

## ANNUAL REPORT-2002-03

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## Introduction

The Department of Ocean Development (DOD) set up in July 1981 witnessed a phenomenal growth with manifold expansion of the Department's activities during the 9<sup>th</sup> Five Year Plan period, involving a plan outlay of Rs.510.62 crore. A wide range of subjects and activities introduced during the 9<sup>th</sup> Five Year Plan period include Ocean Thermal Energy Conversion (OTEC), Assessment of the Marine Living Resources, Integrated Coastal and Marine Area Management, Ocean Observation and Information Services, Delineation of Outer Limits of Continental Shelf, etc. They were directed towards development, dissemination and use of Ocean Science and Technology for socio-economic benefit of the country, with the active participation of a large number of national research laboratories, academic institutions, etc. In addition, two autonomous institutions, viz., National Centre for Antarctic and Ocean Research (NCAOR) at Goa and Indian National Centre for Ocean Information Services (INCOIS) at Hyderabad were established as autonomous societies of the Department for carrying out and implementing programmes in the areas of Polar Science and Ocean Observation and Information services, respectively. For implementation of the Environment Management Capacity Building project and the related infrastructure, R&D and training programmes, the Integrated Coastal and Marine Area Management (ICMAM) Project Directorate was established in Chennai, jointly funded by the International Development Association and the DOD. The Sagar Sampada Cell of Kochi was renamed as a "Centre for Marine Living Resources and Ecology" for implementing the programmes relating to Assessment of Marine Living Resources in the Indian EEZ. Some of the major accomplishments include the development and successful testing of a seabed mining system at a depth of 410 m off Tuticorin in Tamil Nadu coast, as a forerunner to the development of deep sea mining system for operation at 6000 m water depth; deployment of 12 Met Ocean Data Buoys along the Indian coastline for collection and dissemination of oceanographic data on real time basis; establishment of Ocean Science and Technology Cells in 8 different disciplines for human resource development and capacity building in Ocean Science and Technology.

During the first two decades of its existence, the DOD has performed creditably in the areas of creation of several ocean related institutes, catalysing interaction with the global community, assisting in policy definitions and extending the reach of India's influence in ocean matters.

The Vision statement highlighting the Perspective Plan 2015 of the Department was formulated and released during this year (2002-03). This document spells out the Vision, the Mission, the mandate and the priority areas, to be pursued by the Department over the next decade.

### **Mission**

To improve 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.

### **Vision**

To improve our understanding of ocean processes through conceiving and implementing long-term observational programmes and incubating cutting edge marine technology:

So that we are able to:

- Improve understanding of the Indian Ocean and its various inter-related processes
- Assess the living and non-living resources of our seas and their sustainable levels of utilisation
- Contribute to the forecast of the course of the monsoons and extreme events
- Model sustainable uses of the coastal zone for decision making
- Forge partnerships with Indian Ocean neighbours through the awareness and concept of one ocean
- Secure recognition for the interests of India and the Indian Ocean in regional and international bodies.

In line with the Vision statement declared by the Department, during the 10<sup>th</sup> Five Year Plan period, a number of new initiatives have been introduced, which *inter alia* include Gas Hydrate Exploration and Technology Development for Exploitation, Comprehensive Swath Bathymetric Survey of Indian EEZ, Geophysical study of Lakshmi Basin, etc. This is only a beginning and, to achieve the mission and the mandate envisaged in the Vision Document, a lot more will be done in the years to come.

This report gives a vivid picture of the achievements/accomplishments of the various programmes/ projects implemented by the Department during 2002-03.

## 2. Polar Science

### 2.1 Accomplishments of the XXI Scientific Expedition to Antarctica

#### *Scientific Aspects*

##### *Geomagnetic studies*

The data on very strong magnetic storms, sub-storms and geomagnetic pulsations recorded during the winter period, are being analysed at Indian Institute of Geo-magnetism, India, which may lead to establishment of the electrical climate of Antarctica as well as in studying the interaction of solar wind with Geo-magnetic Field, solar magnetic sector boundary crossing, etc.

##### *Study of meteorological parameters and ozone hole phenomena at Schirmacher Oasis Antarctica*

Operation of Brewer Spectrophotometer, for measurement of Total atmospheric Ozone, sulphur dioxide and Nitrogen dioxide, Damaging Ultraviolet radiation, to supplement the ozone-sonde programme for the study of Ozone hole phenomena was undertaken. In addition to total Ozone, DUV, SO<sub>2</sub>, NO<sub>2</sub> measurements using Brewer Spectrophotometer, Atmosphere Ozone profile by ozone-sonde and meteorological parameters were observed.



##### *Balloon launching with Ozone Sonde for measuring ozone profile in the atmosphere*

For the study of climatology of Schirmacher Oasis daily synoptic data were used for computation of daily and monthly mean of temperature, wind, pressure and clouding.

##### *Measurements of green house gases*

Data were collected cyclically every day on half hourly basis during daytime and occasionally night times. Once a week, 24 hourly data were also taken.

Carbon dioxide measurements carried out at Maitri, Antarctica during 2002 showed an increase of CO<sub>2</sub> from about 280 ppm in the pre-industrial era to about 366 ppm.

#### *Teleseismic Studies*

Continuous monitoring and archival of seismic data was carried out. More than 400 earthquakes, most of which were teleseismic in nature were recorded during the winter period. Few regional earthquakes with their epicenter in Indian Ocean and localized earthquakes of low magnitude were also recorded.

#### *Permanent GPS Tracking Station at Maitri*

With the main objective of filling the GPS data gap in Antarctic region between Lat 0° to 30° south and long 60° to 80° east in the context of global GPS network as well as to study the ongoing Indian Plate Motion south of Indian Peninsula, a permanent GPS tracking station was set up at Maitri. GPS data so far collected will entail access to global Antarctic data for crustal deformation studies.

An Energy Budget Model, based on reflectance (Albedo), glaciological and meteorological parameters of Antarctic Ice Sheet was worked out through ground based observations, Automatic Weather Station data and Satellite imagery. The main objective of albedo measurements at Maitri, Antarctica was to study the local climate, atmospheric circulation and energy balance of different media e.g. main emphasis on shelf ice and continental ice.

#### *Study of Crack propagation on Ice Sheet*

Failure of ice shelf in Antarctica governs the formation of icebergs in Antarctic Ocean. These ice shelves break off from the main mass to form icebergs, owing to temperature variation and other interactions between the ocean and ice. Continuous monitoring of cracks in the India Bay using GPS, has revealed many weaknesses and cracks in the ice shelf near Indian Bay

#### *Communication at Maitri*

To improve the convoy communication, a HF communication system was added for the first time in convoy with VHF and mobile terminal.

## **Polar Logistics**

*The logistic activities of the XXI IAE include:*

- Upkeep of Maitri Station, which is over 13 years old and subjected to severe blizzards, resulting in snow ingression, poor thermal insulation and leakage
- Maintenance of the central heating system, generators and power supply system, water supply system, etc.
- Repair and maintenance of the snow vehicles, cranes, bulldozers, etc.
- Maintenance of fire fighting system, field camps, etc.
- Maintenance and upkeep of the containerized store yard, fuel storage yards, etc. and restoration of the national habitat of Maitri and its surroundings, in compliance with the environmental protocol of Antarctic treaty.

## **2.2 XXII Indian Scientific expedition to Antarctica**

The XXII Scientific Expedition to Antarctica was finalised on 6<sup>th</sup> July 2002 by the National Committee for Antarctic Programme. Dr. Arun N. Hanchinal, a geophysicist from Indian Institute of Geomagnetism was selected as the Leader of the expedition. The launching ceremony of XXII IAE was held at Goa on 10.01.2003 and the expedition was flagged off from Cape Town on 14.01.2003. XXII expedition to Antarctica, which arrived Antarctica on 25.01.2003, consisted of 48 members including a total of 33 scientists drawn from 14 National Institutions, out of which 23 members shall winter over in Antarctica and return only during the summer of 2004. The logistic and medical support to the expedition was provided by a contingent from the Indian Army and doctors from the CGHS.



***Expedition ship in frozen Antarctic waters***

The major scientific and logistic objectives of the expedition are:

#### Atmospheric Sciences

- Meteorological studies
- Geomagnetic storm & sub-storm through ground magnetic observation
- Application of GPS for crustal deformation, glaciology & atmospheric studies
- Coordinated study of very low frequency (VLF) Phenomena at Antarctica
- Monitoring of green house gases and radiation at Maitri

#### Earth Sciences & Global Change

- Geological, glaciological and geo-morphological investigations
- Inter plate kinematics & crustal deformation studies through GPS
- GPR studies to map thickness of ice and rock topography
- Hydrographic surveys in Antarctica using ship fitted echo sounder & GPS
- Study of dielectric properties of Antarctic geophysical materials at c-band microwave frequencies
- Study of crack propagation on ice shelf using GPS, GPR and satellite imagery

#### Biology and Environmental Sciences

- Exploration of faunal diversity and ecology of moss, algae and lichen inhabiting terrestrial invertebrate fauna of Schirmacher Oasis



***Weddell Seal ( Leptonychotes weddellii )***

- Distribution, diversity and air pollutant analysis in lichens of Queen Maudland area
- Monitoring of “Mercury” in the environmental Matrix and Bio-indicators

## Human Physiology and Medicine

- Study of higher mental functions in relation to stress and behaviour in expedition members

## Logistics

- Up-Keep of Maitri station
- Maintenance of generators and power supply, central heating, and water supply systems
- Convoy operation and maintenance of vehicles/cranes/bull-dozers
- Cargo handling at shelf
- Establishing the field camps

## Scientific experiments with international linkages

- Tele seismic studies of Antarctic continent
- Monitoring of icebergs
- Planetary Geodetic studies
- Bathymetric survey for preparing hydrographic charts
- Measurement of geomagnetic field currents in Antarctica
- VLF whistler monitoring
- Climatological database generation

In addition to conducting various scientific experiments and the commissioning and utilization of Telemedicine facilities at Maitri, the following operations, maintenance and repairs were carried out during the wintering period of XXI Antarctic expedition:

- Maintenance of the vehicles.
- Waste water treatment and disposal.
- Wood works.
- Power generation and distribution system.
- Support in the conduction of scientific activities.
- Fire fighting and its prevention.
- Central heating and water supply.
- Deep Freezers.
- Fuel decanting, storage and supply.

- Running of service convoys and handling of fuel.

After Successful completion of the scientific & logistics task, the summer component of the XXII expedition shall commence its return voyage from Antarctica tentatively on 27<sup>th</sup> March, 2003 leaving behind the winter team of 23 persons. Accompanying the returning team would be the winter team of the XXI expedition consisting of 25 members led by Shri. R.P. Lal, a Meteorologist from India Meteorological Department.

### **2.3 National Centre for Antarctic and Ocean Research (NCAOR)**

As a part of its ongoing in-house research activities, the Centre continued its research activities in the discipline of Polar Remote Sensing, as a collaborative venture with SAC, Ahmedabad. Action was initiated to establish the basic laboratory facilities catering to sedimentological, geochemical and stable isotopic studies.

NCAOR with the support of the Department of Science & Technology organised a 4-day International Seminar titled “ Indo-Russian Scientific Collaboration in polar science” during April 9-12, 2002 to formulate joint research programme between India and Russia under Integrated Long Term Programme of cooperation in Science & Technology (ILTP).

NCAOR jointly with the Centre for Geopolitics, Punjab University, Chandigarh organised a 2-day National Seminar titled “Indian in Antarctic: Challenges and opportunities for the 21<sup>st</sup> century” during February 3 – 4, 2003 to discuss the issues related to geopolitics and science of Antarctica.

Under a collaborative research project on “Antarctic Remote Sensing between NCAOR and SAC, Ahmedabad”, the MSMR Brightness temperature data obtained from June 1999 to 30 September 2001 (entire MSMR period) were analysed to study the sea ice extent over the different sectors of Antarctic circumpolar.

For indirect validation of the brightness temperature observed by MSMR with near-simultaneous measurements from SSM/I over the Antarctic Circumpolar, simultaneous MSMR and SSM/I data from two contrasting seasons – summer and winter were collected and analysed. The analysis brought out very high level of compatibility in the measurement produced by the two sensors. The quantitative inter-



comparison with the non-operational sea ice analysis from SSM/I paved the way for the continuous and reliable monitoring of polar ice with MSMR. Polarization Difference of the study area showed a possible melting signature during the fourth week of June in the year 1999 and 2000, but no melting possibility was found during the year 2001.

### **3. Polymetallic Nodules (PMN) Programme**

Based on extensive research carried out by India in the area of exploration of Polymetallic Nodules, India was accorded the status of Pioneer Investor by United Nations. The International Seabed Authority (ISBA) allocated an area of 1,50,000 sq. Km. in Central Indian Ocean Basin (CIOB), to India. India is a member of the Council of International Seabed Authority, under the Investor's category. As a part of the commitment to the ISBA, India fulfilled her obligation of relinquishment of 50% of Area to International Seabed Authority, retaining the remaining 50% for future exploration and exploitation by relinquishing the balance 20% of the total area assigned to India. India also signed a 15-year contract with ISBA for undertaking work for exploration of Polymetallic Nodules.

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

#### **3.1 Survey and 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 5 km. in selected marginal blocks. In addition, updating of geo-statistical resource evaluation based on 12.5 km. grid sampling in selected blocks was also taken up.

### **3.2 Environmental Impact Assessment (EIA) Study**

A comprehensive EIA study as a result of potential exploitation of nodules has been undertaken at the pioneer area. 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 carry out monitoring of environmental parameters by collecting samples at the test and reference areas and create appropriate data bases.

### **3.3 Technology Development Mining**

Development of technologies for mining from the deep ocean is viewed as a contribution to the long-term objective. A mining system capable of operating at 6000 m depth with a mining capacity of 25,000 tonnes nodules per year was designed under the ongoing joint collaborative effort of NIOT with Institut for Konstruktion ( IKS), University of Siegen, Germany.

Design and development of technology for measurement of *in-situ* soil sample for 6000 m depth is under progress. Re-furbishing of shallow bed mining system has been undertaken for re-demonstration to improve the confidence level before taking up collector and crusher development.

### **3.4 Technology Development – Metallurgy**

A 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 was commissioned in March 2003 and campaigns have been taken up. About 120 tonnes of nodules collected from Central Indian Ocean Basin will be consumed for the metallurgical demonstration campaigns. The data generated during the demonstration campaigns will be used for evaluation and validation of process package already developed. R&D activities for efficiency optimization for extraction of metal., viz. Cu, Ni, Co and Mn were continued.



***Bulk sulphide precipitation and dissolution section of pilot metallurgy plant at HZL***

#### **4. Ocean Observation and Information Services**

Climate variability in the recent past has caused a great deal of impact on the weather pattern resulting in droughts, floods, and extreme heat events in various countries of the Indian Ocean. The Climate predictability is an imperative need for India that is heavily dependant on monsoons for its economy. Although, the Oceans play an important role in the climate change, the symbiotic connection between ocean and atmosphere particularly in terms of exchange of heat and mass is not yet well understood. This could be due to lack of systematic observational network in the seas around India.

Recognizing the importance of information and knowledge of the seas around India, the department formulated an integrated programme called “Ocean Observation and Information Services (OOIS)” for implementation during the 9<sup>th</sup> Plan. The OOIS aims at development of a wide range ocean-atmospheric & coastal models; generation of algorithms for retrieval of satellite parameters; augmentation of ocean observations including *in-situ* and satellite measurements; and operationalisation of ocean advisory services. In view of the contribution of data generated through observational platforms for weather/climate forecasting and other coastal developmental activities, it is proposed to strengthen and augment the observational network during 10<sup>th</sup> plan by deployment of a variety of state-of-the-art technology buoys and floats. Several national agencies, such as, NIO, Goa, NIOT, Chennai, Survey of India, Dehradun have been involved in the

generation of data pertaining to coastal and open seas of India. Towards collating and archival of the data and effective dissemination of information to the end users through a single window, a dedicated centre “Indian National Centre for Ocean Information Services (INCOIS)” was established at Hyderabad in February 1999. Significant accomplishments under this scheme during the year are as follows:

#### **4.1 Ocean Observing System**

The ocean observations, both *in-situ* and satellite measurements, play a vital role in understanding the ocean atmospheric processes. Systematic time-series surface meteorological and oceanographic observations are essential primarily to improve oceanographic services and predictive capability of short and long-term climate changes. The time series observations/data on waves, wind, currents, air temperature, pressure and others are required for carrying out the basic research, developmental activities in the coastal / ocean areas and to study ocean processes. Recognising the importance of these measurements, the department has proposed to augment the observational network during 10<sup>th</sup> plan by deployment of a set of state-of-the-art profiling floats and moored ocean data buoys.

##### **4.1.1 Moored Ocean Data Buoy Programme**

The primary objectives are to support national, regional and international programmes relating to Ocean Sciences and Technology by providing real-time and archived data and related information and to provide real-time data for programmes relating to prediction of movement of cyclones and consequent storm surges that are devastating in nature.

Initially the data buoy programme had received both technical and financial assistance to the extent of 27 million NOK from the Government of Norway, NORAD and an equal contribution from Govt. of India. 15 data buoys were procured by NIOT from a Norwegian Company. The data buoys are equipped to record the data on Atmospheric Temperature, Humidity, Pressure, Sea Surface Temperature, and Salinity and Wave parameters through their sensors. They are transmitted to the International Maritime Satellite (INMARSAT) and received at NIOT. These data are disseminated to users, like Indian Meteorological Department who use them regularly for weather predictions. The other user groups include, Climate Research group in DST and Indian Institute of Science, Bangalore, Navy, Ports, etc. NIOT, is currently operating 14 moorings out of which 12 are providing the real time data.

In order to attain self-reliance, the NIOT had undertaken the task of indigenous production of these data buoys. The very important task in this programme is 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 and transceiver for INSAT, which has been jointly developed by NIOT and Space Application Centre (SAC), Ahmedabad. NIOT has evolved the protocol for handshaking between the CPU and INSAT transceiver in the buoy format; miniaturising the complete electronics and its enclosures, to suit marine conditions, testing procedure, etc. Besides the above two buoy electronic components, other important components like buoy hull, instrument cylinder, mast and power system have been indigenised and produced through indigenous sources.

A fully indigenised data buoy with INSAT communication for data transmission was deployed off Ennore Port on 31<sup>st</sup> December 2002 for extensive sea trials. NIOT on satisfactory sea trials has planned to deploy 6 more indigenous data buoys in Indian seas and increase the total buoy network to 20 nos. before the end of this financial year. Out of 8 buoys proposed at new locations, a set of 4 new buoys was deployed in the Bay of Bengal at the following locations. The remaining 4 sets of buoys would be deployed in the Arabian Sea

- OB8 - Lat: 11° 30' 09" N Long: 81° 28' 24" E
- MB10 - Lat: 12° 30' 48" N Long: 84° 58' 57" E
- MB11 - Lat: 14° 59' 50" N Long: 87° 30' 14" E
- MB12 - Lat: 17° 29' 30" N Long: 89° 55' 26" E



***A fully indigenised data buoy with INSAT communication for data transmission deployed off Ennore Port on 31<sup>st</sup> December 2002***

To facilitate INSAT communication, an INSAT HUB station fabricated by Bharat Electronics Limited (BEL) has been installed at NIOT campus. For the first time the interfacing of Climate sensors (Solar radiation, Net radiation, Humidity sensor) with the CPU has been achieved and a buoy with climate sensors fit has been deployed at location MB10. Automated real time data dissemination to IMD through its Area Cyclone Warning Centre, Chennai has been established. NDBP carried out regular and emergency maintenance of data buoys accounting for 25 deployments and 11 retrievals of buoys.

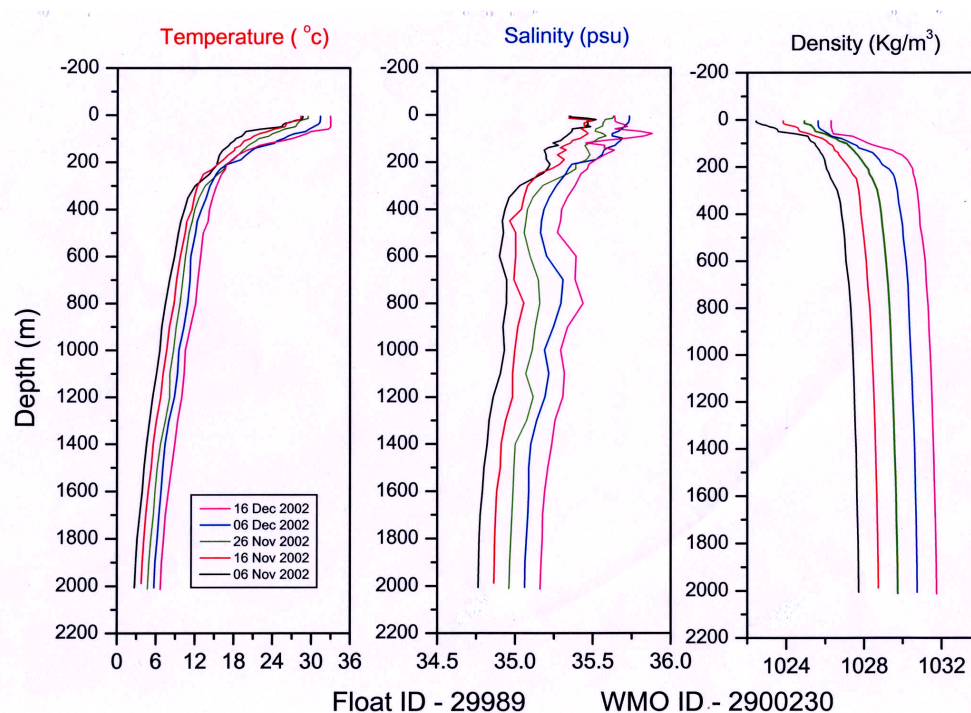
#### ***4.1.2 Indian Array for Real-time Geotropic Oceanography (ARGO) Project***

The International ARGO project envisages deployment of 3000 profiling floats in the global ocean at approximately 3° spacing. About 20 countries including India, have committed resources to the project. The floats in ARGO will provide temperature and salinity data over the entire world ocean at 10 day intervals. These floats are designed to dive up to 2000 m depth to make measurements and transmit the data through satellite to ground stations, when they pop up. Each float is capable of making 200 profiles over a period of 5 years.



### ***ARGO profiling float***

The ARGO is an internationally coordinated programme for deployment of an array of 3000 profiling floats at a spatial resolution of  $3^{\circ} \times 3^{\circ}$  (300 km x 300 km) to measure temperature and salinity profiles of the upper ocean (up to a depth of 2000m) periodically. The expected life of each float is about 4 years. In the Indian Ocean region 450 ARGO floats are to be deployed under this programme. The Department has made a commitment for deployment of about 150 in the northern Indian Ocean north of  $10^{\circ}$  South over a period of 5 years (2002-2007), of which 12 have been deployed. For the first time in the Indian Ocean, India conducted 3 ARGO float missions with 10 days, 5 days and 10 & 5 day cycles to capture the inter-annual variability in the region. 10 ARGO floats were deployed during the IOGOOS Cruise overboard ORV Sagar Kanya. Data from these floats are being received and made available on the Website for the user community after the real time quality checks.



