

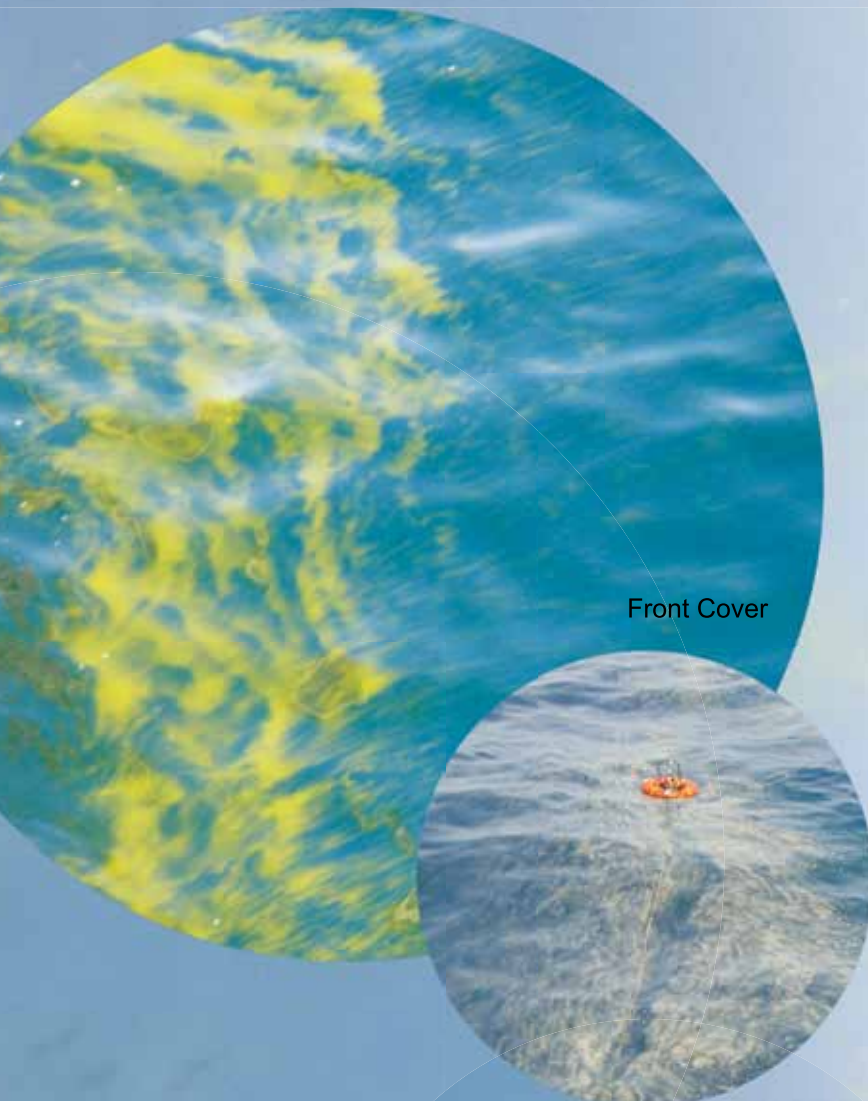


ANNUAL REPORT 2013-14



ESSO-Indian National Centre for Ocean Information Services

(An autonomous body under the Ministry of Earth Sciences, Government of India), Hyderabad



- ◀ Algal bloom (*Noctiluca scintillans*) observed during a research cruise on board ORV Sagar Sampada in the Arabian Sea during the North East Monsoon period, February, 2009.

Courtesy: Satya Prakash,
Information Services and Ocean
Sciences Group (ISG),
ESSO-INCOIS.



- ◀ Algal bloom (*Trichodesmium erythraeum*) observed during a research cruise on board ORV Sagar Kanya in the Arabian Sea during the Intermonsoon period, April, 2009.

Courtesy: Satya Prakash,
Information Services and Ocean
Sciences Group (ISG),
ESSO-INCOIS.



- ◀ Deployment of a buoy during the Indo-US 'Ocean Mixing and Monsoon' Pilot cruise in Bay of Bengal, on board ORV Sagar Nidhi, November 2013.

Courtesy: K. Dinesh,
Modelling and Ocean
Observations Group (MOG),
ESSO-INCOIS.

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From Director's Desk



Welcome to our 2013-14 Annual Report, another milestone in the history of Operational Oceanographic Services. From humble beginnings with operational oceanographic services 15 years ago, Earth System Sciences Organisation-Indian National Centre for Ocean Information Services (ESSO-INCOIS) matured to be a world class operational oceanography centre. The signing of a Memorandum of Agreement with the Intergovernmental Oceanographic Commission (IOC)/UNESCO, on 4 July, 2013 to cooperate in capacity development through the International Centre for Operational Oceanography (ITCOocean) established at ESSO-INCOIS, is a testimony to the acceptance of the competency of ESSO-INCOIS in operational oceanography, by the international community. During the year, ITCOocean conducted 4 training courses benefitting 90 students from 11 countries.

The tsunami warning service provided by ESSO-INCOIS functioned successfully capturing and reporting 50 earthquake events having magnitudes higher than 6.5 in the global oceans. Among them, 7 earthquakes occurred in the Indian Ocean. As required, the centre provided information on all of them within the stipulated time. None of these generated a tsunami in the Indian Ocean. However, a delayed mini tsunami (2-50 cm height at many locations along the coast) was detected, probably caused by a mud slide/landslide (off Iran-Pakistan coast) that was triggered by the 7.6 Mw (mB) earthquake inside Pakistan on 24 September, 2013.

Considering the proximity of Andaman & Nicobar Islands to a potential tsunami source, we have taken up the task of establishing GNSS & Strong Motion Accelerometers network at 35 locations on the islands. The VSAT network linked through GSAT will ensure the real-time data availability for tsunami warning purposes. Taking advantage of this VSAT network and considering the frequent disruptions in normal modes of communication during emergencies, ESSO-INCOIS has implemented a fail-safe satellite-based communication system at 7 Emergency Operation Centres (EOCs) in Andaman & Nicobar Islands so that they can connect with the tsunami warning centre at ESSO-INCOIS through Voice over Internet Protocol (VoIP), telephony etc.

The services on ocean state forecast got further strengthened with the adoption of improved models and more extensive data sets. The WAVEWATCH III model that has been used for the forecasting of waves in the open ocean was replaced with a newer version on a multi-grid. Due to these improvements, we could provide accurate forecasts to the coastal community and navigators during the passage of cyclones. The accuracy with which we forecasted waves during the severe cyclonic storm Phailin that struck Odisha coast on 12 October, 2013 is an example of the higher accuracies that we have attained. This year also saw the launch of customised ocean state forecast services for ports and harbours and for Lakshadweep Islands.

The Potential Fishing Zone (PFZ) Advisory programme is one of the flagship programmes of ESSO-INCOIS and efforts were made to ensure the timely availability of multilingual advisories. Based on user demand, PFZ maps are now overlaid with surface current vectors, with clear demarcations of EEZ and district boundaries of coastal states.

It is gratifying to note that more organisations are coming forward to disseminate the PFZ advisories and ocean state forecasts generated by ESSO-INCOIS to fishermen through mobile services. This year, ESSO-INCOIS signed MoUs with M/S. Tata Consultancy Services (TCS) Ltd., M/S. IKSL and Reliance Foundation.

As practised during the previous years, we have further strengthened the ocean observing network through the deployments of Argo floats, wave rider buoys, shipboard AWS, tide gauges, tsunami buoys, ADCPs and a mooring in the central Bay of Bengal with a suite of sensors. The analyses of data from such observing systems resulted in several research papers. In addition, we have also taken up measurement of fine scale structure of temperature-salinity profiles in the Bay of Bengal, to understand air-sea exchange and mixing processes in the upper ocean at different spatial and temporal scales under a joint research program with institutes in India and the United States. One such joint cruise involving Indian research vessel Sagar Nidhi and US research vessel Roger Revelle was conducted in November 2013.

Data from all observing systems have been archived at the data centre and are made available to the users through web or email access. Value added products (monthly mean SST, SST anomaly, Oceanic Niño Indices, Tropical Cyclone Heat Potential (TCHP), etc.) derived from the ocean analysis generated by INCOIS-GODAS were also made available to users via FTP along with the daily-reanalysis products.

In our resolve to provide accurate forecasts on the 3-dimensional structure of coastal waters around India, a high resolution ROMS model has been set up for the west coast of India and a high resolution SWAN model has been set up to forecast the waves at Puducherry coast on pilot basis. Our effort to develop data assimilation schemes for high resolution coastal models and inclusion of biogeochemistry in such models is progressing well in the right direction.

The storm surge modeling that we took up last year has now fructified into an operational service that enables us to provide early warnings on the expected height of storm surge and the extent of inundation in the coastal areas. This forecast service was tested and validated during the cyclones Mahasen (12-14 May 2013), Phailin (9-13 October 2013), Helen (19-21 November 2013), Lehar (23-28 November 2013) and Madi (6-11 December 2013) and remained fully operational during the cyclone season in 2014.

On the infrastructure front, to accommodate the growing storage needs of various operational and R&D projects at ESSO-INCOIS, a centralised storage of 300 TB capacity with backup was installed and commissioned. Several software tools have also been upgraded and updated to take advantage of new utilities and technologies.

Campus development activity is progressing towards completion. Residential blocks, the 1st Floor extension of the amenity building and multi-purpose hall will be completed soon along with the guest house and the vertical extension of main building.

During 2013-14, our scientists authored/co-authored 41 research papers in peer-reviewed journals. The cumulative Impact Factor (IF) for the year is 58.5. Twenty three students carried out their B.Tech./M.Tech./M.Sc. dissertation/project works at ESSO-INCOIS under the guidance of our scientists. At the request of University of Hyderabad, our scientists served as faculty for the course "Ocean Modeling and Ocean Dynamics", delivering required lectures to 21 students.

'Hindi Pakhwara' was celebrated in September 2013 by conducting competitions in Hindi and organising seminars and symposia.

Four scientists at B and C level joined ESSO-INCOIS during this year, increasing the total strength of scientists to 44. A scientific assistant was also recruited. In addition, we have also recruited 9 project scientists (at B and C levels) and 7 project assistants on contract basis to execute the mission mode projects. One Quick Hire Fellow was also hired to carry out R&D work in mixing processes in the Bay of Bengal at shorter timescales using very high frequency observations.

ESSO-INCOIS continued its association with Indian Ocean Global Ocean Observing System (IOGOOS), Regional Coordination of Argo programme, Partnership for Observation of Global Oceans (POGO), Regional Integrated Multi-hazard Early warning System (RIMES) and the Intergovernmental Coordination Group (ICG) of Indian Ocean Tsunami and other hazards Warning System (IOTWS) of Intergovernmental Oceanographic Commission (IOC)/UNESCO. ESSO-INCOIS continued hosting the secretariats of IOGOOS and Sustained Indian Ocean Biogeochemistry and Ecosystem Research (SIBER) and the data centre for the Ocean Bio-Informatics System (OBIS).

At the International Conference for Humanitarian Logistics held at the Indian Institute of Management, Raipur the *ICHL Award for Excellence in Humanitarian Action* was presented to ESSO-INCOIS in the category of Early Warning and Dissemination. Andhra Pradesh Akademi of Sciences elected me as a Fellow in January 2014. Shri. Nagaraja Kumar received the Certificate of Merit and Shri. Moinudeen received the "Best Employee" award on the occasion of Foundation day of the Ministry of Earth Sciences held on 27 July, 2013. These awards and accreditations are a testament to the staff's dedication and commitment to ESSO-INCOIS.

Overall 2013-14 was another successful year for ESSO-INCOIS and a decade since we started ocean related services for the fishermen of our country, we continue to find ourselves in times with a buoyant future. In this report, we will leave you with some of the highlights and new developments achieved in 2013-14.

Before I leave this page, let me thank my colleagues at ESSO-INCOIS who are instrumental in helping us maintain our position as a centre of excellence in operational oceanography. Also, I express my gratitude to Dr. Shailesh Nayak (Chairman, Governing Council), Chairmen of

the Finance Committee and Research Advisory Council and all members for their support and guidance at every moment. ESSO-INCOIS owes a lot to organisations such as NIOT, NCAOR, IITM, NCMRWF, IMD, CMLRE, ICMAM, NRSC, SAC, NIO, IISc, IITs and universities for their continued collaboration on operational and R&D activities. The support and guidance from colleagues in the Ministry of Earth Sciences are gratefully acknowledged. The editorial committee chaired by Francis with Satyaprakash, Girish, Suprit, Nimit, Annapurnaiah, Celsa and Sidhartha as its members, compiled this report based on inputs from colleagues. I am extremely grateful to all of them.



S.S.C. Sheno

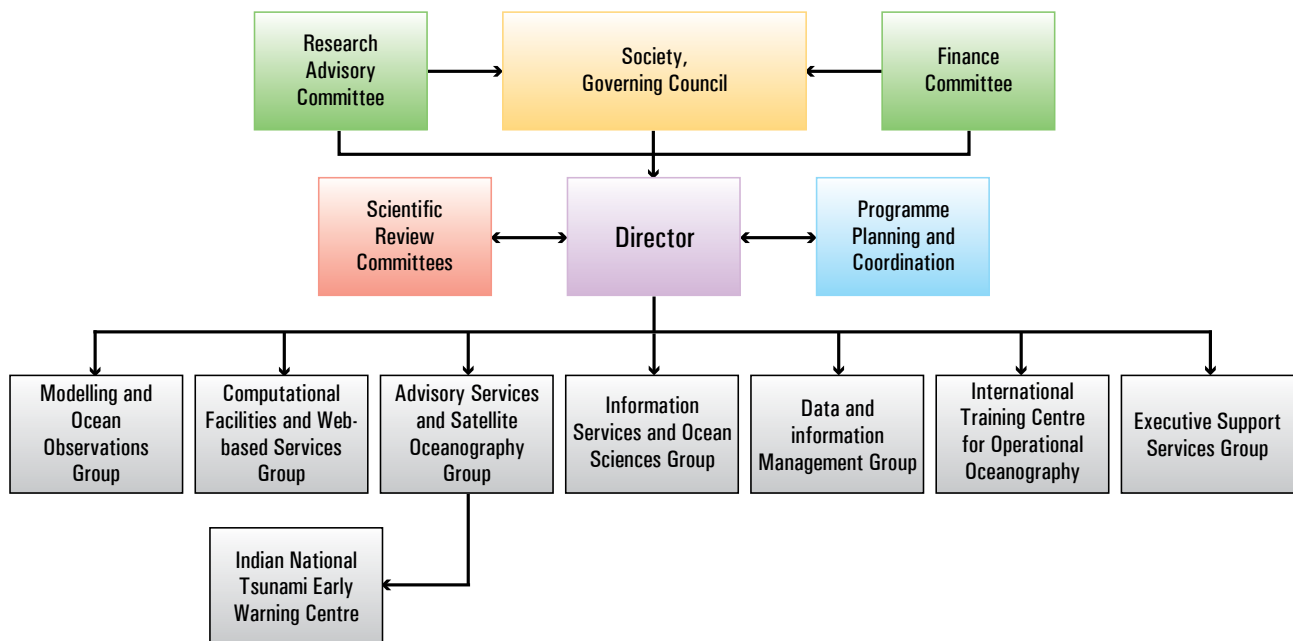
2. ESSO-INCOIS Organisational Structure

ESSO-INCOIS is an autonomous institute under the administrative control of the Ministry of Earth Sciences (MoES), Government of India and a member of the Earth System Science Organisation (ESSO-INCOIS), chaired by the Secretary to Government of India for Ministry of Earth Sciences.

ESSO-INCOIS was registered as a society under the Andhra Pradesh (Telengana) Public Societies Registration Act (1350, Falsi), at Hyderabad on 3 February, 1999. The affairs of the Society are managed, administered, directed and controlled, subject to the bye laws of the Society, by the Governing Council.

2.1 ESSO-INCOIS Society

Secretary, Ministry of Earth Sciences	President
Director, National Remote Sensing Centre, Hyderabad	Vice President
Joint Secretary, Ministry of Earth Sciences	Member
Advisor, Ministry of Earth Sciences	Member
Director, National Institute of Oceanography, Goa	Member
Director, National Institute of Ocean Technology, Chennai	Member
Director, National Centre for Antarctic and Ocean Research, Goa	Member
Director, Indian National Centre for Ocean Information Services	General Secretary



Organisation Structure of ESSO-INCOIS

2.2 ESSO-INCOIS Governing Council

- | | | |
|-----|--|---------------------|
| 1. | Secretary, Ministry of Earth Sciences | (Chairman) |
| 2. | Dr. Harsh Gupta, Hon'ble Member, NDMA, New Delhi | (Member) |
| 3. | Director, National Remote Sensing Centre, Hyderabad | (Member) |
| 4. | Director General, India Meteorological Department | (Member) |
| 5. | Financial Advisor, Ministry of Earth Sciences | (Member) |
| 6. | Chairman, Research Advisory Council, ESSO-INCOIS | (Member) |
| 7. | Additional/Joint Secretary, Ministry of Earth Sciences | (Member) |
| 8. | Director, National Centre for Antarctica and Ocean Research, Goa | (Member) |
| 9. | Director, National Institute of Oceanography, Goa | (Member) |
| 10. | Director, National Institute of Ocean Technology, Chennai | (Member) |
| 11. | Principal Advisor (S & T), Planning Commission | (Member) |
| 12. | Director, Space Application Centre, Ahmedabad | (Member) |
| 13. | Director, Indian National Centre for Ocean Information Services | (Member Secretary) |
| 14. | Programme Officer, Ministry of Earth Sciences | (Permanent Invitee) |

2.3 ESSO-INCOIS Research Advisory Committee

1. Prof. B.N. Goswami, Director, Indian Institute of Tropical Meteorology, Pune (Chairman).
2. Prof. (Mrs). P. Venkatachalam, Principal Research Scientist, Indian Institute of Technology, Mumbai (Member).
3. Dr. V. K. Dadhwal, Director, National Remote Sensing Centre, Hyderabad (Member).
4. Dr. M. Dileep Kumar, Chief Scientist, National Institute of Oceanography, Goa (Member).
5. Dr. B. K. Saha, Adjunct Professor, School of Oceanographic Studies, Jadavpur University, Kolkata (Member).
6. Dr. M. Ravichandran, Head, Modelling and Ocean Observations Group, ESSO-INCOIS, Hyderabad (Member Secretary).

2.4 ESSO-INCOIS Finance Committee

1. Financial Advisor, MoES (Chairman).
2. Additional/Joint Secretary, MoES (Member).
3. Director, ESSO-INCOIS (Member).
4. Director/Deputy Secretary (Finance), MoES (Member).
5. Programme Officer, MoES (Member).
6. Sri. E. Pattabhi Rama Rao, Scientist, ESSO-INCOIS (Member Secretary).

2.5 The Mission

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

The major objectives of ESSO-INCOIS are:

1. To establish, maintain and manage systems for data acquisition, analysis, interpretation and archival for Ocean Information and related services.
2. To undertake, aid, promote, guide and coordinate research in the field of ocean information and related services including satellite oceanography.
3. To carry out surveys and acquire information using satellite technology, ships, buoys, boats or any other platforms to generate information on fisheries, minerals, oil, biology, hydrology, bathymetry, geology, meteorology, coastal zone management and associated resources.
4. To generate and provide data along with value added data products to user communities.
5. To cooperate and collaborate with other national and international institutions in the field of ocean remote sensing, oceanography, atmospheric sciences/meteorology and coastal zone management.
6. To establish Early Warning System for Tsunami and Storm Surges.
7. To support research centres in conducting investigations in specified areas related to oceanic processes, ocean atmospheric interaction, coastal zone information, data synthesis, data analysis and data collection.
8. To organise training programmes, seminars and symposia to advance study and research related to oceanography and technology.
9. To publish and disseminate information, results of research, data products, maps and digital information through all technologically possible methods to users for promoting research and to meet societal needs for improvement of living standards.
10. To provide consultancy services in the fields of ocean information and advisory services.
11. To coordinate with space agencies to ensure continuity, consistency and to obtain state-of-the-art ocean data from satellite observations.
12. To encourage and support governmental and non-governmental agencies/organizations for furthering programmes in the generation and dissemination of ocean information.
13. To undertake other lawful activities as may be necessary, incidental or conducive to the attainment and furtherance of all or any of the above objectives of ESSO-INCOIS.

2.6 Quality Policy

The ESSO-Indian National Centre for Ocean Information Services (ESSO-INCOIS), Earth System Sciences Organization (ESSO), Ministry of Earth Sciences (MoES) is committed to provide the best possible ocean information and advisory services to society, industry, the government and the scientific community through sustained ocean observations and constant improvement through systematic and focused research. To achieve this, we will continue to align our actions with organizational values and shall ensure our commitment to continually improve our performance with the Quality Management System, by setting and reviewing quality objectives.

3. Highlights during 2013-14

3.1 Established International Training Centre for Operational Oceanography

Realising the importance of Operational Oceanography and lack of facilities for capacity building, Ministry of Earth Sciences (MoES), Government of India established the International Training Centre for Operational Oceanography (ITCOcean) at ESSO-INCOIS. ESSO-INCOIS signed a Memorandum of Agreement with the Intergovernmental Oceanographic Commission/UNESCO on 4 July, 2013 in Paris during the 27th session of the IOC Assembly to mutually cooperate in capacity building for operational oceanography. During the FY 2013-14, ITCOcean organized 4 training programmes related to operational oceanography. The two weeks training course on “Ensemble Kalman Filtering-Methods and Algorithms” during July 15-26, 2013, the two week summer school on “Fundamentals of Ocean Climate Modeling at Global and Regional Scales” during August 5-14, 2013, organized in collaboration with the International Centre for Theoretical Physics (ICTP), Italy and CLIVAR and the one week long training course on “Remote Sensing of Potential Fishing Zones and Ocean State Forecast” during March 24-29, 2014 are notable among them.

3.2 Advisory and forecast services during the passage of severe cyclone Phailin

A severe cyclonic storm, Phailin had hit the coast of Odisha on 12 October, 2013. Three days ahead of the landfall of the cyclone, ESSO-INCOIS started issuing warnings about the possibility of occurrence of very high waves (about 8.5 m) for the coast of Srikakulam district of Andhra Pradesh and the coastal districts (Ganjam, Puri and Jagatsingpur) of southern Odisha during its landfall on 12 October, 2013. The predicted wave heights compared very well with observations from a wave rider buoy, off Gopalpur, which was very close to the landfall point. ESSO-INCOIS also issued forecasts on the height of the storm surge and the extent of inland inundation based on the storm surge model predictions.

3.3 Ocean Mixing and Monsoon (OMM)-Pilot cruise

To increase the understanding of air-sea exchange and horizontal and vertical mixing in the upper ocean at different spatial and temporal scales in the Bay of Bengal, a joint research programme, OMM-ASIRI, is being carried out with active collaboration between MoES and different government agencies of the United States of America. Under the OMM-ASIRI programme, joint research

cruises were conducted during November, 2013 to study the lateral and vertical gradients of temperature, salinity and density in the upper waters of the Bay of Bengal. The Indian research vessel Sagar Nidhi and the US research vessel Roger Revelle participated in the field programme. Scientists from ESSO-INCOIS led this field campaign, during which, very fine scale near surface thermohaline structure was observed using underway CTD (uCTD), wire walker (WW), chi-pod, bow chain, glider, ship mounted ADCPs, automatic weather stations (AWS) and thermosalinograph (TS graph).

3.4 Establishment of GNSS & Strong Motion network in A&N Islands

In order to establish GNSS & Strong Motion network in Andaman & Nicobar (A&N) Islands, ESSO-INCOIS started the installation of co-located Strong Motion Accelerometers, GNSS receivers and meteorological sensors with real-time VSAT connectivity at 35 locations in A&N Islands. The project is very significant as the A&N Islands are very close to the subduction zone and hence there is a possibility of a near source tsunami, leaving a very small response time for tsunami warnings.

3.5 Tsunami warning during the earthquake in Pakistan on 24 September 2013

An earthquake of magnitude 7.6 Mw (mB) occurred in Pakistan on 24 September, 2013 at 1659 IST (24 September, 2013 at 1129 UTC). The earthquake happened about 180 km away from the coast (epicentre at 26.99° N and 65.52° E at a focal depth of 10 km). Indian Tsunami Early Warning Centre (ITEWC) issued two bulletins for the event indicating that a tsunami threat did not exist for India and for the Indian Ocean rim countries. However, the Indian tsunami buoys (STB02 and TB12) and about 8 sea level gauges on the coast of India, Iran and Oman showed an open ocean tsunami wave of 9-11 mm height and a coastal tsunami of 2-55 cm. Using backward ray tracing techniques, it was established that underwater landslides or land movements off the coast of Iran-Pakistan triggered by the earthquake had caused the tsunami.

3.6 Early warning for storm surges

ESSO-INCOIS started a new service to provide early warning for storm surges during the passage of cyclones from May 2013. The ADCIRC (ADvanced CIRCulation) storm surge model was used to provide experimental storm surge and associated inundation forecasts for cyclones that occurred in 2013. Experimental forecasts for the cyclones Mahasen (12-14 May 2013), Phailin (9-13 October 2013), Helen (19-21 November 2013), Lehar (23-28 November 2013) and

Madi (6-11 December 2013) were issued. The predicted surge values were compared with reports from the India Meteorological Department (IMD) as well as with available observations. Inland extent of inundation values for the Phailin event were validated with a post storm survey conducted by ESSO-INCOIS and the ICMAM team.

3.7 Sea state forecasts for ports and harbours

ESSO-INCOIS has developed a new customized daily sea state forecasts service for ports (up to a distance of 50 km from the shoreline) wherein three-hourly sea state forecasts information will be given for the forthcoming two days. A web based service to disseminate customized sea state forecasts for ports and harbours was inaugurated by Commander M. A. Talha, DIG, Indian Coast Guard during the Fourth User Interaction Workshop, held at ESSO-INCOIS on 25 February, 2014.

3.8 High-resolution Operational Ocean Forecast and reanalysis System

Setting up a series of very high resolution numerical ocean models for the operational prediction of coastal ocean parameters is planned under the High resolution Operational Ocean Forecast and reanalysis System (HOOFS) project, which is being implemented during the 12th five year plan period. As a first step, a very high resolution (approximately 2.25 km x 2.25 km) setup of the Regional Ocean Modeling System (ROMS) was implemented for the domain 65° E - 78° E; 8° N - 26° N, covering the west coast of India. It was found that this new high resolution coastal setup of ROMS performs very well in simulating circulation features observed by ADCP. The model setup is now ready for experimental predictions.

3.9 Ecosystem model for the Indian Ocean

As a first step to build the capability in ecosystem modeling, a biogeochemical model based on ROMS, at a horizontal resolution of $1/4^\circ \times 1/4^\circ$ was set up for the Indian Ocean domain. The comparison between satellite-derived ocean colour images and model simulated chlorophyll demonstrates that the model could capture the annual cycle as well as the spatial distribution of the sea surface chlorophyll distribution very well. The model also simulated the presence and characteristics of oxygen minimum zone (OMZ) climatology in the Arabian Sea and Bay of Bengal with reasonable accuracy.

3.10 Value added services based on INCOIS-GODAS

A few new value added products derived from the ocean analysis generated by INCOIS-GODAS were made available to the users. Monthly averaged SST, SST anomaly and Oceanic Nino Indices (ONI) for monitoring the evolution of ENSO events in the Pacific Ocean and the global and regional maps of Tropical Cyclone Heat Potential (TCHP), which is considered to be one of the important parameters for the intensification of the tropical cyclones are a few among these. All this information is disseminated through the ESSO-INCOIS FTP server to targeted users.

3.11 Enhanced Computer Storage Facility

With a view to accommodate the growing storage needs of various operational and R&D projects at ESSO-INCOIS, centralised storage of 300 TB capacity with backup was installed and commissioned.

3.12 Coastal Multi-hazard Vulnerability Mapping

Multi-hazard Vulnerability Mapping (MHVM) along the Indian coast had been carried out using the historical extreme water levels (from tide gauge records and historical events from the published literature), historical shoreline change, sea level change and high resolution topographic data. After careful corrections, synthesis and extensive GIS analyses the multi-hazard vulnerability maps were finalized for the Indian mainland where the topographic data is available. Preparation of 929 maps on 1:25000 scale, covering the coasts of Indian mainland spread over 42319 km² was completed. These maps are very useful tools for disaster management. Highly vulnerable areas were identified from MHVM in the coastal zone between Kochi and Paradeep for further detailed mapping.

4. Services

4.1 Indian Tsunami Early Warning Centre (ITEWC)

Indian Tsunami Early Warning Centre (ITEWC) monitored 50 earthquakes of magnitude ≥ 6.5 during the period 1 April, 2013 to 31 March, 2014. Out of these high magnitude earthquakes, 7 earthquakes occurred in the Indian Ocean region. ITEWC assessed the situation carefully during each of the earthquakes in the Indian Ocean. In all cases, ITEWC had declared that there would not be any tsunami threat for India due to those earthquakes. Being the Regional Tsunami Service Provider (RTSP), the earthquake bulletins were also sent to Indian Ocean rim countries and IOC through emails, GTS, FAX and SMS.

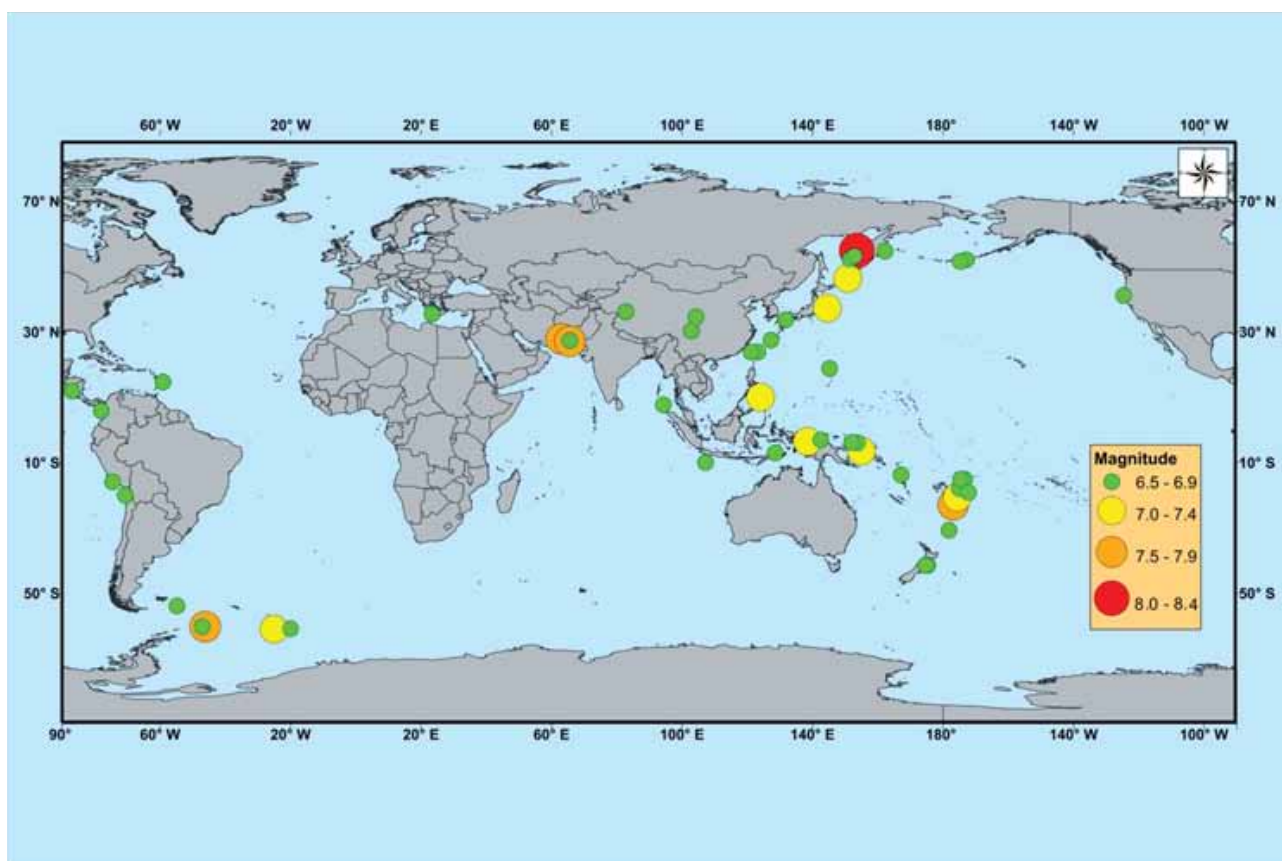


Fig. 4.1 Locations of earthquakes with magnitude ≥ 6.5 during the period April 2013 to March 2014.

4.1.1 Pakistan earthquake on 24 September, 2013

An earthquake of magnitude 7.6 Mw(mB) occurred in Pakistan on 24 September, 2013 at 1659 IST, (24 September, 2013 at 1129 UTC). The earthquake happened about 180 km away from the nearest coast (epicentre at 26.99° N and 65.52° E at a focal depth of 10 km). ITEWC issued two bulletins for the event indicating that tsunami threat did not exist for India and the Indian Ocean rim countries. However, later the Indian tsunami buoys (STB02 and TB12) and about

8 sea level gauges on the coast of India, Iran and Oman showed an open ocean tsunami wave of 9 -11 mm and coastal tsunami of 2-55 cm, perhaps due to the motions/landslide in the sea that followed the large earthquake on land. Using backward ray tracing techniques, it was established that underwater landslides or land movements triggered by the earthquake off the Iran-Pakistan coast had caused the tsunami.

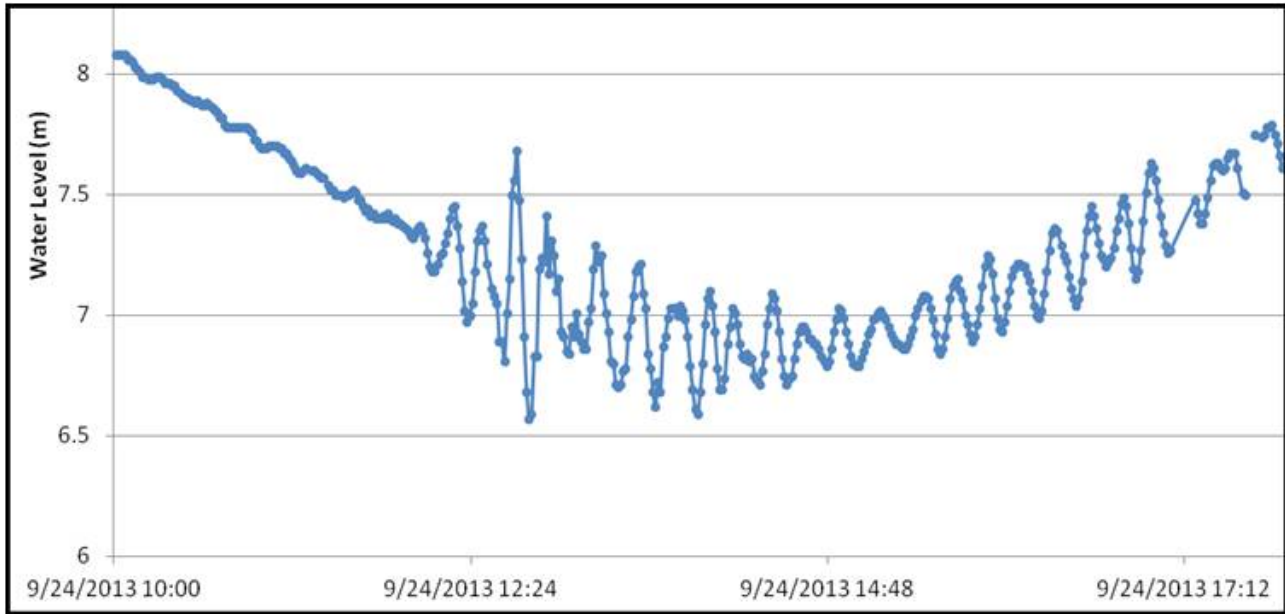


Fig. 4.2 Tide gauge data from Qurayat, Oman, depicting the Tsunami following the 7.6 Mw earthquake in Pakistan on 24 September, 2013.

Since the earthquake had occurred 180 km inland from the coast of Pakistan, ITEWC had issued 'No threat' for India & Indian Ocean rim countries. The observed sea-level variations are given in the table below.

Table: 4.1 Observations at various tide gauges and tsunami buoys installed in the Arabian Sea showing water-level variations due to the minor tsunami generated by the earthquake occurred on 24 September, 2013 in Pakistan

S. No.	Station name (Country)	Latitude (°N)	Longitude (°E)	Observed time of 1 st arrival (UTC)	Observed maximum wave height (cm)
1	Qurayat (Oman)	23.26	58.92	1205	57
2	Muscat (Oman)	23.633	58.566	1206	22
3	Suro (Oman)	22.57	59.59	1208	20
4	STB02 (India)	20.80	65.34	1225	1.0
5	Chabahar (Iran)	25.29	60.60	1240	19
6	ITB12 (India)	20.18	67.65	1255	1.1
7	Khawr Wudam (Oman)	23.82	57.52	1314	11
8	Diba (Oman)	25.64	56.26	1345	08
9	Jask (Iran)	25.63	57.77	1412	06
10	Okha (India)	22.46	69.08	1712	02

4.1.2 Performance of ITEWC as Regional Tsunami Advisory Service Provider (RTSP) for Indian Ocean

Being one of the regional tsunami advisory service providers for the Indian Ocean, Indian Tsunami Warning Centre is responsible for providing earthquake information supplemented by model outputs to the Indian Ocean Rim countries. Hence, the earthquake bulletins for all the 50 earthquakes monitored by ITEWC in the past one year were sent by email, GTS, fax and SMS to the national tsunami warning centres as well as to other regional tsunami service providers. Statistics depicting the performance of ITEWC on this regard is listed below:

Table:4.2 Performance indicators of ITEWC

S. No	Parameter	Targets	Performance
1	Elapse time from EQ to initial EQ info issuance (local/distant)	10/15 min	9.8 minutes
2	Probability of detection of IO EQ with Mw ≥ 6.5	100 %	Achieved
3	Accuracy of hypocentre location	within 30 km	17.28 km
4	Accuracy of hypocentre depth	within 25 km	5.0 km
5	Accuracy of earthquake Mw magnitude	0.3	0.12
6	Reliability of RTWP operations (power, computer, communications)	99.5%	Achieved
7	Contact information updated & quarterly communication tests		COMMs test, held on 12 June and 11 December, 2013

4.1.3 Communication Test (COMM Test)

ITEWC conducted two communications (COMM) tests, one on 12 June, 2013 and another on 11 December, 2013. The tests were aimed to validate the communication lines used for the effective functioning of ITEWC. During these tests, dissemination process of bulletins by the RTSPs to various National Tsunami Warning Centres (NTWC), the dissemination processes for tsunami notification messages to national disaster management contacts, reception of the notification messages by NTWCs and the access to RTSP password-protected web sites by NTWCs were tested.

Fifty institutions/organizations (MHA, NDMA, NDRF, coastal state disaster relief commissioners, Indian Navy & Coast Guard, Ports & Harbour, Disaster Management Administrators from Andaman & Nicobar Islands and coastal strategic installations like the nuclear power plants, thermal power plants etc) participated in the COMM test conducted on 12 June, 2013. The COMM test conducted on 11 December, 2013 was primarily to validate the communication links to RTSP and NTWC contacts. ITEWC disseminated notification messages to 23 NTWCs and other RTSPs (Australia &

Indonesia) in the Indian Ocean and also received the notification messages from other RTSPs of Indian Ocean Region. During the tests tsunami notifications were disseminated to contacts through email, fax, GTS, SMS as well as the ESSO-INCOIS website.

Together with the Directorate of Disaster Management (DDM) and Andaman & Nicobar administration, ITEWC conducted a specific COMM test and mock drill for the Andaman & Nicobar Islands on 20 November and 22 November, 2013. Eleven villages of Andaman and Nicobar Islands participated in the mock drill.



Fig. 4.3 Scientists engaged in issuing tsunami bulletins during COMM test on 12 June, 2013.

4.1.4 Early warning for storm surges

During the FY 2013-14, ESSO-INCOIS started a new service to provide early warnings on storm surge during the passage of cyclones. ADCIRC (ADvanced CIRCulation) storm surge model was used to give experimental storm surge and associated inundation forecasts for the cyclones that occurred in 2013. Experimental forecasts for the cyclones Mahasen (12-14 May 2013),



Fig. 4.4 Storm surge heights predicted by the model and its associated inland extent of inundation for VSCS Phailin based on the track predicted by IMD at 1500 IST of 12 October, 2013.

Phailin (9-13 October 2013), Helen (19-21 November 2013), Lehar (23-28 November 2013) and Madi (6-11 December 2013) were issued. The predicted surge values were compared with India Meteorological Department (IMD) reports as well as with available observations. Inland extent of inundation values for the Phailin event were validated with a post storm survey conducted by ESSO-INCOIS and the ICMAM team.

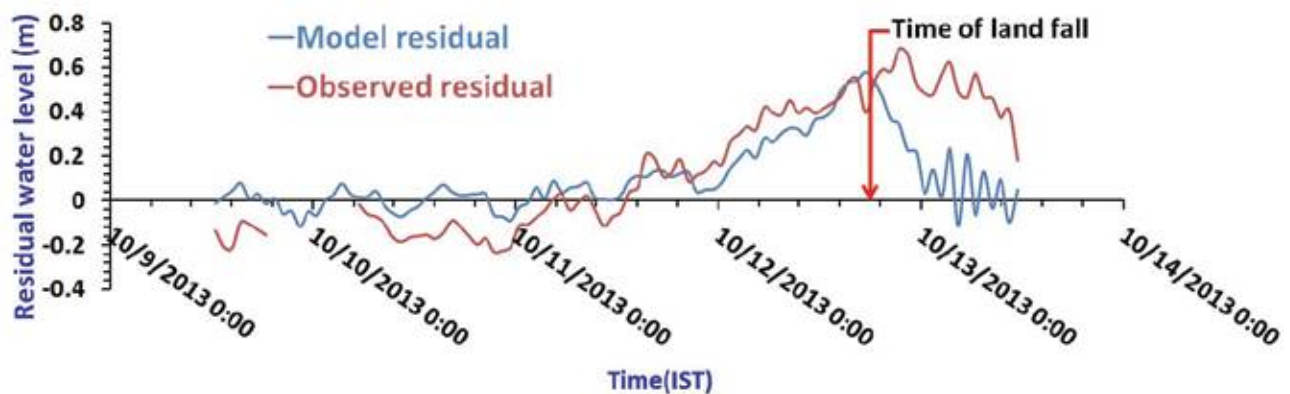


Fig. 4.5 Comparison of model estimated residual water level (based on the track forecasted by IMD at 1500 IST for 12th October, 2013) with the residual water level recorded by a tide gauge at Paradeep (nearest tide gauge to the landfall point). Note that Paradeep is about 220 km north of landfall point

4.2 Ocean State Forecast

ESSO-INCOIS continued to provide ocean state forecasts, on a daily basis, to a wide spectrum of users. ESSO-INCOIS also issued high wave alerts to coastal regions when the predicted wave/swell height exceeded 3 m within 100 km distance from the shoreline.

