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MINISTRY OF OCEAN DEVELOPMENT

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1. INTRODUCTION

Ever since the establishment of the Department of Ocean Development in 1981, the Ocean Science and Technology in the country has witnessed a significant progress primarily guided by the principles enunciated in the Ocean Policy Statement. In February, 2006, Government has notified the Department as Ministry of Ocean Development. The major responsibilities of the Ministry are formulation and implementation of programmes relating to long term economic and technological implications. The Ministry acts as a nodal agency to formulate and coordinate Marine Scientific and Technological projects for exploration of living, non-living and energy resources of the sea and protection and preservation of its environment. Ministry is implementing its programmes mostly through three autonomous bodies - National Institute of Ocean Technology (NIOT), Chennai, Indian National Centre of Ocean Information Services (INCOIS), Hyderabad and National Centre for Antarctic and Ocean Research (NCAOR), Goa, and 2 attached offices - Centre for Marine Living Resources and Ecology (CMLRE), Kochi and Integrated Coastal and Marine Area Management (ICMAM), Chennai.

The salient features of the Policy Statement relate to:

- Optimum utilization of living resources and sea weeds, exploitation of nonliving resources such as hydrocarbons and heavy placer deposits, harnessing of renewable resources of ocean energy from the waves, temperature difference in water column, etc.
- Technological advances geared to the utilization and preservation of the marine environment.
- Research and development in basic ocean sciences.
- Development of indigenous technology and setting up of infrastructure facilities and services to operate large sized fishing vessels.

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.

- Development of technologies relating to instrumentation, diving systems, position fixing, materials development, oceanic data collecting devices, submersible, etc.
- Broadening and strengthening of available infrastructure facilities.
- Establishment of a centralized data system with appropriate mechanism for collection, collation and dissemination of ocean related information both from indigenous and foreign sources.
- Training of skilled manpower and creation of self-reliant technological base.
- Establishment of an integrated legal framework and commitment for its enforcement.
- Cooperation with both developed and developing countries.

The Ministry of Ocean Development functions in association with other concerned agencies. The major thrust areas of development pursued by the Ministry over the years relate to:

- Development of technologies relating to seabed mining, extractive metallurgy.
- Contribution towards front ranking research in polar sciences.
- Exploration of marine resources and their correlation with oceanographic parameters, studies to evolve exploration parameters and strategies.
- Development of technologies and infrastructure for exploration and sustainable utilization of marine living and non-living resources.
- Developmental activities related to ocean integrated coastal and marine area management, coastal community development, ocean information services, etc., with direct application to the welfare of the society.
- Basic research in Ocean Science and Technology, Human Resource Development, creation of Centres of Excellence in academic institutions and public awareness on the potential and uses of ocean.

Vision

To improve our understanding of the 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 utilization
- 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

The underlying philosophy of the programmes and activities undertaken by the Ministry of Ocean Development is one of sustainable and environment friendly exploration and utilization of marine living and non-living resources for the socio-economic benefit of the country. While formulating the research and development programmes, stress is laid on the development of applied technology for the benefit of the society. The vision statement highlighting the Perspective Plan 2015 of the Ministry was formulated. In line with the vision statement declared by the Ministry, during the 10th Five Year Plan period, a number of new initiatives have been introduced, which inter alia include Gas Hydrates Exploration and Technology Development for exploration, Geophysical study of Lakshmi Basin, etc.

2. POLAR SCIENCE

2.1 Scientific and logistic accomplishments of XXIV Indian Scientific Expedition to Antarctica

Meteorology and Atmospheric Sciences

Weather parameters over Antarctica

Various meteorological parameters such as wind speed, wind direction, ambient air temperature, pressure and total global solar radiation in the Schirmacher Oasis area were recorded systematically by the Indian Meteorological Department. Two ozonesonde ascents were made during the summer period for vertical profiling of ozone. 78 atmospheric turbidity observations were also made during this period.

Direct Radiative Forcing due to Aerosol and Precursor in terms of their Optical, Physicochemical and Radioactive Properties over Antarctica Region

This study was undertaken by the Indian Institute of Tropical Meteorology and comprised measurement of the down-welling radioactive flux, short wave radiation, total columnar ozone, and water vapour concentrations in and around the Indian Antarctic base.

Physical and Chemical characterization of Aerosols in the Antarctic Marine Boundary Layer

Systematic measurement of various boundary layer processes and their dynamics in a complex Antarctic environment in relation to the marine aerosols was carried out by the National Physical Laboratory. Acoustic Sounder and UV-B Biometer were operated continuously during the summer period of the expedition. Sun Photometer was also operated on all sunny days.

Measurement of Atmospheric Aerosols and ions

Small, intermediate and large atmospheric ion concentrations and size distribution of atmospheric aerosols were measured at Maitri, by the Indian Institute of Tropical Meteorology, Pune as a part of their ongoing programme.

Space Weather Programme at Antarctica

Continuous data on total electron contents, scintillation, ionospheric delay and tropospheric delay was collected from the summer camp area of Maitri by Barkatullah University, Bhopal.

Earth Sciences, Glaciology and Global Change

Geological Mapping of Western Muhilg Hofmann Fjell, Central Dronning Maud Land, East Antarctica

Geological mapping of an area of about 1000 sq. km. (35x30 km) between 04° 00' to 05° 00' S latitude and 71° 47' to 72° 08' E longitude was carried out by the Geological Survey of India.

Mapping the Electrical Conductivity Structure in the Schirmacher Oasis

This study was undertaken by NCAOR and NGRI as a collaborative endeavour. Magneto-telluric observations were carried out at ten stations comprising eight stations in the Schirmacher oasis and two stations on the ice covered region towards south of the Oasis. The time varying magnetic field and

associated electric field were continuously recorded for a period of more than four days at each station. The resistivity variations at different depths (0.1-100 km) were quantified to understand the geodynamical processes and for a comparison between the geo-electric structure and seismic density models.

Fixing of Precise Mapping Controls to the west of Maitri and data collection for Neotectonic Studies

The work was carried out by the Survey of India and 14 new control points were constructed. The first epoch observation from the newly-constructed 14 control points and the second epoch observations on 14 previous control points were taken up using the GPS.

Lake Sediment Coring for Palaeoclimatic Studies

Two sediment cores were successfully collected from the lakes in the Schirmacher Oasis by NCAOR scientists, for palaeoclimatic studies.

Bathymetric Studies and Ice Shelf Delineation in and around India Bay, East Antarctica

These studies were carried out by the National Hydrographic Office, Dehradun. Hydrographic sounding data covering about 318 M was collected from two areas in the Leningrad Skij by using the echo sounder on board. Current meter data was also collected from the India Bay area deploying a two-dimensional acoustic current meter. In addition, ice-shelf delineation studies were carried out covering about 40 M on the eastern side of Leningrad Skij using Geodetic Leica GPS-200.

Geomagnetism and GPS Studies

As a part of an ongoing programme, systematic measurements of geomagnetic intensity, atmospheric electricity and, crustal deformation were carried out by the Indian Institute of Geomagnetism, Mumbai. Magnetic storms and sub storms of different intensities were recorded. Continuous measurements of Fluxgate Magnetometer, Proton Precision Magnetometer and 30 M Hz Riometer were also made. To study the global electric circuit, weak current system was measured by using long wire antenna.

Biology and Environmental Sciences

Studies on the Influence of Ultraviolet-B radiation on Survivalship and Pigment Concentration in Flora of Schirmacher Oasis

This study was undertaken by the Avadh University and field survey for identification and collection of three different groups of plant species, i.e. aquatic algae, lichen and moss, were carried out in the Schirmacher Oasis. Lichen samples were also collected from the Muhlighofmann Mountains about 350 km southwest of the Oasis. Plant species exposed to UV radiation were analysed for different pigment concentration such as chlorophyll a, chlorophyll b and carotenoids. UV-visible absorbance spectra of individual species were recorded with UV-VIS Spectrophotometer for quantification of pigment concentration.

Faunal Diversity and Ecology of moss inhabiting Terrestrial Invertebrate Fauna of Schirmacher Oasis

This study was undertaken by the Zoological Survey of India in ten lake embankments in the Schirmacher Oasis. The moss samples were collected on ten different dates during the summer of 2005 to study the biodiversity and ecology of moss inhabiting lower invertebrate fauna of the Oasis.

Anthropogenic Impact on Fresh Water Bodies and Nutrient Budget

Water samples from various fresh water bodies were collected and analysed for their physicochemical parameters by the Barkatullah University, Bhopal.

Molecular Bacterial Diversity of Schirmacher Oasis

This study was carried out by the Malaysian scientists who participated in the Expedition. A total of 81 soil and 9 water samples was collected and suspended in Luria Bertani medium and incubated for bacterial growth. The mix bacteria cultures were preserved and brought back to laboratory for further analysis.

Human Physiology and Medicine

Changes in Sleep, Biorhythm and Melatonin Secretion on Antarctic Winter Team Members

Base line recording of Sleep, EEG and Melatonin level changes for 24 hours was carried out on the winter team members in Delhi before the start of the expedition. Saliva samples for estimation of melatonin level were collected during the ship's voyage to Antarctica. Body temperature and ELISA tests were also recorded for estimation of melatonin level.

Establishment of the New Indian Base in the Larsemann Hills, East Antarctica

As a part of the XXIV Expedition, scientific studies were also initiated in the Larsemann Hills, the probable site of the third Indian scientific base in Antarctica. The ship along with the helicopters was diverted to Larsemann Hills, about 1693 nautical miles due East of present area of Indian activity for 19 days from 8th to 27th February 2005. The expedition team managed to erect and commission an Igloo Satellite Cabin, the first Indian structure at the proposed site.

2.2 XXV Indian Scientific Expedition to Antarctica

The silver jubilee Indian Scientific Expedition to Antarctica with 50 scientific and logistic personnel drawn from 21 national organizations/ institutes set sail from Cape Town on board the ice-class vessel M. V. Paardeberg on the morning of the 29th December 2005. The Expedition reached Antarctica on the evening of the 9th January 2006 and the summer-period scientific and logistics activities commenced the next day itself. The team is led by Shri L. Prem Kishore, a scientist from the National Geophysical Research Institute, Hyderabad.

The summer complement of the team is scheduled to return to India during March/April 2006 along with the winter-over members of the XXIV Expedition.

Scientific and Logistics objectives of the Expedition

Meteorology & Atmospheric Sciences

The Indian Meteorological Department will continue the ongoing programme of continuous recording of various surface meteorological parameters including synoptic hourly observations for preparing the climatological map of the Schirmacher Oasis area and its surroundings. It will also carry out the recording of surface ozone concentration and the measurement of vertical distribution of ozone in the atmosphere through weekly ozone-sonde ascents at Maitri.

National Physical Laboratory will concentrate on the study of the vertical distribution of aerosol and optical properties of PSCs on continuous basis by micro pulse lidar, assessment of the momentum and heat fluxes associated with thermal convection, gravity waves, katabatic winds and all other ABL phenomena over the Schirmacher region, Antarctica, signatures of long-period acoustic gravity in the lower atmosphere, validation of katabatic wind model developed earlier, and investigation of the spatial-temporal variation of atmospheric trace gases, aerosols, etc., their chemistry and dynamic mechanism in the southern hemisphere air-ice-ocean interactive system. To achieve these scientific objectives, it is proposed to establish a major facility at the Maitri station-a Doppler Acoustic Sounder for mapping wind profiles on round- the clock basis. Apart from this, measurement of above-mentioned trace gases will be carried out onboard the ship during the voyage in summer period using various in-situ as well as remote sensing equipments.

Department of Physics, Barkatullah University will undertake the study of the influence of geomagnetic disturbances on VHF/GHz scintillation and TEC activities, the characteristics of the ionospheric irregularities under different geophysical conditions at high to low latitude and specially for polar caps, and the latitudinal and longitudinal variations in the occurrence of the VLF whistlers and their statistical properties under quiet and disturbed period.

Geomagnetic studies

The Indian Institute of Geomagnetism carried out studies aimed at (i) quantifying the statistical occurrence of storms and substorms with intensification of auroral electrojet currents, (ii) understanding the relationship between the strength of a storm with the strength/occurrence frequency of the substorms, (iii) identifying the global signature in the atmospheric electrical parameters and to distinguish the atmospheric, ionospheric and magnetospheric signatures, (iv) ascertaining the influences of solar magnetic sector boundary crossing, understanding the decline in Total Magnetic Field 'F' observed over the last few decades in southern hemisphere, and (v) monitoring the ionospheric TEC, scintillation and tropospheric water vapour content.

Earth Science, Glaciology and Global Change

Geological Survey of India will continue its ongoing programme of elucidation of the lithology, structure, metamorphism and magmatic history of the central Dronning Maud Land area with a view to understanding the crustal evolution of this region and gather evidences for Gondwanaland and Rhodinia breakup/ amalgamation. In addition, it will undertake glaciological studies of two lakes in Gruber and/or Schirmacher area, to map the interfaces of ice, water column, sediment, bedrock and bottom ice. Besides highlighting the glaciological features and bathymetry, this would give a 3-D profile of the distribution pattern of sediments within these lakes. It is also proposed to initiate shallow ice-core drilling along a transect from the ice shelf to the polar plateau, in collaboration with NCAOR and collection of sediment cores from the freshwater lakes of the Schirmacher Oasis for paleoclimatic studies.

National Geophysical Research Institute will continue its ongoing programme of understanding the inter-plate motion and crustal deformation between India and Antarctica. In addition, the following ongoing programmes will be continued during the XXV Expedition also:

- crustal uplift after deglaciation and elevation changes in Antarctica.
- study of the dynamics and the kinematics of the newly emerging platelet named as Capricorn and their influences on the Indian Plate.

- operation of an 'A' type permanent Seismological Observatory at Maitri, Antarctica.
- recording and analysis of the seismicity in and around Antarctica and also global seismicity with the state-of-the-art Broadband Digital Seismometer.
- to delineate electrical structure in and around Maitri, Antarctica.

Survey of India will continue its ongoing programme of establishment of Horizontal and Vertical reference frames for detailed mapping as well as initiate large scale mapping of the Schirmacher Oasis on scale 1:5,000 with a contour interval of 5 metres.

Continued data collection towards creation of a detailed Bathymetric and Physical Oceanographic database of the India Bay area and delineation of the coastline adjoining the Bay are two of the major activities proposed to be undertaken by the National Hydrographic Organisation during the XXV Expedition.

NCAOR plans to undertake detailed bathymetric survey of Antarctic lakes using single/dual frequency echo sounder and prepare bathymetric charts of lakes as the initial step towards an envisaged major multi-disciplinary programme on limnological studies of Schirmacher Oasis area.

Biology and Environmental Sciences

The Botanical Survey of India has undertaken the taxonomic and floristic studies of diatoms in the Oasis, and their phytogeographical affinities with the Indian flora will continue its ongoing programme of plant diversity profiling of Schirmacher.

Nicholas Piramal Research Centre will initiate studies of microbial diversity with the long-term aim of utilizing them for various biotechnology purposes, isolation and culture of microorganisms from different Antarctic habitats and Phylogenetic analysis of the collected microbial isolates.

Engineering and Communication

Besides providing round the clock uninterrupted Communication to the Indian expedition team, the Defence Electronics Applications Laboratories will mount such experiments as establishing link with HAMSAT, transmission of image data over HF band in the form of Progressive JPEG etc.

Human Physiology and Medicine

DIPAS will carry out physiological research related to human circadian rhythm that regulates the temporal organization of the physiological functions and sleep pattern based on the melatonin hormone.

Student Participation Scheme

Under the Student Participation Scheme, young researchers from the National Botanical Research Institute and the MES Abasaheb Garware College will be carrying out the following experiments/studies:

- Estimation of the age of exposed rock surfaces, marine and important land marks in Schirmacher Oasis using lichens.
- Assessment of the seasonal pattern of visceral parasite diversity and abundance of Adelie penguins (*Pygoscelis adeliae*) and Emperor penguins (*Aptenodytes forsteri*) around Schirmacher region
- Correlation of the parasite load and the life events of penguins

Establishment of the New Indian base in the Larsemann Hills, East Antarctica

To continue the various scientific activities leading to the establishment of the new Indian Antarctic base in the Larsemann Hills of East Antarctica, a special expedition was mounted onboard the Ministry-chartered vessel R. V. Akademik Boris Petrov. This Expedition comprising 24 scientists drawn from various scientific laboratories and institutes set sail on a 60-day voyage on the 25th January 2006. During this expedition, it is proposed to carry out multibeam bathymetric surveys of the approach to the Larsemann Hills promontory and collection of ship-borne oceanographic and meteorological parameters off Larsemann.

2.3 National Centre for Antarctic and Ocean Research (NCAOR)



NCAOR Campus at Goa

Following the commissioning of the state-of-the-art ice-core archival and analytical facilities at NCAOR during early 2005, the Centre has embarked on a major programme of analytical studies of the ice-cores retrieved from Antarctica. Over 500 ice-samples were analysed during the year on the newly commissioned ICP-MS system. The elements that were quantitatively analysed include: Li, Na, K, Be, Mg, Ca, Sr, Rb, Sr, Ba, V, Cr, Mn, Mo, Fe, Co, Ni, Cu, Zn, Ga, As, Se, Cd, Pb, Al, B, Bi, etc. Calibration was obtained by NIST standard reference water. Further, ~350 samples were analysed by the Ion Chromatograph (IC) system for trace level anions and cations in the ice. The major cations that were analysed include: Na⁺, K⁺, Ca⁺, NH₄⁺, Mg⁺; the major anions analysed include: PO₄⁻, SO₄⁻, F⁻, Cl⁻, etc. The data thus obtained are being processed and interpreted.

As a part of the Centre's endeavors to initiate a programme of systematic ice-core drilling in Antarctica, a high-level meeting was held on 9th May 2005 between the officials of NCAOR and the Geological Survey of India to discuss the future of ice Core Drilling program in Antarctica. A Memorandum of Understanding has been signed between these two organizations to start a long-term program (2005-2011) to drill and analyse ice cores from Antarctica along a pre-planned transect in Central Dronning Maud Land (CDML).



State-of-the-art instruments installed for analysis of sample

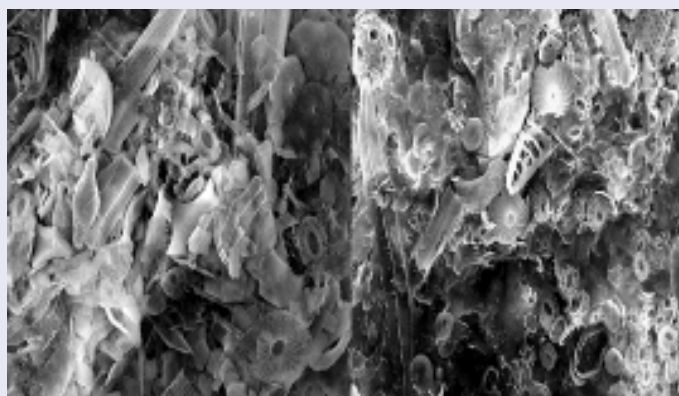
More than 200 water samples from Antarctica were analysed in ICP-MS as part of NCAOR's Environmental Impact Assessment program. Several samples were also analysed in Ion Chromatograph.

The ongoing experiments on performance evaluation of the waste treatment arrangements at Maitri were continued at NCAOR on RBC models through physicochemical analysis of organic, nutrient and demand parameters. In addition, carbon and pigment analyses of sediment samples from three lakes in the Schirmacher Oasis were carried out during the year.

2.4 Southern Ocean Studies

As a part of NCAOR's ongoing scientific endeavors in the Southern Ocean realm, a multidisciplinary and multi-institutional pilot cruise was undertaken in the Southern Ocean up to 56° S Latitude, onboard Sagar Kanya during early 2004. In continuation of the above studies, another expedition was launched from Goa on the 25th January 2006. During this expedition, following studies are proposed to be undertaken:

- (a) Underway physical, chemical, biological and geological oceanographic studies including palaeoclimatic and carbon dynamics studies in the Southern Ocean realm between Mauritius and off Larsemann Hills, East Antarctica.
- (b) Oceanographic studies along the meridional transects 45°E and 57.5°E, reoccupying the transects of the earlier pilot expedition to the Southern Ocean.



Assemblage of coccoliths (SEM) at 42-43 degree South

3. POLYMETALLIC NODULES PROGRAMME

Nodule exploration in Indian Ocean now spans close to two and a half decades. During the period, extensive work has been carried out in the Central Indian Ocean Basin (CIOB) in identifying potential areas of nodule occurrence, narrowing down to Pioneer Areas and Allocated Areas. Further, phase-wise relinquishment of 50% was carried out in the allocated area (150,000 km²) to finally have a Retained Area of 75,000 km² in the CIOB. The final phase of relinquishment was carried out during 2002.

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 the long-term objectives.

Survey & Exploration

Table below gives a succinct overview of the total quantum of information and data obtained during the exploration part of the project since its inception.

| | |
|--------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| Area Surveyed | >4 Million Sq.kms |
| Nodule sampling Equipment used- Free fall grab, Photo grab, Van veen grab, Okean grab etc. | Over 2500 locations with 5-7 free fall grab operations in each station. |
| Grid of sampling | Completed 12.5 km grid in entire Pioneer area, and 6.25 km grid in a part of the area measuring approximately 17,500 km ² |
| Total number of sampling operations | ~ 10,900 |
| Total Bulk nodules Collected (by Dredging) | 250 tons |
| Echosounding (12 and 3.5 Khz echosounder) | 500000 lkm |
| Gravity (Bodenswerk Marine Gravimeter) | 320000 lkm |
| Magnetics (Proton Precision- Geometrics magnetometer) | 85000 lkm |
| Multibeam Swath bathymetry (Atlas Hydrosweep system) | 300000 sq.km |
| Multibeam swath bathymetry using vessel Akademik Boris Petrov | 12,000 lkm |
| Sediment Coring (Box/spade cores) | ~ 250 stations. |
| Ships used (8) | RV Gaveshani, ORV Sagar Kanya, MV Farnella, DSV Nand Rachit, MV GA Reay, MV Skandi Surveyor, RV AA Sidorenko, Akademik Boris Petrov |

The following activities have been carried out during the year:

1. Close-grid sampling at a grid of ~6.25 km in the identified area
2. Slow scan multibeam and backscatter studies
3. Detailed resource evaluation of nodules in the retained area

During earlier surveys, entire pioneer area has been surveyed using a multibeam mapping system. This is by far superior to the single beam echosounding used till then. One cruise onboard Boris Petrov has been undertaken during May-June, 2005 using the multibeam system towards slow scan bathymetry for mapping of the delineated area for First Generation Mine Site.

The data obtained shows much better accuracy and higher resolution than any other system before. Preliminary observation of the data shows grooves or furrows on the seafloor having varying frequencies and amplitudes (the amplitudes would reach around 100 metres at times). Approximately 70 % of the delineated area has been mapped using a multibeam system. Further, backscatter data has also been obtained for the area surveyed.

As a part of close-grid sampling at a grid of ~6.25 km in the identified area so far about 140 stations have been successfully covered during the 3 cruises for close grid survey.

EIA studies

Mining of the deep-sea minerals is expected to alter the environmental conditions in the marine ecosystem. Environmental studies for mining of deep-sea polymetallic nodules were undertaken to evaluate the possible impacts of mining on deep-sea environment and develop protocols for environmental studies, to fulfill one of the obligations of the country as a Pioneer Investor under the UN Law of the Sea. In order to study effects of sediment re-suspension and resettlement, monitoring of the environmental parameters is being carried out by collection of samples at the test and reference areas for the benthic disturbance experiment. EIA monitoring programme covers geo-technical and geo-physical properties, sediment and pore water chemistry, meiobenthic, macro-benthic, micro-benthic, macrofauna, etc.

A comparison of results from baseline, pre-disturbance and post-disturbance studies have shown (a) vertical mixing of sediment on the seafloor, (b) lateral migration of sediment plume, (c) changes in physical, geochemical and biochemical characteristics of the sediment, and (d) an overall reduction in benthic biomass. In order to assess the process of restoration and recolonisation, a long-term plan for monitoring of benthic environment has been chalked out. This involves collection of environmental data for environmental variability in and around the proposed first generation mine-site, modelling of sediment plume dispersal and creation of database for deep-sea mining.

During the year 2005, one cruise was completed for monitoring the EIA parameters. Sediment samples collected using a box corer were analysed for sedimentology, sediment and pore water geochemistry, geotechnical properties, microbiology, biochemistry, meiofauna, macrofauna and megafauna. Sediment samples were also collected from selected locations in the test and reference areas during 2005, for further monitoring of the restoration and recolonisation of benthic environment.

Results of the 4 monitoring cruises from 2001-2005 have indicated that whereas some of the sediment characteristics appear to have regained the conditions similar to that of pre-disturbance stage, the numbers

and diversity of benthic organisms showed only marginal restoration. The parameters indicate that the benthic conditions are steadily moving towards restoration and the effect of disturbance is waning off. Ongoing analysis of environmental parameters would help in establishing the long term restoration processes in the benthic ecosystem. In addition data on various environmental parameters was collected in the proposed first generation mine site.

Dispersion characteristics of the sediment plume that is generated on account of any sediment disturbance activity such as mining largely depend upon the current velocities and their vertical structures in the benthic layer.

