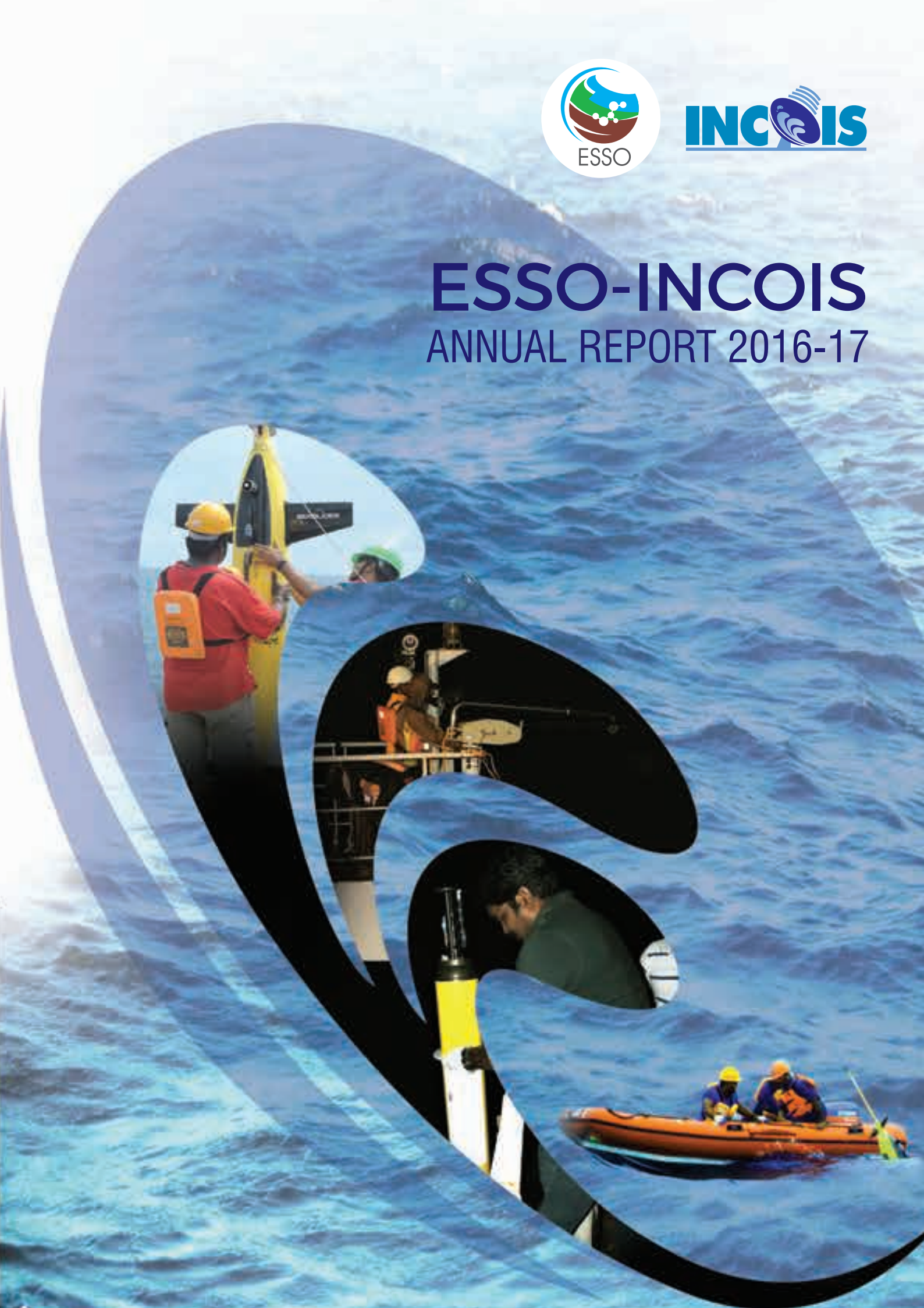
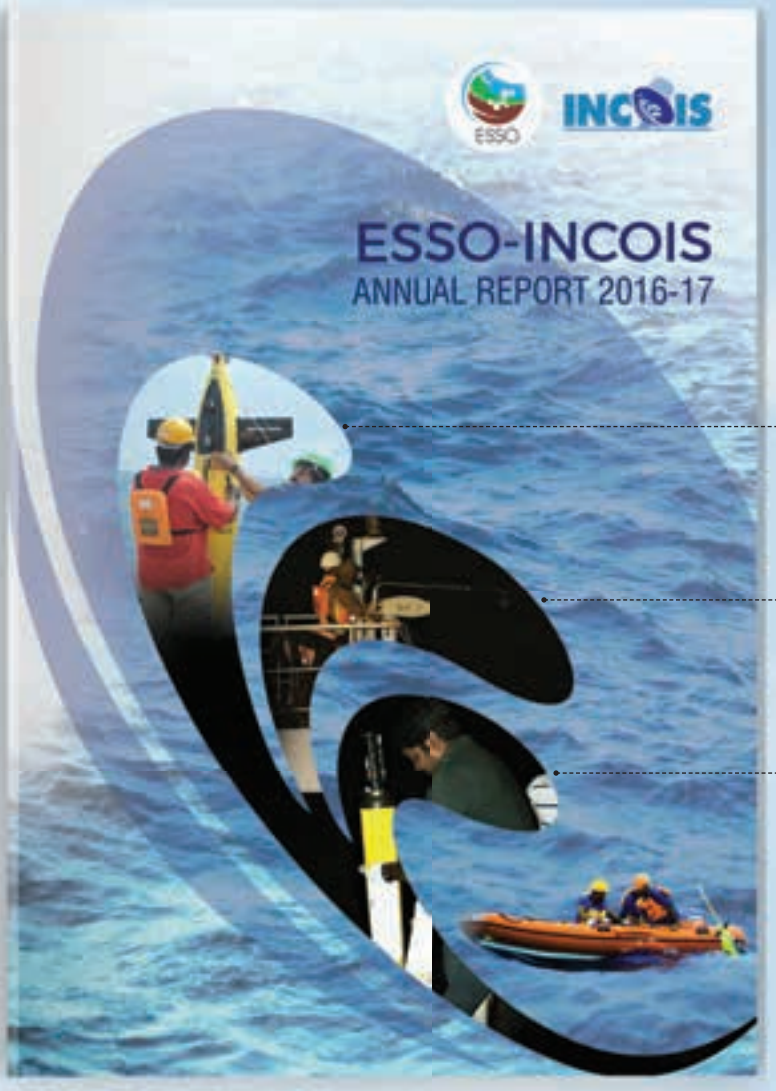
ESSO-INCOIS
ANNUAL REPORT 2016-17



Front Cover
Ocean Mixing and Monsoon Research Cruise



Launching of Sea Glider

Deployment of Vertical Micro Profiler

Deployment of Argo Float

Background- Team conducting recovery of Sea Glider

Photo Courtesy-
N. Suresh Kumar,
Modelling and Ocean Observations Group (MOG), ESSO-INCOIS.

Back Cover

Entrance to ESSO-INCOIS' Main Building

Photo Courtesy-
Knowledge Resource Centre,
ESSO-INCOIS

Annual Report 2016-17

ESSO-Indian National Centre for Ocean Information Services (INCOIS)
(An Autonomous body under Ministry of Earth Sciences, Government of India)
Hyderabad

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From Director's Desk

It gives me immense pleasure in presenting the Annual Report of ESSO-INCOIS for 2016-17 inventorying happenings and achievements. During the past year, INCOIS has lived up to expectations as well made giant strides in the areas of ocean information and advisory services and in ocean modelling. Several feedbacks were received from users, on information and advisories we have provided, yet again testifying their usefulness and benefits received.

To aid in the search and rescue of lost objects/men at sea, we came out with a Search And Rescue Aid Tool (SARAT) amalgamating ocean state forecasts and probablity models. This tool is of great help for agencies like the Indian Coast Guard who are engaged in search and rescue at sea. We have also established a state-of-the art ocean state forecast laboratory to aid the generation of ocean state forecasts using multiple data sets and models.

We have lived up to the expections of all in our country as well as the countries of the Indian Ocean Rim in providing tsunami early warnings without missing a single large earthquake event ($M > 6.5$) on the floor of the Indian Ocean or elsewhere. During the last year, we have also deployed a new Decision Support System (Ver. 2016) to enhance our capability in providing tsunami early warnings more efficiently. While continuing to conduct communications tests (comms-tests) every 6 months to ensure the connectivity between the warning centre and other agencies, we also coordinated IOWave16, a mock drill to prepare the disaster management agencies and coastal population on what to do in case of a real tsunami event. The tsunami mock drill, IOWave16, was conducted during 7-8 September 2016 in coordination with IOC/UNESCO and 23 countries on the Indian Ocean rim. About 40,000 people were evacuated from 350 districts/villages spread over 8 states in India.

Since we depend on satellite data for our services, a new X-Band ground station (3rd ground station on campus) was established to acquire direct broadcast data from Suomi-NPP satellites. To understand turbulent mixing in the mixed layer of Bay Bengal in the winter season, a special cruise on board ORV Sagar Nidhi was conducted during 18 December 2016 to 3 January 2017. The data is being analysed.

As promised in the 12th plan project, we have completed setups and operationalized high-resolution ocean models to forecast the temperature-salinity and currents in the entire water column in the seas around India. The last one was set up for the Bay of Bengal with a spatial resolution of 2.25 x 2.25 km. This has enhanced our capability in providing high-resolution forecasts, covering the entire water column, to marine industries.

Experiments with Global Ocean Data Assimilation System showed that the assimilation of temperature and salinity observations from bounded observation networks such as tropical moorings degrades the quality of ocean reanalysis due to the genesis of shock and its subsequent westward propagation as Rossby waves, particularly in the pre-Argo era.

The International Training Centre for Operational Oceanography (ITCOocean) of ESSO-INCOIS conducted 4 international and 3 national training courses on different aspects of operational oceanography. More than 200 participants, including 36 foreign nationals from 20 countries attended the courses. The construction of buildings for ITCOocean are in progress.

Padma Bhushan, Dr. Pushpa Bhargava, Founder Director of Centre for Cellular and Molecular Biology (CCMB) delivered the foundation day lecture. The "Open Day" on 3 February 2016 attracted several hundred students and public to visit INCOIS facilities.

In order to promote the usage of language, Hindi, the Official Language Implementation Committee of INCOIS organized three seminars during 2016-17. In addition, a Hindi Pakhwara Progamme was conducted during 1-14 September 2016. The programme included competitions like Elocution, Essay Writing, Quiz etc. for staff and their family members.

During the year, INCOIS also under went critical review by an Independent Peer-Review Committee constituted by Secretary, MoES under the chairmanship of Prof. Goverdhan Mehta, National Research Professor, University of Hyderabad. Prof. B. L. Deekshatulu, Distinguished Fellow, Institute for Development and Research in Banking Technology, Hyderabad, Dr. George Joseph, Honorary Distinguished Professor, ISRO, Prof. A.K. Singhvi, Honorary Scientist, PRL, Dr. (Ms) B. Meenakumari, chairperson, National Biodiversity Authority were the members of the committee. Dr. Somasundar, Programme Officer, acted as the member convenor of the committee. The review was in pursuance of the recommendations of the Expenditure Management Commission of the Department of Expenditure, Government of India and as per GFR that stipulates periodical review of autonomous bodies to ascertain whether autonomous bodies are meeting the purpose for which they were established and whether they need to continue as autonomous institutions. The committee reviewed the activities and performance of INCOIS on 28 November 2016 and submitted the report to Secretary, MoES.

ESSO-INCOIS scientists also published 65 research papers in reputed national and international journals with a cumulative impact factor of 150.

During the FY 2016-17, no manpower was added, either on regular basis or in project mode, in INCOIS. However, 3 Project Scientists and 8 Project Assistants resigned/completed their term during the FY. Two CSIR-UGC NET (LS) qualified JRFs and 2 DST-INSPIRE qualified JRFs joined INCOIS to carry out research leading to Ph.D. degree.

ESSO-INCOIS continued its association with the Indian Ocean Global Ocean Observing System (IOGOOS), Regional Co-ordination of Argo Programme, Partnership for Observation of Global Ocean (POGO), Regional Integrated Multi-hazard Early warning System (RIMES) and at Intergovernmental Coordination Group (ICG) of Indian Ocean Tsunami and other hazards Warning System (IOTWS) of Intergovernmental Oceanographic Commission (IOC)/UNESCO. INCOIS continued hosting the secretariats of IOGOOS, Sustained Indian Ocean Biogeochemistry and Ecosystem Research (SIBER) and Ocean Bio-Informatics System (OBIS). In addition, the Indian node of Joint Programme Office (JPO) for IIOE-2 has been hosted at ESSO-INCOIS to coordinate the IIOE-2 project (2016-2020) jointly sponsored by IOC, SCOR and IOGOOS.

ESSO-INCOIS was recognised with several awards and recognitions. Dr. T. M. Balakrishnan Nair, Dr. R. Harikumar, Dr. P. A. Francis and Ms. K. G. Sandhya were awarded with the National Geoscience Award at a function held at Rashtrapati Bhavan, New Delhi. Dr. Kunal Chakraborty received the Young Researcher award instituted by MoES and was also selected for the award of INSA Young Scientist. AMET University, Chennai conferred the Honorary Degree (Honoris causa) of Doctor of Science on Dr. S.S.C. Shenoi.

The continuous support and guidance received from the Governing Council under the chairmanship of Dr. M. Rajeevan was excellent. I thank Dr. Rajeevan for the continued support and guidance in conducting the activities of ESSO-INCOIS. My thanks to the members of the Governing Council for their support and guidance. Also would like to thank the chairs and members of financial committee and Research Advisory Committee for their critical comments and advice in conducting the financial and scientific affairs of ESSO-INCOIS. Colleagues in Ministry of Earth Science and at the ESSO centres: NIOT, NCAOR, IITM, NCESS, NCMRWF, IMD, CMLRE, and ICMAM were always there with generous support for any issue that we wanted to solve. I thank them all.

I would like to say a heartfelt thank-you to ESSO-INCOIS members of staff for wholeheartedly cooperating and contributing to the progress of ESSO-INCOIS. Together, we have made significant progress and I hope ESSO-INCOIS will continue its journey to the future. My special thanks to the Editorial Committee of this report under the chairmanship of Francis and its members Hari, Kiran, Praveen, Suprit, Ajay, Nimit, Celsa, Anil and Sidhartha.

I hope, you will enjoy reading this report.

Thank You.

Jai Hind.

S. S. C. Shenoi

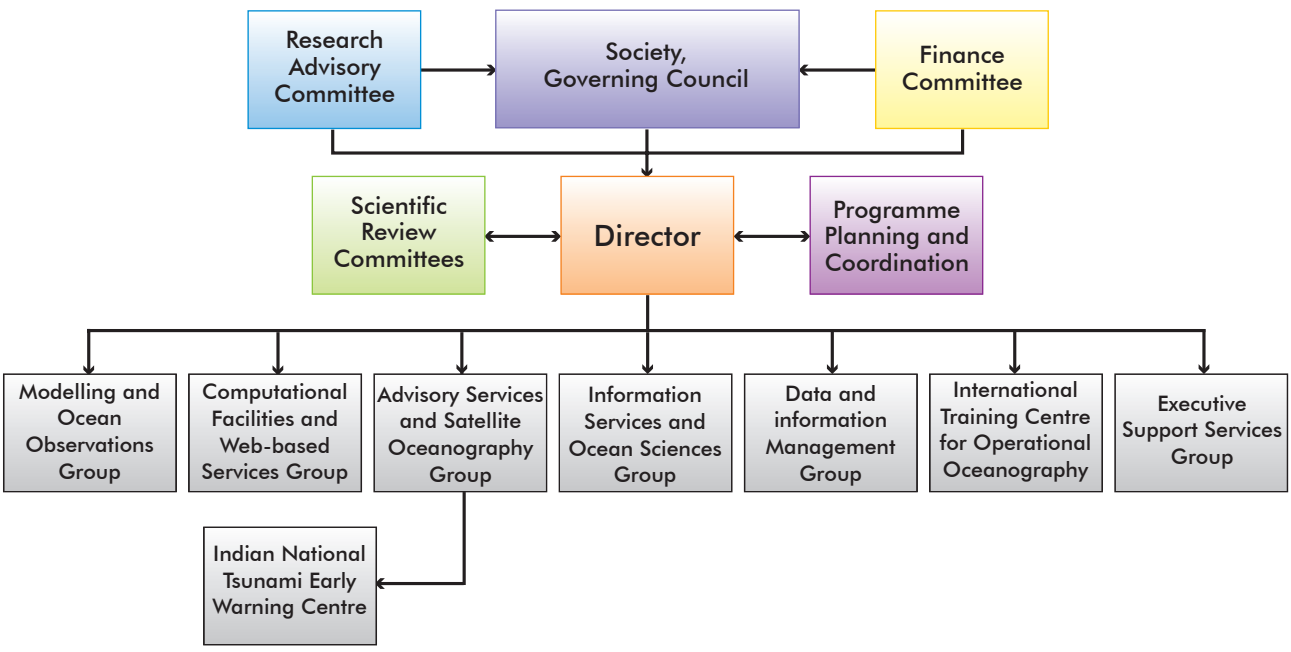
2. ESSO-INCOIS Organizational Structure

ESSO-INCOIS is an autonomous institute under the administrative control of Ministry of Earth Sciences (MoES), Government of India and a member of the Earth System Science Organization (ESSO).

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 by the Governing Council, subject to the Bye Laws of the Society.

2.1 ESSO-INCOIS Society

Secretary to Government of India, 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 to Government of India, Ministry of Earth Sciences	(Chairman)
2.	Director, National Remote Sensing Centre	(Member)
3.	Director General, India Meteorological Department	(Member)
4.	Financial Advisor, Ministry of Earth Sciences	(Member)
5.	Joint Secretary, Ministry of Earth Sciences	(Member)
6.	Director, National Centre for Antarctica and Ocean Research	(Member)
7.	Director, National Institute of Oceanography	(Member)
8.	Director, National Institute of Ocean Technology	(Member)
9.	Chairman, INCOIS Research Advisory Committee	(Member)
10.	Dr. R. R. Rao, Scientist 'G', (Rtd) NPOL, Kochi	(Member)
11.	Advisor (S & T), NITI Aayog	(Member)
12.	Programme Officer, Ministry of Earth Sciences	(Member)
13.	Director, Indian National Centre for Ocean Information Services	(Member Secretary)

2.3 ESSO-INCOIS Research Advisory Committee

1. Prof. G.S. Bhat, Indian Institute of Science (Chairman)
2. Dr. M. Dileep Kumar (Rtd.,), NIO (Member)
3. Dr. Prakash Chauhan, SAC (Member)
4. Dr. N.L. Sarda, IIT, Mumbai (Member)
5. Dr. Kusala Rajendran, IISc (Member)
6. Dr. M. Mohapatra, IMD (Member)
7. Dr. T.M. Balakrishnan Nair, INCOIS (Member-Secretary)

2.4 ESSO-INCOIS Finance Committee

1. Financial Advisor, MoES (Chairman)
2. Joint Secretary, MoES (Member)
3. Director, ESSO-INCOIS (Member)
4. Director/Deputy Secretary (Finance), MoES (Member)
5. Programme Officer, MoES (Member)
6. Shri. 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 co-ordinate 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 & shall ensure our commitment to continually improve our performance with the Quality Management System, by setting and reviewing quality objectives.

3. Highlights

1. **Search And Rescue Aid Tool (SARAT):** The Search And Rescue Aid Tool developed by INCOIS was dedicated to the nation on 27 July 2017 by Dr. Harsh Vardhan, Hon'ble Minister for Science and Technology and Earth Sciences, Govt. of India.

2. **State-of-the-art Ocean State Forecast Laboratory:** A state-of-the art ocean state forecast laboratory established in INCOIS was inaugurated on 3 March 2017 by Dr. M. Rajeevan, Secretary, Ministry of Earth Sciences, Govt. of India.

3. **New Decision Support System for ITEWC:** A new Decision Support System (Ver. 2016) capable of providing Tsunami early warnings more efficiently was introduced in the Indian Tsunami Early Warning Centre.

4. **COMM Tests:** Two COMMs tests (on 8 June 2016 & 14 December 2016) were conducted by ITEWC to check the efficiency of dissemination process from Tsunami Service Providers to National Tsunami Warning Centres.

5. **IOWave16 tsunami mock drill:** A tsunami mock drill, IOWave16, was conducted during 7-8 September 2016 by IOC/UNESCO. INCOIS also participated in this drill on both days. National Disaster Management Authority (NDMA), Ministry of Home Affairs (MHA), National Disaster Response Force (NDRF) and the Coastal States/UTs participated in the drill.

6. **Stakeholders meet:** A stakeholders meeting focussing on dissemination of MoES services was held on 28 September 2016. More than 100 officials from various coastal states and agencies interested in meteorological and marine forecasting related fields attended the meeting.

7. **New X-band ground station:** INCOIS data centre established a new X-Band ground station to acquire direct broadcast data from Suomi-NPP satellite.

8. **Ocean Observation Campaigns:** INCOIS conducted one research cruise under its Ocean Observation Programme in the Bay of Bengal during 18 December 2016 to 3 January 2017 onboard ORV Sagar Nidhi. The primary objective of the cruise was to understand the upper ocean hydrographic structure and stability characteristics in the northern Bay during the winter season.

9. **HOOFS setup for Bay of Bengal (BB-HOOFS):** The High-resolution Operational Ocean Forecast and reanalysis System, with an objective to provide accurate forecasts of ocean circulation features, was set up for the Bay of Bengal.

10. **Observation System Evaluation:** Experiments with Global Ocean Data Assimilation System showed that the assimilation of temperature and salinity observations from bounded

observation networks such as tropical moorings degrades the quality of ocean reanalysis due to the genesis of shock and its subsequent westward propagation as Rossby waves, particularly in the pre-Argo era.

11. **ITCOocean Training Programmes:** ITCOocean of INCOIS conducted 4 international and 3 national training programmes during 2016-17. More than 200 participants attended the training programmes.

12. **Publications:** Scientists of INCOIS authored/co-authored 65 publications in national and international SCI journals in 2016-17. Cumulative impact factor of the publications in this period is more than 150.

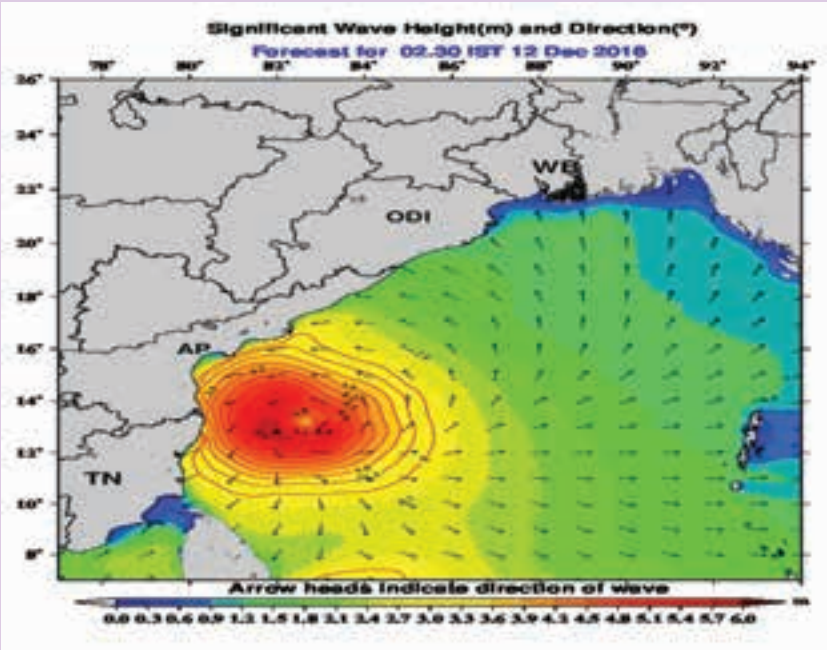
4. Services

4.1. Ocean State Forecast (OSF)

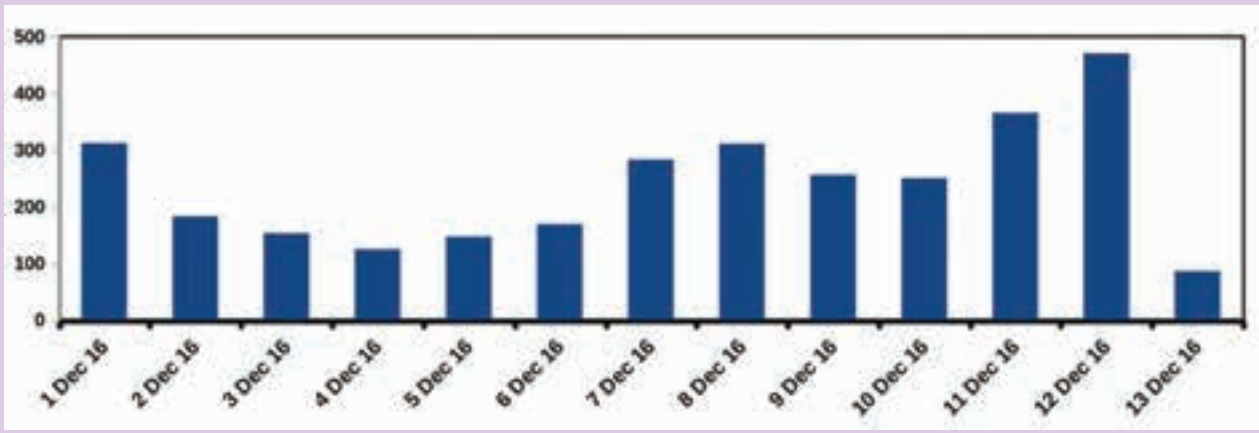
4.1.1 Extreme event forecasts

Forecasts during cyclones

INCOIS disseminates forecasts on the state of the ocean along with the forecasts on marine weather in the INCOIS-IMD joint bulletins during the passage of cyclones. During 2016-17, several such bulletins were issued during the passage of cyclones Roanu (17-21 May 2016), Kyant (20-27 October 2016), Nada (29 November – 2 December 2016) and Vardah (6-13 December 2016). The Ocean state forecasts issued by INCOIS were in good agreement with the data recorded by wave rider buoys and moored buoys.



Significant wave-height and direction forecast issued by INCOIS during Vardah Cyclone



Number of OSF web page views during cyclonic storm Vardah (6 December-13 December, 2016)

- INCOIS issued warnings on the possible occurrence of rough waves on 20 March 2017 in the coastal waters off Alappuzha, Ernakulam and Thrissur districts in Kerala, which was reported to be accurate by the local population.
- INCOIS provided High wave alerts/ Warnings advisories to Sri Lanka during 15-19 May 2016 and to the Deputy Director General (Meteorology), Maldives during 6-20 May 2016.

4.1.2 State-of-the-art OSF Lab

A state-of-the-art Ocean State Forecast Laboratory set up at INCOIS was inaugurated by Dr. M. Rajeevan, Secretary, Ministry of Earth Sciences, Government of India on 3 March 2017. The OSF lab provides the Forecast Assessment and Support Tool (FAST) with the help of the decision support system developed in-house. The new OSF lab also has a videowall with a control unit for displaying forecasts and observations, which helps scientists to assess the state of the ocean and issue forecasts accordingly. The lab also has facilities to continuously monitor the communication networks and status of the observation systems.

Dr. M. Rajeevan, Secretary, Ministry of Earth Sciences, Government of India inaugurating the state-of-the-art Ocean State Forecast Lab and (right panel) QR code-based dissemination of Ocean state forecasts on 3 March 2017 at INCOIS, Hyderabad.

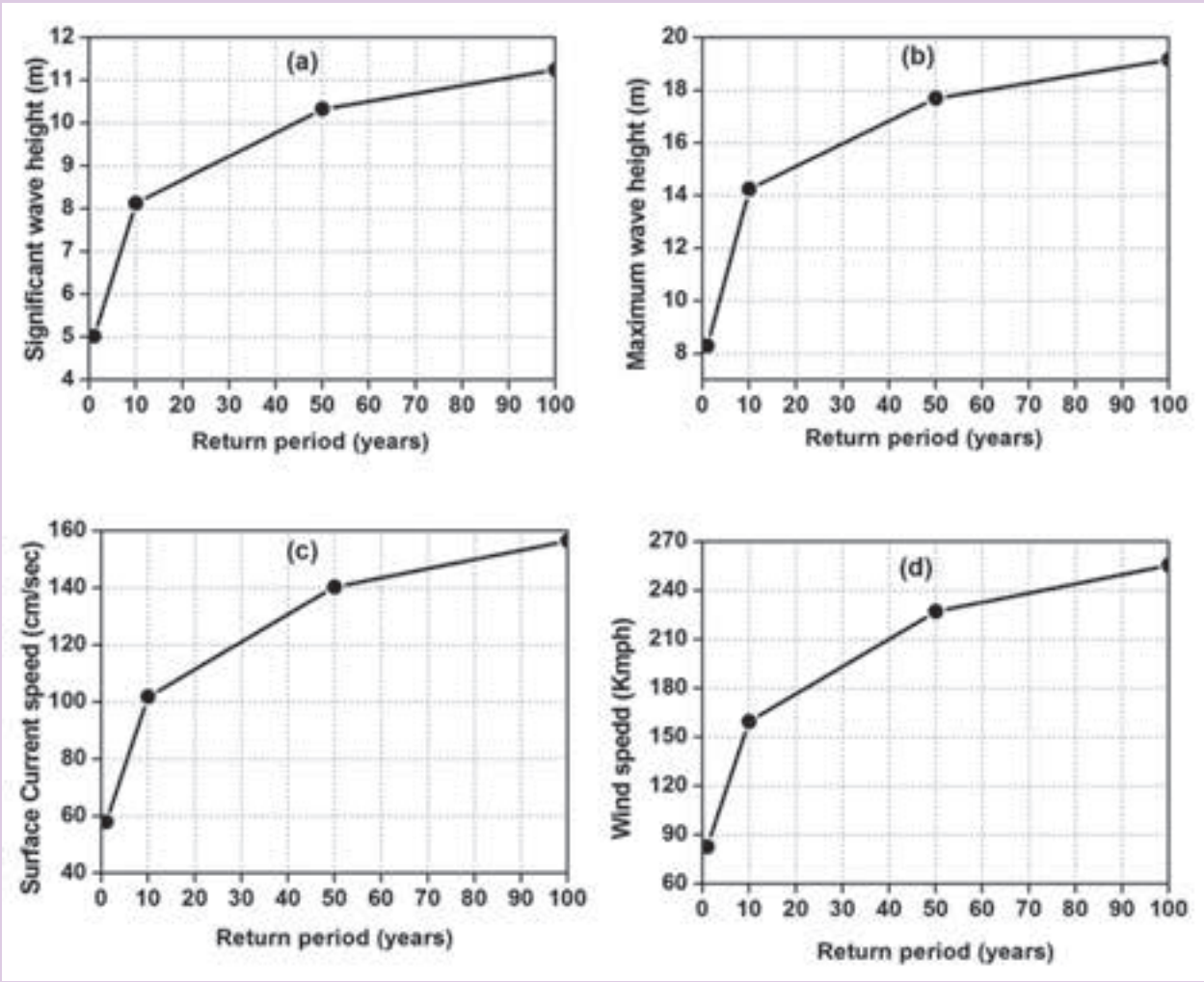
4.1.3 OSF forecasts during Reusable Launch Vehicle Technology Demonstration

INCOIS provided specific ocean state forecasts to Indian Space Research Organisation (ISRO) during the launch of Reusable Launch Vehicle Technology Demonstration (RLV-TD) held on 23 May 2016.

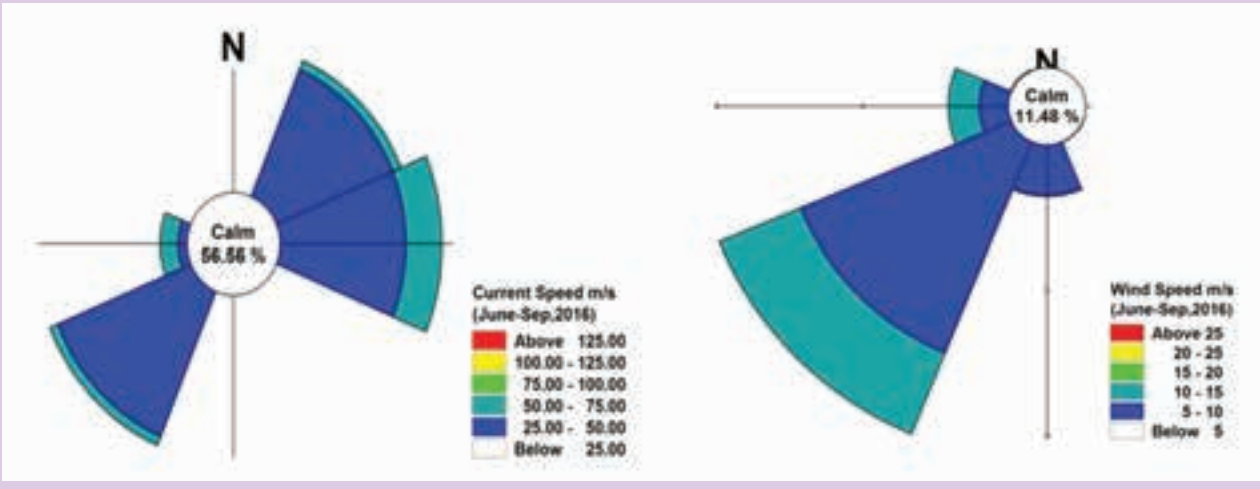
4.1.4 Consultancy projects

Based on a request from Oil & Natural Gas Corporation Limited, Eastern Offshore Asset, Kakinada, INCOIS conducted a detailed study on inter-annual simulated met-ocean data (wind, wave and currents – both surface and sub-surface) for their proposed drilling well to be located off Kakinada (Andhra Pradesh). This work was taken up for an amount of Rs. 23.53 lakhs. The results from the validation experiments suggested excellent agreement of the simulated data with observations.

The extreme value analysis on the wave and wind parameters at the site location revealed significant wave height of 11.25 m, maximum wave height of 19.16 m, period of the highest individual wave 13.66 s and wind speed of 255.6 kmph, for a 100 year return period. The extreme value analysis performed at the specific site location revealed extreme current speed of 283.8 cm/s, 188.8 cm/s and 129.2 cm/s for surface, mid-depth and near-bottom waters for a return period of 100 years. ONGC has also expressed a desire to support its offshore operational activities by acquiring regular ocean state forecasts from INCOIS.



Determination of extreme wave, current and wind parameters using extreme value distribution. Plot (a,b) shows extreme significant and maximum wave heights for return periods 1-100 years respectively. Plot (c,d) shows extreme surface current and wind speeds for return periods 1-100 years respectively.



Typical figures on Directional histogram of surface current speed and (right panel) wind speed during the monsoon period of 2016 for the location of interest of ONGC.

4.1.5 Search And Rescue Aid Tool (SARAT)

INCOIS developed a Search and Rescue Aid Tool (SARAT) to track any objects/persons lost at sea. Forecasted ocean currents and surface winds at the last known location, are used to estim ate the

The SARAT dedicated to the Nation during the XV National Maritime Search and Rescue (NMSAR) Board meeting held at the Vigyan Bhavan, New Delhi on 27 July 2016.

probabilities of finding missing object/person in the sea. Dr. Harsh Vardhan, Hon'ble Minister of Science & Technology and Earth Sciences dedicated SARAT to the Nation during the XV National Maritime Search and Rescue (NMSAR) Board meeting held at Vigyan Bhavan, New Delhi on 27 July 2016.

4.1.6 Oil-spill advisories

The third version of online oil spill advisory (OOSA), a web-based service, was launched during the 21st NOSDCP meeting held at India International Centre, New Delhi on 5 August 2016. The system facilitates the indication of eco-sensitive zones, Potential Fishing zones, Fishing Avoidance Zone in the event of an oil spill in the ocean.

An oil spill occurred off Ennore port due to a collision between two vessels, MV MAPLE and MV DAWN on 28 January 2017 at 0400 hrs. INCOIS issued 4 special bulletins, predicting the path of oil spill during 28 January to 8 February 2017 for the benefit of Indian Coast Guard, which was involved in containing the oil spill through contingency plans.

Predicted trajectory of the oil spill off-the coast of Ennore (Chennai) on 28 January 2017

4.1.7 Training Programme on Marine Weather forecasting for Merchant Navy Officers

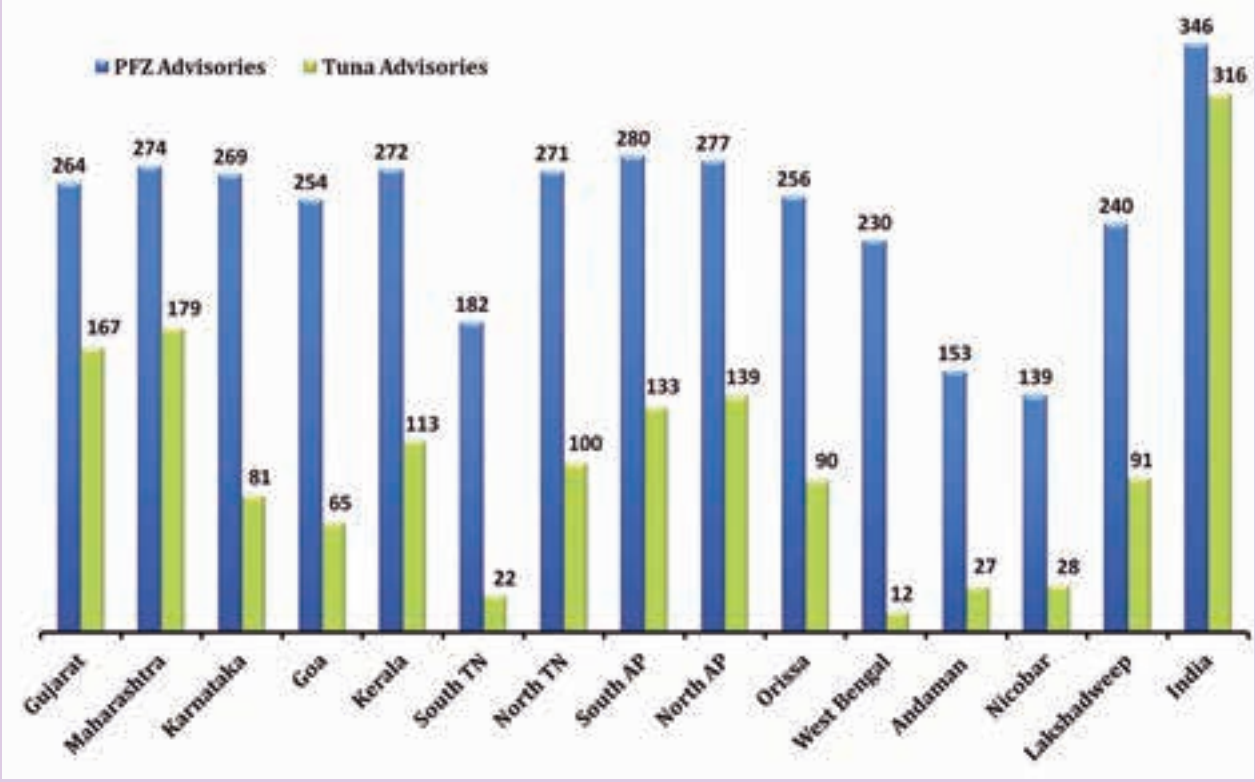
INCOIS conducted a one-day training programme on marine weather forecasting for merchant navy officers in collaboration with AMET University, Chennai on 16 November 2016. The objective of the training programme was to promote the usage of Ocean State Forecast products by officers of passenger and cargo ships. Sixty two merchant navy and related officers attended the training.

Sri. Cyril C. George, Dep. Chairman, Chennai Port Trust inaugurating the Training Programme on Marine Weather forecasting for Merchant Navy Officers on 17 Nov 2016 at AMET University, Chennai, and (right panel) Dr. R. Harikumar, Scientist & In-Charge of Ocean State Forecast Services, INCOIS addressing the delegates.

4.2. Marine Fishery Advisory Services (MFAS)

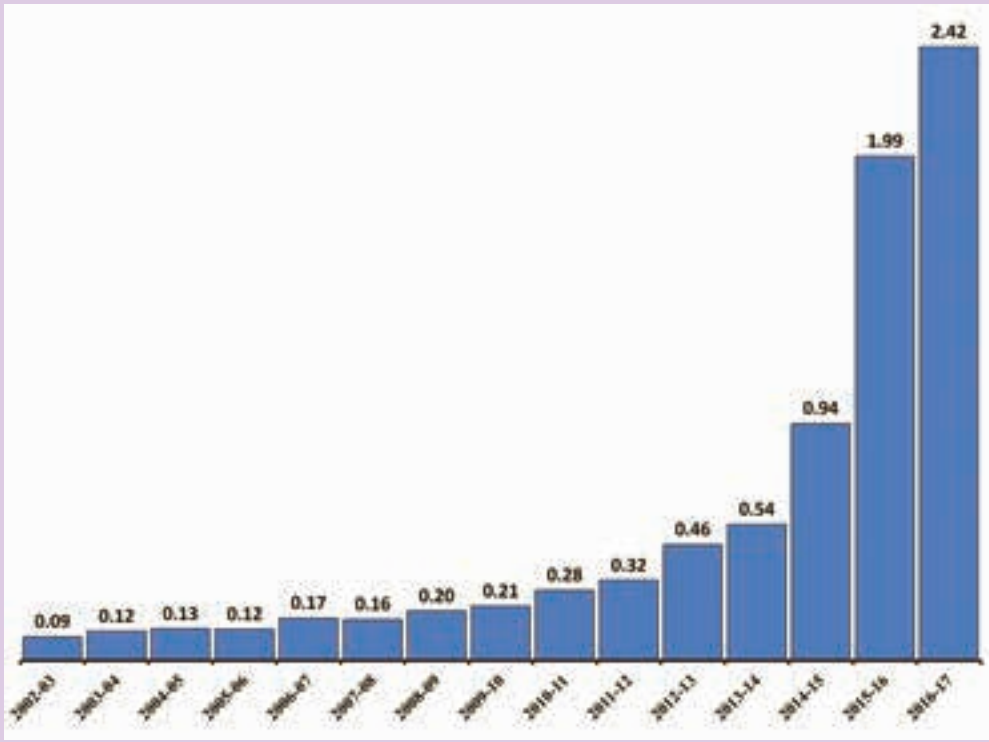
4.2.1 Potential Fishing Zones (PFZ) and Tuna PFZ Advisories

The Potential Fishing Zone advisory services is one of the flagship programmes of INCOIS, which directly benefits lakhs of fishermen in the country. The information on the potential regions of fish availability is derived from satellite measurements of sea surface temperature and chlorophyll. The advisories were disseminated in smart map and text form on daily basis, except during fishing-ban period and adverse sea conditions. During 2016-17, multilingual PFZ advisories were issued on 346 days against the targeted 300 days. In the same duration, Tuna advisories were also issued on 316 days.