### ***Data obtained from ARGO Floats deployed during IOGOOS cruise***

India holds a major share of such buoys in the Indian Ocean region, thus acquiring a leadership in the regional climate programme. INCOIS is the nodal agency for coordination and implementation of the project. The other agencies involved in the programme are National Institute of Ocean Technology, Chennai and Indian Institute of Science, Bangalore.

In the long run, the ARGO data would help to greatly improve our knowledge of scientific problems such as interaction of atmosphere and ocean on inter-annual time scales as well as providing highly useful set of measurements that will be relevant to more practical problems associated with shipping, fisheries and environmental assessment applications. This will also contribute to various national projects being undertaken by India, under Indian Climate Research program (ICRP). These temperature and salinity profiles are expected to improve understanding of the oceanic processes and contribute to improved prediction of climate variability.

Data from the global array of profiling floats would be put on GTS immediately to enable its use in operational forecasting. Delayed mode data, after detailed quality control checks by the ARGO Data Centres, would be available within a few months via internet. One-year time series data collected from the Canadian Float deployed by India were analysed and capability was developed to decide the ARGO float design for the



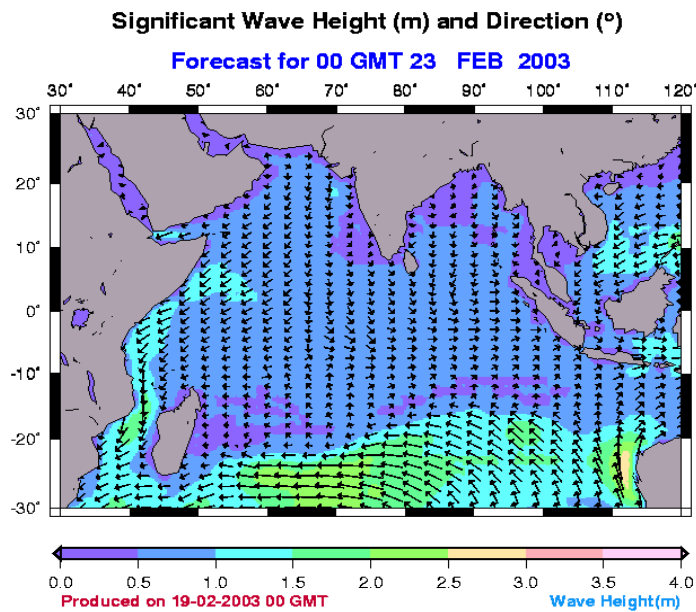
Indian Ocean region. Performance Evaluation Report of the ARGO floats deployed by India was prepared and evaluated by the Expert Committee.

A website for the India ARGO Programme with Web GIS and query facilities for coordination of ARGO float deployment in the Indian Ocean was set up. Data from about 100 floats (about 2600 Temperature and Salinity Profiles) deployed by various countries in the Indian Ocean are available on the INCOIS website for the scientific community. Under a joint project of INCOIS and CAOS/IISc, hydrographic structure of western Arabian Sea was studied using the data from ARGO floats in the region. Tool for conversion of ARGO data from TESAC to ASCII format was developed and ARGO data from 600 floats have been archived. This datum was disseminated to SAC and CAOS/IISc. A software package for online real-time quality control of ARGO data, incorporating 21 quality checks approved by the International Argo Science Team was developed. For delayed mode quality control, a software package was acquired from the Pacific Marine Environment Laboratory (PMEL), USA along with historic data of the world ocean collected from 1800 to 1998 for Temperature and Salinity profiles.

#### **4.2 Indian Ocean Modelling and Dynamics (INDOMOD) Satellite Coastal and Oceanographic Research (SATCORE)**

The INDOMOD project envisages adaptation of a suite of ocean models for study of open and coastal ocean processes and coupled ocean-atmospheric processes. The primary applications of these models are prediction of monsoon variability, storm surges associated with cyclones, waves, biological productivity and coastal processes. There are 13 separate sub-projects under the INDOMOD project addressing a specific activity pertaining to development of ocean-atmospheric modelling.

The SATCORE project was intended to develop 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 obtained through Indian and foreign satellite sensors including IRS P4. Besides, this Project also carries out diagnostic studies and generation of forecast models, customisation of algorithms and development of related software packages.



During the X Five Year Plan, INDOMOD and SATCORE and Ocean Observations programmes have been integrated in a focused way towards development of models. 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 project, which are described below:

#### *Drifting Buoys*

Drifting buoys have the capability for continuous measurement of SST and atmospheric pressure for about a year. The data generated by the buoys are required for estimation of surface currents, which are useful for climate research, synoptic updates for weather prediction and provide sea truth for calibration and validation of satellite sensors. The data sets are transmitted, in near-real time, through Global Telecommunication System (GTS) to various users. NIO sends the processed data sets to INCOIS, NRSA, NCMRWF, IMD and SAC for utilization in the models and validation of Satellite sensors.

#### *XBT Surveys*

The XBT surveys are designed to collect data on vertical temperature profile of the upper ocean up to a depth of 760 m, which would be useful to study the weather patterns, cyclones and variations in the mixed layer depth, etc. The objectives of the programme are: (i) to understand and document the evolution of upper ocean thermal structure along selected XBT sections on annual time scales and to examine its inter-

annual variability; (ii) to establish the relation between upper ocean summer heating and ensuing monsoon activity; (iii) to establish the relation between the heat content in the upper layers after the monsoon cooling and post-monsoon storms in the Bay of Bengal; and (iv) to provide sea truth information of subsurface temperature profiles for validation and calibration of data derived from satellite sensors. XBT observations are carried out along Chennai-Port Blair-Calcutta, Chennai-Singapore and Mumbai-Mauritius shipping routes onboard ships of opportunity (Merchant ships).

#### *Current Meter Array*

Deployment and retrieval of a set of 4 Current Meter Arrays would be carried out at pre-selected locations along the equator in the Indian Ocean for long-term monitoring of current structure. Each current meter array consists of 6 current meters (with pressure, temperature and conductivity sensors) placed at depths varying from near surface to near-bottom (50 m, 100 m, 200 m, 500 m, 1000 m, and near-bottom depth). The major objectives of the programme are (i) to deploy and maintain current meter arrays at three pre-selected locations along the equator in the Indian Ocean, (ii) to understand the seasonal evolution of near-surface and sub-surface currents in the equatorial Indian Ocean, (iii) to understand the propagation of Kelvin waves and Ross by waves along the equator in relation to the evolution of surface mixed layer and upper layer heat content variability, and (iv) to address the deep-sea current variability in the equatorial Indian ocean in relation to climate change and exchange of deep water masses across the equator.

Significant achievements under this project during the year 2002-03 were:

- Software for processing of IRS-P4 Ocean Colour Monitor Data developed by SAC/RRSSC (under SATCORE) on Windows and AIX Platforms and the Meteorological and Oceanographic Application (MOA) shell developed by SAC were utilised by INCOIS for retrieval of SST, Wind vector, Wave Energy and Eddies from ERS-1 data and to derive Chlorophyll, Suspended Sediments and Yellow substance, respectively.
- Ocean Colour and SST were integrated for PFZ forecast for Gujarat, Kerala and Karnataka and validated jointly with the user agencies. Know-how was transferred to INCOIS.
- During the year, 10 drifting buoys, 300 XBTs and 3 current meter arrays were deployed and surface meteorological data were collected from five cruises

conducted by NIO as a part of the project “Sea truth campaigns for validation of IRS-P4 sensors” .

#### **4.3 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 synthesise, 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.

This Centre is marching ahead with a mission to provide the best possible ocean information and advisory services to society, industry, government agencies and scientific community through sustained ocean observations and constant improvements through systematic and focused research. Within a short span of its existence, INCOIS has been recognised as an institution focusing on bringing in the advances in space and ocean sciences to help the common man. Further, the initiatives taken by INCOIS during the last two years with respect to the International Argo Programme and Global Ocean Observing System have enabled India to gain a significant niche in the global scenario.

The major accomplishments during the year under report are as follows:

- Provided Potential Fishing Zone (PFZ) Advisory Services to the Fishing Community in a Mission-mode and implemented several innovative steps to make this information a part of the value chain of Fishing Community. This Mission has been acclaimed as an excellent model for reaching effectively the benefits of Science to Society.
- A national mission on Ocean-Atmospheric System for the Indian Seas was launched to enhance the basic understanding and knowledge base on oceanic and atmospheric processes for predictability of Ocean, Climate and Catastrophic weather events and improving operational prediction by the respective national agencies.
- Operationalised the knowledge base at INCOIS, developed under national projects on Indian Ocean Modelling and Dynamics and Satellite Coastal and Oceanographic Research, to generate Ocean information services and data products.

- A versatile multilingual Web site and Ocean Portal was developed. Web GIS has been implemented for the advisory services, which will facilitate the user community to query, analyse, visualise and download a variety of ocean information and advisory services. Implementation of Data Warehousing and Data Mining and WAP concepts are in progress.
- INCOIS spearheaded the ARGO Programme nationally and played a key role in the planning of the programme in Indian Ocean. INCOIS was selected by the International ARGO Community as the Regional Coordinator and Regional Data Centre for Indian Ocean region.
- INCOIS played a major role in the process of setting up the Regional alliance for Global Ocean Observing System for Indian Ocean (IOGOOS). INCOIS is the Secretariat for the IOGOOS.
- Development of permanent campus for INCOIS is in progress.

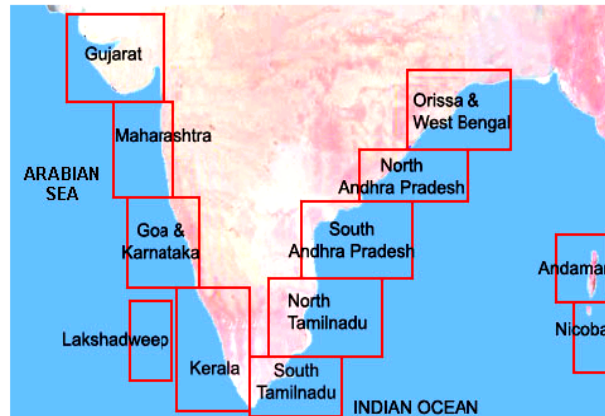
### Information and Advisory Services

#### *Potential Fishing Zone Advisory Services*

Department of Ocean Development, Department of Space and several Institutions under the Ministry of Agriculture have been pursuing an endeavour, for over a decade, jointly with the State Governments of the maritime States and Islands, to provide Potential Fishing Zone (PFZ) Advisories to the Indian Fishing Community, using satellite-based Sea Surface Temperature (SST). Features such as oceanic fronts, meandering patterns, eddies, rings, upwelling areas that are proven to be prospective sites for fish accumulation are identified from SST imagery generated from NOAA-AVHRR satellite data. The availability of chlorophyll data from Ocean Colour Monitor (IRS-P4) has enriched these advisories. In view of the cloud cover during the monsoon season and more importantly since that season corresponds to the breeding season, PFZ advisories are not provided during June-September in the context of maintaining fishery stock at sustainable level.

PFZ Forecast Date :  
18-FEB-2003

Valid up to :  
20-FEB-2003



### ***Potential Fishing Zone Advisories in Text Format***

The progress made during the year under report is as follows:

- Continued generation of PFZ Advisories (SST based) and dissemination twice a week, in local languages (Bengali, Hindi, Kannada, Malayalam, Oriya, Tamil and Telugu) to about 225 nodes till the end of May 2002. Since November 2002, the Integrated Potential Fishing Zone advisories are being generated based on SST data from NOAA-AVHRR and Chlorophyll data from OCM. The frequency of the PFZ advisories has been increased to 3 per week (i.e. on every Tuesday; Thursday and Saturday) to all the maritime states and islands in local languages.
- Know-how acquired from Space Application Centre for generation of Integrated PFZ Advisories using SST and Chlorophyll.
- The processes were streamlined for operational generation and timely dissemination of PFZ advisories through Information Kiosks, Digital Display Boards and Web Site.
- Digital Display Boards were installed at Ratnagiri, Machilipatnam, Kakinada and Visakhapatnam to provide PFZ advisories.



**Digital display board to provide PFZ advisories**

- Pilot Project on satellite audio broadcast initiated with M/s. Worldspace in 5 locations.
- An extensive GIS data base of bathymetry, landing points and lighthouses was built up and entire processing was automated to improve the planimetric accuracy of the PFZ advisories.
- A dynamic web site with Web GIS, query facility and multilingual capability was developed for the PFZ Advisory services to strengthen the delivery chain and improve the time line. PFZ advisories are now available in INCOIS website both in the form of multi lingual textual data as well as in the form of maps.
- Four research projects were commissioned for concurrent validation of the PFZ Advisories for the West coast, around Kochi, Mangalore, Ratnagiri and Mumbai. Similar validation projects for the Orissa coast and Veraval are being planned.
- User interaction workshop was conducted at Central Institute of Fisheries Education (CIFE), Mumbai and awareness programme was conducted for the fisheries officials at Chennai and Kakinada.
- Initiated R & D activities under INDOMOD-SATCORE Project to improve the PFZ forecast and to integrate the information on coastal currents and coastal waves.

#### *Experimental Ocean State Forecast (E-OSF)*

Ocean State Forecast was identified by the Department of Ocean Development as one of the primary goals for the 9<sup>th</sup> Plan. The Satellite Coastal and Oceanographic Research (SATCORE) and Indian Ocean Modelling and Dynamics (INDOMOD) projects of the department would feed the OSF activity. The OSF has emphasis on providing

state-of-the-art ocean information and forecast to the users e.g. navy, shipping, oil, fishery industry, etc., and the information encompasses predictions and dissemination of geo-physical information like surface winds, sea surface temperature, surface waves, mixed layer depth and storm surge. The OSF activities are envisaged in two phases – Phase I involves near real time prediction up to 5 days and dissemination of the aforesaid five ocean state parameters to the users and Phase-II involves consolidation of the achievements in Phase-I and taking up R&D efforts to enhance the scope by introducing more ocean parameters.

The significant achievements made during the year 2002-03 are as follows:

- WAM 3 Model (for Wave forecast) and ID Price Model (for Mixed Layer Depth-MLD) were implemented and customized for operational use.
- Tidal circulation model for the Gulf of Kambath was customised for forecasting tidal currents from Ratnagiri to Porbandar for 3 days at 3 hourly intervals. Validation with Moored Buoy data is in progress.
- 4-day forecasts at 6 hourly intervals for Wave parameters and MLD were generated and validated with Topex-Poseidon and ERS-1 data products. Further validation with data from Moored Buoys and ARGO floats is in progress for publishing on the Web to the selected users.
- A dynamic web site with Web GIS and query facility was developed and implemented for E-OSF. Forecasts for the Wave parameters are available for the general public and forecast of the Mixed Layer Depth only to the restricted users.
- Efforts are underway to integrate the E-OSF information with the PFZ Information.

#### *Ocean Information Bank and Web-based Services*

The Ocean Information Bank is the backbone of INCOIS to provide Web-based services in real time or near-real time to the scientific community and operational agencies. The Information Bank of INCOIS is currently having the various databases including:

- NOAA AVHRR Satellite data from 1991 and Sea Surface Temperature archives for North Indian Ocean from 1992 to January 2003, including daily, weekly and monthly images and grid data, brightness temperatures,
- Data from Moored and Drifting Data buoys, XBTs and Current Meter Mooring Array for the period 1997-2002,
- 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, and



- Bathymetry charts for the entire coast of India including Islands on 1:15,000 / 1:50,000 / 1:1,50,000 scale.

INCOIS has been chosen by ICRP/DST for archival of sub-surface oceanographic data collected from Arabian Sea Monsoon Experiment Phase-II (ARMEX-II).

#### *INCOIS Ocean Portal and Web-based Services*

INCOIS initiated development of a multilingual web-based on-line solution that facilitates the User community to query, analyse, visualise and download a variety of ocean information and advisory services.

The goals of INCOIS Web-site and Ocean Portal include (i) Ocean Data Warehousing and Data Mining, (ii) Web enabled Ocean Advisory services, (iii) providing timely, reliable and up-to-date ocean information to user community, and (v) user-friendly access, ease of navigation and regular information updates.

Salient features of this Web Site are:

- Multilingual Web site and Ocean Portal, which provides services over the web. The multilinguality comprises interfaces in Hindi, English and other Indian languages.
- A Web Geographical Information System (Web GIS) which will allow the user to query, analyse and visualise Spatial and Non-spatial data over the web. The information required by the client can be fetched from the RDBMS / Spatial Server and displayed on the web as maps.
- Provision for WAP Interface by using a Wireless Gateway, where the users can view the data through mobile phones.
- The web site is being built in four phases. The first phase involves a static site giving insight into the various activities planned for the Ocean Community through the web site. The next two phases involve a dynamic site with Web Geographical Information System (GIS) interface to the online data and Warehousing and mining of the historical data, respectively. The last phase will have design availability for the WAP enabled information systems. Once the website becomes fully operational it would be a single window solution for the entire ocean community.

Progress during the year under report is as follows:

- Phase-1 A of the Project viz. Static Website which gives insight in to various activities planned by the INCOIS for the ocean community was implemented in June 2002 (<http://www.incois.gov.in>) including mail and FTP services.
- Separate sites for Indian Ocean GOOS, Indian Ocean Argo have been implemented on the INCOIS website.

- Phase-1 B viz. Dynamic Website comprising Potential Fishing Zone Forecast, Experimental Ocean State Forecast and Indian Argo Programme with Web-GIS, Query facility and multilingual capability was implemented in October 2002.
- Design development and implementation of Phase-2 with Data Warehousing and Data Mining facilities is underway.

#### **4.4 Marine Data Centres**

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 in the Geological Survey of India, Kolkata; KD Malavia Institute of Petroleum Exploration, Dehradun; India Meteorological Department, Pune; Survey of India, Dehradun; Naval Hydrographic Office, Dehradun; National Institute of Oceanography, Goa; Fishery Survey of India, Mumbai; Central Marine Fisheries Research Institute, Kochi; Central Drug Research Institute, Lucknow; Central Salt and Marine Chemicals Research Institute, Bhavnagar; Orissa Remote Sensing Applications Centre, Bhubaneswar; Institute for Ocean Management, Chennai; Regional Centre, National Institute of Oceanography, Mumbai; and National Remote Sensing Agency, Hyderabad.

Efforts are underway to acquire the metadata and catalogue the databases generated at the 14 Marine Data Centres and integrate them with the INCOIS Portal for wider accessibility.

#### **4.5 Value Added Services**

At the request of Andhra Pradesh State Fisheries Department, INCOIS conducted a pilot study on operationalisation of the Fishing Harbour at Bhavanapadu, Srikakulam District, Andhra Pradesh, using *in-situ* oceanographic data, coastal area maps and remote sensing data received from various satellites. Results of the time-series analysis using remote sensing data in conjunction with collateral data and field visits were presented to the AP Fisheries Department.

#### **4.6 Indian Ocean Global Observing System (IOGOOS)**

The Global Ocean Observing System (GOOS) of the Intergovernmental Oceanographic Commission, co-sponsored by WMO, UNEP and ICSU, is an internationally organized system for gathering, coordinating, quality control and distribution 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. 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.

Nineteen organizations of 10 Indian Ocean countries signed a Memorandum of Understanding to create and actively participate in a Regional Alliance for IOGOOS, during the Indian Ocean Conference on 5 November 2002. This Memorandum of Understanding is one of the strongest instruments of cooperation and collaboration in the context of oceanographic development of the region. IOGOOS is intended to elevate the Indian Ocean from one of the least studied to one of the most studied of the world's major oceans, with a real emphasis on the link between societal and scientific issues.

Director, INCOIS was elected as the Chairman and a Scientist, INCOIS was selected as the Secretary of the IOGOOS. INCOIS was chosen to host the Secretariat of IOGOOS for a period of 6 years.

#### **4.7 IOGOOS Cruise**

INCOIS organised a Research Cruise on board ORV Sagar Kanya from Chennai to Mauritius via Seychelles and Mauritius to Chennai during October 17 – November 29, 2002 in conjunction with the Indian Ocean Conference at Mauritius during November 4-9, 2002.

Thirty Scientists from six countries (Kenya, Mauritius, Sri Lanka, South Africa and India) participated in the Research Cruise. Multi-disciplinary observations related to marine physics, marine chemistry, marine biology, marine geology, marine geophysics and marine meteorology were carried out during the cruise. Argo floats, drifting buoys and XBTs were also deployed during the Cruise. Training programmes were conducted during the cruise period and open house demonstrations were organised at Seychelles and Mauritius during the port calls.

#### **4.8 Global Ocean Observing System (GOOS)**

GOOS is an internationally organised system for the 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.

To maintain the focus, efficiency and effectiveness of GOOS in changing time and circumstances, the Intergovernmental Oceanographic Commission (IOC) constituted a Panel of 4 Experts to review the organizational structure of GOOS.

## **5. Marine Research & Technology Development**

### *5.1 Assessment of Marine Living Resources*

The Centre for Marine Living Resources & Ecology (CMLRE) – the erstwhile Sagar Sampada Cell in Kochi has the mandate of:

- Evaluation of existing information on marine living resources, correlating it with the influence of physico-chemical parameters on the biota, identifying the gaps and formulating future strategies for sustainable exploitation of marine living resources.
- Encouraging optimal utilization and effective conservation of marine living resources.
- Evolving, coordinating and implementing time targeted national/regional R&D programmes in the field of marine living resources and ecology, through effective utilization of the Fishery and Oceanographic Research Vessel 'Sagar Sampada'.
- Strengthening of research on Marine Living Resources and Ecology including establishment of a Data Centre for storage and dissemination of data/information to end users.
- Coordinating the national programmes relating to Southern Ocean Living Resources (Antarctic Marine Living Resources).

The Centre has established a Data Center for compilation and archival of all fishery, environmental and oceanographic data collected during FORV cruises under various programmes carried out by different organizations. Activities are undertaken in a phased manner towards achieving the above goal. Data retrieved from CTD profiles and auto-analyser data in a 5° X 5° grid resolution have already been archived. ADCP and meteorological data are also collected for archival at the data center.

#### **5.1.1 Assessment of Environmental Parameters & Marine Living Resources in Indian EEZ**

The major objectives of this project initiated during 1997-98, are to study physical, chemical and biological oceanography relevant to fisheries, to delineate areas

of upwelling and sinking and its significance on productivity, to study the oxygen minimum layer and its vertical and horizontal shifts and adaptability of associated fauna, to study primary production, chlorophyll-a, phytoplankton abundance, particulate organic carbon and suspended load, to assess secondary production, its vertical, horizontal and seasonal distribution with notes on feeding migration and studies on fish eggs and larvae to assess tertiary recruits. Under this programme, 24 cruises were conducted covering almost the entire Indian EEZ.