4.2.1 Sea-state forecasting during the passage of cyclone Phailin

ESSO-INCOIS issued timely and accurate sea state forecasts during the passage of the very severe cyclone Phailin that made landfall on the Odisha coast at 0900 IST on 12 October, 2013. As early as three days ahead of the landfall of the cyclone, ESSO-INCOIS had issued warnings about the possibility of occurrence of very high waves (upto 8.5 m) along the coast of Srikakulam district of Andhra Pradesh and the coastal districts in southern Odisha (Ganjam, Puri and Jagatsingpur) during its landfall. The predicted wave heights compared very well with the observations from a wave rider buoy, off Gopalpur which is close to the landfall point.

Starting from 10 October, 2013 high-wave alerts were posted on the ESSO-INCOIS website and also disseminated through e-mail, SMS, radio, TV, newspapers, telephone, etc. This helped in cautioning the public about the impending high waves, high winds and strong currents along Odisha, Andhra Pradesh and West Bengal coasts.

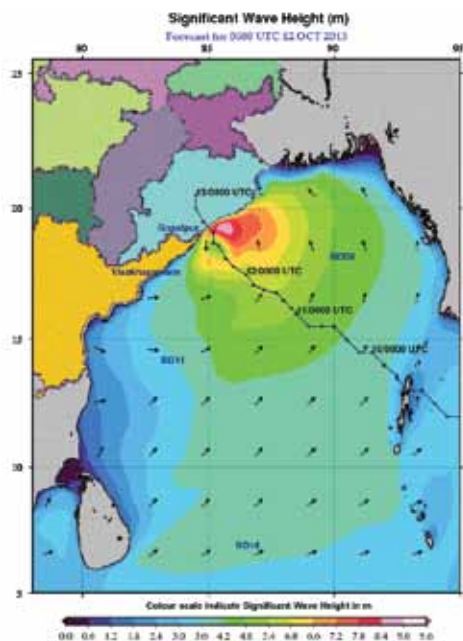


Fig. 4.6 Wave height and direction predicted at 16:00 IST on 11 October 2013 by ESSO-INCOIS for 11:30 IST on 12 October, 2013.

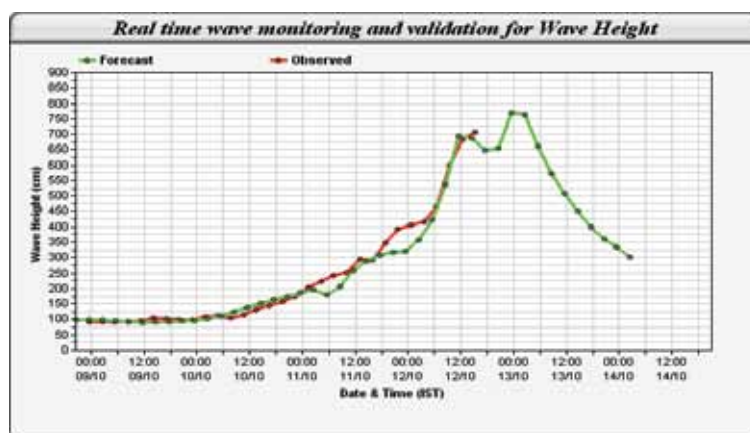


Fig. 4.7 Predicted and observed wave heights off Gopalpur during the passage of cyclone 'Phailin'.

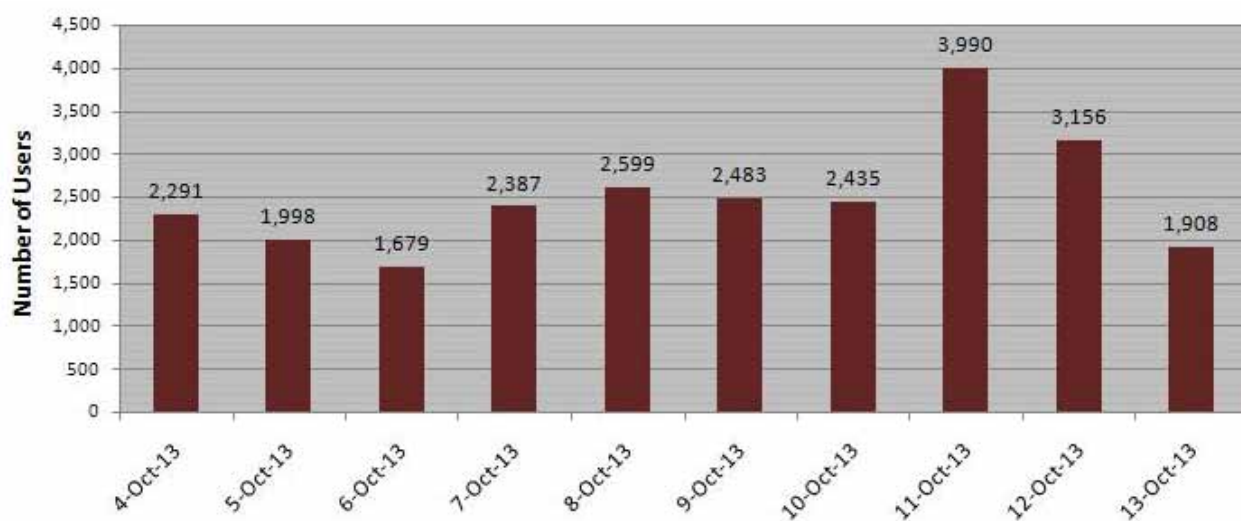


Fig. 4.8 The number of users that accessed ESSO-INCOIS/INDOFOS web page during the cyclone 'Phailin'.

ESSO-INCOIS also issued high-wave alerts during the cyclones Helen, Lahar, and Mandi which affected the coasts of Andhra Pradesh and Tamil Nadu during 18-22 November, 24 – 28 November and 7-11 December, 2013, respectively.

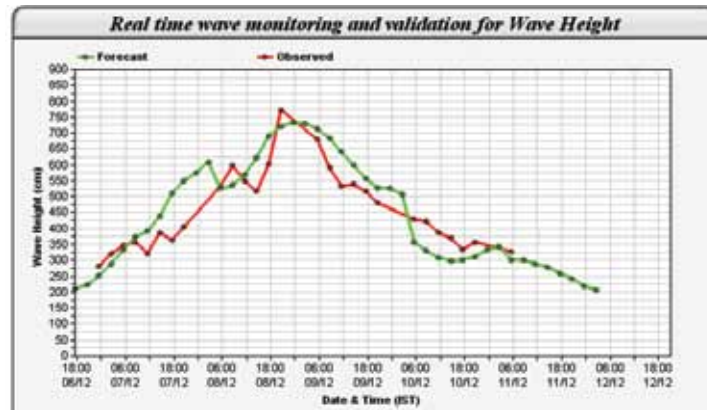


Fig. 4.9 Predicted and observed wave heights at the location of the buoy BD11 (13.49° N, 83.98° E) during the passage of Madi cyclone.

4.2.2 Sea state forecasts for ports and harbours

ESSO-INCOIS developed a new customized daily sea-state forecast service for ports (up to a distance of 50 km from the shoreline) wherein three-hourly forecast information will be given for the forthcoming two days. A web based service to disseminate customized sea state forecasts for ports and harbours was inaugurated by Commander M. A. Thalha, DIG, Indian Coast Guard during the Fourth User Interaction Workshop, held at ESSO-INCOIS on 25 February, 2014.

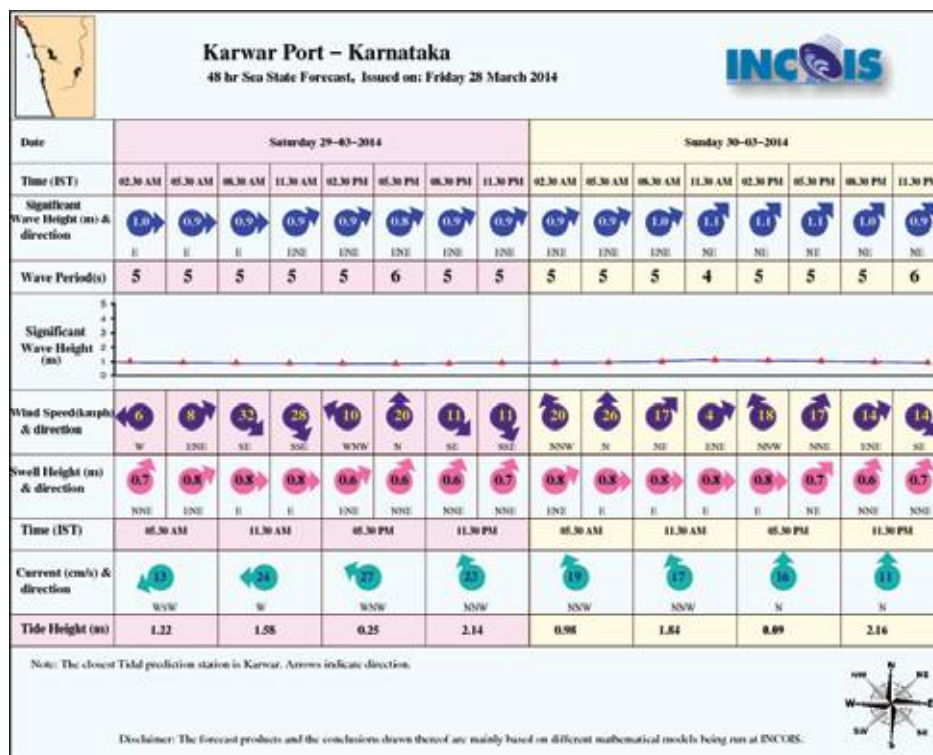


Fig. 4.10 Sea state forecasts for Karwar port.

4.2.3 Validation of predicted wave heights along ship routes

ESSO-INCOIS is providing ocean state forecasts along ship-routes since May, 2012. The predicted wave heights were compared with the Wave Height Meter (WHM), on board ORV Sagar Nidhi and also with the wave heights estimated from the satellite based altimeters on board Cryosat 2, Jason-1 and Jason-2 satellites.

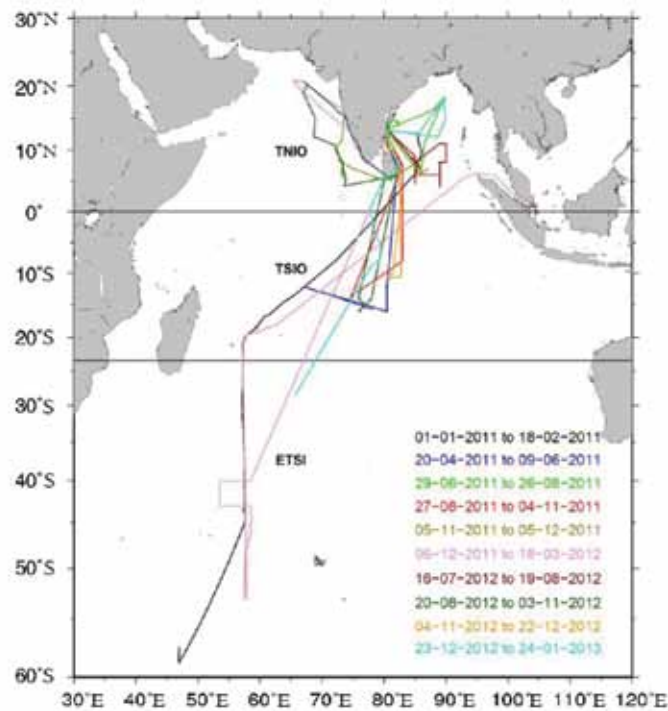


Fig. 4.11 Tracks of ORV Sagar Nidhi along which the wave-height metre data are available.

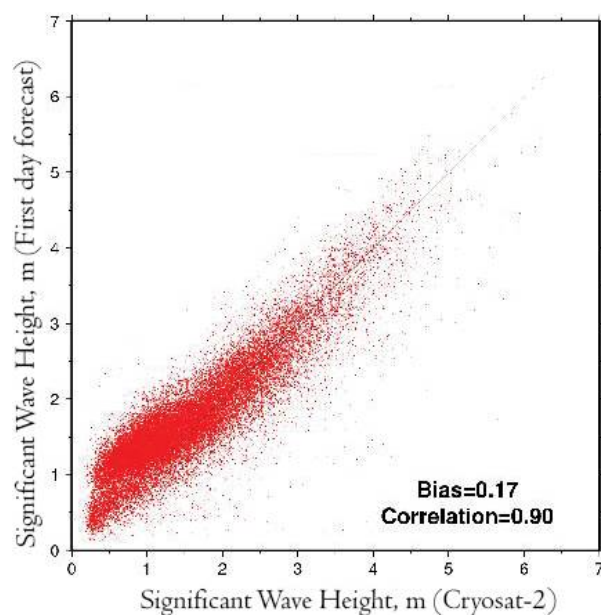


Fig. 4.12 Scatter plot showing the comparison between the predicted significant wave height along the ship routes and the significant wave heights estimated from Cryosat-2 satellite passes over the tropical northern Indian Ocean.

4.2.4 Offshore wind potential assessment based on observational data

During 2012-13, ESSO-INCOIS had assessed the wind energy potential using QuickSCAT and buoy wind estimates at an oil platform in Bombay High south oil field. Later, a Real-time Automatic Weather Station (I-RAWS) was installed by ESSO-INCOIS on the oil platform at a height of 67 m from the mean sea level (MSL). This data was used to reassess the wind energy potential.

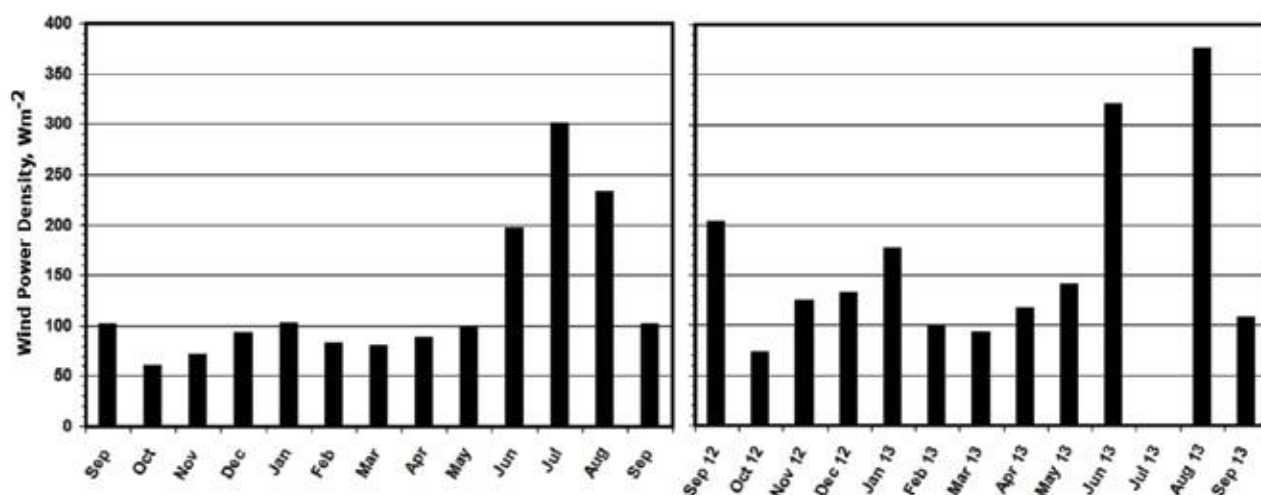


Fig. 4.13 Wind potential in terms of Wind Power Density (WPD) for the BHS oilfield complex using the 10 year climatology based on QuickSCAT wind (left) and I-RAWS for the period September 2012 to September 2013 (right) at a height of 67 m from MSL in Mumbai High.

4.2.5 Search and rescue operations for MV Bingo, which sank on 12 October 2013 at 13:10 IST

A cargo vessel named MV Bingo sank in the vicinity of Sagar island in the northern Bay of Bengal on 12 October, 2013 in the wake of the very severe cyclone Phailin. The Indian coast guard sought the help of ESSO-INCOIS to locate the personnel who left the ship in a life raft on 13 October, 2013 at 09:17 IST. Accordingly, the trajectory from the last known position (21° 13.9' N, 088° 11.6' E; off Sagar Island) of MV BINGO was generated using GNOME which was forced with INDOFOS currents and ECMWF winds. The predicted trajectory was found to be moving towards the coast. This information was sent to the Indian Coast Guard which helped them locate the beached life raft near Digga Mohan at 21°38'20.1" N, 87° 31'8.5" E (which was within 3.5 km of the predicted location). The timely and accurate prediction of the likely path of the raft helped the Indian Coast Guard to carry out search and rescue operations faster and efficiently.

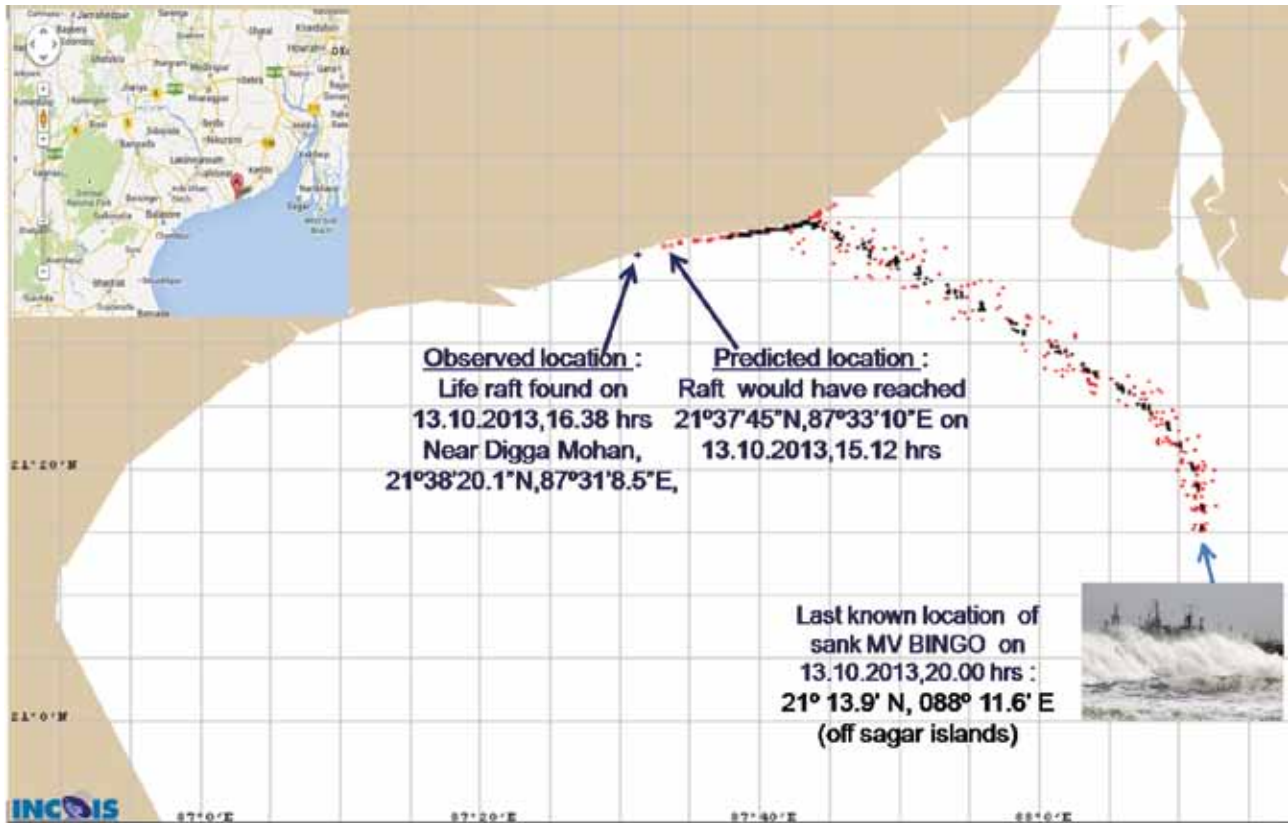
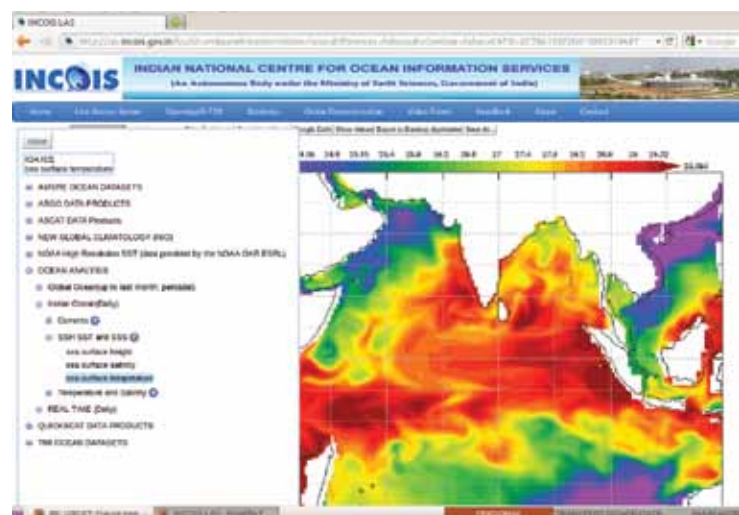


Fig. 4.14 Predicted path for the search and rescue of life raft left MV Bingo, that sank off Sagar Island on 12 October, 2013 - Black dots indicate the output of best estimate and red dots indicate the output with 10 % uncertainty.

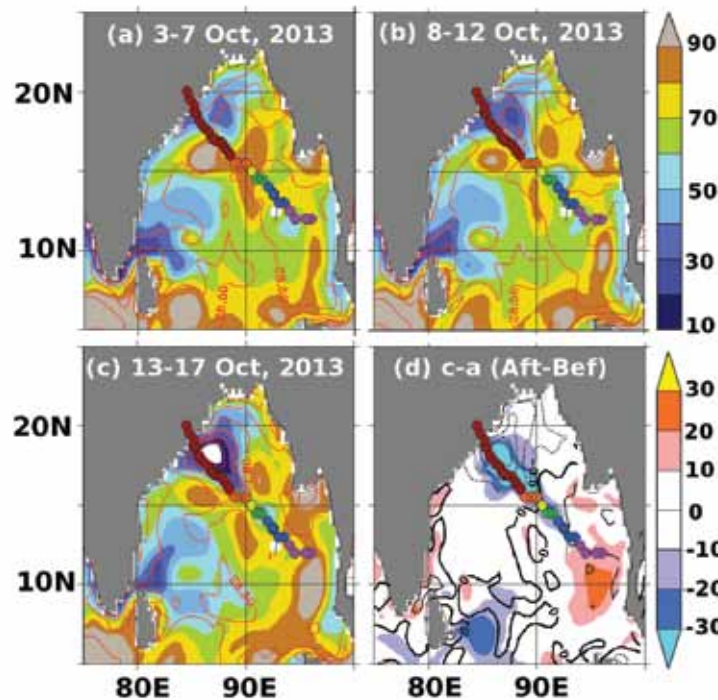
4.3 Ocean analysis using INCOIS-GODAS

ESSO-INCOIS continued to generate and provide the analysed fields of ocean parameters (SST, SSH, temperature, salinity and ocean currents) on a daily basis using the ESSO-INCOIS setup of the Global Ocean Data Assimilation System (GODAS). The system assimilates the profile of temperature and salinity, that qualify the predefined quality checks, using a 3D-VAR scheme. The SST anomaly, monthly averaged SST and Oceanic Nino Indices (ONI) derived from INCOIS-GODAS data helps to monitor the evolution of the ENSO event in the Pacific Ocean. Global and regional maps of Tropical Cyclone Heat Potential (TCHP) are also prepared from the data from INCOIS-GODAS.



4.15 Snapshot of the content of INCOIS-GODAS LAS server.

All these products are disseminated through the ESSO-INCOIS FTP server to targeted users.



4.16 Spatial distribution of TCHP (KJ cm^{-2} ; shaded) and SST ($^{\circ}\text{C}$; contour), in the Bay of Bengal (BoB), (a) before, (b) during and (c) after the Phailin cyclone event, as simulated by INCOIS-GODAS. Difference between "c" and "a, for the parameters TCHP (shaded) and SST (contoured) are shown in the panel "d".

4.4 Marine Fishery Advisory Services

4.4.1. Potential Fishing Zone Advisories

Being one of the flagship programmes of ESSO-INCOIS, all efforts were made to ensure that the multi-lingual Potential Fishing Zone (PFZ) advisories reach the fishing community well in time. ESSO-INCOIS could meet the target of 250 PFZ advisories for the FY 2013-14. As a step to safeguard the fishermen from potential threat to life due to rough seas, PFZ advisories were not sent to the sectors for which high wave alerts had been issued. Another improvement brought in to meet the user-demand, was to overlay surface current vectors (replacing wind vectors earlier) on the PFZ maps. For better readability by users, EEZ and district boundaries of coastal states were also included in these maps. From 1 January, 2014, ESSO-INCOIS has started generation and dissemination of advisories everyday, including Sundays.

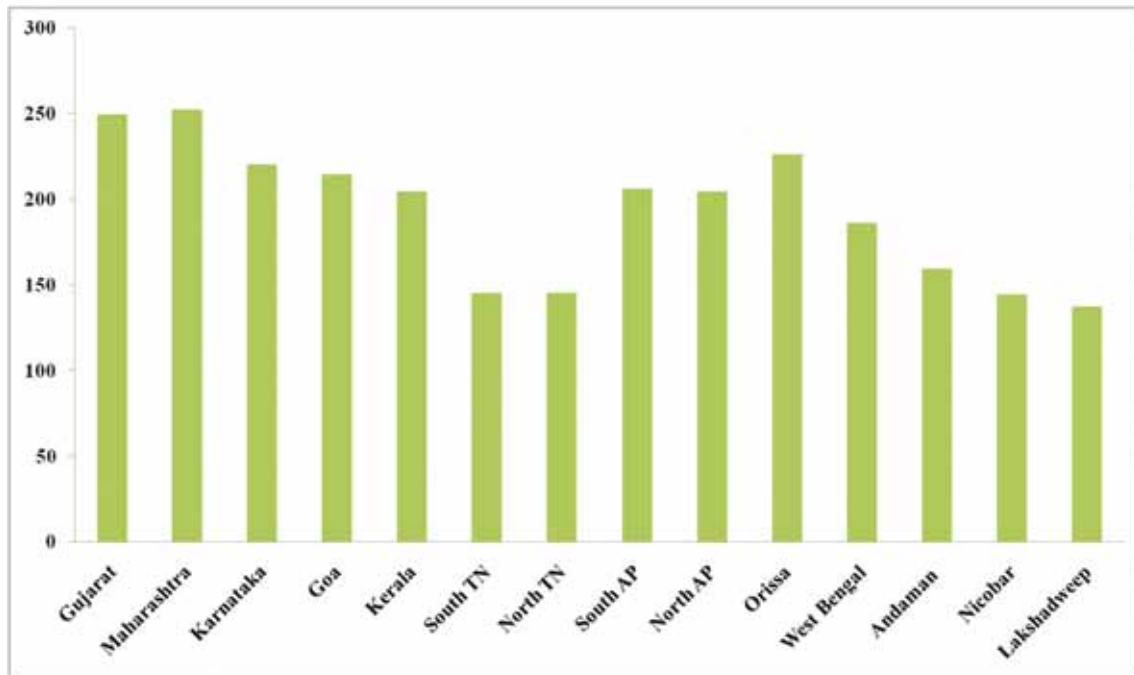


Fig. 4.17 Number of PFZ Advisories disseminated during April 2013-March 2014.

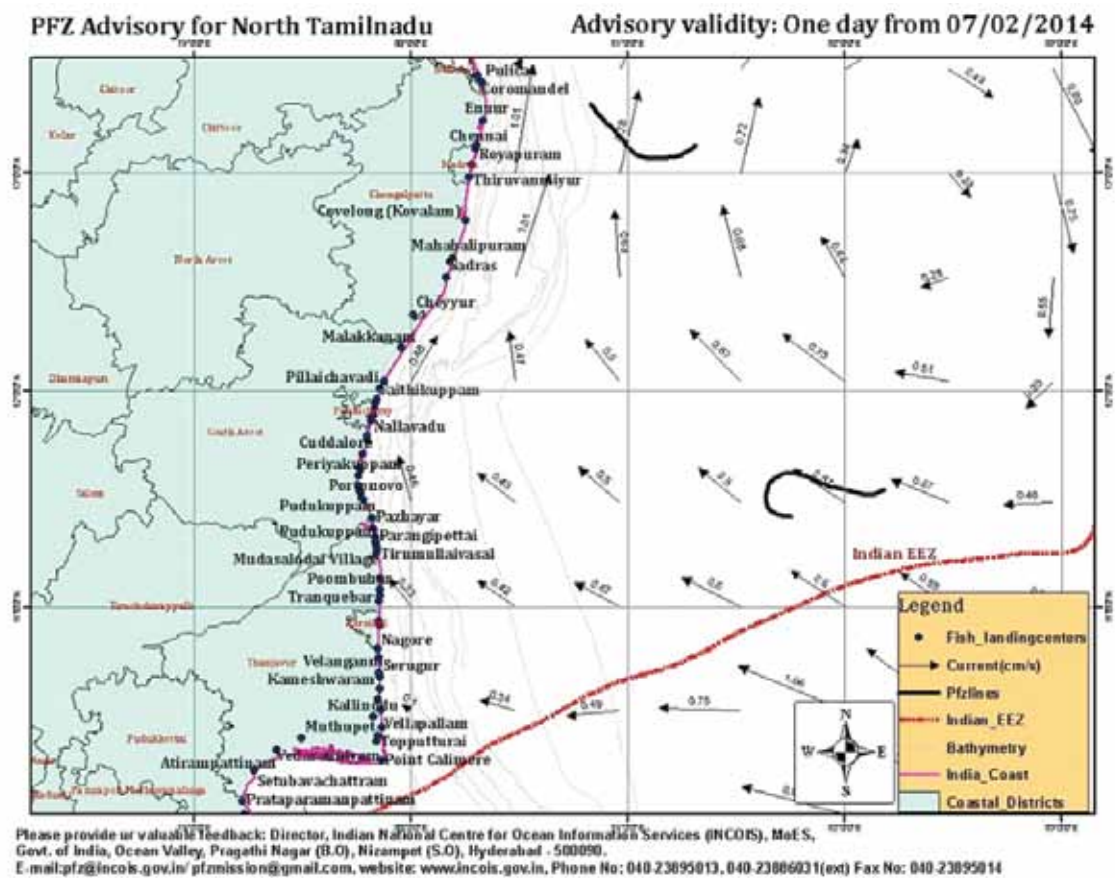


Fig. 4.18 A sample PFZ advisory map issued by ESSO-INCOIS.

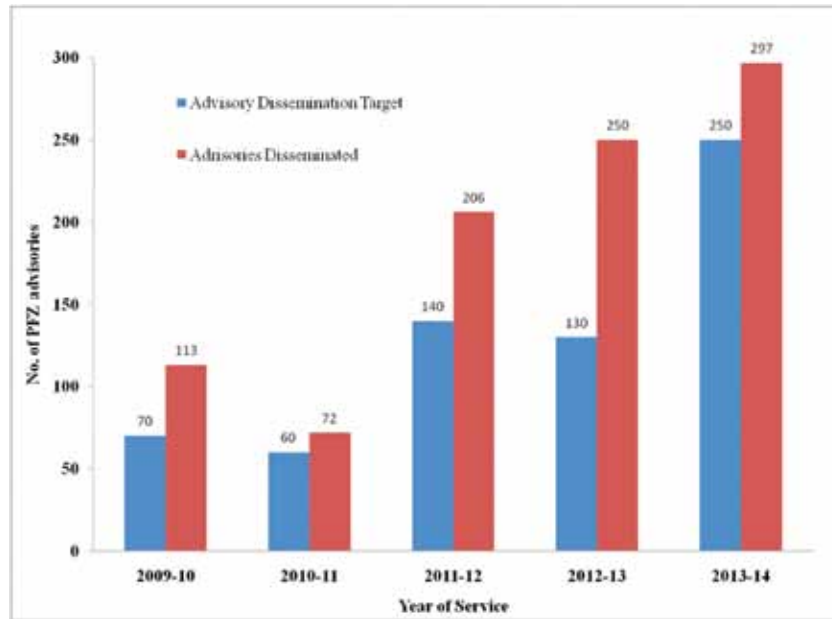


Fig. 4.19 Number of PFZ Advisories disseminated against the target.

4.4.2 PFZ Frequency Density analysis

A study was undertaken to understand the distribution of PFZs within the Indian EEZ for the period 2002-2013. This study quantified the probability for a grid-box of dimension 25 x 25 km to have PFZs for any given day and the average length of each of the features respective to the grid-box. The analysis of distribution of PFZ density suggested that productive features tend to occur in high numbers over the continental shelf. However, in some regions in the open ocean, recurring episodes of large features such as eddies and blooms also contributed to high frequency occurrences of PFZs.

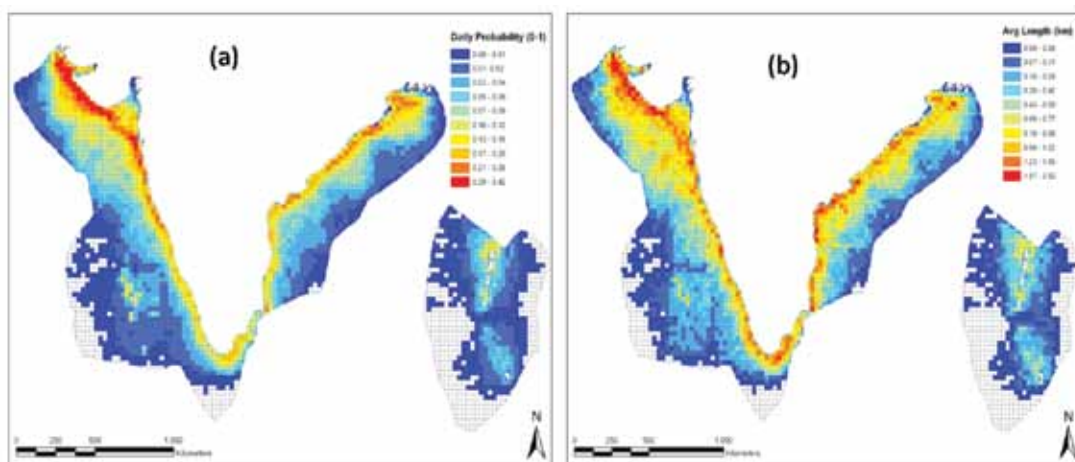


Fig. 4.20 Map showing (a) probability of a grid-box getting a PFZ at any given day and (b) average length (km) of PFZ feature for respective grid-box.

4.4.3 Tuna fishery advisories

ESSO-INCOIS continued to provide multi-lingual Tuna fishery advisories based on satellite derived Sea Surface Temperature, Chlorophyll and Kd490 (water clarity) data. Tuna advisories are now being provided on a daily basis via email and through the ESSO-INCOIS website from 1 January, 2014. As requested by fishermen, an improved version of Tuna advisory maps containing surface currents (as arrows), mixed layer depth (as background raster) and depth of 20°C isotherm (as a contour) was also made available since March, 2014. Tuna advisories are not disseminated to regions which are issued high wave alerts by ESSO-INCOIS.

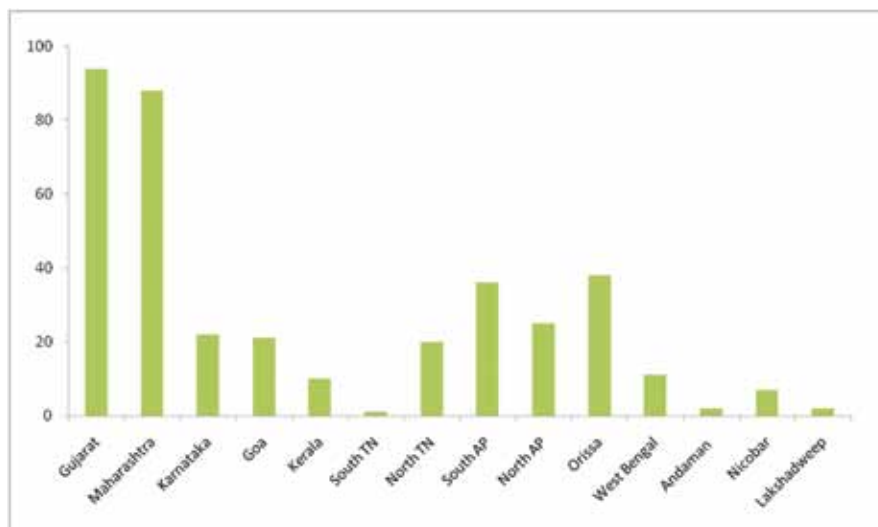


Fig. 4.21 Number of Tuna PFZ Advisories disseminated during April 2013-March 2014.

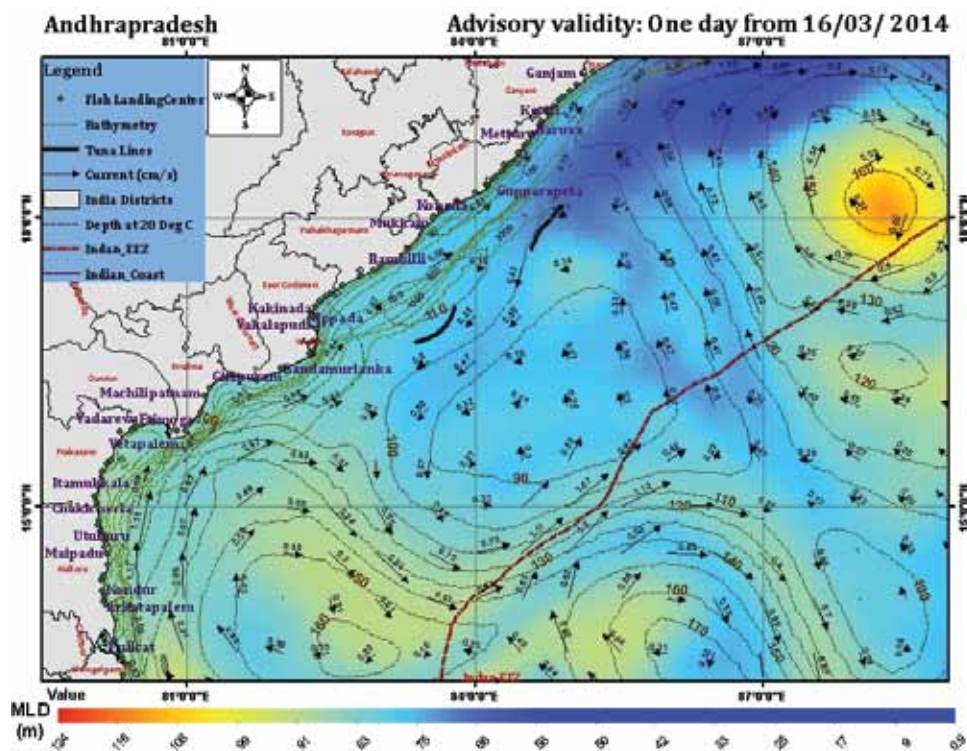


Fig. 4.22 Tuna advisory map as disseminated by ESSO-INCOIS.

4.4.4 SAtellite Telemetry of TUNA in Indian seas (SATTUNA)

During the fishing season of 2013-14, 7 Yellowfin tuna (*Thunnus albacares*) were tagged under the multi-institutional SATTUNA project, which is being implemented in collaboration with CMFRI and FSI. In order to understand tag retention and movement patterns, underwater migration routes of four Tuna were processed with Track-and-Loc Program at CLS, France. Further data analysis is being carried out at ESSO-INCOIS along with FSI and CMFRI scientists. Post pop-up temperature data were compared with remotely sensed SST and performance of the temperature sensor onboard tag was found in good agreement. The distance between tagging and pop-off locations averaged to about 200 km. This indicated that, on an average, the tuna moved up to 45 km per day.

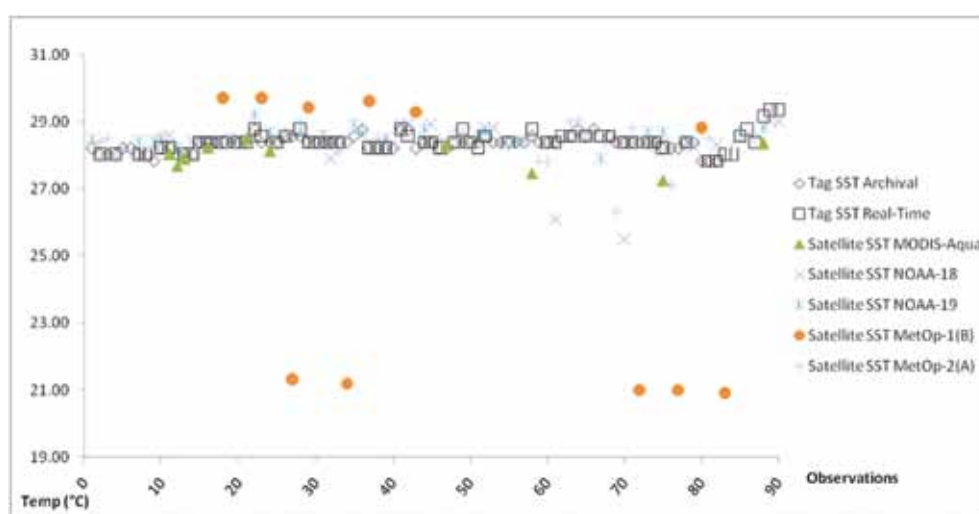


Fig. 4.23 Comparison of Sea Surface Temperatures recorded by a tag with satellite.