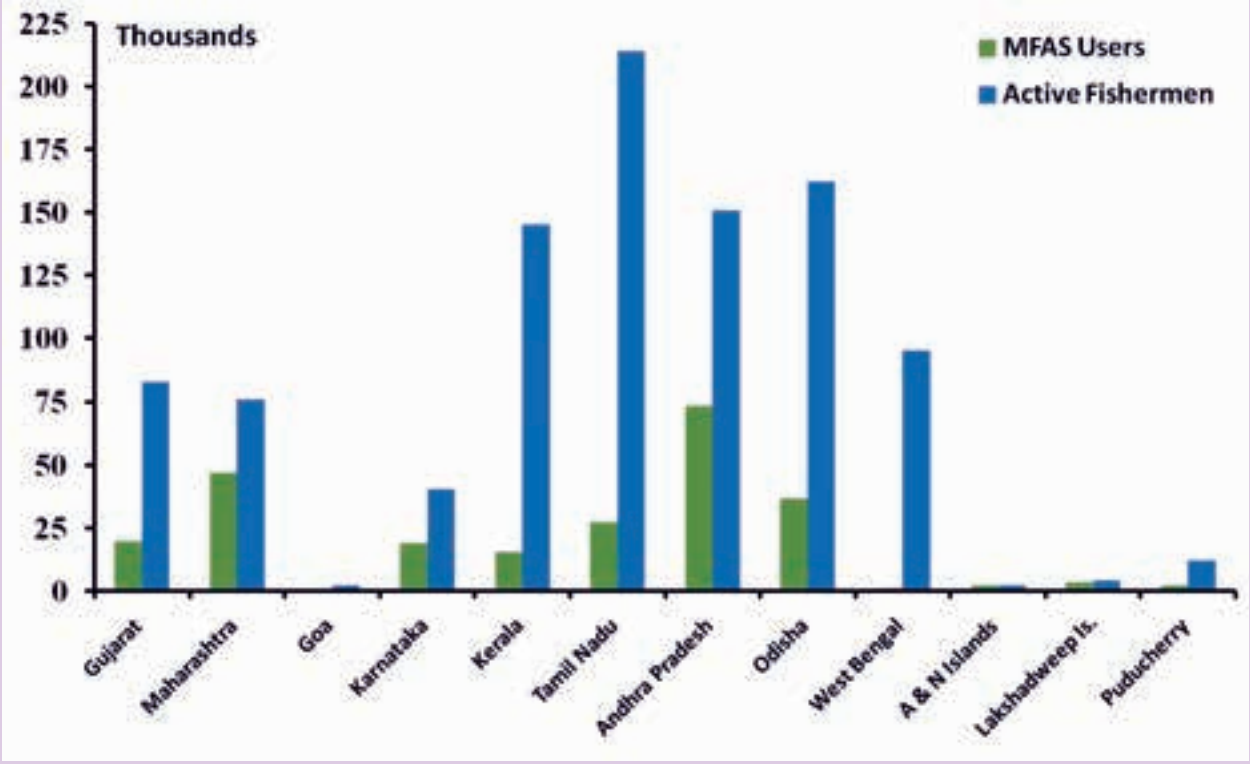


Number of PFZ and Tuna PFZ advisories disseminated

The user-base of MFAS has increased almost five-fold in last three years, chiefly due to improved last-mile mobile penetration in the country. With the support of Ministry of Home Affairs and Ministry of Agriculture, INCOIS is coordinating with the state fisheries departments to obtain the mobile numbers of all the sea-going fisherfolk. So far, 98,922 mobile numbers have been added to the user-database. These fishermen will directly receive PFZ advisories on their mobile phones. Efforts are underway to include more fishermen in the user-base.



Number of fishermen registered with INCOIS to received the PFZ / Tuna advisories (Numbers in lakhs)

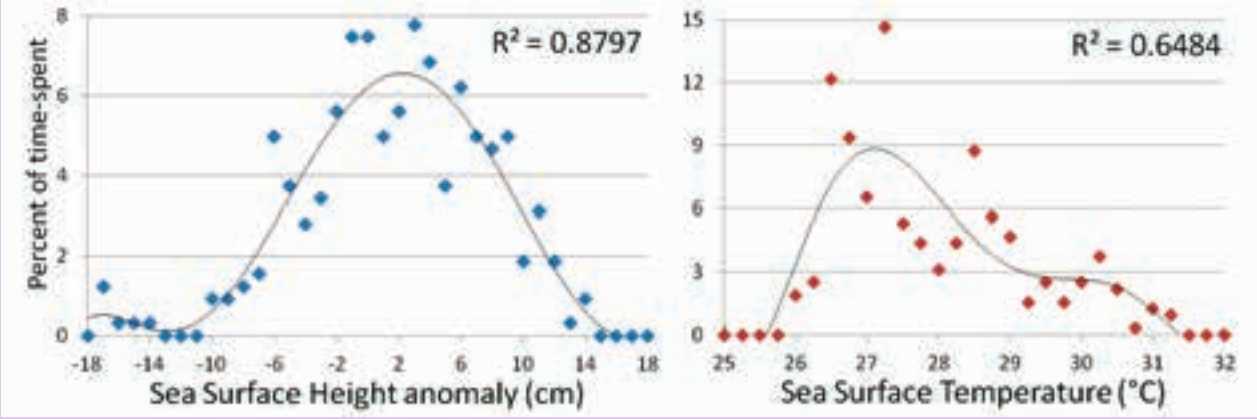


State/UT-wise reach of INCOIS PFZ / Tuna advisories

4.2.2 Species specific research efforts

1. SATTUNA (Satellite Telemetry of Tuna)

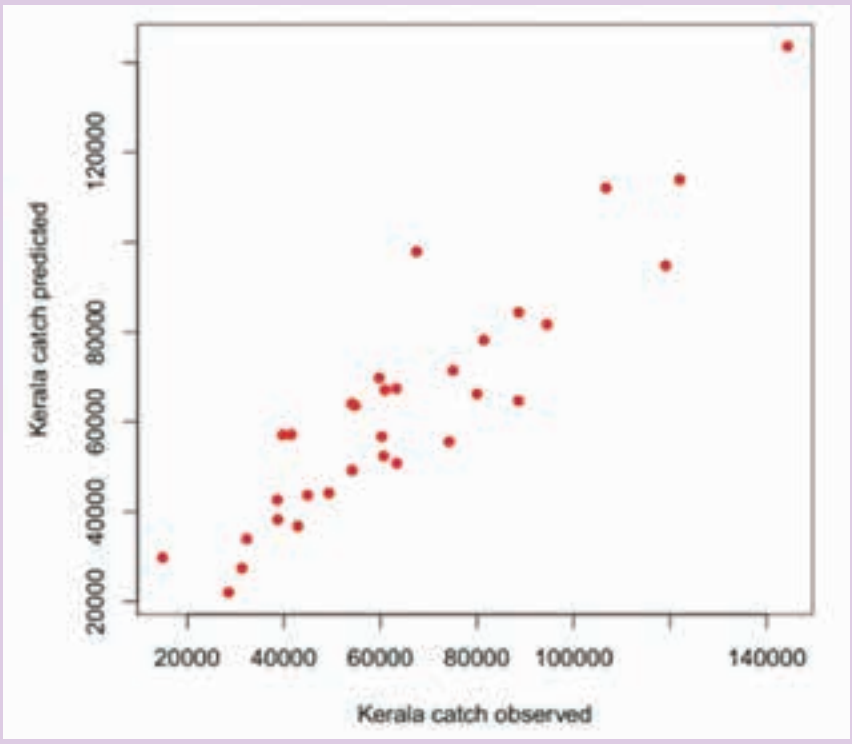
Under the SATTUNA (Satellite Telemetry studies on migration patterns of Tunas in Indian Seas) project, during 2016-17, fifteen Yellowfin tuna were tagged with Pop-up Satellite Archival Tags (PSATs) in collaboration with CMFRI and FSI. Data collected by these tags were used to analyze and understand the Tuna habitat. From the results, it was observed that Tagged fish did not exhibit significant deep diving or diurnal behaviour, and preferred ambient temperatures of 26-30°C and 25-29°C in the Arabian Sea (AS) and the Bay of Bengal (BoB), respectively. In general, tuna spent 60% and 70% time in the regions with Sea Surface Temperature of 26-29°C and Sea Surface Height-anomaly of ±6 cm, respectively. Tuna often avoided moving below the oxycline depth, which we infer to be a response to the stratified waters of the AS and the BoB. Thus, low dissolved oxygen levels could be a governing factor for tuna movement given their high oxygen demand.



SST and SSHa preference of Yellowfin Tuna (Thunnus albacores) in the Indian Seas

2. Indian Oil Sardine

Analysis of quarterly fish-catch landing data of the Indian oil sardine (*Sardinella longiceps*) off the southwest coast of India, was carried out to study its relation with various environmental parameters (such as precipitation, SST, Upwelling Index, SSHa and Chlorophyll). The analysis revealed that chlorophyll and sea surface height anomaly data are significantly correlated with the fish landing data with a time lag of 8-9 quarters'

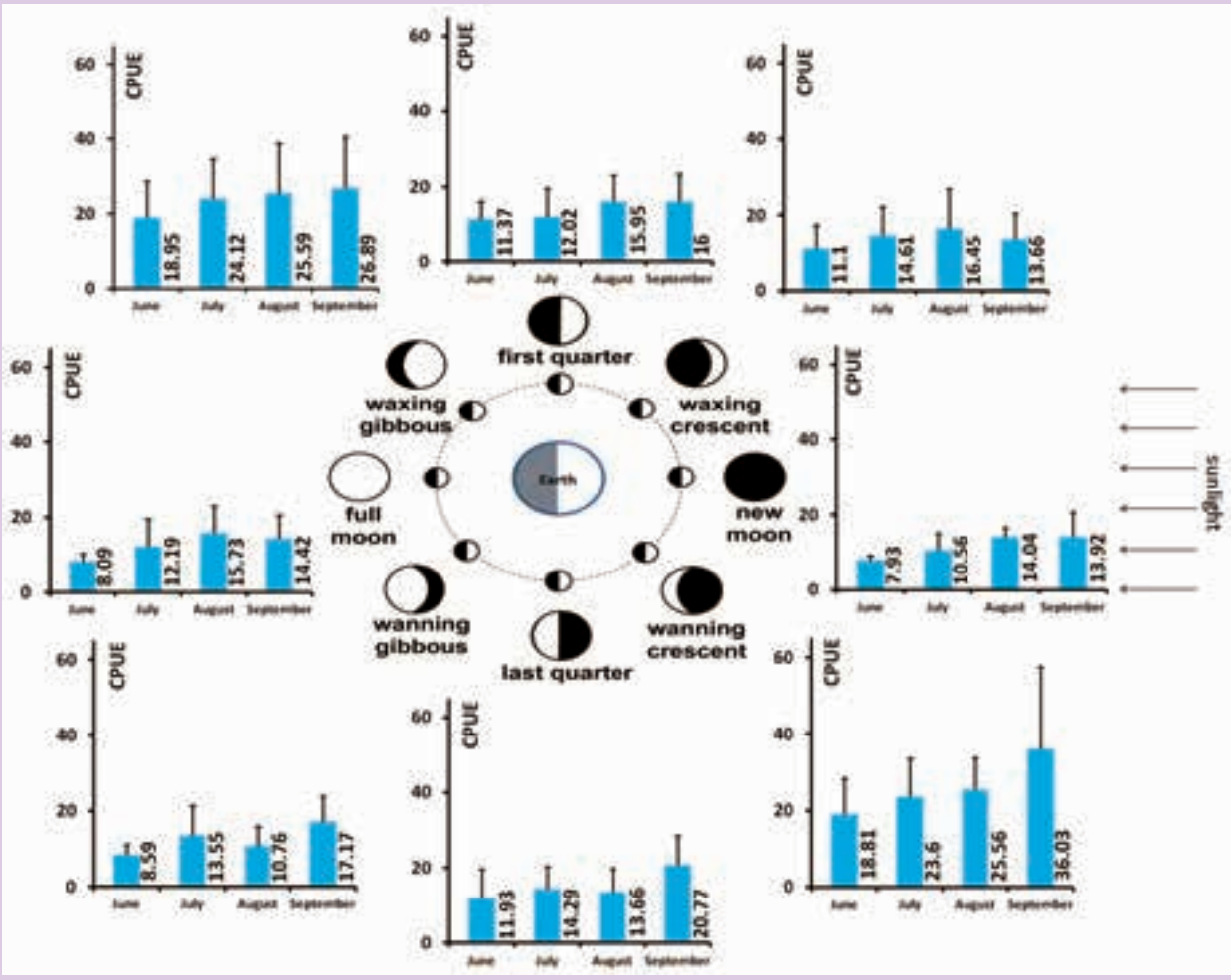


First proof-of-concept for monthly Kerala fish landings (in kg) prediction

(i.e. ~2 years'). Based on this observation, a primary statistical model is being developed to provide seasonal outlooks of oil sardine fishery with acceptable margin of error. Such outlooks are important for resource managers and policy makers to take timely informed decisions.

3. Hilsa Shad

Hilsa Shad *(Tenualosa ilisha)* is a euryhaline anadromous shad that spends most of its lifespan in the open ocean, and migrates to the estuaries along the northeast coast of India for breeding during the southwest monsoon. INCOIS, in collaboration with Jadavpur University, has derived a relationship between Hilsa catch and the lunar phases, and the wind directions. It has been observed that catch-per-unit-effort (CPUE) was substantially high during the waning crescent and waxing gibbous of lunar phase. Furthermore, significant enhancement in CPUE was observed during the southwesterly wind. These observations will be useful for providing short-term stock prediction based on lunar phase and wind direction.

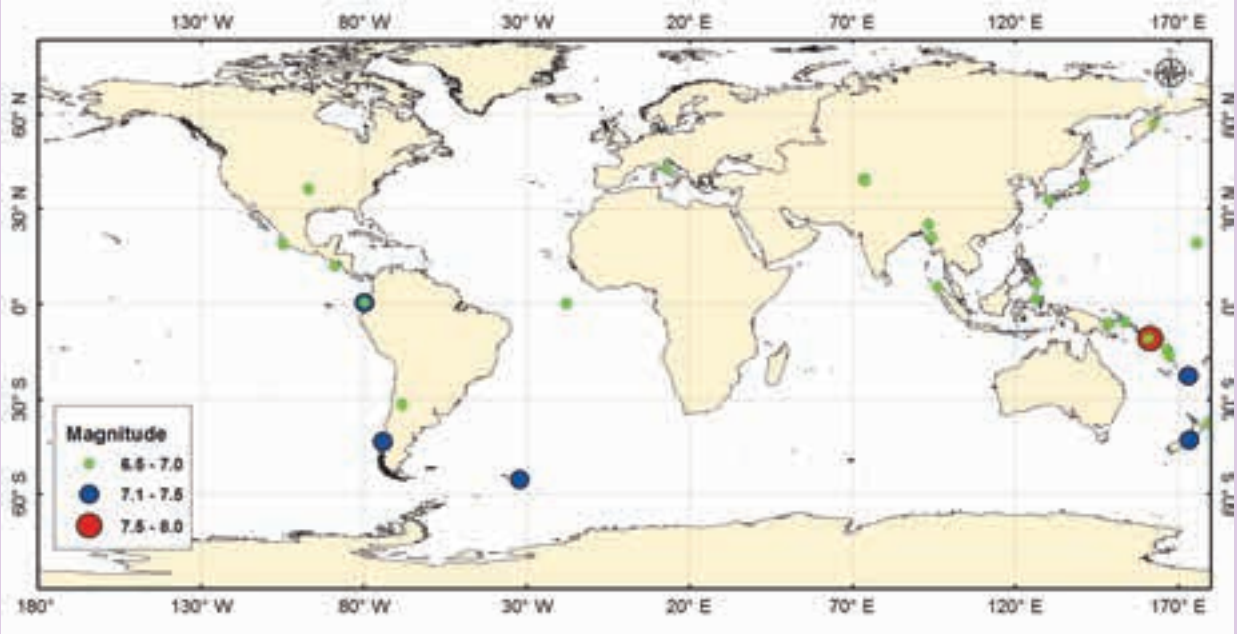


Lunar phases vs. Hilsa catch - Average CPUE of Hilsa is substantially high during waxing gibbous and waning crescent.

4.3 Multi-Hazard Early Warning System (MHEWS)

4.3.1 Tsunami Early Warning

The Indian Tsunami Early Warning Centre (ITEWC) monitored 32 earthquakes of magnitude ≥ 6.5 during the period April 2016 to March 2017. Out of these, only 2 moderate earthquakes



Location map of earthquakes of magnitude ≥ 6.5 monitored at ITEWC during 2016-17

Table : Performance indicators of ITEWC during April 2016 - March 2017

Parameter	Target	Achievement	
		Indian Ocean (9)	Global Ocean (28)
Elapse time from earthquake origin time to initial earthquake information issuance	10/15 min	7.0	9.0
Probability of detection of Indian Ocean earthquakes with Mw ≥ 6.5	100%	100%	100%
Accuracy of hypocenter location (with respect to USGS final estimates)	Within 30 km	18.8	19.13
Accuracy of hypocenter depth (with respect to USGS final estimates)	Within 25 km	25.0	15.9
Accuracy of earthquake Mw magnitude (with respect to USGS final estimates)	0.3	0	0.13

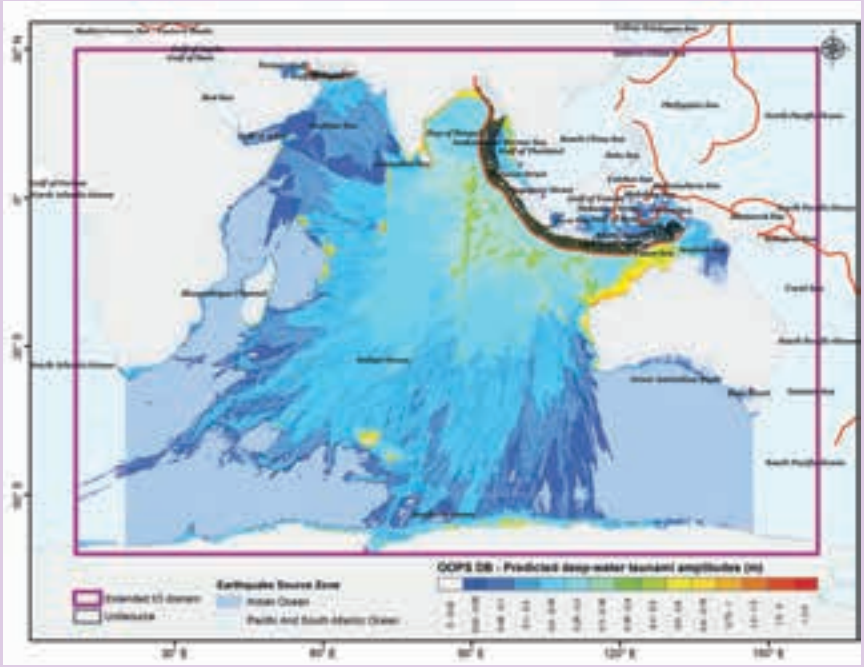
occurred in the Indian Ocean region. For these earthquakes, ITEWC disseminated the bulletins as per standard operating procedure to its regional and national stake holders through Email, FAX, GTS and SMS.

4.3.2 Tsunami Modeling

i. Tsunami scenario database for the Indian Ocean

As per the recommendations of the Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System (ICG/IOTWMS), ITEWC enhanced its Tsunami modeling system and generated an open ocean propagation scenarios database (OOPS DB). Scenarios based on the earthquakes in Makran and Sunda Tsunamigenic Zones were generated with TUNAMI FF - Cuda version in spherical coordinates and optimized for operational quantitative tsunami forecast.

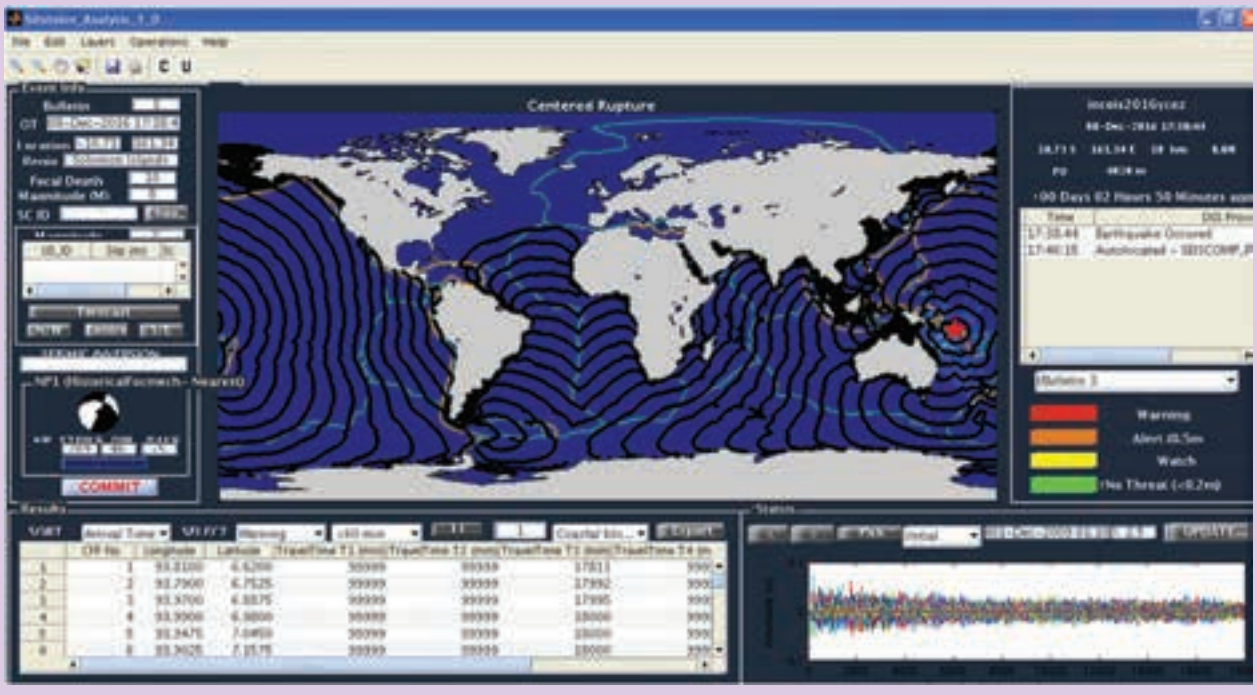
The model outputs consist of expected wave arrival and amplitude forecasts for 4380 Costal Forecast Points (CFPs) in the Indian Ocean. This information is used to create threat profile for Coastal Forecast Zones (CFZs) with detailed tsunami threat potential.



Open Ocean Propagation Scenario Database (Optimized to 5.0 km resolution)

ii. Real -Time Tsunami Modelling:

For assessing the impact of tsunamis originating from global tsunamigenic earthquakes in Pacific Ocean and South Atlantic Ocean, INCOIS has set up a global ocean tsunami modeling system with domain covering from 90° S to 90° N and 180° W to 180° E and having a spatial resolution of 15 km. This global ocean tsunami model is based on TUNAMI Far Field version in spherical coordinates. This setup enables ITEWC to provide quantitative tsunami forecasts within 20 minutes from the detection of global earthquakes having magnitude M >8.0.

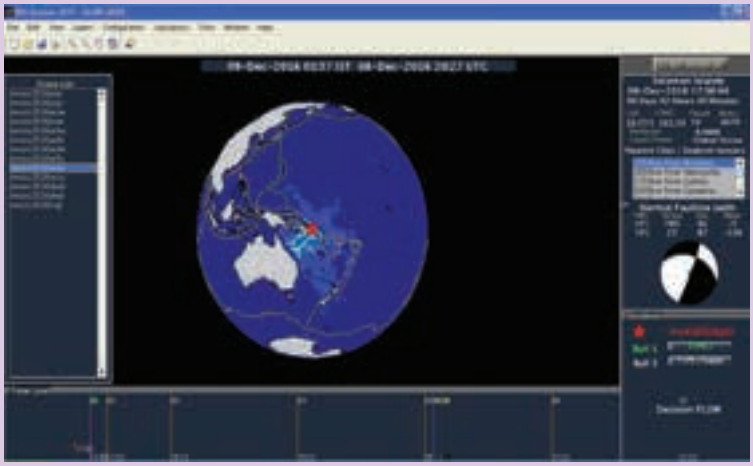


Real time (Operational) model forecasts during major event on 8 December 2016

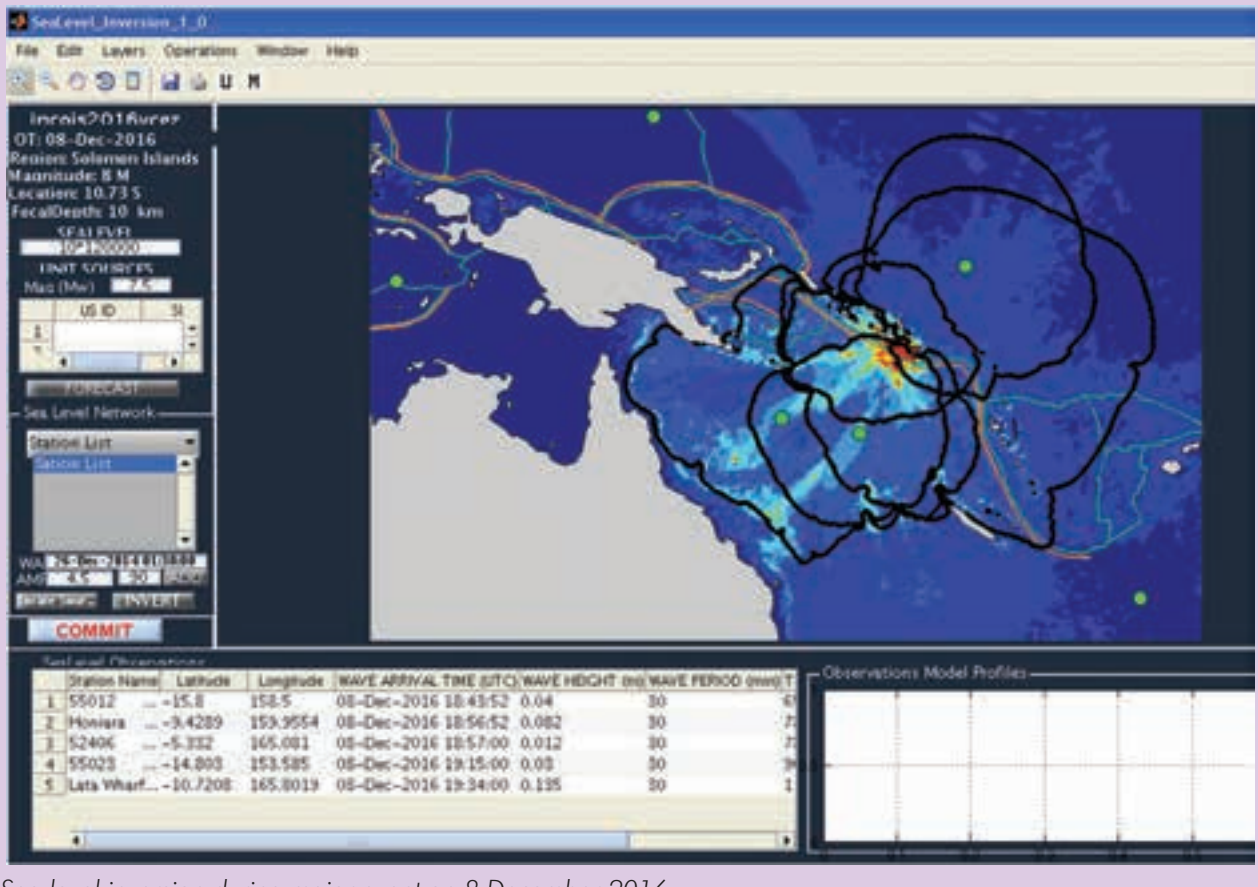
4.3.3 Operationalisation of New Decision Support System (Version 2016)

The new Decision Support System (DSS) version 2016 was tested extensively during IOWave16

tsunami mock exercise and made operational since December 2016. The new DSS was integrated with the necessary metadata layers, latest version of Area of Service (AoS), Earthquake Source Zone (ESZ), CFPs and CFZs. The latest version (20 August 2016) of spatial layers was shared with other two TSPs for their implementation as part of ICG/IOTWMS framework. In the new DSS, the extended modelling domain of the Indian Ocean is incorporated and the simulation time has been increased from 15 hours to 25 hours. Also this new DSS is capable of capturing the real-time earthquake information from multiple sources and display earthquake location with focal mechanism. It also has access to optimized Open Ocean Propagation Scenario Database (OOPS DB) and the data from National and International Sea level stations. The DSS launches the near real time Tsunami model for Open Ocean Propagation for the earthquake in Pacific and South Atlantic Oceans. Real-time sea level inversion module was integrated in DSS 2016 and tested successfully during the 8.0 Magnitude earthquake at Solomon Island on 8 December 2016. This integration includes travel time inversion to constrain tsunamigenic source region and selection of unit sources and backward ray traces to constrain the 'rupture area' based on the sea level station observations in real time.



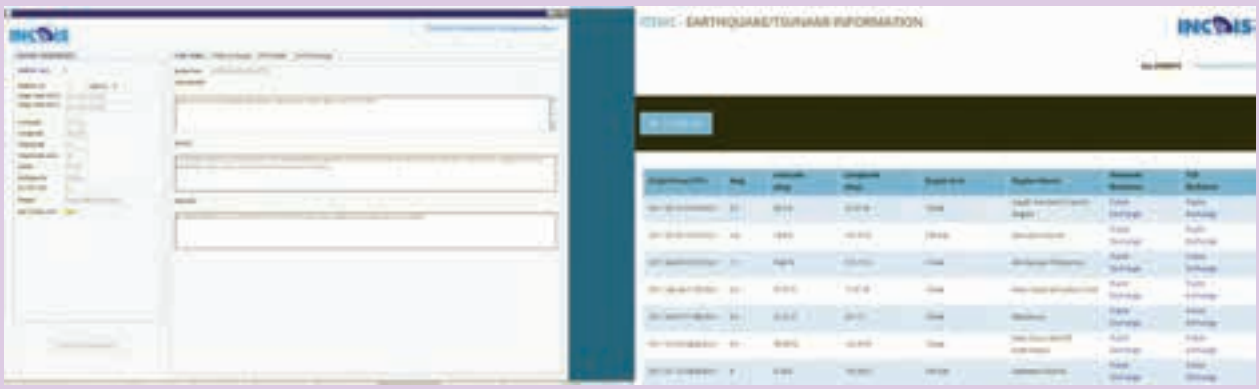
New Decision Support System version 2016



Sea level inversion during major event on 8 December 2016

New Dissemination server

In order to minimize the processing delays, to enhance the computational efficiency and to streamline the dissemination, a separate dissemination server was installed in ITEWC. Whenever new event information becomes available from DSS, based on the rules of SOP, the dissemination server starts processing it automatically in the background. The dissemination server also processes the XML file received from DSS and generates the necessary bulletins and notification messages that includes generation of geo-spatial threat maps, directivity map, tsunami travel time map, bulletin information based on the SOP, to be published on the website and disseminates the bulletins through e-mail, fax, SMS, GTS, CAP, RSS feeds and web.



New Dissemination server for tsunami services

4.3.4 Workshops, Communication Tests and Tsunami Mock drills

a) National Workshop on "Standard Operating Procedure" for Tsunamis

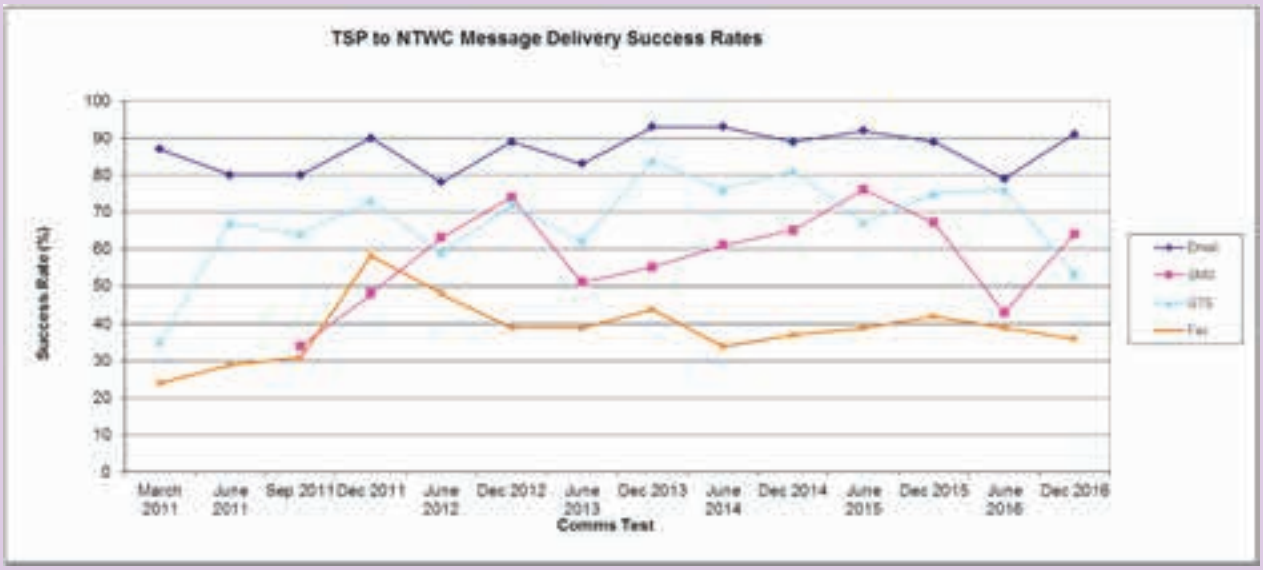
In preparation to IOwave16 tsunami mock drill at the national level, ITEWC conducted a National workshop on Standard Operating Procedure (SOP) and tabletop exercises on 2 August 2016

Participants of Tsunami Standard Operating Workshop on 2 August 2016

at INCOIS to enable the national stakeholders to streamline their SOPs. A manual comprising information on conduct of the tsunami drill, detailed bulletins and feedback form, was circulated to stakeholders. Ninety five officials from state disaster management divisions, NDRF, Navy and Coast Guard participated in the workshop.

b) COMMs Test

Two COMMs tests (on 8 June 2016 & 14 December 2016) were conducted to validate the TSP's dissemination process to NTWCs such as the dissemination processes for tsunami notification messages with national disaster management contacts, reception of the notification messages by NTWCs and the access by NTWCs to TSP password-protected websites. During both the COMMs tests, ITEWS disseminated notification messages to 22 NTWCs and the two TSPs (Australia & Indonesia) in the Indian Ocean and also received notification messages from other TSPs.



Message delivery success rate during COMMs Tests

c) Tsunami mock drills

IOWave16 tsunami mock drill

A tsunami mock drill named IOWave16, was conducted during 7-8 September 2016 by ICG/IOTWMS of IOC/UNESCO. The drill was part of the regular exercise to enhance the awareness and preparedness among all stakeholders that includes vulnerable communities. The major objective of IOWave16 was to test the efficiency of communication links between TSPs, NTWCs, Disaster Management offices and the local communities at risk. The drill was also aimed to evaluate the efficiency of the standard operating procedures (SOPs) of the emergency services. INCOIS participated in this drill on both the days. Fifteen test notification messages were issued by INCOIS to National and Indian Ocean Regional contacts and they were disseminated through email, SMS, fax, web and GTS.

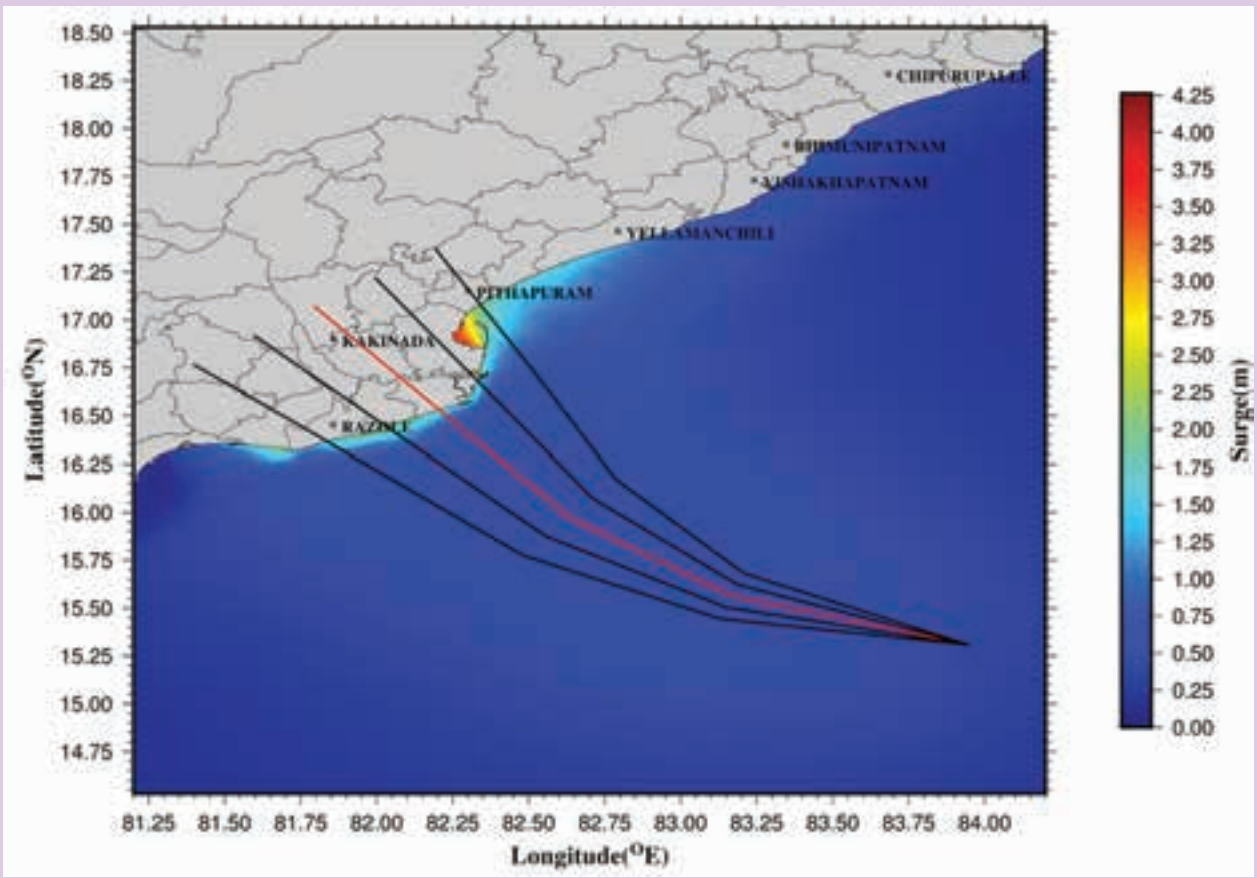
In India, IOWave16 tsunami mock drill was coordinated by INCOIS with the support of National Disaster Management Authority (NDMA), Ministry of Home Affairs (MHA), National Disaster Response Force (NDRF) and the Coastal States/UTs. During the exercise, around 40,000 people from about 350 coastal villages in Odisha, Andaman & Nicobar Islands, Andhra Pradesh, Tamil Nadu, West Bengal, Kerala, Gujarat and Karnataka were evacuated to safe places.

IOWave16 during September 2016

4.3.5 Storm Surges Early Warning

Probabilistic Storm Surge Guidance System

The accuracy of the storm surge levels predicted by numerical models greatly depend on the accuracy of the forecast of track, size, and intensity of the cyclones. As there are difficulties in predicting these parameters accurately, INCOIS has adopted the probabilistic storm surge (P-Surge) prediction, in which the probabilities of different storm surge heights and the region of its occurrences are included. This system is being integrated with the Decision Support System (DSS),



Computed P-surge by considering the landfall error of an ideal cyclone

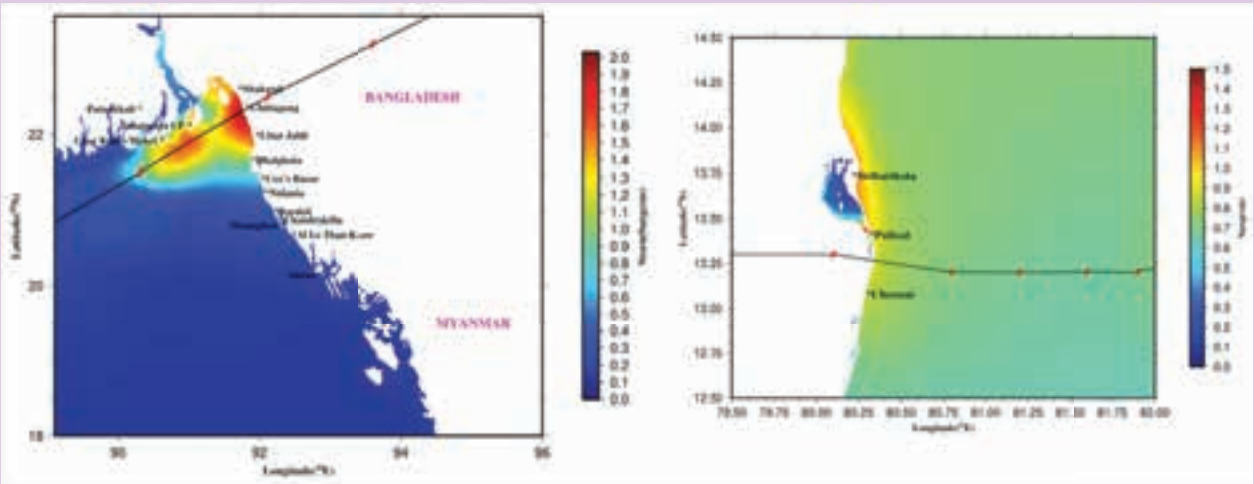
which is enhanced to incorporate the open-source GIS processing engine to analyze the storm surge scenarios.

Storm surge prediction for Bangladesh coast

In order to extend the INCOIS services to WMO-ESCAP countries, a storm surge model was configured for the Bangladesh coast. Based on this setup, INCOIS issued storm surge warnings during cyclone Roanu (17-21 May 2016) for the Bangladesh coast through IMD. As per IMD reports, the storm surge predicted by ESSO-INCOIS for the Bangladesh coast was in agreement with the reported surge.

Real time storm surge forecasting for cyclonic storm Roanu and Vardah

Cyclonic storm Roanu (17-21 May 2016) and Vardah (6-13 December 2016) were continuously monitored in real time and storm surge warnings were issued. The predicted storm surge heights were found to be in agreement with the reported values.



Real time storm surge forecast for cyclonic storm Roanu (left), severe cyclonic storm Vardah (Right).

4.4 INCOIS User interactions and initiatives

i) A special stakeholders meeting focussing on dissemination of MoES services was held on 28 September 2016 and was attended by over 100 officials from various coastal states and from agencies working in meteorological and marine forecasting related fields. Special emphasis was laid on boosting usage of MoES services and extending the current

Director, INCOIS addressing the guests during the Stakeholders meeting on Dissemination Strategy for Marine and Weather Services of MoES

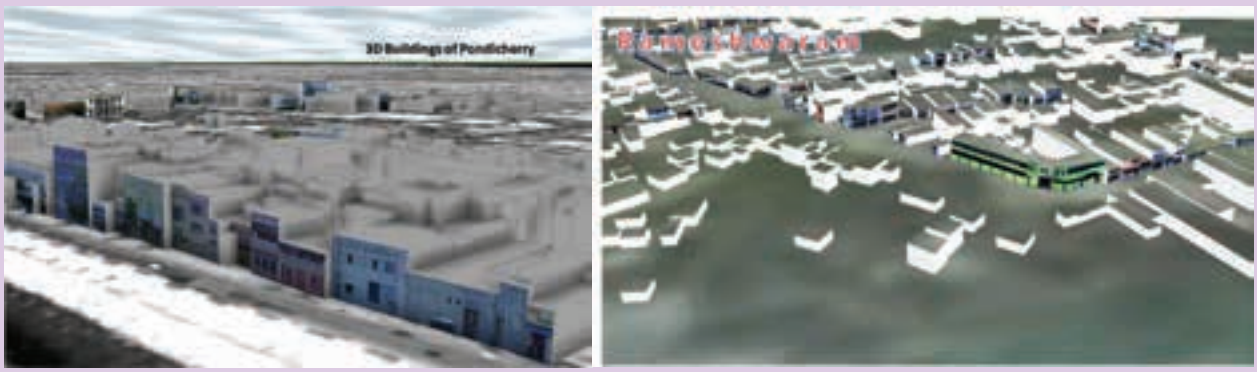
reach of Agro-Met services to up to 94.5 million farmers and that of Marine Information/ Disaster alert services to serve the existing large potential base that includes 9 lakh coastal fishermen. There were also presentations and discussion regarding usage of a planned integrated system of mobile Apps with crowd-sourcing, satellite-enabled communication for enhanced connectivity in the open ocean through affordable dongles etc. Hon'ble Secy., MoES, Dr. Madhavan Nair, Rajeevan, Director General of Meteorology, Dr. K. J. Ramesh and Director, ESSO-INCOIS, Dr. Satheesh Shenoi presided over the meeting.

ii) An awareness program on OSF and PFZ services was conducted at Murud-Janjira (Raigad district), Maharashtra on 27 January 2017. Around 150 fishermen attended the meeting. OSF services - through SMS - was inaugurated during this meeting.