## **Arabian Sea**

### *Upwelling*

With the onset of Summer-Monsoon, under the influence of the south-westerly winds along the west coast of India, the surface waters were replaced by colder, nutrient rich and often oxygen depleted waters from the sub-surface layers. The vertical profiles of temperature, salinity and density indicated the signatures of upwelling. The vertical distribution of nitrate ( $\text{NO}_3^-$ ) and silicate ( $\text{SiO}_4^{4-}$ ) revealed high concentrations at the surface layers along southwest coast of India. The distributions for nitrate ( $\text{NO}_3^-$ ) at 0, 10, 20, 30 and 50 metres showed strong regional differences over the west coast.

During summer monsoon, coastal belt of the southwest India showed the maximum surface and column chlorophyll-a and the values ranged between 0.3-1.4  $\text{mg m}^{-3}$  (avg. 0.6) and 3.3- 62.2  $\text{mg m}^{-2}$  (avg. 33.5). Surface and column primary production were between 2.2-117  $\text{mg C m}^{-3} \text{ d}^{-1}$  and 182-2094  $\text{mg C m}^{-2} \text{ d}^{-1}$ , respectively. Average surface and column primary production was higher during summer-monsoon (30.4  $\text{mg C m}^{-3} \text{ d}^{-1}$ , 787  $\text{mg C m}^{-2} \text{ d}^{-1}$ ) compared to winter-monsoon (11.5  $\text{mg C m}^{-3} \text{ d}^{-1}$ , 676  $\text{mg C m}^{-2} \text{ d}^{-1}$ ).

### *Denitrification*

During winter, almost all stations were characterized by a nutrient depleted surface layer as evidenced from the nitrate ( $\text{NO}_3^-$ ) distribution. Subsurface nitrate maximum was found to coincide with oxygen minimum zone ( $< 5\mu\text{M}$ ) where a portion of nitrate also has been utilized.

## Bay of Bengal

### *Eddies*

During spring Inter-monsoon, the flow field inferred from the hydrographic observation confirmed the anti-cyclonic circulation pattern and the equator-ward western boundary current. The pools of low saline waters observed at 200 – 250 km away from the coast showed the presence of a strong western boundary current. Hence, the anti-cyclonic circulation pattern converges surface waters and generates a warm core eddy of less salinity with poor production at some points. Concurrent with temperature distribution, the chemical and biological parameters support the eddy signatures. Dissolved oxygen at 150m depth ranged between 11 $\mu$ M - 22 $\mu$ M, decreased towards north. Nitrate ranged between 25 – 35  $\mu$ M and the minimum at the core of anti-cyclonic eddy. Similar trend was also observed in the silicate distribution with the minimum (12 $\mu$ M) at the core of the eddy. For the western Bay of Bengal, the column chlorophyll-*a* in the euphotic zone (0-120m) ranged between 8.5-22.3 mg m<sup>-2</sup> (avg. 14.9 mg m<sup>-2</sup>) and the corresponding integrated primary production was 139-394 mgC m<sup>-2</sup> d<sup>-1</sup> with an average of 262 mgC m<sup>-2</sup> d<sup>-1</sup>. The integrated chlorophyll-*a* and primary production at the core of anti-cyclonic eddy was relatively low (8.5 mg m<sup>-2</sup>: 144 mgC m<sup>-2</sup> d<sup>-1</sup>).

A significant feature observed in some points along the western Bay was the presence of cold core eddy with high salinity below 40m depth. Under the influence of the subsurface cyclonic eddy, the nutrients are pumped into the upper layer with consequent high production in this region. In addition to the temperature distribution, nutrient, dissolved oxygen, chlorophyll-*a* and primary productivity pattern give the confirmative evidence of the cold core eddy.

### *Upwelling*

Along the east coast of India the western boundary current weaken and change its direction during summer. Along the southeast coast of India, weak coastal currents and wind pattern are favorable for the upwelling processes. Upsloping of isolines, shallow mixed layer, low dissolved oxygen, relatively high nutrients, chlorophyll concentration and primary production (6.7 mg m<sup>-2</sup>; 211 mgC m<sup>-2</sup> d<sup>-1</sup> - 30 m water column) near the coast along 11°N substantiates the upwelling process but the values are not comparable with those of Arabian Sea.

### *Differential response of winter cooling processes in the Northeastern Arabian Sea and Northwestern Bay of Bengal*

Higher biological production in the Arabian Sea (chlorophyll-*a* 47.5 mg m<sup>-2</sup>, primary production 1114 mgC m<sup>-2</sup> d<sup>-1</sup>, mesozooplankton biomass 175 mmoleC m<sup>-2</sup>, microzooplankton biomass 26 mmoleC m<sup>-2</sup>) compared to the Bay of Bengal (chlorophyll-*a* 10.3 mg m<sup>-2</sup>, primary production 117 mgC m<sup>-2</sup> d<sup>-1</sup>, mesozooplankton biomass 71 mmoleC m<sup>-2</sup>, microzooplankton biomass 10.6 mmoleC m<sup>-2</sup>) was observed. In Arabian Sea winter cooling assisted by the high ambient salinity (>36 psu) resulted in densification of surface layers leading to convective mixing and deepening of the mixed layer (Average.70m).

Northern part of the Bay of Bengal however responded differently to atmospheric cooling. Prevailing low salinity (27 psu), resulted in thermal inversion and stratification of the water column. Shallow mixed layer (average <15m) and the absence of nitrate in the top 50m water column appeared to be the causative factors for low biological production in the Bay of Bengal.

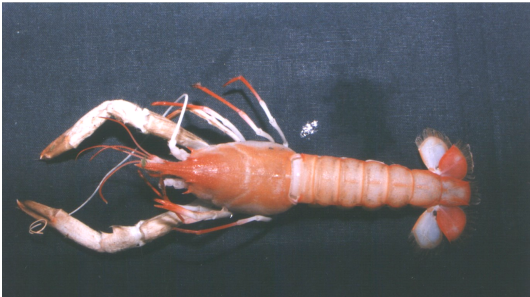
### **Andaman Sea**

The SST distribution exhibited a frontal pattern along the eastern Andaman Sea. The distribution of integrated mean concentration of dissolved oxygen and nitrate up to 75 metres showed low dissolved oxygen (<150µM) and elevated nitrate concentration (>2µM) along the southeast Andaman Sea, extending towards the southwestern region. The integrated chlorophyll-*a* varied between 7.9 and 19.6 mg/m<sup>2</sup> with an average of 13.2 mgm<sup>-2</sup> and the corresponding primary production ranged from 48 to 336 mg Cm<sup>-2</sup>d<sup>-1</sup> with an average of 187 mg Cm<sup>-2</sup>d<sup>-1</sup>.

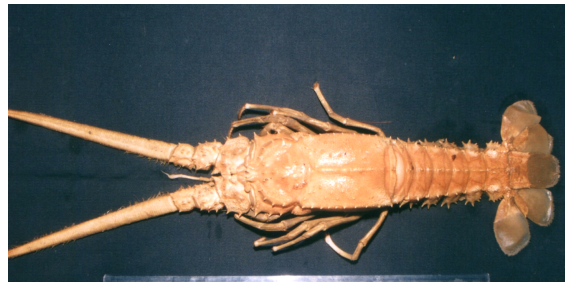
#### **5.1.2 Resources Assessment and Biology of Deep Sea Fishes in the Continental Slope of Indian EEZ.**

The objectives of this project include estimation of deep-sea fish biomass through acoustic surveys, assessment of deep-sea fishery resources by experimental trawling, studies on population dynamics and predictive modeling, correlation of environmental data with abundance, biological studies, development of a GIS based Fishery Information System, preparation of fishery chart, etc.

Two dedicated cruises of FORV Sagar Sampada were carried out for these studies. The depth of operation ranged from 53 to 796 metres covering the pre-monsoon and monsoon seasons. A total of 44 trawl operations were made using Expo model fish trawl, HSDT II (Crustacean version) and HSDT II (Fish version). 29 operations were conducted between 200 – 300 metres, 11 operations between 300 – 500 metres and 2 between 500 – 800 metres.



***Nephropsis ensirostris***



***Linuparus somniosus***



***Zenopsis conchifer***



***Polymixia nobilis***

Totally 25 stations were sampled, 20 hauls in the east coast of India and 5 hauls in the Andaman & Nicobar waters, all beyond 200m depth. Studies along the East coast registered a CPUE of 44.7 kg/hr. A total of 19 species of finfish, 7 species of shrimps, 4 species of lobsters and 2 species of cephalopods were identified from this region. The 5 trawl operations made in the Andaman & Nicobar waters registered a CPUE of 33.41kg/hr. Altogether, 20 species of fin-fishes, 8 species of shrimps and 7 species of lobsters were identified from this area.



Demersal trawl operations at 19 stations conducted on the west coast of Indian EEZ using Expo model fish trawl and HSDT II recorded an average CPUE of 37.96 kg/hr. All together 20 species of fin-fishes, 5 species of shrimps and 2 species of lobsters were identified from the catches of the region.

#### 5.1.3 Studies on Deep Scattering Layers (DSL)

The objective of the project is to study the DSL within the EEZ of the Arabian sea and Bay of Bengal on the basis of acoustic recordings and by Issac Kidd Mid-water Trawl (IKMT) operations. Samples and forage organisms collected by IKMT, pelagic trawl and bottom trawl were analysed to establish the occurrence, distribution and seasonal abundance of DSL organisms; survey of migration of ichthyo-plankton and other nektonic organisms for assessment of potential fishery resources; distributional studies of decapod crustaceans and cephalopods; Resource abundance of species such as myctophids, gonostomatids, bregmaceros, etc.; preparation of DSL charts on the major components; modeling of DSL fishery including hydrographic parameters; identification of indicator organisms for aggregation of exploitable species of mesopelagics and demersals; and harvest technology for DSL fish and shell fish resources.

Six cruises were undertaken during the year onboard FORV Sagar Sampada as a multi- institutional programme on DSL.

##### *West coast*

Two cruises were conducted covering the north-west and south-west coasts collecting samples from 21 IKMT stations which included 4 day and 17 night stations. Station depth ranged from 328 – 1566 m and sampling depth varied from 20 – 145 m. DSL observed were either in single or multiple layers with thickness of layers ranging from 50 – 100 m. Volume of IKMT varied from 200 – 300 ml/haul. The percentage of the nektonic components was less when compared to zooplankton in almost all stations which had a good collection of swarming crabs (*Charybdis smithii*). The DSL catch consisted of salps that dominated among plankton, whereas macrozooplankton like euphausiids, alima and amphipods were poorly represented. Among the nekton, myctophids and *Bregmaceros* dominated. Concurrent data on the hydrography and environment were also collected to establish interrelations.



*Swarming crab (Charybdis sp), of the DSL recorded from the South west coast*



*Vinciguerria nimbaria*

### *East coast*

Four cruises were conducted in the east coast, of which three were in the Andaman sea. IKMT samples were collected from 23 stations in the area (15 night and 8 day stations). Station depth varied from 232 – 2462 m and the sampling depth varied from 30 – 320 m. DSL thickness ranging from 20 – 100 m were recorded either as single or multiple layers. IKMT volume varied from 75 – 1000 ml/haul. Important nektonic groups encountered during the above cruises were myctophids, photichthids, pelagic shrimps, leptocephalus and among the plankton the groups encountered were chaetognath, euphausiids, megalopa, siphonophore, salps and alima.

Among the important observation during the cruises in general was that catches from bottom trawls had considerable numbers of larger myctophids (10 cm and above) compared to samples from IKMT. A study on trophic relations was also conducted.

The DSL biodiversity included 72 families, 95 genera and 116 species belonging to cephalopods (9 species), crabs (1 species), pelagic shrimps (29 species) and mesopelagic fishes (77 species) in the surveyed area, besides a wide spectrum of unidentified macrozooplankton species. Among the many micronekton groups the most dominant groups of ecological/economic value are myctophids and pelagic shrimps. The former is abundant in the northern sector and latter in the southern sector of the Arabian sea.

### 5.1.3 Harvest Technology and Catch Composition of Deep-Sea Fishery Resources in the Indian EEZ

The main objectives of the project are perfection of demersal, pelagic and semi-pelagic trawl systems with the aid of ITI sensors, with a view to design and optimize deep-sea trawls for cephalopods, deep-sea prawns and lobsters. Resource specific studies for gear specificity, efficiency and fuel economy, trawl configuration

measurements (net-height, wing end and door spread) at different speeds, model testing of gears at experimental tanks, selectivity of square mesh and diamond mesh with respect to major deep-sea fin-fish and shell-fish resources, and shoal characteristics of deep-sea resources, were attempted.

During the year, the project team participated in two cruises of FORV Sagar Sampada, and conducted studies on comparative performance of two different types of trawl nets (expo model and HSDT crustacean and fish versions) presently used as demersal sampling gears in survey of fishery resources of the deep sea at depths beyond 200 metres.

Field trials of two different types of mid water trawls (47m and 50m) designed and developed by CIFT, were also undertaken in the Bay of Bengal. The large meshes in the fore parts of these nets facilitated less resistance while towing.

Catch composition studies covering 24 stations in the Arabian Sea, in depth ranges of 200 - 400 metres, using HSDT and Expo Model trawls revealed no significant difference in species composition. The comparative CPUE of HSDT and Expo nets was calculated to assess the efficiency of the two gears at depths beyond 200 m. The CPUE for HSDT was found to be 522 kg / hr., while that of Expo Model was 299 kg/hr.

ITI studies showed that higher vertical opening of 5.4 m was obtained in Expo net while HSDT recorded a maximum of 3.4 m. Scope ratio studies revealed that it was 1:2.5 and 1: 2.7 for HSDT and Expo, respectively instead of conventional 1:3 for deep water operations. On analyzing the catch data with CPUE of major groups mentioned above, it was observed that HSDT showed higher catch and CPUE for finfishes, crustaceans and elasmobranches, while in Expo net, the catch of cephalopods was slightly higher.

In Bay of Bengal 30 were covered for species composition studies. Six fishing operations were conducted with HSDT and Expo model trawls at depths varying between 50 and 200 m. The percentage catch composition from HSDT and Expo net were dominated by finfishes. The percentage composition of catch from HSDT recorded 83%, 12% and 5% for finfishes, crustaceans and cephalopods, respectively and in Expo net it was 92%, 6% and 2%.

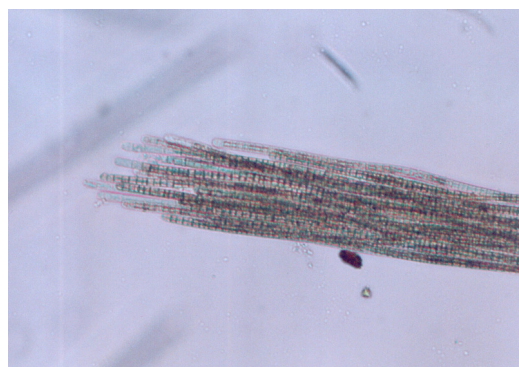
#### 5.1.5 Investigations on the Toxic Algal Blooms in the Indian EEZ

The project is aimed at identifying the harmful and toxic algal bloom forming species in the Indian EEZ and to study the dynamics of bloom formation and culture aspects.

Toxic algal studies were carried out by CUSAT (School of Marine Sciences), CMFRI and Andhra University by participation in seven FORV Sagar Sampada cruises during the period. Samples were collected from 150 stations for toxic algal studies. 234 species of microflora consisting of 118 species of dinoflagellates, 112 species of diatoms, and 4 species of blue green algae were recorded during this period from the EEZ. 146 species of microflora recorded from the Bay of Bengal constituted 87 species of dinoflagellates, 56 species of diatoms and 3 species of blue green algae. 165 species of microflora comprising 82 species of dinoflagellates, 81 species of diatoms and 2 species of cyanobacteria were recorded in the Arabian Sea.

Harmful microalgae recorded from the EEZ included 11 species of dinoflagellates, 5 species of diatom and 3 species of cyanobacteria. Out of these 19 species, eight species of microalgae such as *Dinophysis spp*, *Gonyaulax catenella*, *Prorocentrum lima*, *P. micans* and *Pseudonitzschia seriata* produce potent toxins.

All the three algal blooms recorded during the period were caused by *Trichodesmium thiebautii*. The locations of the bloom were off Mumbai, off Calicut, and off Port Blair.



***Bloom formation of Trichodesmium thiebautii***

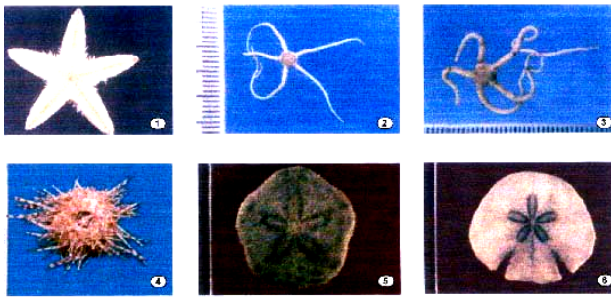
Water quality studies at the bloom sites revealed that there was a depth-wise increase in the quantity of nutrients. While the concentration of  $\text{NO}_2$ ,  $\text{NO}_3$ ,  $\text{SiO}_4$  and  $\text{PO}_4$  in the surface water recorded was 0.06, 0, 0, and 0.8  $\mu\text{g/l}$ , respectively; the corresponding values at 50 m were 0.16, 2.54, 6.8 and 1.13  $\mu\text{g/l}$ . The very low concentration of the nutrients in the surface may be due to the high rate of utilization by the standing crop. The pH, temperature and salinity values showed a slight decrease at 50 m depth compared to those at surface. The concentration of *Trichodesmium thiebauttii* was found to be  $4.3 \times 10^3$  cells /l. The chlorophyll-a value in the surface was 0.85  $\mu\text{g/l}$ . Chlorophyll-a values were high concomitant with increasing depth. The chlorophyll-a content registers the presence and age of the bloom. A relatively low oxygen value in the upper 10 m water column indicates the dissipation of bloom bringing in an increase in BOD.

#### 5.1.6 Investigations on the Benthic Productivity in the EEZ of India

The objectives of this project are to understand the spatial distribution of standing crop of benthos and its seasonal variations, if any; composition of benthic community; microbial production, its role and the mineralisation process; benthic diversity in the Indian EEZ and creation of a data base on benthos of the Indian EEZ.

Benthic samples indicated that among macro-benthos of our continental shelf, while molluscs were the dominant group along the east coast, polychaetes along the west. Analysed data indicated benthic production of in-faunal macro-benthos at 415 kg C  $\text{Km}^{-2} \text{yr}^{-1}$  and that of meio-benthos at 1610 Kg  $\text{Km}^{-1} \text{yr}^{-1}$ , which were much less compared to values reported earlier.

A decrease in biomass of macro and meio-benthos was observed with increase in depth of the shelf, both along the east and west coasts. In the west coast, samples collected registered a total reduction of 63 % from 30-50 m depth range to the edge of the continental shelf. The highest biomass of benthic fauna was observed in sandy substratum followed by silty-clay and silty-sand. However, numerical abundance was the highest in silty- clay soil. While about 165 species of polychaetes and 100 species of free living nematodes were identified up to species level from samples of the west coast, no specific pattern of latitudinal variations, neither in biomass nor in numerical abundance was observed.



***Some of the echinoderms – benthic fauna  
fauna recorded***



***Some of the molluscs – benthic  
recorded***

Dissolved oxygen and temperature were identified as major hydrographical factors that control faunistic abundance. From the data analysed for the west coast, no direct correlation could be observed between organic matter and richness of macro benthos in-fauna.

#### **5.1.7 Development of Acoustic Techniques for Fish and Biomass Estimations**

Study of Target Strength (TS) of fishes such as mackerel, sardines, anchovies and ribbon fishes; design and development of software for signal processing, its validation and fine tuning and manpower training, are the objectives of this project.

TS measurements of various commercially important species of marine pelagic fish, were carried out at 38 kHz frequency using portable ES60 echo-sounder. Studies were also conducted on variations in TS values corresponding to size of individual fish, seasonality and transmitting frequencies of acoustic pulses.

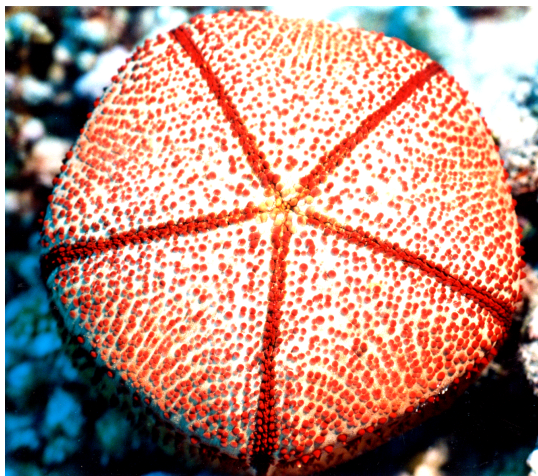
A special type of cylindrical cage (1.2 m in diameter and 1.0 m in height) was designed using material with negligible acoustic absorption coefficient for *in-situ* TS measurement of pelagic fishes. The cage was field-tested overboard FORV Sagar Sampada. Studies on fish biomass estimates using conventional echo-integration method and the recent direct estimation method are at various stages of progression, with a view to develop suitable correction factors relevant to tropical/Indian scenario.



***Experimental cage developed for in situ TS measurements***

## **5.2 Drugs from Sea**

The ocean living resources provide ample scope for extraction of drugs and chemicals for medical and other purposes. During the year, About 500 marine organisms, representing Porifera, Coelenterata, Echinodermata and Mollusca, Chlorophyta, Rhodophyta, Cyanophyta and some mangroves were collected. Organisms possessing anti-diabetic, anti-diarrheal, anti-fungal, anti-cholesterol, anti-bacterial and spermicidal activities were identified. The regulatory pharmacology and toxicology of the anti-diabetic lead and toxicity test of anti-cholesterol molecule are being conducted. More exploratory work to identify organisms, which show bioactive potential is being undertaken.



***Marine fauna useful for developing drugs***

### **5.3 Assistance to Research Projects & Manpower training**

As part of its efforts to promote research and stimulate original path-breaking scientific work on oceans, the Department supports such activities organised by universities, national laboratories, scientific institutions, etc., geared towards strengthening of science infrastructure and building up of human resource pool in oceanography. In order to create a platform to generate technologies in the ocean sector, Ocean Science and Technology Cells have been set up in key focus areas, and also to support the scientific and technological activities, coastal Universities were identified as a hotbed to pursue frontier-area applications during 2002-2003.

Presently 87 research and development projects are being supported in the interdisciplinary field of Marine Science & Technology. This includes 12 projects exclusively under Marine Manpower Development Programme and 75 projects being supported under the 9 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.

