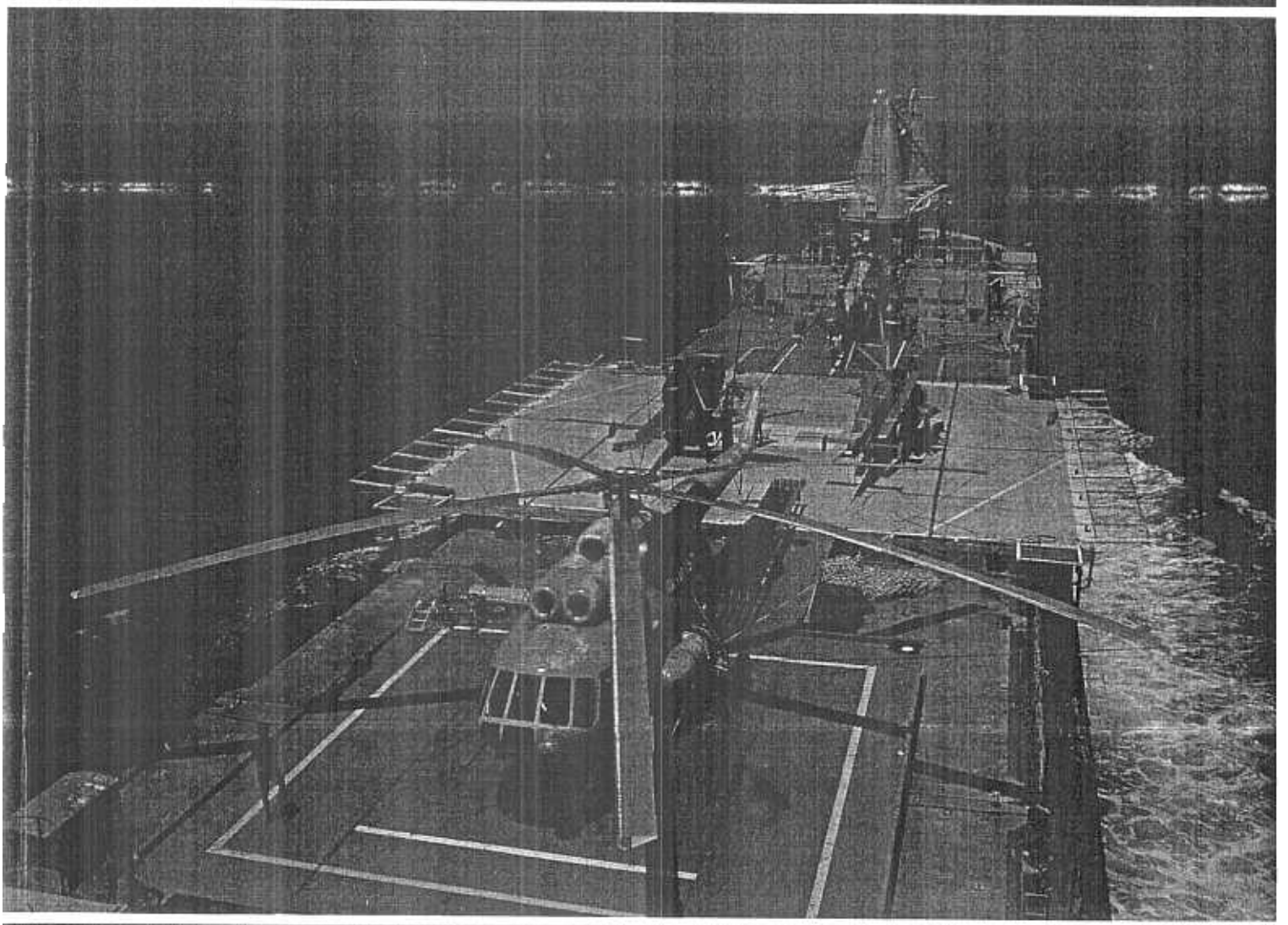
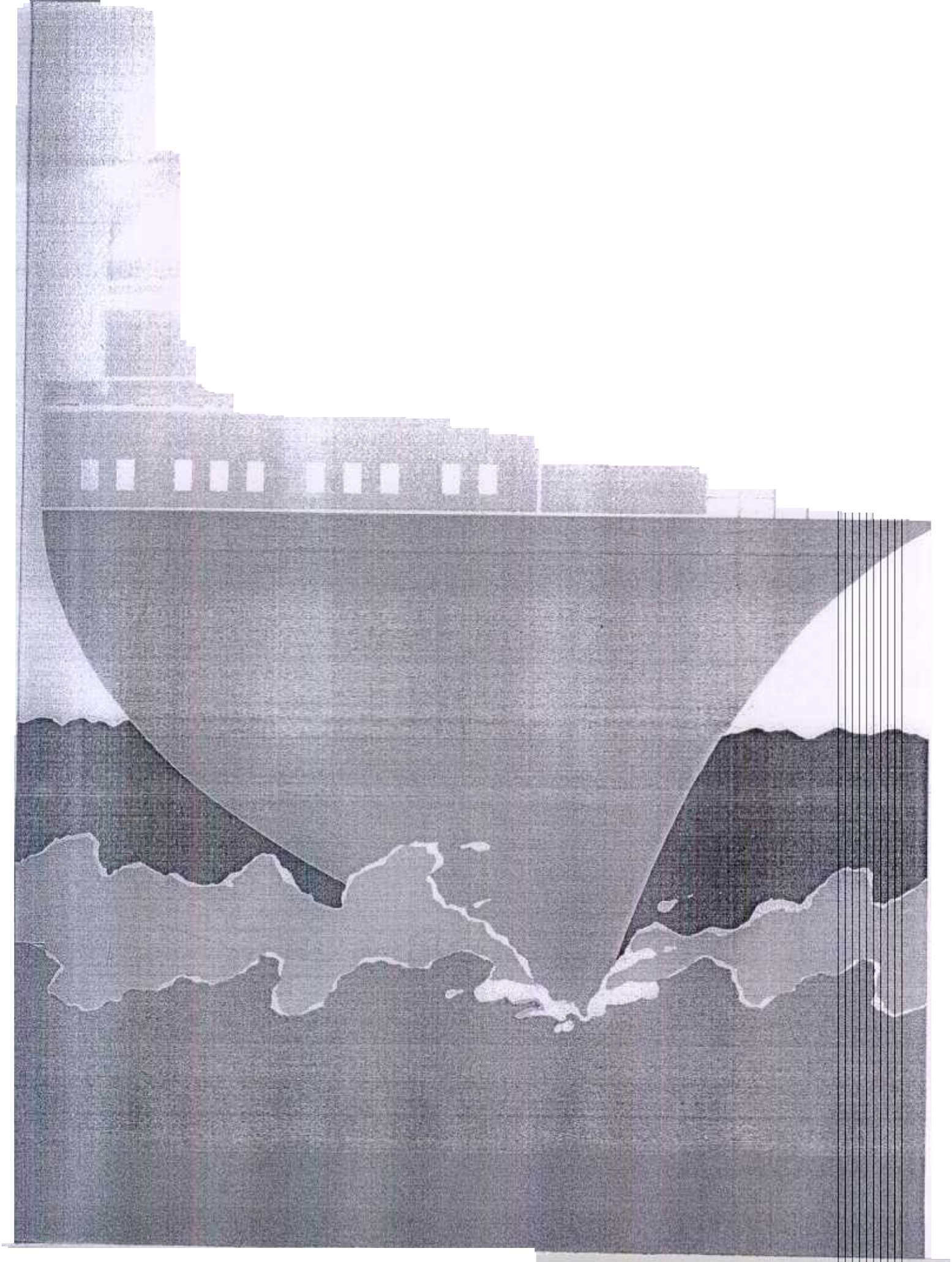
सत्यमेव जयते

Department of Ocean Development
Government of India, New Delhi



Annual Report 1985–86

Contents



Introduction

The Department of Ocean Development, established in July 1981 during the Sixth Five Year Plan period, was entrusted with the following functions:–

— Promotion of research and development in the marine sector (including fundamental research)
— Surveys to locate and map the availability of living and non-living resources of the Exclusive Economic Zone and of the continental shelf (excluding hydrocarbons)
— Development of skills and manpower
— Protection of marine environment in the high sea areas
— Survey, exploration and development of deep seabed mining and
— Promotion and coordination of Antarctic research.

The protection and preservation of the marine environment on the high seas, policy coordination, legal regime for the oceans and matters not specifically allotted to other Departments in the ocean sector were also assigned to the Department.

The United Nations Convention on the Law of the Sea was adopted on 30 April 1982. This Convention provides for the establishment of an Exclusive Economic Zone extending upto 200 nautical miles and for the rights and jurisdiction of the coastal States over the exploration and exploitation of living and non-living resources of such a zone. The Convention establishes a comprehensive framework for the regulation of all ocean space and contains provisions governing, *inter alia,* the limits of national jurisdiction over the ocean space (such as territorial sea, economic zone and continental shelf), access to the seas, navigation, protection and preservation of the marine environment, exploitation of living resources and conservation, marine scientific research, seabed mining and other exploitation of non-living resources and the settlement of disputes. It also establishes new international bodies to carry out functions for the realisation of specific objectives. Having provided the guidelines for the determination of the limits of national jurisdiction, the Convention sets out the principles and regulations governing the seabed and the ocean floor beyond those limits. Simultaneously, protections are also granted to qualifying seabed miners to conduct exploratory activities in the international seabed area. India, France, Japan and the Union of Soviet Socialists Republic and four multinational consortia have been accorded pioneer status in deep seabed activities.

The basic policy underlying the ocean development has been defined in the Ocean Policy Statement adopted by both the Houses of Parliament in November 1982, full text of which is given in the Annexure. The objectives of ocean development include: optimum utilisation of living and non-living resources of the sea; promotion of research in basic sciences; exploration and exploitation of polymetallic nodules from the deep seabed; harnessing of renewable sources of energy; acquisition and development of appropriate technology; development of supporting infrastructure; promotion and strengthening of institutional capabilities; development of requisite manpower, etc.

Accordingly, the major efforts of the Department during the Sixth Five Year Plan period have been directed towards the promotion of research and development in marine sciences. Surveys, mapping, delineation and assessment of the fishery resources of the economic zone and the continental shelf areas, exploration for polymetallic nodules from the deep seabed, harnessing of renewable sources of energy, acquisition of oceanographic research vessels and the development of requisite manpower formed the main thrust areas. In addition, the despatch of five scientific expeditions to Antarctica and the establishment of a permanently manned station there for undertaking studies in the pursuit of science have been the major milestones in enhancing the country's capabilities in the ocean sector

2. Marine Programmes handled by the Department

Consistent with the objectives of the Sixth and Seventh Five Year Plans and with an emphasis on the enhancement of capabilities in marine science and technology, the Department of Ocean Development has been implementing on a continuing basis the following programmes, which have a significant impact on the development process:

Surveys for living and non-living resources in the Exclusive Economic Zone and in the continental shelf

Systematic survey, detailed mapping and scientific assessment of the living and non-living resources of the economic zone and of the continental shelf is a pre-requisite for any programme of effective utilisation and harvesting. More than 2 million square kilometre area of the economic zone and continental shelf, which extends upto 350 nautical miles, needs to be explored. Two research vessels, ORV *Sagar Kanya* and FORV *Sagar Sampada* were acquired for this purpose during the Sixth Five Year Plan period. The survey of the entire economic zone is expected to continue for a decade or so. During the year 1985-86, a general survey of the fishery resources in the offshore areas and oceanographic studies to understand the space and time variability of the oceans and their correlation with the climate variability was carried out. Intensive efforts were made to map out the mineral resources of the continental shelf.

India occupies the eighth position in the world for the total annual catch of fish. Regarding the need-based futuristic studies, the projected fish requirements of India's population by the year 2000 AD are estimated to be 11.4 million tonnes. At present 56 percent of the total annual catch of over 3.5 million tonnes from the Indian Ocean is harvested from the narrow coastal zones.

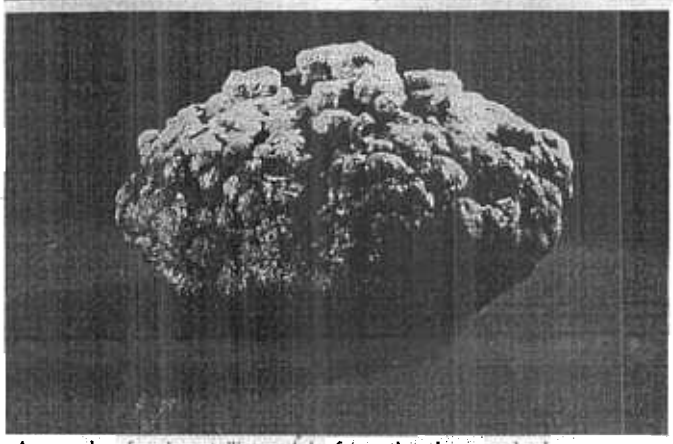
Desalination of brackish water

Oceans form an inexhaustible source of desalinated potable water. There are many areas in India which lack potable water. In many parts of Kutch, Saurashtra, Rajasthan, Haryana, Andhra Pradesh, Orissa, Tamil Nadu and Karnataka, people still drink brackish water with salinity ranging from 5 to 20‰. Besides being saline, this water sometimes contains undesirable chemicals.

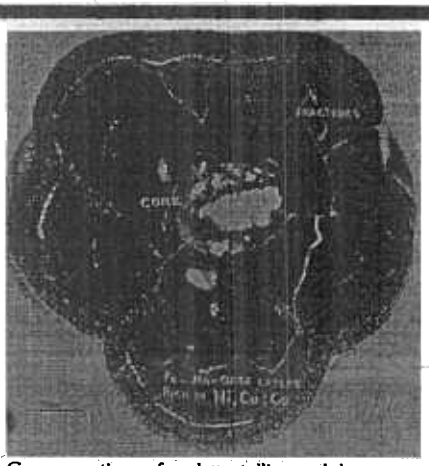
The desalination programme is intended to develop a viable technology for converting brackish water into potable water. In this field, considerable research work has been done by the Central Salt and Marine Chemicals Research Institute, Bhavnagar using several technologies including the reverse osmosis. The Institute has already done the necessary R&D work and has transferred the technology of reverse osmosis to Bharat Heavy Electricals Limited (BHEL) for setting up desalination plants in the country. One such pilot plant, capable of producing 50,000 litres of potable water per day from brackish water has been installed recently near Madras. Work on the second plant is continuing and it is expected to be installed in the East Godavari District of Andhra Pradesh by April 1986.

Deep seabed exploration

Polymetallic nodules form an abundant source of commercially important metals like manganese, nickel, copper and cobalt and to a lesser extent metals like molybdenum, vanadium, zinc, lead, cadmium, etc. They are known to be scattered on the ocean floor at a depth of 3500 to



A sample of polymetallic nodule from the deep seabed.



Cross section of polymetallic nodule.

6000 metres. The polymetallic nodules programme consists of the following components:

- Survey and exploration
- Transportation of material
- Extractive metallurgy
- Mining and environmental study.

Extensive survey work has been completed within a short time of four years since the Department came into existence in July 1981, by utilising the services of the oceanographic reasearch vessel *Sagar Kanya* and the research vessel *Gaveshani* and for some period by chartering other vessels namely *Skandi Surveyor* and *Farnella*. During the year 1985-86, a vessel *Ga Reay* was chartered. The first phase of the survey work has been completed covering an area of more than 3 million square kilometres in the central Indian Ocean. As a result of this survey work, two mine sites, each of approximately 1,50,000 square kilometres have been identified in the central Indian Ocean. An application has already been filed by India with the United Nations for registration of one of the sites. Its allotment to India is awaited.

Processing technology (extractive metallurgy) consists of extracting the metals such as nickel, copper, cobalt and manganese from the nodules. Several laboratories in the country, namely, the Regional Research Laboratory, Jamshedpur, Hindustan Zinc Limited, Udaipur and Vizag and Hindustan Copper Limited, Khetri are at present engaged in the R&D work. The final selection of the processing route will depend upon the results obtained from full scale pilot plant operations as well as on the decisions regarding which metals are to be recovered.

Human resources development

In a new frontier area such as the ocean development programme, manpower forms the most crucial element. The various projects in the marine sector require technically trained manpower for their implementation. Considering the vast ocean resources which need to be fully explored and exploited, the vessels and the infrastructure available for training manpower in the ocean sector are indeed limited. During the coming years, the manpower requirement in the ocean sector is bound to increase and more particularly for the deep sea exploration and for the development of technology associated with it, for underwater instrumentation and offshore structures and their installations, for diving, submersibles, offshore mineral exploitation, ocean data processing, management, etc

To meet the present and future needs of technically trained manpower, the Department is providing inputs to various academic and training institutions. Short-term training programmes, and establishment and upgradation of advanced centres for training in ocean technology at the post-graduate level in the Institutes of Technology are encouraged through financial assistance and Fellowship/Associateship programmes.

Antarctic Research Programme

Antarctica has remained an object of scientific curiosity for decades. Its vastness, geophysical isolation and climatic peculiarities offer unique opportunities for undertaking studies in the pursuit of science. The potential and significance of scientific research in Antarctica, however, is not confined to the field of academic sciences. The continent and its surrounding seas contain resources which are potentially of considerable economic value. The objective of the Indian Antarctic Programme, therefore, is to undertake scientific studies on its living and non-living resources.

In pursuance of this objective, four expeditions were successfully launched between the years 1981 and 1984. The purpose of these expeditions was to identify and initiate studies and programmes which were of significance in scientific and economic terms, and to establish infrastructural facilities and expertise which would enable India to sustain and expand its programme. Successful commencement of the Antarctic Programme has brought many Indian scientific institutions on a common platform and enabled India to participate in international negotiations on Antarctic issues.

During the four expeditions, the required infrastructure for conducting scientific investigations in Antarctica has been speedily established. A permanent station was set up in Antarctica during the Third Expedition. The station is equipped with essential telecommunication links with India through satellites and HF and also contains a meteorological wing.

The scientific investigations during the past expeditions have been primarily in the spheres of geology and geophysics, meteorology, oceanography, glaciology and biology. During the year 1985-1986, the Fifth Indian Expedition was launched.

Marine environment—control of coastal pollution

Due to the increase in population and industrial activities, the estuaries and nearshore waters are being polluted as a result of the disposal of waste materials. Problems of thermal and oil pollution are also becoming common. To develop suitable solutions to pollution problems, investigations are to be undertaken to study the diffusion and dispersion characteristics of coastal waters in which waste disposal is being poured in. To deal with the oil pollution problems, research and development on chemicals and oil cleaning equipment will have to be intensified. Suitable oil booms and skimmers are to be developed.

After the Department of Ocean Development was established, planning on the prevention and control of marine pollution was brought within its purview. The Department shares this work with the other related Ministries/Departments/Organisations in the country.

During the Seventh Five Year Plan period, some 20 pollution monitoring stations at selected points along the coasts are expected to be established.

Underwater technology

Submersibles are necessary for on-the-spot inspection of the sea bottom, for undertaking the repair work and for visually verifying the results of surveys made from shipboard. Submersibles

play an important role in carrying out oceanographic studies, *e.g.*, measurement of transparency of water, light penetration, collection of undisturbed water and sediment samples, study of living plankton and coral reefs, observations on the fauna and flora and their habitat (which are difficult to carry out from the surface), mapping the area of potential scientific and economic value.

