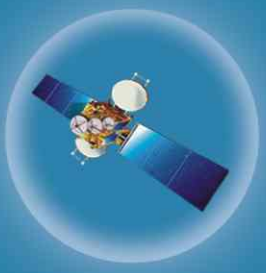
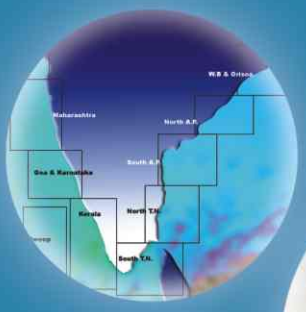




Annual Report 2005-06

Indian National Centre for Ocean Information Services

(An Autonomous Body under the Ministry of Earth Sciences, Government of India) "Ocean Valley", Hyderabad 500 055

Contents

Director's Report

It is my privilege to present this report highlighting the contributions to the national endeavor on ocean information and advisory services, after taking charge as the Director of INCOIS in May 2006 with 28 years of experience in ocean remote sensing.

INCOIS had established a lead role in the Indian Ocean and coordinated wide range of scientific activities related to ocean observation, data and information management, modelling and providing services for the societal benefits. The feedback particularly on advisory services of potential fishing zone (PFZ) and ocean wave forecast has been very encouraging. Efforts are on to further strengthen these services. The major challenges now are to setup a system for the early warning of tsunami and storm surges and developing robust ocean and coastal forecasting system.

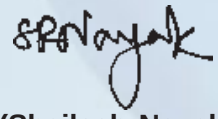
Major accomplishments during the year 2005-06 are as follows:

- After the devastating tsunami in December 2004, INCOIS played pivotal role in conceptualizing and formulating an Early Warning System for Tsunami and Storm Surges for the country. An Interim Centre was setup at INCOIS which is operational on 24x7 basis. A Standard Operating Procedure has been implemented for providing tsunami warnings.
- The PFZ Mission, a satellite remote sensing based societal service for providing timely and reliable advisories on potential fishing zones, has been sustained and enriched. This unique service has brought direct economic benefits to the fishing community. The delivery chain to provide PFZ advisories was further enhanced. New technologies are being pursued to include additional information on ocean state and weather.
- The experimental forecast of ocean state was sustained and dissemination network has been strengthened. R&D efforts are underway for operational coastal ocean wave forecast.
- The Argo Data Centre at INCOIS has acquired temperature and salinity data from 107 Argo profiling floats deployed by India since 2002. A set of 46 Argo floats were deployed during this year, and achieved 70 percent of the planned deployment of 150 floats in the Indian Ocean by 2007. The Regional Data Centre for the Indian Ocean had acquired temperature and salinity profiles from 586 floats deployed in the Indian Ocean. The data were made available to the global and Indian scientific community through INCOIS website. The Indian scientific community had fruitfully utilized the Argo data provided by INCOIS for several studies related to monsoon, cyclone and climate that were published and presented in national and international fora.
- Ocean modelling studies were continued at INCOIS as well as at participating agencies of the project Indian Ocean Modelling and Dynamics (INDOMOD) and Satellite Coastal and Oceanographic Research (SATCORE) Projects.

- Ocean Information Bank was updated regularly with the latest data sets and the state-of-the-art data base driven user-friendly dynamic web site with multilingual capability, Web-GIS facilities were maintained and updated periodically for providing ocean information and advisory services such as PFZ, OSF, Argo data and products, etc.
- INCOIS hosted a series of major international events, viz. 7th meeting of International Argo Science Team (IAST-7), 7th meeting of Partnership for Observation of the Global Oceans (POGO-7) and 2nd meeting of Intergovernmental Coordination Group on Indian Ocean Tsunami Warning and Mitigation System (ICG/IOTWS-II) at Hyderabad during this year. Further, the IOGOOS Secretariat at INCOIS organized the IOGOOS Workshop and 3rd Annual meeting at Bali, Indonesia.
- INCOIS continued to play lead role in the Indian Ocean region as the Regional Co-coordinator for Argo Programme in the Indian Ocean, Chair for the Indian Ocean Global Ocean Observing System (IOGOOS). INCOIS is hosting the IOGOOS Secretariat. One of significant milestones of IOGOOS has been the finalization a strategy and implementation plan for a unified Indian Ocean observation system for climate.

Dr. K. Radhakrishnan, Dr. V. Sampath and Dr. B.R. Subramanian, who steered INCOIS during this year, deserve special thanks.

I take this opportunity to place on record the unstinted support, able guidance and encouragement received from Dr. P.S. Goel, Chairman, Governing Council and the Members of Governing Council and the Officials of the Ministry of Earth Sciences.



(Shailesh Nayak)
Director

1. The Organisation

The Indian National Centre for Ocean Information Services (INCOIS) is an autonomous body under the Ministry of Earth Sciences (MoES), Government of India, registered as a Society under the Andhra Pradesh (Telangana Area) Public Societies Registration Act 1350, Fasli at Hyderabad on February 3, 1999. The affairs of the Society are managed, administered, directed and controlled, subject to the Bye laws of the Society, by the Governing Council.

INCOIS Society		
1	Secretary, Ministry of Earth Sciences	President
2	Director, National Remote Sensing Agency	Vice-President
3	Joint Secretary, Ministry of Earth Sciences	Member
4	Advisor, Ministry of Earth Sciences	Member
5	Director, National Institute of Oceanography	Member
6	Director, National Institute of Ocean Technology	Member
7	Director, National Centre for Antarctic & Ocean Research	Member
8	Director, INCOIS	General Secretary

INCOIS Governing Council		
1	Secretary, Ministry of Earth Sciences	Chairman
2	Director, National Remote Sensing Agency	Vice-Chairman
3	Financial Advisor, Ministry of Earth Sciences	Member
4	Dr. George Joseph, Distinguished Professor, Indian Space Research Organisation	Member
5	Director General, India Meteorological Department	Member
6	Joint Secretary, Ministry of Earth Sciences	Member
7	Director (Admn.), Ministry of Earth Sciences	Member
8	Director, National Institute of Oceanography	Member
9	Director, National Institute of Ocean Technology	Member
10	Director, National Centre for Antarctic & Ocean Research	Member
11	Principal Advisor (S&T), Planning Commission	Member
12	Director (Civil-1), Ministry of Surface Transport	Member
13	Director, Space Applications Centre	Member
14	Director, Earth Observation Systems, Indian Space Research Organisation	Member
15	Head, Centre for Mathematical Modelling and Computer Simulations	Member
16	Director, INCOIS	Member-Secretary

The Mission

To provide ocean information and advisory services to society, industry, government agencies and scientific community through sustained ocean observations, information management, modelling and constant improvements through systematic and focused research.

The major objectives of INCOIS are:

(i) To establish an early warning system for tsunami and storm surges,

(ii) To undertake, aid, promote, guide and co-ordinate research in the field of ocean information and services including satellite oceanography,

(iii) To establish, maintain and manage, hire the systems for data acquisition, analysis, interpretation and archival for ocean information and services,

(iv) To carry out surveys and acquire information using satellite technology, ships, buoys, boats, any other platforms and remote sensors, generate information on fisheries, minerals, oil, biological, hydrological, bathymetry, geological oceanography, meteorology, coastal zone management and associated resources and island development, mangroves and associated coastal, forest, soils, wetlands, estuarine mapping, seabed and to undertake studies in marine archaeology, environmental monitoring of India and Antarctica and surrounding oceans and land masses,

(v) To generate and provide data and value added data products to user communities in coastal and ocean areas using space, aerial and conventional sources,

(vi) To establish ocean data bank, including acquisition of all data obtained from satellite, air-borne sensors, ships, boats, buoys and field surveys, storage, retrieval, dissemination, evaluation, scrutiny, synthesis, analysis, interpretation of information and providing services and consultancy,

(vii) To cooperate and collaborate with other national and international institutions in the field of ocean remote sensing, oceanography, atmospheric sciences/meteorology and weather forecasting centres, coastal zone management, usage of satellite data and data acquisition by all technologically possible means in all allied science fields, subject to that prior approval of MoES shall be obtained for collaboration with institutions abroad,

(viii) To provide support to research centres for conducting investigations in specified areas related to oceanic parameters, ocean atmospheric interaction studies, coastal zone information, synthesis, analysis, data collection and undertake developmental work,

(ix) To provide training lectures, seminars and symposia for advanced study and research related to oceanographic parameters, related sciences and technology and in allied fields related to ocean information services,

(x) To publish and disseminate information, results of research, data products, maps and digital information through all technologically possible methods like print, voice or electronic media to

users for promoting research and to meet societal needs in improving environmental conditions and living standards, provided that dissemination of data is as per guidelines of the Government of India,

