1. Introduction

Being one of the leading maritime countries, India has a deep interest in oceans and ocean related activities. This interest has acquired new dimensions with the knowledge gained about the influence the ocean has on the landmass and its potential for providing rich resources for the benefit of mankind. Recognising this status, the Government of India established the Department of Ocean Development through a notification on 27th July, 1981 with a mandate to formulate and implement programmes in ocean science and technology with long term scientific, technological, economic and geo-political benefits, like the Antarctic programme and the Polymetallic Nodule Programme; to formulate and co-ordinate scientific and technological projects for exploration and exploitation of marine living and non-living resources; and protection, preservation and conservation of its environment.

The programmes of the Department were formulated based on the 1982 Ocean Policy Statement of the Government, the Allocation of Business Rules and activities specifically assigned by the Government. Some of the salient features of the Ocean Policy Statement are:

- Exploratory survey, assessment and sustainable utilisation/harnessing of the ocean resources including living, non-living and renewable sources of ocean energy.
- Technological advances geared to the utilisation and preservation of the marine environment.
- Development of technology relating to instrumentation, diving systems, position fixing, materials development, oceanic data collecting devices, submersibles, etc.
- Developmental activities related to integrated coastal and marine area management, coastal community development, etc., with direct application to the welfare of the society.
- Establishment of an ocean related information system using indigenous and foreign sources.
- International cooperation in Ocean Science & Technology.
- Development of technologies relating to seabed mining, extractive metallurgy and conducting Environmental Impact Assessment studies.
- Contribution towards front ranking research in Polar Sciences.
- Basic and applied research in Ocean Science & Technology, Human Resource Management, creating Centres of Excellence in academic institutions and public awareness on the potential and uses of ocean.

The Department is mandated to formulate and implement programmes with long term economic and technological implications, to act as a nodal agency for technology development in areas relevant to the economic and social development of coastal population and to act as an agency to formulate and coordinate scientific and technological projects for exploration of living, non-living and energy resources of the sea and protection and preservation of its environment.

Consequent to the coming into force of the UN Convention on the Law of the Sea (UNCLOS) in 1994, which provides extended area of national jurisdiction in sea and increased base for exploration of non-living resources in the Exclusive Economic Zone (EEZ) and Continental Shelf and UN Conference on Environment and Development (UNCED) of 1992 with integrated approach towards environment and development and coastal zone development and management, the Department has augmented and oriented its activities towards exploration and exploitation of marine living and non-living resources for the socio-economic benefits and protection of the marine environment.

One of the important limitations the Department has felt during the implementation of priority programmes was the lack of institutional infrastructure directly under its control. The Ocean Policy Statement envisages that the complex programmes of ocean development entail well-designated management and institutional extension of the Department of Ocean Development with sufficient powers vis-à-vis other agencies to help proper and speedy developments in ocean sector, which will enable India to be in the forefront of the international effort.

With the ratification of the UN Convention on Law of the Sea, a new international order has been established for the oceans. India has to build an integrated approach for scientific planning, formulation, implementation

and overall management of the programmes with a comprehensive organisational and institutional back up. Therefore, the activities of the Department address:

- Scientific Research & Technology Development with orientation towards applications;
- Obligations and provisions arising out of international conventions, treaties, bilateral and multi-lateral cooperative ventures;
- Capacity Building and Human Resource Development for self-reliance.

The thrust areas pursued by the Department inter-alia include - contribution towards front ranking research in polar sciences; development of technologies relating to seabed mining, extractive metallurgy, exploration of gas hydrates, the marine living resources and sustainable exploitation and utilization of these resources; developmental activities related to integrated coastal zone and marine area management; establishing a cost-effective, reliable and user-friendly ocean observation system and disseminating on-time ocean information and advisory services to all users, capacity building in Ocean Science and Technology, etc.

The 9th Five Year Plan (1997-2002) envisaged implementation of programmes in line with the Ocean Policy Statement and strengthening the institutional infrastructure of the Department. As our technology advanced, the relentless quest towards the resources of the ocean assumed greater importance. The programmes pursued by the Department over the years, therefore, have kept pace with developments world over and addressed national needs and issues. During the 9th Five Year Plan period (1997-2002), the programmes of the Department were reoriented and re-structured to cover a wide spectrum of activities in the ocean sector for development and dissemination of sustainable technologies for the benefit of the society, involving a plan outlay of Rs.510.62 crore, as detailed below:

- Polar (Antarctic) Science
- Marine Living Resources
- Marine Non-living Resources
- Marine and Coastal Area Management
- Ocean Observation & Information Services
- Marine Research and Capacity Building
- Coastal Community Programmes
- Ocean Awareness, and
- International Cooperation.

The Vision statement highlighting the Perspective Plan 2015 of the Department enunciated in 2002 aims at "improving our understanding of the Ocean, specifically the Indian Ocean, for sustainable development of ocean resources, improving livelihood, and timely warnings of coastal hazards, that will make India an exemplary steward of her people and ocean".

The Planning Commission has allocated an outlay of Rs. 1125.00 crore for the Tenth Five Year Plan (2002-07) for Ocean Development, keeping in view the futuristic role of DOD in exploration, conservation, development and judicious/sustainable exploitation of the Marine Living and Non-living Resources, Polar Science, Ocean Observation and Information Services, Ocean Engineering and Technology Development, Marine & Coastal Zone Management, Marine Research & Capacity Building, International Cooperation, etc., for the benefit of the society and local community and to meet the needs of Global Change.

During the 10th Plan Period, the efforts of the Department are focused on development of sustainable technology for exploration and utilisation of various living resources; non-living resources like minerals from sea bed; ocean energy, gas hydrates, etc., besides addressing major geo-political issues and issues of national and global relevance.

In line with the Vision statement declared by the Department, a number of new initiatives have been introduced, during the 10th Five Year Plan period, which inter-alia include Gas Hydrate exploration and technology development for exploitation, Comprehensive Swath Bathymetric Survey of Indian EEZ, Geophysical study of

Lakshmi Basin, design and construction of new vessels to serve as an offshore platform for technology development, etc.

Cutting edge science, optimum infrastructure and incubators for novel instrumentation and technology will be the foci for the Department, because it is only through the balance of intriguing science queries and advanced technology, that India will be in a position to initiate and receive cooperation in oceanographic programmes of global significance. The technology will produce new generations of submersibles, autonomous underwater vehicles, floats and buoys. Innovative human resource development programmes will form the core of the Department's strategy and this aspect will be pursued at different fora. Science and technology issues in the ocean sector demand a wide spectrum of skills. Management of so diverse a sector means that no one governmental agency could have the necessary authority, human and financial resources, or experience to act in a proactive manner.

The Department will work to blur the compartments between science, observations and technology so that a vital organic ensemble emerges where these three facets will continuously interact to their mutual benefit.

This Report gives in detail the major projects/programmes implemented by the Department and their accomplishments during 2003-04.

2. Polar Science

2.1 Scientific and logistic accomplishments of XXII Expedition

Scientific accomplishments

Atmospheric Sciences

Observations on total ozone, SO_2, NO_2 and UVB were carried out using the Brewer Spectrophotometer. Measurement of carbon dioxide, methane, integrated ozone, water vapour and aerosol optical depth was done in continuation of the experiments initiated during the previous expedition. Studies on the ongoing storm-substorm relationship, monitoring of the Total Magnetic Field at Maitri using a Proton Precession Magnetometer, collection of data on Cosmic Radio Noise Absorption using a 30 MHz Riometer, measurement of the atmospheric electrical parameters in connection with the Global electric circuit, which will be used to differentiate atmospheric, ionospheric and magnetospheric signatures, were carried out by India Meteorological Department (IMD), National Physical Laboratory (NPL), Indian Institute of Geomagnetism (IIG), etc. 21 GPS platforms were set up by IIG group to monitor the movement of polar glacier. Space Science Laboratory, Barkatullah University continued its studies on very low frequency (VLF) seismo-electromagnetic signals and a borehole study at 50 metre depth. Studies on the Total Electron Content (TEC) were also carried out with the help of IIG group through GPS receivers.

A team of five Indian scientists observed the total Solar Eclipse in Antarctica on 23rd November 2003 from a strategically selected site on a high plateau about 25 km off Maitri. The Eclipse was unique in many-a-ways, being perhaps the first total solar eclipse to be observed by a large scientific community and tourists. The eclipse produced a splendid and spectacular display of some Bailey's Beads, crimson and beautiful

GPS platform for monitoring movement of polar glacier

Air quality monitoring near Maitri

Diamond Ring, and a corona in its full golden glory with extended streamers. In addition, it resulted in generation of extensive shadow-bands, which are easily the rarest and of longest durations running into minutes.

Digital photography of the entire eclipse was done by the team and other scientists at Maitri to capture various phases of the eclipse. The experiments conducted by the Indian team were highly successful in recording valuable digital data on all aspects such as diamond rings, extended coronal streamers, long duration shadow band activity, monitoring of atmospheric aerosols, etc., using state-of-the-art instruments.

Telescope - 'Heliostat' established at Antarctica near Maitri - for observing Solar Eclipse

First Diamond Ring stage just before total solar eclipse as observed in Antarctica

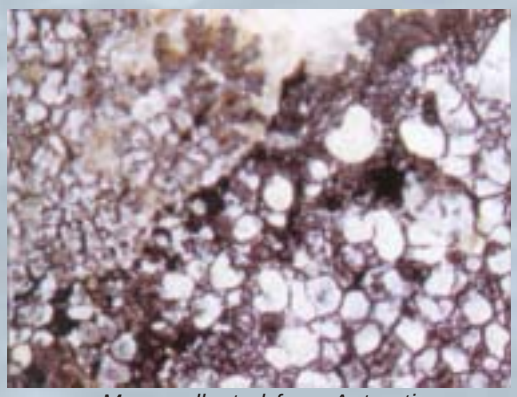
Biology and Environmental Sciences

Exploration of faunal diversity and ecology of moss, algae and lichen from Schirmacher Oasis of East Antarctica and Ultra structural studies of hair of mammals were carried out by Zoological Survey of India (ZSI). Apart from this, soil samples and moss turf were collected from different locations and some of them have been extracted with the Tullgren Funnel in the field. To study the trace elemental analysis of feathers, feathers of snow Petrel, Penguin and South polar Skua were collected. The behaviour of Skua along with chick was videographed. Fifteen species of birds and three species of mammals were recorded.

National Botanical Research Institute (NBRI) undertook a study on lichens in and around Schirmacher Oasis. About 300 lichen specimens were collected. The lichen species *Umbilicaria decusata* collected from Vettiyya and near the generator complex were used to test the heavy metals and gaseous pollutants in the generator emission. Moss collection was also done for studying trapped modern pollen spore.

Monitoring and analysis of the source of drinking water for the inmates of Maitri and the performance evaluation of wastewater treatment plant were carried out by Veer Mata Jijabi Technological Institute.

An Antarctic Bird



Moss collected from Antarctica

Earth Sciences, Glaciology & Global Change

Geological Survey of India (GSI) continued the mapping programme of Antarctic rocks, primarily composed of charnockite-granite-gness terrain. The area of 1000 sq. km. have been covered in the Muhlig-Hofmann mountains, East Antarctica between latitude 71° 45' and 72° 10' S and longitudes 6° 00' and 6° 30' E to complete the gaps. This area is composed of three igneous suits viz., pink granite, gray granite and igneous charnockite which occur intermingled although charnockites dominate the northern area.

Mapping of Antarctic Rocks

The GSI team carried forward their glaciological work, which indicated the retreat of snout at all the points. With reference to February 1996, the overall average rate of retreat is 4.76 metre. These observations indicate that the polar ice margin is retreating not only at the snout of the Dakshin Gangotri glacier, but all along the Schirmacher range. Monitoring of ice shelf installed away from the earlier site was carried out through a network of stakes. This study would help in accumulation/ablation studies and also in finding out the direction and velocity of the movement of stakes.

Ice cores obtained for palaeoclimatic studies

Iceberg monitoring during the Antarctic expedition was carried out. A total of 131 icebergs were recorded till the Antarctic coast. Last iceberg recorded was at 53° 19' S latitude and 15° 08' E longitude.

Ice coring for palaeoclimatic studies was carried out by the GSI group with overall coordination of NCAOR. A total of 222 metre of ice core has been brought to NCAOR from Antarctica for isotope and Thermoluminiscence (TL) studies.

Geomorphological features which included Felsenmeer, Ice scoured plains, U-shaped valleys, hanging valleys, Roche Mountonnes, Outwash plains, Glacial terraces, recessional morainic flats, polished surfaces, glacial striations and grooves, erratics, morainal ridges, debris cones, ice-cored moraines, kettle lakes and patterned ground, were recorded by GSI under the geomorphological studies. Ten sediment samples from recessional moraines, terraces of lake, lake bottom and pebble horizon have been collected for carrying out TL dating. This would be of immense help in quantifying the rate of recession of polar ice. A portable sediment corer was used to core lake sediments and cores of 35 and 50 cm were successfully recovered. Also water samples from lakes were collected to understand the hydrochemical characteristics.

Studies were initiated on the ice dynamics to monitor the velocity of movement of continental ice, in collaboration with IIG by setting up permanent wooden markers and their locations marked by Trimble GPS system.

National Geophysical Research Institute (NGRI) has two major goals at Antarctica, the Teleseismic study and a permanent GPS Tracking station at Maitri. About 400 teleseismic and local earthquakes were recorded.

Survey of India carried out Topographical mapping for preparing a large-scale map during the expedition. Contour survey at 5 metre intervals on scale 1:500 covering an area of 2.5 sq. km. was carried out by original Plane Tabling Method.

Central Water and Power Research Station (CWPRS) has taken approximately 2500 metre long GPR profiles in all the directions of ice core drilling site near Tallaksenvarden nunatek using RAMAC Ground Penetrating Radar (GPR). The ice and firm interface has been mapped very efficiently. Depending upon the required resolution and depth of investigation, three different frequencies of radio waves, 250 MHz, 800 MHz and 1 GHz have been used. Mainly GPR work was of two types; (i) locating buried vehicle hanger at Dakshin Gangotri and the on-site reporting of the location of entrance shaft, and (ii) studies over thin ice cover zones. The results obtained through this high-resolution radar have revealed the internal layers of the ice structure. A crevasse was also mapped up to a depth of 30 metre at the northern side of the nunatek. Three frozen lakes (L48, L53 and L54) and their associated glaciers have been studied. GPR profiles effectively measure the thickness of the top ice layers and saturated boulder beds of these areas.

Snow and Avalanche Study Establishment (SASE) concentrated on three major areas namely microstructural studies of different snow and ice media, study of crack propagation on ice sheet using GPS and satellite imagery and energy budget model based on albedo, glaciological and meteorological parameters of Antarctic ice sheet through ground based observations, automatic weather station data and satellite imagery.

Department of Physics, J.E.S College, Jalna set up the C-Band Microwave Bench for measurement of dielectric properties of Antarctic geophysical materials like ice, soil and water.

Engineering & Communication

Defence Electronics Application Laboratory (DEAL) took charge of the all important logistic task of connecting people between Antarctica and their Indian counterparts back home.

Logistic accomplishments

The following operations, maintenance and repairs were carried out during the summer and winter period of XXII Indian Antarctic Expedition.

- Up-keep of Maitri Station.
- Maintenance of Generators and power supply system.
- Central Heating System.
- Water Supply System.
- Waste water treatment and disposal.
- Deep freezers.
- Wood works.
- Fuel decanting, storage and supply.
- Convoy operation and maintenance of fire extinguishers.
- Establishment of field camps and support.
- Environmental tasks in compliance with the Environment Protocol requirements.
- Support to conduct the scientific activities of the expedition.

Field Camp for scientific experiments

2.2 Launching of 23rd Indian Antarctic Expedition (IAE)

The XXIII Indian Scientific Expedition to Antarctica with 55 members drawn from 17 institutions comprising 30 member summer team and 25 member winter team was formally launched from Goa on 12th December 2003 for onward voyage to Antarctica from Cape Town, S. Africa on board the vessel "MV Emerald Sea". Out of these 55 members 38 were scientists including doctors and 17 logistic personnel. M/S New Zealand Helicopters Pvt. Ltd. provided the Air support.

Invited scientific proposals in the contemporary and thrust areas of polar science for 23rd IAE were presented in a workshop titled "Research Programmes of Indian Antarctic Expeditions: Retrospect & Prospects". Thirteen scientific institutions as recommended by the National Committee on Antarctic Programme carried out various scientific studies in Antarctica. In addition to the ongoing projects, two new experiments in different domains

of polar science were also inducted. Seven of these experiments directly contributed to the international scientific campaigns under the aegis of Scientific Committee on Antarctic Research (SCAR).

A special aerial survey to identify an ideal site for carrying out scientific activities in future was also conducted, for which a special team of Scientists/Engineers was deputed along with the 23rd IAE.

2.3 Scientific and logistic objectives/accomplishments of 23rd Indian Antarctic Expedition

Meteorology and Atmospheric Sciences

Surface observations for weather parameters like wind speed, wind direction, visibility, air temperature, atmospheric pressure and clouds were made by IMD at three hourly interval and six hourly observations of main synoptic hours and transmitted to IMD, New Delhi. IMD also provided weather forecast services for fieldwork parties and helicopter sorties and the meteorological data to all summer team members and their institutions for their expedition work. Three ozonesonde ascents were carried out for vertical profile of ozone and one radiometer sonde ascent was attempted. The installation for diffused solar radiation stand in concrete foundation along with pyranometer, shading ring assembly in observatory enclosure and the installation of its pyranograph in IMD Lab was completed and recording was initiated.

Measurement of green house gases

Data on green house gases using Gas Chromatograph were collected on a regular basis by NPL for CO_2 and CH_4. Data for Methane and CO_2 have been found to be in good agreement. Surface concentration of Atmospheric Methane (CH_4) was found to be in the range of 1.69 to 1.72 ppm. Water vapor concentration was found to be in the range of 0.3 to 1.2 cm. The monthly mean total column ozone was found to be around 298 DU. Sun-Photometer - MICROTOP incorporating five channels to maneuver the solar radiation at 300, 305, 312, 940 and 1020 nm was set up to estimate the ozone on all clear sunny days on hourly basis. The first three channels were adapted for ozone computation while other two for water vapor and aerosol optical depth.

Geomagnetic Studies

The Proton Precession Magnetometer (PPM) recording of total magnetic field intensity has indicated a drop of about 120 nT per year (as of 2002), as compared to global average drop of 30 nT per year. An earlier study of high-latitude stations in the northern and southern hemispheres has shown that this decline is confined to a narrow horseshoe shaped belt in Antarctica, encompassing Maitri. The rate of decline falls in the pole-ward and equator-ward directions.

A Digital Fluxgate Magnetometer (DFM) was proposed to be installed as unmanned Magnetic observatory in Wohlthat Mountains but in the absence of a Portacabin, at this point of time, this is being installed at Dakshin Gangotri and operated throughout winter. A chain of unmanned magnetic observatories is being set up to study and monitor the movement of small-scale auroral current systems. Riometer and Magnetometer data have been collected in analog and digital mode on a continuous basis.

Nineteen existing GPS stations set up during 2003 were reoccupied during this summer and data collected from each station for a period of 72 hours to study crustal movement. New markers were fixed for 21 GPS stations set up on the polar glacier and data collected for 48 hours at 15 locations. One GPS was operated permanently at Maitri to provide the baseline data. The data will be used for TEC, scintillation and water vapor content and other atmospheric studies. Indian Institute of Geomagnetism is carrying out these studies.

Earth Sciences, Glaciology and Global Change

The first ever reference gravity station at Indian Antarctic base in Maitri, was successfully established by the National Geophysical Research Institute (NGRI) and precise Absolute Gravity Measurements (AGM) for deformation studies were completed. Fourteen days of nearly uninterrupted measurements of Absolute Gravity were made except during a 2-day blizzard. The most crucial requirement of maintaining a temperature within the range of 15^0 to 25^0 Celsius was achieved by installing auto-cut-off heater, during these measurements. Gravity observations made earlier were connected with AGM reference point and reoccupied five GPS stations of Survey of India by digital relative Gravimeter. Continuous magnetic observations were also made for 20 days and a magnetic traverse across litho units in Schirmacher area was carried out.

Bathymetry and physical oceanography

National Hydrographic Department collected bathymetric and physical oceanographic data (sound velocity, sea temperature profile and water conductivity) on board MV Emerald Sea using Acoustic Current Meter and CTD probe. A total of 250 nautical miles of oceanographic survey was completed. Geodetic and meteorological observations were also undertaken during this period. A total of 22 CTD probe casts - 15 in ocean and 7 in lakes - both at India Bay, Priyadarshini Lake in Maitri and during task force voyage to Vestford and Larsemann Hill areas were carried out to measure salinity, depth and conductivity of lakes.

GPS observations

Survey of India identified fourteen sites in the planned area of Schirmacher Oasis. Concrete pillars of one cubic foot with brass plug were erected as a monument in all the places. GPS observations were made at all the points with respect to the base station Maitri-S. GPS data will be analyzed in the head quarters at Dehra Dun.

Geological and glaciological studies

The GSI team carried out studies pertaining to geological, glaciological and associated work in Gruber Mountains and Schirmacher oasis.

Geological mapping of Gruber anorthosite complex revealed an outer rim of plagioclase megacryst-bearing noritic anorthosite to norite and a core occupied by medium to coarse-grained leucocratic anorthosite with accessory orthopyroxene and ilmenite. The rim portion shows rare metric-scale ilmenite-rich layers. The megacrystic noritic anorthosite is usually foliated, trending broadly E-W with steep southerly dips in the northern rim area of the complex. Foliation is defined by stretched and aligned plagioclase megacrysts with mafics and feldspar, forming anastomosing fabric around the megacrysts. The western contact of the anorthosite with the N-S trending foliated charnockitic rocks was observed in an area close to the Peterman range. From the presence of rafts and enclaves of megacrystic noritic anorthosite within the leucocratic anorthosite, the latter has been inferred to intrude the megacrystic noritic anorthosite. A 500m long basaltic dyke and several lamprophyre dykes were mapped and sampled in the western part of the Gruber Mountains. Several discrete mylonites, both layer-parallel and also trending at high angles to the foliation in the noritic anorthosite was observed. The rocks are intensely jointed in two major directions, broadly trending N-S and E-W with sub-vertical dips. Sub-horizontal sheet joints were also observed at several places. Selective weathering in the glaciated terrain along joints has accentuated the alpine topography resulting in a jagged and highly rugged relief of the Gruber Mountains. During mapping 62 rock samples were collected for patrological, geo-chemical and geo-chronological studies.

Geological work in Schirmacher Oasis was mainly centered around the post-tectonic lamprophyre and basaltic dykes. The lamprophyre dykes include biotite and amphibole-phenocryst bearing aphinitic rocks and alkaline lamprophyres. The biotite phenocryst-bearing lamprophyres have an E-W trend whereas the basaltic dykes generally trend N-S. A total of 40 samples were collected to study the patrological, geo-chemical, geo-chronological and palaeomagnetic aspects. This integrated approach will be useful in determining palaeo-latitudes for regional correlation. A notable feature has been the occurrence of white powdery encrustations of 'marbilite' on various rocks. Eight samples have been collected to study its geochemistry that may indicate role of wind-blown seawater evaporated salts vis-à-vis salinity of lake water in Schirmacher area.

Iceberg monitoring was continued onboard the ship MV Emerald Sea during the onward journey in December 2003. The first iceberg was sighted at Latitude 44° 47' S and Longitude 17° 51' E. A total of 193 icebergs of various shapes (weathered, tilted and tabular) were recorded between latitudes 44° 47' and 69°29' S. The polar ice front -monitoring was continued during the present austral summer in the DG snout area and in its western continuity using earlier reference points. Out of 13 points, 11 recorded an annual retreat (base Feb. 2003) ranging from 0.38 m to 14 m. At two locations an advance of 0.57 m and 5.27 m was observed. In the DG snout area 15 points were monitored which revealed annual average retreat of 3.51 m with a range between 0.87 m (point 13) and 10.19 m (point 5). Snow accumulation studies in Dakshin Gangotri were initiated in March 2004.

Lake sediment and water samples for geo-chemical assessment were collected from 33 proglacial, land locked and epishelf lakes in continuation of the ongoing programme. Various parameters such as temperature, pH and TDS were recorded using portable pH and TDS meters. A core sample of about 50 cm was obtained from Priyadarshini Lake for sedimentological studies.

GPS surveys were carried out in collaboration with Indian Institute of Geomagnetism (IIG) in the Schirmacher and adjoining nunataks. A total of 14 marker points on continental ice sheet and its northern front were monitored using high precision GPS measurements for deciphering movement of ice sheet. In addition 19 more GPS points in surrounding nunataks were recorded for assessing regional crustal deformation in this part of the Antarctic Shield.

Four terrace sediment samples were collected from Priyadarshini Lake area for Thermoluminiscence (TL) dating, representing clay-rich layers sandwiched between glacier boulder horizons at 116 m and 109 m datum levels ASL to estimate rate of deglaciation since the last glacial maxima.

Biology and Environmental Sciences

National Center for Antarctic and Ocean Research (NCAOR) carried out environmental monitoring and waste management of Maitri, Antarctica. Following objectives were identified for the study by the summer team of the 23rd expedition.

- To enhance the present environment laboratory with modern analytical tools and infrastructure facility
- Efficacy improvisation of wastewater treatment system and its management
- Environmental monitoring of Air, Water, Wastewater and Soil

EIA Lab in Maitri

Environmental Impact Assessment Laboratory: An environmental monitoring laboratory was set-up during the XIX expedition, with a few basic instruments for analysis of physico-chemical parameters of water and wastewater. The facilities were expanded and located in the Green House of Maitri. At present the laboratory is equipped with the analytical tool to carryout the basic water, wastewater and air quality analysis. Following instruments viz. Distilled Water Unit; COD analysis unit; Nitrogen distillation unit; B.O.D. Incubator; Auto Temperature Controlled Oven; Muffle furnace; Hot Plate; Turbidity Meter; Conductivity Meter; pH Meter; Spectrophotometer; and Analytical Balance have been calibrated and placed in proper working condition in the lab. This EIA laboratory was formally inaugurated on January 26,2004.

Environmental Monitoring: Ambient Air Quality Monitoring is carried out at five places (Upwind Direction, near Summer toilet, near Aaditya generator, near Maitri toilet and near Incinerator) around Maitri for Suspended Particulate Matter on the basis of 24 hour sampling and monitoring carried out at all the places for 5 days. Stack sampling was carried out for the stacks of Summer toilet, Maitri toilet, Boiler, Generator and Incinerator, for Suspended Particulate Matter.

Water and Waste Water Sampling and Analysis: Drinking water samples were collected from various points of Priyadarshini lake and Glacial lake and analysis was carried out for basic physico-chemical parameters. Wastewater samples are collected from both the effluent treatment units and analysis was carried out for the basic physicochemical parameters.

Efficacy Improvization: The present water treatment system was assessed to take necessary action for improvising the water treatment efficacy.

Waste Management: Seawater samples were collected to carryout the dilution dispersion study of the treated effluent with the help of CTD and flow meter. Oil spill area was studied to prepare proper waste management plan for Maitri station.