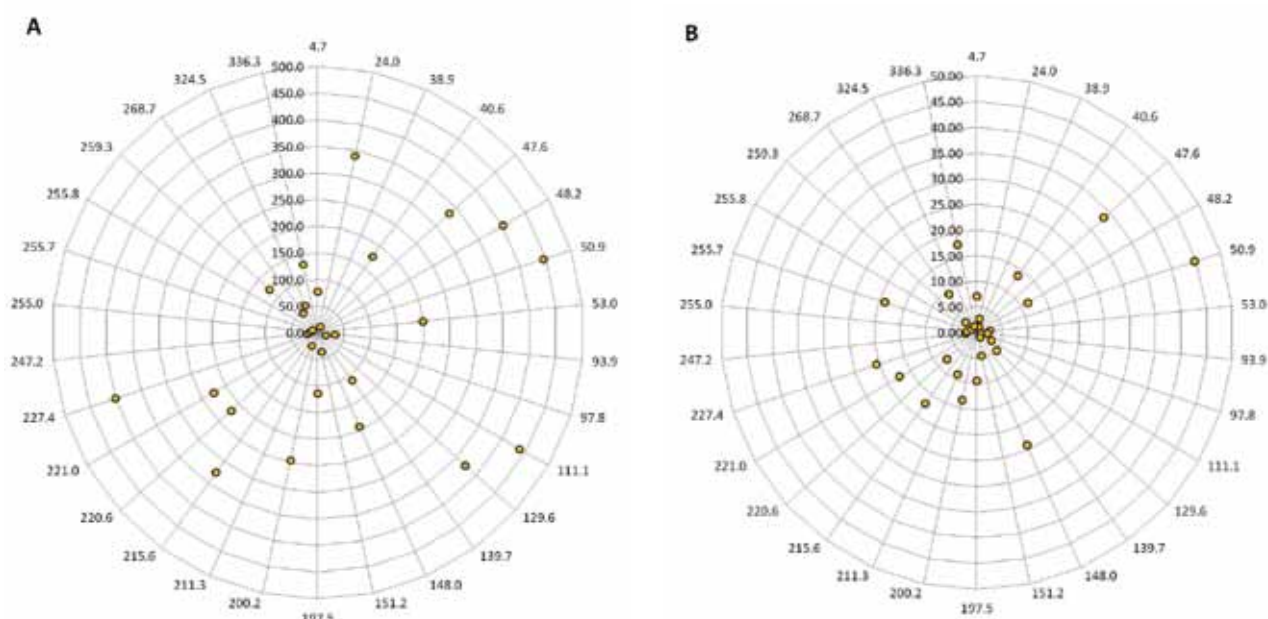


Fig. 4.24 Total (A) and daily (B) average direction of movement and minimum-distance (in km) covered by each Tuna.

4.4.5 Marine Fishery Advisory Services User-base

PFZ advisories are disseminated in a timely manner to the fisher community through a wide variety of modes such as mobile applications (mKRISHI, FFMA), voice messages / audio advisories, multi-lingual SMSs, Fishermen Help-line System (for Tamil Nadu, Andhra Pradesh, Odisha & Kerala), FM/AIR/community radios, etc. in addition to the traditional and existing modes of dissemination viz. telephone/fax, e-mail, web (including Web-GIS), electronic display boards and Doordarshan (DDSaptagiri). In order to reach out to more fisher folk, PFZ and OSF information are disseminated through a rural IVR service named 'Behtar Zindagi' on the short code "55678" and "556780", available for Airtel and Tata mobile service subscribers at pan India level and to Idea & Uninor mobile service subscribers in limited regions. About 8000 users have subscribed to this service. MoUs were also signed with M/s. Tata Consultancy Services (TCS) Ltd., Indian Farmers Fertiliser Cooperative Limited (IFFCO) and Kisan Sanchar Limited (IKSL) for the dissemination of Potential Fishing Zone (PFZ) advisories and Ocean State Forecast (OSF) information through mobiles / mobile applications. Another MoU was signed with Reliance Foundation for effective dissemination and awareness towards MFAS. Training was also provided to staff on "Indian Marine Fishery Advisory Services and Ocean State Forecast" on 26 February, 2014 at ESSO-INCOIS, Hyderabad.

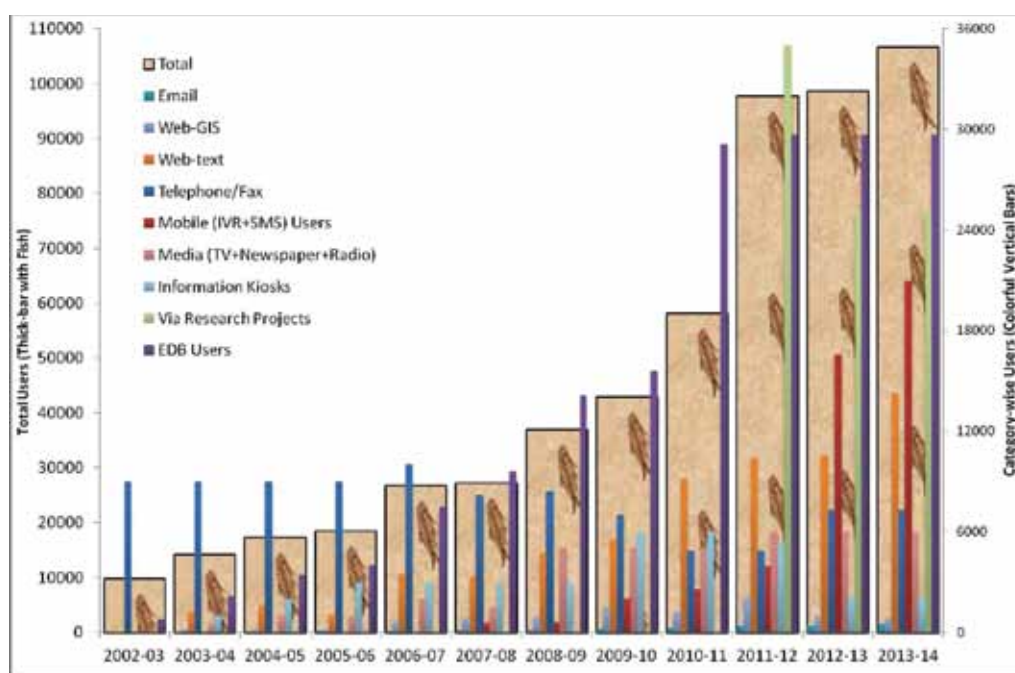


Fig. 4.25 Graph showing categorized estimates of PFZ beneficiaries.

4.5 Geospatial Services

4.5.1 Coastal Multi-hazard Vulnerability Mapping

Multi-hazard Vulnerability Mapping (MHVM) along the Indian Coast has been carried out using the historical extreme water levels (from tide gauge records and historical events from the published literature), historical shoreline change, sea level change and high resolution topographic data.

After careful corrections, synthesis and extensive GIS analyses, the multi-hazard vulnerability maps were finalized for the Indian mainland where the topographic data are available. The MHVM along coasts of the Indian mainland, covered in 929 maps on 1:25000 scale, spreads over an area of 42319 km². These maps are very useful tools for disaster management. Highly vulnerable areas were identified from MHVM in the coastal zone between Kochi and Paradeep. In the next phase, 3D GIS mapping on 1:10000 scale will be carried out in these selected vulnerable areas.

Table: 4.3 Area of MHVM recorded in each state and corresponding

1:25000 scale maps

State	Area (sq. km ²)	No of Maps	Length of Coast (km)*
Gujarat	7866	257	2308
Maharashtra	2206	88	940
Goa	222	16	177
Karnataka	324	32	326
Kerala	1701	72	623
Tamil Nadu	5765	117	1025
Andhra Pradesh	8965	168	1073
Odisha	7554	100	496
West Bengal	7717	79	1927
Total	42319	929	8895

* Including the estuary and major creeks

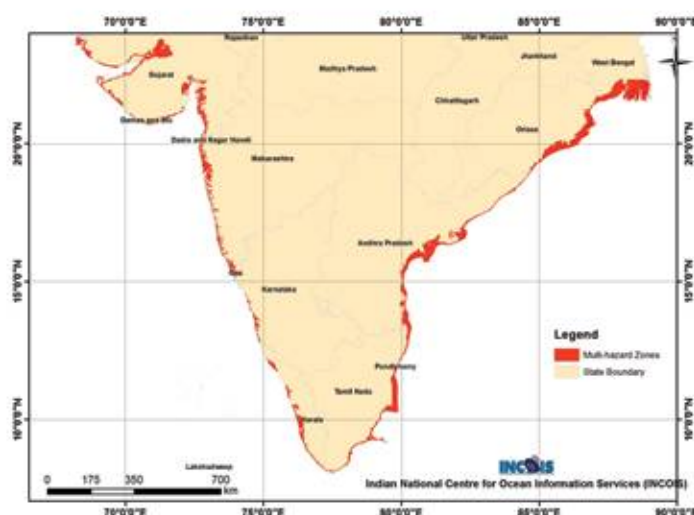


Fig. 4.26 Map showing the multi-hazard zones along the coast.

4.5.2 Coral Bleaching Alert system

ESSO-INCOIS continued to issue coral bleaching alerts in 2013-14 and 122 standard advisories were issued during this period. The advisories disseminated through the web service included information on hot spots, degree of heating weeks and time-series plots of SST anomaly on a bi-weekly basis. No warnings were recorded during this period.

4.6 Data Services

ESSO-INCOIS, designated as National Oceanographic Data Centre (NODC) by the International Oceanographic Data Exchange (IODE) programme of the Intergovernmental Oceanographic Commission (IOC), continued to serve as the central repository for oceanographic data in the country. Recently, ESSO-INCOIS has been identified as the Data Assembly Centre for the Geotraces-India programme also. While continuing to serve as the National Argo Data Centre and Argo Regional Data Centre for the Indian Ocean Region, ESSO-INCOIS is consistently improving the services of the data centre by strengthening the real-time data reception, processing, quality control of surface meteorological and oceanographic data from wide variety of ocean observing systems, such as Argo floats, moored buoys, drifting buoys, wave rider buoys, tide gauges, wave height meters, ship mounted autonomous weather stations and HF radar. ESSO-INCOIS also disseminated surface met-ocean data to various operational agencies in the country through email/web-site/ftp in near real time.

4.6.1 Ocean in situ data products

The data centre at ESSO-INCOIS obtained and archived the in situ data from the ocean observing systems [moored buoys (21), RAMA buoys (21), drifting buoys (9), ship mounted AWS (18), wave rider buoys (11) and HF Radar (5 pairs)]. The data centre also received data on XBT/XCTD, Met observations (NODPAC), OSCAT data (SAC), data from CTCZ programme through various agencies in delayed mode.

Table: 4.4 Details of the in situ data received during the FY 2013-14

Programme (Institute)	Parameters	No. of Platforms / Stations Reported	Status
Moored buoys (ESSO - NIOT)	Surface met-ocean parameters	21 buoys	Updated in the database
Drifting buoys (NIOT)	Surface met-ocean parameters	07 buoys	Updated in the database
Ship-mounted AWS (ESSO-INCOIS)	Met parameters	17 ships	Updated in the database
Wave rider buoys (ESSO-INCOIS)	Wave parameters	08 stations	Updated in the database
Wave Height Meter onboard ORV SN (ESSO-INCOIS)	Wave Parameters	1 ship	Updated in the database
HF RADAR (ESSO - NIOT)	Currents	5 pairs of stations	Updated in the database
RAMA buoys (PMEL)	Surface met-ocean parameters	21 buoys	Updated in the database

XBT, XCTD (NIO)	T Profiles	33 profiles	Archived
	T & S Profiles	47 profiles	Archived
Met Observations along Ship track (NODPAC)	Surface met parameters	Oct 2012 – Sep 2013	Archived
CTCZ (IMD, IITM, IISc, BIT, IAF, IIT Kharagpur, Indian Navy)	Satellite imageries, Satellite OLR, Tower Data, Met Ocean Data etc.	Monsoon 2012-13	Archived
SIBER	Bio-Geo-Chem-Phy parameters	Jan 2012 onwards	Archived
CTD (ESSO - CMLRE)	T & S Profiles	Aug 2008 – Oct 2011	QC performed

4.6.2 Ocean remote sensing data products

The remote sensing data from various sensors flown on board Oceansat-2, NOAA series of satellites, METOP, Terra and Aqua satellites were received in real time at the ground stations at ESSO-INCOIS and the processed data are made available for in-house operational activities as well as to other operational agencies in the country. All data thus received has been archived at the data centre.

Table: 4.5 Satellite data archived at ESSO-INCOIS

Sensor/satellite	Parameters	Period
NOAA-AVHRR	Sea Surface Temperature	2005 to till date
MODIS/Terra and Aqua	Sea surface temperature and chlorophyll (but several other atmospheric and ocean parameters can also be generated using the radiance data obtained from this sensor)	2005 to till date
OCM/Oceansat-2	Chlorophyll	2011 to till date
Altimeter/TOPEX	Wave height, sea level, sea ice	1996-2007
TMI/TRMM-TMI	SST, rainfall, wind speed	1997-2007
Quicksat	Wind vector	1998-2007
SeaWifs	Chlorophyll	1997-2005

4.6.3 Satellite derived SST validation

ESSO-INCOIS is generating operational AVHRR-SST (Metop-2, NOAA-18 & 19) products and providing these in real time to users. To enhance user confidence with the product, satellite derived SST was validated with in situ observations from moored buoys. The utility of SST global algorithms (e.g., Multi channel and Bernsteen etc.) in the North Indian Ocean during day and night were also examined. Nearly 15,000 co-located points spanning over the period 2005-2013 were analyzed.

4.6.4 Data from OMNI buoy network

High resolution in situ observations from moored ocean buoys deployed by ESSO-NIOT under the National Data Buoy Program (NDBP) in the Bay of Bengal and Arabian Sea are being received at ESSO-INCOIS in real time as well as in delayed mode. The observations from OMNI (Ocean Moored buoy Network for Northern Indian Ocean) buoys include upper ocean profiles of temperature, conductivity, currents, and wave parameters and surface wind, humidity, atmospheric pressure, temperature, rainfall and radiation. Real-time data, after standardized quality control checks, go into the database for archival, distribution and visualization. Data visualization and metadata information are available online from <http://www.odis.incois.gov.in/index.php/in-situ-data/moored-buoy/moored-data>.

Delayed-mode data, obtained directly from the sensors during servicing of the buoys are available in scientific analysis-friendly NetCDF format to users from October 2010 onwards.

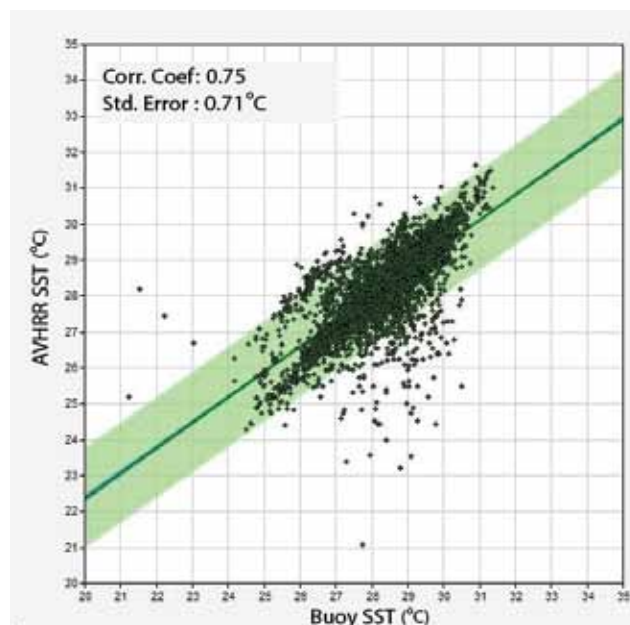


Fig. 4.27 Scatter plot of NOAA-19 AVHRR-SST and in situ SST during August 2005 to March 2014. In situ SST observations were obtained from the moored buoys in the North Indian Ocean.

Good quality high-resolution OMNI buoy data proved to be highly useful for the study of extreme events such as Tropical Cyclones (TC). For example, during TC Phailin (October 2013), OMNI buoys provided a crucial platform to observe environmental conditions accurately in real time. Phailin passed over the OMNI buoy BD10. Surface pressure dropped ~ 80 hPa, the oceanic surface layer cooled by $\sim 1^\circ\text{C}$ and salinity increased by ~ 2.5 psu. Similarly, BD13 in Bay of Bengal helped in documenting the ocean's responses due to another TC named Jal during November 2010.

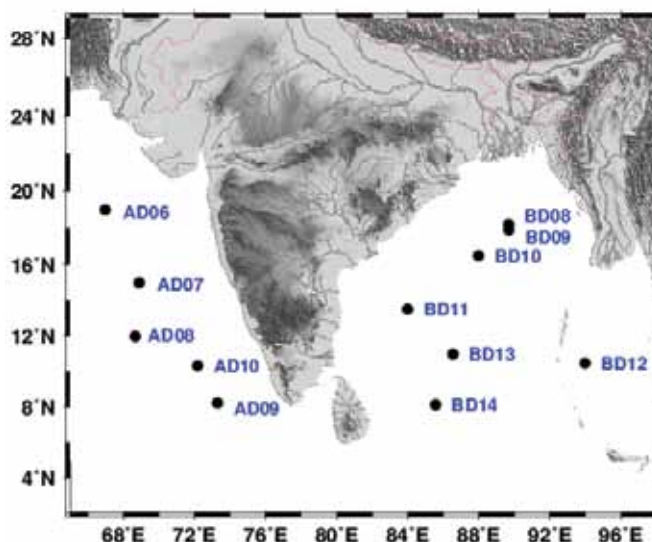


Fig. 4.28 OMNI buoy network in the northern Indian Ocean region. Twelve active buoys are transmitting high-quality real-time data from Arabian Sea and Bay of Bengal.

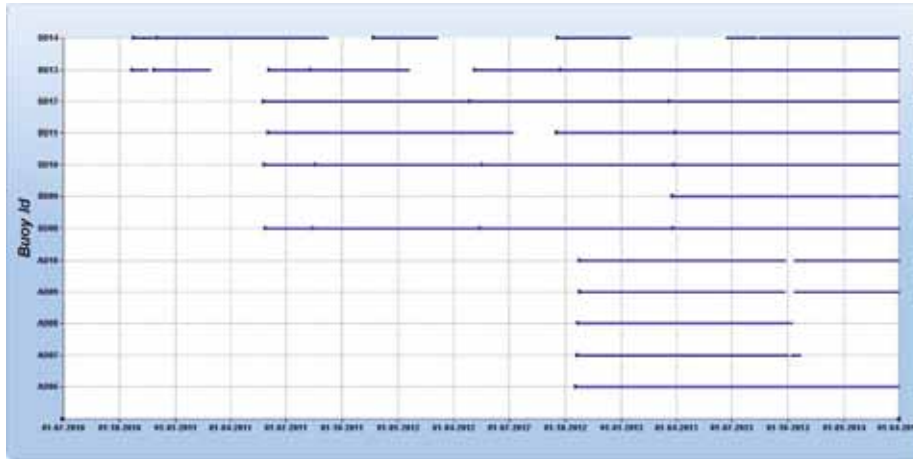


Fig. 4.29 Data availability from OMNI buoy network.

4.6.5 HF radar data

A network of coastal HF radar comprising of 10 stations (5 pairs) at Puri and Gopalpur in Odisha coast, Yanam and Machilipatnam in Andhra Pradesh coast, Kalpakkam and Cuddalore in Tamil Nadu coast, Jagri and Wasi in Gujarat coast and Port Blair and Hutbay in Andaman and Nicobar Islands coast continued to provide data on surface currents and waves in the coastal waters up to 200 km offshore. Current meter moorings are deployed in each of the radar locations to validate the current data. Data from HF radar, which were received in real time at ESSO-INCOIS, were converted into a user friendly format (NetCDF) and are archived.

4.6.6 TropFlux: Air-Sea Fluxes for the Global Tropical Oceans

The TropFlux product has been developed under a collaboration between the Laboratoire d'Océanographie et du Climat : Expérimentations et Approches Numériques (LOCEAN, France) from Institut Pierre Simon Laplace (IPSL, France), CSIR-National Institute of Oceanography (CSIR-NIO, India) and ESSO-INCOIS, India. TropFlux product consists of all components of heat fluxes (latent and sensible fluxes, shortwave and longwave radiations at the sea surface), momentum fluxes (zonal and meridional components of wind stress and wind stress magnitude) and all basic met-ocean parameters for flux calculation (sea surface and air temperature, surface wind speed



Fig. 4.30 HF radar network in the Indian coast.



Fig. 4.31 Data availability from HF radar network.

and humidity) for the entire tropical region (30°N-30°S) on a daily time scale. It is planned to make regular updates of data (~ monthly) so that the data will be available with 3-4 months lag.



Fig. 4.32 Snapshot of the webpage to access tropflux data (www.incois.gov.in/tropflux/).

4.6.7 Other notable achievements of the data centre

- A bilingual content management system for ocean data and information was launched so as to ensure uniformity in web pages and system compatibility. Bilingual pages in English and Hindi are now available.
- Operationalised the dissemination of data collected by INCOIS Real-time Automatic Weather Stations (I-RAWS) through Global Telecommunication System (GTS).
- Argo DVD Version 2.2 was released with ~ 2,00,000 T-S profiles collected by Argo floats during the period 2002-2012 and Gridded Data Products (plots) in ASCII & netCDF formats. The DVD features user friendly GUI for easy navigation, browsing, data extraction with user defined spatial and temporal domains.
- The INCOIS Live Access Server (I-LAS) was maintained.
- New web interface for the submission of cruise summary reports was developed to allow chief scientists of various cruises on ocean research vessels of the Ministry of Earth Sciences to submit cruise summary reports.



Fig. 4.33 Ocean Data and Information System



Fig. 4.34 Web-interface for submission of cruise summary report



Fig. 4.35 Web interface for Geotraces-India Data Assembly Centre

- Extended specialized services to NODPAC, Indian Navy by setting up a secured FTP access for delivering classified data. All data sets from the Indian EEZ are disseminated using this secured access.

5. Ocean Observation

Sustaining the continuous measurements of various oceanographic variables is an important component of operational oceanography. Data from ocean observation systems are transmitted in real time, providing crucial information about the state of the ocean which directly contributes to the quality of advisory and forecast services. These data are also essential for ocean analysis/re-analysis products in that they are assimilated in ocean models to generate the said products. Data from the ocean observation systems deployed in the Indian Ocean have significantly contributed to improve our understanding of the Indian Ocean variability. In 2013-2014, ESSO-INCOIS continued to support global ocean observation programmes by deploying and maintaining several ocean observation systems in the Indian Ocean. Data from most of these observations are being received at ESSO-INCOIS in real time for operational use.

5.1 Tsunami buoys

To detect the propagation of tsunami waves in the open ocean, a network of 7 tsunami buoys have been established close to the tsunamigenic source regions in the Bay of Bengal and Arabian Sea. The deployment and maintenance of 5 buoys are done in collaboration with National Institute of Ocean Technology (NIOT), Chennai and two through a contract with Science Applications International Corp (SAIC), USA. The data from all buoys were transmitted in real time to the Indian Tsunami Early Warning System (ITEWS) through the satellite communication network. In addition to these buoys, near real-time data were also received from tsunami buoys maintained by Australia and Thailand in the Indian Ocean.



Fig. 5.1 Indian tsunami buoy network in the northern Indian Ocean region.

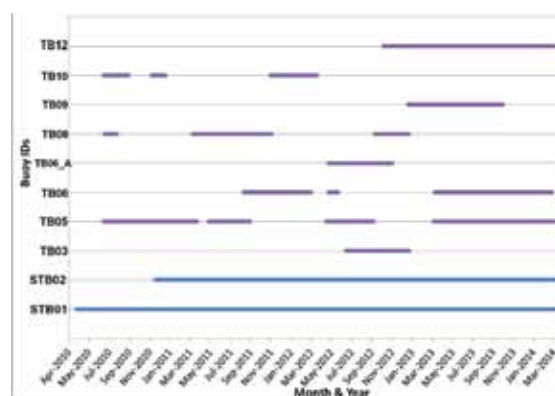


Fig. 5.2 Data availability from Tsunami buoy network during 2010-14.

5.2 Tide gauge network

The network of 21 tide gauges set up along the Indian coast worked satisfactorily. The maintenance of these tide gauges were carried out in collaboration with Survey of India (Sol). Real-time data from these tide gauges are being received at ITEWS through INSAT and GPRS. In addition, ESSO-INCOIS received data from around 80 international tide gauges maintained by Indonesia,

Thailand, Sri Lanka, Australia, Maldives, Myanmar, Malaysia, Singapore, Oman, Bangladesh, Pakistan, Iran, Kenya, Yemen, Mozambique, Djibouti, UK, Mauritius, Seychelles, Reunion, Comoros, Tanzania and South Africa in near real time.

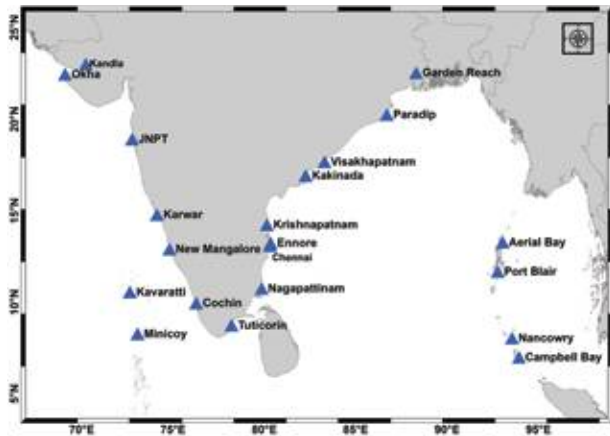


Fig. 5.3 Tide gauges network maintained by ESSO-INCOIS /SOI in the northern Indian Ocean region.

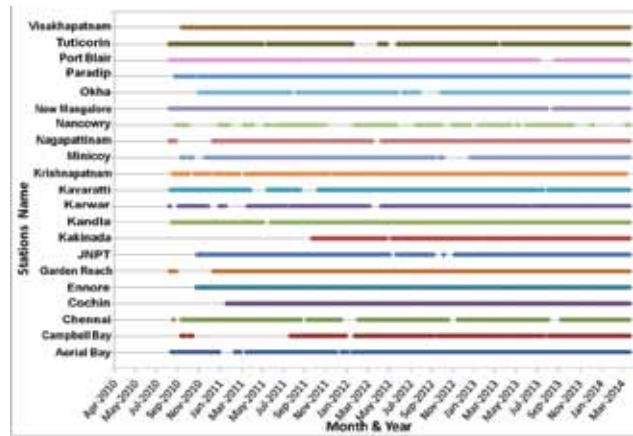


Fig. 5.4 Data availability from Tide gauge network during 2010-14.

5.3 Bay of Bengal mooring

Successful retrieval of the third phase and deployment of fourth phase of the Bay of Bengal (BoB) mooring (18° N, 89.5° E) was conducted during November 2013. The third phase of the BoB mooring provided continuous data for a period of 11 months (January 2013 to November 2013) on temperature, salinity and current without any data loss. The fourth phase of the BoB mooring was equipped with 8 temperature-conductivity-pressure sensors and 2 Doppler Volume Current meters (at 5 m and 30 m) along with additional biological and chemical sensors to measure chlorophyll, dissolved oxygen and turbidity at 1 m depth.

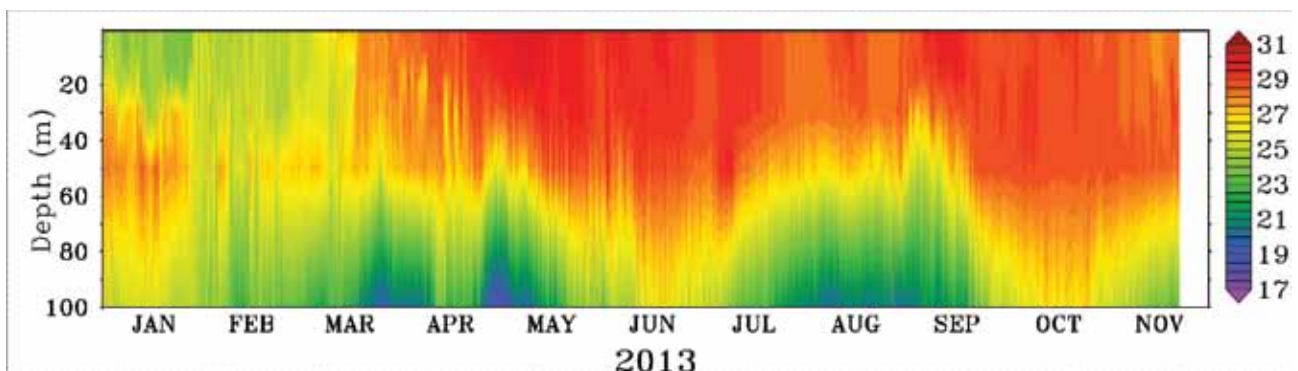


Fig. 5.5 Temperature ($^{\circ}$ C) data from the third phase of Bay of Bengal mooring.

5.4 Indian Argo project

India continued to contribute to global efforts in the Argo floats programme by deploying 33 Argo floats during 1 April, 2013 to 31 March, 2014 in the Indian Ocean. Nineteen floats were of ARVOR-L model, ten were of PROVOR-BioArgo and seven floats were of ARVOR-I model. ARVOR floats have CTD sensors and PROVOR floats are equipped with sensors for measuring dissolved oxygen, chlorophyll fluorescence and backscattering. With these deployments, the total number of floats deployed by India has now increased to 320; of which, 107 floats are currently active and providing data in real time. In addition to the deployments by India, 68 Argo floats were deployed in the Indian Ocean by other countries (US, France, Japan, China, UK, Australia, Mauritius, and Netherlands) and the data were received at ESSO-INCOIS in real time. As on 31 March 2014, 655 floats are active in the Indian Ocean. During the past one year ESSO-INCOIS received and archived 27676 temperature and salinity profiles, 404 chlorophyll and 630 dissolved oxygen profiles from the Indian Ocean.

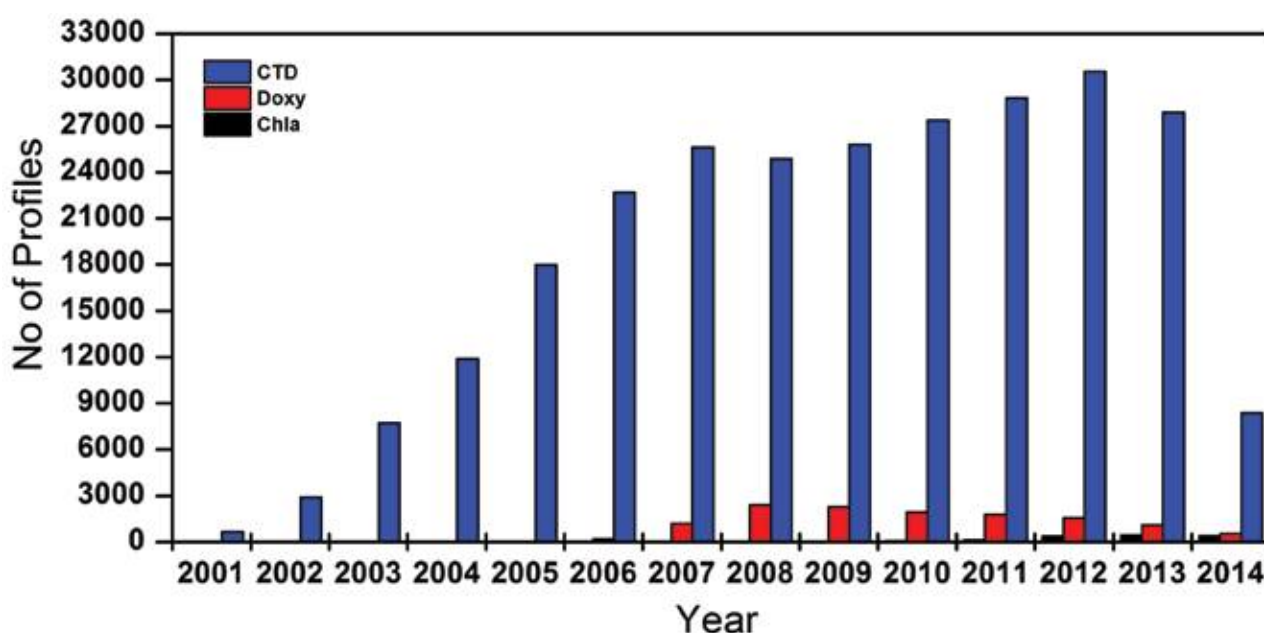


Fig. 5.6 Year-wise distribution of temperature-salinity (blue), Dissolved Oxygen (red) and chlorophyll (black) profiles measured by Argo.

5.5 Automated Weather Station (AWS)

With the deployment of 8 new AWS, the AWS network on board ships and oil platforms has increased to 18. A new suite of water quality sensors, FLNTUS-ECO chlorophyll fluorometer, turbidity meter and sea surface temperature sensors with bio-wiper was attached to the AWS on board RV Sagar Nidhi and INS Sarvekshak.

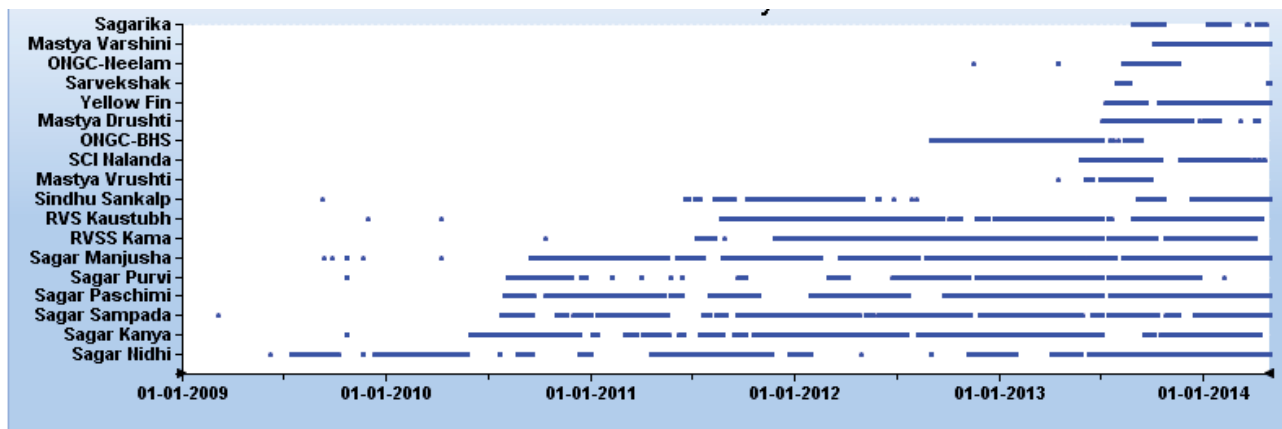


Fig. 5.7 Availability of data from the automated weather stations installed on board ships.

Table: 5.1 List of AWS Installations on board ships during 2013-14

Agency	Vessel Name	Installation Date
SCI	Nalanda	25 May, 2013
FSI	Mastya Vrushti	5 June, 2013
	Mastya Drushti	5 July, 2013
	Yellow Fin	11 July, 2013
	Sagarika	31 August, 2013
	Matsya Varshini	5 October, 2013
NHO	INS Sarvekshak	30 July, 2013
ONGC	Neelam	12 August, 2013

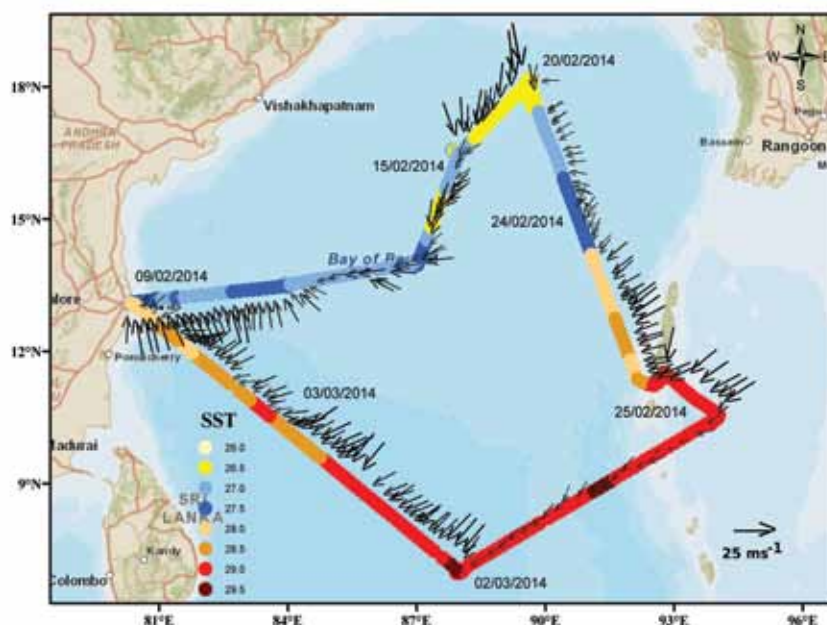


Fig. 5.8 SST (in shades) and wind vectors (magnitude in ms^{-1}) observed during February 2014 by the AWS installed in Sagar Kanya.

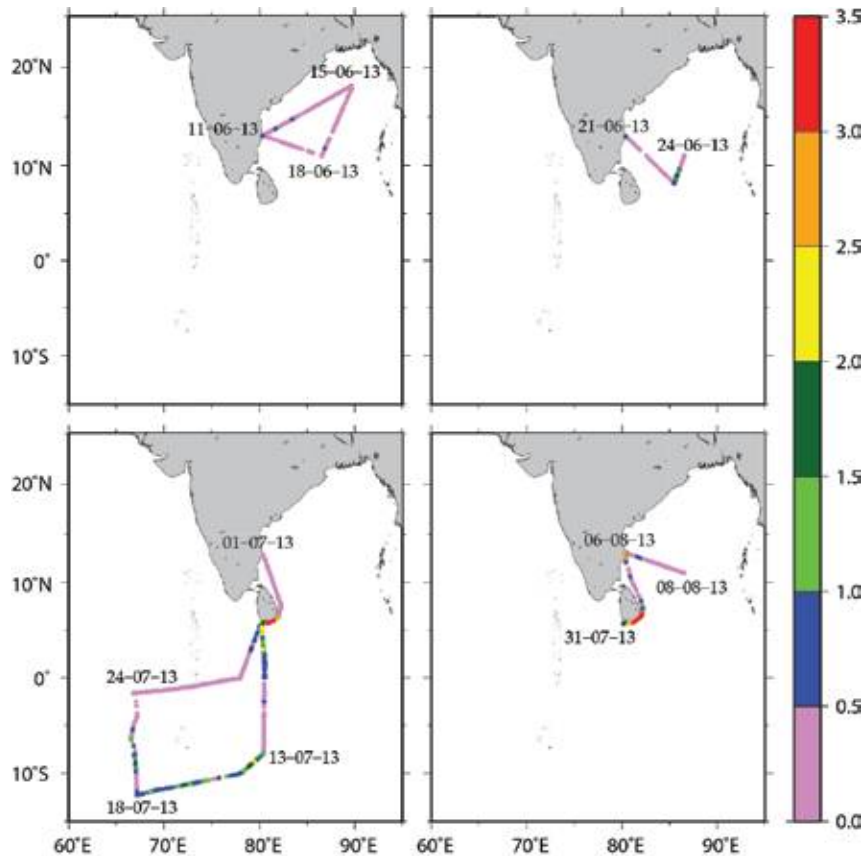


Fig. 5.9 Chlorophyll ($\mu\text{g l}^{-1}$) measurements from the water quality sensors installed on board ORV Sagar Nidhi.

5.6 Wave rider buoys

With the deployment of two more wave rider buoys off Kozhikode and Tuticorin, the number of wave rider buoys in the network was increased to 11. The wave rider buoys at Ratnagiri, Karwar, Port Blair and Puducherry were retrieved and redeployed after equipping them with INSAT.

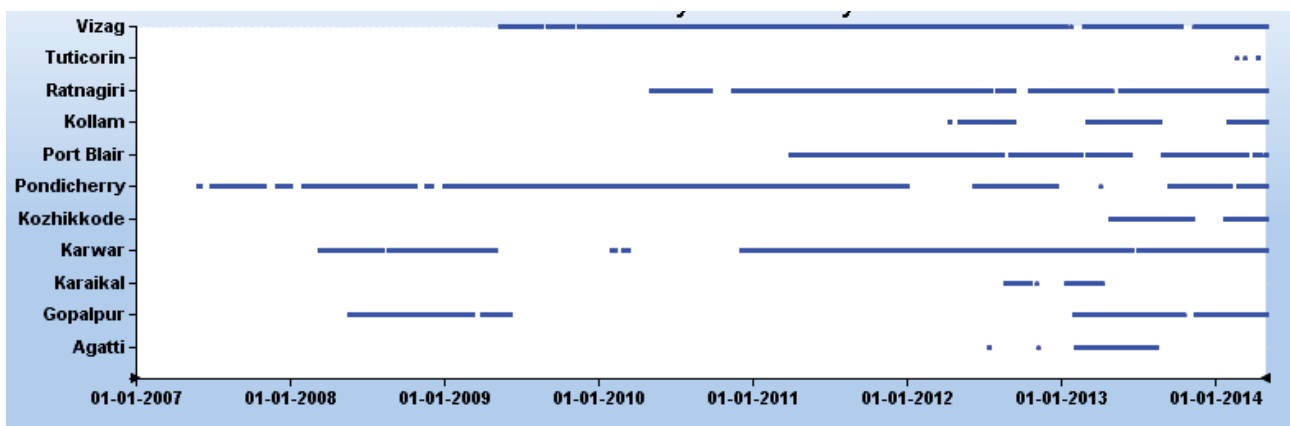


Fig. 5.10 Availability of data from the wave rider buoy network established by ESSO-INCOIS.

5.7 ADCP current meter moorings in the Equatorial Indian Ocean

To understand the dynamics of the current system in the Indian Ocean region, a deep-sea ADCP current mooring system was established by CSIR-NIO with funding from ESSO-INCOIS. During 2013-2014, 3 moorings at the equator at 93° E, 83° E and 77° E; 4 moorings across the equator at 1.5° S, 77° E; 1.5° N, 77° E; 1.5° S, 93° E and 1.5° S, 93° E were functional.

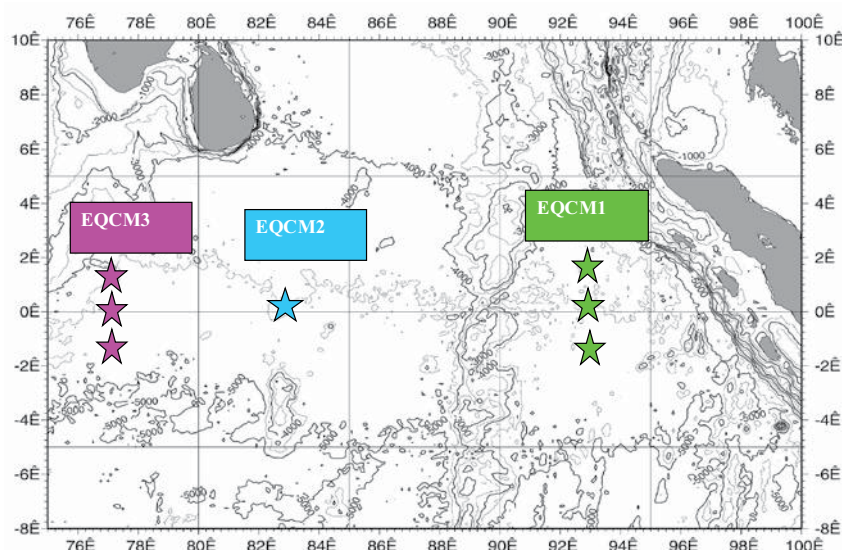


Fig. 5.11 Equatorial Indian Ocean Observational Array

5.8 XBT transects

Two hundred and eighty seven XBT and 125 XCTD profiles were collected along the XBT transects along Chennai - Port Blair – Kolkata and Kochi – Lakshadweep during 2013-14 by CSIR-NIO with funding from ESSO-INCOIS. With this, a total of 7384 temperature profiles and 653 salinity profiles were collected under the XBT project since 2007. Data up to January, 2014 has been added to the ESSO-INCOIS database.