(xi) To provide consultancy services in the fields of ocean information and services,

(xii) To co-ordinate with all space agencies to ensure continuity, consistency and state-of-the-art quality of ocean data derived from satellite observations,

(xiii) Generate data, data products, value added data products and market for coastal and ocean applications,

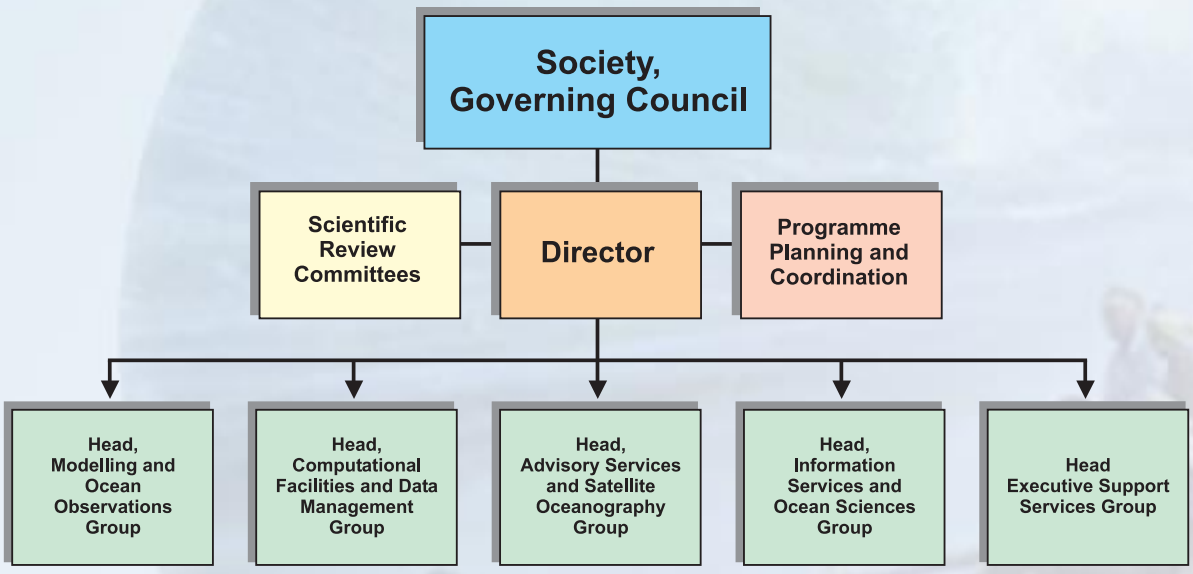
xiv) To encourage and support Governmental and non-Governmental Agencies or organizations for furthering ocean and related programmes in the generation of ocean information, and

(xv) To undertake all such other lawful activities as may be necessary, incidental or conducive to the attainment and furtherance of all or any of the above objects of the Society.

INCOIS, in its pursuit for organisational excellence, national relevance and international significance, translates the scientific knowledge into useful products and services through synergy and knowledge networking with centres of excellence in ocean sciences, atmospheric sciences, space applications and information & communication technology.

INCOIS presently has thirteen scientific and three administrative regular posts and nineteen project positions. In addition, ten more project positions are being added as part of the Interim Tsunami Warning Centre at INCOIS. Further, human resources are being developed with focused groups in several premier institutions, especially for implementation of INDOMOD and SATCORE Projects. Outsourcing has been effectively followed for system/software maintenance, operation and maintenance of technical support facilities, house keeping, canteen, transport and security services.

The organization structure of INCOIS is as given below:



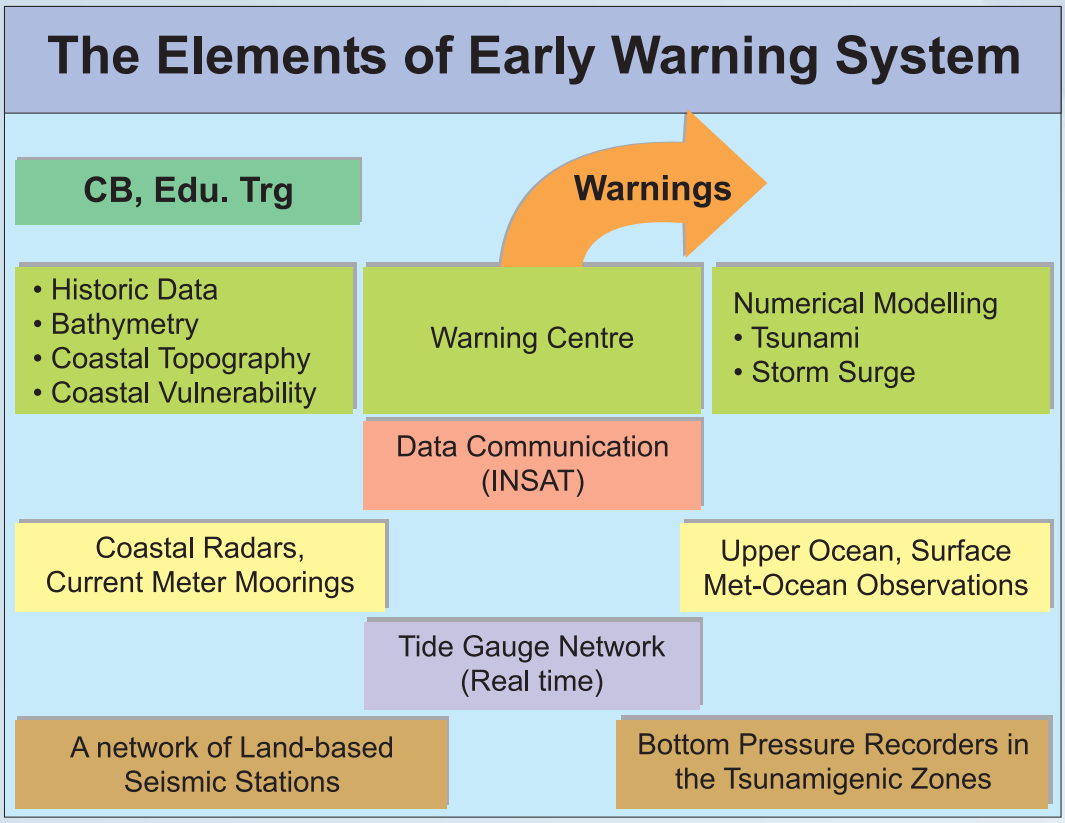
The Organisation Structure

2 Ocean Information and Advisory Services

2.1. Early Warning System for Tsunami and Storm Surges

Recognising the imperative to put in place an Early Warning System for mitigation of those oceanogenic disasters that cause severe threat to nearly 400 million of our population live in the coastal belt particularly the national calamity due to the Indian Ocean Tsunami of December 26, 2004, the Ministry of Earth Sciences (MoES) formulated the project on 'Early Warning System for Oceanogenic Disasters: Tsunami and Storm Surges', in consultation with the Department of Science and Technology (DST), the Department of Space (DOS) and the Council of Scientific and Industrial Research (CSIR). INCOIS contributed significantly to the conceptualization and formulation of the project proposal. The system design is based on end-to-end principle encompassing:

- 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 Tsuna\mi 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.



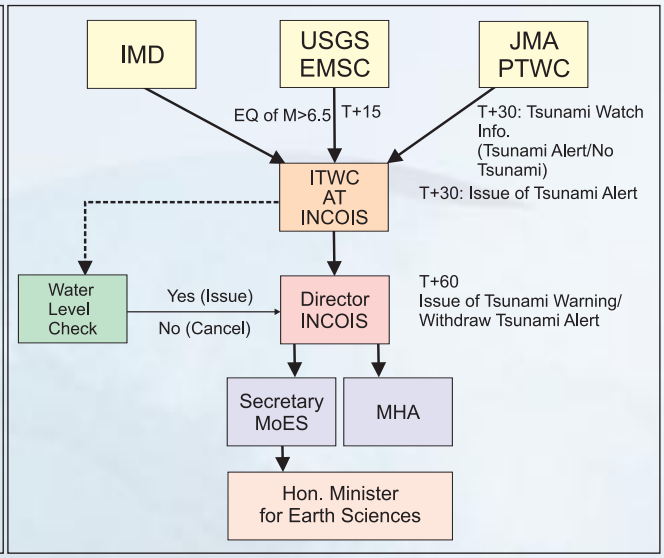
- Setting up a dedicated Tsunami Warning Centre (including Storm Surge) in India and operating it on 24 x 7 basis for generation of timely advisories.
- Capacity building, education and training of all stakeholders.