Botanical Survey of India collected algal samples from lakes (landlocked lakes, proglacial lakes and epishelf lakes), surrounding areas of moss carpet and melt water streams of Schirmacher Oasis. The collected algal samples were studied under microscope and preserved in 4% formalin for further study. While collecting the algal samples, the water temperature, pH, conductivity and IIS, apart from their precise location (by GPS) and altitude of collection points were also measured. Samples were also collected from nunataks and extreme western part of the Schirmacher Oasis.

Four lake sediment cores have been collected from Priyadarshini lake, by NCAOR. Out of these, one core was collected manually and three cores with the support of helicopter. The collection of core samples with the help of helicopter was successfully attempted for the first time, as a new method, in the history of coring. One core sample has been preserved in formalin for the study of morphotaxonomy, and three cores in -20°c for evolutionary studies. The biota of these core samples may also throw light on the Palaeoecology, paleoenvironment and pulsatary glaciation of the ancient past. For study of Ecology & Biodiversity of Schirmacher Oasis and nearby Nunataks; 54-Samples of Algae, 120 samples of Mosses and 750 samples of Lichens have been collected from different habitats. The latitude & longitudes of habitats; Temperature, pH, and conductivity of water were noted Thirty five water samples have been collected from different lakes of Oasis & Nunatak for laboratory analysis. For insights on soil biodiversity from extreme environments, 100 samples of soil have been collected from Oasis & Nunatak. Fifty different varieties of rock samples have been collected form Oasis & Nunatak for NCAOR museum. Twenty pairs of wings and bones of snow petrels have been collected for the study of fungus.

Engineering and Communication

A HF CODAN Adaptive Transceiver was installed by Defence Electronics Application Laboratory for voice and data communication in the radio room of Maitri Station and to maintain good HF voice communication links with MV Emerald Sea and DEAL, Dehradun. An antenna DOME (ADE) of Inmarsat-M terminal was installed on the rooftop of Maitri station and MCU with all accessories (BDE) in Radio room. Testing of ADE and BDE was carried out by installing Nera initialization software and by initiating telephone and fax calls with the help of existing Inmarsat system through ARVI LES (VSNL) and found the system functional. The 9102 HF Data Modem of CODAN HF Adaptive Transceiver handles dialogue and sending of messages and binary files. It is a high speed DSP modem with a signaling rate of 2,400 bits per second. All types of calls like selective, group and broadcast to and from DEAL, Dehradun were sent and received.

The programme of work on 'Review of Liquid Effluent Management System at Maitri' was completed as per schedule by Engineers India Limited (EIL). With the help of SOI, the GPS (Global Positioning System) data for various environmental components like effluent pond, disposal point, raw water lake bank nearest to pond, water intake (pump house) point, and Control Lake, were collected and maintained as Maitri database.

The programme of work related to assessment of structural strength of Maitri Building was completed as per objectives by EIL. Collection, validation and compilation of all available data on Maitri station structure have been carried out. Detailed visual inspection of various structural components of the stilt of Maitri building; physical measurement of structural components of the stilt and superstructure; grid marking and preparation of working sketches in AutoCAD; visual inspection of the composition of wall, floor and roof panels of Main Block, A Block, B Block and C Block; inspection of base connection under columns by removal of the back-filled earth up to founding level; study of damages found in structural columns along grid by removal of the back-filled earth below existing ground level; and detailed inspection of floor panel in the main block passage area after removal of the false flooring, were completed.

The Structural Engineering Research Institute conducted a thorough assessment of the structure and status of Maitri station using various techniques for taking action as appropriate for strengthening and protecting the station from the hostile weather/climatic conditions prevailing in Antarctica.

Human Physiology and Medicine

The programme of work on "The Effect of certain established ayurvedic drugs (Rasayana) as food supplements on aging process in cold climatic conditions of Antarctica" has been completed by the Central Council for Research in Ayurveda and Siddha (CCRAS). For this project, 21 subjects among the team members of 23rd IAE were registered, out of which 13 continued the regimen for the stipulated period of 6 weeks. Various parameters

like lean body mass index, MAC (mid arm circumference), Blood pressure, Pulse rate, etc., were taken before starting the study and repeated at fortnightly intervals. Parameters under visual analog scale (VAS) like dizzy spells / giddiness, breathlessness on exertion, constipation, urgency to micturate, aching muscles and joints, lumbago or shoulder pain, numbness, tremors, sleep abnormalities, loss of appetite and irritability were also observed. Besides this, the blood samples were collected and analyzed for routine pathology and chemistry of the serum to evaluate the effect of the regimen on liver and kidney functions, enzymes, immuno-globulins and free radicals.

The bio-waste generated during the process of analysis was collected in waste cans, sealed and sent as back load for proper disposal.

Defence Institute of Physiology and Medicine collected baseline readings for various parameters namely blood pressure for 48 hours at every 2 hours interval, hand grip strength for 48 hours at every 2 hours interval, monitoring of heart rate for 24 hours, estimation of energy expenditure while normal walking, etc. The subjects were so selected that their data could also be obtained while returning from Antarctica, thus the selection was made from among the summer team. The second phase of experiments were repeated after spending about 20 days at the Maitri station so as to provide time for the body to make adjustments, to suit the Antarctic environment. Estimation of energy expenditure was done simultaneously with measurement of Physical Fitness Index (PFI).

Logistics Support

The layout of the Medical Store in the loft area in the MI Room, Maitri hospital was totally revamped. All equipment for use in the Operation Theatre was shifted to the A Block OT complex. Old expired medicines were removed from the store and shifted to a container for back loading. The remaining medicines were laid out group-wise. Medicines of common use were shifted to the MI Room and displayed category-wise for ease in dispensing. A new Ultrasonography machine, which was brought along with the XXIII IAE, was set up in the Maitri hospital and was made fully functional. This equipment can prove to be a very useful diagnostic tool. However, doctors selected for the Antarctica expeditions need to be given basic training in using this equipment and interpretation of the same. A semi Auto-Analyser was also made functional and is now being utilized for carrying out investigations.

New Scientific Experiments in the XXIII IAE

- Evaluation of effect of certain Ayurvedic food supplements in cold climatic conditions - CCRAS
- Environmental monitoring, efficacy improvisation of wastewater treatment system and lab set up at Maitri-Antarctica - NCAOR

Scientific Experiments in the XXIII IAE with International Linkages

- Teleseismic studies of Antarctic continent by NGRI. (International program on Antarctic Seismic Networking of SCAR).
- Monitoring of icebergs by GSI (International ship observations of Antarctic icebergs coordinated by Norwegian Polar Institute).
- Planetary Geodetic studies by NGRI (Geodetic Infrastructure in Antarctica [GIANT] of SCAR).
- Measurement of geomagnetic field currents in Antarctica by IIG (Antarctic Geomagnetic Networking [AGONET] of SCAR).
- Climatological database generation by IMD (Contributing to Antarctic weather forecasting by WMO).

The summer Team of 23rd Indian Antarctic Expedition (IAE) and Winter Team of 22nd IAE expedition returned to India on 4th April 2004, after successfully accomplishing the scientific and logistic objectives assigned to them.

2.4 Southern Ocean Expedition

NCAOR initiated way back in September 2001, a Pilot Cruise to Southern Ocean utilizing the services of the research vessel ORV Sagar Kanya aimed at studying the Southern Ocean up to 55°S latitude.

The Southern Ocean represents 10% of the world oceans and comprises several physically and biologically distinct regimes, latitudinally separated by fronts. This region is characterized by high production of nutrients and low chlorophyll (HNLC) zone. There is low utilization of these nutrient rich waters and therefore, needs further studies. Further, this is also the region of major wind stress and in turn the mixed layer gets deepened specially during the winter. Lastly, the waters of the Southern Ocean directly or indirectly affect the Indian Ocean and thereby the Indian climatic regime. Therefore, a Pilot Expedition to Southern Ocean (PESO) was undertaken on board ORV Sagar Kanya during 23.1.2004 to 4.3.2004 up to 56° S (Sub-Polar regions) for the first ever survey in the region. During the survey, multidisciplinary data collection was carried out by the participants from NCAOR, NIO, CMLRE, SPL, IISc, SAC, IITM and IMD, the results of which are summarised and presented below.

Atmospheric Observations:

Aerosol Black Carbon

The black carbon (BC) affects the climate by absorbing solar energy that in turn heats up the atmosphere. Continuous measurements of BC mass concentration were made onboard using an Aethalometer. From the preliminary assessment of measurements, it is clear that the BC mass concentration over Southern Ocean is very low compared to tropical oceanic regions. This is due to the pristine nature of the air mass prevailing over Southern Ocean. Because of the anthropogenic nature of the origin of BC, even the low BC concentration observed is surprising, and can be due to long-range transport.

Aerosol Optical Depth (AOD)

Optical depth is a measure of the transmittance of a vertical atmospheric column of unit cross-sectional area. Aerosol optical depth (AOD) is a very important parameter controlling the aerosol radioactive forcing. The spectral AOD measurements were made onboard using a hand held Microtops sun photometer at wavelengths 380, 500, 675 and 870 nm. The instrument manually aimed at the Sun, makes measurements of the direct solar irradiance and derives AOD based on its calibration, and the observation co-ordinates and time as recorded using a GPS receiver attached to it.

Automatic Weather Station & Radiosonde

Various meteorological parameters over Southern Ocean like air temperature, pressure, relative humidity, rainfall, solar radiation, wind speed and wind direction were continuously measured using Automatic Weather Station and Radiosondes, respectively and stored at one-minute average interval.

Upper atmospheric parameters were measured using high precision Vaisala GPS Radiosondes. Radiosondes measured parameters like air temperature, relative humidity, pressure, wind speed and wind direction. As proposed, 13 Radiosondes were launched at every 2.5° S latitude.

Physical Oceanographic Observations

These observations are aimed at understanding the Temperature - salinity (T-S) structures, morphology of circumpolar fronts, circulation regimes in the water column and air-sea interaction processes pertaining to the Indian Ocean sector of the Southern Ocean. For this purpose, CTD (38 stations) and XBT systems (78 locations) were used onboard. Apart from obtaining the T-S profiles, a hull-mounted ADCP was operated along the ship's track in the study area. A ship-borne wave recorder was operated at CTD stations to record the wave data for 15 minutes period. The preliminary results of CTD data analysis indicate the presence of different water mass regimes in the study area. It is clearly seen that the Sub-Tropical Front (STF) around 41°S separates the high saline sub-tropical waters of the north from the freshwaters of the sub-Antarctic region. Further, the low-salinity surface waters sink around 47°S latitude to intermediate depths of about 1200 m and then spread northward along 27.0 potential density surface. Lowest bottom temperatures below 0° C are found at Station No. 34 in the South Indian Basin.

Chemical Oceanography

Dissolved Oxygen

CTD operation in Southern Ocean

Seawater samples were collected for analysis of DO in 32 stations from surface to near bottom extending up to ~ 4000 m water depth. The preliminary results of analysis indicated the concentrations of DO in the surface layer to range from ~180 to 360 µM. There was a significant increase in the DO concentrations in the surface layer between station 19 and 20 (41º S and 42º S latitudes) suggesting a boundary between two distinctive water masses viz. Sub-Tropical water masses and Sub-Antarctic water mass. There was an inverse relationship (r = 0.98) with sea surface temperature. North of Sub-Tropical Front (STF), DO concentration decreases in general with depth reaching to a minimum at intermediate depths (1000-2000 m) and then slowly increase to ~200 µM in the deeper and near bottom depths. South of STF, the depth of intermediate oxygen minimum is somewhat low i.e., ~ 500 m.

pH

The pH of the water samples was determined immediately after the collection with the help of Digital pH meter with automatic temperature compensation probe.

Nutrients

The well proven method of continuous analysis of numerous water samples was achieved by Autoanalyser (Skalar) instrument. The nutrient values calculated in the cold region were having unique signatures of the water mass circulations and biogeochemical activities in the region of the study. The nutrient data observed show correlation with other oceanographic observations like salinity, temperature and also with pH of the corresponding samples measured.

Living Resources of the Southern Ocean

A team of 11 scientists and researchers drawn from various National Institutes/Universities participated in the Southern Ocean Cruise and carried out studies on the environmental parameters, biological productivity, benthic ecology, survey of marine mammals and avian fauna and monitoring of algal blooms.

Onboard analysis of water samples collected from 18 different stations for estimation of macronutrients demonstrated poor nutrient content in the subtropical waters in comparison to the southern waters, south to latitude 45° S. South to north down sloping nutrient isolines were noticed indicating an equator-ward movement of nutrient rich water from the south. Sediment samples from 15 stations north to 53° S latitude, were collected for further analysis.

Primary productivity in the southern ocean waters was estimated at 14 stations by deck incubation method following C14 technique. Mesozooplankton collected from 18 stations using Bongo and MPN operation at different depth strata indicated higher biomass in the mixed layer in comparison to the deeper strata. An extensive bloom of *Trichodesmium erythraeum* was detected at 27°14'S, 50°32'E.

Twenty-one instances of sighting of marine mammals were reported during the cruise, of which whales (Sei, Minke and Blue) contributed 80% while the rest were mostly dolphins. A white-chinned petrel was sighted throughout the ship's route along with few numbers of wandering albatross. Yellow nosed albatross, Black-browed albatross and Giant petrels were also observed at a few places along the cruise path.

To understand the modern day microfaunal assemblage, plankton net vertical hauls were carried out at two depths (surface and 200/100 m) to decipher the changes from surface with depth at nearly all locations. This will be the first hand information on the distribution of pelagic microfauna in relation to the various parameters. Water samples were collected up to a depth of 200 m, to ascertain the distribution pattern of coccolithophorids and diatoms. The region is one of the best-known High Nutrient Low Chlorophyll Zones and it is of much interest as to how these two different microfauna, one at nano level (coccolithophorids; size ~10-9 nm) and

other microscopic (diatoms) and different composition behave in these conditions and across the oceanic fronts and changing conditions. Further, it will provide information on the coccolithophorid population and how the carbonate flux is changing with depth and also with changing SST pattern and in turn reflect upon the carbon sequestration in this ocean. This study is interesting as this region is also known with less carbonate preservation in sediments but on the contrary siliceous microfauna are known to dominate. The idea is to develop a cause-factor relationship between the two different microfaunal groups and their influence on the oceanic carbon and silica cycle.

Geological Sampling

Surficial and sub-surficial sediment records were collected using various techniques like grab and coring. Surface sediment samples were collected (3 stations) using a Van Veen Grab, whereas subsurface samples were collected (8 cores) using gravity or piston coring technology. The sediment collected varied from sandy silt to silty sand, with large presence of shells and benthic organisms.

The water, vertical net, surface sediment as well as subsurface sediment sampling carried out during this expedition will provide excellent opportunity to understand the influence of Southern Ocean dynamics on the distribution and preservation of microfauna and/or sediments as well as its influence on global climate system on a spatial and temporal scale.

The core collected from one of the stations revealed systematic changes in sediment type and colour with presence of several banded intercalations, suggesting intermittent large-scale environmental variations during the time represented by it. A piston core collected at a station from 2730 m water depth revealed abundance of micro-nodules and occasionally larger nodules (~5 cm diameter) distributed throughout the core below 75cm from the sea floor. They certainly point to some large-scale changes in the bottom water conditions compared to the modern times during their deposition. A gravity core collected from another station at 4389 m water depth revealed excellent variations in sediment type and colour, with alternate layers of dark and light bands. It was found that the darker layers are abundant in rock fragments and debris of various size and shape. Most interestingly, preliminary investigations revealed that the above core consists of layers of siliceous and carbonaceous sediments, indicating dramatic changes in the oceanic chemistry during the past. Further, a piston core collected from the Antarctic revealed siliceous sediments interspersed with rock debris and rock fragments throughout that may indicate presence of ice rafted debris (IRD) in this region. In order to confirm this, further detailed investigations will be required that may ultimately unravel the importance of Southern Ocean in modulating the global circulation system during the geologic past as well as the possible inter-hemispheric linkages.

2.5 National Centre for Antarctic and Ocean Research (NCAOR), Goa

The National Centre for Antarctic and Ocean Research is a premier R&D institution in the field of polar science. Its main aims and objectives are :

- To serve as a nodal agency for the overall coordination and implementation of the Indian Antarctic Programme.
- To promote polar science (Antarctic & Arctic) and Southern Ocean oceanography.
- To facilitate scientific activities by coordination and guidance.
- To conduct research programmes especially in the emerging areas of science at national and international levels in close coordination with other countries.
- To devise, formulate and initiate programmes of strategic importance in the realm of polar science, which will create a knowledge base for future commercial and thematic interests of India in Antarctic and Southern Ocean.
- To build and maintain permanent research station in Antarctica and provide all operational and logistic supports.
- To interact and liaise with various Antarctic programme governing bodies i.e. Scientific Committee on Antarctic Research (SCAR), Council of Managers of National Antarctic Programme (COMNAP), Standing Committee on Antarctic Logistics and Operations (SCALOP), and other international bodies in order to keep the Indian Antarctic Programme at par with the international scenario and ensure a perceptible presence of India in the global framework of nations in Antarctica.

- To establish research laboratories i.e., environmental analysis, deep drilling technology; low temperature ultra-clean labs for the preservation and analysis of ice cores; instrument facilities like MS and ICP-MS for isotopic and trace metal analysis; microcosm lab for biological investigations; remote sensing tools and techniques for application of advanced satellite technology, for studies of the polar region.
- To coordinate, address and monitor all environmental issues and implementation of the Environmental Protocol to the Antarctic Treaty.
- To develop a complete database inventory and repository for Antarctic science and logistics including establishing a polar museum and library.

Infrastructure

To implement the mandate as well as to ensure the efficient functioning of the Centre, NCAOR has been organised into different scientific, technical and management divisions/sections (http://www.ncaor.org), as follows:

- National Antarctic Programme comprising the Divisions of Antarctic Science and Expedition Logistics.
- Scientific Wing comprising the Research and Development Group (In-house Research Programmes).
- The Legal Continental Shelf Programme (LCS).
- Ocean Survey and Services Group (OSSG).
- Programme Planning and Evaluation Division.
- National Antarctic Data Centre and Information Services.

Scientific Research Activities at NCAOR

Palaeoclimate Research Division

Scientific knowledge on the past variations in climate is important in assessing the natural environmental changes that have taken place and that may occur in the future. Palaeoclimatic research mainly utilizes proxy-related reconstruction, which attained international attention due to the absence of any instrumental records beyond some decades in the past. This exciting area of research is being explored at NCAOR through a multi-archive, multi-proxy approach.

Antarctic Ice Core Research

- Antarctic ice cores that were drilled by the Indian team have been brought to NCAOR for archival in a "clean" and contaminant-free repository. During the first stage, the cores would be studied for accumulation rate and for chronology. The pH and electrical conductivity measurements will be made on the cores. These studies will provide benchmarks for testing and validation of the cores. In the second stage, the ice core samples will be analysed for their oxygen ($d^{18}O$) and hydrogen (dD) isotope composition. These will provide the past variations in atmospheric temperature and precipitation, respectively. Additionally, ion chromatographic and trace elemental studies are planned.
- A wet chemistry laboratory is already operational. Facilities like laboratory ovens, muffle furnace, distillation plant, analytical balances, hot plates, fumehood, glassware and chemicals are available.

Marine Research

- Laboratory studies have been initiated with analysis of marine sediment cores collected from the Arabian Sea.

Polar Remote Sensing Division

Antarctic Sea-Ice Variability Research

- Data have been collected using Passive Microwave Radiometer (SMMR, MSMR, SSM/I), Synthetic Aperture Radar (SAR) and Scatterometer & Altimeter.

- Preliminary results indicated weakly accelerating trend of sea ice extent in Antarctica, leading to computation of mass balance of Antarctic ice sheets and an understanding of the mechanisms that maintain Inter-Hemispheric Circulation and providing the signature of global warming in Antarctica.

Atmospheric and Oceanic Heat Budget in the vicinity of Drake Passage

- Advanced Very High Resolution Radiometer (AVHRR), 9-km Sea Surface temperature (SST), Scatterometer-based surface winds, NCEP/ECMWF based surface meteorological data, climatological temperature profiles and surface chlorophyll-a data sets, were collected.
- Using surface data sets and bulk aerodynamic formulae, surface heat budget was estimated. Mixed layer heat budget was deduced using mixed-layer temperature. Heat equation was used to quantify and identify the most significant terms that control the upper-ocean heat budget. Temporal variability was monitored using statistical tools.
- Atmospheric forcing on ocean and the role of oceanic currents in advection of heat has been investigated. This physical forcing ultimately translates into characteristic chlorophyll-a patterns, which enhance the primary production.

Frontal Air-Sea interaction, Cross-Frontal Transport and Air-Sea Heat Flux Studies, South of 40^{o} S

- Data were collected using AVHRR SST images, Chlorophyll-a images (Coastal Zone Colour Scanner, Moderate-resolution Imaging Spectro-radiometer and SeaWiFS), Brightness temperature from Special Sensor Microwave/Imager & heat flux estimates using bulk aerodynamic formulae.
- Using these data, heat and momentum transport across ACC front, location and frequency of fronts etc., were monitored. Quantification of air-sea interaction was done through surface heat budget of atmosphere and upper ocean and Eddy field.

Polar Environment and Ecology Division

Environmental Monitoring and Impact Assessment Study

According to the Protocol on Environmental Protection to the Antarctic Treaty, continuous environmental monitoring of existing scientific and logistics activity and Environmental Impact Assessment for any new activity is mandatory. To meet these requirements an environmental laboratory with state-of-the-art equipment has been set up at NCAOR, besides strengthening of the environmental laboratory at Maitri. Keeping in view of the requirement, a continuous environmental monitoring, Initial Environmental Examination (IEE) and Environmental Impact Assessment study for any new major scientific or logistic activity and new permanent research station in future, shall be carried out to meet the demanding framework of Protocol on Environmental Protection to the Antarctic Treaty. Further, the efficacy improvisation of the wastewater treatment system and waste management at Maitri shall be one of the focal research programmes.

Ecological and Molecular Studies of Antarctic Flora.

Ecological and Molecular studies of Antarctica are the thrust areas. Antarctica is reported to contain the species of Bacteria, Algae, Mosses and Lichens. Genetic information of Antarctic algae, moss and lichens is an exciting and gap area. Thus "DNA amplification profiles" and "nucleotide sequences" of different plant genes are needed. For this the ribosomal RNA cistrons and a few Chloroplast and Mitochondrial genes will be amplified and sequenced (wholly or partly) from representatives of several taxa. Then these data will be used for establishing Taxonomic and Phylogenetic relationships.

Since, Antarctica is in general an exciting continent for preserved ancient DNA and cold tolerant genes, many aquatic and terrestrial species of Antarctica may have higher economic value as sources of phytochemicals, drugs and other pharmaceutical products. Considering the phytochemicals and pharmaceutical importance of Antarctic species in general, it is essential that the species must be correctly identified. The study shall be carried out to provide a reliable Taxonomy and Phylogeny of Antarctic species. Further, it will also help in resolving the other Taxonomic bottlenecks using the molecular techniques.

Southern Ocean Oceanography Division

The Antarctic Ocean - Cryosphere system is one of the most important players in the Global Climate System as also it is one of the areas of the most active current system. A Southern Ocean Oceanography Division is set up in the Institute, as the multiproxy data pertaining to the Indian sector of the Southern Ocean is lacking even though 40% of the Southern Ocean forms a part of the southern part of the Indian Ocean.

A concerted effort has been made by this Institute to set up state-of-the-art laboratory, which also includes setting up of Scanning Electron Microscope facility for ultrastructural studies for which the process has already been started. This division will concentrate on quaternary paleoceanography and paleoclimatology of the Southern Ocean as also the physical processes of the area. The past oceanic changes deciphered with the help of multiple proxies would be used as "Biomonitors" and also the climatic changes of immediate past, which is of interest to the national as well as international scientific community.

National Antarctic Data Centre (NADC)

National Antarctic Data Centre, which is being developed at NCAOR, is a repository of the Antarctic science database for India. The vast amount of data generated from Antarctic expeditions in all areas of science will be collated, formatted and synthesized for easy accessibility and utilization.

Easy online search tool and online data entry via Internet will facilitate easy and free exchange of the data with the scientific community. The international data format called Directory Interchange Format (DIF) has been implemented for easy and reliable exchange of data over the Internet, concurrent with Australian Antarctic Data Centre and Global Change Master Directory (NASA).

Further, the above facility for online data access and online search tools will be extended for ORV Sagar Kanya cruises database, which will give ready access to the available data in the Indian Ocean.

3. Polymetallic Nodules Programme

India is the first country to have attained the status of Pioneer Investor in 1987 and was allocated an area of 1,50,000 sq. km in Indian Ocean Basin by UN. India is one among the top 8-countries/contractors and is implementing a long-term programme for exploration and exploitation of Polymetallic Nodules. India has also made considerable contributions in development of technologies in extractive metallurgy and mining.

India is also a Member of the Council of International Seabed Authority (ISBA) under Investor's category. ISBA is an institution created under United Nations Convention on Law of the Sea, which looks after the seabed resources of high seas. India is a Member of the Legal and Technical Committee and also of the Finance Committee of ISBA. In 2002, India (DOD) has signed a 15-year contract with ISBA. India has surrendered 50% of the area to ISBA and has retained 50% area (75,000 sq. km) based on a detailed survey and exploration as a part of the obligation.

The Polymetallic Nodules programme is oriented towards exploration and eventual exploitation of the nodules from the mine site allocated to India in the Central Indian Ocean Basin (CIOB). The various components of the programme viz. Survey & Exploration, Environmental Impact Assessment, Technology Development (Mining), Technology Development (Metallurgy) and Unmanned submersible, are aimed at fulfilling this long-term objective.

Survey & Exploration

With a view of firmly establishing the nodule resource and validating the resource assessed for updating relative concentration and quality characteristics of the polymetallic nodules, survey and exploration activity is targeted and carried out at a closer grid of 6.25 km. in selected blocks in the proposed first generation mine-site area. During 2003-2004 one research cruise on AA Sidorenko was conducted wherein, detailed sampling using the Okean Grabs was taken up at 60 stations. In addition, updating of geo-statistical resource evaluation based on 12.5 km. grid sampling in selected blocks was also taken up.

Environmental Impact Assessment (EIA) Study

A comprehensive EIA study as a result of potential exploitation of nodules has been undertaken at the

pioneer area. The 3rd monitoring cruise of the test and reference area was carried out on board research vessel AA Sidorenko. Under the study, CTD and Rosette observations near seabed at the test and reference areas were carried out. In addition, the box corer samples at the test and reference areas were collected. It is proposed to collect samples covering various environmental parameters at the retained area in addition to the continuation of monitoring cruise at the test and reference areas and creation of appropriate databases.

Technology Development - Mining

As a part of continued efforts, refurbishment of shallow bed mining system has been undertaken for re-demonstration to improve the confidence level. A new project on unmanned submersible capable of operating up to a depth of 6000 m (ROV 6000) has been taken up with Russian collaboration. The detailed design has been completed and necessary action has been initiated for procurement of components. The design and development aspects of collector and crusher are also proposed to be taken up during 2004-05.