Mining Research and Development

- This component presently involves (i) development of shallow bed mining system for its re-demonstration and (ii) design and development of collector and crusher qualification.
- The project “Developmental tests on underwater mining system for long term operation using DP system” is in progress.
- A 500m rated underwater crawler is getting ready for demonstration of the systems capability for long-term operation.
- The dry test & wet test of crawler has been completed.
- The Launching and Retrieval System (LARS) was delivered to the Colombo Dockyard and integration (with Sagar Kanya) work is in progress.
- Studies on manganese nodule Pick up devices for the collector system is in progress.
- A test setup is to be formed in NIOT campus for conducting tests on the collector systems.
- A Scaled down model of experimental setup was developed and performance of scooping blades has been studied. The sea floor was simulated using bentonite mixtures during this test.
- Design of test setup is in progress.
- New types of crushers are being studied with the interaction with Indian manufacturers.
- Preliminary conceptual designs for artificial nodule laying at 500m depth has been completed.
- Studies on pressure drop and plugging characteristics of large solids conveyance in hoses is being carried out by IIT Madras.
- A test setup is being designed for carrying out studies on the plugging of solids in Dump valve (drain valve).
- Experimental studies on creating artificial sea bed in the collector test setup is in progress.

The shallow bed mining system has been refurbished for re-demonstration. For re-demonstration DP system is being installed on ORV Sagar Kanya. Thereafter, the demonstration is likely to be taken up this year-end. The site for the demonstration activity has already been finalized with the help of ORV Sagar Kanya.

The design and development of collector and crusher qualification is under progress. The specifications have been completed. The development of collector and crusher would be taken up in 2006-07.

Metallurgy

A demonstration pilot plant of 500 kg nodules/ day capacity was set up at HZL, Udaipur successfully for extraction of precious metals viz. Copper, Nickel and Cobalt. The pilot plant campaigns were carried out for validation of the flow sheet developed by RRL, Bhubaneswar. Another pilot plant is coming up at NML, Jamshedpur for production of ferro-silico-manganese ore from the residue obtained from the HZL plant.

The metal recovery efficiency is achieved more than the designed capacity of the plant set up at HZL, Udaipur. Copper, Nickel, Cobalt are extracted from the nodules. Joint campaign on RRL (B) Process was carried out in the pilot plant at higher pulp density (15% solids). The metallurgical performance was in line with the earlier data. The average recovery efficiency achieved in Phase I was as follows: Cu: 92%, Ni: 96%, Co: 82%.



Hammer Crusher in Pilot Plant for nodule Crushing

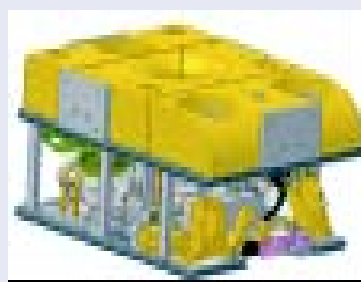
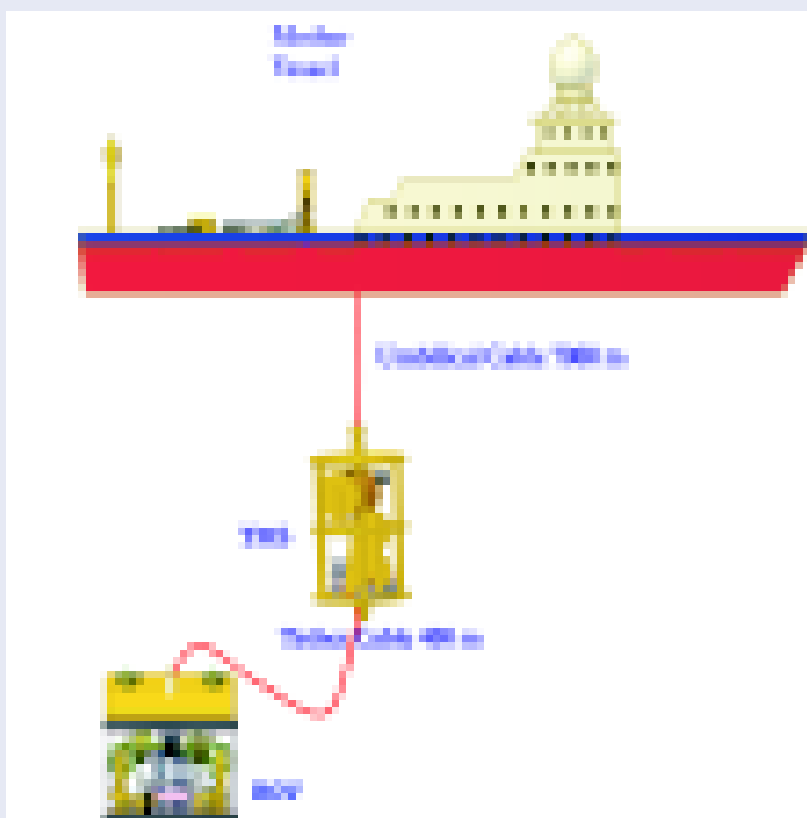
In Phase II several modifications were introduced which includes change of solvent for cobalt extraction from PC88A to Cyanex272. It helped in arresting cobalt losses as well as in reducing the number of stages from 18 to 5. Further, successful laboratory work was carried out for HZL process to increase leach pulp density from 20 to 30% solids.

Optimization of recovery efficiency in second section of the plant is achieved. Shortly, a new ferro-silico-manganese plant is expected to be working at NML, Jamshedpur with 500 kg/day capacity. The campaigns will be continued for testing the HZL (U) process route in addition to supporting the R&D endeavour for improvement in optimal metal recoveries from nodules at NML & RRL (B).

Unmanned Submersible

Development of deep water ROV (ROSUB) by NIOT in collaboration with Experimental Design Bureau of Oceanological Engineering, Moscow was initiated by Polymetallic Nodule Management (PMN) Board of the Ministry of Ocean Development, Govt. of India. The ROSUB unit consists of Remotely Operable Vehicle (ROV), Tether Management System (TMS), Ship based Launching and Recovery system (LARS), Power transmission and data telemetry system, integrated navigation system (INS), Control and operational system (soft). The Submersible is equipped with multifunctional tools and sensors for offshore applications such as sea bed imaging, pipeline routing, submarine cabling, well head detections, sampling etc.

The system is in its final phase of integration for the sea trials. 90% of the subcomponents have been realised for ROV integration; major subcomponents are placed in the mockup frame to arrive the final shape of the ROV.



Conceptual view of ROSUB - 6000



4. OCEAN OBSERVATION & INFORMATION SERVICES (OOIS)

4.1. Indian National Centre for Ocean Information Services (INCOIS)



View of the INCOIS Campus at Hyderabad

The Indian National Centre for Ocean Information Services (INCOIS), an autonomous body set up under the Ministry of Ocean Development in February 1999, started as a provider of operational data and services and swiftly transformed into a knowledge and information technology enterprise for the oceanic realm. INCOIS has become: (a) a provider of operational ocean information and advisory services to the entire country using advances in satellite remote sensing, ocean science and information & communication technology, (b) an observer of Indian Ocean using cutting edge technology, including the Argo profiling floats, (c) prime mover for R&D in frontier area of ocean-atmosphere modelling, and (d) most recently as the responsible national organisation for triggering tsunami warnings. The mission of INCOIS is to provide ocean information and advisory services to society, industry, government agencies and scientific community through sustained ocean observation and constant improvement through systematic and focussed research.

INCOIS sustained its key role in the Indian Ocean region as the Secretariat for the Indian Ocean Global Ocean Observing System (IOGOOS), Basin level Coordinator and Regional Data Centre for International Argo project in Indian Ocean. Further, INCOIS was designated as the National Oceanographic Data Centre (NODC) under the International Oceanographic Data Exchange (IODE) programme of the Intergovernmental Oceanographic Commission of UNESCO.

Major accomplishments during the period are as follows

- The PFZ Mission, a matured operational application of satellite remote sensing for providing timely and reliable advisories to fishermen on potential fishing zones, was sustained. This mission became a part of the Common Minimum Programme of the Government of India. The delivery chain was further enhanced with several electronic display boards at fishing harbours and information kiosk. This mission is bringing direct economic benefits to the fishing community.

- The experimental forecast of ocean state (wave parameters in Open Ocean and tidal currents in part of west coast) was sustained.
- The Argo Data Centre at INCOIS acquired temperature and salinity profiles (up to 2000 metres) from 107 Argo profiling floats deployed by India in the Indian Ocean since 2002. As the Regional Data Centre for the Indian Ocean, temperature and salinity profiles acquired from 586 floats deployed in the Indian Ocean have been archived at INCOIS and made available to the scientific community through INCOIS website.
- A Satellite Data Acquisition and Processing System established at INCOIS, has been made operational and started acquiring in-situ data from ocean observing platforms such as Argo profiling floats and Drifting Buoys as well as remote sensing data from NOAA Series, Tera, Aqua and Feng Yun satellites.
- Significant progress has been achieved in the implementation of Indian Ocean Modelling and Dynamics (INDOMOD) Project and Satellite Coastal and Oceanographic Research (SATCORE) Project including setting up of computational infrastructure and human resources development in the participating institutions.
- Setting up of Interim Tsunami Warning System, which is operational on 24x7 basis to provide tsunami warnings.
- IOGOOS sustained its place of pride among the GOOS regional alliances of IOC. One of significant milestones has been the finalization of a strategy and implementation plan for a unified Indian Ocean observation system for climate through the Indian Ocean Panel of Experts set up by IOGOOS, jointly with IOC and the Climate Variability Research Programme of World Climate Research Programme.

4.2. Ocean Information and Advisory Services

Potential Fishing Zone Advisories

The concerted efforts of scientists from ocean development, space and fishery science in conjunction with the coastal states have culminated in a unique service to provide reliable and timely potential fishing zone (PFZ) advisories using satellite data to the fishing community of the entire coastline of the country in a Mission mode with active participation of all stakeholders.

PFZ advisories are generated using both the Sea Surface Temperature (SST) from NOAA-AVHRR and Chlorophyll from Oceansat-1 based on the features such as oceanic fronts, meandering patterns, eddies, rings, up-welling areas that are proven to be prospective sites for fish accumulation. PFZ advisories prepared in local languages and local measurement units are disseminated thrice a week through innovative and novel initiatives such as Electronic Display Boards and Information Kiosks at the fishing harbours, radio and internet supplementing fax and telephone. This is the only short term forecast available to the fishing community of the country.

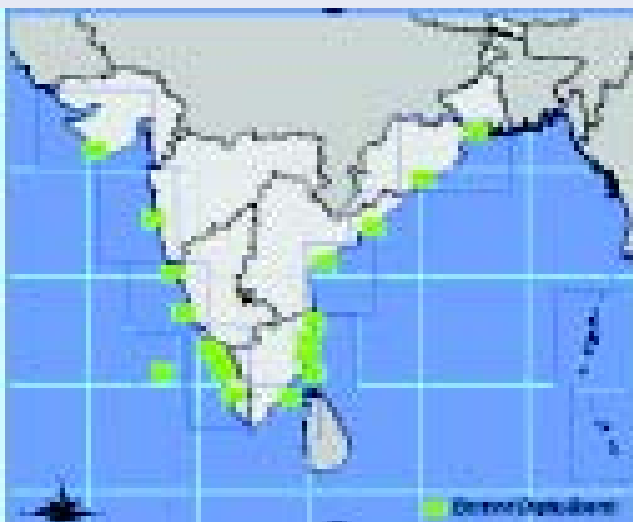
Frequent and intense interactions at the fishing harbours between scientists and fishing community are ensuring improved awareness and effective use of these advisories. Concurrent validation and feedback are integral to this mission and the necessary institutional mechanisms are in place. It has been validated

that the search time has been reduced by 30 to 70 % due to the usage of these advisories. The recent study conducted in the Kerala coast has brought out that saving on account of using this information is to the extent of Rs 1.50-3.00 Lakhs per vessel per year. This is an excellent example of reaching the benefits of science to society.

The challenge for the near future is to sustain and enrich the PFZ Advisory Mission with (i) additional parameters such as Wind, (ii) forecast for commercially important species such as Tuna, (iii) improving the dissemination chain by installation of additional electronic display boards and information kiosks at fishing harbours.

The significant achievements during the period under report are as follows:

- Operational Generation of PFZ advisories was sustained and enriched.
- PFZ advisories were generated and disseminated thrice a week during the non-ban and non-monsoon periods.
- PFZ advisories were transmitted through the Electronic Display Boards at Veraval, Ratnagiri, Malpe, Panjim, Vypeen, Neendakara, Beypore, Munambam, Royapuram, Veerampattinam, Thengaithittu, Thangachimadam, Kakinada, Machilipatnam, Visakhapatnam, Gopalpur and Diamond Harbour and Agatti. The forecast is being updated thrice a week directly from INCOIS and about 1000-3000 fishermen from each fishing harbour use this information for their fishing activities.
- PFZ advisories along with SST and Chlorophyll images, vector coverage and text information were made available through INCOIS Web-site to the user community. PFZ advisories in both map and text forms are e-mailed to about 60 users.
- PFZ advisories were also disseminated through Telugu daily news paper (coastal district editions of AP) weekly thrice in the local language. Efforts are underway to publish PFZ advisories in the newspapers of the other coastal states in their respective languages.
- The Pilot Information Kiosk set up at Brahmavar in association with M/s Hindustan Lever Limited (HLL) is providing locale-specific fishery forecasts to about 3,000 fishermen in the region.
- An Electronic Display Board was installed at Tele Fisheries Village Resource Centre, Nagapattinam and PFZ awareness workshop was conducted to the fishermen of Nagapattinam on July 06, 2005.

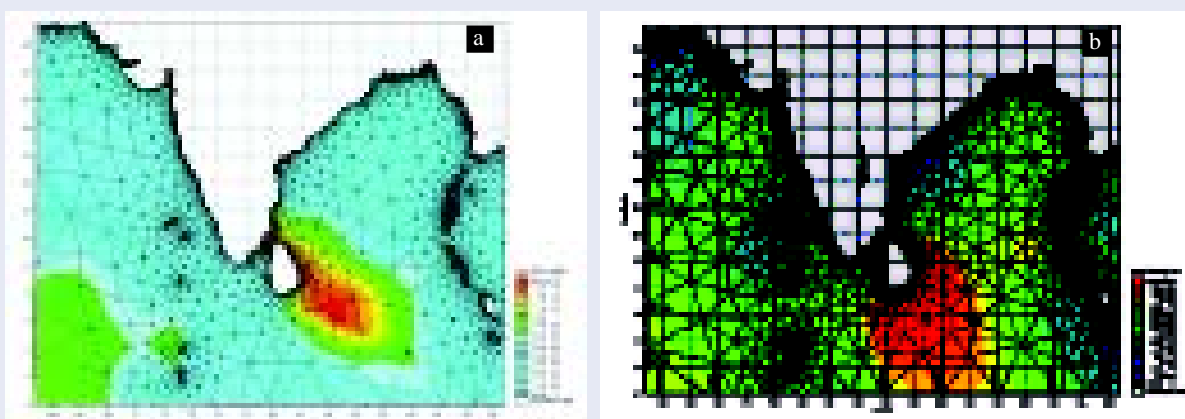


Locations of Electronic Display Board along the coast of India

4.3 Experimental Ocean State Forecast

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

The focus has been on forecasting ocean state parameters that meet the operational needs of Navy, Shipping, Oil industries and Fishing community. Forecast of wave and swell parameters using ocean models for the Indian Ocean, and tidal circulation for Gulf of Kambath have been published on INCOIS web site in GIF format. Numerical values of the forecast for the above parameters are provided through the web to more than 10 organisations. The wind field generated by mesoscale atmospheric models such as Eta and T80 (by NCMRWF) are provided to WAM-3GC model for forecast of wave parameters over the Indian Ocean



Forecast of (a) significant wave height and (b) wave period, using MIKE 21 software flexi mesh model during the cyclone on 7th December, 2005

region. There is a mechanism in place for getting feedback from the users including continuous validation of the forecasts using in-situ and satellite observations.

Experimental Ocean State Forecasts are made available through INCOIS website with WEB-GIS capabilities. Forecast of tidal currents from Ratnagiri to Porbandar are operational.

Forecast of surface waves generated by cyclone was carried out with MIKE Software for the cyclonic conditions in the Bay of Bengal during December 7-9, 2005 with the Eta model wind forecast from NCMRWF, New Delhi. The model uses unstructured mesh module of spectral wave model with coarse resolution at the open ocean region and very fine resolution at the coastal region.

Interactions were held with users on OSF products generated by INCOIS during the International Maritime Expo-India held at Mumbai on October 5, 2005.

4.4 Indian Ocean Dynamics and Modelling (INDOMOD)

INDOMOD Project during the IX Plan made a significant initiative towards realising a national capability in Ocean Atmosphere modelling. During the X Plan, a new phase of modelling efforts was initiated under INDOMOD project, focussing towards the end goal of achieving ocean predictability and enabling climate predictability in a mission-mode with concomitant efforts in Modelling, Data Assimilation and Validation.

Building a national team with a network of institutions viz. IISc, CAS/IIT-D, Centre for Mathematical Modelling and Computer Simulation (C-MMACS), Indian Institute of Tropical Meteorology (IITM), IMD, INCOIS, NIO, NCMRWF, Naval Physical Oceanographic Laboratory (NPOL), NRSA, SAC and SOI is the key to realise this mission. Significant progress has been achieved in setting up of computational infrastructure and human resources development in several centres of excellence for implementation of Indian Ocean Dynamics and Modelling (INDOMOD) Project.

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

- Computational infrastructure was upgraded at INCOIS for Modelling Studies.
- Seasonal mean and intra-seasonal variability of surface wind from NCEP has been compared with Quikscat and Buoy.
- Examined basin wide and global tropical estimates of solar penetration and its effects on upper ocean thermodynamics.
- Simulation were conducted to study the biweekly oscillation of v component in the NIO.
- Carried out a 35 year integration CCM-3 AGCM (climate SST as boundary condition), 5 year integration with TMI-SST (1999-2003), 10 year integration with Hybrid coupled model (CCM-3 + Slab Ocean mixed layer), 10 year integration with the CCM-3 with the daily SST from the hybrid coupled model run. Role of air-sea coupling on the northward propagation of the rain band & phase difference between convection and SST have been identified.
- The hydrology model and its ancillaries were assembled and it is being tested with data from Mandovi River.
- Heat budget of the near surface North Indian Ocean was studied.
- Different control experiments were performed. OGCM simulations show good resemblance with observation in capturing IOD and ENSO events and associated subsurface variability in the tropical Indian Ocean and Pacific Ocean.
- Control experiments revealed that (i) anomalies of temperature, heat content (HC) and Thermocline depth in the Equatorial region is closely linked with wind-stress variations.(ii) Interannual variations in the NHF found to have significant impact on changes in SST, MLD in the equatorial Central Pacific, North Pacific and sub-tropical Southern Indian Ocean.

- Analysis of MLD and thermocline interactions associated with monsoonal forcing over North Indian Ocean has been studied using Argo floats observations.
- Observations and experiments using AGCM provide new insight about the role of ENSO in influencing the Indian Monsoon through convection changes over NW Pacific.
- Monsoonal wind forcing play a crucial role in the generation of anomalous sub-surface cooling in the EEIO
- Developed IOM from MOM and trained 25 scientists bringing experts from GFDL/Princeton.
- Different control experiments (KPP and PP mixing, with and without tidal forcing and Indonesian through flow, effect of lowering viscosity, neutral physics replaced with simple horizontal diffusion, etc.,) were performed.
- Depth-averaged and breadth averaged suspended sediment transport model was developed and applied to the Hooghly estuary. Depth-averaged suspended sediment transport model was developed for the Gulf of Khambhat.
- A shallow water model SWAN is nested in deep water model WAM. The wave set up generated by SWAN model was tested with IIT Delhi storm surge model.
- The impact / importance of non-hydrostatic dynamics in simulation /prediction of intense convective vortices were investigated through a number of experiments. The use of non-hydrostatic dynamics significantly improved the simulation of track and intensity of the storm.
- Experiments with parameterization (Four cumulus, two PBL and two radiation parameterization schemes are investigated in non-hydrostatic model).
- Incorporation of temporal variation of SST has significant positive impact in simulating the track and intensity of the storm. The track and intensity of the storm is better simulated with the use of satellite observed SST.
- Based on the experience gained with IOM, established a base model from which assimilation studies were carried out. The interannual runs performed gave an idea of systematic model errors when compared with Topex/Poseidon and in-situ data.
- POM and MOM were customized for Indian Ocean region (1 deg) and forced with NCEP winds and diagnostically derived heat fluxes. The interannual variability in the surface and subsurface temperature of equatorial Indian Ocean is studied during 1982-2001. Both POM and MOM could simulate Indian Ocean Dipole very well.
- The interannual variability in the temperature inversions, their westward propagation and its contribution to the warm pool were studied using Argo floats data. Argo float observations in the Arabian Sea during 2002 and 2003 are objectively interpolated. Analysis showed that Arabian Sea was warmer in 2003 and the warming extended up to the thermocline.
- Several historic in-situ, satellite oceanographic and surface marine meteorological, oceanographic model analysis/simulation output data were acquired and archived. Generation of Atlas on surface marine meteorology, TMI SST, T/P SSH, SeaWifs Chlorophyll-a and near surface thermal structure

is underway to characterize and resolve the observed variability on intra-seasonal and interannual time scales.

- A hydrographic survey cruise was carried out for high-resolution multi-disciplinary observations (temperature, salinity, chlorophyll, primary production, zooplankton, dissolved oxygen, pH and nutrients and ocean currents) during 10 May-8 June 2005, to understand the response of physical forcing on the biogeochemistry of the equatorial Indian Ocean.
- Deployed 15 Drifting Buoys, retrieved and redeployed 3 Current Meter Moorings, and sustained the XBT observations.
- Monthly climatology of surface currents in the Indian Ocean derived from the drifting buoy data was updated.
- Upgraded the drifting buoy data archives. The present archive of drifter data from the Indian Ocean (60°S to 25°N) contains data from 918 buoys spanning over the period 1976 to 2005.
- Generated time series currents, temperature, pressure and salinity data from 18 depths from all the three moorings: 4 years at 93°E, 3 years at 83°E, 1 year at 76°E and 2 years at 77°E. Examined the temporal variability of measured currents in conjunction with the OGCM results.
- Vertical Temperature profiles collected under the XBT program constitutes the largest data set ever collected for the Indian Seas under any National or International Programs.

4.5 Satellite Coastal and Oceanographic Research (SATCORE)

INCOIS, jointly with the Department of Space played a catalytic and facilitating role in building national capability for application of satellite remote sensing for oceans and coasts. SATCORE project envisages development of various algorithms and models for retrieval of met-ocean parameters (e.g. sea surface temperature, winds, wave parameters, bathymetry, suspended matter, mixed layer depth, chlorophyll, aerosol, water vapour, clouds, currents and sea level) from the data from Indian and foreign satellite sensors including Oceansat-1 (IRS P4). Besides, this project would also carry out diagnostic studies and generation of forecast models, customisation of algorithms and development of related software packages. The SATCORE project is executed primarily through SAC and NRSA.

Significant progress has been achieved in the implementation of Satellite Coastal and Oceanographic Research (SATCORE) project in the participating institutions.

4.6 Indian Argo Project

Argo is a revolutionary concept that enhances the real-time capability for measurement of temperature and salinity through the upper 2000 meters of the ocean which contributes to the global description of the seasonal and inter-annual variability of the upper ocean thermohaline circulation. Argo will effectively monitor the pulse of global heat balance and improving our understanding of ocean's role in climate as well as spawn enormous range of valuable ocean applications.

International Argo Project endorsed by WMO and IOC of UNESCO aims to deploy 3000 floats in the global ocean by the year 2006 to establish a global array at a spatial resolution of 3° x 3°. The data from Argo floats are acquired through ARGOS satellite system and processed at designated data centres before

disseminating to the world community within 24 hours through internet and GTS. Free and timely availability of the data is the fundamental tenet of the Project.

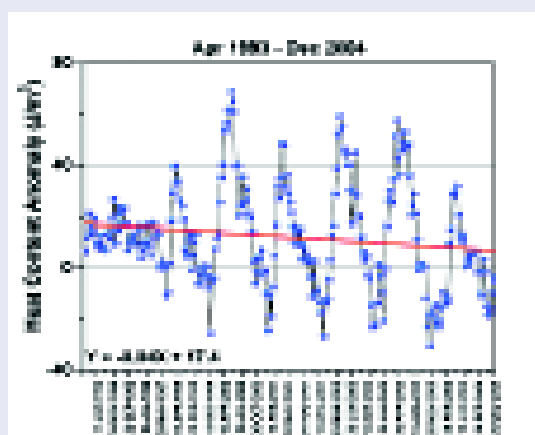
The Argo array of the Indian Ocean requires about 450 floats. India is a partner in the International Argo Project by contributing 150 floats for the Indian Ocean. The Indian Argo Project is being implemented by INCOIS jointly with National Institute of Ocean Technology (NIOT) and IISc with active participation from a network of other premier institutions. Further, INCOIS has a lead role in the project as (i) the Regional Coordinator for implementation of Argo programme in the Indian Ocean and (ii) the Regional Argo Data Centre for the region.