The Early Warning System is expected to be operational by September 2007, with the key elements were put in place by March 2006.

INCOIS played a lead role in setting up of Early Warning System for Tsunami and Storm Surges in the country. The significant progress made during the period under report is as follows:

- An Interim Tsunami Early Warning Centre (ITWC) was set up at INCOIS. The Centre is operational on 24 x 7 basis and receiving Tsunami warnings from the Pacific Tsunami Warning Centre (PTWC), the Japan Meteorological Agency (JMA) and the Indian Meteorological Department (IMD) and tide gauge data from the Global Telecommunication System (GTS).
- A Standard Operating Procedure (SOP) for the Interim Tsunami Warning Centre at INCOIS issued by the Ministry of Earth Sciences was launched for implementation at ITWC, INCOIS.

Interim Tsunami Warning Centre operational at INCOIS on 24 x 7 basis



Standard Operating Procedure at Interim Tsunami Warning Centre

- System requirements for communication, data storage, computation and display as well as to arrive at baseline configuration for the Interim Tsunami Warning System; basic specifications for Tide Gauges at the Andaman & Nicobar Islands and the east and west Coasts of India and Deep Ocean Assessment and Reporting Systems were worked out by a Task Team, set up by the Ministry of Earth Sciences, Government of India.
- A 4.5 M Antenna was installed in 2005 as part of Virtual Private Network for Disaster Management Support.

4.5m Antenna for VPNDMS

Dr. Patricio Bernal, Executive Secretary, IOC inaugurating the ICG/IOTWS-II at Hyderabad hosted by INCOIS

- 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.

2.2. Potential Fishing Zone Advisories

The Ministry of Earth Sciences had formulated a programme to provide the fishing community with credible advisories on Potential Fishing Zones (PFZ). The concerted efforts of scientists from ocean, space and fishery sciences in collaboration with the maritime states have resulted the timely and reliable service of Potential Fishing Zone (PFZ) advisories. This mission became part of the Common Minimum Programme (CMP) of the Government of India.

The integrated PFZ advisories generated using both the Sea Surface Temperature (SST) and Chlorophyll 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. The integrated PFZ advisories prepared in local languages and local measurement units were disseminated thrice a week (i.e. Tuesday, Thursday and Saturday) during non-ban and cloud free days, through innovative and novel initiatives such as Electronic Display Boards and Information Kiosks at the fishing harbors, radio, print media, emails and web sites supplementing fax and telephone. This is the only short-term forecast available to the fishing community of the country.

Besides, frequent and intense interactions at the fishing harbors between scientists and fishing community ensured better awareness and effective use of these advisories. Parallel affirmation and feedback are integral to this mission for which necessary institutional mechanism is in place. It has been observed, from the data collected from 295 Gill netters and 400 Ring Seiners off the Kerala coast, that the search time has been reduced by 30 to 70 per cent for pelagic fish due to the usage of these advisories and resulted in a saving of Rs. 1.50-6.00 Lakhs per vessel per year. This is an excellent example of providing the benefits of science to society.

The significant achievements during the period are as follows:

a) Generation and dissemination of PFZ Advisories:

- Operational generation of PFZ advisories was sustained and enriched.
- NOAA-AVHRR data from Ground Station at INCOIS were used for operations generation of SST for PFZ Mission.
- Fax/Telephone: Messages to over 225 nodes covering the entire coast of India under 12 sectors, viz., Gujarat, Maharashtra, Karnataka and Goa, Kerala, South Tamilnadu, North Tamilnadu, South Andhra Pradesh, North Andhra Pradesh, Orissa and West Bengal, Andaman, Nicobar and Lakshadweep Islands were sustained.
- PFZ advisories were also transmitted directly from INCOIS through 20 Electronic Display Boards installed at Veraval, Ratnagiri, Malpe, Panjim, Vypeen, Neendakara, Beypore, Munambam, Royapuram, Veerampattinam, Thengaithittu,Thangachimadam, Kakinada, Machilipatnam, Visakhapatnam, Gopalpur, Diamond Harbour, Agatti, Kochi and Nagapattinam for effective and timely dissemination. About 1000-3000 fisherman from each fishing harbour were expected to avail this information for their fishing activities.
- INCOIS, in collaboration with Orissa State Government targeted to install 10 Electronic Display Boards along the Orissa coast. The new version of these boards would be equipped with voice communication, siren and alert system for alerting the coastal states during disasters and Tsunami warnings.
- PFZ advisories along with SST and Chlorophyll images, vector coverage and text information have been made available through INCOIS web-site to the user community.
- PFZ advisories in both map and text forms were e-mailed to about 100 registered users located along the coast of India.
- PFZ advisories were also disseminated through Telugu daily newspaper (coastal district editions of AP) weekly thrice in the local language.
- 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.

b) User Interaction/Awareness Workshops:

User interaction/awareness workshops were conducted regularly to update the fishing community of the latest advances in the advisories and to solicit their feedback.

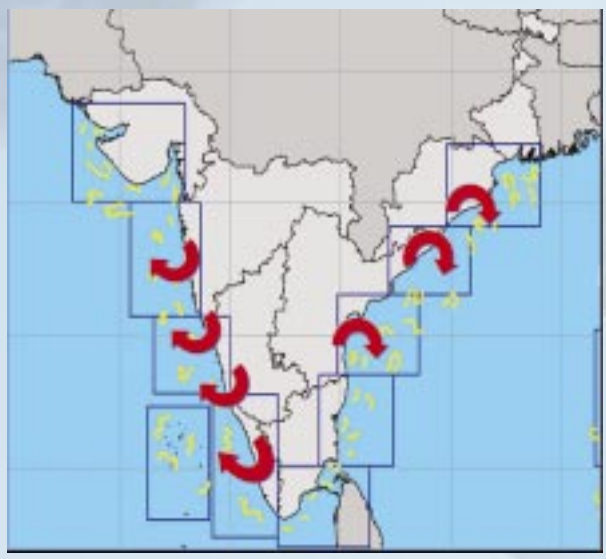
- PFZ Awareness Workshop was conducted for the fishermen of Nagapattinam on July 06, 2005. An Electronic Display Board was installed at Tele Fisheries Village Resource Centre, Nagapattinam and the fishermen were trained on how to use the PFZ information displayed on Electronic Display Board.
- PFZ User Interaction Workshop held at Machilipatnam on Jan 25, 2006 by INCOIS and Centre for Studies on Bay of Bengal, Andhra University. The use of PFZ advisories and benefits were explained to the fishermen by the officials.

PFZ User interaction at Machilipatnam

c) Validation Projects:

Continuous validation and feedback is imperative for improving the operational forecast of PFZ. INCOIS commissioned seven validation experiments along the east and west coasts of India (Maharashtra, Goa, Kerala, Karnataka, Andhra Pradesh and Orissa) in collaboration with the academia and other central institutions for concurrent validation of PFZ Advisories.

A review meeting was held at INCOIS on March 23, 2006 on validation projects. It is proposed to extend these validation experiments so as to cover the entire coastline of the country.



Locations of PFZ Validation Projects

d) Visit of Maldivian Officials:

Hon'ble Abdullah Kamaludeen, Minister of Fisheries, Agriculture and Marine Resources, Maldives visited INCOIS on February 06, 2006 to explore the possible collaboration with INCOIS to extend PFZ services to Maldives.

The Hon'ble Minister expressed interest to have collaborative pilot project to extend the PFZ Service to the Maldives. It was agreed initially to provide training to the scientists from the Ministry of Fisheries, Maldives.

Hon'ble Abdullah Kamaludeen, Minister of Fisheries, Agriculture and Marine Resources, Maldives interacting with Scientists on PFZ Advisory Services

e) Training Programmes:

A training programme was organised for two officials from Amrita Vishwa Vidyapeetham on February 27, 2006 on the generation and user of PFZ advisory services.

