the southern coast of Port Blair Inland Sea (Fig. 1) and the northern slope of Marine Hill forms a part of it. Herein lie the space alloted for CARI and FTC. Immediately after the CARI's western sector lies the ship repair yard and there after lie the piers from which inter-island shipping is being conducted. The deep sea fishing trawlers too are being berthed here. Opposite to the western sector lies a small triangular piece of land belonging to the repair yard (Fig. 3) in which is an old tin roofed building. Chatham Island where famous woodworks and the wharfs are located is about 1.5-2.0 km along the shore, westward and beyond this lies the WIMCO match splinter factory, Haddo wharf and oil storage tanks. A floating dry dock has been anchored about 1.5 km westward from Chatham. Further 2-3 km inside the bay, lies the Viper Island.

Adjacent to the eastern sector is a large piece of land said to belong to the Bay Islands Hotel. The Hotel itself lies about 300 m from the eastern sector. Further east lie the General Hospital, Aberdeen Jetty (Fig. 1) (for smaller fishing crafts) and Ross Island. Adjacent to Aberdeen jetty the city sewage is let into the sea on one side and on the other side lies the enclosed swimming area. Thereafter come the open waters, which is about 2.5-3 km, from the Marine Hill. On the opposite shore; opposite to Chatham lies Bamboo Flat wherein lie the Andaman Timber (Plywood) Industries from which wood waste enters the bay and close to it logs are also allowed to rot. Domestic sewage enters the inland sea at various points.

From this description it is clear that the Port Blair Bay is not free of pollutants. The team did not notice any oil sick. The current patterns (surface and bottom) is not known and so presently one does not know how all the saw dusts and timber wases move about. The bay being deep, probably is able to contain the pollutants, all these years. Presently the pollutants seem not in alarming concentration, as to hinder positioning of marine hatchery at Marine Hill. The water close to Marine Hill is good and very clear. The sea water intake need to be fixed at a deeper area and should be neither close to surface nor bottom. A rocky pit is preferred.

4. Pearl oyster survey

A survey was conducted on the natural resources of pearl oysters of both *Pinctada margaritifera* and *P. fucata* in the shallow and deeper waters of various islands in the National Marine Park around Wandoor. Prior to the survey, the divers were given necessary guidelines to record the occurrence of pearl oysters along with the coaral reef survey and to report these details to the first team.

Accordingly eight pearl oysters belonging to the species *P. sugilata* were collected at 3 m depth around the island Alexandra. They occurred only at a few places indicating sparse settlement. The size of these oysters ranged from 22.0 mm to 58.0 mm in dorso-ventral measurement (DVM) with an average of 43.9 mm. The slope around the island extended upto 7 m and beyond this limit a sudden increase in depth was noticed with no visibility of bottom. *P. margaritifera* and *P. fucata* beds were not seen in the island at any depth.

A large size live specimen of *P. margaritifera* measuring 107 mm in DVM, and shell of the same species measuring 106 mm (DVM) were collected from a coral rock on the western side of the Jolly Boy Island at a depth of 10 m. A similar sized *P. margaritifera* was also seen in small numbers in the Malay Island at 5 m depth beyond which there was a sudden steep. In the above two islands there were only stray specimens. *P. fucata* or *P. sugillata* were not recorded. Though the area around Grab Island was rocky no pearl oyster was seen.

The sea front area just opposite to Marine Hills on the eastern side of the Phoenix Bay was surveyed. Upto 4 m depth along the shore, there were rocks and huge boulders and between 4 to 8 m depth round brain corals were seen here and there and the interspace was covered by white coraline sand. Beyond 8 m depth the bottom consisted of coral sand and mud. Fifteen specimens of *P. margaritifera* were seen in this area upto 4 m depth. The size of the oysters was around 70mm. There were no other species of pearl oysters in all these depths.

The survey at North Bay indicated no pearl oysters. The entire bay was occupied by different types of dead and live corals mostly brain corals. The interspace was filled with white coral sand. The minimum 5 m depth required for pearl culture work was not available at this Bay. The depth soundings given in the Admiralty chart has no relevance to the present condition of the Bay beacause of profuse growth of live corals. Though the Bay appeared to be suitable for pearl culture in view of its protected and enclosed nature, it may not be so. However, the mouth of the Bay may be chosen as one of the sites for mooring pearl culture rafts (Fig. 1).

The survey in and around the Bamboo Flat and Panighat revealed no pearl oysters. The bay at Bamboo Flat received effluents from timber factory and domestic wastes mostly from the shopping complex. As a result, in the areas surveyed, the coast line had less fauna except the rock oyster *Soccostrea cuculata*. Among the areas surveyed Aberdeen Bay (Sesostris Bay) was found ideal and potential for pearl oysters especially *P. margaritifera*. The Bay has a vast area with large boulders and rocks. In addition, many artificially constructed structures like the Aberdeen jetty, breakwaters and cement panels in the swimming pool provide additional substrata for settlement of pearl oysters. Though the fishing harbour and discharge of domestic wastes pollute the bay waters, the water is replenished by tidal waves from the open sea. Another remarkable feature of the Bay is the occurrence of different broods of *P. margaritifera*. During low tide, most of the Bay is exposed which resulted in the removal of oysters by the local people for marketing. A pair of polished shells of *P. margaritifera* was sold at Rs. 15/- in the market. Among all the places, the area between Aberdeen Bay and South Point provide comparatively good source of *P. margaritifera*.

Observation at Pongi Balu, opposite to Rutland Island revealed the presence of a few flat oysters (*P. sugillata*) at the intertidal areas. Numerous soft corals were seen all along the coast. Careful survey of deeper waters in this area indicated no pearl oysters but small to large sized *Pteria penguin* were seen at 10 m depth. Numerous parrot fishes and coral fishes were observed. In earlier experiments culture of mussels and pearl oysters suspended at this place by CARI was not successful because of heavy predation by parrot fishes. The pearl oysters present at hidden crevices were left alive.

It was summarised that (i) only stray specimens of older *P. margaritifera* could be observed both in the National Marine Parks near Wandoor and in the places around Port Blair except in Aberdeen Bay where younger specimens of the above species could be noted. (ii) Thick population of any species of pearl oysters could not be located even in deeper waters around Port Blair. (ii) The absence of *P. fucata* population in and around South Andaman was worth-noting. (iv) The available limited population of *P. margaritifera* could be utilised only for spawning purposes and it may not be sufficent for pearl culture.

At Port Blair and its surroundings the area between the Phoenix Bay and South Point indicated the presence of pearl oysters. This is because of its close proximity to open sea which supply fresh sea water. The northwest and western portion of Port Blair comprising Bamboo Flat, Haddo, Mitha, Khari, Viper Island and Dandus Point have less resources of pearl oysters except a few on constructed structures. This was probably due to the stagnation of water, shipping activity by the Indian Navy, passenger ships, dry - docking, fishing trawlers and other activities like timber works by Andaman Plywood Factory, Wimco Factory etc.