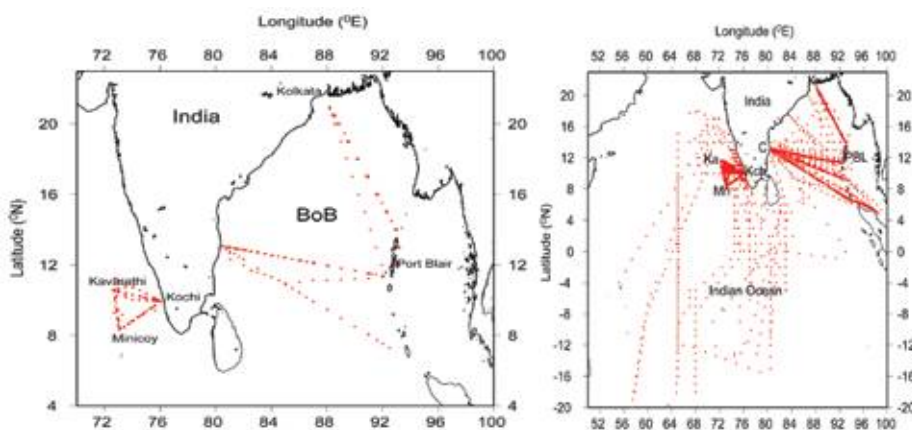


Fig. 5.12 XBT data density map for the (left) full period (2007-2014) and (right) last one year.

5.9 Coastal ADCP network

The coastal ADCP network established by CSIR-NIO with funding from ESSO-INCOIS, along the east and west coast of India continued to function, yielding data on the vertical structure of currents along the Indian coastline. Forty one operations, that included 19 recoveries (8 on the west coast and 11 on the east coast), 22 deployments (10 on west coast and 11 in the east coast) and partial recovery of a missing buoy were carried out during the last year. A new mooring was deployed off Bhatkal on 19 November, 2013. At present, 21 moorings (west coast: 4 paired and 2 individual moorings and east coast: 4 paired and 3 individual moorings) are active.

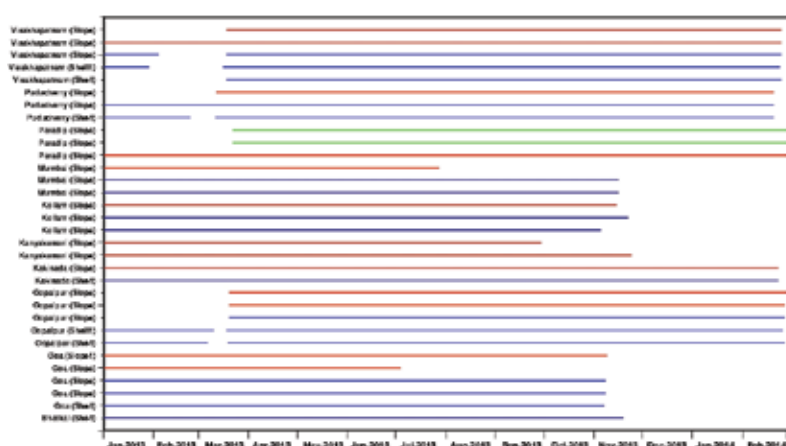


Fig. 5.13 Coastal ADCP data availability chart during 1 January, 2013 to 31 March, 2014. Blue, red and green line indicates 150 kHz, 75kHz and 300 kHz respectively.

5.10 Ocean Mixing and Monsoon (OMM)-Pilot cruise

To increase the observations of air-sea exchange and those of horizontal and vertical mixing in the upper ocean at different spatio-temporal scales in the Bay of Bengal, a joint research program, OMM-ASIRI, is being carried out with active collaboration between MoES and different government agencies of the United States of America. The Air-Sea Interactions in the northern Indian Ocean–Regional Initiative (ASIRI) component of this programme is funded by the US Office of Naval Research, and Ocean Mixing and Monsoons (OMM) component is funded by the Monsoon Mission Program of Ministry of Earth Sciences (MoES), India. Under OMM-ASIRI program, there were joint research cruises to study lateral and vertical gradients of temperature, salinity and density in the upper waters of Bay of Bengal during November, 2013, in which the Indian research vessel Sagar Nidhi and the US research vessel Roger Revelle participated. During this field campaign, very fine scale near surface thermohaline observations were made using underway CTD (uCTD), wire walker (WW), chi-pod, bow chain, glider, ship mounted ADCPs, automatic weather stations (AWS) and thermosalinograph (TS graph). It is expected that the analysis of these data sets will provide new insights into the upper ocean thermohaline structure and its evolution in the Bay of Bengal.

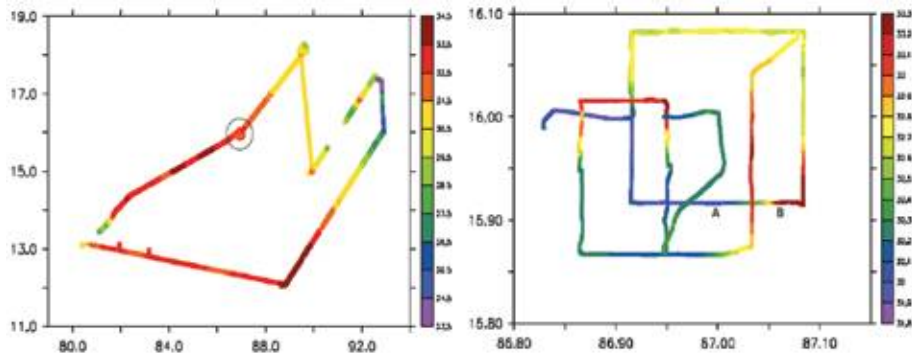


Fig. 5.14 Sea surface salinity (psu) measured by the thermosalinograph along the track of Sagar Nidhi during 15 November to 2 December, 2013 (left panel). The range of salinity is from 23.5 to 34.5 psu. Expanded view (grey circle in the left panel) of sea surface salinity (psu) during 17-19 November, 2013. The salinity range is 31.5 to 33.3 psu; sharp lateral gradients/fronts can be seen.



Fig. 5.15 Scientists engaged in making observations during the OMM cruise.

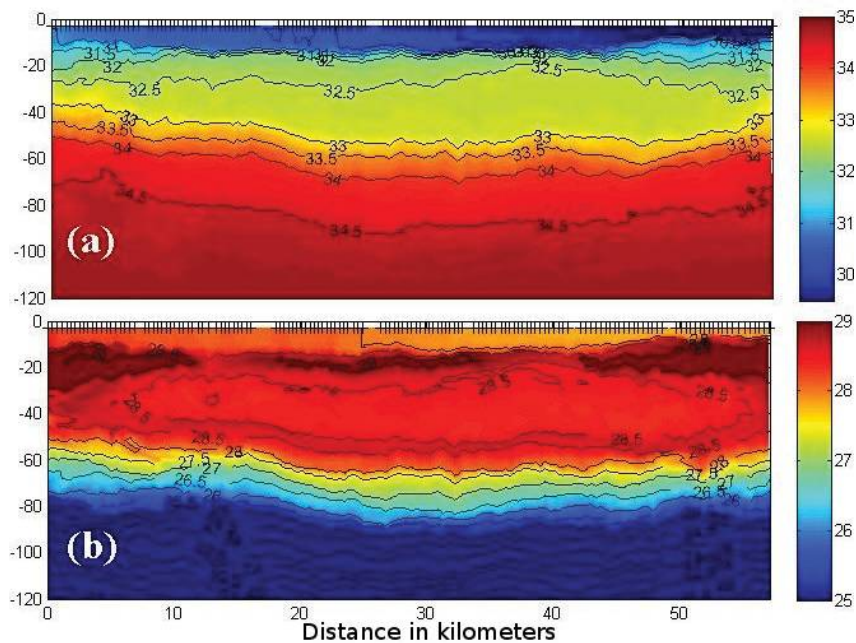


Fig. 5.16 Salinity (top panel; psu) and potential temperature (bottom; °C) in the upper 30 m measured by the underway CTD along the ship track in the vicinity of 18°N, 89.5°E. The x-axis is distance assuming the ship moved at 4 knots.

5.11 Indian Ocean drifting buoy program

Satellite tracked drifting buoys are one of the cost-effective methods to continuously observe upper ocean currents and other met-ocean variables. CSIR-NIO is implementing this project with funding from ESSO-INCOIS. With the deployment of two new buoys during 2013-14, nine drifters were active in the northern Indian Ocean.

5.12 RAMA Observation Network

ESSO-INCOIS continued the support for RAMA moorings under the MoU between MoES and NOAA. Fifty three operations (deployment and retrieval) were carried out during the past one year. As of now, 32 out of the proposed 46 buoys (70%) are in place.

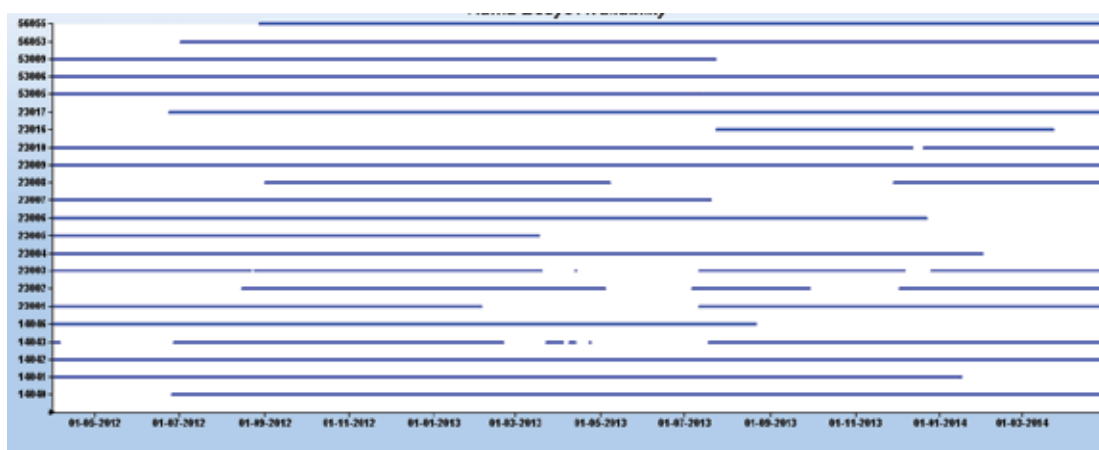


Fig. 5.17 Data availability map from RAMA buoys.

5.13 Network communication systems

5.13.1 Establishment of Indian Seismic and GNSS Network (ISGN)

With an objective to enhance the capability in monitoring seismic activity as well as to provide high quality data for research and development, on the directive of MoES, ESSO-INCOIS took up the establishment of the Indian Seismic and GNSS network (ISGN) project. Through this network of seismic and GNSS stations, data are being received at ESSO-INCOIS and IMD, New Delhi in real time. The real time connectivity is provided through VSAT to various seismic and GNSS stations existing all over India.

Currently the Indian Seismic and GNSS Network (ISGN) is connecting (i) 90 standalone seismic and GNSS stations

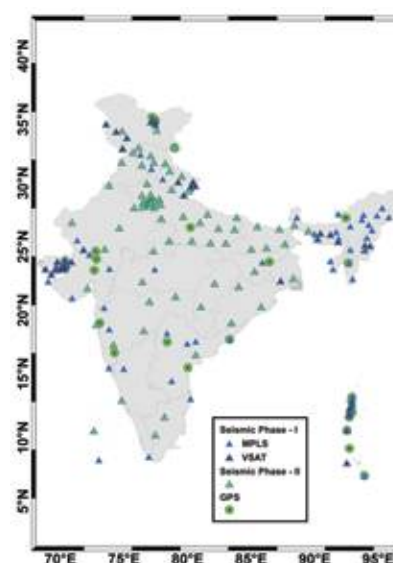


Fig. 5.18 Indian Seismic and GNSS network.

established under various programmes of MoES and DST and (ii) Regional Seismic Centres at NGRI, Hyderabad and ISR, Gandhinagar through VSATs and terrestrial links. Data centres have been established at ESSO-INCOIS, Hyderabad and IMD, New Delhi, to simultaneously receive the data at both centres and archive it for operational and future use.

The real-time data received from the seismic as well as GNSS stations are being archived at ESSO-INCOIS and IMD data centres and made available through the website: www.isgn.gov.in. The data centre was inaugurated by Dr. Shailesh R. Nayak, Secretary, Ministry of Earth Sciences (MoES), Govt. of India on 21 November, 2013. Users can request seismic or GNSS data for a chosen time period. In addition, earthquake event data for all those stations that recorded the particular event will be automatically made available on the website or on request for specific stations. Data is made available as per the agreed data sharing policy.

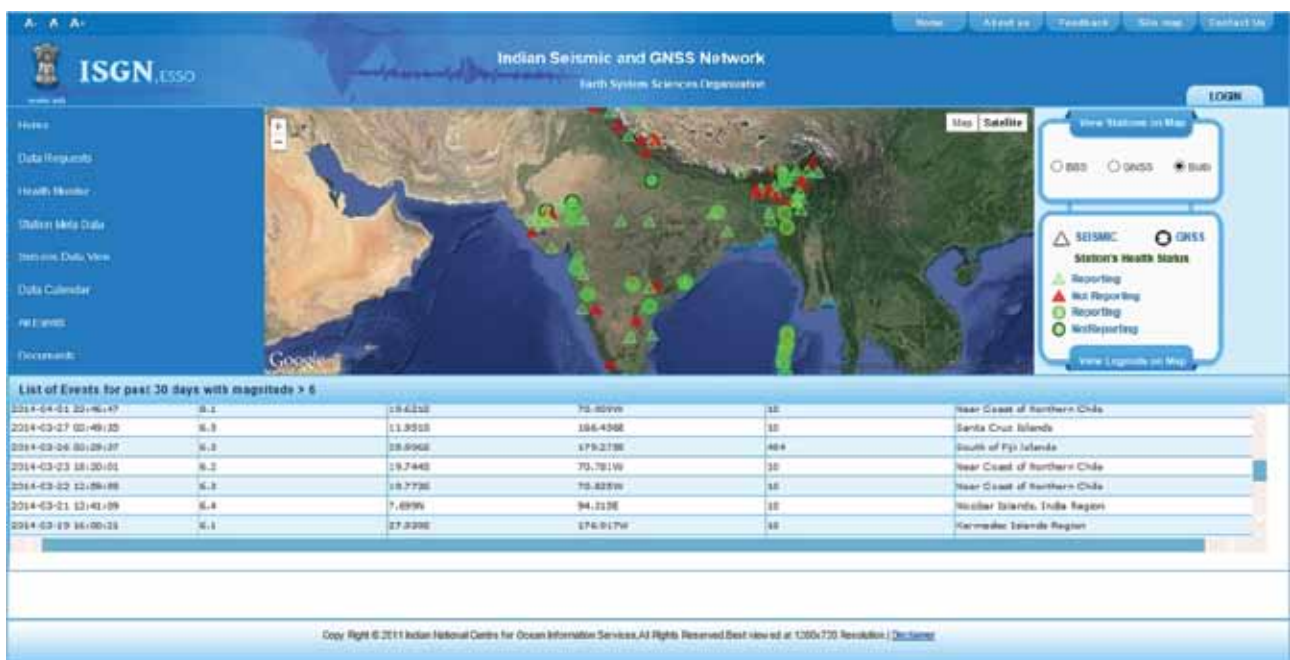


Fig. 5.19 Indian Seismic and GNSS Network (ISGN) web interface.

5.13.2 Establishment of GNSS & Strong Motion network in A&N Islands

In order to improve the tsunami early warnings of tsunamis caused by near field earthquakes, ESSO-INCOIS is in the process of installing co-located Strong Motion Accelerometers, GNSS receivers and Meteorological sensors with real-time VSAT connectivity at 35 locations in A&N Islands. This project is extremely important, for A&N Islands considering their proximity to the subduction zone and very low response time available for tsunami warning. The project is being implemented in two phases (Phase-I: 15 sites and Phase-II: 20 sites). Equipment was procured for the implementation of Phase-I of the project and ESSO-INCOIS had awarded the construction work of observatories to

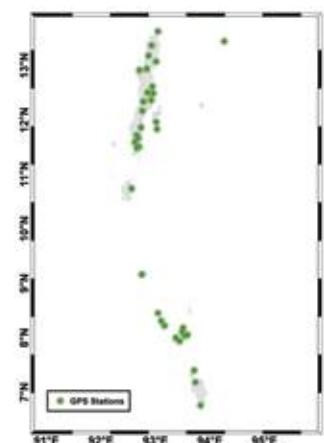


Fig. 5.20 Co-located GNSS & SMA Network in A&N Islands.

the Andaman Public Works Department. As soon as the observatories are ready, the installations of instruments will be started.

5.13.3 VSAT-aided Emergency Communication System (VECS) for A&N Islands

Considering the vulnerability of Andaman & Nicobar (A&N) Islands to various disasters such as cyclones, floods, earthquakes, tsunamis and the disruptions in normal modes of communications, it was decided that the proposed real-time VSAT connectivity at 35 locations in A&N Islands should also be used for emergency communication purposes, in the event of a disaster. Accordingly, ESSO-INCOIS has implemented a fail-safe satellite-based communication system at 7 Emergency Operation Centres (EOCs) of A&N with VSAT aided Emergency Communication System (VECS) to operate through GSAT-12. The system has three major components viz. Voice over Internet Protocol (VoIP) Phone, Electronic Display Board (EDB) as well as a computer based Earthquake alert and Web-access System.

6. Ocean Modeling and Data Assimilation

6.1 High-resolution Operational Ocean Forecast and reanalysis System (HOOFS)

In order to meet the requirements of accurate forecasts of various oceanic parameters, ESSO-INCOIS is now setting up the High-resolution Operational Ocean Forecast and reanalysis System, in which it is planned to set up a hierarchy of ocean models. The horizontal resolution of the general circulation models varies from approximately 25 km x 25 km outside the Indian Ocean to 2.25 km x 2.25 km near the coast.

6.1.1 Eddy resolving basin scale ocean models

A basin-scale eddy resolving ocean model setup is an integral component of the HOOFS programme since the lateral boundary conditions for the coastal high resolution models are extracted from this setup. In order to meet this requirement, two ocean general circulation models viz. Regional Ocean Modeling System (ROMS) and Hybrid Coordinate Ocean Module (HYCOM) were set up at a horizontal resolution of $1/12^\circ \times 1/12^\circ$ for the Indian Ocean domain (30°S - 30°N and 30°E - 120°E). These model setups take lateral boundary conditions for their southern and eastern boundaries from INCOIS-GODAS. The nested setups were integrated from January, 2010 using 6 hourly atmospheric forcing from the NCMRWF T254 model. In the HYCOM setup, a bias correction was applied within the model as an offset in heat flux, which was estimated from the bias in SST. Analysis of the simulations suggested that the performance of these models is very good in most parts of the Indian Ocean.

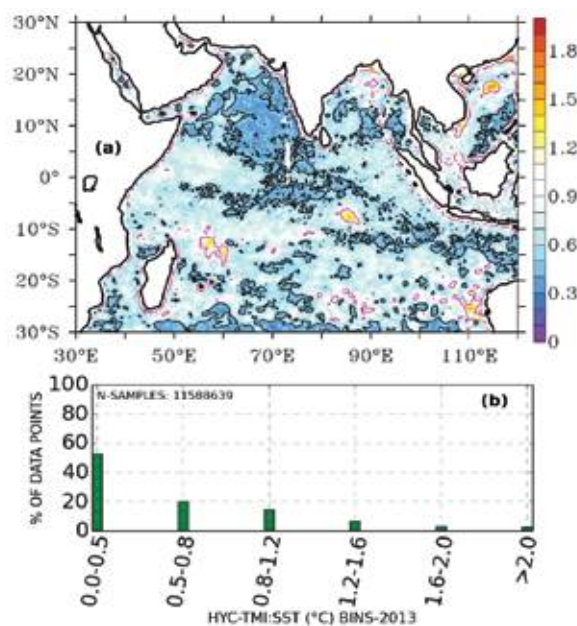


Fig. 6.1 Spatial RMS difference (top) and absolute difference (bottom) in SST (°C) between HYCOM simulation and TMI after the third year (2013) of integration. Pink contour indicates RMS differences of 1°C.

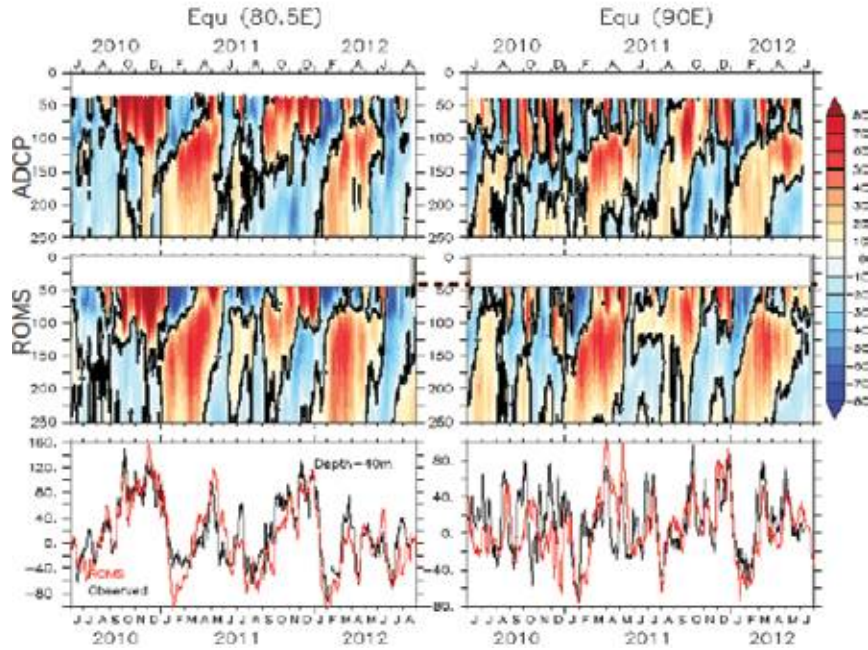


Fig. 6.2 Zonal current (cm s^{-1}) simulated by basin-scale ROMS setup with horizontal resolution of $1/12^\circ \times 1/12^\circ$ are compared with observations from two ADCPs at the equator (80.5° E and 90° E).

6.1.2 Coastal ocean modeling

Setting up of the high-resolution coastal model using Regional Ocean Modeling System (ROMS) for the operational prediction of ocean general circulation features in the coastal waters around India is one of the important components of the HOOFS project. It was proposed that as a pilot experiment, the model will be set up for the west coast of India. After several experiments designed to identify the optimal horizontal resolution, domain and physical parameterisation schemes, the model is now set up for the domain $65^\circ \text{ E} - 78^\circ \text{ E}$; $8^\circ \text{ N} - 26^\circ \text{ N}$ at a horizontal resolution of $1/48^\circ \times 1/48^\circ$ (approximately $2.25 \text{ km} \times 2.25 \text{ km}$). The atmospheric fields from NCMRWF were used for forcing the model and boundary conditions were extracted from the basin-scale setup of ROMS at a horizontal resolution of $1/12^\circ \times 1/12^\circ$.

The new coastal high-resolution setup of ROMS has very good skill in simulating the circulation features when compared with the coastal ADCP observations. The simulated SST and SSH anomalies also compare very well with the observations. The model setup is now ready for experimental predictions.

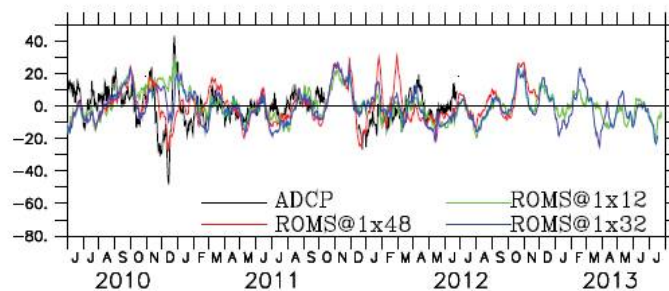


Fig. 6.3 Daily time series of depth averaged ($50\text{-}100 \text{ m}$) along-shore.

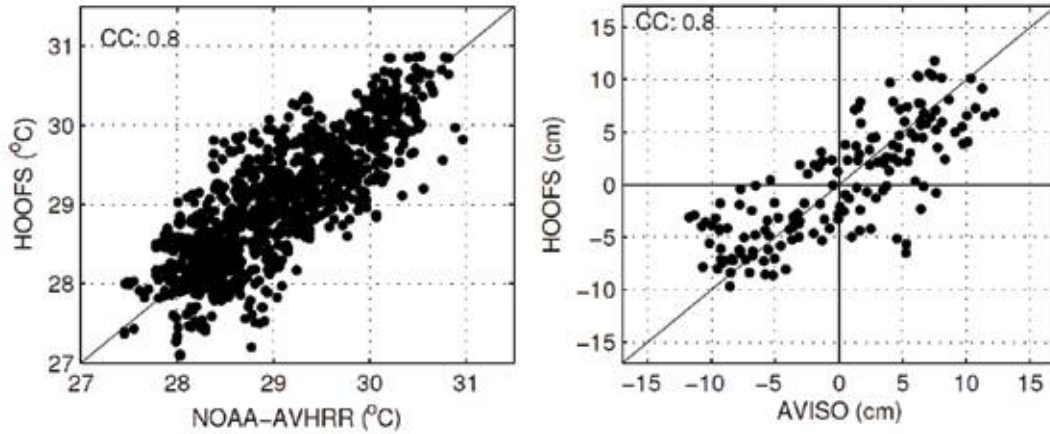


Fig. 6.4 The SST (left) and SSH (right) simulated by ROMS are plotted against satellite observations at 72.7°E and 15.1°N (off Goa).

6.1.3 Data assimilation

Data Assimilation (DA) is one of the key components of operational ocean prediction systems. Considering the importance of DA, ESSO-INCOIS started this activity from the fundamentals, so that it will be possible to have built-in DA schemes in the coastal models, which are being developed for operational forecasts. As an experiment to gain experience in data assimilation, attempts have been made to assimilate gridded sea surface anomaly data from AVISO in a $1\frac{1}{2}^\circ$ layer linear reduced gravity model setup with half degree horizontal resolution for the Indian Ocean using EnKF based assimilation scheme. The initial ensemble was generated by a 200-year integration of the model forced with climatological atmospheric forcing derived from NCEP Reanalysis data. During the assimilation process the model was forced with monthly mean surface wind obtained from NCEP Reanalysis for the year 1993. The results showed that the assimilation of gridded sea level anomaly data from AVISO, not only reduced the root-mean-squared error and variance of the analysed sea level anomaly, but also significantly improved the surface currents. The experience gained from this experiment is very useful for the implementation of EnKF based assimilation in the ROMS setup as proposed in the HOOFS project.

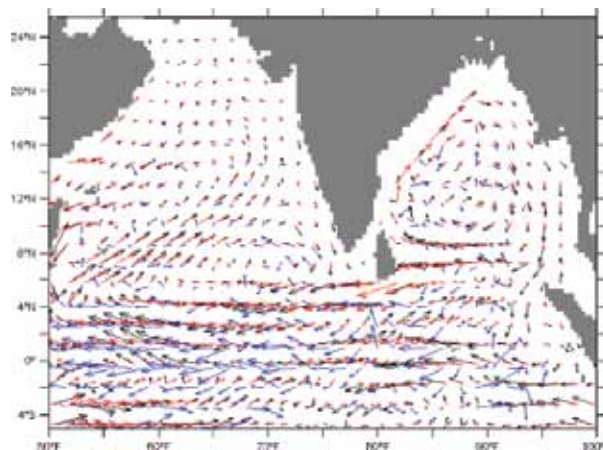


Fig. 6.5 The surface currents simulated by the $1\frac{1}{2}$ layer RG (Reduced Gravity) model before (red) and after (green) the assimilation of the SLA data is compared with the OSCAR data (black) for the month of February 1993.

6.1.4 Ecosystem modeling to study the biogeochemical variability in the Indian Ocean

Ecosystem modelling is a key scientific technique to elucidate the mechanism of the marine system and predict its evolution in short and long terms. As a first step to build capability in ecosystem modeling, a biogeochemical model based on ROMS at a horizontal resolution of $1/4^\circ \times 1/4^\circ$ has been set up for the Indian Ocean domain. This model consists of the nitrogen cycle model with parameterised sediment denitrification and carbonate chemistry. The comparison between observed satellite-derived ocean-color images and model simulated chlorophyll demonstrated that the model could successfully capture the seasonal inter-regional contrasts in sea surface chlorophyll distribution. The model could adequately characterise the two distinct growth periods of phytoplankton; one in summer during the South West Monsoon (SWM) and the other in winter during the North East Monsoon (NEM). The existence of subsurface oxygen maxima also could be seen during the spring inter-monsoon below the mixed layer which could be attributed to the process of photosynthesis in the subsurface chlorophyll maximum zone. The model also effectively simulated the presence and characteristics of oxygen minimum zones (OMZs) in the Arabian Sea and Bay of Bengal.

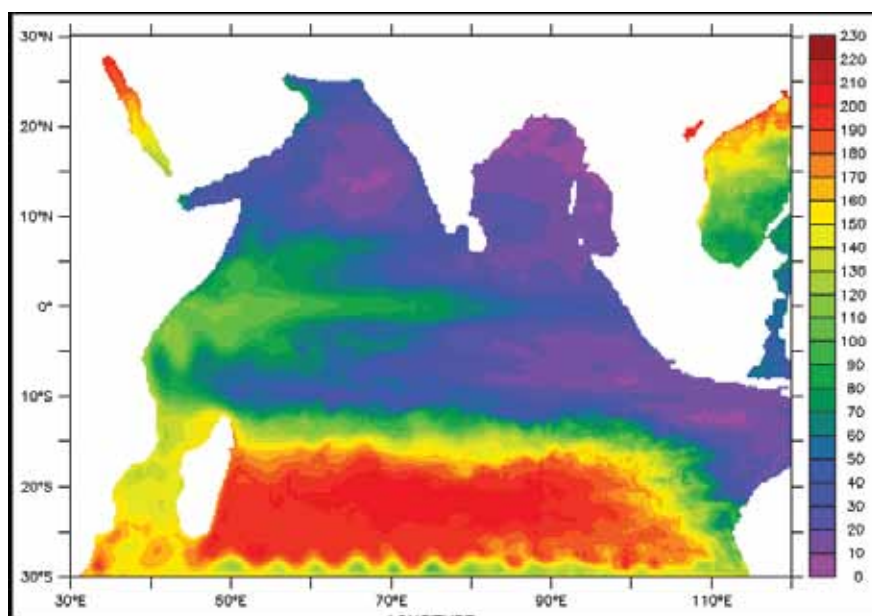


Fig. 6.6 Climatological distribution of oxygen for the month of February at 160 m depth as simulated by ROMS-FENNEL model set up.

6.1.5 WAVEWATCH III

Global WAVEWATCH III has been operational at ESSO-INCOIS at a resolution of $1^\circ \times 1^\circ$ since 2008. As an improvement to this, the Multi-grid WAVEWATCH III (MWWIII) was installed in ESSO-INCOIS HPC and was made operational in October, 2013. The MWWIII setup at ESSO-INCOIS consists of six grids including a global grid ($1^\circ \times 1^\circ$), Indian Ocean grid ($0.5^\circ \times 0.5^\circ$), Arabian Sea grid ($0.25^\circ \times 0.25^\circ$), Bay of Bengal grid ($0.25^\circ \times 0.25^\circ$), West coast grid ($0.05^\circ \times 0.05^\circ$) and East coast grid ($0.05^\circ \times 0.05^\circ$). The model was forced with NCMRWF forecast wind fields at

0.25° x 0.25° resolution. Validation of MWWIII indicated good agreement of simulated wave heights with observations.

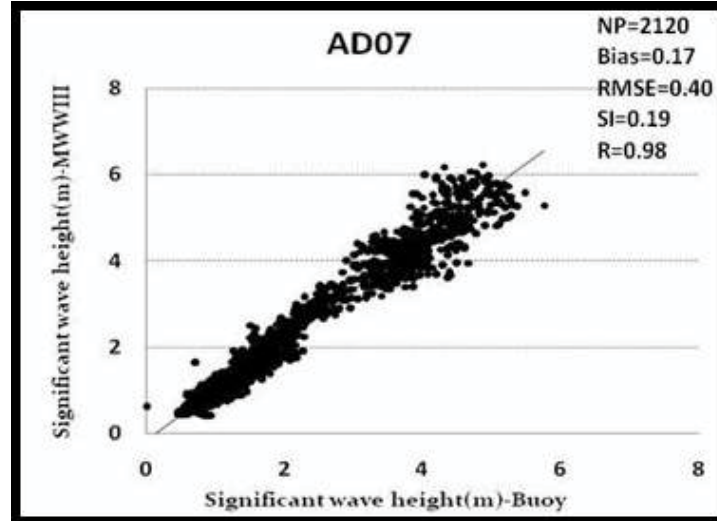


Fig. 6.7 Significant wave height simulated by multi-grid WAVEWATCH III is compared with moored buoy data at 15° N, 69°E in September, 2013.

6.1.6 Simulating WAVes Nearshore (SWAN) wave model

SWAN (version 40.91) model nested with the multi-grid WAVEWATCH III model was set up for the coast of Puducherry at a horizontal resolution of 250 m x 250 m. A detailed validation of the model simulated wave parameters and wave spectra were carried out by comparing with the wave rider buoy observations. It was observed that the nesting of SWAN model with WAVEWATCH III has improved the simulations considerably. It was also found that the simulations were very good during the northeast monsoon season compared to other seasons. It could be due to the long and consistent fetch of northeast winds and due to the dominance of wind sea during the season. The model is now used to generate experimental forecasts of waves in the coastal waters of Puducherry.

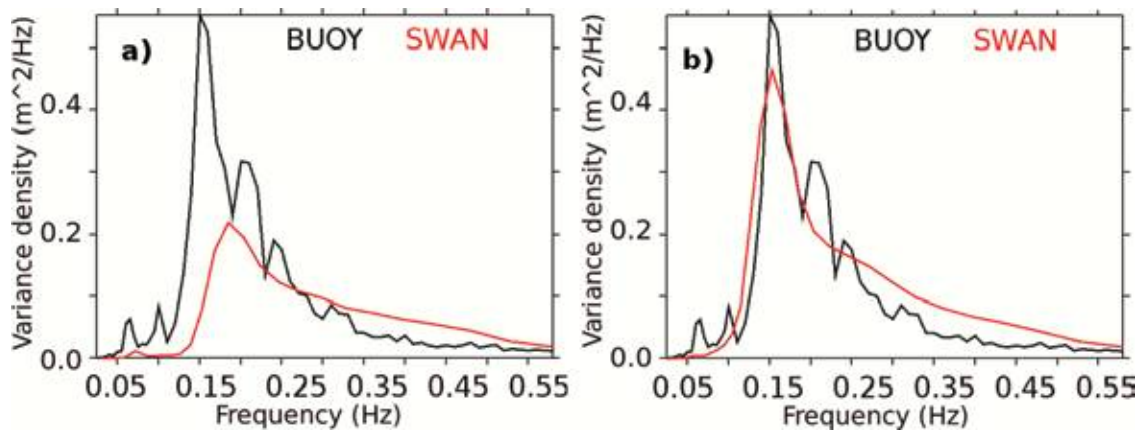


Fig. 6.8 Comparison of one-dimensional wave energy spectra (m^2Hz^{-1}) simulated by the model with observed spectra by a buoy off Puducherry during 2 January, 2008 (2012)
(a) without nesting and (b) with nested in WAVEWATCH III.

6.2 Three way nested eddy resolving north Indian Ocean model setup using MOM4p1

A high resolution triply nested regional Indian Ocean model has been developed using the recent version of Modular Ocean Model (MOM4p1). A multi-model approach is adopted using MOM4p1 and INCOIS-GODAS. In this setup, a regional model in the Indian Ocean region (IOM-1/4) at a horizontal resolution of $1/4^\circ \times 1/4^\circ$ and less than 1 meter vertical resolution in the near surface, takes initial and lateral boundary conditions from INCOIS-GODAS. IOM-1/4 solutions are then used to give lateral boundary conditions to an eddy resolving ($1/12^\circ \times 1/12^\circ$) north Indian Ocean Model (IOM-1/12). The analysis of model simulation from the eddy resolving model during the period January, 2010 to June, 2013 showed significant improvements in IOM-1/12 as compared to INCOIS-GODAS and IOM-1/4.

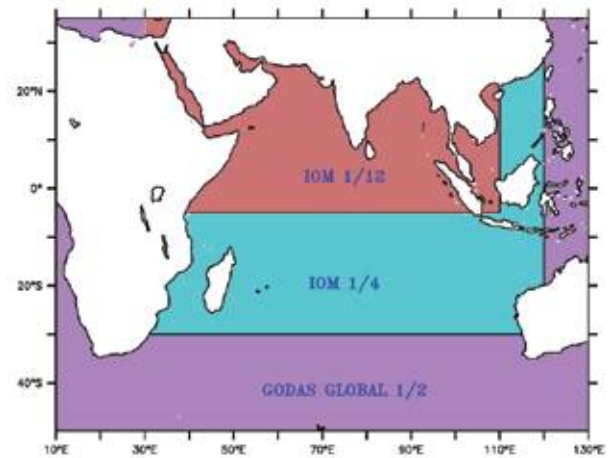


Fig. 6.9 The domains of 3 way nested regional Indian Ocean model setup using MOM4p1.

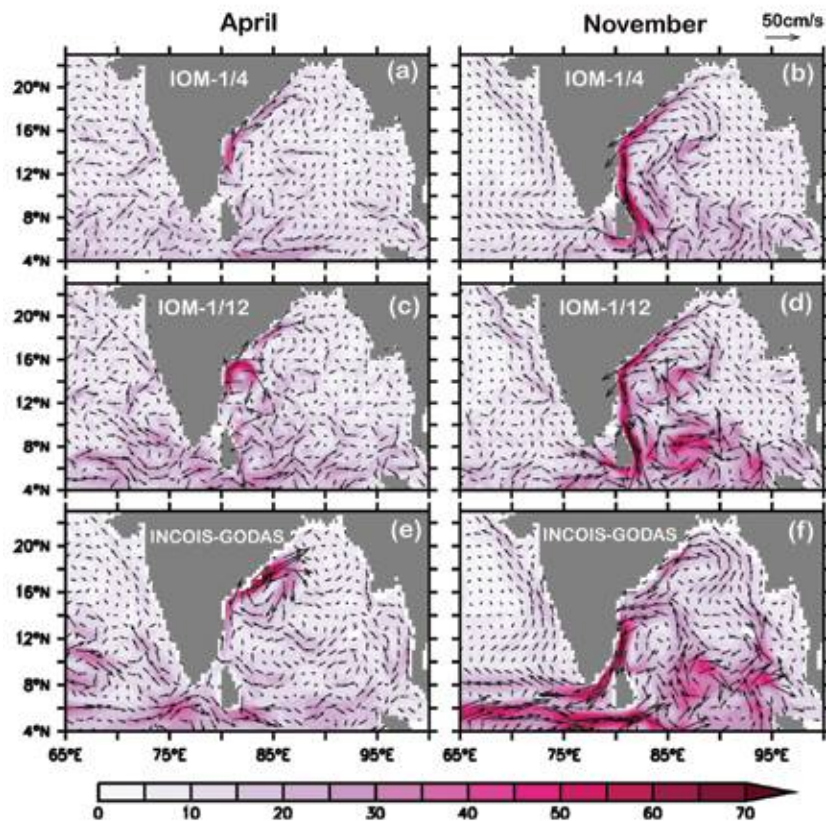


Fig. 6.10 The upper ocean (0-30 m) currents (cm s^{-1}) from the nested solutions from IOM-1/4 (upper panel), IOM-1/12 (middle panel) and INCOIS-GODAS (lower panel).

7. SATellite Coastal and Oceanographic REsearch (SATCORE) programme

7.1 Time Series stations

As part of the SATCORE programme, 12 time-series stations were established for the measurement of bio-optical and physico-chemical parameters. All 12 stations were equipped with the instruments (spectrophotometer, integrated sphere, sunphotometer, fluorometer, weighing balance, weather station and filtration unit) required for the measurement of essential parameters such as chlorophyll-a concentration, total suspended matter concentration, nutrients, dissolved oxygen, aerosol optical thickness, meteorological parameters, apparent optical properties and inherent optical properties of phytoplankton, detritus and coloured dissolved organic matter as defined under SATCORE sampling strategy.

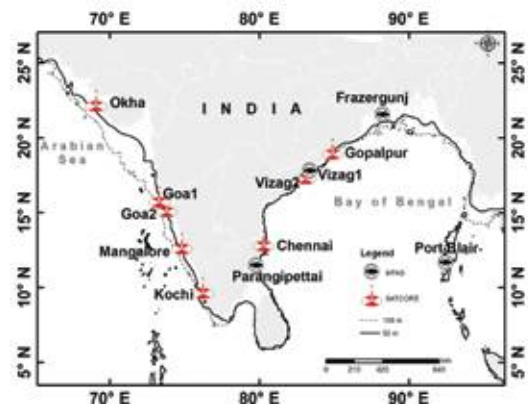


Fig. 7.1 Locations of time series stations for measuring the bio-optical and physicochemical parameters, as part of SATCORE programme.

