INCOIS ANNUAL REPORT

2019-2020

Front Cover

Presently, affordable at-sea communication is unavailable for the Indian fishermen. INCOIS has developed an innovative dissemination system called GEMINI (GAGAN-Enabled Mariner's Instrument for Navigation and Information). GEMINI is a cost effective satellite based dissemination platform that has potential to directly improve livelihood for lakhs of Indian fishermen. The GEMINI device receives messages in the middle of the sea directly from INCOIS, via Indian satellites and transfer them via Bluetooth to any smartphone. The information can be displayed in any coastal Indian languages within a feature-loaded app of the same name. This is INCOIS vision of empowering society with the help of technology, materialized.

Cover concept and description: Dr. Nimit Kumar

Back Cover

Entrance to
INCOIS Main Building

Photo Courtesy-
Knowledge Resource Centre,
INCOIS

Annual Report 2019-2020

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

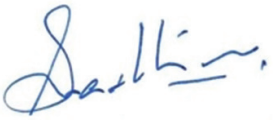
FOREWORD

I am pleased to introduce this year's Annual Report, which illustrates INCOIS's shared commitment to advancing excellence in ocean research, capacity building and oceanographic services for the benefit of common man. It is, as always, difficult to overestimate the central importance of INCOIS to the Society.

Through its extensive operational oceanographic services like ocean state forecasts, tsunami early warnings, advisories on Potential Fishing Zones, etc., and their dissemination, focused research on oceanographic processes, ocean observations and training programmes, publication of the findings in peer reviewed top-quality journals, etc. enables INCOIS to have a truly global reach and impact. The central belief in the importance of what is being done at INCOIS should reach and help the maritime users, from low-tech fishermen to high-tech maritime industries, is its biggest asset.

INCOIS is a grateful recipient of exceptional level of support from MoES, other research institutions, NGOs and industry. Rapid advancements in technology are affecting all our lives and it is fascinating to see how INCOIS is responding to the challenges and opportunities that are offered by these ongoing developments. By partnering with Airport Authority of India INCOIS developed the GEMINI system, an easy to use gadget for receiving the ocean information and warnings by the fishermen irrespective of their location at sea. This will enable in widening the access of tsunami, weather and ocean state warnings by the fishermen irrespective of where they are at the mid-seas. The 'Digital Ocean' that utilised the rapid advancements in web technology opens the new avenues in data archival, data management, data viewing and preliminary analysis. The PFZ forecasts based on ocean models combined with the satellite observations will increase the potency of PFZ services and its usability. The Ph.D. research at INCOIS benefit the women and men who are fiercely intelligent, articulate, and committed to explore the oceanic processes using newer ideas and modern tools.

Indeed, one reason for INCOIS's ongoing success is that it works tirelessly to maintain the operational oceanographic services accurate and timely and reach them to a vast user community. INCOIS seeks what Tennyson called the ever-moving margins of the 'untraveled world'. Its achievements are the result of commitment to excellence, professionalism, creativity, and innovation of its staff. In the pages that follow, you will see that my statement is justified.



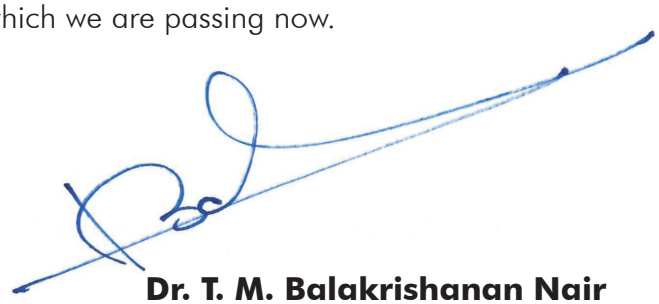
S.S.C. Shenoi
Former Director
INCOIS (2009-2020)

FOREWORD

I am happy to write a 'foreword' for this year's Annual Report of INCOIS, which highlights the achievements of the institute in the past one year. During the past one year, INCOIS continued to play a leadership role in the field of operational oceanography and allied services through sustained observations and focused R&D. INCOIS has emerged as one of the most sought places for getting trained in the operational oceanography and ocean services.

One of the most notable achievement in the past one year is the development of GEMINI instrument and mobile app to disseminate warnings/alerts and forecasts to fisher-folks at sea, which is innovative dissemination system for Integrated Marine Fishery Information System (InMarFIS) to safeguard the life and livelihood of common man. Our team could complete the setup of Isotopes Ratio Mass Spectrometry (IRMS) lab for improvement of PFZ advisories. INCOIS also operationalized the early warning services such as Small Vessel Advisory System (SVAS) and Swell Surge Warning System which have direct link to life of fisherman in sea and at shore. INCOIS also could support the marine industries and thus blue economy growth of country by providing value added products and services for oil, shipping, port and harbours etc including industries in our neighbouring countries. Scientists of INCOIS have demonstrated their scientific temperament and institutional commitment by publishing their research articles in reputed national and international SCI journals and converting it to useful services/products for maritime need.

INCOIS could effectively manage Covid 19 cases both preventive and welfare level through a Covid task team. This inspired the employees to work with certain level of confidence and sustain our services without break during the pandemic period. I take this opportunity to congratulate my fellow scientists and other scientific and administrative staff for their tireless efforts to serve the society during the most difficult times through which we are passing now.



Dr. T. M. Balakrishanan Nair
Former Director, I/C

Contents

From Director's Desk

It is my great privilege to take charge as the Director of the Indian National Centre for Ocean Information Services (INCOIS), an institution that I have been an integral part since its inception in 2001. Originally conceived as a provider of oceanographic data and services, INCOIS quickly evolved into a knowledge and information technology hub for the oceanic realm. Not many countries in the world can boast of institutions such as INCOIS, that transform the benefits of ocean science and technology into products and services useful to the society. It will be my endeavour to take INCOIS further along this growth trajectory, ensuring that the services of INCOIS will continue to improve our understanding of the oceans, and enhance the safety of lives and livelihoods of coastal communities.

It is also my pleasure to present the annual report of INCOIS for the financial year 2019-20. At the outset, let me thank Dr. S. S. C. Shenoi, who retired as Director INCOIS in May 2020, after providing an exemplary leadership to INCOIS for more than a decade and transforming INCOIS as an international leader in Ocean Services, Operational Oceanography, Ocean Science and Capacity Building. The Services of INCOIS have now become integral part of maritime activities in India and many Indian Ocean rim countries. I also wish to thank Dr. Balakrishnan Nair for holding the charge as interim Director during June to August 2020 and guiding the activities of INCOIS during the challenging times of Covid-19.

During the period under report, INCOIS continued to provide Potential Fishing Zone (PFZ) advisories, Ocean State Forecasts, Tsunami Early Warnings as well as data and information services. For the benefit of fishermen venturing out into sea for multi-day fishing, INCOIS has developed a PFZ forecast system to provide predictions on the potential regions of fish availability with up to 3 days lead time based on physical and biogeochemical parameters from the High-resolution Operational Ocean Forecast System. The system is now ready for two sectors viz. Gujarat and northern Andhra coast and will be extended to other sectors in due course of time.

The increasing frequency of algal bloom is a major concern due to its ill effects on fishery, marine life and water quality. In order to detect and forewarn about the presence of Harmful Algal Blooms (HABs), INCOIS has developed a service for "Detection and Monitoring of Bloom in the Indian Seas". This service complements the Potential Fishing Zone advisories being provided by INCOIS.

Swell surges and associated flash floods are nightmares for many living in the low lying areas along our coast. In order to issue warnings of approaching high period swells, INCOIS designed and developed a Swell Surge Forecast System for the Indian coasts. The system comprises a suite of interacting models such as WAVEWATCHIII, SWAN and ADCIRC. In addition, INCOIS provided timely warnings about the high-wave conditions due to cyclonic storms in the Bay of Bengal and Arabian Sea, which helped to save life and livelihood of many fishermen and coastal communities.

As an important and innovative means of disseminating advisories to fishermen out at sea where other traditional modes of communication are not feasible, INCOIS, together with Airports Authority

of India (AAI), developed a low-cost one-way satellite communication system. This system works on the "GPS Aided Geo Augmented Navigation (GAGAN)" platform and is named "GAGAN Enabled Mariner's Instrument for Navigation and Information (GEMINI)".

INCOIS continued the acquisition of data on various ocean parameters from the coastal and open ocean waters by deploying Argo floats, wave rider buoys, sea level gauges, ADCPs, drifters, XBTs, ship board AWS, etc. The profiles of turbulent kinetic energy dissipation rates collected using vertical micro-structure profilers during two cruises in the Bay of Bengal adds to our data archives and will aid in research to understand mixing process in the seas around us. INCOIS also completed the development of the Digital Ocean (a web-based application) aimed to provide a dynamic framework to integrate heterogeneous ocean data and its online viewing and analysis.

Our tsunami early warning service continued to function, detecting every earthquake that occurred on the ocean bottom anywhere in the world. INCOIS closely monitored the situation during two significant earthquakes that occurred in the Indian Ocean during 2019-20 and declared a 'no tsunami threat' for India, avoiding unnecessary coastal evacuations. INCOIS in association with the state government of Odisha piloted the Tsunami Ready community recognition programme in 6 villages, with 2 of those villages applying for UNESCO-IOC Tsunami Ready recognition tag.

INCOIS continued efforts on ocean modelling and data assimilation to improve the quality of operational oceanographic services provided by us. Efforts are underway to assimilate sea level anomaly and biogeochemical observations in the Regional Ocean Modelling System, used for the operational ocean forecasts for the coastal waters. The coupled HYCOM-HWRF model configured by INCOIS is now being extensively used by IMD for tropical cyclone predictions. Focused R&D with observations and models provided new insights on the interior ocean mixing due to internal tides in the Bay of Bengal.

The International Training Centre for Operational Oceanography (ITCOocean) conducted 11 courses on various aspects of operational oceanography. The first meeting of newly constituted Governing Board (GB) of UNESCO Category 2 Center under the chairmanship of Dr. M. Rajeevan, Secretary, MoES was held on 8 January 2020 at National Institute of Ocean Technology (NIOT), Chennai.

INCOIS scientists published 64 research papers in reputed national and international journals with a cumulative impact factor of 143. Dr. M.S. Girishkumar was selected for the *'Vocational Excellence Award 2019-20'* for excellence in oceanographic research by the Rotary Club of Hyderabad, Deccan which is a primary unit of Rotary International. Dr. Abhishek Chatterjee has been elected as associate fellow of Telangana Academy of Sciences in recognition of his contributions in earth and planetary sciences. The Eugene LaFond Medal was awarded to Rohith Balakrishnan, Project Scientist B, for the paper "Basin-wide sea level coherency in the tropical Indian Ocean driven by Madden-Julian oscillations" at the International Union of Geodesy and Geophysics - IUGG General Assembly in Montreal, Canada, held during 8-18 July 2019.

Dr. Satheesh Shenoi, Former Director, INCOIS was unanimously elected as the Vice-Chair (Group IV) of UNESCO's Intergovernmental Oceanographic Commission for the period 2019-2021 during the 30th session of the IOC Assembly held at UNESCO Headquarters, Paris, France between 26 June and 4 July 2019. He is also reappointed as chair of Union Commission for Data and Information (UCDI) for the period 2019-2023, a position he had been holding for the period 2015-2019.

A special event on the "Vishwa Hindi Diwas" under the aegis of Town Official Language Implementation Committee-3 Hyderabad was conducted at INCOIS on 28 January 2020. INCOIS was honoured with the "Rajbhasha Hindi Karyanvayan Ratna Award" by the Parivartan Jan Kalyan Samiti- Delhi during a three-day Akhil Bhartiya Vishesh Rajbhasha Hindi Aavasiya Karyashala Evam Sangoshti held between 30 May and 1 June 2019 at Thiruvananthapuram.

On the occasion of 5th International Yoga Day on 21 June 2019, a three-hour comprehensive seminar on Yoga was conducted for INCOIS Staff. INCOIS also celebrated International Women's Day 2020 with a special programme on 6 March 2020. Apart from the regular efforts to keep our campus and neighbourhood clean, on the eve of World Environment Day on 4 June 2019 a bio-gas plant was inaugurated within the INCOIS campus. Swachhta Pakhwada was organised during 1-15 July 2019. Swachhta Hi Seva drive was organized from 17 September to 2 October 2019.

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 the Intergovernmental Coordination Group (ICG) for the Indian Ocean Tsunami Warning and Mitigation System (IOTWMS) of the 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 continued to be hosted by INCOIS to coordinate the IIOE-2 project (2016-2020) which is jointly sponsored by IOC, SCOR and IOGOOS.

Dedicated efforts of our scientists, scientific and administrative support staff ensured that INCOIS continue to remain at the helm of operational oceanography. I sincerely acknowledge the unflinching support and guidance of Dr. M. Rajeevan, Chairman of INCOIS Governing Council (GC) and the members of GC. I also thank the Chairs and members of Finance Committee and Research Advisory Committee for their advice and support in conducting the financial and scientific affairs of INCOIS. Colleagues in Ministry of Earth Sciences, especially the Programme Officer and his team, and at the MoES centres: NIOT, NCPOR, IITM, NCESS, NCMRWF, IMD, NCS, CMLRE and NCCR were always there to support. I thank them all.

The Annual Report was prepared by the Editorial Committee chaired by Francis with the support of its members Hari, Kiran, Praveen, Ajay, Nimit, Celsa, Sidhartha, Greeshma. I thank them for doing a wonderful job.

Thank you

Jai Hind

T. Srinivasa Kumar

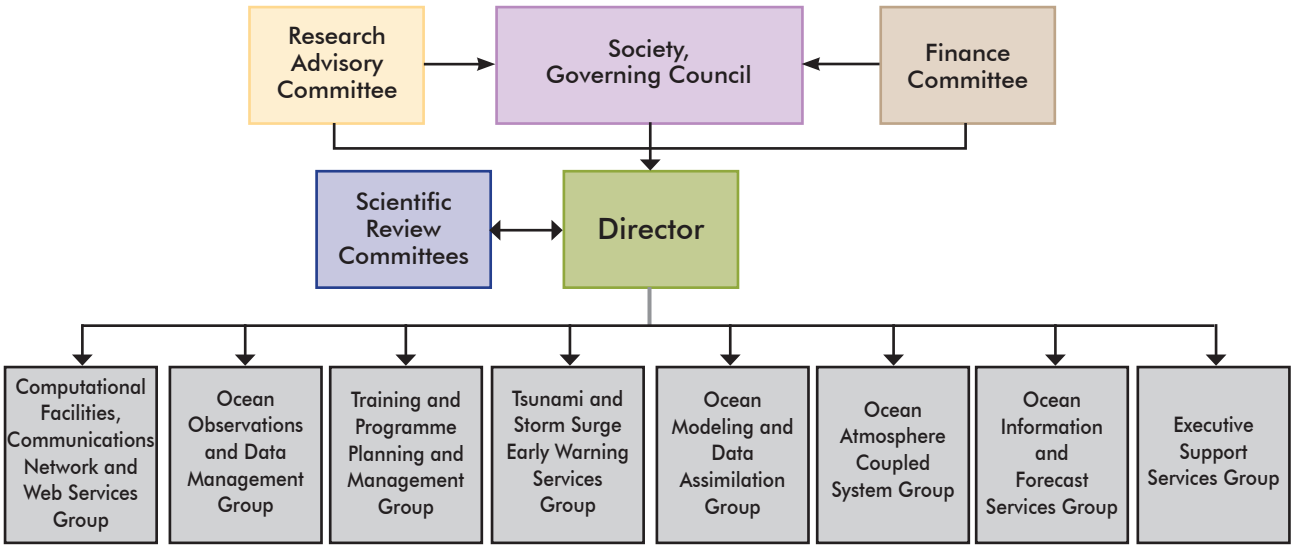
2. INCOIS Organizational Structure

Indian National Centre for Ocean Information Services (INCOIS) is an autonomous institute under the administrative control of Ministry of Earth Sciences (MoES), Government of India.

INCOIS was registered as a society under the Andhra Pradesh (Telangana) 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 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 Polar and Ocean Research, Goa	Member
Director, Indian National Centre for Ocean Information Services	General Secretary



Organization Structure of INCOIS

2.2 INCOIS Governing Council

1.	Secretary to Government of India, Ministry of Earth Sciences	(Chairman)
2.	Additional Secretary & Financial Advisor/ Joint Secretary & Financial Advisor, MoES	(Member)
3.	Additional Secretary/ Joint Secretary, MoES	(Member)
4.	Prof. G.S. Bhat, IISc Bangalore & Chairman, INCOIS-RAC	(Member)
5.	Dr. R.R. Navalgund, ISRO, Bangalore	(Member)
6.	Director, National Remote Sensing Centre	(Member)
7.	Director, Indian Institute of Tropical Meteorology	(Member)
8.	Director, National Institute of Oceanography	(Member)
9.	Head, National Centre for Medium Range Weather Forecasting	(Member)
10.	Programme Head (INCOIS), MoES	(Permanent Invitee)
11.	Representative, NITI Aayog	(Invitee)
12.	Director, Indian National Centre for Ocean Information Services	(Member Secretary)

2.3 INCOIS Finance Committee

1.	Additional Secretary & Financial Advisor/ Joint Secretary & Financial Advisor, MoES	(Chairman)
2.	Additional Secretary/ Joint Secretary, MoES	(Member)
3.	Programme Head (INCOIS), MoES	(Member)
4.	Director/Deputy Secretary (Finance), MoES	(Member)
5.	Director, INCOIS, Hyderabad	(Member)
6.	Dy. Chief Administrative Officer, INCOIS, Hyderabad	(Member)
7.	Senior Accounts Officer, INCOIS, Hyderabad	(Member Secretary)

2.4 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)

2.5 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 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 INCOIS.

2.6 Quality Policy

The Indian National Centre for Ocean Information Services (INCOIS), 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 our Quality Management System, by setting and reviewing quality objectives.

3. Highlights

1. **UNESCO-IOC Tsunami Ready Villages:** Indian Tsunami and Storm Surge Warning Centre in association with the state government of Odisha implemented Tsunami Ready Programme on pilot basis in 6 villages in Odisha. India is the first country to implement the Tsunami Ready Programme in the Indian Ocean region.

2. **Satellite based dissemination system using GEMINI:** In order to send OSF and PFZ advisories to fishermen at sea, INCOIS, together with Airports Authority of India (AAI), has developed a low-cost one-way communication system through a GAGAN (GPS Aided Geo Augmented Navigation) based receiver named "GAGAN Enabled Mariner's Instrument for Navigation and Information or GEMINI".

3. **PFZ Forecast System:** INCOIS developed a PFZ forecast system for two sectors viz. Gujarat and Coastal Andhra Pradesh to provide predictions on the potential regions of fish availability up to 3 days lead time based on the forecasts of physical-biogeochemical parameters by the High-resolution Operational Ocean Forecast System.

4. **Swell Surge Forecasts:** In order to issue warnings of approaching high period swells, INCOIS designed and developed a Swell Surge Forecast System for the Indian coasts. The system comprises a suit of interacting models such as WAVEWATCHIII, SWAN and ADCIRC.

5. **Digital Ocean:** As a one-stop solution for all data related services such as archiving, visualising and dissemination, INCOIS developed the "Digital Ocean", an innovative web-application to manage ocean data. The system is now being used experimentally by INCOIS users.

6. **Specific Ocean Observations:** INCOIS conducted two process specific research cruises during the reporting period - one in the Arabian Sea on board ORV Sagar Kanya and another in the Bay of Bengal on board ORV Sagar Nidhi for understanding the turbulent characteristics of the upper ocean using microstructure profiler, lowered ADCP (LADCP), underway CTD (uCTD), and meteorological measurements with ASIMET sensors.

7. **Coupled HWRF-HYCOM for cyclone prediction:** A coupled HWRF-HYCOM with moving nest has been implemented by INCOIS. The coupled model obtains the ocean initial and boundary conditions from high resolution (1/16°) operational Indian Ocean HYCOM nested to a 1/4th degree global HYCOM.

8. **ITCOocean:** The first meeting of Governing Board (GB) of UNESCO Category 2 Center under the Chairmanship of Dr. M. Rajeevan, Secretary, MoES was held on 8 January 2020 at National Institute of Ocean Technology (NIOT), Chennai. ITCOocean also conducted 11 training programmes at INCOIS.

9. **Memorandum of Understanding:** INCOIS signed an MoU with Swami Ramanand Teerth Marathwada University (SRTM) Nanded, Maharashtra for active collaboration in academic and research activities on 6 September 2019.

10. **Chair, Union Commission for Data and Information (UCDI):** Dr. S.S.C. Shenoi, Director, INCOIS who served as the chair of UCDI during 2015-2019 is reappointed as its chair for the period 2019-2023.

11. **Vice-Chair, IOC-UNESCO:** Dr. Satheesh Shenoi, Director, INCOIS was unanimously elected as the Vice-Chair (Group IV) of UNESCO's Intergovernmental Oceanographic Commission for the period 2019-2021 during the 30th session of the IOC Assembly held at UNESCO Headquarters, Paris, France between 26 June and 4 July 2019.

12. **Awards and Recognitions:** Dr. M.S. Girishkumar was selected for the *'Vocational Excellence Award 2019-20'* for excellence in oceanographic research by the Rotary Club of Hyderabad, Deccan which is a primary unit of Rotary International. Dr. Abhishek Chatterjee has been elected as associate fellow of Telangana Academy of Sciences in recognition of his contributions in earth and planetary sciences. The Eugene LaFond Medal was awarded to Rohith Balakrishnan, Project Scientist B, for the paper "Basin-wide sea level coherency in the tropical Indian Ocean driven by Madden-Julian oscillations" at the International Union of Geodesy and Geophysics - IUGG General Assembly in Montreal, Canada, held during 8-18 July 2019.

13. **IISF Curtain Raiser:** A special curtain-raiser event was organized at INCOIS on 24 October 2019 for the India International Science Festival (IISF) 2019.

14. **Promotion of Hindi:** A special event on the "Vishwa Hindi Diwas" under the aegis of Town Official Language Implementation Committee-3 Hyderabad was conducted at INCOIS on 28 January 2020. INCOIS was honoured with the "Rajbhasha Hindi Karyanvayan Ratna Award" by the Parivartan Jan Kalyan Samiti-Delhi during a three-day Akhil Bhartiya Vishesh Rajbhasha Hindi Aavasiya Karyashala Evam Sangoshti held between 30 May and 1 June 2019 at Thiruvananthapuram.

15. **International Yoga Day:** On the occasion of 5th International Yoga Day on 21 June 2019, a three-hour comprehensive seminar on Yoga was conducted for INCOIS Staff.

16. **Women's Day Celebrations:** International Women's Day 2020 was celebrated with a special programme on 6 March 2020.

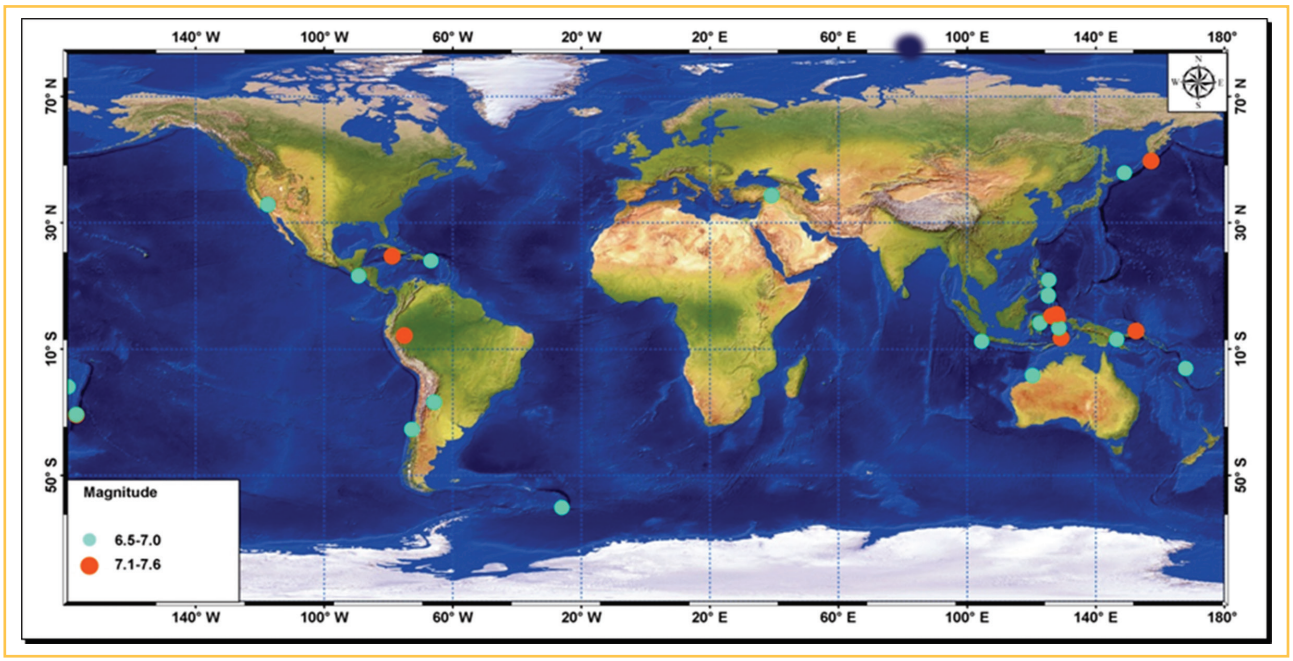
17. **Swachh Bharat Programme:** On the eve of World Environment Day on 4 June 2019 a bio-gas plant was inaugurated in INCOIS campus. Swachhta Pakhwada was organised during 1-15 July 2019. Swachhta Hi Seva drive was organized from 17 September to 2 October 2019.

18. **Publications:** Scientists of INCOIS published 64 papers in reputed national and international SCI journals with cumulative impact factor of 143.

4. Services

4.1 Tsunami and Storm Surge Early Warning System

The Indian Tsunami Early Warning Centre (ITEWC) had monitored 29 earthquakes (Ocean and near coast) with magnitude ≥ 6.5 Mw during April 2019 to March 2020. Of the 29 earthquakes only 2 earthquakes have occurred in the Indian Ocean. ITEWC assessed the situations carefully during each earthquake in the Indian Ocean. In all cases, ITEWC had declared that there would not be any tsunami threat for India. Being the Tsunami Service Provider (TSP) for Indian Ocean, necessary bulletins were also sent to Indian Ocean rim countries and IOC through E-mails, GTS, FAX and SMS.



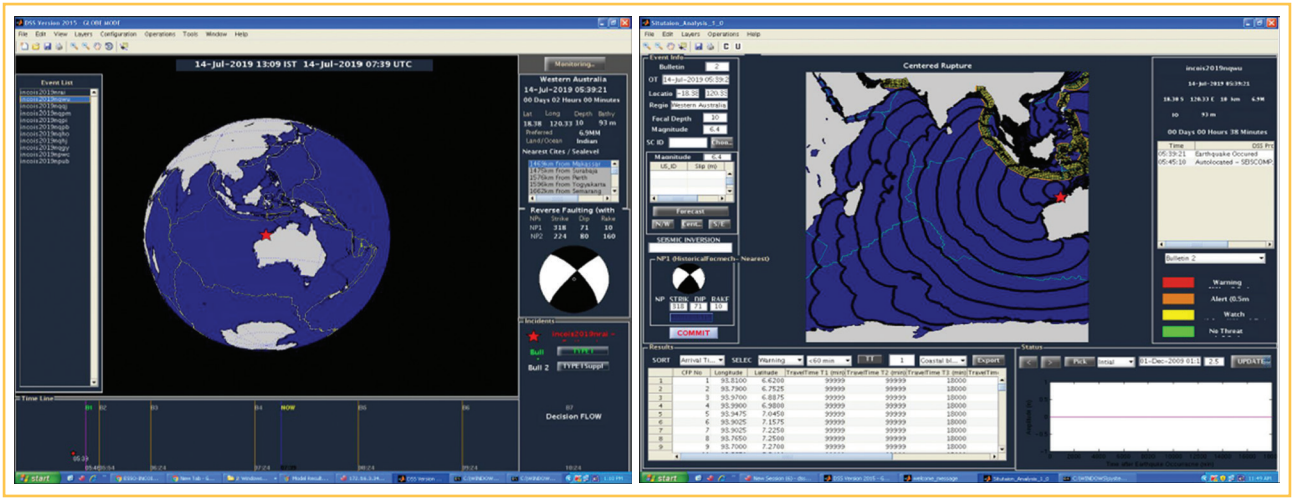
Location map of earthquakes of magnitude ≥ 6.5 Mw monitored at ITEWC during 2019-20

Key Performance Indicators (KPI) of ITEWC

	Performance Indicator	Target	ITEWC Performance
KPI 1	Elapsed time from earthquake to issuance of first Earthquake Bulletin	10 Min	10.8
KPI 2	Probability for detection of IO EQ with magnitude >= 6.8 Mw	100%	100%
KPI 3	Accuracy of earthquake magnitude in comparison with Final USGS parameters	0.3	0.15
KPI 4	Accuracy of earthquake hypocenter depth in comparison with Final USGS parameters	30 Km	55.4
KPI 5	Accuracy of earthquake hypocenter location in comparison with Final USGS parameters	30 Km	24.1
KPI 6	Elapsed time from earthquake to issuance of first Threat Assessment Bulletin	20 Min	18

Monitoring of Tsunamigenic Earthquakes in Indian Ocean (IO)

1) An earthquake of magnitude 6.9 Mw occurred off the western side of northern coast of Australia on 14 July 2019 at 05:39 UTC. The epicenter of the event was 18.38°S, 120.33°E with the focal at a depth of 10 km. ITEWC issued first bulletin at 05:46 UTC with tsunami evaluation statement. In the second bulletin issued after 28 min, INCOIS revised the magnitude of earthquake to 6.4 Mw and declared the situation as 'No Threat' to India.

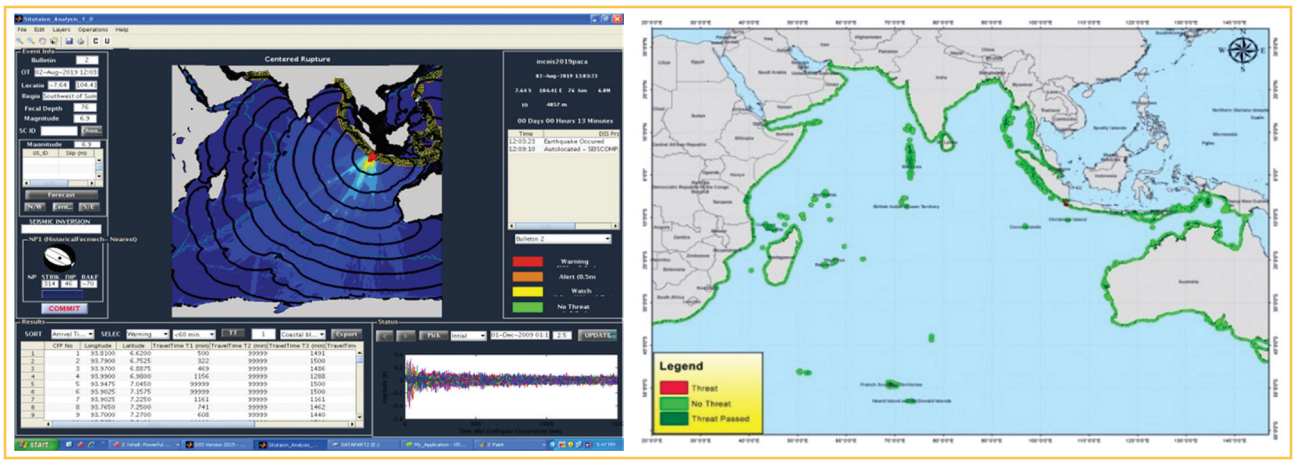


Operational model forecasts during a major event on 14 July 2019

Table: Bulletin timelines for Western-north Australian earthquake on 14 July 2019

Time (UTC)	Event	Elapsed Time from EQ Origin Time (min)
0539	Earthquake Occurrence	0
0546	Bulletin-1 Issued (Magnitude 6.9)	7
0607	Bulletin-2 Issued No Threat (Revised Magnitude 6.4)	28

2) An earthquake of magnitude 6.8 Mw occurred off the south-west coast of Sumatra, Indonesia on 2 August 2019 at 12:03 UTC. The epicenter of the earthquake was at 7.64°S, 104.41°E and the focal point was at a depth of 10 km below the surface. Based on the numerical modeling, ITEWC issued a bulletin at 12:21 UTC with 'No Threat to India, and tsunami threat



Operational model forecasts during a major event on 2 August 2019

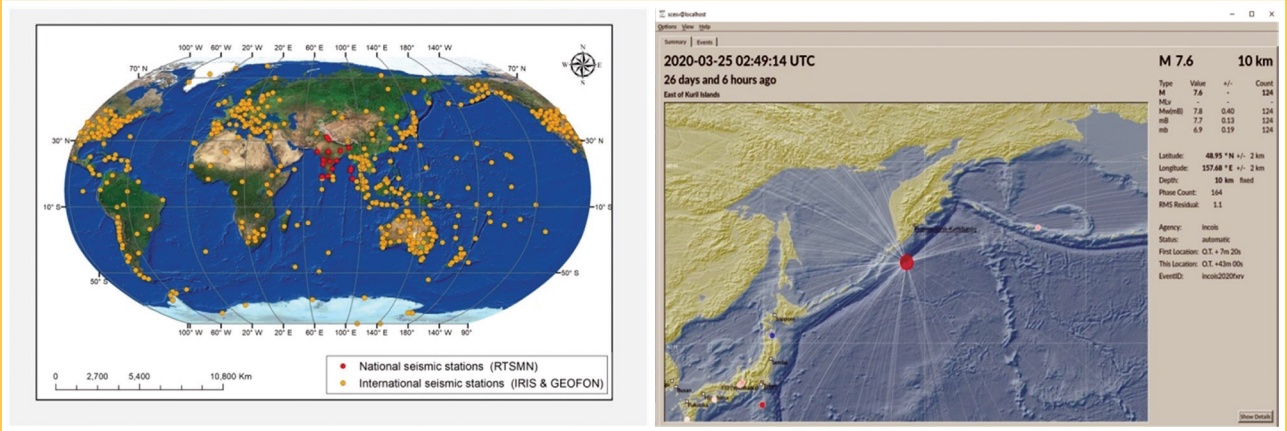
for 3 coastal zones in Indonesia'. As there were no significant tsunami wave recorded by any of the sea level stations, a bulletin with message 'threat passed' was issued at 15:25 UTC.

Table: Bulletin timelines for Southwest of Sumatra, Indonesia earthquake on 2nd August 2019

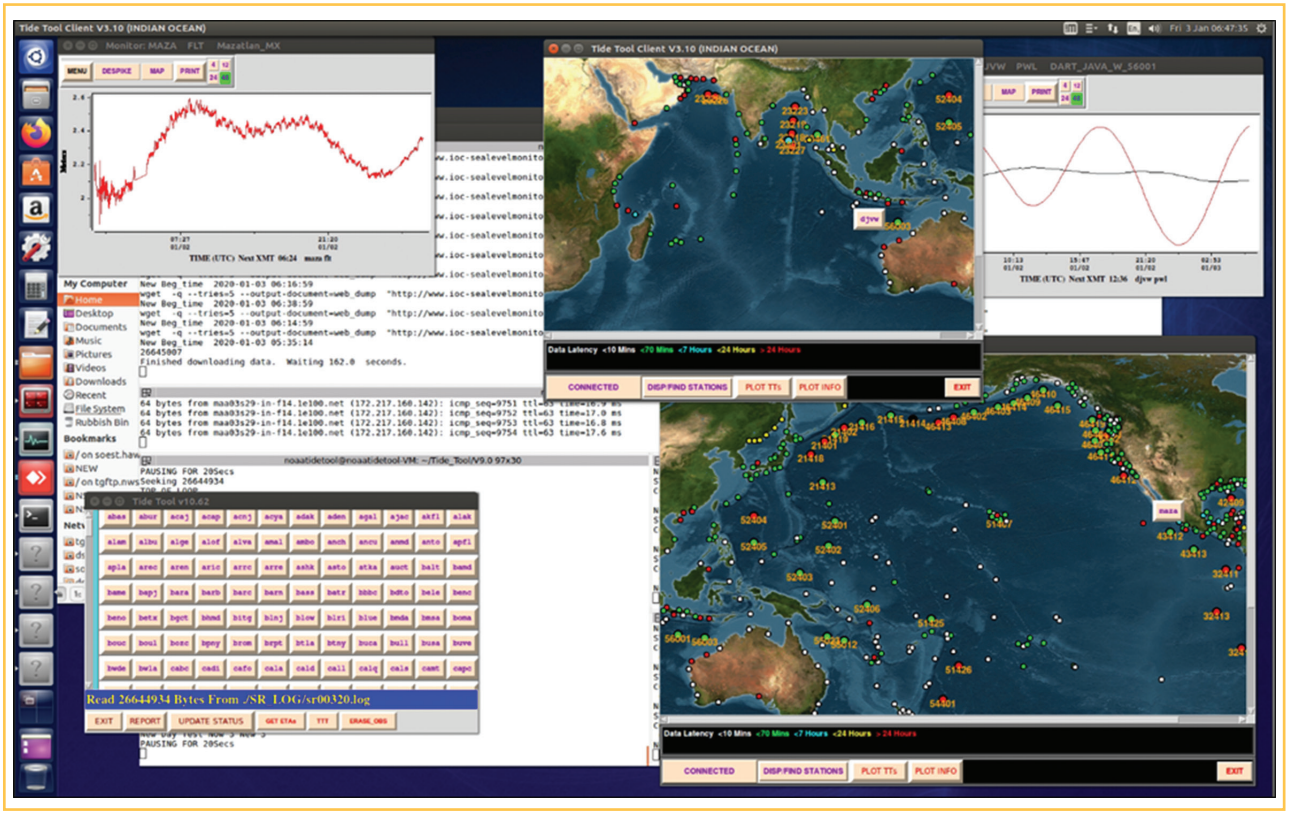
Time (UTC)	Event	Elapsed Time from EQ Origin Time (min)
1203	Earthquake Occurrence	0
1212	Bulletin-1 Issued	9
1221	Bulletin-2 NO-THREAT to India (Final) Threat for Indonesia 3 area	18
1525	Bulletin-3 No significant tsunami wave was observed Threat passed off	202

Technology Refreshment

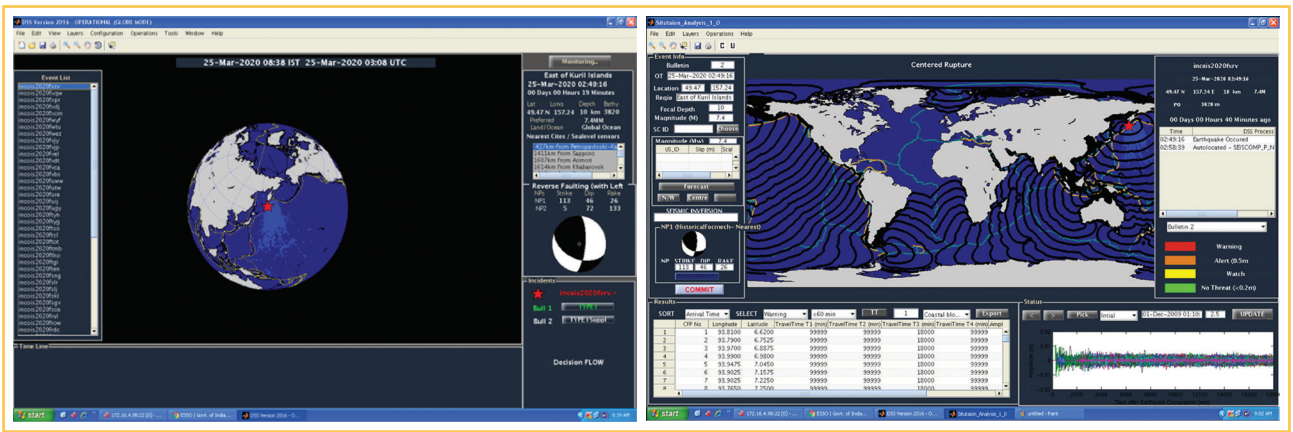
INCOIS completed porting of the end-to-end tsunami applications and migration software to the new servers at INCOIS and Disaster Recovery site (DR site) at IITM, Pune. Both systems are capable of detecting and processing of earthquake information and dissemination, including publishing the tsunami bulletins in the web. This was made operational on 19 March 2020. Major components those underwent technology refreshment are (i) seismic subsystem (SeisComP3) which collects data from seismic sensors in the region and worldwide in real-time, (ii) sea level subsystem used for real time acquisition and processing of observations from tsunami buoys and tide gauges networks, (iii) Open Ocean Propagation Scenario Database (OOPS DB) generated by TUNAMI-FF model and (iv) the state-of-the art Decision Support System (DSS), version 2016 with all the necessary metadata and spatial layers viz., latest version of Area of Service (AoS), Earthquake Source Zone (ESZ), Coastal Forecast Points (CFPs) and Coastal Forecast Zones (CFZs). DSS-2016 uses the scenario database for the Indian Ocean events and launches a tsunami model on CUDA GPUs in near real time for simulating the open ocean propagation of tsunamis generated by the earthquakes in the ocean other than Indian Ocean for generating tsunami advisories as per Standard Operating Procedure (SOP) of ITEWC. An enhanced dissemination server, developed



a) Seismic observation network, b) Earthquake with magnitude 7.6 Mw detected by SEISCOMP3 for the event occurred east of Kuril Island on 25 March 2020



Sea level data acquisition from international DARTs and tide gauges and their processing using NOAA Tide tool configured in the new processing system and dashboard.



A snap of DSS frame for Kuril Island event on 25 March 2020

completely using web services is disseminating the advisories and notification messages to both national and international stakeholders seamlessly. A dissemination dashboard was also setup to provide real-time status of the delivery of warnings to the operators of the warning centres. The efficiency of the end-to-end system was tested during the earthquake of 7.6 Mw occurred on 25 March 2020 at 0249 UTC in the Pacific Ocean.