Significant achievements under the programme during 2004-05 are as follows:

- 75 floats are operational out of 107 floats deployed by India. Data from the active floats, directly received at INCOIS Satellite Data Acquisition and Processing System, is processed and disseminated to user agencies after real time quality control.
- Regional Argo Data Centre at INCOIS archived data from 536 Argo floats deployed by various countries in Indian Ocean and published on INCOIS website. 393 floats deployed by various countries in the Indian Ocean are active currently.
- Argo value-added data products viz. waterfall plots for temperature and salinity, time series plots for temperature, salinity, surface pressure and bottom pressure, temperature vs salinity, float trajectories and objectively analysed monthly data products viz. sea surface temperature, sea surface salinity, mixed layer depth, heat content up to 300 m, depth of 20°C isotherm and depth of 26°C isotherm were published on INCOIS website.
- Satellite Data Acquisition and Processing System (SDAPS) is operationally receiving data from Argo floats deployed by India in the Indian Ocean and also the remote sensing data from NOAA, Terra, Aqua and Feng Yun Satellites in real time.
- Argo floats data were analysed to study the upper ocean response during the active and break phases of Indian Summer Monsoon.
- The upper ocean circulation was studied using the geostrophic currents derived from Argo float data for the last four years and compared with the satellite derived geostrophic currents.
- Surface currents were estimated from the Argo float drift data in the Bay of Bengal. The results were compared with SODA data sets and found in good agreement. Analysis of error statistics of the currents is being studied.
- Computed geostrophic velocities using the Argo float data and Altimeter data and Ekman drift from Scatterometer winds to map the monthly variation of currents in the Arabian Sea.
- Temperature and salinity of upper ocean were simulated for the last 20 years using MOM model and the results were compared with the available Argo float data. The temperature simulations are in good agreement with observations and efforts are underway to improve the simulations of salinity.
- The SST derived from the Argo float data is validated with the in-situ SST from moored buoys,

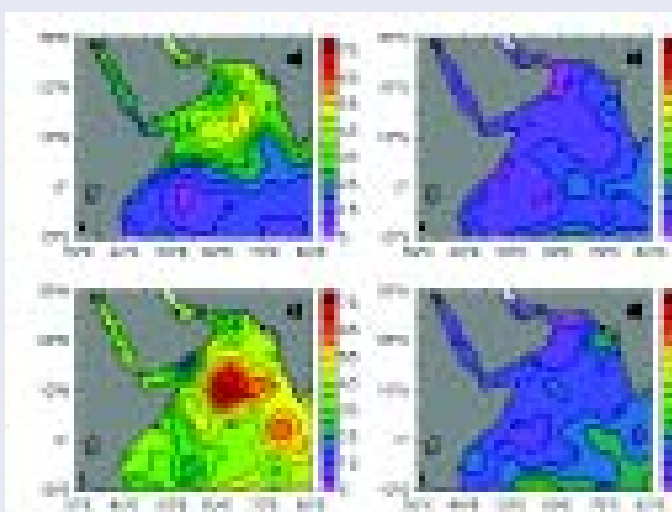
drifting buoys and satellite derived SST and it is observed that except for the month of July, due to strong wind forcing, all the other months, the error is $+ 0.5^{\circ}\text{C}$.

- Studied the (i) intra-seasonal variability of sub-surface temperature and salinity in the equatorial Indian Ocean using the data from Argo floats and TAO moorings (ii) relation between thermocline depth, dynamic height and sea surface height anomaly in the Arabian Sea and Bay of Bengal using the data from Argo floats and Altimeter.
- Observed mini-cold pool off the southern tip of India and its advection into the south central Bay of Bengal (BoB) during the summer monsoon season was examined utilizing the available satellite and in-situ measurements. The co-evolution of the sea surface temperature (SST) cooling and the causative factors such as surface wind field and its curl, net surface heat flux and divergence in the near-surface circulation (Ekman + geostrophic) were examined. The summary of results was communicated to a suitable journal for publication.
- Variability of the Heat Content (HC) was studied using the Temperature and Salinity profiles obtained from Argo floats in the Arabian Sea for the period 2002-05. Heat Content anomaly was derived by subtracting the HC computed from the Argo float data and the HC computed from the World Ocean Atlas 2001 data. Further this HC anomaly was correlated with Sea Surface Height Anomaly (SSHA) data sets of TOPEX/POSEIDON Altimeter for the years 1993 to 2001 (prior to the availability of Argo) by obtaining a linear relation between them.



Heat Content Anomaly for April 1993 – Dec 2004

- A new method for mean dynamic topography (MDT) was developed utilizing Argo data in describing the monthly circulation and major eddy fields of Arabian Sea for the period 2004 and 2005.
- Spatial variability of sonic layer depth (SLD) was studied using temperature and salinity (T/S) profiles from Argo floats and World Ocean Atlas in Arabian Sea from January 2003 to December 2004. There was good agreement of distributions and variability features between World Ocean Atlas SLD and Argo SLD, however with underestimation in the former.



SLD in 2004 for the months (a) January (b) April (c) July (d) October

4.7 Ocean Information Bank and Web-based Services

Ocean Information Bank

Ocean Information Bank is the back bone for providing information on physical, chemical, biological and geological parameters of ocean and coasts on spatial and temporal domains that is vital for both research and operational oceanography. The Ocean Information Bank is supported by the data retrieved from both the in-situ platforms and satellites and a national chain of Marine Data Centres and Ocean Observing Systems.

The Ocean Information Bank was updated regularly with (i) AVHRR data from NOAA Satellite series (of USA) from 1991 and Sea Surface Temperature archives for North Indian Ocean from 1992 to December 2005, including daily, weekly and monthly images and grid data, brightness temperatures, (ii) Data from Moored and Drifting Data buoys, Expendable Bathy Thermographs (XBTs), Current Meter Mooring Array for the period 1997-2005, (iii) Data from the 1700 Argo Floats deployed in the global Ocean (iv) PFZ Maps from 1992 onwards along the Indian coastline and Islands (for non-monsoon months), and (v) Autonomous Weather Station Data from Kavaratti and Port Blair.

Information Bank archived the data available from web pertaining to (i) Altimeter (1990-2005), (ii) TMI (1997-2004), (iii) Simple Oceanographic Data Assimilation products (1955-2001), (iii) temperature profiles from Joint Environmental Data Analysis Centre (1955-2004), (iv) Surface meteorological parameters (surface winds, solar radiation, net long wave radiation, sensible heat flux and latent heat flux) for the Indian Ocean from National Centre for Environmental Prediction (1998-2004), (v) rainfall data from CMAP (1979-2000), and (vi) Quikscat (1998-2005).

Web-based Services

INCOIS has been providing ocean information and advisory services through Website & Ocean Portal especially in the areas of (i) Potential Fishing Zone Mission, (ii) Indian Ocean Argo Project, (iii) Experimental Ocean State Forecast and (iv) IOGOOS, besides facilitating users with Information Bank, various projects and programmes, Ocean Tutor, etc. The web-based multi-lingual on-line information delivery system with Web-GIS capability (www.incois.gov.in) enables all users to query, analyse, visualise and download ocean data, information and advisories for their regions of interest. This has been widely used website among wide spectrum of users.

Content updation of INCOIS website was carried out periodically and several new web pages were developed. INCOIS has initiated the development of data warehouse and data mining facility to improve the functionality of the website and maintain a centralised repository of enterprise data. A data base was designed using Oracle data warehousing tools for managing in-situ as well as remote sensing data. Also, a GIS based interface for selection and retrieval of data from various observing platforms in the Indian Ocean was developed.

INCOIS web-site has been visited by 11,585 visitors and recorded 83,164 hits over a period of 6 months. PFZ Forecast page, PFZ Multilingual pages, Web-GIS pages of PFZ, E-OSF, Argo and IOGOOS web pages are the prominent pages visited.

Modelling Activities at INCOIS

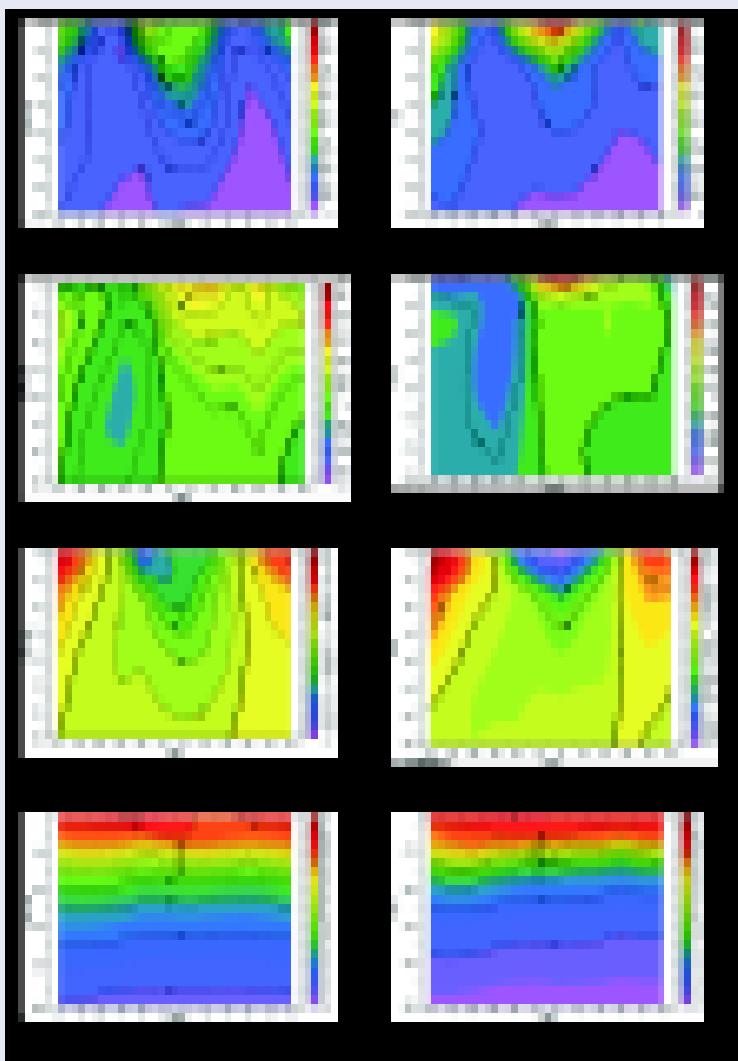
A core team was developed at INCOIS for Ocean Modelling as part of capacity building. Regional Ocean Model (ROMS) developed by Rutgers University, USA and Modular Ocean Model (MOM) developed by GFDL, customized for Indian Ocean region was installed at INCOIS for modelling studies on Ocean and Climate. Further, coastal ocean modelling studies were carried out using WAM 3GC and SWAN models.

Three different experiments were carried out using MOM to study the response of forcing fields on different parameters for five years during the period 1990-1994 and the resulting fields were compared with SODA data. The model is spun up for 20 years from cold start and forced with climatology fields for attaining stability. These outputs were used as restart files for different experiments.

In the first experiment, the model was forced with observational data i.e. Quikscat satellite winds and the rest of the forcing fields i.e., heat fluxes, salt flux (evaporation minus precipitation), temperature field and salinity fields were done with climatology the results pertaining to ocean currents were compared with the Simple Ocean Data Assimilation Datasets.

In the second experiment, the model was forced with NCEP heat fluxes and the rest of the forcing fields i.e., winds, salt flux (evaporation minus precipitation), temperature field, salinity fields etc were done with climatology and the resulting ocean temperature fields were compared with SODA temperature fields.

For the third experiment, forcing was done with ECMRWF evaporation minus precipitation fields retaining the rest of the forcing fields i.e., winds, heat flux, temperature field, salinity fields to climatology. the resulting ocean salinity fields were compared with SODA salinity fields of the corresponding years.



5. MARINE RESEARCH & TECHNOLOGY DEVELOPMENT

5.1 Assessment of Marine Living Resources

The Marine Living Resources Programme envisages survey, assessment and exploitation of the MLR and studies on the response of MLR to changes in the physical environment with the objective of developing an ecosystem model for the management of the living resources in the Indian EEZ. The Fishery Oceanographic Vessel (FORV) Sagar Sampada is fully utilized for these studies. On-going MLR surveys in the EEZ focus on Deep-sea fishery, Tuna-resources, Harmful Algal Blooms, Bioluminescent planktons, marine mammals, environment and the productivity patterns. These efforts are complimented through allied activities under MLR namely studies on the benthos of the continental slope area, studies on biodiversity of planktons in Andaman sea, studies on the near-shore dynamics with special reference to upwelling and mud-banks, application oriented R&D on production of pearls from the black-lip pearl oyster, development of antifouling compounds from marine organisms, modelling efforts and maintenance of a Data & Referral Centre on FORV collections.

Fishery Oceanographic Research Vessel (FORV) Sagar Sampada

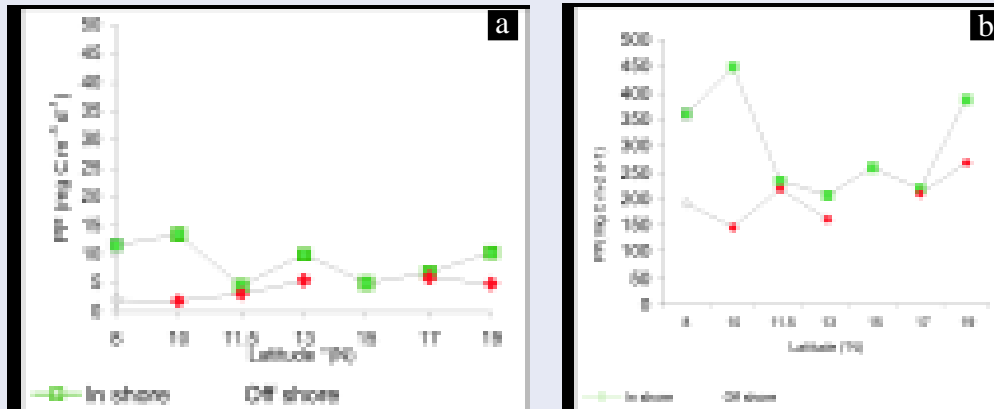
FORV Sagar Sampada was fully utilized for MLR surveys. During the year, the vessel undertook 13 scientific cruises in 301 days of steaming covering 24743 nautical miles and occupying 344 number of stations. The break up of scientific cruises are; 9 in the Arabian sea, 2 in the Bay of Bengal, and 2 in the Andamans. Environment and productivity patterns were surveyed during the inter monsoon and summer monsoon periods in the Arabian sea, and winter monsoon in the Bay of Bengal and Andaman sea. Three dedicated cruises were conducted for collection of sediment samples from the continental slope area for studies on benthos, of which 2 cruises were in the Arabian sea and one in the Bay of Bengal. Further, three cruises were conducted for fishery survey, 2 for plankton biodiversity in the Andamans and 1 for studies in the Near-shore dynamics of the west coast. Scientists from National Institute of Oceanography, Central Marine Fisheries Research Institute, Fishery Survey of India, Central Institute of Fishery Technology, Centre for Marine Living Resources & Ecology, Cochin University of Science and Technology, Andhra University and Annamalai University participated in these cruises.

Marine Living Resources Programmes

Environment and Productivity Patterns in the Indian EEZ

Two inter monsoon coverages and one summer monsoon coverage of the Arabian sea were undertaken during the year. One winter monsoon coverage was undertaken each in the Bay of Bengal and the Andaman sea.

The summer monsoon SST in the Arabian sea varied between 26°C along the coastal stations and 31.5°C in the off-shore waters. Strong upwelling signatures were observed over the entire west coast from 8° to 17° N. Latitudinal variations in primary production and chlorophyll-a were not prominent. Maximum surface primary production of 122 mg C m⁻³d⁻¹ was recorded in the inshore stations off Kochi (10°N). An abundance of *Noctiluca miliaris* was observed in the open waters of Ratnagiri and Veraval. Secondary productivity in the Mixed Layer Depth (MLD) was higher along the southern latitudes (8°N and 10°N). The distribution of mesozooplankton biomass in the MLD was high during peak phase of summer monsoon than in the early phase.



Latitudinal variation in (a) surface production and (b) column production

Abundance of Siphonophores (8.66ml/m³) in the mixed layer and a swarm of Euphausiids (9.1ml/m³) in the thermocline layer were observed at 10°N75°E during peak summer monsoon.

In the Bay of Bengal, strong temperature inversions were observed below 30 meters at 20.5°N during the winter monsoon 2005, the intensity of which decreased towards the southern transects. Cold core eddy was observed between 15° - 19° N. Very low MLD along the northern transects were found to be due to

low wind stress and high fresh water influx.

a

b

Reversal of winds during the early (south easterly) and late phase (north easterly) of winter were observed in the Andaman sea. Correspondingly the Sea Surface Temperature (SST)

Distribution of mesozooplankton biomass in the MLD during (a) early summer monsoon, and (b) peak summer monsoon

was higher in the northern region (29.2°C) during early winter. The northern areas of Andaman sea showed inversion of temperature (~3°C). The northern areas also showed Oxygen Minimum Zone (OMZ) at intermediate depths (150-300m). Average chlorophyll-a in the surface was 0.26 mg m⁻³ and in the column, it was 29.54 mg m⁻². The mesozooplankton biomass was high during late winter than early winter monsoon.

During the year, studies on the nearshore dynamics of the southwest coast of India with special references to upwelling and mudbanks were carried out by occupying 72 stations in the depth range 20m-200m between Kanyakumari and Mangalore. Current measurements off Kochi during April-May 2005, showed alongshore currents with strong coherence at various depths suggesting a barotropic flow field. Superimposed on the

Cold core eddy at 19° N

tidal oscillations were other oscillations seen to be quite strong during the first fortnight. These oscillations were not seen during the second fortnight. The flow also reversed during the last fortnight of the observation period. The flows are not strongly correlated to the tides of Cochin. Another interesting observation during the year was the increased abundance and frequency of *Trichodesmium* blooms along the southwest coast.

Marine Benthos of the Indian Continental slope

Numerical abundance of macrofauna was found to be maximum at 250m depth regions with a decreasing trend towards 1000m depths. Polychaetes dominated in the macrofauna and the other groups encountered were crustaceans, molluscs and echinoderms. Amphipods and ostracods were dominant among crustaceans. Among meiofauna, numerical abundance was maximum at 250m depth region and decreased with depth. Nematodes were the dominant group followed by foraminiferans and crustaceans respectively. Crustaceans were represented mainly by copepods. A high degree increase in numerical abundance of nematodes was observed at 250m depth off Kollam. In the case of epifauna, crustaceans (crabs and deep-sea prawns) were the dominant forms followed by molluscs and fishes.

Total heterotrophic bacterial population was found to be maximum at 200m depth range followed by 1000m. Total heterotrophic bacterial population was found to be maximum at 500 m off Ponnani.

Fungal population was found to be maximum at 500m depth regions. The population at 1000m was found to be higher when compared to that of 200m depth. Microbial population was found to be maximum in the sediment samples off Mumbai coast.



Epifauna collected from east Coast of India



Investigation on the heterotrophic bacteria has revealed that the Gram positive groups predominate more than the Gram negatives in the sediments. Generic

composition of the sediment bacteria showed that genus *Bacillus* predominated, followed by *Pseudomonas*, *Coryneformes* and *Micrococcus*.

Assessment and Biology of the deep-sea fishery and tuna resources in the Indian EEZ

Survey for the deep-sea fishery resources along the continental slope area off Kerala coast was undertaken during September- October 2005. Deep-sea trawl surveys were carried out at 19 stations (150m to 822m depth) along the continental shelf break. *Psenopsis cyanea* was the dominant species. Between 200-500 meter depths, the dominant species were *Coloconger raniceps* and *Psenopsis cyanea*. In the deeper waters, *Alipocephalus bicolor* was the dominant species. The survey also indicated abundance of deep-sea shrimps in many of the stations. Catch per unit effort varied from 19 kg to 457 kg/hour. Under the Tuna tagging programme which also commenced in August 2005, the project scientists visited Lakshadweep and carried out preliminary studies on the catch composition and biology of Yellow fin and Skipjack tunas.

Farming and Pearl production in Black-lip pearl oyster

The project is being carried out at Andamans. Farms have been set up at Marine Hill, Havelock islands and Chidiyatapu after initial surveys. At present, 101 adults and 313 spats of *Pinctada margaritifera* and 141 adults and 125 spat of *Pteria penguin* are maintained in the farms at Marine Hill and Havelock islands.

Implantation trials have been carried out on more than 25 oysters in March '05. Harvest is expected



Mabe Pearl Production from *P.margaritifera*



Marine Hill - Raft

from the 8 surviving oysters by March 2006. Mabe Pearl implantation trials were carried out in 12 *Pinctada margaritifera* and 27 *P.penguin*. Three Mabe images were obtained from *P.margaritifera*.

Bioactive antifouling compounds from marine organisms

Preliminary screenings indicates that 36 species of sponges, 19 species of soft corals, 21 species of sea weeds, 7 ascidians and 16 surface bacterial strains have shown potential for antifouling activity. Crude extracts of samples were subjected to various antifouling assays, with 8 samples being listed against all the assay organisms. Broad-spectrum antifouling activity was obtained for one sponge species and one soft coral. Two strains of bacteria were found to exhibit activity against fouling bacterial strains. After fractionation and purification, samples were subjected to NMR spectral analysis. Of the two fractions obtained for the sponge sample, one fraction was found to be a mixture of sterols, while the second fraction is suspected to be mixture of fatty acids.

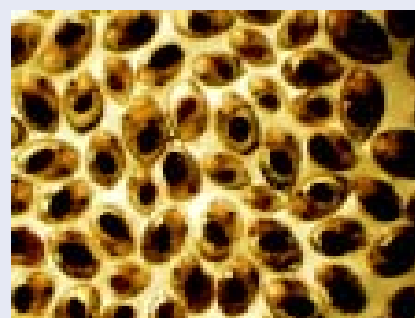


Thin Layer chromatographic observation of different fractions of crude extract under UV.

Bioluminescence of Plankton

Among the planktons, Ostracods were found to be the major bioluminescent group. Species responsible for the bioluminescence was identified as *Cypriaina dentata*. Negligible number of copepod *Saphrina* sp. at Kochi and a doliolid off Ratnagiri in the August 2005 collections also showed bioluminescence.

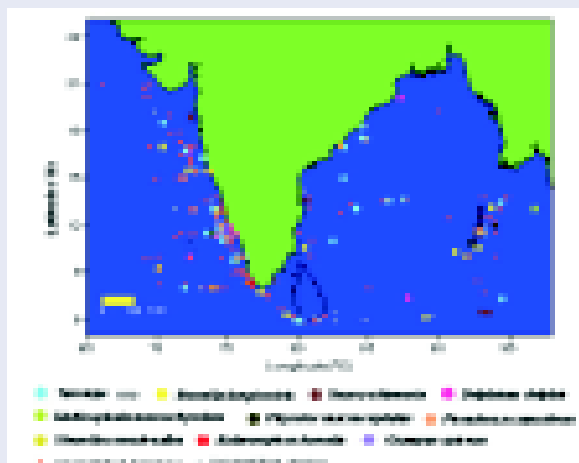
Swarms of the Ostracod *C. dentata* were observed off Kollam in January and off Ratnagiri in August. The number of ostracods in the coastal and oceanic waters were very high during inter-monsoon and less in the early summer monsoon.



Cypridina dentata

Marine Mammals in the Indian EEZ

The distribution of marine mammals in the Indian EEZ was worked out on the basis of data collected through 13 cruises in the Arabian sea and 5 cruises in the Bay of Bengal.



Distribution of marine mammals in the Indian EEZ and contiguous seas (Oct 2003-Jun 2005)

The concentration of heavy metals in the tissues of marine mammals were monitored. Iron was found to be high in both liver and muscle tissues while cadmium was found high in kidney. Liver samples showed high concentration of zinc, cadmium, copper, mercury and lead. Mitochondrial DNA (mt DNA) sequencing of 4 species of cetaceans viz. *Tursiops abuncus*, *Stenella longirostris*, *Grampus griscus* and *Physcter catodon* were carried out.

The mt DNA sequences were listed for species identity by aligning with sequences available in WITNESS FOR WHALES (DNA surveillance) and BLAST. Using this method, the bottle nose dolphin specimen which were earlier identified as *T. truncatus* based on morphological features were unambiguously identified as *T. aduncus*.



FORV Data and Referral Centre

FORV data collected through cruise 233 (April 2005) to 239 (November 2005) have been archived at the Data Centre. Reference sample collected through these cruises are maintained at the FORV Referral centre. Using the data sets, derived data products on Mixed Layer Depth, Thermocline, Oxygen Minimum Zone, Upwelling Patterns, Chlorophyll-a distribution and zooplankton distribution were generated. Preliminary studies on the upwelling patterns along the south west coast were carried out using wind stress data and incorporating the role of remote forcing. Fishery oceanographic bulletins for the year 2003-04 and 2004-05 are in the final stages of preparation.