Harnessing of wave energy

The estimated wave energy potential along the 6,000 kilometre long Indian coast is 60,000 MW. In addition to electricity, a wave energy system has other benefits like control of coastal erosion due to waves, creation of small harbour facilities and promotion of aquaculture. However, the energy is thinly distributed and the conversion system has to stand in hostile cyclonic environment at times. Therefore, for successfully harnessing the wave energy, careful development of a suitable system is vital, and this would involve the development of technology not known hitherto.

The long-term objectives of the Wave Energy Project is the establishment of wave energy systems at several locations along the mainland and islands for generating electricity and also for coastal protection, harbour facilities and aquaculture.

Ocean Thermal Energy Conversion (OTEC)

OTEC utilises the temperature difference which exists between the surface sea water (28–30°C) and the water occurring at a depth of 800–1000 metres (5–7°C) to generate power through the medium of a suitable fluid which vaporises at high temperature and condenses at low temperature and in this process turns a special type of turbine. Some of the best potential sites for OTEC are located near the islands of Lakshadweep and Andaman and Nicobar. The OTEC potential around India has been estimated to be 50,000 MW.

Investigation on OTEC was taken up during the Sixth Plan through the National Institute of Oceanography and it is now being continued in association with the Department of Non-Conventional Energy Sources. OTEC has a strong oceanographic component. Promotion of R&D work in ocean-related problems of the project, such as the study of bio-fouling in the heat exchangers and the impact of the OTEC system on the environment, fall within the purview of the Department's activities.

Other activities

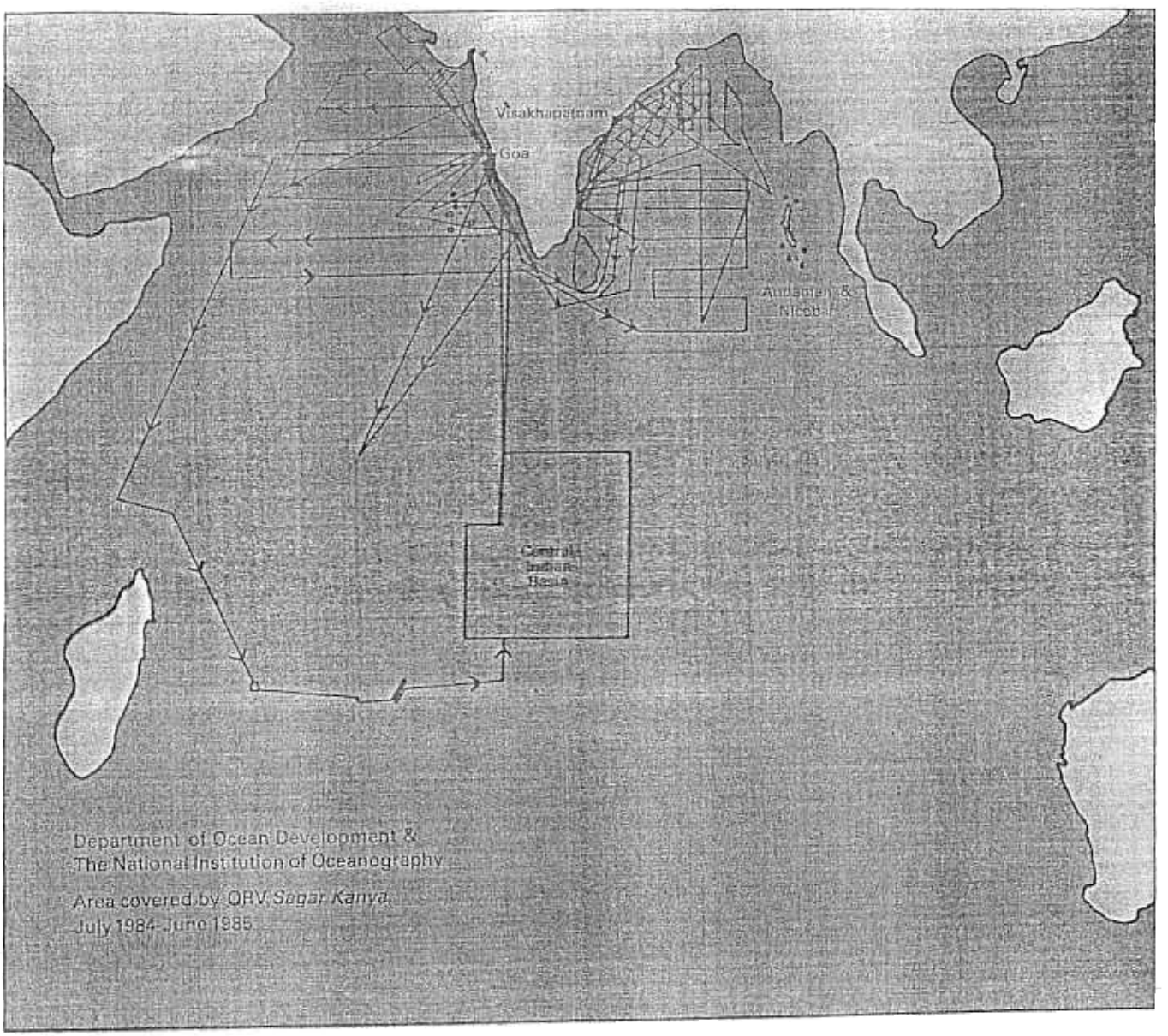
Legal regime

With the establishment of a new international ocean regime under the United Nations Convention on the Law of the Sea in 1982, our existing national laws and regulations are required to be reviewed, updated and strengthened. The process of review and amendment of the Maritime Zones Act of 1976 and 1981 was completed and proposals emerging from such a review are under consideration of the Government.

Organisation of workshops, seminars, etc.

During the year the Department offered assistance and support to several academic and scientific institutions in organising seminars, workshops and exhibitions on ocean-related activities in different parts of the country.

As summarised above, the Department is implementing nine major projects. The activities and achievements under each of these projects during the year 1985-86 are given in the following chapters.


Visakhapatnam
Goa
Andaman &
Nicobar
Central
Indian
Basin
Department of Ocean Development &
The National Institution of Oceanography
Area covered by ORV Sagar Kanya
July 1984- June 1985

3. Surveys for Living and Non-living Resources

The Ocean Policy Statement and the strategies for realisation of the long-term objectives of ocean development envisage the promotion of research and development in the marine sector, including fundamental research and training, surveys for mapping and delineation of resource potential of the Exclusive Economic Zone and the continental shelf of India. The Exclusive Economic Zone which extends upto 200 nautical miles from the baselines and the continental shelf which extends upto 350 nautical miles need to be surveyed systematically. The northern Indian Ocean is one of the few oceanic regions of the world which comes under the influence of the monsoon. The uniqueness of this region, therefore, lies in the seasonal and inter-annual variation that it exhibits. Little is known about the nature of this variability and lesser still, about the causes behind this variability. With the acquisition of two sophisticated research vessels ORV *Sagar Kanya* and FORV *Sagar Sampada* during the Sixth Plan period, a beginning has been made for the systematic study of the ocean phenomena and the collection of time variable oceanographic data. ORV *Sagar Kanya* has been entrusted to the National Institute of Oceanography, Goa and FORV *Sagar Sampada* acquired in December 1984 is being used by the Central Marine Fisheries Research Institute, Cochin.

These two institutions coordinate and implement the scientific programmes on behalf of the Department of Ocean Development. By the end of 1984-85, *Sagar Kanya* had completed twelve multi-disciplinary oceanographic cruises in different parts of the Arabian Sea, Bay of Bengal and the central Indian Ocean upto the latitude 20° S. Both these vessels were deployed during the year 1985-86 for research and survey work. In addition, RV *Gaveshani* (CSIR research vessel) was also utilised for various other scientific programmes.

Detailed scientific programmes for the ORV *Sagar Kanya* were prepared at the National Institute of Oceanography, Goa and these were reviewed at an inter-agency workshop based on the requests received from different research and development organisations and universities. Scientific research and survey programme for the FORV *Sagar Sampada* was drawn up by the Central Marine Fisheries Research Institute, Cochin.

ORV *Sagar Kanya* completed eleven cruises during the year 1985-86 upto January 1986. Of these, three cruises were devoted to meteorology and physical oceanography, four to geology and geophysics, one was multi-disciplinary and two were for the investigation on tidal power. During these cruises, the ship was utilised for 82.6 percent (including 21 days for the annual dry docking and refitting).

A brief summary of the nature of work carried out during each one of the Cruises is as follows:

ORV *Sagar Kanya*

Cruise 13 A (9–14 February 1985: Mormugao to Port Okha)

The cruise was planned for a comprehensive study of tidal level and currents at the edge of the continental shelf off the Gulf of Kutch. Field investigations were carried out for the 600 MW tidal power project proposed for the Gulf of Kutch. In order to collect data on currents and tides, which are required for the design of the tidal power project, instrumented sub-surface moorings at 7 pre-defined locations were deployed during this cruise. The instruments were retrieved during the

cruise 13 C. Sixteen scientists from the National Institute of Oceanography, seven from the Central Water and Power Research Station and two from the Central Electricity Authority participated.

Cruise 13 B (14 February–14 March 1985: Port Okha to Mormugao)

The objectives of the cruise were to study the oceanic circulation in relation to wind system, and the pelagic fisheries and related aspects in the northern Arabian Sea. During the cruise, hydrographic data were collected from 7 stations for diurnal studies. Swarming and abundance of salps were noticed in the area off the west coast of India, between 17° and 21° N. Twenty-three scientists from the National Institute of Oceanography, one from the Central Marine Fisheries Research Institute and two from the Annamalai University participated.

Cruise 13 C (14–21 March 1985: Mormugao to Mormugao)

This cruise was planned for the retrieval of the instrumented mooring systems deployed off the Gulf of Kutch during Cruise 13A. The data recorded by the *in-situ* self recording type current meters and tide gauges are analysed further at the Central Water and Power Research Station, Pune for the engineering parameters. The analysed results are expected to form inputs for the mathematical model developed at the Central Water and Power Research Station, Pune, related to the study of the effect of tidal barrier on the tide levels. Eight scientists from the National Institute of Oceanography, seven from the Central Water and Power Research Station and one from the Central Electricity Authority participated.

Cruise 14 (24 March–30 April 1985: Mormugao to Bombay)

The objectives of this cruise were to study oceanic circulation, ocean boundary layer and heat budget in the southern Arabian Sea south of 16° N. During the cruise, hydrographic and surface meteorological observations at 57 stations and radiosonde observations at 63 stations were carried out. Nine scientists from the National Institute of Oceanography, five from the India Meteorological Department, two from the Central Marine Fisheries Research Institute, one from the Centre for Earth Sciences Studies and one from the Naval Hydrographic Office participated.

The ship was laid up at Mazagon Docks, Bombay from 29 April to 24 May for its annual survey and refit.

Cruise 15 (24 May –1 June 1985 : Bombay to Mormugao)

This cruise was planned to collect bathymetric and magnetic data on the shelf and slope areas, off the Saurashtra Peninsula. A total of about 1200 km of underway data was collected along 7 lines. The preliminary interpretation of the data indicated that this area is characterised by the presence of well developed broad wave-length magnetic anomalies. Fourteen scientists from the National Institute of Oceanography and one from the Centre for Earth Sciences Studies participated.

Cruise 16 (6 June–23 July 1985: Mormugao to Mormugao)

In the central Indian Ocean and Arabian Sea, 370 surface observations and 51 upper air soundings were carried out for monsoon studies. In the second leg, dredging, coring and boomerang grab operations were made at 21 stations. Geophysical data were collected along the track covering the inverted 'Y' junction of the Somali basin and central Indian Ocean. During the cruise, pillow lava basalts with hydrothermal incrustations were recovered from locations where high

heat flow values were reported earlier. Seven scientists from the National Institute of Oceanography, three from the National Geophysical Research Institute, one from the Physical Research Laboratory, five from the India Meteorological Department and three from Jadavpur University participated.

Cruise 17 (26 July–29 August 1985 : Mormugao to Mormugao)

This cruise was devoted to observations in the western Arabian Sea. Although this was a multi-disciplinary cruise, emphasis was given to biological work. The ship covered 9,736 line km and worked at 73 stations between latitude 4° N to 6° S and longitude 48°-58° E. High biological production and nutrient concentration were noticed in the Somali region. In the surface waters dissolved and particulate hydrocarbon distribution was found to be low. Twenty scientists from the National Institute of Oceanography, five from the India Meteorological Department, two from the Annamalai University and one from the Government Polytechnic, Panaji participated.

Cruise 18 (1 September–8 October 1985 : Mormugao to Visakhapatnam)

The objectives of this cruise were to conduct studies relating to the dynamics of monsoon and the cyclones in the central and northern part of the Bay of Bengal and collection of physical oceanographic data on the sea surface, waves, temperature, salinity and oxygen. The cruise was planned in consultation with India Meteorological Department to cover areas of low pressure system in the month of September and October, usually formed at the head of the Bay of Bengal and in the central region. Six scientists each from the National Institute of Oceanography and the India Meteorological Department, two each from the Naval Physical and Oceanographic Laboratory and the Andhra University and one from the Indian Institute of Technology, New Delhi participated.

A trial cruise was conducted on 14 September 1985 in which seven scientists from the National Institute of Oceanography, three from the India Meteorological Department and two from the Federal Republic of Germany participated.

Cruise 19 (10 October–15 November 1985 : Visakhapatnam to Mormugao)

The objectives of this cruise were to study the meteorological conditions over the Bay of Bengal during the withdrawal phase of south-west monsoon, to track the monsoon depressions and cyclones when they form over the Bay of Bengal for the study of the dynamics of these disturbances, to study the physical oceanographic conditions in the Bay of Bengal along 88° meridian or mixed layer dynamics and heat balances at the stationary position, and testing of gravimeter. During the cruise radiosonde observations, hydrographic observations and surface meteorological observations down to a depth of 500 m and experiments on the measurements of solar radiation using multichannel spectro-fluorometers, vertical distribution of atmospheric electricity, total suspended particulate matter in the atmosphere over the sea, measurement of condensation nucleii and aerosol size distribution, chemical composition of rain water during the entire cruise were carried out. Data on the distribution of hydrocarbons, particularly organic matter and chlorophyll at various depths and data relating to biofouling and corrosion were collected. Eight scientists from the National Institute of Oceanography, five from the India Meteorological Department, four from the Indian Institute of Tropical Meteorology, two from the Naval Physical & Oceanographic Laboratory and one from the Indian Institute of Technology, New Delhi participated.

Cruise 20 (26 November 1985–9 January 1986 : Mormugao to Mormugao)

The cruise was planned for 45 days for surveys for polymetallic nodules in the central Indian

Ocean basin and for survey for polymetallic sulphides in the rift valley system at the northern part of the inverted 'Y' junction of the central Indian Ridge. During the above cruise 303 operations were carried out at 53 stations for polymetallic nodules by using boomerang grabs, and at 10 stations sediment samples were collected by using box corer, spade corer and Van Veen grab. Rock samples were collected in the rift valley system by using chain bag dredge. Besides 13,588 line km bathymetric data and 3,822 line km magnetic data were also collected. Twenty scientists from the National Institute of Oceanography, two from the Physical Research Laboratory and one each from the Centre for Earth Sciences Studies and Delhi University participated.

Cruise 21 14 January 1986 : Mormugao)

At the initial stages of the cruise, the seabed magnetometer of Indian Institute of Geomagnetism, Bombay, was tried out successfully with three of their scientists and one Japanese expert on board along with the National Institute of Oceanography scientists and technicians. They disembarked at Mormugao on 18 January 1986.

Four scientists from the Oil and Natural Gas Commission boarded the vessel at Mormugao on 18 January 1986 and the ship went to their survey area between Ratnagiri and Karwar. On 27 January the ship was diverted towards Cochin at the request of the Indian Navy to help them in their search for the wreck of the Sea King helicopter in the sea.

Research vessel management

To streamline the proper maintenance and essential servicing of the instruments on board, a senior technician of the National Institute of Oceanography has been nominated as Technical Officer for the ship with a technical assistant to help him. The duties of the Technical Officer will also include the preparation of a list of essential spares to be kept on board, maintenance of the inventory of all the existing instruments, furniture and fittings. This officer will arrange a permanent display of these lists in all the laboratories and cabins and will take charge of all the scientific gears during the port calls of the ship within India. He will also be responsible for keeping all the scientific machinery on the deck in "ship shape". He will maintain a close liaison with the ship's masters for general cleanliness on board.

After the expiry of the warranty period, the Department has signed a service and maintenance contract with the Computer Maintenance Corporation of India for the maintenance and servicing of the computers on board ORV *Sagar Kanya.* Under the contract, the representatives of the CMC would be available at the ports of call and would also provide the necessary spares.

A comprehensive list of spares required for the scientific equipment for the next 3 to 5 years has been prepared. Some of these spares have recently been received. The Department has recently finalised a contract with the suppliers in the Federal Republic of Germany for the supply of all spares.

An exercise has been initiated for the preparation of a five year cruise profile for the ship. This exercise is initially being carried out for the time-variable data which largely include physical, chemical and biological oceanography. The India Meteorological Department have been invited to suggest their programme for the next five years. This programme at this stage would broadly indicate only the disciplines and the areas of interest during the various seasons.

FORV *Sagar Sampada*

The Fishery and Oceanographic Research Vessel *Sagar Sampada* left the Port of Arhus in Denmark on 27 November 1984 and reached Bombay on 23 December 1984. Later it arrived in Cochin on 30 December 1984, after successfully completing its maiden voyage. After completing the formalities required as a foreign-going vessel, FORV *Sagar Sampada* undertook 3 trial cruises off Cochin to check rigorously all the scientific and fishing equipment and systems on board. Subsequently, the vessel commenced its regular cruises on a multi-disciplinary theme to assess the marine fishery resources of the Exclusive Economic Zone of India. Summaries of the various cruises are given below:

Trial cruises

Three trial cruises were organised from 9 January to 14 January 1985, from 18 January to 25 January 1985 and from 29 January to 4 February 1985. All the scientific equipment on board were tested rigorously and defects noted were notified as guarantee claims. The fishing systems were tested by carrying out bottom and pelagic trawling operations. Fish freezing and storage facilities were also checked. In all, 13 scientists from the Central Marine Fisheries Research Institute (CMFRI) 8 scientists from the Central Institute of Fisheries Technology (CIFT) and 1 scientist from the Naval Physical & Oceanographic Laboratory (NPOL) participated in these exercises. The fishing masters and fishing hands were drawn from CMFRI. A Danish fishing master and a Danish fishing gear expert guided the fishing operations. Besides testing the equipment and systems, the trial cruises were used for the familiarisation of scientists to FORV *Sagar Sampada*'s laboratories and facilities.