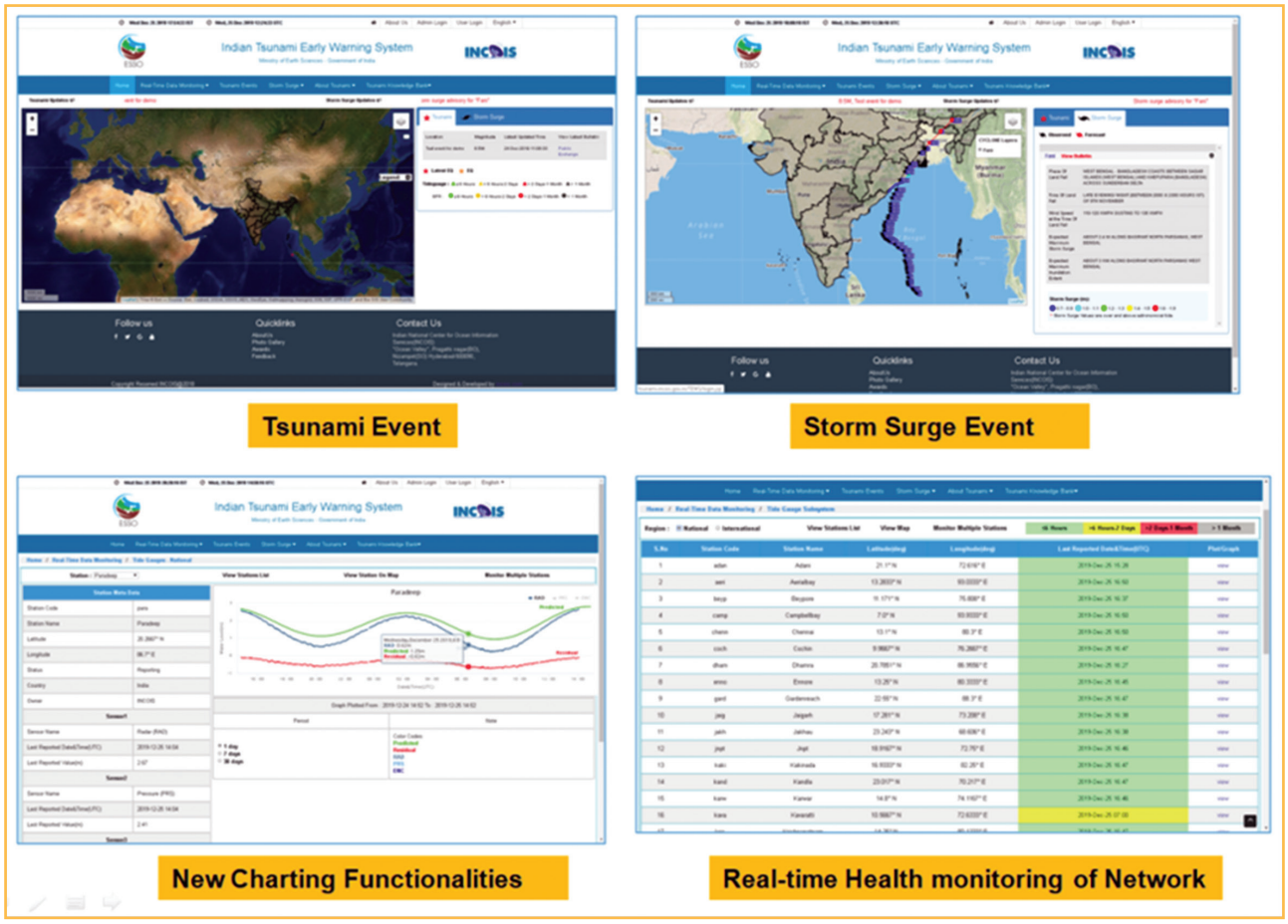
New Tsunami Website

INCOIS re-redesigned the Tsunami website, www.tsunami.incois.gov.in, by adopting latest technologies such as responsive web design framework, J2EE technologies and Mapping frameworks to make it more efficient and user friendly. This website is now capable of delivering dynamic contents using database and GeoJSONs and it can deliver the content to wide range of users, platforms, devices at various resolutions. This new website was made operational on

19 March 2020. Key features of the webpage are:

- Responsive user interface to support viewing in mobile phones and tablets
- Provides quick overview of tsunami and storm surges;
- Leaflet mapping framework to view real time and catalog of historical events
- Improved charting functionality for sea level data visualization

Responsive Website of Tsunami and Storm surge Early Warning System



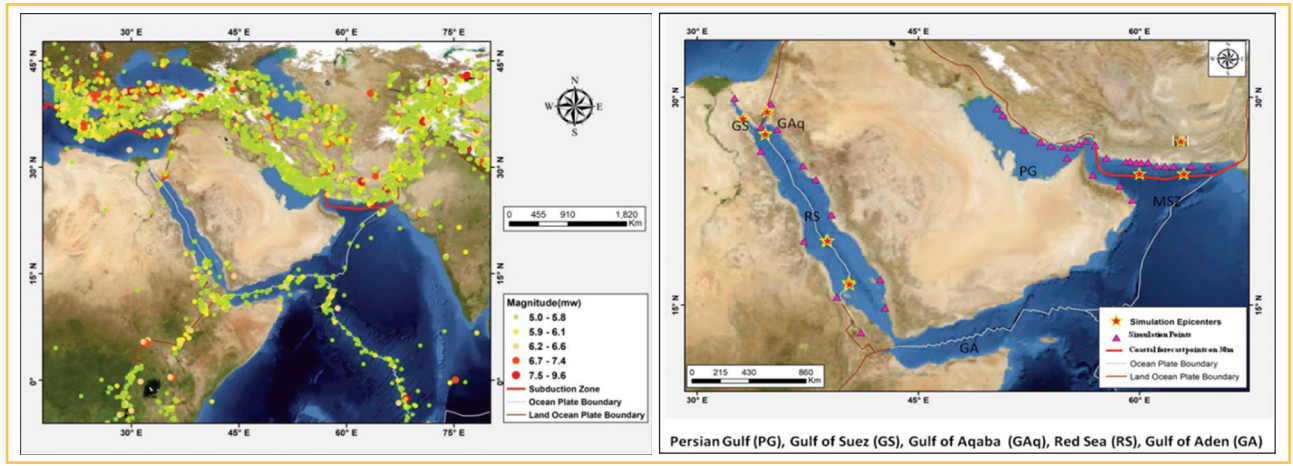
Tsunami Website: (clock wise) Home page during a tsunami; Home page during a cyclone; Real-time health monitoring of Sea level network; New charting functionalities along with metadata

Generation of tsunamis in the Arabian Sea, Persian Gulf and the Red Sea from Typical and Atypical Sources

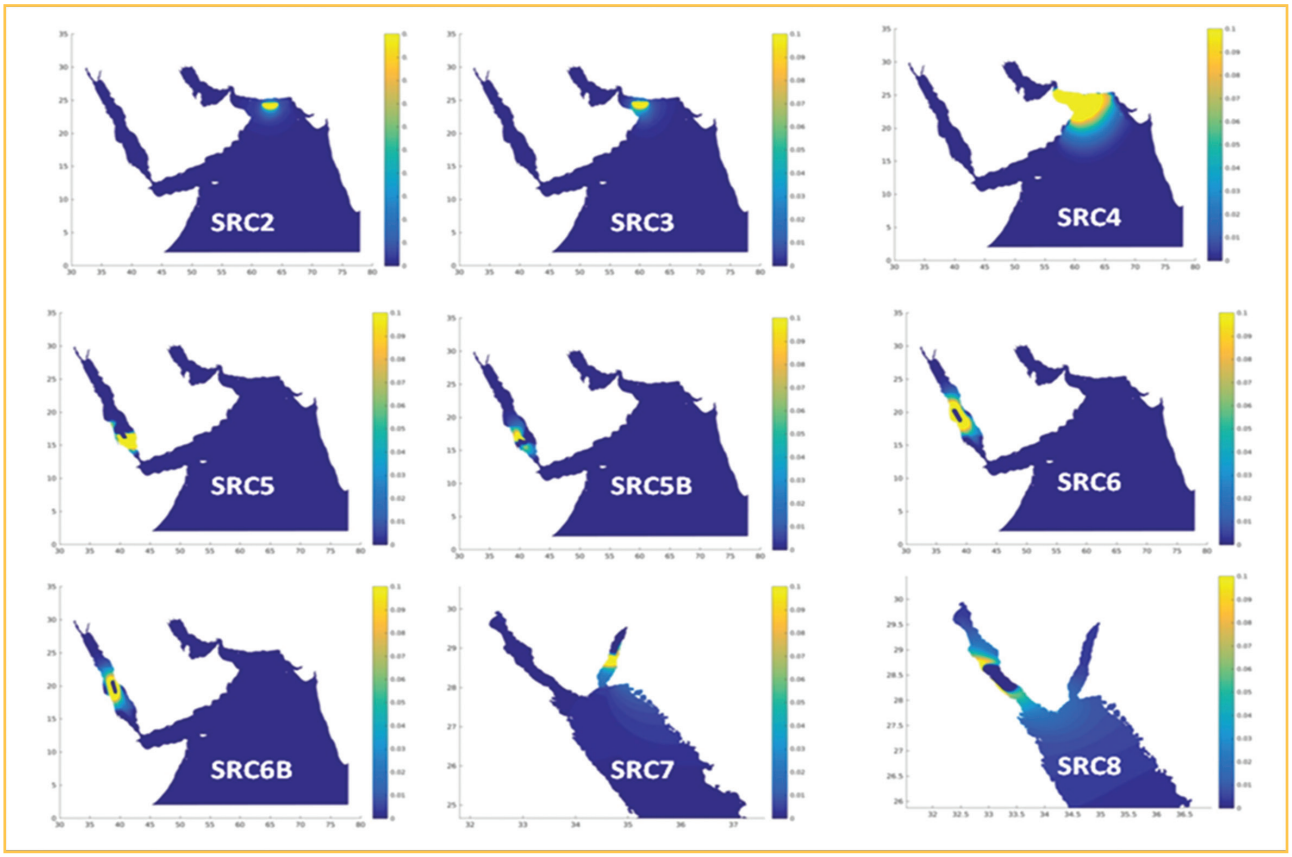
A study was carried out to assess the impact of tsunamis generated due to typical and atypical sources in the Arabian sea, Persian Gulf and Red Sea. The finite element model, ADCIRC, was used for this study. The study suggested that the tsunamis triggered by atypical sources can impact

(clock wise) Sea level network; Admin services dashboard; Web GIS enabled bulletins

the coastal areas in the Arabian Sea with wave heights more than the threat threshold of 50 cm. The tsunamis generated due to typical sources can impact Arabian Sea and Persian Gulf with wave heights more than the threat threshold. The tsunamis, those generated in Gulf of Red Sea, Gulf of Aqaba can have local impacts within these gulf areas only with wave heights more than the threat threshold of 50 cm. For such tsunamis, it is estimated that the travel times to different coastlines will range from 1 hour to 9 hours.



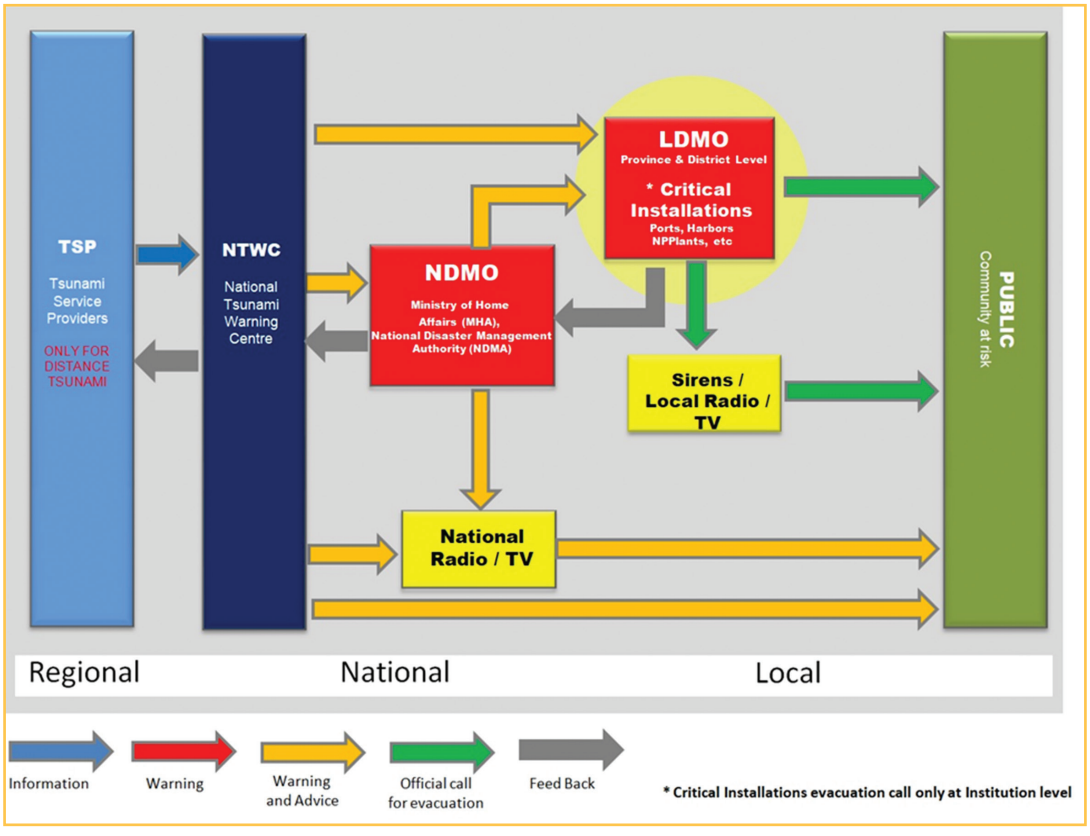
a) Historical seismicity of NWIO region b) Selected earthquake sources to study the impact of tsunamis on PG, GS, GAq, RS and GA



Deepwater maximum wave amplitudes generated from ADCIRC tsunami model for selected sources

Warning Chain adopted under ICG/IOTWMS framework

Based on the recommendations of ICG/IOTWMS meeting held in Muscat, in September 2019, ITEWC updated the warning chain graphics in co-ordination with National Disaster Management



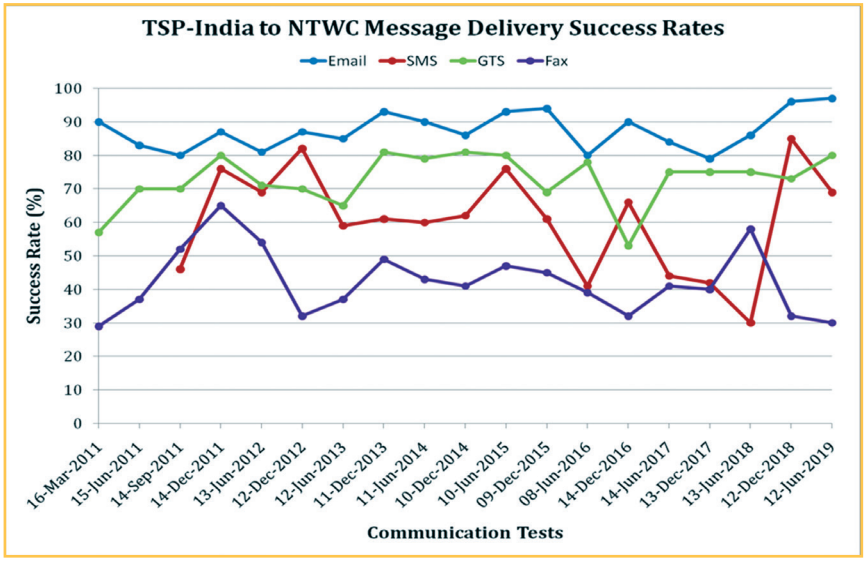
A schematic of Warning Chain for India

Authority (NDMA). The color codes and symbols in the graphics as suggested by ICG/IOTWMS was adopted to achieve uniform representation of warnings within the Indian Ocean rim countries.

Communication Tests & Tsunami Workshops

a) COMM Tests

In order to validate the TSPs dissemination efficiency to NTWCs two communication (COMM) tests were conducted on 12 June 2019 and 11 December 2019. During the COMM tests, ITEWC disseminated notification messages through email, fax, GTS, SMS and through the website to 25 NTWCs and the two TSPs (Australia & Indonesia) in the Indian Ocean Region.



Success rates of message delivered during COMMs Tests

b) Tsunami Workshops and Meetings

ICG/IOTWMS PTHA Meeting

INCOIS, in association with the Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System (ICG/IOTWMS), UNESCO, organised a meeting of Expert Teams (1&2) for the development of Probabilistic Tsunami Hazard Assessment (PTHA) for the Makran region during 2-4 December 2019 at INCOIS, Hyderabad. Fourteen experts from 6 countries (Australia, Germany, India, Iran, Oman and USA) participated in this meeting.

Participants and experts of the ICG/IOTWMS PTHA Meeting

UNESCO-IOC Tsunami Ready Program

The IOC-UNESCO Tsunami Ready Programme is a community performance based programme designed to strengthen tsunami preparedness of coastal communities through a structural and systematic approach in fulfilling the best-practices set by ICG/IOTWMS. The main objective of

Tsunami Ready programme is to improve the preparedness of coastal community for tsunami emergencies and to minimise the loss of life and property. A National Board was constituted under the Chairmanship Director, INCOIS with members drawn from Ministry of Earth Sciences (MoES), National Disaster Management Authority (NDMA), Ministry of Home Affairs (MHA), Odisha State Disaster Management Authority (OSDMA), Andaman & Nicobar Islands Directorate of Disaster Management (DDM) and INCOIS. Based on the recommendations of the National Board, INCOIS conducted a capacity building programme to familiarize the concept of the Tsunami Ready Programme to the disaster management officials of coastal states and UTs. Odisha implemented Tsunami Ready Programme on pilot basis in 6 villages, one each from the tsunami prone districts in the state. The National Board along with IOTWMS delegates visited two villages, Boxipalli (Venkatraipur) in Ganjam district and Noliasahi in Jagatsinghpur district in Odisha during 13-14 December 2019 and evaluated the prepredness of the villages against the performance indicators devised by IOC/UNESCO. After the critical evaluation of the indicators, the Board decided to recognize the two villages as 'Tsunami Ready' and forwarded their applications to IOC-UNESCO for recognition. India is the first country to implement the Tsunami Ready Programme in the Indian Ocean region.

Visit of the members of National Board and IOTWMS delegates to Boxipalli and Noliasahi villages in Odisha during 13-14 December 2019.

Workshop

INCOIS, in collaboration with Intergovernmental Coordination Group for Indian Ocean Tsunami Warning and Mitigation System (ICG/IOTWMS) and Indian Ocean Tsunami Information Centre (IOTIC) of IOC-UNESCO, organised the "UNESCO-IOC Tsunami Ready Workshop" for the disaster management officers of the coastal states and union territories during 10-12 December 2019. The aim of the workshop was to help the disaster management agencies of the coastal states/UTs to understand the concept of Tsunami Ready programme and the necessity to prepare

Participants of UNESCO-IOC Tsunami Ready Workshop jointly organized with INCOIS

action plans, maps and procedures required to implement the programme at community level. Twenty five disaster management officials from all coastal states/UTs participated in the workshop.

World Tsunami Awareness Day

On the occasion of the 4th World Tsunami Awareness Day on 5 November 2019, INCOIS organized an open day for school children and public. Movies to build awareness on tsunami were exhibited. Competitions for school children on exhibition of conceptual models related to tsunami science and services, drawing, painting and essay writing were conducted. About 450 students from various schools and colleges in Hyderabad visited INCOIS on the open day. Forty students participated in drawing/painting, essay writing and model exhibition competitions. Director, INCOIS distributed the prizes to the winners of the competitions.

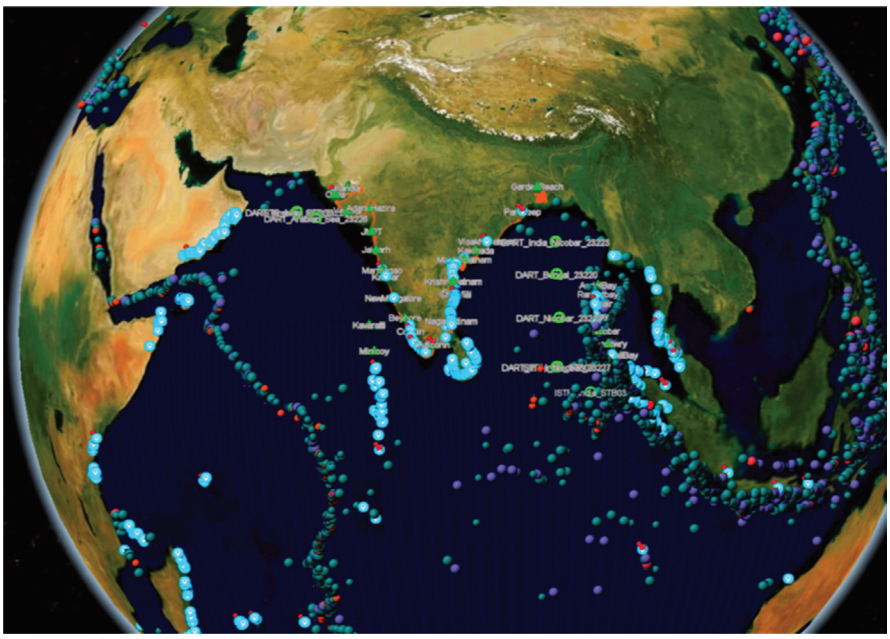
4th World tsunami awareness day activities at INCOIS on 5 November 2019

Storm Surge Early Warning Service

During 2019-20 successfully monitored the Very Severe Cyclonic Storms Fani, Bulbul, Hikka and Vayu and generated the storm surge forecast bulletins as and when India Meteorological Department (IMD) provided the updates parameters of the cyclone in real time. The bulletins were shared with IMD for dissemination to general public together with the special bulletins on cyclone.

Multi Hazard Vulnerability Mapping

The 3D Visualization and analysis system (3DVAS) application was integrated with updated 3D data on realistic buildings and associated socio-economic data and high resolution coastal topography and the 2D data aerial photos and images. All such information, the administrative boundaries, land-use, roads, landmarks can now be overlaid on multi-hazard vulnerability maps for Puri, Kakinada, Nizampatanam, Machilipattnam, Chennai, Cudallore, Pondichery, Rameswaram, Nagapatanam, Tuticorin, Alappuzha and Kochi and viewed 3-dimensionally.



3DVAS integrated with 3D and 2D spatial data (a), MHVM (b) and 3D Buildings (c) overlaid on 3D terrain

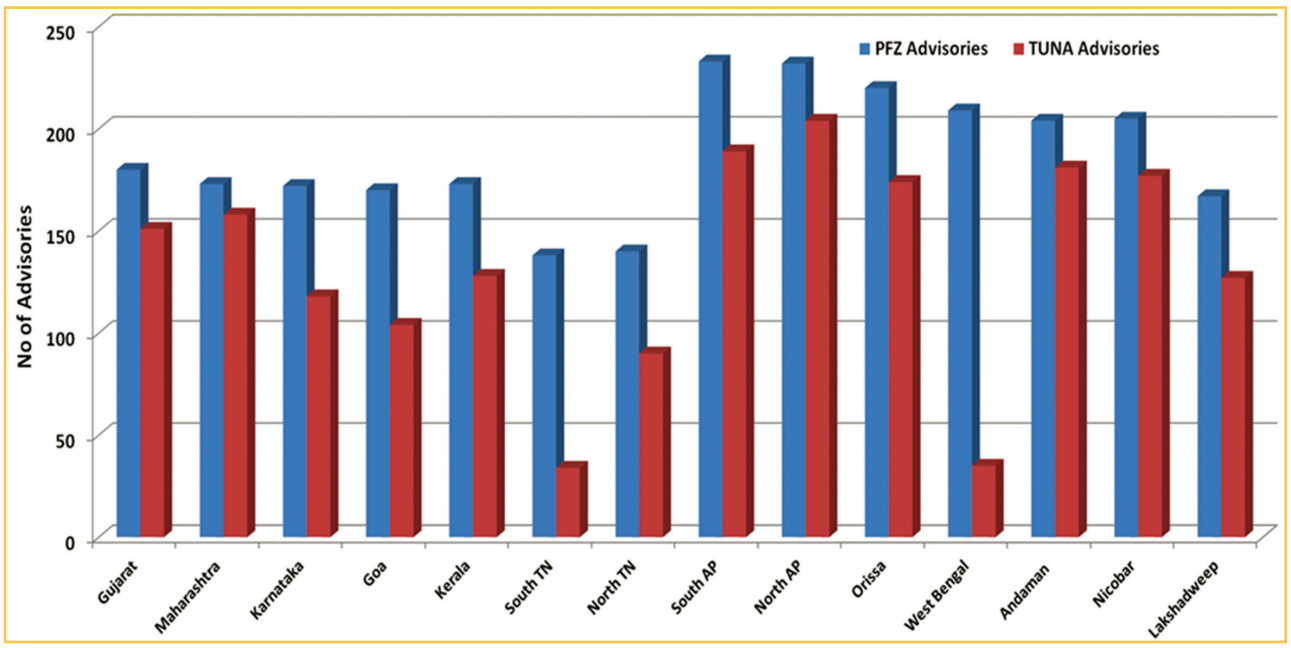
Coral Bleaching Alert System

During the summer months of April and May, INCOIS provides the advisories on Coral Bleaching Alerts by identifying hotspots and degree of heating weeks estimated using SST anomalies derived from satellite data on a bi-weekly basis. No events of hotspots and high degree of warming has been noted during 2019-20 necessitating the issue of Coral Bleaching Alerts.

4.2 Marine Fisheries Advisory Services (MFAS)

Potential Fishing Zones (PFZ) and Tuna PFZ Advisories

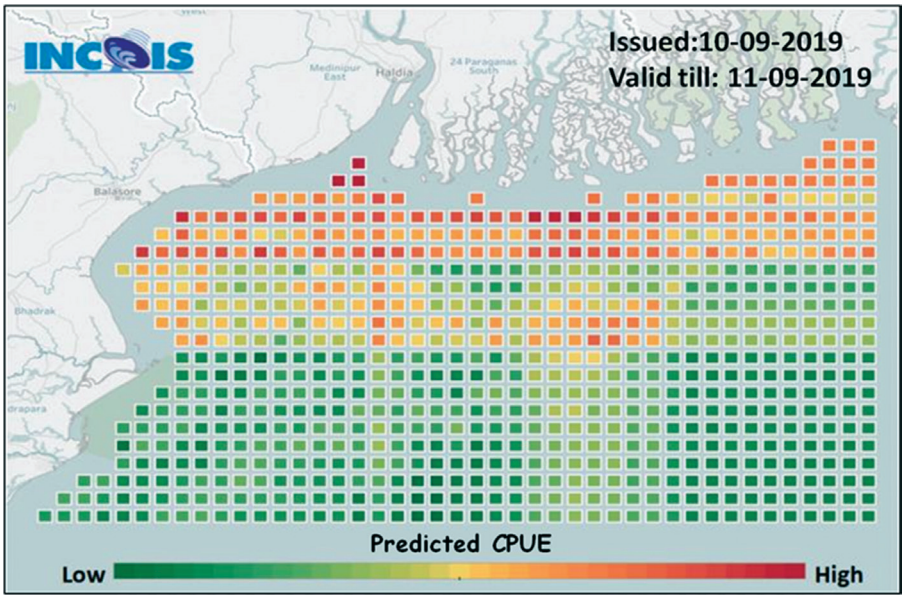
INCOIS continued to provide the advisories on Potential Fishing Zones (PFZ) generated using the satellite based sensor derived Sea Surface Temperature (SST), chlorophyll concentration, water clarity and sea level. The advisories were disseminated in smart map and text form on daily basis, except during fishing-ban period and during adverse sea-state. During the period April 2019 to March 2020, multilingual Potential Fishing Zones (PFZ) advisories and Yellowfin Tuna advisories were provided for 302 and 269 days respectively.



Number of PFZ and Tuna PFZ advisories issued during 2019-20.

Development of Species-Specific fishery advisories on Hilsa shad

A new small-pelagic fish habitat-suitability model has been developed based on the data of Hilsa shad (*Tenualosa ilisha*) fish catch collected from the fishing boats operating off Hooghly-Matla estuary within the Indian exclusive economic zone (EEZ) along with oceanic/ecological parameters such as sea surface temperature (SST), chlorophyll concentration (CC), salinity and rainfall



Sample experimental advisory for Hilsa shad

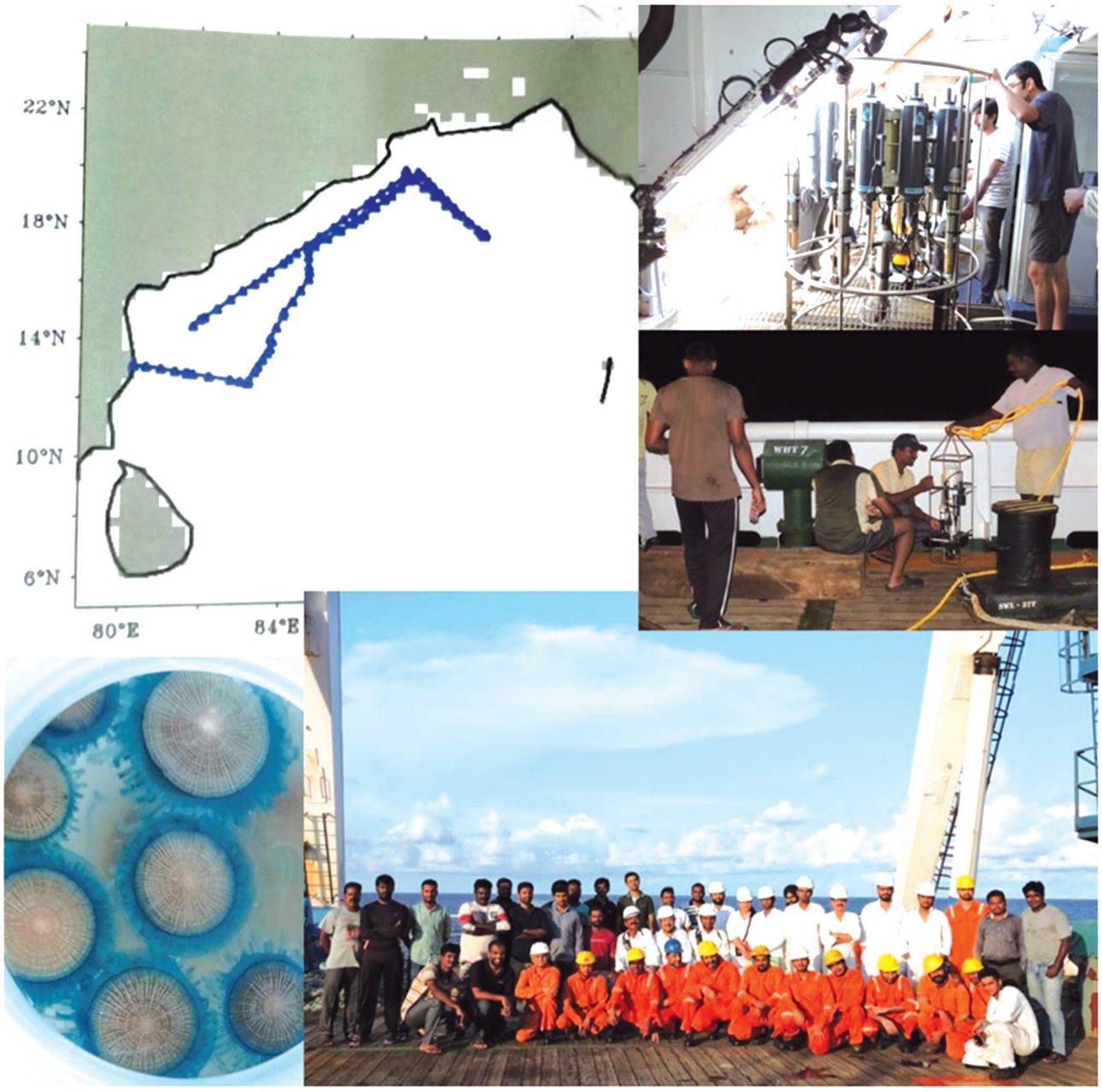
Field sample collection

data. Generalized Additive Model (GAM) are used to identify the conducive environment for Hilsa shad and predict the habitat of matured Hilsa in terms of Catch per Unit Effort (kg h^{-1}). These experimental predictions will be validated with field experiments in collaboration with Vidyasagar University, West Bengal.

Ecosystem-based Fishery Advisory Services (EFAS)

Modelling Marine Primary Productivity

A team of scientists and research scholars working towards modeling of marine primary productivity participated in the reseach cruise SN-144 in the western Bay of Bengal on board RV Sagar Nidhi (SN-144; 17-09-2019 to 10-10-2019). Water samples were collected in this cruise and are being analyzed.



Data collection for marine primary productivity during cruise SN-144 (Sep-Oct, 2019).

Satelite based dissemination system using GEMINI

Considering that the reach of mobile signals and VHF communication are usually less than 15 kms, INCOIS, together with Airports Authority of India (AAI), has developed a low-cost one-way communication system through a GAGAN (GPS Aided Geo Augmented Navigation) based receiver named "GAGAN Enabled Mariner's Instrument for Navigation and Information or GEMINI". In GEMINI, advisories and information provided by INCOIS is broadcasted through the GAGAN constellation of satellites. INCOIS also designed and developed a mobile app, the GEMINI App, to convert the satellite messages into readable maps and text format, so that the decoded information can be viewed on the mobile in any of the languages spoken in the coastal states of India. Dr. Harsh Vardhan, Hon'ble Minister for Science & Technology, Earth Sciences & Health and Family Welfare inaugurated the GEMINI System on 9 October 2019 at MoES, New Delhi. INCOIS and National Fisheries Development Board (NFDB), Ministry of Fisheries have formulated a scheme for providing GEMINI Devices to fishermen. As part of this, INCOIS is now executing a project funded by NFDB for procuring and distributing 1000 units of GEMINI receivers in collaboration with State fisheries departments on a pilot basis.

Inauguration of GEMINI device and app by Dr. Harsh Vardhan, Hon'ble Minister for Science & Technology, Earth Sciences & Health and Family Welfare on 9th October 2019 in MoES, New Delhi.

Outreach and Capacity Building

INCOIS, in collaboration with the Directorate of Fisheries, Lakshadweep UT Administration (UTL Fisheries), conducted two user interaction meetings and a training session for UTL fisheries officials at Kavaratti and Agatti Islands during 31 July to 5 August 2019. To strengthen the collaboration in capacity development, user awareness and dissemination of PFZ and OSF information, an MoU has been signed with Directorate of Fisheries, UTL on 30 September 2019.

Participants of the user interaction workshops held at Lakshadweep islands during July-Aug, 2019. The participants have been sensitized about INCOIS services, especially the tuna advisories.

INCOIS also conducted the awareness workshops on the newly developed satellite based dissemination system, GEMINI, at Diu, Veraval and Mumbai during 11-15 November 2019. A cover-story on GEMINI was published in the February 2020 issue of 'Cyber Safar', a Gujarati magazine. Series of articles on INCOIS services, GEMINI and ocean colour remote sensing were published in the February 2020 and March 2020 issues of Cyber Safar magazine.

Photographs from the media coverage on user interaction workshops in Veraval and Diu.

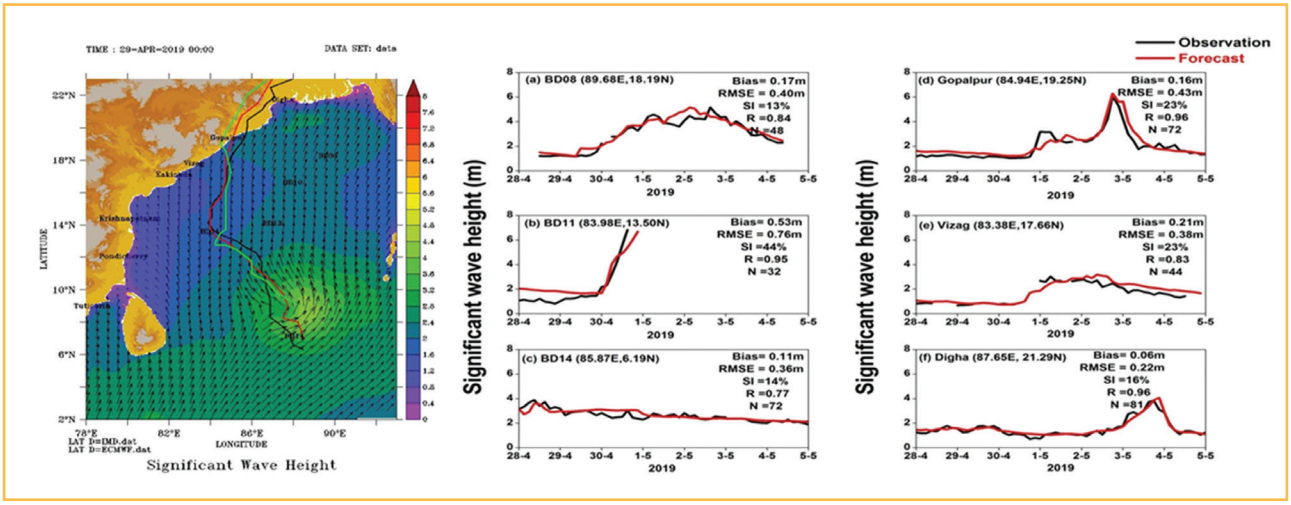
4.3 Ocean State Forecast

Ocean state forecasts during the passage of cyclonic storms in the Bay of Bengal and Arabian Sea

INCOIS issued the forecasts on waves and other ocean state parameters like currents during the passage of extremely severe cyclonic storm "Fani" occurred during 25 April to 4 May, 2019. The forecasts on waves were validated in near-real time using the observations from the wave rider buoys deployed at Puducherry, Krishnapatnam, Visakhapatnam, Gopalpur and Digha and the OMNI buoys BD14, BD11 and BD08. A comparison of significant wave height (Hs) predicted by INCOIS and those observed by the buoy locations are summarized below.

Table: significant wave height (Hs) predicted by INCOIS and those observed by the buoy locations

Buoy	Predicted Max. Hs (m)	Observed Max Hs (m)
BD14	3.6	3.9
BD11	6.5	6.8
BD08	4.8	5.2
Visakhapatnam	2.5	2.5
Gopalpur	7.5	6.2
Digha	2.6	2.8



Forecasted Significant Wave Height (top panel) and comparison with buoy data at various locations during Cyclone Fani.

INCOIS also monitored the movement of Very Severe Cyclonic Storm "Vaayu" and predicted the associated ocean state and issued warnings/alerts to public about the impending sea conditions through various dissemination modes. Sixty one INCOIS-IMD Joint Bulletins were issued on this event during 10-17 June 2019. Veraval, Versova, Ratnagiri and Karwar buoys reported significant wave heights ~ 4.5 m. Kozhikode buoy reported ~ 3 m. In the open ocean, the OMNI buoys (AD06 and AD07) recorded significant wave heights higher than 5 m. INCOIS also monitored the oceanic conditions during the passage of cyclones Hikka (22-25 September 2019), Kyarr (24 October - 2 November 2019), Maha (30 October-7 November 2019), Bulbul (6-11 November 2019) and Pawan (2-7 December 2019) and issued appropriate warnings.

Swell Surge Forecasts:

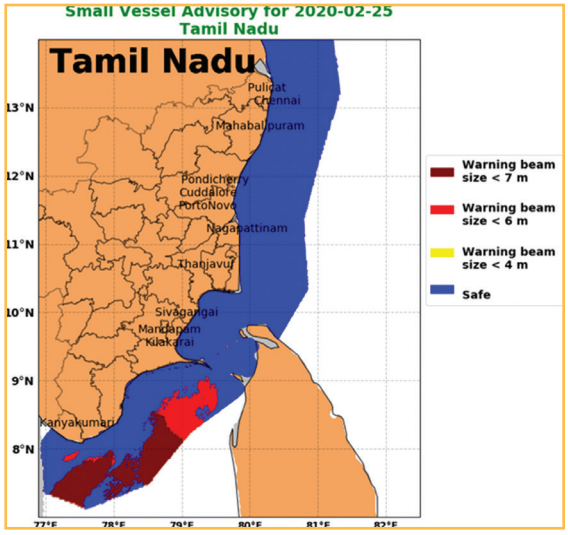
INCOIS provided early warnings on swell surges due to long period swells (periods in the range of 16-21 second) originated from distant southern Indian Ocean and caused rough sea conditions along Indian coastline, especially along the west coast and Islands during 20-22 August 2019 and 25-27 August 2019. In order to issue warnings of approaching high period swells, INCOIS designed and developed a Swell Surge Forecast System for the Indian coasts. The system comprises a suit of interacting models such as WAVEWATCHIII, SWAN and ADCIRC. While the SWAN model predicts the wave parameters near shore and ADCIRC model predicts the extend of inundation after including effect of tides. In this system, the swell events are identified from the simulations

of WAVEWATCHIII model forced with ECMWF winds. Once a swell event is identified, the system triggers a coupled SWAN-ADCIRC model run forced with ECMWF winds and the lateral boundary conditions extracted from the WAVEWATCH III model. The system predicts nearshore wave parameters and the inundation along the coast up to 3 days in advance, which will help the local authorities for contingency plans.

Warnings on Perigean Spring Tides: INCOIS issued Perigean Spring Tide Alerts for the coastline of India during 19-24 February 2019.

High Wave warnings: Warnings on high waves along with high tides were issued for the period 2-4 August 2019 for Maharashtra coast.

Small Vessel Advisory and Forecast Service (SVAS): In order to facilitate the operations of small vessels (boats), particularly fishing vessels plying in Indian coastal waters, INCOIS developed a Small Vessel Advisory and Forecast Service (SVAS). SVAS forewarns the users about potential zones where vessel overturning can take place based on the estimated 'Boat Safety Index' (BSI) derived from the forecasted significant wave height, wave steepness, directional spread, the rapid development of wind at sea and the size class of the boat. The advisories are valid for small vessels of beam width up to 7 m.



SVAS warnings for Tamil Nadu coast for various categories of boats.

Dr. M. Rajeevan, Secretary to Government of India, Ministry of Earth Sciences, launching the new services of INCOIS on 25 February 2020, at MoES, New Delhi during the Governing Council meeting of INCOIS.

4.4 Data Services

INCOIS, designated as the National Oceanographic Data Centre (NODC) by the International Oceanographic Data Exchange (IODE) Programme of the Intergovernmental Oceanographic Commission, continued serving as the central repository for the oceanographic data in the country. The INCOIS data centre sustained and strengthened the real-time data reception, processing, and quality control of surface meteorological and oceanographic data from a wide variety of ocean observing systems such as Argo floats, moored buoys, drifting buoys, wave rider buoys, tide gauges, wave height meter, ship mounted autonomous weather stations, HF radars, XBT/XCTD, Met observations from NODPAC, ship cruises, ADCP moorings and the data from remote-sensing

satellites. The surface met-ocean data has been regularly disseminated to various operational agencies in the country through email/web-site/FTP in near-real time. Data centre also served the ocean science community by providing tailor-made data products to various users, especially to Indian Navy. The past data on marine meteorology from IMD, and high resolution data retrieved from the storage disks of OMNI were also archived. Details of data received in the present reporting period are provided in Table 1 (from in-situ platforms) and Table 2 (from remote-sensing platforms).