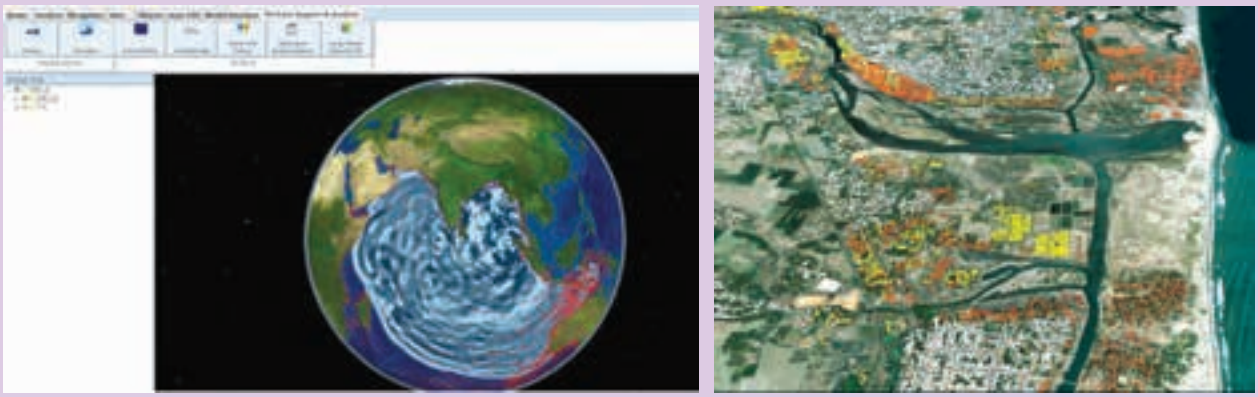
Awareness program on OSF and PFZ services conducted by INCOIS at Murud-Janjira (Raigad district), Maharashtra on 27 January 2017.

4.5 Coastal MVHM (Multi-hazard Vulnerability Mapping)

As part of the Tsunami Warning System, INCOIS has been mapping the coastal regions highly vulnerable to natural disasters such as tsunami and storm surges. As part of this Multi Hazard Vulnerability Mapping (MHVM), 3D GIS mapping of 520 sq km was completed, which covers the coastal areas of Cuddalore, Pondicherry, parts of Machalipatnam and Rameshwaram. The risk to each building from a potential tsunami event was assessed based on the simulation of tsunami run-up height (derived from tsunami inundation model). Socio-economic data pertaining to the mapped buildings were also collected form door-to-door surveys. Both data types were used for further analysis to generate the building-level risk assessment for a tsunami disaster. Development of visualization and analysis system for 2D and 3D geospatial data (3DVAS) was also completed. This application integrates all geospatial data pertaining to coastal zones including the outcomes of the 3D GIS mapping. This application executes the tsunami and storm surge models during an



Sample map of 3D GIS pertaining to Pondicherry (top) and Rameshwaram (bottom) showing the 3D Buildings

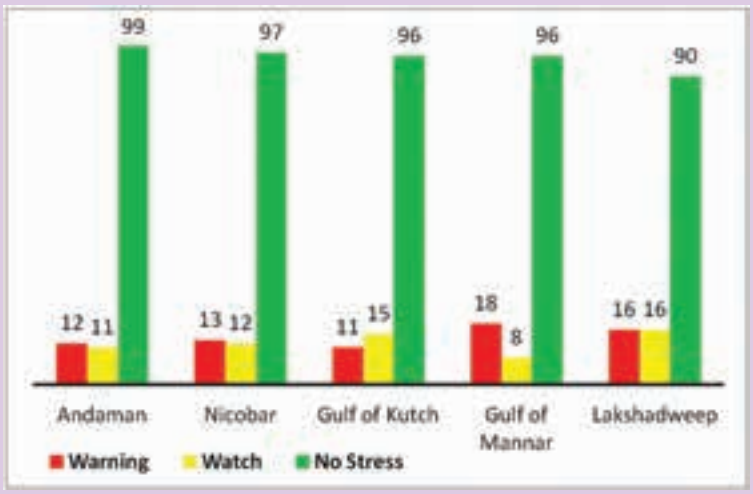


Simulation of 2004 Indian Ocean Tsunami in 3DVAS Application (left). Automatically generated building level tsunami risk map through 3DVAS Application for Cuddalore coast (right).

event and overlays the inundation details to then generate risk maps and scenarios that can be included in the tsunami/storm surge advisories.

4.5.1 Coral Bleaching Alert System

INCOIS provides bi-weekly alerts on coral bleaching based on satellite based imageries. These alerts, which are disseminated through the web, contain information on the hotpots, degree of heating weeks and the variation of SST anomalies. During 2016-17, 18 such warnings were issued to indicate the stress on the corals in the Gulf of Mannar. Coral bleaching was recorded during field investigations in the summer months (April-May) of 2016.



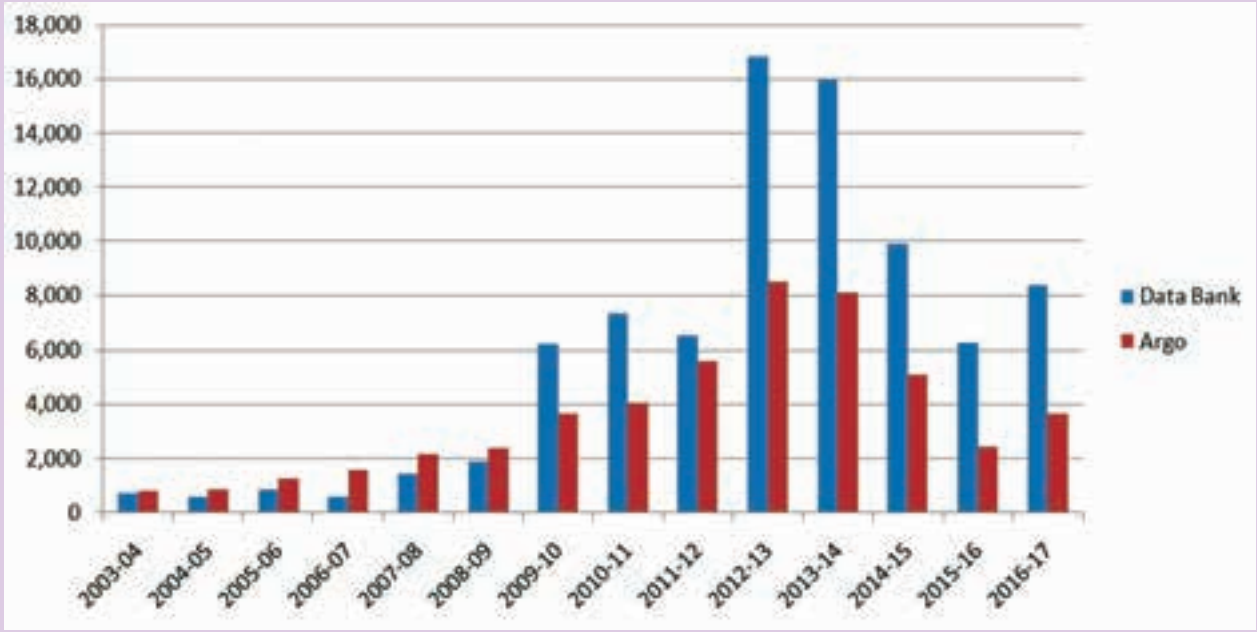
Numbers of Coral bleaching advisories issued during 2016-17

Underwater photographs captured at coral environs of North Bay, Andamans on 26 Apr, 2016 showing signs of coral bleaching. (Photo Courtesy: ESSO-NIOT)

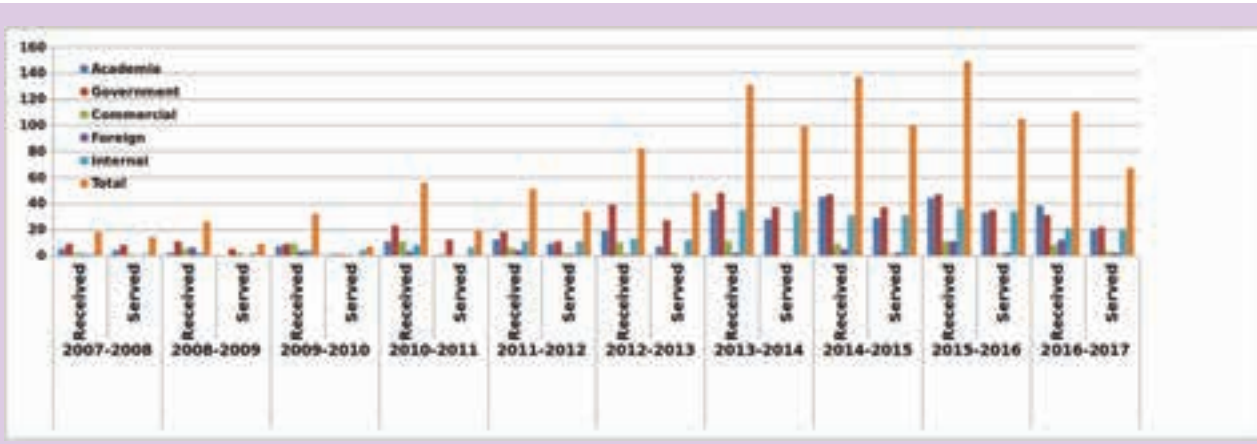
4.6 Data Services

INCOIS' data centre sustained and strengthened real-time data reception, processing and quality control of surface meteorological and oceanographic data from a wide range 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 radars. Data collected by other agencies/

programmes such as NODPAC, SAC, CTCZ, ADCP network, etc. were also processed and archived. The data centre provided surface met-ocean data to various operational agencies in the country through email/web-site/FTP in near-real time. INCOIS also attended to several data requests from academic/research institutions.



Number of online data users for both the Argo and Data Bank over the past few years



Number of customised offline data requests served over the past few years

4.6.1 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 established at INCOIS. These data were processed and made available for in-house operational activities as well as to other operational agencies in the country.

4.6.2 Establishment of new X-band ground station

INCOIS established a new X-Band ground station to acquire direct broadcast data from Suomi-NPP satellite. A remote-sensing data-processing chain was also implemented to process the data

Table: Details of in situ data received during the reporting period

Institute / Programme	Parameters	Period of Observation	No. of Platforms / Stations Reported	Status
NIO (XBT, XCTD, SSS)	XBT Profiles	Apr 2016 - Mar 2017	44 profiles	Added to the database
	XCTD Profiles	Apr 2016 - Mar 2017	55 profiles	
NODPAC (Met Observations along Ship track)	Surface met parameters	Jan 2016 - Jun 2016	02 quarterly data	Archived
NODPAC (Met Observations along Ship track)	Surface met parameters, XBT, CTD	1971 - 2010	-	Archived
NIOT - NDBP (Moored buoys)	Met-ocean parameters	Apr 2016 - Mar 2017	19 buoys	Added to the database
NIO (Drifting buoys)	Met-ocean parameters	Apr 2016 - Mar 2017	27 buoys	Added to the database
NIO (ADCP)	Ocean currents	2011 - 2015	-	Archived
PMEL (RAMA buoys)	Met-ocean parameters	Apr 2016 - Mar 2017	16 buoys	Added to the database
INCOIS (Ship-mounted AWS)	Met parameters	Apr 2016 - Mar 2017	33 stations	Added to the database
INCOIS-NIO-NIOT (Coastal AWS)	Met parameters	Apr 2016 - Mar 2017	13 stations	Added to the database
INCOIS (Wave rider buoys)	Wave parameters	Apr 2016 - Mar 2017	16 stations	Added to the database
NIOT (HF RADAR)	Currents	Apr 2016 - Mar 2017	05 pairs of stations	Updated in the database
Argo CTD (INCOIS)	Temperature and Salinity	Apr 2016 - Mar 2017	35079 profiles	Added to the database
ICMAM (COMAPS)	Bio-Geo-Chem-Phy parameters	2011 - 2015	12 stations	Added to the database
CTCZ	IMD's ARG data	Jun - Sep 2013	Archived	
NCAOR - GSI (Bathymetry Data)	Bathymetric data	Archived		
NIOT - VMC (T/S profiles)	CTD data	Archived		
GEOTRACES	Trace Elements	Archived		
SIBER	CTD data	Archived		

Table: Details of remote sensing data holdings

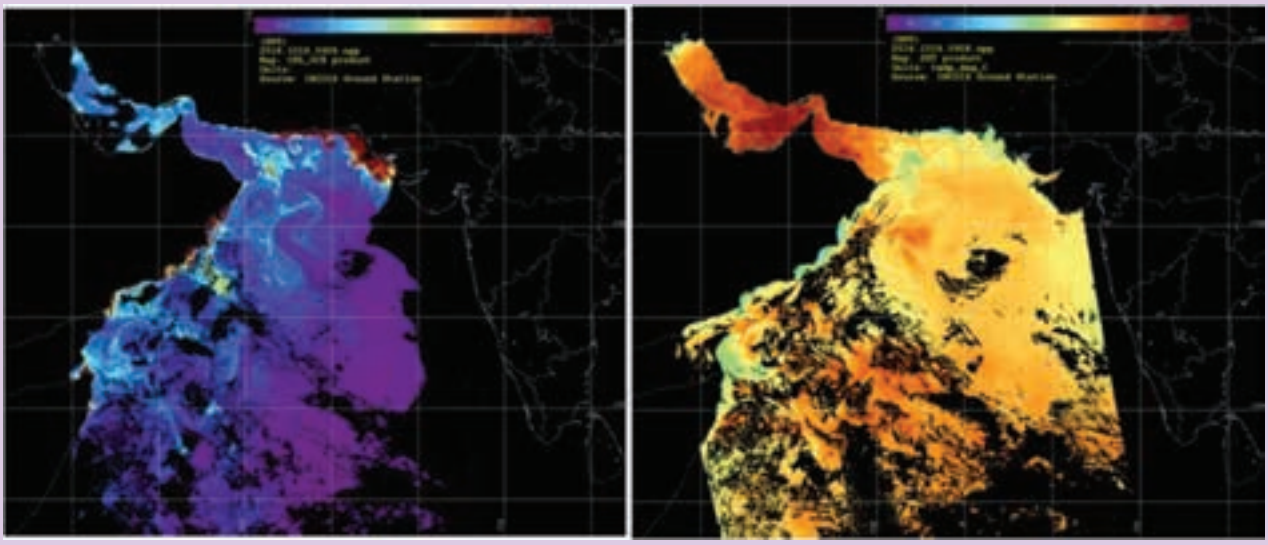
Sl. No	Sensor/Satellite	Data products	Period of availability
1	OCM-2/Oceansat-2	• Radiance bands	
		• Chlorophyll-a	
		• Kd 490	
		• TSM	
		• AOD	Feb 2011 to till Date
2	AVHRR, ATOVS /(Metop-1, 2 & NOAA-18, 19)	• Radiance bands	
		• Brightness temp's	
		• Cloud top temp's	
		• SST	
		• FOG	
		• NDVI	
		• Temp, humidity profiles	Aug 2005 to till date (with few data gaps)
3	VIIRS (Suomi-NPP)	• Ocean Color (chl_a, chl_ocx, Kd_490, par, pic, poc)	
		• SST (Split Window, Triple Window)	May 2016 to till date
		• Other (Fire Points, FOG, NDVI, Cloud products etc..)	
4	MODIS/TERRA & AQUA	Ocean, Land & Atmospheric products	Near real time, till date

obtained from the VIIRS (Visible Infrared Imaging Radiometer Suite), CrIS (Cross-track Infrared Sounder) and ATMS (Advanced Technology Microwave Sounder) sensors on board the Suomi-NPP satellite.

New X-band ground station for acquisition of Suomi-NPP data

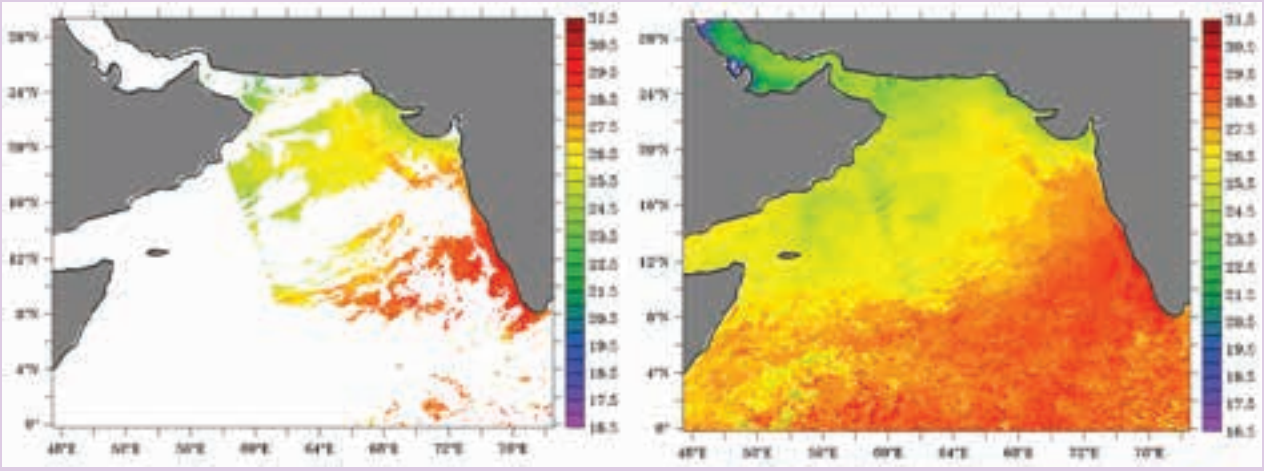
4.6.3 Gap filling algorithm for remote sensing and spatial datasets

Gaps in the satellite data due to persistent cloud cover affects the usability of the data, particularly for the applications such as PFZ identification. A gap-filling algorithm based on the Data Interpolation Empirical Orthogonal Functions (DINEOF) tool has been developed to reconstruct the missing data from satellite images (or any spatial data) in an efficient manner. The DINEOF is an EOF-based technique developed to reconstruct missing data in geophysical datasets. It exploits the spatio-temporal coherency of the data to infer a value at the missing location. The DINEOF method is based on the fact that an



Chlorophyll-a (left panel; mg/m^3) and SST (right panel, °C) image obtained from Suomi-NPP for 18 October 2016.

EOF analysis aims to extract a small number of significant modes, present in the physical system, from a large data set. These reduced variables should represent a large fraction of the original variability of the data set. The combination of the dominant EOF modes and their amplitudes can therefore help recover missing data values. This technique is capable of filling data even when there are 90% gaps in the data by the use of satellite pass data corresponding to certain number of days (15 days here in our case).



Effectiveness of the algorithm applied to SST (°C) data obtained from the NOAA-18 satellite. Left panel shows original unfilled sample image and right panel shows filled data.

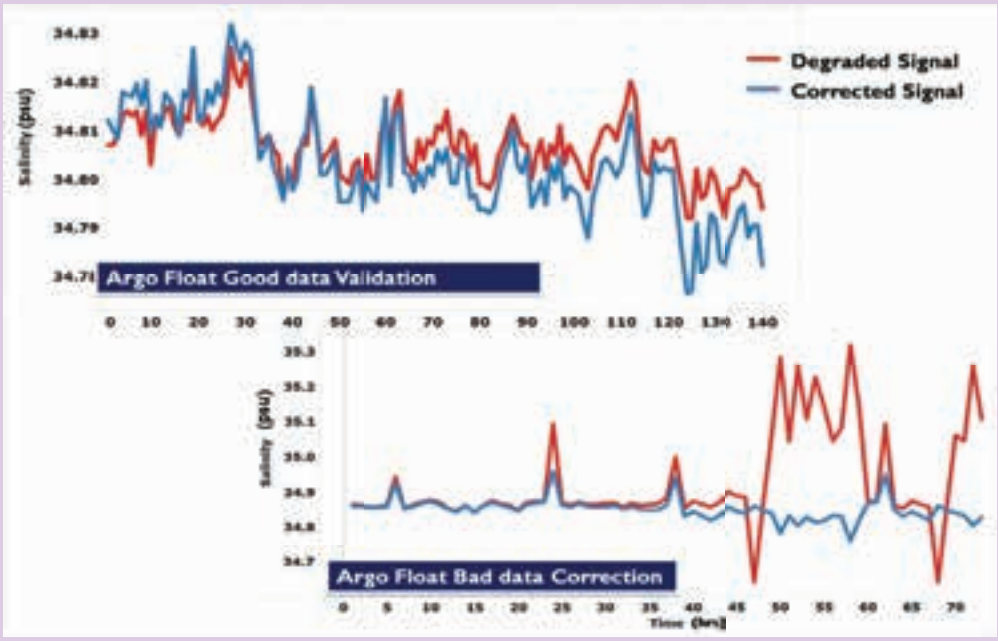
4.6.4 Detection and correction of sensor degradations of Argo floats

The salinity sensors in the Argo floats are sensitive to bio-fouling and can cause the degradation of data. As these floats cannot be retrieved for periodic calibrations, it is important to detect and correct the errors in the observations due to bio-fouling. An Artificial Neural Network based method has been developed to detect the degradation of the sensors and to apply necessary corrections in the data.

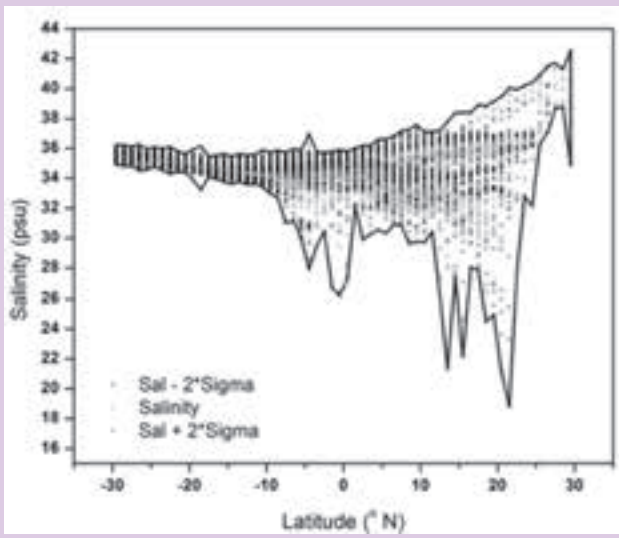
4.6.5 Polygon based method for the quality control of marine met data sets

INCOIS carries out thorough quality check of all data archived in the repository. In order to

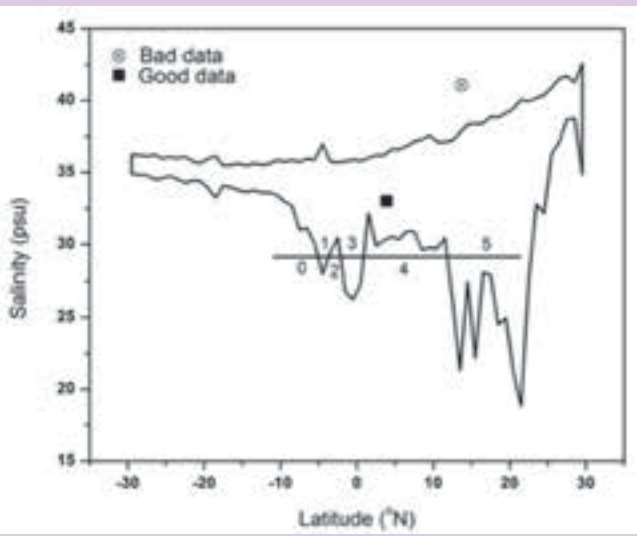
identify the erroneous surface meteorology data obtained from ICOADS, a new method based on polygon using the Jarvis-March algorithm has been developed. It was found that all the possible outliers in the data can be identified using this method.



Correction of degraded salinity (psu) values using Neural Networks



*Generation of n-sided polygon (convex hull) based on the mean and standard deviation of gridded fields of salinity from World Ocean Atlas 2013. Open Circle, crossed triangles and crossed circles represent the mean, (mean - 2*SD), (mean + 2*SD) respectively*

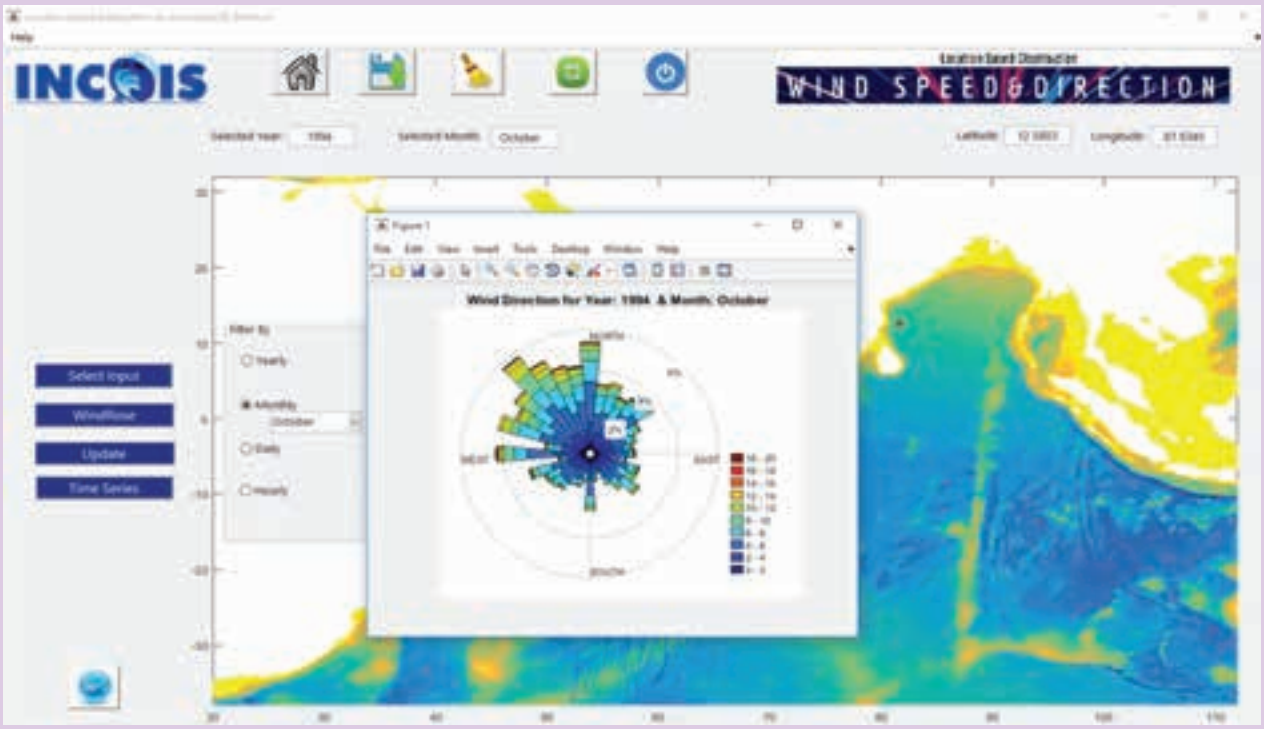


Identification of good (filled square) and bad (crossed circle) data based on polygon method

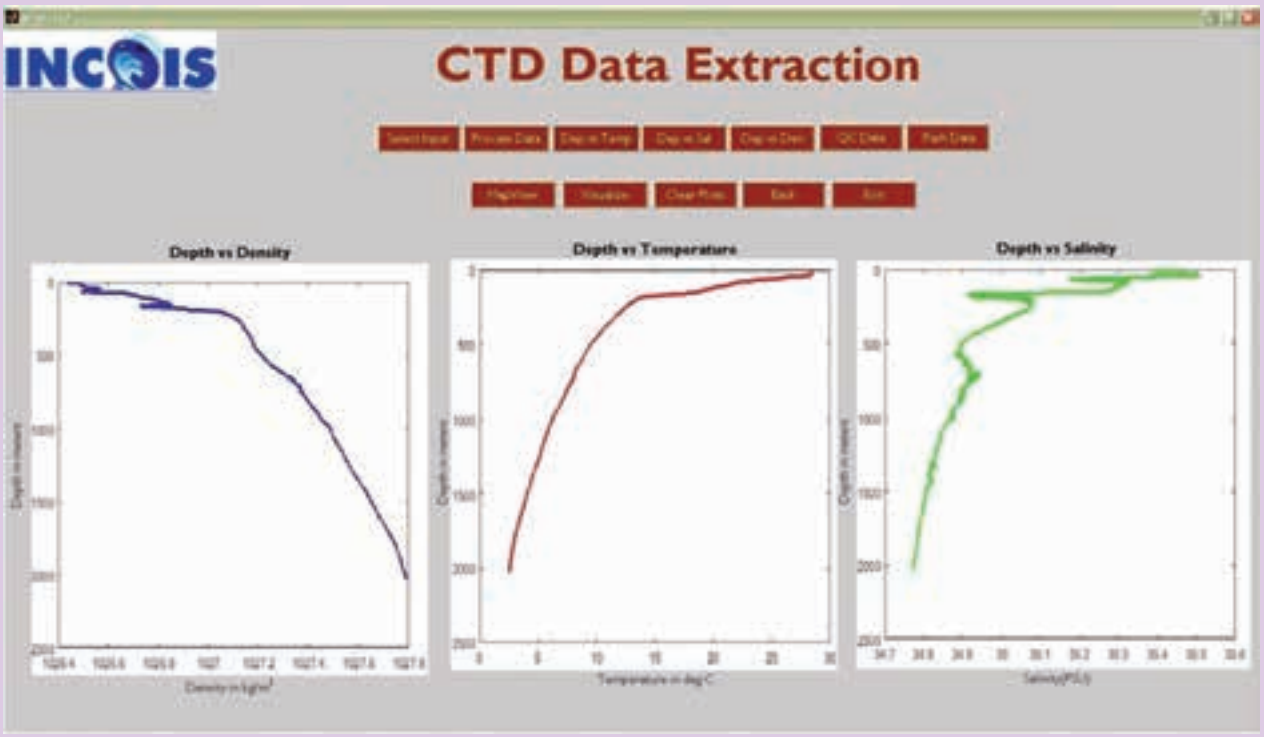
4.6.6 Tools for analysis and visualization of Met-Ocean data

1. INCOIS developed a Matlab based Graphical User Interface (mWiSDi) for the visualization of met-ocean data obtained from ICOADS, IMD and NODPAC. The primary functionality of mWiSDi is to display climatological data at each grid point or along the track location on-board naval ships. The tool has both along-track and gridded wind data visualization and analysis support.

2. INCOIS developed a Matlab based GUI to process, analyze, quality control and visualize historical CTD and XBT data. This interactive tool facilitates the data discovery and



Snapshot of the mWiSDi tool



Matlab based GUI for CTD and XBT data extraction

provide on-the-fly preliminary analysis and visualization of data. With the help of this tool, XBT meta-data were extracted and archived from the log sheets.

3. INCOIS developed, a Windows based standalone NetCDF toolbox to handle large netCDF datasets. This toolbox is useful for the visualization and analysis of large oceanographic data sets in netCDF format quickly.

4.6.7 ESSO and IIOE-2 metadata portals

The MoES metadata portal

A metadata portal for the ease of search and discovery of various geo-spatial datasets collected and maintained under the various MoES programmes was developed by INCOIS. The ESSO Meta data portal includes a metadata editor based on ISO-19115 standards relevant to the basic geographic information and extensions for imagery and gridded data. A search interface, based on the standard GCMD Science keywords directory, was also developed to search relevant datasets using simple keywords. Meta-data of the data collected through moored buoys, wave rider buoys, HF radars, tide gauges etc are made available through this portal.

The IIOE-2 metadata portal

A metadata portal was also developed for the ease of search and discovery of data collected under the IIOE-2 programme. This metadata portal will serve both completed and future data collection expeditions. Metadata of past IIOE-2 cruises (cruise nos. 1,2 and 3) are uploaded in this portal.

4.6.8 Data archaeology

INCOIS' data centre has made significant progress in rescuing historical Met-Ocean data sets. In this project, several valuable historical datasets available in the physical form such as cruise reports or handwritten notes are being digitized and archived. Digitization of 100 physical records of earlier cruises from FORV Sagar Sampada is in progress. Legacy XBT and met-ocean data for the period starting from 1971 till present were obtained from the NODPAC. This data are being processed for improving the Marine Meteorological Atlas.

4.6.9 Tropflux data

Tropflux data provides accurate, objectively analyzed fluxes of heat and momentum fluxes. Radiation and turbulent flux, wind stress and other basic parameters for air-sea flux estimation are updated up to December 2016 on 1°x1° grids in daily and monthly timescales.

4.6.10 Bio-Argo floats data

INCOIS data centre archived 10022 bio profiles from Laboratoire d'Océanographie de Villefranche-sur-Mer (LOV), France for validation of the profiles from bio-Argo floats. A dedicated working-group formulated protocols and standard operating procedures for quality control of the data obtained from the Bio-Argo floats.

4.6.11 Service to Indian Navy

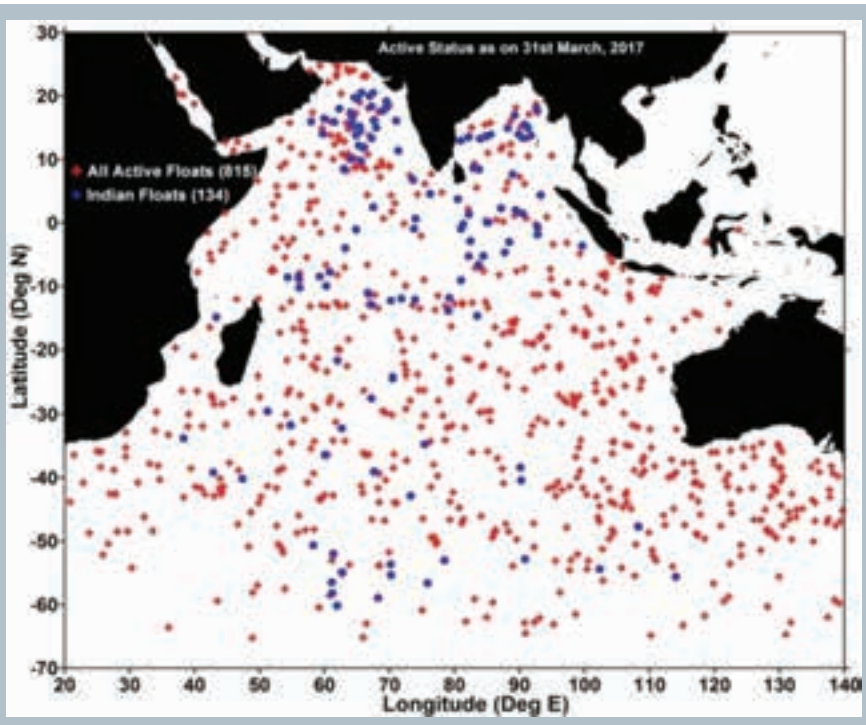
INCOIS data centre continued to support Indian Navy by providing oceanographic data. Data centre also developed a software for visual quality control of XBT profiles for Naval Operations Data Processing and Analysis Centre (NODPAC).

5. Ocean Observations

ESSO-INCOIS leads the national ocean observation programmes and partners with various international agencies in the establishment of ocean observation systems in the Indian Ocean. In 2016-2017, ESSO-INCOIS continued to collect data on several critical marine parameters by deploying and maintaining several observation platforms in the Indian Ocean.

5.1 The Argo programme

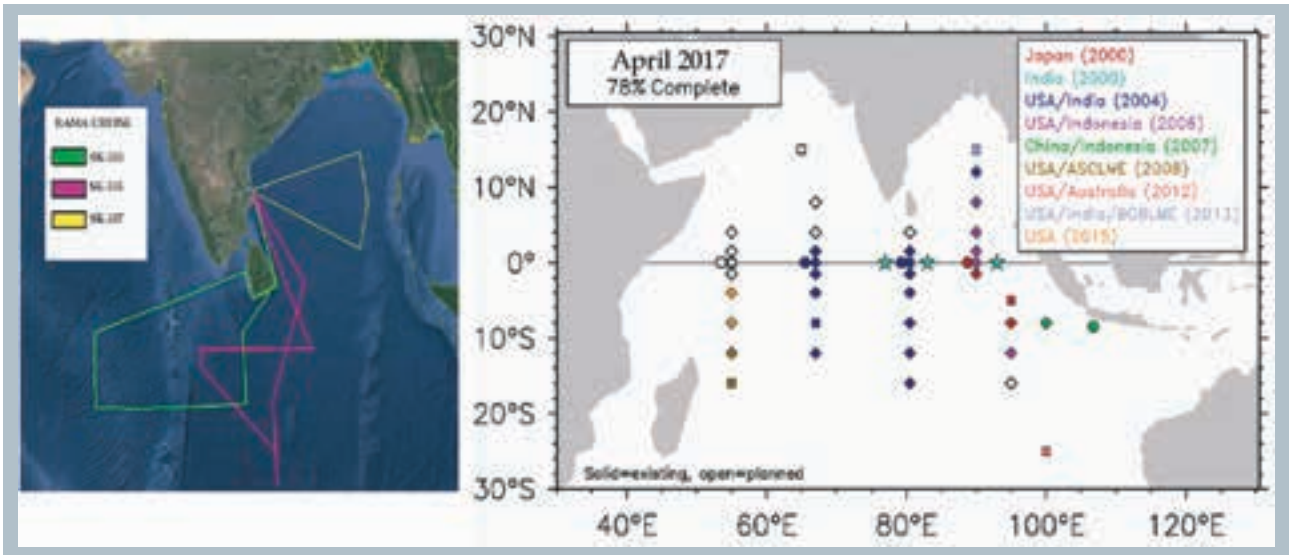
The Argo programme, a component of the Global Ocean Observing System (GOOS), is a collaborative initiative of more than 30 nations to monitor the thermohaline structure of the upper ocean. INCOIS deployed 22 Argo floats in the Indian Ocean during 2016-17, which include 13 standard floats (temperature and salinity sensors only), 7 bio-Argo floats (temperature, salinity, chlorophyll, backscattering and dissolved oxygen sensors) and 2 EM-APEX floats (temperature, salinity and currents). With this, the Indian contribution to this international project increased to 418 floats, of which 134 are active and transmitting data in real time. Along with the 172 Argo floats deployed in the Indian Ocean by other countries (US, France, Japan, China, UK, Australia) in 2016-17, 815 floats are active in the Indian Ocean (as on 31 March 2017). Thirty-five thousand and seventy-nine temperature and salinity profiles from the Indian Ocean were collected by these Argo floats in the past one year.



Distribution of active Argo floats in the Indian Ocean. Floats deployed by India are shown in blue color while that from other countries are shown in red color.

5.2 The RAMA mooring programme

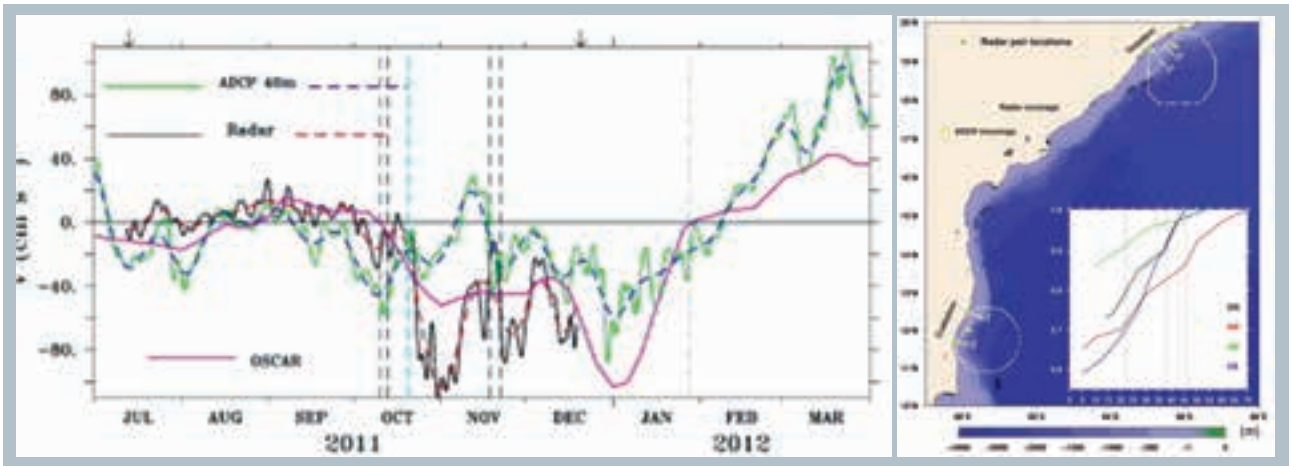
The RAMA moored buoys array was designed and implemented to study the African-Asian-Australian monsoon system. In the past one year, INCOIS in collaboration with NOAA-PMEL, USA, has carried out 32 operations at 15 mooring locations to retrieve, repair and deployment of RAMA ATLAS, T-FLEX surface moorings and ADCP sub surface moorings. This was accomplished in 3 cruises in the Indian Ocean onboard ORV Sagar Kanya, totaling 89 cruise days. Seventy eight percent of the planned moorings in the RAMA array have been deployed in the Indian Ocean.



Tracks of three cruises conducted by INCOIS during the last year for RAMA operations (left panel). Present status of RAMA buoy network (right panel). 36 out of 46 locations are occupied as of April 2017.

5.3 Coastal ADCP network

With funding from ESSO-INCOIS, CSIR-NIO maintained 18 ADCP moorings during 2016-17 period, which record the vertical profiles of currents in the Indian coastal waters. Out of the 18 moorings, 5 (4) moorings were deployed on the shelf while 4 (5) were deployed in the slope regions in the Arabian Sea (Bay of Bengal). The data from these coastal ADCPs were not only used for the validation of the coastal forecast systems, but also used to ascertain the optimal configuration of the circulation models. For example, a study using numerical circulation model shows that higher spatial resolution is required to simulate the observed variability of the East India Coastal Current (EICC) than that required for the simulation of currents in the equatorial Indian

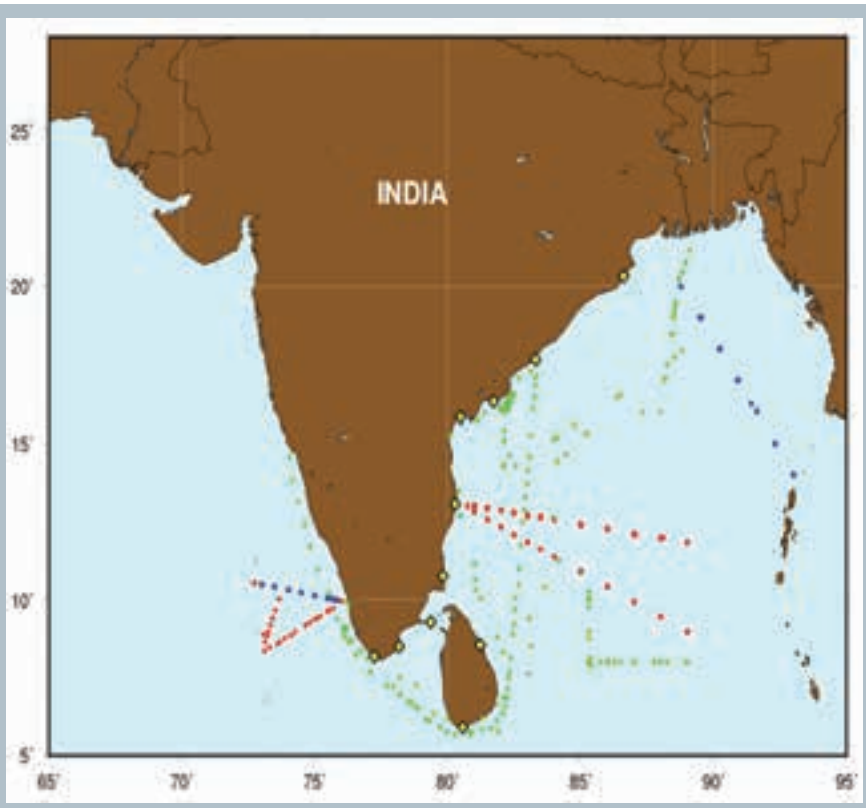


Location of the ADCP moorings (yellow circles) and HF radars (green circles) near Gopalpur and Cuddalore (Right). The white dotted line marks the range over which radar data is available. GS and GN (CS and CN) represent sections off Gopalpur (Cuddalore) used for plotting the correlation between the alongshore current measured at the outermost (offshore) location and the other locations. The correlation, shown in the inset, decreases inshore, but is still ~ 0.6-0.85 at the location nearest the coast, showing the strong connection between the EICC, which is a large-scale boundary current forced by basin-scale winds, and the nearshore current. The vertical dashed lines mark the shelf break (200 m). HF radar, ADCP (40 m), and OSCAR alongshore currents (cm. s-1) from the continental slope off Cuddalore (Left). The solid curves represent the sub-inertial current and the dashed curves the 17-day low-pass filtered current. The sign convention is that the poleward current (upwelling favourable) is positive. The vertical dashed lines mark the period of equatorward flow. Note the shear between the equatorward surface current measured by the HF radars and the 40 m current measured by the ADCP: the ADCP current even reverses (poleward) during November.

Ocean (EIO). The simulations showed that while the forcing by local winds (off the east coast of India) and Ekman pumping in the Bay of Bengal dominated the variability at annual period all along the coast and at intraseasonal periods in the south, forcing from the Equatorial Indian Ocean dominated at the intra-annual period (100-250 days) and at intraseasonal periods in the northern Bay of Bengal. The strong stratification in the upper layers of the Bay of Bengal plays an important role in determining the magnitude of the surface current.