Data for hydrological parameters collected at 12 centres (Table 1 - 3) around Port Blair by the CARI for about 18 months were critically studied with regard to the suitability for prawn and molluscan hatcheries and for pearl culture operations. The average salinity at Fisheries Jetty- the proposed area for prawn and molluscan hatcheries varied from 27.4 ppt in January to 34.2 ppt in April. A similar condition was also observed in the other 11 centres. The salinity seems to be ideal for prawn and molluscan hatchery works. The average water temperature at Fisheries Jetty ranged from 28.9° (September) to 31.1°C (April). The average dissolved oxygen fluctuated between 3.0 ml/l (September) and 5.1 ml/l (January). As far as the hydrology was concerned there was no drastic change and was quite optimum for mariculture activities. Other factors such as the proximity to open sea, possibility of pollution, physical conditions of the sea and wind action must be looked into.

The proposed prawn and molluscan hatcheries are to be located at Marine Hills on the eastern side of the Fisheries Jetty. The sea is just opposite to Marine Hills. Pollution is negligible at the site. The bottom is rocky upto 8 m depth with intermittent coral sand , and hence the water remains clear. Close proximity of the site to open sea is an added advantage. Report indicates less silt from the land during rainy season. The wind action during northeast and southwest monsoons is almost prevented by the mountains in the North Bay and the Marine Hills respectively. The expected moderate wave action might allow mooring of serial rafts as in Japan rather than unit raft system as in the mainland. The vast area available for farming at this site will form no hinderance to navigation of ships. As the hatcheries are to be located at the elevated place, the problem of watch and ward for the farm may not arise. It can easily be monitored by remaining in the residence or in the laboratory. The well constructed break-water just at the door step of the hatchery and the proposed construction of a jetty would provide facilities for berthing vessels meant for farm work. Moreover the hatchery and the farm are to be located close to Port Blair city and hence round the clock vigilance is possible.

A similar farm condition is available on the western side of Ross Island in Sesostris Bay (Fig. 1). As the island is under the control of the Indian Navy, the rafts at the site may receive protection from poaching. Farming of pearl oysters here may also promote seed supply to the Bay during spawning seasons. Good quality sea water and sufficient depth exist in the site. However, physical conditions of the sea should be taken into account during the other periods of the year.

5. Permanent station for fisheries research at Viper Island

1. Viper Island (Fig. 2) is the largest (0.5 km^2) of the two islands present in the Port Blair inland sea; the other being Chatham Island (Fig.1). The Viper Island is situated

far inside close to Minnie Bay and is hilly. In the north and in the south it is separated by sea of about 200 and 700 m respectively from the South Andaman (Fig. 2). In the SE-NW and NS directions it is 1.05 km and 0.50 km long respectively. There are four promontories, two in the west and two in the east which could be used for jetties. The jetty in the southern tip of the western side is in good condition. From this jetty, the distance to Chatham pier is 4.3 km, to Junglighat jetty 3 km and to the western tip of Minnie Bay only 700 m. During the southwest monsoon, waves beat hard especially along the western coast. Therefore sea wall has been constructed at many places along the coast. The narrow (about 200 m) water space in the north has a maximum depth of 12 m for a limited area and presently this depth is being silted up. Similarly in the southern side lies an east - west stretch (1200 m × 30 - 160 m) of deeper area (9-17 m). The NW, SE portions and the southern tip of western side of the island are rocky. The southern coastline is strewn with rocks and pebbles while the rest of the coast is muddy (Fig. 2). A saw mill is present north of Viper on the South Andaman coast. From this, saw dust and other timber wastes reach the sea. At Viper only a very limited area is covered by mangrove.

Close to the jetty lies the old guard house, a red building of about 60 m^2 in area. The building is in a reasonable state. It could be used to store construction materials when the fishery complex is taken up. The red domed building situated, close to jetty on the top of a small elevation of about 8 m is the remnant of the old jail and gallows which is not in use for quite a long time possibly since 1910 when the cellular jail was completed. All these being in a small secluded portion quite removed from the rest of the island do not interfere with the development of Viper as a centre for fishery research. The rest of the island forms the major portion comprising of a small hillock of 67 m height. An old track which is in bad state runs north westward from the jetty to the central part. The whole island is fully covered with thickets, bushes and groves. Coconut, mango, banana and arecanut grow in plenty. In between these and at random grow a variety of trees. There are at least five fresh water catchments of different capacities. The largest among them is about 18 × 10 m and is said to be over 5 m deep. The smallest reservoir is about 2 × 1 m. Two other reservoirs are dry. All the reservoirs have quality slabs for steps but presently are in loose condition. Of the two wells one is in use and the water is soft and fit for drinking.

There are many levelled stretches of different dimensions at various elevations. All are presently overgrown with flora. Well planned tracks connecting these stretches are also discernable. Though there are not much of thorny bushes, the thick cover of vegetation made the survey by foot difficult. Presently two watchmen are on duty in this island.

Team's views about the facilities proposed

Regarding the quality of sea water around Viper, data collected (Table 1) by scientists of CARI indicated prevalence of marine conditions throughout the year. Since the width of water body north and south of Viper is narrow the enormous quanitity of water resulting from heavy rains and tidal changes cause fast water current close to shore. Further the silt load in the water is also high. Therefore close to this island it may not be possible to keep rafts for culture purposes. Thus mariculture activity needs to be restricted to pond system. But Viper suits well for having laboratory and residential facilities for the conduct of research in marine fishery.

The jetty at Viper can be lengthened toward a safe direction keeping in mind the safety of vessels berthed herein during southwest monsoon, to accommodate larger research vessels like FORV *Sagar Sampada.*

Support facilities for such research vessels can also be provided here. Other facilities like manned and unmanned submersibles and decompression chamber connected with deep diving also need to be located.

South Andaman Island suits best to locate an oceanarium for entertainment and to inculcate love for marine life in the public. Further it can also be a source of revenue.

Fresh water and electricity can be supplied to Viper from South Andaman probably through Elephant point or Minnie Bay area.

For the facility contemplated at Viper, a support facility covering an area of 15-20 ha in the shore close to port Blair is a must. This needs to have a small jetty to serve Viper, and garages for vehicles and transit facilities. Unless there is proper communication facilities the Viper will be sea-locked.

Since the availability of levelled ground close to sea at Viper is very limited for the construction of large pond culture systems (for research and demonstration) the adjoining shore of South Andaman (near Elephant Point) where levelled areas are available may be utilized.