Technology Development - Metallurgy

Dedicated campaigns were carried out at the semi-continuous demonstration pilot plant to process 500 kg per day of polymetallic nodules to validate the process package developed for extraction of metal values from nodules at Hindustan Zinc Limited (HZL), Udaipur. Nodules collected from Central Indian Ocean Basin are utilized for the metallurgical demonstration campaigns. The RRL process route for extracting the metals viz. Copper, Nickel and Cobalt was successfully tested at plant level. The campaigns are still continuing and studies are being carried out for optimization of power and chemical requirements. R&D activities for efficiency optimization for extraction of metal, viz. Cu, Ni, Co and Mn were continued.

The process package "acid leach - pressure leach" developed by HZL (U) would be demonstrated at the Pilot Plant to have comparative advantage of various process packages.

4. Ocean Observation & Information Services (OOIS)

4.1 Ocean Observing System

Systematic observation is imperative for understanding the structure and dynamics of ocean, improving predictability of ocean and climate, sustainable development of coastal ecosystem and for generation of ocean information and advisory services for the society, industry, government and scientific community especially in the context of sustainable development of the coastal and marine ecosystem, weather prediction, disaster management and environmental monitoring.

India has made significant progress in ocean observation systems, with a mix of in-situ platforms and satellite systems and concomitant capability in retrieval of data, use of models, generation of value-added services and advisories in specific areas.

The Ocean Observing System programme is designed for generation of systematic, scientific and long-term data of oceanographic and meteorological parameters by deployment of state-of-the-art technology instruments i.e. Met-Ocean Moored Buoys, Argo Floats, Drifting buoys, XBTs, Current Meter Mooring Array, and Tide-Gauges. During the X Plan, INDOMOD, SATCORE and Ocean Observing System programmes have been integrated in a focused way towards development of a model. Accordingly, selective deployment of buoys, current meters and XBT surveys are planned for generation of surface oceanographic and meteorological data. These observations are intended primarily for validation of ocean atmospheric models envisaged under INDOMOD and SATCORE Projects.

While NIOT is in-charge of implementing the moored data buoy programme, INCOIS has the responsibility to coordinate and implement, through NIO, Ocean Observation Systems such as drifting buoys, expendable bathythermographs (XBT), current meter moorings and sea-truth campaigns.

Moored Ocean Data Buoy Programme

During the IX Five Year Plan period, Department of Ocean Development (DOD), Government of India has successfully implemented the National Data Buoy Programme (NDBP) with the deployment of 12 moored

Indigenisation of data buoy design and fabrication

data buoys in Arabian Sea and Bay of Bengal at selected locations. On finding the efficacy of real time data from data buoys, major end - users like Indian Meteorological Department (IMD), Climate Research Groups (Department of Science & Technology), Ports and others approached DOD for increasing the number of data buoys. The Working Group constituted by the Planning Commission for formulating the X Five Year Plan proposals for Ocean Development, recommended the establishment of a 40-buoy network through indigenous production, operation and management, keeping in view various data end users and national necessities.

NIOT took initiative for indigenisation of the buoy network and contributed in a big way in drawing up suitable design and drawings; specifications and documentation for various critical buoy components. The very major task was the development of Central Processing Unit (CPU) for data acquisition, processing and data communication through Indian Satellite, which has been totally evolved in-house and developed through a local indigenous source. Another critical component is the satellite transmitter for INSAT which was jointly developed by NIOT and Space Applications Centre (SAC), Ahmedabad. NIOT has evolved the modus operandi for handshaking between the CPU and INSAT transceiver in the buoy format; miniaturizing the complete electronics and its enclosures to suit marine conditions, testing procedure, etc. The other accomplishments during the period under report are up-keeping of the 20 buoy network and development of a new design buoy, which could be transported through ISO containers with the assistance of IIT, Chennai.

Storm surges associated with stern cyclonic storms recurrently have an effect on the coastal India and Bangladesh and cause huge loss of lives and damages to properties. This in turn fatally affects the economy of this region. The devastation caused by the storm surge can be mitigated considerably if the height and time of occurrence of peak water level at the coast and the ensuing coastal inundation can be forecast reliably. The Indo - Bangladesh Storm Surge project is a five - year programme to build up infrastructure, obligatory for providing effectual and opportune storm surge forecasts and warnings along the Bay of Bengal bordering India and Bangladesh. The primary objective is to save lives, reduce damages to properties and encourage sustainable development of the low - lying coastal areas in this region. In addition, the project will make considerable contributions to hearten investments for sustainable coastal development and to radically condense the provocation of poverty caused by storm surge disasters in the region. This project proposes improvement of the meteorological, marine and hydrological observing systems and data processing systems required to achieve this. Suitable storm surge models and improvement (including inland inundation) are proposed along with an operational oceanographic and hydrological storm surge prediction facility. A key component of the proposal is capacity building and human resources development in the region through training, workshops and provision of equipment.

A joint project proposal to establish CALVAL site for calibration of optical payloads on satellites by NIOT and SAC has been prepared. The design and the prelude mechanism for the same is on and the project will be realized in the financial year 2004 - 2005. The CAL site has been finalised in consultation with the authorities in Lakshadweep Administration.

NDBP has agreed for providing Deep Water Meteorological, Wave & Surface Current observations for ONGC through Elcome Surveys Pvt. Ltd for 30 days each for six selected locations in Bay of Bengal. Measurements at Five locations have been completed.

Tide gauges & Buoys for proposed Storm Surge Project

The new facilities created for NDBP in NIOT were inaugurated on 3rd March 2004, which include:

- 300 sq. m bay for assembly and full testing of Data Buoy.
- A five - tone EOT crane has been installed in the Bay for assembling and testing of the Data Buoy. About 100 sq. m air-conditioned space has been created for proper storage of electronic components and testing. It is also equipped with high accuracy test and measuring instruments.

- The Shore Station for data reception through satellite link housed in the NDBP building is equipped with Sun Ultra Sparc Machines, adequate number of Servers and various other supporting devices.
- The buoy data received from the buoys are required to be processed systematically, for which NDBP has acquired dedicated software's' like Orkan, Neptune, Ocean info, etc.

4.2 Indian National Centre for Ocean Information Services (INCOIS)

The Indian National Centre for Ocean Information Services (INCOIS), an autonomous body under the Department of Ocean Development, has a mandate to synthesize, generate, promote, provide and coordinate various endeavours in the field of ocean sciences, ocean observations, satellite oceanography, ocean information and advisory services. INCOIS has a vision to emerge as a knowledge and information technology enterprise for the oceanic realm. Synergy and knowledge networking with centres of excellence in ocean, atmospheric sciences, space applications and information technology as well as translating this scientific knowledge into useful products and services comprise the cornerstone of INCOIS.

INCOIS has been striving to address this national agenda with missionary zeal through (i) Potential Fishing Zone Advisory Services (ii) Experimental Forecast of the Ocean State (iii) Ocean Observation using Argo Profiling Floats and several other in-situ platforms (iv) Satellite Oceanography and (v) Ocean-Atmosphere Modelling efforts. Concomitant with this, INCOIS has been striving to play a significant role in the Indian Ocean region.

Infrastructure Development

Phase-II of Computational Infrastructure has been commissioned and the existing network facilities, storage management of SAN and the Internet connectivity were augmented. Presently, the computational facilities consist of high-end Unix Servers and Work Stations, Windows 2000 Servers and Workstations, Enterprise Storage Server, high end desktop systems, various peripherals, etc. which continue to provide round the clock service. All the systems have been maintained in good working condition with 97% uptime. Back-ups are being obtained as scheduled. A Coastal Ocean Modelling Laboratory was set up and MIKE software was installed on Desktop Systems.

Development of permanent campus for INCOIS is in progress at Gajularamaram, Quthubullapur Mandal, Ranga Reddy District, Hyderabad. Development of INCOIS campus is progressing as per schedule, with the first phase of the building slated to be ready by end-May 2004. Movement plan is scheduled for June 2004.

Other Ocean Observation Programmes of INCOIS

The progress made under the other Ocean Observing System programmes implemented by INCOIS is as follows:

- Seven drifting buoys were deployed in the Indian Ocean. Analysis of buoy trajectories and hypothetical trajectories using the model surface current out puts has been taken up.
- Successfully retrieved the three deep-sea current meter moorings at 93°E, 83°E and 76°E along the equator and obtained the currents data at different levels. The three moorings were re-deployed after obtaining the data. One cross-equatorial hydrographic section was occupied along 77°E (5°N - 4°S) and multi-disciplinary data were collected.
- Analysis of the current data and hydrography has been taken up. Temporal variability of measured currents in conjunction with the OGCM results is examined.
- About 370 XBT probes were deployed along three sections viz. (i) Chennai-Port Blair-Calcutta, (ii) Chennai-Singapore and (iii) Mumbai-Mauritius. In addition to the temperature profiles, water samples for sea surface salinity and phytoplankton and surface marine meteorological parameters were also collected along these sections.
- Eleven out of 21 tide gauges installed along the Indian Coast by the Survey of India are working well and providing data. Mean Sea Level data for these 11 stations were processed up to 2000. Monthly Mean Sea Level data from 16 tide gauge stations up to 1999 were processed and submitted to Permanent Service for Mean Sea Level (PSMSL) Programme as part of Global Sea Level Observing System (GLOSS) Programme.

4.3 Ocean Information and Advisory Services

Potential Fishing Zone (PFZ) Advisory Services

The significant achievements are as follows:

- Operational Generation of PFZ advisories was sustained and enriched.
- Latitude and Longitude information has been included in the advisories.
- Bathymetry was upgraded for all the coastal areas along the entire Indian Coast, including islands by digitising the point data from NHO charts and Digital Elevation Models for the bathymetry have been created to provide to the fisher- folk along with the PFZ advisories.
- Dissemination Strategies.

Fax and telephone-based multi-lingual (Gujarathi, Hindi, Kannada, Malayalam, Telugu, Oriya and Bengali) PFZ messages were disseminated to around 225 nodes spread across the entire coast of India, under 12 Sectors, viz., Gujarat, Maharashtra, Karnataka & Goa, Kerala, South Tamil Nadu, North Tamil Nadu, South Andhra Pradesh, North Andhra Pradesh, Orissa & West Bengal, Andaman, Nicobar and Lakshadweep.

For timely and effective dissemination of the PFZ advisories, Electronic Display Boards (EDB) were established in the fishing harbours at Veraval, Ratnagiri, Malpe, Munambam, Royapuram, Veerampattinam, Visakhapatnam, Machilipatnam, Kakinada, Gopalpur and Diamond Harbour. The forecast is being updated thrice a week directly from INCOIS.

Participants in the PFZ Interaction meet at Malpe

Under the pilot project on Satellite Audio Broadcasting initiated with M/S. WorldSpace, Bangalore, the PFZ forecast messages were broadcast to the World Space Radio receivers installed on 9 fishing boats operating from Visakhapatnam, Kakinada, Machilipatnam and Berhampur along the east coast and Manakkodam, Kochi, Munambam, Mangalore and Ratnagiri along the West coast of India. These messages were broadcast directly from INCOIS in Hindi, Kannada, Malayalam, Telugu and Oriya languages twice a day between 07.00 and 7.15 A.M., in the morning and 3.30 and 3.45 P.M. in the afternoon.

A dynamic web site with web GIS, query facility and multi-lingual capability was developed for the PFZ Advisory services to strengthen the delivery chain and improve the time line. The PFZ advisories (containing SST and chlorophyll images, vector coverage and multi-lingual text) were simultaneously made available to the users at INCOIS website (www.incois.gov.in). Both map and text forms of these advisories are mailed to some of the users on their request.

PFZ Advisories for the Andhra Pradesh Coast are being published in Telugu in a leading Telugu daily newspaper thrice a week, in its coastal district editions. Efforts are underway to publish PFZ Advisories in the newspapers of the other coastal states in their respective languages.

User interaction workshops were conducted at Gopalpur in Orissa, Thiurvananthapuram in Kerala and Malpe in Karnataka. A documentary film on PFZ Advisory Services was broadcast on Doordarshan (DD-1) on June 15, 2003. Two day orientation workshop was conducted for the project personnel and research fellows working under various PFZ Projects.

Four research projects were carried out for concurrent validation of the PFZ Advisories around Ratnagiri, Mangalore, Kochi and Gopalpur. Review was conducted on the preliminary results of the PFZ validation projects taken up in these places. Initial results of the validation exercises indicate a reduction in searching time, varying form 30% to 70 % while using PFZ Advisories than that of traditional fishing. Consequent reduction in fuel consumption and also valuable human effort has been reported. Improvement in Catch-per-unit-effort (CPUE) has been reported. Importance of various other parameters that lead to species specific

forecast was identified. A uniform methodology was evolved for all the validation studies in order to have a comprehensive picture within a common framework.

Experimental Ocean State Forecast

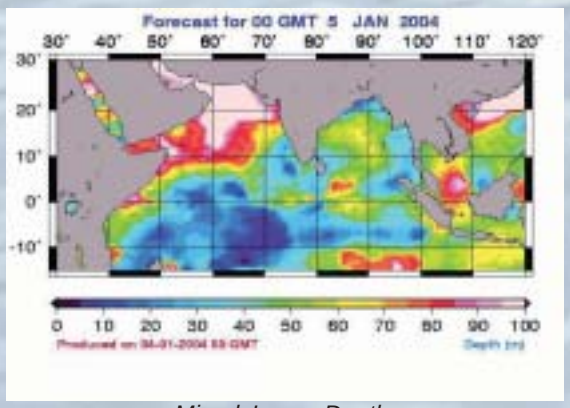
The Experimental Ocean State Forecast (E-OSF) emphasises on providing the state-of-the-art ocean information and forecast to the users e.g. Navy, Shipping, Oil and Fishing Industry, etc., and the information encompasses predictions and dissemination of geo-physical information such as surface winds, sea surface temperature, surface waves, mixed layer depth and currents. The E-OSF activities are envisaged in two phases - Phase I, mainly focused on open ocean forecast in coarser grid and in Phase II, the coastal forecast in fine grid.

E-OSF is developed out of a joint initiative taken by INCOIS and the Space Applications Centre. The wind forecast from the National Centre for Medium Range Weather Forecast (NCMRWF), Delhi is the prime input for the E-OSF forecast. The Centre for Atmospheric Sciences (CAS) of Indian Institute of Technology (IIT), Delhi, the Centre for Atmospheric and Ocean Science (CAOS) of Indian Institute of Science (IISc), Bangalore and the National Institute of Oceanography (NIO), Goa contributed to this multi-institutional endeavour to translate scientific knowledge into a service useful for safe operations in the sea.

The progress made during the year 2003-04 is as follows:

Open Ocean Forecast

- Operational Forecast is being generated for wave and swell parameters using WAM-3C model. The forecast is valid for four days at 6 hourly intervals and on 1.5º x 1.5º and 1º x 1º spatial resolution. Wind data generated by NCMRWF is the forcing for the model.
- WAM Model has been customised for higher resolution (0.5^0 x 0.5^0) winds provided by NCMRWF.
- Fine resolution NCMRWF winds (0.5º x 0.5º) were further interpolated to 0.25º x 0.25º using bilinear interpolation and the WAM model was forced with these winds for Indian seas. The resultant wave products at 0.25º x 0.25º resolution from WAM model are being validated.
- Mixed layer depth forecast is being generated using 1 dimensional price model with NCMRWF wind and radiation flux as forcing. Forecast is four days and 12 hourly intervals and 1º x 1º spatial resolution.
- Frequent validation of wave, wind and tidal circulation parameters is carried out with in-situ (Moored buoy) and satellite data (Topex-Poseidon and ERS-1) in real time by Naval Operations Data Processing & Analysing Centre (NODPAC), Kochi during the naval exercises. The forecasts are in close match with the observations.



Mixed Layer Depth

- Quality control programs were developed to check the input data to the E-OSF Models and these programmes are being operational. Development of quality control programs for output products of E-OSF is underway.

Coastal Ocean Forecast

- Tidal circulation model is being operational for forecasting tidal currents from Ratnagiri to Porbandar for 3 days at 3 hourly intervals and at 6 km spatial resolution. Validation of model results with moored buoy data showed good correlation.
- WAM model was customized for forecasting the wave and swell parameters in 25 km resolution for the coastal regions.
- Simulating Waves Near Shore (SWAN), a shallow water wave model was successfully

implemented and sensitivity experiments were performed using synthetic winds and NCMRWF forecast winds for a limited region in the Bay of Bengal. The SWAN Model was successfully nested with deep water WAM, where coarse boundary condition from WAM was provided as one of the inputs to SWAN for a limited region in the Bay of Bengal. Experiments on SWAN model are being carried out for different conditions of different areas.

Dissemination to Users

- Experimental Ocean State Forecast products were delivered through the INCOIS Web Site both in image format and numerical data formats. Images for wave and swell forecasts are available in public domain. Numerical data for ocean sate forecast are provided for registered users.

User interaction

- User interaction meeting for utilization of E-OSF forecast was held with NODPAC, Kochi and DNOM.

Projects

INCOIS has the responsibility for coordination and implementation of:

(a) Indian Ocean Modelling and Dynamics (INDOMOD),

(b) Satellite Coastal and Oceanographic Research (SATCORE) and

(c) Ocean Observing Systems and

(d) Indian ARGO Project

4.4 Indian Ocean Dynamics and Modelling (INDOMOD)

During the IX Plan INDOMOD Project had made a significant contribution towards realising a national capability in Ocean Atmosphere Modelling. During the X Plan, a new phase of modelling efforts was initiated under INDOMOD project, focusing towards the end goal of achieving ocean predictability and enabling climate predictability in a mission-mode with concomitant efforts in modelling, data assimilation and validation.

A networking of institutions (viz. CAOS/IISc, CAS/IIT-D, C-MMACS, IITM, IMD, INCOIS, NIO, NCMRWF, Naval Physical Oceanographic Laboratory (NPOL), NRSA, SAC and SOI) with capability, capacity, compatibility, credibility and commitment as well as building a national team is the key to realise this mission.

Fifteen separate sub-projects under the INDOMOD Project are addressing a specific activity pertaining to development of ocean-atmospheric modelling in 5 modules viz. (i) Ocean and Climate, (ii) Coastal Ocean, (iii) Hazardous Weather events, (iv) Ocean Data Assimilation and Information Bank, and (v) Validation of observations using concurrent observations.

Bay of Bengal Process Studies (BOBPS)

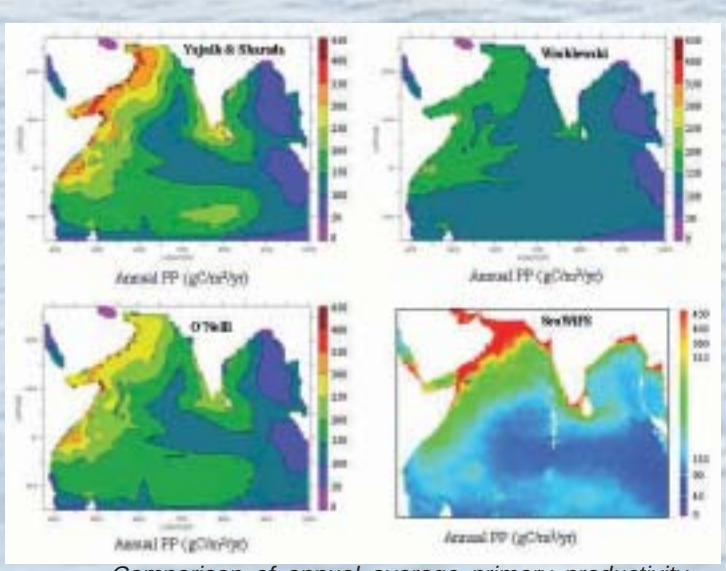
Under Indian Ocean and modeling dynamics programme, the Department implemented two programmes during 9th Plan, pertaining to International Biosphere Geosphere programme (IGBP). These are Joint Global Ocean Flux Studies (JGOFS) and Land Ocean Interaction in the Coastal Zone (LOICZ).

The Indian JGOFS programme has been designed to address fluxes of carbon and nitrogen in the Arabian Sea and Bay of Bengal. A series of experiments were conducted in the Arabian Sea to understand the Bio-geo-chemical processes. These investigations have contributed to the understanding of the biogeochemical process in the Arabian Sea. Currently, similar experiments are being conducted in the Bay of Bengal to study biogeochemical processes (BOBPS). The BOBPS project comprises 9 subprojects that are being carried out by four institutes i.e., NIO, Goa, PRL, Ahmedabad, CMMACS-Bangalore, and Goa University. The objectives are (i) to study the spatial and temporal variations in physical, chemical and biological properties (i.e., temperature, salinity, density, wind pressure, SST, air temperature, humidity, nutrients, primary productivity, abundance and annual cycle of bacterial, micro- & meso-zooplankton, POC) and effect of various forces (such as freshwater, suspended discharge, evaporation, precipitation etc.) to these variabilities in the Bay of Bengal, (ii) to assess the seasonal and inter-annual variability in the overall CO_2 air-sea exchange balance in

the Bay of Bengal and (iii) to understand the role of cyclones and remote forces, in the spatio-temporal variability of the water column in terms of nutrient and productivity.

The major observations during the year 2003-04 are as follows:

- The surface as well as the integrated chlorophyll-a in the Bay of Bengal during summer monsoon (June to September) is 4-5 times lesser than that in the Arabian Sea, while the integrated primary productivity is about 8 times less. One of the major factors responsible for this is the physical process leading to increase in stratification.
- Copious rainfall and river water freshen the upper layers of the Bay by 3-7 psu during summer, while warm SST (1.5-2°C compared to the Arabian Sea) leads to a strongly stratified surface layer, which inhibits turbulent mixing and hence upward pumping of nutrients.



Comparison of annual average primary productivity generated from coupled model simulation

- Cold-core subsurface eddies appear to play an important role in upward pumping of nutrients and enhancing the chlorophyll and biological production in the Bay of Bengal.

4.5 Satellite Coastal and Oceanographic Research (SATCORE)

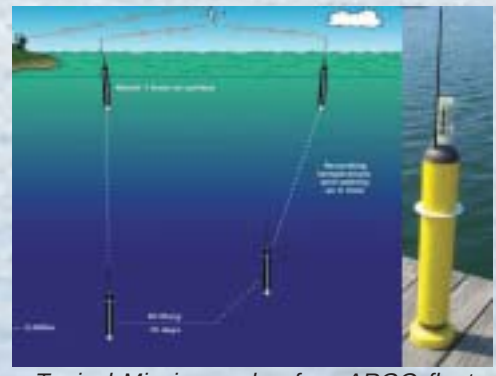
SATCORE Project envisages development of various algorithms and models for retrieval of met-ocean parameters (e.g. sea surface temperature, winds, wave parameters, bathymetry, suspended matter, mixed layer depth, chlorophyll, aerosol, water vapour, clouds, currents and sea level) from the data from Indian and foreign satellite sensors including Oceansat-1 (IRS P4). Besides, this Project would also carryout diagnostic studies and generation of forecast models, customisation of algorithms and development of related software packages. The SATCORE project is executed primarily by the Space Applications Centre (SAC) and the National Remote Sensing Agency (NRSA). There is an imminent need to gear up for the effective utilisation of the forthcoming Indian Ocean remote sensing satellite missions such as Meghatropiques, Oceansat-2 and Radar Imaging Satellite for operational generation of met-ocean parameters and their assimilation, along with the in-situ data, for a host of products and services.

The SATCORE Project for the X Plan was formulated jointly with SAC and NRSA including work packages viz. (i) Advanced Ocean State Forecast, Ocean Processes (Convection), Geophysical Parameter Retrieval and Validation, (ii) Ocean Colour Applications, Ocean Biology, Coastal processes, Ocean Lithosphere, Coral reef Studies, (iii) Improvement of Mixed Layer Depth Predictions, (iv) Development of Integrated Fishery Forecast Model, and (v) Observation platforms in Islands.

4.6 Indian Argo Project

One of the recent advancements in in-situ observations is the profiling Argo floats. Argo (earlier known as Array for Real-time Geo-strophic Oceanography) is a revolutionary concept that enhances the real-time capability for measurement of temperature and salinity through the upper 2000 metres of the ocean, which contributes, to the global description of the seasonal and inter-annual variability of the upper ocean thermohaline circulation. The periodic profiles of temperature and salinity would improve better understanding of Ocean circulation and enhance climate predictability.

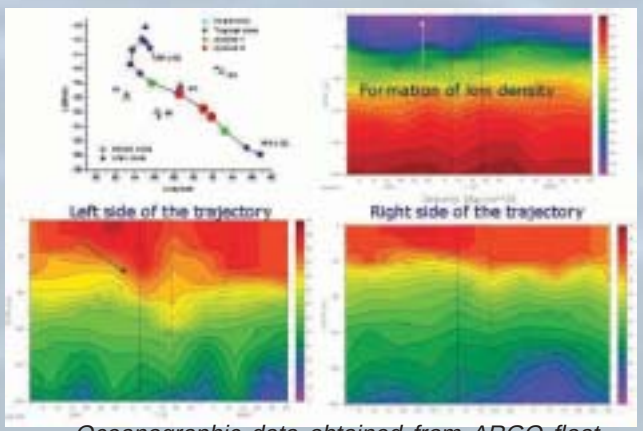
The international community is moving ahead to realise a global array of 3000 Argo floats by the year 2006 out of which 450 floats will be deployed in the north Indian Ocean. India is participating in the Argo programme and plans to deploy 150 floats in the north Indian Ocean (north of 10°S) by 2005. International planning for Argo programme is coordinated by the International Argo Science Team (IAST). Director, INCOIS is the Member of IAST and also the Regional Coordinator for the International Argo Programme in Indian Ocean. INCOIS has been identified as the Regional Argo Data Centre for the Indian Ocean region. Regional Argo Data Centre has been set up at INCOIS and Regional Coordination is being implemented by INCOIS.



Typical Mission cycle of an ARGO float

Significant achievements under the programme during 2003-04 are as follows:

- Twenty-two Argo floats out of thirty-one deployed by India in the Indian Ocean are working well and providing good data.
- So far, 277 Argo floats have been deployed in the Indian Ocean by various countries. Data from 277 floats are archived at INCOIS and made available to the scientific community through INCOIS website.
- A software has been developed to convert the Argo data from the new Argo data format version 2.1 and to load the data on INCOIS website.
- Heat content, mixed layer depth and dynamic heights computed from the Arabian Sea are being analysed along with the World Ocean data sets and Quikscat data to study the upper ocean variability.
- The temperature and salinity data from Argo floats were analysed to study the mixed layer response to the cyclone on both sides of the track of the cyclone. It is observed that deepening of thermocline was predominant on the left side of the cyclone before arrival of the storm.
- Water mass structure of the northern Arabian Sea is being analysed with Argo float data.
- Seasonal variations of thermocline depth, dynamic height and mixed layer depth in the equatorial Indian Ocean using Argo float data for the last 36 months were analysed for comparing the results with Altimeter data for further investigations.
- Heat budget for the different regions of the entire Indian Ocean has been calculated using Argo floats for the year 2002 and 2003. Surface heat flux, wind, rainfall and Sea surface height data for the year 2002 and 2003 were obtained. These data sets are used to compare any significant relation with heat content of the particular region with All India Summer monsoon rainfall.
- The variability of the meridional heat and mass transport in the Pacific Ocean and Indian Ocean are under investigation using the OGCM integrations and the atmospheric reanalysis (NCEP) data sets. These results are to be verified with other observed sea surface height anomalies (TOPEX, Jason) and Argo observations.
- Argo data have been found useful in cyclone prediction, to study the inter-annual variability of monsoons and for the climate change studies.