Cruise 1 (9 February–22 February 1985: Cochin to Goa)

The fishery resources assessment programme of FORV *Sagar Sampada* commenced with Cruise 1. The vessel operated off the south-west coast from latitude 11°25′ N to 16°30′ N upto the outer limit of the Exclusive Economic Zone. The depth zone covered was from 64 m to 4,341 m. Thirty stations were occupied during this cruise. The fishing programme included 10 bottom trawls and 11 pelagic trawls. The oceanographic programme covered 23 stations for physical oceanography, 19 stations for zooplankton and 13 stations for the mesopelagic survey. Acoustic survey was also carried out simultaneously. The scientific component of the team included 6 from CMFRI, 2 from CIFT, 1 from Fisheries College of Konkan Krishi Vidyapeeth, 1 from Cochin University and 1 from Fisheries College of University of Agricultural Sciences, Karnataka.

Cruise 2 (26 February–13 March 1985: Goa to Cochin)

The fishery resources assessment programme was continued northwards and the area covere was from latitude 17° 30′ N to 22° 30′ N upto the outer limit of the Exclusive Economic Zone. The depth zone covered was 47 m to 3,410 m. Twenty-two stations were occupied. Scientific programme carried out included 9 bottom trawls, 6 pelagic trawls, 20 stations for physical oceanography, 20 stations for zooplankton and 18 stations for the mesopelagic survey. 4 scientists from CMFRI, 3 from CIFT, 2 from National Institute of Oceanography (NIO) and 1 from the Fisheries College of Konkan Krishi Vidyapeeth participated in the cruise.

Acoustic trial (20 March–22 March 1985: Cochin to Cochin)

Some defects in the acoustic equipment were rectified by the test engineer from SIMRAD,

Norway and trials were taken to test the scientific and depth echosounders, netsonde and sonar. Three scientists from CMFRI participated in the cruise, besides the Danish fishing gear expert and the SIMRAD engineer.

Cruise 3 A (25 March–4 April 1985 & 13 April–18 April 1985: Cochin to Cochin)

Cruise 3 of *Sagar Sampada*, which was originally planned to cover the Exclusive Economic Zone area along the south-west and south-east coasts (Cochin to Madras), had to be subdivided into 3 parts due to major problem of inadequate power and consequent failure of one of the split winches.

Cruise 3 A occupied 23 stations in the latitudinal section from 10°31.7′ N to 7°24.4′ N in the depth zone ranging from 89 m to 4,340 m. The programme included 3 bottom trawls, 4 pelagic trawls, 19 stations for physical oceanography, 23 stations for zooplankton and 18 stations for mesopelagic survey. The participation of scientists was 7 scientists from CMFRI, 5 from CIFT, one from Andhra University and one from Annamalai University.

Cruise 3 B (25 April–1 May 1985: Cochin to Cochin)

The objective of the cruise was to study the mesopelagic resource and zooplankton distribution in the area off Cochin between latitude 9°29.5′ N and 10°30′ N. The depth zone of observations was from 112 m to 2,489 m. In all, 6 stations were worked for the zooplankton and mesopelagic surveys. Three scientists from CMFRI participated in the cruise.

Cruise 3 C (2 June–13 June 1985: Cochin to Madras)

The multi-disciplinary programme of the assessment of fishery resources of the Exclusive Economic Zone was the object of this cruise. The area covered was south of Cape Comorin and latitude 10°30′ N to 13°30′ N off the east coast to the margin of the Exclusive Economic Zone. The depth zone of this cruise was from 81 m to 3,624 m. Eighteen stations were occupied with 5 bottom trawls, 3 pelagic trawls, 18 stations for physical oceanography, 18 stations for zooplankton and 5 stations for the mesopelagic survey. Scientific participation included 9 scientists from CMFRI and 3 from CIFT.

Cruise 4 (17 June–10 July 1985: Madras to Madras)

The objective of this multi-disciplinary cruise was to assess the fishery resources of the Exclusive Economic Zone off the east coast in the latitudes from 14°30' N to 20°29.5' N. The depth zone surveyed extended from 190 m to 3,195 m. The work carried out included 3 pelagic trawls, 1 bottom trawl, 7 stations for physical oceanography, 8 stations for zooplankton and 5 stations for the mesopelagic survey. Six scientists of CMFRI, three of CIFT and one each of Zoological Survey of India and the University of Madras participated in this cruise.

Cruise 5 (15 July–26 July 1985: Madras to Cochin)

This cruise was performed in lieu of the scheduled cruise of Nicobar as the vessel could not undertake this trip due to very bad weather. The vessel surveyed the fishery resources of the Exlcusive Economic Zone along south-east and south-west coasts in the latitudinal sections from 13°00′ N to 06°59.6′ N and 07°15′ N to 10°00′ N. During the cruise, 27 stations in the depth range of 42 m to 1,571 m were occupied with 7 bottom trawls, 5 pelagic trawls, 27 stations for physical

oceanography, 26 stations for zooplankton and 17 stations for the mesopelagic survey. Scientific participation included 7 scientists from CMFRI, 3 from CIFT and 1 each from the Zoological Survey of India and Fisheries College, Tuticorin.

Cruise 6 (31 July–13 August 1985: Cochin to Cochin)

This was a monsoon cruise for the survey of the young fish and meso and bathypelagics. *Priacanthus hamrur* was the main demersal resource located off Cape Comorin. The oceanic crab *Charybdis edwardsii* was the important component in the pelagic trawl collections. These included juveniles of squids, prawns such as *Hymenopenaeus* sp. and *Pasiphaea* sp. Mesopelagics included fishes such as *Diaphus* and *Myctophum* and prawns (family Pasiphaedae) in the southern sector and tunicates, euphausiids, siphonophores and crustacean larvae in the northern sector. Microbiological studies were also carried out.

The area of operation was in the latitude 05°00′ N to 11°00′ N and 71°00′ E to 77°30′ E longitude. The total area covered by sampling at stations on the cruise tracks was 49,275 sq. n. miles and the line distance covered 1,728 n. miles. The number of stations covered by this cruise were: multi-disciplinary 27; pelagic fishing 11, demersal fishing 5; physical and chemical oceanography 27; zooplankton 27; mesopelagic surveys 27; acoustic survey for fish concentration and biomass estimation at intervals as required.

Cruise 7 (18 August–30 August 1985: Cochin to Mormugao)

The objective of this cruise was the survey of young fish and bathy and mesopelagics of the eastern Arabian Sea. The area of operation was in the latitude 12°00′ N to 16°00′ N and 68°28.5′ E to 74°30′ E longitude. The total area covered by sampling at stations on the cruise tracks was 46,350 sq. n. miles and the line distance covered 1,685 n. miles. The number of stations covered during this cruise included: multi-disciplinary 25; demersal fishing 1; physical and chemical oceanography 25; zooplankton 25; mesopelagic surveys 23; acoustic survey for fish concentration and biomass estimation at intervals as required.

Large tuna shoals were sighted between 69°00′ E and 70°00′ E longitude along the 15° N latitude. Similarly shoals of flying gurnards were noticed. *Priacanthus hamrur* was caught off Goa in the bottom trawl. Among the mesopelagics were found juvenile fishes of a number of species, *Acetes* sp., eel larvae and pelagic crabs.

Cruise 8 (10 September–22 September 1985: Mormugao to Bombay)

Survey of young fish and bathy and mesopelagics of the eastern Arabian Sea was the objective of the cruise. The area of operation was in the latitude 16°59.8′ N to 22°00′ N and 65°27.5′ E to 72°00′ E longitude. The total area covered by sampling at stations on cruise tracks was 49,725 sq. n. miles and the line distance covered 1534 n. miles. During this cruise the number of stations covered included: multidisciplinary 26; demersal fishing 3; physical and chemical oceanography 26 zooplankton 26; mesopelagic surveys 23; acoustic surveys for fish concentration and biomass estimation at intervals as required.

The demersal resources in 88-93 m depths included *Saurida* sp., *Trichiurus* spp., *Nemipterus* spp., *Rachycentron* sp. and cuttlefishes. Jellyfish, myctophids, gonostomatids and juvenile squids

formed the important components in the mesopelagic collections. Fish larvae were present in 75% of the zooplankton samples.

Cruise 9 (30 September–21 October 1985: Bombay to Bombay)

The objective of this cruise was the assessment of fishery resources of the eastern Arabian Sea, with special reference to cephalapods. The area of operation was in the latitude 15°30′ N to 23°30′ N and 65°00′ E to 72°30′ E longitude. The total area covered by sampling at stations on the cruise tracks was 89,760 sq. n. miles and the line distance covered 3,085 n. miles.

The number of stations covered included: multi-disciplinary 44; demersal fishing 2; physical and chemical oceanography 44; zooplankton 44; mesopelagic surveys 44, acoustic survey for fish concentration and biomass estimation at intervals as required.

Presence of oceanic squid *Symplectoteuthis oualaniensis* (268 mm DML) was confirmed in hand-jigging experiment. The demersal resources identified included *Priacanthus hamrur, Saurida tumbil, Nemipterus japonicus* and several species of cuttlefish belonging to the genus *Sepia.* Large number of fish larvae and juveniles were collected. Tuna shoals, accompanied by flocks of birds were sighted in the area 15°30′ N; 72°26′ E.

Cruise 9 A (25 October–3 November 1985 : Bombay to Cochin)

The objective of this cruise was to study the oceanography of shelf waters between Goa and Cochin. The area of operation was in the latitude 12°00′ N to 16°00′ N and 71°44′ E to 75°04′ E longitude. The total area covered by sampling at stations on the cruise tracks was 18,480 sq.n. miles and the line distance covered 1,005 n. miles.

During this cruise the stations covered included: multidisciplinary 27; physical and chemical oceanography 27; zooplankton 27; mesopelagic surveys 27; acoustic survey for fish concentration and biomass estimation at intervals as required.

Acoustic survey indicated good concentration of fish shoals at 250-320 m depth south-west of Goa. Tuna shoals were sighted south-west of Mangalore. Biomass was found to be higher in the neretic waters than in the oceanic waters. Thermocline layer extended at 20-120 m in most of the area surveyed and at some places upto 200 m. Oxygen values as low as 0.5 m1/1 were recorded below thermocline.

Cruise 10 (29 November–22 December 1985 : Cochin to Mormugao)

The objective of this cruise was the assessment of bathy and mesopelagic resources of the outer continental shelf and slope off the west coast of India. The area of operation was in the latitude 06°30′ N to 21°00′ N and 67°40′E to 77°30′E longitude. The total area covered by sampling at stations on the cruise tracks was 65,040 sq. n. miles and the line distance covered 3,090 n. miles.

The number of stations covered during this cruise included: multi-disciplinary 39; pelagic fishing 5; demersal fishing 5; physical and chemical oceanography 39; zooplankton 39; mesopelagic surveys 29; acoustic survey for fish concentration and biomass estimation at intervals as required.

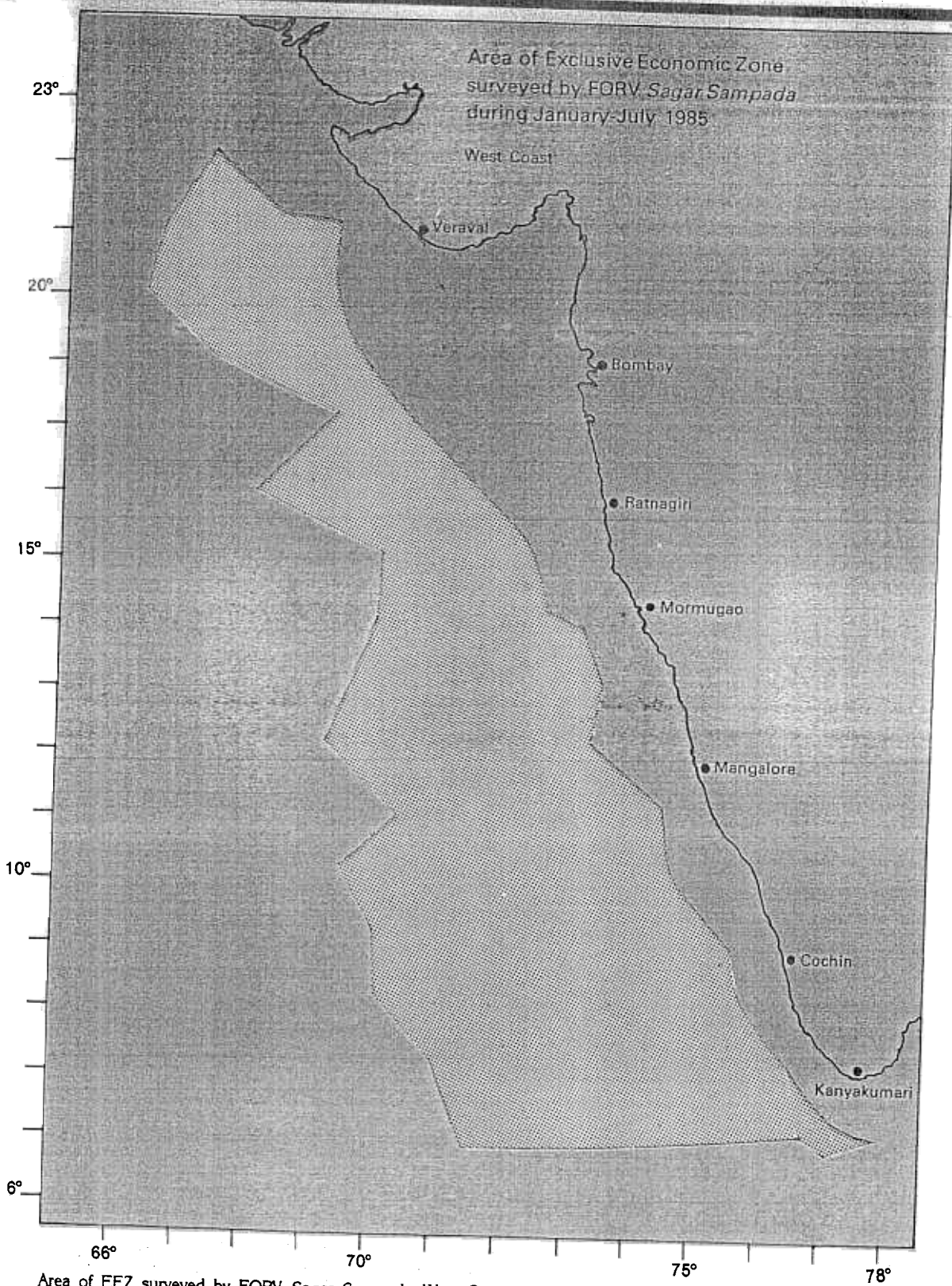
Phyllosoma larvae of palinurid and scyllarid lobsters were recorded at 76 m off Kerala and Karnataka coasts. Among the pelagic resources, *Cubiceps* sp.,*Psenes indicus* and juveniles of

carangids were caught in large numbers. Catfish, *Nemipterus* sp., *Trichiurus* sp. and *Priacanthus* sp. dominated the demersal catch.

Cruise 11 (26 December 1985 : Mormugao)

This cruise was in progress at the time this report was finalised.

FORV *Sagar Sampada*



Area of EEZ surveyed by FORV *Sagar Sampada*, West Coast.

Major findings of the survey work done by *Sagar Sampada*

— For the first time a general survey of the fishery resources of the Exclusive Economic Zone has been carried out. Greater coverage could be given to the west coast and south-east coast as compared to the other regions.

— Oceanographic features of different areas upto a maximum depth of 1,500 m have been studied.

— The acoustic survey has provided data on the relative abundance of biomass in different regions.

— The presence of juveniles of *Lactarius* at 100 m depth off Okha indicated nursery grounds for the species.

— The abundance of fish eggs off the Angria Bank suggests that the area has the spawning grounds of several species of fish.

— A good catch of the ribbon fish in ripe and running conditions and its juvenile at 47 m depth off Veraval indicated the breeding grounds of these species.

— The first authentic record, in the recent times, of the availability of deep-sea aristeid prawn *Plesiopenaeus edwardsianus* at a depth of about 900 m off the south-west coast has been established. Specimens of average weight of 130 g have been collected and this is the largest among the deep-sea prawns so far recorded in the Indian waters.

— A good resource of trumpet fish (Macrorhamphosidae) with small quantities of pandalid prawns and deep-sea lobster *(Puerulus sewelli)* have been located at 200 m depth on the Wadge Bank.

— Juveniles of oceanic squid have been collected along the south-west coast.

— Good collections of the phyllosoma larva of lobsters and juveniles of the ribbon fish in the Gulf of Mannar indicated the spawning and nursery grounds of these species.

— Acoustic survey indicated the abundance of whitefish *(Stolephorus)* in the Gulf of Mannar at a depth of 40 m. The resource of the area included the Indian mackerel in ripe and running condition, horse-mackerel, leather-jackets (Balistide), large rays, catfish and barracuda.

— Extensive distribution of oceanic crab *Charybdis edwardsii* has been noticed at depth zone of about 80 m from Cape Comorin to Anjengo along the south-west coast.

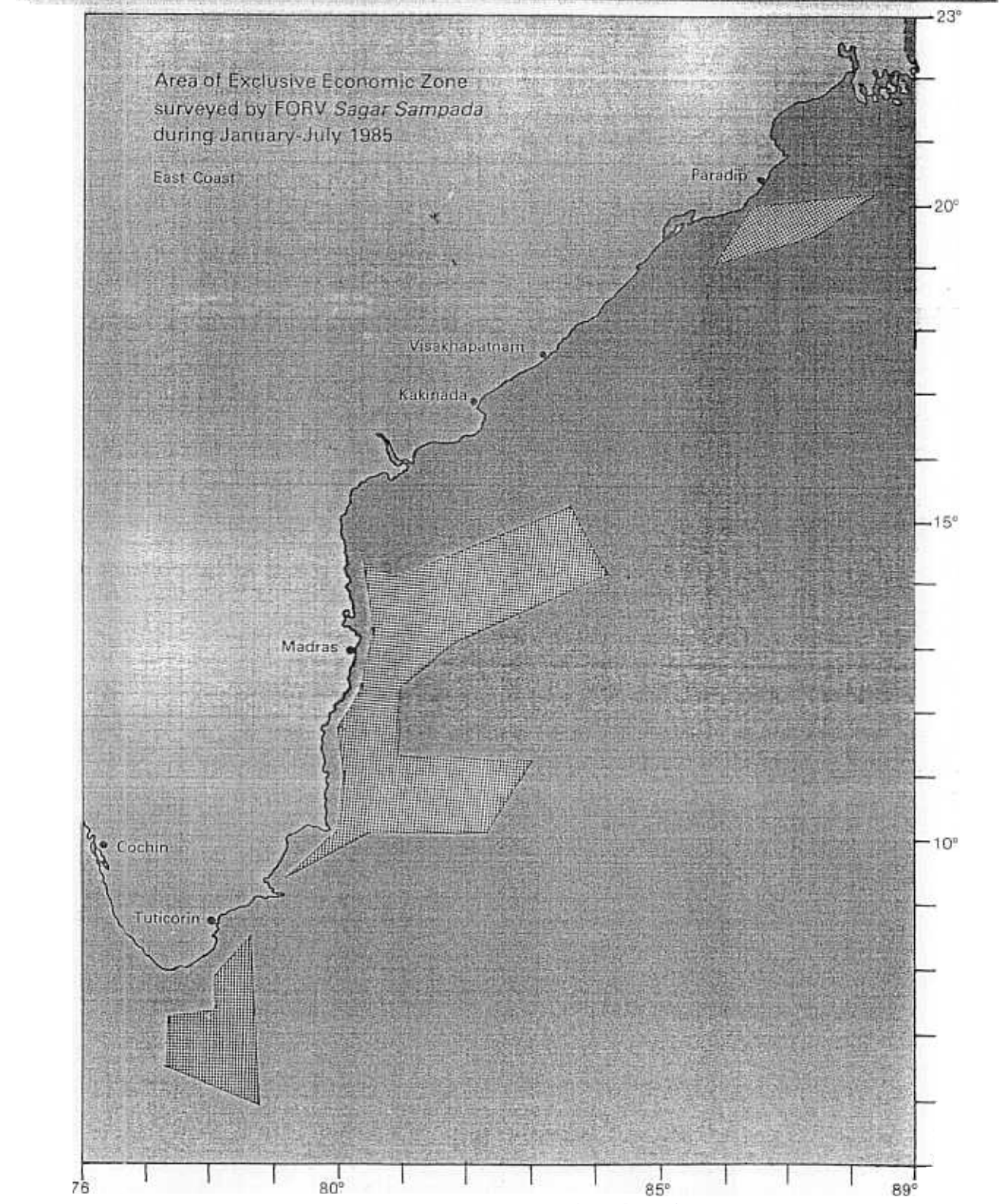
— Good pelagic and bottom fish recordings have been obtained off Point Calimere and in the Cuddelore-Pondicherry sector at about 65 m depth. The area off Point Calimere is a good nursery ground for the squids.