Due to the large area involved, nature of the ground and vegetation cover it is not possible to give a layout plan in this report. Therefore it is suggested that a contour survey of Viper be carried out, giving details about the levels, stretches, course of the track, sites of the water reservoir etc. Based on it, layout plan and detailed sketches could be drawn.

6. Strategies for overall development of marine fisheries and identification of priorties

The human population of A & N Islands according to 1981 census was 1,88,737 of which 1,58,283 were at Andaman group of islands and 30,454 at Nicobar group of islands. The population at South Andaman Island comprising Port Blair was 97,133. By 2000 AD the population at South Andaman is expected to be 2,44,350, for Andaman group of islands 3,80,100 and for Nicobar group of islands 65,000 (Singh and Gaja, 1987). Among the people of A & N Islands, vegetarians form only a small fraction. Thus almost every one needs meat and fish. Among the people the majority are Bengalees, followed by Tamils and Keralites. Bangalees and Keralites are regular fish comsumers. Based on A & N Administration data the CARI estimates that by 2000 AD the requirement for meat and fish will be of the order of 4,633 tonnes per year (Singh and Gajja, 1987).

The data board exhibited at the Office of the Director of Fisheries, A & N Administration gives the following statistics. There are 2063 licenced fishermen who operate 92 mechanised and 1086 country fishing crafts and land their catches at 54 landing centres. The total quantity of marine fishes caught during the years 1981 to 1986 respectively in tonnes are 1,909, 3,879, 3,868, 6,231, 4,462 and 10,638. If this is true, the A & N Islands must have a large glut of fishes. But it is not true. Data on size groups caught, their seasonal fluctuation and CPUE are not available. In the main land, fishery statistics are being collected scientifically based on "space-time-stratification", wherein "centre day" is the basic unit. Since no such well tried scientific sampling design is used at A & N, the available fishery data is only a rough 'over' estimate. Therefore collection of proper fish landing data on scientific lines needs to be initiated. The study of biology and population dynamics of the fishes forming fishery at A & N Islands also need to be initiated at the earliest.

A. First priority

Presently no continuous data for a full year period for any one station in A & N sea is available pertaining to any one of biological or oceanographic parameters. Therefore the quantity, composition and seasonal fluctuation of phytoplankton and zooplankton including fish and lobster larvae and data pertaining to salinity, dissolved oxygen, pH and dissolved nutrients need to be collected.

To take up the first phase of programme immediately, the infrastructure available currently at Port Blair is insufficient. Further, some delay in planning and developing the facility at Viper is anticipated. Therefore for the immediate requirement it is felt that a laboratory to deal with the following needs to be set up at Port Blair close to Phoenix Bay and Aberdeen, the two fishing ports where the following studies can be undertaken:

1. Fish catch oriented data collection and processing
2. Fishery biology
3. Plankton studies - phyto, zoo and fish eggs and larvae
4. Water chemistry
5. Monitoring the status of coral reef and mangrove ecosystems
6. Maricultural resources and site identification (investigation pertaining to cultivable candidate species, its distribution in A & N sea, population structure, fluctuation etc. need to be carried out for the identification of possible species and culture sites. These are in a way a continuation and updating of the 1978 survey initiated by two teams of CMFRI scientists).

The above given facility requires the following equipments during the first phase:

1.	Cadalmin type vessel (42 feet & 210 HP) with winch	- 1	No
2.	Zoo and phytoplankton nets with flow meter	- 2	Sets
3.	Water sampling bottles	- 4	Nos
4.	Glassware & chemicals for the estimation of nutrients, salinity, dissolved oxygen and pH		
5.	Dissection (stereo) microscope	- 3	Nos
6.	Inverted binocular microscope	- 1	No
7.	Binocular research microscope	- 3	Nos
8.	pH meter (with facility and electrode for reading Eh)	- 1	No.
9.	Spectrocolorimeter (ECIL make)	- 1	No
10.	Balances to weigh fish samples (Tulaman (marine), counter pan, index balances, 5 kg with 0.5 g readability)		
11.	Chemical balance (Top pan) max. 600 g with 1 mg readability (Sartorius 1419)	- 1	No
12.	Monopan electronic balance max. 160 g with 0.01 mg readability (Sartorius 1712)	- 1	No
13.	Mantis distilled water unit (2 element)	- 1	No
14.	Folssom plankton splitter	- 1	No
15.	Plankton volume determiner	- 1	No
16.	Plankton counting chamber	- 1	No
17.	Thumb tally	- 2	Nos
18.	*SCUBA	- 4	Sets
19.	*Air compressor (to fill SCUBA cylinders) with working accessories	- 1	No
20.	A modest library having literature pertaining to identification (pisces, crustacea, mollusca, phyto and zooplankton, corals, echinoderms, marine mammals and sea weeds) and water analytical methods and data processing.		

* To be made available in the Marine Hill facility.

B. Strategies for longterm overall development

Andaman and Nicobar sea along the Ten Degree Channel is unique (Annexure I - Biogeography) in being the last of the marine ecosystems almost free from human interference. Thus remains a marine treasure trove awaiting scientific enlightenment. The ecosystems in the A & N sea are highly locational, patchy, delicate and fragile. Therefore while investigations are undertaken to augment the fish catch, as fish husbandman we need to remember that fishery research need poised not only towards exploitation of resources but also in finding ways of conserving the standing stock, conserving the ecosystem in which it lives, understanding eco-physiology of marine animals and means of culturing them. The second and the subsequent phases of research investigations are suggested to be taken up in the following areas:

1. Rate of primary production
2. Food chain and energy transfer
3. Physical oceanography especially patterns of surface and benthic currents, its role in the dispersal and migration of marine life. Chemical oceanography - nutrients, eutrophi-cation, nutrient cycle and upwelling.
4. Marine zoology of A & N sea
5. Benthos - mapping, community structure in areas of plate tectonics, benthic communities (possibility of finding out deep thermal vents is always there) and their ecology, use of SCUBA, underwater photography and submersibles (manned and unmanned)

6. Marine ecosystems and resources around volcanic islands. During IIOE high levels of phosphate was reported close to Barren Island. Recently huge quantities of prime sized shrimps were caught by foreign vessels near Narcondam. In this context, physico-chemical and biological parameters need to be investigated with reference to the volcanic Barren and Narcondam islands and the ridge on which they lie. 90° East Ridge too being a series of underwater elevations, the resources on it need to be studied

7. Identification, quantification and fixation of harvest size per year for non-conventional living resources like gorgonids), sponges, holothurians, echinoids (whose ovary is highly relished), cephalopods, deep water lobsters, ornamental fishes and shell fishes, turtles, their migration and rookeries and marine mammals including whales etc., towards judicious exploitation

8. Ecology, biota and conservation of reef forming corals, non-reef forming corals and reef community ecosystem

9. Study of mangroves, marine algae and sea weeds

10. Marine benthic microbiology

11. Biochemistry and pharmacology of marine toxins, venoms and other bio-active chemicals specially in gorgonids, sponges, echinoderms, ascidians etc.