Oceanographic data obtained from ARGO float

4.7 Ocean Information Bank and Web-based Services

Ocean Information Bank

The Ocean Information Bank is supported by a national chain of Marine Data Centres and Ocean Observing Systems. The Ocean Information Bank consists of the following data sets for facilitating its user community.

- NOAA AVHRR Satellite data from 1991 and Sea Surface Temperature archives for North Indian Ocean from 1992 to December 2003, including daily, weekly and monthly images and grid data, brightness, temperatures.
- Data from Moored and Drifting Data buoys, XBTs, Current Meter Mooring Array for the period 1997-2003,
- Data from the 700 Argo Floats deployed in the global Ocean.
- PFZ Maps from 1992 onwards along the Indian coastline and Islands (for non-monsoon months)
- Coastal Area Maps from Nellore to Orissa border on 1:25,000 scale.
- Bathymetry charts for the entire coast of India including Islands on 1:15,000 / 1:50,000 / 1:1,50,000 scale.
- Arabian Sea Monsoon Experiment Phase-I (ARMEX-I) data.

A network of 14 Marine Data Centres (MDC) was established by DOD in the 90's under the MARSIS Programme, in National Laboratories and Academic Institutions to collect and collate data, undertake quality control exercises and archive in digital data bases. The Marine Data Centres are located at (1) Geological Survey of India, Kolkata, (2) KD Malavia Institute of Petroleum Exploration, Dehradun, (3) India Meteorological Department, Pune, (4) Survey of India, Dehradun, (5) National Hydrographic Department, Dehradun (6) National Institute of Oceanography, Goa, (7) Fishery Survey of India, Mumbai, (8) Central Marine Fisheries Research Institute, Kochi, (9) Central Drug Research Institute, Lucknow, (10) Central Salt and Marine Chemicals Research Institute, Bhavnagar, (11) Orissa Remote Sensing Applications Centre, Bhubaneswar, (12) Institute for Ocean Management, Chennai, (13) Regional Centre, National Institute of Oceanography, Mumbai and (14) National Remote Sensing Agency, Hyderabad.

A comprehensive assessment of the Marine Data Centres is underway addressing (a) the need for marine/ oceanic data and metadata of seas around India to be preserved at INCOIS (b) an appraisal of marine/ oceanic data generated through various DOD programmes as well as programmes of other Agencies/ Departments, (c) inventory of marine/oceanic data available with INCOIS and the existing institutional arrangements for exchange of data or meta-data with INCOIS, and (d) the marine/oceanic component of the National Spatial Data Infrastructure being evolved in the country and suggest a framework for the future of the Marine Data Centre Network of INCOIS.

Web-based Services

INCOIS has been providing ocean information and advisory services through Website & Ocean Portal, especially in the areas of (i) Potential Fishing Zone Mission, (ii) Indian Ocean Argo Project, (iii) Experimental Ocean State Forecast, and (iv) IOGOOS, besides facilitating users with Information Bank, Information on various projects and programmes, Ocean Tutor, etc. INCOIS has made significant progress during the period of report in development and implementing the Web Based Services and made it operational for the benefit of user community.

The development of Website & Ocean Portal was completed in September 2003, in a phased manner with M/s Tata Consultancy Services (TCS) as partner. The first phase involved a static site giving insight into the various activities planned for the Ocean Community. The next two phases involved a dynamic site with Web Geographical Information System (GIS) interface, Data Warehousing and Data Mining facility.

Some of the highlights and achievements of INCOIS Website & Ocean Portal development during the period include (i) Provision of both Static and Dynamic pages which give insight in to various activities of INCOIS, (ii) Web GIS facility for Potential Fishing Zone Forecast, Experimental Ocean State Forecast and Indian Argo

Programme, (iii) Multilingual facility in ten languages including English & Hindi, (iv) Data Warehousing & Data Mining facility which provides users with Graphical User Interface (GUI) for selecting, querying, analysing and downloading data of interest, etc. This was well received and appreciated by the user community. The web-site is periodically updated both in terms of information and facilities, based on feed back from the user community. About sixty users have been registered for the PFZ and E-OSF Services on the INCOIS Web-site.

5. Marine Research & Technology Development

5.1 Assessment of Marine Living Resources

The Centre for Marine Living Resources and Ecology (CMLRE), Kochi, an attached office of the Department is entrusted with the responsibilities of the erstwhile Sagar Sampada Cell in managing the Fishery and Oceanographic Research Vessel (FORV) Sagar Sampada ensuring optimal utilization of her facilities and equipment for research of national relevance in ocean and atmospheric sciences, with specific emphasis on generation of long-term time series data on fisheries oceanography, marine living resources and related environmental parameters.

The FORV Data and Referral Centre

Aiming at advancements in research on marine living resources and environmental ecology has set up a centralized FORV Data and Referral Centre in Kochi. Major objectives of the Data Centre include creation and maintenance of an exhaustive database by way of compilation and archival of all FORV based fishery, environmental and oceanographic data collected by different organisations through sponsored projects under this programme.

FORV Data Centre at CMLRE, Kochi

Historical and current data generated so far on vertical profiles of salinity and temperature including sea surface measurements, nutrients, dissolved oxygen, primary productivity of the surface and column waters, etc., sourced through CTD, Autosal, Auto analyzer measurements / other methods such as in-situ C_{14} technique, Winkler's method, etc., have been compiled and archived in electronic format. Efforts are on for compiling, formatting, cleaning and archiving data pertaining to Particulate Organic Carbon, current speed and direction, met-ocean data, species composition and biomass of zooplankton, composition and seasonal abundance of toxic and harmful algal species, data on fisheries and acoustic surveys, qualitative and quantitative abundance of macrobenthos, DSL resources, measurements of sea bottom topography, etc. Data in the form of print / hard copies have been gathered for majority of the programmes / cruises. Preparation of time series seasonal Fishery Oceanography Data Sets for the period 1998-2001 with a 5°X5° grid resolution have been initiated.

Samples of Zooplankton and DSL organisms

Complementing the utility of data archived at the Data Centre, the objective of the Referral Centre is to preserve and maintain representative sub-samples of the marine living resources including plankton, fishery and benthic samples collected during FORV cruises for future studies and reference by researchers and academicians.

Samples of Zooplankton and DSL organisms collected during FORV Cruises have also been preserved and maintained. The Referral Centre further maintains echograms of acoustic back scattering recorded during the cruises (No.165-200), while subsequent acoustic recordings are available in digital format through the EK 60 echosounder.

Assessment of environmental parameters and Marine Living Resources and the role of Myctophid fauna in the mesopelagic habitat

Participating in four different cruises of the FORV Sagar Sampada, which covered the entire EEZ of India and different seasons, NIO, RC, Kochi, sampled and carried out studies on physical, chemical and biological parameters from 110 stations along 20 distinct longitudinal transects.

The major findings are as under:

In the Andaman waters, during the inter-monsoon (spring) the mesozooplankton biomass of the mixed layer ranged between 80 ml/1000 m^3 (more than one station) and 9729 ml/1000 m^3. The upper 50m-water column was characterized by saturated dissolved oxygen concentration (O_2 > 190 µM) and non-detectable concentrations of nutrients. A lobe of less oxygenated (O_2 < 20 µM) water was traced between 100 and 200m depths along the Western longitudes. A westward increase in the phosphate concentrations and an eastward increase in nitrate concentration were observed in deeper waters.

In the winter-monsoon in some sampling points MLD showed longitudinal variations with a minimum of 47m and a maximum of 97 m. Surface waters to a depth of 475m showed higher values of dissolved oxygen (~ 4.5 ml/l), beyond which the values drastically declined to 0.31 ml/l at about 750m with a gradual increase with depth thereafter. Low values of nitrate, phosphate and silicate in the euphotic zone combined with high oxygen values recorded suggest active primary production, which was found to support the macro and meso zooplankton biomass of the area. About 82% of the total zooplankton biomass was observed to be supported by mixed layer and thermocline layer, the general distribution revealing a decreasing trend in biomass with depth. Highest biomass (529.4 ml / 1000 m3) of zooplankton was recorded from Eastern Andaman Sea and the lowest (39.75 ml/ 1000 m3) from the oligotrophic waters of the South Andamans. An unusual swarming of cephalopod juveniles; swarms of salps, pyrosomes and a euphausid were also observed in certain areas of the Andaman waters.

In the Bay of Bengal the mixed layer depth along coastal areas ranged from 13-40 m while in the open ocean it was between 34 and 85 m. The depth of thermocline showed an increase towards higher latitudes from 150m to 211m. While the SST of the coastal ocean showed fluctuations (ranging from 25.9-27.7°C) the values remained fairly constant in the open ocean with small diurnal fluctuations. The mesozooplankton biomass of the mixed layer in the Bay of Bengal ranged between 127 ml/1000 m^3 and 533 ml/1000 m^3. The highest biomass recorded in different depths is given below:

Depth	Biomass (ml/1000 m^3)
TT-BT	5000
BT-300	368
300-500	800
500-1000	48

Nutrient rich waters (NO_3 > 2.0 µM, SiO_4 > 2.0 µM and PO_4 > 0.8 µM) with low oxygen concentrations (O_2 < 190.0 µM) were observed near the coast at certain sampling points. In certain transects the mid-depths were characterized by oxygen-depleted waters (O_2 < 10.0 µM) due to decomposition of organic matter. Like the Arabian Sea an Oxygen Minimum Zone (O_2 < 10.0 µM) exists at the intermediate depths (150-300 m) along an open ocean transect parallel to the coast. The absence of secondary nitrite patch at the intermediate waters was evident of the absence of denitrification in Bay of Bengal. Surface meteorological values show relatively high values of humidity (average of 85 %) in the Bay of Bengal region.

In the Arabian Sea the mesozooplankton biomass of the mixed layer in the Arabian Sea ranged between 68 ml/1000 m^3 and 3704 ml/1000 m^3. The average mesozooplankton biomass during inter-monsoon spring is about 163.05 ml/1000 m^3. Day and night variation of biomass during this season is about 3704/1000 m^3 at day and 2727 ml/1000 m^3 at night. The highest biomass recorded in different depths are given below:

Depth	Biomass (ml/1000 m^3)
TT-BT	305
BT-300	173
300-500	280
500-1000	72

Swarms of bioluminescent Ostracods were recorded, which were emitting blue light. Signatures of strong upwelling prevail along the southern transects of the west coast of India. The surface waters along the southwestern region of India were characterized by comparatively low oxygen (O_2 < 170 µM) and high nutrients (NO_3 > 2 µM, SiO_4 > 5 µM and PO_4 > 0.6 µM). A severe depletion in the dissolved oxygen concentration (O_2 < 5µM) was observed along the northern transects. Appreciable concentrations of primary nitrite were observed near the coast along

all transects at a depth of ~ 50m. Predominantly southwesterly winds with an average speed of 6 m/s, atmospheric pressure ranging from 1012 to 1009 mb (average 1008 mb) and MLD between 9 and 81 m depth increasing from coastal to offshore was observed during the summer monsoon.

Swarms of bioluminescent ostracods observed in the Arabian Sea

Bottom fauna of the continental slope from 200-1000 m depths of Arabian Sea and Bay of Bengal

This multi-institutional project is implemented with the School of Marine Sciences of the Cochin University of Science and Technology, Kochi as the nodal agency. The present study focuses on the benthic productivity of the continental slope region of the Indian EEZ.

A total number of 88 stations falling under 28 longitudinal transects have been taken up for sampling in four cruises during the study with 50 stations (17 transects) along the west and 33 stations (11 transects) along the east coasts. Two cruises onboard the FORV Sagar Sampada were carried out during the review year for collection of benthic and sediment samples. Analysis and identification of benthic fauna among the samples to species level are progressing at shore based laboratories.

Numerical abundance of macrofauna was found to be the highest at 250 m depth regions, which decreased towards 1000m depths. While polychaetes dominated the macrofauna, the other groups encountered were crustaceans, molluscs and echinoderms. Among meiofauna, nematodes were the dominant group followed by foraminiferans.

Maximum bacterial population was also found at 250m depths followed by 500m and 1000m depth zones. However, no such trend could be observed for fungal and actinomycete population. Fungal population was more or less the same at 250 and 1000m depths with almost double the value at 500 m depths. In the case of actinomycetes the population was the highest at 250 m depth and the lowest in the 500m depth zones. Among the 17 transects studied along the west coast of India the microbial population was found to be the maximum in the regions off Mumbai.

Development of Acoustic Techniques for Fish and DSL biomass estimations

Department of Electronics of the Cochin University of Science and Technology, Kochi is the nodal agency of this project.

Target Strength (TS) of the fish is a stochastic parameter. Hence target strength measurements of certain dead species of different length groups, covering different aspects such as dorsal, ventral, and lateral at different angles from 0 to 90 degrees were conducted, under controlled conditions in a laboratory. Physical models have been developed for sardine and ribbonfish. The validation of this model vis-à-vis correlating the model TS values with the measured TS values has been carried out.

Dentalium sp. and Ophiuroids among dredge samples collected from 1000 m depth off Kochi

A field trial was conducted for ensuring the suitability of the cage for TS measurement at the floating platform facility of NPOL The calibration of ES-60 was conducted by setting up the standard target for 120 kHz underneath the transducer mounted by the rigging method.

To gather the TS values of commercially important species such as sardines, mackerels, anchovies and ribbonfish, an in-situ measurement was conducted using FORV Sagar Sampada. Modeled and experimental Target Strength of sardines and ribbonfish is given below:

Modeled and experimental Target Strength of Sardines

Fish dimensions				Modelled Target strength(dB)	Experimental Target strength(dB)
Fish length(Cm)	Weight(gm)	h/b(cm)	t_a /t_m /t_p (cm)		
20.5	90	4.7/2.7	2.7/1.7/0.6	-44.59	-45.18
19.8	70	4.9/2.4	2.4/1.6/0.6	-45.16	-45.83
19	90	4.5/2.4	2.4/1.8/0.6	-45.25	-45.25

Modeled and experimental Target Strength of Ribbonfish

Species	Total length (cm)	Weight(g)	Direct TS	Model TS
Live Ribbonfish	50 54 58 59 75	135 110 140 160 ---	-45.5 -46.0 --- -44.0 -36.5	-45.50 -45.00 -44.75 -43.50 -37.00
Dead Ribbonfish	90 75		-33.5 -36.5	-30.50 -37.00

Live sardines and mackerels collected for TS measurements

Deploying the cage and mount for TS measurements from the FORV

Studies on marine mammals of Indian EEZ and the contiguous seas

CMFRI, Kochi being the nodal agency has procured the essential Geographical Information System (GIS) software and necessary training on the use of this software has been imparted to the scientists associated with the project activities. A field identification key has been prepared for onboard and onshore observation of marine mammals. A Workshop to impart training to the scientists and researchers involved in the implementation of this project was organized. A training manual was also prepared and distributed to the participants of the Workshop.

Since November 2003 in all the FORV cruises a study on mammals in the Indian seas and also relevant environmental and oceanographic observations for correlation studies were carried out. In total, over one hundred and fifty instances of sightings of marine mammals including dolphins and whales have been reported. The identified groups/species include humpback dolphins (*Sousa chinensis*), bottlenose dolphins

(*Turisiophs sp*) and gray spinner dolphins (*Stenella longirostris*), common dolphin (*Delphinus delphis*), etc.

Harvest technology and catch composition of deep sea fishery resources

The research project 'Harvest Technology and Catch composition of deep sea fishery resources in the Indian EEZ' was completed and final report submitted to the Department of Ocean Development.

Main thrust was given to design and optimization of demersal and mid-water trawls, trawl configuration measurements and studies on selectivity of square mesh and diamond mesh cod ends with respect to selected deep-sea finfish and shellfish resources. The development and optimisation of trawls for exploitation of deep-sea fishery resources will be highly beneficial to the fishery industry and entrepreneurs. The use of square mesh cod-ends and square mesh panels will facilitate the escapement of juveniles and sub-adults and reducing the quantum of by-catch thus contributing to resource conservation. The distribution of finfish and shellfish off the west coast and east coast of Indian EEZ, seasonal abundance and gear-wise catch composition and comparative efficiency of demersal trawls were the aspects covered in the study.

Study on biodiversity of phytoplankton and zooplankton with special emphasis on island ecosystem

Regional Centre of the National Institute of Oceanography, Kochi is the implementing agency. Collection and compilation of available data/information on zooplankton is being carried out for the preparation of handbooks on zooplankton of the Indian EEZ and methods of monitoring marine ecosystems. Collection of samples in relation to thermocline to a depth of 300m in the open ocean stations and by vertical and oblique hauls from bottom to surface in coastal stations on board FORV Sagar Sampada has been initiated. 70 species of phytoplankton have so far been identified from the 35 samples collected from 7 stations, which included diatoms and dinoflagellates. Dominant among the zooplankton where copepods, followed by chaetognaths, euphausids, decapods, fish larvae and ostracods.

Predictive modeling of Bombay duck landings off northwest coast of India

Data on length composition and weight of Bombay duck and golden anchovy (*Coilia dussumeri*) were collected since August 2003 from 5 landing centres in Maharashtra and one in Gujarat. Historical data on annual landings of Bombay duck, non-penaeid prawns and golden anchovy were collected for the period 1961 to 2002 for the northwest coast of India.

Preliminary analysis of data was carried out using univariate Autoregressive Integrated Moving Average (ARIMA) model. These models combine three processes viz. auto regression (AR), differencing to strip off integration (I) of the series and moving average (MA). Autocorrelation and partial auto correction coefficients up to lag 16 were worked out to tentatively select one or more ARIMA models.

Predictive modeling in marine fisheries of southwest coast of India

Time series data on quarterly landings of different species/groups in Kerala during 1960-2000 were collected and stored in the format necessary for time series data analysis. For the time series data on total marine fish landings intervention analysis was carried out. Using time series data on quarterly total marine fish landings at Cochin Fisheries Harbour and Mean Maximum Temperature at Cochin, periodograms were computed and seasonal and cyclical components estimated for both the series.

Farming and pearl production in the black lip pearl oyster Pinctada margaratifera in Andaman and Nicobar islands

Central Marine Fisheries Research Institute is the nodal agency for implementation of this project, which commenced its activities during the current year. The activities initiated include:

- Selection of sites for setting up hatchery and farms for spat collection and farming in A&N Islands.
- Preparation of design for *P. margaritifera* hatchery in A& N Island.

Pinctada margaratifera collected from the Andaman Waters.

- Identification of water intake and storage system for the hatchery operations
- Training of recruited project staff in identification of molluscs, farm construction and maintenance.

Investigations on toxic algal blooms

This programme taken up for implementation during the 9th Plan period completed its activities during the current year. Entire Indian EEZ was monitored through 34 FORV cruises covering 761 sampling stations, representing almost all 1°X1° grids and all seasons. In all 392 species of microalgae belonging to 10 orders, 40 families and 99 genera were identified, of which 52% were diatoms, 42% dinoflagellates and 4% blue green algae. Maximum species diversity was shown by the genus *Ceratium* represented by 37 species followed by the genus *Peridinium* with 31 species. It was observed for the first time that dinoflagellates were predominant than diatoms with distinct regional variations (coastal) along the west coast of India. Among the blue green algae only *Trichodesmium* species appeared in blooms. No distinct relationship was noticed between nutrient abundance and occurrence of *Trichodesmium* blooms. Blooms of *Trichodesmium theibautii* appeared only along the west coast of India and the Andaman Sea. The quantity of chlorophyll-a in the areas of blooms depicted a concomitant reduction towards the bottom. Phosphate concentration was indirectly proportional to chlorophyll-a abundance. Only 3 blooms of *Noctiluca miliaris* were observed during the period and appeared only along the west coast of India. Thirteen cyst-forming dinoflagellates were observed, of which 9 were toxic microalgae.

Studies on the near shore dynamics of the southwest coast of India with special reference to upwelling and mud banks.

Investigations on the oceanographic and environmental parameters in the near shore waters along the southwest coast were initiated.

5.2 Drugs from Sea

The work on the two marine organisms identified for product development as anti-diabetic and anti-hyperlipidaemic has progressed quite satisfactorily. The anti-diabetic agent extracted from CDR-134 has been found to be safe in monkey. Chronic toxicity and genotoxicity and initiation of Phase-I clinical trials are in progress. The Committee for the purpose of control and supervision of experiments on animals has given clearance to conduct 90-days toxicity studies of anti-hyperlipidaemic compound in monkeys. Quality parameters for the anti-hyperlipidemic compound have been assessed and found quite safe for toxicity studies. Extracts of organisms showing promising biological activities earlier were subjected for reconfirmation of bioactivity and a few of these have been identified for follow-up studies. A total of 16 leads in the areas of diabetes, dyslipidemia, antifungal antiviral, larvicidal and spermicide have been identified from these extracts and these have been confirmed repeatedly and product development work has been initiated on some of these extracts. Besides these, three NIO-extracts have also shown promising CNS activity.

Extensive sampling for newer organisms in Andaman and Nicobar waters, in the offshore waters of Vizag and other areas, was carried out. Over 250 new marine flora and fauna for general and specific biological screening and repeat collection of over 300 marine species was also made for the confirmation of the biological activities and for follow-up studies. Over 1500 samples have been subjected to bio-evaluation. The biological activities of crude extracts from the participating laboratories were evaluated.

Marine organisms useful for production of bioactive substances

In addition, sixty-four compounds were isolated and characterised, among these 5 were new and remaining 59 were known compounds. CDRI has published four issues of "Ocean Drugs Alert" Bulletin with special emphasis on the international patents on marine products. 119 spectra (NMR, 1H and 13C, CIMS, EIMS, FABMS, GCMS, FTIR) were run for the participating institutes under analytical facilities at CDRI, Lucknow. Data on 417 samples were entered and the database is being updated. 111 voucher specimens have been deposited with National Repository at NIO Goa.

5.3 Assistance to Research Projects & Manpower Development

The Department of Ocean Development lays emphasis on encouraging Universities and academic institutions besides the national research laboratories in building up a skilled human resource base in Marine Sciences. The objectives of this programme are to encourage cutting edge research in newly emerging and frontline areas of Marine Geology and Geophysics, Marine Biology, Marine Ecology, Exploration and Exploitation of Marine Resources, Coastal Engineering, etc., with a view to create infrastructure facilities in Universities and to inculcate scientific temper among the people in relation to marine science and technology.

Presently 98 research and development projects are being supported in the inter-disciplinary field of Marine Science and Technology. This includes 12 projects exclusively under Marine Manpower Development Programme and 86 projects being supported under the Ocean Science and Technology Cells set up in the chosen priority areas viz., "Marine Microbiology" at Goa University, "Marine Geology & Geophysics" at Mangalore University, "Beach Placers" at Tamil University, "Coastal Marine Culture Systems" at Andhra University, "Marine Biology" at Annamalai University, "Marine Benthos" at Cochin University of Science & Technology, "Marine Coastal Ecology of West Coast" at Bhavnagar University, "Marine Coastal Ecology of East Coast" at Berhampur University and "Ocean Engineering & Underwater Robotics" at IIT, Kharagpur. In addition to this 8 projects are being supported outside the purview of the OSTCs in various disciplines of ocean sciences.

Some of the major accomplishments under the OSTC programme during the period under report include:

- ❖ Successful breeding and rearing of marine ornamental fish viz., clown fish and seahorse under OSTC on Marine Biology.
- ❖ Isolation of linoleic and linolenic acid from marine microbes; microbes/viruses responsible for shrimp disease and marine actinomycetes under the OSTC on Marine Microbiology;
- ❖ Assessment of the impact of bottom trawling on the benthic fauna along the Indian coastline under the OSTC on Marine Benthos;
- ❖ Assessment of anthropogenic pressures and impacts on the marine ecology along the east and west coasts under the OSTC on Marine Coastal Ecology, etc.;

About 200 fellowships have so far been given to various Universities/Institutes for pursuing research in these areas.

A new project on "Impact of mining on the Mandovi-Zuari estuarine system in Goa, West Coast of India - A study through remotely sensed and *in-situ* observed data," under this programme was approved. Another project entitled "India's Antarctic & Ocean Policy Research Group" was approved for implementation outside the purview of OSTC projects.

The project titled "A monograph on Indian Barnacles" was completed during this year. Under this project ontogenic and environmental variations in the normally used taxonomic characters of different species of barnacles were assessed in relation to ecological and geographical implications to barnacle phylogeny.

Another project "Amino Acid dating & biomarkers of carbonate fossils in relic sediments of the continental shelf off Visakhapatnam, East cost of India" was also completed during this period. Determination of amino acid racemization and amino acid DL ages, with reference to radio carbon ages in sediments of the SW Bay of Bengal, extraction and derivation of amino acids in 140 sediment samples of 3 cores, foraminiferal enumeration of the Tuticorin core, lipid extractions for alkenone study and their GC on more samples, were completed. The profiles of major ecologically significant foraminiferal species, amino acid racemization and geo-chemical results are in good agreement with the calibrated ages (obtained from radio carbon dates) of 6 sediment samples, three each from one core off south east coast of India.

5.4 Coastal Ocean Monitoring and Prediction System (COMAPS)

DOD has been carrying out studies relating to monitoring of marine pollution and the health of the coastal and offshore areas of the country under the programme viz. Coastal Ocean Monitoring and Prediction System (COMAPS) since 7th Five Year Plan period. The COMAPS programme has been in operation at 82 locations for systematic collection of data and analysis with respect to 25 parameters relating to physical, chemical and biological including microbiological characteristics of water and sediment. The thrust of this programme is to elucidate the trends of increase and decrease of pollutants in the sea and also the processes associated with land and sea-interface. The study also envisages concentration of heavy metals and pesticide residues. Besides, models are being developed for the evaluation of assimilative capacities of coastal marine areas for contaminant of pollution and to enable the Pollution Control Boards to evolve a mechanism for mitigating the adverse impact of pollution on marine environment, prescription of appropriate disposal standards as per the assimilation capacity of the receiving water bodies, water quality criteria, etc.

Regional Research Laboratory, Bhubaneswar; Centre of Advanced Study in Marine Biology, Annamalai University, Parangipettai; Centre for Earth Science Studies, Trivandrum; National Institute of Oceanography, Goa; Centre for Marine Analytical Reference & Standards, Trivandrum; Institute for Ocean Management, Anna University, Chennai; and National Institute of Ocean Technology, Chennai are participating in this programme, presently.

Besides the studies on chemical, biological, microbiological parameters and studies on physical oceanographic parameters, creation of facilities for referencing of important pathogenic microbes, a GIS based information system on sources of pollutants and a COMAPS database were introduced under this programme during the 9th plan.

The primary source of pollution is from domestic sewage and the industrial wastes account only 10 - 15% to the volume of domestic sewage. The pollution due to sewage by and large is observed in the estuaries, creeks and only at a few locations close to the shore. The data collected on pollution and related parameters over the past decade have indicated that the coastal waters beyond 2 km are clean through the country, except that off Mumbai, where the sea is clean beyond 5 km. Even in the areas other than Mumbai, the pollution related problems are found to be confined only in the limited areas of the sea close to cities like Chennai, Visakhapatnam and Trivandrum.