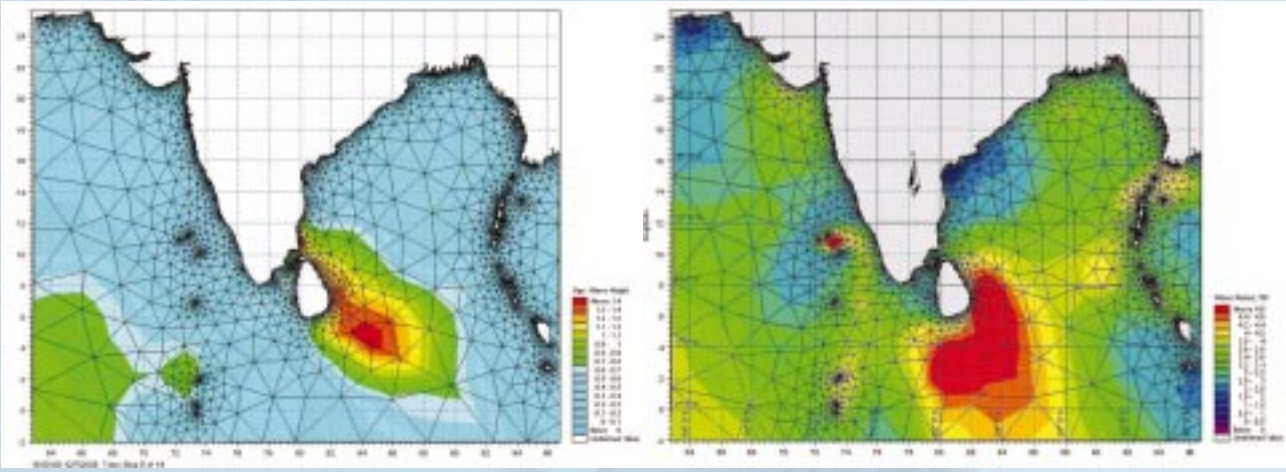
2.3. Experimental Ocean State Forecast

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

The wind forecast from the National Centre for Medium Range Weather Forecast (NCMRWF), Delhi is the prime input for the E-OSF Forecast.

INCOIS has been operationally providing forecast on ocean state parameters to cater the operational needs of Navy, Shipping, Oil and Fishing community and these services are extremely useful for safe operations and navigation at sea.

- Sustained the operational forecasts for wave, swell, mixed layer depth, sea surface temperature and tidal circulation from Ratnagiri to Porbandar. These forecasts (both in the form of graphical images and numeric data) are made available through INCOIS website with Web-GIS capabilities.
- More than 60 registered users from various sectors such as navy, industry, academia and fishery avail OSF products through INCOIS website. E-group was formed and products are being disseminated to the users by e-mail.
- User interaction workshops have been organized to understand the user requirements and to increase awareness. Interactions were held with users on OSF products during the International Maritime Expo-India held at Mumbai on October 5, 2005. Survey was conducted with users on the requirements for the Coastal Ocean State forecast.
- A national level expert committee was constituted to monitor the timely progress of OSF including operationalisation, utilisation and planning for the future.
- OSF validation experiments were conducted in association with other premier national institutions in the Country. This has provided useful inputs for improving the accuracy of the forecast.
- R & D activities are pursued for improving forecast of waves on coast and extreme weather conditions.
- 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.
- Customisation of SWAN Model for forecast at 0.5° resolution and coupling the WAM and SWAN models to give boundary information to SWAN is underway.



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

2.4. Ocean Information Bank and Web-based Services

Ocean Information Bank

Ocean Information Bank is the one stop shop for providing information on physical, chemical, biological and geological parameters of ocean and coastal waters 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 generated by various national agencies including a chain of Marine Data Centres.

The Ocean Information Bank was updated regularly and consists of the following data sets for facilitating its user community

(i) AVHRR data from NOAA Satellite series (of USA) from 1991 and Sea Surface Temperature archives for North Indian Ocean from 1992 to March 2006, including daily, weekly and monthly images and grid data, brightness temperatures, IRS P4 OCM raw and processed data from 2000 to 2005 and MODIS – Tera/Aqua data from 2005 onwards,

(ii) Data from Moored and Drifting Data buoys, Expendable Bathy Thermographs (XBT)s, 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),

(v) Coastal Area Maps from Nellore to Orissa border on 1:25,00 Scale,

(vi) Bathymetry charts for the entire coast of India inclding Islands on 1:15,000 / 1:50,000 / 1: 1,50,000 Scale,

(vii) Arabian Sea Monsoon Experiment Phase-1 (ARMEX-1) data,

(viii) 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 (1998-2005) (v) rainfall data from CMAP (1979 – 2005) (vi) Quicksat (1998-2005).

Marine Data Centres: A network of 14 Marine Data Centres (MDC) was established by then the Department of Ocean Development in the 90's under the Marine Satellite Information Service (MARSIS) Programme, in National Laboratories and Academic Institutions to collect and collate data, undertake quality control exercises and archive in digital data bases. The location of the Marine Data Centres and the type of data held are as given below:

Marine Data Centres and the type of data held by them		
1	Geological Survey of India (GSI), Kolkata	Marine Geological Data
2	K.D. Malavia Institute of Petroleum Exploration (KDMIPE), Dehradun	Magnetic, Seismic and Gravity data
3	India Meteorological Department (IMD), Pune	Ocean Surface Meteorological data
4	Survey of India (SOI), Dehradun	Tidal data
5	Naval Hydrographic Office, (NHO) Dehradun	Hydrographic data
6	National Institute of Oceanography (NIO), Goa	Physical, Chemical and Biological Oceanographic data
7	Fishery Survey of India (FSI), Mumbai	Offshore Fisheries
8	Central Marine Fisheries Research Institute (CMFRI), Kochi	Coastal Fisheries
9	Central Drug Research Institute (CDRI), Lucknow	Bio-active substances in the Sea
10	Central Salt and Marine Chemicals Research Institute (CSMCRI), Bhavnagar	Marine Algal Resources
11	Orissa Remote Sensing Applications Centre (ORSAC), Bhubaneswar	Coastal Zone Information System for Orissa and West Bengal
12	Institute for Ocean Management (IOM), Chennai	Coastal Geomorphology, Coastal Zone
13	Regional Centre, National Institute of Oceanography, Mumbai	Marine Pollution
14	National Remote Sensing Agency (NRSA), Hyderabad	Satellite Oceanography

INCOIS plans to strengthen the Ocean Information Bank with the data generated from the chain of Marine Data Centres, MoES Institutions, Academia, etc. by networking of these centres and enabling them on the INCOIS web-site with appropriate access privileges.

Apart from serving as a national repository of marine data, the INCOIS as the National Oceanographic Data Centre from India, also acts as national contact point for the International Oceanographic Data and Information Exchange (IODE), and Global Ocean Observing System (GOOS)-programmes of Intergovernmental Oceanographic Commission (IOC).

Web-based Services

INCOIS Website (www.incois.gov.in) matured as a prime vehicle for delivery of ocean data, information and ocean information and advisory services especially in the areas of (i) Potential Fishing Zone Mission, (ii) Indian Ocean Argo Project, (iii) Experimental Ocean State Forecast, (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 enables the 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.

Statistics of INCOIS web-site usage during the period July – December 2005:

Page	Hits	Visitors
INCOIS Home Pate	71368	12491
PFZ Forecast Page	6887	372
PFZ Multilingual Pages	6536	724
PFZ Web GIS	532	203
OSF Forecast	4071	552
OSF Web GIS	225	60
Argo Array Web GIS	4065	575
Argo Data Downloads	5566	59
Argo Data Products	328	35
IOGOOS Home Page	2905	906
SST/Chrolophyll Data	354	78

3. Ocean Observations, Modelling and Satellite Oceanography

INCOIS has the responsibility for coordination and implementation of:

(a) Indian Argo Project

(b) Ocean modelling activities at INCOIS

(c) Indian Ocean Modelling and Dynamics Project (INDOMOD) and

(d) Satellite Coastal and Oceanographic Research Project (SATCORE)

3.1 Indian Argo Project

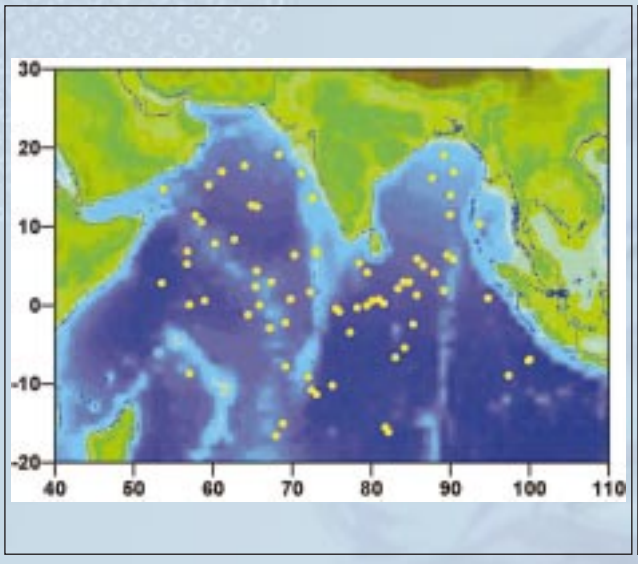
Argo, an international programme designed to collect periodic profiles of temperature and salinity for better understanding of the structure of upper ocean and for enhancing climate predictability. International Argo Project endorsed by World Meteorological Organization (WMO) and International Oceanographic Commission (IOC) of United Nations Education, Scientific and Cultural Organization (UNESCO) aims to deploy 3000 floats in the global ocean by the year 2006 to establish a global array at a spatial resolution of 300 km. The Argo array of the Indian Ocean requires about 450 floats. India has a responsibility to deploy 150 Argo floats and the remaining 300 would be deployed by other countries.