12. Biotechnology of marine yeast

13. Damage due to shipping, man made alterations and pollutants

14. Since CARI is a unitary agricultural research organisation, fresh water biota also comes under its perview. Though fresh water bodies are available only in a limited extent, because of the unique geographical isolation, A & N Islands are bound to harbour fauna and aquatic flora endemic to them and new to science. The mighty Galathea and other rivers in Great Nicobar need special mention

15. Turning towards aquaculture, in the recent past in and around Port Blair, the following attempts in aquaculture have been made: A & N State Fishery Department experimented fish culture at Chipighat in the early seventies. Dr. D.B. James of CMFRI carried out some preliminary holothurian (*Holothuria scabra*) culture near Aberdeen which though yielded marginal result, could not be continued because of his transfer to mainland. Fishery scientists of CARI are doing their best to culture shrimps at Chippighat farm. The acid nature of the soil is a problem. Another problem is the changing water conditions; saline/brackish water turning into fresh water during rains. The old ponds presently have started showing trends of becoming less acidic and a species of grass has started growing on the bunds.

Breeding fresh water fishes is easier than marine fishes. By hypophysation almost all fresh water fishes can be made to spawn with very little modification of the technique. Fresh water fishes tolerate high stocking densities and reasonable load of biological wastes due to over crowding and lower ambient oxygen levels. Further they require lesser stretch of water for swimming and so smaller tanks are sufficient and are not very much fussy about environmental conditions for maturation and breeding. Not of the least, fresh water does not change drastically with evaporation on standing for days together, while brackish water becomes hyper saline. The problem of corrosion and fouling by borers is also absent in fresh water culture. Though the scientists of CARI are able to meet the demand for fresh water fish seeds in Port Blair area, they could not do so with brackish water organisms. Their attempts to cultivate *Perna viridis* and pearl oysters collected from the natural bed was badly affected by poaching and predation by fishes.

The team considers the following as the best choice of candidate species for mariculture in A & N Islands:

Crustaceans:			
	Penaeus merguiensis	.. ..	(B)
	P. monodon	.. ..	(A)
	Metapenaeus dobsoni	.. ..	(A)
	M. ensis	.. ..	(B)
Molluscs:			
	* *Pinctada margaritifera*	.. ..	(B)
	* *P. fucata* (Spat to be brought from Tuticorin)	.. ..	(A)
	* *Pteria penguin*		
	Crassostrea madrasensis	.. ..	(A)
	C. cucullata		
	Perna viridis	.. ..	(A)
	Trochus niloticus	.. ..	(C)
	Tridacna crocea and related species		
	Turbo marmoratus		
Echinoderms:			
	Holothuria scabra	.. ..	(C)
	H. atra		
	Actinopyga mauritiana		
	A. echinites		
	A. miliaris		
	Tripneustes gratilla		
	Echinometra mathaei		

*for the production of cultured pearls.

(A) Presently technology is available with CMFRI for these species. (B) the technology available with CMFRI can be modified to suit the current needs. (C) : the technology is underdevelopment. Under phase one, A & B could be taken up.

IV. Literature cited

Ahamed, Enayat 1972. *Coastal Geomorphology of India*. Orient Longman, New Delhi. x + 222 pp.

6. Marine ecosystems and resources around volcanic islands. During IIOE high levels of phosphate was reported close to Barren Island. Recently huge quantities of prime sized shrimps were caught by foreign vessels near Narcondam. In this context, physico-chemical and biological parameters need to be investigated with reference to the volcanic Barren and Narcondam islands and the ridge on which they lie. 90° East Ridge too being a series of underwater elevations, the resources on it need to be studied

7. Identification, quantification and fixation of harvest size per year for non-conventional living resources like gorgonids), sponges, holothurians, echinoids (whose ovary is highly relished), cephalopods, deep water lobsters, ornamental fishes and shell fishes, turtles, their migration and rookeries and marine mammals including whales etc., towards judicious exploitation

8. Ecology, biota and conservation of reef forming corals, non-reef forming corals and reef community ecosystem

9. Study of mangroves, marine algae and sea weeds

10. Marine benthic microbiology

11. Biochemistry and pharmacology of marine toxins, venoms and other bio-active chemicals specially in gorgonids, sponges, echinoderms, ascidians etc.

12. Biotechnology of marine yeast

13. Damage due to shipping, man made alterations and pollutants

14. Since CARI is a unitary agricultural research organisation, fresh water biota also comes under its perview. Though fresh water bodies are available only in a limited extent, because of the unique geographical isolation, A & N Islands are bound to harbour fauna and aquatic flora endemic to them and new to science. The mighty Galathea and other rivers in Great Nicobar need special mention

15. Turning towards aquaculture, in the recent past in and around Port Blair, the following attempts in aquaculture have been made: A & N State Fishery Department experimented fish culture at Chipighat in the early seventies. Dr. D.B. James of CMFRI carried out some preliminary holothurian (*Holothuria scabra*) culture near Aberdeen which though yielded marginal result, could not be continued because of his transfer to mainland. Fishery scientists of CARI are doing their best to culture shrimps at Chippighat farm. The acid nature of the soil is a problem. Another problem is the changing water conditions; saline/brackish water turning into fresh water during rains. The old ponds presently have started showing trends of becoming less acidic and a species of grass has started growing on the bunds.

Breeding fresh water fishes is easier than marine fishes. By hypophysation almost all fresh water fishes can be made to spawn with very little modification of the technique. Fresh water fishes tolerate high stocking densities and reasonable load of biological wastes due to over crowding and lower ambient oxygen levels. Further they require lesser stretch of water for swimming and so smaller tanks are sufficient and are not very much fussy about environmental conditions for maturation and breeding. Not of the least, fresh water does not change drastically with evaporation on standing for days together, while brackish water becomes hyper saline. The problem of corrosion and fouling by borers is also absent in fresh water culture. Though the scientists of CARI are able to meet the demand for fresh water fish seeds in Port Blair area, they could not do so with brackish water organisms. Their attempts to cultivate *Perna viridis* and pearl oysters collected from the natural bed was badly affected by poaching and predation by fishes.

The team considers the following as the best choice of candidate species for mariculture in A & N Islands:

Crustaceans:	
Penaeus merguiensis	(B)
P. monodon	(A)
Metapenaeus dobsoni	(A)
M. ensis	(B)
Molluscs:	
* *Pinctada margaritifera*	(B)
* *P. fucata* (Spat to be brought from Tuticorin)	(A)
* *Pteria penguin*	
Crassostrea madrasensis	(A)
C. cucullata	
Perna viridis	(A)
Trochus niloticus	(C)
Tridacna crocea and related species	
Turbo marmoratus	
Echinoderms:	
Holothuria scabra	(C)
H. atra	
Actinopyga mauritiana	
A. echinites	
A. miliaris	
Tripneustes gratilla	
Echinometra mathaei	

*for the production of cultured pearls.