5.4 XBT programme

This is the longest ongoing observational programme executed at CSIR-NIO, Goa with the financial support from ESSO-INCOIS. The main objective of this program is to collect high quality temperature / salinity profiles along selected shipping lanes in the seas around India using ships of opportunity to understand and document the variability of thermohaline fields on different time scales. During 2016-17, 140 vertical temperature profiles (XBTs), 133 vertical temperature / salinity (XCTDs) profiles were obtained. As part of this programme, more than 1000 water samples were also collected to determine the sea surface salinity.



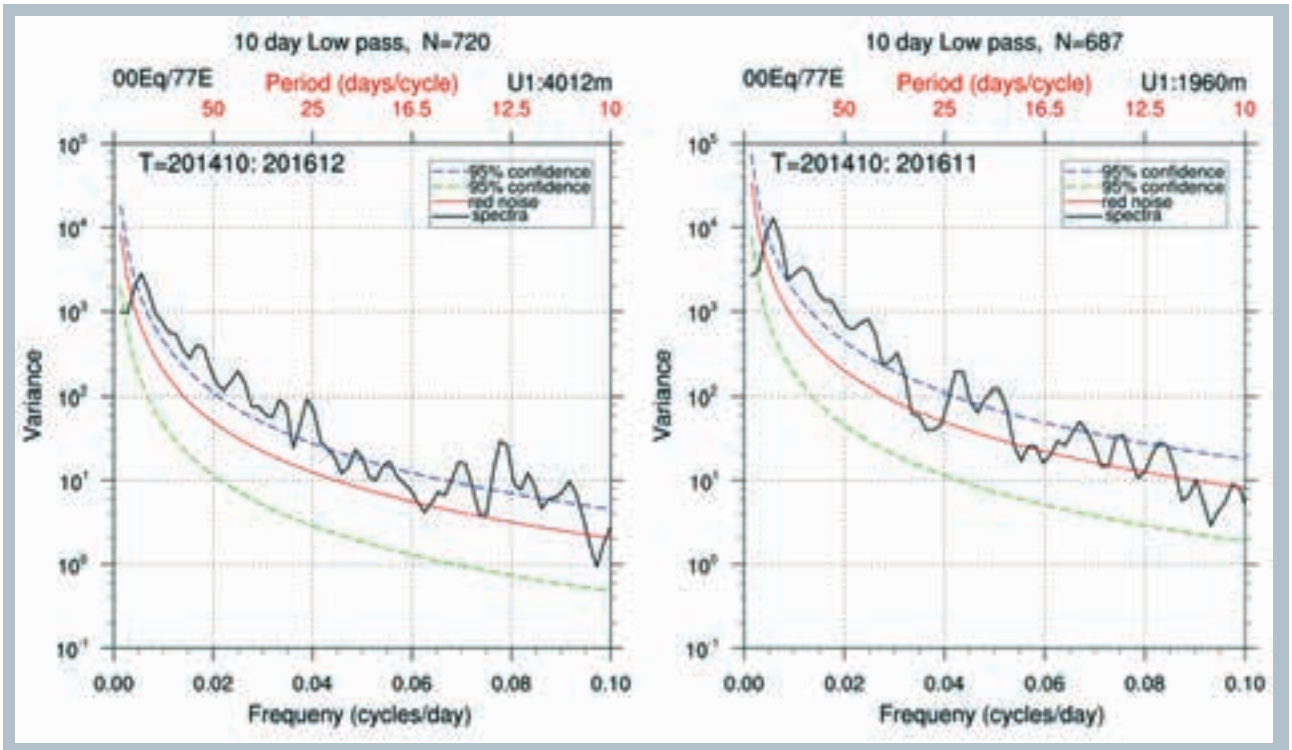
XBT (blue), XCTD (green) and Sea Surface Salinity (red) data coverage in the seas around India during April 2016-May 2017. Yellow diamonds indicates the Coastal salinity collection stations.

5.5 Equatorial current meter moorings

With funding from ESSO-INCOIS, CSIR-NIO continued to maintain the equatorial current meter array during 2016-17. Three moorings were recovered from 1°N, 77°E, Eq., 77°E and 1°S, 77°E during this period. Two more active moorings could not be serviced due to inclement weather and rough seas. Presently there are only two active deep-sea moorings at 1°N, 83°E; Eq., 83°E in the Equatorial Indian Ocean deployed under the project.

The spectral analyses of the zonal current data from these networks suggest the dominance of intraseasonal variability in the zonal currents at deeper depths (>2000 m), much like the dominant

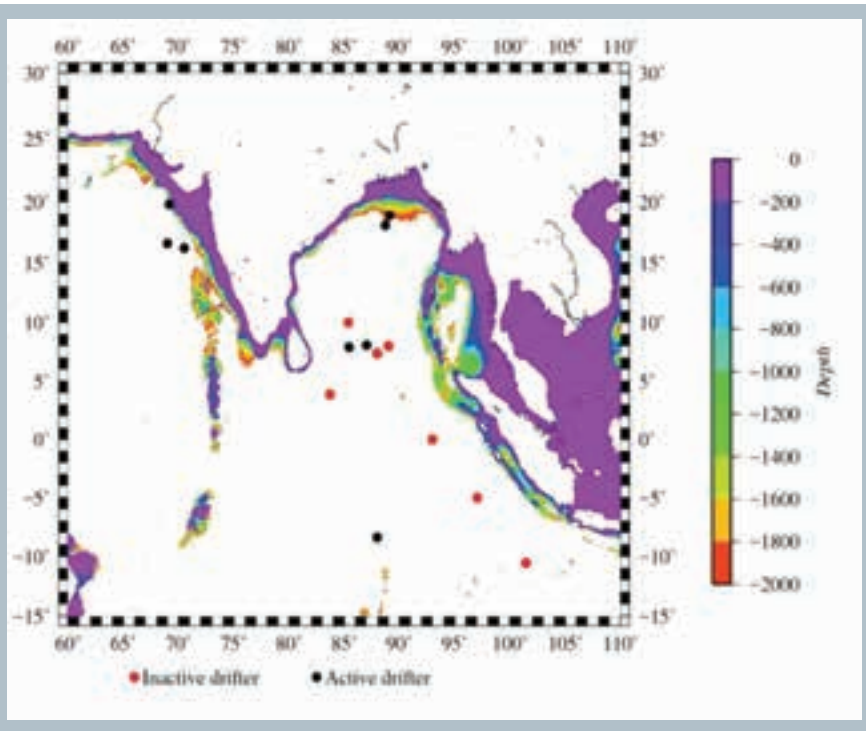
intraseasonal current variability in the surface layers. The dominant periods in the zonal currents constitute biweekly (10-20 days), Madden-Julian Oscillations (40-60 days) and semi-annual (180 days) periods are shown in figure.



Variance spectra of zonal currents (cm.s^{-1}) at deeper depths 1960 m (left) and 4000 m (right) at Eq., 77E based on the data from October 2014-December 2016.

5.6 The Drifter programme

CSIR-NIO with financial support from ESSO-INCOIS maintains the drifter buoy network in the Indian Ocean to collect surface meteorological and oceanographic data using the satellite tracked drifting buoys. During 2016-17, 17 drifters were deployed in the Indian Ocean.



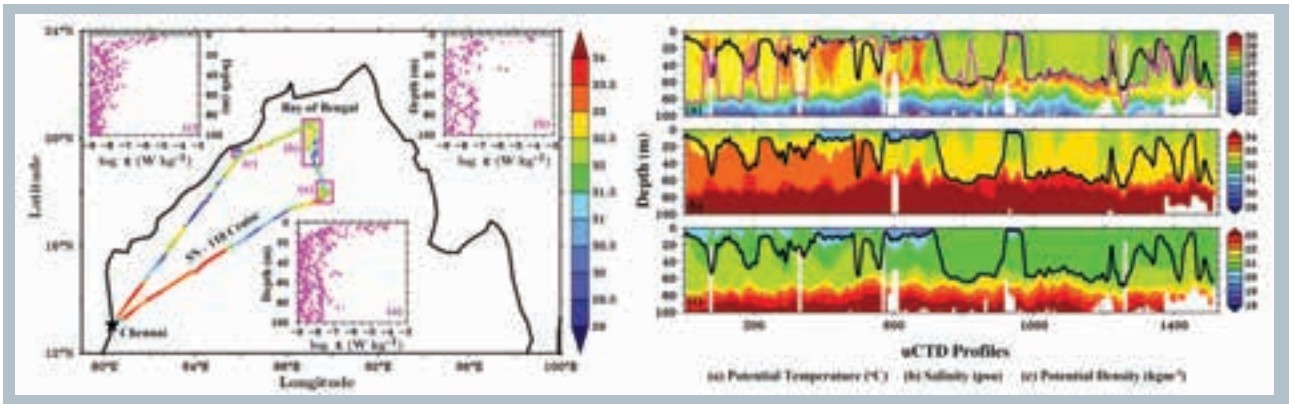
Circles show the locations at which the drifting buoys were deployed during 2016-17. Red circles indicates, the drifters which are not active in April 2017. Black circles show the drifters that are active.

5.7 Ship-based Observations

INCOIS conducted one research cruise under its Ocean Observation Program in the Bay of

Bengal during 18 December 2016 to 3 January 2017 onboard ORV Sagar Nidhi. The primary objective of the cruise was to understand the upper ocean hydrographic structure and stability characteristics in the northern Bay during the winter season. Many sophisticated instruments like underway CTD, ASIMET meteorological sensors, vertical microstructure profilers, acoustic doppler current meters, radiometers etc. were operated during this cruise to collect high quality data on upper ocean and near surface atmosphere.

The turbulent kinetic energy (TKE) dissipation rate (ε) estimated at three different locations in the northern Bay shows turbulence intensity of higher magnitude 10^{-3}-10^{-5} W kg^{-1} in the upper 10 m of water column and it never penetrate to deeper depths. From 10 m to 20 m depth TKE dissipation rate decreases rapidly to 10^{-6}-10^{-8} W kg^{-1}. Below 20 m depth mixing intensity is relatively weaker and is almost constant (10^{-9} W kg^{-1}). However, observations from west coast of the Bay show that the TKE dissipation rate becomes weak at 10 m onwards. The presence of strong upper ocean stratification due to presence of low saline water in the near-surface layer might be the plausible explanation of weak dissipation rates at deeper depths.



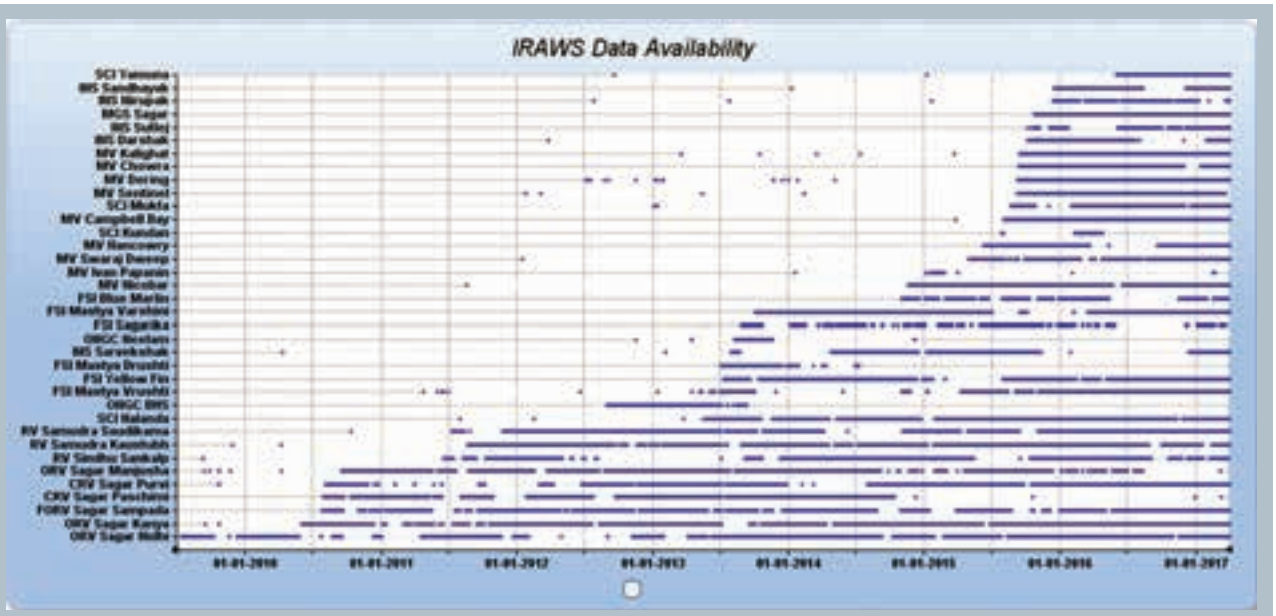
(a) Sea Surface Salinity from Thermosalinograph along the SN-110 Cruise track and vertical profiles of the turbulent kinetic energy dissipation rate (ε; W Kg^{-1}) estimated from VMP-250 at three different locations in the northern Bay of Bengal (b) Potential temperature, salinity and potential density during the cruise.

5.8 Automatic Weather Stations (AWS):

As part of the 12th five year plan INCOIS procured 25 Automatic Weather Stations (AWS) for shipboard installations. Installations of all the 25 AWSs were completed by April 2016. With this, total number of ship-mount AWS installed by ESSO-INCOIS till date is 35 and 32 of them are operational. The systems were installed on board vessels owned by SCI, NHO, GSI, FSI and MoES. In the FY 2016-17, INCOIS carried out 75 preventive maintenances, 31 breakdown maintenances and 10 calibrations of AWSs to ensure continuous availability of data from these systems.

5.9 Wave Rider Buoy Network

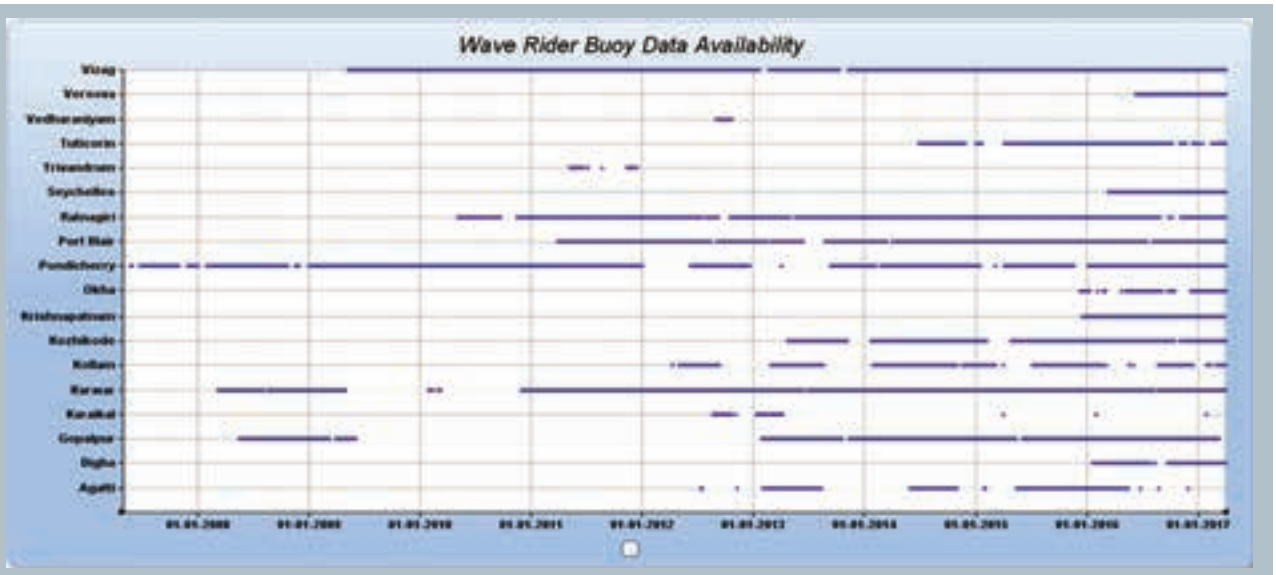
ESSO-INCOIS maintains a network of wave rider buoys for monitoring the state of the ocean as well as the online/offline validations of the ocean state forecasts. Regular calibration of the systems in recommended intervals were done to maintain the quality data from these buoys.



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

With the deployment of a wave rider buoy off Versova, Mumbai, on 9 June 2016, the number of wave rider buoys in the network has now increased to 15. The INSAT communication for these buoys developed and integrated by ESSO-INCOIS has helped in successfully retrieving 9 buoys drifted away from the locations of their initial deployment (Gopalpur, Port Blair, Digha, Karwar, Okha, Kollam, Kozhikode, Versova and Tuticorin). These buoys were later redeployed at respective locations.

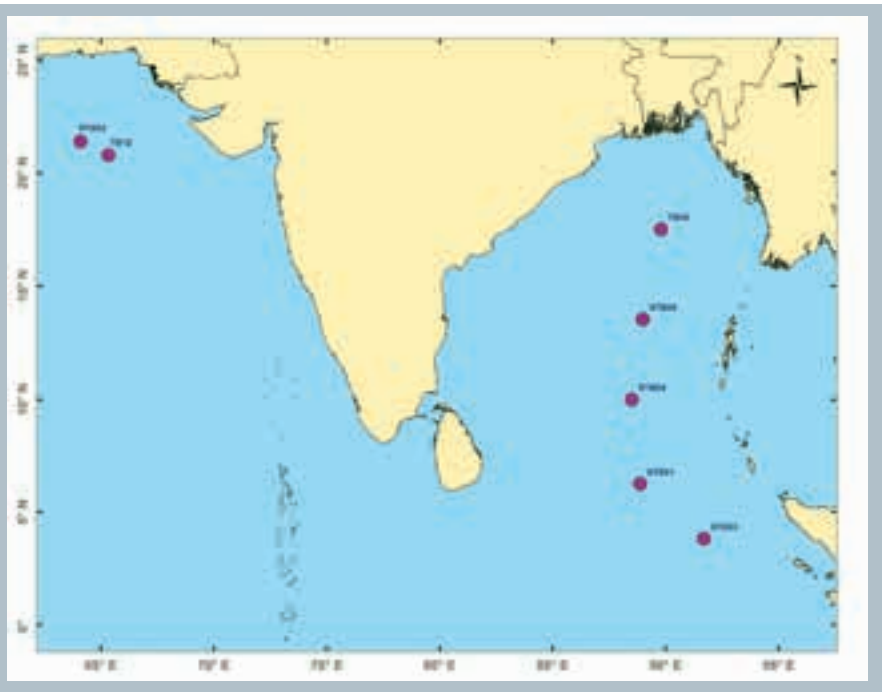
Wave rider buoy network maintained by ESSO-INCOIS



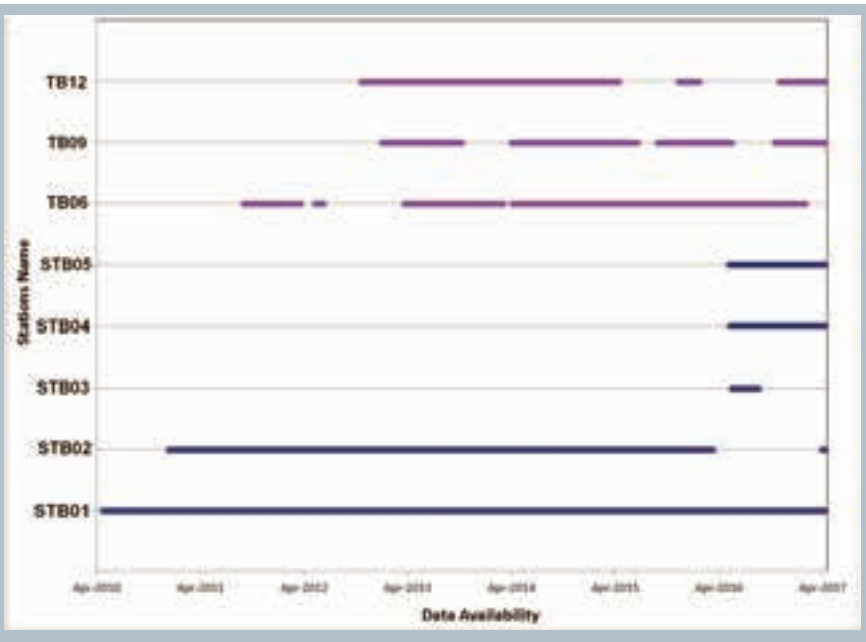
Data availability chart from the Wave Rider Buoy network

5.10 Tsunami Buoys:

ESSO-INCOIS continued to maintain a network of 7 tsunami buoys deployed close to the tsunamigenic source regions in the Bay of Bengal and Arabian Sea in collaboration with National Institute of Ocean Technology (NIOT, Chennai) and through a contract with Science Applications International Corp. (SAIC, USA). These high-precision buoys are capable of detecting minor water level changes of even 1 cm at water depths up to 6 km. The data from these buoys are transmitted in real-time to the Indian Tsunami Early Warning Centre (ITEWC) at ESSO-INCOIS through satellite communication. In addition to these buoys, real-time data from around 50 tsunami buoys operated by other countries in the Indian and Pacific Oceans also received at ITEWC and the data is made available on the tsunami website.



Locations of the Sea level network of Tsunami buoys



Data availability of tsunami buoys from April 2010 - March 2017 (Blue: INCOIS STBs; Purple: NIOT tsunami buoys)

ESSO-INCOIS deployed 4 new SAIC Tsunami Buoys (STBs) at the locations of STB01, STB03, STB04 and STB05 in Bay of Bengal during a cruise conducted onboard Sagar Kanya in May-June 2016. Due to vandalism, the surface buoy of STB03 was lost in the month of August 2016. As part of the annual maintenance, STB02 system (Arabian Sea) was redeployed during a cruise held onboard Sagar Nidhi in March 2017.

Tsunami buoys deployment and servicing cruises during May-June 2016 and March 2017

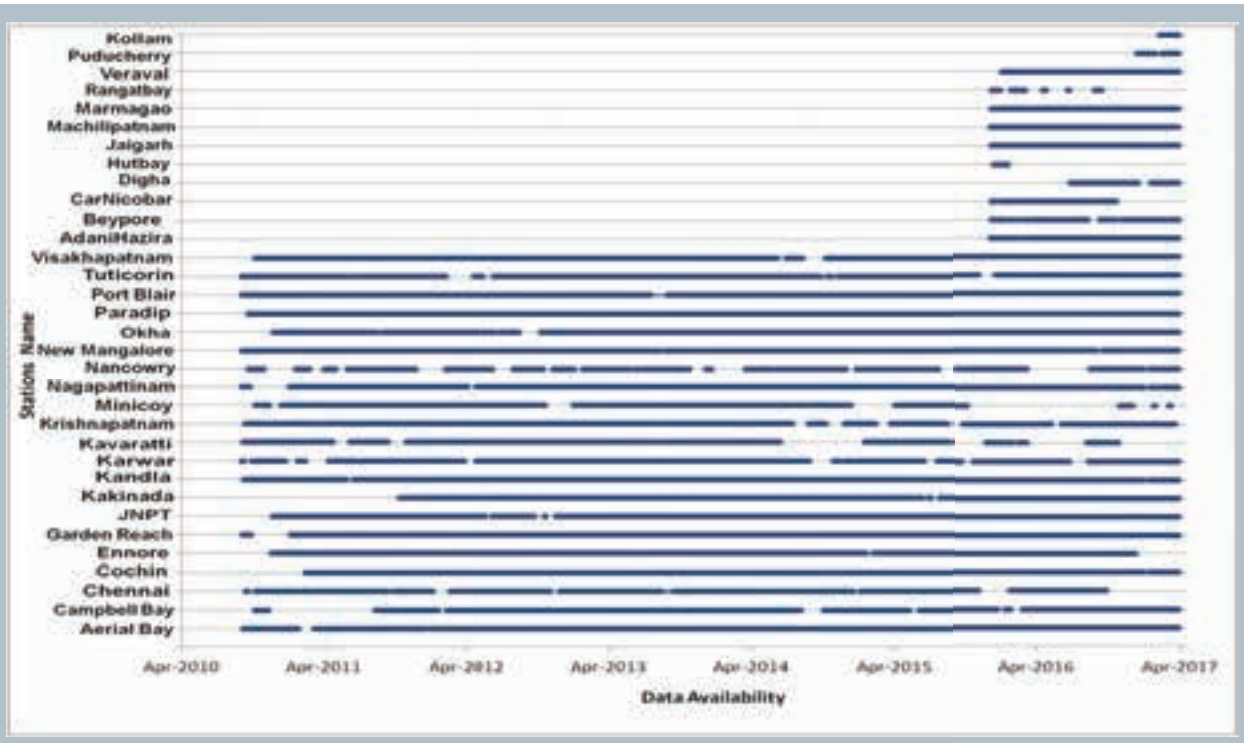
5.11 Tide gauges

ESSO-INCOIS set up additional 3 new Radar-based tide gauge stations and continued to maintain the 31 tide gauges which were earlier established at strategic locations along the coasts of the Indian mainland and islands to monitor the progress of tsunami waves. In addition, ESSO-INCOIS also received data from around 300 international tide gauges in near-real time operated by other countries. The data from tide gauges were also used to validate the model results. Continuous real-time data from tide gauges were received at ITWEC through INSAT and GPRS communications. The Tide gauge located at Gopalpur was shifted to Digha in July 2016 due to technical issues.

Locations of the Sea level network of tide gauges

Locations of new Radar-based tide gauges established by ESSO-INCOIS

S. No	Station Name	Latitude (°N)	Longitude (°E)	Installed Date
1	Puducherry	11.93	11.93	December 2016
2	Kollam	8.864	76.603	February 2017
3	Porbandar	21.621	69.522	March 2017



Data availability from the tide gauge network during April 2010-March 2017

New Radar tide gauge stations at Kollam (Left) and Puducherry (Right)

5.12 Network of communication systems

a) Establishment of GNSS and Strong Motion network in A&N Islands

ESSO-INCOIS has taken up a project to install co-located strong motion accelerometers,

GNSS receivers and meteorological sensors with real-time VSAT connectivity at 35 locations in the Andaman & Nicobar (A&N) Islands. As on March 2017, installation of GNSS receivers and strong motion accelerometers were completed at 28 locations. Construction of observatories is in progress at the remaining locations.

Co-located SMA and GNSS stations in Nimbuthala (left) and Namunaghar (right)

b) Establishment of Indian Seismic and GNSS Network (ISGN)

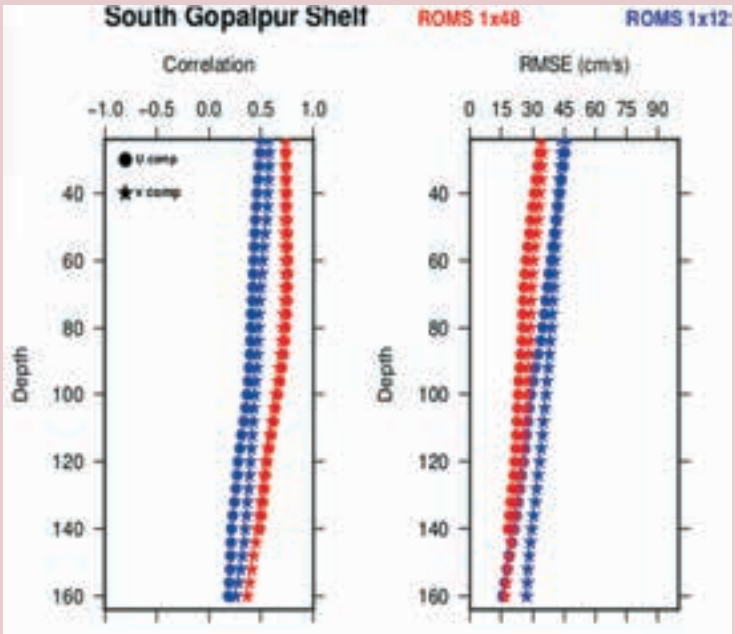
A real-time network of seismic and GNSS stations was established through VSAT communications by connecting local networks operated by regional institutes and the standalone stations operated under various projects of Ministry of Earth Sciences (MoES). Currently data from 130 stations are being received at ESSO-INCOIS, Hyderabad and National Centre for Seismology (NCS), New Delhi which act as the Central Receiving Stations (CRSs). The seismic as well as GNSS near real-time data from these stations are available through the website www.isgn.gov.in. As of 31 March 2017, 98 registered users are receiving data from the ISGN web portal. The historical data collected by ESSO-NCESS and other regional centres also have been archived as part of the project. The archival of historical seismic data available with IMD is progressing.

6. Ocean Modeling and Data Assimilation

Numerical modeling of ocean circulation and wind-waves and the assimilation of ocean data in the numerical models is one of the most important research and development activities of INCOIS, which support the Ocean Forecast services. Major achievements in the field of ocean modeling and data assimilation during 2016-17 are listed below.

6.1 High-resolution Operational Ocean Forecast System (HOOFS) for the Bay of Bengal

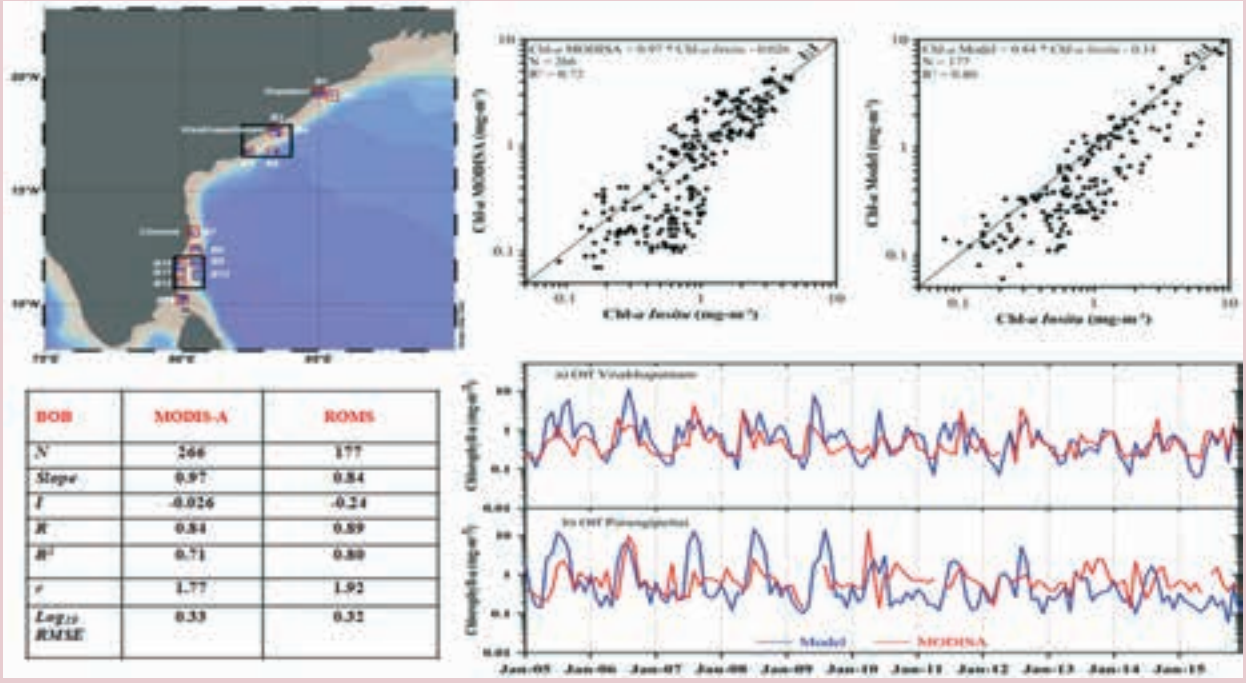
The HOOFS project envisaged setting up of a series of very high-resolution numerical ocean models based on Regional Ocean Modeling System (ROMS) for the coastal waters around the country. The final setup in this series (for the Bay of Bengal) has also now been configured for operational use. The HOOFS setup for the Bay of Bengal (BB-HOOFS) has a spatial resolution of 1/48 degree (~2.25 x 2.25 km) with 40 sigma levels in the vertical. The model takes boundary conditions from the basin-scale setup of ROMS (IO-HOOFS) and the boundary conditions are exchanged on daily time-scales. The BB-HOOFS setup has better skills in simulating the observed general circulation features in the Bay of Bengal compared to the IO-HOOFS setup.



Vertical structure of correlation (left) and RMSE (right) between the HOOFS simulations and observations at south Gopalpur Shelf location. Zonal (dot) and meridional (star) currents simulated by IO-HOOFS (blue) and BB-HOOFS (red) are compared with ADCP observations.

6.2 Marine Ecosystem Modeling

A coupled bio-physical model integrated with an ecosystem model has been configured at high resolution using Regional Ocean Modeling System (ROMS) to study the upper ocean biogeochemical variability in the Bay of Bengal. A comparison of the sea surface chlorophyll (chl) data retrieved from MODIS-Aqua satellite using standard OC3M algorithm, and that from a Regional Ocean Modeling System (ROMS) biophysical model with the in situ data, measured in surface waters of the western Bay of Bengal, for the period March 2008 to November 2015 showed that the simulated chlorophyll concentration is better correlated with the in situ observations ($R^2 = 0.806$) compared to that retrieved from satellite ($R^2 = 0.717$). Although, the model underestimated the chlorophyll concentration, significant correlation proves its capability to reproduce its variability.

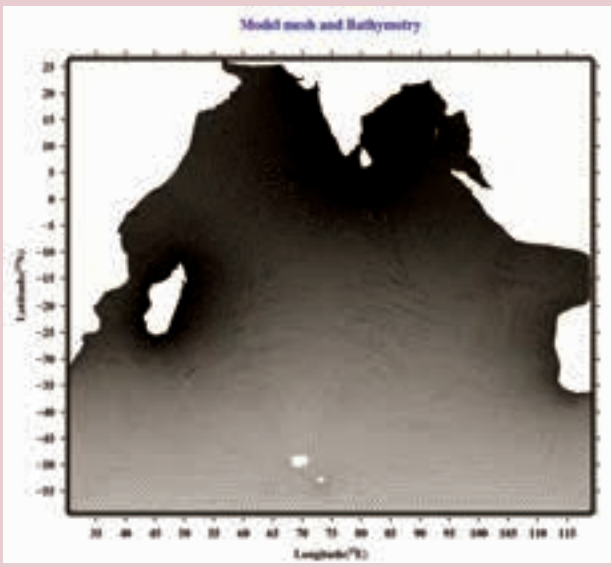


BOB	MODIS-A	ROMS
N	266	177
Slope	0.97	0.84
I	-0.026	-0.24
R	0.84	0.89
R^2	0.71	0.80
e	1.77	1.92
Log_{10} RMSE	0.33	0.32

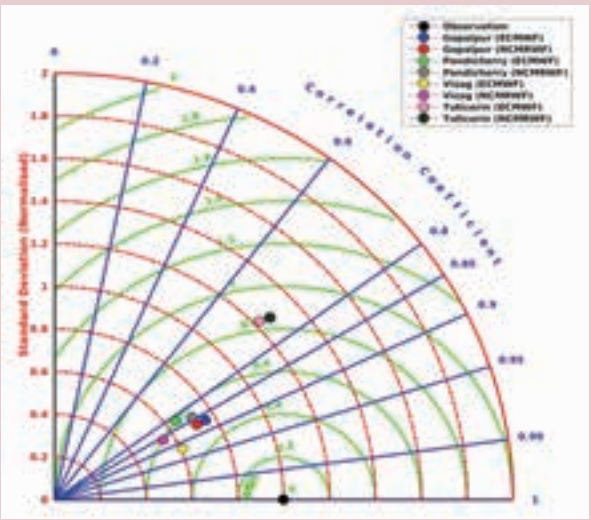
Upper left: Locations of observations, Upper right: Plot of model vs observations, Lower left: Table of statistic, Lower right: Time series plot of model and observations at two locations.

6.3 Unstructured SWAN for east coast of India

Unstructured SWAN model (PUnSWAN) was set up for the whole Indian ocean with very fine resolution along the east coast. This setup better represents the coastline compared to a regular mesh set up of SWAN. Further, no nesting is required because of the use of flexible meshes which allows fine resolution in areas of interest and coarse resolution elsewhere. Preliminary experiments were done using this setup to simulate wind waves and swells in the Indian ocean, with special interest in the Indian east coast. Different forcing fields such as ECMWF (0.25 x 0.25 deg resolution, 3-hrly) and NCMRWF (0.25 x 0.25 deg resolution, 6-hrly) were given as input to the model and simulations were performed for 2014. Comparison of simulated wave heights with the wave-rider buoy data along east coast



Configuration of unstructured setup of SWAN model for the Indian Ocean Domain.

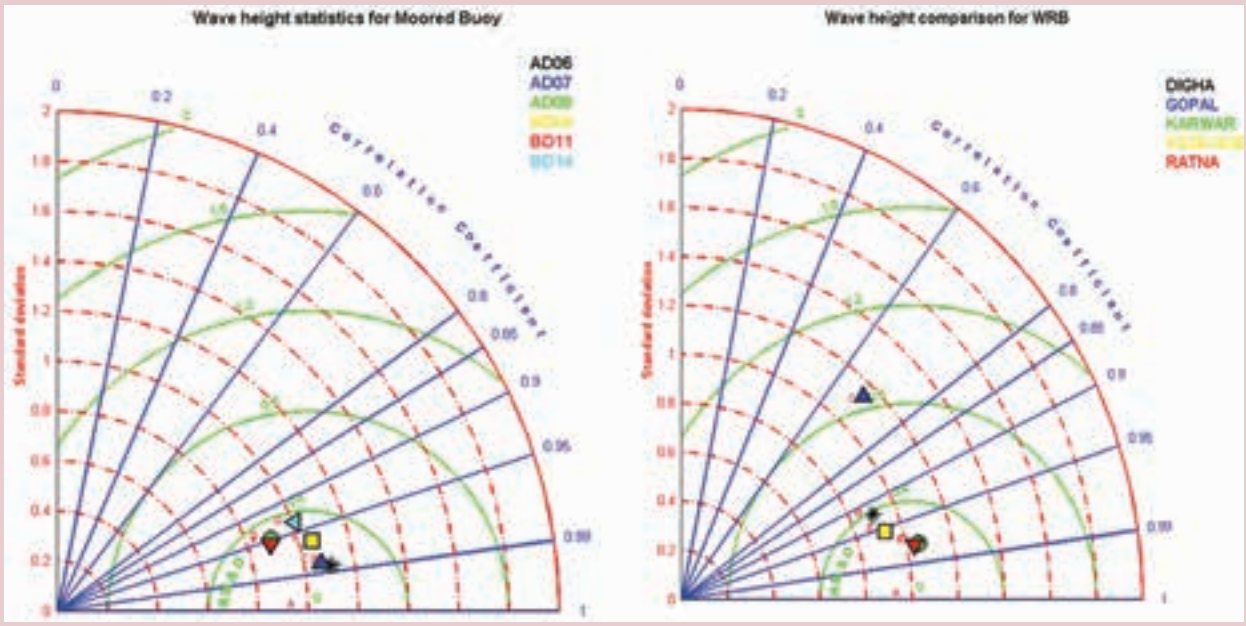


Taylor diagram representing the performance of PUNSWAN for different coastal locations using two different forcing fields.

(off Tuticorin, Pondicherry, Vizag and Gopalpur) showed that the model is able to simulate the observed variation in the significant wave height very well.

6.4 Wave forecast System using WAVEWATCH III

INCOIS uses a multigrid setup of WAVEWATCH III to provide global wave forecasts for various users such as the navy, shipping industries, coast guard, fisherfolk, the coastal community etc. These forecasts are used by Indian Ocean Rim countries also. The three coastal models, SWAN, MIKE21 and ADCIRC also acquires boundary conditions from the WAVEWATCH III model forecasts. Verification of the forecasts using the observation showed that the forecasts have very high degree of accuracy in the Indian Ocean.



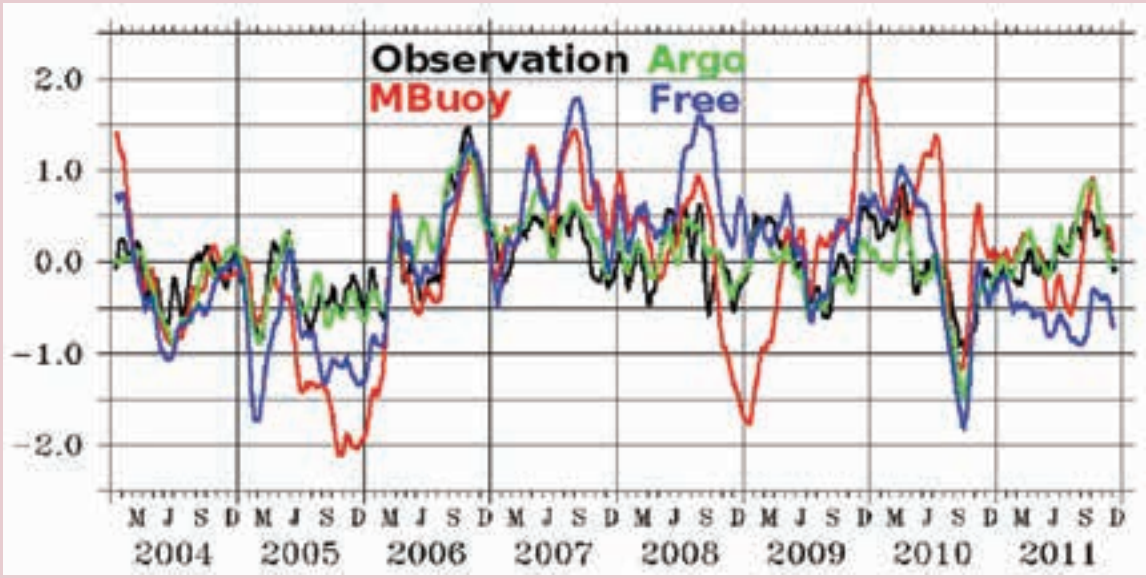
Taylor diagram displaying a statistical comparison of modeled wave height with observations

6.5 Global Ocean Data Assimilation System (GODAS)

A fundamental deficiency across ocean data assimilation systems has been discovered by conducting Observation System Evaluation (OSEs) and Observation System Simulation Experiments (OSSEs). It was shown that the assimilation of temperature and salinity observations from bounded observation networks such as tropical moorings degrades the quality of ocean reanalysis due to the genesis of shock and its subsequent westward propagation as Rossby waves. The problem is especially larger in the pre-Argo era. The negative impact of bounded observations on the simulations of Indian Ocean Dipole in the ocean reanalysis was also revealed. This work raises serious concerns on the veracity of ocean reanalysis in the pre-Argo era.

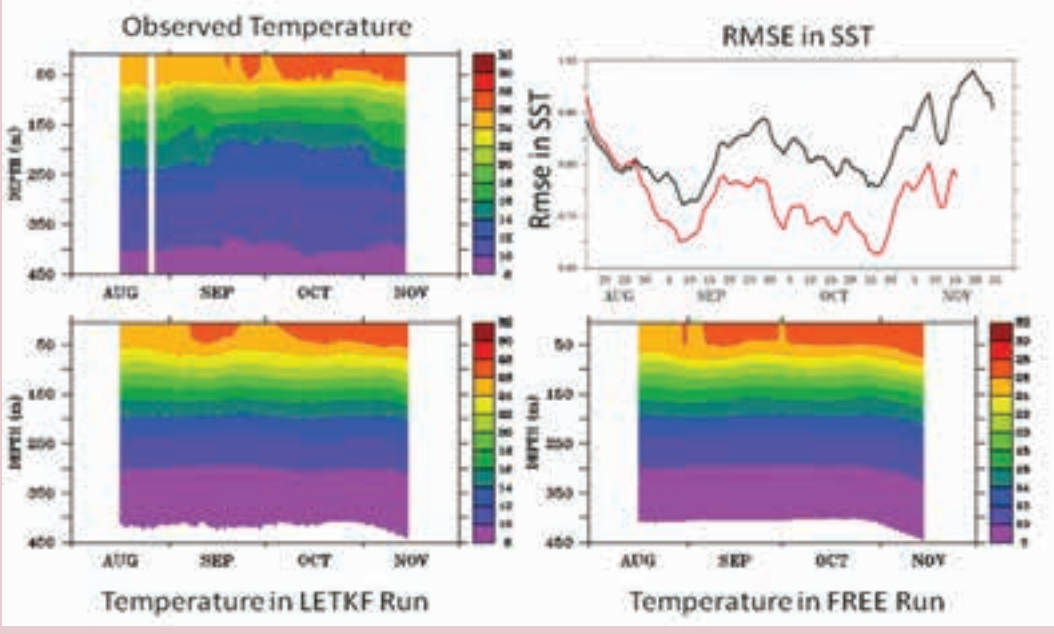
6.6 ROMS-LETKF

Local Ensemble Transform Kalman Filter (LETKF) based data assimilation scheme has been implemented in the Regional Ocean Modeling System (ROMS) to improve the forecasts of ocean



IOD Mode estimated from TMIAMSRE SST obs and model simulations from OSEs of INCOIS-GODAS. Mbuoy: only moored buoys are assimilated, Argo: only Argo floats are assimilated, Free: no obs are assimilated. IOD simulation from MBuoy is worse than Free run.

circulation features. INCOIS-LETKF is an ensemble based filter with an ability to assimilate in-situ temperature and salinity profiles, satellite track data of sea-surface temperature, sea-surface salinity and sea-level anomaly. It is under testing now and shows promising results with 80 ensemble members forced by an ensemble of atmospheric fluxes. It showed a decrease in root-mean-squared error spatially averaged over the entire Indian Ocean by as much as 0.2 degrees when compared to TMI SST. The assimilation also improves the temperature profiles of the system when compared to in situ RAMA moorings.