The major achievements during the period under report have been enumerated below:

- Under the project "Rock magnetic studies of marine sediments" completed in the current year at the Deptt of Marine Geology, Mangalore University, sediment cores from the Western continental margin of India, and surface sediment samples from the deep Arabian Sea were investigated employing rock magnetic techniques that reveal a wet phase (increased rainfall) during early Holocene. For the first time, a pollen record extending to 202 ka BP for the eastern Arabian Sea was obtained. The pollen data indicate that sediment is transported from the slopes of the Western Ghats.



- Studies undertaken on biogeochemical cycling and sea-to-air fluxes of Dimethyl Sulphide (DMS) in the northern Indian Ocean at NIO, Goa reveal a large variability in DMS in both space and time in the Indian Ocean. It has been shown that due to intense biological activity, the Arabian Sea produces 0.12 million tonnes of DMS in the upper 100 m of the water column while the Bay of Bengal and the Central Indian Ocean Basin produce 0.06 and 0.02 million tonnes of DMS, respectively. In contrast to this pattern, the sea-to-air fluxes of DMS are the highest in the Bay of Bengal (1.4 thousand tonnes/day) followed by Central Indian Ocean (0.9 thousand tonnes/day) and the Arabian Sea (0.8 thousand tonnes/day). These results strongly suggest that the efflux from this region accounts for less than 10% of the total DMS produced.
- Another project “Boat typology and fishing communities – A contextual study – Bengal & Andamans” by Dr.Lotika Varadarajan was completed during this year.
- A new project “Development of Autonomous Underwater Vehicle” under this programme was approved during this year.
- For the first time in the country three species of sea horses were bred under controlled conditions, raised up to third generation and sea ranched off Porto Novo/Vellar estuary.
- Preparation of Monographs on fish eggs and larvae of Vellar estuary and sea fans of Indian coast was nearing completion.
- Till this year about 200 fellowships were awarded to various Universities/Institutes.

#### **5.4 Coastal Ocean Monitoring and Prediction System (COMAPS)**

A wide range of developmental activities viz., industry, tourism, fishing, aquaculture, etc., and large-scale human inhabitation take place in the coastal areas. Development of these activities clustered along the narrow strip of coastal waters, creates conflicts between activities and the goal of conservation of the nature.

The natural coastal systems and the areas in which human activities involve the use of coastal resources may therefore extend well beyond the limit of territorial waters. The natural habitats of the coastal waters are varied, but being small in area, have been shrinking fast for several decades, primarily due to excessive use for a variety of purposes. This leads to generation of different kinds of waste, which are discharged into the coastal marine environment either directly or indirectly through the rivers, canals and

creeks. This results in degradation of coastal water quality, which has become a major cause for concern. These known problems are likely to be compounded in future as a result of the general trend in environmental and socio-economic conditions.

Protection and preservation of marine environment is one of the priority areas of Government of India. As per the Allocation of Business Rules, 1961, Department of Ocean Development is responsible for preservation and conservation of marine environment. Under this directive, the department has been carrying out studies relating to monitoring of marine pollution in the coastal and offshore areas of the country under the programme viz. 'Coastal Ocean Monitoring and Prediction System (COMAPS)' since 7<sup>th</sup> 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 sediments. 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 introduction and to enable the Pollution Control Boards to evolve a mechanism for mitigating the adverse impact of pollution on marine environment. During the current year Development of GIS based data base for marine pollutants has been initiated under the programme. For ensuring data quality, Inter-calibration exercises are also carried out.

Regional Research Laboratory, Bhubaneswar; Centre of Advanced Study in Marine Biology, Annamalai University, Prangipettai; 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 the participating institutions in the programme.

### **West Bengal and Orissa Coasts**

The waters, sediment and biological samples collected along the Orissa and West Bengal coasts showed more or less clean water quality except at a few near-coast stations. The increased concentration of ammonia and inorganic phosphates was recorded at the near-shore region of the Mahanadi and Paradip transects due to discharge of effluents from nearby fertilizer industries and the port activities. Sandheads has the highest value of suspended solids and turbidity. The Hoogly estuary is

generally characterized by higher NO<sub>2</sub>, NO<sub>3</sub>, NH<sub>3</sub>, PO<sub>4</sub>, total Phosphorous, total nitrogen, Cd, Pb, Hg and pathogenic bacteria.

### **Andhra and Tamilnadu Coasts**

The BOD values were high in the Vishakapatnam coast. This region also recorded a slight build up of petroleum hydrocarbon and the observed value was found to be 633.2 µg/l. Similarly, the Chennai and Tuticorin waters have also recorded higher organic pollution especially during dry season in association with the discharges of the urban and industrial wastes along with the river discharges such as Ennore, Adyar and Cooum.

Slightly higher concentrations of heavy metals in water and sediment were recorded in Vishakapatnam, Chennai, Tuticorin, Pondicherry and Cuddalore. Among the metals Pb (Lead) recorded a maximum of 213.45 µg/g in Vishakapatnam while Cd (Cadmium) (89.5 µg/g) and Hg (Mercury) (59.0 µg/g) was found to be high in Pondicherry waters.

Total coliforms were more in number in the coastal stretch between 0.5 and 1 km transect. The observed maximum count of  $42 \times 10^5$  was found at Visakhapatnam – 0.5 km. Among the 10 strains recorded, the order of abundance of indicator species are as follows: Total Coliforms, *E.Coli*, Faecal coliforms, *Vibrio Cholerae* like organisms, *Vibrio parahaemolyticus* like organisms, *Proteus Klebsiella* like organisms, *Pseudomonas aeruginosa* like organisms, *Shigella* like organisms and *Salmonella* like organisms.

In Cuddalore waters large number of fish eggs and larvae were observed (9,90,000 No./m<sup>3</sup>). Bivalve larvae (veliger) were generally present in all hot spots and in offshore regions of 0.5, 1, 3, 5 and 10 km. This may be due to the spawning of bivalves like *Crassostrea madrasensis*, *Perna viridis*, *Meretrix meretrix*, *M. casta*, *Katelysia opima*, *Anadara granosa*, etc. This indicates that the waters beyond 0.5 km had better quality of seawater.

### **Lakshadweep, Kerala and Karnataka coasts**

Along the Kerala coast, the near-shore area with low pH, high suspended solid load and absence of live benthos substantiate that the area around Veli, Trivandrum is under stress due to discharge of Titanium factory wastes. The concentration of inorganic phosphate along Cochin estuary showed higher value due to disposal of untreated sewage. Also Cochin estuary recorded the presence of pathogens like *Salmonella* sp. in

very high density. Also Mangalore estuary showed more faecal coliforms and faecal *Streptococci*. However, Cochin and Mangalore estuaries are dynamic and plankton diversity showed an healthy trend.



*Colour change in the dead remains of the shoreline bivalves near the effluent discharge point at Veli, Trivandrum.*



*TTP effluents spreading on the beach at Veli, Trivandrum.*

The sea off Kavaratti waters, Lakshadweep, showed higher values of primary and secondary productivity than the lagoon region. Faecal contamination is prevalent in the near shore region of the lagoon, where moderate oxygen content and higher nutrients were observed.

### **Goa, Maharashtra and Gujarat coasts**

The BOD values of the Mandovi estuary were slightly higher as compared to coastal stations, which varied from 2.58 – 3.40 mg/l due to sewage disposal. However, the Dissolved oxygen levels showed no oxygen deficiency. It indicates that the oxygen consumed is readily replenished. In Mandovi estuary the phytoplankton and the Chlorophyll-a levels were low compared to coastal stations. Similarly, zooplankton biomass was also found low (1.05 ml/100m<sup>3</sup>). However, the highest faunal diversity with 17 groups of zooplankton and 7 groups of benthic fauna, was observed at the hotspot. Microbiological data didn't show any specific variation as occurrence of TC, VLO, PKLO was low, which indicate the good health of this estuarine ecosystem.

Along the Maharashtra and Gujarat coastal waters, the suspended solid load showed a substantial increase off Hazira due to the influence of high tidal movements in the Gulf of Khambat. The DO was above 3mg/l except off Veraval and Tarapore (1-3 mg/l). BOD was generally below 2mg/l indicating efficient utilization of oxidizable organic matter reaching the coastal waters. The concentration of nutrients, primary and

secondary productivity was in the range expected for the coastal waters of India. The petroleum hydrocarbon was low in water as well as in sediment. Macrobenthic biomass varied widely due to sediment texture as well as stability of the substratum. The levels of Co, Ni, Cu, Zn, Hg and phosphorous in the sediment indicate lithogenic generation, except for marginally higher levels of Hg (0.25 µg/g dry wt.) off Bassein.

The water and sediment quality along Ratnagiri to Valsao clearly shows that the area is well oxygenated except along Ratnagiri transect. Nitrite concentrations were higher in Valsad than that of Ratnagiri transect. Incidentally, at this transect relatively lower DO values were observed indicating high regenerative activity. The highest benthic faunal density dominated by Polychaetes (average 85.17%) was observed along Ratnagiri transect. A wide diversity of phytoplankton was also observed but none of them formed a bloom during the study period. Coastal and offshore stations did not show any regular trend of decrease or increase in zooplankton biomass. It was always noticed that the copepods dominated the zooplankton community (average 51.06%). The concentration of heavy metals in water and sediment are well within the acceptable limits and comparable with clean tropical coastal areas. Petroleum hydrocarbon showed a wide range in concentration due to shipping activity and movement of barges and fishing trawlers. The Microbiological data revealed that the TVC fluctuated widely showing a decrease towards the offshore. In general the coastal waters from Ratnagiri to Velsao remained stable compared to the previous years.

Under the COMAPS programme lot of microbial strains were collected during the last decade. Microbial culture collections are assets of a country for its economic development. Even though the biodiversity of marine microbes is very large, there has been no central facility in India to collect, preserve and distribute such microbial cultures for various activities. In this context, the DOD is implementing a project to establish a Marine Microbial Reference Facility aimed at: (a) Preparation of guidelines for collection and transportation of cultures; (b) Identification of microbial strains (bacteria) using conventional, computer aided and nucleic acid based techniques; (c) Preservation of these cultures by freeze drying and in liquid nitrogen; and (d) Development of knowledge base on marine microbes and web based information services. At present the Centre is handling only bacterial strains and in future fungal and actinomycete cultures would be preserved. These databases will be made available on Internet. The Centre will also conduct periodical workshops as a part of capacity building.

Since COMAPS programme is a multidisciplinary and multi-institutional activity, the data generated should be standard and intercomparable. Further, taking into account our long coastline and high percentage of population consuming seafood, it was felt necessary to prepare standards related to marine environment and to encourage greater monitoring of seawater for trace elements. The sea water is analysed for trace elements by a multi-laboratory technique approach, in which a number of International marine laboratories participated. The results for trace metals were statistically analyzed and the values certified. The certified values are Cd at  $0.053 \pm 0.008 \mu\text{g/l}$ , Pb at  $0.560 \pm 0.080 \mu\text{g/l}$ , Fe at  $2.900 \pm 0.200 \mu\text{g/l}$ , Ni at  $0.400 \pm 0.040 \mu\text{g/l}$ , Cu at  $2.4301 \pm 0.08 \mu\text{g/l}$  and Zn at  $10.580 \pm 0.400 \mu\text{g/l}$ . Thus, India is the second country in the world next to Canada to come out with such a standard for trace metals in our Coastal Sea Water.

Upgradation of Data base structures and GIS format for the data bases have been pursued as a part of the development of an information system for the COMAPS programme.

## **5.5 Ocean Awareness**

### *5.5.1 Exhibitions & Fairs*

With a view to promote awareness among public and school children, Department of Ocean Development participated in the following exhibitions and fairs during 2002-03:

#### Enviro International, New Delhi

Tafcon group had organized an exhibition and seminar on Environment International 2002, which highlighted technologies and equipment for environment protection. The fair was organized to project the state-of-the-art technologies, services, products and capabilities in the development of Environmental sector. DOD projected all environment related activities of ICMAM and Coastal and Environmental engineering and OTEC of NIOT. Department's pavilion received an award of appreciation.

#### Swadeshi Mela, Allahabad

Swadeshi Mela was organized by Centre for Bhartiya Marketing Development at K.P. Ground, Allahabad during Oct.25-30, 2002. The objective was to showcase the latest development in its research and scientific capabilities to public at large. DOD

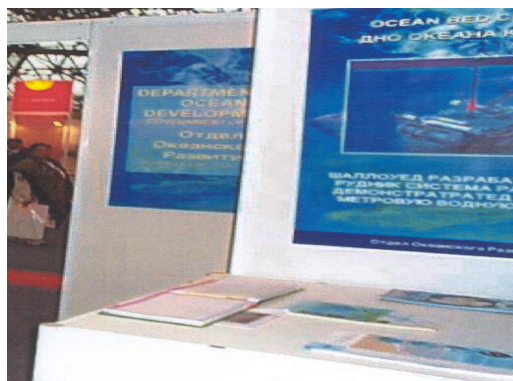
projected achievements under Polar Science, Ocean Observation and Information Services, Ocean Energy and Deep Seabed Mining programmes. Information through brochures and booklets on the achievements in the Ocean technology sector were made available to the visitors. The Department won the best participant award.

#### India International Trade Fair(IITF) 2002, New Delhi

The IITF is the most popular trade exhibition organized by the India Trade Promotion Organisation (ITPO) every year at Pragati Maidan, New Delhi from November 14 to 27<sup>th</sup>. In the 2002 IITF, recent achievements under Ocean Energy and Antarctic programmes were displayed. Educative films on Antarctica, the scientific programmes of the Department and ocean technologies developed by National Institute of Ocean Technology ( NIOT ) were shown at regular intervals. Brochures, books and mementos were distributed to the visitors.



*DOD pavilion in IITF 2002, New Delhi*



*DOD pavilion at Indian Trade Fair,2003,  
Moscow, Russia*

#### EEWAC 2002 INDIA, Chennai

ICMAM-PD and NIOT participated in the Exhibition and Conference on Environment, Energy, Water and Cleaning Technology held at Chennai during June, 21-23, 2002 and showcased the activities and accomplishments of the two institutes on coastal zone management, coastal and environmental engineering, ocean energy, etc.

#### Swadeshi Mela, at Mumbai

Department participated in Swadeshi Mela organised by Centre for Bharatiya Marketing Development (CBMD) at Mumbai from 28<sup>th</sup> Jan.– 4<sup>th</sup> Feb.2003. One of the highlights of the event was a special pavilion on Indian achievement in the field of Ocean development and Science & Technology. Department projected its achievements in

polar science, Ocean Observation and Information Services, Ocean Energy Technology, Deep Sea Bed Mining, etc.

#### Exhibition on “ The Ocean and the World, New Delhi”

Department of Ocean Development, in collaboration with India International Centre, New Delhi organised an exhibition “ The Ocean and the World” at IIC Annexe, New Delhi, during 11-16<sup>th</sup> February, 2003. The target audience for the exhibition was mainly school children for enabling them to appreciate the importance of the ocean sector and in order to generate genuine ocean awareness. The selected themes of Antarctica, living and non-living resources of the oceans covering biological aspects of the sea and its resources and major activities of the Department were displayed. A major component of the exhibition was the colloquium on the topics like Antarctica, weather, energy/wealth from the oceans and ocean information.

#### Indian Trade Fair 2003 at Moscow from 17 to 21 February, 2003.

Department of Ocean Development participated in India Trade Exhibition 2003, organized by ITPO at Moscow from 17<sup>th</sup> to 21<sup>st</sup> February 2003. Various activities of the Department in the field of Ocean Thermal Energy Conversion, Deep Sea Bed Mining, Polar Science, Marine Archeology, Gas Hydrates, Ocean Observation, Coastal Zone Management, etc., were displayed.

#### *5.5.2 Seminar/Symposia/Conferences/Workshops, 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, 30 International and National Seminars/symposia/workshop/ etc., were sponsored on ocean and related topics during 2002-03.

INCOIS hosted the National Systems Conference 2002 jointly with Systems Society of India, during November 18-19, 2002, with main theme on “Ocean Observing Systems and Services”. INCOIS hosted another National Seminar on Modern Techniques for Digital Geography, Land, Coast and Ocean, jointly with Andhra Pradesh Geographical Society (APGEO) during February 22-23, 2003.



### 5.5.3 *Information Technology & Computers*

- Website of the Department has been updated with latest Annual Report, performance Budget, Detail Demand for grants.
- Online Vacancy circular
- Proceedings of Indo-Russian joint workshop on Gas hydrates has also been included in the web-site

## 5.6 **Integrated Coastal and Marine Area Management (ICMAM)**

The Integrated Coastal and Marine Area Management project initiated during 1997-98 has two main objectives namely, Capacity Building and Development of Infrastructure for R&D training. The Capacity Building component is supported by the International Development Association (IDA) under the Environmental Management Capacity Building Project of the Ministry of Environment and Forests. It is having four major components. They are:

- i) Development of Critical habitat Information System for 11 selected critical habitats
- ii) Determination of Waste Assimilation Capacity in Tapi estuary, Ennore creek and Hooghly estuary.
- iii) Development of Environmental Impact Assessment Guidelines for Ports and Harbours, Coastal Tourism, and Waste disposal through marine out falls,
- iv) Development of Model ICMAM Plans for identified areas such as Chennai, Goa and Gulf of Kachchh.

The activities related to the development of infrastructure, training and R&D programmes for Zonation of Coastal waters through Use Classification and No Impact Zone studies on Pulicat and Coringa are directly funded by the Department of Ocean Development (DOD).

The following programmes were initiated during the current year of the Tenth Plan.

- Development of Critical Habitat Information System (CHIS) using GIS for 3 selected Critical Habitats (Andaman & Nicobar islands, Lakshadweep islands and Goa)

- Determination of the Zonation of Coastal waters at 10 additional sites
- Development of specific habitat/ water quality criteria through Marine Ecotoxicology and related R&D activities
- Studies on Ecosystem Modelling
- Management of tidal inlets
- Shoreline management
- Satellite based R&D programme

The progress under each of the activities is presented below:

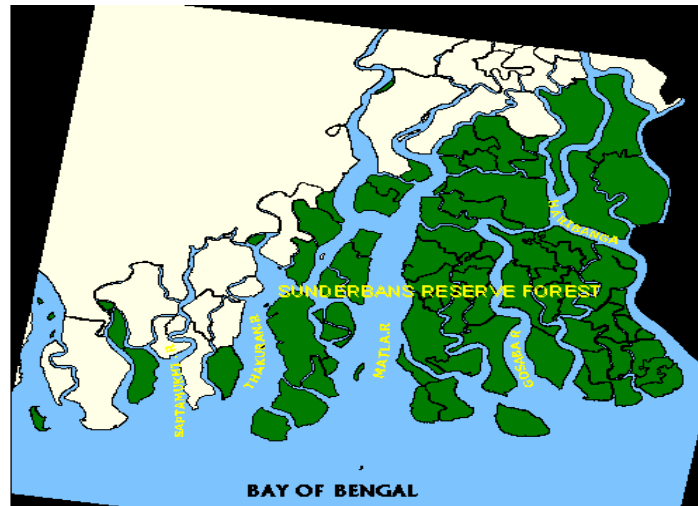
#### **5.6.1 Development of Critical Habitat Information System for 11 selected critical habitats**

To assess the status of some of the critical coastal habitats such as mangroves, coral reefs, sea grass beds, estuaries, beaches, backwaters, etc., and to suggest suitable management plans for protection, conservation and restoration, Development of Information System using GIS was taken up during the 9<sup>th</sup> plan period. Out of 11 critical habitats chosen, development of GIS based information system for 5 habitats namely, Gulf of Kachchh, Gulf of Khambat, Karwar islands, Cochin islands and Sundarbans, was completed during the current year, while for the other 6 habitats namely Malvan, Kadmat island, Gulf of Mannar, Pichavaram, Coringa and Gahirmatha, it was completed during 2001-02. Resource mapping of Andaman and Nicobar islands and Goa using GIS was initiated during the current year.

Some of the salient findings of the studies undertaken during the year under report are as under:

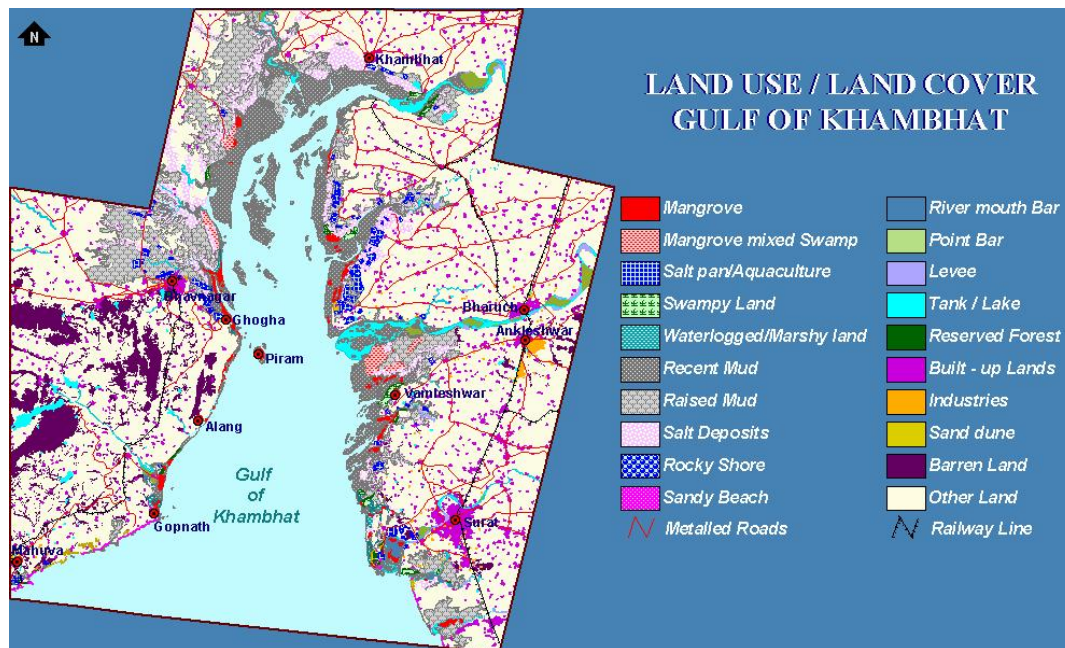
- Mangroves in the Sundarbans, West Bengal, the largest formation in India, cover an area of about 4,200 sq. km. Out of 50 species of mangroves recognised world over, more than 35 species are known to occur here. Sundarbans derives its name from a particular mangrove species commonly known as the Sundari tree (*Heritiera fomes*). However, today, the Indian part of Sundarbans is almost devoid of Sundari trees except for a few stunted trees that occur in the core region of the Sundarbans Tiger Reserve. Using remote sensing data, extensive field data and GIS, the total area under mangrove vegetation was estimated to be 1737 sq.km. The exposed muddy areas have also been mapped and these areas can be taken up for afforestation in future. Human settlement,

indiscriminate felling of trees, reclamation of forest land for cultivation and exploitation of timber, honey, fish, etc, were observed to be the causes of degradation of the pristine environment. Based on these observations, management plans to combat the threats and preserve the ecosystem have been suggested.