Argo profiling floats provide continuous monitoring of the temperature, salinity, and velocity of the upper ocean periodically. 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.

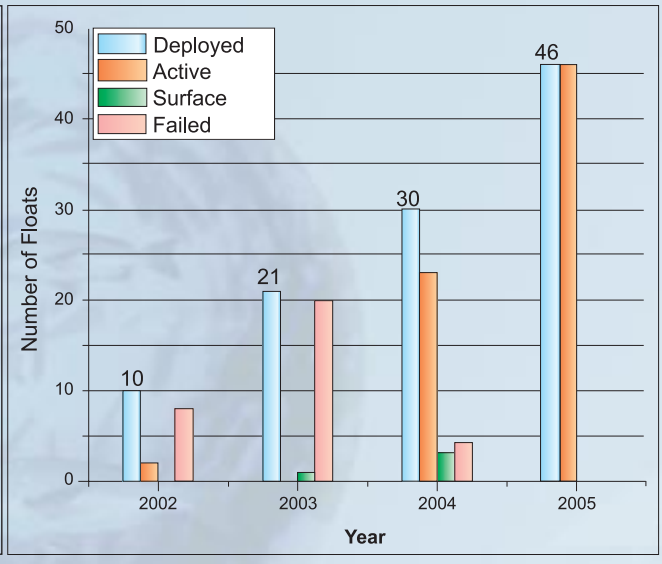
The Indian Argo Project has been implemented by INCOIS jointly with National Institute of Ocean Technology (NIOT) and Centre for Atmospheric and Ocean Sciences, Indian Institute of Science (CAOS/ IISc) with active participation from a network of other premier institutions. The Indian Argo Project envisaged deployment of 150 Argo floats in the Tropical Indian Ocean, setting up and operation of Argo Data Reception and Processing System at National level, setting up and operation of Regional Argo Data Centre, regional coordination for deployment in the Indian Ocean, development of Ocean Data Assimilation System, analysis and utilization of Argo data and capacity building at National level. INCOIS has a lead role in the project as (i) National Argo Data Centre (ii) the Regional Argo Data Centre for the region and (ii) the Regional Coordinator for implementation of Argo programme in the Indian Ocean.

Significant achievements under the programme during 2005-06 are as follows:

- A set of 46 Argo floats were deployed in the Indian Ocean during the year. 71 floats are operational out of 107 floats deployed by India. The data from the active floats, directly received at INCOIS Satellite Data Acquisition and Processing System, were processed and disseminated to user agencies after real time quality control.

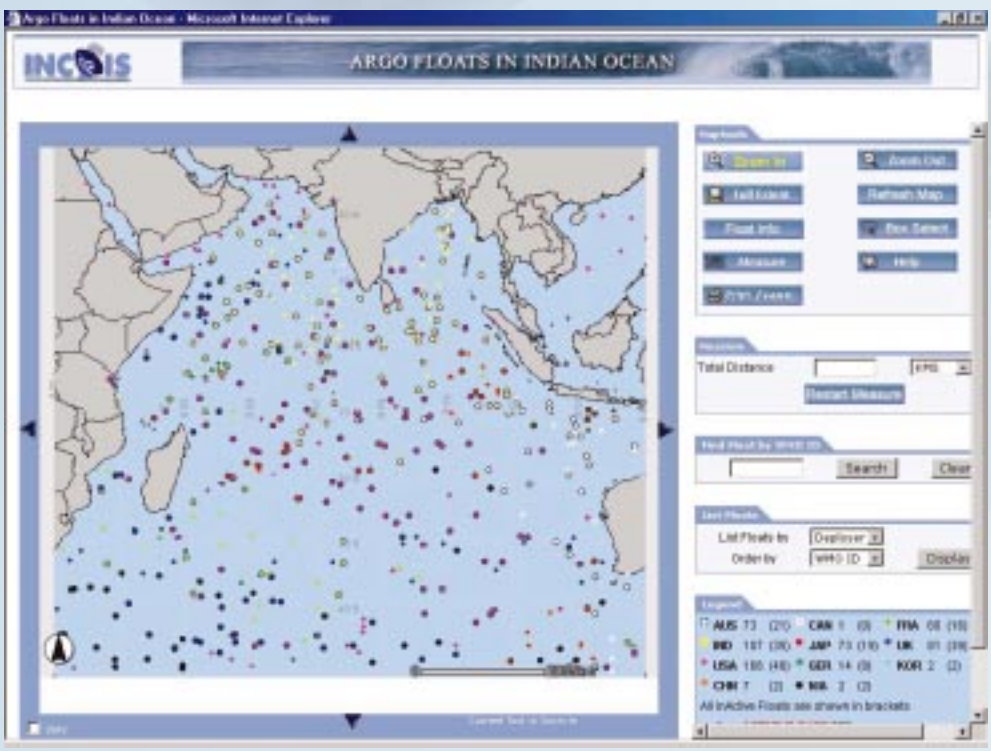


Present locations of the Argo Floats deployed by India



Performance analysis of Argo Floats deployed by India

- The Regional Argo Data Centre at INCOIS archived data from 536 Argo floats deployed by various countries in Indian Ocean and published on INCOIS website. Currently 408 floats deployed by various countries in the Indian Ocean are active out of 536.



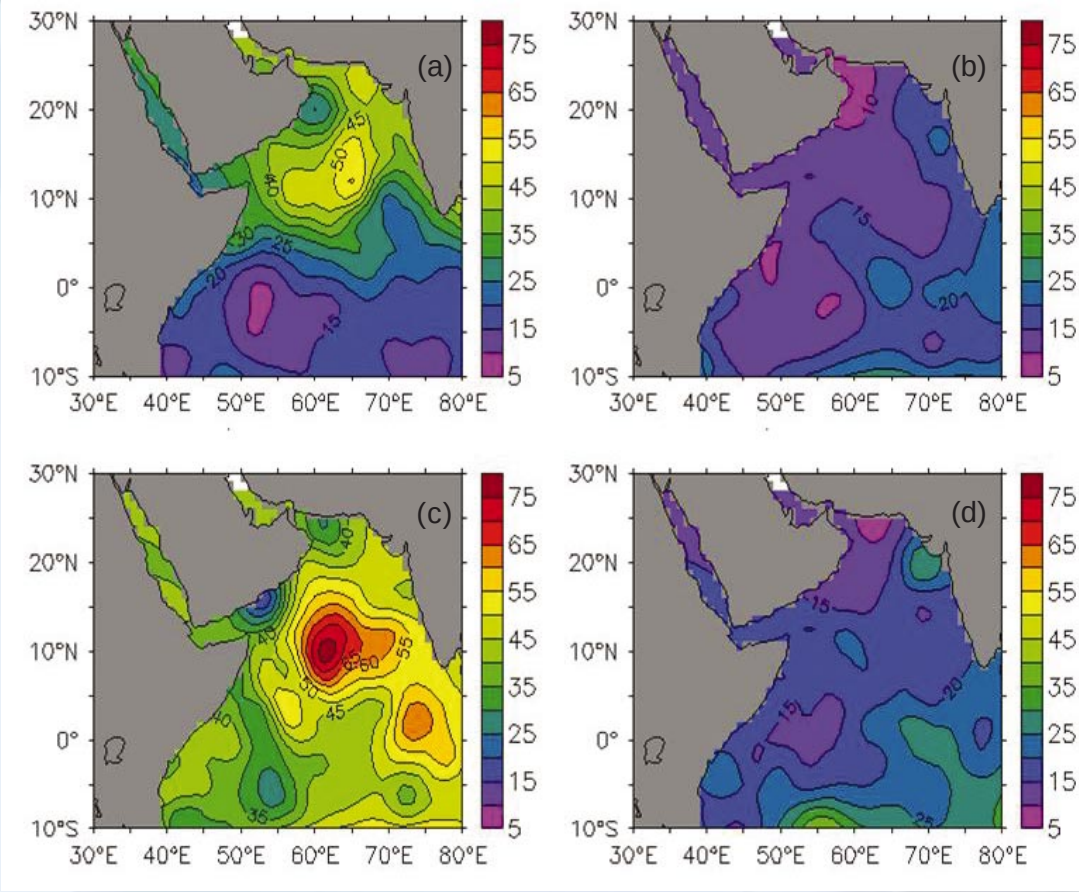
Data from the Argo floats deployed by Australia, Canada, China, France, Germany, India, Japan, UK and USA in the Indian Ocean on INCOIS

- A set of Argo value-added data products (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 (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 web site.