— Fishing gear research has been carried out on the behaviour and performance of different fishing gears available in *Sagar Sampada.*

— Post-harvest technology research has been conducted on the conventional and unconventional fishes caught by the vessel.

— For the first time decapod larval rearing work was carried out on board using the aquarium facility.

— Surface temperature profile between Okha and Kasaragod in March showed an increase from 24.2°C in the north to 27.6°C in the south. The area having a lower temperature was associated



surveyed by *Sagar Sampada*.

with big swarms of large tunicates and poor pelagic fish biomass.

— Primary and secondary production rates have been worked out from several sections of the area covered.

— Diurnal vertical migration of Deep Scattering Layer (DSL) and its components have been studied in detail in the Lakshadweep area in May 1985. The DSL was mainly composed of euphausiids, mesopelagic fishes including gonostomatids and myctophids, pelagic crabs, siphonophores and deep-water prawns.

— While some of the results of *Sagar Sampada*'s exploration work have been given above, detailed analyses of the fishery resources and oceanographic data are in progress.

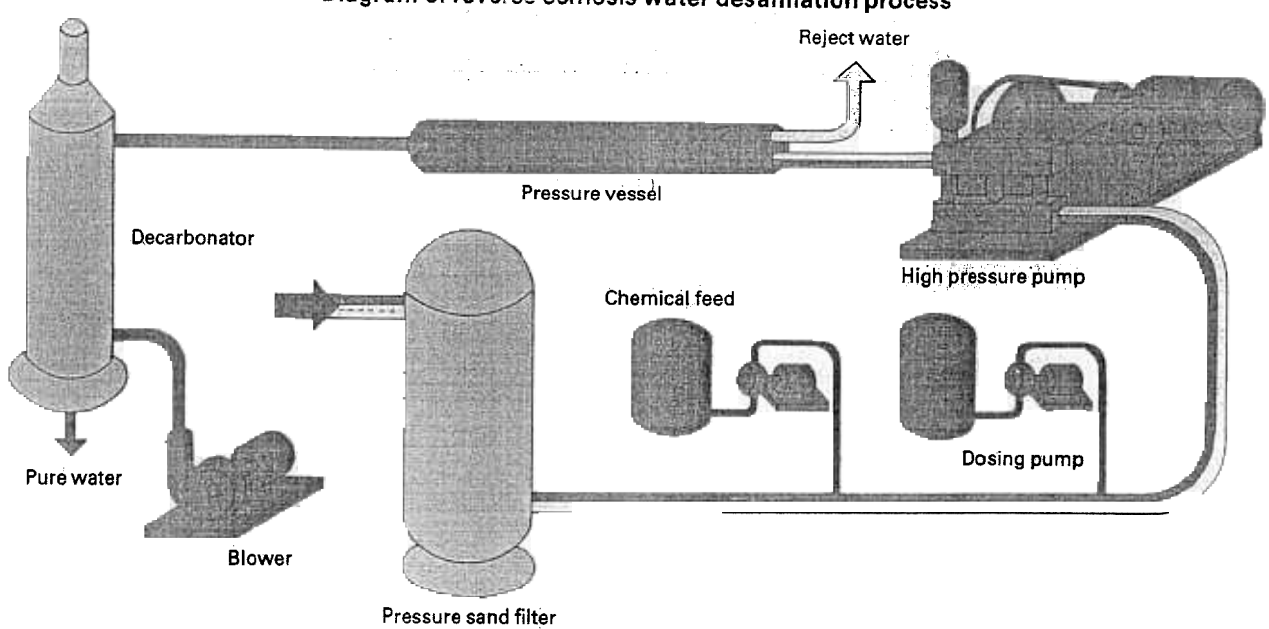
4. Desalination Programme

The desalination programme, sponsored and funded by the Department of Ocean Development is being implemented by the Central Salt and Marine Chemicals Research Institute, Bhavnagar and the Bharat Heavy Electricals Limited. When salt water and pure water are separated by a semi-permeable membrane, nature allows pure water to pass through the membrane to bring down the concentration of salt water. This process is known as osmosis. This flow can be made to cease by applying a higher balancing pressure on the salt water side and this is known as osmotic pressure. By application of much higher pressure on the salt side, natural osmotic flow is reversed and water is forced out of the salt solution to produce fresh water. This process is called reverse osmosis.

As a result of considerable research and development efforts made by the Central Salt and Marine Chemicals Research Institute, Bhavnagar, desalination technology has been standardised, using the process of reverse osmosis. This technology was made available to the Bharat Heavy Electricals Limited for the design and construction of plants for desalination of brackish water. The plant fabricated by BHEL offers a simple and flexible method of purifying brackish water for drinking purposes. In addition of salt, the system also removes harmful matter and bacteria from brackish water. The energy saving in reverse osmosis, as compared to conventional thermal desalination system, also makes this process economically viable. Reverse osmosis systems are designed and fabricated in modular blocks, enabling fast erection and commissioning of the plant.

A pilot desalination plant capable of producing 50,000 litres of potable water per day was established at Puthagaram in Tamil Nadu during the year. A second plant with identical capacity is likely to be installed and commissioned in East Godavari District of Andhra Pradesh by April 1986.

Diagram of reverse osmosis water desalination process



5. Deep Seabed Exploration

The ocean and, in particular, the deep sea floor offers a vast potential for various minerals. These include polymetallic nodules, metalliferous sediments of hydrothermal origin, phosphorites, uraniferous mud and mineral sands as well as oil and gas. It is now established that manganese nodules, which occur at a depth of 3,500 to 6,000 metres contain copper, nickel, cobalt, manganese, molybdenum, etc. Covered by several hundred metres of water column and what was once considered a hostile or even deadly environment, these minerals can be turned into resources by applying new technologies for exploration, mining and processing. The total reserves of polymetallic nodules in the world oceans is estimated to be several trillion tonnes. It is also known that about 15 million sq. km of the Indian Ocean contains nodule deposits of different sizes and qualities.

Recent developments in acoustics, hydraulics and material research have led to new exploration equipment and strategies to locate and quantify the minerals in areas of deep ocean floor. Advances in hydraulics and offshore technologies indicate ways to mine the minerals from the deep seabed. Similarly, research and development in mineral processing and metallurgy indicate the possibility of producing and refining the metals from the nodules.

India has been engaged in the survey and exploration of the deep seabed areas during the last few years. As a result of intensive surveys in the central Indian Ocean area and site specific activities, India was qualified to become a "Pioneer Investor" in deep seabed mining in terms of the new ocean regime established by the United Nations Convention on the Law of the Sea 1982. India shares this privilege with three developed countries, viz., France, Japan and the USSR and four other multinational consortia. An application for the registration and allotment of a mine site (pioneer area) in the central Indian Ocean for further exploration and development has been submitted to the Preparatory Commission for the International Seabed Authority. Intensive survey work is continuing at lesser grid intervals in the area identified as the application area. During the year 1985-86, detailed surveys were carried out at 10 km sampling interval (phase III) and about 0.5 million sq. km. area was surveyed. During this period about 5.5 tonnes of bulk nodule samples were collected which were sent to CSIR laboratories (Regional Research Laboratory, Bhubaneswar and National Metallurgical Laboratory, Jamshedpur) for metallurgical studies. The bulk sampling was done with a chartered vessel *Ga Reay* and ORV *Sagar Kanya.* For the above surveys, ORV *Sagar Kanya* completed 3 cruises of 45 days each. The analyses of polymetallic nodules were carried out in 7 different Research & Development laboratories including 3 of the CSIR.

techniques like the Deep Sea TV, Deep Tow System and Multi Frequency Exploration System are proposed to be acquired for detailed exploration of the Pioneer Area.

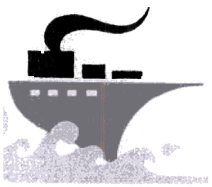
Research and development work on extractive metallurgy was continued in the Regional Research Laboratory, Bhubaneswar, National Metallurgical Laboratory, Jamshedpur, Hindustan Zinc Limited, Udaipur and Hindustan Copper Limited, Khetri and Ghatsila. After the identification of different metallurgical process routes, a semi-pilot plant capable of handling 200 kg of nodules per day using hydrometallurgical and ammonical leaching-cum-solvent extraction method was installed at the Regional Research Laboratory, Bhubaneswar and this was put on trial run. A rotary kiln capable of handling 5 kg of nodules per hour using pirometallurgical sulphation roasting technique is being commissioned. The Hindustan Zinc Limited, Udaipur has undertaken fabrication and modification of the existing zinc plant to suit the handling of manganese nodules. Trial tests on this plant were undertaken. The Hindustan Copper Limited continued research and development work on the extractive metallurgy by employing the hydrometallurgical and pirometallurgical process routes. Thus, a significant progress in the field of extractive metallurgy was achieved during the year 1985-86.

The two dimensional character of the polymetallic nodule deposits, their location on an irregular sea floor, morphology of the soft sediments, variation in mass and grade and the large water depths are the factors which were earlier regarded as major constraints in the development of mining technology. It is undoubtedly a high risk and capital intensive venture. The deep seabed mining system will comprise all three components, viz., collector, lead system and surface system. In some advanced countries, different types of collector systems have been tested. Their feasibility for commercial mining is yet to be established. Continuous transport of ocean minerals from the deep sea floor to the surface have also been successfully tested by either pumping or air lifting through steel pipes. The final choice of the method will, however, depend upon the scale of operation, reliability, maintenance and availability of the components, etc. A techno-economic viability and the feasibility studies of deep seabed mining need to be carried out. This phase of work is expected to be taken up after detailed exploration of the area and a geostatistical analysis has been completed.

Progress in the implementation of Resolution II at the Preparatory Commission for the International Seabed Authority and for the International Tribunal for the Law of the Sea

The Preparatory Commission for the International Seabed Authority and for the International Tribunal for the Law of the Sea met in two sessions in Kingston and Geneva. The substantive work of the Commission includes (i) drafting of administrative, procedural and technical rules for the working of the International Seabed Authority required in terms of the UN Convention on the Law of the Sea, 1982, (ii) adoption of measures for early entry into the effective operation of the Enterprise, *i.e.*, the business arm of the Authority, (iii) studies on the problems which would be encountered by the land-based producer states who are likely to be affected by deep seabed mining, and (iv) implementation of 'Pioneer Investors' regime incorporated in the Resolution II adopted on 30 April 1982.

While the Commission has made progress on some of the substantive issues, the progress on the implementation of Resolution II, *i.e.*, registration and allotment of pioneer areas has been slow.



6. Manpower Development

On the basis of the projections of the Seventh Five Year Plan and after taking into account the existing and future needs of the ocean sector, the manpower requirement for the next 15 years has been estimated to be about 3500 trained persons in various disciplines of marine sciences. During the coming years, the requirement of technical manpower will increase, particularly for the offshore and deep sea mining, offshore structures and installations, remote sensing, submarine pipelines, ocean data processing and management of fishing and other marine industries. At present there is no national centre for training manpower in the ocean sector. Some universities have been imparting training in a few branches of marine science such as physical oceanography, chemical oceanography, marine biology, marine geology, etc. The Institutes of Technology at Bombay and Madras have introduced courses in ocean engineering and technology. In addition, institutions such as the National Institute of Oceanography, Central Marine Fisheries Research Institute, Central Institute of Fisheries, Central Institute of Fisheries Education, Oil and Natural Gas Commission, Geological Survey of India and Defence Research and Development Organisation have also programmes for the development of technical manpower in the ocean sector to meet specific objectives for the research and development programme. Today, some 30 academic and training institutions are imparting education in marine sciences. On the other hand, there the more than 30 organisations having the potential for employing trained manpower in the ocean sector.

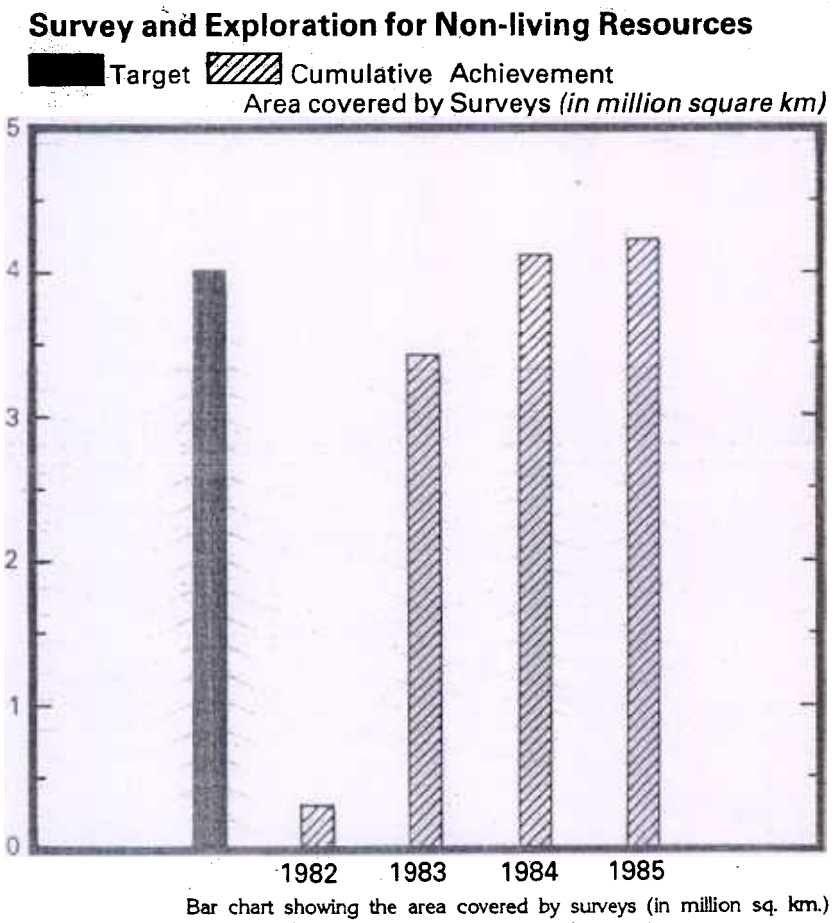
For building an adequate manpower of scientists, engineers and technicians in the newer areas of the ocean sector, the establishment of post graduate centres and short-term and long-term laboratory training and shipboard training will be very necessary. Facilities available in the research vessels, *Sagar Kanya, Sagar Sampada* and *Gaveshani* will be fully utilised. Full support has been provided to the academic institutions to participate in the research cruises. In addition, during the year a sum of Rs. 8 lakhs was spent by the Department on various research projects and fellowship schemes intended to promote manpower development in marine chemistry, marine biology, marine geology, ocean engineering, etc. 70 Fellowships and 15 Research Associateships in various Universities and Research Institutions were funded during the year 1985-86.

Marine Research and Development Fund

A Marine Research and Development Fund (MRDF) has been created in the Department as a part of its effort to encourage meaningful ocean-related activities in different institutions in the country. In promoting research and development programmes in the ocean sector, the support of various organisations (universities, scientific institutions, industrial units) is needed. This is being actively pursued.

R&D projects of relevance are selected by the Department after these are scrutinised by experts in the field. Recently a high powered committee has been constituted to evaluate the research proposals and to make appropriate recommendations. Assistance to be provided include grants for

This was mainly due to the fact that there have been overlapping claims for the deep seabed mine sites in the Pacific Ocean for which the applications were filed by France, Japan and the USSR. Japan and France have overlapping claims with the USSR. The overlap between Japan and the USSR was provisionally resolved, but France and the USSR were not in a position to do so because of the magnitude of the overlap and were unable to fulfil the requirements of Resolution II. Settlement of overlapping claims has involved complex technical, legal and political questions. The three pioneer applicant States, *viz.*, France, Japan and the USSR have met several times to resolve the problem and find an acceptable solution. Although India's application area in the Indian Ocean is free from overlappinig claims, the Preparatory Commission is not in a position to register and allot the pioneer area, since the rules in this respect have not been established. Therefore, a satisfactory solution to the problem of overlap is a pre-requisite for the registration of mining sites. Further efforts in this regard are being made by all the pioneer applicants including India and compromise package proposals are being evolved. The chairman of the Preparatory Commission is expected to make a report at its next session in Kingston.



Bar chart showing the area covered by surveys (in million sq. km.)

the purchase of equipment, for holding exhibitions, for organising symposia, conferences, workshops, etc. and for bringing out publications. Financial support of the order of Rs. 53 lakhs has been provided to various organisations in the country.

The following organisations and institutes have received help during the year 1985-86.

Andhra Pradesh Academy of Sciences, Hyderabad.
Berhampur University, Berhampur (Orissa).
Benaras Hindu University, Varanasi.
Bureau of Public Enterprises.
Central Institute of Fisheries, Nautical & Engineering Training, Cochin.
Central Institute of Fisheries Education, Bombay.
Centre for Advanced Studies, Annamalai University, Porto Novo.
DAV Post Graduate College, Muzaffarnagar.
Goa University, Goa.
Indian Institutes of Technology, Bombay, Madras, Kanpur and Kharagpur.
Indian Institute of Geomagnetism, Bombay.
Indian Society of Earth Sciences, Presidency College, Calcutta.
Indian Society of Analytical Sciences (BARC), Bombay.
Instruments Research & Development Establishment, (DRDO), Dehradun.
India Meteorological Department, New Delhi.
Indian Fisheries Association, Bombay.
Jadavpur University, Calcutta.
Karnataka University, Dharwar.
Mangalore University, Mangalore.
Marathawada University, Aurangabad.
Madurai Kamraj University, Madurai.
National Remote Sensing Agency, Hyderabad & Bangalore.
National Institute of Oceanography, Goa.
National Academy of Sciences of India, Allahabad.
National Physical Laboratory, New Delhi.
National Geophysical Research Institute (CSIR), Hyderabad.
Osmania University, Hyderabad.
Physical Research Laboratory, Ahmedabad.
Regional Research Laboratory, Bhopal.
Shivaji University, Kolhapur.
Surveyor General of India, Dehradun.
University of Kerala, Trivandrum.
University of Madras, Madras.
University of Cochin, Cochin.
Vishwabharati University, Shantiniketan.