***Arcview output of Sundebans reserve forest. Sundri magrove plant in the inlay***

- In Gulf of Kachchh the areal extent of mangroves, mudflats and salt pans has been estimated. The Resource Information System indicated a total mangrove cover of 210 km<sup>2</sup> and mudflat cover of 2176 km<sup>2</sup> in the entire Gulf of Kachchh, excluding Kori and adjoining creeks. The Gulf also supports intensive salt farming in an area of around 404 km<sup>2</sup>. The integration of models of various parameters (hydrodynamic, meteorological, pollutant characteristics, etc) in GIS has enabled to plan mitigation measures in case of disasters for the protection of the ecologically sensitive areas.
- The GIS based CHIS for Gulf of Khambhat developed would serve as the base data for the decision makers to monitor the coastal habitats and to draw up and implement suitable integrated management plans to protect, conserve and manage the coastal environment and its resources around Gulf of Khambhat.



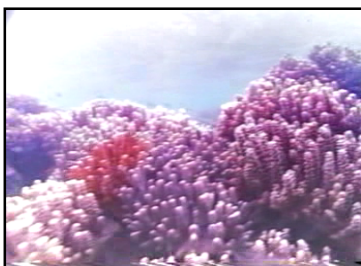
- The GIS based critical habitat information system developed for the islands of Karwar revealed that the water quality in the ecosystem is conducive for rich bio-diversity. However, the latest trends in upland area development besides the seabird project and the land use changes seem to have impacts on the island waters requiring constant monitoring.
- Cochin backwaters support sustainable fishery. However, the backwaters are under developmental pressure due to land reclamation, industrial development, berthing of various categories of ships, activities related to port, tourism, fishing harbour, fish processing, domestic sewage and industrial outfalls, pollution due to coconut husk retting, siltation, etc. It is believed that there is stress on the ecosystem besides over- exploitation of its living resources including fishing for fin and shell fishes. To regulate the domestic and industrial pollution, regulation of fisheries in the waters, restriction of natural shrimp seed collection and fishing for undersized targeted species, replenishment of the stock of the depleting species through sea ranching and awareness creation among the stakeholders including the local inhabitants on the sensitiveness of the ecosystem, have been suggested.

### *Query Development for Critical Habitat Information System*

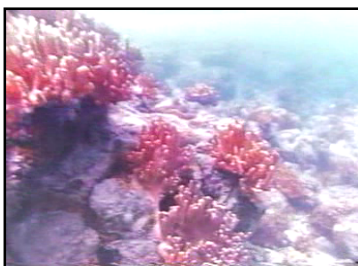
A standalone programme for querying the database of 11 critical habitat sites has been developed. The package has several features like graphical representation of seasonal and location-wise variations of physico-chemical parameters, biodiversity and socio-economics. It is having the capability of generating the database report for documentation purposes. This package gives a Bird's eye view of the database for the critical habitat information system.

### *Development of CHIS using GIS for 3 Selected Critical Habitats (Andaman & Nicobar Islands, Lakshadweep Islands and Goa)*

Development of GIS based information system for Andaman and Nicobar islands, was taken up by involving the National Institute of Ocean Technology (NIOT), Chennai to assess the status of coral reefs, mangroves, etc., using remote sensing data and field data. The major objective of this programme is to create an information system on the coral reefs and other resources of Andaman & Nicobar Islands with special reference to Mahatma Gandhi Marine National Park in Wandoor. Assessment of the status of the coral reefs and factors that cause degradation are important for scientific management and protection of coral reefs. This would help the decision makers to effectively monitor and manage the reef and related ecosystems in the region.



*Live soft corals – Sinularia sp.*



*Lobophyton*

*sp.*

A preliminary coral reef survey was carried out by Scientists of ICMAM Project Directorate, in Mahatma Gandhi Marine National Park during August 2002 to assess the status of coral reefs. The coral reef survey provided information on the distribution and abundance of the species diversity. The information obtained can be used to assess the status of coral reef ecosystem and for comparison at regional or global scales. Overall status of Corals in the Marine National Park are given in the following table:

Overall status of corals in Mahatma Gandhi Marine National Park in Wandoor,  
A&N Islands

Sl.No.	Island name	Live coral cover%		Dominant genera	No. of species recorded	Probable causes for degradation
		Inter-tidal	Reef slope			
1.	Grub island	10	50	<i>Acropora spp. &amp; Porites spp.</i>	46	Boat anchorage & Sedimentation
2	Chester	Small patches	15	<i>Fungia spp. &amp; Porites spp.</i>	29	Siltation
3	Red Skin	20	60	<i>Porites spp., Montipora spp. and soft corals</i>	48	Tourism activities and Boat anchorage
4	Boat	Small patches	15	<i>Porites spp. and Patches of Acropora spp.</i>	20	Siltation and Boat anchorage
5	Belle	10	40	<i>Porites spp.</i>	21	Sedimentation
6	Tarmughli	30	65	<i>Porites spp. and Acropora spp.</i>	40	Sedimentation and Boat anchorage
7	Snob	10	43	<i>Porites spp. and soft corals</i>	25	Siltation
8	Surrounding areas of Hobday, Pluto and Malay islands	20	45	<i>Porites spp. and Patches of Acropora spp.</i>	34	Sedimentation
9	Jolly Buoy	30	70	<i>Massive, Branching and soft corals</i>	63	Tourism activities, Boat anchorage.

Effluent discharges, unfavourable environmental conditions, human interference like trampling, overturning the coral blocks, snorkeling and scuba diving, etc., also appear to be responsible for the damage and destruction of corals in the Marine National Park.

The GIS based Critical Habitat Information System has been initiated for Goa. The agency for implementation of the project has been identified and the administrative

sanctions have been issued to initiate the project. The information system for Lakshadweep is proposed to be initiated by involving NIOT in the ensuing year.

#### **5.6.2 Determination of Waste Assimilation Capacity**

Determination of Waste Assimilation Capacity for Ennore creek is in progress. The data collection and compilation is completed. The analysis of data modelling and preparation of report are being completed.

The Waste Assimilation Capacity related data collection for Hooghly estuary is in progress. The data collection for 3 seasons is completed and analysis, modelling and preparation of report are nearing completion.

#### **5.6.3 Development of Guidelines for Environmental Impact Assessment**

Development of Environmental Impact Assessment guidelines was envisaged for ports and harbours, coastal tourism and waste water disposal through marine outfalls. The guidelines for ports and harbours have been completed during the financial year 2001-2002 and the report furnished to the Ministry of Environment and Forests.

In view of its uniqueness, coastal tourism is gaining importance day by day requiring impact assessment for setting up of tourism based projects. To ensure eco-friendly environment for sustainable development, the guidelines to examine the natural sites in the coast such as, beaches, coral reefs, mangrove areas, cultural heritage centres, recreational events, etc. and to arrive at the techno-economic feasibility by assessing the beneficial and adverse impact of tourism was initiated. The guidelines highlighted the relevant regulations and recommended the criteria for general guidelines to set up tourism related projects in the coastal areas. The guidelines cover the institutional mechanism for waste management in the coast besides monitoring of the projects. It contains the sample EIA and baseline design for pre-project environmental impact assessment also.

The draft report containing the guidelines for marine outfalls recommends the steps for optimisation of the outfalls on the basis of examination of the environmental legislations, assessment of the status, and the alternatives. It also identified the protocol for monitoring of the performance of the outfalls.

#### **5.6.4 Development of Model ICMAM Plan for Chennai, Goa and Gulf of Kachchh**

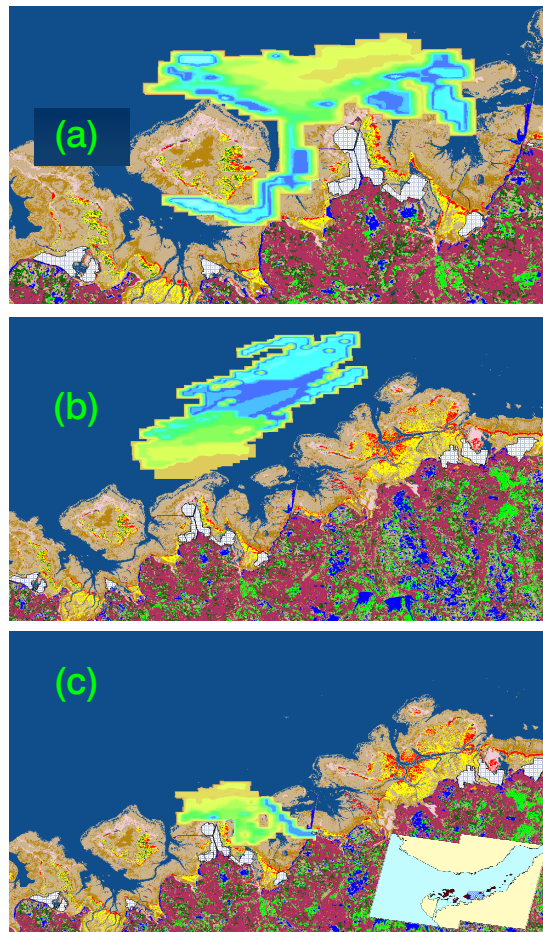
The draft ICMAM plan for Chennai was circulated to various state departments and stakeholders. Based upon the comments received from various stakeholders the report has been finalised. A Decision Support System (DSS) was developed to address the cross-sectoral issues like accretion/erosion, pollution, tourism and human settlements by selecting Ecology, Environment and Economy as the criteria. Various options of the interventions such as provision of training jetties to keep open the tidal inlets, beach nourishment to protect the coast from erosion and effluent treatment to improve the water quality, were analysed using DSS.

For the preparation of Model ICMAM Plan for Goa and Gulf of Kachchh, the design, structure and basic requirement of DSS including Activity, Impact, Entity and Attribute (AIEA) inputs were finalised. A comprehensive data collection programme for physical, chemical and biological parameters was initiated in association with NIO, Goa for ICMAM plan covering three seasons. Time series measurements for two seasons were completed and sophisticated equipment like Valeport tide and wave recorders, Aanderaa self recording current meters, Acoustic Doppler Current Profiler (ADCP) and Acoustic Doppler Velocimeter (ADV) were deployed to collect the accurate data. The third and final phase measurements will be completed by April 2003. The monsoon observations on water quality in Mandovi and Zuari estuaries of Goa revealed that DO and nitrate behaved conservatively, while phosphate behaved non-conservatively during estuarine mixing. The dissolved metals such as iron and manganese did not show any significant trend with salinity as these were introduced to the system mainly as non-point sources from the wash water from the iron ore beneficiation plants, ore loading points, washings of barges, etc.

Hydrodynamic and oil spill modelling studies are initiated to study the transport and fate of oil pollutants in the Gulf water using DHI software MIKE 21. The model takes into account the important phenomena of oil physics in an aquatic environment and provides the rapid prediction of the movement of spilled oil. The model is constructed based on the data viz. oil properties, tide, circulation pattern, wind and available spill details for the Gulf. Model is able to predict the oil slick thickness, movement and fate of oil related information, which are very helpful in decision making during a oil spill response. It demonstrates the usefulness of modelling approach in contingency planning and environmental impact assessment studies. The likely threat due to the oil spill at the



Single Point Mooring (SPM) of Reliance Industries located at Vadinar-Sikka has been modeled under three different wind scenarios. The model output was linked to GIS and overlaid on the ecological map. The integrated output showed the transport of oil towards the downwind direction. In no wind condition, the spilled oil has moved between Karumbhar Island and Narare Bet. While the movement of oil is towards northern coast when wind blows from southwest, in the northwestern wind condition, the first oil residue hit the coast at Narare Bet in 12 hrs and moved further towards Sikka affecting the ecological habitats.



*Ecological areas affected by Oil cover after 48 hrs of spill in 3 wind conditions*

*(a) No wind, (b) 5 m/s from 240°N and c) 5 m/s from 330°N*

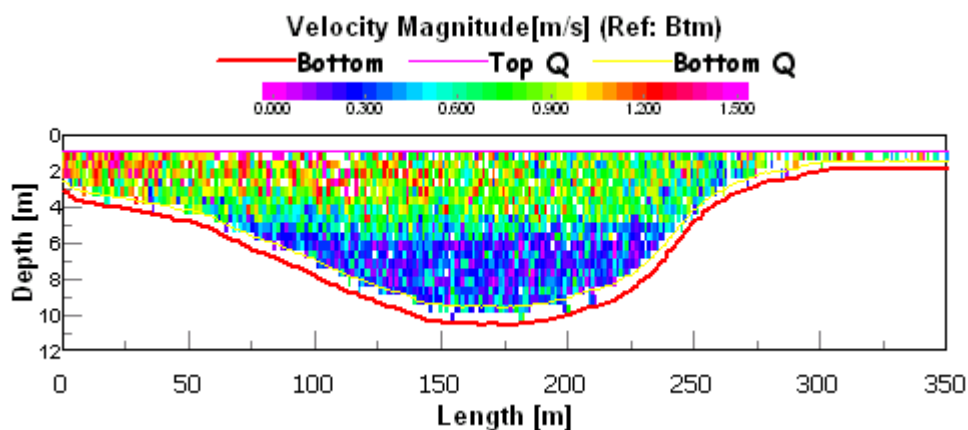


Fig. Measurement of velocity magnitude in an estuarine cross section system using ADCP

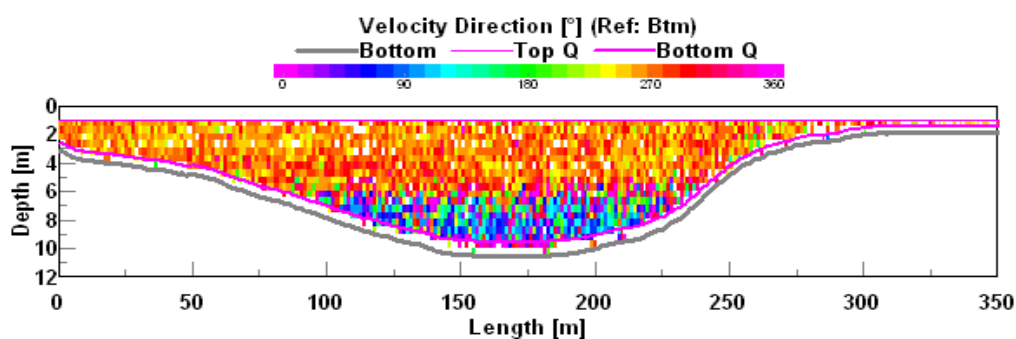


Fig. Measurement of velocity direction in an estuarine cross section system

#### *Decision Support System (DSS) for Chennai*

A prototype Decision Support System (DSS) for Chennai has been developed as a standalone package in Windows environment. This package contains a powerful user interface and thus facilitates the decision-makers to identify the various coastal activities and their cross impacts on ecology, economy and society and evaluates best strategies in a digital framework in a user-friendly environment. Similar type of DSS for Goa and Gulf of Kachchh will be taken up during 2003-04.

#### **5.6.5 Development of Infrastructure, Training and R&D Programmes**

##### *Determination of Best Designated Use of Coastal Waters*

Coastal waters play a vital role in the Nation's economy owing to their rich natural resources and by supporting trade, commerce, navigation and other developmental activities. The qualities of coastal waters vary considerably due to their interaction with the landmass and marine environment. Coastal waters also receive enormous amounts of pollutants from various land based sources and other coast related activities. Based

on the types of uses and activities, coastal water quality criteria have been specified to determine its suitability for a particular purpose. Based on this primary water quality, following 5 best designated uses have been developed by the Central Pollution Control Board.

No.	Class	Best Designated Use
1.	SWI	Salt pans, Shell fishing, Mariculture and ecologically sensitive zones
2.	SWII	Bathing, Contact water sports and commercial fishing
3.	SWIII	Industrial cooling, recreation and aesthetics
4.	SWIV	Harbour
5.	SWV	Navigation and controlled waste disposal

The task of developing a database to determine the “Best Designated Use of Coastal Water” for 18 selected coastal sites in phase I was entrusted to the Institute for Ocean Management, Anna University, Chennai. They are : Trivandrum, Calicut, Honavar, Mangalore, Ratnagiri, Daman, Hazira, Veraval and Porbandar in the West Coast and Tuticorin, Nagapatnam, Pondicherry, Krishnapatnam, Visakhapatnam, Gopalpur, Puri, Konark and Digha in the East coast .

Land use and land cover changes during the past 30 years were assessed and taken into account for determining the present and future use. Recent tools such as Remote Sensing and GIS were employed in determining the best designated use of coastal waters. The data collected during the past 10 years were organized in a database using ORACLE software as back end and D<sub>2</sub>K as front end. The database could be accessed and queried for the various water quality parameters to know the trends and variability in 30 important water and sediment quality parameters. The database is also useful for various users such as entrepreneurs, academicians, planners, coastal managers, policy makers and decision makers engaged in Coastal Development and Management.

Out of these 18 sites 16 were classified as belonging to SW-I class assuring the relatively unpolluted status and suitability of coastal waters for the uses such as saltpans, shell fishing, mariculture and ecologically sensitive zones.

In the 2<sup>nd</sup> phase of this study, 10 sites were selected for the study viz. Vadinar, Mahim, Mandovi, Quilon, Kanyakumari, Kudankulam, Bhuminipatnam, Chandipur, Saptamukhi and Port Blair.

#### *Coastal Habitat Studies*

The project for the development of methodology for identification of various biotic communities was completed by involving Space Applications Centre, Ahmedabad as an implementing agency. For coral reef studies Gulf of Kachchh, Lakshadweep, Gulf of Mannar and Andaman & Nicobar islands; for mangroves Gulf of Kachchh, Goa, Coringa, Bitharkanika, Sunderbans and Andaman and Nicobar islands were chosen, utilizing IRS LISS III and panchromatic data.

#### *Determination of No Impact Zone for Pulicat in Tamilnadu and Coringa in Andhra Pradesh*

The data collection for two seasons related to hydrodynamics, water quality and biological parameters was completed. To assess the dispersion of the pollutants numerical modelling studies are being carried out.

#### **5.6.6 Marine Eco-Toxicology and R & D Activities**

Coastal marine ecosystems have been considered as reservoirs of productivity and a massive sink with unlimited capacity to assimilate wastes. The dramatic increase in coastal population, over the years, associated with the establishment of industries, maintenance of harbours and waterways, development of coastlines, demands of tourism and other uses of coastal land have been the causes for coastal pollution. Since water quality is very important for the survival and well being of living resources in coastal and marine waters, pollutants from both point and non-point sources enter through receiving water bodies and affect the marine biota. Since most of the contaminants affect the productivity of the ecosystem through food chain, the levels at which the most common pollutants affect these organisms could be established through eco-toxicology studies. By comparing the levels of pollutants, the habitat quality of the ecosystem could be evaluated for their capacity to sustain their productivity. Impacts of pollutants on marine organisms are initially at the molecular and cellular levels and subsequently at a higher level of biological organization. Some toxicants would cause acute effects and others produce chronic effects and the effects would be greater on larval and juvenile stages. Most of the toxicants affect the metabolism of marine organisms, which will ultimately lead to their mortality. Bioassay systems will be

employed for assessing the environmental impact on toxicants alone, mixtures of toxicants, and in combination, based on parameters like temperature, pH, salinity and alkalinity, etc., and also the biodegradation, bio-accumulation and assimilation of xenobiotics. Assessment of different bioassay test systems, varying from enzyme assay to field models for variability, sensitivity and validity indicates the need for multiple tests for regulatory feedback.

In view of the above, Marine Ecotoxicology and R & D activities have been undertaken during the 10<sup>th</sup> Five year plan period. The main aim of this study is to develop specific habitat/water quality criteria to facilitate better management of marine and associated ecosystems in view of growing problems like pollution and waste disposal etc., so that the levels prescribed for various chemical elements in this criteria/standard can be properly assessed for their suitability for coastal waters and specific ecosystems like corals, mangroves, etc. The Institute for Ocean Management (IOM), Anna University, Chennai; Centre for Marine and Coastal Studies, Madurai Kamaraj University; and Department of Pharmacology and Environmental Toxicology, Dr.ALM PGIBMS, University of Madras, are participating in this programme.

The major tasks involved in the Ecotoxicology and R & D activities are as follows:

- Documentation of water quality parameters in and around Gulf of Mannar, the Chennai coast and Pulicat lagoon ecosystem, source of pollution and coastal developmental activities;
- Documentation of literature on acute toxicity and sub-lethal effects on aquatic organisms based on the continuous flow through system;
- Conduct of acute toxicity studies to arrive at LC<sub>50</sub> and EC<sub>50</sub> values using continuous flow through system based on the following parameters:

- a) Essential metal : Copper (Cu)
- b) Non-essential metal : Lead (Pb)
- c) Pesticide : Endosulfan
- d) Oil : Diesel (Water-soluble fractions)
- e) Abiotic variable : Dissolved oxygen
- f) Test organisms : Phytoplankton, Zooplankton,  
Shrimps: larvae and juveniles,  
Molluscs: Green mussel (*Perna viridis*) &  
Oyster (*Crossostrea madrasensis*)  
finfish : eggs & larvae; Mullet and *Ephenephelus* .

- g) Histology, histo-pathology and histo-chemical studies in respect of the acute toxicity studies on the test organisms.

Sub-lethal chronic tests and bio-accumulation would be carried out on the following aspects:

- a) Biochemical studies including enzymes
  - b) Biomarkers
  - c) Behavioural studies
  - d) Histology, histopathology & histochemical studies
- Conduct of toxicity studies using animal models in order to elicit the effect of lethal concentration at acute, sub-lethal levels and bio-accumulation for understanding the cause-effect relationship.
  - Development of specific water quality criteria for Gulf of Mannar; coastal waters of Chennai and Pulicat lagoon ecosystem.

The work plan for implementation of the project activities was defined and documentation of water quality parameters and compilation of literature on acute toxicity and sub-lethal effects on aquatic organisms based on the continuous flow- through system completed.

### ***Trace Metal Laboratory***

As a part of Eco-Toxicological studies, to assess the toxic effects of pollutants and their tolerance levels in marine organisms during the X Five Year Plan period, involving various universities and research institutes, a Trace Metal laboratory has been set-up, aiming at delineating the toxic effects of metals and their threshold limits on various marine organisms. This infrastructure will serve as a National facility.

The laboratory is covered under "*Clean Room facility of Class 10,000 / 100*" comprising a Garment Locker, Air Shower and Chemical Work Benches to minimise the contamination during processing of the samples. The laboratory is equipped with the following sophisticated instruments for analysing metals at trace levels.