(A) Presently technology is available with CMFRI for these species. (B) the technology available with CMFRI can be modified to suit the current needs. (C) : the technology is underdevelopment. Under phase one, A & B could be taken up.

IV. Literature cited

Ahamed, Enayat 1972. *Coastal Geomorphology of India*. Orient Longman, New Delhi. x + 222 pp.

Easterson, D.C.V. and S. Mahadevan 1980. Review of open sea environmental conditions along Indian coast. *Bull. Cent. Mar. Fish. Res. Inst.*, No. 29 : 17-21.

James, D.B. 1986. Zoogeography of shallow-water echinoderms of Indian seas. In: *Recent Advances in Marine Biology.* P.S.B.R. James (Ed.), Today &Tomorrow's Publishers, New Delhi, 569-591.

James, D.B. 1989. Echinoderms of Lakshadweep and their zoogeography. *Bull. Cent. Mar. Fish. Res. Inst.*, No. 43: 97-144.

Kloss, C. Boden 1902. *Andaman and Nicobars* (1971 reprint). Vivek Publishing House, Delhi, xiii + 373 pp.

Krishnan, M.S. 1968. *Geology of India and Burma.* Higginbothams, Madras, 1974, viii + 536 pp.

Mahadevan, S and D.C.V. Easterson 1983. Topographical feature of areas surveyed. In : *Mariculture Potential of Andaman and Nicobar Islands - An Indicative Survey. Bull. Cent. Mar. Fish. Res. Inst.*, No. 34 : 10-25.

Mani, M.S. 1974. Biogeography of the eastern borderlands. In : *Ecology and Biogeography in India,* M.S. Mani (Ed.), Dr. W. Junk x.b.r. Publishers, The Hague, 648-663.

Richmond, C.W. 1903. Birds collected by Dr. W.L. Ablott and Mr. C.B. Kloss in the Andamann and Nicobar Islands. *Proc. US. Nat. Mus.*, 25 : 287-314.

Singh, N.T and B.L. Gajja 1987. *Ecological Considerations and Agricultural Development of A & N Islands.* Central Agricultural Research Institute for A & N Islands, Port Blair, 55 pp.

Singh N.T., A.D. Mongia and A.N. Ganeshmurthy 1988. Soils of Andaman and Nicobar Islands. *CARI, Bull.*, No. 1 : 1-80.

Wedia, D.N. 1975. *Geology of India.* IV Edition. Tata McGraw-Hill, New Delhi, xxiv + 508 pp + 19 plates.

ANNEXURE 1

Andaman and Nicobar Islands - a biogeographical sketch

Andaman and Nicobars (6°45' - 13°41' N, 92°12' - 93°57'E) is one of the seven union territories in the Indian Republic. Being located in the eastern part of Bay of Bengal, between Cape Negrais of Burma (Myanmar) in the north and Achin Head (Cape Pedro) in Andalas (Sumatra) in the south, these are also known as Bay Islands. In zoogeography A & N sea is considered as a separate marine biotope. Andaman and Nicobar Islands are two groups of chain of islands numbering 572 (only 315 seem to be of sizable dimension) formed in an arc directed towards Bay of Bengal. The distance between Port Blair to continental India (Madras) is 1191 km by ship. Pygmalion point, recently named as Indira Point in Great Nicobar is 146 km from Sumatra. The Ten Degree Channel having depths over 1000 m isolates the two groups by 96 km. The islands north of Ten Degree Channel from Little Andaman upto Cocos and Preparis Islands are known as Andaman Islands. Of these, Cocos and Preparis Islands belong to Burma. The Nicobar groups are south of Ten Degree Channel comprising islands from Car Nicobar in the north to Great Nicobar in the south.

The islands extend to a length of 700 km. The average and maximum widths of the islands are 24 km and 51 km. The total area is 8293 km^2 of which Nicobar group covers 1953 km^2. Kloss (1902) was of opinion that Andaman ridge on which Andaman and Nicobar Islands are present is just an extension of a series of hilly ranges extending from Eastern Himalayas, Araken and Yoma ranges through Cape Negrais.

East of the Andaman ridge is a volcanic ridge on which are situated Narcondam (7.2 km^2) and Barren Islands (Krishnan, 1968). What is now seen of Barren Island is a mere "truncated remnant of a once much larger cone — its basal wreck or caldera. It consists of an outer amphitheatre, about 3 km in diameter, breached at one or two places, the remains of the old cone, surrounding an inner much smaller but symmetrical cone composed of regularly bedded lava sheets of comparatively recent eruption. At the summit (353 m) of this newer cone is a crater about 300 m above the level of the sea. But the part of the volcano seen above the waters is quite an insignificant part of its whole volume. The base of the cone lies some thousands of metres below the surface of the sea" (Wadia, 1975). Capt. Blair reported the volcano to be active during 1795. Springs of hot water issue at several places along the coast. About 120 km, WSW is an elliptical submarine bank which could be the remains of a third cone (Ahamed, 1972). "The oval-shaped Narcondam Island is a craterless 100 m high volcano composed wholly of andesitic lava. From the amount of denudation the cone has undergone, it appears to be an old extinct volcano" (Wadia, 1975) which should have been active during prehistoric time. Baratang Island which lies between Middle and South Andaman possesses mud volcanoes associated with oil and gas (Singh *et al.*, 1988). The third ridge viz., Ninety Degree East Ridge lies submerged west of Andaman Ridge and is considered as the underwater continuation of Naga Ridge (Krishnan, 1968).

East of Car Nicobar along 94 degree longitude is a lengthy strip of deep area in which lies the deepest (4198

Easterson, D.C.V. and S. Mahadevan 1980. Review of open sea environmental conditions along Indian coast. *Bull. Cent. Mar. Fish. Res. Inst.*, No. 29 : 17-21.

James, D.B. 1986. Zoogeography of shallow-water echinoderms of Indian seas. In: *Recent Advances in Marine Biology.* P.S.B.R. James (Ed.), Today &Tomorrow's Publishers, New Delhi, 569-591.

James, D.B. 1989. Echinoderms of Lakshadweep and their zoogeography. *Bull. Cent. Mar. Fish. Res. Inst.*, No. 43: 97-144.

Kloss, C. Boden 1902. *Andaman and Nicobars* (1971 reprint). Vivek Publishing House, Delhi, xiii + 373 pp.

Krishnan, M.S. 1968. *Geology of India and Burma.* Higginbothams, Madras, 1974, viii + 536 pp.