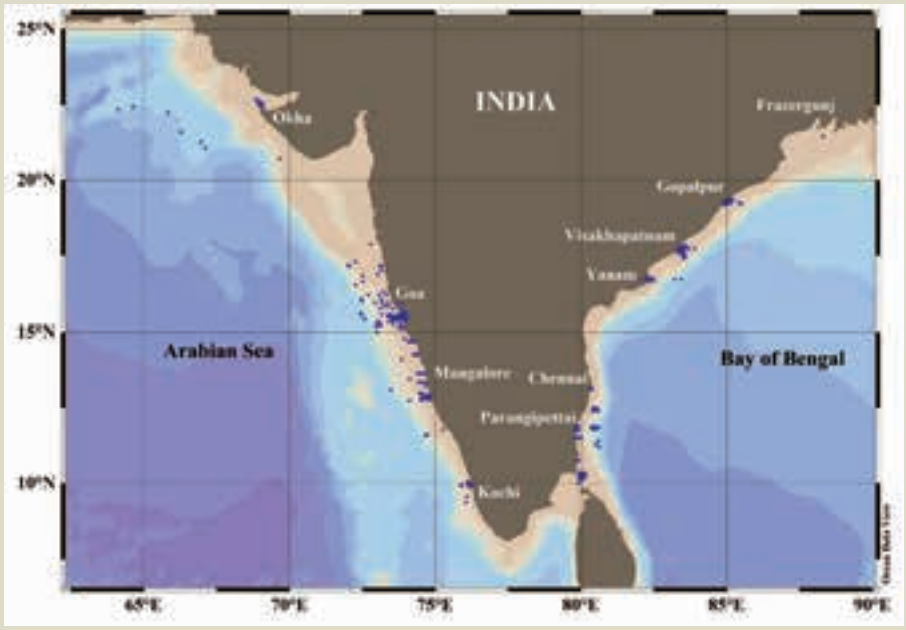


Time series of the vertical temperature profiles; Upper right: RMSE in SST of Free run (Black) and Assimilated run (Red) with respect to TMI SST

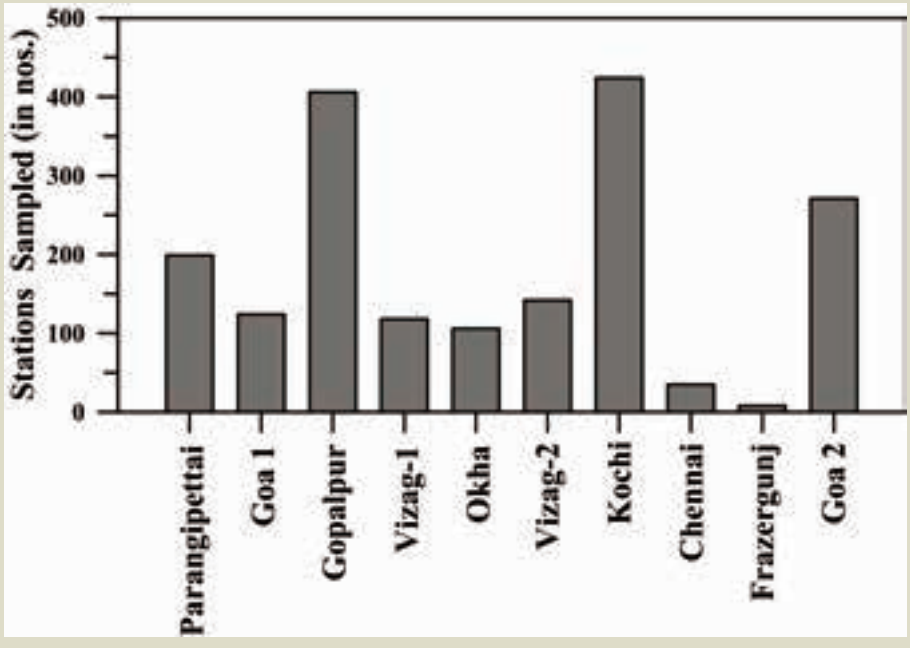
7. SATellite Coastal and Oceanographic REsearch (SATCORE) programme

7.1 Time series stations and data statistics

As part of SATellite Coastal and Oceanographic REsearch (SATCORE) programme, eight time-series stations were established and sustained, in the Indian coastal waters, for the measurement of bio-optical and physico-chemical parameters (Fig. 1). All stations were equipped with common instruments (Spectrophotometer, Integrating Sphere, Sunphotometer, Fluorometer, Weighing Balance, Automatic Weather Station, Vacuum Filtration Unit, Aspirator Pump) required for the measurement of essential parameters such as chlorophyll-a (chl-a), total suspended matter (TSM), chromophoric dissolved organic matter (CDOM), inherent optical properties (IOP), apparent optical properties (AOP), aerosol optical thickness (AOT), nutrients, phytoplankton, pH, dissolved oxygen (DO), salinity and water temperature (WT) -as defined under SATCORE sampling strategy.



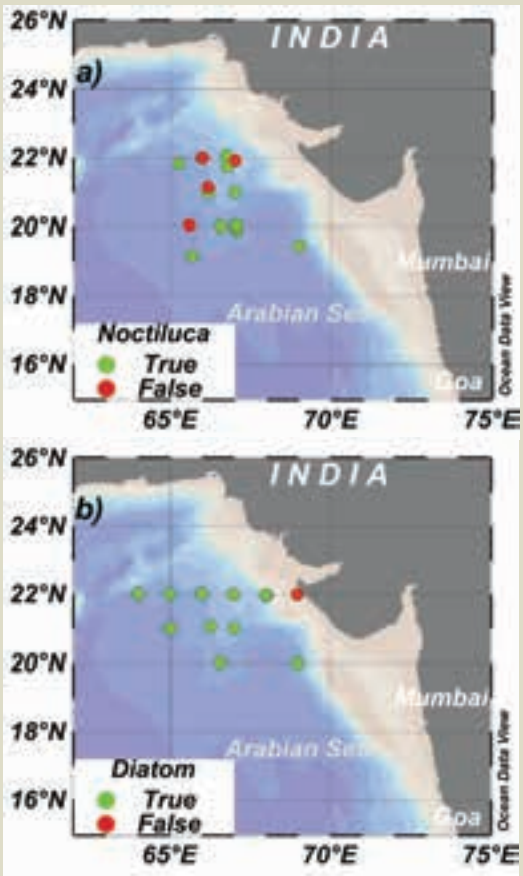
Locations of time series stations for measuring the bio-optical and physico-chemical parameters, as part of SATCORE programme



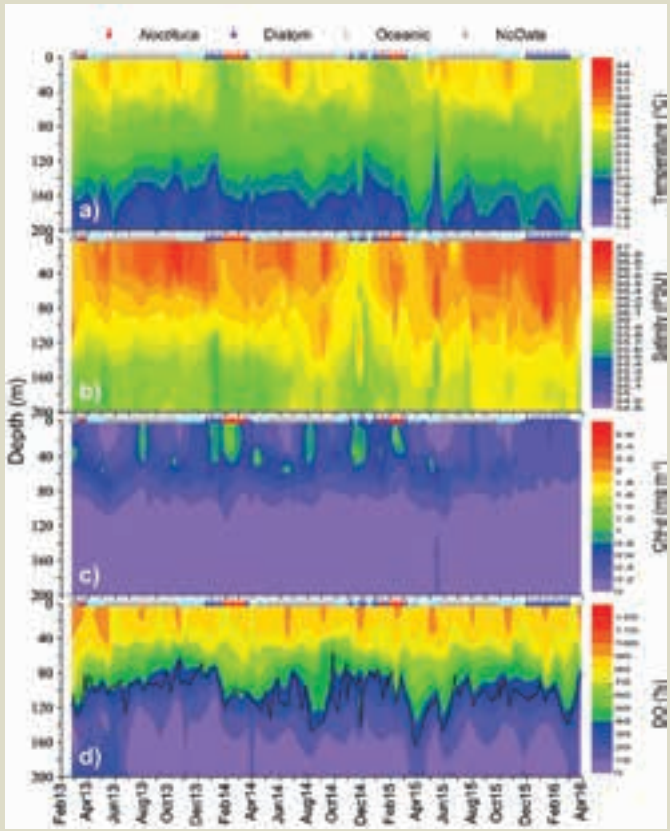
Database on total number of stations sampled at different SATCORE time-series locations during 2008-2016.

7.2 Sub-surface bio-physics in north-eastern Arabian Sea during algal bloom

Spatio-temporal phytoplankton class products discriminating green *Noctiluca scintillans*, diatom, and non-bloom regions were generated using remote sensing reflectance data retrieved from MODIS-A. A sensitivity analysis was also carried out to assess the accuracy of the retrieval method of *Noctiluca* and diatom showed that 71% accuracy in the detection of green *Noctiluca* and 91% in detection of diatom. In addition, vertical profiles obtained from Bio-Argo profiling floats were analyzed to understand the subsurface water quality during bloom and non-bloom conditions. The higher chl-a concentration within upper water column of green *Noctiluca* predominated regions depicted no subsurface maxima attributed to active mixing resulting in nutrient entrainment to surface water column. This is also evident from reduced water temperature. The higher values of DO in upper 40 m of the water column in the green *Noctiluca* dominated regions indicated no signature of hypoxia in association with the bloom.



Map indicating agreement of satellite algorithm with in situ data for a) Noctiluca and b) diatom blooms.



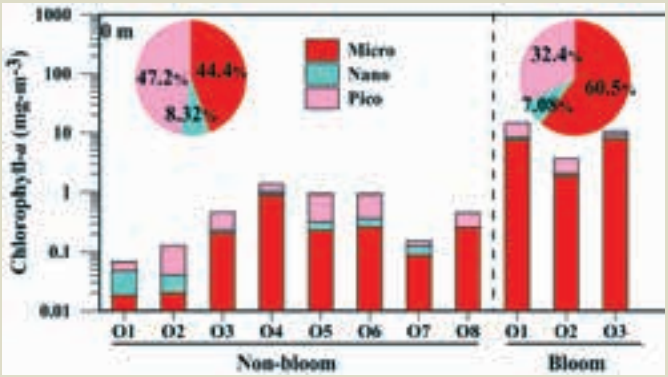
Vertical profiles of temperature, salinity, chlorophyll-a (chl-a) and dissolved oxygen (DO) saturation measured by Bio-Argo profiling float 2092. The dotted line in panel "d" corresponds to 60-65 µM DO concentration.

7.3 Response of phytoplankton community and size classes to green Noctiluca bloom

A comprehensive analysis on the phytoplankton ecology with special reference to different phytoplankton size classes was carried out at green *Noctiluca* bloom and non-bloom locations in the north-eastern Arabian Sea. Phytoplankton community structure was composed of 18 diatoms, 8 dinoflagellates and one cyanobacteria species. Among the dinoflagellates, green

Thick bloom of green Noctiluca in north-eastern Arabian Sea on 7th March 2016

Noctiluca represented a dense mono-specific bloom with average cell density of 9.86x104 cells/l and relative abundance share of 96.8%. Vertical profile of phytoplankton abundance discerned maximum restriction of green *Noctiluca* assemblage to the surface waters. Active photosynthesis through prasinophytic endosymbiont was depicted from net community production reaching 85.26 mgC/m^3/Day under low prey abundance. Total phytoplankton abundance and micophytoplankton biomass co-varied in the green *Noctiluca* predominated waters. One of the preferred diatomic diet of *Noctiluca*, *Thallassiosira sp*. was observed at the bloom stations. Parallel swarming of *Porpita porpita*, a voracious copepod feeder signified the competitive advantage of *Noctiluca* to have the phytoplankton prey. Despite bloom conditions, picophytoplankton contributed more than 30% to the total phytoplankton biomass which could be due to non predation of green *Noctiluca* on picophytoplankton assemblage. Green *Noctiluca* bloom onset subsequent to diatom rich conditions was evident from spatio-temporal ocean colour satellite imageries.

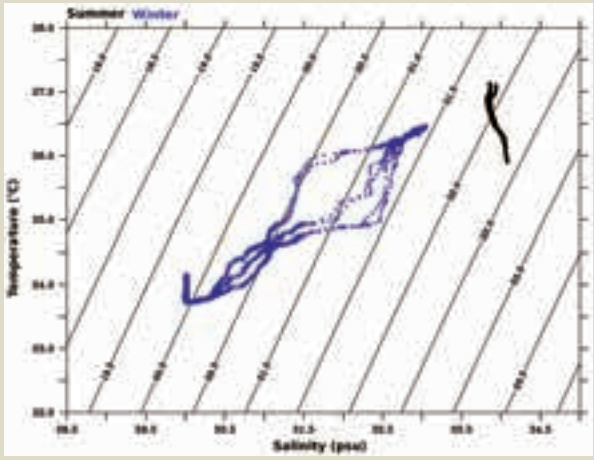


Chlorophyll-a concentration of pico, nano and micro-phytoplankton at Noctiluca bloom and non-bloom stations. The inset pie charts shows percentage contribution of mico, nano and pico-phytoplankton to total chlorophyll-a.

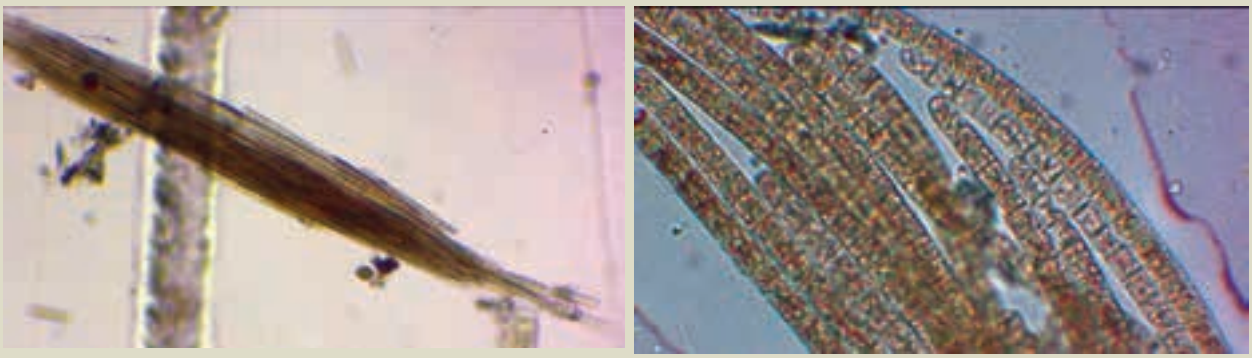
7.4 Winter Thermal Inversion and Trichodesmium Dominance

Thermal inversion in winter season is a regular phenomenon in the northern Bay of Bengal (BoB). A clear thermal inversion was observed with cold surface waters (<24°C) overlying the warm (>26°C) subsurface water in the coastal water of the northwestern BoB in January 2015. Simultaneously, preponderance of the cyanobacteria *Trichodesmium erythraeum* was observed reaching maximum density of 9.8 × 105 filaments/litre and dominating the phytoplankton community with >90% of total population. In general, *Trichodesmium* blooms or predominance were often observed in coastal and offshore waters of the BoB during summer season associated with high water temperature. In contrast, the present observed *T. erythraeum* predominance during winter season was in association with low water temperature (<24°C).

Map of study area showing sampling location



T-S diagram for the profiles in the coastal waters of the north-western Bay of Bengal during winter (January) and summer (April) season of 2015. Contours represent density.

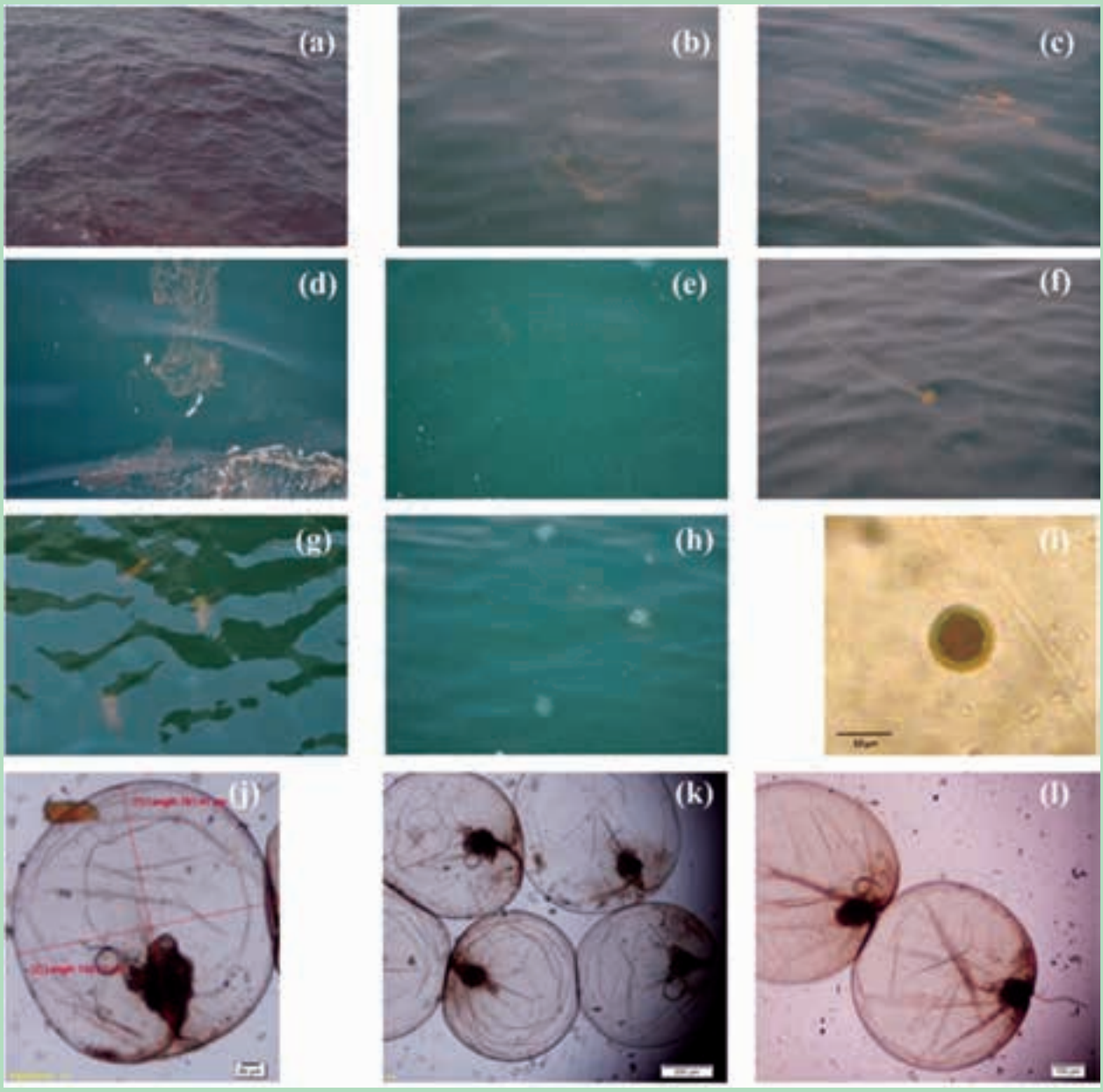


Trichodesmium erythraeum (left panel) 100X magnification (right panel) colony in 400X

8. Research Highlights

8.1. Red tide of *Noctiluca scintillans*

An ecosystem disruptive *Noctiluca scintillans* bloom occurred in coastal waters of the north-western Bay of Bengal prior to the onset of the southwest monsoon, generating lowered oxygen concentrations within the photic zone, increased ammonium concentrations, and anecdotal evidence of fish avoidance in the region. Co-occurrence of gelatinous planktivors at the early stages of the *Noctiluca scintillans* bloom likely facilitated the *Noctiluca scintillans* growth by feeding



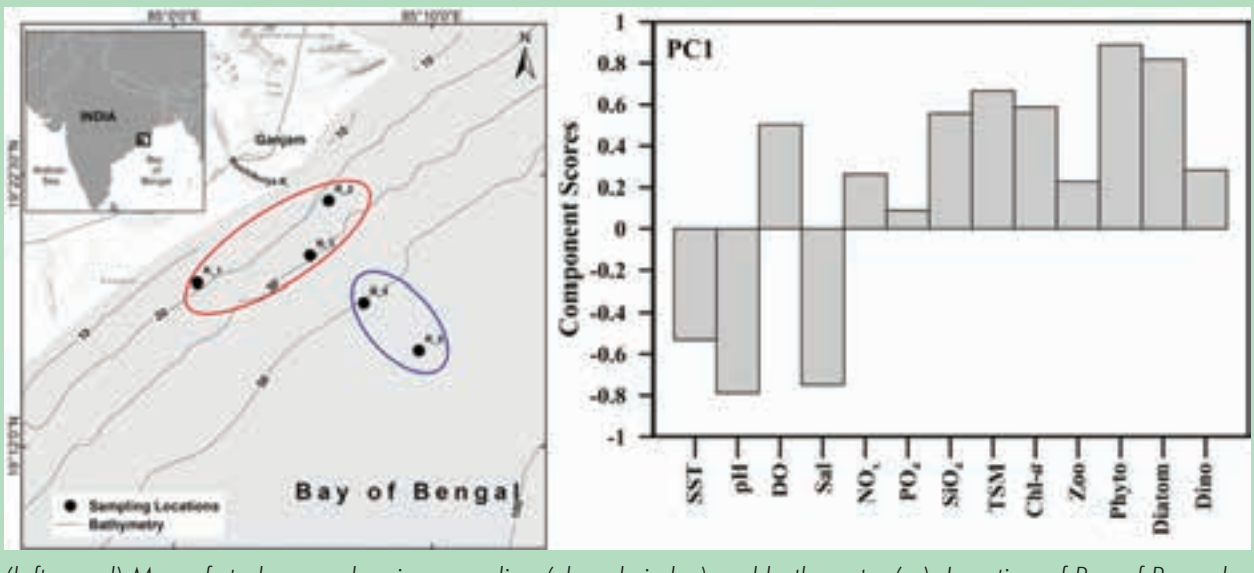
Discoloration of water and floating bloom off the Rushikulya estuary (photographed on 13-16 April 2014; a-e), swarming jellyfish off the Rushikulya estuary (f-h), microscopic images of Mesodinium rubrum (40x magnification; i), microscopic images of Noctiluca scintillans (4x magnification; j-l).

Ref: Baliarsingh, S. K., Lotliker, A.A., Trainer, V.L., Wells, M.L., Parida, C., Sahu, B.K., Srichandan, S., Sahoo, S., Sahu, K.C. & Sinivasa Kumar, T. Environmental dynamics of red Noctiluca scintillans bloom in tropical coastal waters (2016) Marine Pollution Bulletin, 111(1-2), pp. 277-286.

on their copepod competitors. Nutrient concentrations were low during the bloom, consistent with both the picoplankton dominance of the assemblage. Collapse of the red *Noctiluca scintillans* bloom likely occurred when availability of diatom prey declined. Diatom and photosynthetic dinoflagellates emerged as an increasing proportion of chlorophyll biomass as the *Noctiluca scintillans* bloom declined. A small increase in silicate concentrations may have contributed to this community shift, but more importantly there was a sharp decrease in picoplankton biomass. This decline was coincident with increasing grazing pressure from the ciliate *M. rubrum*, which became abundant in the declining phase of the *Noctiluca scintillans* bloom. These findings show how recurrent *Noctiluca scintillans* blooms can disrupt ecosystem balance in Indian coastal waters, and provide insights into the trophic interactions that support the initiation, development and decline of *Noctiluca scintillans* blooms.

8.2. Phytoplankton community structure in local water types

A comprehensive analysis on seasonal distribution of phytoplankton community structure and their interaction with environmental variables was carried out in two local water types (Type-1<30m isobath and Type-2>30m isobath) at a coastal site in north-western Bay of Bengal. Phytoplankton community was represented by 211 taxa (146-marine, 37-fresh, 2-brackish, 20-marine-fresh, and 6-marine-brackish-fresh) belonging to seven major groups including 45 potential bloom forming and 22 potential toxin producing species. The seasonal variability depicted enrichment of phytoplankton during pre-monsoon in both water types. Total phytoplankton abundance pattern observed with inter-annual shift during monsoon and post-monsoon period at both water types. In both water types, diatom predominance was observed in terms of species richness and abundance comprising of centric (82 sp.) and pennate (58 sp.) forms. Pennate diatoms, *Thallassiothrix longissima* and *Skeletonema costatum* preponderated in both the water types.



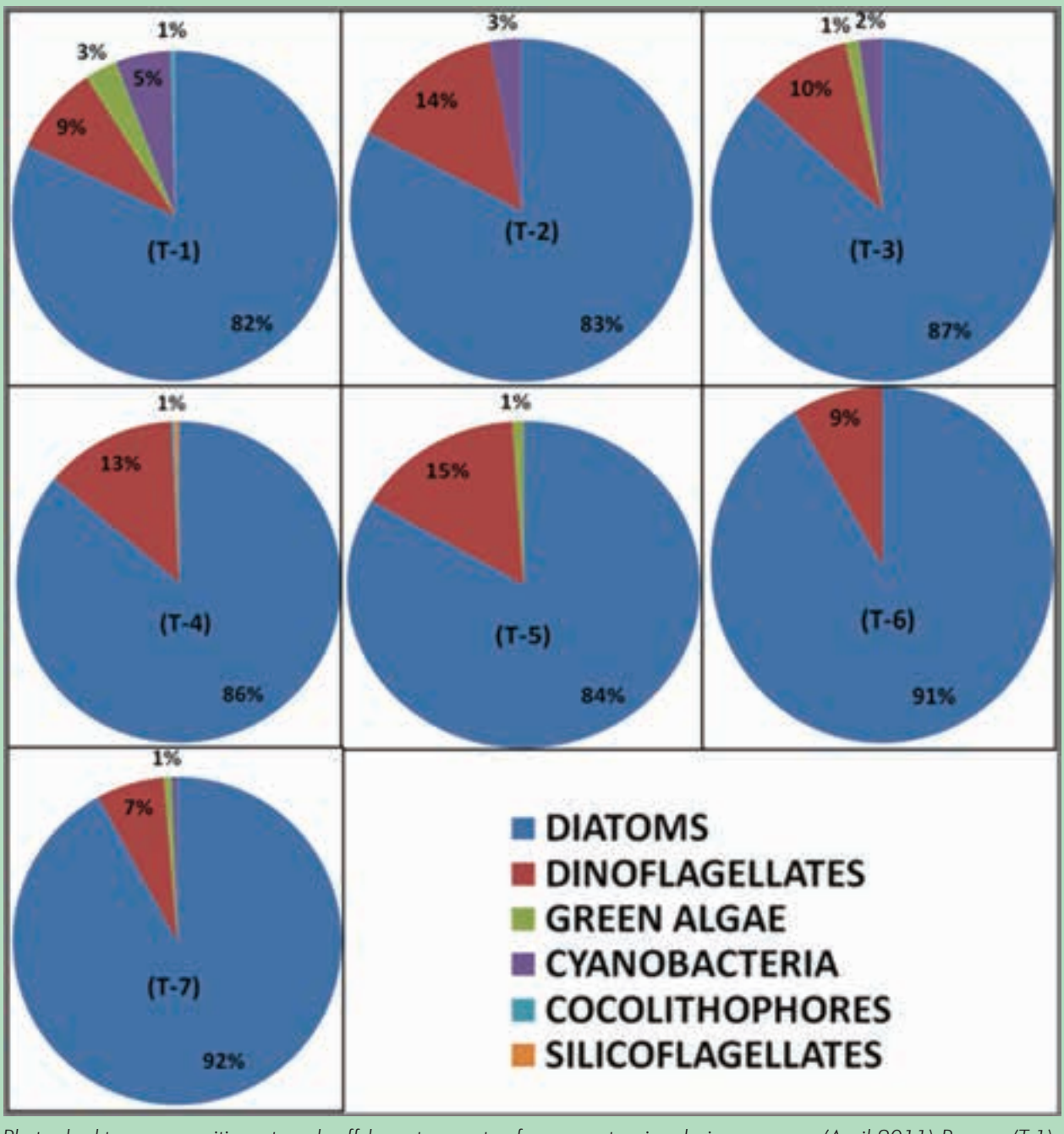
(left panel) Map of study area showing sampling (closed circles) and bathymetry (m). Location of Bay of Bengal (inset). Stations within red circle represent Type-1 and within blue Type-2 (right panel) Hydro-biological parameter loading in principal component 1 (Varimax Rotated; rotation method: Varimax with Kaiser normalization; rotation converged in 4 iterations)

Ref: Baliarsingh, S.K., Suchismita S., Lotliker, A.A., Sahu, K.C., Srinivasa Kumar T., Phytoplankton community structure in local water types at a coastal site in north-western Bay of Bengal (2016) Environmental Monitoring and Assessment, 188(427), pp. 1-15.

The diatom abundance were higher in Type-1 in comparison to Type-2. In general, silicates found to fuel growth of the dominant phytoplankton group, diatom in both the water types despite comparative lower concentration of other macronutrients in Type-2.

8.3. Phytoplankton along offshore transects in Indian estuaries

Species composition, abundance and distribution of phytoplankton, and water quality parameters (transparency, water temperature, salinity, pH, dissolved oxygen, nutrients and chlorophyll-a) were examined during a summer (2011) cruise along offshore transects of some Indian estuaries of



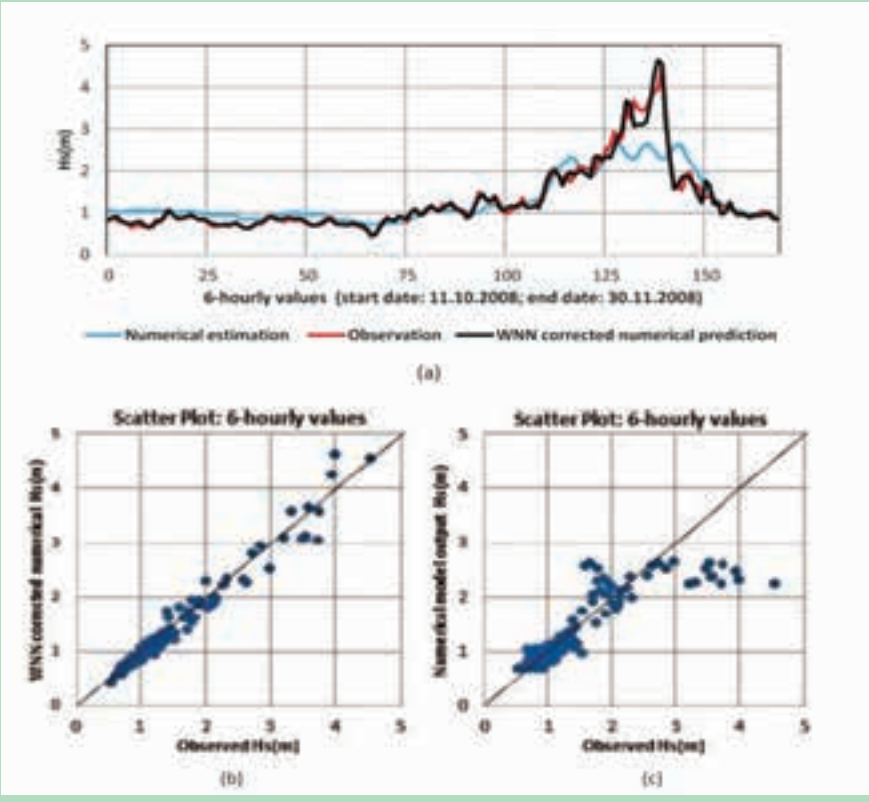
Phytoplankton composition at each offshore transects of seven estuaries during summer (April 2011) Pennar (T-1), Krishna (T-2), Godavari (T-3), Gosthani (T-4), Rushikulya (T-5), Devi (T-6), Mahanadi (T-7)

Ref: Baliarsingh, S.K., Srichandan, S., Pati, S.K., Sahu, K.C., Dash, S.K., Lotliker, A.A., Kumar, T.S. Phytoplankton community structure along offshore transects of some Indian estuaries of east coast: An experience with a summer cruise (2016) Indian Journal of Geo-Marine Sciences, 45 (8): 960-973.

east coast. A total of 123 phytoplankton species were identified. Of total, 86 species of diatoms from 44 genera, 22 species of dinoflagellates from 10 genera, 5 species of green algae from 5 genera, 4 species of cyanobacteria from 4 genera, 2 species of cocolithophores from 2 genera and 1 species of silicoflagellate were identified. Phytoplankton communities were found to vary from transect to transect. Highest and lowest values for species diversity index are associated with Godavari and Gosthani transects respectively. The highest phytoplankton abundance was found at transect Krishna (26680 cells/l) and the lowest at Godavari (9480 cells/l). *Thalassiothrix longissima* was quantified as the dominant species among diatoms and *Dinophysis caudata* among dinoflagellates. Abundance of bloom forming species *Asterionellopsis glacialis* was observed at transects Godavari & Mahanadi. Diversity and evenness indices of phytoplankton were found highest at Godavari transect. There exhibited a linear relationship between chlorophyll-a and phytoplankton abundance at all the transects with deviations at Gosthani and Godavari.

8.4 Neural-network based data assimilation in wave models

Studies were conducted which demonstrated the skill level of a wavelet neural network in improving numerical ocean wave predictions of significant wave height (Hs) and peak wave period (Tp). The Wavelet Neural Network was trained using error time series obtained as the difference between numerical model output (SWAN+WW3) and observations (Wave Rider Buoy) which in turn predicted errors with lead time varying from 3h to 24h. The predicted errors when incorporated into the model values provided the updated prediction of Hs and Tp. It was observed from the study that numerical estimations were significantly improved using this procedure. A comparison between the suggested prediction method with the standalone neural network model trained with measured data off Puducherry showed that the former approach is preferred over the latter in obtaining a sustained



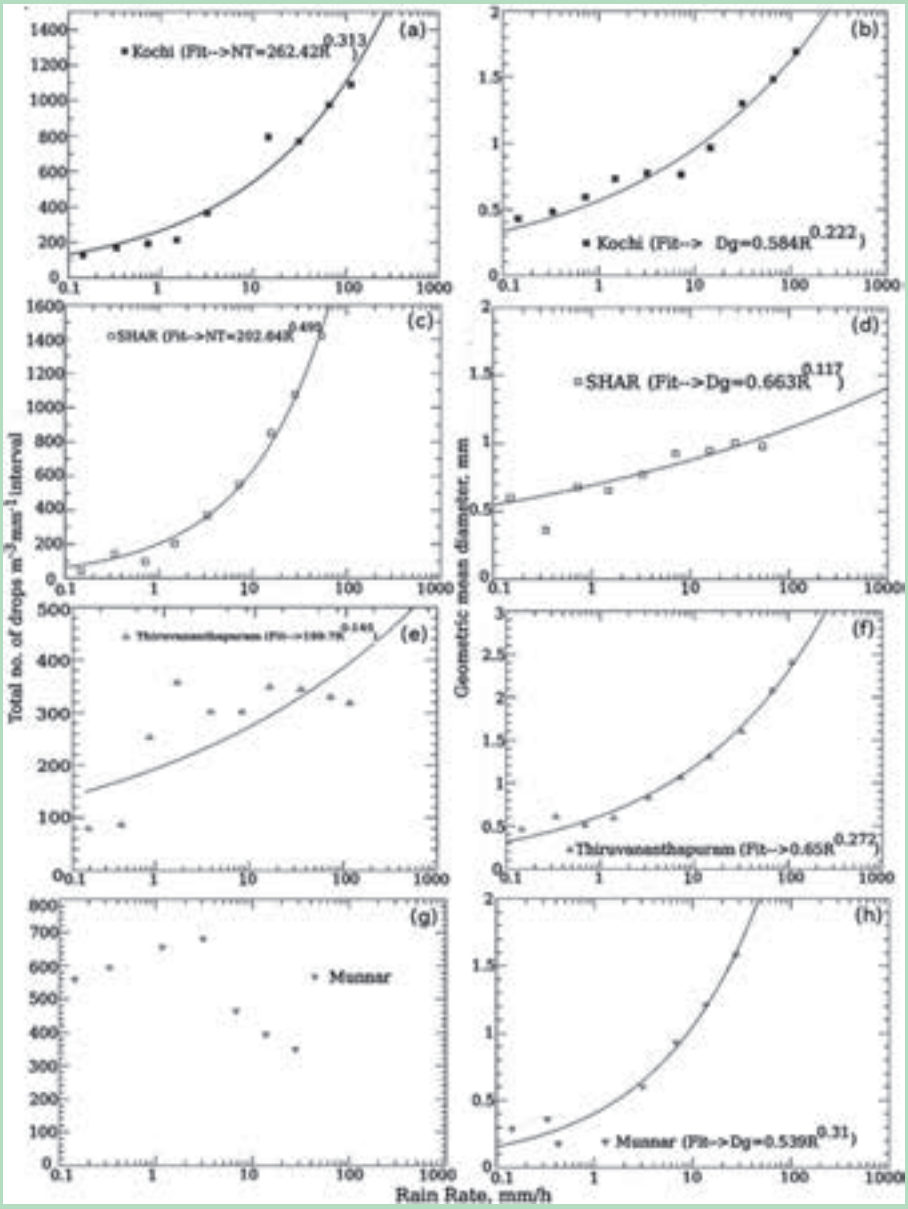
Six-hour-ahead prediction of Hs during the post-monsoon season for testing data. (a) Time history of the numerical estimation, WNN-produced and observed Hs. (b) Scatter plot of the WNN-corrected numerical versus observed Hs. (c) Numerical versus observed Hs (start date: October 11, 2008; end date: November 30, 2008)

Ref: Deshmukh A. N., Deo M. C., Bhaskaran P. K., Balakrishnan Nair T. M., Sandhya K.G., Neural-Network-Based Data Assimilation to Improve Numerical Ocean Wave Forecast, (2016) IEEE Journal of Oceanic Engineering , 41(4), pp. 944-953.

prediction performance. Separate models were setup for monsoon, non-monsoon, pre-monsoon and post-monsoon season.

8.5. Orographic effect on tropical rain physics

Rain Drop Size Distribution (DSD) was studied using a Joss-Waldvogel Disdrometer, at three coastal and a hill station in the tropics. The variation in the characteristics of three physically significant parameters (viz. Total number of drops, Geometric mean diameter and Standard geometric deviation of drop size, which are derived from the DSD) with rain rate clearly unraveled the effect of orography on rain physics. It was shown that a heavy rainfall at a hill station, Munnar, consists of less number of bigger drops than coastal stations in the plane Kochi, Sriharikota (SHAR), and Thiruvananthapuram. This suggests that the orography is seen to affect the drop size and thus orographic rain seems to have larger drops when rain rate is high. This situation is very crucial because larger drops could cause more soil erosion that may lead to the triggering of land slide.



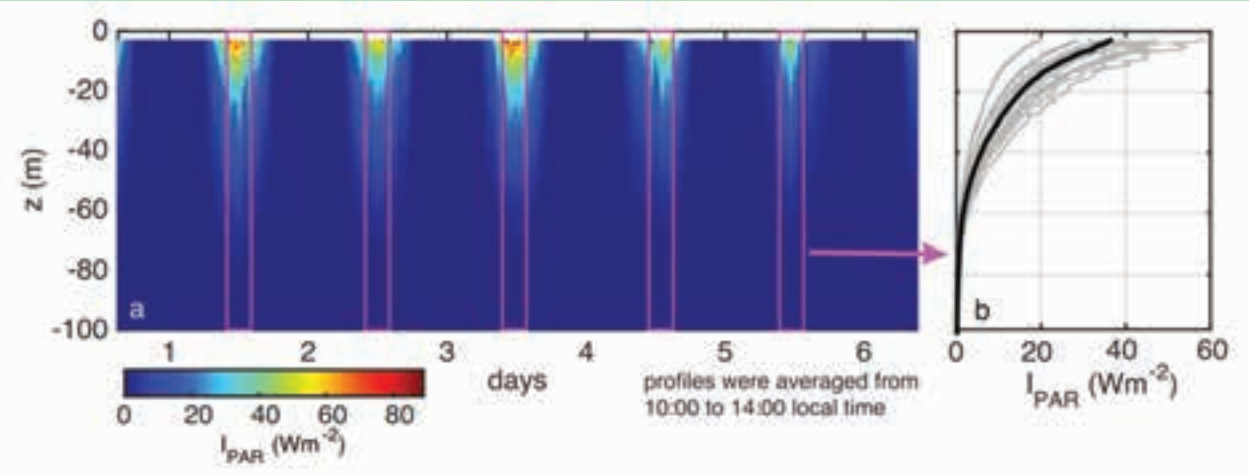
Variation of Total number of drops (left panels) and Geometric mean diameter (right panels) (with fits of the form $Y=aR^b$ are shown as legend) with rain rate at stations (a & b) Kochi, (c & d) Sriharikota (SHAR), (e & f) Thiruvananthapuram and (g & h) Munnar. Since there is no remarkable variation in the Standard geometric deviation of drop size with rain rate, it is not depicted here

Ref: Harikumar R., Orographic effect on tropical rain physics in the Asian monsoon region (2016) Atmospheric Science Letters, 17 (10), pp. 556-563.

8.6. Penetrative radiative flux in the Bay of Bengal

The Bay of Bengal (BoB), a semi-enclosed basin in the northern Indian Ocean, is a complex region with large freshwater inputs and strong vertical stratification that result in a shallow, spatially variable mixed layer.

With the exception of shortwave insolation, the air-sea heat exchange occurs at the sea surface and is vertically redistributed by mixing and advection. Strongly stratified, shallow mixed layers inhibit vertical mixing, and the penetration of solar radiation through the base of the mixed layer can lead to redistribution of upper-ocean heat. observations of hyperspectral downwelling irradiance (Ed) from 67 profiles collected during six research cruises in the BoB that span a broad range of regions and seasons between 2009 and 2014 were compiled. The attenuation length scales were computed using double and single exponential models and the penetration of radiative flux below the mixed layer depth (Qpen) were quantified. The new estimates showed that a largest penetrative heat flux (up to 40% of the incident Ed) occurs near 16°N where the mixed layers are shallow and the water is optically clear.

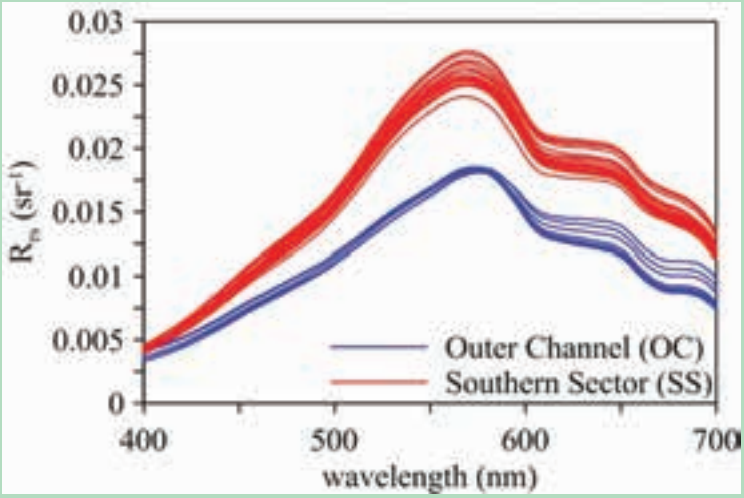


(left) Time-series of subsurface E(d,tot) (λ) profiles (integrated between λ= 400 and 950 nm), measured from the wirewalker during RR2. Purple lines indicate the period between 10:00 to 14:00 hrs that were averaged to obtain a single representative E(d,tot) (λ) profile for each day. (right) An example from day 5 of the individual E_(d,tot) (λ) profiles (gray) and the mean profile used for subsequent analyses (black)

Ref: Lotliker, A.A., Omand, M.M., Lucas, A.J., Laney, S.R., Mahadevan, A., Ravichandran, M. Penetrative radiative flux in the Bay of Bengal (2016) Oceanography, 29 (2), pp. 214-221.