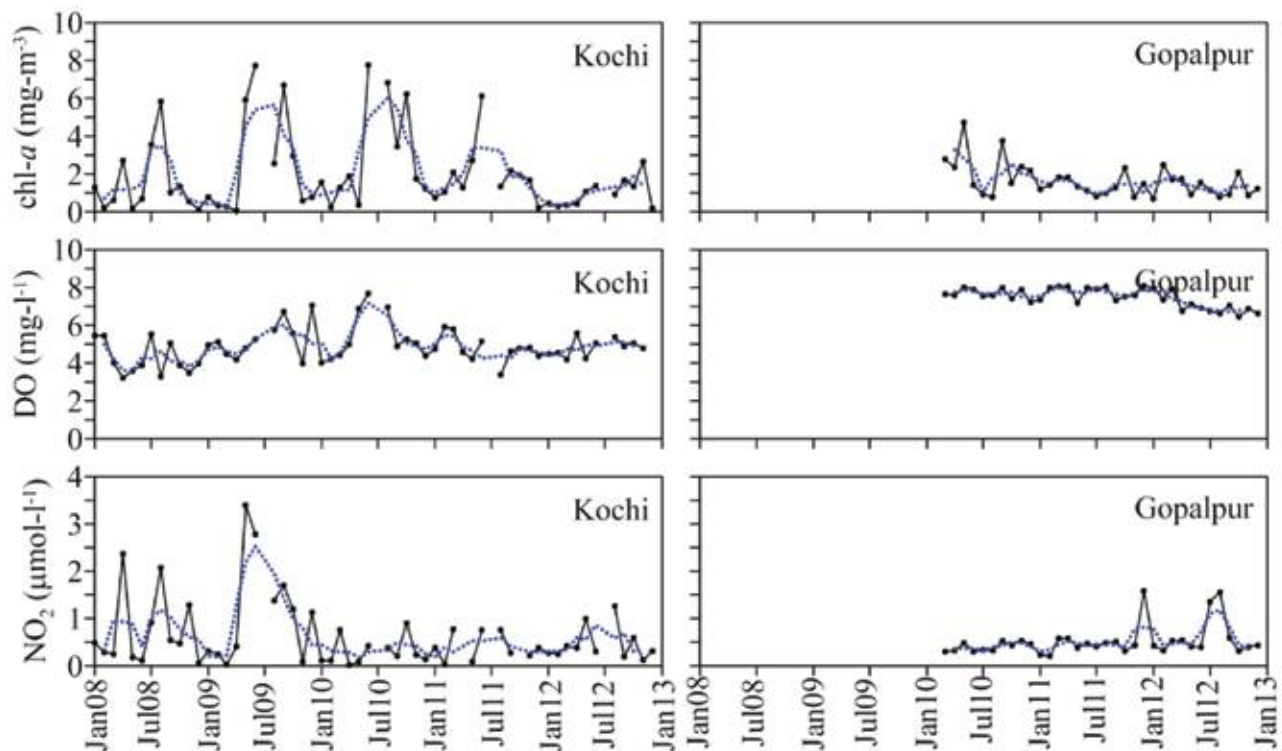


Fig. 7.2 Observations of NO_2 ($\mu\text{mol l}^{-1}$), DO (mg l^{-1}) and Chl-a (mg m^{-3}) at Kochi and Gopalpur.

7.2 Enhanced productivity following passage of cyclone *Phailin*

Analysis of Chlorophyll-a (Chl-a) and SST data from MODIS-A satellite showed that the very severe cyclonic storm *Phailin* of category -5 hurricane, that made landfall on 12 October, 2013 at the Gopalpur coast, Odisha, elevated the concentration of Chl-a and decreased the SST along the cyclone track. The changes were more significant in the nearshore waters. The increase in Chl-a was 710% and decrease in SST was 2.3°C during the passage of the cyclone.

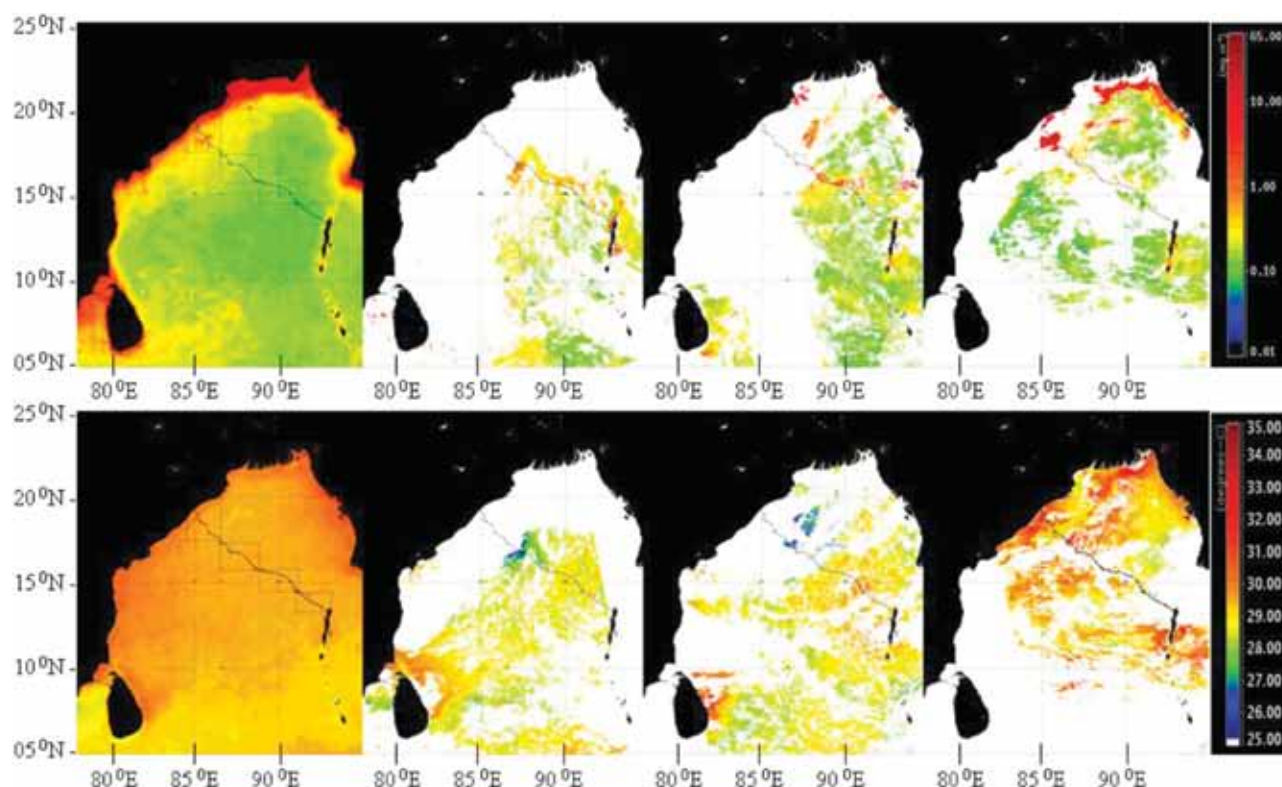


Fig. 7.3 Spatial distribution of MODIS-A derived Chl-a (top) and SST (bottom) after the passage of cyclone *Phailin*. Left panels show the climatology for the month of October overlaid with the cyclone track.

7.3 Physico-chemical forcing on spatio-temporal distribution of chlorophyll-a

A study on the effect of physico-chemical parameters on the distribution pattern of chlorophyll-a (Chl-a) was carried out in coastal waters of north-western Bay of Bengal (southern coast of Odisha) using in situ data for the period from January, 2010 to December, 2013. The study showed that the Chl-a has a bimodal distribution having peaks during pre-monsoon (March) and the later stage of monsoon (September). The high Chl-a concentration during pre-monsoon was due to diatom bloom of *Asterionellopsis glacialis* and the peak during the end of monsoon was due to the influx of nutrients from the adjoining Rushikulya River. This was also evident from factor analysis that showed close association of low salinity and high nutrients with Chl-a. The analysis of all biogeochemical data sets resulted in two distinct clusters of similar variability. The distinction of clusters were around 30 m depth, which concludes that the estuarine and terrestrial influence reaches up to 30 m depth.

7.4 Spatio-temporal extent of North-eastern Arabian Sea winter bloom

The increasing frequency of algal blooms has been a major concern as it affected the ecology of aquatic medium. The geo-spatial data from ocean colour satellite (MODIS-A) for the period from July, 2002 to December, 2013, was analysed to understand the inter-annual variability in spatial and temporal extent of recurring bloom (*Noctiluca milaris*) event in the north-eastern Arabian Sea. The temporal variability in Chl-a showed a high degree of consistency. For all the years, peak blooming phase was confined during the period between 30 December and 8 April. Further it was also observed that the extent of the bloom was till north of 16°N.

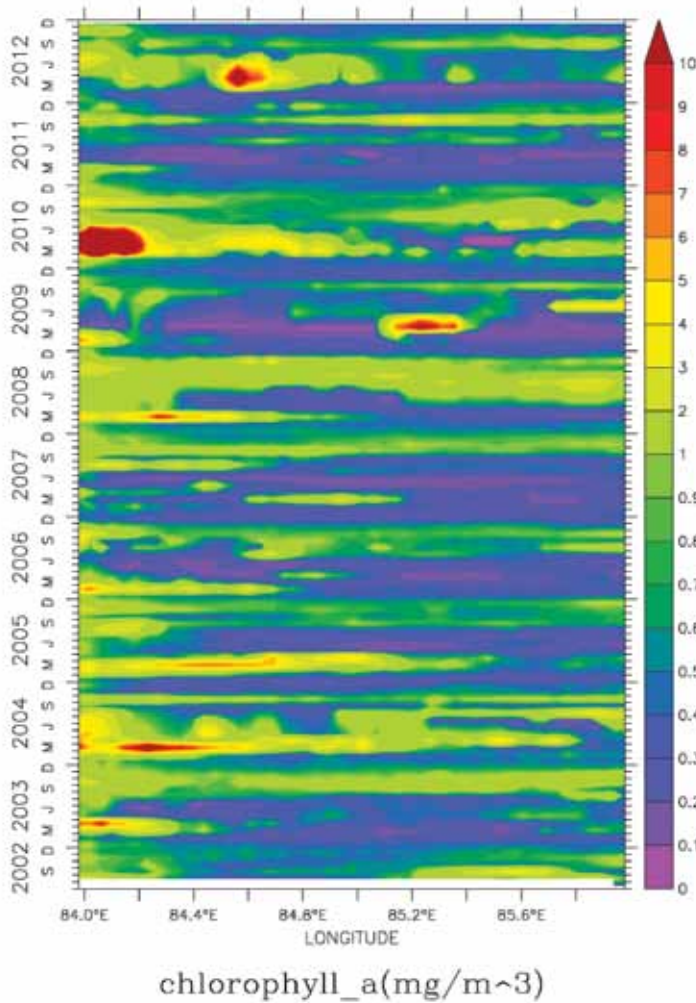


Fig. 7.4 The latitudinal (18° N to 20° N) averaged Hovmoller plot showing the distribution of MODIS-A Chl-a from July, 2002 to December, 2012 in the southern coast of Odisha.

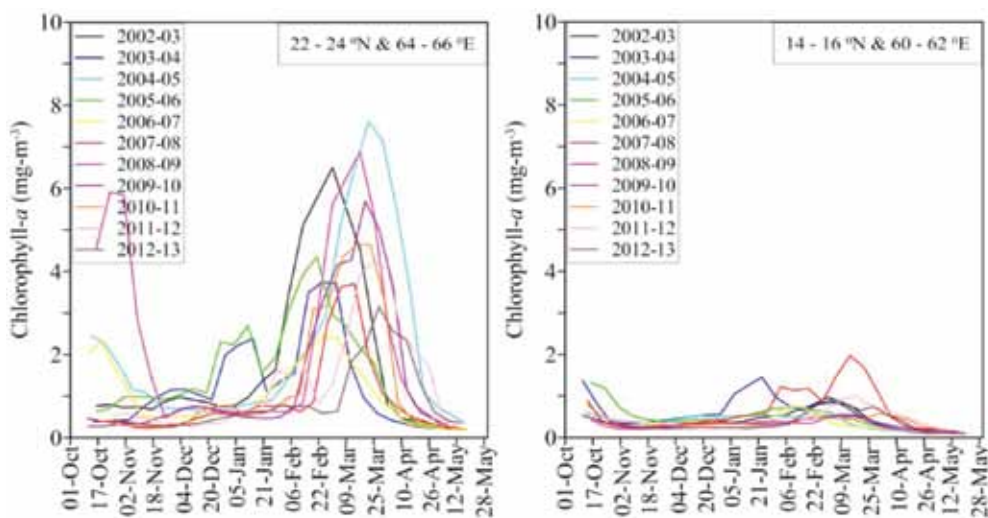


Fig. 7.5 Temporal variability in MODIS-A derived Chl-a for the years from 2002 to 2013 at two locations (a) 22 - 24° N & 64 - 66° E and (b) 14 - 16° N & 60 - 62° E in northeastern Arabian Sea.

8. Extramural Projects Funded by ESSO-INCOIS

In addition to focussed in-house R&D programmes, ESSO-INCOIS also funds research proposals submitted by scientists from different academic and research institutions in the country. Major categories of extra-mural research proposals are a) Marine Fisheries Advisories Services b) Ocean State Forecast services c) High resolution Operational Ocean Forecast and reanalysis System d) SATellite Coastal and Oceanographic REsearch (SATCORE), e) Palaeo tsunami studies and f) Ocean Observation Systems. The project proposals were selected for financial support based on peer review and the recommendations of the respective Project Monitoring Committees (PMC) chaired by eminent scientists before whom evaluated the presentations of the principal investigators. PMCs play a very important role in deciding the merit/suitability of the proposal so that it may augment the in-house R&D efforts and contribute towards improving the services provided by ESSO-INCOIS. PMCs also critically assess the progress in the implementation of the projects during annual review meetings. Approximately Rs.128.1 Cr. has been sanctioned for 49 projects in different categories, so far. Details of the extramural projects funded by ESSO-INCOIS during the 12th five year plan in each category are given below.

8.1 Marine Fisheries Advisories Services

PMC chairperson: Dr. Meena Kumari, Deputy Director General, Indian Council for Agricultural Research.

Table: 8.1 Marine Fisheries Advisories Services project details

Sl No.	Principal investigator	Title of project proposal	Sanctioned Budget (Rupees in Lakhs)	Duration
1	Dr. V. R. Madhu, Veraval Research Centre of Central Institute of Fisheries Technology (CIFT), Veraval	Studies on the ecological linkages between plankton production and <i>Acetes</i> sp. abundance along Gujarat Coast	23.3476	2013- 2017
2	Dr. A. S. Kulkarni, RP Gogate College of Arts and Science and R V Jogalekar College of Commerce, Ratnagiri	Monitoring marine phytoplankton community structure and seasonality as a food-web indicator for commercially important fishes off Ratnagiri Coast	54.3632	2013- 2017
3	Dr. Gangadhara Gowda, College of Fisheries, Karnataka Veterinary, Animal and Fisheries Sciences University, Mangalore	Study of influence of oceanographic parameters on plankton assemblage and pelagic fishery, using satellite data, along the coast of Dakshina Kannada and Udipi districts of Karnataka	60.1712	2013- 2017

4	Dr. V. Kripa, Central Marine Fisheries Research Institute (CMFRI), Kochi	Eco-biological investigations on major pelagic fishes and ecological modelling of epipelagic habitat off Kerala and Lakshadweep	88.2608	2013-2017
5	Dr. R. Jyothibabu, CSIR-NIO, Regional Centre, Kochi	Advanced studies on the plankton food web in relation to the oceanographic environment in the PFZ off Kochi	60.488	2013-2017
6	Dr. T. Saravana Kumar, Annamalai University, Tamil Nadu	Influence of in situ bio-optical properties in determining the phytoplankton community structure and their role in ocean colour algorithms along the southeast coast of India and its application to fisheries	67.2860	2013-2017
7	Prof. K. Sree Ramulu, Andhra University, Visakhapatnam	Impact of ocean parameters on fishery resources and development and validation of regional algorithms for ocean color constituents off Visakhapatnam coast	84.2480	2013-2017
8	Dr. U. Sreedhar, Research Centre of Central Institute of Fisheries Technology (CIFT), Visakhapatnam	Validation of Tuna advisories off East Coast	32.4952	2013-2017
9	Prof. Sugata Hazra, Jadavpur University	Bio-Optical studies and Ecological modeling in case II water of West Bengal coast towards Hilsa fishery forecast	69.3056	2013-2017
10	Dr. S. Dam Roy, Central Agricultural Research Institute (CARI), Port Blair	Location-specific augmentation of Potential Fishing Zones (PFZ) using satellite altimetry and fishing ground database	71.0056	2013- 2017
11	Ms. Nancy J. Anabel, M.S. Swaminathan Research Foundation, Chennai	Fisher Friend Programme – Capacity Building of Fisher folk for the effective use of ESSO-INCOIS Potential Fishing Zone Services for enhancing their lives and livelihoods in 5 states of Indian Coastline	108.46	2013-2017
12	Dr. Pratibha Rohit, Central Marine Fisheries Research Institute, Kochi	Satellite Telemetry Studies on Migration Patterns of Tunas in the Indian Seas (SATTUNA) – CMFRI Component 01	63.4096	2013-2017
13	Dr. Premchand, Fishery Survey of India	Satellite Telemetry Studies on Migration Patterns of Tunas in the Indian Seas (SATTUNA) – FSI Component 02	52.1456	2013-2017
14	Dr. V. S. Somvanshi, Dr. Babasaheb Ambedkar Marathwada University, Aurangabad	Writing a scientific book entitled “Remote Sensing Science and Societal Benefits to Coastal Fishermen”	9.9	2013–2015

8.2. Ocean State Forecast

PMC Chair : Prof. P. Rajendra Prasad, Sir Arthur Cotton Chair Professor, Andhra University.

Table: 8.2 Ocean State Forecast project details

Sl No	Principal investigator	Title of project proposal	Sanctioned Budget (Rupees in Lakhs)	Duration
1	Dr. V. Sanil Kumar, NIO, Goa	Real-time wave data collection at six locations in Indian waters for coastal ocean forecast.	191.08	2013-2017
2	Dr. Prakash Mehra, NIO, Goa	Establishment of a network of near real-time reporting surface meteorological stations at selected coastal and Island locations of India	66.25	2013-2017
3	Mrs. Sheela Nair, NCESS, Thiruvananthapuram	Establishment and maintenance of wave gauge stations along the Southwest coast of India	98.49	2013-2017
4	Prof. P. Bhanumurthy, Andhra University, Visakhapatnam	Validation, dissemination and refinement of the location-specific Coastal Ocean State Forecasts	59.23	2013-2017
5	Dr. J. L. Rathode, Karnatak University, Karwar	Sea state forecast off Uttara Kannada - Dissemination, validation and societal impact studies	30.025	2013-2017
6	Dr. A. N. Vedpathak, CCMB, Ratnagiri	Development and usage of ocean state forecast products from the display boards and the wave rider buoys for application of soft computing techniques in reduction of errors along Maharashtra coast	40.88	2013-2017
7	Prof. Shreenivas Londhe, VIIT, Pune	Improving location specific wave forecast using Soft Computing Techniques	15.099	2013-2017
8	Prof. N. G. Akolkar, JAU, Okha	Ocean State Forecast validation and research (off Okha and Veraval coasts of Gujarat)	26.34	2013-2017
9	Dr. Mohanraj, Kamaraj College, Tuticorin	Monitoring and dissemination of data from the wave rider buoy and comparison of physio-chemical parameters along the Tuticorin coastal waters	12.04	2013-2017

8.3. High-resolution Operational Ocean Forecast and reanalysis System (HOOFS)

PMC co-chairs : Prof. B. N. Goswami, Director, IITM and Dr. S. R. Shetye, Vice-chancellor, Goa University

Table: 8.3 HOOFS project details

Sl No	Principal investigator	Title of project proposal	Sanctioned Budget (Rupees in Lakhs)	Duration
1	Prof. P. N. Vinayachandran, IISc, Bangalore	Modeling physical-biological interactions in the Indian Ocean	181.66	2013-2017
2	Dr. Meenakhshi Chatterjee, Basanti Devi College, Kolkata	Sundarbans Estuarine Programme, Observational study of tidal propagation, salinity and temperature variations in the Sundarbans Estuarine System	25.21	2014-2015
3	Prof. Ravi S. Nanjundiah, IISc, Bangalore	Study of teleconnections and Ocean-Atmosphere coupling over Indian Region using AOGCM	53.96	2013-2017
4	Dr. Prasad Kumar Bhaskaran, IIT, Kharagpur	Development and implementation of coupled ADCIRC-SWAN model for the Indian seas	32.31	2013-2017
5	Prof. M. C. Deo, IIT, Mumbai	Improved predictions of sea surface temperature using neural networks	31.54	2013-2017
6	Prof. U. C. Mohanti, IIT Bhubhaneswar	High resolution regional ocean-atmosphere coupled modeling system for the prediction of intense vortices over the Indian seas	112.62	2013-2017
7	Shri. I. Suresh, NIO, Goa	Dynamics of intraseasonal variability in the North Indian Ocean waveguide	60.20	2013-2017
8	Dr. A. S. Unnikrishnan, NIO, Goa	Tidal currents on the continental shelf and slope off Indian Ocean	33.17	2013-2017
9	Prof. A. D. Rao, Indian Institute of Technology, Delhi	Development of an improved prediction system for storm surges and its inland inundation along the Indian coast	91.99	2013-2017
10	Dr. Arun Chakraborty Indian Institute of Technology, Kharagpur	High Resolution Bay of Bengal Circulation using adjacent point source river discharge using ROMS	47.00	2013-2017

8.4. SATellite Coastal and Oceanographic REsearch (SATCORE)

PMC chair : Dr. R. Navalgund, Vikram Sarabhai Distinguished Professor at ISRO, Bangalore

Table: 8.4 SATCORE project details

SI No.	Principal investigator	Title of project proposal	Sanctioned Budget (Rupees in Lakhs)	Duration
1	Prof. Harilal B. Menon, Goa University	Optical characterization of case II waters and retrieval of colour components from an optical sensor	61.23	2013-2017
2	Dr. P. Shanmugam, Indian Institute of Technology Madras, Chennai	Observations, analysis and algorithms for characterization and monitoring of harmful algal blooms in Indian coastal waters	67.77	2013-2017
3	Dr. N. H. Joshi Junagadh Agricultural University, Gujarat	Effect of optically active substances on diversity in phytoplankton community structure off Gujarat	47.91	2013-2017
4	Dr. T. Suresh, NIO, Goa	Remote sensing of phytoplankton functional types	59.43	2013-2017
5	Dr. Muhamed Ashraf P. Fishing Technology Division Central Institute of Fisheries Technology (CIFT), Kochi	Retrieval of phytoplankton biomass and associated optical constituents based on long term bio-optical studies	66.30	2013-2017
6	Prof. Kali Charan Sahu, Berhampur University, Odisha	Characterizing coastal water quality using bio-optical properties with special emphasis to phytoplankton size class	65.03	2013-2017
7	Prof. Nittala S. Sarma, Andhra University, Visakhapatnam	Studies on CDOM variability, structure and affecting factors for improving Ocean colour algorithm in the mid-western Bay of Bengal	70.10	2013-2017
8	Prof. B. R. Raghavan Mangalore University, Mangalore	Size distribution of total suspended matter and measurement of optical properties to derive a local scale algorithm in a time sequenced scenario off Mangalore	63.83	2013-2017

8.5. Ocean Observation System (OOS)

PMC Chair : Secretary, MoES

Table: 8.5 OOS project details

SI No	Principal investigator	Title of project proposal	Sanctioned Budget (Rupees in Lakhs)	Duration
1	Dr. D. Shankar, NIO, Goa	Current Observation and Simulation in the Indian EEZ (COSINE)	1850	2013-2017
2	Dr. V. S. N. Murty, NIO, RC, Visakhapatnam	Equatorial Mooring Array for Current Observations and Research on Indian Ocean Dynamics (EMAC-IOD)	1200	2013-2017
3	Dr. V. V. Gopalakrishna, NIO, Goa	Observed trends in the near surface layer temperature/salinity fields in the Indian Seas (XBT/XCTD)	1250	2013-2017
4	Dr. V. V. Gopalakrishna, NIO, Goa	Acquiring data on ocean surface current velocities, salinity and meteorological parameters using satellite tracked drifting buoys in the Indian Ocean	810.00	2013-2017

8.6. Palaeo Tsunami

PMC Chair: Dr. A. K. Singhvi, outstanding scientist and J. C. Bose National Fellow, PRL, Ahmedabad.

Table: 8.6 Palaeo Tsunami project details

SI No	Principal investigator	Title of project proposal	Sanctioned Budget (Rupees in Lakhs)	Duration
1	Dr. M. Ravi Kumar NGRI, Hyderabad	Investigation of Seismicity & Lithospheric Structure in the ANDaman-Nicobar Subduction Zone (ISLANDS)	222.25	2012-2017
2	Dr. Kusala Rajendran, IISc, Bangalore	Seismo-tectonic history, plate boundary deformation and state of stress in the Andaman-Sumatra subduction zone and its adjoining areas	30.06	2013 - 2016
3	Dr. C. P. Rajendran JNC SAR, Bangalore	Evaluating earthquake/tsunami recurrence along the Andaman arc from the study of shallow cores	59.64	2013 - 2016
4	Dr. Nilesh P. Bhatt, The M.S. University of Baroda, Baroda, Gujarat	Studies of response control variables in application of geological signatures in paleo-tsunami investigations	32.41	2013 - 2017

5	Dr. Javed N. Malik, IIT Kanpur, Kanpur	Paleo-seismic and Paleo-Tsunami investigations along South-Middle Andaman & Car Nicobar Islands towards earthquake & tsunami hazard assessment of A&N Islands	149.415	2013 - 2018
6	Dr. S. Srinivasulu, Anna University, Chennai, Tamil Nadu	Tsunami and Storm dynamics from coastal sedimentary archives: A multi-proxy, multi-site, event to millennial timescale study to resolve the origin of paleo washover deposits	20.83	2013 - 2014

9. Research Highlights

Sustained progress of ESSO-INCOIS in Operational Oceanography is possible due to the research and development activity that has been translated as services. Outcomes of R&D activities are published in peer reviewed journals. Some of the published research is highlighted here.

9.1 The accuracy of Ocean State Forecasts during cyclone 'Thane'.

The reliability of the operational Ocean State Forecast system at ESSO-INCOIS during tropical cyclones that affect the coastline of India is described in this article. The performance of this system during cyclone Thane, that severely affected the southeast coast of India during the last week of December, 2011 was reported. Spectral wave model was used for forecasting the wave fields generated by the tropical cyclone and the validation was done using real-time automated observation systems. The validation results indicated that the forecasted wave parameters agree well with the measurements. The feedback from the user community indicated that the forecast was reliable and highly useful. Alerts based on this operational ocean state forecast system are thus useful for protecting lives of the coastal communities along the coastline of India.



Fig. 9.1 a) The forecasted wave heights and directions, issued during tropical cyclone Thane for Puducherry and Tamil Nadu, b) High wave alerts were displayed through electronic display boards, c) On-line real-time validation posted on the ESSO-INCOIS website.

Ref: Balakrishnan Nair, T.M., Sirisha, P., Sandhya, K.G., Srinivas, K., Sanil Kumar, V., Sabique, L., Nherakkol, A., Krishna Prasad, B., Kumari, R., Jeyakumar, C., Kaviyazhahu, K., Ramesh Kumar, M., Harikumar, R., Shenoi, S.S.C., Nayak, S. Performance of the Ocean State Forecast system at Indian National Centre for Ocean Information Services (2013) *Current Science*, 105 (2), pp. 175-181.

9.2 Daily composite wind fields from Oceansat-2 scatterometer

Oceansat-2 scatterometer (OSCAT) is an active microwave sensor, intended to provide ocean surface wind vectors over the global oceans. Daily composites of OSCAT Level-3 (L3) wind vectors generated using Data-Interpolating Variational Analysis (DIVA) method from ascending and descending passes over the Indian Ocean region was validated by comparing with Advanced Scatterometer (ASCAT) and wind from in situ buoys for the year 2012. Wind composites generated using DIVA method were found to match well with the in situ and ASCAT wind products. Minor deviations were observed with respect to ASCAT wind, which could be attributed to the difference in interpolation techniques used for the two scatterometer products. Given that the repeat period of ASCAT is 5 days and that of OSCAT is only 2 days, OSCAT wind products could be conveniently used for real-time met-ocean studies.

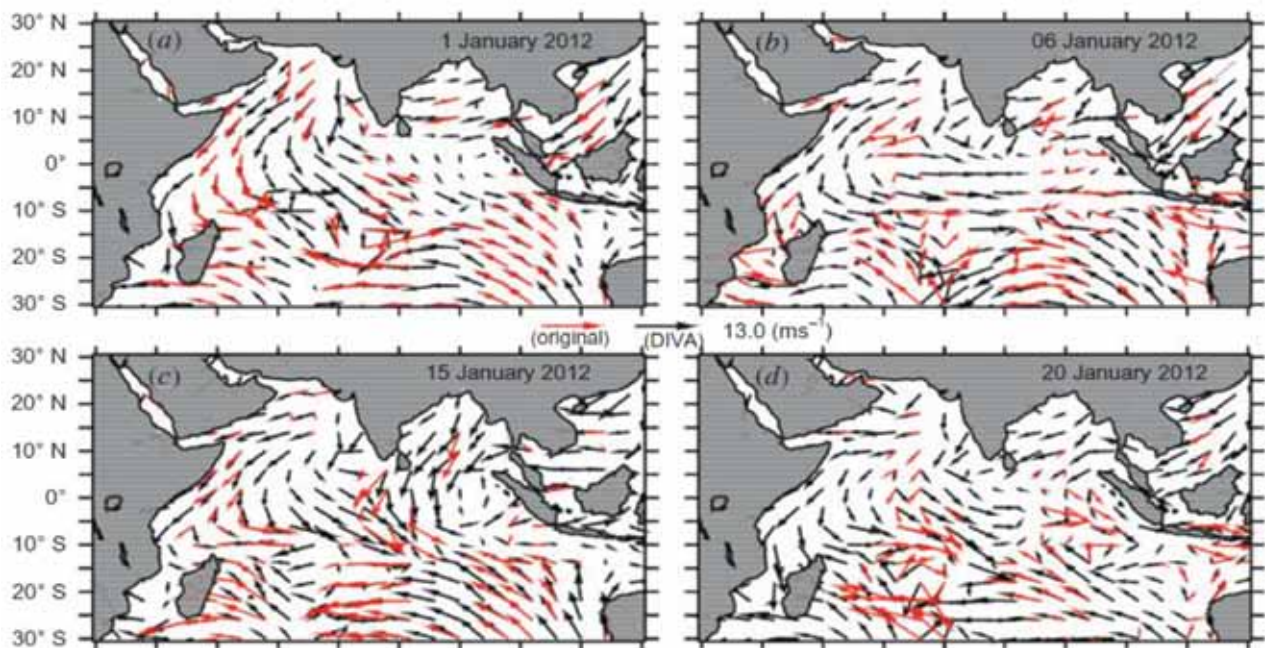


Fig. 9.2 DIVA-interpolated daily composites of wind vectors and the uninterpolated wind vectors from OSCAT for 4 different days in January 2012.

Ref: Chiranjivi, J., Udaya Bhaskar, T.V.S., Swain, D., Rama Rao, E.P., Bansal, S., Dutta, D., Rao, K.H., Daily composite wind fields from Oceansat-2 scatterometer (2014) *Remote Sensing Letters*, 5 (3), pp. 258-267.

9.3 Performance evaluation of the Indian Ocean Forecast System (INDOFOS)

Forecasts of SST, surface currents, MLD and depth of thermocline generated by the Indian Ocean Forecast System (INDOFOS) were validated using in situ and remotely sensed observations. It was found that while the accuracy of prediction of SST in the Arabian Sea and the Bay of Bengal was much higher than that in the equatorial Indian Ocean, the quality of predictions of surface currents and the depth of the thermocline was better near the equatorial Indian Ocean compared

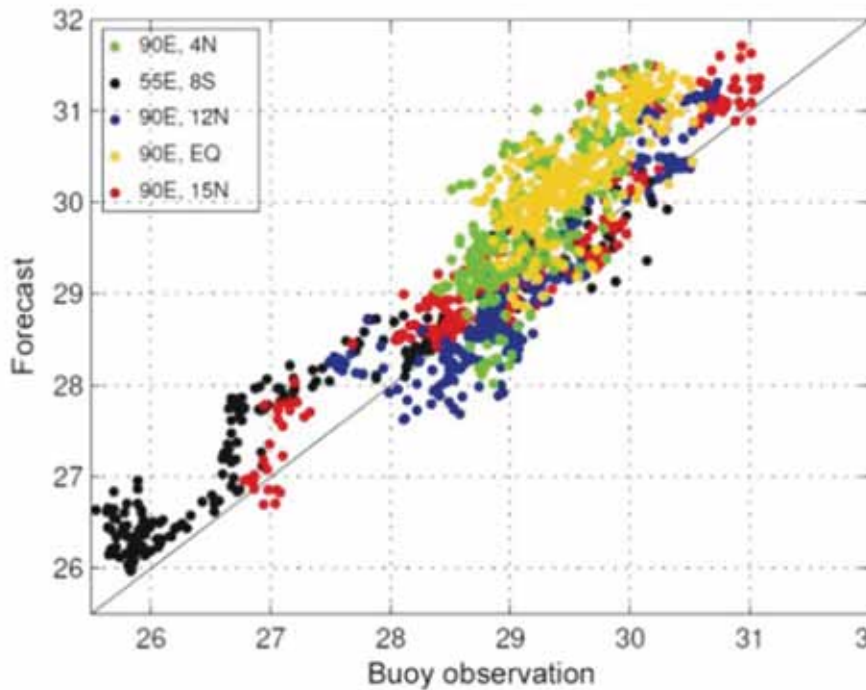


Fig. 9.3 SST (°C) predicted by INDOFOS plotted against the observations (RAMA buoys) at selected locations in the Indian Ocean. Dots with different colours represent data from different locations.

Ref: Francis, P. A., Vinayachandran P. N. And Shenoi S. S. C., *The Indian Ocean Forecast System*, *Current Science*, 104 (10), 1354-1368

to that in the Bay of Bengal. It was also found that the shorter timescale variations in isothermal layer depths were predicted by INDOFOS realistically, but the magnitudes of this variation were underestimated.

9.4 New indices for the equatorial Indian Ocean oscillation

It is now well known that there is a strong association between the extremes of Indian summer

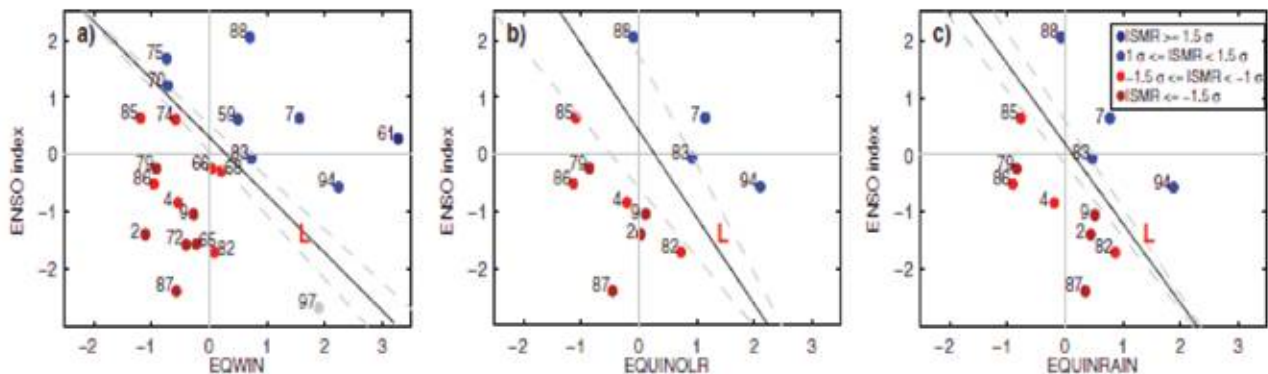


Fig. 9.4 Extremes of ISMR during 1958–2011 represented on the phase-plane of (a) EQWIN and ENSO index, (b) EQUINOLR and ENSO index for (1979–2011) and (c) EQUINRAIN and ENSO index for (1979–2011).

Ref: Francis P. A. and Sulochana Gadgil, *A note on new indices for the equatorial Indian Ocean oscillation*, 2013, *J. Earth System Sciences*, 122(4), 1005-1011.

monsoon rainfall (ISMR) with the El Nino - Southern Oscillation (ENSO) and the Equatorial Indian Ocean Oscillation (EQUINOO). So far, the index used for EQUINOO is EQWIN, which is based on the surface zonal wind over the central equatorial Indian Ocean. Since the most important attribute of EQUINOO is the oscillation in convection/precipitation, the indices based on convection or precipitation would be more appropriate. Continuous and reliable data on outgoing longwave radiation (OLR), and satellite derived precipitation are now available from 1979 onwards. Hence, new indices for EQUINOO, based on the difference in the anomaly of OLR/precipitation between eastern and western parts of the equatorial Indian Ocean are introduced. It is shown that the strong association of extremes of the Indian summer monsoon with ENSO and EQUINOO is also seen when the new indices are used to represent EQUINOO, which further indicates the robustness of this relationship.

9.5 Inertial oscillations in the thermocline observed in the Bay of Bengal after the passage of cyclone 'Jal'

Upper oceanographic and surface meteorological time-series observations from a moored buoy located at 9.98°N, 88°E in the south-western Bay of Bengal (BoB) were used to quantify the variability in upper ocean, forced by the tropical cyclone (TC) Jal during November 2010. After the passage of cyclone, an abrupt increase of 1 psu (decrease of 1°C) in salinity (temperature) in the near-surface layers (up to 40 m depth) was observed for up to 10–12 days during the relaxation stage of cyclone. Mixed layer heat budget analysis showed that the vertical processes were the dominant contributors towards the observed cooling. The net surface heat flux and horizontal advection together contributed approximately 33% of observed cooling, during the forced stage of TC Jal. Analysis showed the existence of strong inertial oscillation in the thermocline region and currents with periodicity of ~ 2.8 days. During the relaxation stage of the cyclone, upward movement of thermocline in near-inertial frequencies played a significant role in mixed layer temperature and salinity variability, with much freer turbulent exchange between the mixed layer and thermocline.

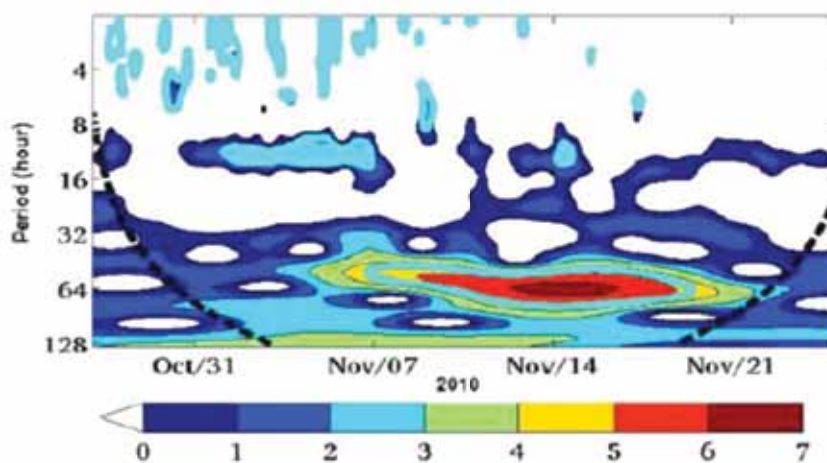


Fig. 9.5 The wavelet power spectrum (m^2) of hourly D23 derived from BD13 at 9.98° N, 88° E in BoB. The thick dashed line indicates the cone of influence. Cyan contour is the 95% confidence level, using a red noise background spectrum

Ref: Girishkumar, M.S., Suprit, K., Chiranjivi, J., Udaya Bhaskar, T.V.S., Ravichandran, M., Shesu, R.V., Pattabhi Rama Rao, E. Observed oceanic response to tropical cyclone Jal from a moored buoy in the south-western Bay of Bengal (2014) *Ocean Dynamics*, 64 (3), pp. 325-335.

9.6 Observed intraseasonal thermocline variability in the Bay of Bengal

The time series of temperature data obtained from moored buoys deployed at 8° N, 12° N, and 15° N along 90° E in the Bay of Bengal (BoB) showed a persistent intraseasonal variability on a 30–120 day time scale in three distinct periods 30–70 day, near 90 day, and near 120 day in the thermocline region. The standard deviation of moored buoy temperature data shows that half of the variability in the thermocline region was contributed from 30–120 day variability. The relative contribution of local Ekman pumping velocity and remote wind forcing from equatorial Indian Ocean (EIO) to the intraseasonal thermocline variability in the BoB was examined using satellite-derived sea surface height anomaly (SSHA), wind and depth of 23°C isotherm (D23, proxy for thermocline depth) derived from moored buoys temperature data. The analysis showed that the large amplitude intraseasonal oscillations of thermocline—particularly the near 90 day and 120 day variability—could not be explained by local Ekman pumping velocity alone. The SSHA, D23, and wind fields reveal that the first and second baroclinic mode Kelvin and Rossby waves, which are generated remotely by winds from the EIO and eastern BoB, have significantly influenced the thermocline variability in the BoB. The near 90 day and 120 day thermocline variability was driven primarily by the variability of equatorial zonal wind stress. On the contrary, the 30–70 day thermocline variability was affected by interior Ekman pumping over the Bay, the zonal wind stress in the EIO and the alongshore wind stress in the eastern BoB.

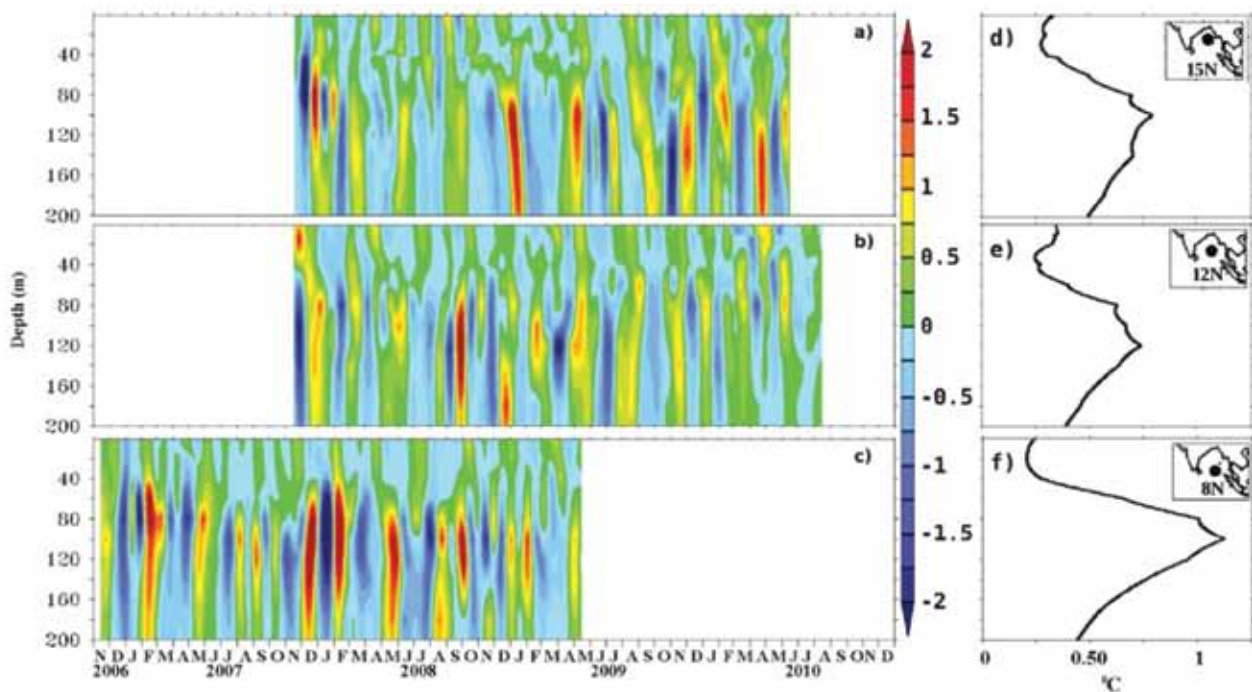


Fig. 9.6 Time series of intraseasonal (30–120 day band-pass-filtered) vertical temperature profiles and its standard deviation at 15° N, 90° E (a and d); at 12° N, 90° E (b and e); at 8° N, 90° E (c and f). Units: °C.