Mahadevan, S and D.C.V. Easterson 1983. Topographical feature of areas surveyed. In : *Mariculture Potential of Andaman and Nicobar Islands - An Indicative Survey. Bull. Cent. Mar. Fish. Res. Inst.*, No. 34 : 10-25.

Mani, M.S. 1974. Biogeography of the eastern borderlands. In : *Ecology and Biogeography in India,* M.S. Mani (Ed.), Dr. W. Junk x.b.r. Publishers, The Hague, 648-663.

Richmond, C.W. 1903. Birds collected by Dr. W.L. Ablott and Mr. C.B. Kloss in the Andamann and Nicobar Islands. *Proc. US. Nat. Mus.,* 25 : 287-314.

Singh, N.T and B.L. Gajja 1987. *Ecological Considerations and Agricultural Development of A & N Islands.* Central Agricultural Research Institute for A & N Islands, Port Blair, 55 pp.

Singh N.T., A.D. Mongia and A.N. Ganeshmurthy 1988. Soils of Andaman and Nicobar Islands. *CARI, Bull.*, No. 1 : 1-80.

Wedia, D.N. 1975. *Geology of India.* IV Edition. Tata McGraw-Hill, New Delhi, xxiv + 508 pp + 19 plates.

ANNEXURE 1

Andaman and Nicobar Islands - a biogeographical sketch

Andaman and Nicobars (6°45' - 13°41' N, 92°12' - 93°57'E) is one of the seven union territories in the Indian Republic. Being located in the eastern part of Bay of Bengal, between Cape Negrais of Burma (Myanmar) in the north and Achin Head (Cape Pedro) in Andalas (Sumatra) in the south, these are also known as Bay Islands. In zoogeography A & N sea is considered as a separate marine biotope. Andaman and Nicobar Islands are two groups of chain of islands numbering 572 (only 315 seem to be of sizable dimension) formed in an arc directed towards Bay of Bengal. The distance between Port Blair to continental India (Madras) is 1191 km by ship. Pygmalion point, recently named as Indira Point in Great Nicobar is 146 km from Sumatra. The Ten Degree Channel having depths over 1000 m isolates the two groups by 96 km. The islands north of Ten Degree Channel from Little Andaman upto Cocos and Preparis Islands are known as Andaman Islands. Of these, Cocos and Preparis Islands belong to Burma. The Nicobar groups are south of Ten Degree Channel comprising islands from Car Nicobar in the north to Great Nicobar in the south.

The islands extend to a length of 700 km. The average and maximum widths of the islands are 24 km and 51 km. The total area is 8293 km^2 of which Nicobar group covers 1953 km^2. Kloss (1902) was of opinion that Andaman ridge on which Andaman and Nicobar Islands are present is just an extension of a series of hilly ranges extending from Eastern Himalayas, Araken and Yoma ranges through Cape Negrais.

East of the Andaman ridge is a volcanic ridge on which are situated Narcondam (7.2 km^2) and Barren Islands (Krishnan, 1968). What is now seen of Barren Island is a mere "truncated remnant of a once much larger cone — its basal wreck or caldera. It consists of an outer amphitheatre, about 3 km in diameter, breached at one or two places, the remains of the old cone, surrounding an inner much smaller but symmetrical cone composed of regularly bedded lava sheets of comparatively recent eruption. At the summit (353 m) of this newer cone is a crater about 300 m above the level of the sea. But the part of the volcano seen above the waters is quite an insignificant part of its whole volume. The base of the cone lies some thousands of metres below the surface of the sea" (Wadia, 1975). Capt. Blair reported the volcano to be active during 1795. Springs of hot water issue at several places along the coast. About 120 km, WSW is an elliptical submarine bank which could be the remains of a third cone (Ahamed, 1972). "The oval-shaped Narcondam Island is a craterless 100 m high volcano composed wholly of andesitic lava. From the amount of denudation the cone has undergone, it appears to be an old extinct volcano" (Wadia, 1975) which should have been active during prehistoric time. Baratang Island which lies between Middle and South Andaman possesses mud volcanoes associated with oil and gas (Singh *et al.*, 1988). The third ridge viz., Ninety Degree East Ridge lies submerged west of Andaman Ridge and is considered as the underwater continuation of Naga Ridge (Krishnan, 1968).

East of Car Nicobar along 94 degree longitude is a lengthy strip of deep area in which lies the deepest (4198

			Nos
(2)	*Maturation tanks*		
	Fibreglass tanks 10 t capacity	–	1
(3)	*Spawning tanks*		
	Fibreglass tanks 200 l capacity	–	3
(4)	*Larval and juvenile rearing*		
	Fibreglass tanks 1 t capacity	–	10

B. *Instruments*

(1)	Electro cautery apparatus 230 V; 50 HZ.	–	1
(2)	Colorimeter (Erma) 230V; 50 HZ.	–	1
(3)	Hand pelletiser (stainless steel)	–	1
(4)	Hand held refractometer (in S‰, calibrations and Temperature compensated; AO or similar make)	–	1
(5)	Pressure vacuum pump (heavy duty, oil free and suitable for continuous operation) single phase; 230 V; 50 HZ	–	1
(6)	All glass double water distillation unit (manufacturer: Vensil, Doravinagar, Bangalore)	–	1
(7)	Air compressor with pressure tank and John Fowler oil vapour filter 1 HP	–	2
(8)	Stereo microscope Olympus Indian, with Japanese optics with lamp	–	2
(9)	Sea water pump with polypropylene impeller, 1 HP; single phase; 230 V; 50 HZ	–	2
(10)	Hot air oven 50 x 50 x 60 cm with 0-200°C thermometer (stainless steel interior & trays)	–	1
(11)	Deep freezer, vertical (to store feed for brood stock)	–	1
(12)	pH meter (ECIL make) with electrode	–	1
(13)	Thermometer 0-50°C (1/10 Div.)	–	4
(14)	Balance, 60/600 g, readability 0.01/0.001 g (Sartorius 1419)	–	1
(15)	GI pipes and pin valaves for taking air supply Air line (PVC flexible tube), 4,3,2, way joints, valves and diffuser stones		

C. Glassware (Borosilicate glass)

(1)	Beaker with spout	100 ml	(graduated)	6
		250 ml	"	6
		500 ml	"	12
		1000 ml	"	12
		500 ml	"	10