8.7. Optical characterization in Chilika lagoon

Asia's largest brackish water ecosystem, Chilika lagoon, supports livelihood of millions of inhabitants and also known to be bio-geo-chemically dynamic. This demands continuous monitoring of lagoon for which optical remote sensing may be crucial. The *in situ* bio-optical parameters were analyzed in two sectors (Outer Channel: OC and Southern Sector: SS) of the lagoon. The spectral Remote Sensing Reflectance (R_{rs}) ranged from 0.003



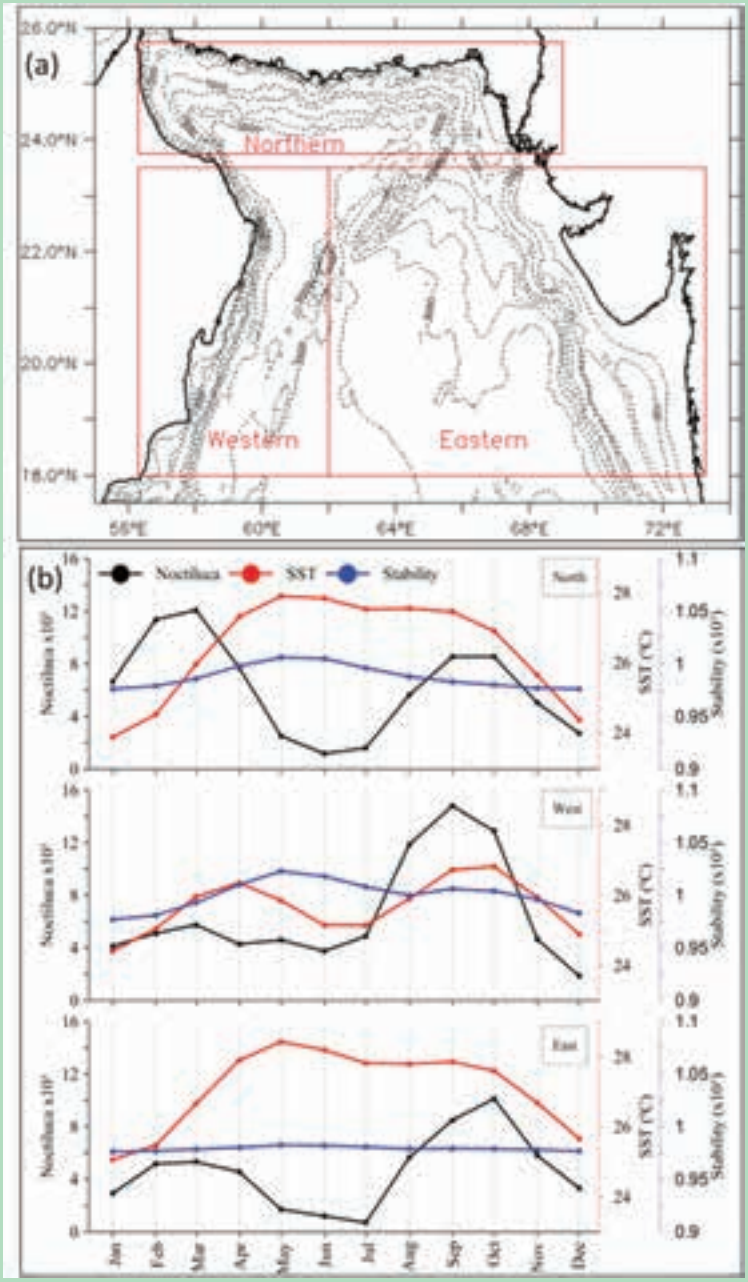
Spectral variability of remote sensing reflectance (Rrs) at individual sampling station in OC and SS of Chilika lagoon

Ref: Lotliker, A.A., Sahoo, S., Baliarsingh, S.K., Parida, C., Sahu, K.C. Optical characterization and assessment of ocean colour algorithms in Chilika Lagoon (2016) Proceedings of SPIE - The International Society for Optical Engineering, 9878, art. no. 987813.

to 0.02sr^{-1} in OC whereas in SS it was between 0.003 and 0.028sr^{-1}. The minimum Rrs was at 400nm that gradually increased with a peak at 580nm and subsequently decreased towards longer wavelength. R_{rs} exhibited similar pattern in both the sectors from 400 to 600nm. Beyond this wavelength, R_{rs} was relatively higher in SS. The shifting of peak towards longer wavelength could be attributed to high absorption due to chlorophyll-a (chl-a) and chromophoric dissolved organic matter (CDOM) that varied largely between sectors with relatively higher concentration of chl-a in OC and CDOM in SS. Further, we modelled chl-a by seven ocean colour algorithms (OC4, OC4E, OC4O, OC3M, OC3V, OC3C and OCMO2) using in situ Rrs. The modelled chl-a was overestimating in situ at all stations due to high concentration of CDOM contaminating chl-a signals. However in OC, in situ and modelled chl-a followed the same trend (R^2=0.88 to 0.90) probably due to strong co-variance of chl-a with CDOM. The analysis of this study points out towards the requirement for sector specific bio-optical algorithm for accurate chl-a retrieval for synoptic monitoring of lagoon health.

8.8 Algal species dynamics in North Arabian Sea

Northern Arabian Sea experiences massive proliferation of variable algal species. The variability of Noctiluca bloom and its association with hydrographic parameters such as sea surface temperature (SST) and water column stability were studied using satellite data pertaining to a decade in the Northern Arabian Sea. The study area was divided into three regions as North, West and East to assess the frequency of Noctiluca blooms. The Noctiluca dominated areas were extracted based on slope of monthly Remote Sensing Reflectance (Rrs) derived from the MODIS-A data between



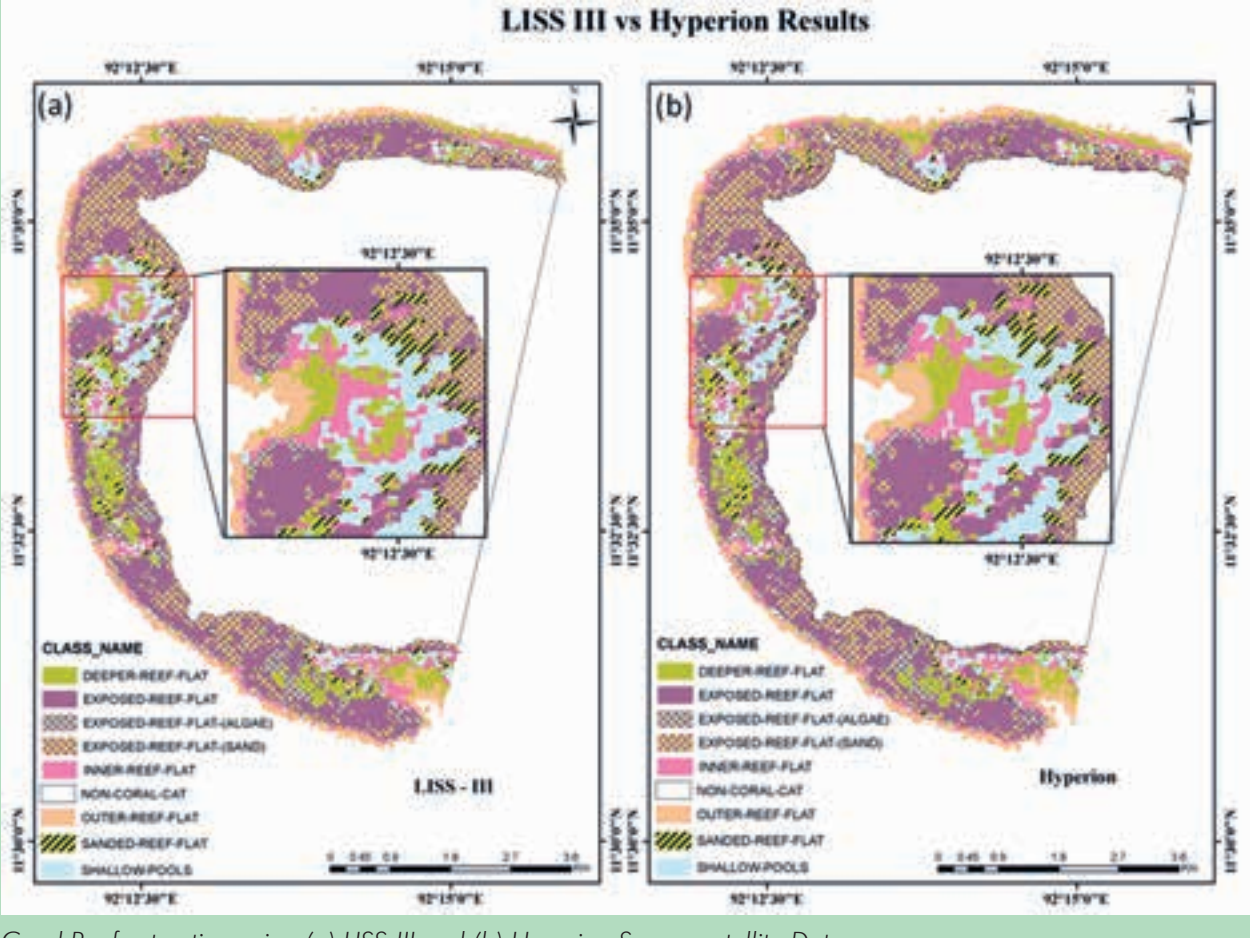
Monthly climatology, computed over (a) Western, Eastern and Northern (red box) part of study area (b) The variability of Noctiluca, Sea Surface Temperature (SST) and Water Stability at North, West and East part during 2005 to 2014.

Ref: Mohanty, P.C., Lotliker, A.A., Baliarsingh, S.K., Mahendra, R.S., Kumar, T.S. Algal species dynamics in North Arabian Sea using long term ocean colour satellite data (2016) Proceedings of SPIE - The International Society for Optical Engineering, 9878, art. no. 987812,

wavelengths 488 to 443 nm and 488 to 531nm. It is observed that there is a bi-modal distribution at an annual scale in the occurrence of Noctiluca, with the dominance in the northern region during winter monsoon (February-March). Higher frequency of Nuctiluca was recorded during post monsoon period in southern parts of the study area, western Arabian Sea was recorded high frequency during September month and with one month lag eastern area was recorded higher frequency during October month in the eastern area. The periodicity of Noctiluca occurrence was carried out using Fourior analysis shown predominant frequency at annual scale in northern area and semi-annual scale in western and eastern areas. This study suggests that the Noctiluca bloom in the northern region is primarily triggered by winter mixing, whereas, the Noctiluca bloom is associated with cumulative influence of summer upwelling and winter mixing in the eastern and western regions of the study area.

8.9. Identification of Coral Reef feature using Hyper-spectral remote sensing

The coral reef zones along the Sentinel Island of Andaman were mapped using hyper spectral imagery of Hyperion sensor onboard NASA's Earth Observation-1 (EO1) satellite. The Coral Reef Zones (CRZ) were extracted based on threshold limits using slope of spectral signature between 782.95nm band from 579.45nm band of Hyperion imagery. Both of these bands were chosen due to their property of exhibiting maximum spectral contrast that determines threshold limits to



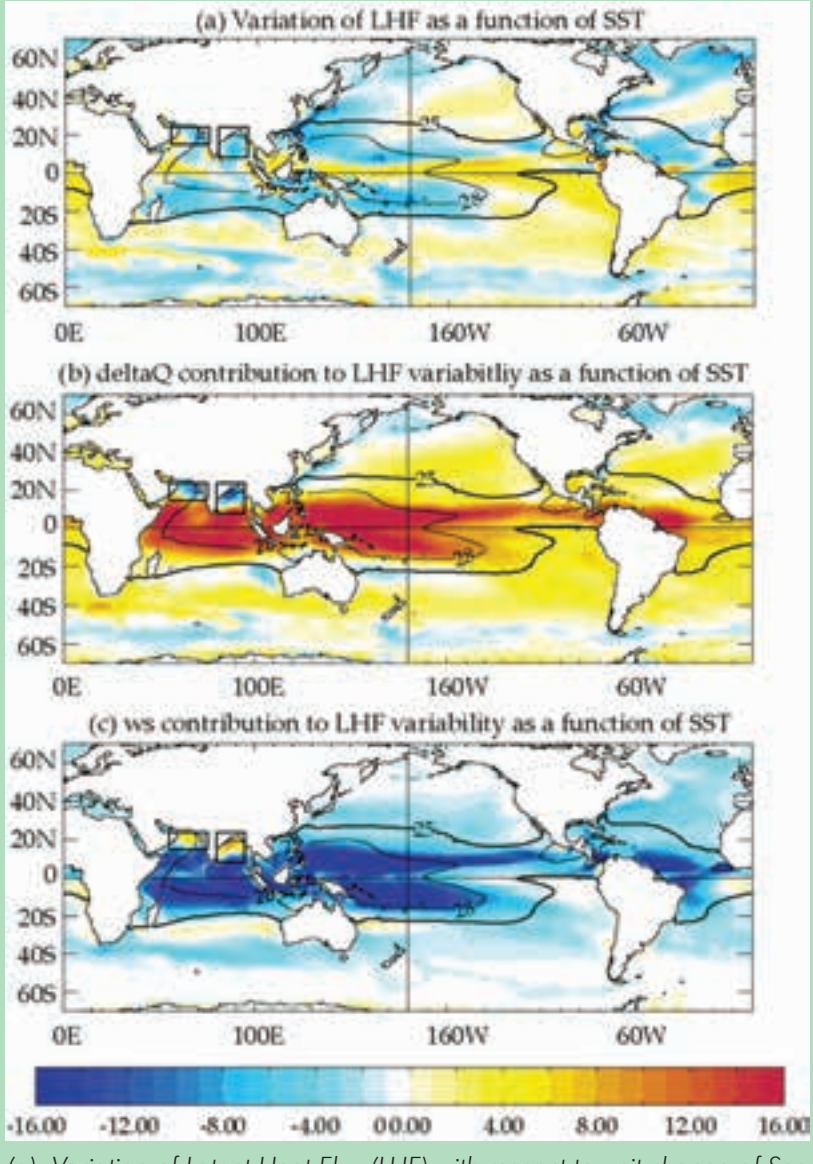
Coral Reef extraction using (a) LISS-III and (b) Hyperion Sensor satellite Data

Ref: Mohanty, P.C., Panditrao, S., Mahendra, R.S., Shiva Kumar, H., Srinivasa Kumar, T. Identification of coral reef feature using hyperspectral remote sensing (2016) Proceedings of SPIE - The International Society for Optical Engineering, 9880, art. no. 98801B,

distinguish a coral area from its non-coral counterpart. That the CRZs extracted were matching well with the earlier base map (manual method) published by INCOIS and SAC, Ahmadabad using the LISS-III data. It was also shown that new approach can be adopted for the routine operational mapping and monitoring the changes in the coral environs.

8.10. Latent heat flux sensitivity to sea surface temperature

A global analysis of Latent Heat Flux (LHF) sensitivity to Sea Surface Temperature (SST) suggested a unique relationship in the North Indian seas. Generally, over the global oceans, an increase in SST causes convergence that weakness the surface winds and subsequently decreases the LHF loss, suggesting a dominant role by the dynamic (wind driven) processes. Since the air-sea temperature gradient is generally large (~1°C) over global oceans (and hence the humidity gradient), the increase or decrease of SST do not produce adequate changes in the air-sea humidity gradients to have a large response from thermodynamic (humidity driven) processes. But Bay of Bengal and Northern Arabian Sea remain an exception. In these basins, air-sea temperature (and humidity) gradients are large during winter and minimum during summer. This suggests that as the SST increases from winter to summer, the air-sea humidity gradient decreases to a minimum value, beyond which any increase in monsoonal winds are not adequate to produce more latent flux loss. Hence in these two basins, the thermodynamic processes (humidity driven) control the LHF variability.

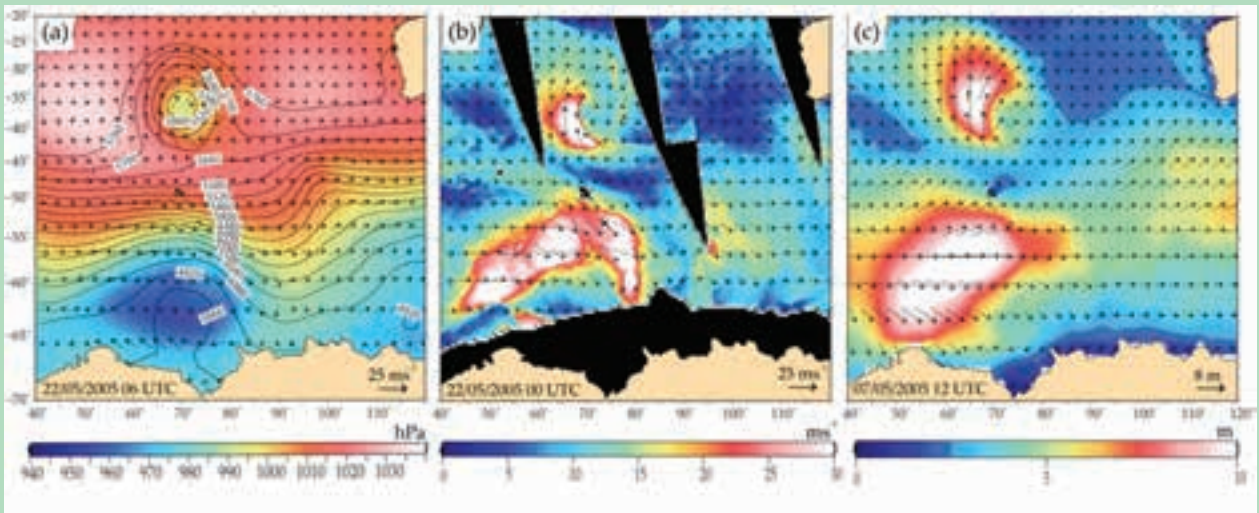


(a) Variation of Latent Heat Flux (LHF) with respect to unit change of Sea Surface Temperature (SST), (b) thermodynamic contribution of humidity gradient variation associated with unit SST change on LHF change and (c) dynamic contribution of wind speed variation associated with unit SST change on LHF change. Mean SST contours for 25°C and 28°C are marked in the three figures. Unit of shaded values is W/m²/°C.

Ref: Praveen Kumar, B., Cronin, M.F., Joseph, S., Ravichandran, M., Sureshkumar, N. Latent heat flux sensitivity to sea surface temperature: Regional perspectives (2017) Journal of Climate, 30 (1), pp. 129-143.

8.11. High swell in North Indian Ocean and Southern Ocean cut-off low

High waves, without any sign in the local winds, sometimes cause severe flooding events along the south-west coast of India, locally known as the Kallakkadal events and cause major societal problems along the coasts. The link between North Indian Ocean (NIO) high swell events and the meteorological conditions in the Southern Ocean (SO) was explored using a combination of in-situ measurements and model simulations for the year 2005. In-situ observations report ten high swell events in NIO during 2005. It was shown that these events are caused by swells propagating from south of 30°S. In all cases, 3-5 days prior to the high swell events in NIO, it was observed that a severe low pressure system, called the Cut-off Low (COL) in the SO. These COLs were quasi-stationary in nature, providing strong (~25 ms^{-1}) and long duration (~3 days) surface winds over a large fetch; which are the essential conditions for the generation of long period swells. The intense winds associated with COLs in the SO triggered the generation of high waves which propagated to NIO as swells. Furthermore, these swells, upon reaching the coast, depending on the local topography, angle of incidence and tidal conditions, cause high wave activity and sometimes Kallakkadal along the NIO coastal regions. Study showed that such natural hazards along NIO coasts can be effectively monitored and predicted at least 2 days in advance, if the meteorological conditions of the SO are properly monitored.



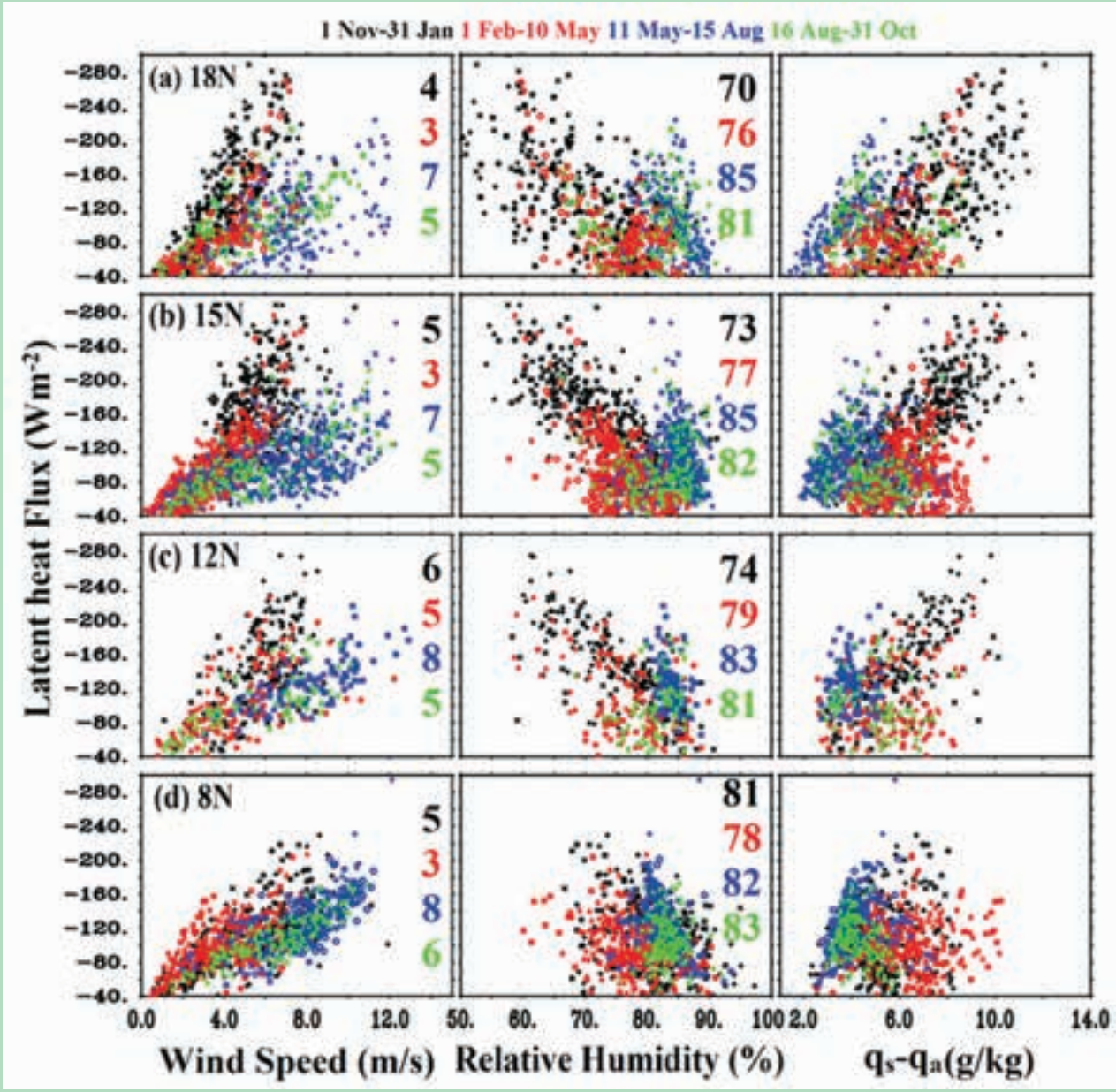
Maps utilised to identify COLs during 22 May 2005. (a) Geopotential Height at 500 hpa (contours), sea level pressure (shaded) and surface wind (vector). (b) Surface wind fields (shade and vectors) from QuikSCAT scatterometer. (c) Maps of Hs (vector shows the direction) shows wave propagation from COL region.

Ref: Remya, P.G., Vishnu, S., Praveen Kumar, B., Balakrishnan Nair, T.M., Rohith, B. Teleconnection between the North Indian Ocean high swell events and meteorological conditions over the Southern Indian Ocean (2016) Journal of Geophysical Research: Oceans, 121 (10), pp. 7476-7494.

8.12. What controls seasonal evolution of sea surface temperature in the Bay of Bengal?

Continuous time series measurements of near surface met-ocean variables obtained from Research Moored Array for African-Asian-Australian Monsoon Analysis and Prediction (RAMA) moorings at 15°N, 90°E; 12°N, 90°E and 8°N, 90°E and Ocean Moored buoy Network for Northern Indian Ocean (OMNI) mooring at 18°N, 90°E were used to understand the air-sea interaction processes

and mixed layer (ML) temperature variability in the Bay of Bengal (BoB) at seasonal time scales. The analysis showed that the ML heat balance is primarily controlled by net surface heat flux. The penetrative component of shortwave radiation plays a crucial role in the ML heat budget in the BoB, especially during the spring warming phase, the period of a thin ML. During the winter and summer, vertical processes make significant contributions to the ML heat budget. During winter, the presence of a strong barrier layer and a temperature inversion with warmer water below the ML leads to warming of the ML by entrainment of warm subsurface water into the ML.



Scatter plots of latent heat flux (Wm^{-2}) with wind speed (ms^{-1}; left) relative humidity (%; middle) and air-sea specific humidity difference (qs-qa; g/kg; right) during different seasons (black (1st November to 31st January), red (1st February to 10th May), blue (11th May to 15th August) and green (16th August to 31st October) at the buoy location ((a) 18°N, 90°E (WHOI data), (b) 15°N, 90°E (c) 12°N, 90°E and (d) 8°N, 90°E) in the BoB. The number in the left and middle panel indicates seasonal (winter, spring, summer and fall; top to bottom) average of wind (m/s) and relative humidity (%) respectively at each buoy location.

Ref: Thangaprakash, V.P., Girishkumar, M.S., Suprit, K., Suresh Kumar, N., Chaudhuri, D., Dinesh, K., Kumar, A., Shivaprasad, S., Ravichandran, M., Farrar, J.T., Sundar, R., Weller, R.A. What controls seasonal evolution of sea surface temperature in the Bay of Bengal?: Mixed layer heat budget analysis using moored buoy observations along 90°E (2016) Oceanography, 29 (2), pp. 202-213.

During summer, the barrier layer is relatively weak and the ML is warmer than the underlying water (i.e., no temperature inversion). Hence, ML entrainment cools the surface layer. The contribution of horizontal advection to the ML heat budget is most prominent during winter when advection serves to warm the upper ocean.

8.13. List of Research Papers Published from ESSO-INCOIS (April 2016 - March 2017)

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6. Basheer Ahammed K.K., Mahendra R.S., Pandey A.C. Coastal Vulnerability Assessment for Eastern Coast of India, Andhra Pradesh by Using Geo-Spatial Technique (2016) Geoinformatics & Geostatistics: An Overview, 4 (3), pp. 1-8.
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11. Das, S., Hazra, S., Lotlikar, A.A., Das, I., Giri, S., Chanda, A., Akhand, A., Maity, S., Srinivas Kumar, T.S. Delineating the relationship between chromophoric dissolved organic matter (CDOM) variability and biogeochemical parameters in a shallow continental shelf (2016) Egyptian Journal of Aquatic Research, 42 (3), pp. 241-248.
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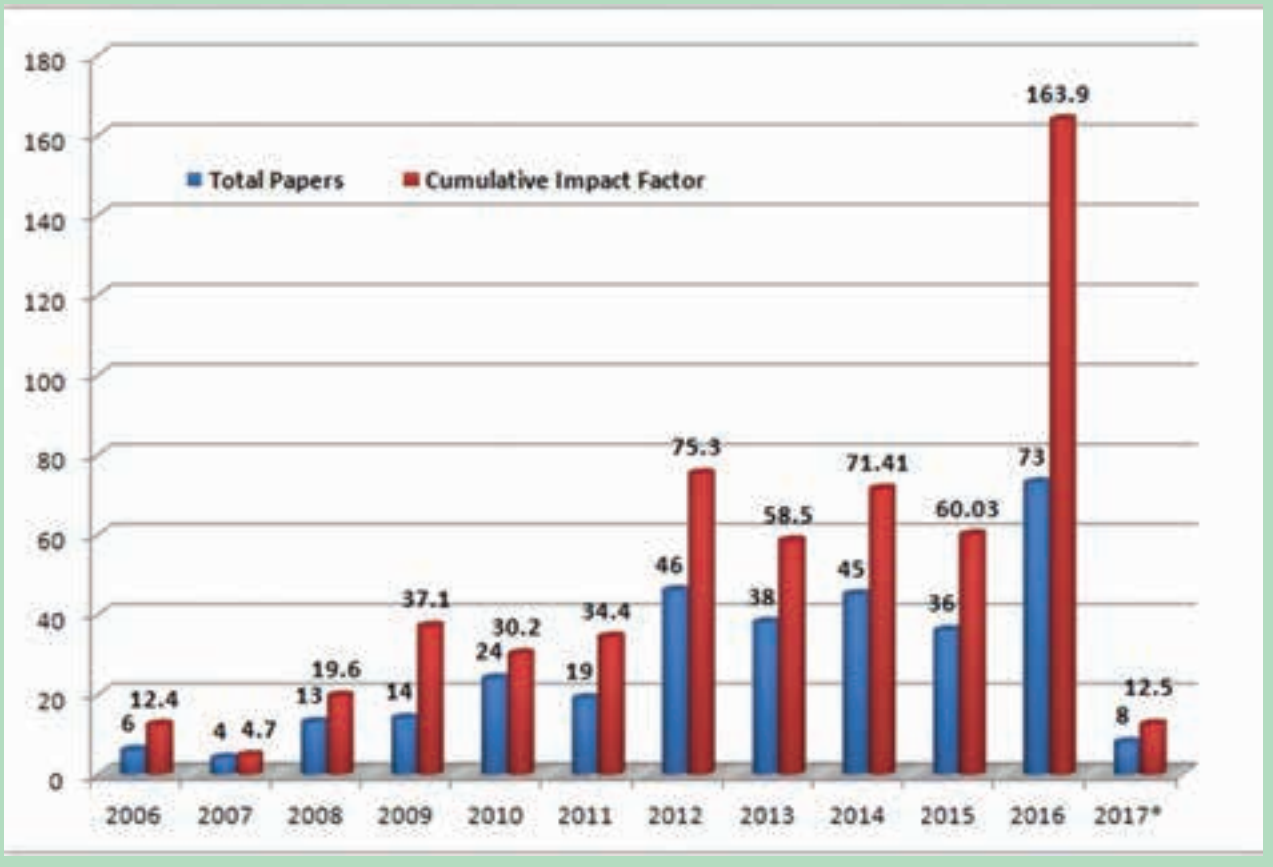


Graph depicting the growth in the number of publications and total impact from ESSO-INCOIS

8.14. List of Technical Reports Published from ESSO-INCOIS (April 2016 - March 2017)

1. Jithin, AK and Francis, PA and Chatterjee, A and Suprit, K and Fernando, V (2017) Validation of the simulations by the High-resolution Operational Ocean Forecast and reanalysis System (HOOFS) for the Bay of Bengal. Technical Report No. ESSO-INCOIS-ISG-TR-01(2017).
2. Padmanabham, J. and Naga Swetha and Krishna Prasad, B. and Venu Gopal Rao V. and Nagaraja Kumar, M. (2016) Dissemination of Tsunami Early Warning, alerts and other services of INCOIS using IRNSS Technical Report No. ESSO-INCOIS-ASG-TR-01(2016).
3. Udaya Bhaskar, TVS and Shesu, RV and Boyer, Timothy P and Rama Rao, EP (2016) Argo data quality control based on climatological convex hulls. Technical Report No. ESSO-INCOIS-DMG-TR-03 (2016).
4. Dwivedi, R and Lotlikar, AA and Kumar, TS and Shenoi, SSC (2016) Study of spatial-temporal variations in the green Noctiluca scintillans and diatom blooms in the Arabian Sea using MODIS data. Technical Report No. ESSO-INCOIS-ASG-TR-04 (2016).
5. Satish, RUVN and Suresh Kumar, N and Udaya Bhaskar, TVS and Ravichandran, M and Dinesh, K and Ashok, Kumar (2016) New Metrics for the Assessment of Quantity and Quality of the data returned by Argo floats. Technical Report No. ESSO-INCOIS-MOG-TR-05 (2016).
6. Lotliker, AA and Baliarsingh, SK and Srinivasa Kumar, T (2016) Satellite Coastal and Oceanographic Research Inter-comparison Exercise (SICOME). Technical Report No. ESSO-INCOIS-ASG-TR-06 (2016).
7. Dwivedi, R and Priyaja, P and Baliarsingh, SK and Srinivasa Kumar, T and Shenoi, SSC (2016) Basin-scale retrieval of zooplankton using split algorithm and MODIS data in the Arabian Sea. Technical Report No. ESSO-INCOIS-ASG-TR-07 (2016).
8. Ajay Kumar, B and Devi, EU and Sunanda, MV and Patanjali Kumar, CH and Padmanabham, J and Kiran Kumar, N and Srinivasa Kumar, T (2016) Assessment of Tsunami Preparedness in East Coast of India through Mock drill conducted on 26 September, 2015. Technical Report No. ESSO-INCOIS-ASG-TR-08 (2016).
9. Rose P, Bright and Swetha, N and Baliarsingh, SK and Nimit, K and Nagaraja Kumar, M and Srinivasa Kumar, T and Dwivedi, R and Shenoi, SSC (2016) Following tagged Yellowfin tuna along the east coast of India explains its feeding behavior: a case study in the Bay of Bengal. Technical Report No. ESSO-INCOIS-ASG-TR-09 (2016).
10. Kameshwari N and Uday Bhaskar TVS and Suprit Kumar and Rama Rao E.P. (2016) Marine Meteorological Atlas of Tropical Indian Ocean. Technical Report No. ESSO-INCOIS-DMG-TR-10 (2016).
11. Dwivedi, R and Baliarsingh, SK and Lotliker, AA and Kumar, TS and Shenoi, SSC (2016) An optical approach for synoptic monitoring of red Noctiluca scintillans bloom and its associates from space. Technical Report No. ESSO-INCOIS-ASG-TR-11(2016).
12. Satish, RUVN and Vivekananda Swamy, M and Udaya Bhaskar, TVS and Girishkumar, MS (2016) Android App for Argo Floats. Technical Report No. ESSO-INCOIS-MOG-TR-12 (2016).

9. Computational Facilities and Web Based Services

9.1. Computing Infrastructure

INCOIS hosts state-of-the-art computational facilities which include a high performance computer and its allied infrastructure, 300 TB storage, ERP servers, FTP server, web and application servers, Live Access Server, workstations, desktops, laptops, link load balancers, application load balancers, firewalls, core switches, edge switches and a 30 km long campus-wide networking. The network and the infrastructure is set up in such a manner that no single point failure can affect operational services. INCOIS continues to maintain a computing and network infrastructure with an up-time of 99% to support operational and R&D activities. Procurement of a new HPC facility, as replacement for old HPC, for the operational and R&D activities was initiated. Hardware solutions for the implementation of the 'Digital Ocean' project and 'Integrated Dissemination System' project are also finalized.

9.2. Web Based Services

The website of INCOIS has matured as a prime vehicle for providing ocean data, information and advisory services such as potential fishing zone, ocean state forecast, Indian Argo, Indian Ocean Global Ocean Observing System, etc. to all stakeholders and the global community. The web-based online delivery system facilitates the user with multi-lingual and WebGIS capabilities to query, analyze, visualize and download the ocean data, information and advisory services on different spatial, temporal resolutions and for their regions of interest. Development of various web applications and periodical updates of website are being carried out both in terms of information and facilities, based on the feedback from the user community. The INCOIS website uses a responsive layout design, which enables access through a wider range of web browsers and devices, including mobiles and tablets.

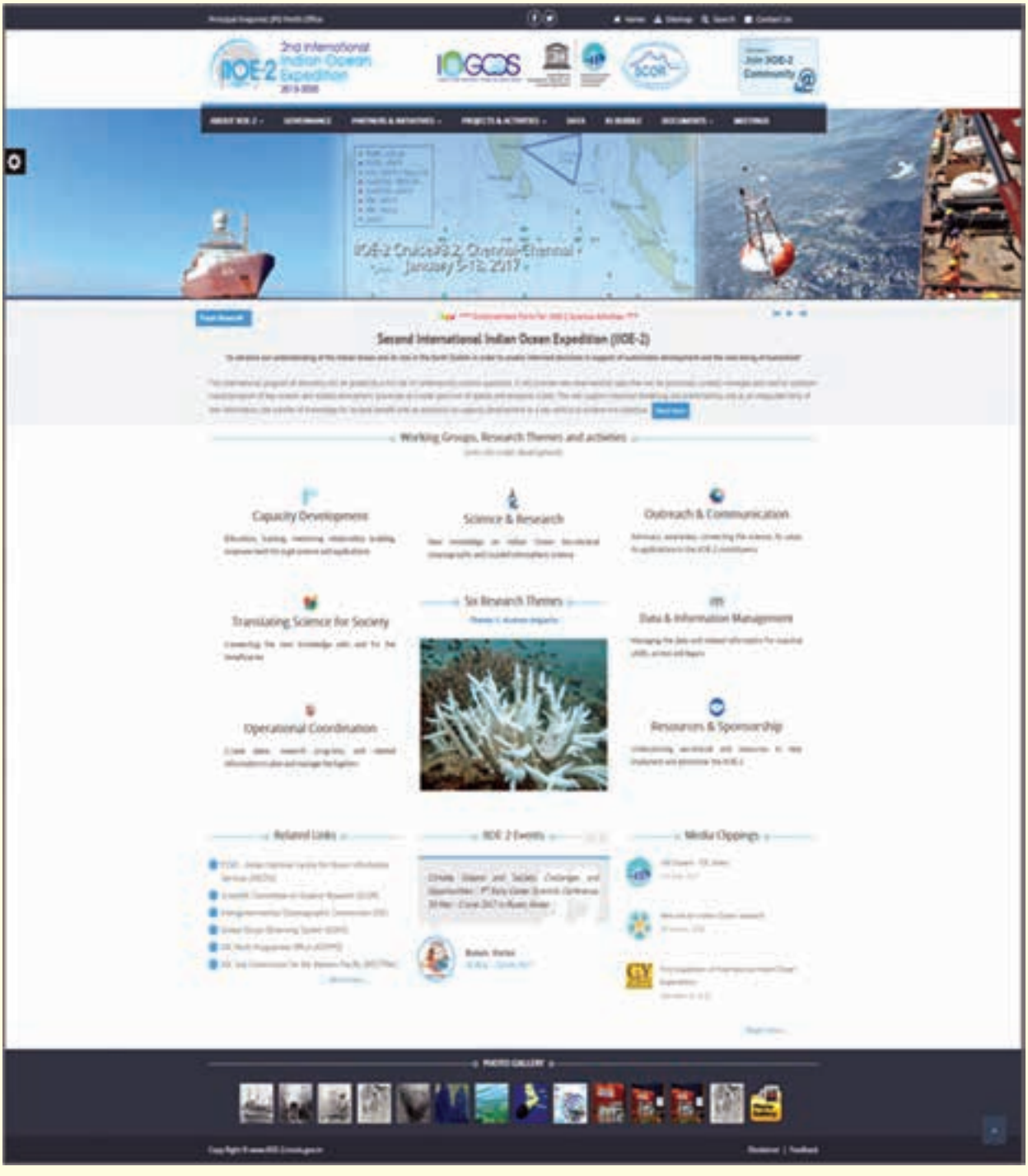
9.3. Web Services for IIOE-2

INCOIS developed a web portal for the activities pertaining to the International Indian Ocean Expedition-2 (IIOE-2), a global initiative co-sponsored by the IOC, IOGOOS and SCOR. The joint programme office of IIOE-2, is hosted at INCOIS. The website developed by INCOIS provides a user-friendly environment for the presentation of various activities under IIOE-2 and their progress. The responsive layout of the website makes it accessible through a wide range of web browsers and devices, including mobiles and tablets. All activities related to the updation and management of the web portal are handled on a daily-basis by INCOIS. In addition, the website also hosts the IIOE-2 community database and the dissemination of IIOE-2 monthly Newsletters.

IIOE-2 website can be accessed at http://www.iioe-2.incois.gov.in.

Some of the other notable activities during this period are as below:

- Development of an Online Recruitment Application for various posts at INCOIS, NCAOR & NCESS.
- Integration and hosting of RSS feeds for High Wave and Wave Surge Alerts.
- Enhanced display of Real-time Wave Comparisons together with Weather Observations.
- Development of a login-based One Time Registration (OTR) ITCOocean Online Application to apply for Training Courses.
- Design and development of an Enhanced Version of NTWC Warning Status Reporting Form.



A snapshot of IIOE-2 Website

10. Capacity Building Training and Outreach

INCOIS conducted 8 training courses during 2016-17 under the aegis of ITCOocean in different fields of operational oceanography and 1 training related to SATCORE.

10.1 International Training Centre for Operational Oceanography (ITCOocean)

1. The Ocean Teacher Global Academy /IODE- Inter-governmental Oceanographic Commission course on *"Discovery & Use of Operational Ocean Data Products & Services"* was organised at ITCOocean from 6-10 March 2017. There were 18 participants from Vietnam, Oman, Iran, Bangladesh, China and India. Availability of data resources was demonstrated with a special focus on analysis of upwelling/download and visualization of data for operational activities. Faculty from ESSO-INCOIS conducted the course.

2. A training course on *"Ocean Data and Information System - Data and Applications"* was held during 5-7 December 2016. The course benefited over 25 post-graduate students from various IITs (Indian Institute of Technology; Delhi, Kharagpur, Bhubaneshwar). A mix of theoretical and practical sessions were included to address various aspects of data collection as well as processing and analysis of in situ and satellite data. ESSO-NIOT and ESSO-INCOIS conducted the course.

3. During 7-11 November 2016, a training course on *"Indian Ocean Currents: Data, Processing and Applications: ITCOocean"* was held to introduce the basics of processing,

quality control and analysis of currents from ADCPs and HF Radars. Use of data sets on ocean currents, in different applications was also demonstrated. Twenty-two trainees from national institutes participated. Course faculty was drawn from CSIR-NIO, ESSO-NIOT and ESSO-INCOIS.

4. The *International Winter School- "Operational Oceanography: Indian Ocean Circulation & Sea Level Variation"* organized by ITCOocean, ESSO-INCOIS in collaboration with the Nansen Scientific Society and Nansen Environmental and Remote Sensing Centre (NERSC), Bergen, Norway and Nansen Environmental Research Centre India (NERCI), Kochi, was held during 16-21 October 2016. Focus topics included monsoon variability at intra-seasonal and inter-annual time scales and its impact on Indian Ocean circulation, operational Indian Ocean circulation and modelling, data assimilation for ocean forecasting, the Nansen-Topaz modelling system, physics of sea level variations and Indian Ocean sea level variation. Twenty-six participants from Cameroon, South Africa, Bangladesh, Norway, Sri Lanka, France, Russia and India attended the course. Course faculty was drawn from NERSC, NERCI, TIFR and ESSO-INCOIS.

5. The ITCOocean training course "Regional Training for Capacity Development in Multi-Hazard Early Warning Systems" was held during 19-23 September 2016. This course focussed on building the capacity of the member States of the WMO/ESCAP Panel on Tropical Cyclones (PTC) and ESCAP/WMO Typhoon Committee (TC) with respect to

multi-hazard early warning and was organised to cater to senior/mid-level professionals with operational responsibilities from National Hydro-meteorological Departments and Disaster Management Authorities from PTC and TC member States. There were over 20 participants from Republic of Korea, Sri Lanka, Vietnam, Cambodia, Myanmar, Thailand, Maldives, Bangladesh and India.

6. Around 60 participants from India as well as foreign countries (Iran, Bangladesh, Vietnam, Morocco, Mozambique, Egypt, and Saudi Arabia) participated in the ITCOocean course on *"Emerging Trends in Ocean Observations and Ocean Data Analysis"* held during 4-15 July 2016. The course addressed better utilization practices and techniques using high quality data sets to provide better operational oceanographic services. Renowned scientists from the Applied Physics Laboratory and School of Oceanography, University of Washington, USA, Department of Physical Oceanography, Woods Hole Oceanographic Institution (WHOI), USA as well as scientists from Indian Institute of Science, Indian Institute of Tropical Meteorology and ESSO-INCOIS served as faculty for the course.

7. Thirty participants from national-level institutes benefited from the ITCOocean Course on *"Tides and Tidal Data Analysis"* held during 13-17 June 2016. The course introduced the basics of physics of tides and the methods of tidal data analysis. Faculty from CSIR-NIO and ESSO-INCOIS conducted the course.