7. Antarctic Research: Scientific Expeditions

India's Antarctic research activities commenced in 1981 with the launching of the first scientific expedition during 1981-82. Since then, scientific expeditions have been sent every year. During the Third Expedition (1983-84), India established its first permanently manned station "Dakshin Gangotri" and the first wintering team consisting of 3 scientists and 9 persons for logistic support were left behind for continuing scientific work throughout the year. The Fourth Expedition, which landed in Antarctica in December 1984, returned to Goa on 25 March 1985. This expedition left behind a 13 member wintering team in Antarctica for manning the permanent station and for continuing the scientific work initiated during the earlier expeditions.

In organising the Antarctic research programme, the Department of Ocean Development had been drawing up the resources and manpower from various agencies in the country. Logistic support for the expedition is provided by the three Services. The scientific component is drawn from different research institutions spread all over the country and from the Government Departments.

The objectives of the Fourth Expedition were two-fold. On the logistic side, construction of additional space for parking of vehicles and for the storage of equipment, construction of small field stations on rocks in the hills near Dakshin Gangotri, the establishment of direct HF communication link between the Indian mainland and the Antarctic station and repair and maintenance of the permanent station were planned. On the scientific side the objective of the expedition was to carry out geophysical surveys and further studies in the fields of geology, meteorology, biology, communications, glaciology, oceanography and environment.

A summary report of the scientific work carried out by the first wintering team and by the Fourth Expedition is given below:

Work carried out by the first wintering team in Antarctica (December 1983–March 1985)

The first Indian wintering party, which consisted of 3 scientists, 1 each from Defence Research and Development Organisation (DRDO), India Meteorological Department and National Institute of Oceanography and 9 maintenance personnel drawn from various branches of Defence Services, stayed in Antarctica for a period of 15 months and thus established a record of their presence throughout the Antarctic winter. During this period the team carried out scientific research in the fields of glaciology, meteorology and microbiology, besides carrying out studies on various aspects of health and hygiene, engineering and other problems in extreme conditions of cold and severe blizzards. Laboratory facilities and various instruments and aids for working were provided in the permanent station at Dakshin Gangotri. Some of the instruments installed inside the laboratory included solar radiation recorder, barograph for recording continuous atmospheric pressure, instruments for recording humidity and daily temperature, 401 MHz ECIL for radiosonde used for

Prime Minister, Minister of State and Secretary Deptt of Ocean Development with the Leader of the Third Expedition and members of the First Wintering Team.

upper air observations, temperature sensors for recording temperature profile of ice-sheet, unconfined compression equipment for recording unconfined compressive strength of snow samples, pH meter, chemical balance, filtration oven, incubator, light panel for photosynthetic study, etc. and all essential facilities for micro-biological work.

The scientific studies carried out by the scientists related to the Dakshin Gangotri ice-sheet and the Schirmacher oasis. The studies involved collection of samples and their preservation, testing of samples *in situ* and in the laboratory, analysis of the results based on the work carried out during the past winters by scientists of different countries in Antarctica. Some of the important observations made and the results achieved are described below.

Glaciology and structural engineering

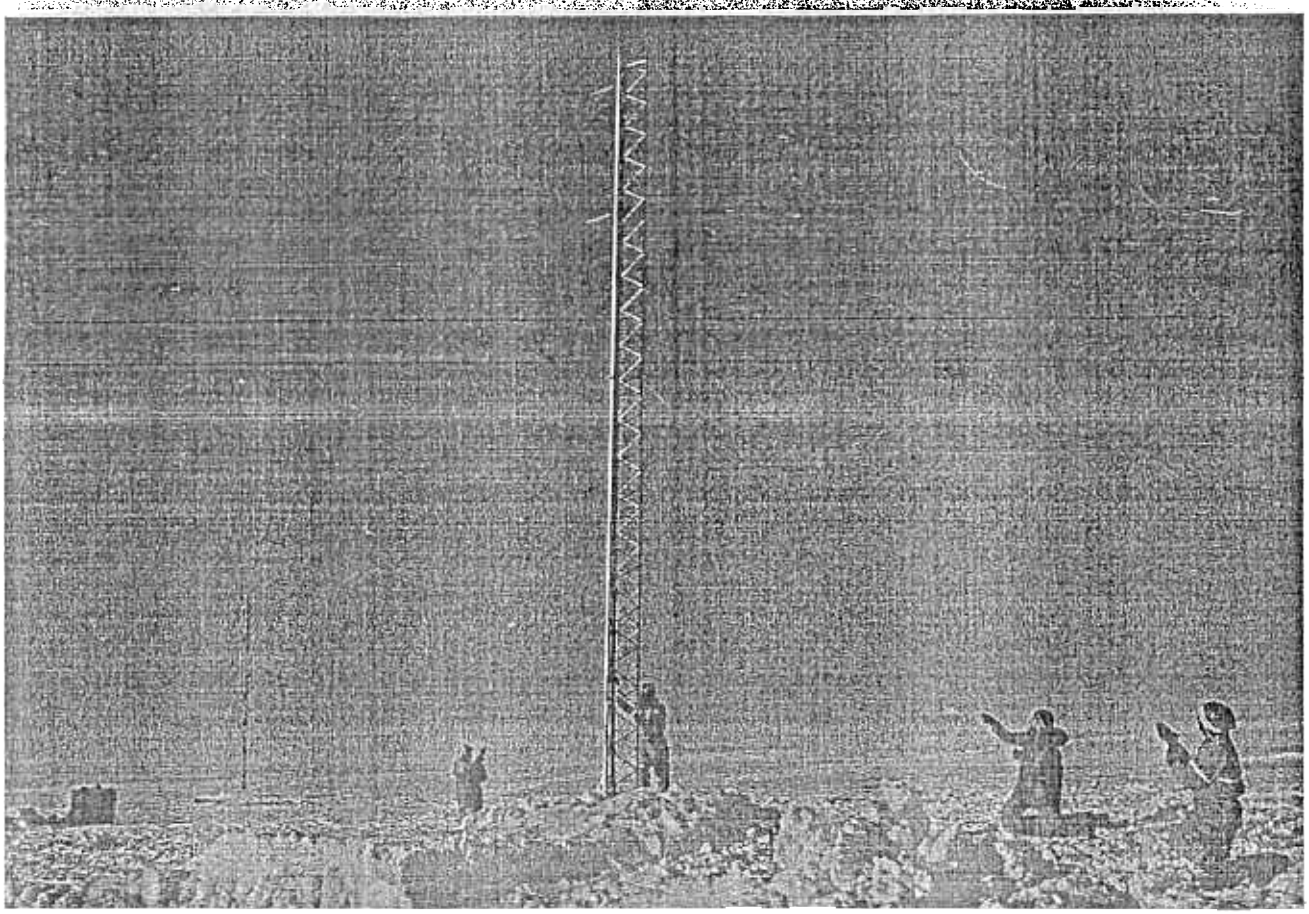
Continuous observations on the increase in strength of snow cover of the general area on the ice-sheet within a distance of 30-40 km were recorded throughout the year, from the point of view of designing the foundations of the structure as well as for developing compressed snow and ice-runway for wheel landing of light and heavy weight aircraft. It was noticed that the ice-sheet around the station is ideally suited for the development of compressed snow and ice-runway for

wheel landing of light weight aircraft. As a trial measure, a ski-way of dimensions 1500×50 m was designed and constructed near the station area for ski-landing of light weight aircraft.

Pattern of snow accumulation caused by blizzards around various objects was studied. Three patterns, namely creep, saltation and turbulent suspension were identified and the amount of snow accumulated due to these patterns was measured. It was seen that the blizzards having a wind speed of the order of 40-100 km per hour cause maximum snow accumulation around the objects. These studies will help in designing various types of structures and installations on the Antarctic ice-sheet in future.

Meteorology

Meteorological observations pertaining to solar radiation, wind speed, air temperature, humidity and ozone level in the atmosphere were carried out with the help of conventionally developed instruments in the country. Upper air studies with the help of hydrogen-filled balloons were carried out and observations of temperature, wind direction and humidity for the upper atmospheric layers were recorded on 401 MHz ECIL set. Studies on the cloud cover in different seasons around Dakshin Gangotri station were also carried out.



Antenna and other fixtures for communication link between India and Antarctica and for meteorological data collection.

It was noticed that from February till November, almost 15 days in each month have blizzards. The highest wind speed recorded was over 250 km / hour during September 84. July and August were the coldest months when the average temperature was of the order of –40°C on all days and the minimum recorded was –50.5°C. Most of the blizzards occurred due to katabatic wind with the wind direction varying from 90° to 110°. Polar night was observed from 21 May to 20 July when the sun remained below the horizon. Polar day was observed from 21 November 84 to 20 January 85 when the sun remained above the horizon throughout. Most of the precipitation occurred during the days of blizzards.

Microbiological studies

The microbiological work carried out during 1983-85 was a continuation of the work started during 1981-82. During the winterisation of 1984-85, emphasis was on the effect of temperature on microflora, with special reference to their habitat, distribution, abundance, type of organisms and their ecology in the oasis environment. Samples were collected from Dakshin Gangotri oasis which is 35 km^2 in area, having lakes, lagoons, ponds, water streams, dome shaped hills, gentle slopes, varieties of soil type and typical polar climate. Samples were also collected from the penguin rookery located on the ice shelf near sea-shore. Temperature in the area goes down to –50° C in winter and increases to + 6° C in summer.

Environmental studies on microflora

Samples from different sites were collected at different times of the year to represent summer microflora (January 84 and December 84), winter microflora (August 84) and spring microflora (early December 84). These samples were analysed for moisture content and organic matter in the station laboratory. Air and soil temperature and pH of soil were measured immediately on collection. Suitable media for population isolation were designed, after trials, and experiments were continued in the laboratory. Samples were also collected from the lakes for the estimation of phytoplankton productivity in lakes. Three lakes in summer of 1983-84, one in winter 1984 and five in December 1984 were studied. Detailed collections of samples were also undertaken in January-February 1985 for microbial population and vegetation cover. The data are being processed for the annual variation in the different components of the ecosystem.

On the basis of the work done during the 15 month period, the following preliminary conclusions are drawn:

(a) Ecophysiological work showed an interesting adaptation of microorganisms during the Antarctic winter.

(b) Microorganisms maintained their continuity in the oasis ecosystem in all seasons.

(c) A bacterial specie (still unidentified) isolated in December 1984 produced dark blue pigments at low temperature. This appears to be a protein like substance.

(d) Productivity of the Antarctic lakes seems to be dependent upon the density of microflora and nannoplankton organisms.

Scientific work carried out during the summer by the team of Fourth Expedition

The summer scientific team consisted of 19 members including one photographer. Scientific work was carried out on board MS *Finnpolaris*, over shelf ice near Dakshin Gangotri station and in

the oasis of Schirmacher Hills. While some of the scientific programmes were in continuation of the previous years *e.g.* meteorlogy, glaciology, marine biology, radiowave propagation, etc., the Fourth Expedition initiated some new scientific programmes, namely reflection seismic work on the shelf ice, electromagnetic surveys of the shelf ice, geoelectric measurements in oasis, and molecular biology of microorganisms of Antarctica, development and application of special type of flame proof polymer coating.

Applied geophysics

The geophysical team carried out a number of useful geophysical experiments over the ice shelf near Dakshin Gangotri station and close to the lakes in the oasis. Magnetic measurements were made to identify the magnetic signatures of a possible warping in the basement below the ice-shelf and to delineate any tectonic feature possibly occurring in the region between the ice-shelf and foothills of the oasis. Seismic reflection surveys were carried out on the ice-shelf to study the characteristics of elastic wave energy propagation throughout the ice medium constituting the ice-shelf. Electromagnetic measurements were carried over the ice-shelf to determine its thickness and geoelectric investigation were carried out over the rocky terrain.

Meteorology

The Antarctic weather is likely to have influence on the major meteorological phenomena like the monsoons. Therefore systematic meteorological investigations in Antarctica are of great significance. Meteorological programme of the expedition was:

(a) On ship

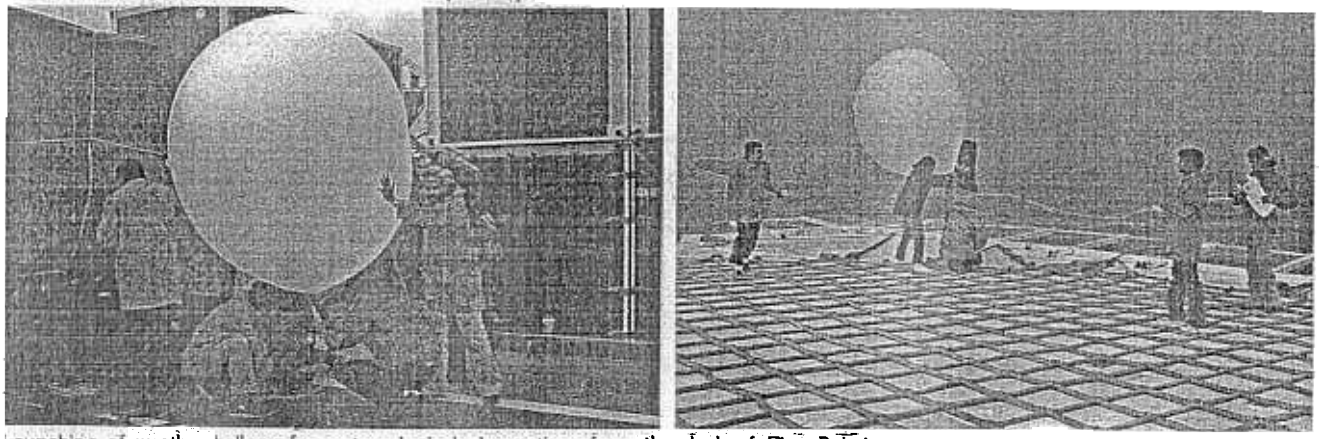
(i) Measurements of meteorological parameters at 3 hourly synoptic observations.

(ii) Reception, on board, of Fax charts from New Delhi. Pictoria (South Africa) and Molodyozhnaya (Antarctic Meteorological Centre).

(iii) Radiosonde ascents.

(b) Dakshin Gangotri

Installation of new meteorological instruments for detailed study of Antarctic weather, *e.g.,* APT (Automatic Picture Transmission) receiver, potential gradient measurements and data collection by the ascent of Radio Meter Sonde (RMS).



Launching of weather balloon for meteorological observations from the deck of *Finn Polaris.*

Determination of meteorological parameters were made every day mainly to assess the difference in the weather conditions between the two stations, one on the ice-shelf and the other in the ice-free hill region to forecast weather for helicopter operations.

Molecular biology of microorganisms

Microorganisms of Antarctica are likely to be unusual, being adapted to extreme cold conditions. Hence, it would be of interest to investigate the molecular biology of these microorganisms with a view to understand the molecular mechanism of such adaptation. Further, microorganisms of Antarctica are likely to be primitive and hence their study and analysis may shed light on the early evolution. With this in view a collection of microorganisms from Antarctica was undertaken during the Fourth Expedition.

Study of polymers

Sri Ram Institute of Industrial Research had successfully developed flame proof polymer coating. After successful demonstration of the paint developed, two tonnes of paint were produced in the pilot plant for its application in Antarctica. The paint has been used in some of the rooms of the permanent building.

Different polymers were exposed to the conditions prevailing in Antarctica for a period ranging from one month to one year. The samples exposed for one year will be brought back for evaluation of their physical, mechanical, thermal and electrical properties. The rest of the samples will be left for exposure in Antarctica.

Biological studies

(a) Phytoplankton studies and primary productivity

Water samples were collected from different stations to study the distribution and abundance of phytoplankton. Samples were collected from the various stations in polynya and from the fast ice ecosystem at every 48 hours interval.

(b) Distribution and density of Antarctic krill

In order to understand the role played by the krill in the Southern Ocean and also for delineating the areas of abundance of harvestable krill, several stations in the area between 58° S to 69° S and 11° E to 18° E were occupied. Shallow hauls were made. Adult krills were sorted out from the total samples and measured for their body length and weight. Some samples of krills were frozen for biochemical studies.

(c) Studies on the distribution and abundance of zooplankton in the Antarctic water

Zooplankton samples were collected from 30 stations using Heron-Tranter net. Generally the krill larvae dominated in the sample constituting more than 50% of the total biomass, followed by calanoid copepods, salps, cheatognaths, amphipods and ostracods.

(d) Studies on benthic communities

Benthic samples were collected from 120 m to 1400 m depths. Laboratory analysis showed that the fauna is very diverse and has a greater abundance near the shelf than in the open sea. Echinoderms, polychaetes, amphipods, isopods, gastropods and bivalves formed the main components of the bottom fauna.

(e) Biology of fresh water lakes

A complete survey of the lake near the permanent station was undertaken to study the biological productivity during the Antarctic summer. All samples were analysed for primary and benthic productivity. Physico-chemical factors like salinity, temperature, pH, alkalinity, dissolved oxygen and dissolved nutrients were also studied. Samples of lichens, mosses and algae from different localities were also collected.

Windmills and solar panels

Meteorological data indicate the presence of strong incessant katabatic winds around Dakshin Gangotri station throughout the year. Such a vast pool of energy existing there, if harnessed, can yield an abundant and almost cost-free and ready to use energy for the Indian stations at Antarctica. For possible design of a wind generator the following jobs were undertaken:

(i) Data collection of the wind speed, wind direction, surface temperature, cloud cover, radiation levels, etc.

(ii) Feasibility studies regarding the installation of a renewable energy system like the windmill were made.

Though the sunshine falling on the Antarctic continent is only during the summer, the total amount of radiation received during this time is quite comparable to the annual amount of radiation received in any other parts of the world. By deploying solar panels, water can be heated in summer, which will be extremely useful in the laboratory for scientific work, for domestic use and also for the room heating. As the stations are likely to remain inhabited by the summer and winter teams during the summer periods, such a facility will be very important in making alternative sources of energy available to the stations.

Radiowave propagation

Studies on VHF and HF communications were continued. These studies were made with special reference to unfavourable weather conditions like blizzards and when exceptionally high magnetic storms occurred.

The study is of a continuing nature and data over a long period of time are required to be recorded to make these studies useful. The state of ionosphere keeps on changing at different times of the day and from season to season. It is, therefore, necessary to predict the state of ionosphere at any time from the HF communication point of view. Since the HF communication is in operation between Antarctica and India, the present study will be quite useful.

Glaciology

The work on glaciology was continued. During the period under report, studies were undertaken in areas adjoining the Dakshin Gangotri station and at glaciers situated south of the Schirmacher oasis. The study was further extended towards the Wholthat mountain ranges.

Photography

Still and movie photography were undertaken by the member of the Films Division included in the team.