				Nos
(2)	Glass dropper (pasteur pipette) : 15 cm length with rubber teat		–	24
(3)	Measuring cylinder with spout and base (class A)	100 ml	–	6
	"	100 ml	–	6
	"	250 ml	–	3
	"	1000 ml	–	3
(4)	Burette (class A)	10 ml	–	4
	"	50 ml	–	4
	"	100 ml	–	4
(5)	Burette (class A)	200 ml	–	3
	"	50 ml	–	3
	(Manufacturer : Vensil, Danavinager, Bangalore)			
(6)	Microscope slides thin type, deluxe		–	3 boxes
(7)	Reagent bottle, narrow mouth, tooled stopper	100 ml	–	10
	"	250 ml	–	10
	"	500 ml	–	10
	"	2000 ml	–	5
(8)	BOD bottles (numbered)	300 ml	–	25
(9)	Petridish (culture, flat) 6 cm dia		–	15
(10)	Test tube with rin	5 ml	–	25
	"	15 ml	–	25
	"	50 ml	–	25
	"	100 ml	–	25
(11)	Aluminium house foil 35 cm x 9 m rolls (Indian Aluminium Co., Ltd, 1 Middletan Street, Calcutta-700 071)		–	6

ANNEXURE 3

Materials required for phytoplankton culture

a. Water sterilisation

(1)	Plastic bins with lid 100 l	–	4
(2)	Silica cased immersion heater 1000W (50 cm length stem)	–	4
(3)	Plastic bucket 20 l	–	6
(4)	Plastic mug 1 l	–	6
(5)	Wooden stand 1.50 m x 1.0m	–	4
(6)	Wooden stand, 1.0 m x 0.25 m	–	4

b. Pure culture

(1)	Wooden rack with 4 tiers	–	2
	lxbxht= 1.75 x 0.5 x 2.25 m		
(2)	Haffkine culture flask: 4 l	–	36

h Algal culture nutrients

			Nos
(1)	Ferric chloride AR grade	–	500 g
(2)	Manganese chloride	–	"
(3)	Orthoboric Acid	–	"
(4)	Dibasic sodium acid phosphate	–	"
(5)	Potassium nitrate	–	"
(6)	Zinc chloride	–	"
(7)	Cobalt chloride	–	"
(8)	Ammonium para molybdate	–	"
(9)	Copper sulphate	–	"
(10)	Hydrochloric acid	–	2.5 l X 2
(11)	Cyanocobalamin	–	2 g
(12)	Thiamine	–	2 g
(13)	Sodium silicate	–	500 g x 2
(14)	Urea	–	1 kg
(15)	Sodium nitrate	–	500 g

i. Volumetric Standard Solutions

(1)	Hydrochloric acid	0.1 N	– 10 Ampoules
(2)	Sodium carbonate	0.1 N	– "
(3)	Potassium dichromate	0.1 N	– "
(4)	Silver nitrate	0.1 N	– "
(5)	Sodium thiosulphate	0.1 N	– "

ANNEXURE 4

Materials required for pearl culture and molluscan hatchery in the proposed permanent buidling at Marine Hill, Port Blair

a. *Spawning*

(1)	Perspex tanks 75 x 45 x 45 cm		–	4
(2)	JUMO thermometer switch 0-50°C with 15 cm long stem		–	3
(3)	JUMO relay 220 V, 50 HZ		–	3
(4)	Nylobolt cloth: 30 μ mesh		–	10 m
(5)	Silica cased immersion heater 500 W, heating stem about 30cm long		–	3
(6)	Beaker with spout	– 10 l	–	2
		– 5 l	–	20
		– 1 l	–	15
		– 500 ml	–	10
(7)	Standard flask, classA	– 100 ml	–	5
		– 250 ml	–	5
		– 500 ml	–	5
		– 1000 ml	–	3
(8)	Measuring cylinder with spout and base (class A)	– 100 ml	–	2
		– 250 ml	–	2
		– 500 ml	–	2
		– 1 l	–	2

			Nos
(9)	Cavity slide (single cavity)	–	2 boxes
(10)	Haemocytometer (neuber ruling)	–	5
(11)	Haemocytometer cover slip	–	2 boxes
(12)	Microscope slide thin type, deluxe	–	10 boxes
(13)	Square, No.1 cover slips	–	10 boxes
(14)	Glass dropper 15cm length	–	20
(15)	Glass trough with glass lid : 10 l	–	10
(16)	Injection syringe with needle: 1 ml	–	2
(17)	Injection syringe with needle 5 ml	–	2
(18)	Embryo cup with lid: 55 x 55 mm	–	25
(19)	Binocular microscope (Carl Zeiss/ Olympus) with photomicrographic attachment	–	1
(20)	Stereomicroscope	–	2
(21)	Camera lucida (Prism type) Erma	–	2

b. Larval rearing

(1)	Embryo cup 55 x 5/5 mm with lid	–	24
(2)	Cavity slide (single cavity)	–	1 box
(3)	Glass dropper 15 cm length	–	10
(4)	Cover slip (rectangular) No.2	–	3 boxes
(5)	Ocular micrometer (0–100 divisions) (Erma)	–	4
(6)	Stage micrometer (Erma)	–	1
(7)	Fibreglass tanks: 76 x 50 x 25 cm inner side light blue coloured	–	20
(8)	" inner side white coloured	–	6
(9)	Plastic Bucket 20 l	–	12
(10)	Plastic mug 1 l	–	12
(11)	Nylobolt silk cloth: 40 μ, 80 μ, 150 μ and 200 μ mesh.	–	2 m each
(12)	Thermometer 0-50° C (1/10 div.)	–	6
(13)	PVC pipe 20 cm dia.	–	15

c. Spat rearing

(1)	Fibreglass tanks 210 x 110 x 50 cm: 1 tonne capacity (inner side light blue coloured)	–	30
(2)	Fibreglass tanks 210 x 110 x 50 cm: 1 tonne capacity (innerside white coloured, for indoor mixed algal culture)	–	6

d. Juvenile rearing

(1)	Cages 40 x 40 x 10 cm	–	400
(2)	Velon screen : 400 μ mesh	–	10 rolls (of 30m each)
(3)	" : 1000 μ mesh	–	10 rolls (of 30m each)