The concentration of heavy metals like lead is mostly found in the sediments and these values were higher in port areas. Otherwise, the concentration of heavy metals like mercury, cadmium and lead were low in the sediments throughout the coastline of the country.

The salient features of the observation made during the period under report are summarised and presented below:

Goa, Maharashtra and Gujarat Coasts

During the monsoon season there is a high freshwater influx and salinity varied from 5 - 30 psu at the surface and from 12 - 33 psu at the bottom. Dissolved Oxygen observations carried out during the pre-monsoon, monsoon and post-monsoon seasons indicate that these areas are well oxygenated. In general low BOD values were observed ranging from ND to 1.43, 0.21 to 1.6 and 0.44 to 1.59 in the pre-monsoon, monsoon and post-monsoon, respectively indicating that the organic matter entering the system is effectively assimilated. The pH values were within the range for normal seawater and varied from 7.45 - 8.14. Nutrients in general showed concentration normally occurring in coastal waters except for elevated values of ammonia in surface and bottom waters. Heavy metal concentrations were within the normal range occurring in coastal waters and did not follow any particular trend in distribution. The waters of Ratnagiri and Mormuagao are well oxygenated and low BOD values were observed at both transects. The concentrations of nutrients (Nitrite and Nitrate, phosphate and silicate) were low in Marmagoa as compared to Ratnagiri.

The biomass did not show much variation from coast to offshore stations. The detailed monitoring on abundance and distribution of pathogenic bacteria was carried out during pre-monsoon, monsoon and post-monsoon along the hotspots in Mandovi, Zuari, Mormugao and Ratnagiri.

Karnataka, Kerala and Lakshadweep

The water at Veli, Kerala was found to be polluted and the productivity was affected up to 2.5 km from the beach. Low DO (3.78 mg/l) and pH (2.5) values were recorded. The occurrence of phytoplankton (96 no/l) and benthos (167 no/m^2) also reflected the impact of the chlor-alkali effluents in the near shore area. The study carried out in Kochi waters indicated that the estuary was under the influence of freshwater and the tides holding considerable influence over water quality. While the benthic community was found to be less at bar mouth, the fish catch from the estuarine mouth showed considerable species diversity. There was no marked variation in bioaccumulation of trace metal concentration among the intertidal organisms. The microbiological investigation revealed the presence of potential pathogens like Shigella, Salmonella, Proteus and Klebsiella like organisms in the Kochi hotspot.

There was no wide fluctuation in physico-chemical parameters along the Lakshadweep waters. Water temperature ranged from 28.4° C to 30.2° C and salinity between 34 psu and 34.6 psu, pH ranged from 8.0 to 8.21 and dissolved oxygen between 4.2 and 4.9 mg/l. No fluctuation was recorded in primary productivity and chlorophyll-a. Among the benthic community, not much variation was noticed. The bacteriological analysis indicates highest TVC (4800 CFU/ml) in November followed by April (2900 CFU/ml).

Mangalore being the hotspot, intensive monitoring of physico-chemical, biological, and microbiological parameters in the coastal waters was carried out. Wide fluctuations in temperature (26.8° C - 31° C), pH (7.4 - 8.11), salinity (6 - 33.2 psu) and DO (2.99 - 4.94 mg/l) were recorded along with moderate nutrient concentration. The lowest value of salinity and pH were observed during low tide and the highest values during high tide. The texture analysis of sediment showed that the sand fluctuated between 76.5 and 89.6% followed by silt (8.4 - 18.1%) and clay (1.5 - 9.8%). Total suspended solids and petroleum hydrocarbon were invariably high at estuarine region. Ten different finfishes and one genus each of prawn and crab represented the fish catch at the estuary. The density of benthic community was recorded minimum, which can be attributed to the harbour activities. Faecal coliforms were in high numbers in the surface waters.

Tamil Nadu and Andhra coast

Periodical sampling was done once in a year at Chennai (Ennore, Chennai harbour, Cooum and Muttukadu), once in two years (Karaikal, Nagapatnam, Thondi, Vembar, Arumuganeri, Kudankulam, Kanyakumari, Bhimunipatnam, Kalingapatnam, Krishnapatnam, Bhuminipatnam and Gothami-Godawari). Both surface and sub-surface water samples were collected at seasonal intervals. Temperature, salinity, transparency, DO, BOD, Nitrate, Nitrite, Ammonia, Total nitrogen, total phosphorous and Inorganic phosphate were monitored. Biological variables were also studied, which included pathogens, plankton (phytoplankton and zooplankton), pigments, productivity and benthos (macro and meio). Sediment samples were also collected and analyzed for various parameters including pathogens, heavy metal, soil structure and texture, besides chemical evaluation.

The study indicates marked differences in the water quality, concentration of heavy metal and pathogenic bacteria, plankton and benthos between stations located in the polluted and unpolluted areas. The dissolved oxygen level was recorded below detectable limits in some stations like Visakhapatnam harbour channels, Cooum and Pondicherry. Similarly, high BOD (100mg/l) and high nutrient levels were observed in Cuddalore and Tuticorin waters, respectively. In Visakhapatnam harbour the outburst of *Skeletonema costatum* (302250 / 302318 cells / l) indicates severe eutrophication of the area.

Andaman & Nicobar Islands

In Campbell Bay area the concentration of ammonia was found to be on the higher side when compared to other islands. The concentrations of phytoplankton vary between low and high tides.

Orissa and West Bengal

The untreated effluent being discharged by the OSWAL, the fertilizer industry in West Bengal is causing pollution in the region. The primary productivity in the affected area has been observed to be low when compared to the other locations.

Physical Oceanographic Studies

Physical Oceanographic Studies towards modeling purpose for waste load allocation at Visakhapatnam, Paradip, Mangalore and Goa (Mandovi River), Tapi and Thane Creek, were continued. A case study has been conducted on Visakhapatnam. The study conducted in Paradip and Mangalore revealed that the concentrations of pollutants are very low and these locations were dropped from modeling exercises.

Inter-calibration exercises

Inter-calibration exercises are carried out to ensure seawater data quality under the COMAPS project. The analytical results for total phosphorous were found to be acceptable. A special training programme was arranged for the scientists from INCOIS, SAC and Navy on the procedures for proper sampling and measurement of Chlorophyll-a in seawater. Besides, a series of studies were undertaken to compare the primary productivity of seawater by the oxygen release as well as assimilation of carbon. It is seen that the former method gives lower values compared to the latter, the major factor being contamination from ambient air, during analysis, unless proper precautions are taken. Using the modified protocol, a series of measurements on primary productivity of the coastal oceans, from Vizhinjam to Karwar were carried out. This covered the primary productivity at the surface, as well as different depths. It is interesting to note that the primary productivity does not show a uniform reduction with depth, as would be the case, if the penetration of sunlight is the only factor. This shows that there are other factors as nutrients, trace metals and the amount of chlorophyll, which are also important to influence primary productivity. Indian coastal seawater standard certified for trace metals for the first time, based on multi-technique approach has been prepared. Apart from Canadian Research Council (CANADA), no other institution has been able to successfully bring out such a standard. This standard is available for calibration purposes.

Development of GIS based database on marine pollutants

The data entry format including facility to upgrade the database has been developed and a model for Kochi waters has been evolved.

5.5 Ocean Awareness

Exhibition & Fairs

With a view to promote awareness among public and school children, Department of Ocean Development participated in the following exhibitions and fairs during 2003-04:

Technology Day Exhibition

The Department participated in the Technology Day Exhibition on 11th May 2003 organized by Department of Science & Technology at New Delhi. The 1st Ocean Science & Technology Development Award - 2003-04 was given to Dr. S.Z. Qasim, former Secretary of Department of Ocean Development by Hon'ble Vice-President of India.

INMEX - 2003

The International Maritime Expo-2003 was organized by the PDA Trade and Fairs, Bangalore during 8th to 11th October 2003 in Mumbai. The Department participated in the exhibition to showcase the scientific and technological advancements made so far under various projects and programmes. Information through brochures and booklets on the achievement in the ocean technology sector was made available to the visitors.

India International Trade Fair (IITF), 2003, New Delhi

The IITF is the most popular trade exhibition organized by the India Trade Promotion Organization (ITPO) every year at Pragati Maidan, New Delhi from 14th to 27th November. In the IITF 2003, recent achievements under Ocean Energy, Antarctic Programmes, Ocean Observation and Information Services, Deep Seabed Mining Programmes etc. were displayed. Educative films on Antarctica, the scientific programmes of the Department and ocean technologies developed by the National Institute of Ocean Technology (NIOT) and Indian National Centre for Ocean Information Services (INCOIS) were shown at regular intervals. Brochures, books and mementos were distributed to the visitors.

DOD Pavilion in INMAX-2003, Mumbai

A view of DOD pavilion in IITF-2003, New Delhi

Swadeshi Mela, Allahabad

Swadeshi Mela was organized by the Centre for Bhartiya Marketing Development at Allahabad during 6th to 11th November 2003. The objective was to showcase the latest development in research and scientific capabilities to public at large. DOD projected achievements under Polar Science, Ocean Observation and Information Services, Ocean Energy and Deep Seabed Mining Programmes. Educative films on Antarctica, the scientific programmes of the Department and ocean technologies developed by the NIOT and INCOIS were also shown at regular intervals. Brochures, books and mementos were distributed to the visitors.

Vigyan Rail - Exhibition of Science on Wheels

Vigyan Rail - Exhibition of Science on Wheels was flagged off on 15th December 2003 from Delhi. The Vigyan Rail is covering various major places in the country during the period of one year. Achievements of the Department so far under various projects and programmes implemented, were projected in the Vigyan Rail. Educative films on the scientific programmes of the Department and ocean technologies developed are also being shown periodically. To educate the visitors the activities are explained by the Department officials and brochures, books, etc., are distributed.

OCEANTEX-2004

The Department participated in the OCEANTEX-2004 - Exhibition & Conference organized by Chemtech Foundation from 11 to 14 February 2004 at Mumbai. Major activities and achievements of the Department were displayed through panels and multimedia and printed materials distributed to the visitors.

Rajasthan International Trade Fair-2004.

DOD participated in the Rajasthan International Trade Fair-2004 organized by Pacific Creative Society, New Delhi from 21 to 28 February 2004 at Jaipur. Major activities and achievements of the Department were displayed through panels and multimedia.

Seminar/Symposia/Conference/Workshop, etc.

In order to exchange information and views among the scientists, user community and general public and also to support the scientific and technological activities in the ocean sector, 35 International and National Seminars/Symposia/Workshop etc., were sponsored on ocean and related topics.

International Conference on Coastal and Ocean Technology (COT-2003)

In commemoration of the completion of a decade of service to the nation by NIOT in the area of ocean technology, a three-day International Conference on Coastal and Ocean Technology (COT-2003) was held at NIOT during December 10 - 12, 2003. Over 175 delegates from USA, Japan, Denmark, Germany, Canada, UK, Norway, Russia and India participated and presented their observations and findings. A total of 65 papers and a special lecture by Secretary, DOD on Gas Hydrates -the future source of energy for India, were presented. A technology demonstration-cum-exhibition was also held, in which 12 exhibitors highlighted the latest marine instruments available for underwater surveys.

ARMEX Workshop

DST sponsored Workshop on Arabian Sea Monsoon Experiment (ARMEX) to discuss the results of the scientific experiments was held at National Institute of Ocean Technology (NIOT) during 22nd and 23rd December 2003. The representatives from 25 institutions and organizations presented their observations and findings in 8 technical sessions spread over 2 days of Workshop. A total of 81 papers have been presented, out of which 41 were oral presentations and 40 poster presentations.

National Seminar on New Frontiers in Marine Bioscience Research

NIOT and Society of Biosciences, Muzzafarnagar, jointly organized a National Seminar on "New frontiers in Marine Bioscience Research - MBR 2004" during 22-23 January 2004 at NIOT, Chennai. During this seminar, 62 papers were presented on three themes viz. Marine Bioactive Substances, Mariculture, Ecosystem Management and Pollution Monitoring. Totally 256 delegates, including eighty students, from 40 different Universities/Institutes from various parts of the country, participated in this Seminar. Out of 62 papers, 47 papers were oral presentations and 15 were by posters.

5.6 Integrated Coastal and Marine Area Management (ICMAM)

The Department of Ocean Development established the Integrated Coastal and Marine Area Management (ICMAM) Project Directorate at Chennai in 1998 to undertake Capacity Building activities in scientific aspects relating to integrated coastal zone management. The capacity building programme with an aim to demonstrating the application of scientific tools and techniques on various aspects relating to integrated coastal and marine area management, was funded by the International Developmental Association through the World Bank from September 1997 to June 2003. While carrying out this programme, parallel R & D programmes funded by the DOD were conceived, as an effort to ensure long-term utility of the developed capacity. In the Tenth Five Year Plan, this effort has been intensified through formulation and implementation of several R & D and application oriented programmes of environmental and social importance (http://www.tn.nic.in/icmam). The activities completed under the Capacity Building Programme and the new activities initiated during the year 2003-04 are given in detail below.

Capacity Building Programme:

GIS based Information System for Critical Habitats

The main aim of this activity was to develop an information system using Geographical Information System (GIS) for 11 critical habitats namely, Gulf of Kachchh, Gulf of Khambhat, Malvan, Karwar Islands, Cochin Islands, Kadmat island of Lakshadweep, Gulf of Mannar, Pichavaram, Coringa, Gahirmatha and Sunderbans.

Critical Habitat Information System in respect of all the above 11 critical habitats has been developed and brought out in the form of reports and Arc View and Power Point presentations. GIS and Remote Sensing were demonstrated as tools for assessing the status of the mangroves, coral reefs, mapping of sea grass beds, biodiversity of the habitats, etc. Changes in the characteristics of mangrove ecosystem, especially the mangrove vegetation coverage and the land cover changes as brought out by the Remote Sensing techniques and the overlay and change analysis facilities available in the GIS software, have clearly indicated the quantitative changes from healthy mangrove to degraded and vice-versa. It has also revealed the extent of conversion of mangrove areas to others like shrimp culture farms (particularly in Coringa, Andhra Pradesh) and mudflats to mangroves. Such information is very useful to analyse the causes for degradation and to take conservation measures.

GIS has helped in accurate mapping of coral reef in Gulf of Mannar, Malvan and Kadmat Island and to indicate the locations of patches of live and dead corals. This information is very useful for periodical monitoring of coral reef cover, assess their health and develop conservation measures. The mapping of turtle breeding grounds in and around Gahirmatha has revealed the possibility of coastal geomorphology playing a significant role for turtles to decide the area of nesting.

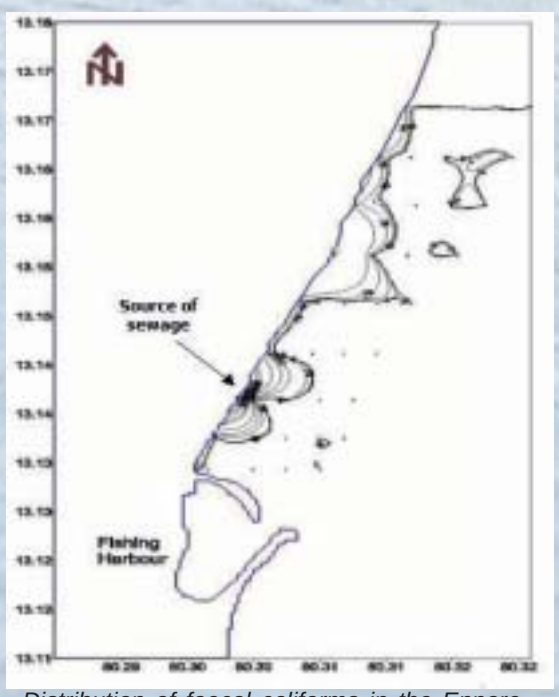
Based on the extensive studies carried out by the ICMAM Project Directorate on Development of GIS based information system for these critical habitats, a number of suggestions/recommendations have been made to the coastal states for conservation and management of these critical habitats, based on sustainability principles. For containing the degradation of mangroves in Pichavaram (Tamil Nadu) and Coringa (Andhra Pradesh),

afforestation programmes have been recommended and initiated. The Govt. of Tamil Nadu has used the GIS based coral reef maps of Gulf of Mannar for demarcation of marine protected areas or areas closed for fishing.

Determination of Waste Load Allocation and Waste assimilation capacity at selected estuaries along coastal areas of India

The concept of Waste Load Allocation based on the Waste Assimilation Capacity (WAC) of our estuaries and coastal waters is new to India. Three sites were selected to demonstrate this concept and they are, Tapi estuary (Gujarat), Ennore Creek (Chennai) and Hoogly estuary (West Bengal).

The assimilation capacity of selected pollutants like organic load (BOD) and bacteria were determined using hydrodynamics and water quality models developed for this purpose. The results obtained indicated excessive BOD load in Tapi estuary and Ennore creek and high bacterial levels along the Royapuram (Chennai) coast and in the bathing ghats of the Hoogly estuary. At Royapuram coast, Chennai, the long shore currents played a key role in distributing the bacteria from the source. Within a few hours of discharge at a distance of 2 - 3 km along shore and offshore, the bacterial concentrations reached the background level. The Pollution Control Boards of respective States were closely associated with the above exercises. The Tamil Nadu. State Pollution Control Board is drawing up plans for treatment of sewage. The Tapi Municipal Corporation has been made aware of the extent of the problem. The project was implemented through the National Institute of Ocean Technology (NIOT), Chennai.



Distribution of faecal coliforms in the Ennore Coast

Development of Guidelines for Environmental Impact Assessment (EIA) studies for marine and coastal developmental activities and processes

EIA Guidelines have been developed through NIOT for conducting Environmental Impact Assessment studies in the Ports and Harbours, tourism related activities in the coastal marine areas and for waste disposal from domestic and industrial sources including discharge of waste through pipelines, etc.

The guidelines prepared for Ports and Harbours address the following issues:

- National and International Environmental regulations relevant to port and harbour projects
- Screening and scoping to determine the type of EIA.
- Baseline studies.
- Prediction of Environmental impacts.
- Risk assessment factors.
- Environmental Management Plan (EMP) to mitigate and offset the adverse environmental impacts including cross-impacts of the project and to protect the environment, and
- Environmental Impact Statement (EIS) giving details of the studies carried out for EIA.

The EIA guidelines for wastewater disposal through marine outfalls address the following issues:

- Environmental legislation applicable to locate an outfall facility in the coastal zone, discharge standards of treated waste water and coastal water quality criteria for different uses.
- Baseline assessment.
- Analysis of alternatives

- Alternative selection of pipeline route.
- Alternative technology i.e. alternative wastewater treatment and disposal option.
- Environmental impacts of marine outfalls.
- Optimisation of the location of the outfall and design, and
- Monitoring the performance of a marine outfall.

The guidelines on the EIA for coastal tourism developed by NIOT highlight:

- Nature of projects,
- Data required for the feasibility study,
- Techno-economic feasibility analysis,
- Environmental clearances required for setting up of the projects,
- Comparison of the tourism projects with alternative projects,
- Evaluation of impacts,
- Baseline assessment of air, land and water environments,
- Prediction of impacts and environmental management.

These guidelines would be useful in pre-project evaluation of the impacts of tourism and for ensuring sustainable use of the natural resources like groundwater, beaches, etc. and protection of beach vegetation, beach fauna, etc.

Development of model Integrated Coastal and Marine Area Management (ICMAM) plans for selected sites along the coastline of India

The concept of integrated coastal and marine area management is being practised in various countries to minimise cross-sectoral impacts. Lack of application of appropriate evaluation tools to predict the cross-impacts of a target activity leads to improper assessment of likely negative impacts and, as a result, the non-target sectors experience unexpected damages. Therefore, it was proposed to demonstrate the use of tools and techniques like GIS, Remote Sensing and Mathematical Modelling in the prediction of cross-impacts by thoroughly analysing the problems using these tools. Solving the cross-impacts is the basic requirement of an integrated management. Hence, it was felt that by preparing model Integrated Coastal and Marine Area Management (ICMAM) Plans, the practical utility of above tools can be demonstrated. Accordingly, model ICMAM Plans have been prepared by ICMAM-PD for Chennai, Goa and Gulf of Kachchh, where a variety of activities are performed along the coast and some of them have cross-impacts on these sectors.

ICMAM Plan for Chennai

The model ICMAM Plan for Chennai has been prepared by ICMAM-PD in association with Tamil Nadu State Govt. and Indian Institute of Technology, (Madras) Chennai. Modern tools like GIS, Remote sensing, and Numerical Modelling (MIKE-21) were used to analyse the issues in the 40 km stretch of Chennai coast extending from Pulicat Lake in the north to Mahabalipuram in the south and for prediction of impacts due to natural and anthropogenic perturbations. Resources, environment and society were taken as criteria to analyse various issues along the Chennai coastal zone. Erosion, accretion, pollution and conflicting land uses due to tourism development were identified as the major issues for Chennai.

The problem of accretion or siltation at the mouth of Adyar and Cooum estuary, Ennore Creek and Pulicat Lake were studied in detail and appropriate solutions like construction of training jetties have been suggested. Different options for waste management in tidal estuaries like Cooum and Adyar have been suggested so that the pollution arising from the domestic sewage in the coastal waters with pathogenic bacteria can be minimized. The issue of coastal erosion at Royapuram, has also been dealt with in detail, where construction of groins/ landing features to solve the erosion problem has been suggested. In order to avoid use of highly rechargeable coastal land along the east coast road from Thiruvanmiyur to Kovalong for tourism and human settlement, which results in conflicting land use, suggestions have been made, not to permit tourism projects that involve large-scale concrete constructions.

ICMAM Plan for Goa

The ICMAM Project Directorate, in association with Govt. of Goa and National Institute of Oceanography, Goa, is engaged in the development of an ICMAM Plan for the coastal areas of Goa. Goa, being the smallest coastal state of the country, is blessed with good forest cover and picturesque beaches. Compared to other states in the country, the coastal areas of Goa are by and large free from major environmental problems like pollution and erosion. It has high commercial value in the form of beach tourism. The investigations made under the ICMAM Plan have revealed that at present there are very little or no environmental problems in the coastal areas of Goa. However, there is a threat of excessive beach tourism in the future. The likely sewage pollution in the event of population increase along the Mandovi estuary has been simulated and it was found that even if the present bacterial load increases by 5 to 6 times, and maintenance of present hydrodynamic conditions sustained in future, there would not be any bacterial pollution in the estuary. The ICMAM Project Directorate has studied the possible impact of excessive tourism activities and predicted negative effects. Integrated management solutions to avoid such problems in future have also been suggested. The plan document is in the final stage of completion.

ICMAM Plan for Gulf of Kachchh

The Gulf of Kachchh (GOK), a large marine ecosystem in the state of Gujarat, encompasses coral reefs and mangroves at its southern coast and mangroves at selected locations along the northern coast. The GOK has a tidal amplitude ranging from 3 to 8 m. The developmental activities like construction of ports and human interventions like mining of corals, destruction of mangroves to expand the saltpan activities etc., have extensively damaged the corals and mangroves in the region.

Map showing locations of tourist beaches of Goa

Due to its proximity to the Arabian Gulf, the GOK has attracted establishment of facilities like ports and Single Point Mooring (SPM) stations for handling large amount of crude oil. The ports and SPMs at GOK handle 40% of the import oil requirement of the country. Due to handling of such large volume of oil (about 40 million tonnes) the threat of oil spills always exists. In the event of oil spills, the rejuvenating corals and protected mangroves will experience extensive damages. Extensive data have been collected through a joint field programme with NIO, and hydrodynamic, water quality, oil spill and sediment transport models have been developed to study the impact of developmental activities and oil spills on the ecosystems of the GOK. In the event of oil spill occurring near SPMs, the oil spill models have predicted extensive damages that will be caused to the corals, mangroves and mud flats. The plan has also suggested measures for disposal of dredged spills by ports, so that transportation of silt and their deposition on coral reef areas can be avoided. Several strategies have been suggested for integrated management of the environment and resources of GOK in the ICMAM Plan for GOK.

Map of Gulf of Kachchh showing locations of mangroves and coral reefs

R & D Projects initiated during the 10th Five Year Plan period

The activities undertaken during the year 2003-04 under the programmes initiated during the 10th Five Year Plan are given below:

Marine Ecotoxicology

The Government has prescribed marine disposal standards for effluents arising from municipalities and a variety of industries. In order to ensure that the resultant seawater quality, as a result of discharge of these wastes is not detrimental to marine organisms, limits have to be set on the load of chemical and biological substances that will be disposed into the sea. These limits are often decided by prescribing safe limits of these chemicals to marine organisms. They are generally termed as Ambient Seawater Quality Standards. These standards vary from organism to organism and may vary for each type of habitat.

In India, the Central Pollution Control Board (CPCB) has prescribed Primary Water Quality Criteria for different uses of seawater. They are for the basic parameters like dissolved oxygen, bacteria, etc. However, attempts are yet to be made to prescribe standards for harmful heavy metals, pesticides, etc., which reach the marine environment through industrial and agricultural sources. To facilitate development of such standards, the ICMAM-PD has launched a marine eco-toxicology project.

A view of the Ecotoxicology laboratory

The main objective of the project is to determine habitat specific water quality standards for heavy metals, pesticides, oil residues for coastal waters, estuaries and habitats like coral reefs and to facilitate better management of water quality in these areas by the State Pollution Control Boards. The task is being carried out by ICMAM-PD, in association with Madurai Kamaraj University (Madurai), ALM PGIBMS, University of Madras (Chennai) and Institute for Ocean Management, Anna University (Chennai). It is proposed to determine the water quality standards for above said chemicals using various groups of animals ranging from planktonic larvae up to marine fishes under a continuous flow through system. Histo-pathological studies will also be conducted as a supportive evidence for toxicity.

A continuous flow system has been designed and fabricated by the Scientists of ICMAM Project Directorate. Several flow though experiments are planned along with project staff of Anna University. The experiments conducted using fry of estuarine/brackishwater animals like *Thilapia mosambica* indicated the LC 50 value of 1.2 to 1.6 ppm for copper sulphate. These results will be confirmed for larval stages of other commercially important animals like shrimp, estuarine fish, etc. Experiments are in progress to test the other heavy metals like lead, mercury and also the organic pollutants like DDT and Endosulfan.

Ecosystem Modelling approach for Area Management

Recent experiences in studying the coastal and marine ecosystem revealed the need for a holistic approach to understand the bio-geomorphological changes that are prevalent in the ecosystem and the resultant impact on their productivity. In order to demonstrate the use of this concept for management of the ecosystem model, areas such as Vedaranyam lake (Tamil Nadu), Chilka lake (Orissa) and Kochi Backwaters (Kerala) have been selected. The project activities are being carried out by ICMAM-PD in association with Centre for Environmental Studies, Anna University (Chennai), Andhra University, Visakhapatnam (Andhra Pradesh), Chilka Lake Development Authority (Orissa) and Regional Centre, National Institute of Oceanography, Kochi (Kerala). Preliminary studies conducted jointly by ICMAM-PD and Centre for Environmental Studies, Anna University for nutrients and productivity at Vedaranyam Lagoon indicate the low productivity despite favourable nutrient concentration, which is as a result of turbidity.