Ref: Girishkumar, M.S., Ravichandran, M., Han, W. Observed intraseasonal thermocline variability in the Bay of Bengal (2013) *Journal of Geophysical Research C: Oceans*, 118 (7), pp. 3336-3349.

9.7 Winter time thermal inversions in the Bay of Bengal influence the mixed layer heat budget

Time series measurements of temperature, salinity and surface meteorological parameters recorded at 8° N, 90° E in the southern central Bay of Bengal (BoB) from a Research Moored Array for African-Asian-Australian Monsoon Analysis and predication (RAMA) buoy were used to document the temperature inversions and their influence on the mixed layer heat budget during the winters, (defined as October to March) of 2006–2007 (W67) and 2007–2008 (W78). There was a marked difference in the frequency and amplitude of temperature inversion between these two winters, with variations much stronger in W78 compared to W67. The formation of temperature inversions were favoured by the existence of thick barrier layers, more prominent in W78 compared to W67. Inversions occurred when heating of the barrier layer occurred due to penetrative shortwave radiation. This study further demonstrated that the intraseasonal and year-to-year variability in the frequency and magnitude of temperature inversions during winter have substantial influence on mixed layer temperature through the modulation of vertical heat flux at the base of the mixed layer.

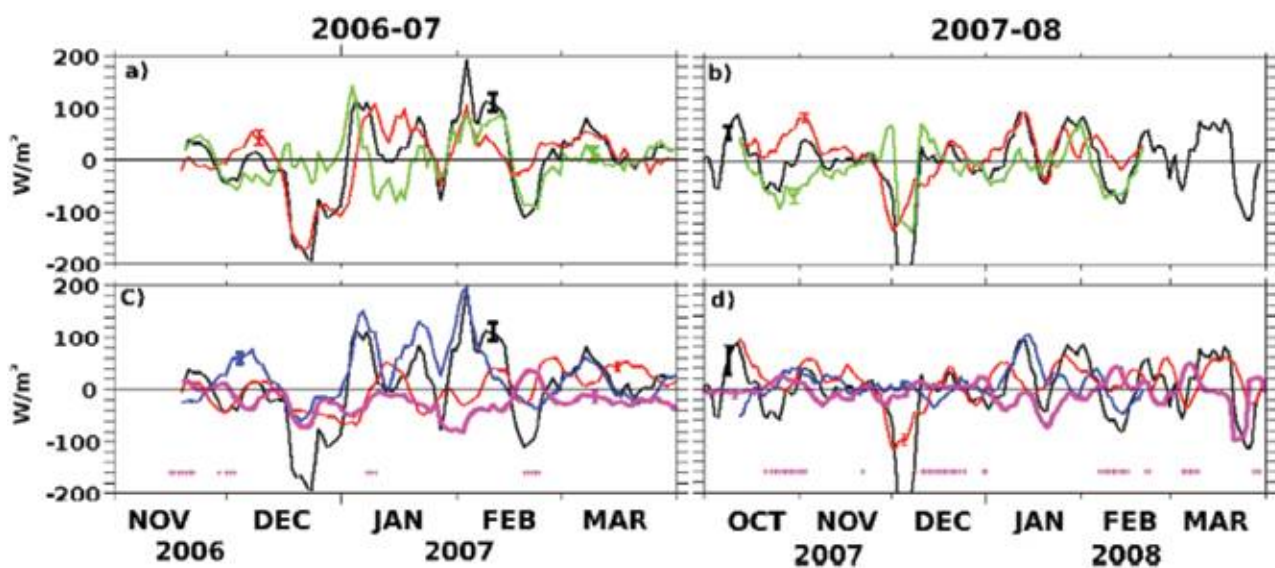


Fig. 9.7 Top panels: Terms of mixed layer heat budget ($^{\circ}C\ day^{-1}$). Temperature tendency (black line), heat flux due to net surface heat flux ($Q_{net}\ Q_{open}$), horizontal advection and vertical process (red line) and residual (green line).

Bottom panels: Temperature tendency (blackline), vertical processes (pink line), net surface heat flux ($Q_{net}\ Q_{open}$; red line) and horizontal advection (blue line). The presence of temperature inversions is marked with pink “*” signs.

Ref: Girishkumar, M.S., Ravichandran, M., McPhaden, M.J. Temperature inversions and their influence on the mixed layer heat budget during the winters of 2006-2007 and 2007-2008 in the Bay of Bengal (2013) *Journal of Geophysical Research C: Oceans*, 118 (5), pp. 2426-2437.

9.8 Observed thermal stress in the coral environs of the Andaman Islands

The bleaching status of the Andaman region was assessed based on the Degree of Heating Weeks (DHW) and Hot Spot (HS) for the bleaching event that occurred in the Andaman region in April/May, 2005. The bleaching status up to Alert Level-1 was recorded with the maximum HS of

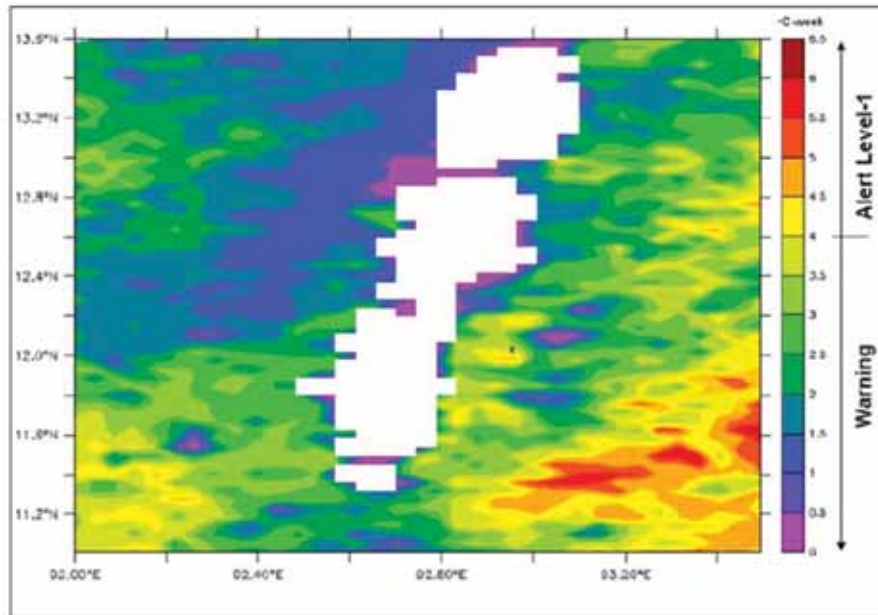


Fig. 9.8 Distribution of DHWs around the Andaman Island depicted the warning and alert level-1 bleaching status. Star mark in the east of Andaman depicts the location of Havelock Island.

Ref: Mohanty, P.C., Mahendra, R.S., Bisoyi, H., Kumar Tummula, S., Grinson, G., Nayak, S., Kumar Sahu, B. Assessment of the coral bleaching during 2005 to decipher the thermal stress in the coral environs of the Andaman Islands using remote sensing (2013) *European Journal of Remote Sensing*, 46 (1), pp. 417-430.

3 °C and DHW 6 °C per week. Simultaneous in situ reef observations conducted in the Andaman Sea confirmed the coral bleaching event. The maximum mortality in the region, due to coral bleaching, occurred for *Acropora* species (43%) followed by *Montipora* species (22%) and *Porites* species (14%).

9.9 Mechanisms controlling the Sea-Surface Temperature interannual Anomalies (SSTA) in the southwestern tropical Indian Ocean induced by El Nino and the Positive Indian Ocean Dipole

The evolution of Sea Surface Temperature interannual Anomalies (SSTA) in the Thermocline Ridge of the southwestern tropical Indian Ocean (TRIO) region was studied in respect to responsible physical processes, using a combination of observational estimates and model-derived surface layer heat budget analyses. It was observed that the vertical oceanic processes contributed most to SSTA variance from December to June, while lateral advection dominated from July to November. It was also found that the atmospheric fluxes generally damp SSTA generation in the TRIO region. As a result of the phase opposition between the seasonal cycle of vertical processes and lateral advection, there was no obvious peak in SSTA amplitude in boreal winter, as previously noted for heat content anomalies. Positive Indian Ocean Dipole (IOD) events and the remote influence of El Nino induced comparable warming over the TRIO region, though IOD signals peaked earlier (November–December) than those associated with El Nino (around March–May). Mechanisms controlling the SSTA growth in the TRIO region induced by these two climate modes

differ strongly. While SSTA growth for the IOD mostly results from southward advection of warmer water, increased surface shortwave flux dominated the El Nino SSTA growth. In both cases, vertical oceanic processes did not contribute strongly to the initial SSTA growth; rather these maintained the SSTA by opposing the effect of atmospheric negative feedbacks during the decaying phase.

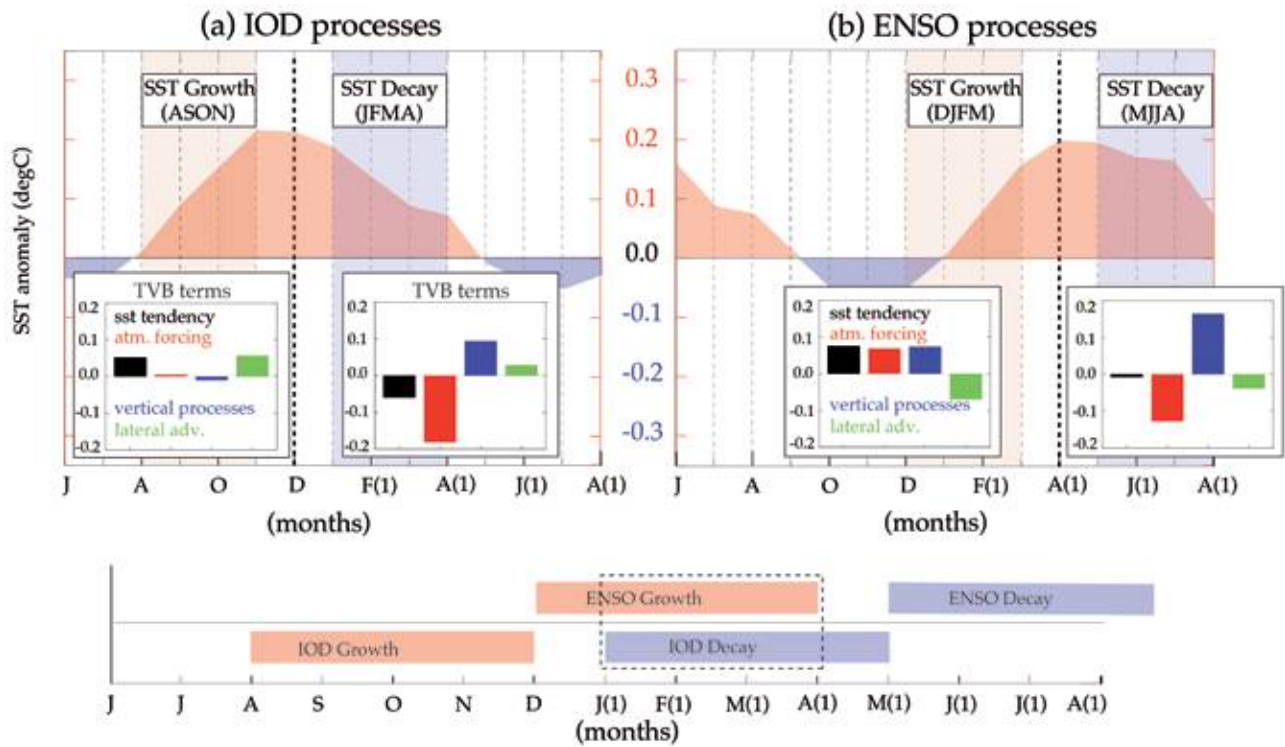


Fig. 9.9 Processes of warming and cooling associated with (a) IOD and (b) ENSO in the TRIO region. SST anomaly related with IOD and ENSO are shown in the two panels where red shading shows positive and blue shading show negative SSTAs. The red and blue strips show periods of SST growth and SST decay respectively. The TVB terms associated with IOD and ENSO related SSTAs are shown as bar diagrams in the insets.

Ref: Praveen Kumar, B., Vialard, J., Lengaigne, M., Murty, V.S.N., Foltz, G.R., McPhaden, M.J., Pous, S., de Boyer Montégut, C. Processes of interannual mixed layer temperature variability in the thermocline ridge of the Indian Ocean (2014) *Climate Dynamics*, pp. 1-21.

9.10 Development of a regional model for the North Indian Ocean

The performance of the regional Indian Ocean configuration of the Geophysical Fluid Dynamics Laboratory's (GFDL) Modular Ocean Model (MOM4p1) nested (one way) within a coarse resolution global setup of MOM was evaluated. The regional Indian Ocean MOM4p1 configuration has a horizontal resolution of 25 km and vertical resolution of 1 m near the surface. The model was forced with Inter-annual forcing based on Coordinated Ocean-Ice Reference Experiments (CORE II) for the period 1992–2005. It was shown that relative to the global simulation, biases in upper ocean temperature, salinity, mixed layer depth and upper ocean currents have reduced. The improvements in model simulation occurred due to refined resolution, more realistic topography and inclusion of seasonal river runoff. Notably, the surface salinity bias was reduced to less than

0.1 psu over the Bay of Bengal using relatively weak restoring to observations, and the model simulated the strong, shallow halocline often observed in the North Bay of Bengal. There was a marked improvement in subsurface salinity and temperature, as well as mixed layer depth in the Bay of Bengal. Major seasonal signatures in observed sea surface height anomaly in the tropical Indian Ocean, including the coastal waveguide around the Indian peninsula, were simulated with great fidelity. The use of realistic topography and seasonal river runoff brought the three dimensional structure of the East India Coastal Current and West India Coastal Current much closer to observations. As a result, the incursion of low salinity Bay of Bengal water into the southeastern Arabian Sea was more realistic.

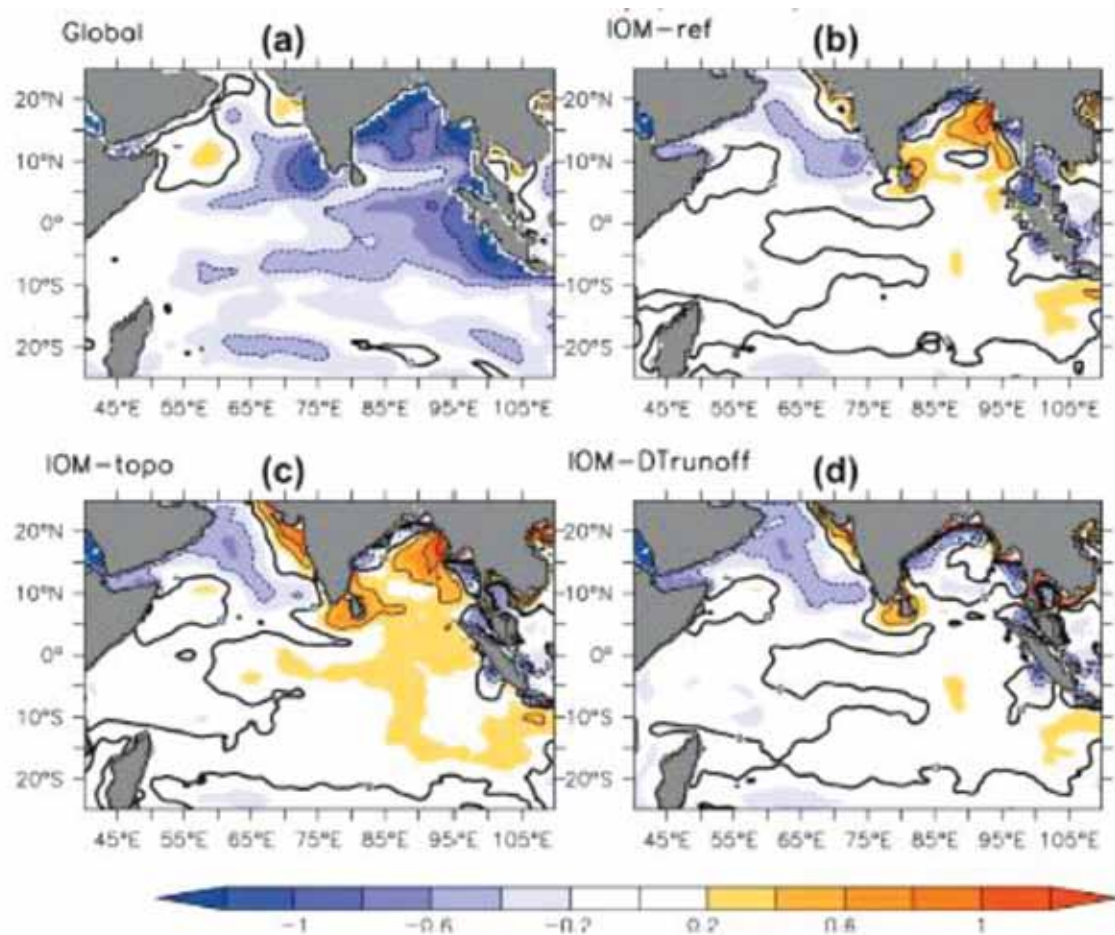


Fig. 9.10 Annual difference (observation minus model) plot of upper ocean salinity [0–30 m] in psu
(a) Global, (b) IOM-ref, (c) IOM-topo and (d) IOM-DTrunoff.

Ref: Rahaman, H., Ravichandran, M., Sengupta, D., Harrison, M.J., Griffies, S.M. Development of a regional model for the North Indian Ocean (2014) *Ocean Modelling*, 75, pp. 1-19.

9.11 Evaluation of near-surface air temperature and specific humidity obtained from various hybrid global products

Daily near-surface air temperature (T_a) and specific humidity (Q_a) from three hybrid flux products, namely, Coordinated Ocean-Ice Reference Experiments version II (COREII), Objectively Analysed

Air-Sea Fluxes (OAFlux), and Air-Sea Fluxes for the Global Tropical Oceans (TropFlux), are evaluated using in situ data over the North Indian Ocean. The analysis showed that the root-mean-square error (RMSE) value of air temperature (T_a) was $\sim 0.5^\circ\text{C}$ for all products. TropFlux captured the daily variability of T_a very well, but it had a systematic deviation in T_a . The large drop in T_a observed during intense rainfall events was very well captured by TropFlux. All products overestimated specific humidity (Q_a) by $0.3\text{--}1.5\text{ g kg}^{-1}$; OAFlux had the smallest systematic deviation, whereas TropFlux had the highest

correlation with buoy data. The overestimation of Q_a by the products was mainly caused by high values of Q_a , in the range of $18\text{--}22\text{ g kg}^{-1}$. The RMSE of Q_a ranges from 0.92 to 1.79 g kg^{-1} , with OAFlux having the lowest values. Latent heat flux (LHF) computed from a

bulk algorithm was underestimated by all products, due to the positive bias in Q_a . In the southern Bay of Bengal, LHF decreased with increasing Q_a during winter and summer monsoons. In this region, a change in 1 g kg^{-1} Q_a can cause about $11\text{--}15\text{ W m}^{-2}$ errors in LHF. Similar to the western Pacific Ocean, the air-sea humidity difference was linearly related to sea surface temperature for values greater than 28°C .

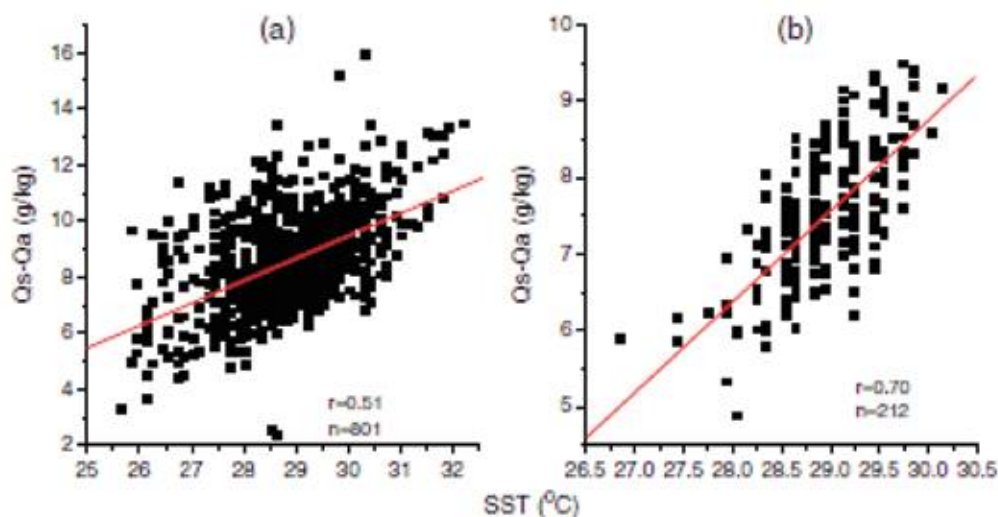


Fig. 9.11 Scatterplots of air-sea Δq (g kg^{-1}) with SST ($^\circ\text{C}$) from buoy observations over the southern BoB: (a) annually and (b) summer monsoon.

Ref: Rahaman, H., Ravichandran, M. Evaluation of near-surface air temperature and specific humidity from hybrid global products and their impact on latent heat flux in the North Indian Ocean (2013) *Journal of Geophysical Research C: Oceans*, 118 (2), pp. 1034-1047.

9.12 Evaluation of the Global Ocean Data Assimilation System for the Tropical Indian Ocean

The quality of ocean analyses in the Tropical Indian Ocean (TIO) obtained from the operational Global Ocean Data Assimilation System (GODAS) which was set up at ESSO-INCOIS was assessed here. The influence of different momentum forcing on the analyses product was also studied using sensitivity experiments. The analysis reproduced most of the observed features of temperature, SSHA and currents with reasonably good accuracy in the TIO at both intra-seasonal and inter-annual time scales. The analyses also showed improvements in the ocean current field, when forced with QuikSCAT winds.

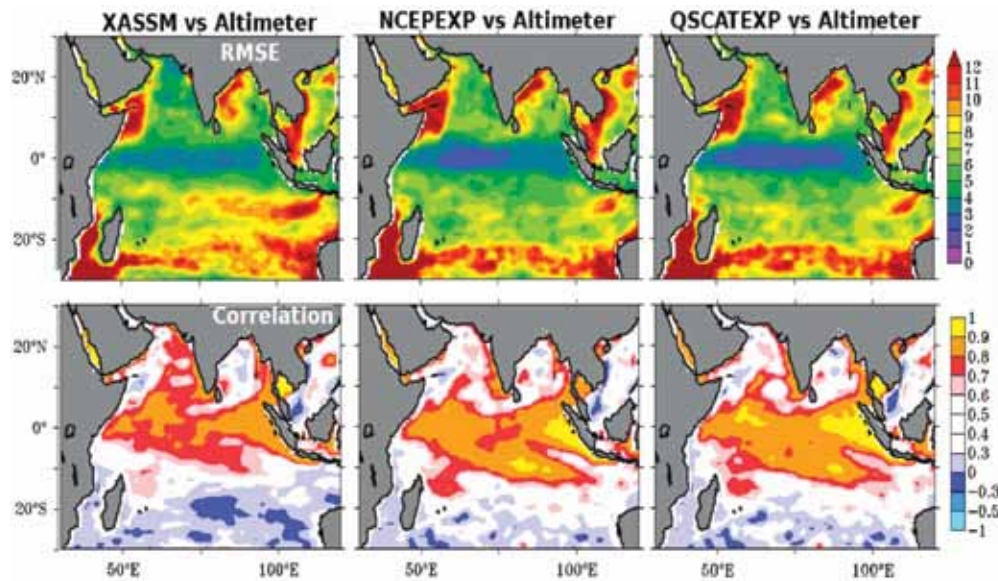


Fig. 9.12 The RMSD (cm, top panel) and correlation (bottom panel) between SSHA derived from the model and altimeter for (a) no assimilation experiment, (b) forced with NCEP reanalysis forcing and (c) forced with QuickSCAT wind forcing during 2004–2009.

Ref: Ravichandran, M., Behringer, D., Sivareddy, S., Girishkumar, M.S., Chacko, N., Harikumar, R. Evaluation of the Global Ocean Data Assimilation System at ESSO-INCOIS: The Tropical Indian Ocean (2013) Ocean Modelling, 69, pp. 123-135.

9.13 Simulations from nested setup of Simulating WAVes Nearshore (SWAN) model

Performance of the nested setup of two state-of-art wave models viz WAVEWATCH III (WW3) and Simulating WAVes Nearshore (SWAN) were evaluated by comparing the simulated wave parameters with the observations from wave-rider buoy located off-the coast of Puducherry. The models were forced with French Research Institute for Exploitation of the Sea/Laboratory of Oceanography From Space (IFREMER/CERSAT) blended surface winds for the period June, 2007 to July, 2009. On an average, the simulations have good agreement with the observations. It is further shown that the spectra derived from the model simulated observed spectra well except at the lower frequencies.

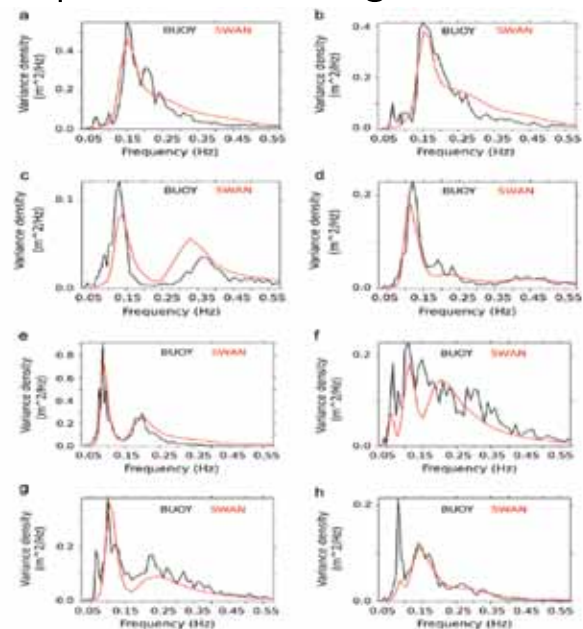


Fig. 9.13 Comparison of one-dimensional wave energy spectra (m^2Hz^{-1}) between model and buoy observation during (a) 2 January 2008 (2100 UTC) (b) 3 January 2008 (0300 UTC) (c) 1 April 2009 (1800 UTC) (d) 3 April 2009 (1200 UTC) (e) 20 July 2007 (0300 UTC) (f) 25 July 2007 (1200 UTC) (g) 1 October 2007 (1500 UTC) and (h) 13 October 2007 (0000 UTC)

Ref: Sandhya, K.G., Balakrishnan Nair, T.M., Bhaskaran, P.K., Sabique, L., Arun, N., Jeykumar, K. Wave forecasting system for operational use and its validation at coastal Puducherry, east coast of India (2014) Ocean Engineering, 80, 64-72.

9.14 Comparison of Daily gridded Advanced Scatterometer (DASCAT) vs QSCAT wind products

In order to examine whether Daily gridded winds from Advanced Scatterometer (DASCAT) are a reliable replacement for the widely used QSCAT wind products, the DASCAT and QSCAT wind products were compared with the observations available from RAMA moored buoy observations. This comparison indicated that DASCAT better captures the overall wind variability compared to QSCAT, especially during rainy and low wind (5 ms^{-1}) conditions. The root-mean-square of the RAMA–DASCAT (RAMA–QSCAT) difference during rains in the zonal and meridional winds is 1.4 and 1.6 ms^{-1} (2.7 and 2.0 ms^{-1}), respectively. Spatial distributions of DASCAT and QSCAT winds showed good agreement with each other in speed and direction, except over a few localized regions. The study found a significant spatial coherence between rainfall and the regions of discrepancy between DASCAT and QSCAT.

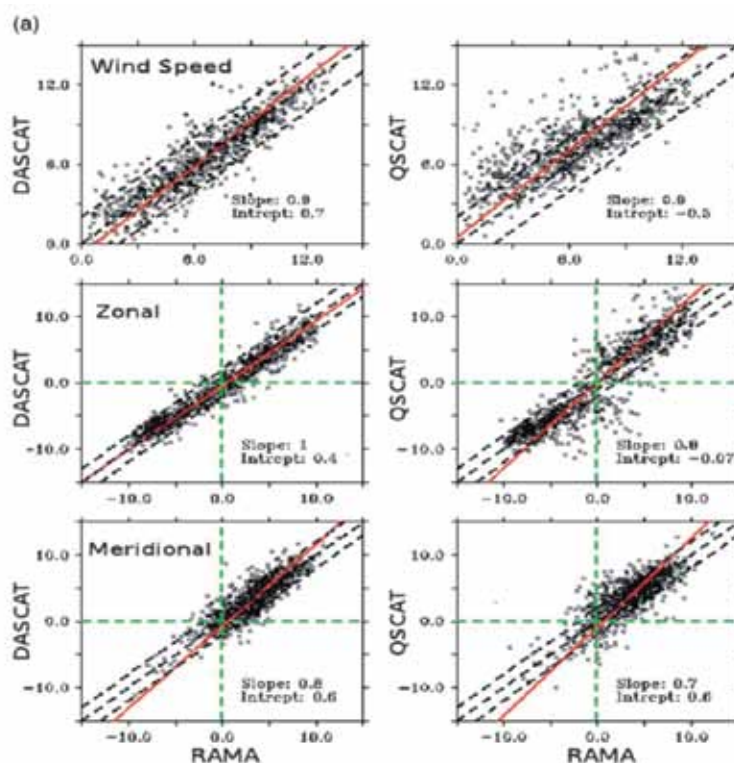


Fig. 9.14 Scatter plots RAMA vs DASCAT and (left) and RAMA and QSCAT (right) wind (ms^{-1})

Ref: Sivareddy, S., Ravichandran, M., Girishkumar, M.S. Evaluation of ASCAT-Based daily gridded winds in the tropical Indian ocean (2013) *Journal of Atmospheric and Oceanic Technology*, 30 (7), pp. 1371-1381.

9.15 Can oxycline depth be estimated using sea level anomaly (SLA) in the northern Indian Ocean?

Information on depth of oxycline is critical not only for understanding magnitude and extent of the hypoxic zone but also for specifying potential fishing zones on operational basis. We analysed Argo-oxygen data from the northern Indian Ocean, along with sea level anomaly (SLA) data from altimeter, to demonstrate the correlation between depths of oxycline, thermocline and SLA. Our analysis suggests that observed variability in oxycline depth is mainly governed by physical processes such as vertical movement in the thermocline depth in the northern Indian Ocean basin. There exists strong positive correlations between depth of thermocline, oxycline and SLA. Oxycline depth and SLA are highly correlated in the Arabian Sea, but the correlation between the two is weaker in the Bay of Bengal and equatorial Indian Ocean. A regression equation between SLA and oxycline depth, which may be used to estimate the depth at which water is oxygen deficient (through oxycline) in the northern Indian Ocean.

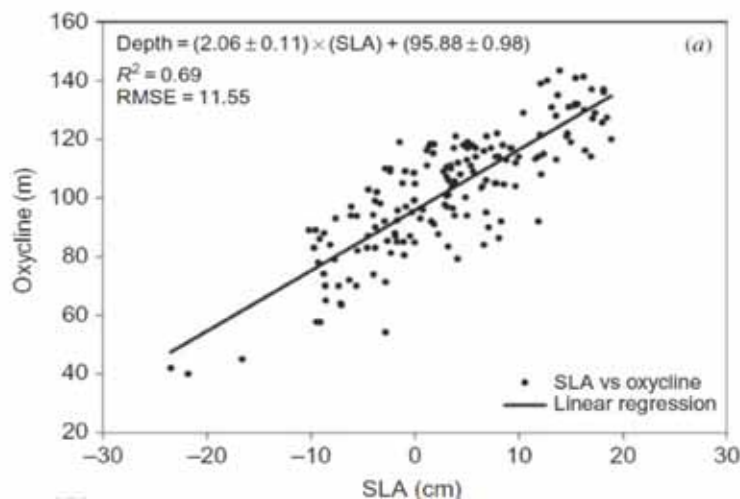


Fig. 9.15 Scatter plot of oxycline depth and sea level anomaly for the Arabian Sea

Ref: Prakash, S., Prakash, P., Ravichandran, M. Can oxycline depth be estimated using sea level anomaly (SLA) in the northern Indian Ocean? (2013) *Remote Sensing Letters*, 4 (11), pp. 1097-1106

9.16 List of publications from ESSO-INCOIS in SCI journals during April 2013-March 2014

1. Balakrishnan Nair, T.M., Sirisha, P., Sandhya, K.G., Srinivas, K., Sanil Kumar, V., Sabique, L., Nherakkol, A., Krishna Prasad, B., Kumari, R., Jeyakumar, C., Kaviyazhahu, K., Ramesh Kumar, M., Harikumar, R., Shenoi, S.S.C., Nayak, S. Performance of the Ocean State Forecast system at Indian National Centre for Ocean Information Services (2013) *Current Science*, 105 (2), pp. 175-181.
2. Baliarsingh, S.K., Sahoo, S., Acharya, A., Dalabehera, H.B., Sahu, K.C., Lotliker, A.A. Oil pollution in Chilika lagoon: An anthropogenic threat to biodiversity (2014) *Current Science*, 106 (4), pp. 516-517.
3. Baliarsingh, S.K., Sahu, B.K., Srichandan, S., Sahu, K.C., Lotliker, A.A., Srinivasa Kumar, T. Seasonal variation of phytoplankton community in Gopalpur Creek: A tropical tidal backwater ecosystem, East Coast of India (2013) *Indian Journal of Marine Sciences*, 42 (5), pp. 622-634.
4. Baliarsingh, S.K., Srichandan, S., Naik, S., Sahu, K.C., Lotliker, A.A., Kumar, T.S. Distribution of hydro-biological parameters in coastal waters off Rushikulya Estuary, East Coast of India: A premonsoon case study (2013) *Pakistan Journal of Biological Sciences*, 16 (16), pp. 779-787.
5. Bhaskaran, P.K., Gayathri, R., Murty, P.L.N., Bonthu, S., Sen, D. A numerical study of coastal inundation and its validation for Thane cyclone in the Bay of Bengal (2014) *Coastal Engineering*, 83, pp. 108-118.
6. Bhaskaran, P.K., Nayak, S., Bonthu, S.R., Murty, P.L.N., Sen, D. Performance and validation of a coupled parallel ADCIRC-SWAN model for THANE cyclone in the Bay of Bengal (2013) *Environmental Fluid Mechanics*, 13 (6), pp. 601-623.

7. Chakraborty, K., Das, K., Kar, T.K. An ecological perspective on marine reserves in prey-predator dynamics (2013) *Journal of Biological Physics*, 39 (4), pp. 749-776.
8. Chakraborty, K., Das, S., Kar, T.K. On non-selective harvesting of a multispecies fishery incorporating partial closure for the populations (2013) *Applied Mathematics and Computation*, 221, pp. 581-597.
9. Chakraborty, K., Haldar, S., Kar, T.K. Global stability and bifurcation analysis of a delay induced prey-predator system with stage structure (2013) *Nonlinear Dynamics*, 73 (3), pp. 1307-1325.
10. Chakraborty, K., Das, K., Kar, T.K. Combined harvesting of a stage structured prey-predator model incorporating cannibalism in competitive environment (2013) *Comptes Rendus - Biologies*, 336 (1), pp. 34-45.
11. Chiranjivi, J., Udaya Bhaskar, T.V.S., Swain, D., Rama Rao, E.P., Bansal, S., Dutta, D., Rao, K.H., Daily composite wind fields from Oceansat-2 scatterometer (2014) *Remote Sensing Letters*, 5 (3), pp. 258-267.
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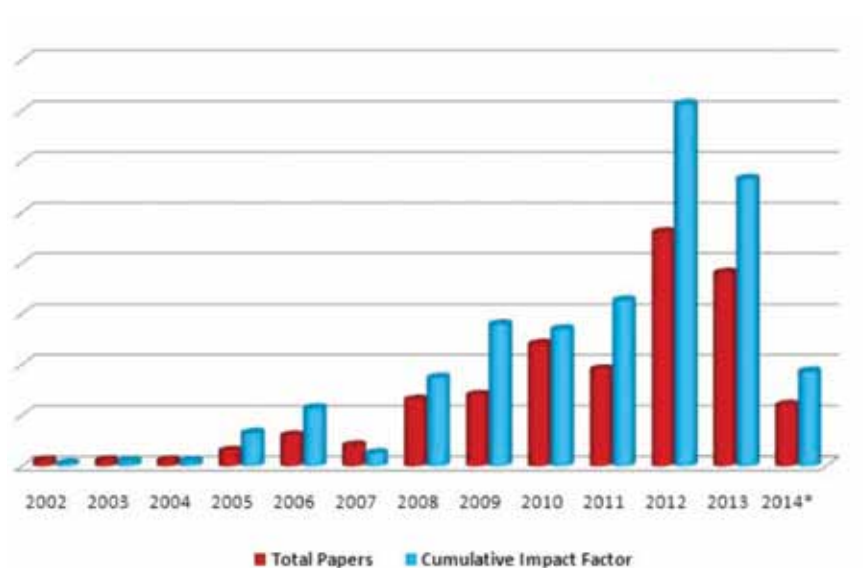


Fig. 9.16 Year-wise number of publications from ESSO-INCOIS and their cumulative impact factors.

10. Computational and Web Capabilities

10.1 Computational facilities

ESSO-INCOIS continued to maintain its computing and network infrastructure with an up-time of 99% to support operational and R&D projects. The computer infrastructure includes link load balancers, application load balancers, firewalls, core switches, edge switches, 30 km long campus-wide networking, high performance computer facility and allied infrastructure which includes a processor cooling system, a precision air conditioning units, uninterrupted power supply units, a redundant computer facility, 300 TB storage facility, ERP servers, FTP server, web & application servers, Live Access Server, workstations, desktops and laptops. The network and the infrastructure is designed such that no single point of failure will affect operational services at ESSO-INCOIS. Office automation was enabled through SAP (Systems, Application and Products). The modules for 'Purchase & Stores' and 'Finance & Accounts' were made operational. The 'HR' module and 'Employ Self Service' module also will be made operational soon.

High performance facility

The 7.2TF computing facility with an associated storage of 150TB is available to users to run their numerical models operationally and also for R&D purpose. This facility is being maintained with an uptime of 99% during the period of this report. 47 internal users and 11 external users are continuously running various numerical models like ROMS, MOM, HYCOM, Wavewatch-III, SWAN, ADCIRC, TUNAMI - N2, GODAS and WRF. The operational models are prioritised dynamically, which pre-empts the ongoing R&D jobs, to complete the operational commitments of ESSO- INCOIS within the specified timelines. This approach reduces the idle time of the computing facility as well as improves the optimal utilisation of the system.

10.2 Web based services

ESSO-INCOIS continued to maintain the multi-lingual, Web-GIS enabled and database driven dynamic website cum ocean portal that provides ocean information and advisory services to the user community. Significant contributions were made to automate the acquisition, processing and archival of data to be disseminated through the ESSO-INCOIS website using latest web technologies. During the past year, the web team developed web applications for (i) management of Indian Argo floats to provide information about year wise deployment status, individual float position etc. and (ii) wave rider buoy drift and maintenance information. A web application for displaying RAMA Buoy data in real time and comparing that with Ocean State forecasts was also developed. Other developmental activities carried out during the past year include upgradation of tide prediction datasets accessible through the Web GIS interface, website development for the

International Training Centre for Operational Oceanography (ITCOcean), website development for the 50th anniversary celebrations of the International Indian Ocean Expedition (IIOE), website development for Tropflux Air-Sea fluxes for the Global Tropical Oceans ,website development for Joint International Workshop of ISPRS WG VIII/1 and WG IV/4 on 'Geospatial Data for Disaster and Risk Reduction' during 21-22 November, 2013 and a web application for online submission of applications for job opportunities at ESSO-INCOIS.

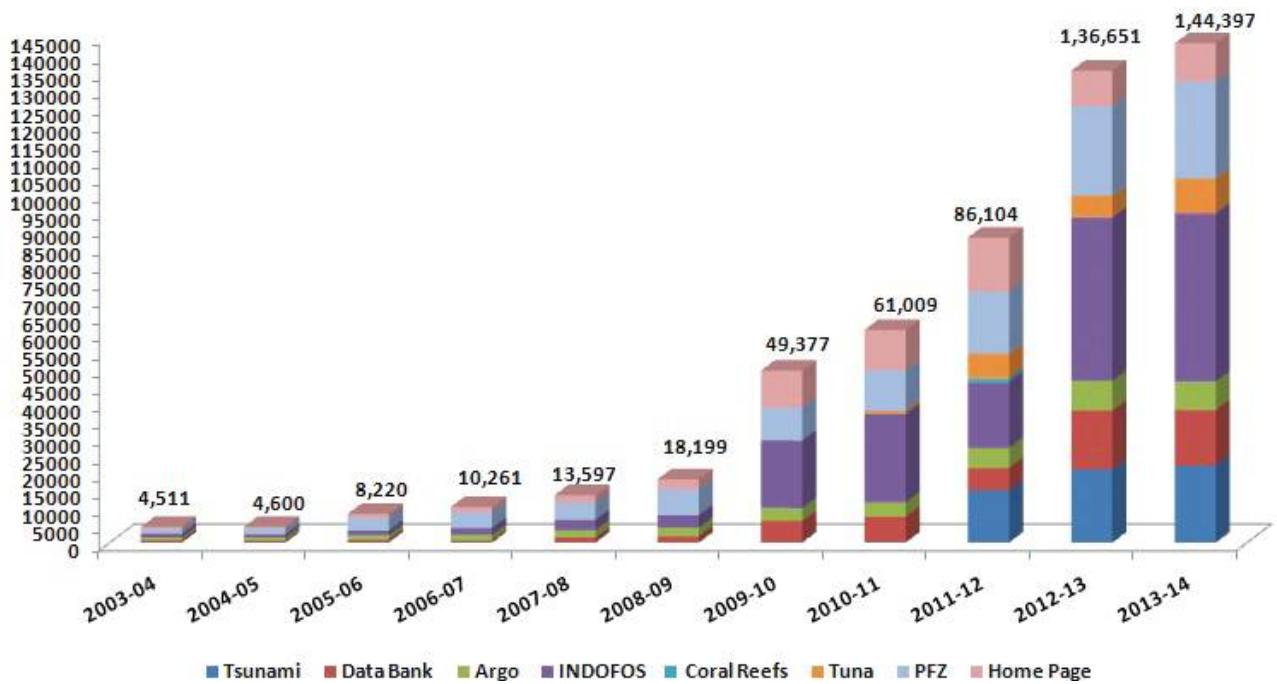


Fig. 10.1 Number of visitors to ESSO-INCOIS webpages

11. Capacity Building, Outreach and Training

11.1 International Training Centre for Operational Oceanography (ITCOcean)

Operational oceanography is becoming increasingly popular due to its importance in sustainable development of marine environment and due to the growing dependency of mankind on the oceans



Fig. 11.1 Signing of MoA between ESSO-INCOIS and IOC/UNESCO on 4 July 2013 in Paris, France

with respect to food and the changing climate. Realising the importance of operational oceanography and lack of facilities for capacity building, the Ministry of Earth Sciences (MoES), Government of India established the International Training Centre for Operational Oceanography (ITCOcean) at ESSO-INCOIS. ESSO-INCOIS signed a Memorandum of Agreement with the Intergovernmental Oceanographic Commission/UNESCO on 4 July, 2013 in Paris during the 27th session of the IOC Assembly to mutually cooperate in capacity building for operational oceanography.