Samples collected by FORV Sagar Sampada after the December 2004 tsunami have been fully analysed. It was noted that the tsunami had extensively disturbed the benthic fauna of the south west coast and that there was a sharp decrease in the surface nitrate values. Based on this, it was concluded that the disturbances in the benthic fauna may adversely affect the fishery. Assessment reports were submitted to the Committee constituted by the Ministry to assess the impact of the tsunami and also to the Kerala State Council for Science, Technology and Environment. Further, a dedicated cruise of FORV Sagar Sampada was conducted

in July 2005 to assess the status of the marine benthos in the shelf area of Kerala and Tamil Nadu coasts. Analysis of the sediment samples collected through this cruise is in progress.

5.2 Assistance to Research Projects and Manpower Training

The Ocean Policy statement enunciated by the Government of India during 1982 lays emphasis on training of skilled manpower in the ocean sector for creating self-reliant technological base and encouraging participation of scientists/technologists and engineers in the programmes of ocean development. The Ocean Policy further provides for appropriately strengthening the existing agencies to meet the demands of this growing challenge. The Ministry of Ocean Development functions in conjunction with other concerned agencies through the medium of Ocean Science and Technology Cells (OSTC), as a focal point to promote institutional capabilities. In line with these provisions and understanding the implicit need for capacity building and creation of effective human resource base, the Ministry of Ocean Development is promoting basic and applied research in the area of ocean science and technology, in academic institutions, national research institutes/organisations, right from its inception in 1981.

The objective of this programme is to encourage cutting edge research in newly emerging and frontline areas of Marine Geology & Geophysics, Marine Biology, Marine Ecology, Exploration and Exploitation of Marine Resources, Coastal Engineering etc. with a view to create infrastructure facilities in Universities and to inculcate scientific temper among the people in relation to marine science and technology.

Presently 73 research and development projects are being supported in the interdisciplinary field of Marine Science & Technology. This includes 13 projects exclusively under Marine Manpower Development Programme and 55 projects being supported under the Ocean Science and Technology Cells set up in the chosen priority areas viz. 'Marine Microbiology' at Goa University, 'Marine Geology & Geophysics' at Mangalore University, 'Beach Placers' at Tamil University, 'Coastal Marine Culture Systems' at Andhra University, 'Marine Biology' at Annamalai University, 'Marine Benthos' at Cochin University of Science & Technology, 'Marine Coastal Ecology of West Coast' at Bhavnagar University, 'Marine Coastal Ecology of East Coast' at Berhampur University and 'Ocean Engineering & Underwater Robotics' at IIT, Kharagpur. In addition to this 5 projects are being supported outside OSTC.

Also a three-member Expert Group, which was constituted to frame the National Programme on Antarctic and Marine Microbiology during the National Seminar on Marine Microbiology held by OSTC, Goa University during February 2005, submitted its report to the Ministry of Ocean Development on 30th June 2005. The Expert Group has recommended a number of programmes for implementation in the next decade both under the Antarctic and Marine Microbiology (including deep ocean water, sediment, sea-ice, ice-core, etc) in line with the global change, which inter alia include:

- Biodiversity of microbes
- Bio-prospecting - Primary and secondary metabolites and biotechnology
- Biogeochemical cycles restricted to annual studies
- Phylogenetic analysis of Antarctic and marine microbes
- Viruses

- Molecular basis of cold adaptation
- Satellite based studies on microbial communities
- Magnetotactic bacteria and their enzymes
- Metagenomics and Marine microbial genomics
- Bioremediation
- Microbe-microbe; microbe-eukaryotic interactions
- New and emerging technologies
- Establishment of Microbial Reference Centres for Antarctic and Marine Microbiology
- Marine Microbial Bioinformatics
- Capacity building and infrastructure

Till this year about 205 fellowships were given to various Universities/Institutes; out of which 81 were women.

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

Centre of Excellence in Marine Biology, Annamalai University

- A Monograph on finfish, which will be used as an identification manual, is under preparation.
- Identification of 16 sp. of *Conus* (Snails) off Visakapatnam coast, of which 7 sp. are new records from Visakapatnam coast.
- Crude Venom was extracted from the *Conus sp.*, purified and tested on mice and fish, and found to be potentially toxic.
- Biology of four species each of marine mammals and shore birds was studied along the Porto Novo coast and their feeding behaviour, heavy metal accumulation and DNA fingerprinting, were assessed to investigate their genetic array.
- Over 130 macrofouling organisms were collected and identified from test panels deployed off Kudamkulam coastal waters, adjacent to the upcoming Atomic Power Plant.
- Experiments with different coloured panels have revealed that green and white colour surfaces attract less foulers, when compared to other colours. Of the four metals such as aluminium, zinc, brass and copper tested for fouling, brass and zinc have exhibited good resistance to fouling growth.
- Embryonic development in alligator pipefish was successfully completed.

OSTC on Marine Microbiology, Goa University

- Under the project “Viruses of marine shrimp along south west coast of India” larval samples obtained from different hatcheries were studied for the prevalence of White Spot Syndrome Virus (WSSV), *Monodon Bacculo Virus* (MBV) and *Hepatopancreatic parvovirus* (HPV). Three scientific papers were published in peer reviewed journals.
- Under the project on “Crustacean chitin waste management for the production of chitin, chitosan and biocontrol agents for plant pathogens”, which was completed in March 2005 maximum chitinase production was found at 144 h by both *Pseudomonas sp.* and *Pantoea dispersa* whereas at 120 h by *Enterobacter amnigenus*. By screening statistical methods, medium components such as peptone, yeast extract, urea, and ammonium nitrate were also produced.
- The project on “Rapid survey of prevalence and geographic distribution of white spot syndrome virus (WSSV) of shrimp along the coast of India by the use of molecular probes” was completed in March 2005. Under this project WSSV infected shrimp with prominent white spots have been collected in different places of Tamil Nadu, Pondicherry, Andhra Pradesh and Kerala states. Two papers were published viz., “A rapid non-enzymatic method of DNA extraction for PCR detection of white spot syndrome virus in shrimp” in *Aquaculture Research* and “Experimental infection of twenty species of Indian marine crabs with white spot syndrome virus (WSSV)” in the journal *Diseases of Aquatic Organisms*.
- Under the Marine Manpower Development Project “Microbiological studies on Mangrove/marine bacterial flora” which has been completed, samples collected from mangrove areas resulted in isolation of 27 gram positive bacterial cultures mainly belonging to genus *Bacillus* that produce asparaginase and glutaminase. Most of these isolates were also capable of degrading benzoate in the presence of toluene.
- One of the nitrogen fixers collected from the sand dunes showed distinct production of EPS, helpful in enhancing moisture retaining capacity of the soils.
- Studies on marine microorganisms producing lipases and polyhydroxy alkanooates (PHA) was completed on 30.3.2005. 102 isolates showed PHA accumulation and 114 cultures showed lipase production. The most potent isolates were further screened for suitable carbon substrate for PHA accumulation and lipase production.

OSTC on Marine Coastal Ecology, Berhampur and Bhavnagar University

- 40 genera of phytoplankton and 10 species of echinoderms were recorded in the Gulf of Mannar.
- Fifteen groups of diatoms, 4 groups of blue green algae and dinoflagellates were recorded from Chilika Lake.
- A biological model was formulated for Chilika Lake including the nutrient concentration, phytoplankton and zooplankton population parameters.
- 48 species of scleractinian corals of 25 genera belonging to 11 families were recorded from Gulf of Mannar, of which 11 species reported for the first time.

- A Workshop on Natural Disasters and their impact on the Coastal Environment was conducted on 4-2-2005 at Berhampur.
- Two mega inter-institutional projects viz., ‘Biodiversity of the coastal ecosystems’ and ‘Coastal pollution and control’ were identified.

OSTC on Beach Placers, Tamil University

- Out of the total length of 925 km of the Tamil Nadu coast, mapping has been completed for 700 km by using aerial photographs and satellite imagery.
- The geomorphological and sedimentological studies revealed the concentration of placers only in beach sediments. The older landforms like beach ridges, sandy plains and other sandy landforms are not enriched with placers.
- Exploration for silica sand studies in Marakkanam region in Northern Tamil Nadu revealed that the size of the silica sands varied from 1.85 phi to 2.70 phi. The silica content ranged from 93.19% to 99% with an average of 96.39% and the iron content 0.01 to 0.1%.
- The ilmenites rich in Mn concentration as well as trace elements like Cr, V and Co, obtained from Visakhapatnam - Bhimunipatnam deposits are characterized by comparatively low average TiO_2 values and higher total iron contents. These deposits are characterized by excellent inter-growths of ilmenite in hematite, hematite in ilmenite exhibiting a wide variety of exsolution textures.
- The Ore microscopic study of ilmenites from Kakinada, Visakhapatnam – Bhimunipatnam, Srikakulam deposits indicate that the ilmenites of Kakinada deposits are completely devoid of exsolutions/intergrowths.



OSTC on Ocean Engineering and Underwater Robotics, IIT-Kharagpur

Preliminary and detailed design for the Autonomous Underwater Vehicle (AUV) have been completed.

- Various algorithms e.g. navigation, control, mapping etc., are being developed.
- A test bed fabrication is nearing completion.
- Vendors for prototype hull fabrication have been identified.

OSTC on Marine Geology and Geophysics, Mangalore University

- Under the project on 'Evolution of late Quaternary climate and coastal geomorphology, eastern Arabian Sea', 30 laterite samples collected from 12 locations around Mangalore showed that they consist mainly of gibbsite, kaolinite and quartz, hematite as minor and anatase as trace.
- The project on 'Amino acid dating and biomarkers of carbonate fossils in relict sediments of the continental shelf off Visakhapatnam, East coast of India' was completed. The dating method using the racemization principle of protein amino acids residing in the sediment was developed, for the first time in India, as an alternative or in the least as an adjunct to the radiocarbon method. The method scores over the radiocarbon method due to its potential applicability up to 2 million years.
- The identity of long chain alkenones in the sediment lipid extracts and to use their unsaturation index in the computation of palaeo SST was established. This method scores over the traditional d18O method due to its immunity from salinity and other considerations that affect the oxygen signal.
- Ancillary investigations such as (i) biostratigraphy using foraminifera, (ii) radiocarbon dating, (iii) oxygen isotope studies, (iv) sediment bulk geochemistry, and (v) monospecific foraminiferal major and trace metal geochemistry, were carried out.
- Under the ongoing project 'Near shore sedimentation process, hydrographic condition and current pattern along the southwest coast between Honnavar and Bhatkal, Uttara Kannada District' palaeo-river channels in the nearshore regions of Honnavar and submerged bars in front of Sharavati and Venkatapur River mouths have been detected.
- A total of 84 sediment and bottom water samples were collected from 21 stations ranging in depth from 0.5 m to 10.0m, for the ecological studies of benthic foraminiferal fauna as a Pollution Indicator in Gulf of Mannar. Ninety one species belonging to 45 genera, 26 families, 13 super families of 4 suborders have been identified. A series of SEM photographs of the foraminiferal fauna has been taken for estimation of heavy metal concentration.

5.3 Integrated Coastal and Marine Area Management (ICMAM)

ICMAM Project Directorate under the ICMAM Programme has been implementing following activities during the Tenth Plan period.

- Marine Ecotoxicology
- Shoreline Management Programme along Ennore, Tamil Nadu; Munambam to Kayamkulam, Kerala and Gahirmatha coast, Orissa
- Ecosystem Modelling at Vedaranyam lagoon, Chilka lake and Kochi backwaters
- Management of tidal inlets at Vellar and Netravathi estuaries
- Development of information system for ecosystem in Goa
- Sediment transport studies using OCM data from Oceansat I
- Coastal Engineering Strategy for shore protection for Kerala
- Tsunami vulnerability mapping
- Training programmes

Marine Ecotoxicology

The Government of India, Ministry of Environment & Forests has prescribed disposal standards for effluents arising from domestic sewage and industries. Since discharge of waste waters have detrimental effects on the marine organisms, limits on the concentration of chemical and biological substances that will be disposed into the sea have to be prescribed to ensure clean/desirable water quality. Such limits could be based on dilution and degradation characteristics of receiving water bodies.

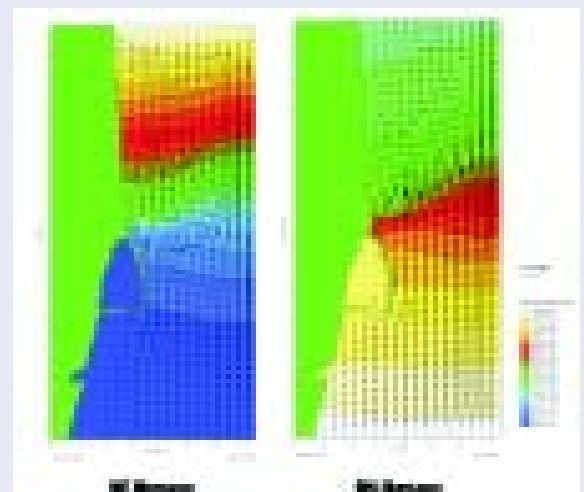
The primary water quality criteria have been notified for the designated best uses for seawater. They are for the limited parameters like dissolved oxygen, biological oxygen demand, suspended solids, turbidity, faecal coilform, few heavy metals, oil, etc., which are not uniformly applicable to all the locations as the physical and chemical processes are location specific. Further, these values prescribed by Central Pollution Control Board (CPCB) appear to be based on expert opinion. Hence the attempt has been made to prescribe standards for harmful chemicals like heavy metals, pesticides, etc., for other areas as they reach the marine environment through industrial and agricultural sources. For development of such standards, ICMAM Project Directorate has been implementing a long-term project on Marine Eco-toxicology in association with Institute for Ocean Management, Anna University (Chennai), Madurai Kamaraj University, (Madurai) and Dr.ALMPGIBMS, University of Madras (Chennai).

Shoreline Management Plan along Ennore Coast

The coastline between Ennore and Pulicat lake located in the northern part of Chennai has been experiencing a number of developmental activities like construction of ports, etc. in the recent past. The increase in developmental activities in the future may affect ecologically sensitive Pulicat lake, which supports prawn fishery and nearly thousand fishermen are depending on the resources of the lake. Presence of wide beaches offered excellent protection during recent tsunami wave attack. Protection of beaches from erosion that is likely to be caused by major developmental activities is the major goal of the project. The project is being implemented by ICMAM-PD in association with NIOT, Chennai.

The coastline starting from Ennore creek has been facing accretion at the mouths of Ennore creek and Pulicat lake due to the geomorphology of the coast. Construction of southern and northern breakwaters for Ennore port has altered the movement of the sediments, which has intensified accretion at the Ennore creek and erosion in the northern side.

In order to address the problems of siltation and erosion, a coastal stretch covering a length of 20 km between Pulicat and Ennore has been identified for study. The entire stretch has been divided into two distinct zones for analysing the problems. The vulnerable areas of erosion/accretion and impact of coastal structures such as Ennore port on shoreline changes was studied using field investigations and numerical modelling. The data on tides, waves, currents and sediment characteristics were studied for two seasons and hydrodynamic model was set up using the above data.



Circulation at Ennore Port for northeast and southwest monsoons

Shoreline Management Plan along Kerala Coast (Munambam to Kayamkulam)

The Kerala coast experiences severe erosion and accretion, which has led to loss of several acres of coastal land. This phenomenon is more pronounced between Munambam and Kayamkulam stretch in the Kerala coast. Majority of the coastline along the Kerala was protected by stone wall, which could not give fruitful solution, due to lack of understanding of the coastal processes and sediment pathways. This project aims at studying the physical and geological processes that are responsible for causing erosion/accretion and suggest appropriate remedial solution for protection of coast. The project is being implemented by the Centre for Earth Science Studies, Trivandrum. The project will determine the extent of erosion and accretion along the stretch and also the areas more vulnerable for such damages. It will suggest remedial measures like construction of shore protection structures after taking into consideration the effect of these structures on the adjoining stretches of the coastline in causing erosion/accretion. Mathematical modelling and GIS will be used in the study.

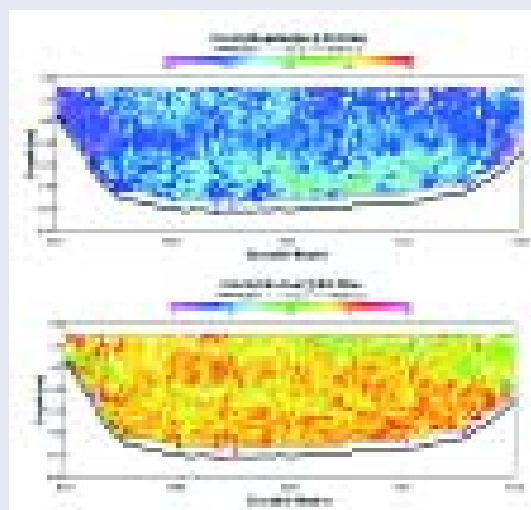
The entire coastal stretch to be studied under the project was divided into two segments, and the data on tides, waves, currents and sediment characteristics were collected for 3 seasons, viz., pre-monsoon, monsoon and post-monsoon at Trikunnappuzha, Mararikulam, Anthakaranazhi and Njarakkal. In addition to the above coastal stations, the Kayamkulam inlet was also monitored to study the siltation pattern.

During the current year, the wave and current data collected in the northern sector during the premonsoon and monsoon seasons were processed to derive the hydrodynamic characteristics of the northern sector during these seasons. The wave data for the pre-monsoon showed a maximum significant wave height of 0.68m at Anthakaranazhi and 0.92m at Njarakkal. During the monsoon the wave height increased

considerably with a maximum value of 2.3m at Anthakaranazhi and 2.2m at Njarakkal. The results show that this sector also comes under a moderate wave energy regime, as is the case with the southern sector. The current data showed that the speed ranged up to 23cm/s at Anthakaranazhi and 27cm/s at Njarakkal during pre-monsoon. During the monsoon the current speed increased significantly, upto 39cm/s at Anthakaranazhi and 61cm/s at Njarakkal. The net movement of water as indicated by the progressive vector plots follows a net southerly movement at both the stations during pre-monsoon as well as monsoon. However, the pattern at Anthakaranazhi during monsoon showed a complicated picture with a net northerly transport. For calibration of hydrodynamic model, the vertical profile of the currents was monitored at Kayamkulam and Cochin inlet. This project also aims at identifying an alternative structure instead of seawall to preserve the natural beach.

Shoreline Management Plan along Gahirmatha Coast

The present project implemented by the ICMAM Project Directorate in association with NIOT, Chennai, intends to investigate the relationship between beach slope, sand characteristics and other coastal environmental parameters with that of nesting site selection by turtles and suggest remedial measures to protect these beaches.



Vertical distribution of currents at Kayamkulam along the transect perpendicular to coast

The beach profiles, foreshore slopes, sand size characteristics were monitored for Gahirmatha beaches during the nesting season (i.e., from Nov'04 to April'05). But, surprisingly, in the year 2005, mass nesting did not take place at Gahirmatha beaches and shifted to northern side of Gahirmatha i.e., Nasi Island beaches (a restricted area). However, nesting took place at Rushikulya beaches (200km south of Gahirmatha) and prompted us to monitor the beaches at Rushikulya. Reconnaissance survey of the site, bi-monthly beach profile measurements (~100 profiles), shoreline mapping and analysis of sediment characteristics for about 250 samples are carried out along 7 km of the coastline since April 2005. So far, four (April 2005, June 2005, August 2005, and November 2005) field observations have been made to understand the various processes of the area.

Ecosystem Modelling for Chilka Lagoon

Chilka Lagoon, Asia's largest brackish water lagoon, represents a unique ecosystem considering that it is a Ramsar Site serving both commercial fishing sector and local tourism. Catchments modification together with the opening of a new mouth in September 2000 substantially altered the Lagoon's environment resulting in what has been apparently a gross shift from limnetic eutrophy to subdued phytoplankton activity. On the basis of water quality (periodic monthly) monitoring (at 36 stations) involving a suite of environmental variables together with (hydrodynamic) investigations on alterations to the flushing and salinity regimes associated with engineering interventions (mentioned above) as well as addressing a set of scenarios such as river discharge, estimating nutrient loads and exchange between the Lagoon and the Sea, (fractionated) phytoplankton biomass, zooplankton biomass, seagrass, (micro) phyto and zoobenthos densities, it was possible to examine system behaviour over the last two years.

River Flow

The annual river(s) discharge is highly variable and a large proportion of the annual flow is typically delivered in "events" of relatively short duration (July-October). This variability in the flows and the associated delivery of suspended sediments and nutrients has a profound influence on the biogeochemical function of the lagoon.

The Salinity within the lagoon is largely determined by the balance between the freshwater inflow from the western rivers (e.g. Makara) and the Mahanadi system and the mixing of saline water from the sea through the new mouth. There is a significant degree of salinity stratification throughout the year. During the period of high freshwater inflow caused by annual floods and rains in the catchments (coinciding with south-west monsoon), surface salinities are greatly reduced as the surface layer is "flushed" out of the system and (spatial) stratification is at its strongest.

The hydrodynamic model shows that during the period of low runoff (e.g. May-June 2005), the exchange between the lagoon and the sea is mainly due to flow driven through the new opening by low-frequency oceanic water level variations.

Nutrient cycling and water quality in the Lagoon

One of the chief objectives of the study is to develop a biogeochemical model to understand the response of the lagoon to catchments flow and load of nutrients, sediments and organic matter by explicitly considering the (coupled) cycles of inorganic sediment nitrogen, phosphorus and carbon within the lagoon system. This work provided a very large (year round) database for ammonia, nitrate, nitrite, phosphate,

silicate, chlorophyll a, dissolved oxygen, salinity, turbidity, secchi-disc transparency, suspended matter and temperature. Similar measurements were made over much shorter periods (diel cycles) and together the studies offered considerable spatial (through multivariate methods) and temporal clues on the behaviour of nutrients into the lagoon vis-à-vis river inflows. Observations have shown nitrogen has been limiting. It would appear from the data collected so far that the key process is bacterial denitrification in the sediments by which means nitrogen is removed from the trophic cycle. Conclusive evidence in this regard would be experimentation through benthic chamber because sedimentary processes are now recognised as essential for modelling the nutrient budgets and understanding how these (shallow) coastal lagoons work as an ecosystem.

Biota

Chilka lagoon is a shallow and generally well mixed water body with continuous but slow exchange with the sea thereby offering adequate time for the nutrients to be converted into phytoplankton or other autotrophic biomass. All other biological and biogeochemical processes in the lagoon are dependent on this photosynthetic process. From the (integrated) work held so far, it was possible to identify five functional groups – (smaller and larger) phytoplankton, microphytobenthos, seagrasses, macroalgae and aquatic weeds – which seem to play a crucial role in regulating nutrient dynamics within the lagoon.

Analysis of model scenarios

One of the chief objectives of this study is to address the lagoon's resilience to anthropogenic interventions (e.g. engineering interventions and catchments modification) and read the effects, if any, on lagoon nutrient dynamics vis-à-vis autotrophic activity. As a prerequisite, it was proposed to develop a saltwater (mathematical) model based on lagoon volume, its salinity and the quantity of freshwater drained into the lagoon. The model has shown a net outflow of water, which is however exceptionally high coinciding with peak river inflow. During dry months (i.e. after 300th day) and beginning 27th May 2004 (coinciding with dry season and low river inflow), there is however a marked incursion of seawater and increased residence times responsible for a rise in salinity in the lagoon.

Ecosystem Modelling for Cochin Backwaters

The objective of this project is to understand the processes that are responsible for deteriorating the environmental quality of the Cochin backwaters through the application of an ecosystem model. The ecosystem model will be developed in three stages of hydrodynamic, water quality and biological model to predict the primary and secondary production of the estuary.

The tasks involved are

- Time-series data collection.
- Collection of coastline and bathymetry data.
- Develop a suitable hydrodynamic model.
- Develop water quality model.
- Develop an ecosystem model

- Solve interactive variables that are currently used for the development of ecosystem model (nutrient uptake, regeneration, assimilation, microbial primary–secondary production, microbial abundance, growth, respiration, grazing, species composition, succession etc.)

Development of Water Quality Model

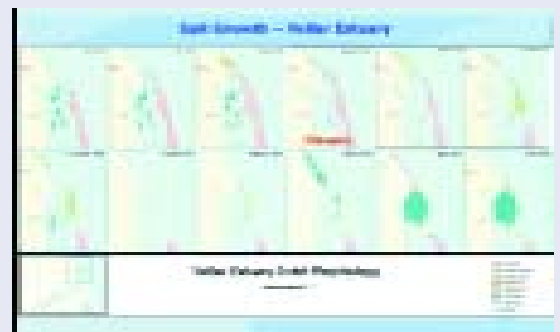
The development, calibration and validation of the hydrodynamic model (Hydrodyn-FLOSOFT) have been performed during 2004. The output of the hydrodynamic model for March 2004 and its simultaneous data on these 8 water quality parameters (chlorophyll, organic-N, ammonia-N, nitrate-N, organic-P, inorganic-P, CBOD and DO deficit) were used to develop the WQ model. The model was simulated by integrating the different state parameters using March 2004 data, after which, the model predicted results were compared with the observed results.