Analysis of Argo float Data

Scientists from several institutions in India effectively utilized the Argo data to study (i) the structure and variability of the Indian ocean (ii) the response of the North Indian Ocean to the summer monsoon (iii) the upper ocean response and to improve the predictive capability of the intensity and track of the cyclone (iv) Arabian sea water mass (iv) short-term variability of sound velocity and (v) assimilation of Argo float data into Ocean General Circulation Models (OGCM), etc. About thirty one papers were presented in national and international symposium/workshop/conference using the Argo float data. Some of the studies carried out at INCOIS using Argo float data during the year are as follows:

- Surface currents were estimated from the Argo float drift data in the Bay of Bengal. The results were compared with Simple Oceanographic Data Assimilation (SODA) data sets well.
- Temperature and salinity of the Upper Ocean were simulated for the last 20 years using MOM model and the results were validated with the available Argo float data. The temperature simulations were in good agreement with observations and efforts are underway to improve the simulations of salinity.
- Spatial variability of sonic layer depth (SLD) and Mixed layer depth (MLD) was studied using temperature and salinity (T/S) profiles from Argo floats and World Ocean Atlas, in the Arabian Sea from January 2003 to December 2004.



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

3.2 Modelling Activities at INCOIS

INCOIS initiated Ocean Modelling activities contributing to weather, monsoon, climate forecast by forcing functions for atmospheric models, understanding the variability of ocean and marine environment and simulation experiments to optimize the observation system.

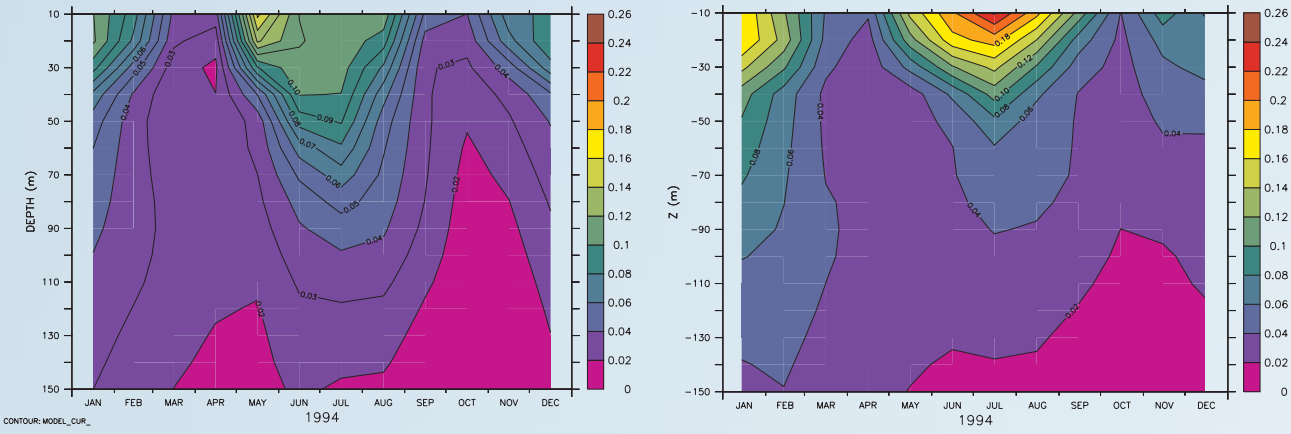
During the year, computational infrastructure was upgraded at INCOIS for modelling studies. Indian Ocean Model (IOM) was configured on SGI System. Three different experiments were carried out using Modular Ocean Model (MOM) to study the response of forcing fields on different parameters for five years 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 (Quickscat satellite winds) and the rest of the forcing fields [heat fluxes, salt fluxes (evaporation minus precipitation), temperature field and salinity fields] were restored to climatology. Ocean currents were compared with the Simple Ocean Data Assimilation Datasets.

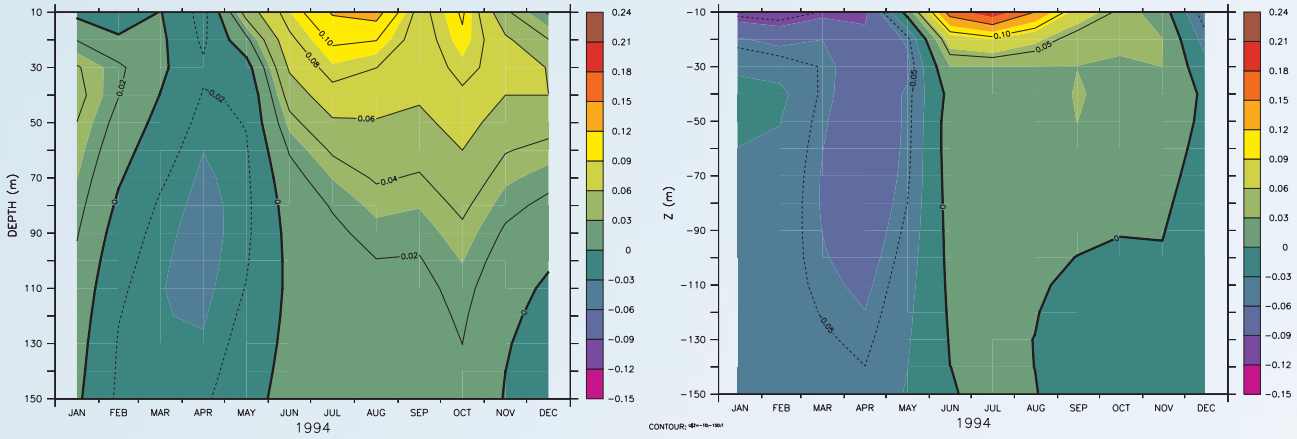
In the second experiment, the model was forced with NCEP heat fluxes and the rest of the forcing fields, i.e., winds, salt flux, temperature field, salinity fields, etc. were restored to climatology and the resulting ocean temperature fields were compared with SODA temperature fields.

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.

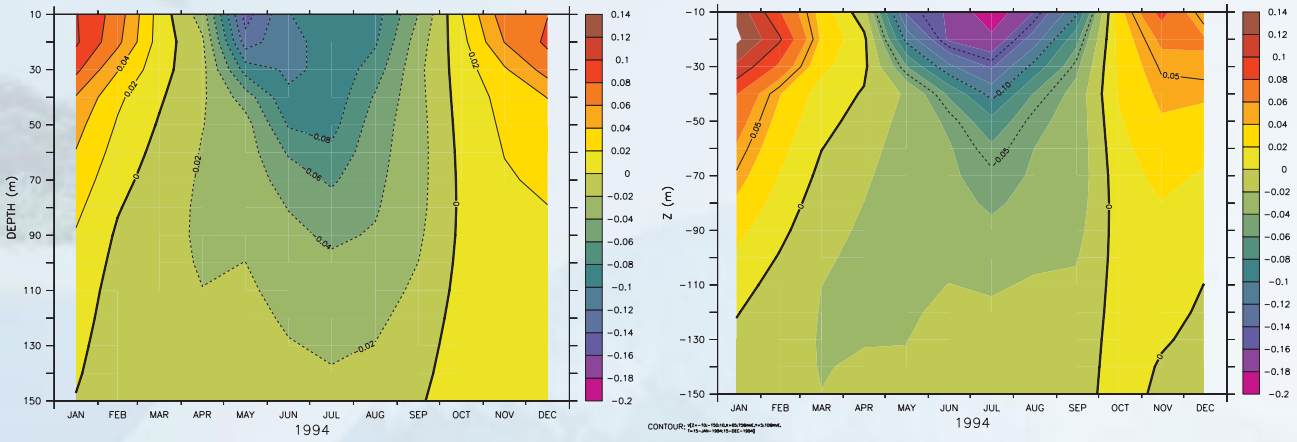
Regional ocean model of the Rutgers University has been configured on IBM server at INCOIS to study the coastal circulation of North Indian Ocean and experiments were carried out.