Preliminary hydrobiological investigations conducted at Chilka lake to select a zone suitable for modelling resulted in the selection of middle zone for this purpose, as it shows dynamic changes in hydrological conditions.

Kochi backwaters, a zone opposite to Regional Centre, NIO, Kochi has been selected for modelling. Extensive data on tides, currents, nutrients and productivity have been collected during November 2003 and March 2004. The data are being subjected to the modelling studies.

Management of Tidal Inlets

The tidal inlets like the mouths of creeks, lakes and estuaries play a vital role in exchange of chemical and biological elements that are essential to sustain the productivity of the ecosystem. Due to manmade activities like construction of breakwater, reclamation of land, etc., around these water bodies, there are evidences of severe accretion at their mouths (inlets) resulting in the poor exchange of water between the estuary/lake/creek and the adjoining sea. Formation of sandbars etc., caused by accretion is preventing the outflow of wastewater from these inland water bodies into the sea, increasing the pollution levels in these inland water bodies. Prolonged closure of the mouth also has other impacts like percolation of polluted water into the nearby grounds, affecting the water quality in the household wells. It is proposed to study the causes of accretion of selected tidal inlets along the East and West coasts of India using mathematical modelling techniques and suggests remedial measures for perennial opening of mouths of these water bodies. Ocean Engineering Centre, IIT-M (Chennai) and National Institute of Technology Karnataka, (Suratkal) are involved in these project activities.

Satellite picture of Kochi Backwaters

Vellar Estuary - a Tidal inlet in Tamil Nadu

Preliminary investigations have been made by a joint team of ICMAM-PD and Indian Institute of Technology, Madras, at Muthukkadu (near Chennai) and Vellar estuary (TN) and prevalent hydrodynamic conditions have been understood. Based on this information, a detailed data collection exercise to measure tides, currents and bathymetry has been initiated during March 2004.

Shoreline Management

The developmental activities like construction of ports and harbours, shore protection measures, expansion of beaches for tourism activities etc., have altered the coastal processes, resulting in periodical erosion of the beaches and loss of human habitats like fishermen villages. These problems are prominent at most of the locations along the coasts of Kerala, Tamil Nadu, Andhra Pradesh, Karnataka, Orissa, West Bengal and Maharashtra. To begin with, these problems will be investigated at selected locations along Kerala (Kayamkulam to Munambam), Tamil Nadu (Ennore) and Orissa (Paradip) coasts.

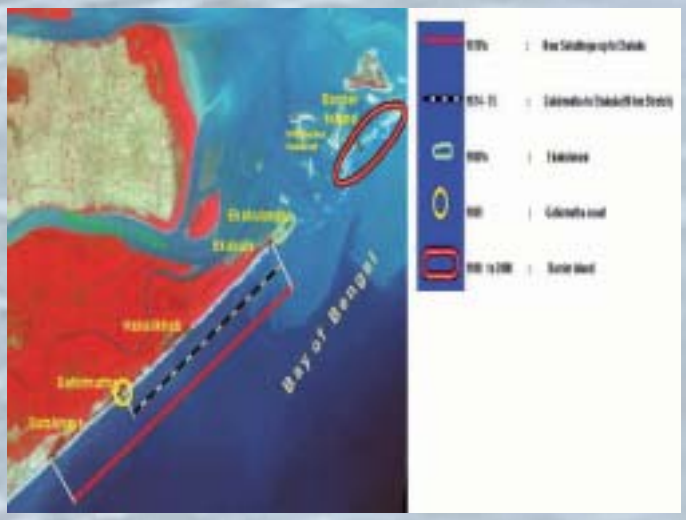
The investigations made during the preparation of ICMAM Plan for Chennai, on the effect of construction of breakwaters for Ennore Port on Geomorphology of the coast from Ennore Creek to Pulicat Lake, including the maritime areas up to 20 m depth have revealed that due to the southern breakwater, the coastal areas from southern breakwater to Ennore Creek had accreted from 50 to 350 m. The likely erosion, which was to occur in the beaches, north to northern breakwater did not occur due to sand-fill created by the Power Plant authorities using the materials dredged from the Ennore Creek. Recent satellite pictures have reveled that the accretion along the southern coasts intensified and northern sandfill areas is also eroding. As a part of the shoreline management programme, the role of nearshore shoals in preventing erosion along the northern coast will be studied. Modelling studies will also be conducted to predict the likely erosion along the northern coast and accretion along the southern coast for a period of at least 10 to 15 years. Possibilities of further increase of accretion/erosion, if any, will be indicated by the modelling studies, paving the way for suggesting and adopting appropriate management solutions like construction of groins etc., as a part of the shoreline management plan.

Paradip is ecologically a sensitive coastal stretch, very dynamic in nature and subjected to frequent storms causing considerable damage to the long sandy beaches and the backshore of the coastal belt. There is a high degree of sediment transport along the coast due to prevalence of long shore currents and the net littoral movement towards the north. Paradip Port, the 8th major port of India, has an artificial lagoon type harbour, formed typically by a pair of breakwaters where the navigational depths are being maintained by continuous dredging. Mahanadi River, which brings a large amount of freshwater and sediment, enters the Bay of Bengal 6 km. north of port. A seawall of about 5 km length was constructed (1973-79) from the northern breakwater along the coast to prevent and control erosion of the shoreline besides sand pumping from south. The seawall is found to be successful to certain extent, however, its effect was noticed in deepening/scouring of the coast, which has resulted in shore-ward shifting of the 5 m contour by about 600 m. There is a proposal to extend the southern breakwater to increase draft in the entrance channel.

Plan view of Paradip coast and Paradip Port

Gahirmatha, an Internationally known nesting ground of Olive Ridley Turtles, is located about 20 km north of the Paradip Port. The nesting area extends approximately along 35-40 km stretch of the coastline. About 0.2 to 0.7 million Olive Ridley Turtles visit this beach during December - April for mass nesting every year. This mass nesting occurs due to the availability of suitable nesting environment like sandy beaches, elevation, soil texture, presence of wetland, backwater and brackishwater and mangrove vegetation in Gahirmatha coast. However, in the last 20 years, large-scale mortality and shifting of nesting ground towards north was observed. Preliminary observations made indicate that the unique topography, shoreline, beach profile and sediment texture of this area are continuously changing due to natural and manmade activities. There is a drastic reduction in the beach width due to erosion processes. The nesting area is also reported to be under serious threat from the erosion process.

The ICMAM-PD has initiated a Shoreline Management programme for Paradip coast with an aim to suggest measures for protection and development of the coastline to suit the nesting of turtles. Mathematical modelling



Shifting of Turtle Nesting Grounds along Gahirmatha coast near Paradip

Soreline management plan area along the Kerala coast

and GIS will be used in predicting sediment movement and identifying the vulnerable areas for erosion/ accretion to develop preventive measures against changing beach slopes in the turtle nursery areas.

The detailed shoreline management plans for protection of the Ennore coast up to Pulicat Lake and Paradip will be prepared by ICMAM-PD. The Kerala coast experiences severe erosion and accretion, which has led to loss of several acres of coastal land and accretion at river mouths/creek mouths. This phenomenon is more pronounced between Munambam and Kayamkulam stretch in the Kerala coast.

In order to study the physical and geological processes that are responsible for causing erosion/accretion, a project has been sanctioned to Centre for Earth Science Studies, Trivandrum. The project will determine the extent of erosion and accretion along the stretch and also the areas more vulnerable for such damages. It will suggest remedial measures like construction of shore protection measures after of these structures on the adjoining stretches of the coastline in causing erosion/accretion. Mathematical modelling and GIS will be used in the study. During the year mapping beach profile of this area and collection of hydrodynamic data in the adjoining sea have been taken up.

Satellite based R&D Programme

India has launched the OceanSat 1 in the year 1999 with the payload of Ocean Colour Monitor (ICM) and Multi-frequency Scanning Microwave Radiometer (MSMR). In order to develop the methodology for utilisation of OCM data for understanding the sediment transport mechanisms at selected locations, a R&D project with the involvement of National Remote Sensing Agency, Hyderabad, has been undertaken. The project will study the sediment transport mechanisms at selected locations along the East and West coasts of India.

Coral Reef Monitoring in Andaman and Nicobar Islands

Based on the preliminary survey of coral reef conducted in 10 islands of Andaman & Nicobar Group, a work plan has been developed by ICMAM-PD in association with the Forest Department of Andaman and Nicobar islands to conduct extensive survey of the distribution of the coral reefs in Redskin and Jolly buoy islands. The data collected will be used for mapping of corals in the islands and also the areas suitable for permitting tourism activities in these islands.

Training on GIS Applications

A state-of-the-art Multimedia Training Facility at ICMAM PD was established in 2001. It is having a capacity to train 25 students at a time on Integrated Coastal Zone Management (ICZM). During the year training courses on application of GIS for management of Critical Habitats and Shoreline Management, have been conducted. Over 30 participants from the Coastal States, Academic Institutions, Research Institutions and other organisations were benefited by these training programmes.

Determination of Zonation (Use Classification) of Coastal Waters

As a part of the effort to determine use classification for coastal waters, a project was implemented during the 9th Plan with the help of the Institute for Ocean Management, Anna University and National Institute of Oceanography, Goa, and use classification was determined for 18 locations. During the 10th Plan period, it is proposed to cover 10 more sites in this exercise. These are Ennore, Arumuganeri, Kanyakumari (Tamil Nadu), Kalingapatnam (A.P), Chandipur (Orissa), Cannanore, Ponnani and Quilon (Kerala), Mandovi (Goa) and Port Blair (Andaman).

The major tasks involved in this exercise are as follows:

- Documentation of water and sediment quality data collected under the COMAPS Programme along the coastal areas, location of industries and human settlements;
- Documentation of details on the coastal habitats, land use/land cover pattern, coastal infrastructure, socio-economic activities and developmental activities;
- Identification of existing coastal water uses of developed, undeveloped and under-developed areas, if any;
- Preparation of designated best use classification for coastal waters.

During the year 2003 - 04, Zonation of Coastal Waters for Ennore coast was completed. The data organisation and preparation of land use maps for other areas have been completed. Development of database to suit GIS format for these sites is in progress.

Services to other programmes

Using the trace metal laboratory facility, Scientists of ICMAM Project Directorate analysed the sediment samples provided by Andaman and Nicobar Centre for Ocean Science and Technology (ANCOST) of NIOT, Centre for Earth Science Studies (CESS), Trivandrum and Regional Research Laboratory (RRL) Bhubaneswar for trace metals like Copper, Cadmium, Lead and Mercury. High background levels of copper were found in marine sediments of Port Blair and Kochi Backwaters.

5.7 Assessment of Marine Non-Living Resources

Palaeoceanographic studies in the Bay of Bengal Fan (BENFAN)

This project on 'Palaeoceanographic studies in the Bay of Bengal Fan (BENFAN) was undertaken to generate high resolution climate change markers in the sediments of the Bay of Bengal and develop a dynamic model of sedimentary accumulation during glacial and inter-glacial periods.

To define the kinematic boundary between the Bay of Bengal lithosphere and the Andaman-Nicobar Islands, long cores (up to 14 metres) collected during the last cruise off Andhra coast in the Bay of Bengal were analysed for geo-chemical, sedimentological and micro-palaeontological investigations by various participating agencies i.e., NIO, PRL, Andhra and Madras Universities. The inference from the various studies shall facilitate meaningful conclusions with respect to the above stated objectives.

Deep Sea Mineral Exploration

i) Cobalt rich crust studies at Afansiy-nikitin and other seamounts

Cobalt rich crusts (Co up to 1%) have been reported from several seamounts from the Pacific Ocean. The seamount slopes and summits between Oxygen Minimum Zone (OMZ) and the Carbonate Compensation Depth (CCD) are most favourable for the accretion of the cobalt rich crusts. The Afansiy-nikitin seamount basin and marginal basins on Arabian Sea in the Indian Ocean are potential areas for the formation of cobalt crusts.

The Afansiy-nikitin seamount is located between 2° and 5° S latitudes and 82° to 84°E longitudes in the Central Indian Ocean Basin. This seamount covers an approximate area of 30,000 sq. km. Nearly 40% of the mount area lies between OMZ and CCD. The summit is at 1550 m water depth and the seamount is divided into two parts: northern part with steep rises and southern part mostly with flat topography having average water depth of around 3500 m. The crusts are studied with the objective of assessing the cobalt crust in the Central/Northern Indian Ocean seamounts.

A cruise was undertaken for collection of samples from Afansiy-nikitin and seamounts in the vicinity of Lakshadweep islands. Cobalt values in the range of 0.3 - 0.9% have been found in the surface encrustations of the snificial exposed surfaces of the seamounts.

ii) Tectonic and oceanic process along the Indian Ridge System and back arc basins

A joint DOD-CSIR study has been initiated to study the 'Tectonic and Oceanic processes along the Indian Ridge System and back arc basin' to investigate the following:

- Tectonic constraints on the spreading rate and ridge segmentation process
- Ridge-hotspot interaction at the ridge axis and its geophysical and geological signatures
- The structure and evolution of the Andaman Back-arc basin
- Hydrothermal mineralisation (sulphide and oxide) along the spreading centres.
- Deep ocean circulation and near seabed oceanographic parameters (particle flux, physical, chemical and biological) and their relation to tectonic processes.

In the three regions, viz. Carlsberg Ridge (CR), Central Indian Ridge (CIR) and Andaman Back-arc Basin (ABB), detailed seabed sampling, water column studies, additional mapping and geophysical data acquisition are required to delineate zones of possible hydrothermal mineralisation and to gain better understanding of the ridge crest processes.

The study encompasses investigation of the hydrothermal vent associated mineralisation in the back arc region in the Andaman Sea. The project is a comprehensive study of the tectonic, geo-chemical and other studies in the spreading centers in the Indian Ocean. The project will be supported by the DOD by way of ship time expenditure, analytical and other facilities.

6. National Institute of Ocean Technology (NIOT)

6.1 Ocean Thermal Energy Conversion (OTEC)

During September 1998, the World's first 1MW OTEC (Ocean Thermal Energy Conversion) floating barge-based power plant was sanctioned under the Jai Vigyan Mission project for demonstrating OTEC technology 60km off Tuticorin coast, Tamil Nadu. OTEC technology uses the temperature gradient available between sea surface warm water (28^{o} C) and deep-sea cold water (7^{o} C) to produce power using ammonia as working fluid with the principle of Rankine cycle.

The OTEC plant barge was constructed at Goa and all plant equipment like heat exchanger, turbine, pumps, DCS, instrumentation and electrical systems were integrated with barge. A HDPE pipe of 1m diameter and 1100m long cold water pipe forms a part of the single point mooring, apart from drawing deep sea cold water from 1000 m depth. Due to unforeseen mishap, during the deployment in March 2001, the cold water pipe system sunk to the seabed and it could not be retrieved. An External Expert Committee, constituted to review the cold water mooring system including barge plant module recommended various modifications based on the analysis, which were implemented to improve the reliability and safety of the entire system. New 1m diameter HDPE pipes each of 12m long were procured and butt fusion welded to form 1km long cold water pipe. Additional buoyancy chambers were designed, fabricated and installed in the modified mooring system for the bullet nose and main elbow in order to retrieve the pipe, in case mooring system fails. With higher confidence level, the new pipe was upended with mooring components and anchored during March 2002. But the transfer hose connection at the main elbow got detached, which was an unexpected incident. Many attempts were made to reconnect the same, but it could not be done due to bad weather. Hence the activities were stopped for carrying out the reconnection works in the next good weather season. The Barge "Sagar Sakthi" was towed back to Tuticorin port to carry out the preventive maintenance of power module equipments till next fair weather season during 2004. Subsequently after about 10-15 days, the main buoy, which was attached to the 1km pipe through pendent chain got detached and drifted. The main buoy was recovered and kept at SPIC jetty in Tuticorin.

Immediately NIOT carried out a survey at OTEC site to find out the exact state of the cold water pipe line and mooring system using Side Scan Sonar and confirmed that the mooring system with main elbow and pipe were floating at 65m water depth. An Expert Committee constituted, met at NIOT under the chairmanship Dr S.C Gupta, reviewed the methodology followed by NIOT from "Concept to Deployment/Operation" and appreciated NIOT for having taken up such a challenging project, and observed that in such challenging projects failures might happen. The committee recommended for carrying out various detailed analysis with the help of EIL, IIT (Madras), John Brown, Bangalore and thorough videographic in-situ inspection of mooring system, in order to plan realistic future course of action for retrieval and reconnection of the transfer hose. Based on detailed review, the Committee recommended for removal of buoyancy chamber from the main elbow and precautions to be taken for the reconnection works

An assessment of structural strength of buoyancy chamber floating at 65-70m water depth was carried out to evaluate survivability during monsoon period in two (2) phases by M/s Structural Engineering Research Centre (SERC) Chennai, based on the inputs from NIOT. The two phases are the structural strength assessment of the buoyancy chamber and overall state/dynamic stability analysis of the total system consisting of buoyancy chamber, HDPE pipes, elbow and all mooring components. Based on the results, M/s SERC concluded that the stresses both in the walls and welds of the buoyancy chamber are less than the yield strength of the material.

Turbine testing with an electrical motor

In order to maintain the barge equipment and the power module equipment installed against salt mist corrosive atmosphere, preventive maintenance of all mechanical, instrumentation and electrical systems are being carried out. Pneumatic leak tests were again carried out as a part of the maintenance and condenser leak was arrested. Servicing of 90kVA DG set, UPS and sensors were carried out.

In order to qualify the mechanical seal and vibration of the 1MW turbine, including cooling system, a turbine run test using 150HP motor was carried out during November 2003, but the turbine could not be run continuously due to sudden temperature rise in the buffer seal liquid. Also it was noticed that turbine outlet temperature increased to 33.9°C. This problem in the seal system was rectified by changing the cooling configuration as forced circulation system instead of thermo-siphon system with new seal.

After assembly of seal and buffer tank pressure transmitter, turbine run-test was again carried out using electrical motor to qualify the seal system in December 2003. The turbine ran continuously for half-an hour without any seal problem at the speed 700rpm.

Further tests were conducted on turbine up to 3000 rpm (full speed of turbine) for the continuous run for 24 hours on 6-7 February 2004 and found satisfactory. The DCS output (speed versus time) of 24 hours run test was computed and recorded.

While running the turbine for 24 hours, the power drawn by the motor was around 42 kW. The case temperature of the turbine during the 24 hr run test was also found to be satisfactory.

In spite of the confirmation from the results given by M/s SERC on the assessment of buoyancy chamber and mooring system, more surveys with the help of M/s Fugro Geonics Pvt. Ltd and NIOT's scientists were conducted using Side Scan Sonar during December 2003.

Due to unfavourable weather conditions and non-availability of suitable marine spread, the offshore activities for recovery and reconnection could commence only in December 2003. Even at this time, the weather was not conducive for garlanding operations though a number of attempts were made. Further attempts were made in January and February 2004 with interruption by bad weather spells during most of the time.

The garlanding operation did not yield any result with many attempts. During 5th - 7th March 2004, using the Naval DP vessel INS Nireekshak, scanning/searching for the pipe was taken up with the help of Side Scan Sonar and underwater video, but the pipe could not be located at 65 m water depth as it could have sunk to the bottom of the sea.

A new configuration for the mooring system and cold water pipe is being worked out on the advise of the Governing Council of NIOT for presenting it to the Experts.

6.2 Wave Energy

NIOT (http://www.niot.res.in) took up an in-house project to use this caisson based wave energy facility to provide desalinated water to the local community at Vizhinjam, which is capable of generating 10 cubic metres per day of potable water. The system was commissioned in June 2003, thus leading to a self-sustaining system where energy from waves is used to generate freshwater out of seawater.

Desalination plant

It was planned to test the scheme with a resistive load before connecting to the main load (RO plant). After successful completion of testing with resistive loads, the RO based desalination plant was loaded. The scheme consisting of turbine, alternator and battery-backup along with RO plant performed as predicted. Parameters such as battery current, alternator voltage, speed of the alternator, output power etc, were acquired with the help of the data acquisition system.

Using PLC, logic was built in to ensure that the system runs safely in any of the three modes namely: Wave Energy, Electricity Board or Diesel generator.Subsequent to the commissioning, performance analysis was carried out. The plant is being run daily either on wave power or EB power. TDS values are being measured to ensure water quality. System fine-tuning is under way.

Wave Powered Desalination System

The caisson based Indian Wave Energy plant at Vizhinjam, which works under the principle of Oscillating Water Column (OWC) is being utilized to power a desalination plant, which was bought off the shelf to produce 10000 liters of potable water per day to distribute to the local community. The Scheme designed for running the wave powered desalination system was simulated and tested in the laboratory to ensure that the system performance was as desired. Since the simulation and the laboratory testing showed that the scheme would be feasible, the system wherein energy from the waves is used to power a desalination system to produce fresh water out of seawater was commissioned successfully in June 2003. Fig.1 shows the impulse turbine coupled to the permanent magnet brush less alternator at Vizhinjam. The plant is run daily and the desalinated water is being distributed to the local community. The TDS level is measured before distribution to ensure the quality of water is well within the standard limits. Performance analysis was carried out and necessary parameters were acquired for future studies and analysis. Since NIOT cannot take up the water distribution, it was felt that the local Harbour Engineering Department (HED) could be requested to take over the plant. Towards this end, a meeting and a press conference was held with the Minister of Cooperation & Ports, Chief Engineer (HED) and others regarding the transfer of Wave Energy Plant to HED. Minister and the members of the press visited the site and saw the functioning of the system. They are willing to take over the plant and modalities are being worked out currently.

Wave Powered Data Buoy-BBDB

Sizing of BBDB was completed. The focus will be on pneumatic power measurements and mooring behavior in the current phase. Power module components will be taken at a later stage. The fabricated buoy will be moored off shore and data for studying its pneumatic efficiency will be collected. Fabrication of BBDB, procurement of instrumentation components and mooring chains is under progress.

6.3 Desalination

Over the last few decades desalination technologies have been used increasingly throughout the world to produce drinking water from brackish groundwater and seawater, to improve the quality of existing supplies of fresh- water for drinking and industrial purposes, and to treat industrial and municipal wastewater prior to discharge or reuse. Desalination technologies include distillation (multiple-effect evaporation (MED), multi-stage flash (MSF) distillation, vapor compression (VC), and solar distillation), reverse osmosis, electro-dialysis, ion exchange, and freeze desalination. The selection of the most appropriate desalination technology for a particular use depends on many site-specific factors.

Desalination processes are divided into (i) thermal methods, which involve heating water to its boiling point to produce water vapour, and (ii) membrane processes, which use a relatively permeable membrane to move either water or salt to induce two zones of differing concentrations to produce fresh water. The main thermal method employed is distillation, where saline water is progressively heated in subsequent vessels at lower pressures.

Besides conventional desalination technologies, Low Temperature Thermal Desalination (LTTD) is an attractive technology with vast potential. It makes use of Ocean thermal gradient across the oceanic depths for desalination of seawater. NIOT is currently pursuing research to develop the LTTD technology to accomplish the task to exploit the thermal potential for generating desalinated potable water for remote islands, where this LTTD technology is particularly suitable. A laboratory model based on LTTD technique and with a capacity of 500 lph was designed, fabricated and installed at OTEC laboratory, NIOT. Extensive studies have been carried out on the laboratory model by varying the cold-water temperature from 7°C to 15 °C and warm-water temperature from 30°C to 50°C. The freshwater generated was tested in terms of quantity and quality and it conforms to drinking water standards of BIS . In order to optimize the power requirements and to obtain maximum yield at design conditions, the entire system was elevated to a height of 4 m so as to obtain appreciable barometric sealing. A complete set of tests was conducted at elevated levels and further studies are underway. Based

on the experimental results, a desalination plant with one lakh litre/day for technology demonstration has been proposed for Kavaratti, Lakshadweep. Further experimental studies on various condensation technologies such as Direct Contact Condenser are envisaged at OTEC laboratory, NIOT for achieving maximum fresh water yield . The experimental results have provided valuable input into the design of proposed plant for Lakshadweep group of islands. For the proposed plant it is intended to draw seawater at 13°C from 350 m depth (if it were for Kavaratti) and that will be used for condensing the vapor that is flash evaporated under vacuum of about 20 m bar from surface seawater at 28-30°C. The design of complete system configuration has been completed.

6.4 Deep Sea Mining and Ocean Mining

An underwater mining system consisting of a crawler based mining machine with a flexible riser system has been jointly developed by NIOT and Institüt für Konstrüktion, University of Siegen, Germany. The system was successfully tested for 410 m depth of operation. Totally four tests have been done on the crawler. The next test will be done in 500m water depth by the end of the year 2004 to prove the reliability of the mining machine for long-term operation as well as to prove the capability of NIOT in designing & indigenising the deepsea mining system. Improvements and modifications of the crawler design are being carried out indigenously. A few conceptual designs of the launching system of the crawler were obtained of which one has been finalized which will be implemented on the vessel ORV Sagar Kanya. The specification for the Dynamic positioning system to be installed in Sagar Kanya has been finalised & the vessel will be equipped with the DP system by the end of 2004.

Bathymetry survey was carried out in two places, one off Goa and other off Gujarat. Flat areas suitable for crawler operation were identified and soil samples were also taken in the identified areas. The soil samples are now being tested to get the soil strength properties, which will be useful to finalise the site for the next test of the crawler.

A test pad with a tank for testing the crawler movement and centre of gravity test is being planned at NIOT. An area within the NIOT campus has been identified for the construction of the test pad. Analysis on the flexible riser system is being done using the software Oracaflex to study the various forces acting on the slurry pipe.

In-situ soil strength values are very useful inputs for design of underwater crawler for mining nodules from soft sea floor. In-situ soil property measurement at 6000m depths was taken up as in-house project. The cone and vane tester of the soil tester is being designed and fabricated through Sevmorgeo, Russia. The umbilical cable of the soil tester has been procured from Norway. Some accessories and peripherals of the soil tester have been procured.

A Remotely Operable Boat (ROB) is being developed for carrying out unmanned survey operations. The boat is controlled by wireless remote operation. ROB derives its propulsive power from an indigenously developed underwater thruster. The boat can be controlled up to a range of 1 km radius (line of sight). It will be operated remotely from the shore using joysticks and it can work for 4h for one full charge. A double hull boat has been fabricated by the Ocean Engineering Centre, IIT, Madras.

The Instrumentation and control scheme have been undertaken by NIOT. Control schematic has been prepared and control instrumentation finalized. Battery, Inverter and charger for the power supply subsystem was procured and tested.

6.5 Coastal & Environmental Engineering

Marine Archaeological findings:

Gulf of Cambay-Gujarat

In continuation of the major discovery in the Gulf of Cambay, detailed surveys for further confirmation were taken up during the current year, which included geo-archaeological materials collected and analysed for geo-chemical signature.