Microbiological studies

The Cochin backwaters are characterized by high bacterial abundance. Bacterial respiration (BR) was always greater than bacterial production (BP) and did not show any correlation. This feature provides the bacteria a metabolic flexibility to cope with changing environmental conditions. In addition studies in respect of qualitative and quantitative parameters in respect of planktons were also carried out.

Management of tidal inlet along the East Coast

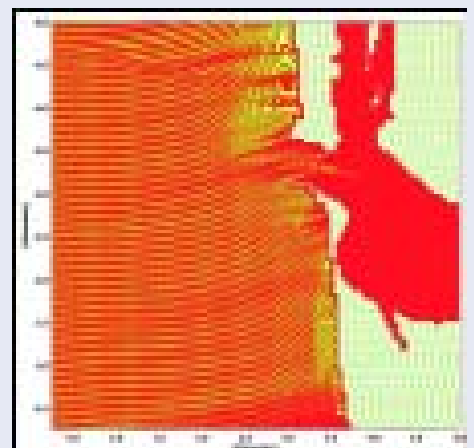
Vellar estuary located in Parangipettai, 20 km north of Chidambaram town, Tamil Nadu, has seasonal flow of freshwater and marine conditions dominate for most of the year, resulting in formation of bars, which is primarily caused by transport of sand by wave action at the mouth of the estuary. The inlet of the estuary experiences siltation from the month of April and partial or complete closure during dry period (September to October) leading to socio-economic implications. The project proposes to study the behavior of movement of sand, which is responsible for the closure of the mouth and to develop strategies to overcome the problem. All necessary investigations required to assess the circulation and sediment transport were completed and numerical modelling to formulate remedial measures for prevention of siltation at inlet is in progress.



Seasonal dynamics of the Vellar Tidal Inlet, East Coast of India

Management of tidal inlet at Netravathi (Mangalore) along the West Coast

The project is being implemented through NITK, Surathkal. The main objective of the project is to understand the impact of breakwaters on prevailing coastal processes, which are influencing the inlet and adjacent coastal processes and to develop permanent conceptual measures and management strategies for shore protection around the inlet.



MIKE21 - PMS model output



Loss of beach and damage to dwelling house due to high wave activities

During the year 2005-2006 collection of data on beach profile, beach sediment, ground water fluctuation were monitored at every fortnight interval. Hydrodynamic and wave modelling studies were conducted using DHI software (MIKE21-HD and MIKE-21 PMS) to assess the circulation pattern and wave transformation around the inlet. Model has been calibrated to the field data. Results obtained from the modal and field data are being analysed to develop a sediment transport model and inlet management plan.

GIS Based Information System on Goa

The objective is to create a GIS based information system to aid in environmental planning and management of ecosystems in Goa. The study will create an information system to aid in the

- assessment of current status of the ecosystem in Goa with respect to various activities, and,
- facilitate future planning to ensure balance between development and environment.

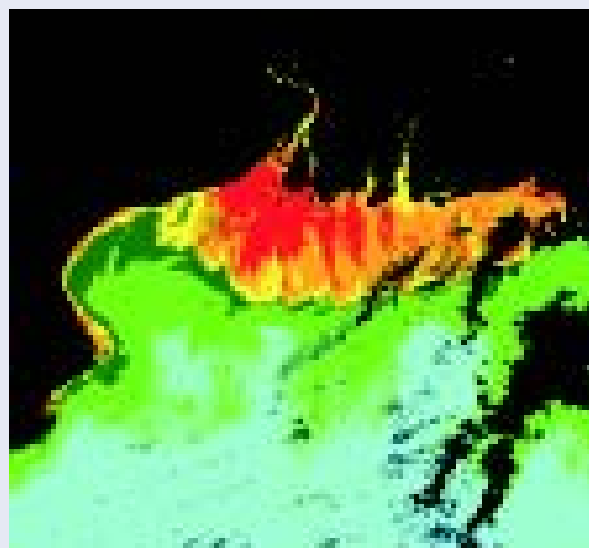
Primary data collection on tourism industry through questionnaires, as per the format furnished by the ICMAM – PD; the data has been collected and compiled for following taluks viz., Pernem, Bardez, Tiswadi, Mormugoa, Saleete. Secondary data collection on tourism, agriculture, forest and mining, mangroves and fisheries are in progress.

Suspended Sediment transport studies using OCM data from Oceansat-1

The project aims to study the retrieval, estimation and transport of suspended sediments in nearshore coastal waters of Bay of Bengal using Ocean Colour Monitor (OCM) data of Oceansat-1 and possible role of mapping seasonal suspended sediment flux and morphodynamics of selected tidal inlets along the east coast.

Testing of SSC retrieval in Case II waters by different SSC algorithms has been attempted. The Optical Back Scattering Method (OCBM) of atmospheric correction is found to have improved the retrieval of Suspended Sediment Concentration (SSC) in coastal waters. Tassan algorithm with OCBM technique has shown consistency in the OCM-SSC retrieval in case II algorithm in Bay of Bengal waters.

Analysis of time series OCM derived SSC revealed seasonal sediment flux at tidal inlet mouths due to river discharge and shoreline sediment transport due to along shore drift. Fine tuning of algorithm with further field data validation will improve the accuracy of quantitative estimation of suspended sediment concentration, which will pave way for understanding the seasonal sediment dynamics and net annual sediment drift to solve problems associated with coastal erosion/accretion.



OCM derived SSC along the northern Bay of Bengal

Coastal Engineering Strategy for Shore Protection for Kerala - A Pilot Project

A project on 'Coastal Engineering Strategy for Shore Protection for Kerala' has been taken up by Kerala State Council for Science and Technology in association with Centre for Earth Science Studies, Trivandrum. The main objective of the project is to evolve an appropriate shore protection strategy to protect one of the critically eroding sites based on site specific information on coastal processes. The strategy is proposed to be implemented by the Irrigation Department, Govt of Kerala at Panathura in Thiruvananthapuram which could be extended to other similar locations in the State. During the year 2005, preliminary investigations were carried out by CESS, Trivandrum in collaboration with ICMAM and NIOT, Chennai.

Various design options were reviewed in a meeting organized at ICMAM during the month of September 2005 which was attended by NIOT, IIT-M, CESS and KSCST. The design option presented by NIOT and IIT include Groin (Transitional or Transitional T), offshore breakwater and geotubes. It was agreed that Indian Institute of Technology Madras, Chennai will work out detailed design with cost estimates for implementation. After reviewing the design, it will be implemented by Irrigation Department, which will be coordinated by Kerala State Council for Science and Technology.

Tsunami Vulnerability Modelling and Mapping

The Ministry of Ocean Development is implementing a project 'Establishment of National Early Warning System for Tsunami and storm Surges in the Indian Ocean' which has components of tsunami /storm wave detection, propagation and inundation. ICMAM Project Directorate has been assigned the task of carrying out tsunami inundation modelling and mapping for the entire coastal areas of the country. After the December 26, 2004 tsunami, the Directorate has carried out measurement of tsunami run-up levels at selected islands of Andaman and Nicobar and along the Tamil Nadu coast. Subsequently a major project was sponsored by Department of Science and Technology to 10 institutions to carry out the run-up measurements and mapping tsunami affected coastal areas of Tamil Nadu. The ICMAM Project Directorate was assigned the task of coordinating and implementing the project. The exercise of tsunami inundation mapping along the Tamil Nadu coast has been completed.

The Directorate has initiated activities relating to development of tsunami inundation model. A Scientist of the Directorate has been trained on the SUTO model at Philippines. Based on the knowledge gained, a preliminary model on tsunami inundation is being developed for Nagapattinam area in Tamil Nadu.

The Directorate along with National Institute of Ocean Technology, Chennai; National Institute of Oceanography, Goa and Centre for Earth Science Studies, Trivandrum is planning to carry out the inundation modelling and mapping for the entire coastline of the country with priority to Andaman and Nicobar islands, Andhra Pradesh, Gujarat, Kerala, Orissa and Tamil Nadu.

Training Programmes conducted in ICMAM-PD

Six training programmes on various themes such as remote sensing, GIS, ICZM, shoreline management were organised and conducted by ICMAM-PD. Following the tsunami of December 2004, a number of institutions were involved in a DST sponsored programme on mapping the extent of inundation in the coastal areas.

A standard methodology was formulated for both mapping and field measurements by ICMAM-PD, and was then communicated to the participating institutes through a one week training programme on “Methodology for mapping of the sea water inundated areas during December, 2004 Tsunami” conducted at the training centre of ICMAM-PD.

5.4 Coastal Ocean Monitoring And Prediction System (COMAPS)

The COMAPS programme was jointly implemented by the Ministry and Central Pollution Control Board, Delhi under the nodal agency of National Institute of Oceanography, Goa to monitor 173 stations along the coastal waters. Later in 1989, Committee of Secretaries (CoS) entrusted the responsibility of monitoring coastal waters to the Ministry. Accordingly the Ministry is continuously carrying out this task on long-term basis since 1991. The main objective of the programme is to constantly assess the health of India marine environment and indicate areas that need immediate and long-term remedial action. Data on nearly 25 parameters (relating to physical, chemical and biological including microbiological characteristics of water and sediment) are being collected at about 80 transects at different frequencies with the help of 11 R&D institutions in the 0-25 km sector of the coastline of the country.

The parameters studied include temperature, salinity, transparency, DO, BOD, nitrate, nitrite, ammonia, total nitrogen, inorganic phosphate, total phosphorous, heavy metals, petroleum hydrocarbons, sediment composition and biological parameters such as primary productivity, pigments, phytoplankton, zooplankton, macrobenthos, meiobenthos and pathogens.

West Bengal and Orissa coasts

Suspended sediment concentrations (SSC) were in normal range, except for occasional high values observed at Hooghly due to river discharge. Low BOD observed in many locations indicate less organic loading. Nutrients in water and heavy metals in sediments were in normal range. Faecal coliform was high in few locations indicating discharge of domestic sewage in coastal waters.

In Orissa, SSC was high at Dhamra followed by Paradip due to river discharge and was in normal range (<100 mg/l) in other locations. DO was in normal range in all the locations except for occasional low values at Paradip. High BOD at Paradip and Puri indicate high organic loading into these coastal areas. Nutrients were in normal range for all locations. Slightly high lead levels were observed in sediment of Paradip and Puri. Faecal coliform was high at Puri and Paradip indicating discharge of untreated domestic sewage.

Tamilnadu, Pondicherry and Andhra Pradesh coasts

Higher level of dissolved oxygen and low level of BOD were recorded in Tamil Nadu coastal waters indicating reduced organic loading and increased productivity. The nutrients did not show any significant variation in the regular monitoring transects as well hot spot areas of Tamil Nadu and Pondicherry. Maximum levels of nutrients were observed in nearshore areas at 0.5 and 1 km stretches. Suspended sediment concentration was high at Tuticorin.

Near Visakhapatnam harbour the phosphate level was high when compared with other nutrients possibly due to handling of fertilizers. Higher oxygen and low BOD recorded in the channels and Visakhapatnam coastal areas indicate higher rate of photosynthesis and mixing of rain water with stagnant channel waters.

During summer season the plankton population increased in Tamil Nadu, Pondicherry and Andhra Pradesh coasts. The most common zooplankton observed were *Acartia sp*, *Eucalanus sp* and *Oithona sp*.

The microbial population showed only minor differences in all the investigated areas. In general, microbial population was higher in sediment compared to the water column. Faecal coliform bacteria were slightly high in most of the nearshore locations indicating discharge of domestic wastes.

Andaman and Nicobar islands

The overall water quality parameters showed that the quality of Andaman and Nicobar waters is clean and healthy. Biodiversity was rich with high number of species of phytoplankton, zooplankton and benthic organisms indicating high productive nature of these coastal waters.

Kerala, Karnataka and Lakshadweep coasts

Among the transects monitored along the Kerala, Karnataka and Lakshadweep coastal waters, the situation in Veli is getting deteriorated by the discharge of untreated effluents from the titanium plant. Low pH was observed at the effluent discharge point at Veli. Higher bacterial load was recorded in the estuaries such as Paravur, Neendakara, Kochi and near shore of Cannanore. Mangalore estuary also experiences high sewage contamination. General distribution of faecal bacteria was confined to the near-shore region. Though Kochi estuary recorded lower benthic productivity, its assimilative capacity was commendable and comparatively the offshore stations recorded higher productivity.

Goa, Maharashtra and Gujarat coasts

In Thane Creek the water quality survey revealed significantly reduced dissolved oxygen levels and increased BOD, ammoniacal nitrogen and faecal coliform levels in polluted stretches of the creek. The data suggests that the organic loadings from municipal sources are significant.

The water quality survey conducted along the stretches of Veraval fishing harbour revealed significantly reduced dissolved oxygen levels and increased faecal coliform levels. The low Dissolved Oxygen levels are accompanied by increase in Biochemical Oxygen Demand (BOD) and increase in ammoniacal nitrogen values. The nutrient value also results in increased chlorophyll a values along these polluted stretches. The data suggests that the organic loadings from fish processing industries and municipal sources are significant and have not been decreasing over the years.

Dissolved oxygen, biochemical oxygen demand, microbiology and nutrient concentrations showed distinct tidal variation, presenting ideal parameters for modelling.

Inter-calibration exercises

Three inter-calibration exercises were organized to ensure quality data generated among the participating institutions, viz., RRL, Bhubaneswar, NIO, Goa, CESS, Trivandrum, Annamalai University, Parangipettai, and Andaman & Nicobar Centre for Ocean Science and Technology, NIOT, Port Blair. Two of the inter comparisons were related to the measurement of conductivity and third for the nutrients in seawater matrix. A major need for assuring quality of data is the availability of standards. In these context, a fish homogenate has been prepared and a multi laboratory, multi analytical approach was attempted for the certification of trace metals – Al, As, Cd, Co, Cr, Cu, Fe, Hg, Li, Mg, Mn, Ni and Zn. 17 international

laboratories participated in this exercise. Besides trace metals, it is proposed to certify the fish homogenate for pesticide analysis. Very few countries with the exception of Canada have embarked on this critical but essential field of standards for marine environment.

Land based sources of marine pollution

The data collected on the status of sources of land-based marine pollutants under COMAPS programme reveals that the municipal sewage is the main single source of pollution to the coastal waters. 101 Class I cities and Class II towns of coastal area generate about 1143.84 MLD of wastewater. The disposal of solid waste generated by 101 coastal cities and towns does not affect the coastal waters, since it is partly disposed in landfill sites, partly dumped openly and partly composted. Besides, the wastewater generated from the large and medium industries located along the coastal area is being treated to secondary/tertiary level. In certain cases there is zero discharge. The treated wastewater is discharged to the estuaries, creeks, gulf etc.

In the case of Small Scale Industries (SSI) and industrial clusters through Common Effluent Treatment Plants (CETP) treat the wastewater. In Gujarat and Maharashtra, there are 17 CETPs near the coastal areas to deal with the 2392 SSI units in Gujarat and 1861 SSI units in Maharashtra. Most of the CETPs comply with the effluent standards. In the case of coastal aquaculture, discharges due to suspended solids and nutrient content are of no concern. As per the guidelines of Aquaculture Authority Govt. of India, Aqua farms having water spread area of 5.00 hectares and above should have Effluent Treatment System (ETS). Most of the aqua farms are in the process of establishing ETS. In Veraval 42 fish processing industries have established a CETP of 5 MLD capacity to handle the wastewater generated by these industries, which is being disposed into the harbour water. It is observed that the quality of the effluent has improved. However, there are other factors like city sewage disposal to the harbour, number of fishing boats handled by the harbour etc. are to be looked into for improvement of the quality of fisheries harbour water.

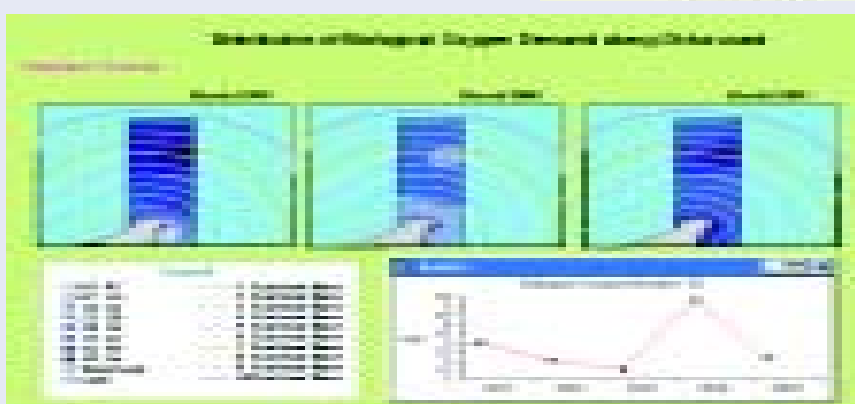
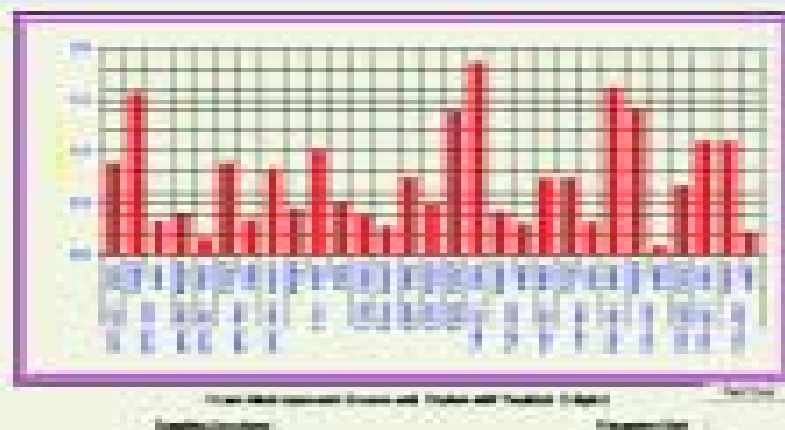
The coastal state-wise scenario of pollution sources and its trend based on the data collected so far, in coastal water beyond 2 km, is found to be clean except Mumbai, where it is beyond 5 km from the shore. The coastal water quality is clean and healthy as per the American standard. It may help people to consume seafood confidently.

GIS Database for Marine Pollution

The Coastal Ocean Monitoring and Prediction System (COMAPS) is a national level programme under the Ministry of Ocean Development, being implemented from 1990 to monitor and assess the health of the coastal environment of India. About 80 locations along Indian coast are being monitored for water quality, sediment quality and biological parameters at various frequencies. These data are being used for assessing the health of coastal environment and to study the trends of pollution in sea, so as to take appropriate steps for control of pollution and mitigating the impacts on the coastal resources.

In order to utilize the data and convert the data into a value-added information product, a GIS based marine pollution database project was initiated. In this project both, spatial data derived from the satellite images and the water and sediment quality data stored in an external database are integrated in Geographical Information system and the results are given in the form of graphical presentation.

Data on various physical, chemical, biological and microbiological parameters that are collected at different locations at various intervals. All these data are being stored in Oracle database. 43 locations have been chosen for development of Oracle database, of which 18 sites have been completed. For analysis from the database and to make available the value added data to



the users, a query development system was generated for 5 sites. This system will enable the user to query the stored data with various options, to assess the trend of various parameters at various locations, so that data as well as graphs could be presented.

5.5 Development of potential drugs from the ocean

Indian coastal water is endowed with a rich marine biota; coral reefs that occur in tropical waters, is having highest levels of known diversity among marine organisms. Of 1.8 million species catalogued to date, about 1,40,000 are from marine environment. The functional diversity in aquatic organisms, which is also typified by the wide range of chemicals found within marine organisms, suggests that oceans could be an important source of new biochemical products, including medicines.

In this context, the Ministry has taken up a National Programme on “Development of Potential Drugs from Ocean” for implementation since 1990, with a view to harnessing the potential bioactive substances from marine flora and fauna for medicinal purposes. This programme is being successfully implemented under the coordination of Central Drugs Research Institute (CDRI), Lucknow by involving 9 other organizations, viz. (i) National Institute of Oceanography (NIO) Goa; (ii) Central Salt & Marine Chemicals Research Institute (CSMCRI), Bhavnagar; (iii) Indian Institute of Chemical Technology (IICT), Hyderabad; (iv) Department of Chemistry, Andhra University, Waltair; (v) Department of Pharmaceutical Sciences, Andhra University, Waltair; (vi) Regional Research Laboratory (RRL), Bhubaneswar; (vii) Dr. B.C. Roy, Post Graduate Institute of Basic Medical Sciences, Calcutta University, Kolkata; (viii) Mother Teresa Women’s University, Kodaikanal; and (ix) National Institute of Ocean Technology, Chennai.

Under this programme, more than 6500 extracts from different species of potential flora and fauna were collected so far from the Indian coast including Island groups and carried out various bio-evaluation activities. The detailed follow-up studies identified 2 compounds for product development i.e., CDR-134-D-123 (anti-diabetic) and CU1-002/004 (anti-hyper-lipidemic). The Phase-I clinical trial for anti-diabetic compound was completed for single dose; the multi-dose trial is underway. Further, the 90-days



Cladiella sp. Soft coral

concentration of the selected markers of the active fractions for pharmacokinetic studies.

The progress made under the project was assessed by the Steering Committee. It is decided to establish an Advanced Research Center for Marine Drug Research at CDRI, Lucknow. The progress of the project was also reviewed by the Parliamentary Standing Committee on Science & Technology, Environment and Forests, on 21st September 2005. The Committee recommended expansion of the programme with industrial participation.

5.6 Coastal Research Vessels

The Coastal Research vessels Sagar Purvi and Sagar Paschimi are used for Coastal Ocean Monitoring & Prediction System (COMAPS) program and also for Integrated Coastal and Marine Area Management program. Both the vessels have completed 45 cruises for various institutions along the east coast and west coast of India during the period April 2005-March 2006. During the above cruises, these vessels have undertaken ADCP observations, CTD castings, collection of various samples for chemical Oceanographic survey and Geo-Physical survey and under water noise data for NRB etc.

Sagar Paschimi

- Vessel has successfully completed the post monsoon sampling and CTD casting in the East coast of India through the Institutes, RRL-Bhubaneswar and CAS-Annamalai University.
- Carried out bathymetry survey off Orissa in the block S-23 for 10 sq Nm as a part of EEZ project.
- Vessel was Dry docked to install hull mounted Multi beam sonar transducer, Make Kongs berg model EM1002 for EEZ Project.
- Vessel was chartered out for Berhampur University to monitor sea turtle at Gahirmatha Wild life sanctuary off Orissa as part of Reliance project.

chronic toxicity studies on the anti-dyslipidemic preparation have also been completed successfully in monkeys and the Phase-I clinical trial is under commencement. The two new additional leads having anti-diabetic cum anti-dyslipidemic activity have undergone detailed efficacy evaluation. The safety pharmacological studies have clearly indicated a wide therapeutic window of both fractions. Besides this, 6 new leads have also been identified having varying pharmacological activities. Efforts were also made to characterize various markers of all the identified products, as this will help to establish the absolute



Acanthella cavernosa Sponge

Sagar Purvi

- Conducted Multi-beam bathymetry survey off Kavaratti Island for desalination project, Lakshadweep Island.
- Vessel was deployed for deployment of cold water pipe line for desalination project at Kavaratti.
- Vessel has successfully completed the post monsoon sampling and CTD casting in the West coast of India through the Institutes, NIO-Bombay, CESS-Trivandrum, RRL-Trivandrum and CAS-Annamalai University.
- Vessel was deployed for NIO-Goa to study back-scattered data of single beam and multi-beam sonar for development of Seabed classification software and hardware.
- Vessel was chartered by M/s. British Gas for environmental study off the oil fields of Panna and Muktha and executed through the Institute of Gujarat Ecology Society.
- Planned maintenance of hull and machinery were carried out during monsoon lay up period.
- Vessel was dry docked and completed all annual survey to renew certificates during the monsoon lay up period.



6. NATIONAL INSTITUTE OF OCEAN TECHNOLOGY (NIOT)



NIOT Campus at Pallikaranai, Chennai

6.1 Desalination

NIOT is continuing research on low temperature thermal desalination plant to generate potable water to islanders and other water starving shore cities. In this process the warm surface seawater is evaporated in a flash chamber under vacuum conditions and the vapour is condensed using deep-sea cold water. The resulting condensed liquid is extremely pure fresh water. This principle can also be utilized for generation of high quality water in thermal power plants by extracting the waste heat from the cooling water discharge.



Plant piping system

A laboratory model desalination plant of 5,000 litres/day capacity has been commissioned at NIOT campus



Inauguration of plant by Late Shri P. M. Sayeed, the then Hon'ble Union Minister of Power, Shri Kapil Sibal, the Hon'ble Union Minister for Science & Technology and Ocean Development

and several experiments were carried out. Based on the experimental results, the design of a 1 lakh litre/day capacity plant at Kavaratti in Lakshadweep was taken up and completed. At Kavaratti, the seabed profile is such that a depth of around 350 m is available at 400 m from shore. To bring the cold deep seawater, a High Density Polyethylene Pipe of 580 m in length and 630 mm in diameter was selected. The pipe was fusion welded and connected with the designed steel components and deployed successfully using a crane barge and local fishing crafts.

The civil work for construction of the shore facilities such as seawater intake sump and realization of the plant components such as Flash Chamber and Condenser etc were completed.