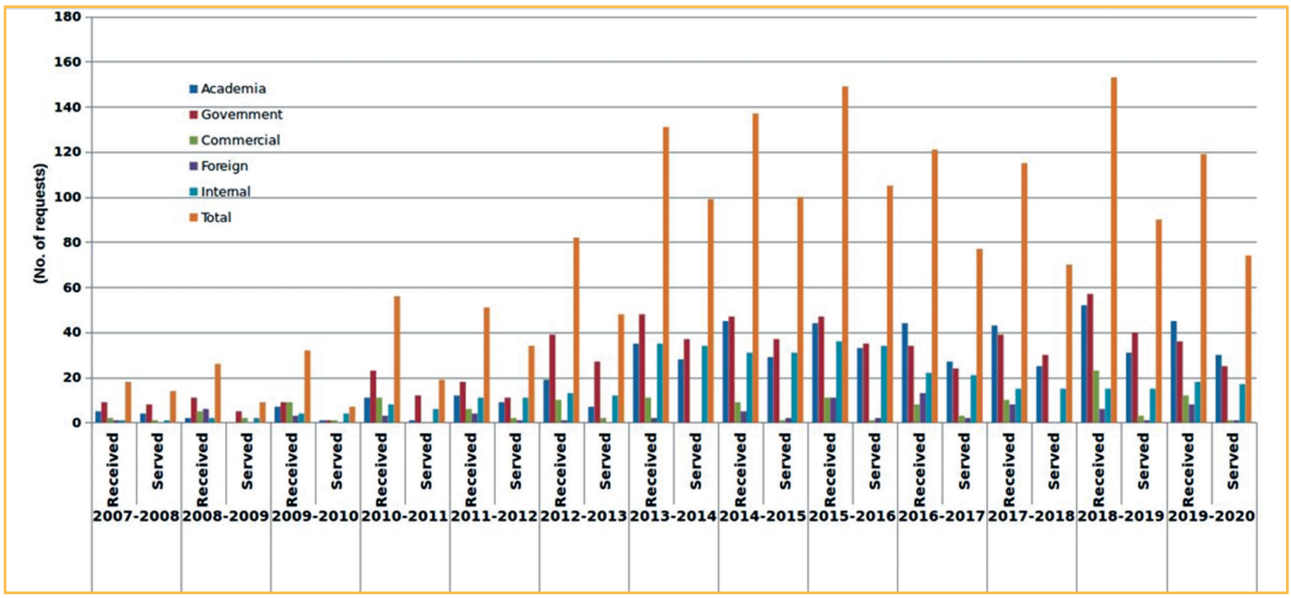


Figure: Number of customized off-line data requests served since 2007-2008.

Table 1: Details of in-situ data received during April 2019-March 2020

Institute / Programme	Parameters	Period of Observation	No. of Platforms / Stations Reported	Status
NODPAC (Met Observations along Ship track)	Surface met parameters	Apr 2018 – Dec 2019	4889 observations	Archived
NODPAC (XBT data)	Temperature profiles	Jan 2017 – Dec 2017	3207 profiles	Archived
NIOT - NDBP (Moored buoys)	Met-ocean parameters	Apr 2019 – Mar 2020	17 buoys	Added to the database
NIO (Drifting buoys)	Met-ocean parameters	Apr 2019 – Mar 2020	09 buoys	Added to the database
NIO (XBT data)	Temperature profiles	Apr 2019 – Mar 2020	41 profiles	Archived
NIO (XCTD data)	Temperature and Salinity	Apr 2019 – Mar 2020	38 profiles	Archived
INCOIS (Ship-mounted AWS)	Met parameters	Apr 2019 – Mar 2020	32 stations	Added to the database

INCOIS-NIO-NIOT (Coastal AWS)	Met parameters	Apr 2019 – Mar 2020	02 stations	Added to the database
INCOIS (Wave rider buoys)	Wave parameters	Apr 2019 – Mar 2020	16 stations	Added to the database
INCOIS (Tide gauges)	Sea level	Apr 2019 – Mar 2020	34 stations	Added to the database
INCOIS-NIOT (Tsunami Buoy)	Sea level	Apr 2019 – Mar 2020	04 stations	Added to the database
NIOT (HF RADAR)	Currents	Apr 2019 – Mar 2020	05 pairs of stations	Added to the database
INCOIS (Argo CTD)	Temperature and Salinity	Apr 2019 – Mar 2020	31785 profiles	Added to the database
INCOIS-OMM	Ocean Monsoon Mixing Cruise Data	Archived		

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, and Suomi-NPP satellites are regularly received in real-time at the ground stations established at INCOIS. The data are processed and made available for operational activities at INCOIS, IMD, etc. in near-real time. The data products are also provided to research organizations on request.

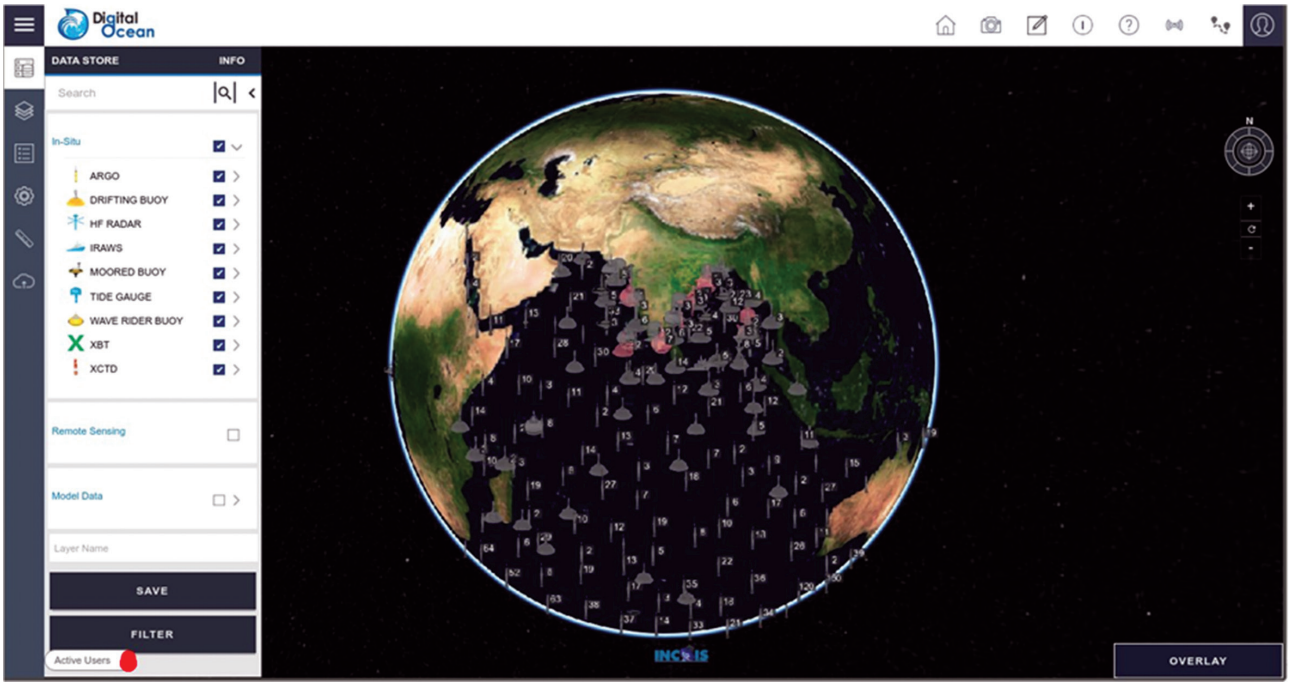
Table 2: Details of remote sensing data availability

Satellite	Sensor	Products	Time peri
MetOp-A&B NOAA-8&19	AVHRR	• Level1B Sea • Surface Temperature • FOG • Cloud top Temp • Normalized Difference Vegetation Index (NDVI)	Sep 2006 to till date
Oceansat-2	OCM	• Level 1B • Chlorophyll-A • Total Suspended Sediments • Diffuse Attenuation Coefficient (Kd_{490}) • Aerosol Optical Depth (AOD)	Feb 2011 to till date

Suomi-NPP	VIIRS, CrIS & ATMS	• Level 1B • Ocean Colour (Chl-A, Kd_{490}, PAR, particulate inorganic carbon, particulate organic carbon) • SST (Split Window, Triple Window) • Other (Fire Points, FOG, NDVI, Cloud products, etc.) • Short Wave (SW), Medium Wave (MW), Long Wave (LW) bands	May 2016 to till date

Digital Ocean

The development of Digital Ocean, an innovative web-application to manage ocean data has been completed. The system is now being used experimentally by INCOIS users. The Digital Ocean provides a dynamic framework to efficiently integrate and manage heterogeneous ocean data along with advanced visualization (including 3D and 4D animations) and analysis tools. It is designed as a one-stop solution for all data related services such as archiving, visualising and dissemination. It also has capabilities for multi-dimensional data visualisation and fusion of heterogeneous data.



Snapshot of Digital Ocean: In situ platforms

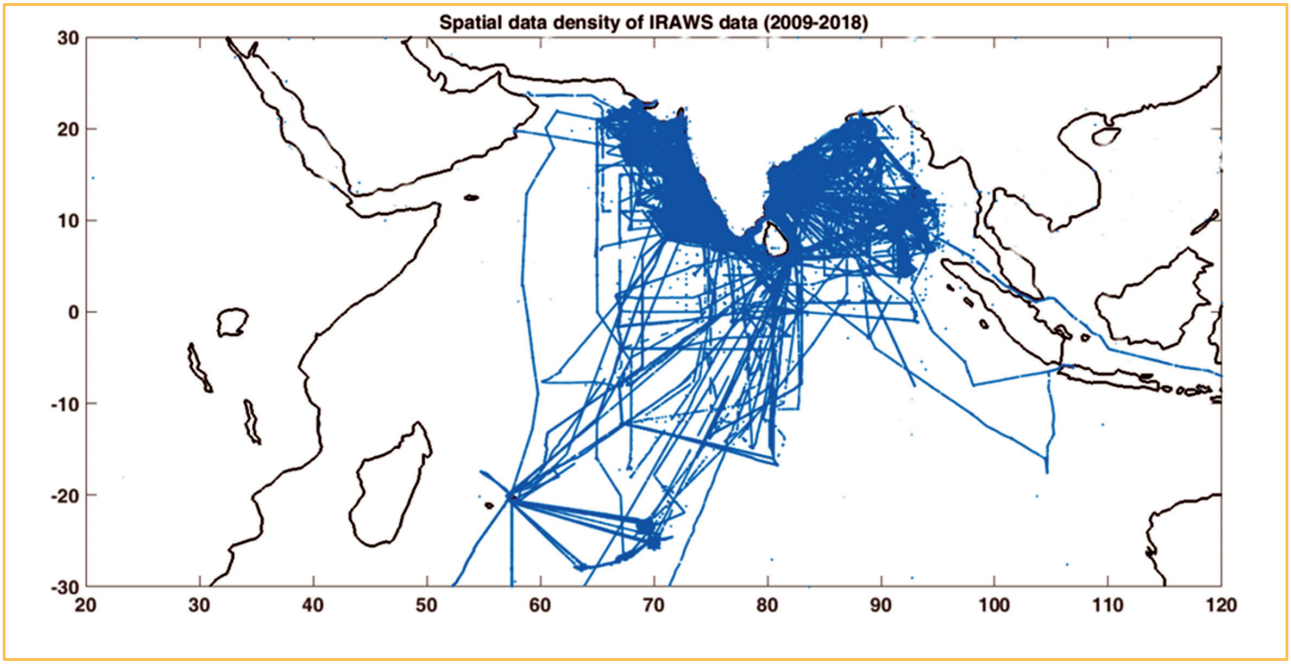
Other Significant achievements:

Assessed the quality of marine meteorological data from INCOIS-Real time Automatic Weather Station (IRAWS) installed onboard 36 ships (Figure 3). Specific quality checks were applied to vector wind, sea surface temperature (SST) and other surface met parameters. Most of IRWAS provided about 70 to 90% good quality data.

- New formats were developed for data transmission on GTS as well as new data sets are added to GTS. New Quality Control methods were developed for improving the quality of the data.

The subsurface temperature, salinity and current profiles from OMNI buoys (outside the Indian EEZ) are also transmitted over GTS in near-real time.

- De-striped the ocean color products viz., Chl, Kd490, TSM, AOD from OCM-2.
- Maintained web based meta data portals for MOES and IIOE-2 data.
- Updated the web based applications such as INCOIS-LAS, INCOIS-ERDDAP, ODIS, etc.
- Digitized the hard copies of cruises records of FORV Sagar Sampada (obtained from CMFRI and CMLRI) and extracted data pertaining to fisheries, bio-geo-chemistry and physical oceanography.



Spatial density of IRAWS data (2009–2018) excluding the Indian Navy ships

4.5 Computational Facilities, Communications Network and Web Based Services

Computing Infrastructure:

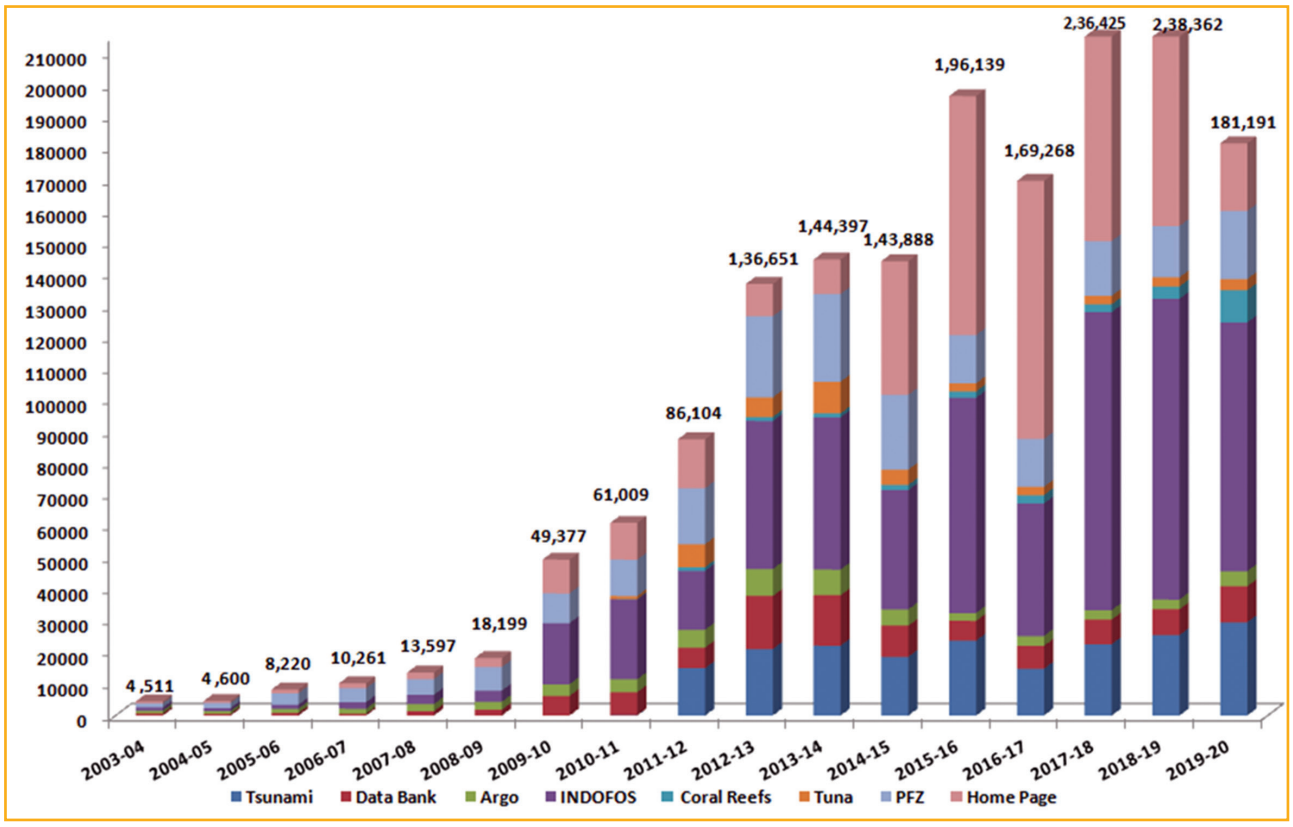
Continued to maintain the computing (Hardware, Software and Networking), Web and communication infrastructure to meet the requirements of the institute. INCOIS hosts state-of-the-art computational facilities that include a high performance computer and its allied infrastructure, 415 TB storage, ERP servers, 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 was set up in such a manner that no single point failure can affect the operational services. The uptime

of computing and network infrastructure was ~ 99%. The technology refreshment of the tsunami warning services and establishment of DR site at IITM, Pune has been completed.

Web Based Services:

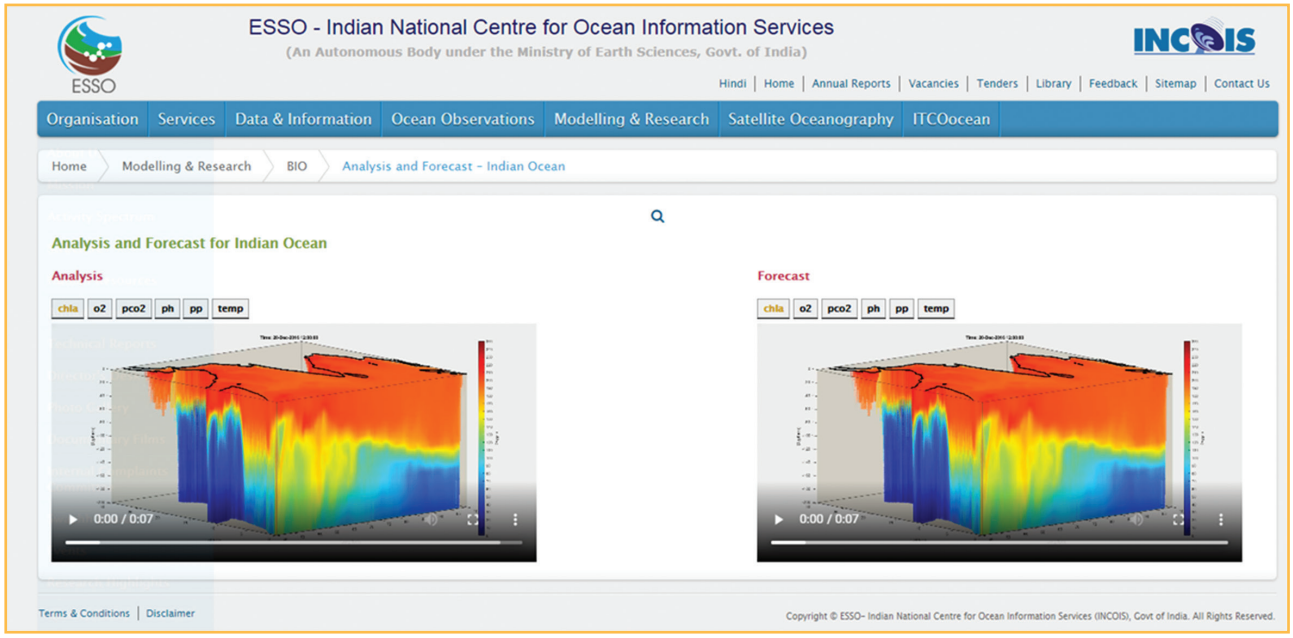
INCOIS provides its ocean information and advisory services through its web portals viz., www.incois.gov.in, www.tsunami.incois.gov.in, www.iioe-2.incois.gov.in and www.isgn.gov.in. Continued to manage the web services besides developing web applications based on the user requirements. Some of the notable activities during this period are:

- Carried out the Security Audit of INCOIS Website (www.incois.gov.in & www.iioe-2.incois.gov.in) by engaging M/S C-DAC, Hyderabad.
- Online Recruitment Portal for various posts at INCOIS, MoES, NCPOR, NCESS & IMD.
- Login Based Web Application for TropFlux Data Products and Downloads.
- Web Application for Cruise and Data Catalog of Ocean Mixing and Monsoon (OMM) Datasets.
- Streamlined the multilingual web application for Marine Fishery Forecast System (MFFS).
- Web Application for BIO (Biogeochemical State of the Indian Ocean) Products.
- Online Project Proposal Submission, review and evaluation of proposals.
- Web Application for publishing PFZ Forecast (3-days).
- Web Application for Swell Surge Forecast System.
- Login based web application for ITCOocean Training Courses.
- Web Application for Algal Bloom Information System (ABIS).

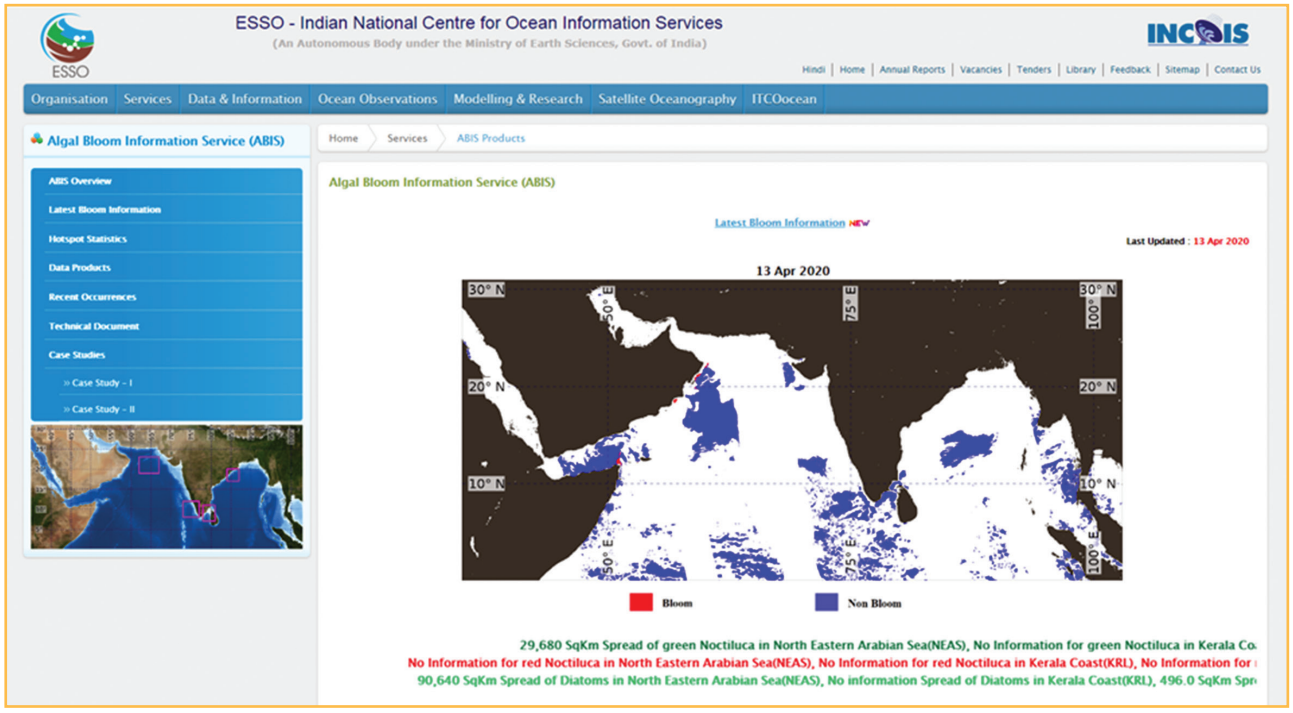


Growth in the number of visitors to INCOIS Website

- Website for "Internal Complaints Committee" activities of INCOIS.
- Website in Hindi for "Official Language Implementation Committee (OLIC)" activities of INCOIS.
- Web Application for Ocean State Forecast (OSF) - Small Vessel Advisory and Forecast Services System (SVAS).



Web Application for BIO (Biogeochemical State of the Indian Ocean) Products (https://www.incois.gov.in/portal/bio/home.jsp)



Website for Algal Bloom Information System (ABIS) (https://incois.gov.in/portal/hab.jsp)

5. Consultancy Projects

The table below presents the projects and services carried out during the report period.

Sl. No	Agency	Project/Data	Amount (in Lakhs INR)
Project done			
1	Maharashtra Maritime Board	Project on IVL & Subscription of Dynamic IVL (Project Report)	30.00
2	JNPT, Mumbai	Oil spill trajectory prediction at the proposed Vadhavan Port, Maharashtra and assessing the probable spread towards Tarapur Atmoic Power Station (Project Report)	14.23
3	Hindustan Consultancy Co. Ltd. (HCC), Mumbai	Data during cyclone Vaayu	0.43
4	HCC, Mumbai	Data during July-August, 2019	1.34
Project being executed (3 year project from Apr 2018)			
5	ONGC	Data Delivery on currents/ eddies for wells (daily forecast mode/ Project Report)	101.60*

** Total consultancy project cost for 3 years (continuing)*

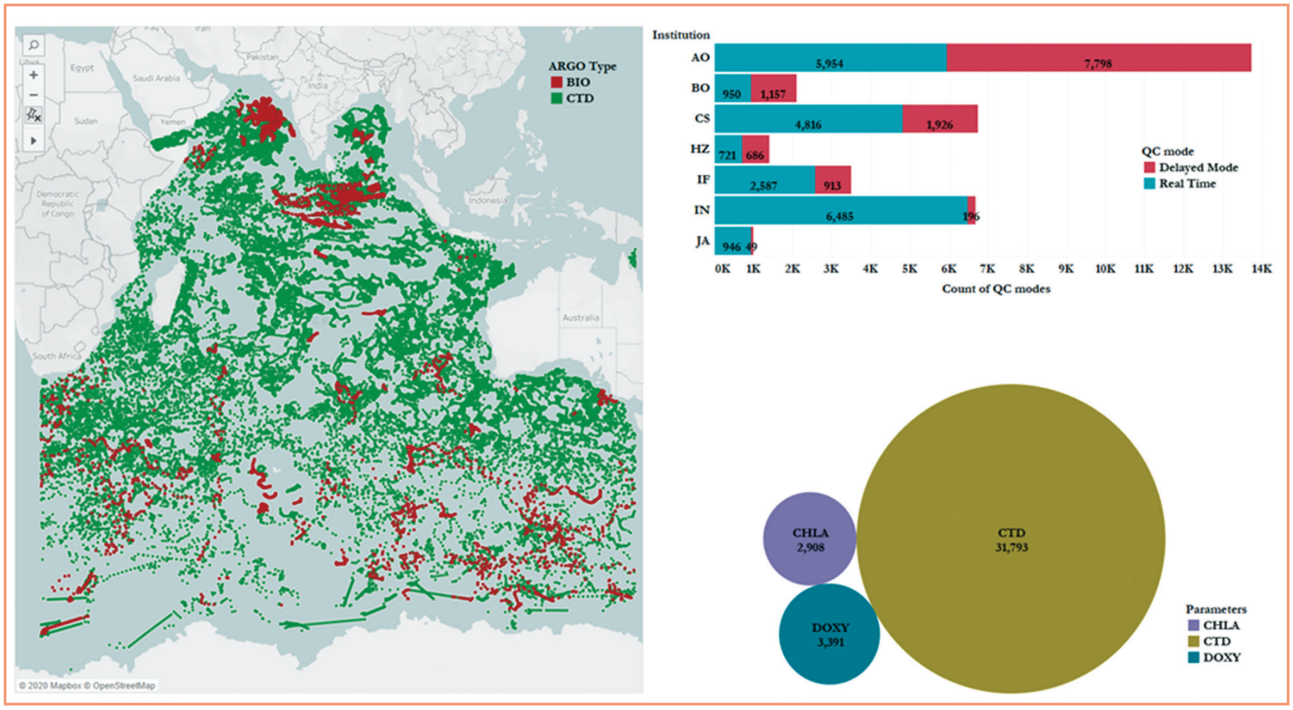
6. Ocean Observations

Sustained ocean observations are crucial to understand complex oceanic processes, continued monitoring of its variability, its interaction with the atmosphere, and for developing products and operational ocean services for the benefit of the society. In order to achieve that, INCOIS maintains an array of ocean observation platforms, most of which transmit data in real time. During 2019-20, INCOIS continued its efforts to collect the ocean data by deploying many observation platforms in the Indian Ocean.

6.1. The Argo Program

The Argo Program is a collaborative partnership of more than 30 countries to collect the hydrographic observations of the ocean. INCOIS, representing India, actively participates in this global ocean observation programme by regularly deploying Argo floats in the Indian Ocean and processing the data by following approved protocols. INCOIS participated in the 20th Argo Data Management meeting held during 13-18 October 2019 at Laboratoire D'Océanography de Villefranche-sur-mer, Villefranche, France. The data visualization schemes developed at INCOIS using Tableau software were presented in this meeting. INCOIS also presented the audits of BGC data and their performance and QC being applied. The recommendations evolved from this meeting were incorporated in the processing chain of INCOIS DAC, all applicable profile data were converted to the latest version and uploaded to GDAC.

During 2019-20 period, INCOIS deployed 20 standard Argo floats (with temperature and salinity sensors only), 14 bio argo floats (temperature, salinity, chlorophyll, backscattering and

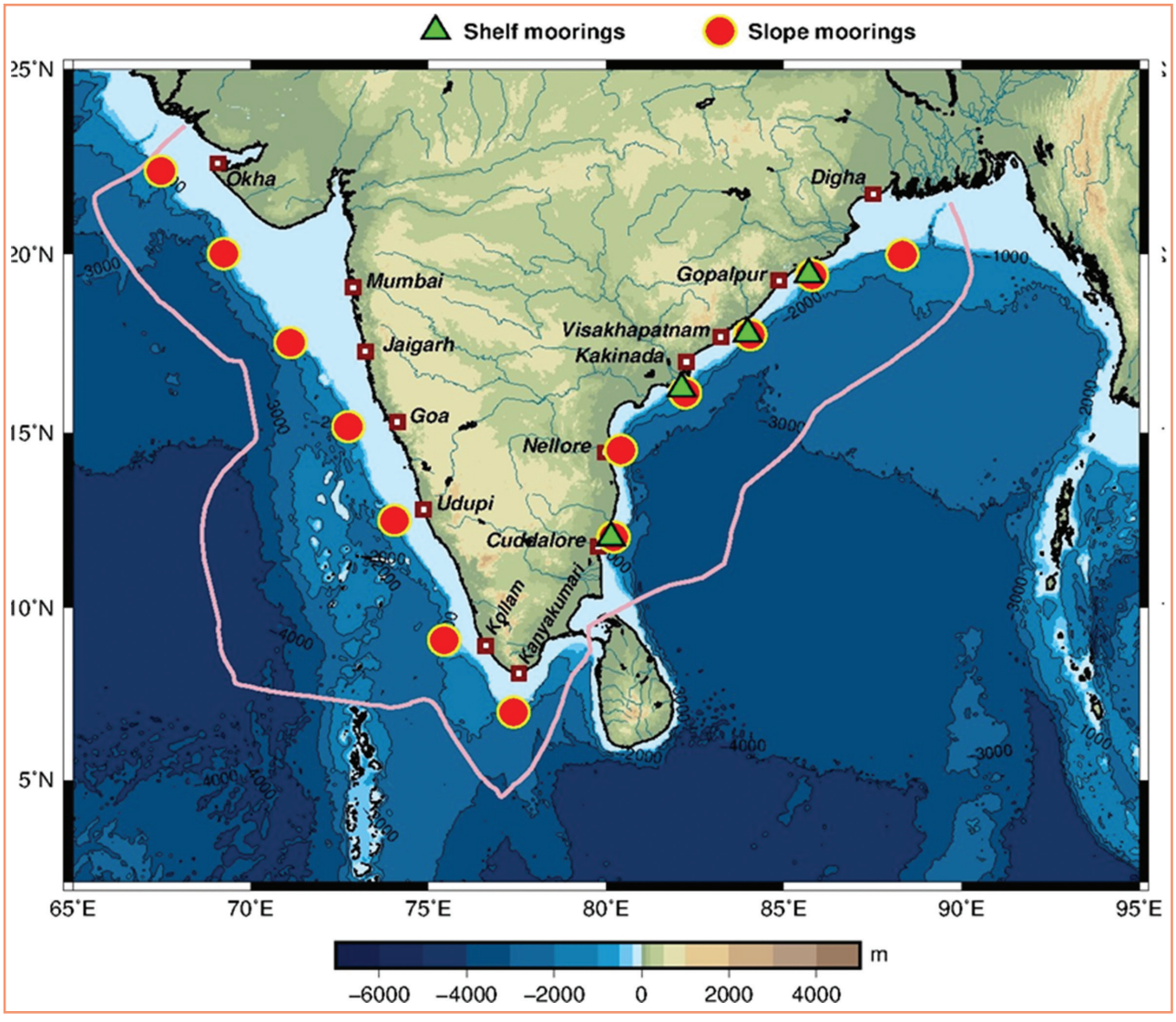


Spatial distribution of Core and BGC Argo profiles, DAC wise distribution of Real Time and Delayed mode profiles and number of Core (Temperature and Salinity) and BGC (Chla, Doxy) profiles.

dissolved oxygen sensors) in the Indian Ocean. With these deployments, Indian contribution to the international project is 493 floats, of which 156 are presently active and transmitting data. During this reporting period, 196 floats were deployed in the Indian Ocean by other countries. At present, altogether 888 floats are active in the Indian Ocean. Thirty one thousand seven hundred and eighty five (31785) temperature and salinity profiles pertaining to the Indian Ocean were received and archived at INCOIS in the past one year.

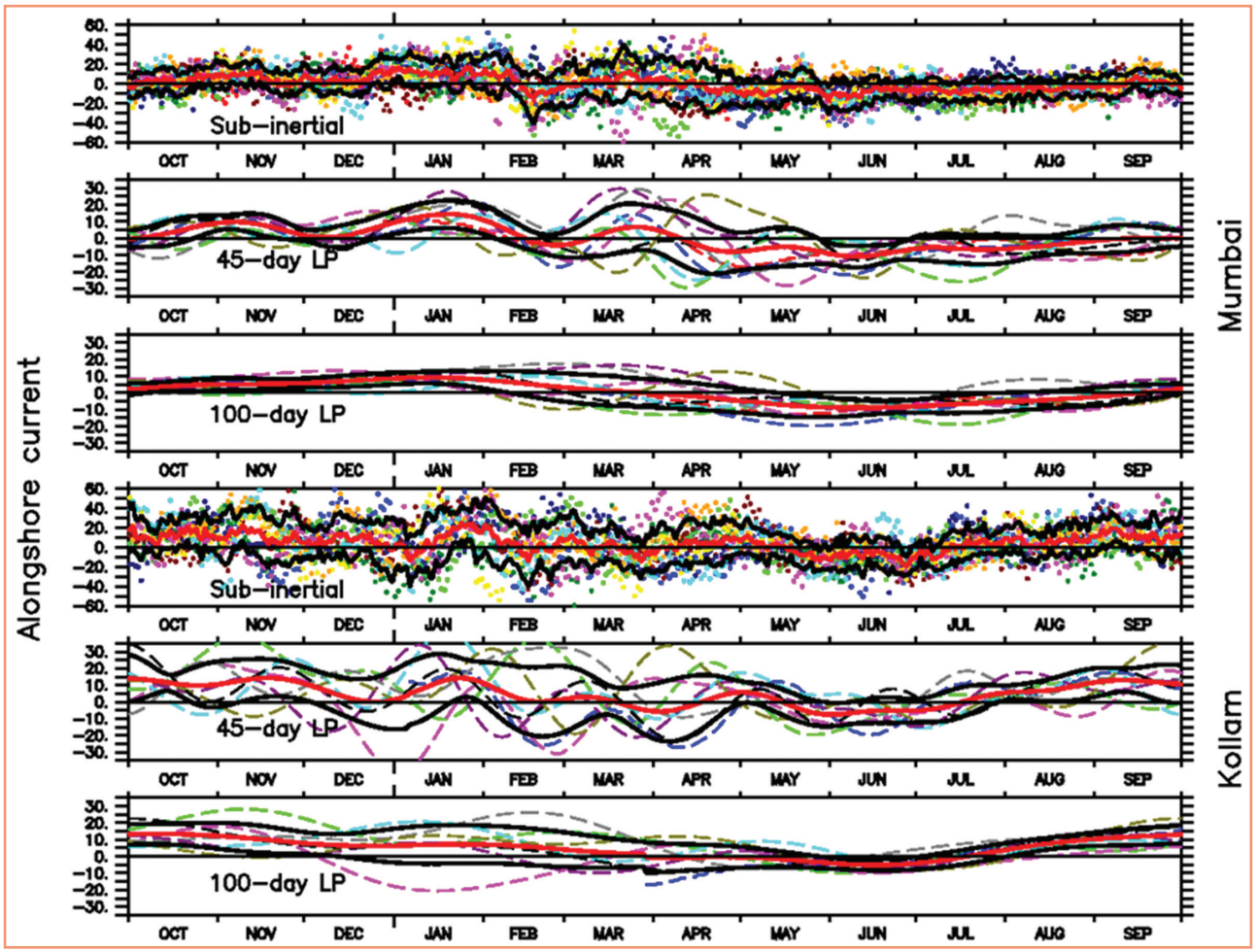
6.2. Coastal ADCP network

INCOIS continued the support to CSIR-NIO to maintain the ADCP network during 2019-20 as well. The network recorded the vertical profiles of currents at 17 locations in the Indian coastal waters. Seventeen moorings are operational as on 31 March 2020. Seven moorings were deployed on the continental slope off the west coast and six (four) on the continental slope (shelf) off the east coast. Three cruises onboard ORV Sindhu Sankalp (SSK-133, SSK-135 and SSK-139) were conducted to service the 17 moorings deployed at shelf and slop locations. An additional ADCP mooring has been deployed off Goa to collect data for one year to validate the data from existing ADCP.



Map showing the locations of ADCP moorings as on 31 March 2020. The slope moorings are shown by red filled circles and the shelf moorings by the green filled triangles; the background is the bathymetry (m) and the pink line marks the Indian EEZ.

Detailed analysis of the currents measured by ADCPs suggest that the direction of West Indian Coastal Current (WICC) is largely determined by the intraseasonal variability. The data shows that the WICC may flow in either direction on a given day of the year. The unpredictability of the direction is stronger off Kollam, and the seasonality is stronger off Mumbai.



The first and fourth panels show the alongshore, sub-inertial WICC (cm s^{-1}) at 48 m off Mumbai and Kollam respectively. Positive values imply poleward flow. The solid red curve is the mean for the available data during 2009–2018 and each colour represents the current during a particular year. The solid black curves mark one standard deviation about the mean. The second and fifth panels show the 45-day low-passed (LP) current off Mumbai (second panel) and Kollam (fifth panel). The third and sixth panels show the 100-day low-passed WICC off Mumbai (third panel) and Kollam (sixth panel); The red curves in these panels represent the climatological seasonal cycle estimated from the ADCP data record.

6.3. XBT Program

This is the longest ongoing observational program executed by CSIR-NIO, Goa with the financial support from INCOIS. This program collects high quality temperature/salinity profiles along selected shipping lanes using ships of opportunity to understand and document the variability of thermohaline field. During 2019-20, 145 vertical temperature profiles (XBTs), 117 vertical temperature/salinity (XCTD) profiles and 496 water samples were collected. In addition, 603 water samples were also collected from 10 coastal locations for salinity analysis.

An improved version of satellite salinity data (SMAP V4.2 L3) was validated at select locations (less than 40 km from offshore) in the northern Indian Ocean. It was found that the SMAP data has very good accuracy. The correlation coefficient between SMAP data and the in situ observations is 0.85.

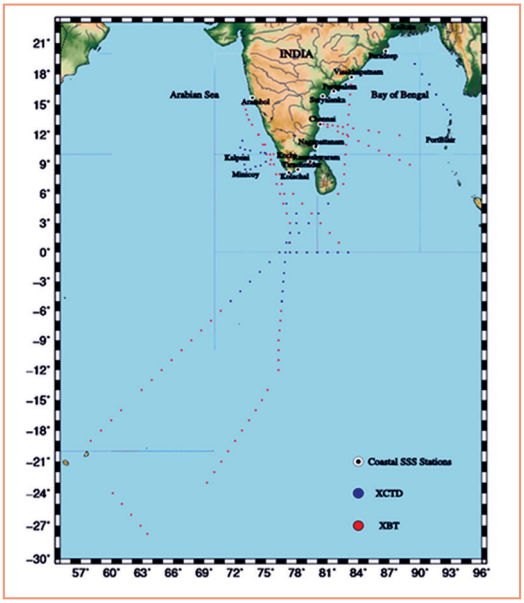
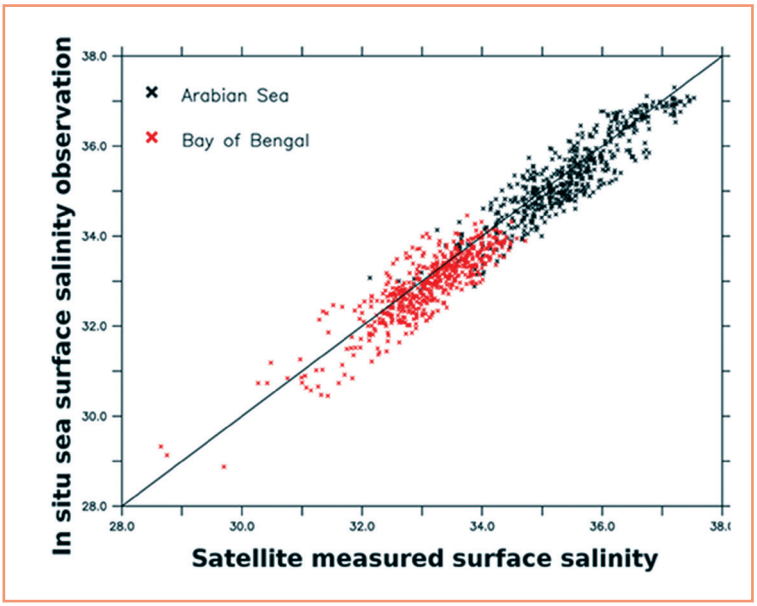


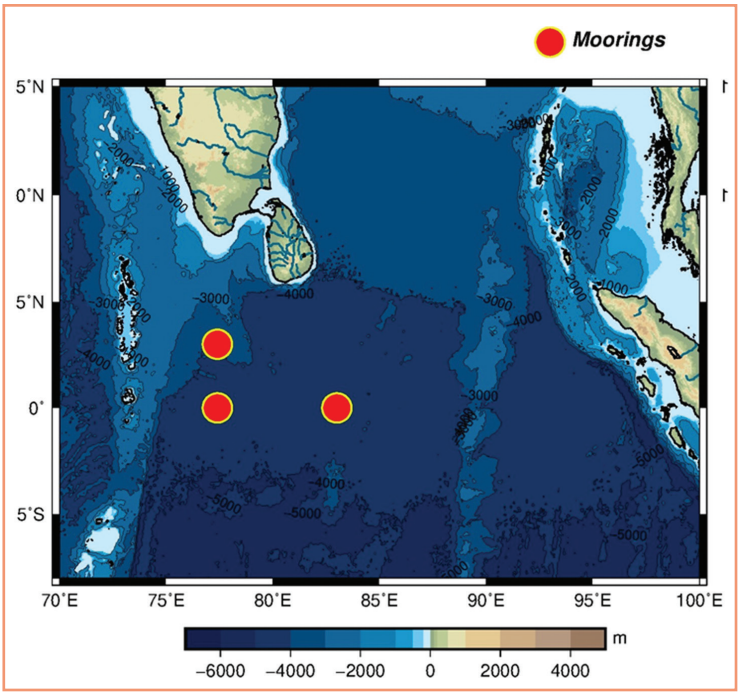
Figure: XBT (red), XCTD (blue) and Sea Surface Salinity (black dot) data coverage in the seas around India during April 2019 – March 2020. Yellow diamonds indicate the Coastal salinity collection stations.