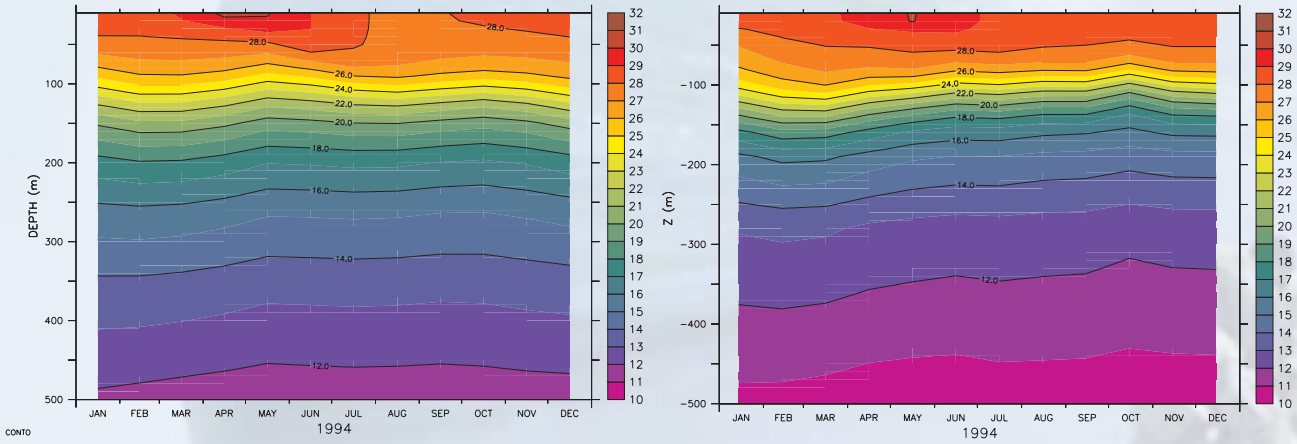
Current Speeds at 65^{0}E to 75^{0}E(ave) and 5^{0}N to 10^{0}N (ave) upper 150m
(a) generated by MOM and (b) derived from SODA data sets



Time depth Section of Currents – U comp at 65^{0}E to 75^{0}E(ave) and 5^{0}N to 10^{0}N (ave) upper 150m (a) generated by MOM and (b) derived from SODA data sets



Time depth Section of Currents – V comp at 65^{0}E to 75^{0}E(ave) and 5^{0}N to 10^{0}N (ave) upper 150m (a) generated by MOM and (b) derived from SODA data sets



Time depth Section of Temperature at 65^{0}E to 75^{0}E average and 5^{0}N to 10^{0}N average upper 500m (a) generated by MOM and (b) derived from SODA data sets

3.3 Indian Ocean Dynamics and Modelling (INDOMOD) Project

The significant initiatives towards realising the national capability in ocean atmospheric modelling during IX Plan resulted in to a new phase of modelling efforts under INDOMOD project during the X Plan. The end goal was achieving ocean predictability and enabling climate predictability in a mission-mode with concomitant efforts in Modelling, Data Assimilation and Validation. The project envisages focused research in 5 modules with active participation of several institutions, with a mission to enhance the basic understanding and knowledge base on oceanic and atmospheric processes and catastrophic weather events and improve operation prediction by the respective agencies.

A national team represented from a network of reputed institutions, viz. CAOS/IISc, CAS/IIT-D, Centre for Mathematical Modelling and Computer Simulation (C-MMACS), Indian Institute of Tropical Meteorology (IITM), IMD, NIO, NCMRWF, Naval Physical Oceanographic Laboratory (NPOL), NRSA, SAC and SOI played a key role in realising this mission.

INDOMOD Project comprises the following Modules:

Sl. No	Modules	Institution
1.	Ocean and Climate	CAOS/IISc, NIO, IITM, CMMACS
2.	Coastal Ocean	CAS/IIT-D
3.	Hazardous Weather Events	CAS/IIT-D, NRSA, INCOIS and SOI
4.	Ocean Data Assimilation and Information Bank	IITM, NCMRWF, INCOIS, NPOL and CMMACS
5.	Observations for validation of models	NIO

Significant progress made under this project module-wise is as given below:

Module-1: Ocean and Climate

- Different control experiments were performed. Ocean General Circulation Model (OGCM) simulations show good resemblance with observation in capturing Indian Ocean Dipole (IOD) and El-nino and Southern Oscillation (ENSO) events and associated subsurface variability in the tropical Indian Ocean and Pacific Ocean.
- Observations and experiments using Atmospheric General Circulation Model(AGCM) provide new insight about the role of ENSO in influencing the Indian Monsoon through convection changes over northwest Pacific.

Module-2: Coastal Ocean

- 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.

Module-3: Hazardous Weather Events

- Investigations using non-hydrostatic dynamics significantly improved the simulation of track and intensity of the storm. 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.

Module-4: Ocean Data Assimilation and Information Bank

- Several historic in-situ, satellite oceanographic and surface marine meteorological, oceanographic model analysis/simulation output data were acquired and archived. Generation ofAtlas on surface marine meteorology, Sea Surface Temperature , Sea Surface Height, SeaWifs Chlorophyll-a and near surface thermal structure is underway to characterize and resolve the observed variability on intra-seasonal and interannual time scales.
- POM and MOM were customized for IO 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.

Module-5: Observations for validation of models

- 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 drfting buoy data were updated. 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.
- Several publications have been emerged out of this project.

3.4 Satellite Coastal and Oceanographic Research (SATCORE) Project

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 carryout diagnostic studies and generation of forecast models, customisation of algorithms and development of related software packages.

Sl. No	Project	Institution
1	Advanced Ocean State Forecast, Ocean Processes (Convection), Geophysical Parameter Retrieval and Validation	SAC
2	Ocean Colour Applications, Ocean Biology, Coastal processes, Ocean Lithosphere, Coral reef Studies,	SAC
3	Improvement of Mixed Layer Depth Predictions	NRSA
4	Development of Integrated Fishery Forecast Model	NRSA
5	Observation platforms in Islands	SAC

Significant progress has been achieved in the implementation of Satellite Coastal and Oceanographic Research (SATCORE) Project in the participating institutions. Some of the products generated under this project have been made operational at INCOIS.

3.5 Satellite Data Acquisition and Processing System

The Satellite Data Acquisition and Processing System(SDAPS) is operationally receiving data from Argo floats within the coverage area (5000km diameter from INCOIS), through ARGOS Data Collection and Location System onboard NOAA series of satellites (NOAA-12, 14, 15, 16, 17) and remote sensing data from NOAA 17, Feng Yun and Aqua & Tera (MODIS) satellites.

The data received from the Argo floats in the Indian Ocean is delivered in real time to the Argo Data Centre at INCOIS for further processing and web publishing. Sea Surface Temperature is generated from the AVHRR of NOAA-17 is being delivered for the Potential Fishing Zone Mission. Software developed for (i) automation of Argo float data processing and SST processing in real-time and disseminating to the Argo Data Centre at INCOIS (ii) exclusive processing and dissemination of SST from AVHRR of NOAA, to meet PFZ mission requirements.

Data Products generated by SDAPS:

AVHRR-NOAA: Sea Surface Temperature.

MODIS-Aqua/Tera: Aerosols, atmospheric water vapor, precipitable water, cloud parameters, atmospheric profiles (temparature, moisture, stability, ozone, etc.), Sea Surface Temperature, Chlorophyll, Normalised Water Leaving Radiances, etc.

4. Infrastructure Development

INCOIS is functioning from its permanent campus developed in a 50 acre land in Hyderabad with state-of-the-art facilities for an S&T institution.

The computational facilities of INCOIS comprising high end UNIX Servers, UNIX Workstations, Windows 2000 Servers, Windows 2000 Workstations, Enterprise Storage Server, Pentium IV Desk Top Systems and peripherals connected using both fibre and Gigabit Ethernet network were utilised fully, and in some cases round-the clock.