The plant was commissioned on 23rd May 2005 and was inaugurated by Late Shri P. M. Sayeed, the then Hon'ble Union Minister of Power and Shri Kapil Sibal, the Hon'ble Union Minister for Science & Technology and Ocean Development.

Continuous freshwater generation and supply to Lakshadweep Public Works Department (LPWD) was started during July 2005. Daily average production of fresh water is more than 1 lakh liters. Parameters namely salinity, total dissolved solids, temperature, pH, conductivity, turbidity, etc are being measured periodically and conforms to Indian Standard (IS) and Bureau of Indian Standards (BIS) standards for drinking water. Till now, the plant is functioning satisfactorily and has crossed the production mark of 1 crore litres of fresh water and is being pumped to PWD tanks for supplying to the islanders.



As a part of establishing higher capacity plant, design of 1 Million Litre per Day (MLD) barge mounted Desalination Plant was undertaken and completed. Purchase orders for procurement / fabrication of major components were awarded and the plant is expected to be commissioned by the end of March 2006.

6.2 Wave Energy

The small rating floating type Wave Powered Device called the Backward Bent Ducted Buoy (BBDB) was fabricated and tested successfully for leak proofness and stability. Necessary sensors like load cell, pressure sensor, flow transmitter etc., and other instruments like data logger, solar panels, batteries etc., were mounted. Mooring configuration

Backward Bent Ducted Buoy

is also finalized and the buoy is ready for deployment. Once the buoy is deployed the performance of the buoy will be studied to design the power module.

6.3 Deep Sea Technology and Ocean Mining

Development and test of the underwater mining system for long term operation using Dynamic Positioning System.

Extensive analysis of bathymetrical data collected from site (16° 15.7'N 72° 1.35'E located near Angria Bank (around 80 nautical miles off Malvan coast) has been done. Safe area for operation of crawler has been studied and the data was analyzed.

The installation and commissioning of the Launching system commenced during October 2005 along with other repair works at Colombo Dockyard Limited (CDL). The deck strengthening work for installation of Launching and Retrieval System (LARS) and winch was parallelly taken up and completed. LARS equipment with updated modern control systems and the complete interfacing of the system to the ship control room was completed. The entire progress of work at CDL was monitored by Shipping Corporation of India (SCI) and National Centre for Antarctic & Ocean Research (NCAOR). NIOT personnel were also trained on the operation of LARS at CDL with emphasis on interfacing / operation of crawler latching system. Load tests were also completed for LARS with a dummy weight and ship is getting ready to make sea trials.

Tests are to be conducted on the launching system and the launching sequence as a whole. Hence for this purpose a dummy load is being fabricated at NIOT. The dummy load weighs approximately 14 T and has dimensions similar to that of the crawler.



Sagar Kanya with LARS in Colombo

The distributed hydraulic tanks of the crawler were merged to a single tank and fins were provided internally in the tanks for efficient heat transfer. The modified tank will be assembled to crawler for the Test pond trials. Due to the changes in Hydraulic tank the assembly of various systems was redistributed to maintain proper center of gravity (CG).

The mechanical over hauling of the crawler has been done after the post test analysis. The crawler structural frames were hot dip galvanized to prevent corrosion. Minor modifications are being carried out in the crawler mechanical system like introducing of wipers near the track belt,

modification of drain valve for slurry pumping. A new track belt of the same type has been procured and is assembled. A new cutter has been designed, fabricated and tested to suit clayey soils.

All the interconnecting underwater cables and bulkheads on new DAS were replaced with new ones. A 500 m rated enclosure for this sensor has been fabricated and successfully tested at 50 bar pressure as part of indigenization of enclosures for transducers. The cutter control has been modified with a provision for both clock wise and anticlockwise rotation which was incorporated to prevent the clogging of soil during mining. The cable of the crawler is being replaced with a new one for forthcoming tests. Arrangements have been done to install the new cable in the present winch. A metal FITA will be made for the underwater termination of the new umbilical cable. The number of underwater electrical connectors from the termination was reduced for ease of handling. A separate earth connector was removed and wiring modified in the crawler HT panel to suit the change.

The analysis of flexible riser system is being done using the software Orcaflex. The optimisation of cable configuration has been carried out for 630m long umbilical cable and 2 ton of net buoyancy.

Development of underwater collection and crushing system for Manganese Nodule Mining

Detailed design of pick up devices for experimental study of collector is in progress. Configuration design of bucket elevator systems for experimental studies is in progress. A test setup is to be formed for testing the collector in NIOT campus. A scaled down model of the test setup has been made and tests were conducted to study the force acting on the scooping blades of the collector nodule pickup device.

The soil condition in the sea floor is being simulated for the laboratory tests for the collector and crusher development. Studies are being done to simulate the soil conditions close to the natural sea bed conditions. Bentonite is used to simulate the condition of the sea bed as it is the closest equivalent to sea bed sediments.



Test setup for study on force acting on scooping blades

Different soil consolidating techniques like gravity consolidation, vacuum consolidation etc. are being experimented to simulate the sea bed soil strength.

Preliminary design of nodule crusher is completed. Availability of crusher locally is being surveyed. Modifying land based crushers for underwater application is also being studied.

The collector and crusher have to be evaluated for its performance in the ocean floor at 500 m depth. As nodules are not available at this depth, it is proposed to lay artificial nodules in an area of 100m – 150m, through a proper controlled and positionable

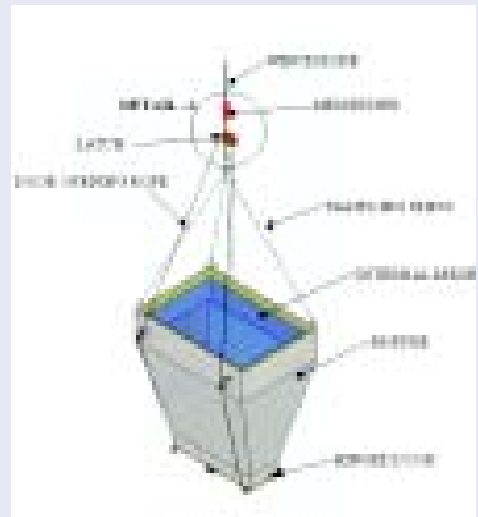
arrangement. Four types of nodule laying schemes were designed and reviewed. One of the nodule laying system has been finalized as per recommendations from the review committee, as the system is simple and can create a reasonably even nodule distribution in the sea floor.

Detailed design of the non powered hopper system is under progress. Flexible riser analysis has been carried out for the non powered hopper system.

Development of soil tester for in-situ measurement of soil properties in the Central Indian Ocean Basin

An in-situ soil tester capable of operation in 6000m depth is being developed to measure the in-situ soil properties in Central Indian Ocean Basin.

The fabrication of the soil tester module (special cone and vane for 6000m operation) is completed. The soil tester module was successfully pressure tested and calibrated at 600bar pressure at Russia. The soil tester module has been



Schematic diagram of non-powered hopper



6000m rated in-situ soil tester

delivered to NIOT. Preliminary tests of the modules has been completed at NIOT. A 3D modelling of the soil tester assembly has been done.

The software modules for the subsea side and the ship side data acquisition and control has been developed. Existing winch of the crawler system is being modified for soil tester cable. A new winch drum with pedestals will be integrated to the available hydraulic power pack of the existing winch. An underwater HT transformer is being indigenously integrated for the soil tester. Mechanical termination of the 7000 m umbilical cable for in-situ soil tester is completed. The interfacing of the data acquisition and control system with the soiltester modules and the fabrication of structures is under progress.

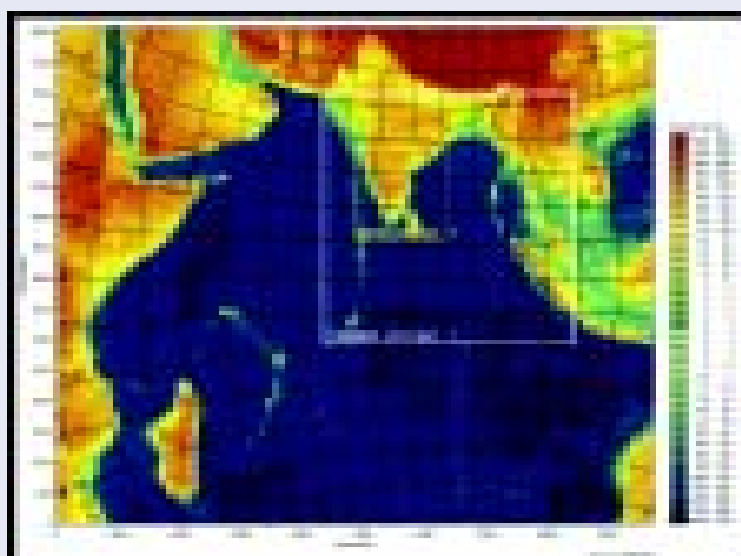
6.4 Coastal and Environmental Engineering

The group was involved in (i) tsunami modelling studies for disaster management planning, (ii) studies for improvement in navigational depths in the Hugli estuary, (iii) port designs and (iv) environmental impact assessment and modelling studies.

Tsunami Modelling

NIOT is actively involved in developing components for an early warning system for Emergency Response Planning for future tsunamis. An early warning system for tsunami requires instrumentation for real-time detection of the earthquake and detection of the tsunami wave in addition to the mathematical model for tsunami propagation. As the modelling takes significant time compared to the available time to react in a real event, it is required to carry out the modelling in advance for various scenarios, creating a database for easy look up.

As a part of Tsunami-modelling studies, the propagation of the tsunami wave for various estimates of the seabed deformation was simulated, with an objective to calibrate the model with available / observed data on the recent tsunami. A nested finite difference model (MIKE 21) for shallow water equations was used to simulate the propagation and run-up of tsunami wave. Bathymetry was obtained from ETOPO2 and GLOBE database and also from CMap. A time varying bathymetry was also used to simulate the recent Indian Ocean tsunami due to phased faulting of the seabed. The magnitude and size of the seabed



Model domain and bathymetry / topography used for Tsunami simulation

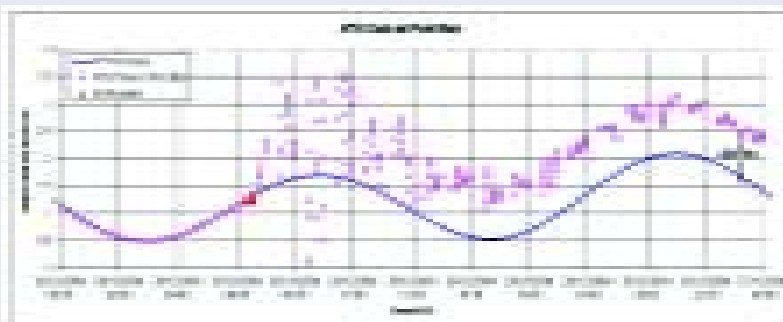
deformation and the delay were arrived at based on various available estimates of seabed deformations and NIOT's tide gauge data at Port Blair. The result was compared with the water level variations observed at various locations and also with the current speed measured by NIOT during the tsunami event. The numerical model was capable of reproducing the event for the purpose of creating a database for early warning system.

The results of the tsunami modelling was briefed to the President Dr. A.P.J. Abdul Kalam by Dr. S. Kathirolu, Director, NIOT and Mr. P.R. Rajesh,

Scientist-D in the presence of Dr. Harsh K.Gupta, Former Secretary, Department of Ocean Development.

First earthquake occurred at 06:28 am and the ATG detected anomaly in water level at 06:41.

The result was compared with the water level variations observed at various locations and also with the current speed measured by NIOT during the tsunami event.



NIO's ATG data at Port Blair with Indian Tide Table predictions

Comparison of model prediction of current speed with observed data at Colachel, Kanyakumari district

Jellingham Channel. The performance of the dredger is being done using multibeam and singlebeam surveys, sidescan sonar, acoustic bottom classification and current profiles.

Mathematical Modelling studies for marine outfall off Chittagong coast of Bangladesh

NIOT undertook a risk assessment study for discharge of process water by the Cairn Energy Oil and gas production unit off Chittagong into the Bay of Bengal. The studies consisted of assessment of baseline conditions and evaluation of environmental damage due to the present discharge conditions, mathematical modelling studies for discharge and recommendations on location of marine outfall.

Mathematical model studies for harbour development projects

- Studies have been undertaken for construction of revetment / retaining wall behind east quay at Chennai Port.
- Studies are undertaken for wave and sedimentation / siltation pattern for Pipavav for modelling their deepening and additional cargo handling characteristics.

Risk Assessment Study for LNG handling

NIOT carried out Risk Assessment studies for Petronet-LNG Limited's (PLL) expansion proposals. PLL has developed facilities for reception, re-gasification and transfer of Liquefied Natural Gas (LNG) in the Gulf of Khambat coast off Dahej, Gujarat.

In order to evaluate the Tier of response required for handling emergencies, Risk analysis was carried out for operations under abnormal condition. Consequence analyses was modeled based on the manual for “Risk Management Program Guidance for Offsite Consequence Analysis” by the US-EPA. LNG release was modelled for its gaseous dispersion after its release (which is most likely to result in flash boiling) using the model ALOHA - ‘Area Locations of Hazardous Atmospheres’, jointly developed by NOAA and USEPA.

Shoreline Management Studies

Field studies including oceanographic measurements, bathymetry surveys etc., are being undertaken for a three-season period for the ‘Shoreline Management’ project sponsored by ICMAM-Project Directorate of the Ministry between Pulicat and Ennore coast off Chennai and

Dhamra-Gahirmatha coast off Paradip. Under this project NIOT undertook, bathymetry surveys, wave, currents and tide measurements including Acoustic Doppler Current Profile (ADCP) surveys, monitoring of beach profiles and sediment characteristics.

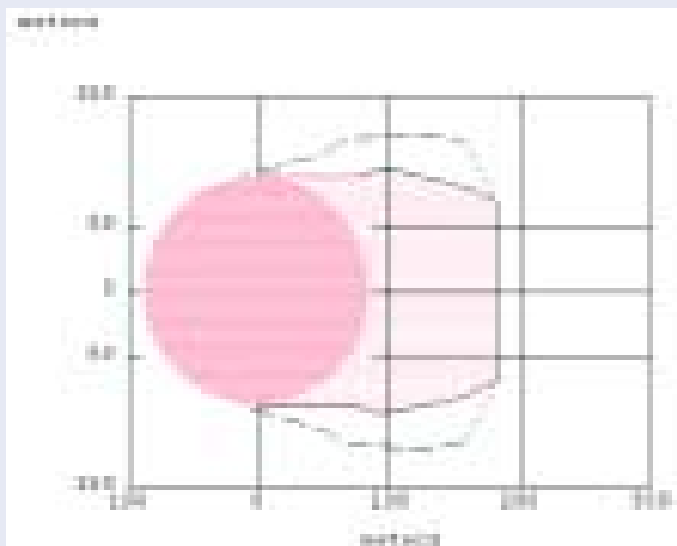
Water quality management and monitoring studies

Under the physical oceanographic component of the COMAPS program of the Ministry, NIOT is presently undertaking comprehensive water quality monitoring studies at Thane Creek, Tapi Estuary and Veraval Fisheries harbor. The studies involve three-season baseline water quality measurements, data collation and mathematical modelling for projected loads. The objective of this exercise is to develop water quality management plans.

The Veraval fisheries harbour is located along the Arabian Sea coast of the Saurashtra region of Gujarat. The location is one of the major fish landing centres in the country. There are about 3600 boats of various types operating in the harbour. This location was specifically chosen as it presents one of the most degraded water environment due to release of municipal sewage, wastes from fish processing and boat operations into the harbour waters. Two season studies are completed for the location and presently options for water quality management is being assessed.

EIA studies for developmental projects in the A&N Islands

- EIA studies were carried out for BSNL tower construction at Katchal Islands, Nicobar where the issue involved was acquisition of forestland.



Maximum threat distances for LNG release from transfer pipeline
(Model results of ALOHA)

- EIA studies were performed for construction and operation of lighthouses at 4 locations (Chidiyatapu, Avis Island, Patries Island and Sister Islands) in the A & N Islands. The project involved development of Environmental Management Plans for managing/mitigating impacts at the 4 different locations.
- EIA studies were performed for installation of reflector stations for Department of Police, Andaman & Nicobar at two locations.

6.5 Instrumentation & Control

The Acoustic tide gauges of NIOT have been networked using GSM modems and the data is uplinked to internet with a password protection.



The ATG at Port Blair monitored the tide levels during the earthquakes on 26th March and 25th July 2005.

National Accreditation Board for Testing and Calibration Laboratories (NABL), Department of Science & Technology has accredited Acoustic Test Facility (ATF) in accordance with the standard ISO IEC 17025 : 1999 in the field of electrical testing, electrical calibration and mechanical calibration.

Under the Transducer technology development programme, Cymbal transducers have been successfully

developed for the first time in the country as a part of NSTL project.

Time series ocean ambient noise measurements have been made in the sea under the project on Characterization of Ambient Noise in Indian Seas funded by NRB. An ambient noise buoy was developed with a vertical array of hydrophones, wind and GPS sensors and deployed at 60m depth off Chennai for this purpose. Analysis of data reveals high correlation of noise field with wind.

Apart from the above projects, the following collaborative projects at national level and bilateral/international level were taken up:

- Monitoring of ATG at Myanmar and training of Myanmar scientists was completed successfully in March 2005.
- Two scientists from Instrumentation & Control group have visited EDBOE, Moscow during 30th May 2005 to 7th June 2005 and had discussions with the Russian counterpart on the joint development of necessary instruments and observing devices to address scientific & technical Gas Hydrate problems. The final proposal has been prepared with details such as time schedule and the budget.

6.6 Ocean Science and Technology for Islands

- Life cycle of scyllarid lobster *Patrarchus rugosus* was completed in Sea Front laboratory, Chennai
- Juvenile deep sea lobster *Palinustus waugensis* was reared upto adult stage in laboratory and its growth rate and moulting interval were recorded.
- Role of vertebrate type steroids, 5-hydroxytryptamine and 20 hydroxy ecdysteriod in moulting reproduction of Indian spiny lobster *Panulirus homarus* was established
- Acoustic noise spectrum of Indian spiny lobster *Panulirus homarus* during various life history/ moulting stages was recorded.
- *Scylla serrata*, *Charybdis affinis* and *Thalamita crenata* collected in early zoeal stages were cultured up to juvenile crab stages. Hatching of *Scylla serrata*, in laboratory condition was achieved and larvae were reared up to third zoeal stage.

Societal Activity

- Under Societal activity, for mud crab fattening programme a demonstration pond was prepared by NIOT for the women SHG (Aqua crab farming SHG) at Diglipur. A survival rate of 87.27% was achieved and 57.22 kg was harvested. The produce was auctioned by the beneficiary, in the presence of Shri. Vivek Pandey, IAS, CD Block, Diglipur, and the revenue generated were handed over to the beneficiary by Shri Vivek Pandey, IAS.
- The Department of Fisheries has funded Rs 12.6 Lakhs to conduct lobster and mud crab fattening programme for fishers in Pulicat Lake. A training programme has been conducted for 25 beneficiaries in November 2005.
- Sea Cage culture of Lobsters is in progress at Tharuvaikulam, Erwadi, Pamban, Parangipettai in Tamilnadu and are being monitored regularly.
- UNDP funded project to study the prospects of mud crab fattening in Chilika and coastal districts of Orissa was taken up. A detailed survey was conducted and report submitted to them along with recommendations. The UNDP and Orissa Government has requested NIOT to plan a detailed work plan for conducting training programme for the beneficiaries.

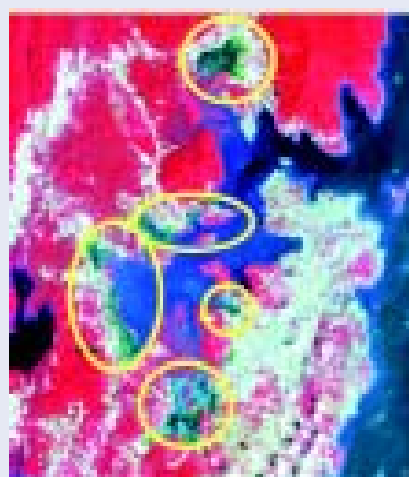
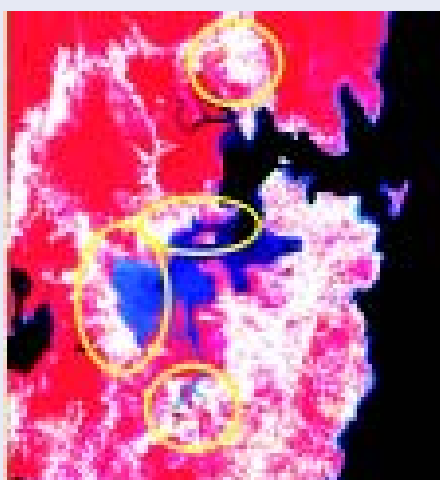
Fish Aggregation Device (FAD) for Lakshadweep Islands

On the request of Lakshadweep Administration with partial financial support of Rs.100 lakhs, FAD (29 units) were installed in January 2006 around Lakshadweep Islands. FADs will help the fishermen to increase tuna fish catch with less travel time.

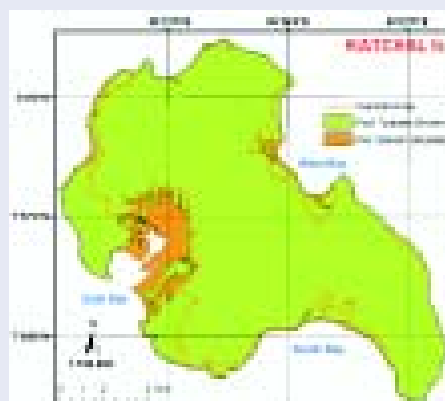
Andaman Centre for Ocean Science and Technology, Port Blair

- Using the GIS facility established at Andaman Nicobar Centre for Ocean Science and Technology for Islands (ANCOST) Port Blair, maps were prepared to study the coastal line changes induced by Tsunamigenic mega earth quake (M9)

- Also the coastal line changes map for Nicobar groups of islands was prepared using GIS. These data were validated using site data collected by RTK GPS in collaboration with ICMAM – PD. Also a Digital Elevation Map for Nancowry group of Islands derived from Survey of India topo sheets of scale 1:25,000 with 10m contour intervals was prepared. These information were made available to Andaman Administration.



Pre Tsunami satellite image IRS 1D LISS-3
Acquired date: 24th February 2003

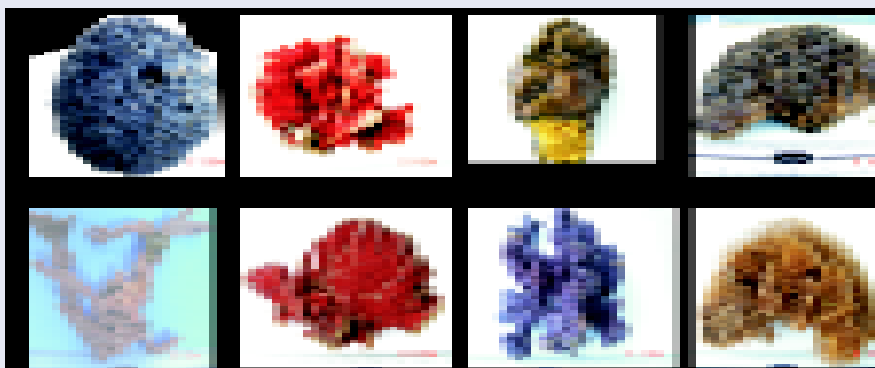


Post Tsunami satellite image IRS P6 LISS-4
Acquired date : 11th February 2005

Marine Natural Products as Antifoulants

Under this project, fifty-two species of marine sponges and ten species of Echinoderms were screened out of which eight sponges showed significant antimicrobial activity against marine Biofilm bacteria. Two species of Sponges prevented bacterial and barnacle settlement in the field. A rapid field-screening assay for testing of extracts was developed.

The sponge *Clathria frondifera* (Order, Poecilosclerida; Family, Microcionidae) collected at a depth of 30 m, off Nagapattinam on the East coast of India exhibited antimicrobial activity against marine bacteria. This is the first report on the isolation and structural characterization of N-methylpyrrolidone (1) from a marine source.



Marine Sponges tested for antimicrobial activity

Surface Modification Approach to Control Biofouling



Polysiloxane – Foul Release coating – Before immersion



After one month of immersion – No Macrofouling

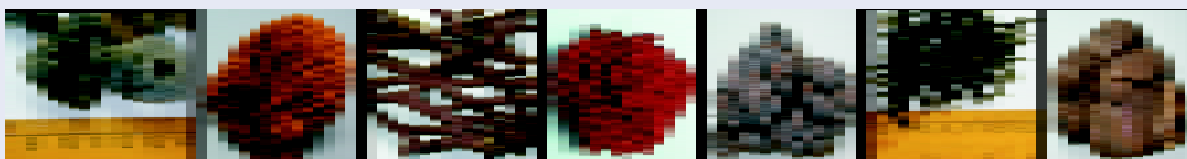
Under this joint S&T programme, polysiloxane foul release coated test coupons were prepared by University of Chemical Technology and Metallurgy, Sofia Bulgaria. These coupons were tested for antifouling activity (barnacle adhesion) in Chennai harbour waters. Adhesion of bacteria was found to be low on three compositions and one showed promising trend with low amount of living biomass as derived from ATP (Adenosine triphosphate) measurements.