The scatter plot showing the consistency of in situ sea surface salinity and Satellite SMAP sea surface salinity in the BoB and Arabian Sea.

6.4. Equatorial current meter moorings

With the funding from INCOIS, CSIR-NIO continued to maintain the equatorial current meter array during 2019-20 also. Two moorings along the equator were serviced during the reporting period, and another mooring was deployed at 77.4°E, 3.0°N. Currently, all the three moorings are operational.

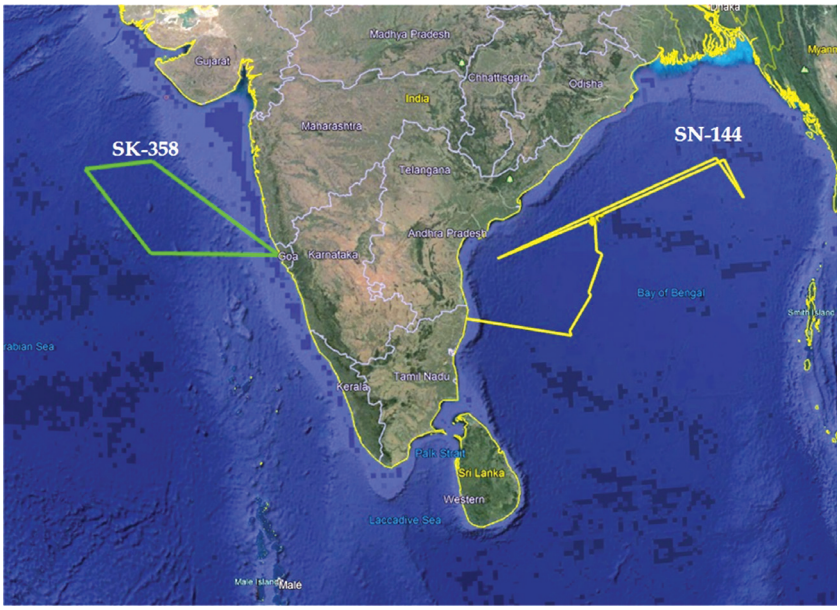


Analysis of the available data shows strong interannual variability in the seasonal cycle of the equatorial currents. It is found that the strong semi-annual cycle is often accompanied by a weak annual cycle. Upward phase propagation, which suggests remote forcing, is evident in the mooring data. The decade long record shows two structures for spring Wyrtki Jet: one with a weak surface current and a subsurface core and the second with a strong surface current with a weak subsurface core.

6.5. Specific Ocean Observations

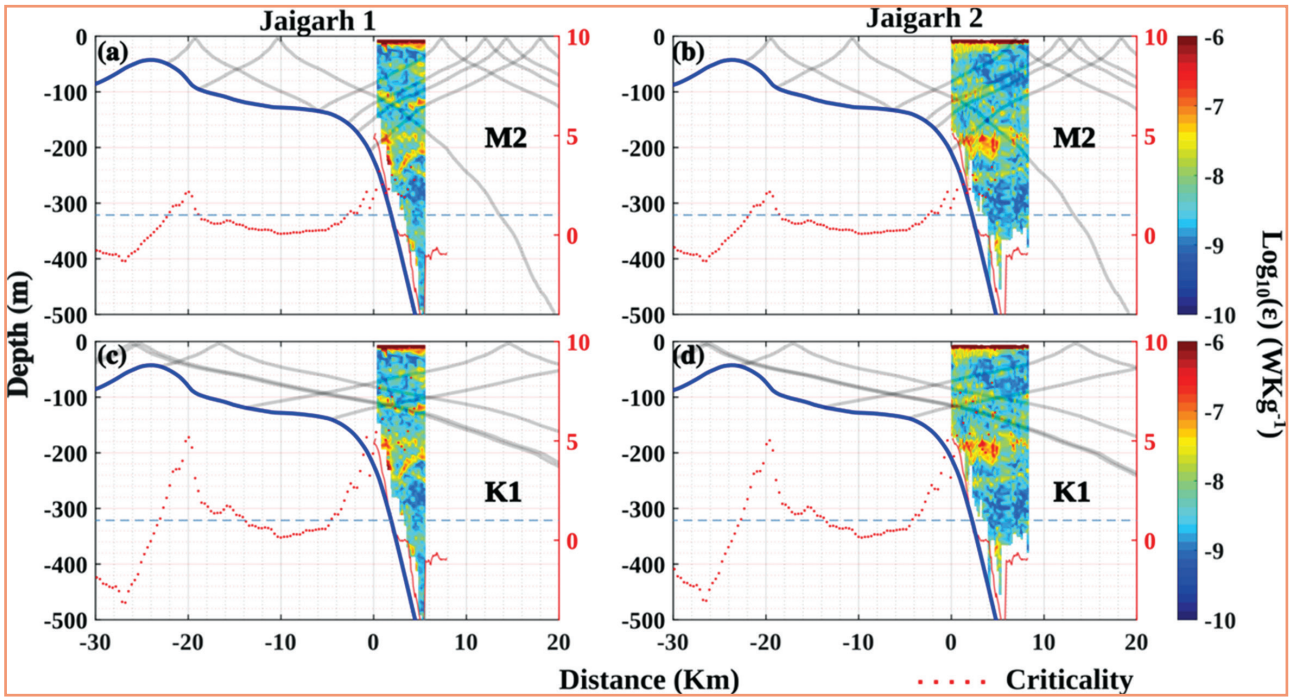
INCOIS conducted two process specific research cruises during the reporting period - one in the Arabian Sea on board ORV Sagar Kanya (SK-358; 01-05-2019 to 29-05-2019) and another

in the Bay of Bengal on board ORV Sagar Nidhi (SN-144; 17-09-2019 to 10-10-2019). Main objective of both the cruises was to understand the turbulent characteristics of the upper ocean using microstructure profiler, lowered ADCP (LADCP), underway CTD (uCTD), and meteorological measurements with ASIMET sensors.



Tracks of two process specific cruises conducted during 2019-20 period. Green line in the Arabian Sea represents ORV Sagar Kanya cruise (SK-358) and yellow line in the Bay of Bengal represents ORV Sagar Nidhi cruise (SN-144)

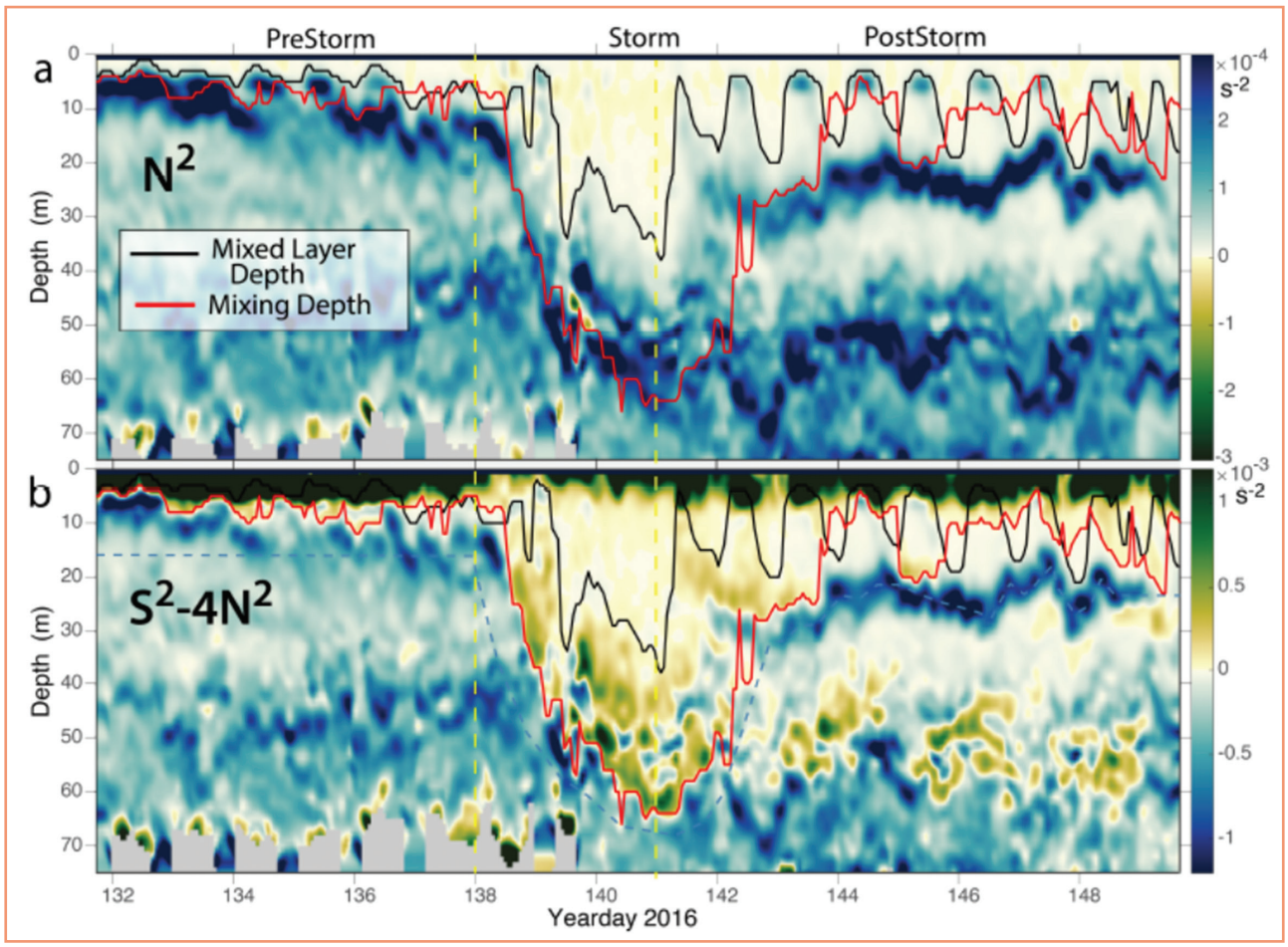
During both the cruises (SK-358 and SN-144) specific experiments were conducted to understand the enhanced mixing induced by internal tides as the internal tide generation in the interior ocean can either result in enhanced subsurface vertical mixing locally, or impart significant energy into propagating internal waves that subsequently dissipate and cause subsurface vertical mixing in the open ocean. Significant TKE dissipation, potentially driven by internal wave activity, was observed even at depths far below the pycnocline (~200 m) in both basins. There are indications that some of the strong dissipation in the subsurface regions falls in the vicinity of the internal wave ray paths.



The turbulent kinetic energy dissipation rates (log(ε)); WKg^{-1}) at the continental shelf of Jaigarh (southern most point in the eastern side of cruise track). The number 1 and 2 represents transect numbers. The blue line represents the bathymetry. The internal tide beam of (a and b) M_2 and (c and d) K_1 tidal constituents.

Widespread cooling of the Bay of Bengal by tropical storm Roanu

Widespread decrease in the SST (1.5–2.0°C) of the Bay of Bengal occurred in response to cyclone Roanu 2016, a weak, pre-monsoon storm. The processes contributed to this cooling was investigated using data from a Lagrangian float, measuring temperature, salinity and velocity profiles in the upper 80 m, and 3 Argo floats. Along the track of the Lagrangian float, cooling was primarily due to mixing of the warm (32°C), fresh cap formed during the previous months of light winds and clear skies. The cooling by mixing accounted for about half of the observed cooling. Air-sea heat fluxes played a secondary role, accounting for about a quarter of the cooling. The remaining quarter of the cooling occurred due to horizontal advection. The depth to which the mixing took place was diagnosed by two measures: traditional mixed layer depth and "mixing depth" defined as the deepest unstable depth estimated from shear instability calculations. The mixing depth was roughly twice (~65 m) the mixed layer depth (~35 m), illustrating the importance of the "transition layer" between them. The mixed layer re-stratified into 2 layers within a day after the cessation of the storm due to the near-inertial frequency waves generated by the storm increasing the diapycnal mixing rates at the depth of transition layer to about 10^{-4} m^2s^{-1}.

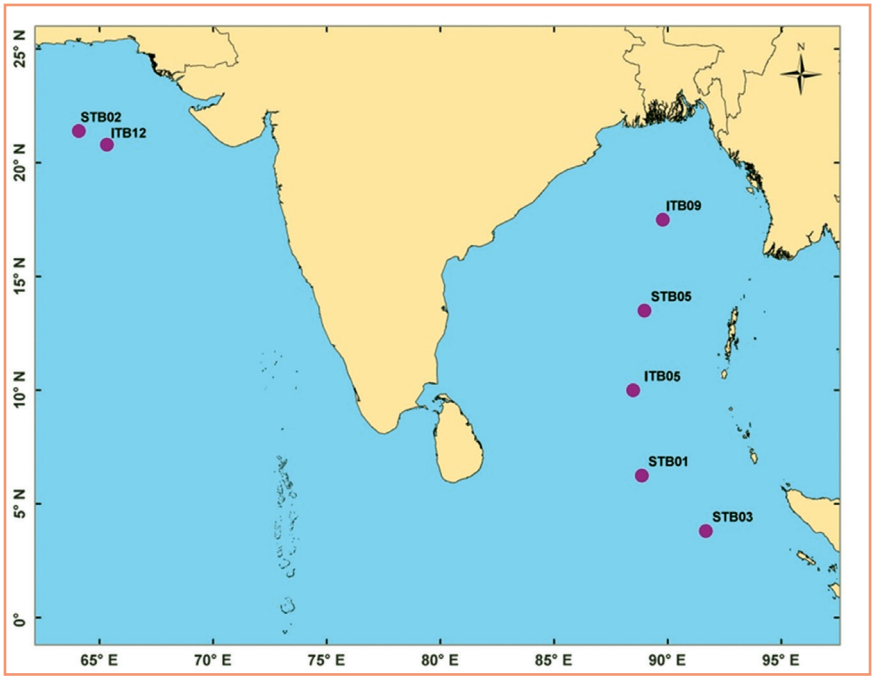


Comparison of mixed layer depth (black line) and mixing depth estimated from reduced shear (red lines) overlaid on the plots of stratification (a) and reduced shear (b). Yellow vertical dashed lines divide the pre-storm, storm and post-storm periods.

6.6 Tsunami Buoys

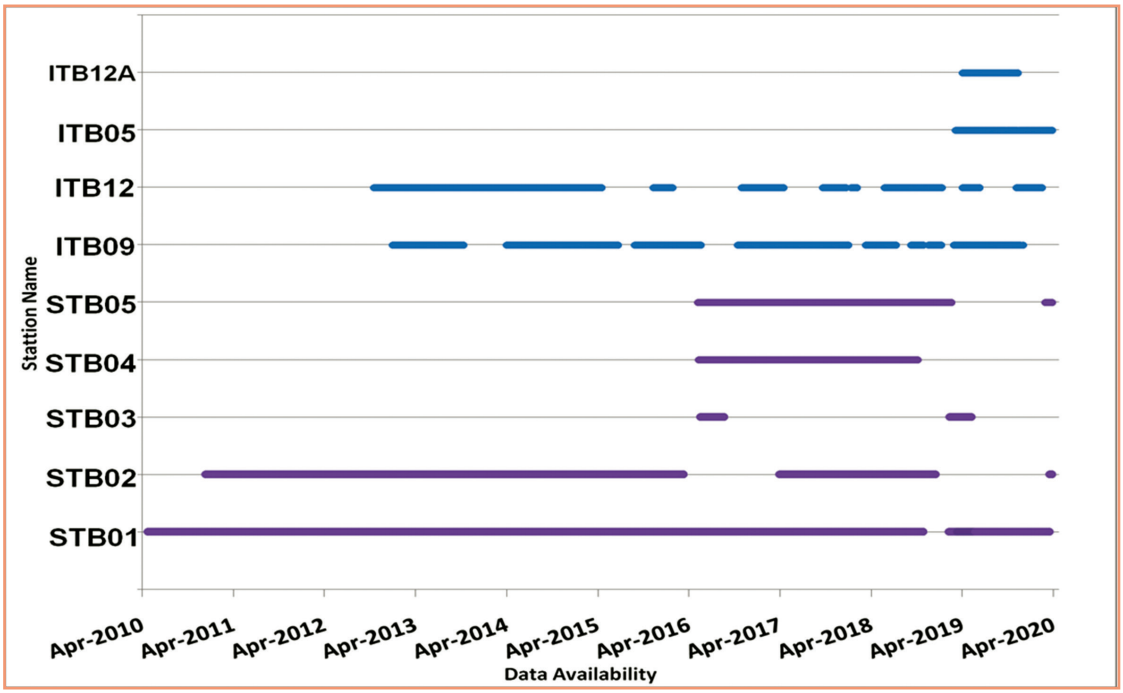
INCOIS continued to maintain a network of 4 tsunami buoys deployed close to the tsunamigenic source regions in the Bay of Bengal and Arabian Sea. In addition to that, INCOIS received

real-time data from three tsunami buoys deployed and maintained by National Institute of Ocean Technology (NIOT, Chennai). The buoys are capable of detecting very minor water level changes of 1 cm at water depths of 6 km. The data from the buoys are transmitted in real-time to the Indian Tsunami Early Warning Centre (ITEWC) at INCOIS via satellites. In addition to these buoys, real-time data from around 50 tsunami buoys operated by other countries in the Indian and Pacific Oceans are also received at ITEWC. The data are used for issuing early warnings. The data are available on the tsunami website. Also shared the data in real time data on NDBC-NOAA web site.



Locations of the Tsunami buoys

Two tsunami Buoys in the Bay of Bengal (STB05) and in the Arabian Sea (STB02) were retrieved and redeployed in a cruise onboard Sagar Nidhi during 5-31 March 2020. STB02 and STB03 systems were also retrieved during the cruise. The STB03 surface buoy that was not reporting since 13 May 2019 was recovered during the cruise. The internal components (payloads, batteries, electronics, etc.) of the surface buoy were missing as the buoy was vandalised. Due to vandalism or accidental run-over by boats/ships, the STB01 surface buoy got detached from the mooring on 22 March 2020 and started drifting in the Bay of



Data availability of tsunami buoys from April 2010 - March 2019 (Purple: INCOIS STBs; Blue: NIOT ITBs)

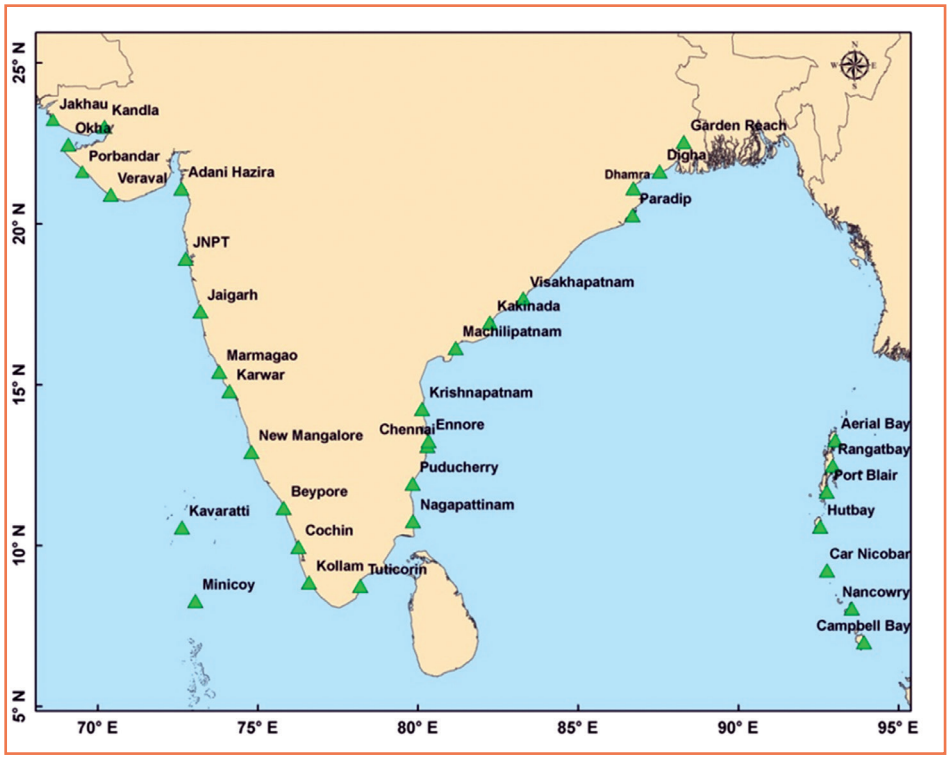
Bengal. The cruise also retrieved this buoy on 15 April 2020 due to the extension of cruise due to lockdown in the country.

Deployment of SAIC Tsunami Buoy onboard Sagar Nidhi cruise in March 2020

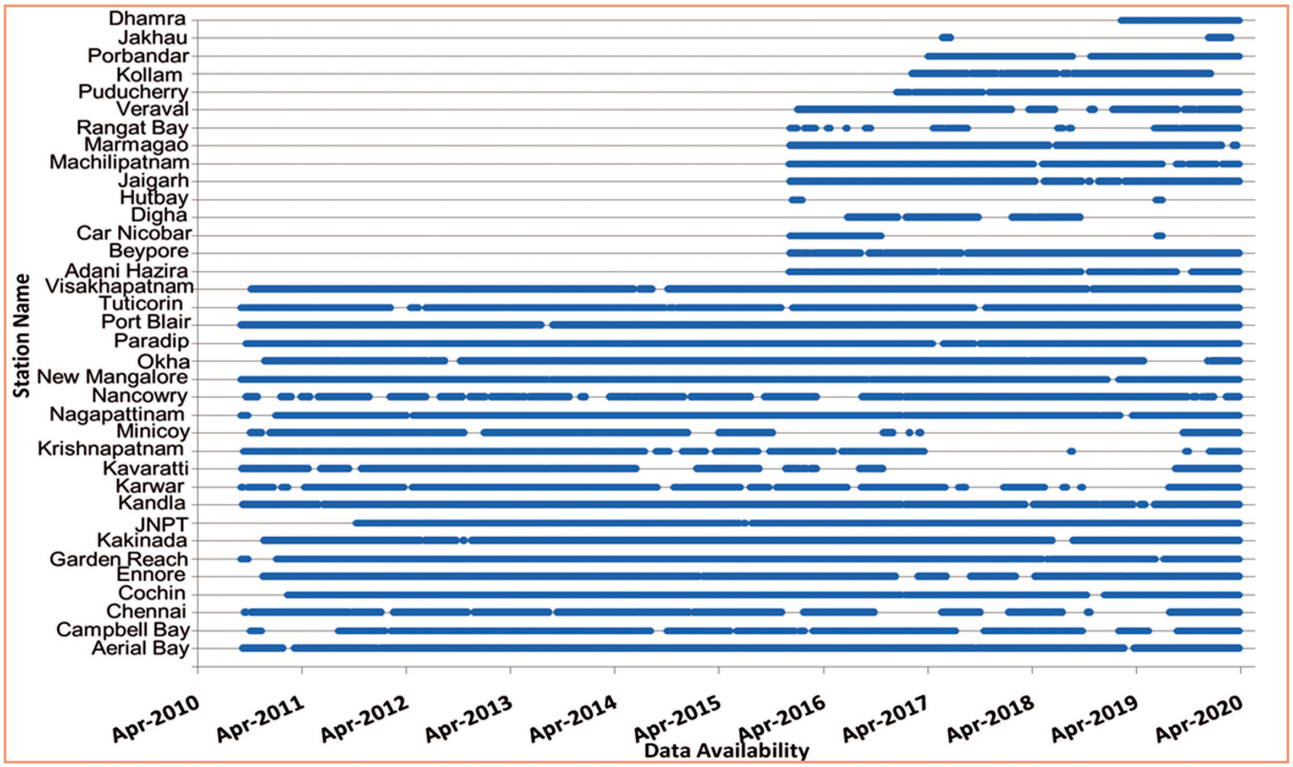
6.7 Tide gauges

INCOIS continued to maintain a network of 36 tide gauges installed along the coasts of Indian mainland and islands to monitor the sea level. Twenty one (21) tide gauges established in 2010-11 were upgraded with the installation of new data loggers, INSAT MSS and UHF transmitters with solar power for primary communication. New GPRS modems were also installed for redundant communication. Real-time data from 36 tide gauges are being received at ITWEC through INSAT and GPRS communications. In addition, INCOIS also received data from around 400 tide gauges installed and maintained by other countries in near-real time. INCOIS shared the data from 8 tide gauges (Chennai, Kochi, Nancowry, Port Blair, Visakhapatnam, Minicoy, Marmagao and Veraval) in real time to IOC Sea level monitoring facility.

The sea level data from all national stations are being archived for operational and research purposes. INCOIS has initiated the Quality Control process of the data. Completed the QC for 12 tide gauges. Hourly quality controlled data are archived. Removal of spikes, gap filling if the gaps are less than 24 hours, and time shift errors were also rectified in the processed data.



Locations of the Sea level Gauges along the Indian coasts



Data availability from the Tide gauges during April 2010-March 2020

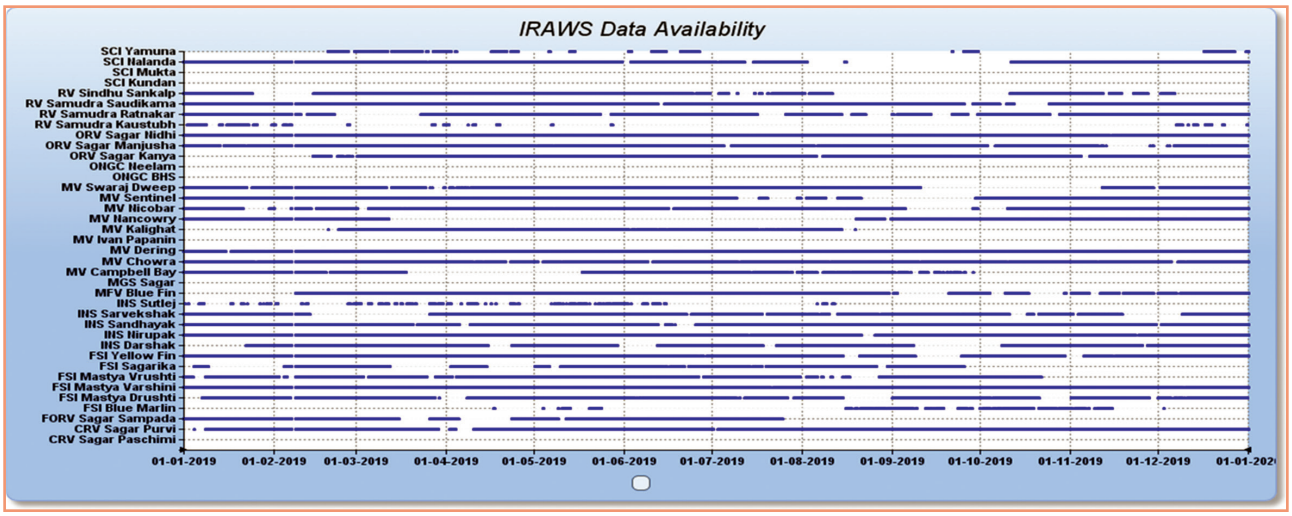
6.8 Automated Weather Stations (AWS)

INCOIS maintained a network of 34 Automatic Weather Stations (AWS) installed in different vessels owned by the Government organizations (NCPOR, NIOT, GSI, NIO, CMLRE, SCI, FSI and NHO) plying in the Indian Ocean region. All AWSs are integrated with sensors to measure true wind speed and direction, air temperature, humidity, short and long wave radiations, rainfall, SST, turbidity, chlorophyll and barometric pressure. The measured data are transmitted to INCOIS through INSAT on real time. Following maintenance activities were carried out during 2019-20 to ensure the availability of quality data from the AWSs.

Regular Maintenance Visits	98
Breakdown Visits	22
Calibration of Sensors	LWR - 12, SWR - 12, Wind - 8, BARO- 6, AT/RH - 15, RG - 6.
• Obtained the permission from Lakshadweep Development Corporation (LDCL) for the installation of AWS in vessels plying in Lakshadweep region and carried out site survey for the installation of AWS system in the vessel "MV Arabian Sea".	
• Installed an Automatic Weather Station (AWS) on board the ship chartered by NCPOR, Goa for Antarctic voyage.	

6.9 Wave Rider Buoy (WRB)

With the deployment of a wave rider buoy off Kavaratti in February 2020, INCOIS wave rider buoy network (WAMAN) is now functioning with 16 buoys to measure wave parameters along the Indian coast. The data are used for configuring the wave models and validating the ocean state forecasts issued by INCOIS. Wave rider buoy deployed off Visakapatanam has been upgraded in March 2020 by adding a current meter and inbuilt solar panel and necessary upgradation in the

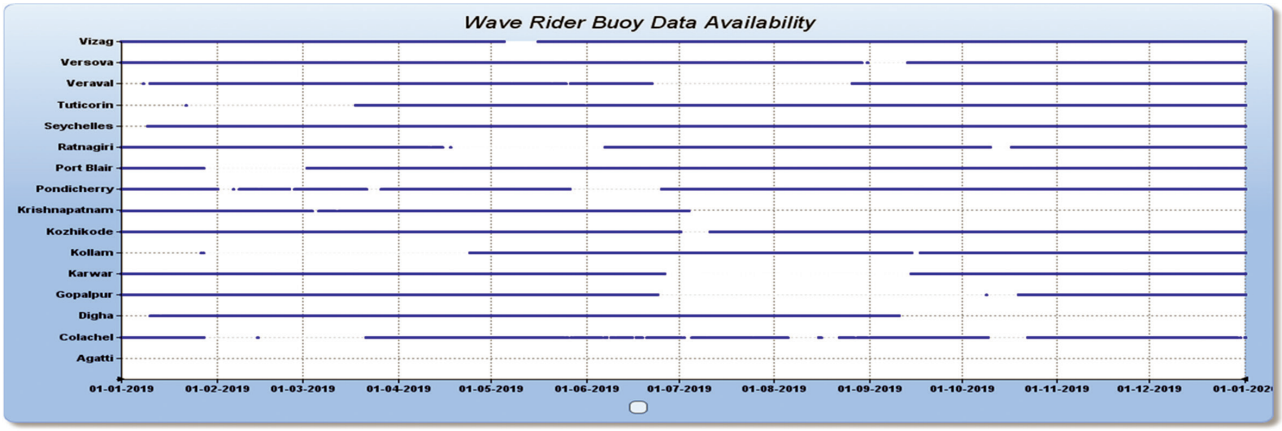


Data availability from the AWS systems installed and maintained by INCOIS

AWSs installed in the ships

INSAT transmitter. In order to maintain the network, INCOIS performed 31 maintenance activities. Fourteen buoys drifts occurred in the reporting period. Except one buoy deployed off Diga which was lost as that became untraceable due to rough sea conditions during monsoon, all other drifter buoys were retrieved successfully.

Locations of WRBs deployed by INCOIS

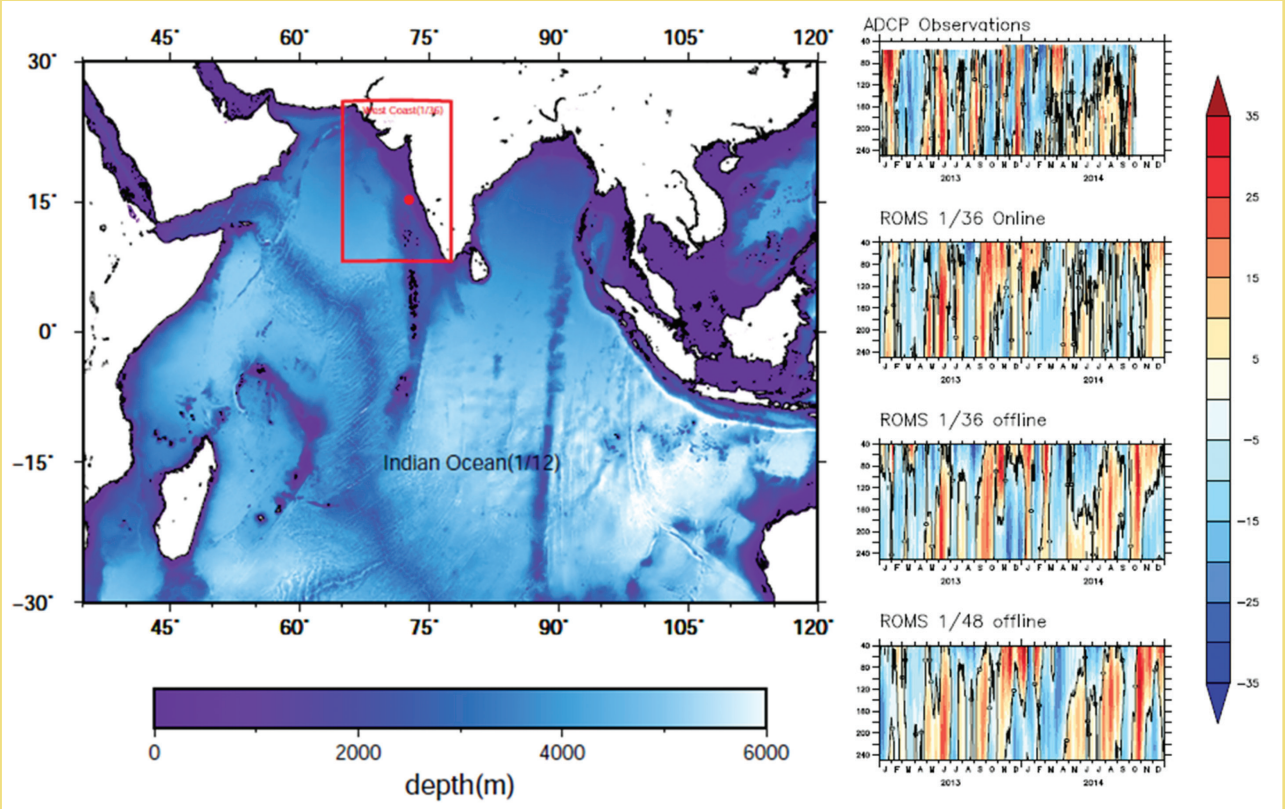


Data availability chart of Wave Rider buoy network

7. Ocean Modelling And Data Assimilation

7.1. Modelling of coastal circulation around India

At present, the operational forecasts of coastal circulation around India are generated using high-resolution (1/48°) configuration of Regional Ocean Modelling System (ROMS) for the north Indian Ocean (NIO-HOOFS) and 1/12° basin scale ROMS model configured for the Indian ocean (IO-HOOFS) and they are nested offline to exchange the boundary conditions on a daily basis. In order to avoid multiple model runs and the uncertainties in the boundary conditions, an online-nesting between the basin-scale parent model at 1/12° resolution (same as IO-HOOFS) and a high-resolution (1/36°) configured for the west coast of India has been setup as a pilot experiment. Comparison of modelled alongshore currents with ADCP observations show that simulations from the online nested configuration could capture the vertical structure and temporal variability better than the offline configuration, despite the horizontal resolution being less than the NIO-HOOFS configuration. Efforts are in progress to expand the domain to cover the entire northern Indian Ocean so that this online nested configuration can replace the existing offline nested configuration of HOOFS.

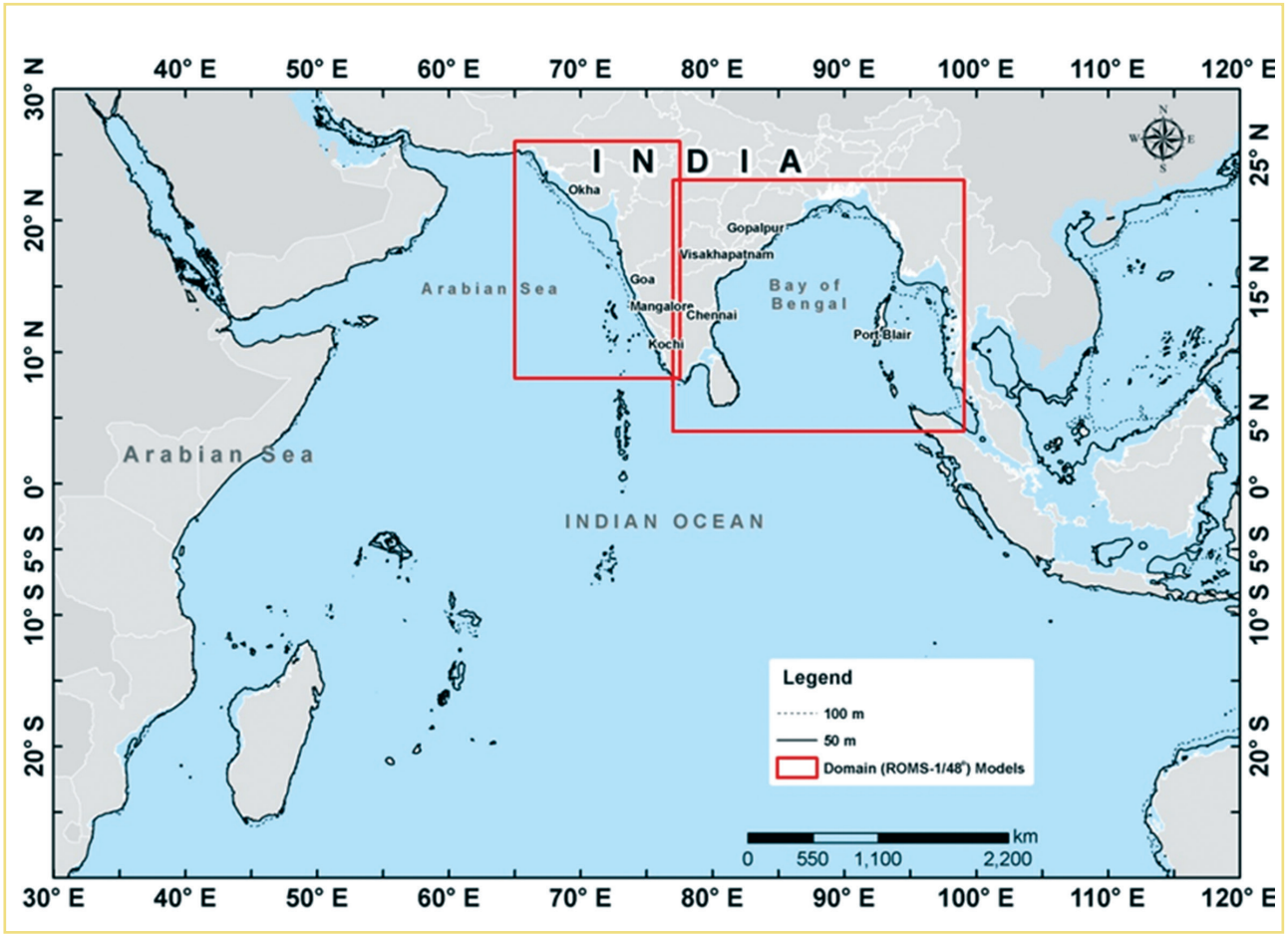


Model domain of the online-nested configuration - Indian Ocean (1/12°) and west coast of India (1/36°). Comparison of modelled alongshore currents at off Goa from online and offline nested simulation of different viscosity values with ADCP observations.

7.2. Biogeochemical State of the Indian Ocean (BIO)

INCOIS has completed the setup of Biogeochemical State of the Indian Ocean (BIO) - a

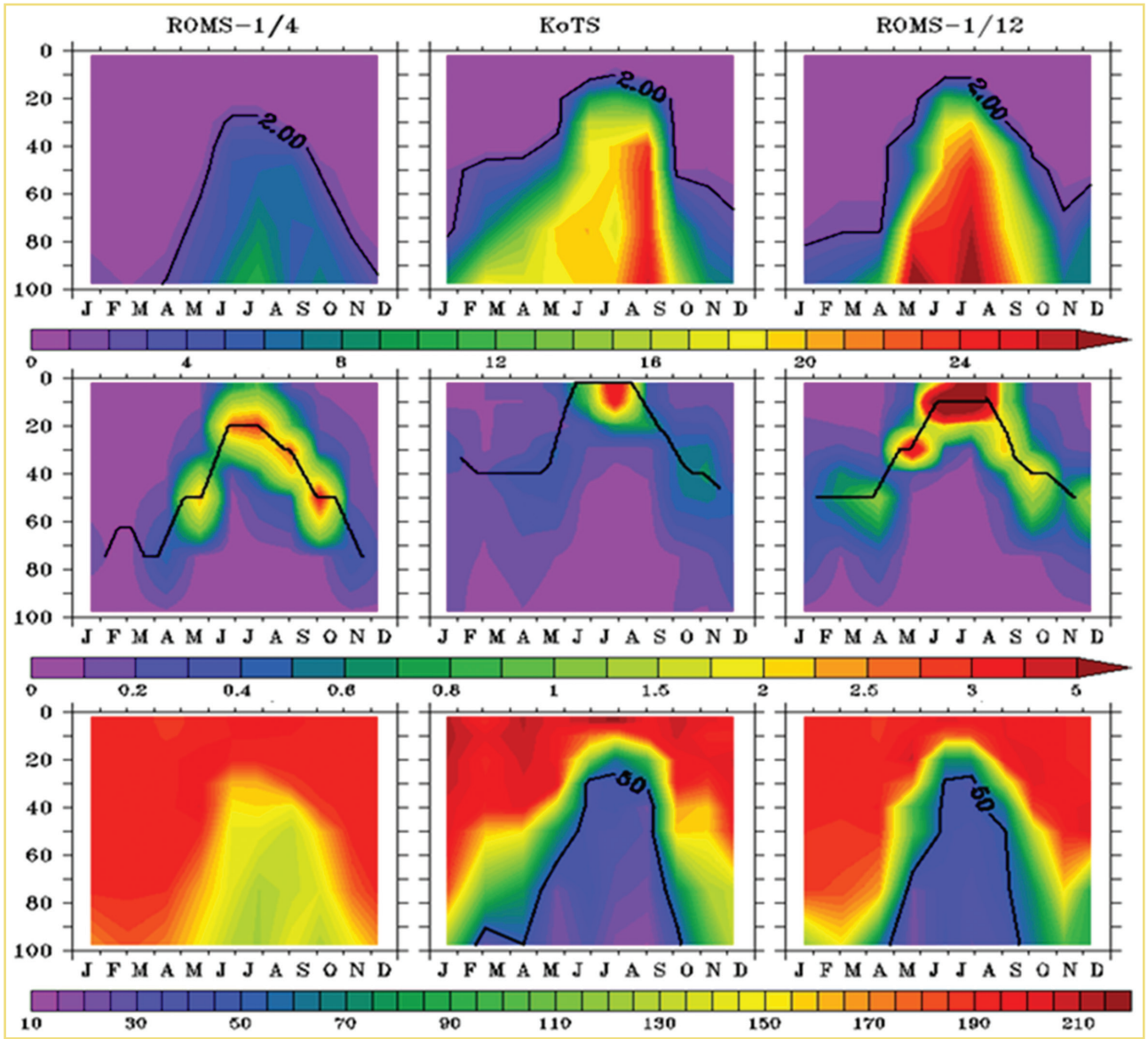
high-resolution bio-physical modelling framework to simulate and predict the evolution of biogeochemical state of the Indian Ocean at short and long time scales. This modelling framework involves online coupling of Regional Ocean Modelling System (ROMS) physics/dynamics integrated with an ecosystem model. The suite of high resolution models include two very high resolution physical-biogeochemical models with horizontal resolution 1/48° (approximately 2.25 km spatially averaged), exclusively for the east (77°E to 99°E, 04°N to 23°N) and west (65°E to 77.5°E, 08°N to 26°N) coast of India, and a high resolution physical-biogeochemical model with horizontal resolution of 1/12° (approximately 9 km) for the entire Indian Ocean basin (30°S to 30°N; 30°E to 120°E). The nesting between the basin wide and the coastal models is done offline. The biological component of the high resolution, coupled modeling system consists of the nitrogen cycle model with parameterized sediment denitrification. The nitrogen cycle model includes seven state variables viz. phytoplankton, zooplankton, nitrate, ammonium, large and small detritus classes with nitrogen concentration and phytoplankton chlorophyll. The time rate of change of concentration of each state variable describes the balance of advection-diffusion and source-sink terms among the related state variables of the nitrogen cycle. The biological model also resolves the full carbon cycle. The model is now being run on a daily basis using atmospheric forcing from NCUM (NCMRWF Unified Model) analysis. The model runs for 5 days in hind-cast mode followed by 5 days in forecast mode thereby regularly updating to generate daily analysis of biogeochemical state of the Indian Ocean. Main objective of the BIO modelling system is convert the operational *Potential Fishing Zone (PFZ) advisories to PFZ forecasts*.