Philately

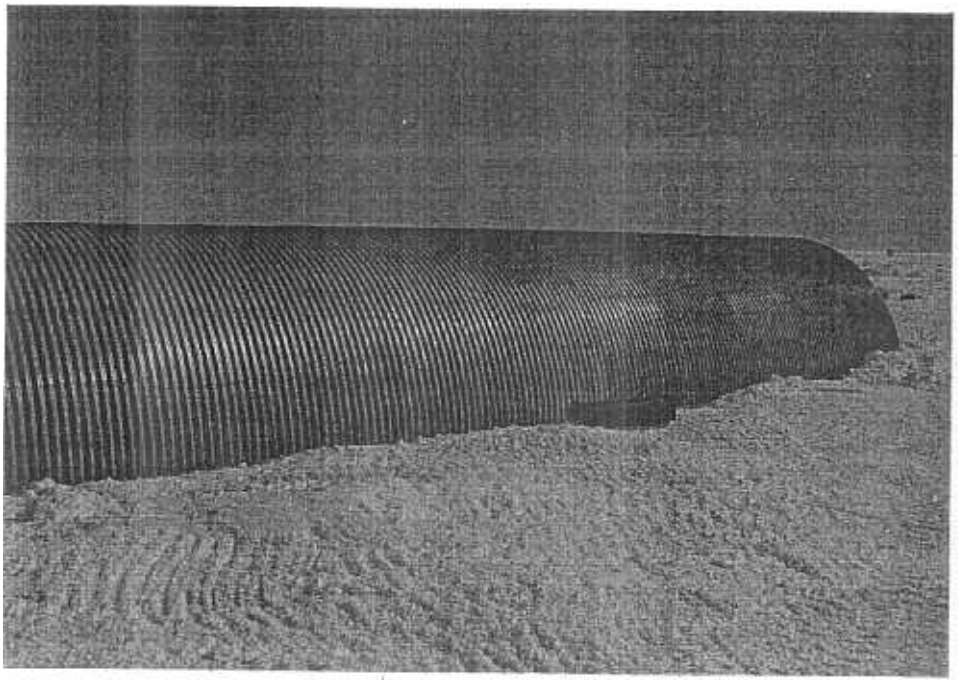
More than 2500 philately mail covers were cancelled at Dakshin Gangotri station.

Medical

Four doctors belonging to the Services were in charge of the medical needs of the expedition. The doctors established excellent medical facilities on board the ship during the ship's journey to Antarctica. They not only treated the expedition members but provided all possible medical assistance to the members of the crew of the ship as and when needed.

Construction work at Dakshin Gangotri site

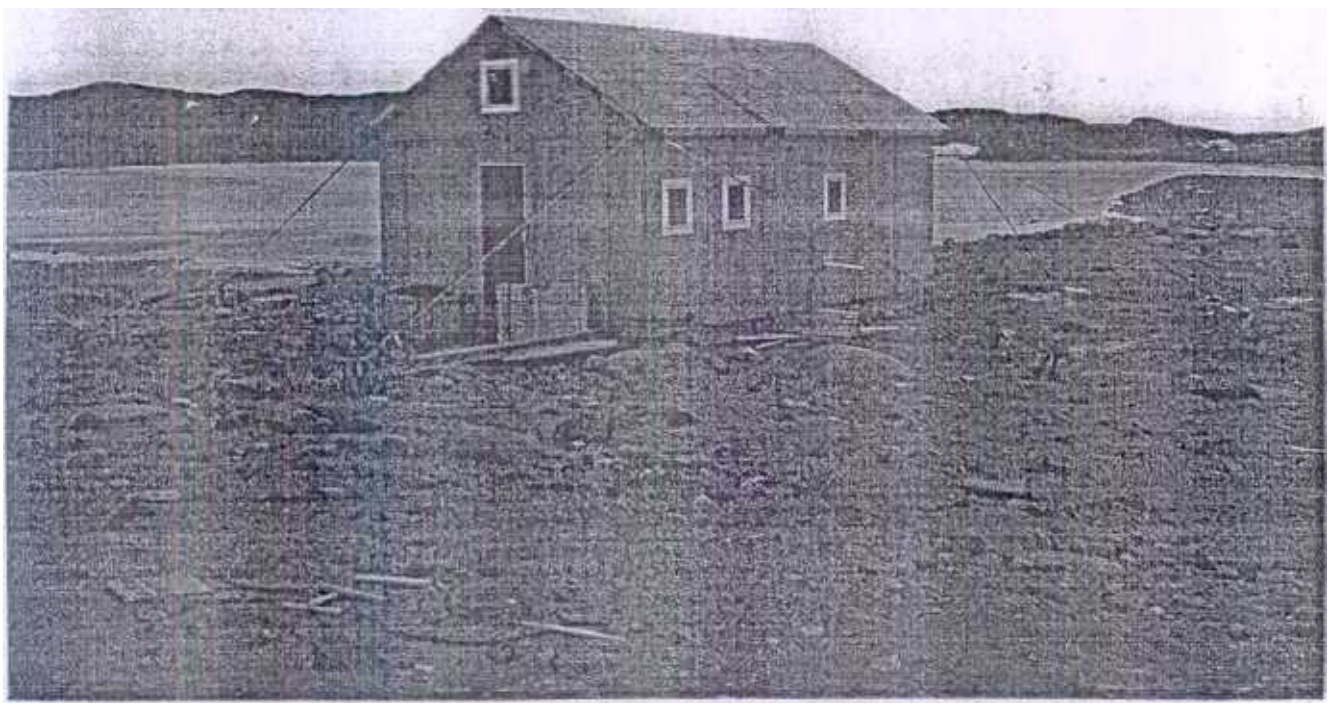
The construction of a garage for parking the snow vehicles, skidoos, snow cutter and heavy duty crane was one of the tasks assigned to the Fourth Expedition, which involved a fair amount of work under very adverse weather conditions. The team was able to accomplish this work within a short span and erected a garage measuring 60 m×10 m size. For facilitating easy access and parking of the vehicles, a ramp of 24 m length covered by detachable wooden structure was also erected. The garage was electrified. A container workshop for the repair and maintenance of vehicles was also set up within the complex.



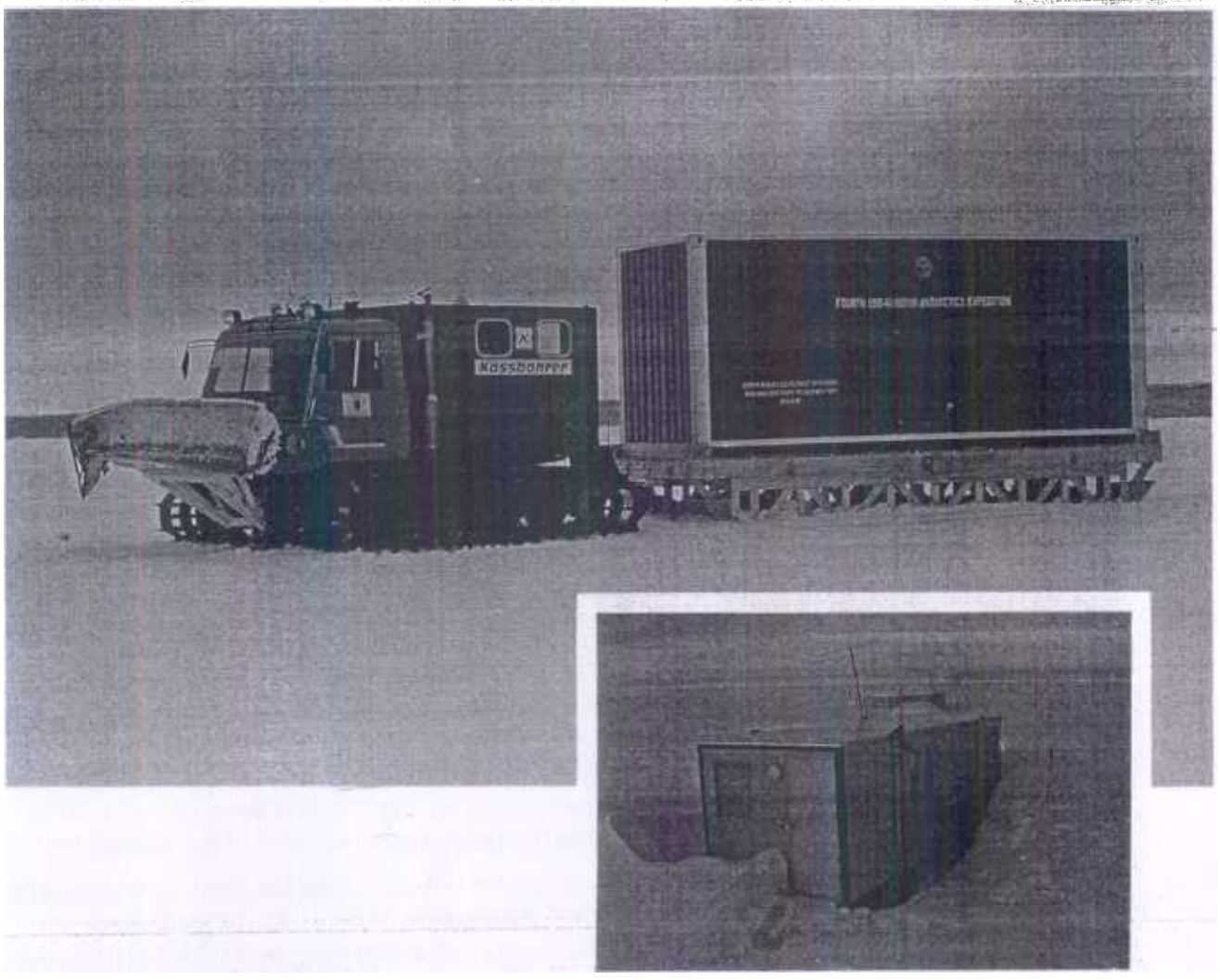
Garage constructed at Dakshin Gangotri for parking of vehicles and storage of equipment.

Construction work in progress.

Another major task of the Fourth Expedition was to construct three cottages on rocks in the ice-free hill region of Dakshin Gangotri. A site, (coordinates of which are 70° 45′39.4″ S, 11°44′48.5″ E approximately) about four kilometres west of the eastern edge of the Schirmacher Hills was selected. This site is some 60 km away from Dakshin Gangotri and close to the USSR station Novolazharveskaya. The height of the area is between 0-228m above the level of epishelf lakes. The average height of the rolling relief of the area with its dome-shaped hills is about 100 m. There are two nunatakes, 2 km south. The climatological parameters of the site are: average annual air temperature −11° C. The temperature in January is −1.5°C and in July −18.2°C. The wind speed is 10.2 m/s in the east and south easterly direction with precipitation of 309 mm/a. The construction of the three cottages, with prefabricated material was accomplished by a team of 8 members. Two double-storeyed huts measuring 7.5 m × 5 m with sleeping accommodation for 6 persons in each cottage on the first floor, one timber structure of a smaller size to house the generator on the ground floor and stores on the left were constructed. These cottages were electrified. Kitchen and toilet facilities and heating arrangements were also provided. The three cottages, with all provisions, medicines and other facilities were handed over to the second wintering team on 27 February 1985.



A view of one of the cottages built at Schirmacher Hills.



Pisten bulley towing habitat module container built by DRDO Inset: Porta cabin (living container)

Alternative accommodation which was designed and fabricated by the Defence Research and Development Organisation was established 200 metres away from the permanent station and a sledge mounted garage to house one snow vehicle were also established. This accommodation contains all facilities like snow melter, water closets, power generators, electricity and heating systems. Food and clothing were also stored for use by the wintering team during emergencies.

Communication

The Naval communication team was assigned the task of establishing and subsequently maintaining a reliable HF link on RT and CW modes with India. The work was carried out in hazardous conditions and two-way-communications with India were established. The results of the HF communication between Antarctica and India are indeed most encouraging. With a view to reducing the field work at Antarctica, a plan for pre-assembly of various sections of the Rhombic mast was drawn out on board *Finnpolaris*. Accordingly work was initiated on 22 December 1984 on the assembly of twelve 5 m long mast sections with their fastening arrangements. This task was

accomplished in a record time and the materials were subsequently transported to the site by *Chetak* helicopter. The installation of Rhombic antenna was undertaken from 29 December 1984 to 9 January 1985. Four long masts each measuring 12.5 m in length have been installed on 1.8 m X 1.8 m base, buried in ice to a depth of about 1.75 m.

The 1 kW Punwire Transreceiver was installed in the radio room while two 5 kW transmitters, BEL Tx and the RS 512 were installed in the transmitter room, on the ground floor of the station building. The power transformer could not be accommodated in the transmitter room and was located under the stairway.

The entire communication work was completed successfully in record time by a small Naval team assisted by the scientist from Punjab Wireless System.

Return journey

After completing all the logistic and scientific work assigned to the members, the team left Antarctica on 1 March 1985 at 14.20 hrs. (17.50 hrs. IST) along with the members of the first wintering team. The ship reached Mauritius on 13 March at 14.10 hrs (local time). The team was received by the representative of Indian High Commissioner at Mauritius. The ship sailed from Mauritius on 17 March at 08.20 hrs. (local time) and reached Goa on 25 March at 09.00 A.M.

Fifth Indian Expedition to Antarctica 1985-86

The Fifth Indian Expedition to Antarctica sailed from Goa with a team of 88 members on 30 November 1985 and landed on Antarctica on 24 December 1985. MV *Thuleland*, a Swedish vessel has been chartered for the expedition. The scientific component of the expedition consists of 21 members drawn from 12 different institutions and includes two women scientists. The logistic component consists of 67 persons from the three Services. Shri MK Kaul of the Geological Survey of India has been nominated as the leader of the expedition. Shri Pavan Raina. Director in the Department of Ocean Development has also been included as a member of the expedition team.

The expedition team also included 14 persons who will constitute the third wintering party. This party will stay in Antarctica till March 1987. Dr. V K Dhargalkar of the National Institute of Oceanography, Goa has been designated as the leader of the wintering team. Two scientists from the Geological Survey of India, one each from India Meteorological Department and the National Institute of Oceanography will constitute the scientific component of the third wintering party. Ten personnel from the Services will provide logistic support.

Name	Agency	Name	Agency
Dhargalkar, Dr. VK Leader	NIO	Achaya, Nb. Sub. MU	EME
Unni, Maj. RK Deputy Leader	EME	Malwade, Poelr. SR	IN
Adya, Maj. CM,	AMC	Chand, Poelr. M	IN
Yadav, Lt. PD	IN	Singh, Hav. Surjit	EME
Singh, Shri RK	GSI	Chandra Choodan, Hav	ENGRS
Mukherjee, Dr. S	GSI	Singh, Nk. Chanan	ENGRS
Bhaskar Rao, Shri TVP	IMD	Das, LCK (O) PB	IN

Members of the Fifth Scientific Expedition to Antarctica

Name	Agency
Pant, Dr. (Miss) A	NIO
Parmar, Shri P P	Films Dvn
Paste, Nk. D R	ENGRS
Patel, Sgt. H S	IAF
Patil, Shri. P A	IN
Prasad, Hav. L	ENGRS
Prasad, Sgt. R	IAF
Puri, Sqn. Ldr. S K S	IAF
Raina, Shri Pavan	DOD
Raj, Shri. K B	IN
Rajgopal, Poelr P N	IN
Ramdass, Lt. Col. T N	DRDO
Ramakrishnan, Shri K C	BHEL
Rama Rao, Hav. E	ENGRS
Ravindran, Lt. K	IN
Reddy, Shri K N S	NGRI
Sharma, Sqn. Ldr. A C	IAF
Sharma, Wg. Cdr. V K	IAF
Shingari, Sgt. D K	IAF
Sidhu, Maj. J S	ENGRS
Singh, Nk. Balbir	ENGRS
Singh JWO Balvinder.	IAF
Singh, Nk. Chanan	ENGRS
Singh, Nk. Gurcharan	ENGRS
Singh, Hav. Jagar	ENGRS
Singh, Shri R K	GSI
Singh, Nk. Sajan	ENGRS
Singh, Nk. Sewa	ENGRS
Singh, Lt. Cdr. Surinderjit	IN
Singh, Hav. Surjit	EME
Sohan Ram, Sgt.	IAF
Sooch, Maj. K S	ENGRS
Srinivasan, Shri J	GSI
Srivastava, Shri D	GSI
Stone, Wg. Cdr. L B	IAF
Sudhakar, Shri T	NIO
Thankappan, Sgt. K	IAF
Thomas, Nk.	ENGRS
Tiwari, HMT. R P	EME
Trivedi, Capt. V I	ENGRS
Unni, Maj. R K	EME
Vijaykar, Shri S S	IIT, Bombay.
Viswanadham, WO G K	IAF
Yadav, Lt.(SDC) P D	IN

Tasks for the Fifth Antarctic Expedition

During the Fifth Expedition, surveys will be carried out in the Schirmacher Hill range and in the eastern Wohlthat region. On the basis of the results of such a survey a suitable site will be identified at the Schirmacher Hill range for the construction of an alternative station during the Sixth Expedition. Aerial reconnaissance will be carried out in the adjoining areas. The HF communication link will also be upgraded.

On the scientific side, the expedition is required to carry out the following:

(i) Geological mapping of the eastern Wohlthat region.

(ii) Geophysical surveys in the Schirmacher Hills; potential of surface "shows" of mineralisation to be established by induced polarisation, electro-magnetic and magnetic surveys.

(iii) Continuation of meteorological study and collection of meteorological parameters. Installation of a Data Collection Platform.

(iv) Collection of biological samples; bioecological studies of the Antarctic environment, studies of phytoplankton, zooplankton, fish and macrophytes.

(v) Collection of meteorites.

(vi) Study of fatigue of metals and other materials exposed to Antarctic conditions.

(vii) Installation of a solar energy system.

Antarctic Study Centre

The Government of Goa has alloted a site for this centre and have handed it over to the Department of Ocean Development. The first phase of the establishment of the Antarctic Study Centre is expected to be completed during the Seventh Plan period.

Antarctic Marine Living Resources

The Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) was concluded in 1980. The objective of the Convention is conservation of the Antarctic marine living resources. Conservation also includes a rational use of the resources. To implement the objectives of the Convention, a permanent Commission at Hobart, Tasmania and a Scientific Committee have been established. The Commission which is an inter-governmental organisation has been entrusted with a broad range of functions which include, *inter alia*, the facilitation of research, formulation, adoption and revision of conservation measures, and implementation of the system of observation and inspection. The original signatories to the Convention are the members of the Commission. An acceding State is entitled to membership during such time as it is engaged in research or harvesting activities of the Antarctic marine living resources.