Marine Bioinformatics Centre

A marine bioinformatics web site <http://www.niot.res.in:82/mbic/osti/index.asp> was launched. Marine taxonomy and molecular database <http://www.niot.res.in:82/mbic/Maritax.htm> has been developed.

Drugs from Sea

Totally fifty six samples were collected for Andaman Islands by SCUBA diving. The Crude extracts were prepared and tested for antimicrobial activity. From the test conducted at Central Drug Research Institute, (CDRI) Lucknow five samples have shown activity for antituberculosis and antifungal activity. Further, 168 crude extract samples were sent to other collaborating laboratories for various pharmacological screening. Also 102 samples were received from other collaborating laboratories and tested for antimicrobial screening.



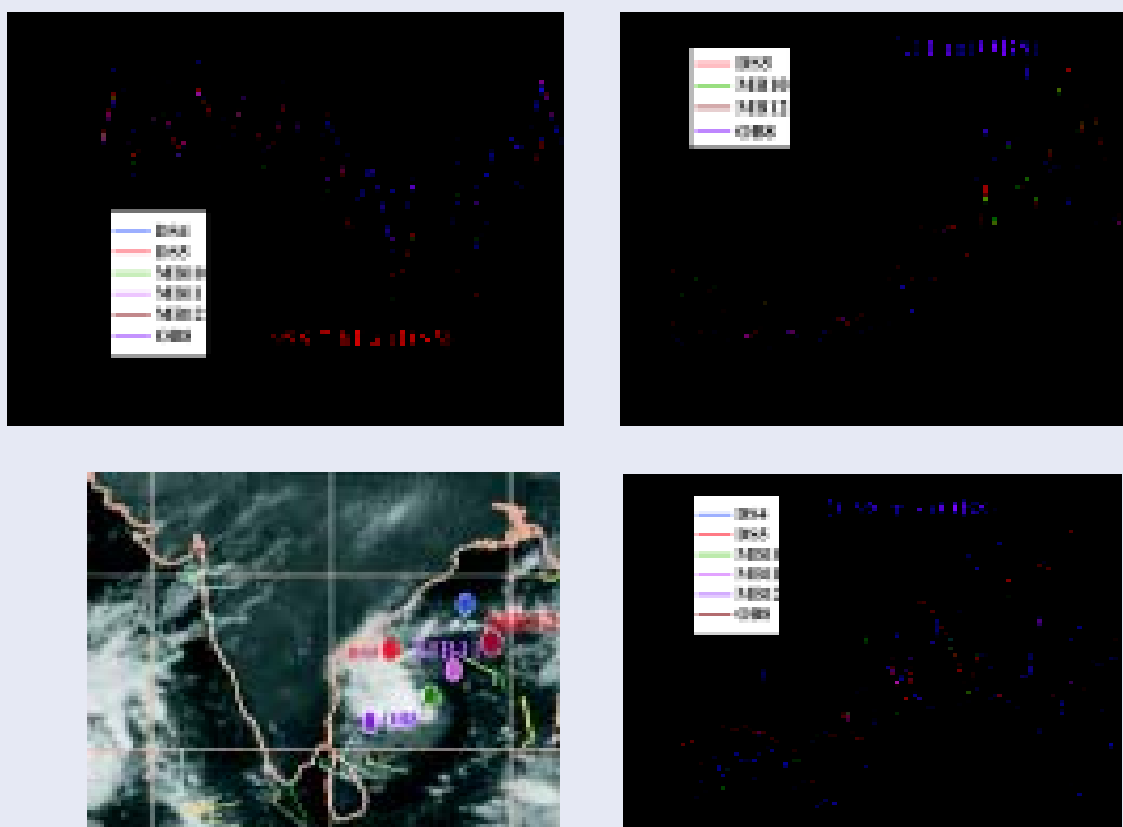
Marine organisms tested for antimicrobial activity

6.7 National Data Buoy Programme (NDBP)

Moored Ocean Data Buoy Programme

During the period under report, 20 buoy moorings were maintained at selected locations both in shallow and deep waters of Indian seas. The data received from buoys are sent on realtime to India Meteorological Department (IMD), Coast Guard (CG), Navy, Ports, National Hydrographic Office (NHO) and Indian National Centre for Ocean Information Services (INCOIS) after necessary quality control checks for weather forecasting, Search & Rescue operations, research, satellite data validation and offshore applications.

The buoy data is also utilized by a wide spectrum of end users like Meteorologists, Oceanographers, Environmentalists, Offshore Engineers for their reference, research and developmental activities in marine related studies/applications. The buoy data is also available to the global community through Global Telecommunication System (GTS). During April 2005 to November 2005, 21 deployments, 22 retrieval operations were carried out. Some interesting observation from buoys:



Data Buoy observation during Bay of Bengal cyclone in October 2005

Acquisition of Buoy Tender Vessel

M/s. Hindustan Shipyard Ltd (HSL), Visakhapatnam was awarded the construction of Buoy Tender cum Research vessel to meet the maintenance requirement of increased buoy network. The vessel was successfully launched on 03.11.2005 by Mrs. Shobha Goel, wife of Dr. P.S. Goel, Secretary, Ministry of Ocean Development.



ARMEX Programme

NDBP team carried out buoy deployment cruise as part of Arabian Sea monsoon experiment during 21.04.05 to 07.05.05 with 2 current meters at a depth of 1.5m and 7m to cater the requirement of ARMEX warm pool study. It was aimed to understand the current pattern and water characteristics existing at two depths in the warm pool region. Initial observations showed that there is low salinity water of eastern origin, very warm SSTs (31 degrees at noon), due to shallow heating of the upper 5m of the ocean. There is clear difference in salinity and temperature between 1.5m and 7m.

The current observation shows a shear between 1.5 m and 7 m. The current at 1.5 m is southward where as the 7m currents are predominantly northeastward. This is first of its kind of observation from the region.

Other activities

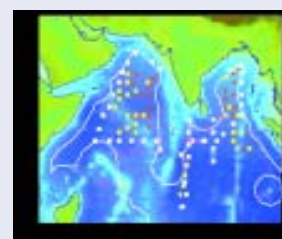
3 buoy systems deployed during Feb. to May 2005, exclusively for Oil and Natural Gas Corporation (ONGC) applications and have submitted detailed data report on 3 buoys (FG6, FG7, FG8) after the successful completion of the project.

A buoy system has been provided to Naval Research Board (NRB) project of NIOT to carry out ambient noise measurement experiment.

Two data buoys have been deployed on 27 July 05 off Ennore for shallow water mock up trials for Calibration and Validation (CALVAL) project of Space Application Centre (SAC), Ahmedabad.

6.8 Indian ARGO Project

This project is committed to deploy 150 profiling drifters fitted with CTD sensors capable of diving up to 2000 m water depth. So far, NIOT has deployed 107 floats. The deployment locations are indicated in the map. These profilers provide in situ data every 10 days on the conductivity and temperature of seawater. Indian profilers will cover North Indian Ocean, Arabian Sea and Bay of Bengal. These in situ data is a valuable input for study on monsoon, long-term climatology and for validation of satellite data.



Deployment locations of Argo floats

Indigenisation

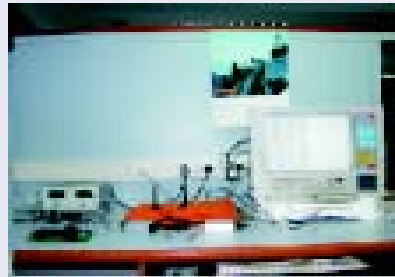
The buoyancy engine development was completed. To study the performance of the buoyancy engine a high- pressure test set-up was realized and initial tests were carried out. Prolonged test of the buoyancy engine is to be taken up to qualify the engine for long-term operation.

The initiatives to buy CTD sensor has been taken-up to be integrated with control electronics. Application software for float control has been developed and tested in the laboratory. The Electronics and control hardware developed for float function is being standardized using Military / Industrial grade SMD components.

As a spin-off of float indigenisation, a surface drifter, handheld GPS system with in-built memory and tide data transmitter using GSM modem were developed and tested successfully.



Handheld GPS with in-built memory



GSM Tide Data Transmitter

6.9 ROSUB – 6000

Remotely operable submersible is in its final phase of integration to proceed further for factory testing and sea trials during 2006. All the major components for the system integration are realized and qualification test for each sub component is in progress.

Remotely operated vehicle (ROV) mockup frame channels arrived from EDBOE, Moscow and the subcomponents integration is in progress. Channels are assembled to the designed shape of the ROV. Major components such as two pressure cases, two manipulators and its hydraulics, sub sea power converters, side thrusters were placed in the mockup frame.



Components integration in mockup frame

Two manipulators (seven functions and five functions), camera and sensors are realized and final qualification test completed. Seven thrusters were realized for maneuvering the ROV and its qualification test is in progress.

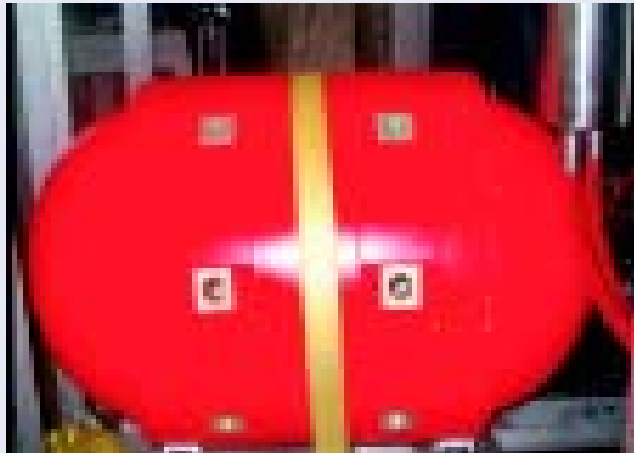


Thruster qualification test at ATF, NIOT

Tether Management system (TMS) and Launching and Recovery Systems (LARS) are realized and its qualification test is in progress. High voltage and high frequency converters and the umbilical cable were realized and tested. Containers for the control console, power transmission system and to carry TMS and ROV are realized and its internal wiring is in progress. Data telemetry system interface wiring is in progress to place inside its pressure case in the ROV.



DTS assembly



Pressure case

Control software development for ROV operation using the joysticks is completed. Integrated testing for the hardware and software control is in progress. Subcomponents of hydroacoustic navigation system are partly realized and the integrated software for the navigation is being developed in collaboration with EDBOE, Russia. Ship modification for the submersible deployment is in progress. After fine tuning during factory testing ROSUB system will be ready for sea trials during mid 2006.

■

7. INDIAN LEGAL CONTINENTAL SHELF PROGRAMME

The Indian Legal Continental Shelf programme is a multi-institutional national endeavor that seeks to establish the outer limits of the country's legal continental shelf in accordance with certain guidelines of the 1982 United Nations Convention on the Law of the Sea (UNCLOS). As per the provisions of this Convention, coastal states having continental shelves that exceed 200 nautical miles from their territorial sea baselines are required to submit the requisite scientific and technical data in support of their claims for an extended shelf to an international commission. This Commission on the Limits of the Continental Shelf (CLCS) in turn will consider the data submitted and make recommendations in accordance with the provisions of the UNCLOS.

Following India's ratification of the Convention in June 1995, it is now mandatory for the country to lodge her claims for an extended shelf latest by May 2009. The Indian endeavours towards this national goal are coordinated by the Ministry of Ocean Development and National Centre for Antarctic and Ocean Research (NCAOR) has been assigned the responsibility of undertaking all the scientific tasks for preparation of the submission. Underpinning our endeavours is a comprehensive multi-institutional marine geophysical work programme. The data acquisition as a part of this work programme comprising multi-channel seismic reflection, refraction, gravity and magnetic profiling was initiated on the 17th July 2002 and was completed on the 7th of February 2004. Spread over 385 days of fair-weather period, 27,897 km of seismic reflection and 28,005 km of gravity and magnetic data were collected from the project area. In addition, for the first time in the country, 72 state-of-the-art Ocean Bottom Seismometers (OBS) were successfully deployed along several seismic transects to constrain the velocities from the reflection data as well as to develop a crustal model of the area.

Considering the scope of the work, the post-processing and interpretation of the data was undertaken by three of the leading National Institutes, viz., NCAOR, NGRI and NIO. A comprehensive flow chart for seismic data interpretation incorporating the various scientific and technical guidelines of the CLCS was drawn to have a uniform strategy for data interpretation between these organizations. While the interpretation of the seismic, gravity and magnetic data collected has already been completed, the work of documentation of the scientific results and cartographic work as per the CLCS format is currently in progress at NCAOR, NIO and NGRI and the final document is scheduled to be finalised shortly.

To archive and retrieve the enormous amounts of data gathered in various media such as IBM 3590 tapes, exabytes, CDs and analog records, a state-of-the-art Data Centre has already been established at NCAOR. In addition, the Data Centre has been equipped with the most-modern geophysical data processing and interpretation facilities.

During April 2005 and October 2005 a five-day training-workshop on delineation of the outer limits of the continental shelf was organised at NCAOR for the scientists from Sri Lanka and Myanmar respectively.

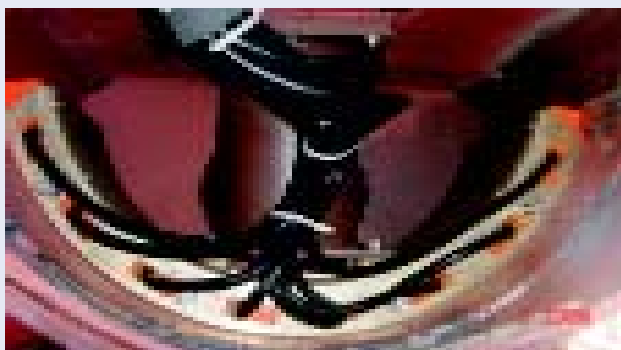
In addition NCAOR initiated as a part of the LCS work programme, a project on "Understanding the plate tectonic evolutionary history of the south-western continental margin of India and the adjoining ocean basins" onboard ORV Sagar Kanya during the period June-July 2005. Bathymetric, gravity and magnetic data collection from the Project area in the Laccadive Basin and to the south of the Laxmi Ridge has already been completed, and interpretation work is in progress. ■

8. GEOPHYSICAL STUDIES OF THE LAXMI BASIN

The project on geophysical studies in the Laxmi Basin-Ridge areas was also undertaken during the IX plan period. The enigmatic Laxmi ridge is a prominent bathymetric feature of the northeastern Arabian Sea located some 300 km oceanwards of the Indian continental shelf and extending in an E-W to NW-SE direction. The origin of this ridge as well as the nature of the crust forming the basement to the ridge and the basin to its east (the “Laxmi Basin”) have been topics of intense academic debate for over a decade now. Considering the importance of the Laxmi Ridge and basin in facilitating an understanding of the evolution of the Arabian Sea in its entirety, and to arrive at a logical conclusion on the nature of the basement beneath these geological features, the Ministry, through NCAOR, initiated during 2002-03, an integrated geophysical study comprising multi-channel seismic reflection, refraction, gravity and magnetic profiling across the Laxmi Basin and the ridge.

The total quantum of work undertaken on completion of the data acquisition during February 2004 comprised 3600 km of seismic reflection, gravity and magnetic profiling and 18 successful OBS deployments. The analysis of data shows interesting light on the nature of crustal characteristics and the affinity towards the continental structure. The report of the work has been prepared. ■

9. SWATH BATHYMETRY SURVEY OF INDIAN EXCLUSIVE ECONOMIC ZONE



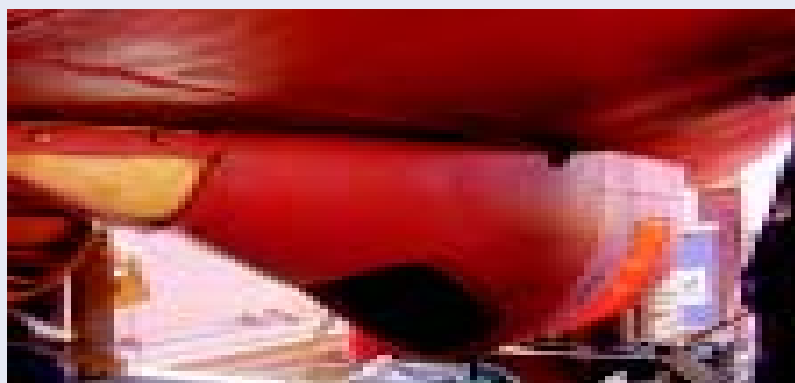
View of Hull mounted EM-1002 Multi beam sonar onboard Sagar Paschimi

Preparation of comprehensive bathymetric map of Exclusive Economic Zone of India across the Eastern coast between 10 m water depth and 500 m water depth in order to serve as a base map for oceanographic researchers, communication purpose, defense, and navigation sectors etc.

The following tasks and targets are achieved for this project:

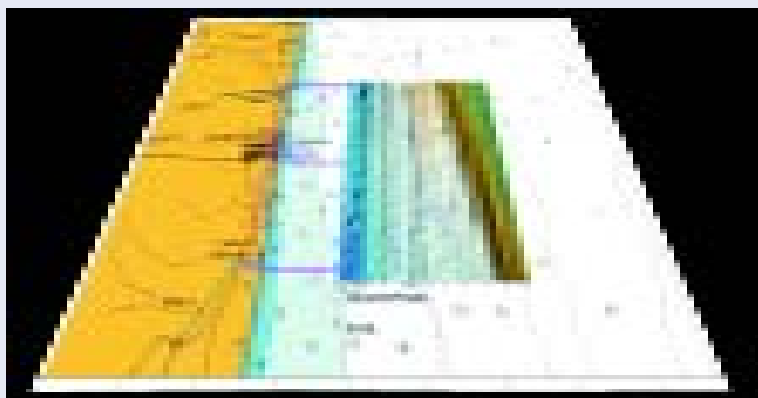
- Carried out survey in the blocks S-23, S-27, S-30, S-31, S-33, S-78 and S-79.

- Data processed and chart prepared for blocks S-78 and S-79 and part of the areas in blocks S-27, S-30 and S-33.
- Processing of data for preparation of chart for block S-23 is in progress.



View of Blister mounted in the Hull onboard Sagar Paschimi

- Acquisition and commissioning of a new Multi-beam sonar system capable of measuring depths up to 1000 m is completed.
- Systematic survey at EEZ area in East Coast using the Coastal Research vessels and including collection of sediment samples at selected locations started.



Processed image of EEZ-Block S-79 off Nagapattinam

10. GAS HYDRATE EXPLORATION & TECHNOLOGY DEVELOPMENT FOR EXPLORATION

Seismic data processing software and heat flow equipments are installed to utilize the identified blocks for the gas hydrate exploration. Detailed fine resolution geophysical survey for gas hydrate exploration and geological sampling in the identified two blocks will be carried out during 2005-2006. Road map for the future activities is being prepared for NIOT, NIO and NGRI.

NGRI involved in following three major activities to explore the occurrences of gas hydrate in Indian continental margins namely 1. Natural processes of gas-hydrate formation 2. Modelling and evaluating resource potential of gas-hydrates and 3. Laboratory synthesis. NIO is involved in geological, ecological studies of gas hydrate sites and working on the economics for gas hydrate exploitation. NIO had established sediment sample storage facility to carry out studies related to gas and pore water chemistry, sediment textural characteristics and biological aspects.

Under technology component NIOT is involved in developing Support Submersible (SS2500) a derivative from ROSUB – 6000. Sensors for gas hydrate exploration using support submersible are realized and tested for integration. Major sensors like methane, oxygen, conductivity and multibeam sonar are in place. After the sea trials of ROSUB-6000 system it will be loaded with all scientific sensors with sampling devices for gas hydrate site ground truth validation. Discussion for the development of an Autonomous Coring System is in progress.

Multibeam Sonar (2 Transmitter & 1 Receiver; No. of Beams – 256)

System will deliver high resolution bathymetry and sea bed features from bottom looking sonar. Forward looking sonar will be used for obstacle avoidance. System realized and sea trials completed for integration. Methane sensor for real time operation in ROV to detect and explore the gas hydrate mounds for ground truth validation is realized and ready for integration in submersible.



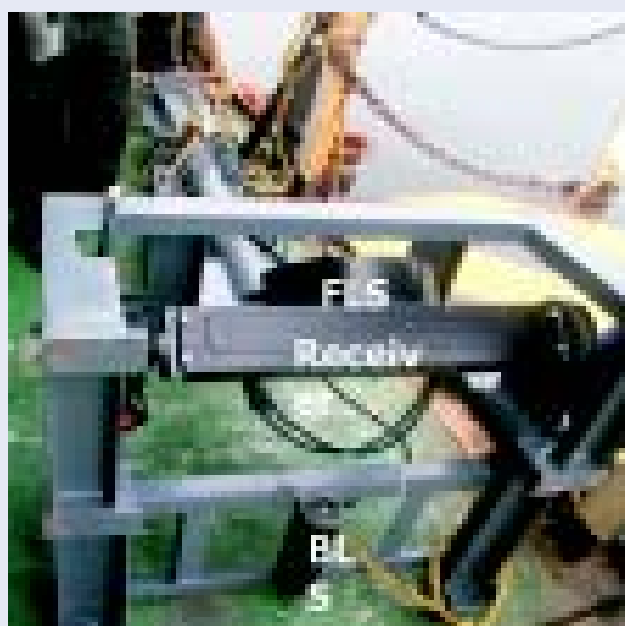
Indo – Russian Centre for Gas hydrates (IRCGH)

Development of basic infrastructural facilities and manpower for IRCGH is completed. The Indian scientists visited Russia and studied nine identified gas hydrate projects. In total seventeen scientists from NIO, NGRI and NIOT visited Russia during March to May 2005. Discussions are in progress to formulate long term research proposals to cater to the need for the ongoing gas hydrate program of the Ministry. A WAN based web page and data storage bank for the gas hydrate studies in India is being designed and completed.

An agreement was signed during March 2005 to interface a Joint research project for gas hydrates in Lake Baikal. A coordinated joint expedition to Lake Baikal was completed in summer (September) 2005. Detailed geophysical survey was conducted to identify suitable gas hydrate sites. A 1.2 m core of gas hydrate sample was extracted from Lake Baikal using 5 m length gravity corer.



Conceptual Mounting arrangement in ROV



Multibeam sonar assembly during sea trials

11. ACQUISITION OF TECHNOLOGY DEMONSTRATION VESSEL SAGAR NIDHI

The Ministry's focus in the next five years will be to develop sustainable technology for the exploitation of various non-living resources. Suitable platform is required to replace the vessels and crafts chartered by the Ministry at present, which caters to the demand for technology demonstration and providing services. This new facility will also cater to shallow water survey, Data buoy maintenance, and act as a supply and support platform for the various coastal and deep ocean activities planned by the Ministry. A Technology Demonstration Vessel SAGAR NIDHI is under acquisition to cater to the technology development and demonstration and ongoing new programs of the Ministry. The vessel will be used extensively for Deep-sea mining, ROV, AUV handling, Gas hydrates extraction technology development and will act as a supply and support platform for the various coastal and deep ocean activities planned by the Ministry.

The proposed vessel will be primarily designed to have all the adequate shipboard permanent facilities like

- Dynamic positioning system.
- Systems for ease of launching of ROV, AUV, etc.
- Low free board.
- Cranes (10 tons) to handle and repair data buoys.
- Salvage and tow capability to assist in emergency situations.
- Large deck space, heli deck, winch zone and ice strengthening.
- Containerized equipment handling for the science programs.
- Modular labs for science vans and containers.

As per the directions of the Ministry, contract has been signed with the lowest technically qualified bidder for construction of the vessel. The detailed engineering and production planning phase is under progress. The steel cutting for the vessel will start by July 2006 and keel shall be laid by October 2006. The vessel is slated for delivery by October 2007. ■

12. EARLY WARNING SYSTEM FOR TSUNAMI & STORM SURGES

The Ministry, in association with Department of Science and Technology (DST), Department of Space (DOS), Council of Scientific and Industrial Research (CSIR), and academia, is setting up an Early Warning System for Tsunami and Storm Surges in Indian Ocean at the total cost of Rs.125 crores with the following objectives:

- Near-real time determination of Earthquake parameters in the two known Tsunamigenic zones of Indian Ocean region, using a network of land-based Seismic Stations.

- Establishing a comprehensive real time Ocean observational network comprising Bottom Pressure Recorders around the two Tsuanmigenic zones, Tide Gauges, Radar-based Coastal Monitoring Stations etc.
- Developing numerical models for Tsunami and Storm Surges with all associated data inputs.
- Generating Coastal inundation and vulnerability maps.
- Setting up a dedicated Tsunami Warning Centre (including Storm Surge) in India and operating it on 24 x 7 basis for generation of timely advisories.
- Capacity building, education and training of all stakeholders.