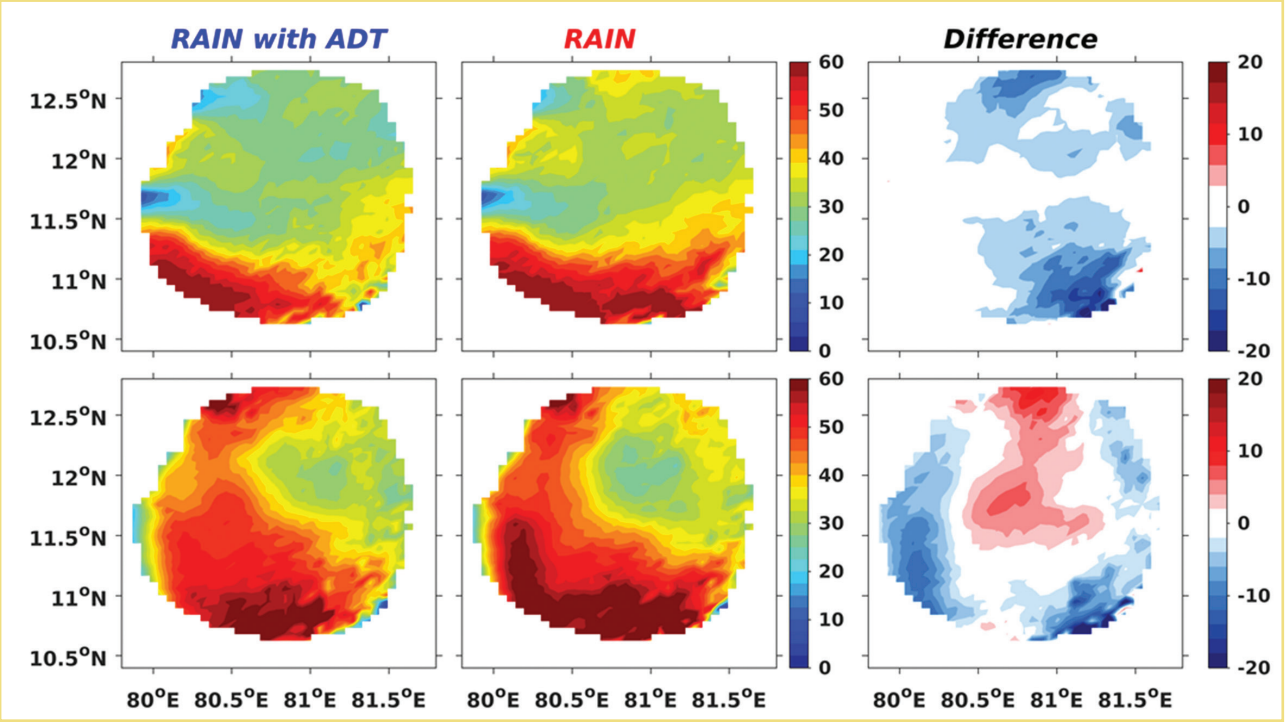
Domains of Biophysical Models Configured at INCOIS using ROMS.

7.3. Data Assimilation in ROMS

The Regional Analysis of Indian OceaN (RAIN) which assimilates ocean observations (temperature and salinity profiles and SST) using Local Ensemble Transform Kalman Filter (LETKF) to the Indian Ocean configuration of Regional Ocean Modelling System (ROMS) is operational at INCOIS since March 2019. Regional analysis for the Indian Ocean are regularly updated in https://incois.gov.in/portal/rain/rain_about.jsp. The website also provides information on the observations that have gone into assimilation for the analysis and validation of the performance of assimilation scheme. INCOIS is also working on incorporating the assimilation of track data of absolute dynamic topography (ADT) from satellites and biological tracers like chlorophyll and oxygen from Argo floats in RAIN. Preliminary results suggest that inclusion of ADT assimilation improves the correlation of the currents and reduces the root mean squared error of the zonal and meridional surface currents by ~ 5 cm/s with respect to OSCAR currents. Similar behavior is observed with respect to surface currents observed by HF radar at Kalpakkam, Tamil Nadu. Development of the assimilation of biological tracers is in progress.



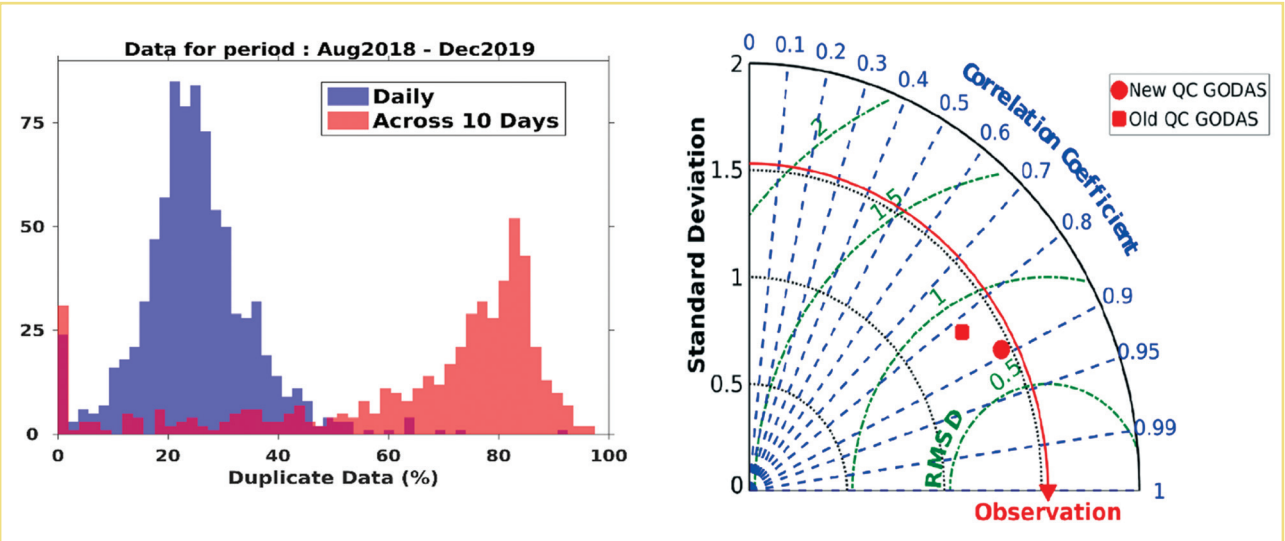
Temporal evolution of nitrate (μM) (upper panel), chlorophyll (mg/m³) (middle panel) and dissolved oxygen (μM) (lower panel) during 2012. In the (upper panel) black line represents nitracline depth (2 μM), (middle panel) black line represents depth of subsurface chlorophyll maxima and (lower panel) black line represents oxycline depth (50 μM)



Comparison of the analysis from RAIN with ADT and RAIN with the HF radar derived surface currents observed at a location on Tamil Nadu coast in 2017. The top (bottom) panels pertains to zonal (meridional) currents. The top (bottom) left panel shows the RMSD of zonal (meridional) current derived from RAIN+ADT system w.r.t HF radar. The top (bottom) middle panel shows the RMSD of zonal (meridional) current derived from RAIN system w.r.t HF radar. The top (bottom) right panel shows the difference RMSD of zonal (meridional) current between the two systems. Negative (positive) difference indicates improvement (degradation).

7.4. Global Ocean Data Assimilation System (GODAS)

INCOIS is providing global ocean analysis based on INCOIS Global Ocean Data Assimilation System (INCOIS-GODAS). It was observed that the data being assimilated in GODAS had certain quality issues such as data duplication, data gaps, etc. Hence, in order to avoid the assimilation of any erroneous observations into the system, a set of quality control procedure has been developed and integrated with the operational run. The quality checks include the removal of

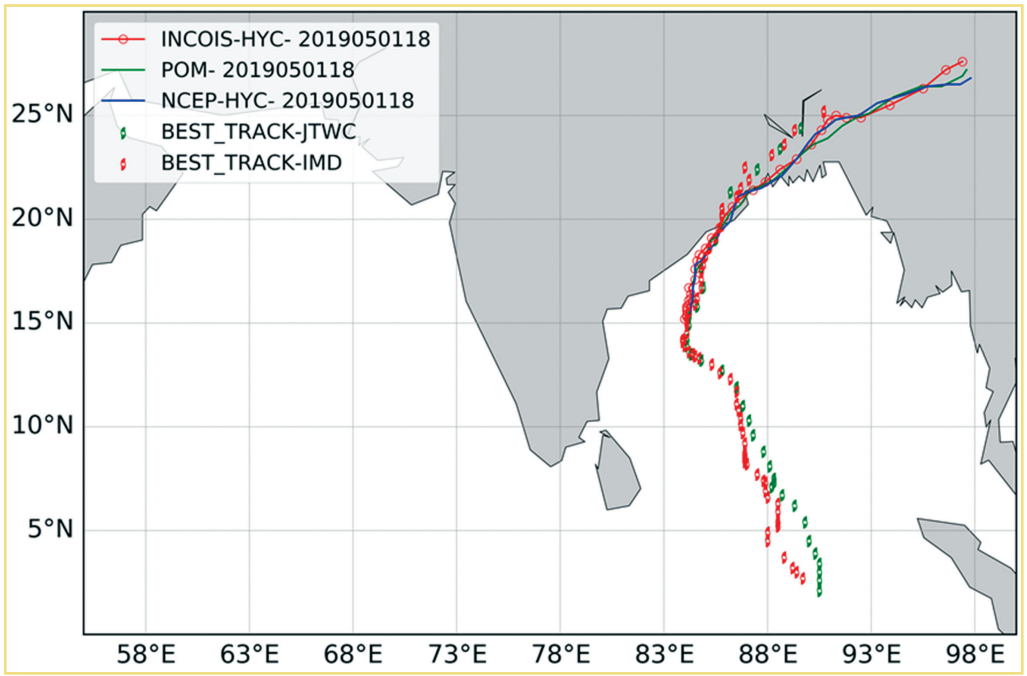


Left: Percentage of duplicates in the observation for the period during Aug 2018 to Dec, 2019. Right: Taylor diagram of temperature averaged in 50-300 m depth range from GODAS simultions with observations based on older and the newer QCs with respect to RAMA moorings at 140°W, 2°N.

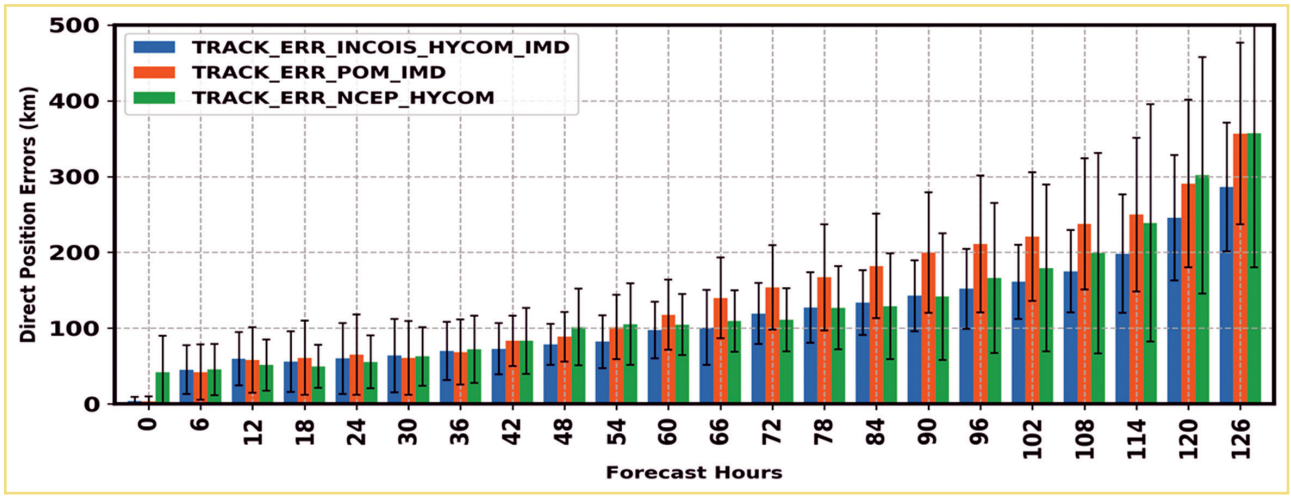
incomplete observations, duplicates and vertical inconsistency. Also, the standard deviation check was improved using the climatological means of available observational data sets. With these modifications in the QCs, the ocean analysis produced by GODAS has improved considerably.

7.5. INCOIS-HYCOM-HWRF coupled simulation of Tropical Cyclone Fani

A coupled HWRF-HYCOM with moving nest has been implemented at INCOIS. The coupled model obtains the ocean initial and boundary conditions from high resolution (1/16°) operational Indian Ocean HYCOM nested to a 1/4th degree global HYCOM. The coupled INCOIS-HYCOM was transferred to IMD for operational use. IMD made the first operational forecast of Tropical Cyclone Fani using HWRF-HYCOM together with other models during April 2019 using the initial and boundary conditions derived from Indian Ocean HYCOM. Tropical Cyclone Fani appeared as a depression on west of Sumatra on 26 April intensified rapidly into a severe cyclonic storm and reached the maximum intensity on 2 May. It was found that the errors in the predicted track and intensity of tropical cyclone Fani based on INCOIS-HYCOM-HWRF were less than



Simulated track of Cyclone Fani using HWRF-HYCOM coupled system run at IMD using INCOIS-HYCOM ocean component compared with POM-based run and NCEP-run. The best-tracks from JTWC and IMD are also shown.

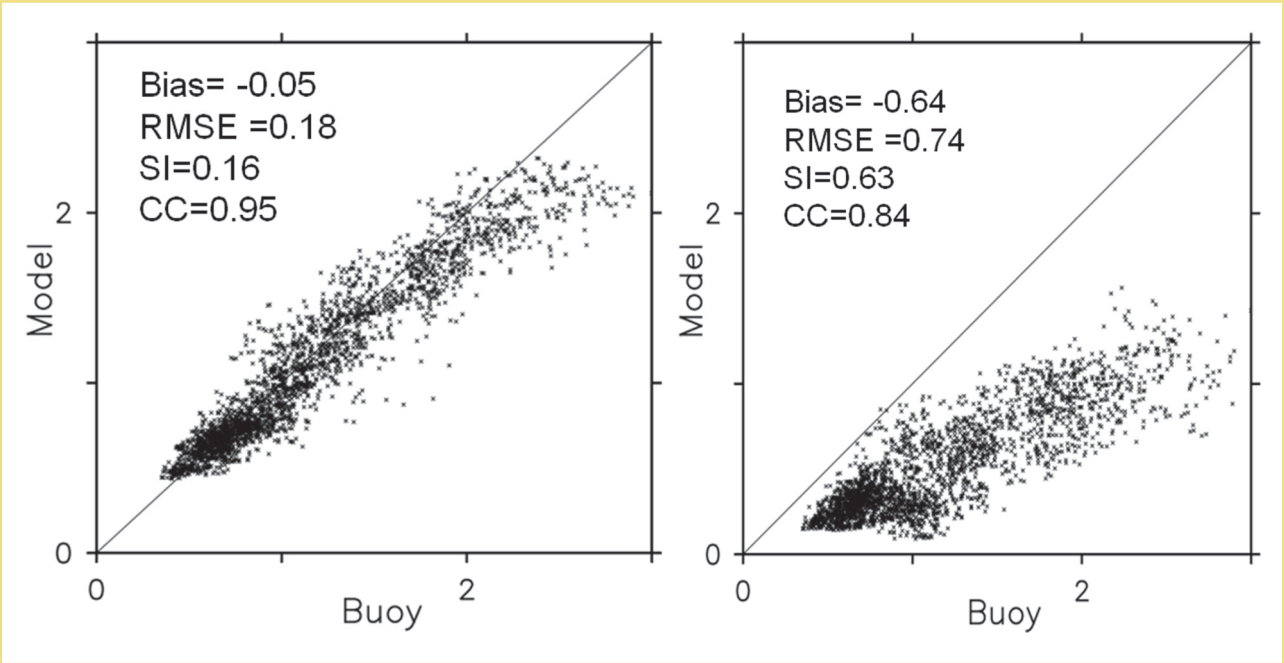


Comparison of mean direct position errors at different forecast lead times from HWRF coupled to HYCOM, POM and of NCEP run.

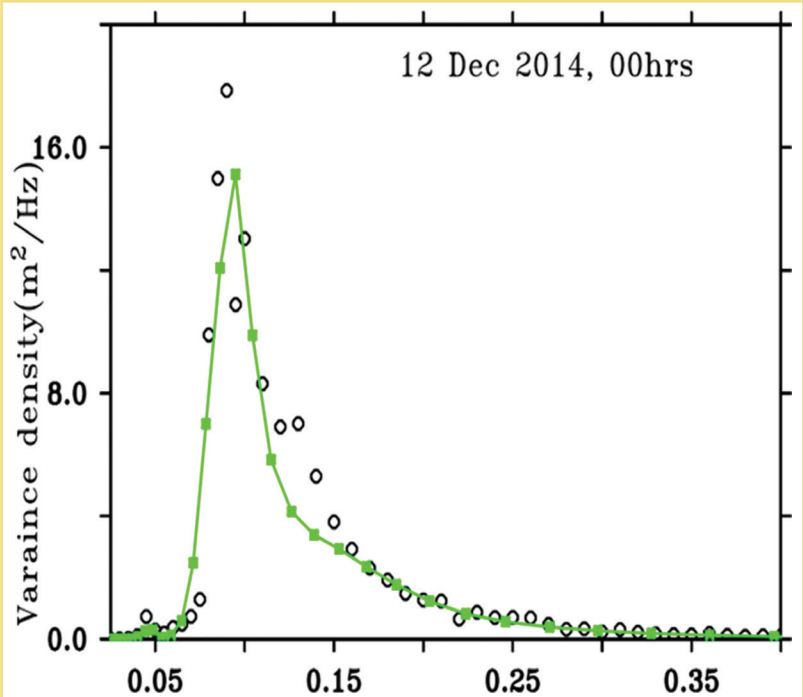
the coupled models based on POM-WRF and NCEP HYCOM-HWRF. INCOIS also provided the ocean initial conditions to IMD for the seven cyclones occurred in the Indian Ocean in 2019.

7.6. Operational SWAN models for the east and west coasts of India

Unstructured SWAN model with spatial resolutions varying from ~350 m near the coast to ~5km in the offshore were nested directly with Wavewatch III model for the east and west coasts of India. Extensive validations of the simulation for the year 2014 were carried out. The errors were significantly reduced upon the nesting with WWIII.



Scatter plots of significant wave height off Kollam before and after the nesting with Wavewatch III.



Validation of wave energy spectra from SWAN model off Gopalpur at 00 hrs on 12 Dec, 2014. Black is buoy and green is model

8. Coastal Monitoring: Marine Observation System Along the Indian Coast (MOSAIC)

8.1 Algal Bloom Information Service (ABIS)

The Indian coastal and open ocean waters experience several forms of algal blooms which have significant effect on the water quality and the food chain. Considering its importance, INCOIS has developed an "Algal Bloom Information Service (ABIS)" based on remotely sensed ocean colour data and bio-optical algorithms. The service is operational since 24 February 2020 after a few months of trial and performance assessment. ABIS provides composite map of bloom, its proxies and ancillary products, on a daily basis.

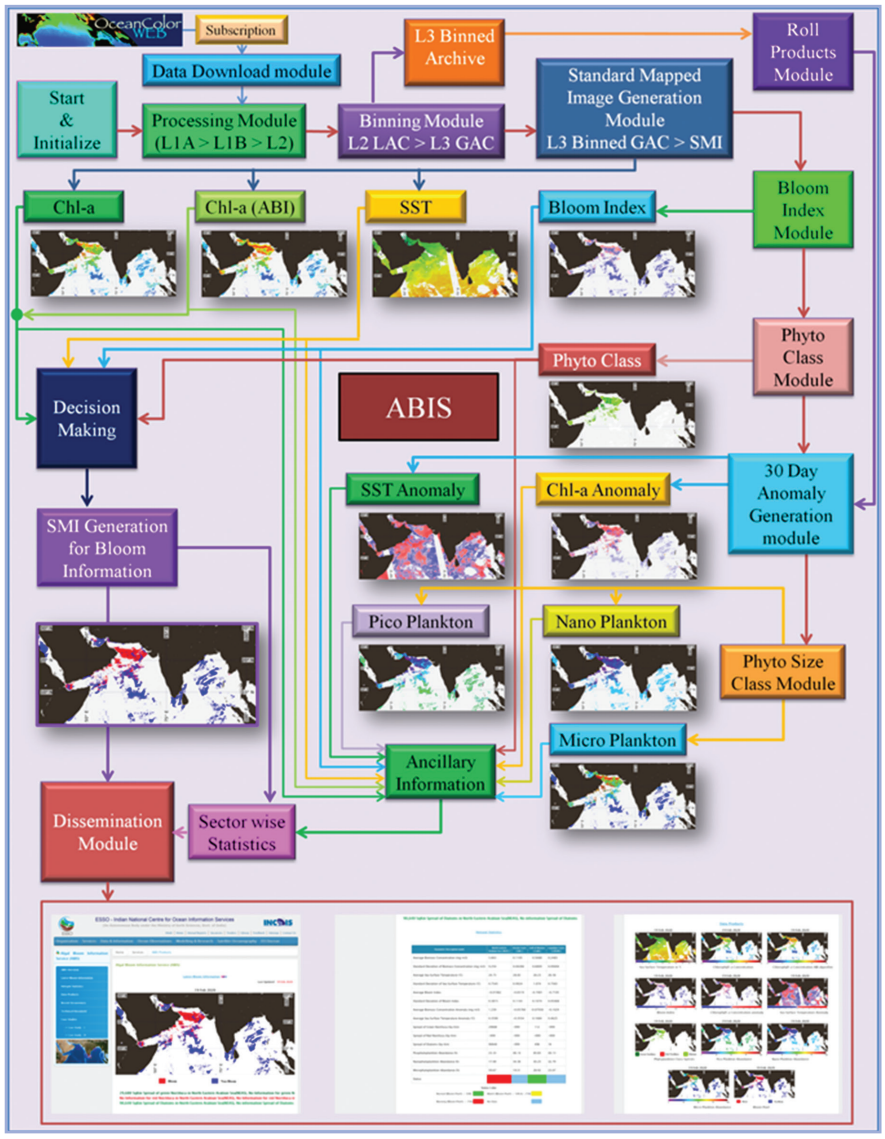


Figure: Schematic of Algal Bloom Information Service (ABIS)

The ABIS uses a set of MODISA (Moderate Imaging Spectroradiometer-Aqua) derived environmental proxies such as chlorophyll-a, Sea Surface Temperature (SST), and Bloom Index (BI), for detection and monitoring of algal bloom events. Subsequent to detection of bloom, ABIS also provides information on the causative group/species of phytoplankton. ABIS is equipped with a scheme for detection of ubiquitous phytoplankton group "diatom" and HAB enlisted frequent bloom forming (in Indian waters) species Noctiluca scintillans. ABIS also provides information on Phytoplankton Size Classes (PSC) during non-bloom and bloom conditions. Four hot-spots, coastal waters off Kerala, Gopalpur, Odisha, Gulf of Mannar and the open ocean waters of Northeastern Arabian Sea are closely monitored. ABIS products are disseminated through INCOIS website. The users include fisheries institutes, pollution

monitoring agencies, fishermen associations, oceanographic research organizations and coastal aquaculture industry.

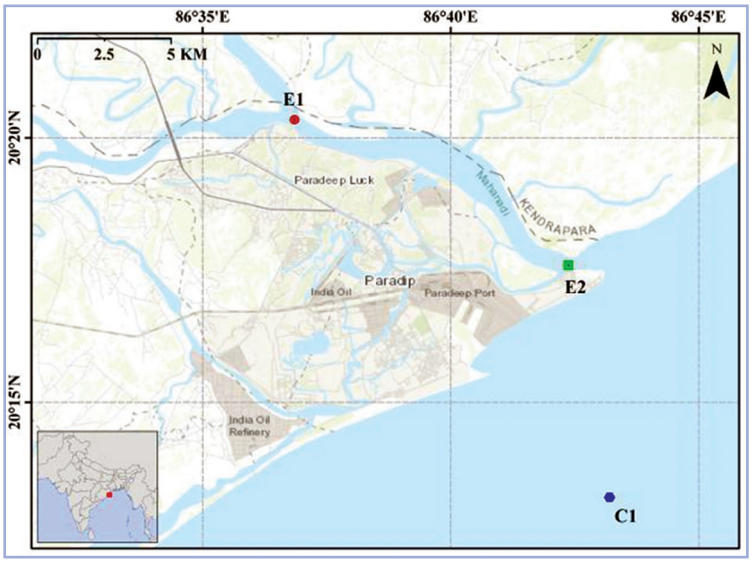
8.2 Response of hydro-biological parameters to semi-diurnal tides in the Mahanadi estuary

Mahanadi, the third largest peninsular river in India receives large amount of agricultural run-off along its course and effluents from industries and urban centres. Hence, as a first step to develope water quality nowcasts and forecasts for Indian coastal waters under "Coastal Monitoring" programme, extensive field work covering the tidal cycle was carried out in the Mahanadi estuary, located at Paradip in the state of Odisha. During this campaign (14-23 October 2019), three stations, one in the upstream, one in downstream and another in the coastal waters were sampled during each high and low tide of the cycle. The following 48 parameters were analysed.

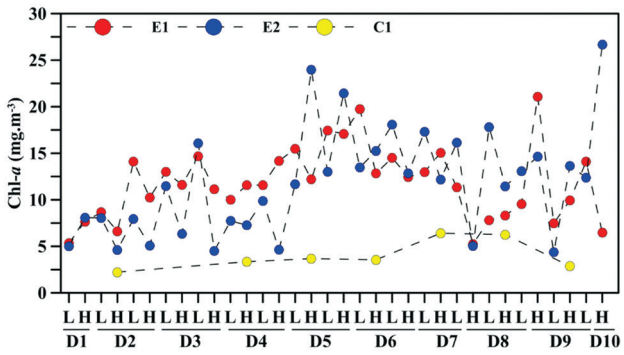
Table: List of parameters

Temperature	Silicate	Lead
Salinity	Dissolved Inorganic Carbon	Mercury
Total Alkalinity	Dissolved Organic Carbon	CDOM (Fluorescence)
pH	Particulate Inorganic Carbon	CDOM (Absorbance)
Dissolved Oxygen	Particulate Organic Carbon	Pigment
Biological Oxygen Demand	Total Organic Carbon	Chlorophyll-a Total
Chemical Oxygen Demand	Total Inorganic Carbon	Chlorophyll-a-Pico
Nitrite	Total Carbon	Chlorophyll-a-Nano
Nitrate	Turbidity	Chlorophyll-a-Micro
Ammonium	Total Suspended Matter	Phytoplankton
Total Inorganic Nitrogen	Fecal Coliform	Zooplankton
Total Organic Nitrogen	E. coli	Apparent Optical Properties
Total Nitrogen	Total Coliform	Dissolved Gases
Inorganic Phosphate	Iron	Dissolved N_2O Isotope
Organic Phosphate	Manganese	POC & PON conc. and Isotope
Total Phosphorous	Cadmium	DIC Isotope

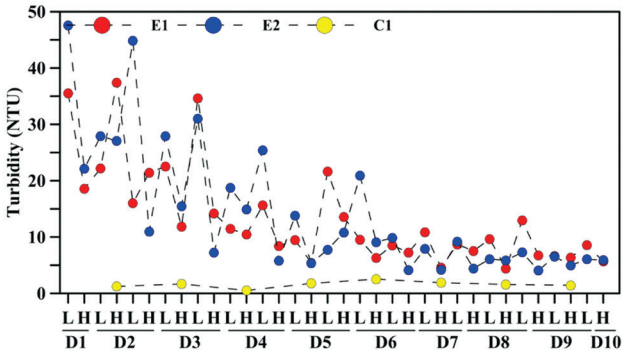
The total chlorophyll-a concentration was observed with significant fluctuations between high and low tide. The estuarine stations were observed with higher chlorophyll-a concentration in comparison to the coastal station. Unlike chlorophyll-a, turbidity levels were higher with higher tidal amplitude at both lower and upper estuary. However, the turbidity condition at the coastal station displayed steady magnitude. Turbidity levels at the estuarine stations gradually decreased with decline in tidal amplitude.



Map of study area showing sampling locations at upstream (E1) and downstream (E2) in the Mahanadi estuary and coastal waters (C1)

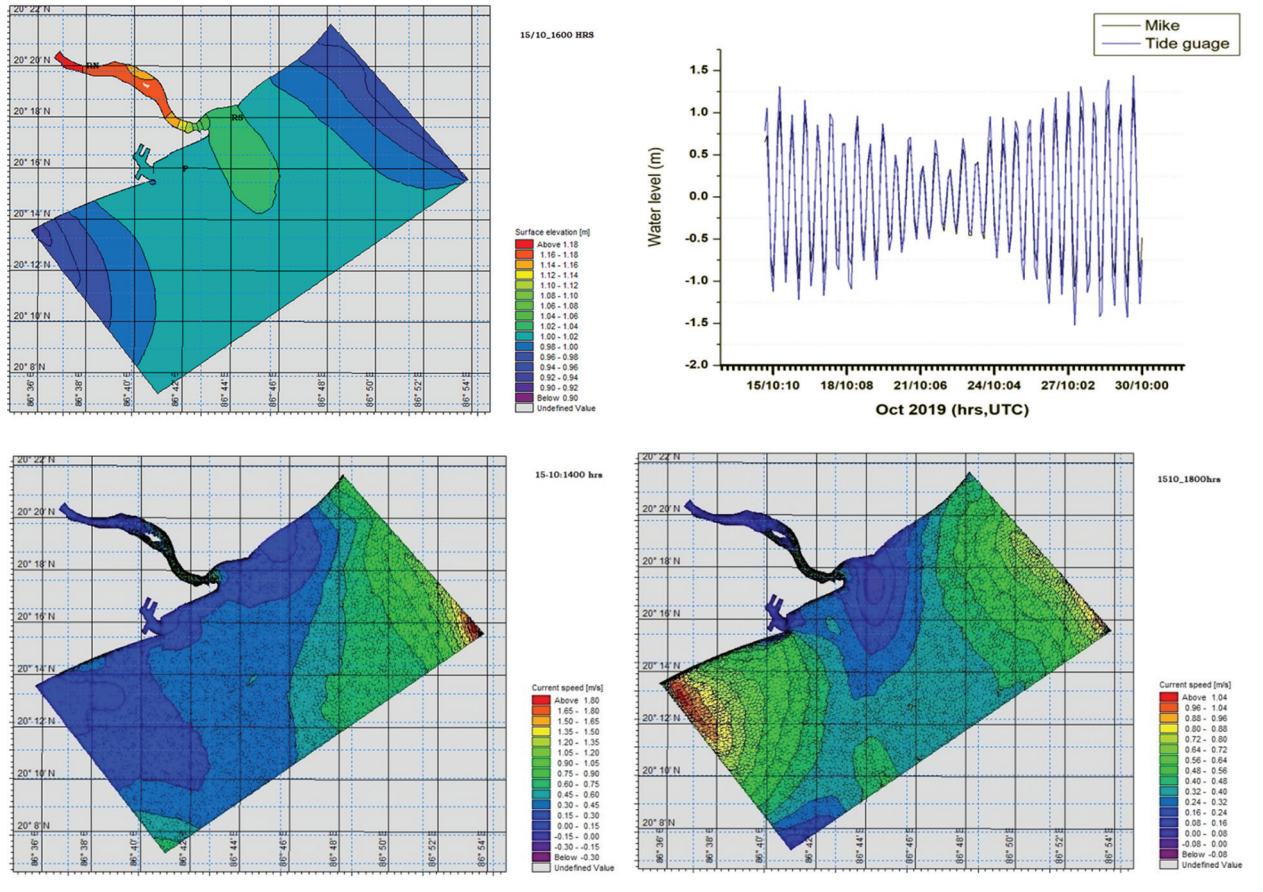


Variation of chlorophyll-a (chl-a) (in upstream (E1), downstream (E2) and in the coastal waters (C1) of Mahanadi estuary corresponding to tide (high (H) and low (L)) during sampling period (D1: 14 October 2019 to D10: 23 October 2019).



Variation of turbidity (in upstream (E1), downstream (E2) and in the coastal waters (C1) of Mahanadi estuary corresponding to tide (high (H) and low (L)) during sampling period (D1: 14 October 2019 to D10: 23 October 2019).

Mike 3 hydrodynamic flow module has been set up for the Mahanadi estuary. A high resolution mesh grid incorporating GEBCO bathymetry and the in-situ observations has been prepared. Preliminary simulation for October 2019 has been completed with a barotropic density setup having state variable zonal, meridional & vertical velocity along with the water level. Initial and boundary conditions are extracted from global tidal model and wind forcing was taken from ECMWF reanalysis wind data. The simulated water level has been compared with the in-situ observation taken by the tide gauge from Paradip port suggested that the phase of the tidal cycle has been captured well by the model, although there is an underestimation of tidal magnitude.



Model simulated surface elevation (top left). Comparison of model simulated water level vs. in-situ observations from tide gauge at Paradip Port (top right). Bottom panels (left & right) shows model simulated surface current speed and direction in different tidal conditions.

9. International Training Centre for Operational Oceanography (ITCOocean)

The Governing Board (GB) of UNESCO Category 2 Center was formed under the Chairmanship of Dr. M. Rajeevan, Secretary, MoES and the first meeting of this GB was held on 8 January 2020 at National Institute of Ocean Technology (NIOT), Chennai. Besides the Chairman and Member Secretary, Dr. S.S.C. Shenoi, Director, INCOIS, other members of the Governing Board, Mr. B Anand AS & FA, MoES, Dr. Vipin Chandra, JS, MoES, Dr. Justin Ahanhanzo, representative of IOC, Prof. Ravi S. Nanjundiah, Director IITM, Dr. S.B. Choudhary, nominee of NRSC Director attended the meeting. Mr. J.D.P. Labonne, Mr. D Norungee, Dr. Ruby Moothein Pillay and Dr. Namrata Reethoo, Observers from Mauritius, Dr. M.P. Wakdikar, Program Head, MoES and Mr. Prasanth Srivastava, Program Officer, MoES also attended the first meeting of the GB. Dr. S.S.C. Shenoi, Member Secretary of the GB briefed the committee about various activities of ITCOocean and the financial support received from MoES and IOC in carrying out the activities which was appreciated by the members. Members from Mauritius requested for collaboration with India and suggested certain areas for cooperation through ITCOocean. The committee recommended the following activities:

- Calendar of future activities to be published on the web site to facilitate the participation of international trainees;
- Emphasis may be laid on the training activities that would directly support the activities planned under UN Decade of Ocean Sciences for Sustainable Development;
- Identify the areas where other member countries of IOC can contribute and invite them to support the training programmes with their expertise;
- Continue to act as Regional Training Centre under OTGA and conduct training as mandated by them;
- Formulate specified courses as required by targeted user group;
- Conduct short term course leading to certificate by tying up with regional universities;
- Collaborate with Category 2 Center in Iran and if possible, conduct training course/s of mutual interest.

During the past year, ITCOocean conducted 11 training courses of 1 to 2-weeks duration. Two hundred and sixty-seven trainees from 23 countries including India attended the courses. List of the courses conducted during the year and the brief details are given below:

- Induction Training Programme for new entrants of INCOIS - conducted during 9-10 May 2019 for 18 newly-joined employees to provide an entry-level introductory briefing on all activities of INCOIS.
- IOCINDIO Training cum Workshop on "Coastal Vulnerability due to sea level rise and Storm Surges" held during 27-31 May 2019. The programme provided a mix of theory, practical and

field sessions on GIS, Image Processing software, field data collection and numerical modeling of coastal hazards. Thirty-nine participants from US, UK, France, Belgium, Australia, Malaysia, Kenya, Kuwait, Saudi Arabia, Bangladesh, Tanzania and India attended the workshop.

- Training on "Marine Meteorology and Operational Ocean State Forecasting" conducted during 17-21 June 2019. Training was provided on forecasting the waves, winds, currents, tides, cyclones, storm surges using numerical ocean models and their usage by the users like NGOs, Fishery Officials, Marine Police and Disaster Managers. Twenty-three participants from various national institutes participated in this course.
- OTGA-INCOIS Training Course on "Discovery and Use of Operational Ocean Data Products and Services" held during 1-5 July 2019. The focus of the course was on operational activities, various data and data products, outputs from INCOIS services, use of visualization softwares, etc. Twenty six participants from Iran, Mauritius, Indonesia, Myanmar, Philippines, Bangladesh and India attended this course.
- Training on "Operational Services Training to Naval Hydrography Officers NHO - Advance Hydrography" conducted on 24 July 2019. It was to provide exposure on the various products and services developed by INCOIS for various operational requirements of Naval Hydrography officers. Two commanders from NHO participated in this training.
- Training on "Coastal Vulnerability Mapping and analysis using GIS/QGIS technique" held during 26-30 August 2019. This course focused on the sustainable use of coastal resources and planning while providing an overview of GIS mapping, applications pertaining to coastal and storm surge vulnerability and analysis, was partially supported by OTGA/IODE/IOC. Thirty-seven participants from Bangladesh, Sri Lanka, Indonesia, Malaysia, Seychelles, Mauritius, Philippines, Japan, Iran, Tanzania, Kenya and India attended the course.
- A one-day training course on "Operational Services Training" held on 5 September 2019 to provide exposure on products and services developed by INCOIS mainly ocean state forecasts (winds, waves, currents, tides), Marine Met Atlas (MaMeAt), Sound Velocity Atlas (SoVeAt) and the Search And Rescue Aid Tool (SARAT) for supporting the search and rescue operations. Five officers from the Indian Navy Eastern Naval Command, Visakhapatnam attended the training course.
- Training course on "Tides and its applications in Oceanography" held during 23-27 September 2019. Major topics covered include physics of tides, methods of tidal data analysis, overview on data quality control and introduction to tide modelling. Eleven participants from various national institutes attended the course.
- Training course on "Ocean Colour Remote Sensing - Data, Processing and Analysis" held during 25-29 November 2019. It focused on the basics of marine optics, ocean colour remote sensing, and related applications. Thirty-eight participants from Philippines, Indonesia, Egypt, Bangladesh, Vietnam, Malaysia, Timor- Leste, Kenya, Sri Lanka, Iran and India attended the course.
- Training course on "Ocean Data Utilization and Ocean Observation System" conducted during 2-5 December 2019. Training mainly focused on awareness about data from various observation platforms archived at INCOIS and utilization of data for scientific applications. Thirty-seven students from IIT-Bhubaneswar and IIT Kharagpur attended in this training course.

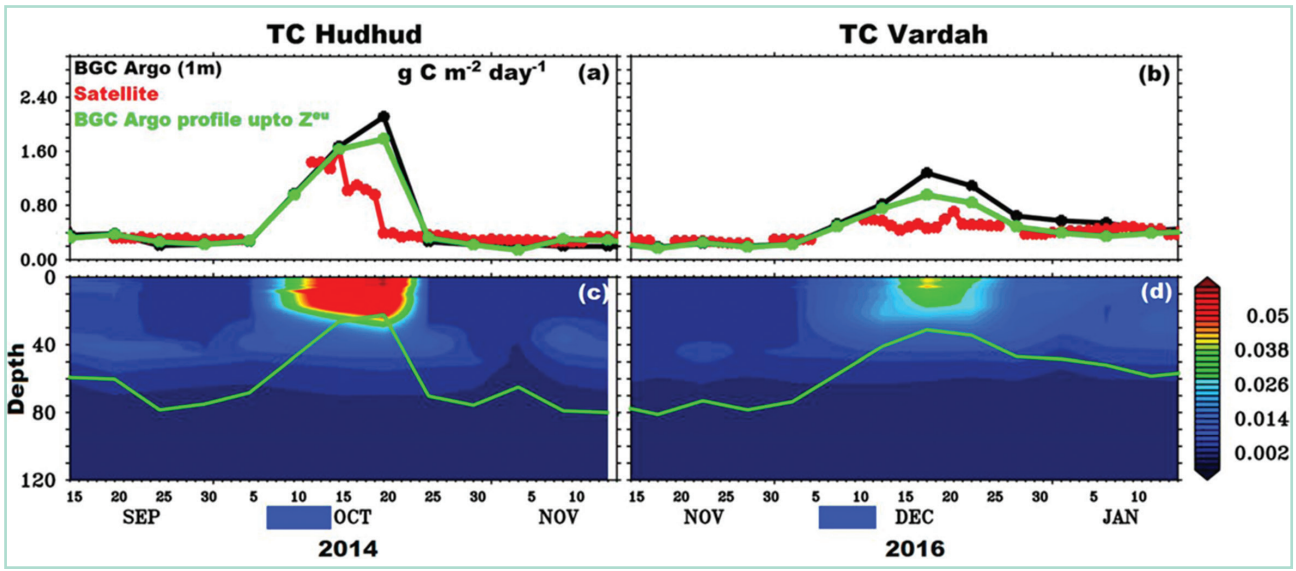
- Training course on "Remote Sensing and GIS Applications using QGIS" held during 16-20 December 2019. for 31 young faculty/research scholars and post-graduate students from School of Earth Sciences, SRTM University, Nanded, Maharashtra. The participants were provided with an overview of GIS applications pertaining to coastal mapping with a focus on coastal erosion, mangrove and coral reefs. Data acquisition, processing, analysis and interpretation of coastal spatial data was also covered. 31 young faculty/research scholars and post-graduate students from School of Earth Sciences, SRTM University, Nanded, Maharashtra attended the training course.