- Flame Atomic Absorption Spectrometer (FAAS)
- Zeeman Graphite Furnace Atomic Absorption Spectrometer (ZGFAAS)
- Microwave Digestion System

- Water Purification System
- Electronic Balance



*Trace Metal laboratory at ICMAM-PD*

The FAAS detects the heavy metals up to ppm level while the ZGFAAS can detect at ppb level. Both the instruments are fully automatic with reference to auto-calibration, auto-dilution and matrix modifier addition, controlled through individual computers.

With the existing facilities and lamps, a total of 11 metals viz., Lead, Cadmium, Iron, Cobalt, Copper, Zinc, Chromium, Aluminium, Arsenic, Selenium and Mercury in water, sediment and biological samples could be analysed. On need basis, additional lamps could be procured for analysing other metals.

The Flame AAS can analyse 50 to 60 samples in an hour, while Graphite AAS can analyse 15 to 20 samples per hour.

The computer controlled Microwave Digestion System is helpful in digesting the samples such as sediment, plankton, effluents, etc. The Water Purification System is intended to provide ultra pure water with elemental concentration at ppt level, which will be used for preparation of standards, sample dilution and in deriving low blank values. The facility was inaugurated by Secretary, DOD on 23<sup>rd</sup> August, 2002.

#### **5.6.7 Studies on Ecosystem Modelling**

The studies on ecosystem modelling were initiated for Gulf of Mannar, Pulicat lake ecosystem, Vedaranyam, Chilka lake ecosystem and Cochin backwaters by involving various implementing agencies such as CES, Anna University, Andhra University, Regional Centre of National Institute of Oceanography, Kochi.

#### **5.6.8 Management of Tidal Inlets**

For the management of tidal inlets along the east and the west coast, IIT Chennai and NIOT, respectively were identified and the project preparatory activities were initiated.

#### **5.6.9 Shoreline Management**

For shoreline management in the east coast covering Ennore, Gopalpur and Digga and in the west coast covering Munambum to Kayankulam stretch in Kerala necessary action was initiated with the finalization of the action plans.

#### **5.6.10 Satellite Based R&D Programme**

The satellite based R&D programme for the selected sites along the Indian coast was initiated by involving National Remote Sensing Agency, Hyderabad. Necessary action plans were formulated and reviewed.

#### **5.6.11 Training Facility**

The state-of-the-art ICMAM Training facility, first of its kind in the entire South Asian region was used for offering training on Application of GIS in the management of Coastal Critical Habitat for different stakeholders. The training programme is an introduction to the use of GIS for effective coastal and marine habitat management. It teaches the concepts, analysis and modelling of geospatial data. The practical application of the software tools, underlying theory and the correct application of the tool are emphasized through hands-on training in the software. GIS applications to habitat management are also being taught in detail. During the period under report, thirty-five trainees from the Coastal State of Tamil Nadu, National Institute of Oceanography and Zoological Survey of India were trained on application of GIS for integrated coastal and marine area management. A number of visitors from India and abroad were appreciative of the facility and have expressed their desire to undergo training in this facility.

#### **5.6.12 Web Page Updation**

The ICMAM PD's web page <http://chennai2.tn.nic.in/icmam> was updated on Jan.01, 2003 with a variety of visuals including digital photographs and video clips, a

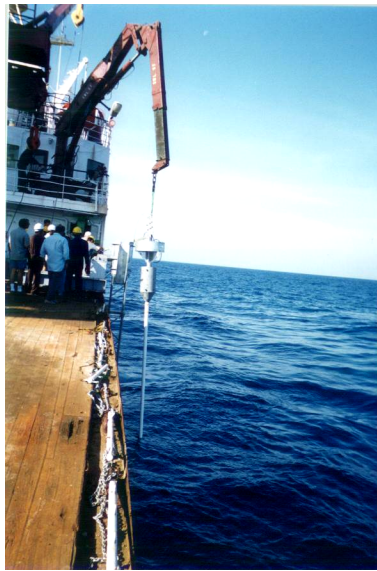


better way of understanding the activities and facilities of ICMAM PD for the internet world.

## **5.7 Deepsea Mineral Exploration**

### *Palaeo-oceanographic Studies in the Bay of Bengal Fan (BENFAN)*

Bathymetric data collected in parts of Bay of Bengal in the Exclusive Economic Zone were analysed to identify areas of long core collection. Gravity core samples were also collected and taken up for analysis at the participating labs/organizations.



*Piston corer in operation over-board ORV Sagar Kanya for BENFAN*

## **6. National Institute of Ocean Technology (NIOT)**

National Institute of Ocean Technology (NIOT) at Chennai was established by the Department of Ocean Development (DOD), Govt. of India as an autonomous institute, in association with IIT-Madras, Chennai during November 1993 with the main aim of developing and promoting technology for specific purposes in ocean related areas. The multifarious activities of NIOT are carried out as in-house technology development programmes and field demonstration projects. NIOT is also implementing two major operational programmes on behalf on DOD, namely the National Data Buoy Programme and operation of Research Vessels for pollution monitoring. The various technology groups form the core strength of NIOT. They provide professional expertise for field demonstration projects. The Planning & Management group helps to plan,

monitor and evaluate the various technology and field projects being implemented for timely results.

The major activities carried out during 2002 – 2003 and the accomplishments are as under:

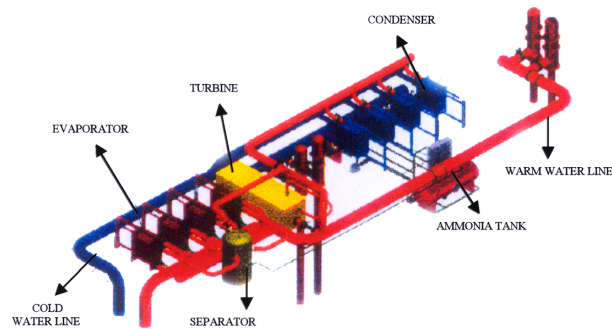
### **6.1 Ocean Thermal Energy Conversion (OTEC)**

Under the Jai Vigyan Mission project, world's first ever 1MW gross rating floating Ocean Thermal Energy Conversion (OTEC) project, was sanctioned during September 1998 for demonstrating the technology 60 km South East of Tuticorin coast in Tamil Nadu. The site was selected after conducting bathymetric Surveys for 1200 m contour and temperature measurements. OTEC uses the temperature difference between the surface of the sea (at about 29° C) and water at a depth of 1100 m (at about 7° C) to generate electricity using Rankine cycle with ammonia as the working fluid. The OTEC plant barge of size 71.5 x 16 x 4 m was named as "Sagar Sakthi". The various sub-systems including world's largest titanium plate heat exchangers with special steel coating on ammonia side to enhance maximum heat transfer and a four stage axial flow turbine required for the plant, were configured, designed and integrated on the OTEC barge. Three moon pools were provided in the barge for cold water, warm water and mixed water sumps. A 14 m high retractable sump system for cold sea water was designed and integrated in the OTEC plant to enable berthing of the barge in the jetty in retractable position. A HDPE pipe of 1 m diameter and 1100 m long, serves as a structural element for a single point mooring apart from drawing deep-sea cold water.

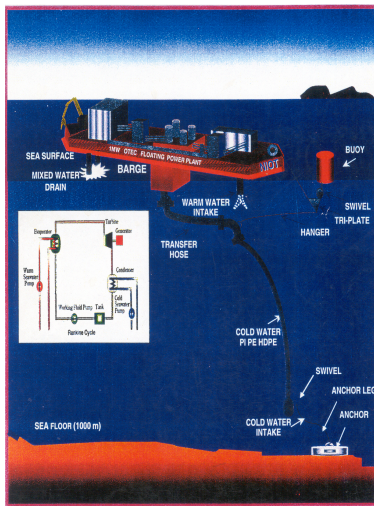
Due to an unforeseen mishap during the deployment in March 2001, the cold water pipe system dropped down to deep sea bed and could not be retrieved. An External Expert Committee was constituted which reviewed the mooring design, choice of material, deployment scheme, etc., which recommended carrying out additional studies relating to the risk analysis and some additions on the various sub-systems of the OTEC plant to improve the safety and reliability of the entire plant. All the recommendations made by the review committee were implemented.

With the additional funds sanctioned, a new pipe / mooring system was procured for the deployment process and special fusion welding process was adopted for HDPE pipes. Additionally a fatigue test was conducted on HDPE pipe on a scaled down model (1:10) of HDPE pipe in IIT (M), Chennai. A proof load of 200 T was applied on the taper

portion of the holdfast assembly and at the weld joint of the HDPE pipe for qualifying the joint. The percentage of the elongation of the HDPE pipe was measured and found within the acceptable limits. New/additional mooring components were designed and produced/procured. In order to retrieve the mooring components in case of any unexpected mooring failure, buoyancy chambers were designed and fabricated for the bullet nose and elbow. All these were done to increase the confidence level in the new technology being developed.



***OTEC Layout***



***OTEC Conceptual diagram***



***Buoyancy chamber being assembled to the main elbow***

A new buoy of inverted T shape to give optimum buoyancy and reduced drag force has been designed and fabricated. An additional elbow was introduced between Dunlop hose and transfer hose to improve the flexibility of the transfer hose system. A concept of stiffening the parent 1 m diameter HDPE pipe using HDPE sleeve adjacent to the hold fast assembly at the transit interface was evolved after a Finite Element analysis.

Several pre-commissioning tests/trials were conducted satisfactory on the OTEC system to gain operating experience for the scientists ahead of the final commissioning, which included, the complete power module including ammonia pipeline system using vapour ammonia and liquid ammonia in stages after ensuring the leakproofness at interface joints; engagement and disengagement of the bullet nose assembly with the cold water sump system at shallow water depth; the interface sealing between the bullet nose and cold water sump; operation of warm and cold water sumps were in the fully lowered condition by allowing water to flow through cold water lines and condenser for the first time. The necessary hazardous installation studies were conducted and emergency procedures evolved.



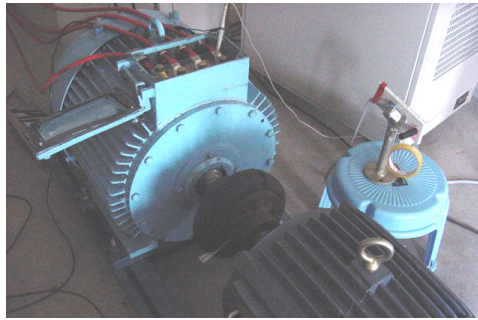
***Discharge of surface sea water back to sea through pumps***

An agreement was signed with a new deployment contractor on 28.12.2002, since the earlier deployment contractor was unable to keep up the time schedule, for deployment of the cold water pipe. The deployment procedure was finalized and approved by NIOT and vetted by third party surveyor agency. The mobilization of the crane barge, tug and other equipment at Tuticorin was completed by 17<sup>th</sup> February, 2003. Presently, the plant barge, cold water pipe and mooring system have been towed to 1200 m depth at the OTEC site 55 km off Tuticorin. The plant commissioning activities are in progress.

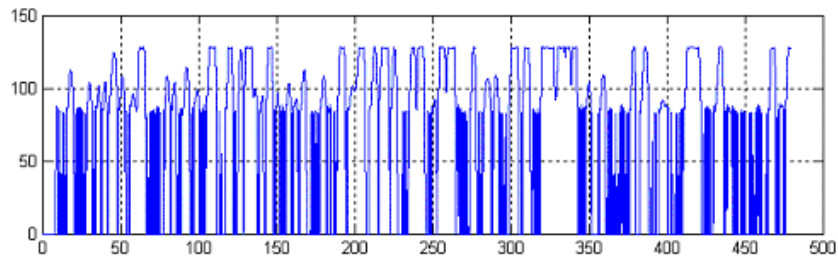
## **6.2 Wave Energy**

The wave energy plant at Vizhinjam, which is declared as a National facility is being maintained by NIOT. A reverse osmosis based desalination plant was established at this Facility, Vizhinjam, with an installed capacity of 10,000 litres per day. In order to operate the desalination plant using wave power, the sub-system components like variable speed alternator, battery and inverter were procured and tested individually. A

special impulse turbine to be driven by wave induced bi-directional airflow was erected on the caisson. The alternator is of Permanent Magnet Brushless type with an electronic regulator, which is capable of producing a constant DC voltage with variable speed input within a range of 400-1000 rpm. Hence, knowing all parameters of the turbine and alternator, numerical simulations were carried out in MATLAB to check the speed of the turbine and output voltage from the alternator. The alternator produced the required DC voltage of 130V in the specified range proving the concept. To ascertain the behavior in the field, an experiment was conducted by using a variable speed drive. The alternator was coupled to the drive, the speed of which was controlled to be similar to that of the wave activated turbine and generated DC voltage was as expected. The battery also charged and discharged as desired. All these components will be commissioned at Vizhinjam shortly.



***Alternator***



***Output voltage of the alternator***

### **Ejector Driven Desalination system**

There are many conventional technologies for converting seawater or brackishwater into potable water. The difference in temperature between surface water and deep seawater can be effectively utilised for the production of fresh water. NIOT has developed an ejector driven “Desalination system” with a capacity of 20 lph in association with IIT Madras. The warm surface seawater is flash evaporated in the vacuum chamber and the vapour is condensed using 6°C cold deep seawater. A two phase ejector creates the vacuum in a flash chamber compared to the conventional

vacuum pumps. The sub-system components like flash chamber, evaporator, condenser and jet pump were fabricated and are being integrated on 3.5 m x 2.5 m skid. The system would be installed on the 1 MW OTEC barge after conducting extensive performance tests in OTEC laboratory in NIOT.

### **6.3 Deep Sea Mining and Ocean Mining**

Deep sea technology group has been actively involved in the development of technology for mining of polymetallic nodules from 6000 m water depth. A major project for development of technology for mining these nodules in collaboration with the Institut für Konstruktion (IKS), University of Siegen, Germany was taken up by NIOT. An underwater mining system consisting of a crawler based mining machine with a flexible riser system was developed and tested for operations at 410 m water depth, which is a significant milestone in establishing India's capability to take up the utilization of the resources of the Oceans at all depths. The two projects namely "Developmental test on under water mining system for long term operation using DP system" and "Modification of existing crawler for shallow water applications" were approved by DOD. Preliminary work on the first project has already commenced. Suitable site having adequate soil bearing strength at a depth of approximately 500 m for deploying crawler is being identified. Improvements in Hydraulic systems, electronics, data acquisition and control system are being incorporated as part of indigenisation to suit to the low bearing strength of soil at 500 m depth. The technical specification of Dynamic Position system to be installed on Sagar Kanya was finalised. The preliminary design of a launching system to launch the crawler was completed.

The measurement of soil bearing strength in Hoogly river basin at Haldia, for the Dredging Corporation of India was carried out using the *in-situ* soil testing equipment, which was jointly developed with University of Siegen.

*The project on "In-situ soil property measurement at 6000 m depth" was taken up as an in-house project, the main objective of which is to measure the in-situ bearing strength and shear strength of the soil at 6000 m water depth in the Central Indian Ocean Basin. As the bearing strength is very low, no commercial off-the-shelf instrument is available for this measurement.*





***In-situ soil testing equipment being launched at Haldia***

An underwater thruster of 800 W output power was successfully tested in the towing tank at IIT(M), Chennai, which developed a thrust of 250 N during bollard pull tests and motion tests. An underwater cable has been ordered for testing the thruster at a depth of 1000 m.

#### **6.4 Coastal & Environmental Engineering**

The main focus of the Coastal & Environmental Engineering group is to explore and protect the coastal & offshore waters of the country for engineering applications and societal benefits. The group acquires its strength from a team of a multi-disciplinary multi-functional engineers and scientists. The spectrum of specialization consists of Ocean Engineers, Archaeologists, Geologists, Geophysicists, Water quality experts, Instrumentation Engineers, Hydrographers, Geotechnical Engineers, Physical Oceanographers, Structural Engineers, Environmental chemists, Marine Biologists and designers. Major activities of the group are encompassed in three categories namely Research, Consultancy which includes design, analysis & technical support, and Capacity Building & application in National infrastructure development in the marine sector.

##### **Marine archeological findings**

One of the major contributions by this group is the discovery of underwater archaeological heritage at 40 m depth, 20 km west of Hazira in the Gulf of Cambay. A Workshop on Marine Archaeological Findings at Gulf of Cambay was held on 1<sup>st</sup> July 2002 in NIOT, Chennai. More than 40 senior Archaeologists and delegates from various disciplines participated in the workshop. Dr. Sukhija of NGRI arranged for the ood

sample from Gulf of Cambay to be analysed by Prof. Manfred Frechen, Head, Geochronology & Isotope Hydrology, Joint Geo-Scientific Research Institute, Hannover, Germany and the  $C^{14}$  date was determined as  $8510 \pm 55$  year BP and the calibrated age range was BC 7545-7490.

Three geo-archaeological samples collected from the site were given to National Metallurgical Laboratory-CSIR, Chennai, for mineralogical analysis for confirmatory studies. The sea was found rough throughout the survey period between October '02 and January '03, though this is normally a fair weather period. Integrated Side Scan Sonar & Subbottom Profiler system (Subscan) and Multibeam Sonar system was acquired for carrying out marine archaeological investigations in the Gulf of Cambay.



***Use of Truss with tug (without a crane)***

***Deployment of Sub-scan during sea-trial for CPT operations***

A paper on Archaeology titled “A New Archaeological find in the Gulf of Cambay, Gujarat” was published in the journal of Geological Society of India.

Underwater surveys carried out using side-scan sonar and sub-bottom surveys followed by underwater videography and diving north of Mamallapuram coast, have indicated promising marine archaeological sites in the offshore areas of Tirupurur in Tamil Nadu. Detailed surveys are necessary for confirmation.

#### *EIA and Water quality assessments*

As part of coastal infrastructure project, the final report for EIA guideline for coastal tourism projects and wastewater disposal through marine outfall have been prepared.

All fieldwork and laboratory analysis for water quality sampling and measurement of currents and tides for post-monsoon season was completed for Waste Load Allocation, Hooghly. Calibration for hydrodynamics and modelling for advection-



dispersion was also completed. Modelling for Faecal Coliforms is being reviewed for Waste Load Allocation, Ennore. Development and demonstration of tide graph with radio linking at Kolkata Port Trust was successfully completed.

### Environmental Management

NIOT has associated with NEERI in the Gujarat State Environmental Action Plan- Phase III (GEC – SEAP) for the coastal and marine activities and technical discussion is in progress. The MoEF accorded environmental clearance for Construction of the 9<sup>th</sup> cargo berth at Kandla Port, based on the Rapid EIA studies. Final report on Comprehensive EIA studies for future expansion of Kandla Port Trust was submitted. The recommendations on Environmental Management plans and Waste minimization were finalised and submitted to Kandla Port Trust.

### Mathematical and Physical modelling for engineering solutions

Software for oil spill analysis has been developed in-house to model wind effect (spreading on water), subsequent evaporation and vapour cloud dispersion of volatile and hazardous liquid cargo transfers / conveyance from Single Point Mooring (SPMs), barges in offshore areas. This software would be extremely useful for contingency planning and emergency response during cargo handling operations.

The following studies were conducted and reports submitted to the concerned authorities.

- Final report for modelling and hydrographic and geophysical studies to identify underwater obstruction in navigational channel and along side of the jetties for Kandla Port Trust.
- Final report Hydrographic and geo-technical investigations (CPT) & engineering recommendations for development of single buoy mooring unloading facility for CPCL.
- Interim report on the Proof consultancy for “River Regulatory Measure” Scheme for improvement of draught in Hooghly estuary of Kolkata Port Trust.
- Analysis of data and numerical modelling for recommendations on shore stabilization measures around Cooum and Adayar rivers.
- Field work for the Dighi Port Development and Sediment budgeting & dredging studies for Cochin harbour.

- Environmental Impact Assessment and Risk Assessment studies for crude oil handling using very large Crude Carrier (VLCC) terminal for Chennai Petroleum Corporation Limited.
- Draft report on shore protection measures along Pondicherry coast by numerical modeling.
- Field work for HTL & LTL marking for Kochi Refineries Ltd., off Pudhuvypeen.

#### Sediment Prevention studies

*An agreement was signed between NIOT and Kolkata Port Trust (KoPT) on September 28, 2002. NIOT will assist KoPT in the reviews and implementation of river regulating measures at Hooghly to improve the navigability. First Phase of fieldwork in the navigational channel at Haldia (Kolkata Port Trust) for the Dredging Corporation of India was successfully completed. Source of problems was identified by seabed engineering surveys consisting of subbottom profiling, side scan survey, hydrographic measurements, water quality analysis and geotechnical investigations. Bathymetry survey is being carried out regularly and recommendations are made for sedimentation prevention studies in the navigational channel at Haldia (Kolkata Port Trust) for the Dredging Corporation of India.*

#### Tower for offshore rock coring

A steel structure of 18 m height has been designed and fabricated for conducting offshore rock core drilling in the intake dyke area.

#### Truss for CPT operations

Field investigations pertaining to the feasibility study for setting up a Very Large Crude Carrier (VLCC) terminal at Ennore port and a Single Point Mooring (SPM) system off Ennore coast were undertaken on behalf of Ennore Port Limited and Chennai Petroleum Corporation Limited. A novel scheme to operate the 10-tonne Cone Penetrometer Testing (CPT) equipment aboard a tug without a crane, was devised and successfully implemented.

A book titled 'Harbour and Coastal Engineering (Indian Scenario)' in 2 volumes was released on September 16, 2002 by the Secretary, DOD. This book has contributions

from many experts of NIOT and outside on various aspects of Coastal Engineering, Ports design and Construction and is edited by Prof. S.Narasimhan, Emeritus Professor of IIT Bombay, Dr. S. Kathirola and Dr. B. Nagendra Kumar of NIOT.

## **6.5 Marine Instrumentation**

Instrumentation & Control group focuses its activities in the development of technology for various ocean related applications and it creates the necessary infrastructure for the calibration of underwater sensors and instruments. The group is actively involved in the research and development of acoustic based instruments. The activities are divided into three categories viz. technology development / demonstration projects, infrastructure development and short-term projects.

The major projects undertaken in the first category include the development of an Acoustic Tide Gauge (ATG), an Integrated Underwater Survey System (IUSS) & Transducer Development. The short-term project includes the development of an intelligent Xenon Beacon.



***IUSS Tow Body***

An IP 65 class ATG with telemetry provision was installed successfully at Mangalore Port. At Haldia port tidal variations up to 6.5 m was demonstrated successfully, using this tide gauge.

The tide data obtained from the ATGs installed at different locations like, Tuticorin, Cochin, Chennai Port have been analysed and the mean sea level studies were carried out by correlating the data with the local atmosphere phenomena and also with the air pressure data obtained from the data buoys deployed under the National Data Buoy Programme (NDBP). The total analysis and prediction using the earlier data has been carried out.

An ATG calibration set up has been created for on-line calibration of ATG system in comparison with accurate pressure sensor modules at Acoustic Test Facility in NIOT.