INCOIS utilised for its operational and developmental studies a wide range of software packages including:

a) Standard packages such as ERDAS, ENVI and E-Cognition (for image analysis), Arc/Info, Arc SDE and Arc IMS (for GIS), Oracle 9i (for RDBMS), MATLAB (for data processing and analysis), Websphere (for web server), MS Exchange etc.

b) Customised packages from SAC/RRSSC for OCM data processing and analysis and SST processing software

c) Customised packages from SAC/IIT-D for WAM3GC Model, Price 1D Model and SST forecast

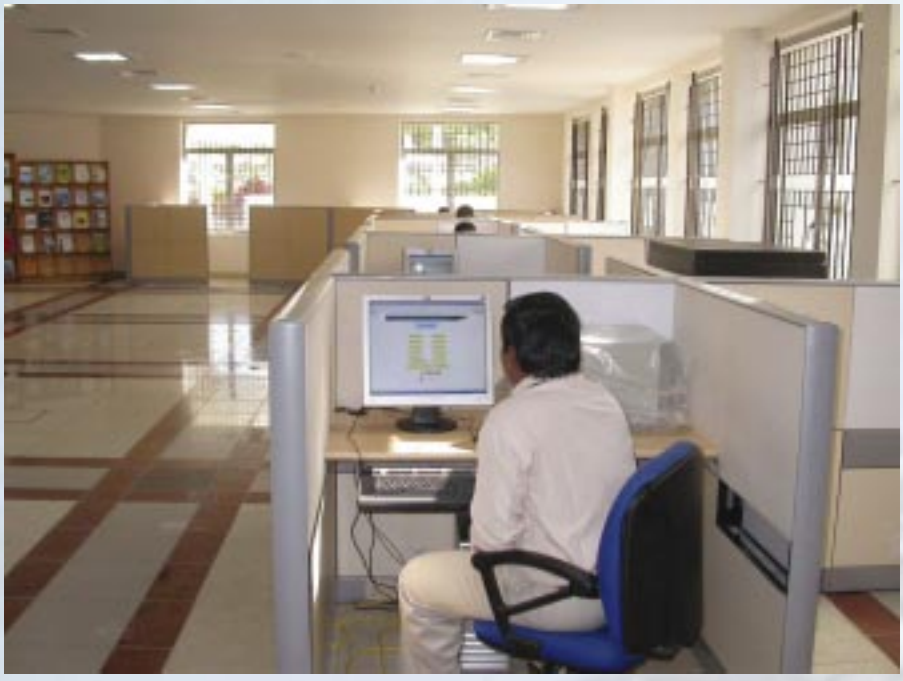
d) Tidal Circulation model developed by NIO for Gulf of Khambat

e) Freeware for Ocean General Circulation Modelling (POM and MOM-4)

Efforts are underway to upgrade the (i) storage capacities to meet the increased data volumes, (ii) processing speeds of Web Environment and (iii) to procure additional hardware/software, viz., ipSAN storage server, File Server, Database Server, Firewall, e-library, Satellite Data Acquisition and Processing System, desktop systems and various peripherals.

INCOIS library has resources in the form of books, reports, bound periodicals, current periodicals, etc. The concept of INCOIS Library is to build a well equipped e-library. The Library has subscribed to many national and international journals, periodicals, magazines both hardcopy as well as online subscription. The e-library facility is being widely used by the scientists.

INCOIS Library offers various services viz., journal content alert service, selective dissemination of information service, current awareness service, reprints service, CDROM database service, reference and bibliographic services, Inter-library loan service and reprographic service.



E-Library Facility at INCOIS Library

5. INCOIS in the International Scene

5.1 Intergovernmental Oceanographic Commission (IOC)

India is the founder member of IOC and also a Member of the Executive Council. Dr. K. Radhakrishnan, former Director, INCOIS continued as the Vice-Chairman of IOC till June 2005.

5.2 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. Dr. K. Radhakrishnan, former Director, INCOIS (up to Nov 07, 2005) played a pivotal role in restructuring the Global Ocean Observing System (GOOS), the largest and most complex of its scientific and technical programmes.

5.3 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 25 institutions from 15 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 are as follows:

- IOGOOS Secretariat coordinated and arranged the IOGOOS Workshop & 3rd Annual Meeting (IOGOOS-III) at Bali, Indonesia during August 9-12, 2005. About 58 participants from 16 countries and the Intergovernmental Oceanographic Commission participated in the Meeting.
- The implementation plan for Integrated Observing System in the Indian Ocean that has been prepared

IOGOOS-III Meeting at Bali, Indonesia

by the Indian Ocean Panel (IOP) has been endorsed by the High-level meeting that was held in conjunction with IOGOOS-III.

- As part of the IOP implementation plan PMEL/NIO deployed 4 moored buoys in the equatorial Indian Ocean onboard ORV Sagar Kanya.
- Two new pilot projects on observations on Whale Sharks in the Indian Ocean and Timor Sea Deep Ocean to Shelf model demonstration have been proposed to be pursued as part of Coastal GOOS.

5.4 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.

IAST-7 Inauguration

INCOIS has hosted the Seventh International Argo Steering Team Meeting (IAST-7) at Hyderabad during January 16-18, 2006.

5.5 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. INCOIS is the Member of POGO since 2004.

INCOIS is hosted the Seventh POGO Meeting (POGO-7) at Hyderabad during January 18-20, 2006.

Participants of POGO-7 Meeting hosted by INCOIS at Hyderabad

6. General Information

Deputations abroad

Official	Meeting/Conference/Training	Period
Dr. K. Radhakrishnan Director, INCOIS (upto Nov 07, 2005)	Second International coordination meeting for the development of Tsunami warning and mitigation system for the Indian Ocean held at Mauritius	April 14-16, 2005
	International Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System (ICG/IOTWS) at Perth, Australia	August 3-5, 2005
	IOGOOS third annual meeting and workshop held at Bali, Indonesia	August 8-12, 2005
	38th Session of the IOC Executive Council and 23rd Session of the IOC Assembly at Paris, France	June 20-27, 2005
	33rd Session of the General Conference of UNESCO held at Paris, France	October 7-11, 2005
Dr. M. Ravichandran	6th Argo data management team meeting held at Japan Meteorological Agency, Tokyo, Japan	November 8-10, 2005
	IOC/IOGOOS/CLIVAR Indian Ocean Panel meeting at Honolulu	February 28 – March 3, 2006
Shri. T. Srinivasa Kumar	IOGOOS third annual meeting and workshop held at Bali, Indonesia	August 8-12, 2005
	First meeting of the India-Brazil-South Africa (IBSA) Inter-Regional Alliance for Oceanography and Antarctic Research held at Angra dos Reis, Brazil	September 14-16, 2005
	Working Group 4 of ICG/IOTWS (WG-4) which deals with the establishment of a system of interoperable advisory & warning centres for Indian ocean held at Singapore	November 24, 2005
	International Ocean Color Coordinated Group (IOCCG) at Busan, South Korea	January 11-13, 2006
Dr. Sudheer Joseph	Argo delayed mode quality control workshop held at Scripps Institution of Oceanography, La Jolla, USA	April 8-13, 2005
	Second Argo Science Workshop and Trajectory Workshop at Venice, Italy	March 13-18, 2006
Shri. E. Pattabhi Rama Rao	The 18th Session of the IOC Committee on International Oceanographic Data and Information Exchange (IODE-XVIII) held at Ostend, Belgium	April 26-30, 2005
	Training on 'Acquisition and Processing Software Modules' of the Satellite Data Acquisition and Processing System at Seaspace Corporation, USA.	October 31-November 04, 2005

Promotion of Official Language

- A Scientist from INCOIS participated in one day National Hindi Workshop organised by DOD at New Delhi on October 10, 2005.

Awards

- Shri. T. Srinivasa Kumar, Scientist from INCIOS received the Certificate of Merit Award given to Young Scientists for the year 2004 during the DOD Foundation Day & Silver Jubilee Year – 2005 held at New Delhi.

GC/FC Meetings

- Eighth meeting of Finance Committee was held at INCOIS on May 26, 2005.
- Tenth meeting of INCOIS Governing Council was held at INCOIS on June 02, 2005.
- Eleventh meeting of INCOIS Governing Council was held at INCOIS on February 07, 2005.

Publications

- R.R.Rao, M.S Girish Kumar, **M.Ravichandran**, B.K.Samala, and **Sreedevi Nandakumar** (2006), Observed mini-cold pool off the southern tip of India and its intrusion into the south central Bay of Bengal during summer monsoon season, *Geophys. Res. Lett., 33*, L06607, doi: 10.1029/2005GL025382.
- **T.M. Balakrishnan Nair**, V. Ittekkot, R. Shankar, M.V.S. Guptha (2005), Settling barium fluxes in the Arabian Sea: Critical evaluation of relationship with export production*, Deep Sea Research Part II, 52 1930-1946.*

Presentations at Conferences

- **G. Anitha** (2005), Signatures of active and break phases of Indian Summer Monsoon (ISM), 14th National Symposium on Environment, held at Osmania University, Hyderabad during June 5-7, 2005.

7. Finance

The Report of the Auditors and Audited Accounts of INCOIS for the year 2005-06 are placed as Appendix-1 to this Report.

Indian National Centre for Ocean Information Services

(An Autonomous Body under the Ministry of Earth Sciences, Government of India)

"Ocean Valley", Hyderabad 500 055, India Email: director@incois.gov.in, URL: www.incois.gov.in