Photos from some of the training sessions on progress at ITCOocean during 2019-2020.

10. Research Highlights

10.1 Effect of Cyclones on the Biogeochemical Processes in the Bay of Bengal

It was shown that significant changes in upper ocean structure was observed in the physical and biogeochemical parameters observed by an autonomous profiling Argo float in the Bay of Bengal during the passage of tropical cyclone (TC) Hudhud (7–14 October 2014). TC Hudhud mixed water from a depth of about 50 m into the surface layers through a combination of upwelling and turbulent mixing. Mixing was extended into the depth of nutricline, the oxycline, and the subsurface chlorophyll maximum and thus had a strong impact on the biogeochemistry of the upper ocean. Before the storm, the near surface layer was nutrient depleted and was thus oligotrophic with the chlorophyll-a concentration of less than 0.15 mg m^{-3}. Storm mixing initially increased the chlorophyll by 1.4 mg m^{-3}, increased the surface nitrate concentration to about 6.6 μM kg^{-1}, and decreased the subsurface dissolved oxygen (30–35 m) to 31% of saturation (140 μM). These conditions were favorable for phytoplankton growth resulting in an estimated increase in primary productivity averaging 1.5 g Cm^{-2} day^{-1} over 15 days. During this bloom, chlorophyll-a increased by 3.6 mg m^{-3}, and dissolved oxygen increased from 111% to 123% of saturation. Similar observations during TC Vardah (6–12 December 2016) showed much less mixing. Analysis suggested that relatively small (high) translation speed and the presence of cold (warm) core eddy leads to strong (weak) oceanic response during TC Hudhud (TC Vardah). Thus,



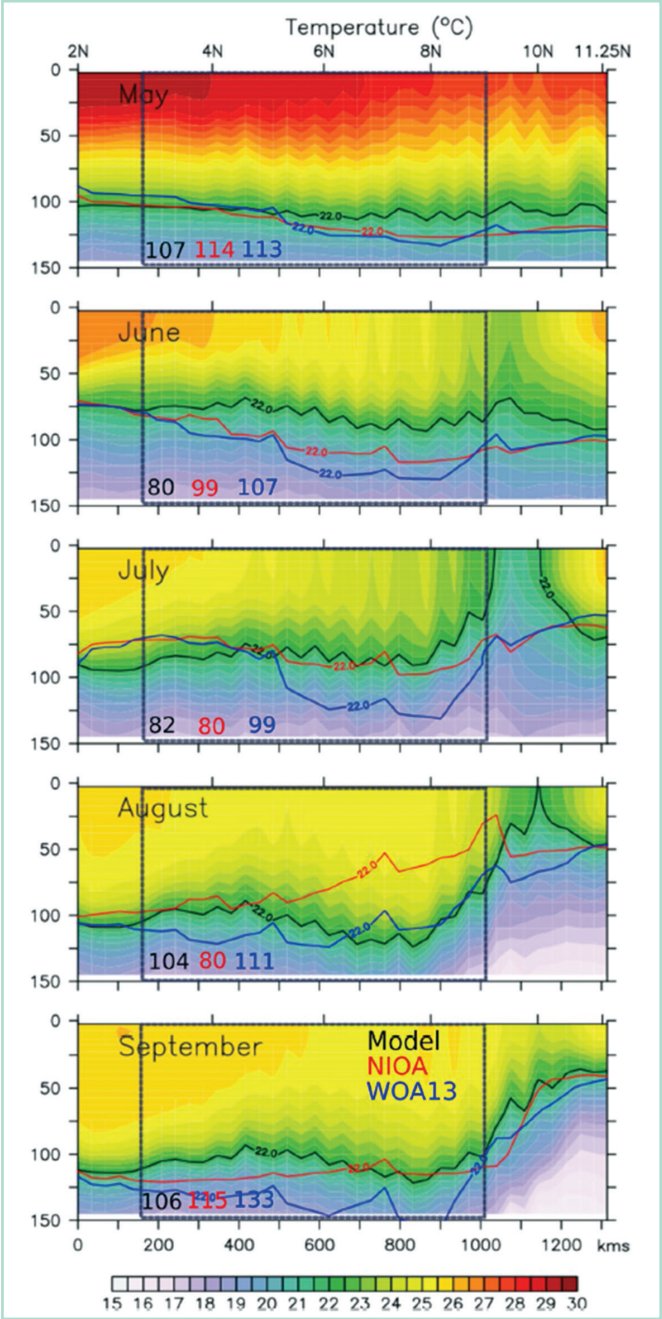
Temporal evolution of integrated primary productivity (PP) from the surface to euphotic depth (g $Cm^{-2}day^{-1}$):using satellite merged chlorophyll-a (mg m^{-3}) and Microwave Optimum Interpolation Sea Surface Temperature (°C; PPSatzeu, redline); using surface chlorophyll-a (mg m^{-3}) and surface temperature (°C) from the C Float and (PPSurfzeu black line); and using chlorophyll and temperature profiles from the C Float (PPSTD VGPM Pzeu; green line) during (a) TC Hudhud and (c) TC Vardah. Temporal evolution of PP profiles (PPSTD VGPM Pz; g $Cm^{-3}day^{-1}$) estimated from the BGC Argo chlorophyll and temperature profiles during (b) TC Hudhud and (d) TC Vardah. The green solid line in the panels b and drepresents the euphotic depth. Blue thick line at the bottom of the figure indicates TC Hudhud period (7–14 October 2014; left panels) and TC Vardah (6–12 December, 2016) period. TC = tropical cyclone; C Float = chlorophyll float.

Ref: Girishkumar, M.S., Thangaprakash, V.P., Udaya Bhaskar, T.V.S., Suprit, K., Sureshkumar, N., Baliarsingh, S.K., Jofia, J., Pant, V., Vishnu, S., George, G., Abhilash, K.R., Shivaprasad, S. Quantifying Tropical Cyclone's Effect on the Biogeochemical Processes Using Profiling Float Observations in the Bay of Bengal (2019) Journal of Geophysical Research: Oceans, 124 (3), pp. 1945-1963

although cyclones can cause strong biogeochemical responses in the Bay of Bengal, the strength of response depends on the properties of the storm and the prevailing upper ocean structure such as the presence of mesoscale eddies.

10.2 Annihilation of the Somali upwelling system during summer monsoon

Somali upwelling system during northern summer is believed to be the largest upwelling region in the Indian Ocean and has motivated some of the early studies on the Indian Ocean. Observations and ocean model simulations show that the upwelling along the Somali coast is limited to the early phase of the summer monsoon and later primarily limited to the eddy dominated flows in the northern and some extent in the southern part of the coast. Major part of the Somali coast (~60% of the entire coastal length) shows prominent downwelling features driven by offshore negative windstress curl and subsurface entrainment mixing. The surface cooling of coastal waters are dominantly driven by subsurface entrainment and surface heat fluxes. These findings not only augment the existing knowledge of the Somali upwelling system, but also have serious implications on the regional climate. Most importantly, this analysis underscores the use of alongshore winds only to project future (climate driven) changes in the upwelling intensity along this coast.



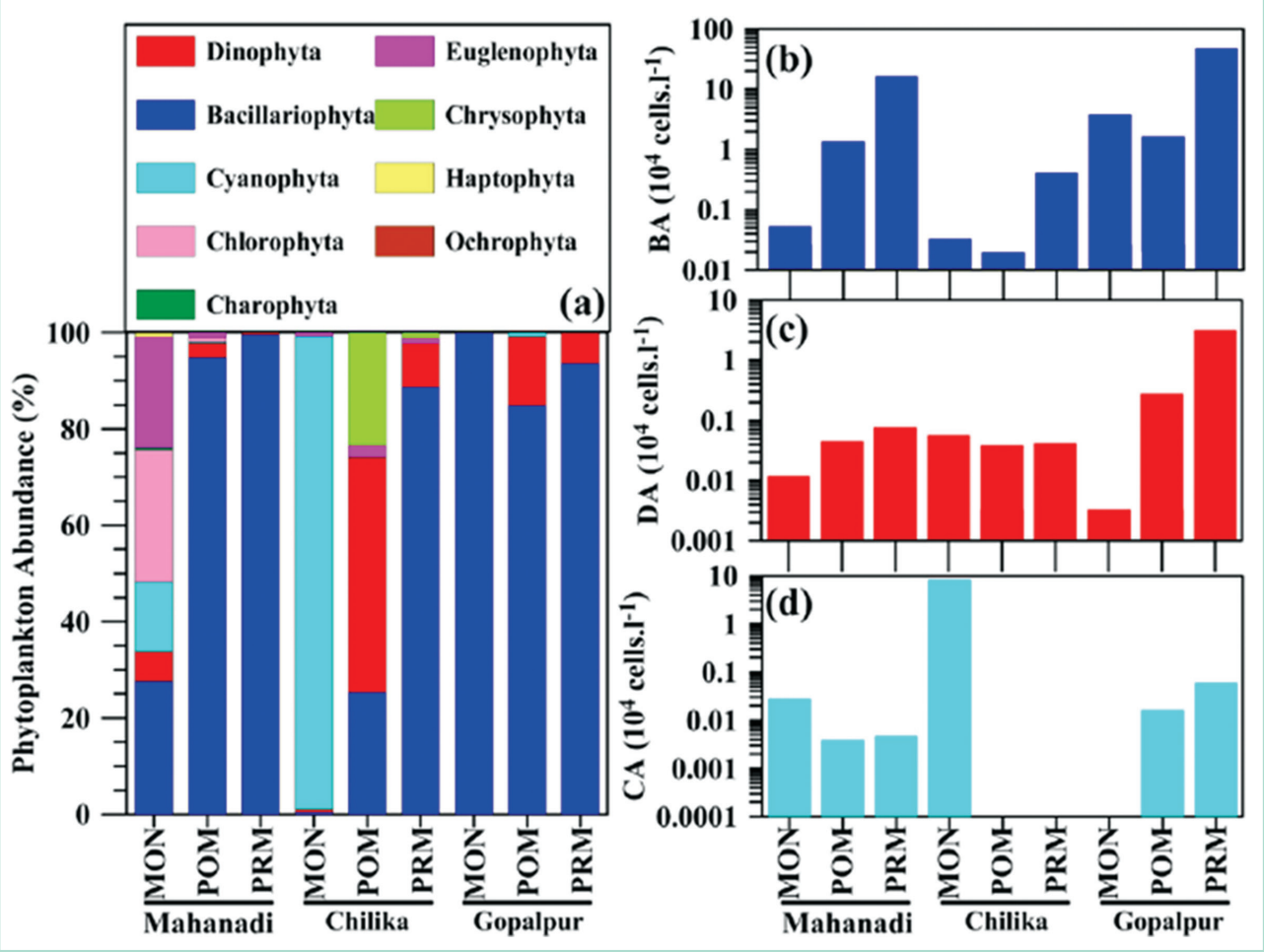
Alongshore section of model simulated temperature along the 1000 m isobath off Somalia. The black,red and blue contour represent D22 isotherm from model, NIOA and WOA13, respectively.

Ref: Chatterjee, A., Praveen kumar B., Prakash, S.,Singh, P., Annihilation of the Somali upwelling system during summer monsoon(2019), Scientific Reports, 7598,9(1)

10.3 Seasonal dynamics of phytoplankton in response to environmental variables in contrasting coastal ecosystems

Seasonal distribution of phytoplankton community and size structure was assessed in three different tropical ecosystems of the western Bay of Bengal viz. estuary (Mahanadi), lagoon (Chilika), and coastal waters (off Gopalpur) in response to ambient hydrobiology. Salinity regimes differentiated the study regions

as contrasting ecosystems irrespective of seasons (pre-monsoon, monsoon, post-monsoon). Taxonomic account revealed a total no of 175, 65, and 101 phytoplankton species in the estuary, lagoon, and coastal waters respectively. Prevalence of marine, brackish, and fresh water types in the coastal waters, lagoon, and estuary, respectively, characterized the contrasting nature of the study regions in hosting the phytoplankton community. In general, phytoplankton abundance was observed in increasing order of coastal waters > estuary > lagoon during postmonsoon and pre-monsoon, while lagoon > coastal waters > estuary during monsoon. Bacillariophyta dominated the phytoplankton community in the estuary and coastal waters during all the seasons. In contrast, the lagoon exhibited a diverse array of phytoplankton group such as cyanophyta, dinophyta, and bacillariophyta during monsoon, post-monsoon, and pre-monsoon, respectively. Over the seasons, microphytoplankton emerged as the dominant phytoplankton size class in the coastal waters. Diversely, nanophytoplankton contributed to major fraction of chlorophyll-a concentration in the estuary and lagoon. Interestingly, pre-monsoon dinophyta bloom (causative species: Noctiluca scintillans with cell density 9×10^4 cells l^{-1}) and monsoon bacillariophyta bloom (causative species: Asterionellopsis glacialis 5.02×10^4 cells l^{-1}) resulted decline in species diversity. Multivariate statistical analysis deciphered salinity as a major environmental player in determining the distribution, diversity, and composition of phytoplankton communities in the three



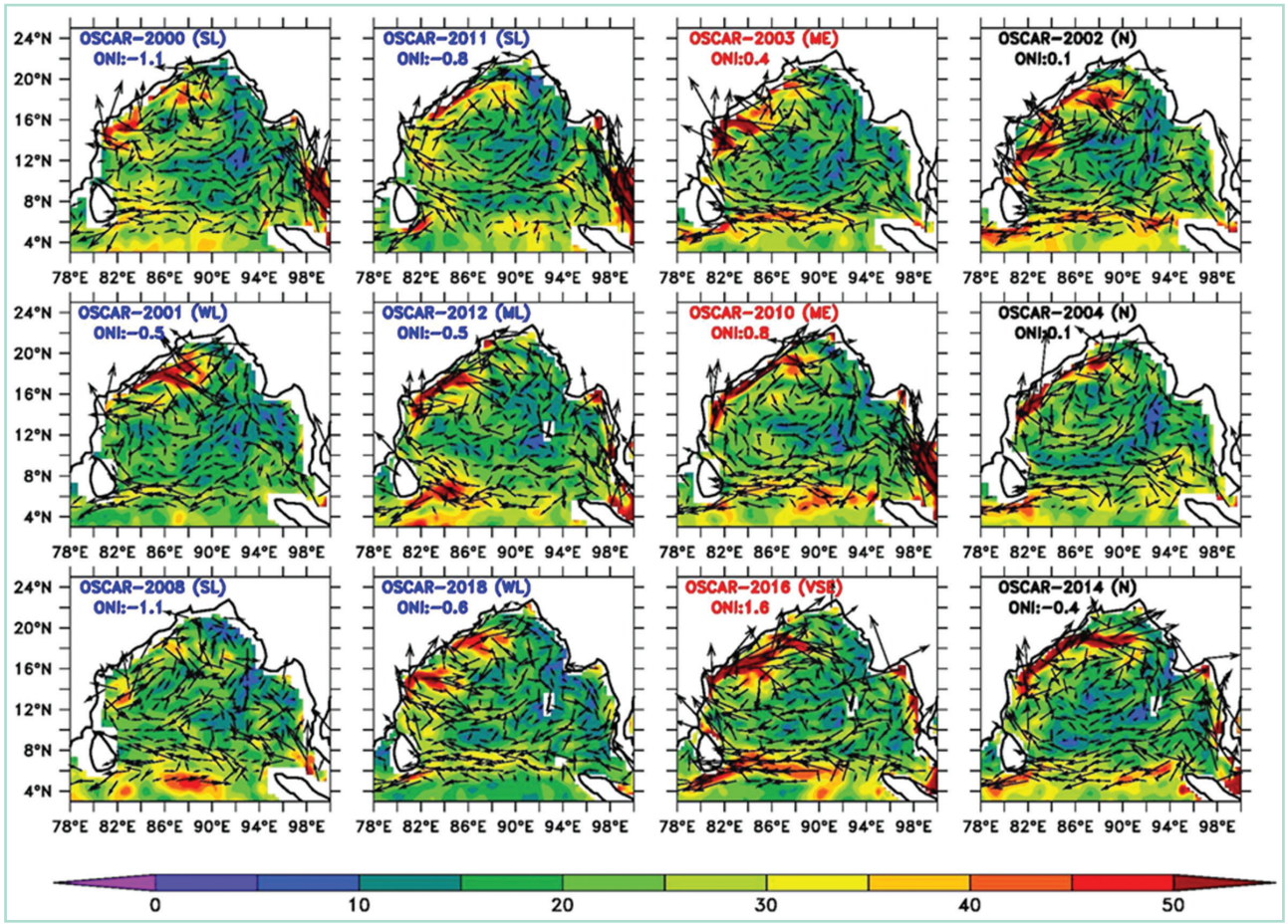
Seasonal variation of percentage contribution of different phytoplankton groups to total phytoplankton abundance. b–d Seasonal variation of bacillariophyta abundance (BA), dinophyta abundance (DA), and cyanophyta abundance (CA), respectively. MON monsoon, POM post-monsoon, PRM pre-monsoon

Ref:Srichandan, S., Baliarsingh, S.K., Prakash, S., Lotliker, A.A., Parida, C., Sahu, K.C. Seasonal dynamics of phytoplankton in response to environmental variables in contrasting coastal ecosystems (2019) Environmental Science and Pollution Research, 26 (12), pp. 12025-12041.

contrasting environments. Trophic state indices signified the lagoon and estuary as hypereutrophic during all season. The coastal water was marked as highly eutrophic through trophic state index during monsoon and pre-monsoon.

10.4 La Nina Signature in the East India Coastal Current

Analysis of OSCAR (Ocean Surface Current Analysis Real-time) current and a linear, continuously stratified (LCS) model simulations showed significant interannual variation in the magnitude of the spring East India Coastal Current (EICC) with a decrease in its magnitude in the spring of 2000, 2008 and 2011- years with high negative value of Oceanic Nino Indices were observed due to the dominance of strong La Nina events. Numerical experiments using LCS model to identify the local and remote forcing response on EICC showed that the dynamics of the EICC during spring are dominated by four different forcing processes; local wind along east coast of India, remote forcing response from the eastern and northern boundary of the BoB including islands, interior BoB and the Equatorial Indian Ocean (EIO). During El Nino and normal spring years, strong poleward interannual EICC are due to very weak negligible (order of 0–5 cm s^{-1}) EICC from EIO remote response and in-phase poleward EICC formation using other three forcings. However, during La Nina spring years, weak (order of 0–10 cm s^{-1}) poleward interannual EICC are formed



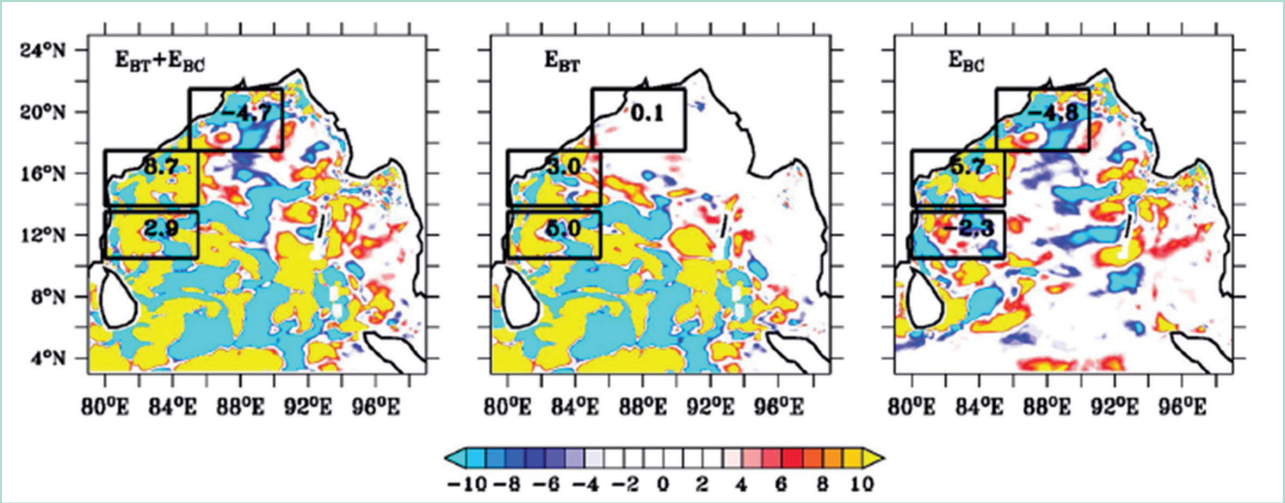
Magnitude of OSCAR current (cm s^{-1}) at BoB during spring (average of February–April) La Nina (left two column), El Nino (third column) and normal events (fourth column) with current vector overlay. ONI value during spring of the respective year are given in each box. Blue, red and black colour in each box represents La Nina, El Nino and normal event respectively.

Ref: Mukherjee, A., Kalita, B.K. Signature of La Niña in interannual variations of the East India Coastal Current during spring (2019) Climate Dynamics, 53(1-2), pp. 551-568.

due to destructive interference between equatorward current (order of 10–25 cm s^{-1}) from EIO forcing and in-phase poleward current from other three forcings. It was found that during with El Nino (La Nina) years, Kelvin wave from EIO via eastern and western boundary of the BoB during spring tend to be upwelling (downwelling). This interannual variation in the propagation of EIO Kelvin waves is associated with the changes in the direction of zonal winds in the EIO due to climate modes like ENSO.

10.5 Andaman and Nicobar Islands and eddies in the western Bay of Bengal

Eddies along western boundary of the Bay of Bengal (WBoB) play an important role in regulating regional climate and marine productivity of the north Indian Ocean. The role of Andaman and Nicobar islands (ANIs) in the formation of eddies along the WBoB was studied using an ocean general circulation model. This study showed that, in the absence of ANIs, there would be a significant reduction in the total number of mesoscale eddies in this region. The impact is particularly evident for the cyclonic eddies as a reduction of ~50% can be noticed in the absence of the islands. In contrast, influence of ANIs on anticyclonic eddies is not homogeneous in the WBoB; while absence of ANIs significantly increases anticyclonic eddies in the central part of the WBoB, a decrease can be noticed in the southern part. We further show that the reduction in number of cyclonic eddies along the WBoB is primarily driven by reduced baroclinic and barotropic instabilities. This process is more conspicuous during winter (October–January) season compared to summer (June–September) and spring (February–May) seasons.



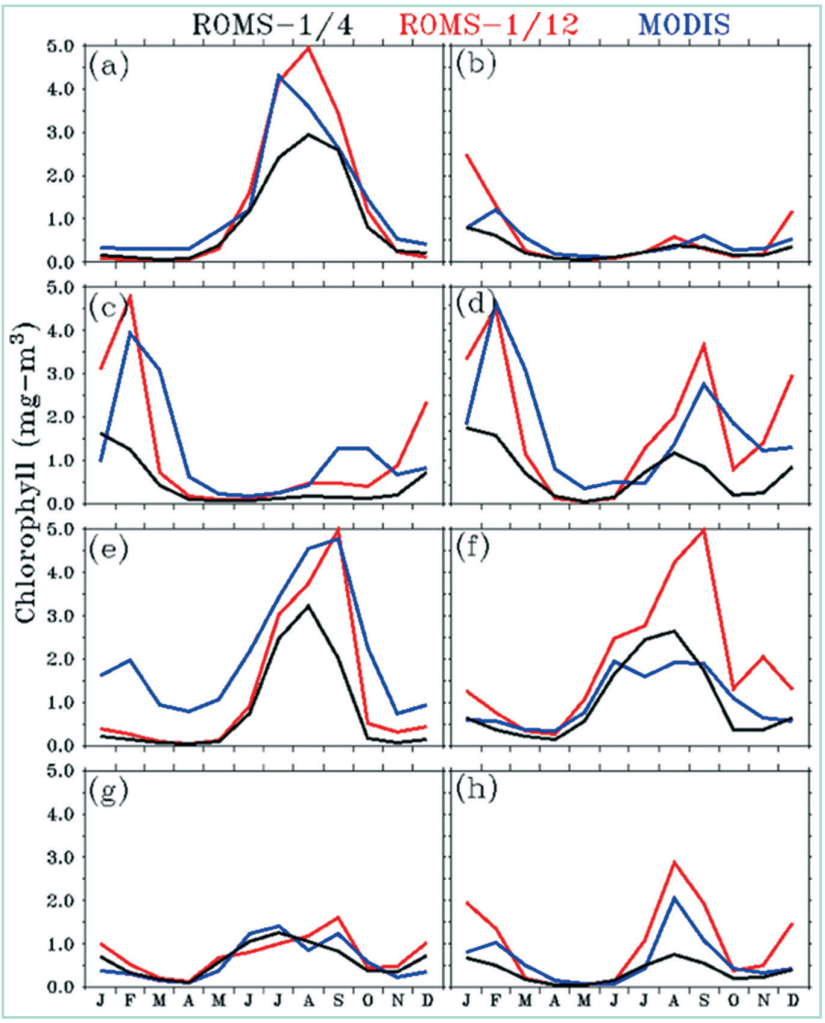
Winter (October–January) climatology of instabilities based on difference between the model simulations with and without Andaman Islands. Left, middle and right panel shows combination of both barotropic and baroclinic ((EBT + EBC, 10^{-3} m2s^{-3}), barotropic (EBT, 10^{-3} m^2s^{-3}) and baroclinic (EBC,10^{-3} m^2s^{-3}) instability difference between the model configurations. Number in each square box denotes mean value of respective domain.

Ref: Mukherjee, A., Chatterjee, A., Francis, P.A., Role of Andaman and Nicobar Islands in eddy formation along western boundary of the Bay of Bengal, (2019) Nature Scientific Reports, 9, 10152.

10.6 Impact of the model resolution on the simulation of upper-ocean biogeochemistry of the Arabian Sea

The resolution of the model emerges to be an important factor in simulating the real oceanic features. Validation of the physical and biogeochemical parameters simulated by two coupled bio-

physical models having spatial resolutions 1/12° (~9 km) and 1/4° (~25 km) configured using Regional Ocean Modeling System (ROMS) with the observations from remote sensing, in-situ ship-borne, and Biogeochemical-Argo (BGC-Argo) floats showed that the high-resolution model reproduced the ocean physical and biogeochemical dynamics, and their seasonality more efficiently. The upper ocean dynamics associated with the variability of mixed layer depth, persistent occurrence of deep chlorophyll maxima, and seasonal phytoplankton blooms. as well as deep ocean characteristics of oxygen minimum zone were much effectively captured by the high-resolution model than by its counterpart. Similarly, the former model performed very well in reproducing the upwelling dynamics over the eastern continental shelf indicating that the open ocean-coastal coupling has been better established. It was shown that the realistic representation of the eddy fields by the high-resolution model leads to the better representation of the ocean fields in comparison to the coarse resolution model.



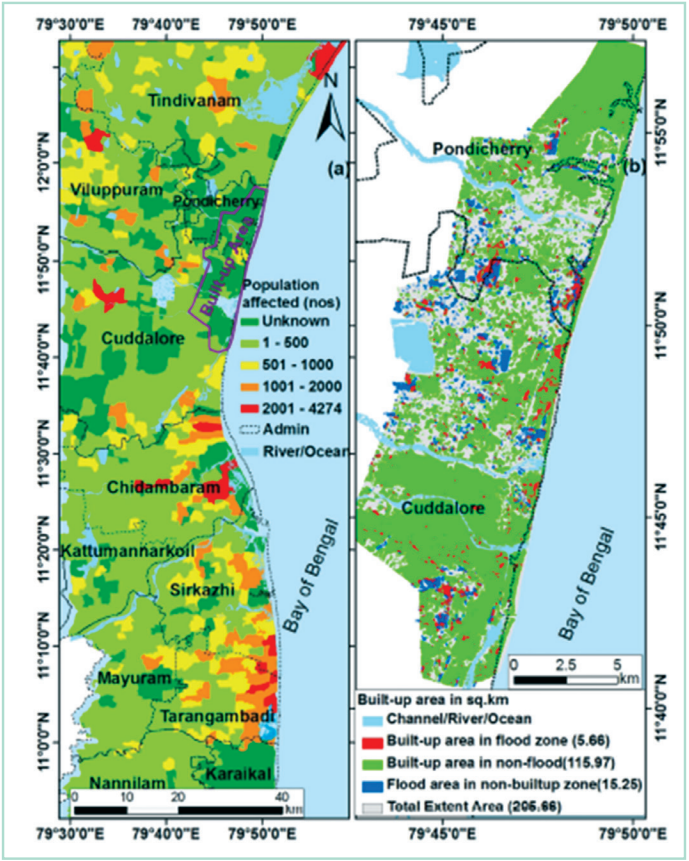
Temporal evaluation of monthly average of surface chlorophyll (mg m^{-3}) obtained from MODIS-Aqua (blue line), ROMS-1/12 (red line) and ROMS-1/4 (black line) at eight different boxes in the Arabian Sea viz. (a) southeast, (b & c) northeast, (d) north, (e) northwest, (f & g) southwest and (h) central Arabian Sea.

Ref: Chakraborty, K., Kumar, N., Girishkumar, M.S., Gupta, G.V.M., Ghosh, J., Udaya Bhaskar, T.V.S., Thangaprakash, V.P. Assessment of the impact of spatial resolution on ROMS simulated upper-ocean biogeochemistry of the Arabian Sea from an operational perspective (2019) Journal of Operational Oceanography, 12 (2), pp. 116-142

10.7 Geospatial Assessment of Flood Hazard Along the Tamil Nadu Coast

During November–December 2015, very heavy rainfall caused severe flood in Southern Tamil Nadu that resulted in severe damages with huge economic losses as per news agency Times of India. Remote sensing data from Sentinel-1 synthetic aperture radar (SAR) and Landsat-8. Operational land imager (OLI) images together with ancillary information such as rainfall and demographic data were used in the current study to assess the extent and impact of flooding. The SAR data are used to map the flood or inundation zones. Landsat-8 OLI is used to extract built-up area affected by the flood employing three methods: built-up area extraction method (BAEM), BAEM with Enhanced Built-up and Bareness Index (EBBI), and modified Normalized Difference Built-up Index (NDBI) approach. The classification accuracies obtained for these three approaches were

89, 83.5, and 78% for BAEM (using EBBI), BAEM, and NDBI, respectively. Aerial comparison of builtup area extracted using BAEM (using EBBI) shows the best accuracy with respect to the built-up area obtained from very high-resolution imagery. This extracted built-up area BAEM (using EBBI) method was used to estimate the extent of inundation covering the built-up area. Further the flooding risk at village level was assessed using the population density and flooding area. Built-up area extracted was also overlaid with flooding area to highlight actual built-up areas under risk due to flood.

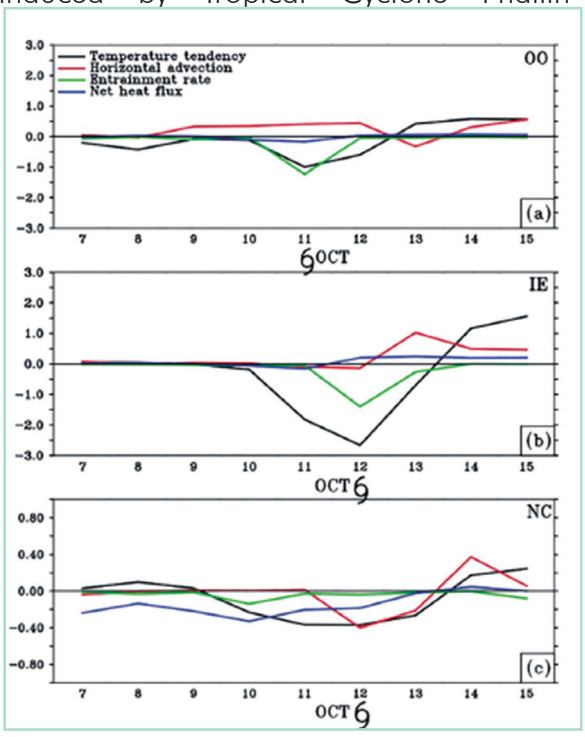


Flooding risk at village level based on population density (left) and built-up area under flood and non-flood zone (right)

Ref: Mohanty, P.C., Panditrao, S., Mahendra, R.S., Kumar, H.S., Bharadwaj, S.P., Nayak, R.K., Ramarao, E.P. Geospatial Assessment of Flood Hazard Along the Tamil Nadu Coast (2019) Journal of the Indian Society of Remote Sensing, 47 (10), pp. 1657-1669.

10.8 Surface and Sub-surface Ocean Response to Tropical Cyclone Phailin

The upper oceanic thermal response induced by Tropical Cyclone Phailin (9–14 October 2013) under the influence of East India Coastal Current (EICC) and a cyclonic eddy was investigated and contrasted with the response from open ocean region using a high-resolution HYbrid Coordinate Ocean Model simulation. It was found that there was significant cooling (7° C) inside the cold core eddy and the cooling was negligible (0.5° C) within the EICC region characterized by the shallow and deeper thermocline, respectively. Analysis of mixed layer heat budget terms showed that the horizontal advection played a significant role in determining the temperature tendency for the location within the EICC, in contrary to the general dominance of vertical processes as reported in previous studies during the cyclone period. The analysis for the locations inside eddy and open ocean concurs with the previous studies showing the dominance of vertical processes toward the temperature tendency. Further, near the coast, the



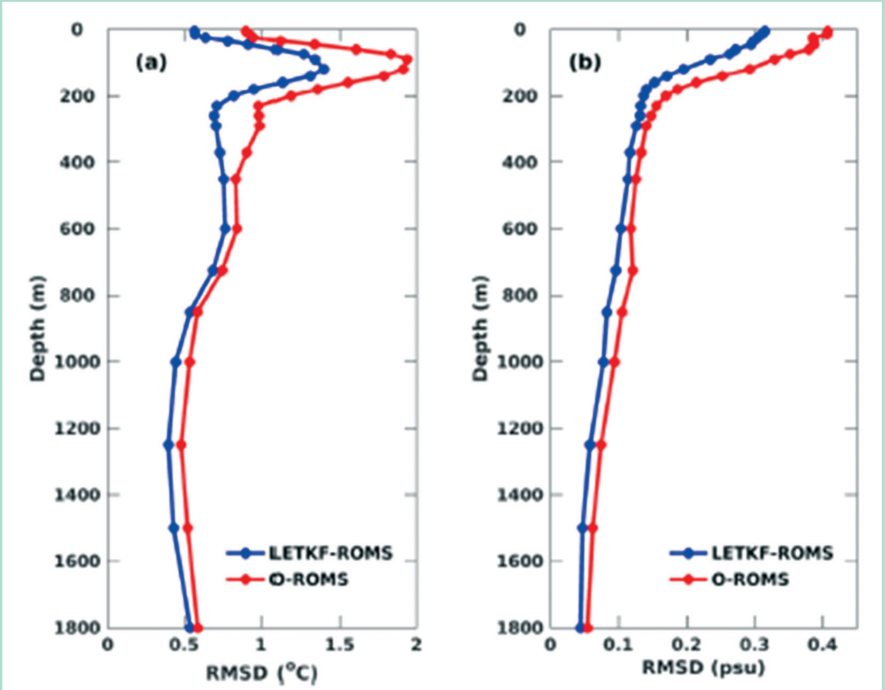
Time series of various mixed layer heat budget terms across box averaged regions of (a) open ocean, (b) inside eddy, and (c) near coast.

Ref: Jyothi, L., Joseph, S., Suneetha, P., Surface and Sub-surface Ocean Response to Tropical Cyclone Phailin: Role of Pre-existing Oceanic Features (2019) Journal Geophysical Research Oceans, 124(9), pp. 6515-6530.

surface cooling was minimal compared to the subsurface cooling, dominantly seen between 50 and 100 m depth. This disparity indicated that the factors responsible for the surface temperature anomalies were different from those of subsurface. Analysis of thermal signatures after the passage of cyclone showed that the EICC and cyclonic eddy contributed to the faster advection of cold wake and recovery of sea surface temperature to the prestorm state.

10.9 LETKF-based data assimilation system in ROMS

A high-resolution ocean circulation model for the Indian Ocean (IO) using Regional Ocean Modeling System (ROMS) is operational at Indian National Centre for Ocean Information Services (INCOIS) which provides ocean state forecasts for the Bay of Bengal (BoB) and the Arabian Sea (AS) to the Indian Ocean rim countries. To provide an improved estimate of ocean state, a variant of Ensemble Kalman Filter (EnKF), viz., the Local Ensemble Transform Kalman Filter (LETKF) has been developed and interfaced with the present basin-wide operational ROMS. This system assimilates in-situ temperature and salinity profiles and satellite track data of sea-surface temperature (SST). The ensemble members of the assimilation system are initialized with different parameters like diffusion and viscosity coefficients and are subjected to an ensemble of atmospheric fluxes. In addition, one half of the ensemble members respond to K profile parameterization mixing scheme while the other half is subjected to Mellor–Yamada mixing scheme. This strategy aids in arresting the filter divergence which has always been a challenging task. The assimilated system simulates the ocean state better than the present operational ROMS. Improvements permeate to deeper ocean depths with better correlation and reduced root-mean-squared deviation (RMSD) with respect to observations particularly in the northern Indian Ocean which is data rich in density. Analysis shows domain averaged RMSD reduction of about 0.2–0.4°C in sea surface temperature and 2–4 cm in sea level anomaly. The assimilated system also manages to significantly improve the thickness of the temperature inversion layers and the duration of its occurrence in northern Bay of Bengal. The most profound improvements are seen in currents, with an error reduction of 15 cm/s in zonal currents of central Bay of Bengal.

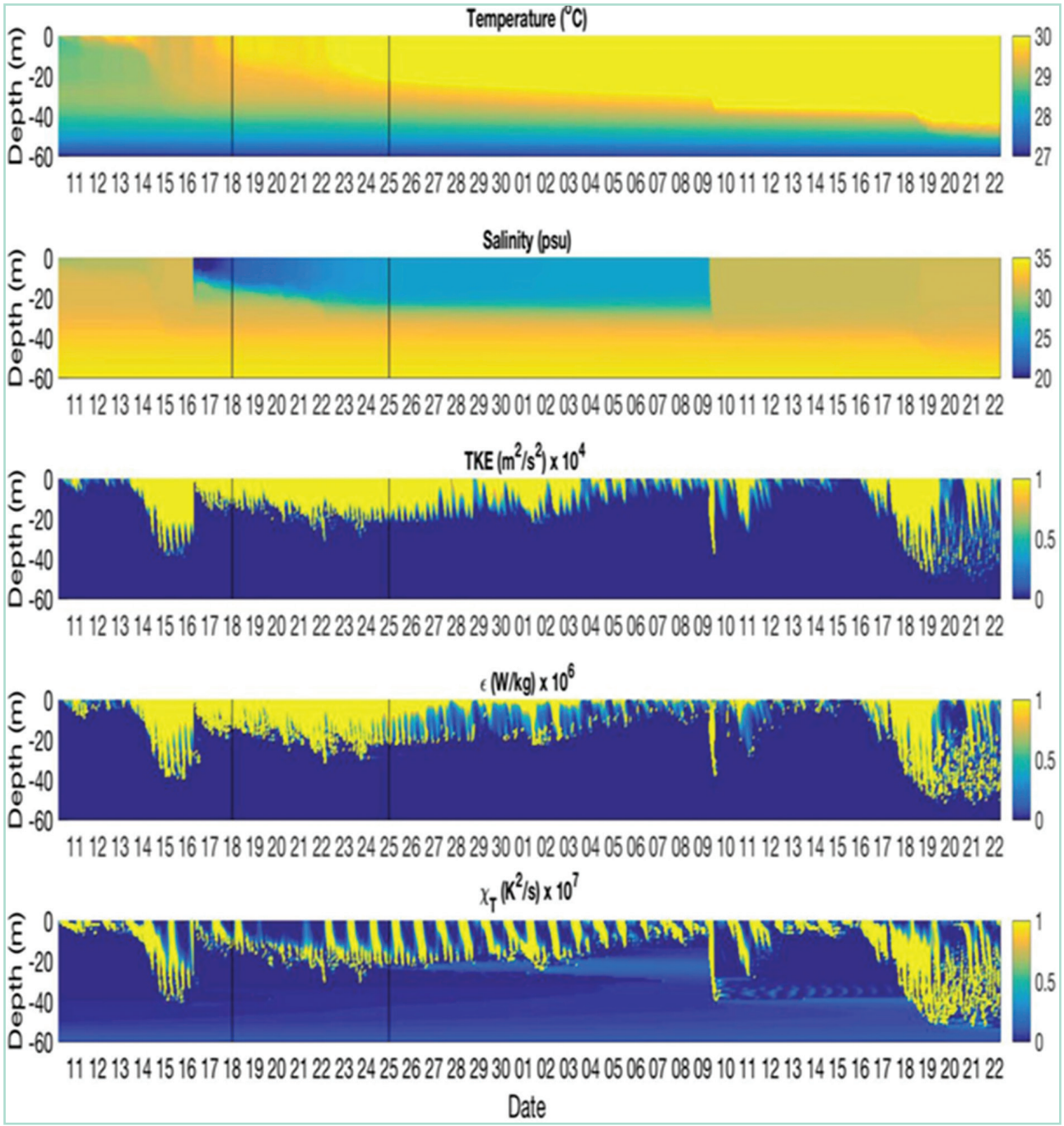


Vertical profile of RMS statistic of (a) temperature (in °C) and (b) salinity (in psu) derived from LETKF-ROMS (blue) and O-ROMS (red) in the observation space averaged over horizontal space and time.