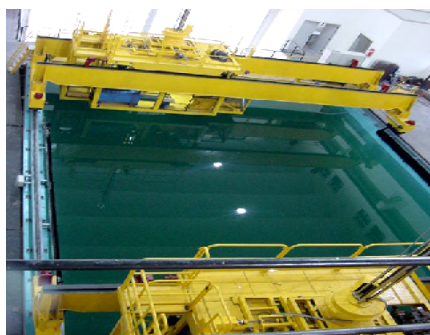
Under Indo-Myanmar bilateral program, two ATGs would be installed in Myanmar at Sittwe and Patheon. A two week training was imparted to four Myanmar Scientists during 3<sup>rd</sup> - 14<sup>th</sup> February, 2003 at NIOT on operation and maintenance of the ATGs. An international U.S. patent has been awarded to NIOT on ATG Technology development.

The design and development of a state-of-the-art reconfigurable Integrated Underwater Survey System (IUSS) comprising a Sub-Bottom Profiler, Side-Scan Sonar and a Single frequency Echo-sounder with the capability to change over from one mode to another mode by changing the tow fish, transducer arrays and control electronics, are underway. A scaled down model of the tow body is ready. The hydrodynamic test is under progress and the results will be incorporated in the IUSS tow body.

As per the request of National Hydrographic Office (NHO), Dehradun, for establishment of a Joint Cell for the implementation of the project on Integrated Under Water Survey (IUWS) system, a Project Definition Document (PDD), is being prepared.

Under the transducer development programme, a second prototype of a 33 kHz echo-sounder having a broad frequency band (32-45 kHz) with a power handling capability of 1.4 kW was designed and tested successfully at a water depth of 3 m. A transmitting/receiving (T/R) switch and a matching coil were also designed and incorporated to serve the transducer as a transceiver. The design of watertight encapsulation of the transceiver to suit the requirement of the IUSS tow body (for 30 m operation) was carried out. Redesigning of the watertight encapsulation of the 2-10 kHz transmitter to operate at a depth of 30 m was completed and fabrication and testing of the transducers are under progress.

An Acoustic Test Facility, for the testing and calibration of underwater sensors has been established and commissioned. This facility comprises an Automated Transducer Positioning System (ATPS) and an Acoustic Calibration System (ACS), which have been tested in the new facility. The data obtained during testing in the ATF has been compared with the standard data provided and the deviations are well within  $\pm 2$  dB.



***A view of Acoustic Test Facility***



***Xenon Marker Lamp with Solar Panel***

A Memorandum of Understanding (MoU) was signed with M/s. Bharat Electronics Ltd. (BEL), Bangalore, for commercialisation of instruments and transfer of technology in the areas of marine sensors and instruments.

An intelligent Xenon beacon marker lamp powered by a solar array was developed and demonstrated. This has high lumens of light output compared to the conventional marker lamps. It is an IP-65 qualified unit and has omni-directional luminance, with a flash energy of 1J at a rate of 1 Hz (pre-settable). It is sensitive to ambient light and automatically switches ON / OFF according to the ambient light.

Apart from the above projects, under a bilateral programme under Integrated Long Term Programme (ILTP) of Russia two projects viz. Technology demonstration of multifunction observatory (Benthic Station), and Development of acoustic tracking system for underwater tow bodies, have been taken up. The necessary technical documents for the projects are under preparation by mutual interaction between NIOT and Experimental Design Bureau of Oceanological Engineering (EDBOE) scientists.

## **6.6 Ocean Science and Technology for Islands (OSTI)**

Lobster fattening and breeding, water quality management, disease control, biochemical analysis in lobsters, deep ocean water application areas, are the major activities taken up under this project. In addition, studies were also undertaken for biofouling control in OTEC heat exchangers. NIOT has been successful in creating the requisite infrastructure for carrying out technology development activities for the benefit of island community, viz. monitoring the health of the seas, calibration and analysis of data

on ocean parameters, bio-fouling control and enhancement of Marine Living Resources through mariculture. The significant contributions by this group are as follows.

*Fattening, breeding and larval rearing of lobsters*

In an attempt to develop an artificial pelletised feed for replacing live feed, a diet composition with 60% of protein comprising fish and soya meal was fed to lobster through which an overall weight increase of 36.73g was achieved over a period of 90 days. Since, the growth is relatively less as compared to the lobster fed with mussel meat, experiments were conducted to improve the growth by changing the composition of the feed.

During the period under report, 9.30 lakh phyllosoma were obtained from hatchery maintained lobsters. For the first time, larval phyllosoma of *Panulirus homarus* reached VI stage in a period of 63 days under captivity at seafront laboratory, Nellankarai. Experiments on feeding the phyllosoma larvae with artemia enriched by Chlorella, Spirulina and Chaetoceros showed that the survival of phyllosoma was relatively better when fed with chlorella enriched artemia. Experiments were also conducted to improve the colouration of fattened lobsters by culturing phytoplankton along with lobsters. This will be useful for the entrepreneurs who will undertake fattening programme using our live feed fattening technology at the time of harvesting.

*Larval rearing facility at seafront laboratory, Neelankarai*

A study on lobster growth under four different salinities namely 25, 29, 33 and 37 ppt was carried out. It was observed that the survival rate was 100% in the control, 80% at salinities 33 & 29 ppt and 60% at 37 & 25 ppt. The water being used for larval rearing is free of Vibrios and the total heterotrophic bacterial (THB) load is reduced to  $< 10^3$  CFU/ml after installing the complete filter system with chlorination of 4.5 ppm. Among various enrichment studies, artemia nauplii enriched with chlorella was found to enhance better survival and growth of phyllosoma larvae.



Larval rearing facility at seafront laboratory, Neelankarai



Bird's eye view of farm complex at Port Blair

*Andaman & Nicobar Centre for Ocean Science and Technology (ANCOST), NIOT's field Unit, Port Blair*

Regular analysis of hydrobiological parameters in the inlet and outlet of Minnie Bay experimental farm at Port Blair was carried out along with the water quality characteristics of Flat Bay for the nutrients like nitrate, inorganic phosphate and silicate. Investigations under Coastal Ocean Monitoring and Prediction System (COMAPS) revealed no significant variation in the hydrobiological and environmental parameters in 13 locations around south, middle and north Andaman Islands. Similar detailed hydrobiological data were collected around Nicobar Islands for the first time. Under mud crab fattening programme, growth rate was found to be highest in the mussel fed mud crabs as compared to other feed like clams, trash fish and chicken waste fed mud crabs.

#### Corrosion and Bio-fouling studies for OTEC

To study the effect of biofouling on heat exchanger, an in-situ flow through experimental set up was designed and fitted onboard the research vessel AA SIDORENKO. The results showed that there were no larvae of macro-fouling organisms during the experimental period of 16 days on the heat exchanger plates as well as flat metal coupons (Pederson device) both in control and chlorinated sections. The microfouling and slime formation were highly reduced at the intermittent chlorination regime of 1.2 ppm once in two hours for two hours compared to controls. Experiments were also conducted at the barge Sagar Sakthi, to optimise the intermittent chlorination regime of 1.2 ppm. Various dosing regimes tested were "1 hour on and 1 hour off", "½ hour on and 1 hour off" and "2 hours on and 2 hours off". Among these regimes, results

with ½ hour on and 1 hour off were found to be effective in controlling micro and macro fouling.

### Consultancy Work

A consultancy project was completed for M/s. GMR PSEG Operations Private Ltd, Mangalore to study 220 MW floating power plant at Tanir Bavi, Mangalore on corrosion. After three visits suitable corrosion maintenance plan was prepared and submitted to the client.

A scientific team visited the shrimp farm named “High Tide Sea Farms” to investigate and suggest corrective measures to control “loose shell” problem in the tiger shrimp *Penaeus monodon*. The team carried out detailed investigation and measured water and soil quality of the ponds. Various parameters in water and in sediments including the bacteriology of pond water, soil and shrimp were assessed. Based on the observations, recommendations were made to reduce the disease incidence in the ponds.

In the ANCOST, Port Blair an EIA consultancy project was carried out in Camorta, Hitui and Munak islands of Nicobar Islands and a detailed report has been submitted to M/s Siddhartha who is a EIA consultant for Andaman Harbour works for the construction of a boat jetty.

A scientific team visited one of the Integrated Farming Systems (IFS) in Mauritius, in order to address the problem of faecal coliform contamination in the crayfish. Samples of water from various areas were collected and analysed for faecal coliform counts. Based on the observation, suggestions were given for the minimization of faecal coliform contamination in the crayfish cultured under IFS.

### *Oceanographic cruises under EIA programme of OTEC*

Under the environmental impact assessment programme at OTEC site two cruises on board FORV Sagar Sampada and one cruise on board AA SIDORENKO were undertaken. During FORV Sagar Sampada cruises, fishes were collected at various depths (50, 150 350, 500 and 850 m) using expo model demersal trawl net. Important findings include presence of huge number of jelly fishes at mid depths (350 to 500 m



depth). This information helped in designing necessary filters in the cold seawater intake system. Further, phytoplankton growth potential of Deep Ocean Water (DOW) was assessed. Results showed that chlorella grow better in DOW compared to other species, confirming the experiments conducted last year.

#### Bathymetry and hydrographical study around Andaman and Nicobar Islands

A scientific cruise arranged onboard A.A. Sidorenko to collect data on bathymetry and hydrography around Andaman Islands to identify suitable site for installation of Ocean Thermal Energy Conversion (OTEC) plant and few sites around Andaman were identified using the admiralty chart. First site was located at South Andaman and second one was located off Cinque Islands. Apart from bathymetry, hydrographical features were studied in three transects near South Andaman and one transect near Cinque Islands. CTD data and water samples were collected at different depths of standard oceanographic importance. Samples were analysed for silicate, phosphate, nitrate, nitrite and Chlorophyll-a. Chlorophyll-a values were found to be relatively high at 25 m depth compared to surface water.

### *Water quality data*

Nitrate concentration at surface water and at 1000 m depth was ranging in between BDL to 3.02  $\mu\text{mol} / \text{L}$  and 55.81  $\mu\text{mol} / \text{L}$ , respectively. Silicate showed increasing concentration with depth and the maximum observed value was 44.83  $\mu\text{mol} / \text{L}$ . Phosphate values showed marginal variation with depth and maximum recorded value of phosphate at 1000 m depth was 4.27  $\mu\text{mol} / \text{L}$ . Nitrite was observed to be less in all the samples, however there was a subsurface maxima of nitrite at some stations.

### *Indian Ocean Global Ocean Observation System (IOGOOS) cruise*

A Indian Ocean Global Ocean Observation System (IOGOOS) cruise onboard ORV Sagar Kanya from India to Mauritius via Seychelles and back during October 17 - November 29, 2002 was launched by Department of Ocean Development in connection with the Indian Ocean Conference at Mauritius during November 4-9, 2002. During the onward cruise, 9 ARGO floats were deployed and , radiometric observations, CTD casts, etc. were carried out at 20 stations. During the return cruise one ARGO float was deployed and CTD observations were carried out at 32 stations vertically across the equator with a distance of about 0.8 km between each station. Hydrographic observations were conducted at five stations. Other than CTD measurements, nutrients and phytoplankton samples were collected. The nutrient concentration in deep ocean water was analysed and phytoplankton collected using plankton net were introduced after sorting out to ensure there were no zooplankton. Growth of phytoplankton was monitored both in terms of abundance and chlorophyll-a.

## **7. Coastal Research Vessels**

The Vessel Management Cell (VMC) of NIOT operates, maintains and manages the two coastal research vessels namely Sagar Purvi and Sagar Paschimi. These vessels are being used for pollution monitoring under coastal ocean monitoring and Prediction system (COMAPS) programme of DOD and also Integrated Coastal and Marine Area Management programme. These vessels have completed 56 cruises for 15 institutions along the west and east coast of India. The ship time is being effectively utilized by engaging the vessels for various programmes and preventive and periodical maintenance was ensured for trouble free functioning of onboard equipment and machineries.

During the above cruises, these vessels undertook CTD, ADCP observations, dredging, water sampling and plankton net operations. In addition to the above cruises, the vessels Sagar Paschimi and Sagar Purvi participated in the Marine Archaeological findings at Gulf of Cambay and Multibeam sonar survey at Ennore and Haldia ports. Public sector undertaking and corporate agencies like IGCAR, ONGC utilized the service of these vessels.

The two CRVs undertook the following cruises for the various institutions and other agencies during the period under report:

<b>Institutions</b>	<b>Vessel</b>	<b>Programme</b>	<b>Site</b>
RRL – Bhubaneshwar	Sagar Purvi	COMAPS	Orissa Coast
Institute of life Science Bhubaneshwar & NRSA	Sagar Purvi	Satellite data validation	Paradip – Tambda Paradip- Gopalpur & Off Vizag
CAS – Annamalai university	Sagar Purvi	COMAPS	Vizag to Chennai and Chennai to Mandapam
NIOT	Sagar Purvi	MIII	Haldia
IGCAR	Sagar Purvi	Chartered	Kalpakkam
Madras University	Sagar Purvi	Research	Chennai
NIOT MIII	Sagar Purvi	Archaeological survey	Gulf of Khambhat
CAS – Annamalai University	Sagar Paschimi	COMAPS	Tuticorin to Kanyakumari
RRL – Trivendrum	Sagar Paschimi	COMAPS	Karwar
CESS - & C –MARS Trivendrum	Sagar Paschimi	COMAPS	Vizinjham, Kochi, Karwar
NIO – Goa	Sagar Paschimi	ICMAM Plan Goa	Goa
NIO – Mumbai	Sagar Paschimi	COMAPS	Mumbai – Okha
ICMAM – PD Chennai	Sagar Paschimi	ICMAM Plan	Gulf of Kachchh -Okha
IPSEM – ONGC	Sagar Paschimi	Chartered	Bombay high
NIOT	Sagar Purvi	OTEC	OTEC site off Tuticorin

*Sampling Operations carried out during the above period are given below*

Vessel Name	Sampling Operations											Survey Side Scan/ Sub bottom in Km	
	CT D	Core	Grab	Water	Zoo Plankton net	Phytoplankton net	Trawl net	Radiometer	Current meter	ADC P	Dredging	Side Scan	Sub bottom
Sagar Paschim	516	23	738	1070	423	39	12	3	82	62	270	120	250
Sagar Purvi	259	40	213	193	81	0	0	15	2	0	69	850	1100

## 8. Delineation of Outer Limits of Continental Shelf

According to the provisions of UNCLOS, the coastal State that intends to delineate the outer limits of the continental shelf beyond 200 nautical miles, is required to submit particulars of such limits along with the supporting scientific and technical data. The claims are required to be submitted by May 2009 and would be examined by the Commission on the Limits of Continental Shelf (CLCS). If the claims are accepted by CLCS India would be in a position to claim substantial area beyond the EEZ.

The States submitting claims are required to determine the (a) baselines (b) foot of the continental slope and 2500 metre isobath, and (c) thickness of sedimentary rocks 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 concert 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 finalised. The data acquisition of various geophysical parameters commenced during the year and is progressing with simultaneous data processing.

National Centre for Antarctic and Ocean Research (NCAOR) at Goa, an autonomous body under the 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**

The area of our Exclusive Economic Zone is over 2 million sq. km. abound with various living and non-living resources. This new programme entails scientific mapping of this area to have an inventory of potential resources and to identify the causes of hazards. The study would help to develop innovative concepts on:

- Submarine fans and their role on accumulation of hydrocarbons
- Submarine canyons and their role in transport and distribution on pollutants.
- Islands- understanding of submarine landslides and stability of coastlines.
- Sedimentary processes- effect on fisheries and biogeochemical cycling.
- Sediment failure along slopes and their effects on communication cable links across the seafloor.
- Tectonics of margins.

Bathymetric survey will be initiated with the acquisition and installation of equipment.

## **10. Gas Hydrates Exploration & Technology Development for Exploitation**

With ever-increasing gap between demand and indigenous production of natural gas and the huge import bill incurred by India, it is necessary to look for alternative resources. viz. Gas Hydrates. Considering the immense potential of Gas hydrates in relation to providing total energy security to our nation, a new programme on “Studies on Gas Hydrates Exploration” has been provided in the Tenth plan for implementation. The programme consists of both scientific & technology development for gas hydrates. The Department, in association with CSIR and other 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:

- Understand the generation, accumulation and distribution of hydrates in sediments.

- Estimate impact of gas dissolution on geological environment and climate.
- Develop or adopt environmentally safe technology for production and transportation of gas from hydrates.
- Draw up plans to monitor and manage environmental perturbation during hydrate harvesting.

During the year it is proposed to examine the multi-channel seismic (MCS) data collected and carry out under special processing and analysis of MCS data acquired under Legal continental shelf programme. It is also proposed to initiate the mapping of Bottom Simulating Reflector (BSR) prone zone.

## **11. Acquisition of New Research Vessels**

The Department's focus in the next 5 years will be to develop sustainable technology for the exploitation of various non-living resources. Under the Vessel for technology services and demonstration programme, suitable platform is required. Accordingly, a new multipurpose vessel for Technology services and demonstration is proposed. This vessel will service as a platform for the programme envisaged in the X Plan and also serve as a utility science vessel which will augment the capacity need of the marine living and non-living resources programme of the Department. The NIOT would be the nodal agency to implement this programme and to operate and maintain the vessel. A detailed design and estimates for the vessel have been worked out and a detailed project report has been prepared, which is under active consideration of the Department.

## **12. Geophysical Study of Laxmi Basin**

The ongoing academic debate is on the nature of the basement in the Laxmi Basin. From a point of view of crustal geology, if the Laxmi ridge is but a continental sliver between oceanic crusts on either side then the foot of the western continental slope may not really call for any "relocation". If on the other hand, the continent-ocean boundary can be established near the western flank of the Laxmi Ridge or that the Laxmi Basin is continental in nature, then from a purely geological point of view, the foot of the slope (FOS) may be off the western flank of the Ridge, near the place where the crust changes from continental to oceanic. Based on gravity modeling 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 would be necessary.

Steps have been initiated for acquisition and processing of geophysical data followed by initiation of activities on interpretation and analysis of data, will be undertaken.

### **13 International Cooperation/Contribution:**

#### **13.1 Bilateral Programmes**

A MOU was signed between the Government of India and the Government of the Republic of South Africa on 5<sup>th</sup> December, 2002 on Antarctic Cooperation. Both countries would promote Antarctic cooperation through:

- exchange of scientific and bibliographical information related to the study of Antarctica and its surrounding seas;
- creating opportunities for exchange of scientists;
- participation by scientists and technical experts involved in the national Antarctic programme of one country in the national Antarctic programme of the other;
- joint scientific conferences and workshops and scientific publications;
- training of scientific personnel;
- collaborative scientific projects involving mutually beneficial research on the natural environment of Antarctica and the Southern Ocean particularly in the areas of atmospheric sciences, earth sciences, global change, biological and environmental sciences; and
- joint logistic and operational activities through the sharing of facilities.

A five member Indian Delegation visited various Institutes involved in advance research in Gas Hydrates and related Technologies in Russia during 10<sup>th</sup> to 17<sup>th</sup> October, 2002.

A Russian Delegate visited India on 1<sup>st</sup> November, 2002 to discuss on "Gas Hydrates Programmes".

An U.S. Delegation visited India on 11<sup>th</sup> February, 2003 to discuss a bilateral project proposal on "Ocean Observation for the Indian Ocean and an Assessment of Data Available" and "Greenhouse Gas Measurements" .

### *13.2 International Sea Bed Authority (ISBA)*

Scientist 'G', Department of Ocean Development and Director, NIOT participated in the 8<sup>th</sup> Session of the International Sea Bed Authority (ISBA) held at Jamaica during 5<sup>th</sup> to 16<sup>th</sup> August, 2002.

### *13.2 Contribution to International organisations*

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 Officers meeting, 35<sup>th</sup> Session of Executive Council and 2<sup>nd</sup> Session of the IOC Oceanographic Data Exchange Policy meetings at Paris, France during June 1-18, 2002. India as one of the Vice-chairmen of the IOC, organised the IOC Officers meeting at New Delhi during January 17-19, 2003.

A three member delegation also participated in the Indian Ocean Conference on Global Observing System held during 4<sup>th</sup> to 9<sup>th</sup> November, 2002 at Port Louis, Mauritius. In the context of developing such a regional alliance, a Research Cruise from India to Mauritius via Seychelles and back was organized from 17<sup>th</sup> October to 28<sup>th</sup> November, 2002 onboard Department's Oceanographic Research Vessel 'Sagar Kanya'. The main objectives of the cruise were to enable participants from the countries of the region to work together and conduct a set of scientific experiments in the field of physical, chemical, biological and geological oceanography and provide training in various types



of ocean observations. The research cruise was led by the Director, NIOT. Scientists from NIOT, NCAOR, INCOIS participated in the cruise. Nine scientists from the Member States of Indian Ocean Region viz., Mauritius, Sri Lanka, Kenya, South Africa and Seychelles also participated in the cruise.

### *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, NCAOR participated as an Indian delegate in the 14<sup>th</sup> COMNAP/SCALOP meeting held at Shanghai, China during 13<sup>th</sup> to 26<sup>th</sup> July, 2002.

The Joint Secretary, Department of Ocean Development and Director, NCAOR participated in the 'First Informal Working Group Meeting of the Antarctic Treaty Secretariat' held from 24<sup>th</sup> to 27<sup>th</sup> June, 2002 at Buenos Aires, Argentina. They also represented India in the 25<sup>th</sup> ATCM meeting held at Warsaw, Poland during 10-20 September, 2002.

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

Twenty first meeting of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) held during 21<sup>st</sup> October to 1<sup>st</sup> November, 2002 at Hobart, Australia from was attended by Director, CMLRE and Deputy Secretary, Department of Ocean Development along with a representative of Deptt. of Animal Husbandry & Dairying. Director, CMLRE also attended the Heads of Delegation Meeting on 20<sup>th</sup> October, 2002.

### *13.7 States Parties on Law of the Sea (SPLOS)*

A delegation from the Department participated in the 12<sup>th</sup> Meeting of the States Parties on Law of the Sea held during 16<sup>th</sup> to 26<sup>th</sup> April, 2002 in New York, USA. An election was held to elect the members of the Commission on the Limits of Continental Shelf (CLCS) and India's representative Dr. N.K. Thakur, Scientist 'F', NGRI was elected for a term of 5 years on the Commission. The Commission was established in 1997 under UN Convention on Law of the Sea to consider the claims on continental shelf submitted by the States Parties to the Convention. Scientist 'F', NGRI also participated in the 11<sup>th</sup> Session of the CLCS held during 24<sup>th</sup> to 28<sup>th</sup> June, 2002 at New York, USA.

### *13.8 Other Visits abroad*

Director, NIOT attended the International Global Ocean Exploration Workshop organized by U.S. National Academies held at IOC of UNESCO at Paris during 13<sup>th</sup> to 15<sup>th</sup> May, 2002.