The samples were sent to institutions like the Oxford University Thermoluminescence Laboratory, Manipur University and the Physical Research Laboratory to find the age of the artifacts. Thermoluminescence dates

for the artifacts were received from the Luminescence Laboratory, Oxford and Manipur University. The dates indicate the presence of human life in the Cambay region for over 5000 years. To know the provenance of the archaeological materials, geo-chemical analyses of the archaeological and geological samples were made at NGRI, Hyderabad. The results indicate that artifacts were not run down material but from geological samples available in-situ.

Draft report of the Gulf of Cambay marine archaeological findings was placed before the Parliamentary Committee. As part of the meeting, antiques collected from the site and findings of the scientific investigation were exhibited to members of Parliament.

Poompuhar - Tamil Nadu

The marine archaeology studies undertaken at Poompuhar revealed interesting features. Further investigations are on.

Environmental Management

A mobile laboratory has been introduced for environmental analysis. This laboratory has got all the facilities for carrying out water quality and biological analysis. This enables quality control in analysis due to on-the-spot analysis being carried out at the site. It minimises the transportation time of the samples to the main laboratory and thus the quality of analysis is maximised. For the first time the mobile laboratory mobilized to the field for the first phase of survey for COMAPS at two sites, Thane creek and Tapi estuary.

EIA and Water Quality Assessments

Final Report for 'Guidelines for wastewater disposal through marine outfalls' was submitted to ICMAM-PD/DOD. Data report for field and laboratory surveys being prepared include those for Hooghly-WLA project - modeling of hydrodynamics, and first phase of survey for COMAPS at two sites, Thane creek and Tapi estuary.

Location map of artifacts collected from Gulf of Cambay for dating

Applied Research catering to the industry

The NIOT completed the surveys for Tamil Nadu Electricity Board and spelt out the modification to the coolant water intake structure at North Chennai Thermal Power Station (NCTPS) and suggestions for keeping the Ennore Creek mouth open.

Following studies were also conducted and reports submitted to the concerned authorities:

- Pre lay surveys off Dahej coast for Aban constructions for GIDC project
- Recommendations for maintenance of navigable depths in Hooghly estuary for DCI - Haldia.
- Oceanographic surveys for Vizhinjam port development for L&T.
- Engineering services for Marine Geo-technical investigations at Ennore Port
- Online data transmission for project on hydrographic survey off Chennai coast for the Chennai Port Trust for Dredging Corporation of India (DCI)
- EIA Studies for Ennore port dredging under preparation
- 'Monitoring of Environmental Management Plans' of Sanghi Industries Limited, Kachchh, Gujarat was undertaken. This is part of the third year monitoring.
- Post dredge Hydrographic Survey near berth no 8 for Tuticorin Port completed.
- Commencement of Hydrographic studies for 6 months as required by DCI at Haldia.
- HTL marking at Ratnagiri for Finolex
- Analysis of bridge failure at Daman

Prestigious projects of national importance which have been awarded to NIOT in Dec-03 and completed by March-04 are the following:

(i) Various river regulatory measures to improve the flow conditions due to heavy siltation in Jellingham Channel are being evaluated by Kolkatta Port Trust. The different schemes under evaluation seem to suggest high investment. In order to examine some short-term measures to improve the navigability, a proposal to build a submerged dyke on an experimental basis has been discussed with KoPT. Work order for experimental submerged dyke construction in Hoogly has been awarded. The first phase of work has commenced.

(ii) The Kalpasar project has been awarded to NIOT by Government of Gujarat. Preparatory work for getting the MoD clearance is in process.

(iii) Geophysical engineering surveys for detection of well heads in the east coast of India has also been awarded to NIOT by ONGC.

6.6 Marine Instrumentation

An improved version of Acoustic Tide Gauge (ATG) with microcontroller, solar power pack and telemetry facilities has been developed in association with the industry and is ready for the transfer of technology. Apart from Chennai, Tuticorin, Kochi, Mangalore and Chatham Island in Port Blair, one more ATG has been installed at NIOT premises at Minnie Bay, Port Blair with additional facilities.

Acoustic Tide Gauge installed at Minnie Bay

The first sub-system of the Integrated Underwater Survey System (IUSS), a single beam echosounder has been developed and field-tested. The Graphical User Interface (GUI) based echosounder with built-in intelligence for survey and navigation has accuracy better than 2 cm in a range of 20 metres. The tow body, which houses the transducers of IUSS, has been successfully field tested for the hydrodynamic stability.

Under the transducer development programme, a 33 kHz wide band transceiver for operation at a depth of 30 metres was redesigned and pressure tested. It was successfully evaluated for its underwater performance after satisfactory pressure testing.

Under the infrastructure development, a state-of-the-art Acoustic Test Facility for the test and calibration of underwater acoustic transducers has been successfully commissioned. The Automated Transducer Positioning System (ATPS) can position the transducers, of dimensions 1.0 m by 1.0 m and weighing up to 0.5 ton, with in an accuracy of a few mm in x, y and z directions. It can rotate with an angular resolution of 0.5°. Transducers in the frequency range 4-100 kHz can be calibrated in the tank of 16 x 9 x 7 metres that can hold 10,00,000 litres of water. Since it's commissioning the facility is being used not only by NIOT but also by other agencies like M/s. Bharat Electronics Ltd., Bangalore and other industries.

Echosounder

Projects to study the ambient noise in the oceans has been initiated under which ambient noise measurement in two places namely Chennai and Goa was successfully made at a shallow water depth of 20m and the analysis is being done. An automated data acquisition system and a small exclusive buoy for noise measurement is being developed as part of the project.

Apart from the above projects, the following national level joint projects and the projects under bilateral programme are being taken up:

a) Establishment of NIOT-NHO joint cell for the implementation of Integrated Under Water Survey (IUWS) System to meet Navy's requirements. A Project Definition Document (PDD) has been prepared and submitted to National Hydrographic Office (NHO).

b) Two proposals for Technology Demonstration of Multifunction Observatory (Benthic Station) and the Development of Acoustic Tracking System for Underwater Tow Bodies in collaboration the EDBOE, Russia have been initiated under the Integrated Long Term Programme (ILTP). The technical proposals have been prepared after mutual interaction between scientists of NIOT and Experimental Design Bureau of Oceanological Engineering (EDBOE). The projects will be implemented after signing of the formal agreement by NIOT & EDBOE.

Under the Indo-Myanmar interaction programme of Ministry of External Affairs (MEA), two ATGs have been fabricated and installed at Yangon and Pathein in Myanmar.

A project proposal on storm surge reduction disaster reduction along the Bay of Bengal bordering India and Bangladesh, supported by Ministry of External Affairs (MEA), Government of India by having a network of data buoys and Acoustic Tide Gauge along the Bay of Bengal has been initiated.

6.7 Ocean Science and Technology for Islands (OSTI)

Under the programme on Ocean Science & Technology for Islands (OSTI), fattening, breeding and larval rearing of lobsters and mud crab in relation to water quality management, disease control, biochemical analysis, and studies pertaining to deep ocean water aquaculture were the major activities taken up. Further, studies were also conducted on biofouling control measures in heat exchangers of OTEC plant. One cruise on board vessel FORV Sagar Sampada around Andaman islands, to collect petroleum hydrocarbon data in 10 degree channel and trawling for collection of samples under the National project on development of potential drugs from ocean was undertaken. Technology development activities for lobster and mud crab cage culture in open sea were successfully demonstrated for the benefit of coastal communities at Tharuvaikulam Tamil Nadu and South Andaman Islands. Under the Coastal Ocean Monitoring and Prediction System (COMAPS) project, regular sampling was completed around Andaman and Nicobar islands. About 150 samples were collected and analyzed under the programme on development of potential drugs from the ocean.

The significant achievements made by this group under the programme on Ocean Science & Technology for Islands are as follows:

- Intensive research efforts on understanding the breeding and rearing aspects of lobster resulted in successful completion of larval cycle of scyllarid lobsters. The larval phase was completed within a period of 51 days. This is the first report on the completion of larval cycle of this species and the larval rearing can be taken up for providing lobster juveniles for marine aquarium.
- The phyllosoma larva of Panulirus homarus has been reared to the VII stage for the first time.
- Phyllosoma larvae of the sand lobster Thenus orientalis has been grown to the III stage and that of the scyllarid lobster Petrarchus rugosus to the VI stage.
- For the first time in In dia, Panulirus ornatus was bred and spawned under captive conditions.
- NIOT in collaboration with the Department of Fisheries, Tamil Nadu has initiated a societal programme for transfer of lobster fattening technology to fishermen of Tharuvaikulam, Tuticorin District. The sea cage designed by NIOT, is first of its kind was deployed on 15th May 2003, in the sea near Tharuvaikulam and lobsters were grown from small size to large marketable size, using natural feeds available locally, collected by the beneficiaries. Three more cages have been deployed in the same area, as requested by the local fishermen. This is a good example of laboratory technique being transferred to the field to the economical benefit of the coastal community.
- A deep-sea lobster collected from 360m depth between Andaman & Nicobar group of Islands is reared successfully for the past nine months in sea front laboratory of NIOT for the fist time in India.

Stocking of juvenile lobsters in new cages distributed to coastal communities at Tharuvaikulam

- During the studies on hormonal control of female reproduction in the spiny lobster, Panulirus homarus, the involvement of serotonergic neurons has been identified. The females with different stages of gonadal maturation exhibited varied levels of vertebrate-type of steroids (estradiol-17ß and progesterone) during radio-immunoassay implying their regulatory role during ovarian recrudescence.
- Another aminergic factor responsible for the control of moulting, namely, dopamine has been identified in lobsters during various stages of moulting.
- A formulated feed designed for spiny lobster was successful in elevating the level of certain essential poly-unsaturated fatty acids during growth studies.
- Protein enrichment studies were carried out in Artemia through liposomes encapsulated with bovine serum albumin. Artemia fed with liposomes encapsulated with bovine serum albumin showed higher growth and survival rate than Artemia fed with liposome without bovine serum albumin. This technology is being applied for the bio-enrichment of Artemia nauplii with essential nutrients for rearing phyllosoma larvae of lobster.

Panulirus ornatus spawner developed under captivity

- A cruise onboard FORV Sagar Sampada to Andaman Islands was undertaken during 12 - 28th June 2003 for collecting baseline hydrographic data and biodiversity assessment in the seas around South Andaman. Benthic marine animals were also collected during the cruise for screening of potential drugs under the programme "Drugs from sea".
- Petroleum Hydrocarbon analysis revealed that the concentration is relatively less as compared to the data reported in the coastal region of Indian coast.
- A prototype test system has been developed to investigate changes in heat transfer coefficient with respect to time as a function of biofouling. To correlate the obtained K value with fouling thickness, bacterial density & bacterial biomass on heat transfer efficiency using the OTEC thermal cycle as a model the Logarithmic mean temperature difference method (LMTD) was used.
- Continuous monitoring of Port Blair Bay, studies on the sea level changes using the Acoustic Tide Gauges installed in Chatam jetty and Minnie Bay, continuous monitoring of meteorological parameters using an automatic weather station, etc., were carried out.
- As part of island social economic development, the mud crab fattening technology was disseminated to fisher folks in Havelock and Kadamatala islands. A Training-Workshop was organised for three villages, viz. Brindaban, Steward Ganj and Shoal Bay.
- A "Beach clean up campaign" was conducted at Govinda Beach in Havelock Island as part of coastal pollution and environmental awareness programme.
- A training on lobster sea cage culture was imparted to 12 women from a Self Help Group identified by the Government at Tharuvaikulam.
- A Marine Bioinformatics Centre has been established at NIOT and a training to students pursuing Post Diploma Course in Bioinformatics is being undertaken by NIOT. So far, 13 students have been trained.
- 15 Post Graduate students have completed their project work at OSTI.

7. Coastal Research Vessels (CRV)

The Coastal Research vessels Sagar Purvi and Sagar Paschimi are used for Coastal Ocean Monitoring and Prediction System (COMAPS) programme of DOD and also for Integrated Coastal and Marine Area Management (ICMAM) programme. These vessels have completed 54 cruises for 12 Institutions along the west and east coasts of India during the year 2003-04.

During the above cruises, these vessels undertook CTD castings, ADCP observations, dredging, water sampling, current meter moorings, gravity cores, trawl net operations, plankton net operations and recovery of two sediment trap moorings, etc. The onboard scientific equipment CTD has been upgraded with pH, turbidity, and chlorophyll sensors and zoom stereomicroscope with live imaging digital camera.

Sagar Paschimi was used as support platform for launching of OTEC pipeline. The vessel collected vital baseline data at site, apart from providing logistics support. During one of its voyages, NIOT discovered interesting sub-sea features off Poompuhar pointing to ancient archeological features. Vessel Paschimi was chartered by M/s. Fugro Geonics Mumbai for physical oceanographic survey off Gujarat coast. A deep towing winch was designed, fabricated, installed and commissioned onboard this vessel for Magnetometer and Side Scan Sonar survey for ONGC project for locating oil wells off Kakinada.

Sagar Purvi circumnavigated Sri Lanka to meet the demand of vessel time in west coast. Both the vessels were operated in tandem in west coast during the peak demand time. Purvi was deployed at archeological site at Gulf of Cambay for over a month and conducted dredging and Side Scan Sonar survey. Vessel responded for emergency location of OTEC main buoy and Side Scan Sonar survey at OTEC site locating the pipeline. A-frame facility was utilized for recovery of two sediment trap moorings deployed off Goa for LOICZ project. A cruise from Kochi to Lakshadweep Island for 12 days was undertaken for various programmes such as validation of satellite data using underwater radio meter, Coral study, thermocline and Bathymetry survey for desalination plant, etc. Sagar Purvi was deployed for Kalpasar Project. British Gas India chartered the vessel for pollution monitoring off Mumbai.Additional facilities like IMO standard sewage treatment plant, A-frame of 1.5 ton capacity and extended aft deck for more working space have been created on board Sagar Purvi. Multi-beam Installation for deep-sea multi-beam system model 8101 has been done on board Sagar Purvi. A derrick arrangement for handling heavy gears has been done onboard Sagar Paschimi.

The two CRVs completed the COMAPS cruises for various Institutions as detailed below.

Institutions	Vessel	Program	Site
RRL Bhubaneshwar	Sagar Paschimi	COMAPS	Orissa, & West Bengal Coast
National Remote Sensing Agency	Sagar Paschimi	Satellite data validation	Off Vizag
Fisheries Survey of India	Sagar Paschimi		Off Vizag
CAS in Marine Biology, Annamalai University	Sagar Paschimi	COMAPS	Kakinada/Vizag to ChennaiChennai to Mandapam.
NIOT/M-III	Sagar Paschimi	Archeological Survey	Pumpuhar
M/s. Fugro Geonics	Sagar Paschimi	Survey	For physical Oceanographic survey off Kakinada/Gujarat
NIOT/VMC/ICMAM	Sagar Paschimi	Multi Beam Survey	Off Ennore
Anna university	Sagar Paschimi	Monsoon studies	Chennai to Cuddalore
NIOT/M-III	Magneto and side scan survey	For locating oil Wells off Kakinada using the deep tow winch for ONGC	ONGC
Sagar Paschimi	Survey	Kakinada	C-MARS &CESSTrivandrum

Institutions	Vessel	Program	Site
Sagar Purvi	COMAPS	Vizhinjam to Karwar	NIOT/OTEC
Sagar Purvi	Survey	Off Tuticorin	NIOT/M-III
Sagar Purvi	Survey	Off Kochi/Tuticorin	NIOT/OSTI
Sagar Purvi	Sample collection	Off Tuticorin	CAS Annamalai University
Sagar Purvi	COMAPS	Tuticorin to Vizhinjam	RRL Trivandrum
Sagar Purvi	COMAPS	Vizhinjam to Cochin	NIO-GOA
Sagar Purvi	COMAPS	Goa, Karwar, Ratnagiri & Back to Goa	NIO-Mumbai
Sagar Purvi	COMAPS	Mumbai to Kandla, Mumbai-Ratnagiri, Mumbai-Gujarat, & Back to Mumbai	British Gas India
Sagar Purvi	Charter	Pollution monitoring off Mumbai	NIOT-M III
Sagar Purvi	Kalpasar Project	Gulf of Cambay	

Sampling operation carried out during the above period is given below:

Vessel	Station	Water Samples	Grab Samples	ZooPlankton Sample	Core Sample	Trawl Net Operation	CTD Operation
Sagar Paschimi	286	545	286	160	25	2	204
Sagar Purvi	124	257	93	119	5	7	124

Vessel	Dredging operations	Current meter operations	Sub bottom survey	Side scan survey	Bathymetry survey	Multi Beam survey
SagarPaschimi	10	-	-	220 Km	-	500 Km
Sagar Purvi	215	8	418 Km	612 Km	170 Km	14 Km

8. Delineation of Outer Limits of Continental Shelf

The programme on Delineation of Outer Limits of Continental Shelf is a multi-institutional national endeavour that seeks to establish the outer limits of the country's legal continental shelf in accordance with the provisions of the 1982 United Nations Convention on the Law of the Sea (UNCLOS). India is a party to the UNCLOS and is entitled to submit the claim over her Continental Shelf. The claim with supporting scientific and technical data are required to be submitted to the UN Commission on the Limits of the Continental Shelf (CLCS) by May 2009. It is estimated that if the delineation is undertaken properly, India may be in a position to make exclusive claims of an area of more than one million sq. km beyond the Exclusive Economic Zone of 200 nautical mile (M).

The delineation of continental shelf claims beyond 200 M have important implications for offshore development. The continental shelf is rich in non-living resources and minerals, including hydrocarbon resources. The resources of the continental shelf also include the sedentary organisms. These resources, if found within the continental shelf, after proper delineation, as stipulated in the Convention, would be the inherent resources of the coastal States.

The objective is to establish the outer limits of the Indian continental shelf and to submit the Indian claim to the Commission on the Limits of Continental Shelf (CLCS), along with the supporting scientific and technical data under UNCLOS.

The data on baselines, foot of the continental slope, 2500 metre isobath, and the thickness of sedimentary rocks are required to establish the outer limits of the continental shelf. Accordingly, a comprehensive desktop study was undertaken considering the data sources available to determine the scope of the project, the type of data to be collected, the scientific and technical issues involved and the development of a data acquisition programme in consonance with the objectives of other programmes viz. Gas Hydrates Programme. Upon identification of the requirement, a data acquisition programme was taken up and various sub-components of the programme viz. parameters of data acquisition, data quality protocol, cruise schedules, area of operation etc., were finalized. The data acquisition of various major geophysical parameters was completed with simultaneous data processing. Strict quality control standards are adopted in acquisition and onboard processing of data.

National Centre for Antarctic and Ocean Research (NCAOR) at Goa, an autonomous Society under DOD, is coordinating this national endeavour with active co-operation and participation of all national institutions.

9. Comprehensive Swath Bathymetric Survey of Entire Indian EEZ

This new programme entails scientific mapping of over 2 million sq. km. area in the Indian Exclusive Economic Zone to have an inventory of potential living and non-living resources and to identify the causes of hazards. The study would help to develop innovative concepts on various aspects which inter-alia include:

Assessment of EEZ resources requires comprehensive accurate and up-to-date bathymetric surveys. Such surveys are useful for:

- Mineral exploration and development.
- Assessment of mineral resources.
- Deployment of research instrumentation on or near seafloor, including submersible operations.
- Fishing, using deep trawl or bottom fishing gear.
- Sub-sea pipeline or cable routing.
- Geological hazard assessment.
- Surveys of ocean waste disposal site.
- Port and Harbor development.
- Fish habitat research.
- Environmental impact assessment.
- Marine archaeological surveys.
- Defence applications.
- Maritime boundary demarcations.

Additional benefits that may accrue from these studies are

- New concepts on accumulation of Hydrocarbons.
- Sewage disposal zones for civic bodies.
- Submarine canyons - new insights into transport and distribution of pollutants.
- Islands - understanding submarine landslides and stability of coastline.
- Sediment failure along slopes- communication links across seafloor.
- Tectonics of margins.
- Rift and sediment filled rift basin configurations.
- Multibeam side-scan image can provide information on pockmarks-gas seepage etc., which will be helpful in identifying the gas hydrate zones.
- Multibeam acoustic back-scatter data can provide data on seafloor sediment characteristics.

During 2003-2004, the specifications for a new state-of-the-art deep-sea multibeam swath bathymetry system were finalized and order placed for procurement. Bathymetric survey will be initiated with the acquisition and installation of equipment.

10. Gas Hydrates Exploration & Technology Development for Exploitation

Gas hydrates with their abundant resource potential are emerging as potential cleaner fuel resources. Gas hydrates are ice like crystalline accumulations formed mainly from methane and water. They are stable, in permafrost regions and in low temperature - high-pressure regimes of the continental margins. According to conservative fuel resource estimates, worldwide gas hydrate contains more organic carbon (about 10,000 billion tons) than all other global reserves combined (about 8780 billion tons). The preliminary assessment of geological condition and limited available seismic data suggest high possibility of occurrence of large quantity of gas hydrates within the EEZ of India.

Gas hydrates exploration is a nascent science and a mission mode programme has been taken up to develop science and technology in India in respect of exploration of gas hydrates and to recommend suitable sites for drilling for ground truth validation and technology development for its exploration.

The proposal consists of science component as well as technology development component. The Department, in association with CSIR laboratories, would focus on scientific research with special emphasis on resource extent evaluation and environmental impacts and development of technology for detection and qualification of gas hydrates in sediments. Thereafter, exploratory drilling will be advised. The steps in this programme will be:

- ❖ To establish geophysical techniques for detection and quantification of gas hydrates;
- ❖ To undertake regional scale investigation to identify promising sites and estimate resource potential;
- ❖ To demonstrate existence of methane hydrate by ground truth sampling/ drilling;
- ❖ To understand the process of generation and accumulation of hydrates in marine sediments;
- ❖ To understand the impact of gas hydrates dissociation on geological environment and climate;
- ❖ To develop environmentally safe technology for production and transportation of gas from gas hydrates in pilot scale;
- ❖ To establish mechanism for monitoring and management of environmental perturbation during harvesting of gas hydrate;
- ❖ To recommend suitable sites for drilling and ground truth validation.

The technology development component will essentially include development of two systems viz., automated underwater corer and a multi sensor-multi activity unmanned submersible for Gas Hydrate Exploration.

During the year common areas work have been chalked out and all available database for identification of a few areas in order of priority have been looked into. Special processing and analysis of MCS data acquired recently are being carried out in these areas for selection of two best possible sites for further detailed work. Under Technology Development, design, development of unmanned submersible up to 2,500 m and automated coring system have been taken up.

An Indo-Russian Centre for Gas Hydrate (IRCGH) Studies has been established at NIOT, Chennai to coordinate and conduct the Gas Hydrate exploration and developing the requisite technologies and the capacity therefor.

Gas Hydrate samples

11. Acquisition of New Research Vessel

A 104 metre long Technology Demonstration Vessel SAGAR NIDHI is under acquisition to cater to ocean technology development and demonstration and to cater to the ongoing and new programmes of DOD during the 10th plan. The vessel will cater to Deep sea mining, ROV, AUV handling, Gas hydrates extraction technology development and will act as a supply and support platform for the various coastal and deep ocean activities planned by the Department.

An artistic view of Sagar Nidhi

The proposed vessel will be primarily designed to have all the adequate ship board permanent facilities (equipment/instruments) like

1. Dynamic positioning system.
2. Systems for ease of launching of ROV, AUV, etc, (Hydraulic lift till water line)
3. Low free board.
4. Cranes (10 tons) to handle and repair data buoys.
5. Salvage and tow capability to assist in emergency situations.
6. Large deck space, heli deck and ice strengthening.
7. Containerised equipment handling for the science programmes.
8. Modular labs for science vans and containers.

NIOT is the nodal agency for design, acquisition, operation and maintenance of SAGAR NIDHI. A Concept design has been developed and detailed engineering design is underway. The construction will start from mid 2005.

12. Geophysical Study of Laxmi Basin

The project is primarily aimed at establishing the crustal characteristics of the basement in the Laxmi Basin in Arabian Sea. Based on gravity modelling across the Laxmi ridge and adjacent margin using geophysical and satellite data, existence of under-plated crust beneath the ridge and the Laxmi Basin and the location of the ocean-continent transition at the southern edge of the ridge has been corroborated.

To establish conclusively the nature of basement in the Laxmi Basin as well as in the area to its north and south, detailed geophysical surveys along the entire West Coast margin upwards of the northern extremity of the Chagos - Laccadive ridge, were undertaken.

The acquisition and processing of geophysical data including seismic, reflection, gravity and magnetic amounting to 3600 line km have been completed. This is being followed by initiation of activities on interpretation and analysis of data.

13. International Cooperation & Programmes

13.1 Bilateral Programmes

A MOU was signed between the Government of India and the Government of the Republic of China on 23rd June 2003 in the field of Ocean Science and Technology. Booth countries would promote ocean science and technology through:

- Exchange of marine data and information;
- Organization of bilateral symposium, training courses and seminars;
- Joint identification of marine problems, projects planning and their formulation and implementation;
- Exchange of development and activities in marine science and technology and experience and know-how resulting therefrom;
- Supply of equipment as may be mutually agreed upon;
- Utilization of facilities for R&D as may be mutually agreed upon; and
- Other forms of cooperation in the field of marine science as may be mutually agreed upon.

13.2 International Sea Bed Authority (ISBA)

Scientist 'G', Department of Ocean Development and Director, NIOT participated in the 9th Session of the International Sea Bed Authority (ISBA) held in Jamaica during 21st July to 8th August 2003.

13.3 Contribution to International organizations

Contributions are being made to International Commissions and organizations like UNCLOS, ISBA, COMNAP/ SCALOP, CCAMLR, IOC, Regional Seas Programmes, etc. India participated in the IOC Executive Council and other meetings of IOC IOCINDO, International Sea Bed Authority, Antarctic Treaty System (ATS), Committee on Environmental Protection of ATS, Commission for Conservation of Antarctic Marine Living Resources, etc.

13.4 Intergovernmental Oceanographic Commission (IOC)

India is the founder member of IOC and also a Member of the Executive Council. During the year, Director, INCOIS in the capacity of the Vice-Chairman of IOC participated in 22nd Session of IOC Assembly and 36th Session of Executive Council at Paris, France during June 23- July 4, 2003. Director, INCOIS was re-elected as the Vice-Chairman of IOC for another two years. Further, as per the IOC rules, Director, INCOIS was elected by the IOC Officers, to replace Chairman whenever he is unable to serve. Director, INCOIS participated in the IOC Officers Meeting at Southampton, UK during January 22-24, 2004.

Third meeting of the IOC Advisory Board of Experts on the Law of the Sea (ABE-LOS III) held during 12th to 15th May, 2003 at Lisbon, Portugal was attended by the Joint Secretary, Department of Ocean Development and Director, INCOIS.

13.5 COMNAP / SCALOP / ATS Meetings

In order to make the Indian Antarctic Programme internationally recognized and perceptible, it is foremost that India contributes effectively in the various international platforms under the aegis of the Antarctic Treaty. To this effect, Director and Scientist 'D', NCAOR participated as Indian delegates in the 15th COMNAP/ SCALOP meeting held at Brest, France from 7th to 12th July 2003.

13.6 Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR)

Twenty second meeting of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) held during 27th October to 7th November, 2003 at Hobart, Australia was attended by the Joint Secretary, Department of Ocean Development and Director, CMLRE along with a representative of Department of Animal Husbandry & Dairying.