10.2. SATCORE Training Programme

SATCORE training programme for research scholars on "Analytical techniques of macronutrients, dissolved oxygen and aerosol optical properties" was organised during 6-13 October 2016 in Berhampur University, Odisha. Lectures on the fundamentals of macro-nutrient and dissolved oxygen distribution characteristics in coastal and offshore waters were presented. Hands-on laboratory exercises included standard and stock solution preparation, factor determination, analytical techniques of different inorganic macronutrient analysis and experimental precautions and data quality assessment. Lectures on the fundamentals of aerosol optical properties, demonstration of sunphotometer measurement, field measurement, data analysis and result interpretation were

also arranged. Twelve participants from eight institutes/universities participated in this training programme.


Participants of training program (left) and sunphotometer validation exercise (right)

10.3 Workshops/Meetings

a. India-Bangladesh Scoping Workshop

A comprehensive joint workshop focussing on 'Maritime Cooperation and Blue Economy' was held during 3-4 October, 2016. It was attended by 10 Bangladeshi and 15 Indian representatives from several marine research related institutions. Focus topics included strengthening of research collaboration and support with respect to operational marine services etc.

b. Meeting of UK Science & Innovation Network in India

A seven-member delegation from the United Kingdom visited ESSO-INCOIS and discussed about sharing of expertise, capacity building opportunities and collaborative research in the field of operational oceanography on 23 February 2017 at ESSO-INCOIS. The visit was organized by UK Science & Innovation Network in India.

11. International Interface

11.1 IOGOOS (Indian Ocean Global Ocean Observation System) Secretariat

The Indian Ocean Global Ocean Observing System (IOGOOS) regional alliance plays a key role in providing oversight for sustained ocean observations as part of the Global Ocean Observing System (GOOS) and related physical, biogeochemical, biological and climate research. Over 27 organizations from 15 countries are members. The IOGOOS secretariat hosted at ESSO-INCOIS, is responsible for project management and coordination activities. M. Nagaraja Kumar, Scientist-E, ASG serves as Secretary, IOGOOS.

IOGOOS and its science alliances (CLIVAR/IOC-GOOS of the Indian Ocean Region Panel – IORP, IMBER/IOGOOS alliance of the Sustained Indian Ocean Biogeochemistry and Ecosystem Research - SIBER, and the Indian Ocean Observing System Resources Forum of IOGOOS –IRF) held their annual meetings during 30 January to 4 February 2017 in Perth, Australia. The IOGOOS Bio-Argo Workshop was also held in Perth on 2 February 2017 with an aim to unite Indian Ocean researchers interested in Bio-Argo observations. Satya Prakash Scientist 'D' and T.V.S. Udaya Bhaskar Scientist 'E' represented ESSO-INCOIS at the workshop and meeting. S.S.C. Shenoi, Director, ESSO-INCOIS was elected as the chair of IOGOOS.

11.2. The Indian Ocean Observing System (IndOOS)

The Indian Ocean Observing System (IndOOS) was implemented to understand the role of the Indian Ocean in the global climate system. IndOOS data is used to address societal and economic needs, in weather and climate forecasting and in the production of routine ocean state maps, re-analyses and predictions. Along with US, Japan, Australia and other countries, India is a major contributor in the implementation of Indian Ocean observing systems. To focus on the resources

of individual nations and to achieve a coherent completion of the IndOOS plan, in particular to sustain the observing system and to build capacity with respect to participating agencies the IndOOS Review meeting was hosted by UNESCO – Intergovernmental Oceanographic Commission (IOC) in Perth, Australia in February 2017. From ESSO-INCOIS, S.S.C. Shenoi, Director, ESSO-INCOIS, S. Rajan (Ex- Director, ESSO-NCAOR), Consultant Scientist and Satya Prakash Scientist 'D' contributed to the preparation of a plan and white paper for the IndOOS Review.

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

The SIBER International Programme Office has been hosted at ESSO-INCOIS since 2010. The office manages various activities such as organisation of annual Science Steering Committee (SSC) meetings and sharing of online updates along with management of the SIBER website. ESSO-INCOIS is represented in SIBER by Satya Prakash, Scientist 'D', ISG, who also manages the programme office. The annual meeting was held during 30 January to 4 February 2017 in Perth, Australia.

11.4 International Society for Photogrammetry and Remote Sensing (ISPRS)

ISPRS is an organization dedicated to enabling international cooperation for advancement of photogrammetry, remote sensing and related applications. E. Pattabhi Rama Rao, Head, DMG, INCOIS chairs the Working Group - IV/4 on Geospatial Data Infrastructure under the Technical Commission IV (Geospatial Databases and Location Based Services) during the inter-sessional period, 2012-16.

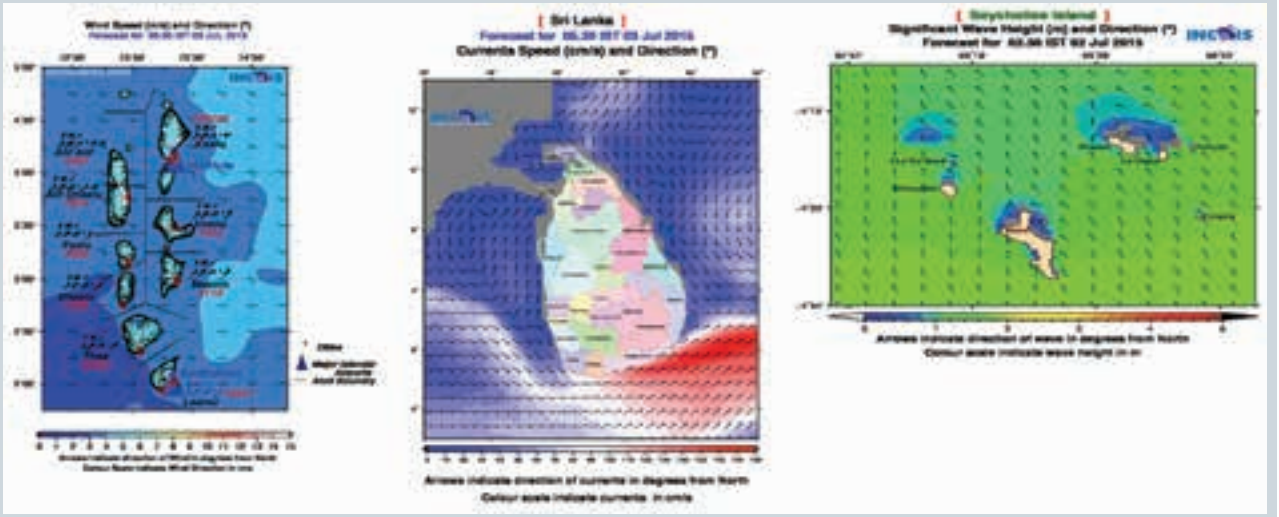
11.5 International Oceanographic Data Exchange

The programme "International Oceanographic Data and Information Exchange" (IODE) of the "Intergovernmental Oceanographic Commission" (IOC) of UNESCO was set up in 1961 to enhance marine research, exploitation and development, by facilitating the exchange of oceanographic data and information between participating member states. IODE designated ESSO-INCOIS as the responsible National Oceanographic Data Centre (NODC) for India a structural element of IODE in 2004. E. Pattabhi Rama Rao is the National Coordinator from India for 'Data Management' under the IODE Programme. He also serves on the Steering Groups on Ocean Biogeographic Information System (SG-OBIS) and IODE Quality Management Framework (SG-IODE QMF).

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

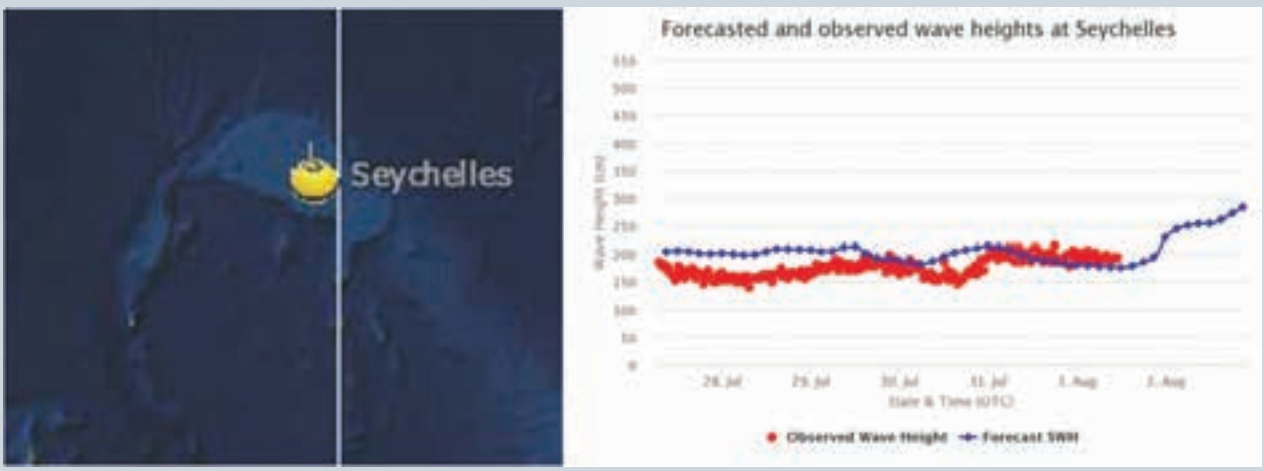
RIMES is an intergovernmental, non-profit registered with the United Nations, aiming to provide

regional early warning services and to build the capacity of its Member States in 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 INCOIS are being provided to Seychelles, Sri Lanka and the Maldives in the Indian Ocean on a daily basis.



Left to Right: Samples of Ocean State Forecasts for Maldives, Sri Lanka and Seychelles provided by ESSO-INCOIS.

A wave rider buoy was deployed off-the coast of Seychelles in coordination with RIMES and the Seychelles National Meteorological Services (SNMS) in April 2016. T. M. Balakrishnan Nair Scientist 'F' and Head, ISG represented ESSO-INCOIS at the recent RIMES meeting in Bangkok, Thailand during 14-15 January 2017.



Location of Wave Rider Buoy deployed off Seychelles (Left), Wave forecast for Seychelles is compared with observation (Right)

11.7 OceanSITES

OceanSITES is a global time series programme which is a recognized component of the Global Ocean Observing System and part of the international JCOMM. 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). E. Pattabhi Rama Rao represents ESSO-INCOIS on the OceanSITES Data Management Team. The OceanSITES Data Management

Team has developed the data management system with appropriate standards, formats and quality control considering the time series data from oceans.

11.8 Partnership for Observation of the Global Oceans (POGO)

POGO is a forum that was 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.

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

ICG/IOTWS was established by the Intergovernmental Oceanographic Commission (IOC) and coordinates implementation of the Indian Ocean Tsunami Warning System that is being established as a network of national systems. The network comprising of respective National Tsunami Warning Centres (NTWCs) of member states (which receive tsunami advisories from the Regional Tsunami Service Providers (RTSPs)) has the capability to issue regional tsunami bulletins for the Indian Ocean. The Indian Tsunami Early Warning Centre (ITEWC) operated at ESSO-INCOIS serves as one of the RTSPs for the Indian Ocean (serving over 23 countries). The Pre-IOWave16 Workshop on" Standard Operating Procedures for Tsunami Warning and Emergency Response for Indian Ocean Countries" was held during 9-13 May, 2016 in Melbourne, Australia. Srinivasa T. Kumar Scientist 'F' and J. Padmanabham Scientist 'C' represented ESSO-INCOIS in this meeting.

11.10 GODAE Ocean View

GODAE Ocean View is a group of scientists representing agencies which provide operational ocean forecasts and manage in situ and remote sensing observation platforms. This forum provides an excellent platform for these scientists to exchange their experiences and collectively carry out inter-comparison exercises of various ocean forecast and analysis products. ESSO-INCOIS has

been part of this group since October 2010 as a member of the science team. From July 2013 onwards, Director, ESSO-INCOIS joined as a member on the Patrons' Group of GODAE Ocean View which is responsible for guiding the GODAE Ocean View Science Team to attain various targets and for supporting the project office established in the UK Met Office.

ESSO- INCOIS hosted the 7th annual meeting of the GODAE Ocean View Science Team (GOVST) in Kochi during 7-11 November 2016. Around 40 scientists from 11 countries participated in this meeting. The meeting was inaugurated by Dr. M. Rajeevan, Secretary, MoES. Satheesh Shenoi, Director, ESSO-INCOIS and Abhisek Chatterjee, Scientist 'C' represented INCOIS, India as a patron and as the member of the GOVST forum, respectively. Several renowned scientists and young researchers in the field of operational oceanography from India delivered invited talks during this event.

11.11 International Indian Ocean Expedition-2 (IIOE-2)

The Second International Indian Ocean Expedition (IIOE-2) was launched with the first expedition in late 2015 during the IO50 International Symposium and will continue through to 2020. It is a major global scientific initiative seeking to build on the legacy of the first international Indian Ocean expedition IIOE (1957-65). IIOE-2 is co-sponsored by Intergovernmental Oceanographic Commission (IOC), the Scientific Committee on Oceanic Research (SCOR) and the Indian Ocean Global Observing System (IOGOOS), with ESSO-INCOIS spearheading Indian activities. Several international collaborative research programmes and outreach activities within the framework of a comprehensive Science Plan are proposed to be initiated under IIOE-2. Besides seeking to advance our understanding of the dynamics of the Indian Ocean and to determine how those dynamics affect climate, extreme events, ecosystems, and human populations, IIOE-2 activities are focused towards helping to build research capacity in the Indian Ocean rim countries and in motivating efforts to make the oceanographic data from the region more widely accessible to the scientific fraternity. Satheesh Shenoi, Director, INCOIS serves as one of three co-chairs of the IIOE-2 Steering Committee. A Joint Programme Office (JPO) of IIOE-2 is hosted at ESSO-INCOIS to coordinate the planned activities of this international. S. Rajan Retd. (Ex-Director, NCAOR) is the JPO-India coordinator. The Australian node of JPO is hosted at IOC, Perth Office.

A half-yearly newsletter "The Indian Ocean Bubble-2" is being published by ESSO-INCOIS on behalf of the IIOE-2 National Committee, aimed at encouraging informal exchange of ideas between scientists having a sustained interest in studies of the Indian Ocean. A monthly newsletter is also published to provide regular programme activity updates (http://iioe-2.incois.gov.in). The first in-person meeting of the Steering Committee (SC) of IIOE-2 was held at the Indian Ocean

Marine Research Centre, Perth, Australia during 2-4 February 2017. Satheesh Shenoi, Director, ESSO-INCOIS and S. Rajan attended this meeting.

11.12 Indian Ocean Panel

Indian Ocean Panel provides scientific and technical oversight for the implementation of the sustained ocean observing system for the Indian Ocean and coordinates research on the role of the Indian Ocean on the climate system. ESSO-INCOIS actively participates in this panel.

11.13 Union Commission on Data and Information (UCDI)

President of the International union of Geodesy and Geophysics (IUGG) with approval of the IUGG Bureau appointed S.S.C. Shenoi as the Chair of UCDI for a period of 3 years 2017-2019. The objective of UDCI is to enable a high-level cooperation within and between scientific communities to ensure the availability of modern data and information systems and services and to provide open access to the various data sets which are distributed globally.

12. Seminars, Lectures and Other Events

12.1 Guest Lectures

Dr. Divakarla Murty, National Oceanic and Atmospheric Administration (NOAA), United States delivered a lecture on "Joint Polar Satellite System (JPSS) Science Data Product Calibration and Validation" on 11 April 2016.

Dr. Prabhat Koner, NOAA Center for Weather and Climate Prediction (NCWCP), United States delivered talks on "Comparison of deterministic and stochastic inverse for remote sensing measurements" and "Improved qualities of satellite derived SST and cloud mask using deterministic methods on 12 and 13 April 2016.

Dr. Yann Krien, University of La Rochelle, France and Indo-French Cell for Water Sciences, IISc, Bangalore, India presented a lecture on "Storm surge dynamics in the head Bay of Bengal: contributions of tide-surge interactions and waves" on 11 July 2016.

Prof. Lakshmi H Kantha, University of Colorado presented a talk on: "Turbulent Mixing in the Oceans and the Atmosphere" on 15 July 2016.

Dr. K.S. Krishna, Chief Scientist, CSIR-NIO, Goa delivered a talk on "Rift architecture and sediment deposition on Eastern Continental Margin of India – new insights on margin evolution and Bengal Fan sedimentation" on 14 September 2016.

Dr. Amala Mahadevan, Woods Hole Oceanographic Institution, **Prof. Amit Tandon,** University of Massachusetts, Dartmouth and **Dr. Terri Paluszkiewicz** Ocean Naval Research, USA jointly delivered a lecture on "Mixed layer and stratification in the Bay of Bengal." on 23 September 2016.

Prof. Sulochana Gadgil, Honorary Professor, CAOS, Indian Institute of Science, Bangalore & Visiting Professor, Indian Institute of Tropical Meteorology, Pune presented a talk on "Model prediction of the monsoon of 2016: what went wrong? " on 6 October 2016.

Dr. C Gnanaseelan, Sr. Scientist, Indian Institute of Tropical Meteorology, Pune delivered a lecture on "New modes of variability in the Tropical Indian Ocean" on 7 December 2016.

Dr. Ibrahim Hoteit, Associate Professor, King Abdullah University of Science and Technology (KAUST), Saudi Arabia delivered a talk on "A Data-Driven Modelling System for Studying and Forecasting the Circulation and Climate of the Red Sea" on 2 February 2017.

12.2 ESSO-INCOIS Foundation Day

In connection with the 18th Foundation Day of ESSO-INCOIS, a special Open Day programme involving detailed interactions with scientists, was held on 3 February 2017. Over 640 visitors including students from 10 colleges and schools participated. This was followed by the Foundation Day Lecture on 13 February 2017 by Dr. P.M. Bhargava (Chevalier de la Legion d' Honneur), Founding Director of Centre for Cellular and Molecular Biology, Hyderabad on the topic "Science, Democracy and Secularism". After the lecture, winners of the ESSO-INCOIS Sports Tournament 2017 were felicitated.

13. General Information

13.1 Awards and Honours

13.1.1. Ministry of Earth Sciences Awards

During the Celebration of 10 Years of Ministry of Earth Sciences (2006-2016) & Foundation Day Function held at Vigyan Bhawan, New Delhi on 27 July 2016, Kunal Chakraborty, Scientist 'D' was awarded the Young Researcher Award-2016 and N. Kiran Kumar, Scientist 'D' was awarded the Certificate of Merit. Also, on the occasion, Dasari Prasad, Asst. Manager and C. Jeyakumar, Scientist Assistant 'B' were awarded Best Employee Awards-2016.

13.1.2. Fellow of Telangana Academy of Sciences

T. M. Balakrishnan Nair, Scientist 'F', Head, ISG, was elected as Fellow of Telangana Academy of Sciences in recognition of his contributions to Science & Technology.

13.1.3. Indian Society of Remote Sensing (ISRS) Award

M. Vijaya Sunanda, Scientist 'C' was selected as Young Achiever -2016 by Indian Society of Remote Sensing (ISRS). This award is presented every four years to a talented young scientist to enable participation in the ISPRS Congress. Accordingly, she participated in the ISPRS 2016 Congress, Prague during 12-19 July 2016.

13.1.4. Best Paper Presentation Award 2016 by TROPMET

Teesha Mathew, JRF, INCOIS won the best paper presentation award at the TROPMET-2016 conference which was held at Bhubaneswar during 18-21 December 2016. Her paper title was "Interannual variability of productivity in the Arabian sea as inferred from an Argo float".

13.1.5 Award of Honorary Doctorate

AMET University, Chennai awarded an Honorary Doctorate Degdree (Honoris Causa) to

Dr. S. S. C. Shenoi in recognition of exemplary services and contributions made in the maritime sector. The degree was awarded at the 6th Annual Convocation on 3 August 2016. He also delivered the Convocation Lecture.

13.1.6 National Geoscience Award

T. M. Balakrishnan Nair, Scientist 'F', Head, ISG, R. Harikumar, Scientist 'D', Francis P. A. Scientist 'E', and Sandhya K. G. Scientist 'D', received the National Geoscience Award -2014 instituted by Ministry of Mines, Govt. of India from Shri. Pranab Mukharjee, Hon'ble President of India, during a function held in Rashtrapathi Bhavan on 5 April 2016. The award was given to them in recognition of their outstanding contributions in developing the Ocean Forecast and Information System for India for maritime safety.

13.1.7 Awards related to Hindi Language promotion

ESSO-INCOIS was honoured with a special award presented by Hon'ble Member of Lok Sabha, Dr. Prasanna Kumar Patasani at the All India Rajbhasha Hindi Conference and Workshop, Kovalam, Trivandrum, Kerala (26-28 May 2016) organized by Parivartan Jan Kalyan Samiti, New Delhi, for implementation of the Official Language Hindi in administrative work, information dissemination etc.

K. K. V. Chary, Senior Manager, INCOIS and Chairman, Official Language Implementation Committee, INCOIS was specially honoured with

"Hindi Karyanvayan Ratna" at the All India Rajbhasha Hindi Conference and Workshop, Goa (3-5 October 2016) organized by Parivartan Jan Kalyan Samiti, New Delhi, for the best implementation of Official Language-Hindi in day to day administrative work of the institute.

13.2 Promotion of Hindi

In order to promote the usage of the Hindi language, the Official Language Implementation Committee, chaired by K. K. V. Chary, Sr. Manager, INCOIS organized three seminars during 2016-17.

- "Policy and Rules of Official Language" by Meenakshi Saxena, Hindi Officer, NRSC, ISRO, Hyderabad.
- "How to use Hindi Effectively" by Rishikesh Meena, PGT, Kendriya Vidyalaya, Secunderabad.
- "Geographic Information System" by Dr. H. K. Solanki, Assistant Professor, NIRD, Rajendranagar, Hyderabad.

Meenakshi Saxena, NRSC

Rishikesh Meena, Kendriya Vidyalaya

H. K. Solanki NIRD

A Hindi Pakhwara Progamme was conducted during 1-14 September 2016. The programme included competitions in Elocution, Essay Writing, Quiz etc. for staff and their families.

13.3 Independent Review of INCOIS Activties

In pursuance of the recommendations of the Expenditure Management Commission of the Department of Expenditure, Government of India, an Independent Peer-Review Committee was constituted by Secretary, Ministry of Earth Sciences (MoES) under the Chairmanship of Prof. Goverdhan Mehta, National Research Professor, University of Hyderabad to review the activities and performance of the Indian National Centre for Ocean Information Services (INCOIS), Hyderabad. The other members of the Committee were Prof. B. L. Deekshatulu, Distinguished Fellow, Institute for Development and Research in Banking Technology, Hyderabad, Dr. George

Joseph, Honorary Distinguished Professor, ISRO, Prof. A.K. Singhvi, Honorary Scientist, PRL, Dr. (Ms) B. Meenakumari, Chairperson, National Biodiversity Authority and Dr. K. Somasunder, Scientist-G, MoES as Member-Convenor. The committee met at INCOIS on 28th November 2016 and reviewed the activties of INCOIS and evaluated its performance.

Dr. S. S. C. Shenoi, Director made an in-depth presentation on the objectives and achievements of various programmes of INCOIS since its inception including highlighting how INCOIS progressed keeping view of its vision and mission and for the purpose for which INCOIS was established as an autonomous Centre. The budget, human resources and infrastructure development was also presented. He also outlined some of the new initiatives and presented a road map for their implementation, budget performance, manpower deployment, infrastructure development and related items. The details of the Indian Tsunami Early Warning System- a responsibility entrusted to INCOIS in the aftermath of the catastrophic tsunami in 2004- and the establishment of the International Training Centre for Operational Oceanography (ITCOocean) following an MoA with the Intergovernamental Oceanographic Commission/UNESCO in 2013 were emphasised. Following the presentation by the Director, brief presentations on the significant achievements of various major initiatives of the Centre such as Ocean Observations and Data Management, Ocean Modelling, Potential Fishing Zone Advisory Services and Ocean State Forecast were made by concerned scientists. After the presentations, the Committee visited different laboratories and facilities at INCOIS and had extensive interactions with concerned personnel. Committee also witnessed live demonstrations on some of the activities. The visit was followed by an 'Ideation Meeting' with the scientists and other staff of INCOIS on their plans and aspirations for the coming years/decade.

In its report submitted to Secretary, MoES, the Committee noted that INCOIS has delivered exceptionally well in terms of the objectives set at the time of its establishment and its achievements are commendable. It also noted that, in addition to its initial mandate, the Centre has taken up new programmes to address some of the contemporary scientific and technological challenges, such as establishment of Tsunami Early Warning System, International Training Centre for Operational Oceanography, focused R&D activities in the field of oceanography, etc.

The Committee recommended that the ongoing programmes of INCOIS need to be continued and sustained with enhanced ocean observational network, improvements to the ocean information and advisory services through ocean modelling activities supported by the state-of-the-art computational and communication facilities and advances in information and communications technology. The Committee suggested that INCOIS may consider augmenting its Mission Mandate further to accommodate some of the emerging challenges to address the issues on Climate Change and Future Earth, Blue Economy, etc. The committee also recommended that in the interest of its scientific and applications potential, INCOIS should continue as an autonomous R&D institution. The autonomy with greater administrative flexibility will help INCOIS to sustain and enhance its current activities and will enable it to take up new challenges in the frontier realms of oceanography, modelling of ocean processes and ocean services. Considering the number of programmes and kind of mission-critical operational activities, the Committee also observed that INCOIS has exceptionally sub-critical manpower in almost all the areas and hence there is an immediate need to augment the existing human resources at the Centre.

13.4 Vigilance Activities

B.V. Satyanarayana, Scientist 'G' & Head, CWG was designated as Vigilance Officer at ESSO- INCOIS w.e.f 8 November 2016. Six complaints have been received during April 2016 to March 2017. Upon verification, as per CVC guidelines, it was found that five complaints were pseudonymous and the other complaint is being investigated. The same has been reported to CVO, MoES. "Vigilance Awareness Week" was observed at ESSO-INCOIS during 27-31 October 2016. INCOIS staff took the Vigilance Pledge on 27 October 2016.

13.5 Right to Information Act

In respect to the Right to Information Act (RTI) 2005, ESSO-INCOIS related queries were regularly updated on the ESSO-INCOS website in prescribed format. E. Pattabhi Rama Rao, Scientist E & Head, DMG is the Public Information officer and S.S.C. Shenoi, Director, ESSO-INCOIS is the First Appelate authority. Twenty-four requests under RTI were received and the requested information was provided. Two appeals were also received during this period.

13. 6 Open House

To increase awareness about ESSO-INCOIS' products and services, special Open Day Programmes were organized on the MoES Foundation Day (27 July 2016), the 1st Tsunami World Awareness Day (5 November, 2016) and the ESSO-INCOIS Foundation Day (3 February, 2017). On request, group visit sessions were also organised for several schools and colleges. INCOIS also organised visits for government officials.

Over 3610 persons including 398 government officials, 1042 college students and 2139 school students and general public members visited INCOIS during 2016-17.

13.7. Students who carried out academic projects at ESSO-INCOIS during April, 2016 to March, 2017

Sl. No	Name of Student	Institute	Project Guide
1.	Neelam Jaishree	Indian Institute of Technology Kharagpur	Pattabhi E. Rama Rao
2.	G. Devipriya	National Institute of Technology Warangal	Prakash Mohanty
3.	Jugadambe Sharma	National Institute of Technology Warangal	R.S. Mahendra
4.	Dinu Maria Jose	Vellore Institute of Technology, Vellore	N. Srinivasa Rao
5.	Merin Mariam Mathew	Vellore Institute of Technology, Vellore	N. Srinivasa Rao
6.	Minnu Abraham	Vellore Institute of Technology, Vellore	R.S. Mahendra
7.	M. Elander Reddy	Jawaharlal Nehru Technological University, Hyderabad	N. Srinivasa Rao
8.	M. Sai Sandeep	Jawaharlal Nehru Technological University, Hyderabad	Sourav Maity
9.	N. Harika	Vignana Bharathi Institute of Technology, Hyderabad	S. Shivaprasad
10.	U. Ashwitha	Vignana Bharathi Institute of Technology, Hyderabad	S. Shivaprasad
11.	Harshitha	Vignana Bharathi Institute of Technology, Hyderabad	S. Shivaprasad
12.	G. Sandhya Reddy	Vignana Bharathi Institute of Technology, Hyderabad	S. Shivaprasad
13.	Umesh	Vignana Bharathi Institute of Technology, Hyderabad	S. Shivaprasad

14.	P. Nanda Kishore	Vignana Bharathi Institute of Technology, Hyderabad	S. Shivaprasad
15.	A. Sudheer Kumar	Vignana Bharathi Institute of Technology, Hyderabad	S. Shivaprasad
16.	Y. Sujith Reddy	Vignana Bharathi Institute of Technology, Hyderabad	S. Shivaprasad
17.	A. Vishwas	Vignana Bharathi Institute of Technology, Hyderabad	S. Shivaprasad
18.	V. K. Sameer	Cochin University of Science & Technology, Kochi	Praveen Kumar
19.	V. G. Kiran	Cochin University of Science & Technology, Kochi	P. A. Francis
20.	B. Yadidya	Andhra University	Abhisek Chatterjee
21.	S. Raghavendran	Anna University	Prakash Mohanty
22.	Joyline Rita Pinto	Mangalore University	N. Srinivasa Rao
23.	U. Chandramouli	Mangalore University	R.S. Mahendra
24.	S. Sameer	Mangalore University	R.S. Mahendra
25.	N.S. Vishnu Narayanan	Kerala University of Fisheries and Ocean studies	Kunal Chakraborty
26.	Akhil N. Nampoothiri	Kerala University of Fisheries and Ocean studies	P.G. Remya
27.	B. Swathi	Jawaharlal Nehru Technological University, Hyderabad	Sourav Maity
28.	Elizabeth Anju Issac	Central University of Hyderabad	P. A. Francis
29.	Lijo Abraham Joseph	Central University of Hyderabad	Sudheer Joseph
30.	Soumya Kanti Panda	Vidyasagar University, West Bengal	Sourav Maity
31.	Debasis Maity	Vidyasagar University, West Bengal	Sourav Maity
32.	M. Swathi	Jawaharlal Nehru Technological University, Hyderabad	Sourav Maity
33.	Aboobacker Siddique Kizhisseri	SRM University, Chennai	Arun Nherakkol
34.	G. Pedunayak	National Institute of Technology Goa	N. Kiran Kumar
35.	R. Rasvitha	Institute of Aeronautical Engineering, Hyderabad	V. Venugopala Rao
36.	Mamatha Vattimalla	Rajiv Gandhi University of Knowledge Technologies, Basar	Ramakrishna Phani
37.	Ramya Navath	Rajiv Gandhi University of Knowledge Technologies, Basar	Ramakrishna Phani
38.	G. Lakshmanan	College of Guindy	P. A. Francis
39.	K. Chiranjeevi	Rajiv Gandhi University of Knowledge Technologies, Basar	M. Venkat Reddy
40.	Y. Vikram Rana	Rajiv Gandhi University of Knowledge Technologies, Basar	B. Krishna Prasad
41.	N. Jyothi	Rajiv Gandhi University of Knowledge Technologies, Basar	B. Krishna Prasad

42.	Paul T Athikalam	Kerala University of Fisheries and Ocean studies	Suprit Kumar
43.	Aman Kumar	Banaras Hindu University	Abhisek Chatterjee
44.	Sudeep Das	Indian Institute of Science Education and Research, Kolkata	Prakash Mohanty
45.	Anila Sebastian	Cochin University of Science & Technology, Kochi	B. Praveen Kumar
46.	Shyno Susan John	Cochin University of Science & Technology, Kochi	B. Praveen Kumar
47.	Nandini Harihar	University of East Anglia, UK	R. Harikumar
48.	Deepthi J Patric	Indian Institute of Information Technology and Management, Kerala	N. Srinivasa Rao
49.	C. Nemi	Indian Institute of Information Technology and Management, Kerala	N. Srinivasa Rao
50.	Adithyan	Cochin University of Science & Technology, Kochi	T. M. Balakrishnan Nair
51.	Saran Rajendran	Cochin University of Science & Technology, Kochi	T. M. Balakrishnan Nair
52.	Vinay Kumar	Amity University Madhya Pradesh	

13.8. Deputations Abroad

No	Name of the Official (Dr./Mr./Ms.)	Meeting/Conference/Training
1	S.S.C. Shenoi, Director, INCOIS	To participate in the 1st State Oceanographic Administration, China-MoES India Joint Committee Meeting at Beijing and Qingdao, China during 16-19 May2016
		To attend the 49th Executive Council of Intergovernmental Oceanographic Commission was held at UNESCO, Paris during 7-10 June 2016
		To attend the IOP, SIBER, IOGOOS joint strategic discussions, IndooS review, IIOE-2 steering committee meeting and Bio-Argo workshop at Perth, Australia during 31 January-4 February 2017
2	T. Srinivasa Kumar, Scientist 'F'	Deputation to participate in Regional pre-IOWave16 Exercise Workshop on Standard Operating Procedures for Tsunami Warning and Emergency Response for Indian Ocean Countries to be held during 9-13 May 2016 at Bureau of Meteorology, Melbourne, Australia
		To attend Workshop on (i) International Standard for Early Warning System at Bangkok, Thailand held during 8-9 August 2016 and (ii) Training on Tsunami Risk Reduction at Seychelles during 16-19 August 2016 at Bangkok, Thailand

3	T. M. Balakrishnan Nair, Scientist 'F'	To participate in WISE-2016 meeting at Institute of Marine Sciences of the Italian National Research Council (CNR-ISMAR), Venice, Italy during 22-26 May 2016
		To attend the Expert Group Meeting on Capacity building for Indian Ocean Operational Forecasting System at Colombo, Sri Lanka during 17-18 November 2016
		To attend the Indo-Thai joint task force on Maritime Corporation at Bangkok, Thailand during 12-13 January 2017 and meeting with RIMES officials at Bangkok, during 14-15 January 2017
4	E. Pattabhi Rama Rao, Scientist 'F'	To participate in the XXIII Congress of International Society of Photogrammetry and Remote Sensing (ISPRS) at Prague, Czech Republic during July 12-19, 2016
		To participate in the 18th Argo Steering Team (AST-18) at Hobart, Tasmania, Australia during 13-17 March 2017
5	T.V.S. Udaya Bhaskar Scientist 'E'	To participate in the 24th Session of the IOC Committee on International Oceanographic Data and Information Exchange (IODE-XXIII) and one-day Scientific Conference at Kuala Lumpur, Malaysia during 27-31 March 2017
		To participate in the 17th meeting of Argo Data Management Team (ADMT-17) at Tianjin, China during 26-30 September, 2016 and workshop on Coordinated Quality Control System for the Historical Subsurface Ocean Temperature (and Salinity) Observation at Tokyo, Japan during 3-7 October, 2016
6	M. Nagaraja Kumar, Scientist 'E'	Deputed for undergoing the training on tuna habitat modeling and data analysis to Monterey, CA, USA during 15 July 2016 to 11 August 2016
		To participate in integrated meetings of Indian Ocean Global Ocean Observing System Worshop and 13th Annual meeting held in conjunction with the meetings of Sustained Indian Ocean Bio-geochemical and Ecological Research, IndOOS Resourse Forum, Indian Ocean Panel and IIOE-2 at Perth, Australia during 30 January to 3 February, 2017
7	Kunal Chakraborty, Scientist 'D'	To participate in the CLIVAR Early Career Scientist Symposium (ECSS) and Open Science Conference on "Charting the course for climate and ocean research" at Qingdao, China during 17-25 September, 2016
		To participate in the annual meeting of SEAVIEW (an international network funded by the Belmont Forum) at Institute Henri Poincare (IHP), Paris, France during 10-11 October, 2016

8	M. Vijaya Sunanda, Scientist 'D'	To participate in the XXIII Congress of International Society of Photogrammetry and Remote Sensing at Prague, Czech Republic during 12-19 July, 2016
		To attend the meeting of Steering Group of Indian Ocean Tsunami Warning and Mitigation System of IOC-UNESCO at Bureau of Meteorology at Perth, Australia during 17-18 January, 2017
9	B. Praveen Kumar, Scientist 'D'	To Mauritius for testing of the ARGO floats to be deployed in Southern Ocean during 24-25 December, 2016
		To attend the 9th Ship Observation Team meeting at the International Maritime Organization, London during 27-31 March, 2017
10	Arya Paul, Scientist 'D'	To participate for 2016 ROMS Asia-Pacific Workshop to institute for Marine and Antarctic Studies, Hobart Waterfront, Tasmania, Australia during 17-21 October, 2016
11	Satya Prakash, Scientist 'D'	To participate in integrated meetings of Sustained Indian Ocean Bio-geochemical and Ecological Research, the Indian Ocean Panel, Indian Ocean Global Ocean Observing System Joint strategic discussions around IndOOS review, IIOE-2 Steering Committee meeting and Bio-Argo Workshop at Perth, Australia during 30 January to 3 February, 2017
12	Venkat Shesu Reddem, Scientist 'D'	To attend the workshop as an invited trainer for "Training workshop on Fundamentals of Oceanographic Data Management" at Tehran, Iran during 5-7 March, 2017
13	Ch. Patanjali Kumar, Scientist 'D'	To participate in the meetings of ICG/IOTWMS Sub-Regional Working Group for the northwest Indian Ocean and joint UNESCAP Workshop at Tehran, Iran during 5-7 March, 2017
14	Abhisek Chatterjee, Scientist 'C'	To participate in the International Symposium on Tropical Meteorology and Marine Science and Technology (2016) at Guangzhou, China and to visit NMEFC in Beijing, China during 5-9 April, 2016
15	J. Padmanabham Scientist 'C'	To attend the Pre-IOWave16 Workshop on Standard Operating Procedures for Tsunami Warning and Emergency Response for Indian Ocean Countries scheduled during 9-13 May, 2016 at Melbourne, Australia
16	P. Vijay Scientist 'C'	To participate in the ICTP-IITM-COLA Targeted Training Activity (TTA) at Trieste, Italy during 13-17 June, 2016
17	S. Shivaprasad Scientist 'C'	To participate in Seaglider calibration and Refurbishment training in Kongsberg (OEM of Seaglider), Seattle USA during 13-16 June, 2016
18	Suprit Kumar, Scientist 'B'	To attend the IORA/IOC/IIOE-2/IODE Research Data Management (RDM) training course organised by Ocean Teacher Global Academy (OTGA), in Kuala Terengganu, Malaysia during 22-26 May, 2016

19	Prerna Singh Scientist 'B'	To participate in the ICTP-IITM-COLA Targeted Training Activity (TTA) at Trieste, Italy during 13-17 June, 2016
20	Biswamoy Paul, Scientist - B	To participate for 2016 ROMS Asia-Pacific Workshop to institute for Marine and Antarctic Studies, Hobart Waterfront, Tasmania, Australia during 17-21 October, 2016
21	Nimit Kumar Joshi, Project Scientist 'B'	To participate in the Pan-Ocean Remote Sensing Conference (PORSEC) 2016 on "Enabling Earth Observations in support of global, coastal, ocean and climate change research and monitoring" at Fortaleza, Brazil during 8-11 November, 2016
22	Sourav Maity, Project Scientist 'B'	To participate in the 'International Symposium on Drivers of dynamics of small pelagic fish resources' by North Pacific Marine Science Organization at Victoria, Canada during 6-11 March, 2017
23	Shailesh Nayak, Distinguished Scientist, ESSO, MoES	For participating in the First meeting of the Steering Committee of IIOE-2 at Perth, Australia during 2-4 February, 2017
24	S. Rajan, Former Director, NCAOR, Coordinator, IIOE-2 Joint program Office and Consultant	For participating in the First meeting of the Steering Committee of IIOE-2 at Perth, Australia during 2-4 February, 2017
25	B. Madhusudan Rao, Consultant	To participate in OTGA Steering Group III meeting of IOC/ UNESCO Project Office for IODE at Oostende, Belgium during 21-24 February, 2017
26	Jeyakumar Chelliah, Scientific Assistant 'B'	For the maintenance of Wave rider buoy to validate the Integrated Ocean Information System for Indian Ocean Countries through Regional Integrated Multi-hazard Early-warning System at Seychelles during 27 March to 1 April, 2017
27	M. Ramesh Kumar, Project Assistant	For the maintenance of Wave rider buoy to validate the Integrated Ocean Information System for Indian Ocean Countries through Regional Integrated Multi-hazard Early-warning System at Seychelles during 27 March 2017 to 1 April, 2017

13.9 ESSO-INCOIS Human Capital

ESSO-INCOIS Human Capital category wise as on 31 March 2017:

Category/Designation	Regular	Category/ Designation	Project Mode
Scientific Staff			
Director	1	Project Sci - C	1
Scientist 'G'	2*	Project Sci - B	23
Scientist 'F'	3*	Project Assistant	21
Scientist 'E'	5	Admin Assistant/Office Assistant	6
Scientist 'D'	16	Lab Attendants	5
Scientist 'C'	17	Driver-cum-Attendant	4
Scientist 'B'	3	Consultants	3
Scientific Support Staff		Research Fellows under Ph.D Programme	7
Scientific Assistant B	18		
Scientific Assistant A	1		
Administrative Support			
Dy.CAO	1		
Manager	1		
Jt. Manager	2		
Asst. Manager	4		
Sr. Executive	3		

* M. Ravichandran, Scientist 'G' & T. Srinivasa Kumar, Scientist 'F' are on lien.