India acceded to this Convention with effect from 17 July 1985 and participated in the fourth annual meeting of the Commission held in Hobart, Tasmania from 2 to 13 September 1985 as an observer. At this meeting, guidelines relevant to the preparation of submissions by the States seeking membership of the Commission were formulated. India's application for the membership of the Commission, in accordance with the guidelines established, is expected to be submitted

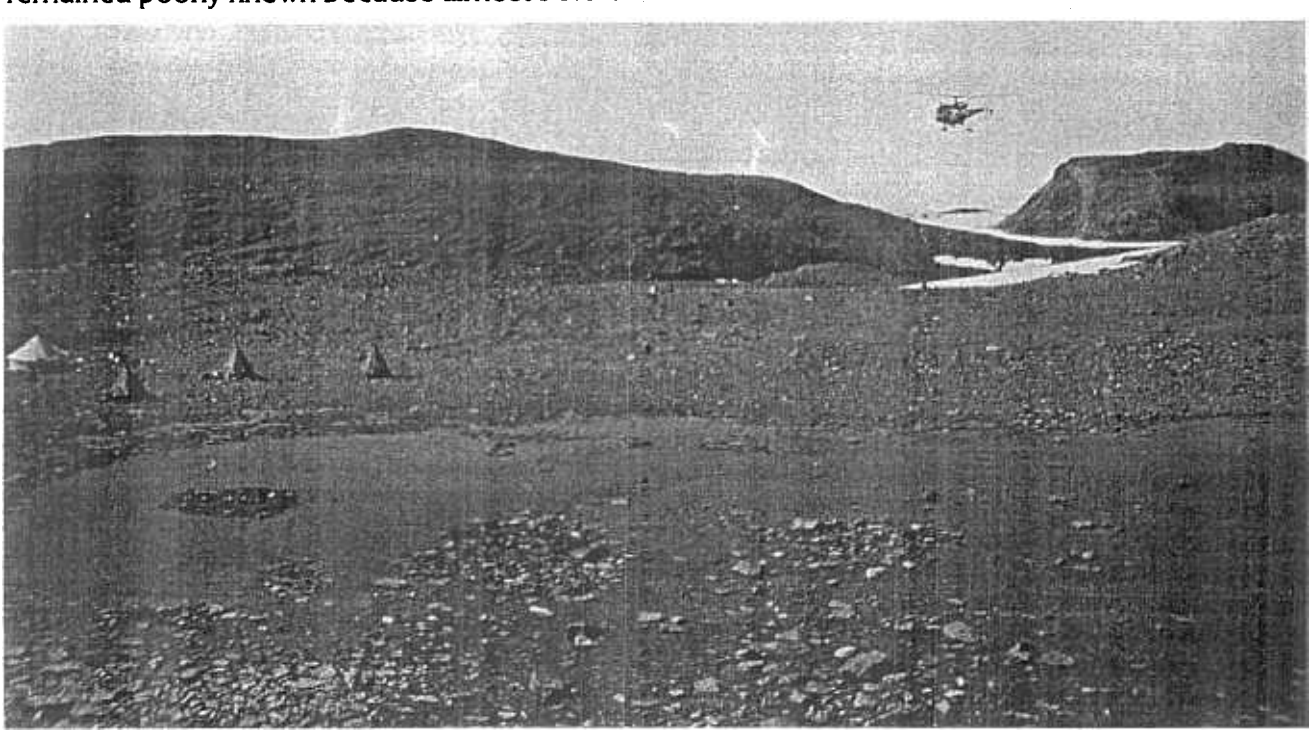
shortly. Membership of the Commission will entitle India to participate in the decision making process. The present membership of the Commission includes Argentina, Australia, Belgium, Chile, the European Economic Community, France, German Democratic Republic, Federal Republic of Germany, Japan, New Zealand, Norway, Poland, South Africa, Union of Soviet Socialists Republic, United Kingdom of Great Britain and Northern Ireland and United States of America. Republic of Korea, Spain, Sweden and Brazil have also acceded to the Convention.

Antarctic mineral resources regime

For a number of reasons, there is an increased interest in the possibility of exploiting mineral resources of Antarctica. As distinct from basic scientific investigation, the question of possible exploitation of natural resources of Antarctica raises a wide range of questions of legal and political nature. The Antarctic Treaty places a special responsibility on the contracting parties to ensure that no State engages itself in any activity in the Antarctic Treaty area which is contrary to the principles and purposes of the Treaty.

The knowledge about the mineral potential of Antarctica at present is rather meagre. Although a large number of mineral occurrences have been reported from Antarctica, the chances of their recovery in commercial quantities do not appear to be attractive enough within the next decade.

The prospecting for hydrocarbons in the continental margins around Antarctica is considered to be a possibility within the foreseeable future but commercial exploitation may take quite some time. Exploration and exploitation of metals and fossil fuels from the land areas of Antarctica appear much less possible, at least in the foreseeable future. Much of the geology of Antarctica has remained poorly known because almost 98% of the land surface is mantled in ice to some



Survey of Schirmacher Hill and Lake region.

1,600-4,500 metres in thickness. The depth of the Antarctic continental shelf varies from 400 to 800 metres on the seaward edge as compared to world average of 133 metres. The geography, geology and extreme conditions of cold and ice offer an enormous challenge for carrying out scientific investigations, exploration and exploitation activities on the continent and in its surrounding waters. The present ignorance of the structure of much of the Antarctic land and continental margin, coupled with the hostile environment and the thick ice cover, would indicate that the exploratory phase is likely to be prolonged in most areas before exploratory drilling or exploitation can be considered.

The primary focus of the Antarctic Treaty of 1959 is on scientific research. However, it neither directly prohibits nor permits commercial exploration and exploitation of mineral resources. In fact, the Treaty does not directly govern the problem of mineral resources. Therefore, the contracting parties have considered it necessary to establish a system to regulate the exploration and exploitation of minerals before such activities commence. During the last few years, a number of proposals in connection with the possible regulation of the exploration and exploitation of Antarctic mineral resources have been considered. An informal Working Group of the Consultative Parties has been working on the establishment of a mineral regime for Antarctica. While the basic elements of a mineral regime have been identified, the details of the regulatory framework are yet to be worked out. India has been participating in the meetings of the informal Working Group after it acceded to the Antarctic Treaty in September 1983. During the year 1985-86 two meetings of the Working Group were held, one in Rio de Jeneiro from 25 February to 8 March 1985 and the other in Paris from 23 September to 4 October 1985. India's participation and contribution were appreciated by the members of the Treaty.

XIII Antarctic Treaty Consultative Meeting

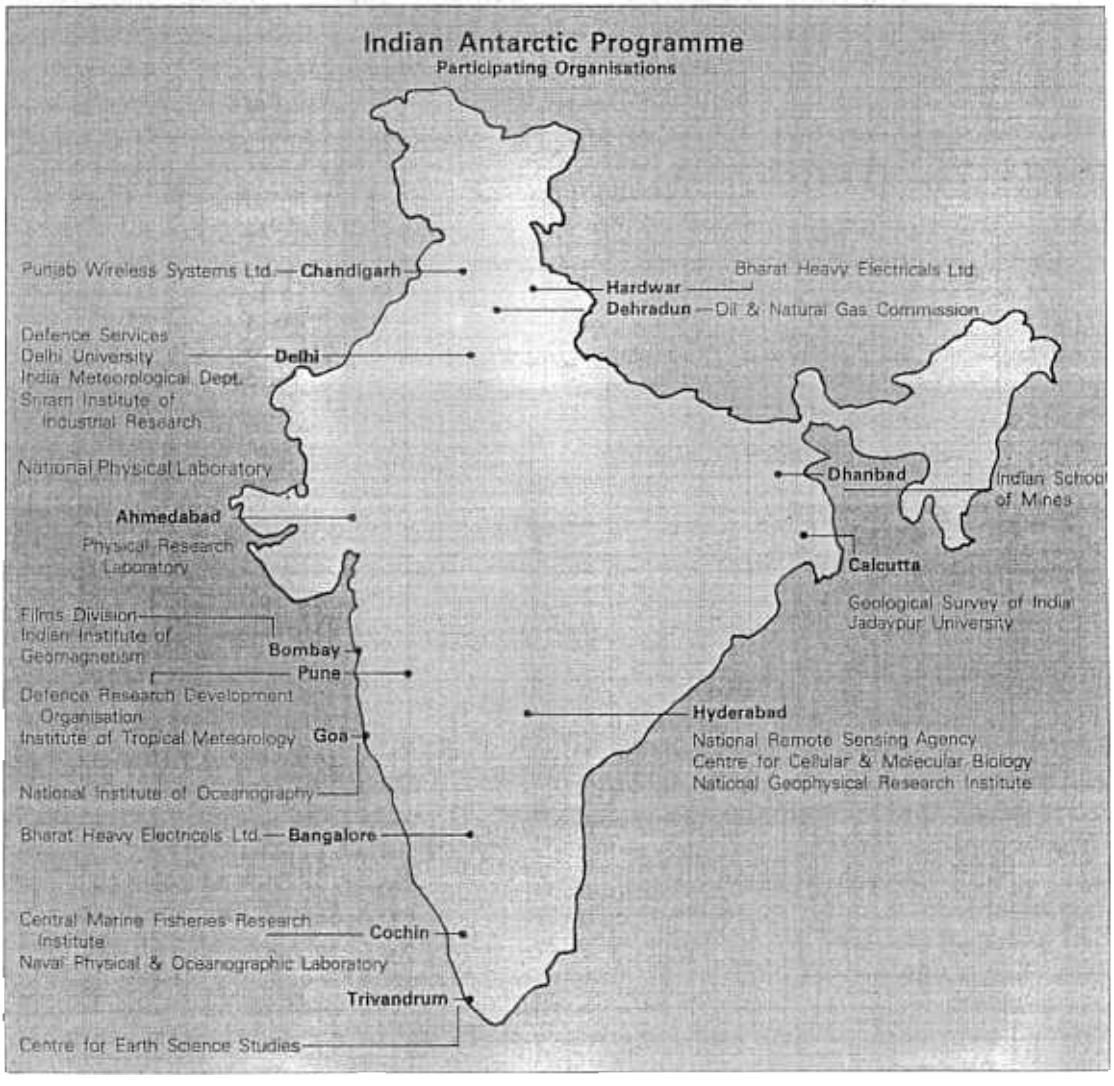
The XIII Consultative Meeting of the Antarctic Treaty Parties was held in Brussels from 7 to 18 October 1985. China and Uruguay were admited as Consultative members, thus increasing the total number of Consultative Parties to eighteen. India, which became a Consultative Party at the XII meeting, also participated. The operation of the Antarctic Treaty System and the impact of man's activities on the Antarctic environment were among the major issues considered by the meeting. Sixteen recommendations covering different aspects of scientific research in Antarctica, exchange of information, specially protected areas, historic monuments and appointment of observers, etc. were also adopted.

Antarctica and the United Nations

For the third time in succession the "Question of Antarctica" was discussed within the United Nations, which was reinforced by a comprehensive, factual and objective study prepared by the Secretary General in response to Resolution 38/77 of 15 December 1983. The study mandated by the General Assembly reaffirmed that Antarctica should be used for peaceful purposes for the benefit of all mankind and should be free from all international discord. It acknowledged the contributions made by the Antarctic Treaty System.

During discussions some States enumerated series of deficiencies in the Antarctic Treaty System and emphasised the need for a regime which would ensure equitable distribution of mineral

resources of Antarctica. The Organisation of African Unity through a resolution sought the recognition of Antarctica as the "common heritage of mankind". There was also a strong move for the expulsion of South Africa from the Antarctic Treaty set-up. The Antarctic Treaty Consultative Parties, however, felt that the prerequisites for applying the common heritage principle in the case of Antarctica were non-existent and refuted the charge of exclusivity of the Antarctic Treaty System The Treaty was open for any member of the United Nations to join. India along with other Consultative Parties emphasised that any attempt to undermine the Antarctic Treaty System could lead to international discord and instability in the working system. It was an evolving system which has worked satisfactorily and was responsive to the view points of all States. India emphasised that the Treaty System should be broadened by the accession of more States. In this context it welcomed the admission of the Republic of China and Uruguay as Consultative Parties. India also emphasised the need to work out modalities to improve upon the Treaty to make it more open and to bring results of scientific research to the notice of developing countries.



8. Marine Environment—Control of Pollution

Although the marine pollution problems in the Indian Ocean have not yet reached the magnitude of those found in the other regions such as the Mediterranean and the Baltic Sea, which are bordered by highly industrialised countries, the coastal areas of the sub-continent are beginning to show signs of deterioration. Increasing industrialisation and population growth in the coastal region, development of offshore oil and gas resources, maritime transportation, dredging operations and several other coastal activities have a negative impact on the coastal environmental quality and these pose a threat to the marine environment. This is especially true in the vicinity of coastal industrial sites and towns such as Bombay, Madras and Cochin. Oil contamination from accidental and operational sources has also become a growing threat to the coastal areas. The dumping of untreated sewage directly into the sea also results in the contamination of many beaches. There are few adequate or satisfactory methods for treatment and disposal of effluents. Often wastes are dumped directly into the rivers and seas causing damage to the coastal marine ecosystem and resulting in hazards to human health. Realising this the various agencies of the Government of India have embarked on an assessment of coastal pollution. The surveys conducted so far have covered the coasts of Gujarat, Goa, Karnataka, Maharashtra and Kerala on the west coast and Tamil Nadu on the east coast.

It has been suggested that the treatment of industrial and domestic wastes needs to be accelerated. There is, therefore, a need to develop monitoring programmes to assess the sources, levels and facts of pollutants and also there is a need to implement programmes on pollution abatement and control.

During the last few years, studies on the presence of oil and oil slicks have also been carried out along the Indian coastline. Research Vessel *Gaveshani* carried out observations along the oil tanker routes across the Arabian Sea and the Bay of Bengal to study (a) oil slicks, (b) petroleum residues (tar like material) and (c) dissolved and dispersed hydrocarbons. From these studies conclusions were drawn that the Indian seas are affected by oil pollution but this has not reached an alarming level. Physical, chemical and biotic factors have also been studied to suggest suitable discharge point for the industrial effluents and sewage. Based on the information gathered during the coastal survey, maps are being prepared by the Central Water and Pollution Control Board and ecologically sensitive areas have also been identified in some parts which require protection and careful monitoring. The entire Gulf of Kutch is an ecologically sensitive area by virtue of its being a breeding and nursery zone for a variety of marine organisms including the commercially important fish and prawn species. The area near the mouth of the Gulf shows high productivity and the presence of coral reefs near Nora and other islands has added further significance to the area. The coastline near Malvan on the Maharashtra coast is of special interest. Malvan with its coral reefs and high biological productivity is also an ecologically sensitive area.

During the Seventh Plan period, the survey of the entire coastline of the country with a view to identifying pollution sources, ecologically sensitive regions and to assess the impact of pollutants is expected to be completed.

A Marine Pollution Group to deal with all issues related to pollution of the seas has been set up as an Apex Body. All maritime States of India, Coast Guards, Ministries of Shipping and Transport, Petroleum, Agriculture, Urban Development, Industry and Departments of Environment and Ocean Development constitute the Group. During the year 1985-86 the Group met twice to consider the problem of pollution. This Group has requested the Coast Guards to prepare plans for combating pollution from oil spills, monitoring of pollution and other enforcement aspects. A national contingency plan for meeting an oil pollution contingency situation is proposed to be finalised. The question of the review of laws and regulations taking into account the relevant international conventions have also been suggested. After examining the various issues, the Group has approved the contingency plan prepared by the Coast Guards and given further suggestions for taking effective measures for combating pollution. The maritime States have also been requested to prepare status reports on pollution in their regions. Steps are being taken to develop monitoring programmes and to acquire suitable equipment for this purpose. Environmental data and information are regularly collected on all the cruises of the research vessels.

9. Underwater Technology - Acquisition of a Submersible

Preparatory work for the acquisition of a manned submersible capable of operating at a depth upto 600 metres, with built in transfer of technology terms, were completed during the year 1985-86. Design, fabrication and the acquisition of a submersible will take about 2 years and it will be available in 1988. The submersible will not only added to the research capabilities in carrying out studies on light penetration, plankton, coral reefs and mapping of shallow areas of the sea, it will also enable on-the-spot inspection of the offshore installations and structures.

10. Harnessing of Wave Energy

The major aims of the Wave Energy Project are

Scientific study of the wave climate along the Indian coast

Theoretical and laboratory model studies on the system to be used for the absorption of waves which in turn will enable the creation of calm pool of water behind the system

Theoretical and experimental studies for the conversion of wave energy to mechanical energy, and its conversion to electrical energy and transmission

Instrumentation and controls for the system

Analysis and design of the structure

Position keeping of the structure and seabed anchors

Choice of materials for the system and their protection in marine environment.

The progress on the implementation of this project is briefly summarised below:

After collecting wave data for more than a year, a special wave rider buoy was deployed off the Madras coast during 1984-85. The signals monitored by wireless instrumentation were recorded and the results were analysed to arrive at the wave spectrum for all the days and months of the year. The necessary computer software has been developed. During the initial stages of the project, various types of wave energy devices were considered. Some model experiments were also carried out on different types of devices and finally it was decided that for the multipurpose wave energy system required for our coast, a terminator type bottom standing Oscillating Water Column device (OWC) is the most suitable one.

Various theoretical and experimental studies were undertaken in the laboratory for the optimisation of the dimensions of the OWC device which will be able to work efficiently near the coast for a long period. Some of the latest modifications to the OWC reported in 1984 in Norway were incorporated in an experimental study which was completed in November 1985. This device known as 'Harbour concept' is being studied in depth.

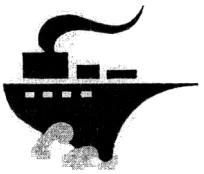
On the development of air turbines, advantages of special turbine rotors with small cambered blades are being studied. The theoretical analysis on the flow around turbine blades has already been completed. One twin rotor of 150 mm diameter has been successfully fabricated for demonstration. Based on the theoretical analysis, a few cambered profiles have been selected for experimental optimisation. Blade and rotor design for the experiments were completed.

After identifying a generator with a permanent magnet with iron-free rotor, a small generator has been fabricated with the assistance of the Madras Port Trust.

All the instrumentation required for the laboratory studies have been chosen/developed and acquired/fabricated indigenously. A concept of the instrumentation required for the sea experiments has been evolved and various instruments/systems have been identified.

A bottom standing concrete structure with skirts penetrating into the sandy seabed has been developed. This is capable of withstanding the most severe wave conditions likely to occur off the Madras coast. A complete design for the structure is in progress.

Concrete has been chosen as the material for the structure with suitable additives/surface



treatment, for its marine application For the turbine, the shaft will be of stainless steel and rotor blade of brass with nickel plating. The ducting for the turbine will be in steel, coated with epoxy paints for corrosion protection.

(i) **Studies on variation of wave energy**

As the waves approach the shallower waters, due to bottom friction and other effects, their energy content gets reduced. On the other hand, the cost of a bottom standing wave energy device increases significantly with increasing water depth. In view of this, studies have been carried out to find the optimum water depth for the device. A theoretical model has been applied for the Madras coast and predictions were obtained. For the verification of these theoretical results, wave measurements are to be taken simultaneously at different water depths. For this purpose additional wave rider buoys are being procured.

(ii) **Wave refraction studies**

A refraction study has been conducted for a 25 km length of the coast near Madras and a location for the concentration of waves has been identified. This will be verified by actual experiments after the two additional wave rider buoys have been installed.

(iii) **Demonstration model on wave energy**

A demonstration model on the wave energy has been developed, designed and fabricated for its installation. This includes a wave maker for a 1.2 m wide flume and an Oscillating Water Column device to absorb the waves with a matching turbine and generator to produce electricity.