13.7 State Parties on Law of the Sea (SPLOS)

The Commission was established in 1997 under UNCLOS to consider the claims on continental shelf submitted by the States parties to the Convention. Joint Secretary and Scientist 'D', Department of Ocean Development participated in the 13th Meeting of the States Parties on Law of the Sea held during 09 - 13 June, 2003 in New York, USA. Scientist 'F', NGRI also participated in the 12th Session of the CLCS held during 28th April to 1st May 2003 at New York, USA.

13.8 Global Ocean Observing System (GOOS)

GOOS is an internationally organised system for gathering, coordination, quality control and distribution of many types of marine and oceanographic data and derived products of common worldwide importance and utility, as defined by the requirements of the broadest possible spectrum of user groups. Director, INCOIS is the Member of the Intergovernmental Committee on GOOS (I-GOOS).

Director, INCOIS participated in the (i) ODINAFRICA Planning and Review meeting held at Brussels, Belgium during September 8-10, 2003, (ii) Global Conference on Ocean Coasts and Island at UNESCO, Paris, France during November 10-13, 2003 and (iii) Briefing meeting on Legal aspects of issues overlapping the concept of scientific research and military intelligence in the EEZ at London on November 14, 2003.

Regional Alliance in Indian Ocean for GOOS (IOGOOS)

It is recognised that one of the most important means of implementation of GOOS is through the development of regional alliances, which are able to focus on issues of common national or regional interest. India led the process of establishing such a regional alliance (IOGOOS) for the Indian Ocean. This is a major milestone towards understanding the oceanic processes of the Indian Ocean and their application for the benefit of all people in the region. IOGOOS was formally established on November 05, 2002 during the Indian Ocean Conference at Mauritius. Nineteen organizations of 10 Indian Ocean countries signed a MoU to create and actively participate in a Regional Alliance for IOGOOS. This MoU is one of the strongest instruments of cooperation and collaboration in the context of the oceanographic development of the region. INCOIS has the responsibility to lead the IOGOOS, host the IOGOOS Secretariat as well as to formulate and guide projects on (a) Ocean Observing Systems, (b) Ocean Data and Information Networking and (c) applications of common concern in the region.

Major accomplishments of IOGOOS during the year under report are as follows:

- Establishment of the Regional alliance in a heterogeneous region, which is being seen as a useful mechanism.
- Activation of several joint efforts over the First year of its inception.
- Increased participation in IOGOOS from 11 to 21 countries; some of them expressing willingness to join IOGOOS formally.
- IOGOOS Workshop on "Capacity Building and Strategy for Data and Information Management" for Indian Ocean Region was held during December 8-10, 2003 at Hyderabad, India. Apart from the 19 initial members, functionaries from 10 more Countries participated in the Workshop. The results of this workshop are a major input for the Ocean Data and Information Networking (ODIN) Project that is being formulated for the Indian Ocean region. IOGOOS Secretariat has been given the responsibility of implementation of Ocean Data Management and Information Networking for the Indian Ocean Region.
- IOGOOS Workshop on "Marine Biodiversity" was held in Goa, India during December 2003 to evolve a strategy and action plan for long-term sustained monitoring of coastal and ocean biodiversity in the region.
- A joint CLIVAR/IOC-GOOS Indian Ocean Panel on Climate has been set-up for a comprehensive Ocean Observation Network and oversees the staged implementation of a Sustainable Ocean Observing System for the Indian Ocean. This Panel met at Pune during Feb 2004 and produced a draft plan for 35 surface moorings and several ADCP moorings between 16°N and 16°S as candidate array for IOGOOS. Three TAO Moorings and 1-2 ADCP moorings at 1.5°N, Equator and 1.5°S along 85°E Section have been planned for 2004.

- Co-sponsored International Workshop on "Role of Indian Ocean on Climate variability over India", held at Pune during February 23-27, 2004.

Ongoing Activities and Projects of IOGOOS

- Participation in the GOOS Regional Alliances Networking Development (GRAND) Project that would facilitate knowledge networking among all regional GOOS alliances and also benefit from the advances made by EuroGOOS and MedGOOS over the last decade. IOGOOS is in the process of becoming a partner of GRAND.
- Formulation of Project proposal on Marine Impacts on Lowlands Agriculture and Coastal Resources (MILAC) jointly with the meteorological community to contribute to Natural Disaster Reduction (NDR) in coastal lowland impacted by Tropical Cyclones. IOGOOS is pursuing MILAC-India Project, a Pilot Project for the Indian Ocean region.
- Formulation of a Pilot project on the Monitoring and Management Systems for the Shallow Water Penaeid Prawns for the Indian Ocean region.
- Formulation of a Strategy for Capacity Building in the Region on Remote Sensing applications for oceanographic and coastal studies.
- Preparations are underway for the forth coming IOGOOS Workshop and Second Annual Meeting to be held at Colombo during April 26-29, 2004. 28 participants from 13 countries as well as IOC and GOOS Regional Alliances (GRA) are expected to participate in the Conference.

Other Visits abroad

- A Scientist of Department of Ocean Development visited Paris, France during 10 - 14 March 2003 to participate in the 6th Session Global Ocean Observing System (I-GOOS-VI) of IOC-WMO-UNEP.
- Scientist 'G', Department of Ocean Development and Project Director, ICMAM, Chennai visited Colombo, Sri Lanka during 28 - 30 April, 2003 to participate in the GPA/South Asia Regional Consultation Workshop.
- Scientist 'G' and Scientist 'F', Department of Ocean Development visited Fiji Islands during 13-20 May 2003 to participate in the Workshop on the Establishment of a Geological Model of the Polymetallic Nodules in the Clarion Clipperton Zone (CZZ).
- Secretary, Department of Ocean Development visited Sapporo, Japan during 29th June to 11th July, 2003 to attend the International Union of Geodesy and Geophysics (IUGC) General Assembly.
- Scientist 'D', Department of Ocean Development visited Ho Chi Minh City, Vietnam during 02 - 09 August, 2003 as a member of Indian delegation to discuss various aspects of the projects of mutual interest under the Indo-Vietnam Inter-Government Programme of cooperation in Science and Technology.
- A Scientist 'E' of NIOT, presented a paper in the International Conference on Bio-deterioration and Biodegradation organized by IBBS and IBRG at University of Manchester, Manchester, UK from 13 - 18 September 2003.
- Senior Technical Assistant, CMLRE, Kochi and Technical Assistant, NIOT, Chennai visited Colombo, Sri Lanka during 22 - 26 September, 2003 to attend the IMO - OPRC Level 2 training course for the supervisors and on Scene Commanders.
- Scientist 'D' and Scientist 'C', ICMAM visited Holland during 29th September to 2nd October 2003 to attend the Training on Flourometer in the Skalar Factory.
- Programme Director, NDBP, NIOT attended the 19th Session of the Data Buoy Cooperation Panel (DBCP) meeting held at Angra dos Reis, Brazil during 20-24th Oct 2003. He was elected as the Vice Chair (Asia) of DBCP for the current session.
- Scientist 'G', Department of Ocean Development and Director, NIOT visited Moscow, Russia during 03 - 08 November 2003 to participate in the Joint Working Group/Joint Monitoring Group Meeting.

- A team of 5 member Indian Scientists visited Antarctica during 9th November to 5th December 2003 for Total Solar Eclipse Observation.
- Secretary, Department of Ocean Development and Director, NIOT visited Paris during 10 - 14 November, 2003 to attend the Global Conference on Oceans, Coasts and Islands at UNESCO Mobilizing for Implementation of the Commitments made of the 2002 World Summit on Sustainable Development (WSSD).
- A Scientist 'C' of NDBP, NIOT, underwent training at University of Athens, Greece during 10-15th Nov 2003 on the SKIRON/WAM Model implementation for the Indian Ocean under the 'ENVIWAVE' Project cooperation between NIOT and EU ENVIWAVE.
- Director, Department of Ocean Development visited Hong Kong SAR China during the 18 - 20 November, 2003 to attend the UNESCO Asia-Pacific Regional Workshop on the 2001 Convention on the Protection of Underwater Cultural Heritage.
- A delegation of 3 members from NCAOR, Goa and Department of Ocean Development visited Cape Town, South Africa during 08 - 15 December, 2003 for making arrangements in connection with the launching of the XIII Indian Scientific Expedition to Antarctica from Cape Town, South Africa.
- Deputy Secretary and Scientist 'D', Department of Ocean Development visited Colombo, Sri Lanka during 17 - 18 December, 2003 to participate in the Indo-Sri Lankan Meeting on Delineation of Continental Shelf.
- Two Scientists of NIOT presented papers in the 7th International Conference and Workshop on Lobster Biology and Management held at Hobart, Tasmania from 8 to13 February 2004.
- Sr. PPS to Secretary attended the External training in "Training of Trainer" for the trainers developing Non-DLM modules under the UNDP project on 'Strengthening of State ATIs in India' from 23rd Feb. to 12th March 2004 at RIPA International, London, UK.
- Programme Director, NDBP, NIOT attended the Buoy workshop 2004 organized by the office of Naval Research and Marine Technological Society of USA at University of South Florida, St. Petersberg, USA as well to National Data Buoy Centre, Stennis Space Centre, Missisipi, USA from 11th to 13th March 2004 and interacted with National Data Buoy Centre group.
- Secretary, DOD visited Oslo, Norway to attend the Executive Committee Meeting and the Ad-hoc Review Committee meeting of the International Union of Geological Sciences (IUGS) from 15th to 20th March 2004.

14. Departmental Ships

14.1 Fishery and Oceanographic Research Vessel (FORV) Sagar Sampada

FORV Sagar Sampada was mainly deployed for the collection of data and samples on Marine Living Resources in the Indian EEZ and contiguous seas. The vessel undertook 13 cruises (Cr. No 211 to 223) and collected data and samples from 350 stations during the year 2003-04. Seven cruises were dedicated for studies on the Environment and Productivity Patterns in the Indian EEZ of which three each for the winter, summer and inter- monsoon (spring) coverage of the Arabian sea and the Andaman sea and one for the summer monsoon coverage of the Bay of Bengal. In all, around 380 castings of CTD, 210 operations of Multiple Plankton Net, 152 operations of Bongo Net and 20 column productivity samples were made under the Environment and Productivity studies. Two cruises of the vessel were dedicated for collection of benthic samples from the Bay of Bengal and Arabian Sea, respectively, two for studies on the Toxic Algal Blooms along the Northern Arabian sea and one each

FORV Sagar Sampada

for studies on near shore dynamics and for acoustic estimation of fish and DSL biomass along the SW coast of India. Sediment samples for studies on the micro, meio and macro fauna along the continental slope area of the west coast were collected from 39 stations and along the east coast from 7 stations using dredge and Smith McIntyre grabs. Samples are being analysed in the laboratory. During FORV Cruise 218, in-situ Target Strength measurements of oil sardines, mackerels, and a few other marine species were carried out using cage and direct readings from EK-60 on-board the vessel. In addition, over 150 sightings of marine mammals have so far been recorded during the cruises since November 2003.

A total of 237 scientific and technical persons from various user agencies viz. National Institute of Oceanography (NIO), Cochin University of Science & Technology (CUSAT), Central Marine Fisheries Research Institute (CMFRI), National Institute of Ocean Technology (NIOT), Space Application Centre (SAC), Physical Research Laboratory (PRL), Institute of Ocean Management (IOM), Andhra University (AU) and Centre for Marine Living Resources and Ecology (CMLRE) participated in the cruises.

CMLRE took special care to keep all scientific equipment onboard in working condition. Scientific equipment of the vessel were maintained in a routine manner through preventive and breakdown maintenance. Particular care was taken to ensure effective functioning of the hull mounted acoustic transducers. To strengthen communication facilities, e-mail facility was provided onboard the FORV.

14.2 Oceanographic Research Vessel (ORV) Sagar Kanya

During the year 2003-04, 16 cruises were undertaken on board the vessel, logging 307 (84 % utility) days at sea. Scientists and technical personnel from some of the country's leading institutes such as NCAOR, NIO, CMLRE, NIOT, NGRI, SAC, PRL, SPL, IITM, IMD and other academic organisations have participated in these cruises for R&D and exploration programmes. The vessel was also deployed in sub-polar regions for the first time for multi-disciplinary data collection.

The BOBPS campaign in Bay of Bengal was conducted successfully. For Ocean Observing System programme, one TOGA drifter buoy and a WOCE SVP-B drifter buoy were deployed in Arabian Sea. Deep-sea current meter moorings were successfully deployed / retrieved after data collection. Support to databuoy maintenance and retrieval was provided. Monsoon studies in Arabian Sea were carried out successfully by ARMEX group. Multidisciplinary data/samples were collected for plume identification in Central Indian Ridge and Carlsberg Ridge. Vessel made her first expedition to sub-polar regions up to 56° S and collected multi-disciplinary data and seabed and water samples. GEODROME experiment was conducted in Bay of Bengal by NGRI in collaboration with Russians.

A core sampler ready for submersion in the Southern Ocean- on board Sagar Kanya

Southern Ocean cruise onboard Sagar Kanya was conducted in three phases. First phase (from 1.1.2004, Kochi to 19.1.2004, Port Louis) in Indian Ocean, second phase (from 23.1.2004, Port Louis to 4.3.2004, Port Louis) in Southern Ocean and third phase (from 10.3.2004, Port Louis to 31.3.2004, Karwar) for Ridge Studies.

The vessel has been equipped with the following new facilities/instruments during 2003-04:

- Upgradation of Deep Sea Echosounder.
- Installation of new Shallow Water Echosounder with repeaters.
- Upgradation of Side Scan Sonar.
- Procurement of Designjet Plotter.
- SS CTD cable.
- pH Meter.
- New Transducers for Sub-Bottom Profiler.

14.3 RV AA Sidorenko

The vessel had been under wet lease to the Department of Ocean Development for four years during 1999-2003. This vessel was used for the following specific programmes during the period under report:

- Scientific exploration in the Arabian Sea for a period of 107 days.
- Cobalt crust programme - Discovered Cobalt enriched crust off Lakshadweep for the first time.
- Baseline EIA study at OTEC site to study the vertical and horizontal extent of the cold-water plume in the event of pumping.
- EIA study at CIOB and this was third monitoring expedition, forming a part of 3rd phase for studying the long-term restoration of benthic disturbances created during 1997.
- PMN surveys and exploration at CIOB. Objective of cruise was to carry out Okean grab sampling at 6.25 km spacing as part of the X Five Year Plan activity to identify the first mine site for polymetallic nodules in the CIOB.
- NDBP: Deployment and recovery of Data Buoys and ARGO floats in the West and East coast of India.

15. Use of Hindi & Parliament Work

15.1 Use of Official Language - Hindi

During 2003-04 all efforts were made to promote the progressive use of Hindi in the Department and expansion of Official Language. The meetings of Official Language Implementation Committee were held regularly under the Chairmanship of the Joint Secretary.

The Annual Report, Performance Budget, Demand for grants, all Cabinet notes, reports, monthly summary to cabinet and documents relating to consultative and standing committee, parliamentary papers, etc., were prepared bilingually. Important materials like "Vision Document" available on the website of the department were translated into Hindi. In addition, Hindi version of the book "Story of the Ocean" was also prepared.

A five-day Hindi Workshop was organised by the Department during 25 - 29.8.2003 to train officers and staff of the Department to sort out and teach them as to how best they could solve the difficulties faced by them while doing their official work in Hindi. In all 22 officers and staff participated in the Workshop.

In the Hindi fortnight organised by the Department from 1st to 15th September 2003, a number of competitions in Hindi were held such as essay writing, noting and drafting, debate and computer typing/stenography. A Hindi quiz programme was also organised to test the knowledge of staff about Departmental activities and official language policy of the Government. Almost all the officers/staff of DOD participated in these competitions. On the concluding day, Secretary distributed the prizes and certificates to prize winning officials, in a ceremony, which was followed by a Kavi Gosthi, in which five reputed poets enthralled the audience.

One-day National Hindi Workshop on "Ocean Services" was organised by INCOIS at Hyderabad on September 01, 2003.

The Department organised 12th National Scientific Hindi Seminar on "Ocean Observation and Weather Forecasting" on 24th November 2003 at New Delhi. Thirteen Scientists from various institutions presented scientific papers on ocean observation, weather forecasting etc., in the Seminar. On the occasion a Hindi book titled "Samudri Oorja Avam Proudyogiki Vikas" - compilation of proceedings of the Hindi Seminar held in 2002, was released.

The Department organised a three day inspection of Centre for Marine Living Resources & Ecology under the supervision of Under Secretary (Admn.) from 3rd to 5th February 2004 with a view to ascertain the progress of implementation of official language policy. A number of important suggestions were made to encourage the use of Hindi in the Centre. Two Sections of the Department in the Head Quarters were inspected by the Committee formed under the Chairmanship of Deputy Secretary (A) to promote the use of Hindi.

The 20th and 21st meetings of Joint Hindi Advisory Committee of Ministry of Science and Technology and DOD were held in June and November 2003, respectively at New Delhi and Chandigarh. A number of suggestions were given by the Committee, which would be implemented gradually.

The Department awarded 2nd and 3rd prize to the books titled (i) Mahasagar se paryavaran Pradushan Mukt Nirantar Naveekarniya Vidyut Oorja and (ii) Sagar Sampada aur Pradushan under the Mahasagar Vikas Vibhag Purskar Yojana for the year 2003.

15.2 Parliament Work

The Department related Parliamentary Standing Committee on Science and Technology, Environment and Forest met on 1st April 2003 at New Delhi to consider the Detailed Demand for Grants in respect of the Department for 2003-04.

The meeting of the Consultative Committee of Parliament for the Ministry of Science and Technology and Ocean Development was held on 10th December 2003 wherein the "Recent Developments in Antarctic and Ocean Research" were discussed.

Between April 2003 and March 2004, 1 Starred Question and 15 Unstarred Questions were answered in the Parliament.

16. Organisation & Finance

16.1 Administrative Support

The sanctioned strength of the Department of Ocean Development including attached offices remained at the level of 181 during the year 2003-2004 also. The detailed break-up is given below:

	Scientific/ technical posts	Non-technical posts	Grand Total
DOD Head Quarters	24	112	136
Centre for Marine Living Resources & Ecology (CMLRE), Kochi	16	6	22
Integrated Coastal and Marine Area Management (ICMAM), Chennai	15	8	23
Total	**55**	**126**	**181**

16.2 Implementation of the 15 Point Programme on Minority Welfare

The activities of the Department do not have a direct bearing on the development of minority communities, Scheduled Castes, Scheduled Tribes, Other Backward Classes, etc. The Department, however, has been taking due care to ensure adequate representation of minority community while making recruitment to the posts. Adequate representation to the officers belonging to the minority communities has also been given on the Selection Committee set up for filling up vacancies in Group A, B, C and D.

16.3 Grievances of Public and Staff and their redressal

The Department of Ocean Development is a scientific Department and it has practically no public dealings. All the same, the Department has taken steps to ensure that due attention is paid to the public/staff grievances. Staff Grievances Redressal Officer and Public Grievances Officer have been nominated. Details have been given on web-site (http://www.dod.nic.in) of the Department.

So far no grievance from the General public has appeared in the grievances column of any newspapers.

16.4 Vigilance activities and achievements

Dr. S. P. Seth, Joint Secretary (Admn.) has been declared as Chief Vigilance Officer in consultation with the Central Vigilance Commission. Vigilance Officers have been appointed in the two attached offices and the three autonomous institutions of the Department. The Vigilance Awareness week was observed w.e.f 3.11.2003 to 7.11.2003 with the taking of pledge by the officers and staff members and organizing various competitions during the awareness week i.e. Slogan writing, Essay writing, Poetry, Debates and Short lecture.

16.5 Training

The following Officers/Staff of the Department were deputed for participation in different training/workshop/ seminar etc., during 2003-04 for upgrading their skill and knowledge:

Sl. No.	Designation	Subject	Place	Duration
1.	Scientist-G	Seventh National Consultancy Congress on "Competitive Capability through Emerging Technologies: Role of Consultants.	Consultancy Development Centre, New Delhi.	2 days
2.	Scientist-G (2)	Induction course on Administrative Procedures and Rules for Heads of Institutions	Indian Institute of Public Administration, New Delhi.	5 days
3.	Deputy Secretary	Orientation Programme for Directors/Deputy Secretaries of CSS.	Indian Institute of Public Administration, New Delhi.	5 days
4.	Deputy Secretary	Half-day workshop on Management of Legislative Business.	Parliament House, New Delhi.	1 day
5.	Deputy Secretary	Training programme for non-IAS officers posted in Government of India under Central Staffing Scheme.	Institute of Defence Study and Analysis, New Delhi.	5 days
6.	Deputy Secretary	One-day briefing course on Departmental Security.	IB Training School, New Delhi.	1 day
7.	Sr. Principal Private Secretary	Workshop of master Trainers & Recognized Users (MTs/Rus) during 20-21 October 2003	Uttranchal Academy of Administration, Nainital.	2 days
8.	Scientist - F	International Symposium in Mining from 1st - 4th November 2003.	Ashoka Hotel, New Delhi	5 days
9.	Under Secretary	Eastern Regional Organisation for Public Administration (EROPA) - 19th General Assembly and Conference on Public Administration and Globalization.	Hotel Meridian, New Delhi.	6 days
10.	Scientist-D	Project Management at India International Centre conducted by Indian Society for Training & Development.	Indian Society for Training & Development, New Delhi.	5 days
11.	Fishing Gear Technician	Managerial skills for Tech. Officers.	ISTM, New Delhi.	12 days
12.	Section Officer	Executive Development Programme for empanelled SOs of Central Sect. Services.	ISTM, New Delhi.	19 days
13.	Section Officer	Training of Trainers programme "Training Needs Analysis (TNA) and use of TNA Tool kit.	National Academy for Training & Research in Social Security, New Delhi.	12 days
14.	Senior Technical Assistant (STA)	National Convention on Library and Information Networking (NACLIN - 2003).	Kolkata	4 days
15.	Assistant	Establishment Rules	ISTM, New Delhi	5 days
16.	Assistant	Distance Learning Module on "Reservation in Services for SC/ST/OBC".	ISTM, New Delhi.	2 days

Sl. No.	Designation	Subject	Place	Duration
17.	Sr. Principal Private Secretary	External Training on "Training of Trainers" for the trainers developing non-DLM modules under the UNDP project on "Strengthening of State ATIs in India, from 23rd February to 12th March 2004.	RIPA International, London (U.K.)	19 days
18.	Section Officer	National Workshop on e-Governance from 18th - 21st March 2004.	National Productivity Council, Jaipur.	4 days
19.	Scientist-F (2)	International Symposium on "HYDRO-IND Seminar" during 26th and 27th March 2004.	World Trade Centre, Mumbai conducted by Naval Hydrography Dept.	2 days

16.6 Finance & Financial Summary

For the year 2003-04 a budget allocation of Rs.199.33 crore was approved by the Government for the Department, which included Rs.175.00 crore for the Plan schemes and Rs.24.33 crore for the Non-Plan schemes. The Revised Estimate (2003-04) approved by the Government was Rs.174.52 crore, comprising Rs.150.00 crore for the Plan Schemes and Rs.24.52 crore for the Non-Plan schemes. For the year 2004-05 the Government has allocated a Budget Estimate of Rs.230.08 crore for implementation of the programmes of the Department, comprising Rs.200.00 crore for the Plan Schemes and Rs.30.08 crore for the Non-Plan Schemes. The details are given in the financial summary that follows.

SUMMARY OF FINANCIAL REQUIREMENTS

(Rupees in Crores)

	Budget Estimates 2003-04			Revised Estimates 2003-04			Actual Expenditure as on 31-03-04			Budget Estimates 2004-05		
	Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total
A. PLAN												
1. Polar Science	24.00		24.00	17.79		17.79	17.79		17.79	24.00		24.00
2. Polymetallic Nodules Programme	22.00		22.00	18.00		18.00	17.86		17.86	22.00		22.00
3. Ocean Observations and Information System	35.00		35.00	25.37		25.37	25.37		25.37	26.00		26.00
4. Marine Research and Technology Development												
4.1 CMLRE and MLR	2.50		2.50	2.20		2.20	2.08		2.08	4.00		4.00
4.2 Drugs from Sea	2.50		2.50	2.75		2.75	2.75		2.75	4.00		4.00
4.3 Assistance for Research Projects	5.00		5.00	5.00		5.00	4.97		4.97	3.50		3.50
4.4 Coastal Ocean Monitoring and Prediction System	2.00		2.00	1.75		1.75	1.75		1.75	2.00		2.00
4.5 Exhibition and Fairs	0.55		0.55	0.59		0.59	0.59		0.59	1.55		1.55
4.6 Assistance for Seminar, Symposia, etc	0.20		0.20	0.16		0.16	0.13		0.13	0.20		0.20
4.7 Information Technology & Computers	0.25		0.25	0.22		0.22	0.15		0.15	4.27		4.27
4.8 Manpower Training for Ocean Research & Management	0.50		0.50	0.34		0.34	0.32		0.32	0.30		0.30
4.9 Integrated Coastal and Marine Area Management	5.50		5.50	5.50		5.50	5.31		5.31	4.00		4.00
5. Deep Sea Mineral Exploration	0.75		0.75	0.75		0.75	0.75		0.75	0.75		0.75
5.1 BENFAN	1.75		1.75	0.16		0.16	0.16		0.16	1.75		1.75
6. National Institute of Ocean Technology (NIOT)	25.00		25.00	25.00		25.00	25.00		25.00	25.00		25.00
7. Coastal Research Vessels (CRV)	5.00		5.00	4.50		4.50	4.50		4.50	5.00		5.00
8. Delineation of Outer Limits of Continental Shelf	8.00		8.00	16.23		16.23	16.23		16.23	2.43		2.43

(Rupees in Crores)

	Budget Estimates 2003-04			Revised Estimates 2003-04			Actual Expenditure as on 31-03-04			Budget Estimates 2004-05		
	Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total
NEW SCHEMES												
9.Comprehensive Swath Bathymetry of Indian EEZ	12.00		12.00	10.00		10.00	10.00		10.00	10.00		10.00
10. Gas Hydrates Exploration & Technology Development for Exploitation	18.00		18.00	11.43		11.43	9.43		9.43	18.00		18.00
11. Acquisition and Operation of New Research Vessels	2.00		2.00	1.01		1.01	1.01		1.01	40.00		40.00
12. Geophysical Study of Laxmi Basin	2.50		2.50	1.25		1.25	1.23		1.23	1.25		1.25
B. NON-PLAN												
1. Secretariat		4.77	4.77		4.96	4.96		3.77	3.77		5.45	5.45
2. ORV Sagar Kanya		10.25	10.25		10.25	10.25		12.21	12.21		16.14	16.14
3. Marine Living Resources and FORV Sagar Sampada		9.31	9.31		9.31	9.31		6.15	6.15		8.49	8.49
TOTAL PLAN	**175.00**			**150.00**			**147.38**			**200.00**		
TOTAL NON-PLAN		**24.33**			**24.52**			**22.13**			**30.08**	
TOTAL (PLAN +NON-PLAN)			**199.33**			**174.52**			**169.51**			**230.08**

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