		Nos
(3)	Electricity generator (Standby and spare) (Kirloskar - Cummins) 110 KV –	2
(4)	Binocular microscope : par focal, wide field with built – in illumination, bright field, phase contrast, fluorescence and colour photomicrography systems (Leitz - Orthoplan) –	1
(5)	Ultra–low temperature freezer (vertical) – -85°C –	1
(6)	Freeze- dryer (tray type) –	1
(7)	Top pan balance (Sartorius 1419 & 1907) (600 g max; readability 0.001 g 5600 g max; readability 0.01 g) –	1 each
(8)	Mono-pan balance (30/160 g max; readability 0.00001/0.0001 g) Sartorius 1712 –	1
(9)	Conductivity meter suitable for sea water use with cable and sensor (with temperature, salinity and resistance values) –	2
(10)	Research pH and Eh meter (accuracy pH 0.000) (Beckman, Radiometer) –	1
(11)	pH meter (accuracy pH 0.0) ECIL –	1
(12)	UV-VIS Double beam spectrophotometer with scanning and microsprocessor controlled recorder (Perkin-Elmer, Beckman, Philips) –	1
(13)	Atomic absorbtion sphectrophotometer, double beam with micro-sample accessory (Perkin-Elmer, Hewlet-Packard) –	1
(14)	Flame photometer (Systronics) –	1
(15)	Refrigerated contrifuge with continuous flow rotor head and other accessories (Sorval) –	1
(16)	HPLC with suitable columns and deductors for amino acid lipids with integrator –	1
(17)	Electrophoretic unit for gel slab (Pharmacia, BioRad) –	1
(18)	Disc electrophoretic unit –	1
(19)	Two Channel power supply unit for above –	1
(20)	Densitometer for TLC and gel –	1
(21)	Scanning Spectrofluorometer with recorder –	1
(22)	Rotary vacuum evaporator (Buchi) –	1
(23)	Refrigerated microtome with cryo attachment (Leitz, AO) –	1
(24)	Knife sharpener for No. 23 above –	1
(25)	Virtis homogeniser with semi–macro and micro attachments –	1
(26)	Fume cupboard suitable for perch loric acid digestion with built -in sink –	1
(27)	" standard unit and with built – in sink –	2
(28)	Milli RQ distilled water system (Millipore) –	1
(29)	Deep freezer vertical type –	3
(30)	Refrigerator –	5
(31)	G.M. Counter (ECIL) –	1
(32)	Liquid scintillation counting system –	1

Table 2. *Monthly range and average water temperature (°C) in inshore waters around Port Blair*

Month/ Year	Fisheries jetty 1	Inter station 2	Panighat 3	Bamboo flat 4	Inter station 5	Haddo 6	Inter station 7	Janglighat 8	Inter station 9	Mithakhari 10	Viper island 11	Dandu point 12
Jan.'85	27.5-31.0 (28.9)	28.5-29.5 (29.0)	28.0-30.0 (29.0)	27.5-30.0 (28.9)	28.0-30.0 (28.9)	27.0-30.0 (28.5)	27.5-29.0 (28.6)	26.5-30.0 (28.2)	26.0-29.0 (28.0)	27.0-29.5 (28.3)	27.0-29.0 (28.2)	27.0-29.4 (28.2)
Feb.	28.0-31.5 (29.6)	28.0-30.0 (28.9)	29.0-30.5 (29.9)	28.5-30.5 (29.7)	28.5-30.0 (29.2)	27.0-30.0 (28.8)	28.0-29.5 (28.8)	28.0-30.0 (28.8)	28.0-30.0 (29.0)	28.0-30.5 (29.1)	27.50-30.0 (29.0)	28.0-29.2 (28.6)
Mar.	29.0-33.0 (31.1)	29.0-32.0 (30.5)	29.0-33.0 (30.8)	29.5-32.0 (30.8)	29.5-32.0 (30.6)	29.0-31.5 (30.5)	30.0-32.0 (30.8)	29.0-31.5 (30.5)	29.0-31.5 (30.4)	29.5-32.0 (30.9)	30.0-32.0 (31.0)	29.0-32.2 (30.6)
Apr.	31.5	31.0	31.0	31.0	31.0	31.0	31.0	31.5	31.0	32.0	32.0	32.0
May	30.0-32.5 (31.2)	30.0-32.5 (31.1)	30.0-32.0 (31.1)	30.0-32.5 (31.2)	30.0-32.5 (31.0)	29.0-32.0 (30.5)	28.0-32.0 (30.4)	28.0-32.5 (30.5)	29.0-32.0 (30.8)	29.0-32.0 (30.7)	29.0-31.5 (30.5)	29.0-32.2 (30.6)
Jun.	28.5-29.5 (28.9)	28.0-29.5 (28.9)	28.0-29.5 (28.8)	28.0-29.5 (28.7)	28.0-29.5 (28.8)	28.0-29.5 (28.7)	28.0-29.0 (28.7)	28.0-29.0 (28.7)	28.0-29.0 (28.7)	28.0-29.0 (28.7)	28.0-29.0 (28.8)	28.0-29.4 (28.7)
Jul.	29.5-31.0 (30.4)	29.5-30.5 (30.1)	29.5-30.5 (29.9)	29.5-30.0 (29.7)	29.0-30.0 (29.5)	28.0-30.0 (29.1)	28.5-30.5 (29.7)	27.50-30.0 (29.0)	28.0-30.0 (29.2)	28.0-30.5 (29.0)	28.0-30.0 (29.1)	28.0-30.4 (29.2)
Aug.	29.0-30.0 (29.3)	29.0-30.0 (29.3)	29.0-30.0 (29.3)	29.0-30.0 (29.4)	29.0-30.0 (29.5)	29.0-30.0 (29.3)	29.0-29.5 (29.3)	29.0-31.5 (29.5)	29.0-31.0 (29.4)	29.0-30.0 (29.2)	29.0-31.0 (29.5)	29.0-29.4 (29.2)
Sep.	27.5-30.7 (28.7)	27.3-28.9 (28.2)	27.5-28.7 (28.3)	27.5-29.2 (28.2)	27.3-29.3 (28.3)	27.5-29.3 (28.3)	27.5-29.0 (28.2)	26.9-29.0 (28.0)	27.4-29.0 (28.2)	27.4-29.2 (28.1)	27.3-29.4 (28.2)	27.6-29.0 (28.3)
Oct.	–	–	–	27.6-28.4 (28.0)	27.8-28.7 (28.3)	27.9-29.9 (28.9)	28.1-29.4 (28.6)	28.3-29.7 (28.8)	28.1-30.1 (29.1)	28.0-30.0 (29.0)	28.2-29.9 (29.1)	28.3-29.7 (29.0)
Nov.	–	–	–	29.1-29.3 (29.2)	28.5-29.4 (29.1)	27.3-31.7 (29.2)	27.3-31.0 (29.2)	27.4-30.7 (29.2)	27.5-31.3 (29.4)	27.5-31.5 (29.4)	28.0-30.7 (29.1)	27.3-30.7 (29.0)
Dec.	–	–	–	29.9-30.0 (30.0)	29.6-30.0 (29.8)	27.1-28.7 (28.0)	28.4-29.0 (28.8)	28.3-29.2 (28.7)	28.2-28.2 (28.2)	28.0-28.5 (28.3)	28.4-28.9 (28.9)	28.0-28.4 (28.2)
Jan.'86	29.1	28.5	27.2-29.2	26.3-29.6	26.2-29.3	27.2-29.3 (28.3)	26.8-29.6 (28.5)	27.6-28.8 (28.0)	27.9-28.7 (28.1)	26.9-30.7 (28.8)	26.8-29.1 (28.3)	26.9-29.1 (28.0)

Data collected by K. Dorairaj & R. Sounderarajan, CARI.