During 2013-14, the following short term courses were conducted by ITCOcean.

A two week training course on **“Ensemble Kalman Filtering -Methods and Algorithms”** was held during 15-26 July 2013. The main faculty was Prof. S. Lakshmivarahan, School of Computer Science, University of Oklahoma, USA, Thirty participants from ESSO-INCOIS, IITM, NCMRWF, NRSC, University of Hyderabad, Jawaharlal Nehru Technological University, Hyderabad and Jadavpur University attended the course.



Fig. 11.2 Prof. S. Lakshmivarahan lecturing on Data Assimilation during the course on “Ensemble Kalman Filtering-Methods and Algorithms”.

A two week summer school on **“Fundamentals of Ocean Climate Modeling at Global and Regional Scales”** was held during 5-14 August, 2013, in collaboration with International Centre for Theoretical Physics (ICTP), Italy



Fig. 11.3 Stephen M. Griffies teaching a class at the Summer School on “Fundamentals of Ocean Climate Modeling at Global and Regional Scales”

and CLIVAR. The faculty consisted of Dr. E. Curchister, Rutgers University, USA, Dr. S. Griffies, NOAA/GFDL, USA, Dr. J. John, NOAA/GFDL, USA, Dr. A. Schiller, CSIRO, Australia, Dr. P.S. Swathi, CMMACS, India, Dr. V. Balaji, Princeton University and NOAA/GFDL, USA, Dr. R. Farneti, ICTP, Italy and Dr. Ravichandran, ESSO-INCOIS. Thirty participants, from six Institutes in India (IITM, ESSO-INCOIS, CMMACS, NIO, IISc and Jadhavpur University) and IOR countries [Australia (CSIRO, University of Tasmania), Belgium (University Catholique de Louvain),

Kenya (Kenya Meteorological Department), Nigeria (University of Nigeria, Togo (University of Lome)] attended the summer school. The selection of participants was done together with ICTP, Italy.

A customized course on “**Oceanography**” for the Scientists of Proof and Experimental Establishment (PXE) of DRDO, Balasore was conducted during 6-10 January, 2014. Faculty members for this course were drawn from ESSO-INCOIS, IIT (Kharagpur) and NIO, Goa, 10 scientists from PXE participated in the training programme.

A short course on “**Remote Sensing of Potential Fishing Zones and Ocean State Forecast**” was held during 24-29 March 2014. Twenty four participants - 15 from India and 9 from seven IOR countries (South Africa, Italy, Comoros, Madagascar, Mauritius, Bangladesh and Sri Lanka) attended the course. The faculty comprised of scientists from the National Remote Sensing Centre, Space Applications Centre (ISRO), Indian Institute of Technology (Kharagpur) and ESSO-INCOIS. Lectures covering the basics of remote sensing, identification of Potential Fishing Zones using satellite data, dissemination of the advisories, review of ocean models, ocean state forecasts and various products were delivered in addition to a number of laboratory sessions and hands-on exercises.



Fig. 11.4 Participants of the short course on “Remote Sensing of Potential Fishing Zones and Ocean State Forecast”

11.2 4th ESSO-INCOIS User Interaction Workshop

The 4th ESSO-INCOIS User Interaction Workshop was conducted at ESSO-INCOIS on 25 February, 2014. One hundred and eighty users/delegates, including officials of ONGC, Indian Navy, Coast Guard, Ports and Harbours, NGOs, universities, various scientific organizations and representatives of fishing community participated in the workshop.

Dr. V. K. Dhadwal, Director, National Remote Sensing Centre (NRSC), Hyderabad was the Chief Guest and Dr. K. Ajay Parida, Executive Director of M.S. Swaminathan Research Foundation (MSSRF), Chennai, and Commander M.A. Thalha, Indian Coast Guard, Andhra Pradesh were the Guests of Honour for the inaugural function.

Several new initiatives/products were launched during this workshop. An ESSO-INCOIS-MSSRF Market Study Report - "Potential Fishing Zone Advisories and Conversion from Bottom Trawling to Gillnetting: Role of MSSRF-INCOIS Partnership in Gilakaladindi Village in Krishna District, Andhra Pradesh - a preliminary study" was released during the user interaction workshop. A new service to provide Ocean State Forecasts for ports and harbours was also launched during the workshop. A Memorandum of Understanding (MoU) for downstreaming the dissemination of ocean information and advisory services was signed between ESSO-INCOIS, Tata Consultancy Services (TCS) and the Reliance Foundation (RF).



Fig. 11.5 Clockwise from top left: Inauguration of the 4th User Interaction Workshop on 25 February, 2014 at ESSO-INCOIS; launch of ESSO-INCOIS service "Ocean State Forecasts for Ports and Harbours"; release of the INCOIS-MSSRF market study report and exchange of the MoU between ESSO-INCOIS and Tata Consultancy Services for the dissemination of ESSO-INCOIS advisory services.

11.3 The Tsunami Standard Operating Procedure (SOP) workshop

The Tsunami Standard Operating Procedure (SOP) workshop was conducted for Disaster Management Officials (DMOs) of coastal states and Union Territories (UTs) at ESSO-INCOIS on 5 June, 2013. Fifty-five DMOs from control rooms of coastal states/UTs, Indian Coast Guard, Indian Navy, NDRF, Ports & Harbours, etc participated in the workshop. Objectives of the training were to familiarize the DMOs of coastal states/UTs with ITEWC tsunami bulletins, understand their tsunami preparedness and guide the preparation of SOPs. The tabletop exercise was conducted by dividing the participants into six groups viz. Tsunami Warning Centre, DMO, Navy/Coast Guard, Strategic Installations, Line Departments/ Ports & Harbours and Media.

A new version of the ITEWC website was inaugurated by Dr. Shailesh Nayak, Secretary, MoES during the inauguration of workshop. Director, ESSO-INCOIS released the Telugu version of the leaflets on 'Tsunami Safety Rules'. The updated Tsunami awareness leaflets (*Early Warning System, Sensing a Tsunami, Tsunami on the move, Tsunami Preparedness, What is Tsunami, Tsunami Safety for boaters and Tsunami Safety Rules*), both in English and Telugu languages were also distributed.



Fig. 11.6 Tsunami SOP workshop inauguration and tabletop exercise (top), group photo (bottom)

11.4 Tsunami Mock Drill and SOP workshop

ESSO-INCOIS and the Directorate of Disaster Management, Andaman & Nicobar jointly organised a tsunami mock drill for Andaman & Nicobar Islands on 22 November, 2013. To prepare for the same, a one day tsunami SOP workshop was also conducted for DMOs of A&N on 11 September, 2013 at Port Blair.

11.5 Training programme on “In situ sampling protocols for SATellite Coastal and Oceanographic REsearch (SATCORE) and Marine Fisheries Advisory Services (MFAS)”

In order to provide hands-on training to research scholars of SATCORE the MFAS programme on Standard Operation Procedure (SOP) for the implementation of sampling strategy, during the measurement of essential parameters and to organize and archive in situ data, a training programme was conducted during 2-5 March, 2014 at Centre for Studies on Bay of Bengal (CSBoB), Andhra University, Visakhapatnam. The training was attended by 27 research scholars working on SATCORE and MFAS projects. The programme included lectures on measurement principles of instruments, field trip and demonstration of analytical laboratory procedures.



Fig. 11.7 Participants of the joint SATCORE-MFAS training programme at Centre for studies on Bay of Bengal

11.6 Interaction meeting on Ocean State Forecast projects

An Interaction Meeting on “Ocean State Forecast Products” was arranged during 17-18 December, 2013. Thirty four participants, including principal investigators and research staff of various projects as well as the representatives from NGOs and related institutes attended the meeting.

A User Interaction & Awareness Meeting for the usage of Ocean State Forecasts was held on 29 January 2014 at Agatti (Lakshadweep Islands). Location-specific Ocean State Forecast for Lakshadweep Islands through sms and e-mail in Malayalam was inaugurated by Sri. K. Nizamudheen Koya, Deputy Collector, Agatti.



Fig. 11.8 The Interaction Meeting on Ocean State Forecast Products during 17-18 December, 2013 at ESSO-INCOIS



Fig. 11.9 User Interaction and Awareness Meeting and the Inauguration of Ocean State Forecast for Lakshadweep through SMS and E-mail in Malayalam at Agatti (U.T. of Lakshadweep).

12. International Interface

12.1 IOGOOS (Indian Ocean-Global Ocean Observation System) Secretariat

The IOGOOS secretariat located at ESSO-INCOIS has the responsibility for (i) maintenance of IOGOOS membership details and their focal contacts (ii) coordination and organisation of annual meetings and general body meetings that include preparation of agenda in consultation with officers, mobilizing funds for the organisation of meetings, preparation of annual meeting reports, notification of vacancies, maintenance of financial accounts of IOGOOS secretariat, etc. (iii) circulating the rules or procedures amended by the annual general body meetings time to time and (iv) coordination with the subsidiary bodies of IOGOOS.

During the period April 2013 – March, 2014, the IOGOOS secretariat successfully coordinated IOGOOS activities including the annual meeting and capacity building activities along with support to the first meeting of the International Indian Ocean Expedition 50th Anniversary Initiative-2 (IIOE-2) Reference Group.

The IIOE-2 programme is being developed by IOC and SCOR with co-leadership of IOGOOS. The first meeting of IIOE-2 was hosted by ESSO-INCOIS during 14-15 May, 2013 at Hyderabad. At this meeting, IIOE history, scientific motivation and outcomes were reviewed in detail to identify the unanswered scientific questions that may be addressed by the programme.



Fig. 12.1 The first IIOE-2 meeting hosted by ESSO-INCOIS

The IOGOOS tenth annual meeting was organized at Port Louis, Mauritius during 21-24 October, 2013. This meeting focused on IndOOS/ IOGOOS / IIOE-2 and also held general discussions on Pilot Projects of IOGOOS. Development of a strategy to reactivate the engagement of members in IOGOOS initiatives was discussed. IOGOOS has strongly endorsed and encouraged its members to engage in IIOE-2's planning phase (especially through discussion at the IOC assembly and executive council Meeting) and also to garner national support for the same. The meeting featured a session of plenary science talks from invited experts and was followed by a science workshop, both of which were part of IOGOOS decadal celebrations.

Dr. T. Srinivasa Kumar, Head, ASG, ESSO-INCOIS serves as an ILOGOOS officer for the Central Indian Ocean and Shri. M. Nagaraja Kumar, Scientist-D, ASG, ESSO-INCOIS serves as Secretary, ILOGOOS.

12.2 SIBER (Sustained Indian Ocean Biogeochemistry and Ecosystem Research) International Programme Office

Since its inception in 2010 the SIBER International Programme Office (IPO) functioning at ESSO-INCOIS has made significant contributions to the SIBER community which includes logistical arrangements for holding annual Science Steering Committee (SSC) meetings, information sharing and maintenance of SIBER website hosted by ESSO-INCOIS.

ESSO-INCOIS is represented in SIBER by M. Ravichandran, Head-MOG and the programme office is managed by Dr. Satya Prakash, Scientist, ESSO-INCOIS. SIBER has extended support to the planning of activities related to IIOE-2 including the first meeting hosted by ESSO-INCOIS in May, 2013. The IOP-SIBER Joint Session was held in Lijiang, China during 10-11 July, 2013.

12.3 International Society for Photogrammetry and Remote Sensing (ISPRS)

ISPRS is a non-governmental organization devoted to the development of international cooperation for the advancement of photogrammetry, remote sensing and their related applications. Shri. E. Pattabhi Rama Rao, Head-DMG, ESSO-INCOIS is serving as the Chair of the Working Group - IV/4 on Geospatial Data Infrastructure under the Technical Commission IV (Geospatial Databases and Location Based Services) and Dr. T. Srinivasa Kumar, Head-ISG, ESSO-INCOIS is serving as the Chair of the Working Group - VIII/1 on Disaster and Risk Reduction under the Technical Commission VIII (Remote Sensing Applications and Policies) for the inter-sessional period 2012-16.

12.4 International Oceanographic Data Exchange

The programme "International Oceanographic Data and Information Exchange" (IODE) of the "Intergovernmental Oceanographic Commission" (IOC) of UNESCO was established in 1961. The objective of IODE is to enhance marine research, exploitation and development, by facilitating the exchange of oceanographic data and information between participating member states, and by meeting the needs of users for data and information products.

The National Oceanographic Data Centre (NODC) is one of the three structural elements of IODE. IODE designated ESSO-INCOIS as NODC, India in 2004. NODC's mission is to provide

access and stewardship for the national resource of oceanographic data. This effort requires the gathering, quality control, processing, summarisation, dissemination, and preservation of data generated by national and international agencies.

Shri E. Pattabhi Rama Rao, Scientist E & Head, Data Management Group at ESSO-INCOIS is the National Coordinator from India for 'Data Management' under the IODE Programme. He is also serving as the Member of IODE Steering Groups on Ocean Biogeographic Information System (SG-OBIS) and IODE Quality Management Framework (SG-IODE QMF).

12.5 Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES)

RIMES operating from the campus of the Asian Institute of Technology in Pathumthani, Thailand is an international, intergovernmental, non-profit-making entity established on 30 April, 2009. Registered with the United Nations on 1 July, 2009, RIMES aims to provide regional early warning services and build the capacity of its Member States in the end-to-end early warning of tsunamis and hydro-meteorological hazards

As per the MoU between MoES, Govt. of India and RIMES for provision of forecast services to RIMES member countries, Ocean State Forecast services of ESSO-INCOIS, Hyderabad are provided to the Maldives Islands in the Indian Ocean in a daily operational mode. It is planned to deploy observational systems to validate the forecasts and the plan is being prepared to address the requirements of Comoros, Seychelles and Mauritius.

12.6 OceanSITES

OceanSITES is a global time series program which is a recognized component of the Global Ocean Observing System and part of the international JCOMM structure. Since 1999, the international OceanSITES science team has shared both data and costs in order to capitalize on the potential of moorings and ship-based time series. The growing network now consists of about 30 surface and 30 subsurface arrays. Satellite telemetry enables near real-time access to OceanSITES data by scientists and the public.

The OceanSITES Data Management Team aimed at development of the data management system by developing standards, formats and quality control procedures for the time series data from oceans. Considering the role of ESSO-INCOIS in this important activity for the Indian Ocean region, ESSO-INCOIS has been identified as the OceanSITES Data Assembly Centre (DAC).

ESSO-INCOIS is represented by Shri. E. Pattabhi Rama Rao, Head-DMG, on the OceanSITES Data Management Team. The 6th OceanSITES Data Management Team meeting was held during 29-30 May, 2013 in Seoul, South Korea.

12.7 Partnership for Observation of the Global Oceans (POGO)

The Partnership for Observation of the Global Oceans, POGO, is a forum created in 1999 by directors and leaders of major oceanographic institutions around the world to promote global oceanography, particularly the implementation of an international and integrated global ocean observing system.

ESSO-INCOIS continued to extend its support to POGO as a representative of India.

12.8 Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System (ICG/IOTWS)

The Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System (ICG/IOTWS) established by the Intergovernmental Oceanographic Commission (IOC) coordinates the implementation of the Indian Ocean Tsunami Warning System that is being established as a network of national systems. The network comprises of respective National Tsunami Warning Centre (NTWCs) of member states which receive tsunami advisories from the Regional Tsunami Service Providers (RTSPs) that have the capability to issue regional tsunami bulletins for the Indian Ocean. The National Tsunami Warning Centres (NTWCs) of individual countries, through bilateral agreements, will be allowed to choose the RTSP(s) from which they wish to access “Tsunami Watch” information. The Indian Tsunami Early Warning Centre (ITEWC) operated by ESSO-INCOIS serves as one of the RTSPs for the Indian Ocean.

Dr. T. Srinivasa Kumar, Head, ASG, ESSO-INCOIS is currently serving as the Vice Chair of the ICG/IOTWS. He is also chairing the task team on “Tsunami Watch Operations” of the Working Group on Tsunamis and Other Hazards Related to Sea-Level Warning and Mitigation Systems (TOWS-WG). ESSO-INCOIS contributed to the IOTWS Regional Workshop on “Standard Operating Procedures for Tsunami Warning and Emergency Response for Northern and Eastern Indian Ocean Countries” was held at Jakarta, Indonesia during 23-27 September, 2013 by providing resource personnel.

12.9 GODAE Ocean View

GODAE Ocean View is a group of scientists representing the agencies who provide operational ocean forecasts and managing in situ as well as remote sensing observation platforms. This forum provides an excellent platform for the scientists who are involved in the development of operational ocean forecasting systems, to exchange their experiences and collectively carry out intercomparison exercises of various ocean forecast and analysis products. ESSO-INCOIS is part of this group from October 2010 as a member of science team.

In July, 2013, ESSO-INCOIS was formally inducted into the patrons' group of GODAE Ocean View. The patrons' group is responsible for guiding the GODAE Ocean View science team to attain the targets of the group and for supporting the project office established in the UK Met Office.

13. Workshops/Lectures/Events

13.1 Joint International Workshop of the International Society for Photogrammetry and Remote Sensing (ISPRS) on Geospatial Data for Disaster and Risk Reduction (WG VIII/1 and WG IV/4)

ESSO-INCOIS hosted the Joint International Workshop of the International Society for Photogrammetry and Remote Sensing (ISPRS) on “Geospatial Data for Disaster and Risk Reduction (WG VIII/1 and WG IV/4)” during 21-22 November, 2013. Dr. Shailesh Nayak, Secretary, Ministry of Earth Sciences (MoES), Government of India and ISPRS Fellow inaugurated the workshop that focused on geospatial technology for disaster preparedness as well as on early warnings & response during landslides, floods, earthquakes, tsunamis, cyclones, storm surges, etc. It was attended by about 150 participants from India and abroad representing various research organizations, academia and industries. In all, 45 papers were presented (2 lead talks, 27 papers in six technical sessions and 16 papers in two short interactive sessions).



Fig. 13.1 Workshop Highlights: Workshop Inauguration; ISGN inauguration; presentation on Tsunami Hazard assessment in the Indian Ocean” by V. K. Gusiakov; presentations and interactions

13.2 15th Foundation day

ESSO-INCOIS celebrated its 15th Foundation Day on 3 February, 2014. Prof. Madhav Gadgil (Retd. Professor, Indian Institute of Science) delivered the ESSO-INCOIS foundation day lecture on “Science in the Service of a Symbiotic Society” and also planted a tree to commemorate the occasion. Celebrations included a special open-house programme in which about 800 students from different schools in Hyderabad participated. Twenty four students representing 8 schools in Hyderabad also participated in a special quiz competition on the theme “Oceanography”.



Fig. 13.2 ESSO-INCOIS Foundation day celebrations

13.3 Symposia, Lectures

1. Prof. L. Kantha, Professor, Aerospace Engineering Sciences, College of Engineering, Colorado Center for Astrodynamics, University of Colorado delivered a lecture on “Sub-grid Scale Parameterisation in Ocean Models: Turbulent Mixing” on 6 May, 2013.
2. Prof. S. Lakshmivarahan, Professor, University of Oklahoma delivered a lecture on “Data Mining vs Data Assimilation” on 29 July, 2013.
3. Dr. Amit Apte, Reader, Tata Institute of Fundamental Research, Bengaluru delivered a lecture on “Lagrangian and En-route Data Assimilation” on 1 October, 2013.

4. Prof. R. Ramesh, Physical Research Laboratory, Ahmedabad, delivered a lecture on "Nitrogen Cycling in the Arabian Sea: Implications to the Global Carbon Cycle" on 15 October, 2013.
5. Prof. V. S. Raju, Former Director, IIT Delhi delivered a lecture on "You have the potential in you to become whatever you want to be" on 18 October, 2013.
6. Prof. B. K. Saha, Jadavpur University delivered a lecture on "Sea level fluctuations with reference to Last Glacial Cycle in the Eastern Continental Shelf of India" 12 November, 2013.
7. Dr. Laurent Testut, LEGOS, Toulouse (France) delivered a lecture on "Review of the Sea Level Research Activities in France" on 20 January, 2014.
8. Prof. Madhav Gadgil, IISc Bangalore delivered a lecture on the Foundation Day of ESSO-INCOIS on the topic "Science in the Service of a Symbiotic Society" on 3 February, 2014.
9. Dr. R. M. Dwivedi, Emeritus Scientist, CMLRE, Kochi, delivered a lecture on "Detection and Species Identification of Algal Bloom in the Northern Arabian Sea" on 19 February, 2014.



Fig. 13.3 Lectures : (Clockwise from top left): Prof. S Lakshmivaran, Dr. Laurent Testut, Dr. Amit Apte, Prof. L. Kantha Prof R. Ramesh, Dr. R. M. Dwivedi, Prof. V. S. Raju, Prof. Madhav Gadgil, Prof. B. K. Saha (centre)

14. General Information

14.1 Student Projects

Twenty three students from various universities, engineering colleges and academic institutions carried out projects towards the fulfilment of the requirement of their curriculum at ESSO-INCOIS.

Table: 14.1 Student project details

Sl.No.	Name of Student	Name of Institute	Project Guide from ESSO-INCOIS
1	S. L. Akhil	Central University, Karnataka	N. Srinivasa Rao
2	Krishna Priya	Siddhartha Institute of Engineering & Technology (SIET), Hyderabad	T. V. S. Udaya Bhaskar
3	Ram Sai Shashank	Siddhartha Institute of Engineering & Technology (SIET), Hyderabad	T. V. S. Udaya Bhaskar
4	G. Arun Kumar	Siddhartha Institute of Engineering & Technology (SIET), Hyderabad	T.V. S. Udaya Bhaskar
5	Sharjeel Mohammed	Jawaharlal Nehru Technological University (JNTU), Hyderabad	M. Nagaraja Kumar
6	Mohammed Hafeez Pasha	Jawaharlal Nehru Technological University (JNTU), Hyderabad	M. Nagaraja Kumar
7	Balu Harish	Jawaharlal Nehru Technological University (JNTU), Hyderabad	R. Venkat Shesu
8	Tarakesh Reddy	Andhra University, Visakhapatnam	N. Srinivasa Rao
9	Nanda Kishore Reddy	Andhra University, Visakhapatnam	Sudheer Joseph
10	K. Jithin Abraham	Cochin University of Science and Technology (CUSAT), Kochi	T. M. Balakrishna Nair
11	T. Mohammed Naseef	Cochin University of Science and Technology (CUSAT), Kochi	Sudheer Joseph
12	S. Sruthi	Birla Institute of Technology & Science (BITS), Pilani	B. V. Satyanarayana
13	Vrinda Sharma	Cochin University of Science and Technology (CUSAT), Kochi	P. A. Francis
14	Sofia Farha	Challa Malla Reddy Engineering College (CMEC), Hyderabad	M. Jeyamani
15	P. Neha Reddy	Challa Malla Reddy Engineering College (CMEC), Hyderabad	M. Jeyamani
16	Piyush Kumar Singh	Challa Malla Reddy Engineering College (CMEC), Hyderabad	M. Jeyamani
17	Sankha Subhra Das	Bengal Engineering and Science University (BESU), Kolkata	Kunal Chakraborty
18	M. Vamsi	Central University, Hyderabad	Kunal Chakraborty
19	Alice Alex	Central University, Puducherry	P. A. Francis
20	P. Roja Ranni	Jawaharlal Nehru Technological University (JNTU), Hyderabad	N. Srinivasa Rao

21	P. Lenin Kumar	Indian Institute of Technology (IIT), Kharagpur	Satya Prakash
22	Mousumi Das	Indian School of Mines (ISM), Dhanbad	T. Srinivasa Kumar
23	K. Muhamed Kabeer	Cochin University of Science and Technology (CUSAT), Kochi	Satya Prakash

14.2 Honours and Awards:

1. Shri. M. Nagaraja Kumar, Scientist, ESSO-INCOIS was awarded with the “Certificate of Merit” in the category of ‘Ocean Sciences’ on the occasion of Foundation Day of the Ministry of Earth Sciences (MoES) held on 27 July, 2013.
2. Shri. S. M. Moinudeen, Scientific Assistant, ESSO-INCOIS received the “Best Employee” award on the occasion of Foundation Day of the Ministry of Earth Sciences (MoES) held on 27 July, 2013.
3. ICHL Award for Excellence in Humanitarian Action in the category of Early Warning and Dissemination was awarded to ESSO-INCOIS on 3 December, 2013 at the valedictory session of the International Conference for Humanitarian Logistics 2013, held at the Indian Institute of Management, Raipur.
4. Dr. S. S. C. Shenoi, Director, ESSO-INCOIS was elected as a fellow of Andhra Pradesh Akademi of Sciences in January 2014.

14.3 Promotion of Hindi

ESSO-INCOIS continued to promote and propagate the use of the official language, Hindi during 2013-2014, through various efforts. A ‘Hindi Pakhwara’ celebration was organized at ESSO-INCOIS during September, 2013. The programme consisted of various competitions in essay writing, official noting, etc for ESSO-INCOIS staff. A Hindi Elocution competition was also organized for the children of ESSO-INCOIS staff. The fortnight of celebrations culminated in a



Fig. 14.1 Left to Right: M. Nagaraja Kumar receiving the “MoES (Ocean Sciences) Certificate of Merit 2013”; S. M. Moinudeen receiving the “MoES Best Employee Award 2013”; On behalf of ESSO-INCOIS, Srinivasa T. Kumar receiving the “ICHL 2013 Award for Excellence in Humanitarian Action” given by Indian Institute of Management

seminar on the “Use of Official Language”. At the seminar Dr. D. D. Ozha (Sr. Scientist, Hindi Advisory Committee, MoES & DST) spoke on “Invisible Pollution in the Environment and its Effect on Health ”, Prof. Mukul Chand Pandey, (Member, Joint Hindi Advisory Committee, MoES&DST) delivered a talk on “Usage Of Hindi in the Indian Scientific Scenario and Guidelines for Official Language Rules” and Dr Ravi Ranjan, (Head of Department-Hindi, University of Hyderabad), spoke on “Language Problem in India”.

14.4 Visitors

As an initiative to increase awareness about the services and products provided by ESSO-INCOIS, special interactive “Open Day” sessions and on-request “Group Visit” sessions were organised. ESSO-INCOIS hosted several field visits for groups of government officials also. Three thousand



Fig. 14.2 ‘Hindi Pakhwara’ Celebrations

three hundred and seventy two visitors, including 358 government officials, 827 college students, 2117 school students and 70 members from the general public visited ESSO-INCOIS during 2013-14.

14.5 Vigilance Activities

Dr. M. Ravichandran, Scientist 'G' & Head - MOG continued to serve as the Vigilance Officer at ESSO-INCOIS. "Vigilance Awareness Week" was observed from 28 October, 2013 to 2 November, 2013. The pledge on Vigilance Awareness was taken by the officers and staff of ESSO-INCOIS on 28 October, 2013 at 11:00 AM. During the period April, 2013 to March 2014 no complaints related to vigilance were received.

14.6 Right to Information Act

As per requirements of the "Right to Information" Act (RTI), 2005, information related to ESSO-INCOIS is uploaded regularly on the ESSO-INCOIS website in the prescribed format. In respect of RTI, Shri E. Pattabhi Rama Rao, Scientist 'E' & Head - DMG served as the Public Information Officer and Dr. S.S.C. Shenoi, Director, ESSO-INCOIS acted as the First Appellate Authority during the period April, 2013 to March, 2014. Thirteen requests under RTI were received and the requested information was provided. No appeals were received during this period.

14.7 Growth of ESSO-INCOIS Human Capital

Scientific, technical and executive support staff

Table: 14.2 Scientific, technical and executive support staff details

Group	Scientists/ managers	Scientific assistants/ executives	Project scientists	Project assistants/ office assistants	JRF s/ SRFs/ Ph.D. scholars	Research assistants	Scientist fellows	Group-C employees (contract)	Total
Director	1	-	-	-	-	-	-	-	1
MOG	11	4	-	1	-	-	1	-	17
ASG	12	8	8	10	-	-	-	-	38
CWG	4	1	4	4	-	-	-	-	13
ISG	10	3	5	3	2	1	1	-	25
DMG	5	1	3	4	-	-	-	-	13
ESG	4	9	-	4	-	-	-	7	21
Grand Total :	47	26	20	26	2	1	2	7	131

14.8 Deputations Abroad

Twenty four scientists/students from ESSO-INCOIS were deputed abroad to attend meetings/workshops/training programmes/symposia etc. Some of them received full/partial financial support for their deputations from the organizers.

Table: 14.3 Deputation details

1	S. S. C. Shenoi, Director, INCOIS	- To attend the 27th Session of the IOC assembly and 46th Session of the IOC executive council at UNESCO HQ. Paris, France During 25 June to 5 July, 2013 - To attend the Executive Committee meetings of the International Association for Physical Sciences of the Oceans (IAPSO) and the IAPSO Assembly jointly with IAHS and IASPEI) at Gothenburg, Sweden during 22-26 July, 2013 - To attend the Indian Ocean Global Ocean Observing System (IOGOOS) workshop and the 10th annual meeting at Port Louis, Mauritius during 21-24 October, 2013 - To attend the meetings of the ICG/IOTWS RTSP and ICG/IOTWS Steering group scheduled held at Perth, Australia during 9-11 December, 2013 - To participate in the 15th Partnership for Observation of the Global Oceans (POGO) scheduled held at Hobart, Australia during 22-24 January, 2014
2	M. Ravichandran, Scientist 'G'	- To participate in the 14th Argo Steering Team (AST-14) meeting held at Wellington, New Zealand during 18-22 March, 2013 - To participate in the "Fourth In-Region Western Indian Ocean (WIO-4) Capacity Building Workshop of the WMO/IOC Data Buoy cooperation Panel (DBCP) and Partners" held at Zanzibar Tanzania during 29 April, 2013 to 3 May, 2013 - To participate in the 10th Indian Ocean Panel (IOP), SIBER-4 and IRF-4 meetings at Lijiang, China during 8-14 July, 2013 - To attend the Indian Ocean Global Ocean Observing System (IOGOOS) workshop and 10th annual meeting at Port Louis, Mauritius during 21-24 October, 2013 - To participate in the 15th Argo Steering Team (AST-15) meeting held at Halifax, Canada during 17-21 March, 2014 and to attend the Review cum Cruise planning and Science meeting of OMM (Ocean Monsoon and Mixing Project) at Scripps Institute of Oceanography, San Diego, USA during 24-26 March, 2014.
3	T. Srinivasa Kumar, Scientist 'F'	- To attend the Indian Ocean Global Ocean Observing System (IOGGOS) Workshop and the 10th Annual Meeting at Port Louis, Mauritius during 21-24 October, 2013. - To attend the meetings of the ICG/IOTWS RTSP and ICG/IOTWS Steering groups scheduled held at Perth, Australia during 9-11 December, 2013. - To participate in the 7th meeting of the WG on Tsunamis and other Hazards related to Sea level warning and mitigation systems (TOWS-WG-VII) preceded by TOWS inter-ICG Task Team 2 on Tsunami Watch operations at Paris, France during 10-13 February, 2014. - To participate in the "PREDICT workshop and Seminar: A Tsunami Detection Initiative for British Columbia by Ocean Network Canada (ONC)" to Canada during 26-28 March, 2014.
4	T. M. Balakrishnan Nair, Scientist 'E'	To attend the WMO-IOC meeting on the Coastal Inundation Forecasting Demonstration Project (CIFDP) during May 28-30, 2013 at Bangladesh Meteorological Department (BMD), Dhaka, Bangladesh

5	E. Pattabhi Rama Rao, Scientist 'E'	- To participate in the 22nd Session of the IOC Committee on International Oceanographic Data and Information Exchange (IODE-XXII) held at Ensenada, Mexico during 11-15 March, 2013. - To participate in the OceanSITES Data Management Team and Steering Committee meeting during 27-30 May, 2013 at Seoul National University, Seoul, South Korea. - To participate in the 3rd Session of the OBIS Steering Group(OBIS-SG) meeting scheduled held at the Project Office of IODE, Oostende, Belgium during 4-6 December, 2013.
6	Sudheer Joseph, Scientist 'E'	To participate in the Expert Team on Operational Ocean Forecasting Systems (ETOOFS-4) (Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM) meeting scheduled held during 25-29 March, 2013 at Washington, DC, USA.
7	T. V. S. Udaya Bhaskar, Scientist 'D'	To participate in the workshop on Coordinated Quality Control System for the Historical Subsurface Ocean Temperature (and Salinity) Observations at Hobart, Tasmania, Australia during 12-14 June, 2013.
8	P. A. Francis, Scientist 'D'	- To participate in the international workshop on "Capacity Building to Progress, Validate and Apply Indian Ocean Forecasting Systems" at Perth, Australia during 27-31 May, 2013. - To participate in the International Workshop on "Operational oceanography for developing countries" at Beijing, China during 9-12 September, 2013.
9	M. Nagaraja Kumar, Scientist 'D'	To attend the Indian Ocean Global Ocean Observing System (IOGOOS) workshop and the 10th annual meeting in Port Louis, Mauritius during 21-24 October, 2013.
10	Satya Prakash, Scientist 'C'	- To participate in the 4th annual meetings of the Sustained Indian Ocean Bio-geochemical and Ecological Research (SIBER-4) group and the IndOOS Resource Forum (IRF-4) during 8-14 July, 2013 at Lijiang, China. - To participate in the UNOLS ship R/V Roger Revcile Cruise (Colombo, Sri Lanka to the Bay of Bengal to Colombo, Sri Lanka) during 26 November, 2013 to 17 December, 2013.
11	C. Patanjali Kumar, Scientist 'C'	To participate in the "Regional Workshop on Standard Operating Procedures for Tsunami Warning and Emergency Response for Indian Ocean Countries" conducted by IOC, UNESCO in Jakarta, Indonesia during 23-27 September, 2013.
12	M. S. Girish Kumar, Scientist 'C'	- To participate in the Belmont Forum and JPI Climate Scoping workshop on the Arctic Observing System at Norway during 14-23 October, 2013. - To participate in the expedition on board the UNOLS ship R/V Roger Revelle Cruise (Colombo, Sri Lanka to the Bay of Bengal to Colombo, Sri Lanka) during 8 November, 2013 to 29 November, 2013.
13	Abhisek Chatterjee, Scientist 'C'	Deputation to attend the International workshop on "Operational Oceanography for Developing Countries" at Beijing, China during 9-12 September, 2013.

14	B. Praveen Kumar, Scientist 'C'	To participate in the expedition on board UNOLS ship R/V Roger Revelle Cruise (Colombo, Sri Lanka to the Bay of Bengal to Colombo, Sri Lanka) during 26 November, 2013 to 17 December, 2013.
15	S. Sivareddy, Scientist 'B'	To attend the International workshop on "Operational Oceanography for Developing Countries" at Beijing, China during 9-12 September, 2013.
16	Arun Nherekkol, Scientist 'B'	To attend the training programme on "Installation of Automatic Weather Stations" at M/s. Coastal Environmental Systems, Seattle, USA during 18-22 November, 2013.
17	S. Shivaprasad, Scientist 'B'	To attend CTD training at Oceanscience, San Diego, California, USA during 14-16 August, 2013.
18	B. Ajay Kumar, Scientist-'B'	To participate in the "The IOC/GLOSS Training Course for Operators of Sea Level Stations" held at Royal Thai Navy Hydrographic Department, Bangkok, Thailand during 17-21 March, 2014.
19	Jeyakumar Chellaiah, Scientific Assistant 'A'	To attend the training programme on "Installation of Automatic Weather Stations" at M/s. Coastal Environmental Systems, Seattle, USA during 18-22 November, 2013.
20	K. Dinesh, Scientific Assistant 'A'	To attend CTD training at Oceanscience, San Diego, California, USA during 14-16 August, 2013.
21	Nimit Kumar Joshi, Proj. Scientist 'B'	To participate in the expedition on board UNOLS ship R/V Roger Revelle Cruise (Colombo, Sri Lanka to the Bay of Bengal to Colombo, Sri Lanka) during 8 November, 2013 to 29 November, 2013.
22	Sourav Maity Project scientist 'B'	To participate in the summer school on "Ocean Observing Systems and Ecosystem Monitoring" at Hatfield Marine Science Center (HMSC), Newport, Oregon, USA during 19-23 August, 2013.
23	B. Rohith, JRF,	To participate in the symposium on "Knowledge for the future, Joint Assembly Gothenburg" at Gothenburg, Sweden during 22-26 July, 2013.
24	Vishnu S. Nair, JRF,	To participate in the International Workshop on "Operational oceanography for developing countries" at Beijing, China during 9-12 September, 2013.