Acronyms

3D GIS	-	Three Dimension Geo Information System
3DVAS	-	Three Dimension Visualization and Analysis System
A&N	-	Andaman and Nicobar islands
ADCIRC	-	Advanced Circulation (Storm surge model)
ADCP	-	Acoustic Doppler Current Profiler
ADMT	-	Argo Data Management Team
AMET	-	Academy of Maritime Education and Training
AOP	-	Apparent Optical Properties
AOT	-	Aerosol Optical Thickness
Argo/ ARGO	-	Array for Real-time Geotropic Oceanography
ASG	-	Advisory Services Group, ESSO-INCOIS
ASIMET	-	Air-Sea Interaction Meteorology
ASIRI	-	Air-Sea Interactions in the northern Indian Ocean–Regional Initiative
AST	-	Argo Steering Team
ATLAS	-	Autonomous Temperature Line Acquisition
AU	-	Andhra University
AVHRR	-	Advanced Very High Resolution Radiometer
AWS	-	Automatic Weather Station
BB-HOOFS	-	HOOFS setup for the Bay of Bengal
BoB	-	Bay of Bengal
CAP	-	Common Alerting Protocol
CC	-	Coast Colour
CCMB	-	Centre for Cellular & Molecular Biology: CSIR, Hyderabad
CDAC	-	Centre for Development of Advanced Computing, Hyderabad
CDOM	-	Colored dissolved organic matter
CFZ	-	Coastal Forecast Zone
Chl-a	-	Chlorophyll-a
CLIVAR	-	Climate Variability and Predictability (World Climate Research)
CMFRI	-	Central Marine Fisheries Research Institute, Kochi
CMLRE	-	Centre for Marine Living Resources & Ecology, Cochin
COMMs	-	Communications Test
CRSs	-	Central Receiving Stations
CRZ	-	Coral Reef Zones
CSIR	-	Council of Scientific and Industrial Research

CSIRO	-	Commonwealth Scientific and Industrial Research Organization
CSIR-UGC NET	-	Council of Scientific and Industrial Research-University Grants Commission National Eligibility Test
CTCZ	-	Continental Tropical Convergence Zone
CTD	-	Conductivity-Temperature-Depth
CUSAT	-	Cochin University of Science and Technology, Cochin
CVC	-	Central Vigilance Commission
DA	-	Data Assimilation
DAC	-	Data Assembly Centre
DINEOF	-	Data Interpolation Empirical Orthogonal Functions
DMG	-	Data Management Group, ESSO-INCOIS
DMO	-	Disaster Management Official
DO	-	Dissolved Oxygen
DSS	-	Decision Support System
DST	-	Department of Science and Technology
ECMWF	-	European Centre for Medium-Range Weather Forecasts
EEZ	-	Exclusive Economic Zone
EICC	-	East India Coastal Current
EIO	-	Equatorial Indian ocean
EOF	-	Empirical Orthogonal Functions
EQ	-	Earth Quake
ERP	-	Enterprise Resource Planning
ERS	-	ERS (European Remote Sensing) d'Archivage et de Traitement, France
ESCAP	-	Economic and Social Commission for Asia and Pacific
ESSO	-	Earth System Science Organisation
FAST	-	Forecast Assessment and Support Tool
FORV	-	Fisheries Ocean Research Vessel
FTP	-	File Transfer Protocol
FY	-	First Year
GCMD	-	Global Change Master Directory
GFR	-	General Financial Rules
GIS	-	Geographic Information System
GNSS	-	Global Navigation Satellite System
GODAE	-	Global Ocean Data Assimilation Experiment
GODAS	-	Global Ocean Data Assimilation System
GOOS	-	Global Ocean Observing System
GOVST	-	Ocean View Science Team

GPRS	-	General Packet Radio Service
GPS	-	Global Positioning System
GTS	-	Global Telecommunication System
GUI	-	Graphical User interface
HF Radar	-	High Frequency Radar
HICO	-	Hyper spectral Imager for the Coastal Ocean
HOOFS	-	High Resolution Operational Ocean Re-Analysis and Forecast System
ICG/IOTWS	-	Intergovernmental Coordination Group for the Indian Ocean Tsunami
ICMAM	-	Integrated Coastal and Marine Area Management
ICOADS	-	International Comprehensive Ocean Atmosphere Data Set
ICTP	-	International Centre for Theoretical Physics, Italy
IIOE	-	International Indian Ocean Expedition
IISc	-	Indian Institute of Science, Bangalore
IIT	-	Indian Institute of Technology
IITM	-	Indian Institute of Tropical Meteorology, Pune
IMBER	-	Integrated Biogeochemistry and Ecosystem Research
IMD	-	Indian Meteorological Department
INCOIS	-	Indian National Centre for Ocean Information Services
INDARE	-	Indian Data Rescue initiative
IndOOS	-	Indian Ocean Observing System
INSAT	-	Indian National Satellite System
IO	-	Indian Ocean
IOC	-	Intergovernmental Oceanographic Commission
IOD	-	Indian Ocean Dipole
IODE	-	International Oceanographic Data and Information Exchange
IOGOOS	-	Indian Ocean Global Ocean Observing System
IO-HOOFS	-	HOOFS setup for the Indian Ocean
IOM	-	Indian Ocean Model
IOP	-	Inherent Optical Properties
IOTWS WG-2	-	Indian Ocean Tsunami Warning System Worging Group
IOWave16	-	IOTWS Indian Ocean Tsunami Exercise 2016
IRF	-	IndOOS (Indian Ocean Observation System) Resource Forum
IRS	-	Indian Remote Sensing
ISG	-	Information Services and Ocean Sciences Group, ESSO-INCOIS
ISGN	-	Integrated Seismic and GNSS Network
ISO	-	International Organization for Standardization
ISPRS	-	International Society for Photogrammetry and Remote Sensing

ISRO	-	Indian Space Research Organisation
ISRS	-	Indian Society of Remote Sensing
IST	-	Indian Standard Time
ITCOocean	-	International Training Centre for Operational Oceanography,
ITEWC	-	Indian Tsunami Early Warning Centre, ESSO-INCOIS
ITEWS	-	Indian Tsunami Early Warning System
JCOMM	-	Joint Technical Commission for Oceanography and Marine Meteorology
JPO	-	Joint Programme office
JPSS	-	Joint Polar Satellite System
KAUST	-	King Abdullah University of Science and Technology , Saudi Arabia
LAN	-	Local Area Network
LAS	-	Live Access Server
LETKF	-	Local Ensemble Transform Kalman Filter
LISS	-	Linear Imaging Self Scanning Sensor
LOV	-	Laboratoire d'Océanographie de Villefranche-sur-Mer,France
MATLAB	-	MATrix LABoratory
Met	-	Meteorological
METOP	-	Meteorological Operational (satellite programme)
MFAS	-	Marine Fisheries Advisory Services
MHA	-	Ministry of Home Affairs
MHVM	-	Multi-Hazard Vulnerability Map
ML	-	Mixed Layer
MLD	-	Mixed layer Depth
MODIS	-	Moderate Resolution Imaging Spectroradiometer
MoES	-	Ministry of Earth Sciences
MOG	-	Modelling Ocean Group, ESSO-INCOIS
MOM	-	Modular Ocean Model
MoU	-	Memorandum of Understanding
MSc	-	Master of Science
MSSRF	-	M.S. Swaminathan Research Foundation
MTech	-	Master of Technology
MVHM	-	Multi-Hazard Vulnerability Map
NCAOR	-	National Centre for Antarctic and Ocean Research
NCEP	-	National Centers for Environmental Prediction, USA
NCESS	-	National Centre for Earth Science Studies
NCMRWF	-	National Centre for Medium Range Weather Forecasting, Noida
NCS	-	National Centre for Seismology

NCWCP	-	NOAA Center for Weather and Climate Prediction
NDBP	-	National Data Buoy Program
NDMA	-	National Disaster Management Authority
NDRF	-	National Disaster Response Force
NetCDF	-	Network Common Data Format
NERSC	-	Nansen Environmental and Remote Sensing Centre, Bergen, Norway
NERCI	-	Nansen Environmental Research Centre India
NGO	-	Non Governmental Organization
NGRI	-	National Geophysical Research Institute, Hyderabad
NHO	-	National Hydrographic Office
NIDM	-	National Institute of Disaster Management
NIO	-	National Institute of Oceanography, Goa
NIOT	-	National Institute for Ocean Technology, Chennai
NMSAR	-	National Maritime Search and Rescue
NOAA	-	National Oceanic and Atmospheric Administration, USA
NOC	-	No Objection Certificate
NODC	-	National Oceanographic Data Center, USA
NODPAC	-	Naval Oceanographic Data Processing and Analysis Centre
NPOL	-	Naval Physical & Oceanographic Laboratory (NPOL) Kochi - DRDO
NRSC	-	National Space Research Centre, Hyderabad
NTWC	-	National Tsunami Warning Centre
OBIS	-	Ocean Biogeographic Information System
OceanSITES	-	Ocean Sustained Interdisciplinary Time series Environment
OC	-	Outer Channel
OCM	-	Ocean Colour Monitor
OEM	-	Original Equipment Manufacturer
OGCM	-	Oceanic General Circulation Model
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
OON	-	Ocean Observations Network
OOS	-	Ocean Observing System
OOSA	-	Online Oil Spill Advisory System
ORV	-	Ocean Research Vessel
OSCAT	-	Oceansat-2 Scatterometer

OSEs	-	Observation System Evaluation
OSF	-	Ocean State Forecast
OSSEs	-	Observation System Simulation Experiments
OTGA	-	Ocean Teacher Global Academy
PAR	-	Photosynthetically Active Radiation
PFZ	-	Potential Fishing Zone
PMC	-	Project Monitoring Committee
PMEL	-	Pacific Marine Environmental Laboratory, USA
POGO	-	Partnership for Observation of the Global Oceans
PRL	-	Physical Research Laboratory, Ahmedabad
PSAT	-	pop-up satellite archival tag
PTC	-	Panel on Tropical Cyclones
PUnSWAN	-	Parallel Unstructured SWAN model
QMF	-	Quality Management Framework Quick SCAT,
QSCAT	-	Quick Scatterometer
R&D	-	Research & Development
Radar	-	RAdio Detection And Ranging
RAMA	-	Research Moored Array for African-Asian-Australian Monsoon Analysis
RIMES	-	Regional Integrated Multi-Hazard Early Warning System for Africa
RLV-TD	-	Reusable Launch Vehicle Technology Demonstration
RMSE	-	Root Mean Square error
ROMS	-	Regional Ocean Modeling System
Rrs	-	Reflectance
RTI	-	Right to Information Act
RTSP	-	Regional Tsunami Service Provider
RV	-	Research Vessel
S & T	-	Science and Technology
SAC	-	Space Application Centre, Ahmadabad
SAC	-	Space Applications Centre
SAIC	-	Science Applications International Corp ,USA.
SARAT	-	Search And Rescue Aid Tool
SATCORE	-	Satellite Coastal and Oceanographic Research
SATTUNA	-	Satellite Telemetry Studies on Migration Pattern of Tuna in Indian Seas
SC	-	Steering Committee
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
SICOME	-	SATCORE Inter-COMparison Exercise
SMS	-	Short Messaging Service
SOP	-	Standard Operating procedure
SOT	-	Ship Observations Team
SS	-	Southern Sector
SSC	-	Science Steering Committee
SSH	-	Sea Surface Height
SSHA	-	Sea Surface Height Anomaly
SSS	-	Sea Surface Salinity
SST	-	Sea Surface Temperature
STB	-	Science Applications International Corporation (SAIC) Tsunami Buoy
Suomi-NPP	-	Suomi National Polar-orbiting Partnership
SWAN	-	Simulating Waves Nearshore (Model)
SWH	-	Sea Wave Height
SWHM	-	Ship-mounted Wave Height Meter
SWM	-	Sea Wave Measurement
T	-	Temperature
T & S	-	Temperature & Salinity
TC	-	Tropical Cyclone
TC	-	Typhoon Committee
TFLEX	-	Tropical FLEXible data acquisition system
TI	-	Temperature Inversion
TIO	-	Tropical Indian Ocean
TMI	-	TRMM Microwave Imager
TRMM	-	Tropical Rainfall Measuring Mission Tropical Rainfall Measuring
TOPEX	-	Topography Experiment
TOWSWG	-	Tsunamis and other Ocean hazards Warning and mitigation Systems-Working Group
TSM	-	Total Suspended Matter
TSP	-	Tsunami Service Providers
UNESCO	-	United Nations Educational, Scientific and Cultural Organization
UNWCDRR	-	United Nations World Conference on Disaster Risk Reduction
US /USA	-	United States of America
UT	-	Union Territories
UTC	-	Coordinated Universal Time

VECS	-	VSAT-Aided Emergency Communication System
VIMT	-	Vertically Integrated Moisture Transport
VOS	-	Voluntary Observing Ships
VSAT	-	Very Small Aperture Terminal
VSCS	-	Very Severe Cyclonic Storm
WC	-	West Coast
WCRP	-	World Climate Research Programme
WebGIS	-	Web Geo Information System
WET	-	Western Environmental Technologies, USA
WHM	-	Wave Height Meter
WHOI	-	Woods Hole Oceanographic Institution, USA
WIO	-	Western Indian Ocean
WISE	-	Waves In the Shallow water Environment
WMO	-	World Meteorological Organization
WRF	-	Weather Research and Forecasting model
WW	-	Wire Walker
XBT/XCTD	-	Expendable Bathythermograph Expendable Conductivity-Temperature
YFT	-	YellowFin Tuna
ZPG	-	Zonal Pressure Gradient
ZWS	-	Zonal Wind Stress

14. Finance

Appendix-1

Y Chakravarthy Associates
CHARTERED ACCOUNTANTS

Head Office:
#6-3-841/1/A,
Padma Plaza, II Floor, Ameerpet,
Hyderabad - 500 016
email: yca_fca@yahoo.com

AUDITORS' REPORT

To

The Chairman and Members,
Governing Council,
ESSO-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 ESSO-INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES as at 31st March 2017, 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 & Expenditure Account , Receipts & 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 2017, Income & Expenditure Account and Receipts & 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 **Y Chakravarthy Associates**
Chartered Accountants

(Y Chakravarthy)
Partner
M.No. : 206456
FRN No.: 007907S

Place: Hyderabad
Date: 02.08.2017

ESSO-INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES

(Ministry of Earth Sciences, Govt. of India)

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

BALANCE SHEET AS AT 31st MARCH 2017

Particulars	Schedules	Current Year (2016 - 17) Rs	Previous Year (2015 - 16) Rs
LIABILITIES			
Corpus fund	1	18,67,62,652	17,95,01,304
Earmarked funds	2	22,16,21,362	3,98,75,963
Current liabilities & Provisions	3	11,06,30,277	7,96,44,939
Total		**51,90,14,291**	**29,90,22,206**
ASSETS			
Fixed Assets	4	5,06,95,617	9,51,27,327
Current Assets, Loans & Advances	5	46,83,18,674	20,38,94,879
Total		**51,90,14,291**	**29,90,22,206**
Notes forming part of Accounts	11		

As per our report of even date
For Y Chakravarthy Associates
Chartered Accountants

Y Chakravarthy
Partner
M.No. 206456
FRN No: 007907S

Place: Hyderabad
Date: 02.08.2017

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

(S. Nageswara Rao)
Sr. Accounts Officer

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

(S.S.C.Shenoi)
Director

ESSO-INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES
(Ministry of Earth Sciences, Govt. of India)
"Ocean Valley", Pragathinagar (BO), Nizampet (SO), Hyderabad - 500 090

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st MARCH 2017

Particulars	Schedules	Current Year (2016 - 17) ₹	Previous Year (2015 - 16) ₹
INCOME			
Income from Sales / Other Income	6	44,63,065	23,44,064
Interest Earned on Investments	7	46,77,951	7,73,945
Recurring Grants	8	35,00,00,000	35,00,00,000
TOTAL - A		**35,91,41,016**	**35,31,18,009**
EXPENDITURE			
Establishment Expenditure	9	12,88,03,070	8,68,62,590
Other Administrative Expenses	10	16,29,62,816	14,67,38,312
Depreciation	4	6,01,13,782	1,99,40,220
TOTAL - B		**35,18,79,668**	**25,35,41,122**
Excess of Income over expenditure (A-B)	1	72,61,348	9,95,76,887
Add / Less: Prior Period Items			-
Balance being net income / deficit transferred to Corpus Fund		72,61,348	9,95,76,887
Notes forming part of Accounts	11		

As per our report of even date
For Y Chakravarthy Associates
Chartered Accountants

Y Chakravarthy
Partner
M.No. 206456
FRN No: 007907S

Place: Hyderabad
Date: 02.08.2017

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

(S. Nageswara Rao)
Sr. Accounts Officer

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

(S.S.C.Shenoi)
Director

ESSO-INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES

(Ministry of Earth Sciences, Govt. of India)

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

RECEIPTS AND PAYMENTS ACCOUNT FOR THE YEAR ENDED 31st MARCH 2017

RECEIPTS	CURRENT YEAR 2016-17		PAYMENTS	CURRENT YEAR 2016-17	
	₹	₹		₹	₹
Opening Balance			**Establishment Expenses**		
INCOIS Current A/c-SBI-HAL Campus Br.	4,21,11,878		Pay, Leave Salary Allowace	10,02,77,162	
INCOIS Current A/c-AB-Pragathi Nagar Br.	1,03,84,057		NPS, CPF, IDBPS	97,85,042	
INCOIS Consultancy SB A/c - Pragathi Nagar Br.	8,49,850		Staff Welfare	24,84,301	
Short Term Deposits with Bank	10,00,00,000	**15,33,45,785**	Leave Travel Concession Expenses	24,31,906	**11,49,78,411**
Earmarked Funds			**Administrative Expenses**		
Construction of New Building (Phase II)	3,00,00,000		Maintenance & Repairs	5,29,31,058	
Ocean Information and Advisory Services (O-IAS)	32,00,00,000		Travel Expenses - Inland	30,97,141	
Ocean Observation Systems (OOS)	9,25,00,000		Foreign	9,78,875	
Satellite Coastal and Oceanographic Research	1,16,00,000		Others	2,65,098	
V Sat Terrestrial Link	7,61,50,000		Emoluments to Consultants	1,46,900	
MH Vulnerability	15,00,00,000	**68,02,50,000**	Vehicle Hiring	6,88,254	
			House Keeping, Plumbing & Garden Expenses	1,15,99,723	
Recurring Grants	35,00,00,000	**35,00,00,000**	Security Expenses	1,28,23,521	
			Electricity Expenditure	3,84,50,881	
Other Receipts			Water Expenses	57,21,281	
Consultancy Projects - Sundry Debtors	9,42,366		Postage & Telegraphs	81,964	
Earnest Money Deposits	58,61,524		Telephone & Fax Expenditure	7,03,577	
Security Deposits	70,000		Honorarium to External Experts	2,05,960	
Service Tax received	36,033		Conveyance Expenses	1,58,147	
LTC Advance	2,610		Printing & Stationery	1,24,882	
Interest on Short Term Deposits	1,31,24,035		Advertisement & Publicity	13,04,619	
Interest on Bank Account	1,32,522		General Expenses	11,10,930	
Interest Margin Money TDR's	5,44,121		Audit Fee	28,137	
Inspire /UGC Fellowship	18,58,400		Seminar, Conference & Workshop Expenses	19,70,480	
EM Other Receipts-ITCOO	15,65,636		International Interface	1,74,34,067	
Income from MP Hall	25,200		Material Consumable	45,43,854	**15,43,69,349**

Income from Tender Sales	20,877				
Interest on Income Tax Refund	2,73,430				
Other Receipts on Sale of Scrap	2,60,000				
Income from Guest House	4,77,572				
RTI Fee	440		**Payments Against Earmarked Funds**		
Other Receipts (missing journals)	11,240		**Construction of New Building (Phase II)**		
Vehicle Advance to Employees	1,06,525		Construction buildings	1,17,19,435	
DST Women in Science Fellowship	7,80,000		Equipments	80,52,138	
IISc, Bangalore	2,50,000		Administrative Expenses	19,753	
Telephone Deposit	23,388		Travel	15,211	
IT refund for FY 2014-15	28,78,280	**2,92,44,199**	Advance to Purchase	37,74,602	**2,35,81,139**
			a) Ocean Information and Advisory Services (OIAS)		
Unspent Balances received from Sub Projects			Construction buildings	3,79,120	
Satellite Coastal and Oceanographic Research	7,05,085	**7,05,085**	Hardware/Software	22,22,551	
			Technical Support	45,00,026	
Margin Money			Administrative Expenses	30,53,611	
Monsoon Mission	1,87,42,100		Seminar Conference	9,92,978	
OIAS	71,88,000		Manpower	1,68,33,421	
OON	1,96,00,000		Telephone Expenses	6,69,633	
SATCORE	13,00,000		Travel	64,57,979	
NCS	31,28,000	**4,99,58,100**	Cosnumable/Material	22,51,183	
			Data	32,80,264	
			Advance to Sub Projects	3,61,78,984	
			Advance to Purchase	8,17,47,069	
			Margin Money	71,88,000	
			Deposit works	43,98,048	**17,01,52,867**
			Ocean Observation Networks - OON		
			Equipments	3,43,875	
			Hardware/Software	79,275	
			Technical Support	29,88,122	
			Administrative Expenses	20,44,293	
			Seminar Conference	1,84,482	
			Manpower	27,57,602	
			Telephone Expenses	1,07,495	
			Travel	22,96,317	

			Cosnumable/Material	49,00,954	
			Data	35,39,009	
			Advance to Sub Projects	1,47,00,000	
			Advance to Purchase	4,44,19,235	
			Margin Money	6,71,00,000	**14,54,60,659**
			Satellite Coastal and Oceanographic Research		
			Equipments	18,99,436	
			Technical Support	1,19,391	
			Administrative Expenses	71,320	
			Manpower	16,13,320	
			Telephone Expenses	18,000	
			Travel	4,36,760	
			Cosnumable/Material	20,09,488	
			Advance to Sub Projects	84,91,169	
			Margin Money	13,00,000	
			Advance to Purchase	27,55,597	**1,87,14,481**
			International Training Centre (ITCOocean)		
			Equipments	12,14,322	
			Administrative Expenses	64,984	
			Seminar Conference	4,48,705	
			Manpower	7,21,686	
			Travel	9,53,233	
			Deposit works	7,00,00,000	**7,34,02,930**
			HROOFS		
			Administrative Expenses	43,615	
			Seminar Conference	6,02,932	
			Manpower	20,75,629	
			Travel	4,27,895	
			Cosnumable/Material	4,150	
			Advance to Sub Projects	1,30,69,160	**1,62,23,381**
			V Sat Terrestrial Link		
			Equipments	7,36,386	
			Hardware/Software	35,230	
			Technical Support	2,85,42,922	
			Administrative Expenses	52,26,742	
			Seminar Conference	1,950	
			Manpower	6,04,590	

			Travel	14,049	
			Advance to Purchase	3,31,689	**3,54,93,558**
			Multi Hazard Vulnerability		
			Hardware/Software	15,23,275	
			Technical Support	92,18,434	
			Administrative Expenses	30,660	
			Travel	48,745	
			Advance to Purchase	63,41,631	**1,71,62,745**
			Monsoon Mission		
			Administrative Expenses	1,300	
			Margin Money	43,45,300	
			Advance to Purchase	2,08,01,592	**2,51,48,192**
			RIMES Afro Asian Region		
			Travel	16,395	
			Advance to Purchase	2,811	
			Margin Money	23,33,000	**23,52,206**
			Characterization Seismic (CSS)		
			Equipments	14,21,621	
			Data	1,213	**14,22,834**
			IIOE2		
			Administrative Expenses	9,201	
			Seminar Conference	46,609	
			Manpower	8,25,000	
			Travel	5,64,223	
			Consumable/Material	17,940	**14,62,973**
			NCS		
			Margin Money	31,28,000	
			Advance to Purchase	31,95,299	**63,23,299**
			Expenditure on Fixed Assets		
			Office Equipment	3,85,691	
			Furniture & fixtures	18,94,585	
			Computer & Peripherals	46,96,865	

			Library	86,19,986	**1,55,97,127**
			Other Payments		
			Earnest Money Deposits	93,01,088	
			Security Deposits	22,73,718	
			Property Tax paid TO GHMC	79,03,354	
			Service Tax paid	36,033	
			Refund to IISc, Bangalore	3,58,118	
			Inspire Fellowship	1,47,811	
			Electricity Deposit	8,66,885	
			Advance for purchase	2,00,00,000	
			LTC Advance	17,31,540	**4,26,18,547**
			Closing Balance		
			INCOIS Current A/c-SBI-HAL Campus Br.	4,91,80,820	
			INCOIS Current A/c-AB-Pragathi Nagar Br.	15,55,699	
			INCOIS Consultancy SB A/c - Pragathi Nagar Br.	18,01,952	
			Short Term Deposits with Bank	34,65,00,000	**39,90,38,471**
Total	**1,26,35,03,169**	**1,26,35,03,169**	**Total**	**1,26,35,03,169**	**1,26,35,03,169**

As per our report of even date
For Y Chakravarthy Associates
Chartered Accountants

Y Chakravarthy
Partner
M.No. 206456
FRN No: 007907S

Place: Hyderabad
Date: 02.08.2017

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

(S. Nageswara Rao)
Sr. Accounts Officer

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

(S.S.C.Shenoi)
Director

ESSO-INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES
(Ministry of Earth Sciences, Govt. of India)
"Ocean Valley", Pragathinagar (BO), Nizampet (SO), Hyderabad - 500 090

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31st MARCH 2017

SCHEDULE 1 – CORPUS FUND

Particulars	Current Year (2016 - 17) ₹	Previous Year (2015 - 16) ₹
Corpus Fund at the beginning of the year	17,95,01,304	7,99,24,417
Add: Net income transferred from Income & Expenditure Account	72,61,348	9,95,76,887
BALANCE AS AT THE YEAR END	**18,67,62,652**	**17,95,01,304**

As per our report of even date
For Y Chakravarthy Associates
Chartered Accountants

Y Chakravarthy
Partner
M.No. 206456
FRN No: 007907S

Place: Hyderabad
Date: 02.08.2017

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

(S. Nageswara Rao)
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(K.K.V.Chary)
Dy. C A O

(S.S.C.Shenoi)
Director

ESSO-INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES

SCHEDULE 2 - EARMARKED FUNDS

(Amount in Rs.)

PARTICULARS	FUND-WISE BREAK UP														TOTALS	
	Building Fund	Ocean Information and Advisory Services(O-IAS)	Ocean Observation Networks	SATCORE	ITCOO	HROOFS	IT & E Governance Fund	V SAT Node	MH Vulnerability	Monsoon Mission	RIMES	CSS	IIOE2	NCS	Current Year 2016-17	Previous Year 2015-16
a) Opening balance of the funds	-1,70,95,335	-14,01,50,698	-1,86,65,465	23,76,627	9,60,61,258	3,29,35,554	27,88,305	-1,21,16,790	36,81,970	7,04,66,505	85,84,045	19,24,531	41,12,334	49,73,121	3,98,75,963	17,69,98,716
b) Additions to the Funds:																
i. Grants	3,00,00,000	32,00,00,000	9,25,00,000	1,16,00,000	-	-	-	7,61,50,000	15,00,00,000	-	-	-	-	-	68,02,50,000	71,79,39,866
ii. Interest if any	-	1,30,527	1,01,490	1,39,419	1,12,64,033	8,08,339	1,11,163	8,68,889	20,82,692	30,27,060	3,11,626	51,361	1,36,055	1,10,973	1,91,43,627	1,52,57,209
iii. Advance for sub projects utilised	-	5,70,84,496	3,66,99,907	1,19,72,324	-	2,33,66,369	-	-	-	-	4,67,05,366	-	-	-	17,58,28,462	16,35,09,738
iv. Advance for purchase Utilised	-	28,74,31,779	4,20,11,116	83,24,117	-	-	-	-	1,14,97,595	1,44,97,953	-	-	-	-	36,37,62,560	40,18,23,313
v. Margin Money Reversed	-	71,88,000	1,96,00,000	13,00,000	-	-	-	-	-	1,87,42,100	-	-	-	31,28,000	4,99,58,100	12,79,98,000
vi. Deposit Advance Utilized		54,82,082	-	-	12,14,95,670	-	-	-	-	-	-	-	-	-	12,69,77,752	-
vii. Mobilisation Advance Reversed	-	-	-	-	70,38,000	-	-	-	-	-	-	-	-	-	70,38,000	-
viii. Other Revenue	-	29,586	1,08,928	1,770	15,65,636	-	-	-	-	-	-	-	-	-	17,05,920	26,55,820
TOTAL (a+b) - A	**1,29,04,665**	**53,71,95,772**	**17,23,55,976**	**3,57,14,257**	**23,74,24,597**	**5,71,10,262**	**28,99,468**	**6,49,02,099**	**16,72,62,257**	**10,67,33,618**	**5,56,01,037**	**19,75,892**	**42,48,389**	**82,12,094**	**1,46,45,40,384**	**1,60,61,82,662**
c) Utilisation/Expenditure																
i. Capital Expenditure																
W.I.P	1,17,19,435	58,61,202	-	-	13,25,15,073	-	-	-	-	-	-	-	-	-	15,00,95,710	4,12,09,106
Architect fee	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Equipments	80,52,138	29,68,49,140	2,17,08,133	18,99,436	12,14,322	32,49,379	-	7,36,386	-	1,49,20,238	-	14,21,621	-	-	35,00,50,793	40,13,01,764
Computers / Software	-	2,08,57,171	2,55,575	-	-	11,10,520	-	35,230	15,23,275	-	-	-	-	-	2,37,81,771	6,05,83,829
Other Assets	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	**1,97,71,573**	**32,35,67,513**	**2,19,63,708**	**18,99,436**	**13,37,29,395**	**43,59,899**	**-**	**7,71,616**	**15,23,275**	**1,49,20,238**	**-**	**14,21,621**	**-**	**-**	**52,39,28,274**	**50,30,94,699**
ii. Revenue Expenditure																
Technical support	-	1,04,51,241	29,88,122	1,19,391	-	-	-	2,85,42,922	92,18,434	-	4,67,05,366	-	-	-	9,80,25,476	12,56,93,613
Adminisrtrative expenses	19,753	6,00,54,139	2,05,79,176	1,04,43,910	12,35,375	1,84,77,998	-	58,33,282	30,661	1,300	-	-	8,80,810	-	11,75,56,404	12,59,63,410
Travel	15,211	1,20,24,118	47,86,976	14,56,499	9,53,233	30,09,793	-	14,049	48,745	-	16,395	-	5,64,223	-	2,28,89,242	1,64,42,471
Consumable Materials / Data	-	2,32,93,230	3,44,96,172	36,51,057	-	12,69,944	-	-	1,14,97,595	-	-	1,213	17,940	-	7,42,27,151	3,80,33,147
Total	**34,964**	**10,58,22,728**	**6,28,50,446**	**1,56,70,857**	**21,88,608**	**2,27,57,735**	**-**	**3,43,90,253**	**2,07,95,435**	**1,300**	**4,67,21,761**	**1,213**	**14,62,973**	**-**	**31,26,98,273**	**30,61,32,641**
iii. Others																
Advance against subprojects	-	3,61,78,984	1,47,00,000	84,91,169	-	1,30,69,160	-	-	-	-	-	-	-	-	7,24,39,313	18,42,19,934
Advance for Purchase	37,74,602	9,24,38,358	4,44,19,235	27,55,597	-	-	-	3,31,689	63,41,631	2,08,01,592	2,811	-	-	31,95,299	17,40,60,814	36,18,75,040
Deposit Works (APWD & RITES)	-	43,98,048	-	-	7,00,00,000	-	-	-	-	-	-	-	-	-	7,43,98,048	7,70,85,586
Margin Money against LC	-	71,88,000	6,71,00,000	13,00,000	-	-	-	-	-	43,45,300	23,33,000	-	-	31,28,000	8,53,94,300	13,38,98,800
Total	**37,74,602**	**14,02,03,390**	**12,62,19,235**	**1,25,46,766**	**7,00,00,000**	**1,30,69,160**	**-**	**3,31,689**	**63,41,631**	**2,51,46,892**	**23,35,811**	**-**	**-**	**63,23,299**	**40,62,92,475**	**75,70,79,360**
TOTAL (i+ii+iii) - B	**2,35,81,139**	**56,95,93,631**	**21,10,33,389**	**3,01,17,059**	**20,59,18,003**	**4,01,86,794**	**-**	**3,54,93,558**	**2,86,60,341**	**4,00,68,430**	**4,90,57,572**	**14,22,834**	**14,62,973**	**63,23,299**	**1,24,29,19,022**	**1,56,63,06,699**
Amount Refunded - C		-	-		-	-	-	-	-	-	-		-	-	-	-
NET BALANCE AS AT THE PERIOD END {A -(B+C)}	**-1,06,76,474**	**-3,23,97,859**	**-3,86,77,413**	**55,97,198**	**3,15,06,594**	**1,69,23,468**	**28,99,468**	**2,94,08,541**	**13,86,01,916**	**6,66,65,188**	**65,43,465**	**5,53,058**	**27,85,416**	**18,88,795**	**22,16,21,362**	**3,98,75,963**

ESSO-INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES

SCHEDULE - 3 CURRENT LIABILITIES & PROVISIONS

Particulars	Current Year (2016 - 17) ₹	Previous Year (2015 - 16) ₹
A. CURRENT LIABILITIES		
Earnest Money Deposit	40,58,730	79,93,294
Security Deposit	69,39,834	70,52,141
Outstanding Expenses	1,91,03,953	2,85,67,131
Sundry Creditors	2,29,44,759	1,60,80,151
INSPIRE/DISHA/RTF-DCS Fellowship	3,30,339	1,29,311
Monsoon Mission Fund (IITM)	-	2,12,812
Total – A	**5,33,77,615**	**6,00,34,840**
B. PROVISIONS		
Gratuity	2,52,17,407	53,66,870
Accumulated Leave Encashment	3,20,35,255	1,42,43,229
Total – B	**5,72,52,662**	**1,96,10,099**
Total (A+B)	**11,06,30,277**	**7,96,44,939**

ESSO-INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES

SCHEDULE – 4 FIXED ASSETS **(Amount in Rs.)**

DESCRIPTION (% of Depreciation)	GROSS BLOCK			DEPRECIATION			NET BLOCK	
	As at 31.03.2016	Additions during the year	As at 31.03.2017	As at 31.03.2016	For the year 2016-17	As at 31.03.2017	As at 31.03.2017	As at 31.03.2016
1. Land (0%)	1,000	-	1,000	-	-	-	1,000	1,000
2. Plant, Machinery & Equipments (15%)	4,53,57,169	-	4,53,57,169	4,43,37,946	1,52,883	4,44,90,829	8,66,340	10,19,223
3. Furniture & Fixtures (10%)	1,53,32,817	18,94,585	1,72,27,402	1,05,34,651	6,01,514	1,11,36,165	60,91,237	47,98,166
4. Office Equipment (15%)	29,70,801	3,85,691	33,56,492	23,27,446	1,51,455	24,78,901	8,77,591	6,43,355
5. Computer / Peripherals (60%)	12,31,71,318	46,96,865	12,78,68,183	4,64,00,926	4,75,36,185	9,39,37,111	3,39,31,072	7,67,70,392
6. Electric Installations (10%)	20,66,959	-	20,66,959	11,05,076	96,188	12,01,264	8,65,695	9,61,883
7. Library Books (100%)	6,19,78,506	86,19,986	7,05,98,492	5,59,51,589	1,08,26,857	6,67,78,446	38,20,046	60,26,917
8. Other Fixed Assets (15%)	64,73,696	84,945	65,58,641	20,70,664	6,73,196	27,43,860	38,14,781	44,03,032
9. Vehicles (15%)	18,49,835	-	18,49,835	13,46,476	75,504	14,21,980	4,27,855	5,03,359
Total	**25,92,02,101**	**1,56,82,072**	**27,48,84,173**	**16,40,74,774**	**6,01,13,782**	**22,41,88,556**	**5,06,95,617**	**9,51,27,327**
Previous Year	17,40,82,148	8,51,19,954	25,92,02,101	14,41,34,554	1,99,40,220	16,40,74,774	9,51,27,327	2,99,47,594

ESSO-INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES

SCHEDULE - 5 CURRENT ASSETS, LOANS & ADVANCES

Particulars	Current Year (2016 - 17) ₹		Previous Year (2015 - 16) ₹	
A. CURRENT ASSETS				
1. Inventories (Valued at cost)	8,43,468	8,43,468	10,13,777	10,13,777
2. Cash & Bank Balance :				
a) With Scheduled Banks – Current Account				
State Bank of India HAL CAMPUS A/c	4,91,80,820		4,21,11,878	
Andhra Bank Pragathinagar SAVING A/c	15,55,699		1,03,84,057	
Andhra Bank Pragathinagar-Consultancy A/c	18,01,952	5,25,38,471	8,49,850	5,33,45,786
b) Short Term Deposits with SBI	34,65,00,000		10,00,00,000	
c) Short Term Deposits with AB	-	34,65,00,000	-	10,00,00,000
TOTAL A:		**39,98,81,939**		**15,43,59,563**
B. LOANS, ADVANCES & OTHER ASSETS				
1. Deposits				
a) Telephone	1,73,186		1,96,574	
b) Electricity	70,16,374		61,49,489	
c) Gas	13,100		13,100	
d) Petrol/Diesel	1,01,400	73,04,060	1,01,400	64,60,563
2. Advances & other amounts recoverable in cash or in kind or for value to be received				
a) Vehicle Advance to Employees	3,49,577		6,39,550	
b) Interest Accrued	1,22,31,769		89,28,880	
c) Other Advances	-		3,100	
d) Advance for Purchase	21,44,317		96,62,859	
e) Sundry Debtors	23,31,464		-	
f) Tour Advance – Foreign	9,26,157		2,15,760	
g) LTC Advance	75,000		9,422	
h) TDS				
Opening Balance Rs. 2,06,15,182				
Less: Refund received during the year Rs. 28,80,140				
Add: Current year accumulation Rs. 23,39,349	2,00,74,391		2,06,15,182	
i) Margin Money against Bank Guarantee	2,30,00,000	6,11,32,675	30,00,000	4,30,74,753
TOTAL B: (1+2)		**6,84,32,675**		**4,95,35,316**
GRAND TOTAL (A + B)		**46,83,18,674**		**20,38,94,879**

ESSO-INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES

SCHEDULE 6 - INCOME FROM SALES / OTHER INCOME

Particulars	Current Year (2016- 17) ₹	Previous Year (2015- 16) ₹
a) Sale of Tender Forms	20,877	42,798
b) Other Receipts	6,29,168	19,57,686
c) Consultancy Services	31,47,433	1,69,350
d) Income from staff quarters	6,65,587	1,74,230
TOTAL	**44,63,065**	**23,44,064**

SCHEDULE 7 - INTEREST EARNED

a) Interest on Short Term Deposits & Others	44,84,628	4,99,915
b) Bank Accounts	1,32,522	2,05,323
c) Staff Advances	60,801	68,707
TOTAL	**46,77,951**	**7,73,945**

SCHEDULE 8 - IRRECOVERABLE GRANTS & SUBSIDIES RECEIVED

a) Central Government (Recurring Grant received from MoES)	35,00,00,000	35,00,00,000
TOTAL	**35,00,00,000**	**35,00,00,000**

SCHEDULE 9 - ESTABLISHMENT EXPENDITURE

a) Salaries, Wages & Allowances	11,85,79,235	7,80,51,191
b) Staff Welfare Expenses	23,83,556	18,25,633
c) Contributory Provident Fund	2,75,229	2,95,914
d) New Pension Scheme	38,03,773	39,51,662
e) IDBPS Trust	13,29,371	13,42,196
f) Leave Travel Concession	24,31,906	13,95,994
TOTAL	**12,88,03,070**	**8,68,62,590**

ESSO-INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES

SCHEDULE 10 - OTHER ADMINISTRATIVE EXPENSES

Sl No.	Particulars	Current Year (2016 - 17) ₹	Previous Year (2015 - 16) ₹
1.	Electricity & Power Expenses	3,55,66,921	3,59,70,698
2.	Water Charges	51,57,399	57,52,405
3.	Operation & Maintenance expenses	5,82,32,215	4,21,50,389
4.	Garden Expenses	-	8,09,113
5.	Vehicle Hiring Expenses	6,88,254	5,98,145
6.	Postage, Telephone, Fax & ISDN Charges	7,57,873	8,39,784
7.	Printing & Stationery	1,24,882	22,23,411
8.	Travelling Expenses :		
	Inland	30,97,141	25,66,766
	Foreign	9,78,875	2,56,216
	Others	2,65,098	7,00,420
9.	Seminar/Workshops Expenses	19,70,480	20,13,587
10.	General Expenses	88,93,200	10,78,744
11.	Audit Fee	30,921	15,467
12.	House Keeping Expenses	1,08,18,905	88,47,492
13.	Security Expenses	1,23,38,454	1,09,23,579
14.	Advertisement & Publicity	13,04,619	24,27,155
15.	Emoluments to Consultants	23,000	-
16.	Internet Expenses	-	45,14,055
17.	Legal Expenses	1,21,084	-
18.	Papers & Periodicals	34,388	28,899
19.	Conveyance Expenses	1,45,353	1,61,389
20.	Material/Consumable	45,43,854	82,66,310
21.	International Interface	1,74,34,067	1,64,21,874
22.	Others	4,35,833	1,72,414
	TOTAL	**16,29,62,816**	**14,67,38,312**

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 2016-17, the Society received Rs.35.00 Crores towards Recurring Grant as shown in the Schedule-8.

The remaining Grant-in-aid of Rs. 68.02 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 Assets schedule.

f) 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 2015-16 towards pension for the employees joined prior to 01-01-2004, was transferred by INCOIS to LIC of India Ltd.

Based on the MoES letters, INCOIS requested all the 11 employees, who are under INCOIS-IDBPS, to exercise the option either to continue in the Contributory Provident Fund or to join the New Pension Scheme as the IDBPS is being discontinued in INCOIS. The funds transfer to LIC of India Limited towards contribution of INCOIS for the IDBPS is deferred with effect from September, 2015 onwards

As per the directives of the GC, INCOIS has sent a letter dated March 19, 2015 to Joint Secretary (Establishment), MoES requesting for post-facto approval for the Defined Benefit Pension Scheme (DBPS) which has been implemented since May 2010 for its employees joined service prior to 1.1.2004.

MoES vide its reply letter dated August 13, 2015 informed that the issue has been examined in consultation with IFD, MoES and it has not been found possible to accede to consider INCOIS proposal for ex-post-facto approval for the Defined Benefit Pension Scheme (DBPS) which has been implemented since May 2010 for its employees joined service prior to 1.1.2004.

The letter further informs that the demand for pension in respect of INCOIS employees who joined prior to 1.1.2004 may please be regulated in terms of guidelines issued vide letter No.MoES/01/Dir(F)/2015 dated May 26, 2015.

All 11 employees in the scheme contested the exercising the option given by the INCOIS and filed a legal case with Central Administrative Tribunal, Hyderabad on November 12, 2015. The hearings are going on. The court has issued status-quo orders on February 24, 2016.

Periodical contributions to IDBPS are charged to revenue up to August 31, 2015 only.

iii) Periodical contributions made towards Contributory Provident Fund (CPF), New Pension Scheme (NPS) are charged to revenue.

iv) **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.

g) **Interest on Deposits:**

The Society invested surplus funds from time to time in Short Term Deposits in Nationalized Banks. For the year 2016-17, an amount of Rs.1,43,67,564/- 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 Society.

Accordingly, out of total interest of Rs.1,43,67,564/-, the management had transferred an interest of Rs.1,06,97,748/- to various projects classified in Earmarked Funds under Schedule – 2 and the balance interest of Rs.36,69,816/- was considered as income of the Society.

The details are furnished below:--

(Amount in Rs.)

a.	Interest earned on regular STDRs	1,31,22,175.00
b.	Add: TDS deducted by bank on interest earned	15,71,285.00
c.	Add: TDS deducted by bank & TSSPDCL on interest accrued	44,027.00
d.	Add: Accrued Interest as on 31.03.2017	55,685.00
e.	Total Interest	1,47,93,172.00
f.	Less: Accrued Interest as on 31.03.2016	4,25,608.00
g.	Net Interest earned for the F Y 2016 - 17	1,43,67,564.00

2. **Notes on Accounts:**

a) **EARMARKED FUNDS:**

The Society during the year 2016-17, received Rs. 68.02 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 31-03-2017 was Rs. 50.98 Crores.

The accumulated value of the capital expenditure as on 31-03-2017 (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 01-04-2016 ₹	Additions 2016-17 ₹	Total Amount as on 31-03-2017 ₹
i)	Building Fund	55,56,75,137	1,97,71,573	57,54,46,710
ii)	MDC & Equipment Fund	6,59,21,618	0	6,59,21,618
iii)	Ocean Information and Advisory Services (O-IAS)	1,21,86,44,819	32,35,67,513	1,54,22,12,332
iv)	Computational Facilities	15,28,06,467	0	15,28,06,467
v)	INDOMOD & SATCORE Projects	42,53,41,294	18,99,436	42,72,40,730
vi)	Ocean Observation Networks	55,74,61,180	2,19,63,708	57,94,24,888
vii)	International Training Center- ITCOocean	2,75,94,223	13,37,29,395	16,13,23,618
viii)	HROOFS	1,10,44,681	43,59,899	1,54,04,580
ix)	HPC System - INCOIS	13,64,14,440	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)	CSS	0	14,21,621	14,21,621
xiii)	V SAT Node	13,23,57,000	7,71,616	13,31,28,616
xiv)	Ernet India	72,00,000	0	72,00,000
xv)	IOAS	51,25,986	0	51,25,986
xvi)	MH Vulnerability	13,07,463	15,23,275	28,30,738
xvii)	Monsoon Mission	2,14,37,780	1,49,20,238	3,63,58,018
	Total	**4,71,21,10,564**	**52,39,28,274**	**5,23,60,38,838**

b) PROJECTS AND UTILISATION CERTIFICATES:

The Committees comprising the heads of respective projects and other technical/scientific experts are monitoring the status of the various projects, including the financial budgets etc. The recommendations of the committee are being reviewed from time to time by the competent authority.

The various assets of the projects and sub projects, purchased either by the INCOIS

or by the respective sub projects, are located at such projects and sub projects. The confirmations of the assets held by them are being submitted from time to time.

The respective project heads submitted 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) **Contingent Liabilities:**

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

d) I. The society had placed an order with M/s. Victory Genset Pvt. Ltd for purchase of two 600 KVS 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 as if two DG sets have been supplied and hence, filed a criminal and civil suit in 2009 against the supplier.

II. The III Additional Chief Judge of City Civil Court, Hyderabad, had passed a decree for Rs.64,89,747/- plus damages Rs.5,00,000/- with future interest till the date of payment by the firm vide their Order OS No.69 of 2010, dated 18-04-2012. 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. maintained at SBI, Versova Branch, Mumbai.

III. Upon grant of decree by Hon'ble court, the society on the advise of legal advisor had requested SBI Versova 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 petition to recover the balance amount. As SBI, Versova 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, Versova Branch for not adhering to the court decree. No response is received from the above.

IV. Society now filed an Executive Petition at III Additional Chief Judge of City Civil Court, Hyderabad for recovery of the amount available in the bank account of M/s Victory Genset Pvt.Ltd.at SBI, Versova Branch, Mumbai. The case is in progress.

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 **Y Chakravarthy Associates**
Chartered Accountants

Y Chakravarthy
Partner
M.No. 206456
FRN No: 007907S

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

(S. Nageswara Rao)	**(K.K.V.Chary)**	**(S.S.C.Shenoi)**
Sr. Accounts Officer	Dy. C A O	Director

Place: Hyderabad
Date: 02.08.2017

ESSO-Indian National Centre for Ocean Information Services

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

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