Ref: Baduru, B., Paul, B., Banerjee, D.S., Sanikommu, S., Paul, A. Ensemble based regional ocean data assimilation system for the Indian Ocean: Implementation and evaluation (2019) Ocean Modelling, 143, art. no. 101470

10.10 Modeling slippery layers in the northern Bay of Bengal

A "slippery" layer observed during September 2011 at a National Institute of Ocean Technology (NIOT) mooring deployed at 18°N, 89°E in the northern Bay of Bengal (BoB) was modelled by a simple slab-type dynamical model and a turbulence closure-based model. The mooring was located close to the mouths of the huge rivers draining the Indian subcontinent. The lateral advection of riverine water masses past the mooring resulted in a shallow brackish layer 10–15m deep bounded by a strong halocline below, giving rise to the possibility of a slippery layer gliding



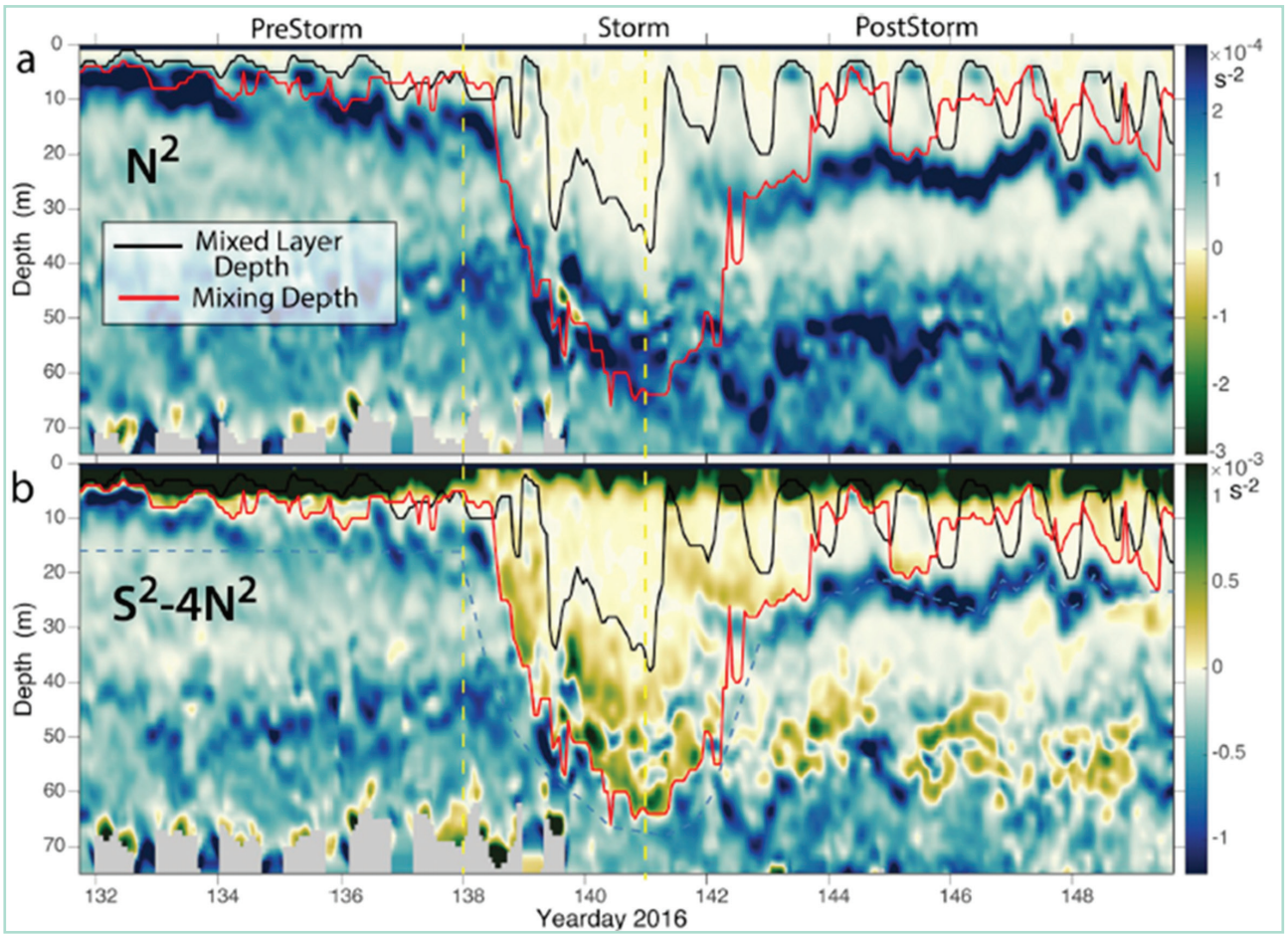
Time-depth plots of model results (temperature, salinity, turbulence kinetic energy, TKE dissipation rate, and the dissipation rate of temperature variance) from 10 September to 22 October 2011, the simulation period. Note the simulated intrusion of less saline water mass on 16 September and back to a more saline water mass on 9 October. The black vertical lines delineate the focus period containing slippery layers. Reinitializations of the model can be clearly seen in the salinity plot on 16 September and 9 October as a sharp change in the salinity profile.

Ref: Jampana, V., Ravichandran, M., Kantha, L., Rahaman, H. Modeling slippery layers in the northern Bay of Bengal (2019) Deep-Sea Research Part II: Topical Studies in Oceanography, 168, art. no. 104616.

past the layers below. The strong currents in this slippery layer were simulated by the simple. In addition, a second moment turbulence closure-based model, driven by surface data from the buoy was also used to simulate the water mass structure and upper layer currents during the event. Both the slab and turbulence-closure models reproduce currents in the slippery layer reasonably well overall, although the currents are somewhat overestimated. This "haline" slippery layer observed in the BoB complements well the "thermal" slippery layers that have been observed under certain conditions during strong diurnal heating of the upper layers of the ocean.

10.11 Widespread cooling of the Bay of Bengal by tropical storm Roanu

Data from a Lagrangian float, measuring temperature, salinity and velocity profiles in the upper 80 m and 3 Argo floats were analyzed to investigate the widespread SST cooling (1.5–2°C) of the Bay of Bengal occurred in response to cyclone Roanu 2016, a weak, pre-monsoon storm. At the Lagrangian float, cooling was primarily due to mixing of the warm (32°C), fresh cap formed during the previous months of light winds and clear skies, accounting for about half of the cooling. Air-sea heat fluxes played a secondary role, accounting for about a quarter of the cooling. The depth of mixing was diagnosed by two measures: a traditional mixed layer depth and a "mixing depth" defined as the deepest depth unstable to shear instability. The mixing depth was



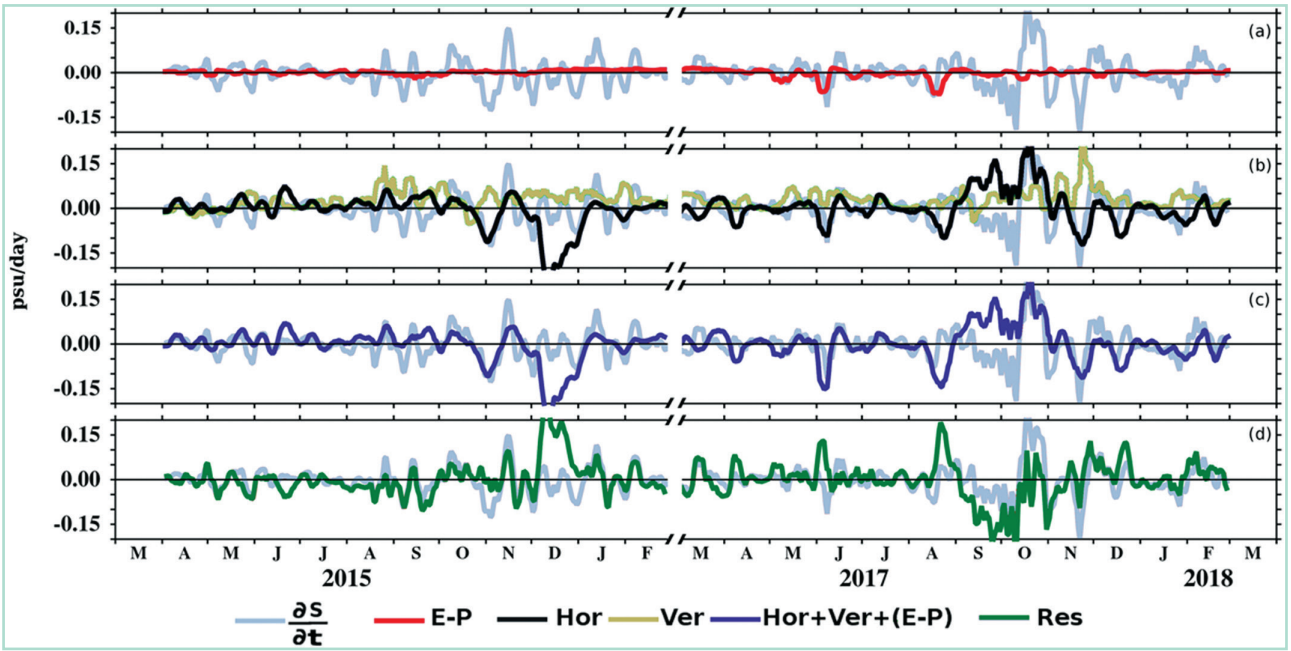
Comparison of mixed layer depth (black lines) and mixing depth from reduced shear (red lines) on plots of a) stratification and b) reduced shear. Thin dashed blue line shows depth limit imposed on computation of mixing depth. Yellow vertical dashed lines divide the pre-storm, storm and post-storm periods. The color scales on the two panels are adjusted to scale N2 in the same way, so that for $S^2 = 0$, they would be identical.

Ref:Kumar, B.P., D'Asaro, E., Suresh kumar, N., Ravichandran, M. Widespread cooling of the Bay of Bengal by tropical storm Roanu (2019) Deep-Sea Research Part II: Topical Studies in Oceanography, 168, art. no. 104652.

roughly twice (~65 m) the mixed layer depth (~35 m), illustrating the importance of the "transition layer" between them. The mixed layer restratified into 2 layers within a day after the end of the storm with near-inertial frequency waves gented by the storm increasing the diapycnal mixing rates at the depth of the transition layer to about 10^{-4} m^2s^{-1}. A popular upper ocean mixing model (PWP) driven by heat, moisture and momentum fluxes from reanalysis products (ERA-5 and CCMP) reproduced the maximum mixed layer depth to within a meter; maximum mixing depth was underpredicted by 10 m. These results were insensitive to uncertainties in the air-sea forcing. The change in SST was underestimated by 0.7°C and the model predicts few of the observed variations in mixed layer salinity. Some of these errors are due to uncertainties in air-sea fluxes, but lateral processes must also play a role, both during the storm and during the subsequent restratification. Data from the Argo floats, although much less detailed, show similar patterns with better simulations of mixed layer depth than of temperature and salinity evolution. Large-scale models generally underestimate the stratification of the upper 50 m of the Bay of Bengal leading to biases in modeling the important air-sea interactions that occur. These results suggest that although these errors may partially be due to errors in modelled vertical mixing rates, errors in modeling horizontal variability and its interaction with vertical mixing are also likely to be important.

10.12 Observed upper ocean variability in the Andaman Sea

The observed seasonal and intraseasonal evolution of near-surface meteorological and oceanographic variables in the Andaman Sea for the period March 2014 to December 2017 are examined using moored buoy observations at 10.5°N, 94°E. The amplitude of temperature inversions is very weak (0.2 to 0.4°C), and they appeared primarily during winter (November–



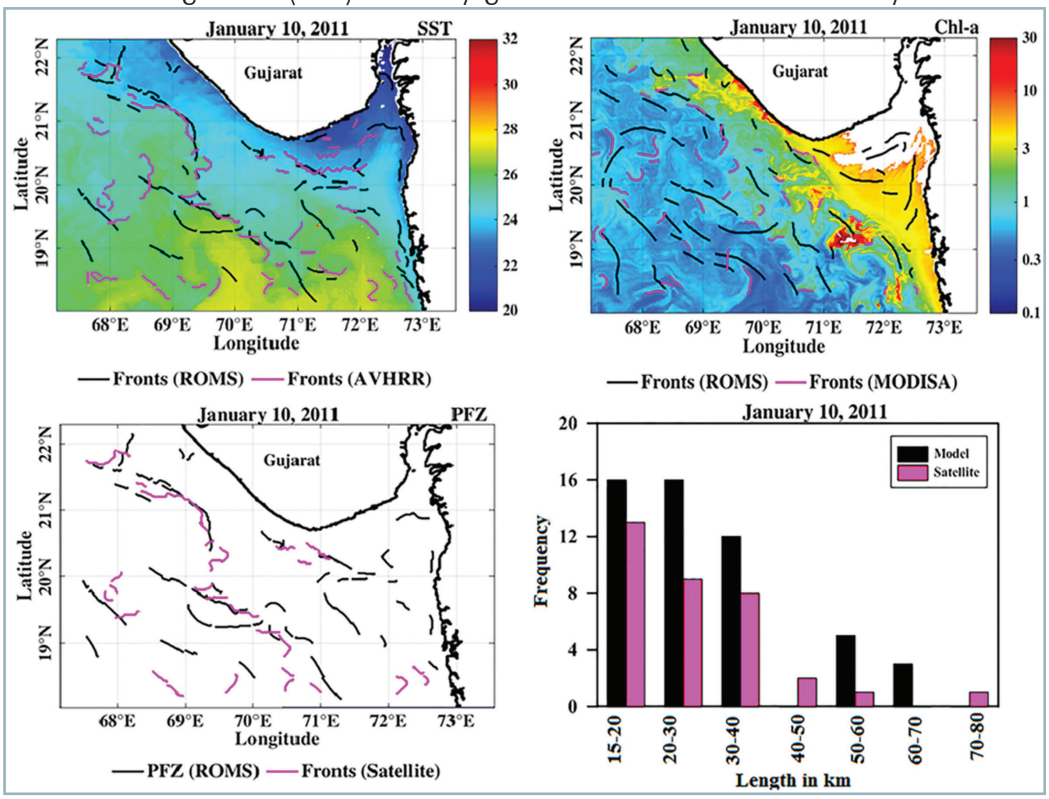
Different terms in the mixed layer (ML) salinity budget (psu/day) at the buoy location in the Andaman Sea based on OMNI analysis. (a) Rate of change of ML salinity (gray; ∂S/∂t) and net fresh water flux (red; E-P); (b) rate of change of ML salinity (gray; ∂S/∂t), horizontal advection (black; Hor), and vertical salinity flux (green; Ver); (c) rate of change of ML salinity (gray; ∂S/∂t), sum of net fresh water flux, horizontal advection, and vertical salinity flux (blue; (E-P) + Hor + Ver); and (d) rate of change of ML salinity (gray; ∂S/∂t) and residual (green; Res).

Ref: Ashin, K., Girishkumar, M.S., Suprit, K., Thangaprakash, V.P. Observed Upper Ocean Seasonal and Intraseasonal Variability in the Andaman Sea (2019) Journal of Geophysical Research: Oceans, 124 (10), pp. 6760-6786.

January) and latter part of summer (May–August). The net surface heat flux plays a primary role, and vertical processes term contributes secondarily to determine the seasonal mixed layer (ML) heat storage variability. Consistent with the seasonal variations of formation and strength of temperature inversion, vertical processes term shows a positive tendency during winter. The sea surface salinity shows large amplitude intraseasonal variability during fall and winter, and it is attributed to the variability of horizontal circulation in the presence of large lateral sea surface salinity gradients at the mooring location. The sea surface temperature shows the presence of strong intraseasonal variability between 20 and 80 days, though its amplitude of oscillation is distinctly higher during May–October than November–April. Band-pass filtered (20–80 days) time series of different components of the ML heat budget shows that the net surface heat flux primarily determines the intraseasonal ML heat storage variability. This analysis further shows that during May–October, both net shortwave radiation and latent heat flux together determine the modulation of the intraseasonal net surface heat flux. In contrast, latent heat flux acts as the sole factor to determine the modulation of the intraseasonal net surface heat flux during November–April.

10.13 Short term prediction of satellite-aided operational fishery advisories

The operational Potential Fishing Zone (PFZ) advisory generated and disseminated by the Indian National Centre for Ocean Information Services has a significant impact on the livelihood of coastal community of India. PFZs are identified as the relatively narrow zones in the ocean where horizontal gradients of physical and/or biological properties are enhanced. The advisories are provided to fishermen on a daily basis using remotely sensed



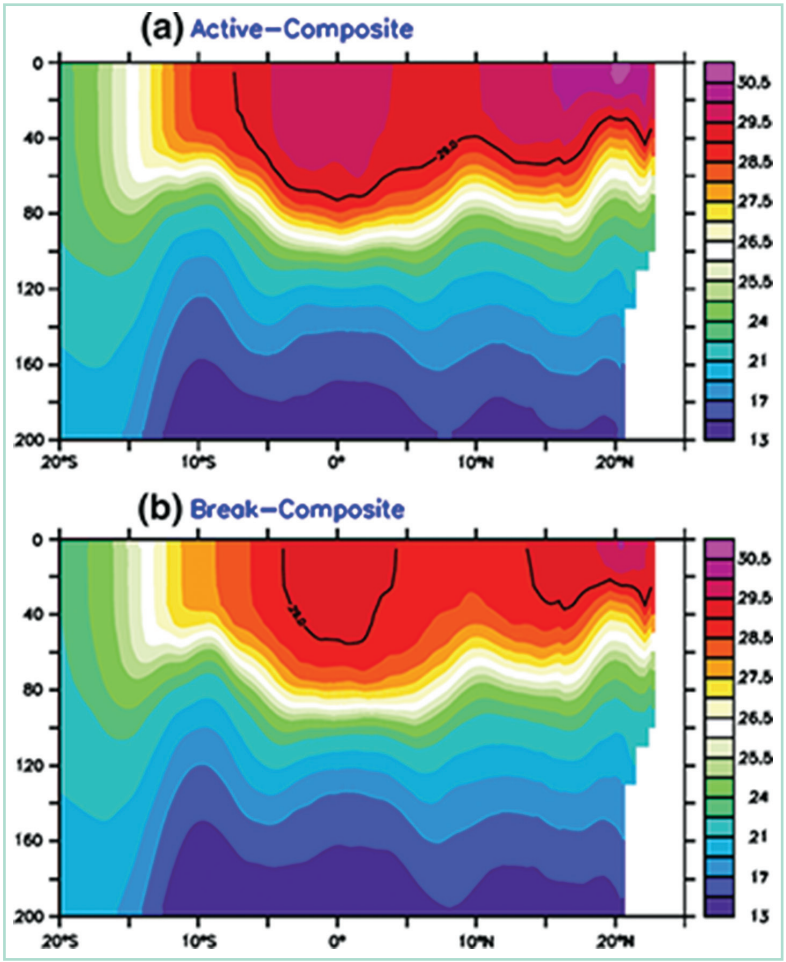
(a) Comparison of SST fronts detected from satellite (Pink) and that of ROMS (Black) data for 10 January 2011; background image (1.1 km spatial resolution) is from AVHRR sensor onboard MetOp 2 satellite, colour bar is in °C. (b) Comparison of Chl-a fronts detected from satellite and that of ROMS (Black) data for 10 January 2011; background image (1 km spatial resolution) is from MODISAqua, colour bar is in logarithmic scale in mg/m^3. (c) Comparison of PFZs identified using both SST and Chl-a fronts detected from satellite (Pink) and ROMS (Black) data for 10 January 2011. (d) Histogram consisting of the binned frequency of the identified PFZs derived from satellite (Pink) and ROMS (Black) with respect to length of PFZs as class interval of 5 km for 10 January 2011.

Ref: Chakraborty, K., Maity, S., Lotliker, A.A., Samanta, A., Ghosh, J., Masuluri, N.K., Swetha, N., Bright, R.P. Modelling of marine ecosystem in regional scale for short term prediction of satellite-aided operational fishery advisories (2019) Journal of Operational Oceanography,12 (s2), s157-s175.

sea surface temperature (SST) and chlorophyll-a (Chl-a) data from NOAA-AVHRR and MODIS-AQUA and/or Oceansat-2 satellites, respectively. Sometimes it becomes a major challenge to retrieve SST/Chl-a data from satellite images, particularly during the extensive cloud coverage. To overcome this operational difficulty, the satellite data is replaced by a coupled physical-biogeochemical model data capable of simulating ocean features leading to PFZs. The use of model data provides an additional advantage towards transforming the existing service from advisories to forecast. The average length of PFZs identified from satellite (model) data (2010–2016) for off Gujarat is 27.80 ± 7.2 km (33.07 ± 3.2 km) whereas for off Andhra Pradesh, it is 28.27 ± 10.9 km (52.48 ± 8.7 km). Considering the capability of the model in identifying PFZs, the existing advisory service can be transitioned into a short term PFZ forecast.

10.14 Coupled Ocean–Atmosphere Summer Intraseasonal Oscillation over the Bay of Bengal

This study shows the active role of subsurface ocean temperature in the evolution of coupled intra-seasonal oscillation (ISO) in the Bay of Bengal (BoB) using multi-satellite observations and ocean analysis product. Satellite-derived humidity profiles obtained from the atmospheric infrared sounder (AIRS) show that intense rains over the BoB are associated with the moistening (drying) in the lower and mid-troposphere during the active (break) phase of summer intraseasonal oscillation (ISO). Anomalous moistening in the mid-troposphere up to 500 hPa ahead of the maximum precipitation band over north BoB gives a precursor signal for the northward movement of the rain band. During the active (break) phase, the upper-tropospheric positive (negative) temperature anomaly ahead of the maximum rain band also sets a precondition by heating the mid- to upper troposphere. Daily subsurface temperature from Global Ocean Data Assimilation System (GODAS) analysis show that during the active phase, tropospheric moistening (drying) coincides with the subsurface warm (cold) temperature up to



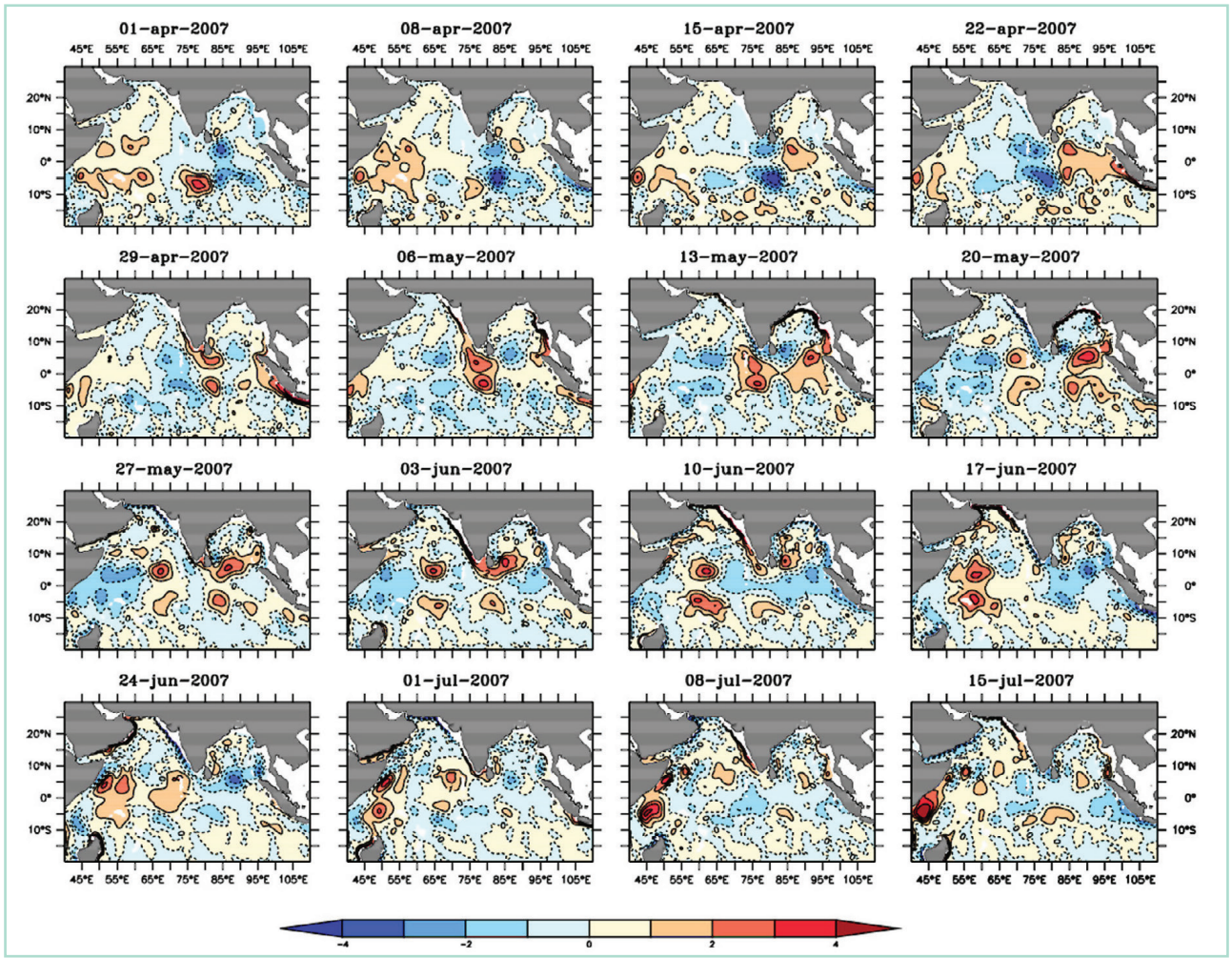
Depth-latitudinal variation (longitudinally averaged over 85–95^{0}E) of upper ocean temperature composite during active (a) and break (b) phases. Please note the non-symmetric values in the scale for the lower temperature values. An overlaid 29^{0}C contour is also shown in each panel as a black line.

Ref: Rahaman, H., Bharath Raj, G.N., Ravichandran, M. Coupled Ocean–Atmosphere Summer Intraseasonal Oscillation over the Bay of Bengal (2019) Pure and Applied Geophysics, 176 (12), pp. 5415-5429.

200-m depth. The upper ocean warms uniformly by ~1°C during the active phase as compared to the break phase in the entire BoB. The presence of a thin warm layer below the maximum rain band creates an environment conducive to sustaining the active phase on the ISO time scale. A positive sea surface temperature (SST) anomaly along with upper ocean warming ahead of a rain band in the north BoB in association with lower and mid-tropospheric moistening sets a precondition for the northward movement of the rain band. The anomalous warming (cooling) in the thermocline is associated with deeper (shallower) thermocline depth [23° isotherms (D23)] and coincides with the mixed-layer warming.

10.15 Anomalous Warming of Western Equatorial Indian Ocean in 2007

Observational data, together with the simulations from a high-resolution numerical ocean model, were used to identify the processes responsible for the anomalous warm sea surface temperature (SST) in the equatorial Indian Ocean during late spring/early summer in 2007. This analysis suggested that the SST in the western equatorial Indian Ocean (WEIO) remained unusually warm owing to the combined influence of the wind induced and reflected Rossby waves in the equatorial Indian Ocean. Anomalous westerly wind burst in the equatorial Indian Ocean in early April generated an eastward propagating downwelling Kelvin wave, which got reflected from the



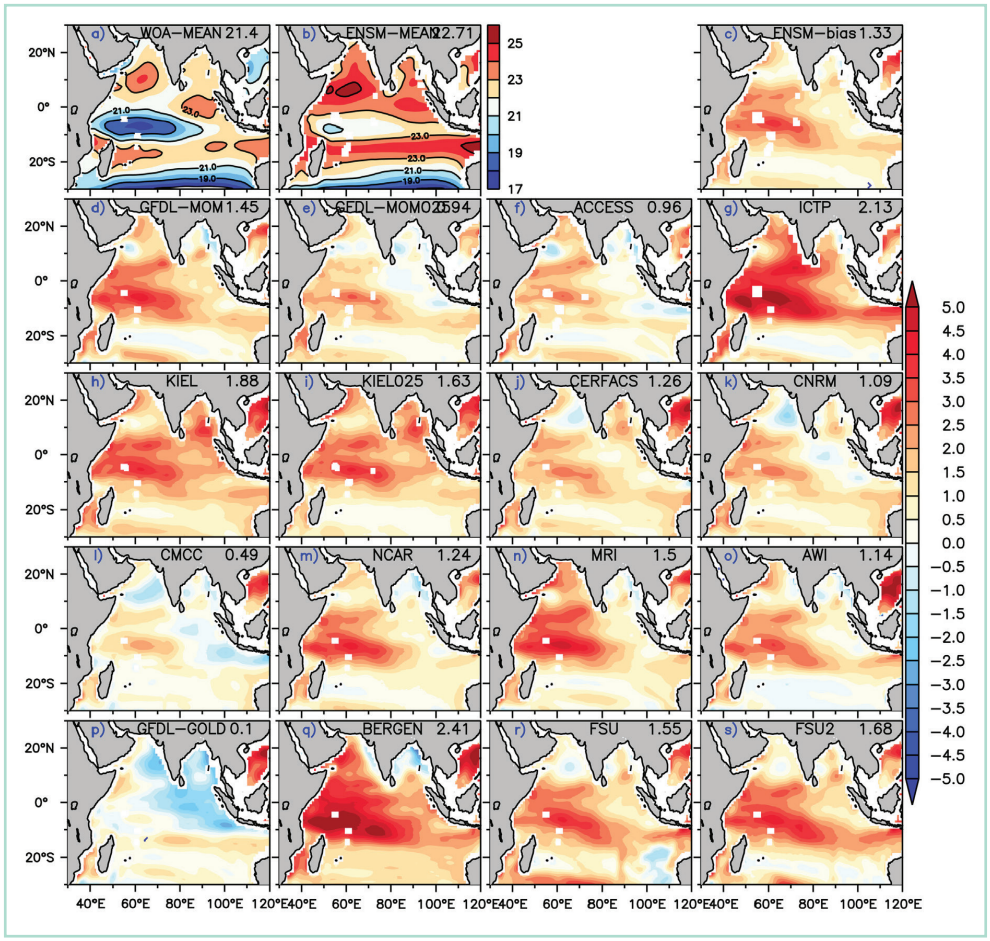
Spatio-temporal evolution of 20–90 days band passed SSHA during 01 April 2007–15 July 2007 in the CTL run by the LCS model. Westward propagation of equatorial Rossby waves are seen in the diagram.

Ref:Effy, J.B., Francis, P.A., Ramakrishna, S.S.V.S., Mukherjee, A. Anomalous warming of the western equatorial Indian Ocean in 2007: Role of ocean dynamics (2020) Ocean Modelling, 147, art. no. 101542

eastern boundary as a downwelling Rossby wave and propagated to the WEIO. The easterlies appeared during the second fortnight of April generated another downwelling Rossby wave, which also propagated to the WEIO. Thus a couple of downwelling Rossby waves, reflected and direct wind induced, propagated to the WEIO, deepened the thermocline and prohibited cooling in the WEIO during the early months of summer monsoon season. This study demonstrates the importance of the equatorial winds and associated oceanic dynamics in modulating the SST variability in the WEIO.

10.16 An assessment of the Indian Ocean mean state and seasonal cycle in a suite of interannual CORE-II simulations

Analysis of annual and seasonal mean characteristics of the Indian Ocean circulation and water masses from 16 global ocean–sea-ice model simulations that follow the Coordinated Ocean-ice Reference Experiments (CORE) interannual protocol (CORE-II) suggests that all the models show a similar large-scale tropical current system, but with differences in the Equatorial Undercurrent. Most CORE-II models simulate the structure of the Cross Equatorial Cell (CEC) in the Indian Ocean. The analysis suggests that the secondary pathway of northward cross-equatorial transport along 75°E is most prominent in the models which represent topography realistically, thus suggesting a need for realistic bathymetry in climate models. When probing the water mass structure in the upper ocean, it was found that the salinity profiles are



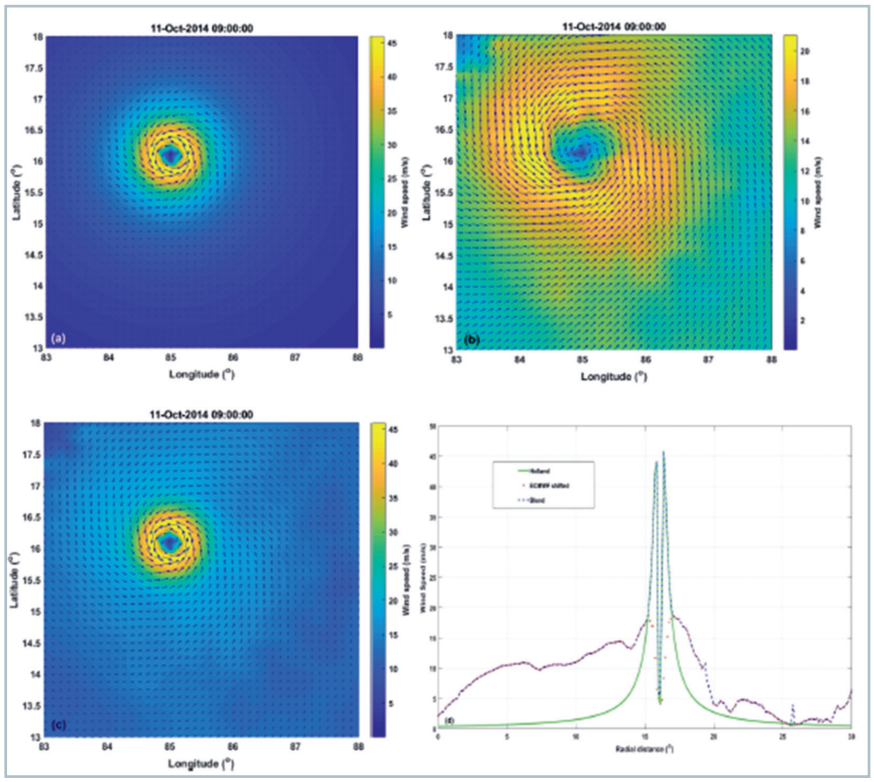
The upper left panel shows the temperature (degrees Celsius) at 100 m depth from WOA (a); the upper middle panel shows the same from the CORE-II ensemble (b) and the upper right panel shows the ensemble bias at 100 m depth with respect to WOA (c). The remaining panels show the temperature bias (model minus observation) at 100 m depth from all CORE-II individual models (d-s). The basin averaged values are given in upper right corner of each panel.

Ref: Rahaman, H., Srinivasu, U., Panickal, S., Durgadoo, J.V., Griffies, S.M., Ravichandran, M., Bozec, A., Cherchi, A., Voldoire, A., Sidorenko, D., Chassignet, E.P., Danabasoglu, G., Tsujino, H., Getzlaff, K., Ilicak, M., Bentsen, M., Long, M.C., Fogli, P.G., Farneti, R., Danilov, S., Marsland, S.J., Valcke, S., Yeager, S.G., Wang, Q. An assessment of the Indian Ocean mean state and seasonal cycle in a suite of interannual CORE-II simulations (2020) Ocean Modelling, 145, art. no. 101503

closer to observations in geopotential (level) models than in isopycnal models. More generally, it is also shown that biases are model dependent, thus suggesting a grouping into model lineage, formulation of the surface boundary, vertical coordinate and surface salinity restoring. Refinement in model horizontal resolution (one degree versus 1/4 degree) does not significantly improve simulations, though there are some marginal improvements in the salinity and barrier layer simulations. The results in turn suggest that a focus on improving physical parameterizations (e.g. boundary layer processes) may offer more near-term advances in Indian Ocean simulations than refined grid resolution.

10.17 Improved cyclonic wind fields over the Bay of Bengal

Tropical cyclone induced storm surge and extreme waves pose a significant threat and danger to coastal inhabitants as well cause significant damage to infrastructure. Nevertheless, significant progress has been achieved over the past several years in tropical cyclone modeling, there are however inherent limitations in the quality of real-time wind forecast for near-field and far-field regions surrounding the cyclone eye. The reliability and quality of computed storm surge and extreme wind-waves remains a challenge due to their primary association with the quality of input wind forcing. Parametric wind field models are widely used owing to their simplicity and also in realistically representing the inner core region of cyclones. On the other hand, global atmospheric models have inherent limitations in underestimating the inner core winds, although they produce outer core winds much better as compared to the parametric formulation. In this study a blending technique is proposed which takes advantage of both these wind fields thereby producing a blended wind field using a smoothing algorithm and superposition technique that provides realistic estimates of both inner and outer core winds. Numerical simulations with a coupled wave-hydrodynamic model using both blended and the parametric winds were also verified against in situ data. The study reveals that simulations using blended winds performed better and has practical relevance to real-time operational forecasts.



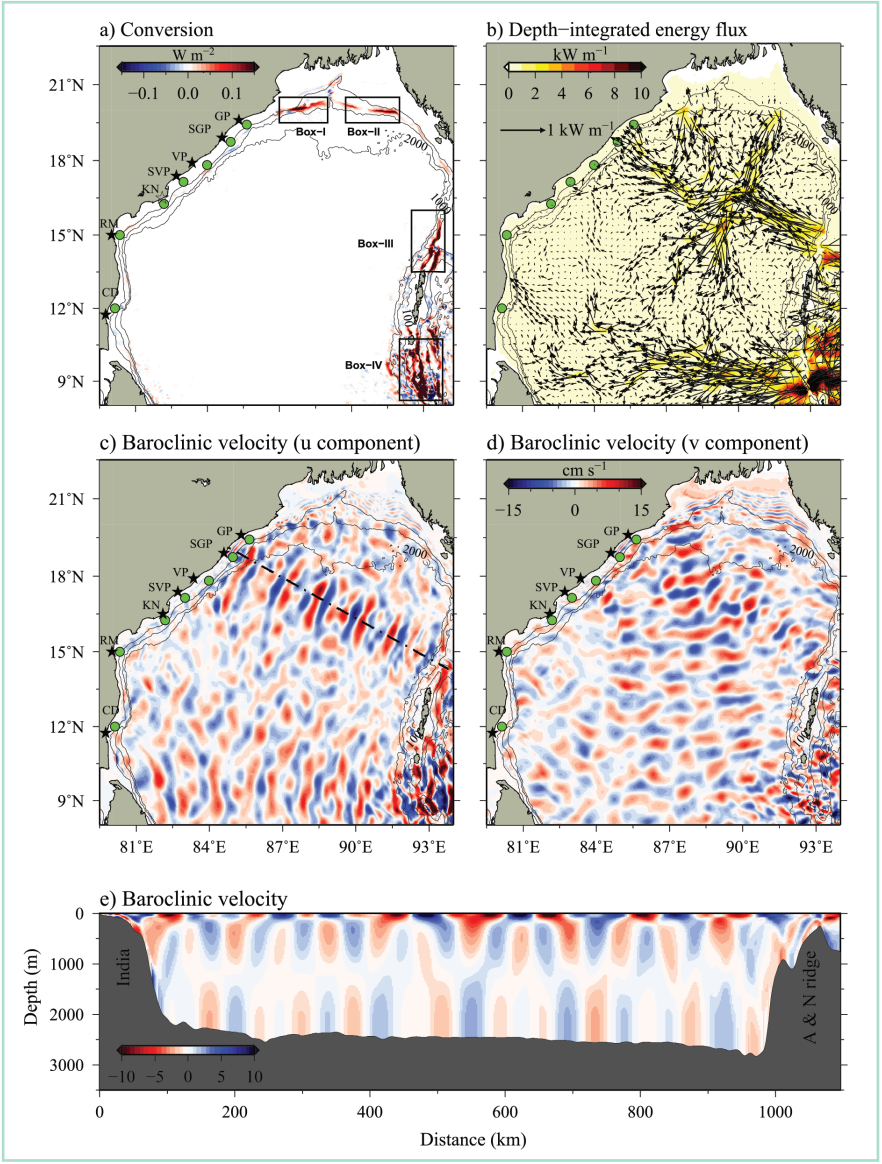
Depiction of (a) parametric wind field, (b) centered shifted ECMWF wind field, (c) blended wind field and (d) radial profile of parametric, ECMWF and blended wind fields. Hudhud cyclonic case is considered in this picture.

Ref: Murty, P.L.N., Srinivas, K.S., Rama Rao, E.P., Bhaskaran, P.K., Shenoi, S.S.C., Padmanabham, J. Improved cyclonic wind fields over the Bay of Bengal and their application in storm surge and wave computations (2020) Applied Ocean Research, 95, art. no. 102048.

10.18 Generation and Propagation of internal tides in the Bay of Bengal

Generation and propagation

of internal tides in the western Bay of Bengal (BoB) were investigated using observations from Acoustic Doppler Current Profilers and simulations from a very high resolution numerical ocean model. Observations show that semidiurnal internal tides in the southern and northern parts of the western BoB are more energetic during neap phase of the local barotropic tide than those during spring phase. Numerical simulations indicate that internal tides generated over the Andaman-Nicobar Ridge propagate westward for about 1,000–1,450 km across the BoB and finally impinge on the continental slopes off the east coast of India after 5–7 days. Energetic internal tides observed during the neap phase of the barotropic tides in the western BoB are mainly due to the arrival of remotely generated internal tides. It is also shown that the variation in the onshore transmission of these remotely generated internal tides due to the topographic slope in the western BoB controls the strength of internal tide activity along the shelf. Superposition of reflected internal tides from continental slope, which are very steep in some regions and onshore propagating-waves generate partly standing waves. Numerical experiments suggest that internal tides coming from remote sources account for more than 80% of the total internal tide energy observed in the western BoB. Internal tide energy dissipation on the continental margins of the western BoB is about 3 to 4 times larger than the local generation, indicating that this region is a sink for remotely generated internal tide energy.

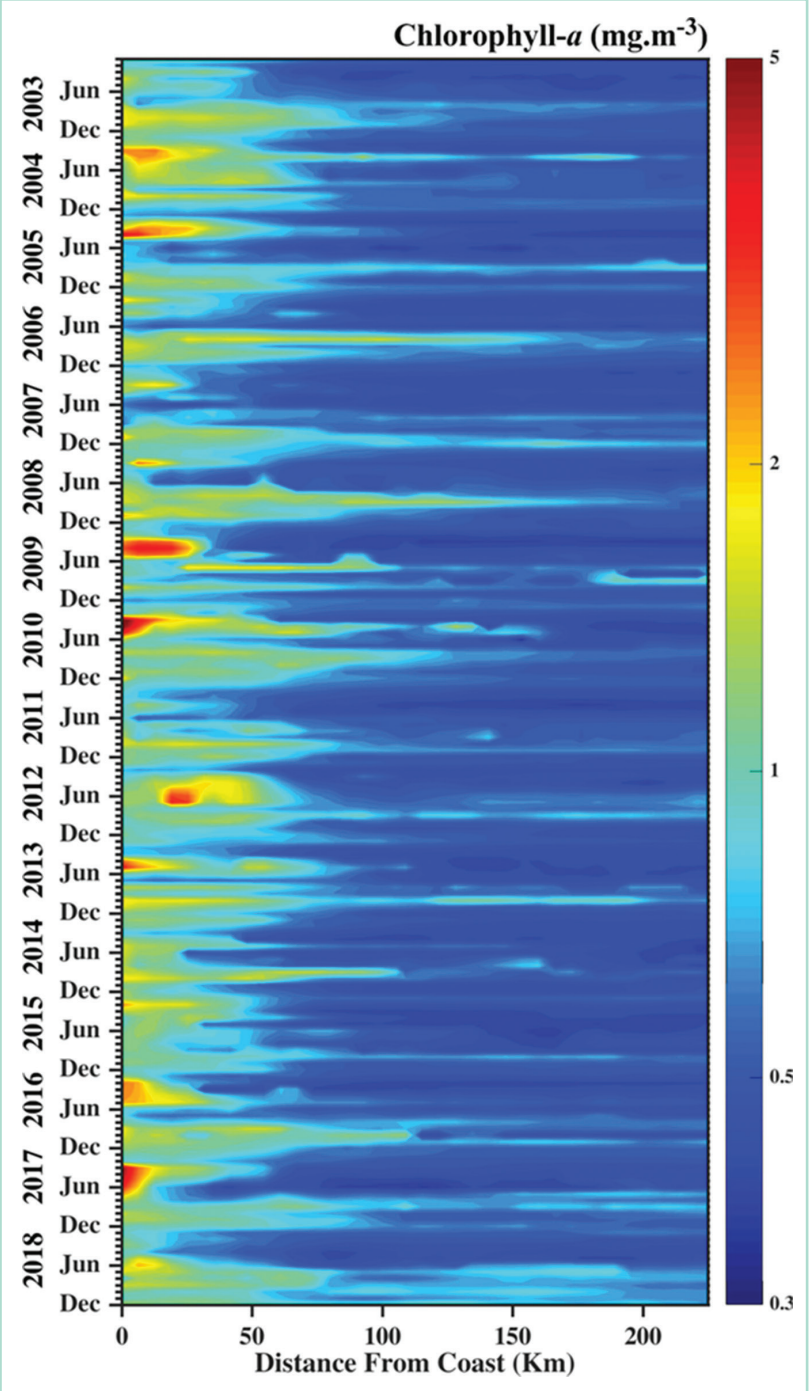


(a) Barotropic to baroclinic M_2 energy conversion rate. Boxes indicate major internal tide generation regions in the BoB. (b) Depth-integrated baroclinic M_2 energy flux in the BoB. Bathymetric contours of 100, 1,000, and 2,000 m are shown. Instantaneous zonal (c) and meridional (d) velocity component of semidiurnal internal tides at surface derived from model simulation (14 March 2012 18:00). Green circles represent the locations of ADCP moorings on the shelf. (e) Vertical section of instantaneous baroclinic velocity (14 March 2012 18:00) of semidiurnal internal tide along the east-west transects in the BoB (black dashed line) shown in (c).