A Scientist of NIOT visited Houston, USA during 06.05.02 to 09.05.02 to participate in the Ocean Technology Conference.

Director NIOT accompanied by two Scientists of NIOT visited Seychelles during 23.06.02 - 28.06.02 to discuss Scientific Exchange Programme between India (DOD /NIOT) and Seychelles.

Scientist 'F', Department of Ocean Development participated in the Meeting of the National Focal Points of the South Asian Regional Seas Programme held on 28-29 June, 2002 and the Second Intergovernmental Meeting of SACEP on 1<sup>st</sup> July, 2002 at Colombo, Sri Lanka.

Four Scientists of NIOT visited Russia during 17.07.02 to 25.07.02 to attend the Integrated Long Term programme.

A Scientist of NIOT visited M/s. Bruel & Kjaer, Sound & Vibration Measurement A/s, Denmark during 15.07.02 to 19.07.02 to undertake factory acceptance test and free training for the purchase of Acoustic Calibration System.

Project Director of NDBP, NIOT visited Australia during 29.07.02 to 02.08.02 to participate in the Sixth International Buoy Programmes for Indian Ocean.

Director NIOT visited Kingston, Jamaica during 03.08.02 – 15.08.02 to attend the Legal and Technical Committee meeting of the International Seabed Authority.

Director, INCOIS participated in the First Meeting of Review Panel of Global Ocean Observing System (GOOS) held at UNESCO Headquarters at Paris, France during 9<sup>th</sup> to 11<sup>th</sup> September, 2002.

A Scientist, INCOIS participated in the Second ARGO Data Management Meeting (a sub committee of International ARGO Science Team -IAST) at Ottawa, Canada during September 17-20, 2002.

Director NIOT visited Russia during 09.10.02 – 17.10.02 to discuss New Cooperative Programme on Gas Hydrates

Project Director of NDBP, NIOT visited Martinique, France during 14.10.02 to 18.10.02 to participate in the Eighteenth Session of the Joint IOC-WMO Data Buoy Cooperation Panel

Director NIOT visited Mauritius, Seychelles during 17.10.02 – 12.11.02 to attend the IOGOOS Cruise, IOGOOS Conference in Mauritius

Three Scientists participated in the IOGOOS Cruise and Indian Ocean Conference at Mauritius during October 17 – November 10, 2002.

Three Scientists of NIOT visited M/s. Edge Tech, Boca Raton, Florida, USA during 08.12.02 to 14.12.02 to undergo Training on Integrated Side Scan Sonar & Sub Bottom Profiler

Director, ICMAM-PD and Deputy Secretary, Department of Ocean Development attended the meeting of the Expert Group to consider the feasibility study on setting up SAARC Coastal Zone Management Centre in Maldives during 16<sup>th</sup> to 17<sup>th</sup> December, 2002 at Male.

Secretary, Department of Ocean Development visited South Africa from 9<sup>th</sup> to 10<sup>th</sup> January, 2003 and flagged off the XXII Antarctic Expedition on 10<sup>th</sup> January, 2003 onboard M.V. Magdalena Oldendorff.

## **14. Departmental Ships**

### *Fisheries Oceanographic Research (FORV) Vessel Sagar Sampada*

Fisheries Oceanographic Research Vessel (FORV) Sagar Sampada is being used for data collection and sampling for various Marine Living Resource (MLR) projects implemented by the Department through different institutions and organizations. FORV Sagar Sampada completed 10 cruises including one at the Ocean Thermal Energy Conversion Power Plant (OTEC) site off Tuticorin to study the Environmental impact assessment, covering 240 days operation occupying 247 stations. The ship time was effectively utilised by 210 scientific and technical participants from various organizations. 52% of the operation was along the Bay of Bengal (East coast), 36% along the Arabian sea (West coast) and 12% in the Andaman waters. To fill up the data gap, maximum cruises were planned along the East coast. Fishery Survey of India, Andhra University (Departments of Marine Living Resources and Department of Zoology), Central Marine Fisheries Research Institute, National Institute of Oceanography, Cochin University of Science and Technology (School of Marine Sciences & School of Industrial Fisheries), Kochi, Central Institute of Fisheries Technology and National Institute of Ocean Technology, participated in various projects implemented by the Centre.

In all, 390 CTD castings, 221 Bongo net, 165 Multiple plankton net, 82 IKMT, 52 Expo-Trawl, 23 HSDT-Trawl, 30 Mid water trawl and 49 grabs were carried out in the east & west coasts, including Andaman waters.

The participating institutions published 12 scientific papers in leading journals on different aspects utilising the facilities, one student obtained Ph.D and three students obtained M.Phil degrees on various aspects of marine living resources.

The vessel facility was also utilised by 104 students/lecturers/technical & scientific personnel from different institutions/organizations including 21 participants of ICAR-Winter School conducted by CIFT, Kochi. The Vessel was also opened to the public during the National Technology Day on 11<sup>th</sup> May 2002.

## *ORV Sagar Kanya*

During the year 2002-03, the vessel undertook 17 cruises and logged 309 days at sea. More than 300 scientists and technical personnel from over 20 organizations participated in the above scientific cruises. Some of the country's leading institutions such as NCAOR, NIO, NIOT, SAC, PRL, IMD, IISc and various academic organisations have taken up cruises for R&D and exploration programmes.

For the LOICZ programme, three time-series sediment trap deployment operations were carried out in addition to physical / chemical parameters collection for studying the sinking particulate matter. Another multi-institutional project on Paleoclimatic Studies in Bay of Bengal (BENFAN) was carried out with the newly installed Hydraulic Piston Corer. Under the ongoing National Data Buoy Programme (NDBP) one cruise was taken up for Data buoy maintenance in Bay of Bengal and four data buoys were deployed and one cruise in Arabian sea.

Two cruises were undertaken for ARMEX under ICRP for monsoon studies in Arabian Sea. Time series and oceanographic / meteorological observations were carried out successfully. For Gas Hydrates Research Programme, two cruises were taken up by NIO for swath bathymetry and geophysical data collection in K-G basin in Bay of Bengal and off Goa Coast in Arabian Sea. A total area of 8900 sq. km was covered by swath bathymetry survey in both the cruises. For IRS P4 Satellite, primary productivity model validation of OCM & data base for parameter retrieval was carried out in Arabian Sea. The vessel passage period from west coast to east and back was utilised by NCAOR and OSTC projects for sampling and underwater data collection.

There were two international expeditions during this year. Indo-Myanmar joint oceanographic cruise was carried out for studying physical, chemical, biological and geological processes in the Andaman Sea in general and on the continental shelf & slope of Myanmar in particular. As part of Indian Ocean - Global Ocean Observing System (IO-GOOS), one cruise was organised by DOD with participation from Indian Ocean rim countries such as Sri Lanka, Mauritius, Seychelles, Kenya and South Africa. The participants of the cruise also attended the IOGOOS conference at Mauritius from 4th to 10th November 2002. Multi-disciplinary data collection, deployment of ARGO floats, Drifting buoys and XBT were carried out during the cruise. At the request of Mauritian Government, Multi-beam surveys were also conducted in their EEZ.

Open Houses were conducted whenever the vessel visited foreign countries. The vessel and the scientific facilities were thrown open to the dignitaries, students and scholars. Three open houses were conducted at Yangoon, Port Victoria and Port Louis during the year.



**Open house at Yangoon on ORV Sagar Kanya**

## **15. Use of Hindi & Parliament Work**

### **15.1 Use of Hindi**

*The Department is constantly working for promotional expansion of Official Language. During 2002-03, all efforts were made to promote the progressive use of Hindi in the Department. 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 committees, Parliamentary papers etc., were prepared bilingually.*

*For the first time in the country, regular Prabodh Hindi teaching course was initiated through the medium of computers at the Integrated Coastal and Marine Area Management (ICMAM) Project Directorate, during July 2002. 12 scientists and staff of ICMAM Project Directorate and National Institute of Ocean Technology (NIOT) had the benefit of the training and have completed the Prabodh course. From January, 2003, through computer medium Praveen course has also been initiated in the NIOT/ICMAM-PD.*

*Department organized a five day Hindi workshop with effect from 23.08.2002 to 29.08.2002 to train officers and staff of Department to remove their difficulties while doing their official work in Hindi. About 15 officers and staff took part in the workshop.*

*Department organised a Hindi fortnight from 14<sup>th</sup> to 28<sup>th</sup> September, 2002. During the period, various competitions including Hindi essay writing, noting and drafting, debate and computer typing were held. A Hindi quiz programme was also organized to test the knowledge of staff about departmental activities and official language policy of the Government. About 60 employees participated in these programmes. Secretary gave away the prizes and certificates to price winning officials during a ceremony, which was followed by a Kavi Gosthi, in which eight poets of repute enthralled the audience.*

*Department organized 11<sup>th</sup> National Scientific Hindi Seminar on “Samudri Orja Avam Proudhyogiki Vikas” on 15<sup>th</sup> November, 2002 at India International Centre, New Delhi. Minister of State for Science and Technology, Shri Bachi Singh Rawat, inaugurated the seminar. About 20 scientists from various institutions related to Ocean Energy presented their papers in the seminar. On the occasion, a Hindi book titled “Tateeya Kshetra Prabandhan” being the compilation of proceedings of seminar held in 2001, was released.*

*Department with the assistance of Assistant Director (OL) inspected the NCAOR, Goa on 26<sup>th</sup> December, 2002 to find out the position of implementation of Official Language policy of the Government in NCAOR and necessary suggestions were given to promote use of Hindi in the Centre.*

*17<sup>th</sup>, 18<sup>th</sup> and 19<sup>th</sup> meetings of Joint Hindi Advisory Committee of Ministry of Science and Technology and DOD were held in June, October and December 2002 respectively at Dehra Dun, New Delhi and Goa. A number of important suggestions were given to the Committee, which would be implemented gradually.*

*The Department was awarded 1<sup>st</sup> and 2<sup>nd</sup> price to the books titled (i) Mahasagar Audyogikaran Hetu Bahumoolya Sansadhan Sroat, and (ii) Mahasagar Aur Jansamridhi under Mahasagar Puraskar Yojna for the original books writing in Hindi for the year 2002.*

## **15.2 Parliament Work**

The meeting of the Department related Parliamentary Standing Committee on Science & Technology, Environment & Forests was held on 9th April, 2002 to consider the Detailed Demand for Grants in respect of the Department for 2002-2003. The

Parliamentary Standing Committee on Science & Technology and Environment & Forests visited National Institute of Ocean Technology (NIOT), Chennai on 11.9.2002 to review activities/programmes of NIOT. The Public Accounts Committee (PAC) reviewed the activities/programmes of National Centre for Antarctic and Ocean Research (NCAOR), Goa on 11.11.2002.

Between April 2002 and December 2002, 4 Starred Questions and 33 Unstarred Question were answered in the Parliament.

## **16. Organisation & Finance**

### **16.1 Administrative Support**

*The sanctioned strength of the Department of Ocean Development including attached offices was 181 during the year 2002-2003. 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
<b>Total</b>	<b>55</b>	<b>126</b>	<b>181</b>

### **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 communities 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 small 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 of the Department.*

*So far no grievance from the General public has appeared in the grievances column of any newspapers, pertaining to this Department.*

#### **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 attached offices and autonomous bodies of the Department. The Vigilance Awareness week was observed w.e.f. 31.10.2002 to 06.11.2002 in the DOD Hq and its attached offices and autonomous bodies, 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. A Senior Officer from CVC was also invited to deliver a talk on the occasion in the DOD Headquarters.

#### **16.5 Welfare, Development and Empowerment of Women**

*The activities of the department do not have a direct bearing on the welfare, development and empowerment of women. The Department, however, has been taking due care to ensure adequate representation of women while making recruitment to the various scientific posts. Adequate representation is given to women in the Antarctic Scientific expedition also.*

#### **16.6 Training**

*During the year, the following Officers/Staff of the Department were sent for different training/workshop/seminar programmes to update their knowledge and skill.*

Sl. No.	Designation	Subject	Place	Duration
1.	Joint Secretary	Orientation Programme on Geo-Informatics for decision makers	Department of Information Technology, New Delhi.	2 days
2.	Scientist D	International Symposium on Resource and Environmental Monitoring	National Remote Sensing Agency, Hyderabad.	4 days
3.	Scientist-D	Remote Sensing an over view for decision makers	Indian Institute of Remote Sensing, Dehradun	4 days
4.	Scientist-C	Harnessing Internet Technologies - Management Development Programme	National Institute of Financial Management, Faridabad	5 days
5.	Assistant Director	High Level Translation training Course	Central Translation Bureau, New Delhi	5 days
6.	Senior Technical Assistant	Harnessing Internet Technologies - Management Development Programme	National Institute of Financial Management, Faridabad.	5 days
7.	Assistant	Workshop on pay fixation	ISTM, New Delhi	2 days
8.	UDC	Workshop on Noting & Drafting	ISTM, New Delhi.	2 days
9.	Assistant / Senior Hindi Translator/ Stenographer / LDC	In House Computer Training Programme MS-Windows	DOD, New Delhi	5 days
10.	Assistant/Personal Assistant/UDC/Junior Accountant	In House Computer Training Programme MS-ACCESS	DOD, New Delhi	5 days
11.	Private Secretary / Assistants / Personal Assistant / Senior Hindi Translator /Junior Hindi Translator/ UDC/ Stenographer / LDC	In House Computer Training Programme MS-OFFICE	DOD, New Delhi	3 weeks

#### 16.7 Finance & Financial Summary

The total budget allocation of the Department for the year 2002-03 was Rs.199.28 crore, which included Rs.175.00 crore for the Plan Schemes and Rs.24.28 crore for the Non-Plan Schemes. At the Revised Estimates (2002-03) stage, it

was Rs.174.28 crore, which included Rs.150.00 crore for the Plan Schemes and Rs.24.28 crore for the Non-Plan Schemes. The Government has approved the Budget Estimates of Rs.199.33 crore for the Programmes of the Department for the year 2003-2004, comprising Rs.175.00 crore for the Plan Schemes and Rs.24.33 crore for the Non-Plan Schemes.

The details of BE/RE 2002-3 and BE 2003-2004 are given in the financial summary that follows.

# FINANCIAL SUMMARY

(In crores of Rupees)										
2002-2003 Budget					2002-2003 Revised			2003-2004 Budget		
Description		Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total
	Revenue	174.00	24.28	198.28	149.10	24.28	173.38	175.00	24.33	199.33
	Capital	1.00	-	1.00	0.90	-	0.90	-	-	-
	Total	175.00	24.28	199.28	150.00	24.28	174.28	175.00	24.33	199.33
<b>Secretariat Economic Services</b>										
Salary			(1.01)	(1.01)		(1.01)	(1.01)		(2.64)	(2.64)
Other than Salary			0.88	0.88		0.88	0.88		2.13	2.13
TOTAL			1.89	1.89		1.89	1.89		4.77	4.77
Direction and Administration										
<b>Salaries</b>			(0.98)	(0.98)		(0.98)	(0.98)	-	-	-
<b>Other than Salaries</b>			-	-		-	-	-	-	-
TOTAL			0.98	0.98		0.98	0.98	-	-	-

Description	<b>2002-2003 Budget</b>			<b>2002-2003 Revised</b>			<b>2003-2004 Budget</b>		
	<b>Plan</b>	<b>Non-Plan</b>	<b>Total</b>	<b>Plan</b>	<b>Non-Plan</b>	<b>Total</b>	<b>Plan</b>	<b>Non-Plan</b>	<b>Total</b>
Oceanographic Research									
Oceanographic Survey (ORV & FORV) & (MLR)									
Salary	0.35	-	0.35	0.35	-	0.35	0.40	-	0.40
Other than Salaries	7.00	21.41	21.41	5.75	21.41	27.16	2.10	19.56	21.66
Marine Living Resources (MLR) & FORV	-	-		-	-		-	-	-
<b>TOTAL</b>	<b>7.35</b>	<b>21.41</b>	<b>28.76</b>	<b>6.10</b>	<b>21.41</b>	<b>27.51</b>	<b>2.50</b>	<b>19.56</b>	<b>22.06</b>
Costal Research Vessel	5.00	-	5.00	5.00	-	5.00	5.00	-	5.00
Capital	-	-	-	-	-	-	-	-	-
<b>TOTAL</b>	<b>5.00</b>	<b>-</b>	<b>5.00</b>	<b>5.00</b>	<b>-</b>	<b>5.00</b>	<b>5.00</b>	<b>-</b>	<b>5.00</b>
Continental Shelf	18.00	-	18.00	18.00		18.00	8.00	-	8.00
Capital	-	-	-	-	-	-	-	-	-
<b>TOTAL</b>	<b>18.00</b>	<b>-</b>	<b>18.00</b>	<b>18.00</b>		<b>18.00</b>	<b>8.00</b>	<b>-</b>	<b>8.00</b>
<b>Antarctic Research</b>	25.50	-	25.50	20.00	-	20.00	24.00	-	24.00
<b>Capital</b>	1.00	-	1.00	0.90	-	0.90	-	-	-
<b>TOTAL</b>	<b>26.50</b>	<b>-</b>	<b>26.50</b>	<b>20.90</b>	<b>-</b>	<b>20.90</b>	24.00	-	24.00
<b>Assistance for Research Projects</b>	3.50	-	3.50	3.50	-	3.50	5.00	-	5.00
Island Development Programme	0.75	-	0.75	0.75	-	0.75	-	-	-
Capital	-	-	-	-	-	-	-	-	-
<b>TOTAL</b>	<b>0.75</b>	<b>-</b>	<b>0.75</b>	<b>0.75</b>	<b>-</b>	<b>0.75</b>	<b>-</b>	<b>-</b>	<b>-</b>
National Institute of Ocean Technology	23.40	-	23.40	23.40	-	23.40	25.00	-	25.00

	<u>2002-2003 Budget</u>			<u>2002-2003 Revised</u>			<u>2003-2004 Budget</u>		
Description	Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total
Polymetallic Nodules Programme	20.00	-	20.00	20.00	-	20.00	22.00	-	22.00
<b>Coastal Ocean Monitoring and Prediction System (COMAPS)</b>	2.00	-	2.00	2.00	-	2.00	2.00	-	2.00
Drugs from Sea	2.00	-	2.00	2.00	-	2.00	2.50	-	2.50
Ocean Observation and Information Services	25.00	-	25.00	24.00	-	24.00	35.00	-	35.00
Capital	-	-	-	-	-	-	-	-	-
<b>TOTAL</b>	<b>25.00</b>	<b>-</b>	<b>25.00</b>	<b>24.00</b>	<b>-</b>	<b>24.00</b>	<b>35.00</b>	<b>-</b>	<b>35.00</b>
Marine Non-living resources (MNLR)	4.00	-	4.00	1.50	-	1.50	2.50	-	2.50
Integrated Coastal & Marine Area Management (ICMAM) cell	-	-	-	-	-	-	-	-	-
Salary	0.50		0.50	0.50		0.50	0.55		0.55
Other than Salary	4.50		4.50	4.50		4.50	4.95		4.95
Capital	-	-	-	-	-	-	-	-	-
<b>TOTAL</b>	<b>5.00</b>	<b>-</b>	<b>5.00</b>	<b>5.00</b>	<b>-</b>	<b>5.00</b>	<b>5.50</b>	<b>-</b>	<b>5.50</b>
Comprehensive swath bathymetric survey of EEZ	14.00	-	14.00	5.25	-	5.25	12.00	-	12.00
Gas Hydrates	8.50	-	8.50	4.50	-	4.50	18.00	-	18.00
Geophysical study of Laxmi Basin	7.00	-	7.00	7.00	-	7.00	2.50	-	2.50
New Research Vessel	2.00	-	2.00	0.10	-	0.10	2.00	-	2.00
Manpower Training	0.30	-	0.30	0.30	-	0.30	0.50	-	0.50
International Cooperation*	-	-	-	-	-	-	-	-	-
Exhibition & Fairs	0.55	-	0.55	0.55	-	0.55	0.55	-	0.55
Assistance for Seminar, Symposia etc	0.15	-	0.15	0.15	-	0.15	0.20	-	0.20
Information Technology & Computers	-	-	-	-	-	-	0.25	-	0.25

# FINANCIAL SUMMARY

Description	2003-2004 Budget			2002-2003 Revised			2003-2004 Budget		
	Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total
Secretariat Economic Services		1.89	1.89		1.89	1.89		4.77	4.77
<b>Direction and Administration</b>		0.98	0.98		0.98	0.98		-	-
<b>Oceanographic Research/Oceanographic Survey (ORV &amp; FORV) and Marine Living Resources (MLR)</b>	7.35	21.41	28.76	6.10	21.41	27.51	2.50	19.56	22.06
<b>CAPITAL</b>	0.00	-	0.00	0.00	-	0.00	-	-	-
<b>Total</b>	<b>7.35</b>	<b>21.41</b>	<b>28.76</b>	<b>6.10</b>	<b>21.41</b>	<b>27.51</b>	<b>2.50</b>	<b>19.56</b>	<b>22.06</b>
<b>Costal Research Vessel</b>	5.00	-	5.00	5.00	-	5.00	5.00	-	5.00
<b>Continental Shelf</b>	18.00	-	18.00	18.00	-	18.00	8.00	-	8.00
Antarctic Research	25.50	-	25.50	20.00	-	20.00	24.00	-	24.00
CAPITAL	1.00	-	1.00	0.90	-	0.90	-	-	-
<b>Total</b>	<b>26.50</b>	<b>-</b>	<b>26.50</b>	<b>20.90</b>	<b>-</b>	<b>20.90</b>	<b>24.00</b>	<b>-</b>	<b>24.00</b>
<b>Assistance for Oceanographic Research</b>	27.65	-	27.65	27.65	-	27.65	30.00	-	30.00
<b>Polymetallic Nodules Programme</b>	20.00	-	20.00	20.00	-	20.00	22.00	-	22.00
Other Research Schemes	69.50	-	69.50	51.35		51.35	82.00	-	82.00
Training	0.30	-	0.30	0.30	-	0.30	0.50	-	0.50
International Cooperation	-	-	-	-	-	-	-	-	-
Other Expenditure	0.70	-	0.70	0.70	-	0.70	0.75	-	0.75
<b>TOTAL</b>	<b>175.00</b>	<b>24.28</b>	<b>199.28</b>	<b>150.00</b>	<b>24.28</b>	<b>174.28</b>	<b>175.00</b>	<b>24.33</b>	<b>199.33</b>
<b>SOURCE OF FINANCE</b>									
<b>REVENUE</b>	<b>174.00</b>	<b>24.28</b>	<b>198.28</b>	<b>149.10</b>	<b>24.28</b>	<b>173.38</b>	<b>-</b>	<b>24.33</b>	<b>199.33</b>
<b>CAPITAL</b>	<b>1.00</b>	<b>-</b>	<b>1.00</b>	<b>0.90</b>	<b>-</b>	<b>0.90</b>	<b>-</b>	<b>-</b>	<b>-</b>