(iv) **Air turbine**

Four different types of blade profiles, selected after the theoretical analysis are expected to be fabricated, assembled in a rotor and tested for their efficiency in a test rig of the Thermal Turbomachines Laboratory at IIT, Madras.

The entire system of Oscillating Water Column device with turbine and generator will be tested and proven in the 4 m wave flume of the Ocean Engineering Centre, IIT, Madras, to demonstrate the conversion of wave energy into electricity.

System development and a design for the sea experiment are expected to be completed in the near future. These will include the design of structure, the methodology of its manufacture, the design of turbine with the necessary generator control. An instrumentation system to monitor and evaluate the sea trial will also form a part of this model.

11. Ocean Thermal Energy Conversion (OTEC)

OTEC technology is being developed world-wide over the past 15 years. Major contributions in this field have been provided by USA, Japan, France, Sweden and Holland. The world-wide OTEC potential is expected to be around 10 million MW.

The first initiative on OTEC in India was taken during 1979-80. A Project Cell was formed at the Ocean Engineering Centre, Indian Institute of Technology, Madras to look into the various aspects of ocean thermal energy and to coordinate the activities on OTEC among a project group consisting of the following industrial/research organisations:

(a) National Institute of Oceanography, Goa
(b) Bharat Heavy Electricals Limited, Hyderabad
(c) Engineers India Limited, New Delhi
(d) Mazagon Dock Limited, Bombay and
(e) Indian Institute of Technology, Madras.

A project group consisting of the representatives from the above mentioned institutions was requested to study the possibilities of putting up an experimental 1 MW OTEC Plant off one of the islands of Lakshadweep. A project team consisting of 8 representatives from the above 5 organisations visited the islands during August 1982 to study the various possibilities. Only two islands, namely Kavaratti and Minicoy were found to offer possibilities for installing an OTEC Plant. From the available bathymetry and temperature profiles around the islands, it has been found that a depth of 1,000 metres will be available within a distance of about 3 km from the islands and a temperature difference of 20° to 22°C between the surface and 1,000 m depth throughout the year. Therefore, it has been considered that a shore-based plant is ideally suited for these island sites which have big lagoons on the western side. These islands are of coral origin and detailed studies for placing the cold water pipeline on the sea slope are necessary. The cold water pipe for this 1 MW Plant is expected to be about 1.5 metre in diameter and one of the proposals under consideration is to provide high density polyethylene (HDPE) pipes, assembled on shore to be floated out in full length and sunk.

After a study of the possible site conditions at Kavaratti and Minicoy islands, it was felt that shell and heat exchangers, having a weight of 200 tonnes to 400 tonnes per unit, will not be suitable for these islands because of the lack of unloading facilities there. Hence the working group has suggested that plate heat exchangers are to be preferred for Lakshadweep islands.

Detailed bathymetry and temperature surveys of the two sites in Kavaratti and Minicoy were done. These surveys indicated that the bed slope in Kavaratti is relatively more uniform and is suitable for the installation of cold water pipe when compared to the corresponding bed slope off the Minicoy island.

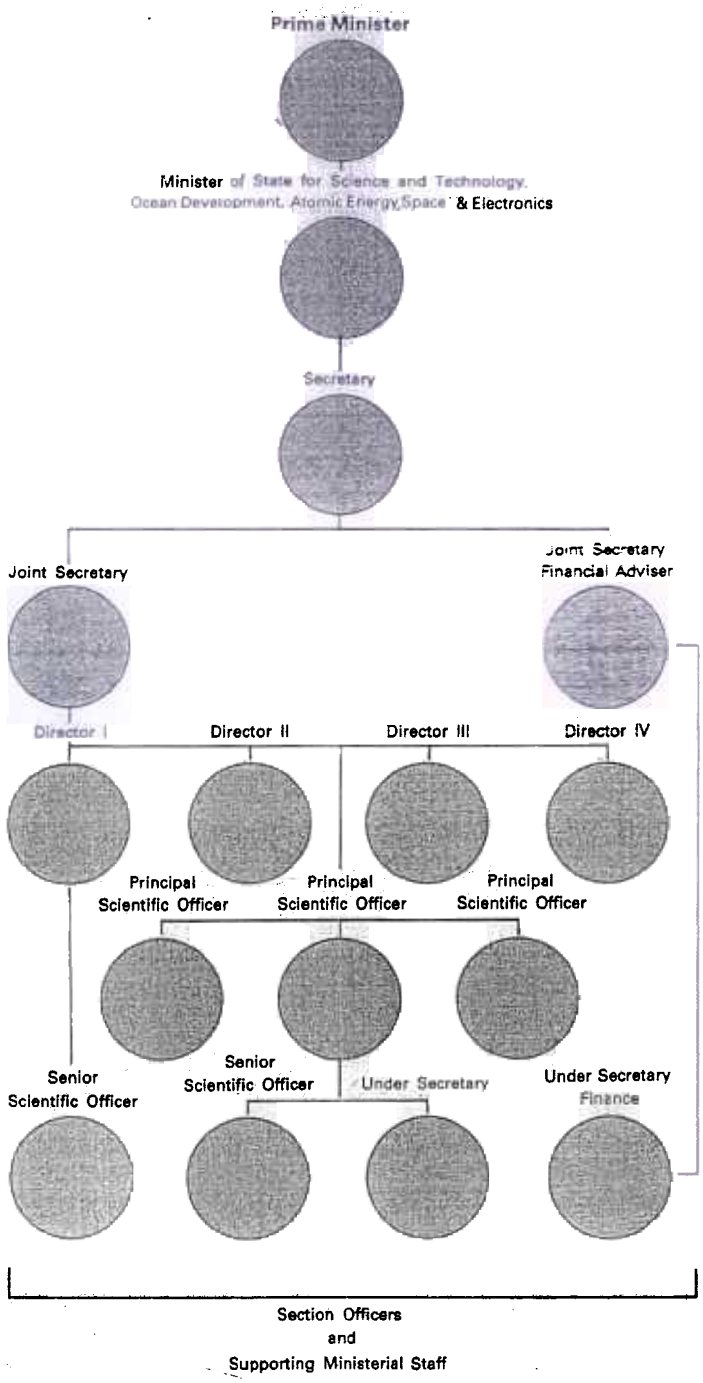
After the hydrographic survey, it has been proposed that the cold water intake may be located at a water depth of 650 metres where the temperature of the sea water will be 10°C. The corresponding length of the cold water pipe will be about 28 kilometres. This will result in the warm water intake temperature of 29°C and cold water intake of 10°C, resulting in a temperature difference of 19°C. Thus the different parameters have been recalculated and the new component specifications have been arrived at.

Action has been initiated to get the details connected with the procurement of the major components like the heat exchangers, cold water pipes, turbo-generators, pumps, etc.

The IIT, Madras, which is implementing this project is continuing with research and development work connected with the experimental plant.

12. Organisation and Finance

The Department of Ocean Development was created in July 1981 under the Cabinet Secretariat and from March 1982 as a separate Department. The organisational set up is indicated below:



Organisation

The Department has no scientific laboratories under its control. Its scientific programmes are implemented through various CSIR/ICAR Laboratories and National facilities. The total staff strength of the Department in all grades was 82 as on 31 January 1986.

During the year 1985-86, the recruitment to the following posts were made: Group 'C' one, Group 'D' one. Action is under way for filling vacancies in the posts of Director, Senior Scientific Officer and Senior Technical Assistant.

The Department is located in the CGO Complex, Lodi Road and occupies 9,032 sq. ft. in Block No. 12 and 3,000 sq. ft. in Block No. 9.

Budget

The budget estimate of the Department of Ocean Development for the year 1985-86 was Rs. 2,889.60 lakhs, while the figures for revised estimates for 1985-86 are Rs. 2,043.63 lakhs. A budget estimate of Rs. 2,817.49 lakhs has been made for the year 1986-87. A summary of the financial requirement is given below:

Sl. No	Item	Budget Estimate 1985-86	Revised Estimate 1985-86	Budget Estimate 1986-87	Allocation for the 7th Plan
2		3	4	5	6
	A. Plan				
					(Rs. in lakhs)
1.	**Oceanographic Survey**				
	Other Research Vessels	50		100	300
2.	**Antarctic Research**				4,500
	Expedition to Antarctica	350	250	300	
	Chartering/running of Ice-breaker	350	350	400	
	Research Stations in Antarctica	200	100	200	
	Antarctic Study Centre	30	10	30	
	Acquisition of Ice-breaker	20		20	
3.	**Polymetallic Nodules Programme**				
	Surveys & Exploration	300	216	370	
	Mining Research and Development	50	5	45	
	Under-water Technology & Submersibles	145	75	150	
	Metallurgy	50	54	60	
	Contribution to International Sea-Bed Authority (ISBA)	30		30	
4.	**Research and Development**				
	Marine Research and Development Assistance for Research Projects, Seminars, Symposia, etc.	40	40	30	

1	2	3	4	5	6
	All India Coordinated Projects on Remote Sensing, Telemetry Buoys System, Oceanographic Towers, etc.	50	15	50	500
	Marine Pollution	50	23	25	200
	Desalination and Marine Chemicals Schemes	25	25	15	100
	Marine Instrumentation	20	5	20	100
	Ocean Energy Programmes				
	Studies on Prevention of Coastal Erosion and Wave Energy	25	5	15	
	Studies on Ocean Thermal Energy Conversion (OTEC)	75	20	20	200
5.	**Training**				
	Manpower Training for Ocean Research & Management (Including Short Term Training Programme)	50	36	70	
	Assistance to Universities, etc. for Post-graduate Centres	75	45	50	
	National Oceanographic Data Information System	30	10	25	
6.	**Other Expenditure**				
	Administrative Support & Infrastructure	10	1	25	100
	Exhibitions & Fairs	50	20	20	100
	Contracts with Industries for Development	—	—	10	200
7.	**International Cooperation**	25	15	20	100
	A. Total				
	B. Non-plan				
1.	Secretariat	28.90	28.65	31.66	
2.	Oceanographic Research Vessel	350.00	350.00	360.00	
3.	Fishery & Oceanographic Research Vessel (FORV)	316.00	291.00	250.00	
4.	Marine Research and Development— Assistance for Research Projects, Seminars, Symposia, etc.	60.00	30.00	40.00	
5.	Manpower Training for Ocean Research and Management	20.00	10.00	20.00	
6.	Administrative Support and Infrastructure	14.70	13.98	15.83	
	B. Total				
	Grand Total A+B				

Progressive use of Hindi

The progressive use of Hindi in day-to-day official work was encouraged. The meetings of the Official Language Implementation Committee (OLIC) of the Department were regularly held. In order to provide in-service training to the employees, a workshop was organised from 27 January to 7 February 1986. Cash prizes and certificates were given to the members of the staff who obtained positions in 'Hindi Nibandh Pratiyogita'. 64 out of 67 officers/staff in the Department have working knowledge of Hindi. A Hindi Week was also organised. A copy each of "Karyalaya Sahayika" and consolidated glossary of administrative terms were provided to each officer. Two officials were sponsored for Hindi language training and two for training in Hindi typing.

Though most of the work of the Department is scientific and technical, efforts have been made to implement the provisions of the Official Language Act, 1963, the Official Language Rules, 1976, and the instructions issued by the Department of Official Languages, Ministry of Home Affairs, from time to time regarding progressive use of Hindi for official purposes. The programme regarding progressive use of Hindi for the current year, recommended by the Department of Official Language, has been taken up for implementation as appropriate.

The Department's Annual Report, Performance Budget and the detailed demands for grants were presented in Hindi and English. All Gazette notifications were issued bilingually. Agenda Notes for the meetings of the Parliamentary Consultative Committee and answers to all Parliament questions were furnished both in Hindi and in English.

A glossary of ocean science terminology in Hindi is under finalisation in consultation with the Commission for Scientific and Technical Terminology (CSTT). More than one hundred and fifty Hindi books on various subjects were added to the library of the Department.

In February 1986, the second sub-committee of Committee of Parliament on Official Language reviewed the progress in the use of Hindi in the Department.

Publications

During the year the Scientific Report of Second Indian Expedition to Antarctica consisting of twenty two papers dealing with geology, geophysics and geomagnetism, glaciology, meteorology and radio physics was published by the Department.

Ocean Policy Statement

Annexure

The oceans are known to be our last frontiers. Our long coast and the sense of adventure of our ancients fostered a great maritime tradition. The Indian Ocean which washes our shores provides opportunities which need to be utilised. For success in ocean development, the entire nation should be permeated by the spirit of enterprise and the desire to explore the frontiers of knowledge. Our experience in other fields of scientific endeavour will help our efforts in ocean development. What is necessary is a policy and structure to facilitate a dynamic thrust, keeping in view developments in other parts of the world.

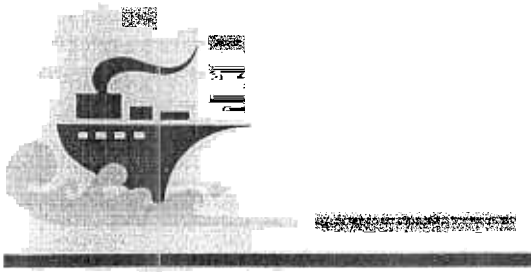
2. The adoption, by an overwhelming majority of nations of the Convention of the UN Conference on the Law of the Sea has established a new international order for the oceans. This extends the economic jurisdiction of coastal states to an area ranging from 200 to 350 miles from the coastline. According to this regime, nearly 2 million square kilometres of area, or very nearly two-thirds of the landmass has come under India's national jurisdiction. In this area, the exclusive right to utilise living and non-living resources vests with the nation. Besides, India has been recognised as a "Pioneer Investor" in ocean mining. This gives India the exclusive right to operate in an area of upto 150,000 square kilometres in the high seas for the recovery and processing of polymetallic nodules.

3. For ages, the sea has enabled our people to sail to near and distant lands and has been a source of livelihood to large numbers of people. Even now Indian public and private enterprises do use ocean resources. The country is producing significant quantities of fish and hydrocarbons from the sea and much scientific work has been done in collecting basic knowledge and information about the sea and seabed and in surveying, charting and exploiting it. Progress has also been made in construction and development of offshore structures.

4. The vastness, complexity and uncertainty of the ocean environment calls for a coordinated, centralised and highly sophisticated development response. This should be based on adequate knowledge of marine space (sea-bed, water and air columns included) as a fundamental prerequisite to the control, management and utilisation of the rich and varied natural resources available in the sea. In addition to basic knowledge to determine the potentialities inherent in the Indian sea-space, we have to develop appropriate technologies to harness these resources. A supporting infrastructure has to be built. Effective systems of management and control of the entire set up are also necessary.

5. We need to map living resources, prepare an inventory of commercially exploitable fauna and to map and assess the availability of minerals from the deep sea. The supporting infrastructure and incentives required are research vessels of different types, manpower, well-laid out programmes of resource exploitation, advanced technology and everything necessary to promote the growth of ocean technology. In the management sector, the high seas and the Exclusive Economic Zone (EEZ) upto 320 kilometres have to be looked into for the exploitation of the wealth occurring therein.

6. The main thrust should be on the optimal utilisation of living resources like fish and seaweeds, exploitation of non-living resources such as hydrocarbons and heavy placer deposits, harnessing of renewable resources of ocean energy from waves, temperature differences in the water column,



tidal heights and salinity gradients and the collection and processing of polymetallic nodules from the deep sea.

7. Marine development is linked with scientific and technological achievements in other areas. Hence while we develop basic marine science and technology, i.e. technology for marine environment, our technological advances have to be geared to the utilisation and preservation of the marine environment. The extension of national frontiers by an area of 2 million square kilometres of ocean space and the consequent access to new sources of energy, minerals and food, requires great strides in ocean engineering, specially in tasks related to structures, materials, instrumentation, submersibles and systems of propulsion of ships. The exploitation of natural food resources such as fish and seaweeds, and the generation of additional food resources by cultivation, also need scientific methods of aquaculture and mariculture. To survey and predict the ocean environment, the main tasks necessary are seafloor mapping, charting, geodesy, ocean dynamics, currents, waves, cyclones, marine fauna, chemistry and physics of the oceans and seabed mineral mapping, delineation and assessment. Research in all these areas must examine the various processes and their origins so as to have a fundamental understanding, ensuring predictive capabilities. Marine science and technology has also to look beyond the current state-of-the-art to achieve major technological break-through in the future.

8. Besides research and development in basic sciences, we should survey the deeper parts of the ocean. Similarly in the deep sea, detailed survey and sampling in the regions of EEZ and the adjacent ocean will be necessary to locate and evaluate the rich and economically viable deposits of polymetallic nodules, heavy metals, fossil placers and phosphorite deposits. The gathering of data from surveys should be coordinated and a cost-effective system of integrated surveys established.

9. Much more needs to be done for the development of indigenous technology for the exploitation of fish from deeper waters. This also means setting up of infrastructure facilities and services to operate large-sized fishing vessels.

10. An important component of the development programme should be the acquisition of technology. To be self-reliant, such technologies would have to be largely developed, tested and operated indigenously. Technologies relating to instrumentation, diving systems, position fixing and position maintenance, materials development, oceanic data collecting devices, anti-erosion capabilities, submersibles, energy and energy-saving devices are priority items. Several new technologies will have to be commercialised and made cost-effective.

11. Infrastructural support forms an essential prerequisite for ocean development. The variegated infrastructure already available in the country will have to be appropriately augmented, and more particularly in basic supporting facilities like safety and rescue at sea, navigational chains, communication net-works, development of appropriate maps and charts, etc. Infrastructural support for providing a complete and reliable information system through a net-work of data centres on marine resources, processing and marketing systems, advanced technologies and financial assistance would also be necessary. This requires a broadening and strengthening of available infrastructural facilities. Provisions of adequate ports and harbours, ship-building and ship-repair facilities will be needed in addition to adequate skilled manpower in various sectors of development.

12. Surveillance and conservation of the marine environment and its resources call for an integrated legal framework and its concomitant enforcement. Several laws have already been promulgated regarding the maritime zone, fisheries, etc. The Coast Guard Organisation looks after the enforcement aspects of several of these legislative measures. The coordinating mechanisms of the overall structure of legislation will have to be suitably strengthened under the aegis of the Department of Ocean Development.

13. In the light of this, we must have a data base to coordinate efforts made by different agencies. This is all the more necessary because of the rapid growth of information in ocean science and technology. A centralised data system will be set up by the Department of Ocean Development with a proper mechanism for collection, collation and dissemination of information acquired both indigenously and from foreign sources.

14. The creation of a self-reliant technological base puts a heavy demand on fully trained personnel. The training of skilled manpower is to be adequately planned. Young scientists, technologists and engineers will be encouraged to participate in the programme of ocean development and steps will be taken to induce Indian scientists from within the country and abroad to participate in it.

15. Existing agencies will have to be appropriately strengthened to meet the demands of this growing challenge. The Department of Ocean Development will function in conjunction with other concerned agencies as a focal point to promote institutional capability in areas where significant work is lacking. The complex programme that ocean development entails will require well-designed management and institutional extension of the Department of Ocean Development with sufficient powers vis-a-vis other agencies to help proper and speedy ocean development, which enables India to be in the forefront of the international effort. This would also mean close cooperation with both developing and developed countries in a spirit of understanding of the concept that the oceans are a common heritage of humankind.