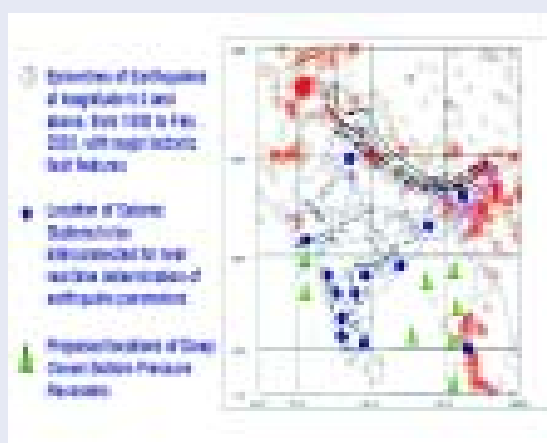
A centre would be set up at Indian National Centre for Ocean Information Services (INCOIS), Hyderabad, Andhra Pradesh on a 24x7 basis. The system is scheduled to be operational by September, 2007.

The progress in respect of the important work packages of the project is as follows:

- Action has been initiated for interconnecting 17 broadband seismic stations and for real time communication of the data to the Central Receiving Station (CRS) of India Meteorological Department at New Delhi and to the Parallel CRS at INCOIS, Hyderabad. This is expected to be ready by March 2006.
- Action has been initiated to procure and install the first phase of 5 DART buoys by March 2006.
- 11 Automatic Tide Gauges have already been installed along the Indian coastline. Online data is being received through GSM connectivity. Efforts are also underway to establish communication between tide gauges and the Early Warning Centre at INCOIS through INSAT.
- Preliminary maps of coastal inundation have already been prepared for some of the areas of the coast line, particularly in the Andaman & Nicobar Islands, Tamil Nadu and Andhra Pradesh, that were affected by the December 2004 Tsunami. Modelling efforts have also been initiated.
- Infrastructural facilities such as UPS, Networking, etc., have already been established at INCOIS, to operate the Early Warning Centre on a 24 x 7 mode. Configuration of the computational and communicational infrastructure is being evolved and this will be put in place by March 2006.

Interim arrangement for Tsunami warning

An Interim Tsunami Warning Centre (ITWC) has been established at Indian National Centre for Ocean Information Services (INCOIS), Hyderabad to take care of any exigencies and is operational round-the-clock with active support of India Meteorological Department (IMD)/ Department of Science & Technology (DST), Japan Meteorological Agency and Pacific Tsunami Warning Centre. Standard Operation Procedure of Interim Tsunami Warning Centre has also been circulated to Ministry of Home Affairs and Department



of Science & Technology. ITWC is receiving tsunami watch and advisories from Japan Meteorological Agency and Pacific Tsunami Warning Centre within 30 minutes after the earth quake in Indian Ocean.

INCOIS hosted the second meeting of the Intergovernmental Coordination Group on Indian Ocean Tsunami Warning and Mitigation System (ICG/IOTWS-II) of IOC, UNESCO at Hyderabad during December 12-16,2005.



13. INTERNATIONAL COOPERATION & PROGRAMMES

Intergovernmental Oceanographic Commission (IOC)

India is the founder member of IOC and also a Member of the Executive Council. Secretary, Ministry of Ocean Development, Joint Secretary, Ministry of Ocean Development, Director, INCOIS and Dy. Director, NIO participated in the 38th Session of the Executive Council of IOC on 20th June 2005 and 23rd Session of Assembly from 21-30 June 2005 held in Paris.

COMNAP / SCALOP / ATS / SCAR Meetings

A five Member delegation comprising the two Directors from the Ministry, Director, NCAOR, Scientist-D, NCAOR and Joint Secretary (L&T), MEA participated in the XXVIII Antarctic Treaty consultative Meetings held from 6th to 17th June 2005 at Stockholm, Sweden.

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

Twenty fourth meeting of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) held during 24th October to 5th November 2004 at Hobart, Australia was attended by Scientist 'E', CMLRE, Kochi.

State Parties on Law of the Sea (SPLOS)

Joint Secretary and Scientist 'F', Ministry of Ocean Development participated in the 15th meeting of the States Parties on Law of the Sea held during 16th to 24th June, 2005 in New York, USA. Scientist 'F', NGRI also participated in the 15th and 16th Sessions of the Commission on Legal Continental Shelf (CLCS) held during 4th to 22nd April, 2005 and 29th August to 16th September 2005 respectively at New York, USA.

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. Director, INCOIS played a pivotal role in restructuring the Global Ocean Observing System (GOOS).

Regional Alliance in Indian Ocean for GOOS (IOGOOS)

INCOIS, as the Secretariat for IOGOOS till 2008, has been effectively leading IOGOOS that has taken a place of pride among the nine such GOOS Regional Alliances. Since its formal launch at the First Indian Ocean Conference held at Mauritius on November 05, 2002, IOGOOS membership has grown from 19

to 21 institutions from 13 countries. Some of the major initiatives of IOGOOS are (i) the setting up of Indian Ocean Panel working towards a strategy and implementation plan for Indian Ocean Observations for Climate, (ii) Data & Information management, (iii) Remote Sensing Capacity Building Strategy, (iv) Prawn Pilot Project, (v) Keystone Ecosystems Project, (vi) Shoreline change monitoring project, etc. IOGOOS members have played a key role in Argo deployments and enhancing the tropical moored buoy array. Major accomplishments of IOGOOS during the year under report are as follows:

- IOGOOS Secretariat co-ordinated and arranged the third annual meeting and workshop held at Bali, Indonesia during August 8-12, 2005
- The Indian Ocean Panel (IOP) in the 2nd meeting held at Australia during Mar 30 – Apr 02, 2005, prepared an implementation plan for Integrated Observing System in the Indian Ocean
- A survey on GOOS Regional Alliances Networking Development (GRAND) has been taken up among IOGOOS members and potential members and a consolidated report has been submitted.
- E-Group and Discussion Forum for Data and Information Management has been developed on IOGOOS/INCOIS website.

International Argo Project

International planning for Argo programme is coordinated by the International Argo Steering Team (IAST). Director, INCOIS is the Member of IAST and also the Regional Coordinator for the International Argo Programme in Indian Ocean. INCOIS has been identified as the Regional Argo Data Centre for the Indian Ocean region. Regional Argo Data Centre has been set up at INCOIS and Basin-level Coordination is being implemented by INCOIS. INCOIS hosted the 7th International Argo Steering Team meeting (IAST-7) at Hyderabad during January 16-18, 2006.

Partnership for Observation of Global Ocean (POGO)

Partnership for Observation of Global Ocean (POGO) is an international network of major oceanographic institutions in the world and established to promote and enhance the implementation and integration of global oceanographic activities. As of now, POGO has 26 institutional members from 16 countries. During the year, INCOIS has become the Member of POGO. Director INCOIS participated in the Sixth annual meeting of the Partnership for Observation of the Global Oceans (POGO) at Brest, France. INCOIS has hosted the 7th POGO meeting (POGO-7) at Hyderabad during January 18-20, 2006.

Visits abroad

- Joint Secretary and Scientist 'D' participated in the 5th Session of the Intergovernmental Oceanographic commission (IOC) Advisory Body of Experts on the Law of the Sea from 11th to 15th April, 2005 at Buenos Aires, Argentina.
- Five-member Indian Delegation headed by Secretary, Ministry of Ocean Development participated in the "Second International coordination Meeting for the Development of the Tsunami Warning and Mitigation system for the Indian Ocean" from 14th to 16th April, 2005 at Grand Baie, Mauritius.
- Dy. Secretary, Ministry of Ocean Development attended a short term training programme on "Modernizing Human Resource Management" at RIPA International, London from 6th June to 17th June 2005.

- Three Scientists one each from Ministry of Ocean Development, NCAOR and NGRI attended the training course on “Preparation of a Submission to the Commission on the Limits of the Continental Shelf on the Outer Limits of the Continental Shelf” from 16-20 May, 2005 at Colombo, Sri Lanka.
- Scientist ‘F’, Ministry of Ocean Development attended the sixth meeting of the Indo-Sri Lanka Joint commission for 2 days i.e. 10-11 June 2005.
- Scientist ‘D’, Ministry of Ocean Development visited Stockholm, Sweden during 25th to 27th July to present a paper at the 10th International Conference of International Society for Scientometrics & Informetrics (ISSI).
- Secretary, Ministry of Ocean Development visited Russia from 8th to 11th September 2005 as a member of team led by Hon’ble Minister Shri Kapil Sibal for discussions on Gas Hydrates programme.
- A three member delegation headed by the Advisor, Ministry of Ocean Development attended the first meeting of IBSA (India, Brazil, South Africa) held at Brazil from 14th to 16th September 2005
- Secretary, Ministry of Ocean Development and Director, NCAOR visited Colombo, Sri Lanka for a short inspection for overseeing major dry-docking of Oceanographic Research Vessel Sagar Kanya at M/s Colombo Dockyard Ltd. from 11th to 12th October 2005.
- Scientist ‘E’, ICMAM-PD, Ministry of Ocean Development attended the International Training workshop on Numerical Modelling of Tsunami held at PHIVOLCS, Quezon City, Philippines from 7th to 19th October 2005.
- Secretary, Ministry of Ocean Development visited Jakarta, Indonesia from 20th to 22nd November 2005 to participate in GC meeting of NAM S&T Centre - representing India a Permanent Vice President on behalf of Secretary DST.
- Secretary, Ministry of Ocean Development visited Cape Town, South Africa from 21st to 22nd December 2005 to flag off the XXV Indian Scientific Expedition to Antarctica.
- Scientist ‘E’, CMLRE participated in the meeting of the Commission for Conservation of Antarctic Marine Living Resources (CCAMLR) held at Hobart, Australia from 24th October to 4th November 2005.



14. OCEAN AWARENESS

Exhibitions and Fairs

It is an important endeavour of the Ministry to generate awareness about the importance of ocean and ocean related activities among the common people. During the year Ministry participated in the following activities.

- “INMEX-China 2005” held at Guanzhou, China during 11-13 May, 2005
- “IFDE 2005” held at Pragati Maidan, New Delhi during 2-5 August, 2005

- “9th National Expo” held at Kolkata during 2-11 September, 2005.
- “INMEX India 2005” held at Bombay during 5-8 October, 2005.
- “Swasraya Bharat 2005” held at Kochi during 15-20 October, 2005
- “Infra R&D 2005” held at Vigyan Bhawan, New Delhi during 7-9 November, 2005.
- “India International Trade Fair (IITF’ 2005)” held at Pragati Maidan, New Delhi from November 14-27, 2005. Various activities of the Ministry in the field of Ocean Science & Technology like Tsunami Early Warning System, Desalination Plant (at Kavaratti, Lakshadweep Islands), Deep Sea Bed Mining, Polar Science, Gas Hydrates, Ocean Observation and Information Services etc. were displayed.



Pavilion of the Ministry at “India International Trade Fair 2005” New Delhi held from November 14-27, 2005.

A number of VIPs, dignitaries and other visitors visited the Ministry of Ocean Development pavilion and all have showed keen interest in the various activities of the Ministry. There was a wide coverage by Press and Media. Photographs of the Ministry pavilion are placed herewith for kind information.

Ministry’s pavilion was awarded special Commendation for excellence in display among Central Government pavilions.

- “Destination Uttranchal 2005” held at Dehradun from 7-11 Dec.2005.
- Science Expo ISC 2006 during 93rd Session of Indian Science Congress held from 3-7th January 2006 at Hyderabad.
- Technology Fairs cum Exhibition on Rural Technologies from 18-22nd February 2006 at Amethi
- CMLRE, Kochi participated in the Swasrya Bharat 2005 exhibition organized by Swasrya Bharat 2005 exhibition organized by Swadeshi Science Movement from 14 to 20th October 05 at Kochi. Swasraya Bharat 2005 highlighted the theme of self -reliance achieved by India in the field of Science and Agriculture.

Seminar/Symposia/Conference/Workshop, etc.

In order to exchange information and sharing ideas among the scientists/engineers, user community and general public and also to support the scientific and technological activities in the ocean sector, 55 International and National seminars/symposia/workshop etc., were sponsored on ocean and related topics during 2005-2006.



15. USE OF HINDI

The Ministry is constantly working for promotion and propagation of Official Language. During 2005-06 efforts were made to promote the progressive use of Hindi in the Ministry. Meetings of Official Language Implementation Committee were held regularly under the chairmanship of the Joint Secretary/Scientist G.

The Annual Report, Performance budget, Demand for grants, all Cabinet notes, reports, monthly summary to Cabinet and documents relating to Consultative and Standing



A poet is seen reciting his poem at the Kavya Gosthi

Committees, parliamentary papers, etc, were prepared bilingually. Important materials like quarterly newsletters of Ministry were published in Hindi also.

The Ministry organized a five-day Hindi Workshop from 29.8.05 to 2.9.06 to help officers and staff of the Ministry to overcome their difficulties in doing the official work in Hindi. In all 25 officers and staff took part in the workshop.

The Ministry organized a Hindi fortnight from 7th to 21st September, 2005. During the period, various competitions including Hindi essay writing, noting, drafting and debate were organized. A Hindi quiz programme was also organized to test the knowledge of staff about Ministerial activities and official



Dr.K.Kasturirangan, MP and former Chairman, ISRO, inaugurating the workshop by lighting the lamp

language policy of the Government. About 60 staff members participated in these programmes. Secretary gave away the prizes and certificates to prize winning officials during a ceremony, which was followed by a Kavi Gosthi, in which six reputed poets enthralled the audience.

National Institute of Ocean Technology (NIOT), Integrated Coastal Marine Area Management (ICMAM) and National Centre for Antarctic & Ocean Research (NCAOR) offices were inspected during 2005 with a view to ascertain the progress of implementation of official language policy and important suggestions were made to encourage the use of Hindi. These offices were inspected by the Inspection Committee of the Ministry.

The Ministry organized the 14th National Scientific Hindi Seminar on “Desalination” on 18th October 2005 at New Delhi. Dr. K. Kasturirangan, Hon’ble Member of Parliament, inaugurated the seminar. Eight scientists from various institutions related to the subject presented their papers in the Seminar. On the occasion, a Hindi book titled “ Samaj Aur Samudra” being the compilation of proceedings of seminar held in 2005, was also released.

The Ministry awarded one second and one third prizes to the books titled *Antarctic Bhavishya Ka Mahadweep* and *Sagar Tal Se Eendhan Sampada* under the Mahasagar Vikas Vibhag Purasakar Yojna 2005.

16. PARLIAMENT WORK

- The Parliamentary Standing Committee on Science and Technology, Environment and Forests met on 1st April 2005 at New Delhi to consider the Detailed Demand for Grants in respect of the Ministry for 2005-06
- Between April to December 2005, Ministry replied questions as below raised in the Parliament.

| | | |
|---|---------------------------------|----|
| 1 | Lok Sabha Starred questions | 03 |
| 2 | Lok Sasbha Unstarred questions | 26 |
| 3 | Rajya Sabha Starred Questions | 02 |
| 4 | Rajya Sabha Unstarred Questions | 13 |



17. ADMINISTRATIVE SUPPORT

The sanctioned strength of the Ministry of Ocean Development including attached offices is 190 during the year 2005-2006. The detailed break up is given below: -

| | Scientific/ technical posts | Non- technical posts | Grand total |
|-----------------------------------------------------------------------|--------------------------------|-------------------------|-------------|
| Ministry Headquarters | 24 | 118 | 142 |
| Centre for Marine Living Resources & Ecology, (CMLRE) Kochi. | 17 | 8 | 25 |
| Integrated Coastal and Marine Area Management, (ICMAM) Chennai. | 15 | 8 | 23 |
| Total | 56 | 134 | 190 |

17.1 Implementation of the 15 Point Programme on Minority Welfare

The activities of the Ministry do not have a direct bearing on the development of minority communities, Scheduled Castes, Scheduled Tribes, Other Backward Classes etc. The Ministry, 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 is invariably given on the Selection Committee set up for filling up vacancies in Group A, B, C, and D.

17.2 Grievances of Public and staff and their redressal

The Ministry of Ocean Development is a scientific Ministry and has no direct public dealings. However, the Ministry 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 are given on web-site of the Ministry. To address the grievances of female employees, a lady officer has been nominated as per the guidelines issued by the Ministry of Human Resource Development (Department of Women & Child Development).

- So far no grievance from the general public has appeared in the grievances column of any newspapers.
- Ministry is implementing 3% reservation in Government job for handicapped and disabled persons.

17.3 Gender Budget

Most of the activities undertaken by the Ministry in the “ocean science” are in the nature of research and technology development and demonstration projects. However, the Ministry through its autonomous institute, NIOT, Chennai has taken up certain programmes on mari-culture to improve the livelihood of fishers where the women folk also participate wherein NIOT also imparts training to the fishermen/women. While the successful implementation of such programmes are entirely within the purview of the State Government of Tamil Nadu and the A&N Island Administration, the NIOT shall continue to provide the technology and the training as and when required.

17.4 Right to Information Act

Right to Information Act, 2005 was circulated to all Officers/staff members of the Ministry including attached offices and autonomous bodies. Information about the activities and staff of the Ministry have been put on website. Public Information Officer and Assistant Public Information Officer have been nominated in respect of the Ministry and its attached offices and autonomous institutes. During the period of report, no request under the Act was received in the Ministry of Ocean Development.

17.5 Vigilance activities and achievements

Shri Ajai Saxena, Director has been declared as Chief Vigilance Officer in consultation with the Central Vigilance Commission. Vigilance Officers have been appointed in attached offices and autonomous bodies of the Ministry. The Vigilance Awareness week was observed from 07.11.2005 to 11.11.2005 with the taking of pledge by the officers and staff members and organizing competitions like Slogan and Essay writing during the awareness week.

17.6 Training for the Human Resource Development

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

| Sl. No. | Designation | Subject | Place | Duration |
|---------|------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------|----------|
| 1. | Deputy Secretary | Workshop on 'Right to Information' | Institute of Secretariat Training and Management, New Delhi. | 2 days |
| 2 | Deputy Secretary | Short Term Training Programme on Modernising Human Resource Management under the Scheme of Domestic Funding of Foreign Training Funded by Government of India | RIPA International, London | 12 days |
| 3 | Senior Principal Private Secretary | Seminar on National Training Policy | ISTM, New Delhi | 1 day |
| 4 | Scientist-D | Management Development Programme on Cyber Crime Investigations & Cyber Forensics | National Institute of Financial Management, Faridabad | 5 days |
| 5 | Scientist-D | One week Training Programme on "Intellectual Property Rights and World Trade Organisation (WTO)". | ASCI, Hyderabad | 5 days |
| 6 | Under Secretary | Management Development Programme on Budgeting and Financial Management | National Institute of Financial Management, Faridabad | 5 days |
| 7 | Section Officer | Training Course on 'Purchase Management in Government' | ISTM, New Delhi | 3 days |
| 8 | Section Officer | Executive Development Programme for Group B Technical and Non Technical Officers | ISTM, New Delhi | 12 days |

| Sl. No. | Designation | Subject | Place | Duration |
|---------|----------------------------|------------------------------------------------------------------------------------------------------------|------------------------------|----------|
| 9 | Section Officer | Executive Development Programme for Expanded Section Officers | ISTM, New Delhi | 19 days |
| 10 | Section Officer | Course on 'Direct Trainer Skills' | ISTM, New Delhi | 5 days |
| 11 | Assistant | Training Programme on 'Establishment Rules' | ISTM, New Delhi | 5 days |
| 12 | Senior Technical Assistant | Residential Programme on 'Productivity in the e-age' conducted by National Productivity Council, New Delhi | Phonex Park Inn Resort, Goa | 5 days |
| 13 | UDC | Training programme on Hindi conducted by CMC Ltd. | Bal Sahyog Bhavan, New Delhi | 5 days |
| 14 | LDC | Training programme on Hindi conducted by CMC Ltd . | Bal Sahyog Bhavan, New Delhi | 5 days |



18. FINANCE & FINANCIAL SUMMARY

The total budget allocation of the Ministry for the year 2005-06 was Rs.377.00 crore, which included Rs.340.00 crore for the Plan Schemes and Rs.37.00 crore for the Non-Plan Schemes. At the Revised Estimate-2005-06 stage, it was Rs.302.00 crore, which included Rs.250.00 crore for the Plan Schemes and Rs.52.00 crore for the Non-Plan Schemes.

The Government has allocated a Budget Estimate of Rs. 475.75 crore to the Ministry for the year 2006-07, comprising Rs.438.00 crore for the Plan Schemes and Rs. 37.75 crore for the Non-Plan Schemes.

The details of BE/RE 2005-06 and BE 2006-07 are given in the financial summary that follows.

ABBREVIATIONS

| | |
|---------|------------------------------------------------------------------|
| AGCM | Atmospheric General Circulation Model |
| ARMEX | Arabian Sea Monsoon Experiment |
| AVHRR | Advanced Very High Resolution Radiometer |
| BoB | Bay of Bengal |
| BSIP | Birbal Sahani Institute of Palaeobotany, Lucknow |
| CAS | Centre for Atmospheric Sciences |
| CMAP | CPC (Climate Prediction Centre) Merged Analysis of Precipitation |
| C-MMACS | Centre for Mathematical Modelling and Computer Simulation |
| COMNAP | Council of Managers of National Antarctic Programs |
| CRS | Central Receiving Station |
| CSIR | Council of Scientific and Industrial Research |
| DIPR | Defence Institute of Physiological Research |
| DOS | Department of Space |
| DST | Department of Science and Technology |
| ECMRWF | European Centre for Medium Range Weather Forecast |
| EDB | Electronic Display Board |
| EEIO | Eastern Equatorial Indian Ocean |
| E-OSF | Experimental Ocean State Forecast |
| GFDL | Geophysical Fluid Dynamics Laboratory |
| GIF | Graphic Interchange Format |
| GOOS | Global Ocean Observing System |
| GRAND | GOOS Regional Alliances Networking Development |
| GSI | Geological Survey of India |
| GTS | Global Telecommunication System |
| HC | Heat Content |
| HLL | Hindustan Lever Limited |
| IAE | Indian Antarctic Expedition |

| | |
|-----------|---------------------------------------------------------------------------------------------|
| IAST | International Argo Steering Team |
| ICG/IOTWS | International Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System |
| ICP-MS | Inductively Coupled Plasma Mass Spectrometry |
| IIG | Indian Institute of Geomagnetism, Mumbai |
| IIT | Indian Institute of Technology |
| IITM | Indian Institute of Tropical Meteorology |
| IMD | India Meteorological Department |
| INDOMOD | Indian Ocean Modelling and Dynamics |
| IO | Indian Ocean |
| IOC | Intergovernmental Oceanographic Commission |
| IOD | Indian Ocean Dipole |
| IODE | International Oceanographic Data Exchange |
| IOGOOS | Indian Ocean Global Ocean Observing System |
| IOM | Indian Ocean Model |
| IOP | Indian Ocean Panel |
| IRS | Indian Remote Sensing Satellite |
| ISRO | Indian Space Research Organization |
| ITWC | Interim Tsunami Warning Centre |
| KPP | K-Profile Parameterization |
| MDT | Mean Dynamic Topography |
| MLD | Mixed Layer Depth |
| MODIS | Moderate-resolution Imaging Spectroradiometer |
| MOM | Modular Ocean Model |
| NCEP | National Centre for Environmental Prediction |
| NCMRWF | National Centre for Medium Range Weather Forecast |
| NGRI | National Geophysical Research Institute, Hyderabad |
| NHO | Naval Hydrographic Office, Dehradun |

| | |
|----------|----------------------------------------------------------|
| NIO | North Indian Ocean |
| NIO, Goa | National Institute of Oceanography, Goa |
| NIOT | National Institute of Ocean Technology |
| NOAA | National Oceanic and Atmospheric Administration |
| NODC | National Oceanographic Data Centre |
| NPL | National Physical Laboratory, New Delhi |
| NPOL | Naval Physical Oceanographic Laboratory |
| NRSA | National Remote Sensing Agency |
| NW | North West |
| OCM | Ocean Color Monitor |
| OGCM | Oceanographic General Circulation Model |
| PBL | Planetary Boundary Layer |
| PRL | Physical Research Laboratory |
| PFZ | Potential Fishing Zone |
| PO | Pacific Ocean |
| POGO | Partnership for Observation of Global Ocean |
| POM | Princeton Ocean Model |
| RDBMS | Relational Data Base Management System |
| ROMS | Regional Ocean Model |
| RRSSC | Regional Remote Sensing Service Centre |
| SAC | Space Applications Centre |
| SASE | Snow & Avalanche Studies Establishment, Chandigarh |
| SATCORE | Satellite Coastal and Oceanographic Research |
| SCALOP | Standing Committee on Antarctic Logistics and Operations |
| SCAR | Scientific Committee on Antarctic Research |
| SDAPS | Satellite Data Acquisition and Processing System |
| SLD | Sonic Layer Depth |
| SODA | Simple Ocean Data Assimilation |

| | |
|---------|------------------------------------------------------------------|
| SOI | Survey of India |
| SSH | Sea Surface Height |
| SSHA | Sea Surface Height Anomaly |
| SST | Sea Surface Temperature |
| SWAN | Simulating WAVes Nearshore |
| T/P | Topex/Poseidon |
| TRMM | Tropical Rainfall Measuring Mission |
| UNESCO | United Nations Educational, Scientific and Cultural Organisation |
| WEB-GIS | Web based Geographical Information System |
| WMO | World Meteorological Organisation |
| XBT | Expendable Bathy Thermograph |



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