List of Acronyms

• 3D-VAR	- Three Dimension Variational
• A&N	- Andaman and Nicobar
• ADCIRC	- Advanced Circulation (Storm surge model)
• ADCPs	- Acoustic Doppler Current Profiler (ADCP or ADP)
• APWD	- Andaman Public Works Department
• Argo	- Array for Real-time Geostrophic Oceanography
• ASG	- Advisory Services Group, ESSO-INCOIS
• ASIRI	- Air-Sea Interactions in the northern Indian Ocean–Regional Initiative
• AST	- Argo Steering Team
• AVHRR	- Advanced Very High Resolution Radiometer
• AWS	- Automatic Weather Station
• BESU	- Bengal Engineering and Science University, Kolkata
• BHS	- Bombay High South
• BIT	- Birla Institute of Technology and Science, Pilani
• BMD	- Bangladesh Meteorological Department
• BoB	- Bay of Bengal
• Chl-a	- Chlorophyll-a
• CIFDP	- Coastal Inundation Forecasting Demonstration Project
• CLIVAR	- Climate Variability and Predictability (World Climate Research Programme)
• CLS	- Collecte Localisation Satellites
• CMEC	- Challa Malla Reddy Engineering College, Hyderabad
• CMFRI	- Central Marine Fisheries Research Institute, Cochin
• CMLRE	- Centre for Marine Living Resources & Ecology, Cochin
• COMMs	- Communications Test
• CORE	- Coordinated Ocean-Ice Reference Experiments
• COSINE	- Current Observation and Simulation in the INdian EEZ
• CSIR	- Council of Scientific and Industrial Research
• CSIRO	- Commonwealth Scientific and Industrial Research Organisation
• CTCZ	- Continental Tropical Convergence Zone
• CTD	- Conductivity-Temperature-Depth
• CUSAT	- Cochin University of Science and Technology, Cochin
• D23	- Depth of 23° Isotherm

• DA	- Data Assimilation
• DASCAT	- Daily Gridded Winds from Advanced Scatterometer
• DD	- Door Darshan
• DDM	- Directorate of Disaster Management
• DHW	- Degree of Heating Weeks
• DMG	- Data Management Group, ESSO-INCOIS
• DMO	- Disaster Management Official
• DRDO	- Defence Research & Development Organisation
• DST	- Department of Science and Technology
• ECMWF	- European Centre for Medium-Range Weather Forecasts
• EEZ	- Exclusive Economic Zone
• EIO	- Eastern Indian Ocean
• EMAC-IOD	- Equatorial Mooring Array for Current Observations and Research on Indian Ocean Dynamics
• EnKF	- Ensemble Kalman Filter
• ENSO	- El Nino Southern Oscillation
• EOC	- Emergency Operations Center
• EQUINOO	- Equatorial Indian Ocean Oscillation
• EQWIN	- Equatorial Zonal Wind Index
• ERP	- Enterprise Resource Planning
• ESSO	- Earth System Science Organisation
• ETOOFS	- Expert Team on Operational Ocean Forecasting Systems
• FAX	- Facsimile
• FFMA	- Fisher Friend Mobile Application
• FM/AIR	- Frequency Modulation / All India Radio
• FSI	- Fisheries Survey of India
• FTP	- File Transfer Protocol
• FY	- First Year
• GFDL	- Geophysical Fluid Dynamics Laboratory
• GIS	- Geo-informatic Information System
• GLOSS	- Global Sea Level Observing System
• GNOME	- GNU Gnetworking Object Model Environment" where GNU stands for "GNU's Gnot Unix."
• GNSS	- Global Navigation Satellite System
• GODAS	- Global Ocean Data Assimilation System
• GPRS	- General Packet Radio Service

- GTS - Global Telecommunication System
- HF Radar - High Frequency Radar
- HOOFS - High Resolution Operational Ocean Re-Analysis and Forecast System
- HPC - High Performance Computing
- HR - Human Resources
- HS - Hot Spot
- HYCOM - Hybrid Coordinate Ocean Model
- I- RAWS - INCOIS Real-time Automated Weather Station
- IAF - Indian Air Force
- IAPSO - International Association for Physical Sciences of the Oceans
- ICG/IOTWS - Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and mitigation System
- ICHL - International Conference for Humanitarian Logistics
- ICMAM - Integrated Coastal and Marine Area Management
- ICTP - International Centre for Theoretical Physics, Italy
- IFFCO - Indian Farmers Fertiliser Cooperative Limited
- IFREMER/CERSAT - Institut Français de Recherche pour l'Exploitation de la MER/Centre ERS (European Remote Sensing) d'Archivage et de Traitement, France
- IIOE - International Indian Ocean Expedition
- IISc - Indian Institute of Science, Bangalore
- IIT - Indian Institute of Technology
- IITM - Indian Institute of Tropical Meteorology, Pune
- IKSL - Iffco Kissan Sanchar Limited
- I-LAS - INCOIS Live Access Server
- IMD - Indian Meteorological Department
- INCOIS - Indian National Centre for Ocean Information Services
- INDOFOS - Indian Ocean Forecast System
- IndOOS - Indian Ocean Observing System
- INSAT - Indian National Satellite System
- IOC - Intergovernmental Oceanographic Commission
- IOD - Indian Ocean Dipole
- IODE - Indian Ocean Drilling Expedition
- IOGOOS - Indian Ocean Global Ocean Observing System
- IOM - Indian Ocean Model
- IOP - Indian Ocean Panel
- IOR - Indian Ocean Rim

- IPO - International Programme Office
- IPSL - Institut Pierre Simon Laplace, France
- IRF - IndOOS (Indian Ocean Observation System) Resource Forum
- ISGN - Integrated Seismic and GNSS Network
- ISLANDS - Investigation of Seismicity & Lithospheric structure in the ANDaman-Nicobar Subduction zone
- ISM - Indian School of Mines, Dhanbad
- ISMR - Indian Summer Monsoon Rainfall
- ISPRS - International Society for Photogrammetry and Remote Sensing
- ISRO - Indian Space Research Organisation
- IST - Indian Standard Time
- ITCO_{ocean} - International Training Centre for Operational Oceanography, ESSO-INCOIS
- ITEWC - Indian Tsunami Early Warning Centre, ESSO-INCOIS
- JCOMM - Joint Technical Commission for Oceanography and Marine Meteorology
- JNTU - Jawaharlal Nehru Technological University, Hyderabad
- JPI - Joint Programming Initiative
- LEGOS - Laboratoire d'Etudes en Géophysique et Océanographie Spatiales, France
- LHF - Latent Heat Flux
- LOCEAN - Laboratoire d'Océanographie et du Climat, France
- Met - Meteorological
- METOP - Meteorological Operational (satellite programme)
- MFAS - Marine Fisheries Advisory Services
- MHA - Ministry of Home Affairs
- MHVM - Multi-Hazard Vulnerability Map
- MOA - Memorandum of Agreement
- MODIS - Moderate Resolution Imaging Spectroradiometer
- MoES - Ministry of Earth Sciences
- MOG - Modelling Ocean Group, ESSO-INCOIS
- MOM - Modular Ocean Model
- MoU - Memorandum of Understanding
- MSL - Mean Sea Level
- MSSRF - M.S. Swaminathan Research Foundation
- MV - Merchant Vessel

- NCEP - National Centers for Environmental Prediction, USA
- NCMRWF - National Centre for Medium Range Weather Forecasting, Noida
- NDBP - National Data Buoy Program
- NDMA - National Disaster Management Authority
- NDRF - National Disaster Response Force
- NEIST - North East Institute of Science And Technology, Jorhat
- NetCDF - Network Common Data Format
- NGO - Non Governmental Organisation
- NGRI - National Geophysical Research Institute, Hyderabad
- NIO - National Institute of Oceanography, Goa
- NIOT - National Institute for Ocean Technology, Chennai
- NOAA - National Oceanic and Atmospheric Administration, USA
- NODC - National Oceanographic Data Center, USA
- NODPAC - Naval Oceanographic Data Processing and Analysis Centre
- NRSC - National Space Research Centre, Hyderabad
- NTWC - National Tsunami Warning Centre
- OBIS - Ocean Biogeographic Information System
- OceanSITES - Ocean Sustained Interdisciplinary Time series Environment Observation System
- OCM - Ocean Colour Monitor
- OLR - Outgoing Longwave Radiation
- OMM - Ocean Monsoon and Mixing project
- OMNI - Ocean Moored Buoy Network for Northern Indian Ocean
- OMZ - Oxygen Minimum Zone
- ONGC - Oil and Natural Gas Corporation
- ONI - Oceanic Niño Index
- ORV SN - Ocean Research Vessel Sagar Nidhi
- OSCAT - Open Source Community for Automation Technology
- OSF - Ocean State Forecast
- PFZ - Potential Fishing Zone
- PMC - Project Monitoring Committee
- PMEL - Pacific Marine Environmental Laboratory, USA
- POGO - Partnership for Observation of the Global Oceans
- QMF - Quality Management Framework
- Quick SCAT, QSCAT - Quick Scatterometer
- R&D - Research & Development

• R/V	- Research Vessel
• RAMA	- Research Moored Array for African-Asian-Australian Monsoon Analysis
• RF	- Reliance Foundation
• RG	- Reduced Gravity
• RIMES	- Regional Integrated Multi-Hazard Early Warning System for Africa and Asia
• RMS	- Root-Mean-Square
• RMSE	- Root-Mean-Square Error
• ROMS	- Regional Ocean Modeling System
• RTI	- Right to Information Act
• RTSP	- Regional Tsunami Service Provider
• RTWP	- Received Total Wideband Power
• SAC	- Space Application Centre, Ahmedabad
• SAIC	- Science Applications International Corp ,USA.
• SAP	- System Application Products
• SATCORE	- Satellite Coastal and Oceanographic Research
• SATTUNA	- Satellite Telemetry Studies on Migration Pattern of Tunas in Indian Seas
• SCI	- Shipping Corporation of India
• SCOR	- Scientific Community on Ocean Research
• SeaWifs	- Sea-Viewing Wide Field-of-view Sensor
• SG	- Steering Group
• SIBER	- Sustained Indian Ocean Biogeochemistry and Ecosystem Research
• SIET	- Siddhartha Institute of Engineering & Technology, Hyderabad
• SIM	- Subscriber Identity Module
• SLA	- Sea Level Anomalies
• SMS	- Short Messaging Service
• SOP	- Standard Operating Procedure
• SSC	- Science Steering Committee
• SSH	- Sea Surface Height
• SSHA	- Sea Surface Height Anomaly
• SST	- Sea Surface Temperature
• STB	- Science Applications International Corporation (SAIC) Tsunami Buoy
• SWAN	- Simulating Waves Nearshore (Model)
• T	- Temperature
• T & S	- Temperature & Salinity
• TB	- Tsunami Buoy

• TC	- Tropical Cyclone
• TCHP	- Tropical Cyclone Heat Potential
• TCS	- Tata Consultancy Services
• TF	- Terra Floating-Point Operations Per Second
• TIO	- Tropical Indian Ocean
• TMI/TRMM	- Tropical Rainfall Measuring Mission Tropical Rainfall Measuring Mission Radio Imager
• TOPEX	- Topography Experiment
• TRIO	- Thermocline Ridge of the Southwestern Tropical Indian Ocean
• TS graph	- Thermosalinograph
• TUNAMI	- Tohoku University's Numerical Analysis Model for Investigation
• UNESCO	- United Nations Educational, Scientific and Cultural Organization
• UNOLS	- University-National Oceanographic Laboratory System
• UTs	- Union Territories
• VECS	- VSAT-Aided Emergency Communication System
• VoIP	- Voiceover Internet Protocol
• VSAT	- Very Small Aperture Terminal
• VSCS	- Very Severe Cyclonic Storm
• WHM	- Wave Height Meter (WHM) (A Microwave Doppler Radar)
• WIO	- Western Indian Ocean
• WMO	- World Meteorological Organization (WMO)
• WRF	- Weather Research and Forecasting (WRF) Model
• WW	- Wire Walker
• XBT/XCTD	- Expendable Bathythermograph Expendable Conductivity-Temperature Depth

FINANCE

The report of the auditors and audited accounts of INCOIS for the year 2013-2014 are placed in Appendix-1 to this report.

Appendix-1

B.SRINIVASA RAO & CO.,
CHARTERED ACCOUNTANTS

Head Office:

Ameer Estate, Flat No.103,
S.R.Nagar, Hyderabad - 500 038.
& : 040-23757406, Fax : 66737406
E-mail: bsrandco@gmail.com

AUDITORS' REPORT

To
The Chairman and Members,
Governing Council,
INDIAN NATIONAL CENTRE FOR
OCEAN INFORMATION SERVICES,
Ocean Valley, Pragathinagar (BO), Nizampet (SO)
Hyderabad – 500 090

We have audited the attached Balance Sheet of the INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES as at 31st March 2014, and also the Income & Expenditure Account and Receipts & Payments Account for the year ending on that date annexed thereto. These financial statements are the responsibility of the Society's management. Our responsibility is to express an opinion on the financial statements based on our Audit.

We conducted our audit in accordance with auditing standards generally accepted in India. Those standards require that we plan and perform the audit to obtain reasonable assurance about whether the financial statements are free of material mis-statements. An audit includes examining, on a test basis, evidence supporting the amounts and disclosures in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by management, as well as evaluating the overall financial statement presentation. We believe that our audit provides a reasonable basis for our opinion and report that:

1. We have obtained all the information and explanations which to the best of our knowledge and belief were necessary for the purposes of our Audit.
2. In our opinion, proper books of accounts as required by the Society, have been kept by the Society so far as appears from our examination of such books.
3. The Balance Sheet, Income and Expenditure Account and Receipts and Payments Account are in agreement with the Books of Account.
4. In our opinion and to the best of our information and according to the explanations given to us and subject to the notes forming part of accounts, the Balance Sheet as at 31st March 2014, Income and Expenditure Account and Receipts and Payments Account for the year ending on that date together with the Schedules and Notes on Accounts Annexed therewith give a true and fair view of the state of affairs of the Society.

For **B.SRINIVASA RAO & CO.,**
Chartered Accountants



(Ch.Anand)

Partner

M.No. : 222732

FRN No.: 008763S

Place: Hyderabad
Date: 10-07-2014

INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES

(Ministry of Earth Sciences, Govt. of India)

"Ocean Valley", Pragathi Nagar (BO), Nizampet (SO), Hyderabad - 500 090

BALANCE SHEET AS AT 31st MARCH 2014

(Amount in Rs.)

Particulars	Schedules	Current Year (2013-2014) ₹	Previous Year (2012-2013) ₹
<u>LIABILITIES</u>			
Corpus Fund	1	6,36,37,102	11,85,48,960
Earmarked funds	2	40,02,71,148	40,16,06,499
Current liabilities & Provisions	3	3,49,95,548	5,16,05,867
Total		49,89,03,798	57,17,61,326
<u>ASSETS</u>			
Fixed Assets	4	2,14,32,861	1,64,53,218
Current Assets, loans & Advances	5	47,74,70,937	55,53,08,108
Total		49,89,03,798	57,17,61,326
Notes forming part of Accounts	11		

As per our report of even date

For **B.SRINIVASA RAO & CO.,**

Chartered Accountants



(Ch. Anand)

Partner

M.No. 222732

FRN No: 008763S

Place: Hyderabad

Date: 10-07-2014

For and on behalf of **INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES**



(S. Nageswara Rao)

Accounts Officer



(K.K.V.Chary)

Dy. C A O



(S.S.C.Shenoi)

Director

INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES

(Ministry of Earth Sciences, Govt. of India)

"Ocean Valley", Pragathi Nagar (BO), Nizampet (SO), Hyderabad - 500 090

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st MARCH 2014

(Amount in Rs.)

Particulars	Schedules	Current Year (2013-2014) ₹	Previous Year (2012-2013) ₹
<u>INCOME</u>			
Income from Sales / Other Income	6	4,18,263	25,22,193
Interest Earned on Investments	7	11,29,139	78,72,721
Recurring Grants	8	14,30,00,000	22,11,68,246
Total-A		14,45,47,402	23,15,63,160
<u>EXPENDITURE</u>			
Establishment Expenditure	9	6,27,96,092	5,11,56,443
Other Administrative Expenses	10	12,40,31,551	13,19,36,067
Depreciation		1,24,14,506	2,64,73,587
Total-B		19,92,42,149	20,95,66,097
Excess of Income over expenditure (A-B)		-5,46,94,747	2,19,97,063
Add / Less: Prior Period Items		- 2,17,111	
Balance being net income / deficit transferred to Corpus Fund		-5,49,11,858	2,19,97,063
Notes forming part of Accounts	11		

For and on behalf of **INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES**

As per our report of even date
For **B.SRINIVASA RAO & CO.,**

Chartered Accountants



(Ch. Anand)
Partner

M.No. 222732

FRN No: 008763S

Place: Hyderabad
Date: 10-07-2014



(S. Nageswara Rao)
Accounts Officer



(K.K.V.Chary)
Dy. C A O



(S.S.C.Shenoi)
Director

INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES

(Ministry of Earth Sciences, Govt. of India)

"Ocean Valley", Pragathi Nagar (BO), Nizampet (SO), Hyderabad - 500 090

RECEIPTS AND PAYMENTS ACCOUNT FOR THE YEAR ENDED 31ST MARCH 2014

(Amount in Rs.)

RECEIPTS	CURRENT YEAR 2013-14		PAYMENTS	CURRENT YEAR 2013-14	
	₹	₹		₹	₹
Opening Balance			Establishment Expenses		
INCOIS Current A/c-SBI-HAL Campus Br.	1,38,62,676		Pay Leave Salary Allowance	5,42,36,263	
INCOIS Current A/c-AB-Pragathi Nagar Br.	2,99,611		NPS, CPF, IDBPS	40,31,555	
INCOIS Consultancy SB A/c-Pragathi Nagar Br.	27,32,332		Staff Welfare	24,10,312	
Short Term Deposits with Bank	46,80,00,000	48,48,94,619	Leave Travel Concession	10,16,654	6,16,94,784
Earmarked Funds			Administrative Expenses		
Ocean Information and Advisory Services (O-IAS)	17,00,00,000		Maintenance & Repairs	4,62,83,221	
Ocean Observation Systems (OOS)	4,00,00,000		Travel Expenses - Inland	13,76,968	
Satellite Coastal and Oceanographic Research (SATCORE)	1,00,00,000		- Foreign	4,86,507	
International Training Centre for Operational Oceanography	9,44,13,000		- Others	15,14,069	
High Resolution Operational Ocean Forecast and Reanalysis System (HROOFS)	9,89,00,000		Membership Fee	3,76,962	
V Sat Terrestrial Link	9,08,13,617		Vehicle Hiring	11,13,950	
RIMES Afro Asian Region	6,00,00,000		Garden Expenses	10,46,604	
Construction of New Building (Phase II)	3,63,00,000	60,04,26,617	House Keeping Expenses	47,12,803	
			Security Expenses	63,24,298	
			Electricity Expenditure	2,98,50,942	
	14,30,00,000	14,30,00,000	Water Expenses	31,13,862	
Recurring Grants			Postage & Telegraphs	1,56,842	
			Telephone & Fax Expenditure	7,98,363	
Other Receipts			Legal Expenses	61,890	
Consultancy Projects - Sundry Debtors	15,79,519				

Earnest Money Deposits	1,18,77,000		Honorarium to External Experts	50,000	
Security Deposits	47,27,988		Conveyance Expenses	1,36,107	
Service Tax	41,287		Internet Expenses	20,22,478	
Experiment over BOB-IITM	3,67,736		Printing & Stationery	8,95,401	
APSRTC-Deposit	46,480		Advertisement & Publicity	12,91,110	
Vehicle advance to employees	3,62,971		Papers and Periodicals	29,636	
TDS Account	38,82,118		General Expenses	5,18,843	
Interest on Short Term Deposits	4,41,88,010		Audit Fee	19,999	
Interest on Bank Account	2,55,997		Seminar, Conference & Workshop Expenses	1,23,95,292	
Interest on Margin Money TDRS	26,90,793		International Interface	39,98,590	
Interest on Phase II works	20,34,455		Material Consumable	39,48,786	12,25,23,523
Phanikkar Fellowship	3,37,864		Payments Against Earmarked Funds		
Phase II HVAC Encashed BG Amount	59,93,986		a) Ocean Information and Advisory Services (OIAS)		
Mobilisation advance BG Encashed Amount	1,81,71,187		Equipment	1,68,60,293	
Other Receipts	1,45,775		Consumables	31,83,440	
Liquidated Damages	80,31,485		Advance to Sub Projects	7,00,71,724	
Sale of Tender Forms	84,505	10,48,19,156	Advance to Purchase	7,00,70,724	
			Technical Support Expenses	2,42,71,064	
			Travel Expenses	70,71,616	
			Manpower	1,00,21,378	
			Margin Money	3,46,02,054	
		53,81,000	Administrative Expenses	92,76,999	24,54,29,292
Unspent Balances received from Sub Projects			b) Satellite Coastal and Oceanographic Research		
Ocean Information and Advisory Services (O-IAS)	19,14,675		Equipment	85,58,105	
Ocean Observation Systems (OOS)	6,86,909		Advance to Sub Projects	28,06,000	
Satellite Coastal and Oceanographic Research (SATCORE)	27,79,416		Advance to Purchase	3,64,28,392	
			Travel Expenses	14,68,934	
Margin Money					
Ocean Information and Advisory Services (OIAS)	4,16,73,215				
Satellite Coastal and Oceanographic Research (SATCORE)	2,66,93,880				
Ocean Observation Systems (OOS)	12,15,48,771	18,99,15,866			

			Margin Money Manpower Administrative Expenses	2,82,25,880 8,32,027 11,27,426	7,94,46,764
			c) Ocean Observation Networks		
			Equipment	5,89,811	
			Software/Hardware	32,498	
			Technical Support Expenses	3,88,072	
			Consumables	2,60,396	
			Advance to Purchase	11,11,11,718	
			Travel Expenses	43,45,920	
			Manpower	15,33,500	
			Administrative Expenses	41,70,917	
			Margin Money	11,39,93,771	
			Data Transfer Charges	68,85,652	24,33,12,255
			d) HROOFS		
			Equipment	13,800	
			Administrative Expenses	4,63,243	
			Travel Expenses	7,21,163	
			Advance to Sub Projects	2,25,59,000	2,37,57,206
			e) International Training Centre (ITCOcean)		
			Equipment	5,61,593	
			Administrative Expenses	12,89,237	
			Travel Expenses	7,87,731	
			Deposit Work	5,00,00,000	5,26,38,561
			f) Construction of New Building (Phase II)		
			Architech Fee	11,34,443	
			Construction of Building	11,91,88,350	12,03,22,793
			g) HPC Systems-INCOIS	5,82,399	5,82,399
			h) MH Early Warning System	68,01,230	68,01,230
			i) V Sat Terrestrial Link	4,96,55,577	4,96,55,577
			j) Multi Hazard Vulnerability	1,03,350	1,03,350
			Unspent balances refunded		
			i) HPC Systems-INCOIS	1,17,58,583	

			ii) MH Early Warning System	3,37,68,229	4,81,13,811
			iii) Portable EDBS	25,86,999	
			Expenditure on Fixed Assets		
			Furniture & Fixture	2,03,268	
			Office Equipment	6,62,125	
			Computer/Peripherals	98,99,143	
			Electrical Installation	51,192	
			Library	65,78,421	1,73,94,149
			Other Payments		
			Earnest Money Deposits	1,06,88,700	
			Security Deposits	83,79,123	
			Service Tax payable	41,287	
			Retention Money	33,43,459	
			Computer Advance	25,000	
			LTC Advance	86,400	
			Vehicle advance to employees	30,000	
			Other Advances	47,71,329	
			Travel Advance-Foreign	20,002	
			Margin Money	52,12,000	
			Advance under Purchase	5,40,26,433	8,66,23,733
			Closing Balance		
			INCOIS Current A/c-SBI-HAL Campus Br.	9,77,21,295	
			INCOIS Current A/c-AB-Pragathi Nagar Br.	45,36,409	
			INCOIS Consultancy SB A/c-Pragathi Nagar Br.	7,80,127	
			Short Term Deposits with Bank	26,70,00,000	37,00,37,831
Total	1,52,84,37,258	1,52,84,37,258	Total	1,52,84,37,258	1,52,84,37,258

As per our report of even date
For **B.SRINIVASA RAO & CO.,**
Chartered Accountants

(Ch. Anand)

Partner
M.No. 222732
FRN No: 008763S

Place: Hyderabad
Date: 10-07-2014

For and on behalf of **INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES**

Smoo

(S. Nageswara Rao)
Accounts Officer

(K.K.V.Chary)

(K.K.V.Chary)
Dy. C A O

8/11/01

(S.S.C.Shenoi)
Director

INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES

(Ministry of Earth Sciences, Govt. of India)
 "Ocean Valley", Pragathi Nagar (BO), Nizampet (SO), Hyderabad - 500 090

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31st MARCH 2014

SCHEDULE 1 – CORPUS FUND

(Amount in Rs.)

Particulars	Current Year (2013-2014) ₹	Previous Year (2012-2013) ₹
Corpus Fund at the beginning of the year	11,85,48,960	9,65,51,897
Add: Net income transferred from Income & Expenditure Account	-5,49,11,858	2,19,97,063
BALANCE AS AT THE YEAR END	6,36,37,102	11,85,48,960

INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES

SCHEDULE 2 - EARMARKED FUNDS

(Amount in Rs.)

Particulars	FUND-WISE BREAK UP												TOTALS		
	Building Fund	Coastal & Ocean Advisory Services (O-IAS)	Ocean Observation Networks	SATCORE	ITCOO	HROOFS	HPC SYSTEMS-INCOIS	IT & E Governance Fund	MH Early Warning System	V SAT Node	MH Vulnerability	Portable EDBs	RIMES - AAR	Current Year 2013-14	Previous Year 2012-13
a) Opening balance of the funds	7,21,18,092	11,51,55,860	6,49,35,955	3,81,24,042	1,52,45,598	-	1,23,40,982	23,85,571	4,05,69,459	-4,41,98,746	8,23,42,687	25,86,999	-	40,16,06,499	37,55,32,547
b) Additions to the Funds:															
i. Grants	3,63,00,000	17,00,00,000	4,00,00,000	1,00,00,000	9,44,13,000	9,89,00,000	-	-	-	9,08,13,617	-	-	6,00,00,000	60,04,26,617	53,53,00,000
ii. Interest if any	49,60,489	64,81,993	20,28,747	21,92,461	58,37,010	31,18,161	-	1,56,728	-	-	54,17,763	-	-	3,01,93,352	4,14,73,512
iii. Advance for sub projects	-	6,89,13,016	1,67,11,079	2,59,20,267	-	-	-	-	-	-	-	-	-	11,15,44,362	21,06,99,762
iv. Advance for purchase Utilised	-	14,22,99,000	6,63,555	1,93,35,076	-	-	-	-	-	30,40,706	-	-	-	16,53,38,337	6,42,55,433
v. Margin Money Reversed	-	4,16,73,215	12,15,48,771	2,66,93,880	-	-	-	-	-	-	-	-	-	18,99,15,866	16,59,74,755
vi. Mobilisation Advance reversed	1,81,71,187	-	-	-	-	-	-	-	-	-	-	-	-	1,81,71,187	78,36,125
vii. Other Revenue	1,40,05,834	19,637	-	-	-	-	-	-	-	-	-	-	-	1,40,25,471	-
TOTAL (a+b) - A	14,55,55,602	54,45,42,721	24,58,88,107	12,22,65,726	11,54,95,608	10,20,18,161	1,23,40,982	25,42,299	4,05,69,459	4,96,55,577	8,77,60,450	25,86,999	6,00,00,000	1,53,12,21,691	1,40,10,72,134
c) Utilisation/Expenditure															
i. Capital Expenditure															
W.I.P	8,69,68,566	-	-	-	-	-	-	-	-	-	-	-	-	8,69,68,566	8,57,62,693
Architech fee	11,34,443	-	-	-	-	-	-	-	-	-	-	-	-	11,34,443	24,50,751
Equipments	-	18,69,84,376	5,89,811	1,29,16,330	5,61,593	-	-	-	-	14,63,499	-	-	-	20,25,15,609	6,79,18,181
Computers / Software	-	1,22,33,031	32,498	1,23,089	-	13,800	-	-	-	64,21,318	-	-	-	1,88,23,736	1,13,034
Other Assets	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5,000
Total	8,81,03,009	19,92,17,407	6,22,309	1,30,39,419	5,61,593	13,800	-	-	-	78,84,817	-	-	-	30,94,42,354	15,62,49,659
ii. Revenue Expenditure															
Technical support	-	2,42,71,064	3,88,072	-	-	-	5,82,399	-	-	2,22,79,969	-	-	-	4,75,21,504	5,18,90,726
Administrative expenses	-	4,06,17,919	95,65,677	1,53,88,558	11,04,969	4,63,243	-	-	68,01,230	4,84,863	67,339	-	-	7,44,93,798	10,00,84,867
Travel	-	72,52,338	65,22,321	40,13,095	7,87,731	7,21,163	-	-	-	4,30,014	36,011	-	-	1,97,62,673	1,77,80,082
Consumable Materials / Data	-	5,35,80,255	1,73,60,383	15,61,483	1,84,268	-	-	-	-	-	-	-	-	7,26,86,389	7,53,06,341
Total	-	12,57,21,576	3,38,36,453	2,09,63,136	20,76,968	11,84,406	5,82,399	-	68,01,230	2,31,94,846	1,03,350	-	-	21,44,64,364	24,50,62,016
iii. Others															
Advances against subprojects	-	7,00,71,724	-	28,06,000	-	2,25,59,000	-	-	-	-	-	-	-	9,54,36,724	14,75,66,897
Advance for Purchase	4,84,837	7,00,70,724	11,11,11,718	3,64,28,392	-	-	-	-	-	1,85,75,914	-	-	-	23,66,71,585	21,70,84,425
Deposit Work	-	-	-	-	5,00,00,000	-	-	-	-	-	-	-	-	5,00,00,000	-
Margin Money against LC	-	3,46,02,054	11,39,93,771	2,82,25,880	-	-	-	-	-	-	-	-	-	17,68,21,705	19,17,75,386
Total	4,84,837	17,47,44,502	22,51,05,489	6,74,60,272	5,00,00,000	2,25,59,000	-	-	-	1,85,75,914	-	-	-	55,89,30,014	55,64,26,708
TOTAL (i+ii+iii) - B	8,85,87,846	49,96,83,485	25,95,64,251	10,14,62,827	5,26,38,561	2,37,57,206	5,82,399	-	68,01,230	4,96,55,577	1,03,350	-	-	1,08,28,36,732	95,77,38,383
Amount Refunded-C	-	-	-	-	-	-	1,17,58,583	-	3,37,68,229	-	-	25,86,999	-	4,81,13,811	61,59,006
Amount Transferred to Schedule 8 - D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3,55,68,246
NET BALANCE AS AT THE PERIOD END (A -(B+C+D))	5,69,67,756	4,48,59,236	-1,36,76,144	2,08,02,899	6,28,57,047	7,82,60,955	-	25,42,299	-	-	8,76,57,100	-	6,00,00,000	40,02,71,148	40,16,06,499

INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES

SCHEDULE - 3 CURRENT LIABILITIES & PROVISIONS

Particulars	Current Year (2013-2014) ₹	Previous Year (2012-2013) ₹
A. CURRENT LIABILITIES		
Project Implementation Agency	-	94,875
Earnest Money Deposit	28,33,000	22,39,700
Security Deposit	40,52,532	77,03,667
Performance Deposit	45,000	45,000
Outstanding Expenses	1,25,16,046	1,92,28,726
Sundry Creditors	31,81,284	36,52,839
Retention Money	-	33,43,459
Experiment over BOB-IITM	3,67,736	-
Total – A	2,29,95,598	3,63,08,266
B. PROVISIONS		
Gratuity	40,56,116	60,02,075
Accumulated leave Encashment	79,43,834	92,95,526
Total – B	1,19,99,950	1,52,97,601
Total (A+B)	3,49,95,548	5,16,05,867

INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES

SCHEDULE – 4 FIXED ASSETS (Amount in Rs.)

DESCRIPTION (% of Depreciation)	GROSS BLOCK			DEPRECIATION			NET BLOCK	
	As at 31.03.2013	Additions during the year	As at 31.03.2014	As at 31.03.2013	For the year 2013-14	As at 31.03.2014	As at 31.03.2014	As at 31.03.2013
1. Land (0%)	1,000	-	1,000	-	-	-	1,000	1000
2. Plant, Machinery & Equipments (15%)	4,53,57,169	-	4,53,57,169	4,36,57,844	2,54,899	4,39,12,743	14,44,426	16,99,324
3. Furniture & Fixtures (10%)	1,49,99,179	2,03,268	1,52,02,448	87,39,189	6,45,751	93,84,940	58,17,508	62,59,991
4. Office Equipment (15%)	28,12,709	40,887	28,53,596	19,66,655	1,33,041	20,99,696	7,53,900	8,46,054
5. Computer / Peripherals (60%)	95,93,920	98,99,143	1,94,93,063	88,03,544	34,43,968	1,22,47,512	72,45,551	7,90,376
6. Electric Installations (10%)	20,15,767	51,192	20,66,959	7,33,146	1,33,381	8,66,527	12,00,432	12,82,621
7. Library Books (100%)	4,30,46,315	65,78,421	4,96,24,736	3,87,82,962	75,60,298	4,63,43,260	32,81,476	42,63,353
8. Other Fixed Assets (15%)	7,31,985	6,21,238	13,53,222	2,60,724	1,17,282	3,78,006	9,75,216	4,71,261
9. Vehicles (15%)	18,49,835	-	18,49,835	10,10,597	1,25,886	11,36,483	7,13,352	8,39,238
Total	12,04,07,879	1,73,94,149	13,78,02,028	10,39,54,661	1,24,14,506	11,63,69,167	2,14,32,861	1,64,53,218
Previous Year	11,40,56,056	63,51,823	12,04,07,879	7,74,81,074	2,64,73,587	10,39,54,661	1,64,53,218	3,65,74,981

INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES

SCHEDULE - 5 CURRENT ASSETS, LOANS & ADVANCES

(Amount in Rs.)

Particulars	CURRENT YEAR 2013-14 (₹)	PREVIOUS YEAR 2012-13 (₹)
A. CURRENT ASSETS		
1. Inventories (Valued at cost)	8,79,068	8,29,878
2. Cash & Bank Balance :		
a) With Scheduled Banks – Current Account		
State Bank of India HAL CAMPUS A/c	9,77,21,295	1,38,62,676
Andhra Bank Pragathiagar A/c	45,36,410	2,99,611
Andhra Bank Pragathiagar-Consultancy A/c	7,80,127	27,32,332
b) Short Term Deposits with SBI	26,00,00,000	46,50,00,000
c) Short Term Deposits with AB	70,00,000	30,00,000
TOTAL A:	37,09,16,900	48,57,24,497
B. LOANS, ADVANCES & OTHER ASSETS		
1. Deposits		
a) Telephone	2,04,350	2,04,350
b) Electricity	48,91,540	48,91,540
c) Gas	13,100	13,100
d) APSRTC	-	1,14,080
e) Petrol/Diesel	1,01,400	1,01,400
2. Advances & other amounts recoverable in cash or in kind or for value to be received		
a) Vehicle Advance to Employees	9,79,452	12,87,423
b) Advance - NRSA (NDC)	15,18,639	16,79,914
c) Interest Accrued	17,10,618	2,38,55,461
d) Other Advances	47,71,329	28,93,432
e) Advance for Purchase	6,69,40,864	1,29,14,431
f) Sundry Debtors	2,32,586	19,99,662
g) Tour Advance – Foreign	18,641	38,643
h) LTC Advance	86,400	-
i) TDS Opening Balance	1,17,66,390	1,14,90,161
j) TDS Accumulation during the year	41,65,061	41,58,347
k) Margin Money against Bank Guarantee	91,53,667	39,41,667
TOTAL B: (1+2)	10,65,54,037	6,95,83,611
GRAND TOTAL (A + B)	47,74,70,937	55,53,08,108

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SCHEDULE 6 - INCOME FROM SALES / OTHER INCOME

(Amount in Rs.)

Particulars	CURRENT YEAR 2013-14 (₹)	PREVIOUS YEAR 2012-13 (₹)
a) Sale of Tender Forms	84,505	21,300
b) Other Receipts	1,45,775	2,93,130
c) Consultancy Services	1,87,983	22,07,763
TOTAL	4,18,263	25,22,193

SCHEDULE 7 - INTEREST EARNED

a) Interest on Short Term Deposits & Others	7,56,094	73,07,199
b) Bank Accounts	2,55,997	93,400
c) Staff Advances	1,17,048	4,72,122
TOTAL	11,29,139	78,72,721

SCHEDULE 8 - IRRECOVERABLE GRANTS & SUBSIDIES RECEIVED

a) Central Government (Recurring Grant received from MoES)	14,30,00,000	18,56,00,000
b) Funds Transfer from Schedule-2	-	3,55,68,246
TOTAL	14,30,00,000	22,11,68,246

SCHEDULE 9 - ESTABLISHMENT EXPENDITURE

a) Salaries, Wages & Allowances	5,53,37,571	4,45,28,006
b) Staff Welfare Expenses	24,10,312	16,50,380
c) Contributory Provident Fund	2,73,974	1,39,883
d) New Pension Scheme	26,82,143	19,24,861
e) IDBPS Trust	10,75,438	9,09,069
f) Leave Travel Concession	10,16,654	20,04,244
TOTAL	6,27,96,092	5,11,56,443

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SCHEDULE 10 - OTHER ADMINISTRATIVE EXPENSES

(Amount in Rs.)

S.No.	Particulars	CURRENT YEAR 2013-14 (₹)	PREVIOUS YEAR 2012-13 (₹)
1.	Electricity & Power Expenses	3,03,07,994	2,86,18,896
2.	Water Charges	31,18,612	9,07,547
3.	Operation & Maintenance expenses	4,68,91,538	4,26,58,647
4.	Garden Expenses	12,29,335	8,81,255
5.	Vehicle Hiring Expenses	12,13,900	19,21,464
6.	Postage, Telephone, Fax & ISDN Charges	10,27,727	8,07,630
7.	Printing & Stationery	8,95,401	6,75,318
8.	Travelling Expenses :		
	Inland	13,76,968	20,18,762
	Foreign	4,86,507	7,23,898
	Others	15,14,069	19,46,644
9.	Seminar/Workshops Expenses	1,23,95,292	2,14,95,197
10.	General Expenses	5,18,843	2,48,621
11.	Audit Fee	19,999	19,999
12.	House Keeping Expenses	47,50,750	38,15,951
13.	Security Expenses	63,64,003	51,71,958
14.	Advertisement & Publicity	12,91,110	18,16,485
15.	Membership / Registration fees	3,76,962	6,12,500
16.	Internet Expenses	20,22,478	19,85,398
17.	Legal Expenses	61,890	1,23,622
18.	Papers & Periodicals	29,636	53,303
19.	Conveyance Expenses	1,39,237	1,98,131
20.	Material/Consumable	39,48,786	34,66,409
21.	International Interface	39,98,590	1,16,67,699
22.	Others	51,924	1,00,733
	TOTAL	12,40,31,551	13,19,36,067

SCHEDULE NO.11

NOTES FORMING PART OF ACCOUNTS:

1. Significant Accounting Policies:

a) Basis of Accounting:

The Society follows the mercantile system of Accounting and recognizes Income and Expenditure on accrual basis. The accounts were prepared on the basis as a going concern.

b) Income Recognition:

The Grant-in-aid was received by the Society from Ministry of Earth Sciences in the form of recurring grant and ear-marked funds.

The Grant-in-aid received from Ministry of Earth Sciences for the purpose of meeting revenue expenditure is treated as Income to the Society and to the extent utilized for capital expenditure is added to the Corpus Fund. During the year 2013-14, the Society received Rs.14.30 Crores towards Recurring Grant as shown in the Schedule-8.

The remaining Grant-in-aid of Rs. 60.04 Crores received from Ministry of Earth Sciences is being utilized for specific purposes for which they were intended and are disclosed under the Earmarked Funds- Schedule-2.

c) Fixed Assets and Depreciation:

- Fixed Assets register was maintained by the Society.
- The management verified the assets physically by appointing a sub-committee.
- The additions to the fixed assets during the period of audit were stated at cost.
- Depreciation on Fixed Assets was provided on written down value, on pro-rata basis, as per the rates prescribed under the Income Tax Rules.

d) Inventories:

Inventory of stores, stationery items and other material of significant value are valued at cost.

e) Building:

As per the guidelines provided to the Central Autonomous Bodies, the Funds inflow and outflow relating to the building are initially to be shown under Building Fund in the Earmarked Funds under Schedule – 2 and on completion of the building; the value of building is to be transferred to the Fixed asset schedule.

e) Employee Benefits:

i) Gratuity:

The present value of the INCOIS obligations under Gratuity is recognized on the basis of an actuarial valuation made by LIC of India Ltd., as at the year end.

ii) Pension:

The IDBPS (INCOIS Defined Benefit Pension Scheme) is managed by a separate trust and employers contributions for the year 2013-14, towards pension for the employees joined prior to 01-01-2004, was transferred from INCOIS to LIC of India Ltd.

iii) Leave encashment:

The present value of the INCOIS obligations under Leave encashment is recognized on the basis of an actuarial valuation made by LIC of India Ltd., as at the year end.

iv) Periodical contributions made towards Contributory Provident Fund (CPF), New Pension Scheme (NPS) and IDBP Scheme (INCOIS Defined Benefit Pension Scheme) are charged to revenue.

g) Interest on Deposits:

The Society invested surplus funds from time to time in Short Term Deposit in Nationalized Banks. For the year 2013-14, an amount of Rs. 2,87,44,722/- was earned as interest on the Short Term Deposits in the bank. Since, the interest received on Short Term Deposits, relate to the grants accruing to the various projects and recurring grants received by INCOIS, the management decided to spread the interest on Short Term Deposits to such projects and INCOIS. Accordingly, out of total interest of Rs.2,87,44,722/-, the management had transferred an interest of Rs. 2,79,88,628/- to various projects classified in Earmarked Funds under Schedule-2 and the balance interest of Rs.7,56,094/- was considered as income of the Society under Schedule-7. The details are furnished below:-

(Amount in Rs.)

a	Interest earned on regular STDRS	4,41,88,010.00
b	Interest earned on Margin Money STDRS	26,90,793.00
c	TDS deducted by bank on interest earned	39,77,504.00
d	Accrued Interest as on 31.03.2014	9,39,069.00
e	Total Interest	5,17,95,376.00
f	Less: Accrued Interest as on 31.03.2013	2,30,50,654.00
g	Net Interest earned for the F Y 2013-14 (g=e-f)	2,87,44,722.00

2. Notes on Accounts:

a) Earmarked Funds:

The Society during the year 2013-14, received Rs.60.04 Crores as Grant-in-aid towards Earmarked Funds from the Ministry of Earth Sciences (MoES) and other institutions in the form of Recurring and Non-Recurring grants as specified under Schedule -2.

The amounts advanced to various Earmarked Funds under Schedule-2, shall initially be shown as Advances to Sub Projects' under "Others" category in the Earmarked Funds Schedule, and, on receipt of Utilisation Certificates from the respective project heads, the utilized amounts are transferred to either Capital expenditure or Revenue expenditure based on the nature of utilization.

The INCOIS is making payments for the acquisition of equipment for the various projects classified under Earmarked Funds of Schedule-2. These payments are initially shown as 'advance for purchase' under Schedule-2, and later, on completion commissioning of the equipment, the total value of equipment is transferred to equipments under the same Schedule. The total value of "Advance for Purchase" as on 31-03-2014 was Rs.40.33 Crores.

The accumulated value of the capital expenditure as on 31-03-2014 (excluding advances to sub-projects and advances for purchases), incurred in each year and specified in the Earmarked Funds under Schedule - 2, are stated below:

Sl. No.	Name of the Fund/ Project	As on 01-04-2013 Rs.	Additions 2013-14 Rs.	Total Amount as on 31-03-2014 Rs.
i)	Building Fund	35,52,10,432	8,81,03,009	44,33,13,441
ii)	MDC & Equipment Fund	6,59,21,618	0	6,59,21,618
iii)	Ocean Information and Advisory Services (O-IAS)	92,84,49,141	19,92,17,407	1,12,76,66,548
iv)	Computational Facilities	15,28,06,467	0	15,28,06,467
v)	INDOMOD & SATCORE Projects	36,64,36,391	1,30,39,419	37,94,75,810
vi)	Ocean Observation Networks	25,97,16,017	6,22,309	26,03,38,326
vii)	International Training Center-ITCOcean	5,040	5,61,593	5,66,633
viii)	HROOFS	0.00	13,800	13,800
ix)	HPC System - INCOIS	13,65,14,440	0	13,64,14,440
x)	IT & E Governance Fund	5,76,21,080	0	5,76,21,080
xi)	HPC Systems - Others	1,33,61,57,396	0	1,33,61,57,396
xii)	V SAT Node	6,32,97,966	78,84,817	7,11,82,783
xiii)	Ernet India	72,00,000	0	72,00,000
xiv)	IOAS	51,25,986	0	51,25,986
Total		3,73,44,61,974	30,94,42,354	4,04,38,04,328

b) Projects and Utilisation Certificates:

The Committees consisting the heads of respective projects and other technical persons are monitoring the status of the various projects, including the financial budgets etc., and noting the minutes of the output of such meetings.

The various assets of the projects and sub projects, purchased either by the INCOIS or respective projects and sub projects, are located at such projects and sub projects. The confirmations of the assets held by them are yet to be received.

The respective project heads sent the utilization certificates for the year ending 31st March of each financial year and these certificates are received by the INCOIS during the subsequent financial year. Hence, the management had decided to pass the entries relating to the Utilisation Certificates actually received upto 31st March of each financial year.

c) Prior period Item:

An amount of Rs.2,17,111/- charged to Income and Expenditure Account arising out of cancellation of service invoice pertaining to the financial year 2012-13 was treated as prior period item as per the accounting policy applicable to Central Autonomous Bodies

- d) i) Contingent liabilities not provided for : NIL
- ii) Estimated amount of Contracts remaining to be executed on capital account-NIL
- iii) Claims against the company not acknowledged as debts-NIL
- iv) The society had placed an order with M/s. Victory Genset Pvt. Ltd for purchase of two 600 KVA DG sets in the year 2009 and released 90% payment by irrecoverable LC as per terms agreed. But, M/s. Victory Genset Pvt. Ltd had supplied only one DG set. The society claims that the documents were fabricated by supplier and hence, filed a criminal and civil suit in 2009 against the supplier.

The Ill Additional Chief Judge of City Civil Court, Hyderabad, had passed a decree for Rs.64,89,747/- plus damages Rs.10,00,000/- with future interest till the date of payment by the firm vide their Order OS No.69 of 2010, dated 18-04-012. During the proceedings of the case, an amount of Rs.18,50,907.98 was blocked through injection petition in the current account of M/s Victory Genset Pvt.Ltd. at SBI, Varsova Branch, Mumbai.

Upon grant of decree by Hon'ble court, the society on the advise of legal advisor had requested SBI Varsova Branch, Mumbai to transfer the available amount to INCOIS and to provide the details of assets of M/s Victory Genset Pvt.Ltd.to file the recovery petition to recover the balance amount. As SBI, Varsova Branch refused to honour the court decree, the society had written letters to Governor, Reserve Bank of India & Secretary, Ministry of Finance, Govt. of India complaining against the SBI, Varsova Branch for not adhering to the court decree. Responses are awaited from RBI and Ministry of Finance.

- e) Figures of the previous year were regrouped wherever necessary.
- f) Paise had been rounded off to the nearest rupee.

As per our report of even date
For **B.SRINIVASA RAO & CO.,**
Chartered Accountants

For and on behalf of **INDIAN NATIONAL CENTRE FOR
OCEAN INFORMATION SERVICES**



(Ch. Anand)
Partner

M.No. 222732
FRN No: 008763S



(S. Nageswara Rao)
Accounts Officer



(K.K.V.Chary)
Dy. C A O



(S.S.C.Shenoi)
Director

Place: Hyderabad
Date: 10-07-2014





ESSO-Indian National Centre for Ocean Information Services

(An autonomous body under the Ministry of Earth Sciences, Government of India)

'Ocean Valley', Pragathi Nagar (BO), Nizampet (SO), Hyderabad-500 090

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