Ref:Jithin, A.K., Francis, P.A., Unnikrishnan, A.S., Ramakrishna, S.S.V.S. Modeling of Internal Tides in the Western Bay of Bengal: Characteristics and Energetics (2019) Journal of Geophysical Research: Oceans,124(12), pp.8720-8746.

10.19 Long-term chlorophyll-a dynamics in tropical coastal waters of the western Bay of Bengal

The long-term distribution of in situ optically active substances (OAS), accuracy assessment of satellite retrieved chlorophyll-a (chl-a) and its long-term trend has been carried out at a coastal site of the north-western Bay of Bengal. The temporal distribution of chl-a, total suspended matter (TSM) and absorption due to coloured dissolved organic matter at 440 nm (aCDOM440) discerned a common peak during southwest monsoon season (August–October). Chl-a also showed a prominent peak during pre-southwest monsoon period (March–April). The spatial variability of TSM and aCDOM440 was maximum during southwest monsoon, whereas in the case of chl-a, it was during pre-southwest monsoon. The accuracy assessment of chl-a retrieved from Moderate Resolution Imaging Spectroradiometer-Aqua (MODISA), Ocean Colour Monitor-2 (OCM-2) and Visible Infrared Imager Radiometer Suite (VIIRS) showed overestimation in nearshore waters. The error in satellite measurement of chl-a was within the range of 33 to 51%. The chl-a retrieved from MODISA was most accurate as indicated by statistical analysis. The longterm trend in satellite chl-a clearly indicated bi-modal distribution with a primary peak during pre-southwest monsoon attributed to recurrent phytoplankton bloom that was mostly confined to nearshore waters. Whereas, the secondary peak in chl-a, during the end of southwest monsoon, spreads far offshore.

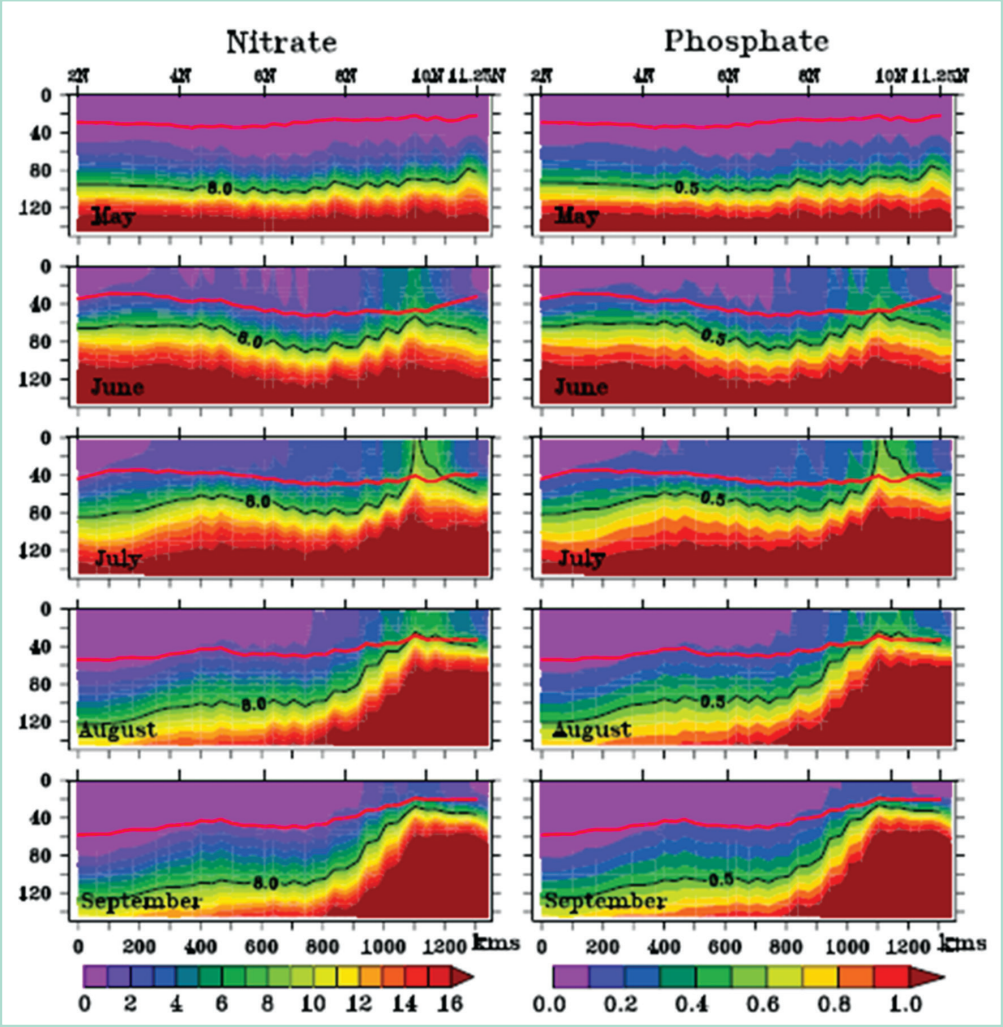


The latitudinal (18 to 20° N) averaged Hovmoller plot showing time series distribution ofMODISA-retrieved chlorophyll-a from January 2003 to December 2018

Ref:Lotliker, A.A., Baliarsingh, S.K., Sahu, K.C., Srinivasakumar, T. (2020). Long-term chlorophyll-a dynamics in tropical coastal waters of the western Bay of Bengal. Environmental Science and Pollution Research.27, pp. 6411-6419

10.20 Biophysical Interactions in Driving the Summer Monsoon Chlorophyll Bloom Off the Somalia Coast

The biophysical interactions along the Somali coast are discussed during summer monsoon based on a numerical model study. The Somali coast is known to be the fifth largest upwelling region of the world ocean and one of the most productive regions of the globe. Based on scattered observations, mostly dated back to 1960s, it is widely accepted that the strong chlorophyll bloom along the Somali coast during summer is driven by upwelled nutrient flux.We show that the upwelling-driven productivity is primarily limited to the northern part of the coast when examined along the shelf break off the Somalia coast. In contrast, productivity in the south of 9^{0}N is driven by weaker upwelling in the early half of the summer monsoon but later dominated by the wind-based mixing induced entrainment and therefore shows much weaker chlorophyll concentration than the north. Further, the strong poleward alongshore currents advect the upwelled nutrients away from the southern and central parts of the coast to the north, thereby controlling the biological community over the Somali region. This abundant locally upwelled and remotely advected nutrients support the enhanced growth of diatoms in the northern part of the transect as earlier observed from in situ measurements. However, limited nutrients allow smaller phytoplankton communities to grow in the southern and central sections. We show that nitrate is the primary limiting nutrient for the phytoplankton growth in the central and southern parts of the Somalia coast.

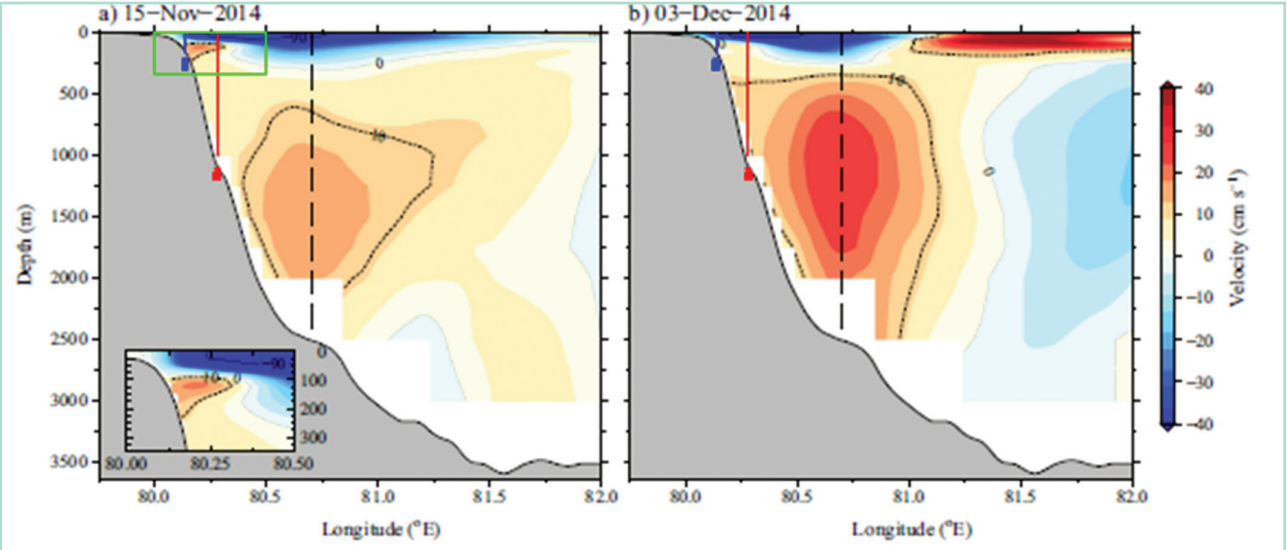


Evolution of model-simulated nitrate (µmol/kg) and phosphate (µmol/kg) along the 1,000 m isobath of Somalia coast (refer to Figure 1) from south to north during summer monsoon. The black lines represent the nutriclines, and the red line is the mixed layer depth computed using density criteria.

Ref: Lakshmi, R.S., Chatterjee, A., Prakash, S., Mathew, T. Biophysical Interactions in Driving the Summer Monsoon Chlorophyll Bloom Off the Somalia Coast (2020) Journal of Geophysical Research: Oceans, 125 (3), art. no. e2019JC015549

10.21 Structure and Dynamics of undercurrents in the East India Coastal Current

The structure and variability of undercurrents in the East India Coastal Current (EICC), which is the western boundary current system in the Bay of Bengal (BoB), and the mechanisms of their formation are examined in this study. We used current data collected by Acoustic Doppler current profilers (ADCP) moored off Cuddalore (~ 12°N), Kakinada (~ 16.5°N), Visakhapatnam (~ 17.7°N), and Gopalpur (~ 19.4°N) and simulations for the period 2013–2014 from a high-resolution model configured for the BoB. The undercurrents were observed at all these locations, mainly during summer (June–August) and winter (October–December). Undercurrents were seen at relatively shallow depths (75 m), and their occurrences were more frequent off Cuddalore, whereas they were deep (100–150 m) and less frequent in the northern part of the east coast (off Visakhapatnam and Gopalpur). Numerical simulations showed that the interaction of the westward propagating anticyclonic eddies with the equatorward EICC weakened the strong surface flow and reversed the weak subsurface flow in the northern part of the western BoB. This interaction resulted in the formation of the poleward undercurrent here. Once these mesoscale eddies dissipated due to the interaction with the continental slope, the poleward undercurrents vanished and equatorward flow in the subsurface reappeared. The observed undercurrents near the shelf break region (75–200 m) in the southern part of the coast (off Cuddalore) were associated with small subsurface eddies (diameter of about 20–30 km), which developed due to large zonal gradient in the alongshore component of EICC. Subsurface anticyclonic circulations of larger spatial extent (diameter > 200 km) were responsible for the observed undercurrents in the deeper levels (deeper than 250 m) off Cuddalore. We further show that intraseasonal variability of undercurrents near the shelf break off Cuddalore was directly linked to intraseasonal variability in the strength of surface EICC itself. Results from this study suggest that the undercurrents observed below the EICC were not continuous poleward flow, but they were part of distinct anticyclonic eddies.



Longitude-depth section of alongshore currents at 12°N on (a) 15 November 2014 and (b) 3 December 2014. Positive values indicate the poleward flow. Inset plot is the zoomed view of shelf break region indicated by green box. Dashed black vertical line shows the core of the undercurrent, and red (blue) vertical lines shows the location of ADCP observation on the slope (shelf).

Ref:Francis, P.A., Jithin, A.K., Chatterjee, A., Mukherjee, A., Shankar, D., Vinayachandran, P.N., Ramakrishna, S.S.V.S. Structure and dynamics of undercurrents in the western boundary current of the Bay of Bengal (2020) Ocean Dynamics, 70 (3), pp. 387-404.

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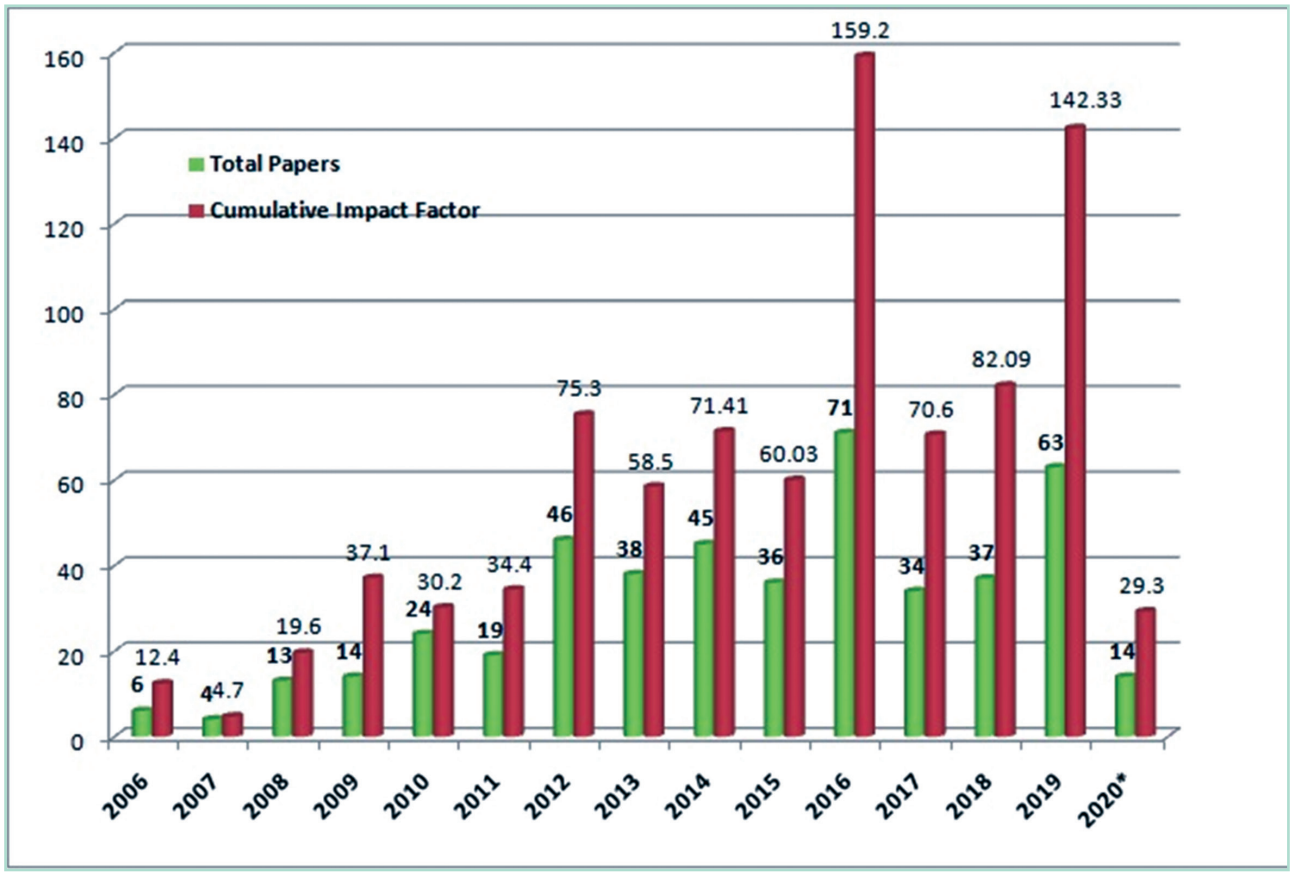


Growth of publications in peer review journals and their cumulative impact factor

11. Involvement in International Coordination

11.1 IOGOOS Secretariat

INCOIS continued to host the secretariat of Indian Ocean Global Ocean Observing System (IOGOOS), a regional alliance formed by 29 institutions from 17 countries in 2002, for the 3rd term of six years (2015-2020). IOGOOS supports physical, biogeochemical, biological and climate related observations and the related modelling aspects. Mr. M. Nagaraja Kumar, Scientist-E coordinated the day-to-day activities of IOGOOS being its Secretary. Dr. S.S.C. Shenoi, Director, INCOIS elected as chair of IOGOOS in 2017 continued to chair IOGOOS in the past year.

11.2 International Oceanographic Data Exchange

INCOIS continued to be the responsible National Oceanographic Data Centre (NODC) for India, as designated by IODE of Intergovernmental Oceanographic Commission (IOC) of UNESCO. Shri. E. Pattabhi Rama Rao acted as the National Coordinator for India for 'Data Management'. He also served as a member of Steering Groups of Ocean Biogeographic Information System (SG-OBIS) and IODE Quality Management Framework (SG-IODE QMF).

11.3 OceanSITES

OceanSITES as a component of the Global Ocean Observing System is a global timeseries programme and a recognized part of the international JCOMM. INCOIS has been designated as OceanSITES Data Assembly Centre (DAC). Shri. E. Pattabhi Rama Rao represented INCOIS on the OceanSITES Data Management Team responsible for ocean data management by devising appropriate standards, formats and quality controls.

11.4 Partnership for Observation of the Global Oceans (POGO)

INCOIS continued to be a member of the POGO created in 1999 by the Directors and leaders of major global oceanographic institutions, to promote global ocean observations and research. POGO focuses on the implementation components of international and integrated global ocean observing systems. Dr. S.S.C. Shenoi was elected as Trustee of the POGO Charitable Incorporated Organisation (CIO), the apex body of POGO in January 2019.

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

RIMES is an intergovernmental organisation registered with the United Nations, aiming to provide

regional early warning services including early warning of tsunamis and hydro-meteorological hazards and to build the capacity of its Member States.

As per the MoU between MoES, Govt. of India and RIMES INCOIS continued to provide the ocean state forecasts for Comoros, Madagascar, and Mozambique along with Seychelles, Sri Lanka and Maldives and the tsunami early warnings to RIMES for its dissemination to members.

11.6 SIBER International Programme Office

INCOIS hosts the Sustained Indian Ocean Biogeochemistry and Ecosystem Research (SIBER) programme office which manages the organisation of annual Science Steering Committee (SSC) meetings and sharing of updates along with management of the SIBER website. INCOIS is represented at SIBER by Dr. Satya Prakash who also manages the programme office.

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

The Second International Indian Ocean Expedition (IIOE-2) is a major global programme co-sponsored by Intergovernmental Oceanographic Commission (IOC), the Scientific Committee on Oceanic Research (SCOR) and the Indian Ocean Global Observing System (IOGOOS), with INCOIS serving as one of the two Joint Programme Offices (JPOs). Dr. Satheesh Shenoi continued as one of the co-chair of the IIOE-2 Steering Committee and Dr. Satya Prakash continued as JPO-India coordinator. Two issues of the half-yearly newsletter of IIOE-2 (11th and 12th issues), named, "The Indian Ocean Bubble-2" has been published from JPO-India. Shri Kiran Kumar and Ms. Celsa Almedia contributed considerably in preparing and publishing the newsletters.

11.8 GODAE Ocean View

INCOIS continued to contribute significantly to the activities of GODAE Ocean View, now renamed as Ocean Predict. Dr. S.S.C. Shenoi stepped down as member of Patrons Group and nominated Dr. P.A. Francis to represent INCOIS on Patrons Group of OceanPredict. OceanPredict promotes ocean observations, ocean modelling, data assimilation and ocean predictions. The Patrons Group of GODAE Ocean View which guides the GODAE Ocean View Science Team to attain various targets and supports the project office in the UK Met Office. Dr. Abhisek Chatterjee is a member of the science team (GOVST) representing INCOIS. In this period, Director, INCOIS continued to serve as a member of the GODAE Ocean View Patrons Group.

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

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

activities. ITEWC at INCOIS serves as one of the Regional Tsunami Service Provider for the Indian Ocean. Shri. E. Pattabhi Rama Rao continued as vice-chair of the group during this period. Shri Patanjali Kumar also continued as Vice-Chair for Working Group-2 (WG-2) on Tsunami Detection, Warning and Dissemination and as member of TT for Scientific Hazard Assessment for the Makran Subduction Zone. Smt. M.V. Sunanda continued as Vice-Chair for the Sub Regional Working Group for the North West Indian Ocean (WG-NWIO) and as a member of TT for Tsunami Preparedness for a Near-Field Tsunami Hazard. Similarly, Shri R. S. Mahendra and Shri. B. Ajay Kumar worked as the members of Working group-1 on Tsunami Risk, Community Awareness and Preparedness. Shri. J. Padmanabham is a member of WG-2 and Dr. Dipankar Saikia is a member of WG-NWIO. Shri B. Ajay Kumar is also a member of TT for the upcoming exercise, Indian Ocean Wave 2020 (IOWAVE20).

11.10 Union Commission for Data and Information (UCDI) of International Union for Geophysics and Geodesy (IUGG)

UCDI of the eight commissions of IUGG established to enable a high level of cooperation within and between scientific communities. President of IUGG appoints the Chair and members of the commissions. Dr. S.S.C. Shenoi who served as the chair of UCDI during 2015-2019 is reappointed as its chair for the period 2019-2023. Dr. Shenoi organised the union symposium "Data-driven Science for Earth and Space Exploration" as its the lead convenor at the 27th General Assembly of IUGG held at Montreal, Canada during 8-17 July 2019.

12. General Information

12.1 Awards and Honours

Vice-Chair, IOC-UNESCO

Dr. Satheesh Shenoi, Director, INCOIS was unanimously elected as the Vice-Chair (Group IV) of UNESCO's Intergovernmental Oceanographic Commission for the period 2019-2021 during the 30th session of the IOC Assembly held at UNESCO Headquarters, Paris, France between 26 June and 4 July 2019. IOC-UNESCO was established in 1960 with functional autonomy within the UN system, to promote international cooperation and to coordinate programmes in research, services and capacity-building in marine science related areas. Group IV encompasses the member countries of IOC situated between Republic of Iran and Republic of Korea.

MoES Awards

Dr. Arya Paul Scientist 'D' was awarded Certificate of Merit for outstanding contributions in Ocean Sciences during MoES Foundation Day-2019 celebrations at Prithvi Bhavan, New Delhi on 27 July 2019. Ms. Naga Swetha, Scientific Assistant B received the best employee award 2019 for outstanding contributions. Mr. Prabhala Srikrishna Chaitanya Asst. Manager received the best Group B employee award.

Vocational Excellence Award:

Dr. M.S. Girishkumar was selected for the *'Vocational Excellence Award 2019-20'* for excellence in oceanographic research by the Rotary Club of Hyderabad, Deccan which is a primary unit of Rotary International.

Telangana Academy of Sciences:

Dr. Abhishek Chatterjee has been elected as associate fellow of Telangana Academy of Sciences in recognition of his contributions in earth and planetary sciences.

Eugene LaFond Medal

The Eugene LaFond Medal was awarded to Rohith Balakrishnan, Project Scientist B, for the paper "Basin-wide sea level coherency

in the tropical Indian Ocean driven by Madden-Julian oscillations" at the International Union of Geodesy and Geophysics - IUGG General Assembly in Montreal, Canada, held during 8-18 July 2019.

Rajbhasha Hindi Karyanvayan Ratna Award

INCOIS was honoured with the "Rajbhasha Hindi Karyanvayan Ratna Award" by the Parivartan Jan Kalyan Samiti- Delhi during a three-day Akhil Bhartiya Vishesh Rajbhasha Hindi Aavasiya Karyashala Evam Sangoshti (All India Special Rajbhasha Hindi Residential Workshop and Seminar) held between 30 May and 1 June 2019 at Thiruvananthapuram.

12.2 Memorandum of Understanding

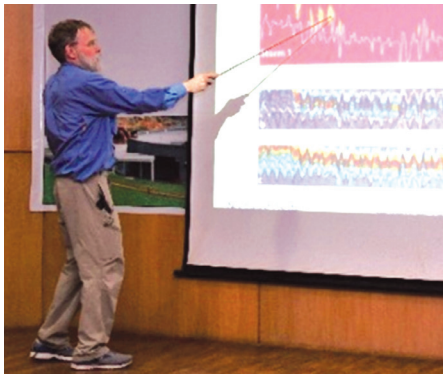
- INCOIS signed an MoU with Swami Ramanand Teerth Marathwada University (SRTM) Nanded, Maharashtra for active collaboration in academic and research activities on 6 September 2019.
- In order to strengthen collaborations in the fields of capacity development, user awareness, dissemination strategies and R&D components in fisheries between INCOIS and U.T. of Lakshadweep, an MoU has been signed between INCOIS and Directorate of Fisheries U.T. of Lakshadweep on 30 September 2019.

12.3 Campus Visitors

During the last one year, INCOIS accommodated over 3700 students from Telangana, Kerala, Karnataka, Odisha, Maharashtra and a few students from USA. Their visit was organized with prior appointments and during the Open Houses on the occasions of MoES Foundation Day, INCOIS Foundation Day, IISF curtain raiser and Tsunami World Awareness Day (TWAD). Student competitions were held as part of the TWAD celebrations and Swachh Bharat Pakhwada. Government employees and defense officers (388 personals) from India as well as from about 23 foreign countries made field visits as part of their professional training in Hyderabad. They include CISF, State Police, Naval, Coast Guard and Air Force officers and trainees from the sectors of agricultural development, academia, disaster management, geology etc.

12.4 Guest Lectures

- Dr. H. Annamalai, Research Professor of Oceanography, IPRC, SOEST, University of Hawaii delivered a lecture on "Modeling Asian monsoon precipitation climatology" on 26 September 2019.



• Prof. Eric D'Asaro, Senior Principal Oceanographer, Applied Physics Laboratory, University of Washington presented lectures on " Review: Langmuir turbulence and Monin-Obukhov scaling" and "Entrainment physics" on 14 and 16 January 2020.

12.5 IISF Curtain Raiser

A special curtain-raiser event was organized at INCOIS on 24 October 2019 for the India International Science Festival (IISF) 2019. As part of this event a Special Public Guest Lecture on "Earth Sciences for Sustainable Development Goals (SDGs)- Major Water Issues in India" was delivered by Dr. V. M. Tiwari, Director, CSIR-National Geophysical Research Institute. Shri. Vivekananda Pai, Secretary, VIBHA (Vijnana Bharati) presided over the proceedings. The lecture was attended by over 60 students from Malla Reddy Women's Engineering College, Hyderabad, 22 state development officers from Tamil Nadu, Kerala and Telangana attending "Climate Change Mitigation" training at the Extension Education Institute Hyderabad and few individual public members, in addition to INCOIS staff.

12.6 Official Language Programme

Promotion of Hindi: The Official Language Implementation Committee of INCOIS conducted regular meetings to review the progress and plan the activities. A special programme during the Hindi Pakhwada celebration during 1-14 September 2019 and a special event on “Vishwa Hindi Diwas” under the aegis of TOLIC-3 Hyderabad were conducted at INCOIS.

Hindi Pakhwada: A Hindi Pakhwada was celebrated from 1 to 14 September, 2019. During the Pakhwada, various competitions were organized separately for the employees of Hindi and non-Hindi speaking areas. The competitions included, essay writing, extempore, scientific presentations, and poetry recitations. Poetry and story recitation competitions were also organized for the children of INCOIS staff. During the closing ceremony on 13 September 2019, the Director, INCOIS and the Chief Guest, Dr. Maya Devi, President, Hindi Department, Osmania University felicitated the winners of the competitions.

Hindi Workshop/Seminars: INCOIS organized following two Hindi workshops during the last year.

- Hindi Workshop was held on June 26, 2019 at INCOIS. The Chief Guest of this Workshop was Mr. Shivanand Kalekar, Hindi Professor, Hindi Teaching Scheme, Hyderabad. He gave a lecture on easy usage of Hindi in official work. He also emphasized on the Rajbhasha rules and regulations. All members were advised to work in Hindi.
- Hindi Workshop was held on December 23, 2019 at INCOIS. The Chief Guest of this Workshop was Mr. Santosh Kumar, Assistant Director, Typewriting and Stenography, Hindi Training Institute, Hyderabad. He gave a message to work in Hindi on computer. He intended to use Unicode to work in Hindi. He explained that Hindi can be easily done on computer. All members were encouraged to work in Department of Official Language, Ministry of Home

Affairs, Hindi Teaching Scheme, Hyderabad conducted a training session for Hindi at INCOIS. Mr. Shivanand Kalekar, Hindi Professor, Hindi Teaching Scheme, Hyderabad was the faculty for this session. The session was held during July-November 2019. Fourteen regular employees

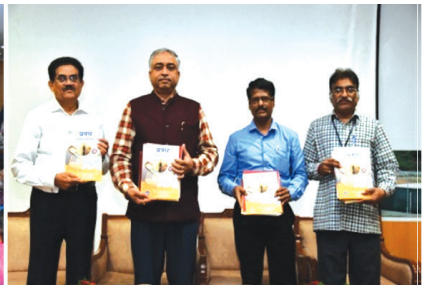
attended the Hindi Pragya examination on 24 November 2019 in which 12 members passed with First Class and 2 with Second Class.

Following staff of INCOIS attended training/workshop as part of promotion of official language

- Mr. Venkat Shesu, Scientist 'E' attended the three-day Residential Official Language Workshop held during 30, 31 May and 1 June 2019 at Thiruvananthapuram.
- Ms. Rakhi Kumari, Scientific Assistant 'B' attended the three-day Official Language Workshop held during 25-27 November 2019 at Kodaikanal, Tamil Nadu.
- Mr. Santosh Kumar, Senior Executive attended the three-day Residential Official Language Workshop held during 9-11 December 2019 in Goa.

Vishwa Hindi Diwas Celebrations: Official Language Implementation Committee and INCOIS jointly organised Vishwa Hindi Diwas Celebrations on 28 January 2020 at INCOIS Conference Hall. The Chairman of the Committee and CSIR-NGRI Director Dr. V. M. Tiwari was the Chief Guest at the function. Dr. P.V.V. Prasad, Director of National Institute of Indian Medical Heritage (NIIMH), Dr. S.S.C. Shenoi, Director, INCOIS and Ch. Subba Rao Senior Hindi Officer were among the prominent personalities who attended the function. Speaking on this occasion, Dr. Shenoi stressed on the need for learning more languages, apart from mother tongue. Citing examples of countries which use native language for scientific writings, he emphasized on the need for creating scientific and technical jargon in Hindi. Dr. P.V.V. Prasad gave a presentation on traditional medical systems of ancient India as Sidha, Unani, Ayurveda and Homeopathy in Hindi. Dr. V.M. Tiwari stressed on the need for the use of Hindi in the field of Science and Technology. A short movie made in Hindi on functioning of INCOIS was screened on the occasion.





12.7 International Yoga Day

On the occasion of 5th International Yoga Day on 21 June 2019, a three-hour comprehensive seminar was conducted for INCOIS Staff by Ms Aktar Parveen, Internationally certified Yoga Instructor from S-Vyasa Yoga University. The training was in line with the protocol issued by Ministry of AYUSH (Ayurveda, Yoga & Naturopathy, Unani, Siddha and Homoeopathy). The seminar included a lecture on the "Origin of Yoga and Basics of Ashtanga Yoga" and practical sessions with demonstrations of 'Yoga for Health', 'Yoga for Well being','Yoga for Peace' and Pranayam techniques.

12.8 Women's Day Celebrations

International Women's Day 2020 was celebrated with a special programme on 6 March 2020. Smt. Swathi Lakra, IPS, Inspector General of Police (Law & Order) and Women Safety, Government of Telangana inaugurated the Women's Day celebrations at INCOIS and delivered a talk on "Women Safety". This is was followed by a Rangoli competition and cultural programmes.

12.9 Swachh Bharat Programme

World Environment Day: On the eve of World Environment Day on 4 June 2019 a Bio-Gas Plant was inaugurated in INCOIS campus. This was followed by cleaning of the outer enclosure of the campus and putting up flyers on the avoidance of plastic to raise the awareness among local residents.

Swachhta Pakhwada: Swachhta Pakhwada was organised during 1-15 July 2019 involving several activities by employees including cleaning of surrounding areas, planting trees, awareness programmes for housekeeping and security staff, awareness programmes for neighboring residential societies and collection and distribution of old clothes for those in need. Special bilingual (Hindi and English) plaques were set up throughout the campus with motivational slogans focused on cleanliness. On 4 July 2019 there was a presentation by Greater Hyderabad Municipal Corporation (GHMC) Health Officer Dr. Chandrshekara Reddy and his Swachhta Awareness Team outlining initiatives of GHMC and the associated challenges encountered. The special fortnight culminated with competitions for school children on 15 July 2019. Nineteen schools participated from all over Hyderabad in 5 competitions: Essay, Painting, Quiz, Play and Best-from-Waste Exhibition. Winners were felicitated by Chief Guest, Ashok Samrat, Dy. Commissioner, GHMC in presence of GHMC Health Officer Dr. Chandrshekara Reddy. The Swachhta Team from GHMC also made a presentation for the students.

Swachhta Hi Seva: Swachhta Hi Seva drive was organized from 17 September to 2 October 2019, which included the cleaning of campus and surrounding areas, donation drive for old

clothes, tree plantation drive, public rally etc. On 18 September 2019, Dr. Y Rami Reddy, MD Physician Care 4 U clinic, Hyderabad gave a brief lecture on "Dengue and health tips" as part of the drive.

12.10 Vigilance and RTI Activities

Shri B.V. Satyanarayana, Scientist 'G' & Head, CWG continued to serve as Vigilance Officer at INCOIS. Eighteen (18) complaints were received during the period 1 April 2019 to 31 March 2020 and upon verification as per CVC guidelines, it was found that 16 complaints were pseudonymous and hence no further investigations were carried out. Two complaints were attended to and disposed off with intimation to CVO, MoES. "Vigilance Awareness Week" was observed at INCOIS during 28-31 October 2019. INCOIS staff took the Vigilance Pledge on 31 October 2019.

In respect of the Right to Information Act (RTI) 2005, INCOIS related queries were regularly updated on the INCOS website in prescribed format. Shri. E. Pattabhi Rama Rao, Scientist F & Head, ODG functioned as the Public Information officer and Dr. S.S.C. Shenoi, Director, INCOIS as the first appellate authority. Under RTI, 21 requests were received and the required information were provided. Three appeals were also received and disposed off under RTI act during this period.

12.11 Academic Projects carried out by students at INCOIS

SL No.	Student Name	Institute	Project Guide
1	Amasa Rao A	Andhra University	Murty PLN
2	Adithya MV	Kerala University of Fisheries and Ocean Studies (KUFOS)	Sourav Maity
3	Adithya TS	Kerala University of Fisheries and Ocean Studies (KUFOS)	Patanjali Kumar C

4	Aditya Komath	Kerala University of Fisheries and Ocean Studies (KUFOS)	Sourav Maity
5	Aiswarya S	Kerala University of Fisheries and Ocean Studies (KUFOS)	Abhisek Chatterjee
6	Ajay Kumar K.	Andhra University	Srinivas Rao N
7	Akilandeshwari A	Central Institute of Fisheries Education, Mumbai	Nagaraja Kumar M
8	Amit Kini	VBIT, Hyderabd	Kiran Kumar N
9	Amrutha Madhusudhanan	Cochin University of Science and Technology (CUSAT)	Remya PG
10	Amrutha Sadanandan	Kerala University of Fisheries and Ocean Studies (KUFOS)	Francis PA
11	Anitha S	RVRJC, Guntur	Venkat Shesu R
12	Anishaa Raj V K	Anurag Group of Institution	Vighneshwar SP
13	Anjana Biju	Kerala University of Fisheries and Ocean Studies (KUFOS)	PLN Murty
14	Anju Gayathri	Kerala University of Fisheries and Ocean Studies (KUFOS)	PLN Murty
15	Anshul Vankar	SHARDA University	Venkat Shesu R
16	Anupama Biju	Kerala University of Fisheries and Ocean Studies (KUFOS)	Patanjali Kumar C
17	Aparna M Nath	Kerala University of Fisheries and Ocean Studies (KUFOS)	PLN Murty
18	Archita Basavaraju	VBIT, Hyderabd	Pavan Kumar J
19	Aritra Chakrabarty	Central University Karnataka	Mahendra RS
20	Arya Jayakumar	Kerala University of Fisheries and Ocean Studies (KUFOS)	Praveen B
21	Ashmika Kumari	Mangalore University	Srinivasa Rao N
22	Ashok Kumar Behera	Khalikote University	Aneesh Lotliker
23	Ashwitha K	Mangalore University	Srinivasa Rao N
24	Aswarth K	VRSEC, Vijayawada	Venkat Shesu R
25	Aswath Balaji	Central University of Tamilnadu	Murty PLN
26	Ateeq Rahman Shaik	Government Polytechnic, Hyderabad	Venugopala Rao V
27	Avimanyu Ray	University of Hyderabad	Abhisek Chatterjee
28	Baga Jyothi D	VRSEC, Vijayawada	Venkat Shesu R
29	Bhavani D	VRSEC, Vijayawada	Venkat Shesu R
30	Chandrasekhar P	VRSEC, Vijayawada	Kiran Kumar N
31	Dessy Davis	Kerala University of Fisheries and Ocean Studies (KUFOS)	Patanjali Kumar C
32	Durga Remya P	VBIT, Hyderabd	Pavan Kumar J
33	Ganana Samaikya	Andhra University	Ajay Kumar B

34	Gandhi K.	Jawaharlal Nehru Technological University, Hyderabad	Vighneshwar SP
35	Gopika C	Mangalore University	Srinivasa Rao N
36	Gopikrishnan GS	Kerala University of Fisheries and Ocean Studies (KUFOS)	Kunal Chakraborty
37	Hari Chandra Prasad A	Government Polytechnic, Hyderabad	Venugopala Rao V
38	Harika M	VRSEC, Vijayawada	Venkat Shesu R
39	Harish K	Government Polytechnic, Hyderabad	Venugopala Rao V
40	Harshita P	MRECW, Hyderabad	Venugopala Rao V
41	Hemanth Kumar A	VITS, Nalgonda	Arun N
42	Jais Jose	Amity University, Noida	Patanjali Kumar C
43	Jaya Krishna B	KITS, Warangal	Kiran Kumar N
44	Ramya Sri JBN	VRSEC, Vijayawada	Udaya Bhaskar TVS
45	Jyothi Agarwal	VBIT, Hyderabd	Kiran Kumar N
46	Kamali Sai Meghalini	VRSEC, Vijayawada	Venkat Shesu R
47	Karthika PS	Kerala University of Fisheries and Ocean Studies (KUFOS)	Harikumar R
48	Kiranmayee B	Andhra University	Patanjali Kumar C
49	Kishore P	Andhra University	Srinivas Rao N
50	Kommu Rajesh	NITK Surathkal	Murty PLN
51	Lakshmi M	Andhra University	Patanjali Kumar C
52	Lakshmi Mounika	VRSEC, Vijayawada	Pavan Kumar J
53	Lakshmi.MS.Padikkal	Kerala University of Fisheries and Ocean Studies (KUFOS)	Patanjali Kumar C
54	Mabibi SK	RVRJC, Guntur	Venkat Shesu R
55	Maniteja B	KITS, Warangal	Kiran Kumar N
56	Manjima A	Mangalore University	Mahendra R.S.
57	Manoj Kumar AS	Mangalore University	Mahendra R.S.
58	Mansi Gupta	University of Hyderabad	Aneesh Lotliker
59	Maria Sansanna	Cochin University of Science and Technology (CUSAT)	Abhisek Chatterjee
60	Meera Nair M	Cochin University of Science and Technology (CUSAT)	Francis PA
61	Mehak	IISER Mohali	Arya Paul
62	Minnu R	Cochin University of Science and Technology (CUSAT)	Francis PA
63	Mitha Rehna T R	Kerala University of Fisheries and Ocean Studies (KUFOS)	Patanjali Kumar C
64	Mounika K	VRSEC, Vijayawada	Venkat Shesu R
65	Nagaraju Naik	Government Polytechnic, Hyderabad	Venugopala Rao V

66	Nandakishore	Kerala University of Fisheries and Ocean Studies (KUFOS)	Arnab Mukherjee
67	Nandana Goswami	IISER Kolkatta	Dipankar Saikia
68	Navyasree S R	Vellore Institute of Technology	Kiran Kumar N
69	Nayana N	NIT Karnataka	Srinivasa Rao N
70	Nethaji K.	VRSEC, Vijayawada	Kiran Kumar N
71	Nidhi Yadav	University of Hyderabad	Satya Prakash
72	Nivetha S	Anna University, Chennai	Murty PLN
73	Parvathy R	Kerala University of Fisheries and Ocean Studies (KUFOS)	Murty PLN
74	Pooja Tiwari	Jawaharlal Nehru University New Delhi	Francis PA
75	Poojith kumar DP	Bharathidasan University	Mahendra RS
76	Prince Arayakandy	Kerala University of Fisheries and Ocean Studies (KUFOS)	Balakrishnan Nair TM
77	Raja Rajeswari Devi	Andhra University	Ajay Kumar B
78	Rajesh K	Andhra University	Udaya Bhaskar TVS
79	Rama Devi	Andhra University	Ajay Kumar B
80	Ranjan Kumar Sahu	University of Hyderabad	Arnab Mukherjee
81	Ravi Krishna K	Anurag Group of Institution	Vighneshwar SP
82	Sagar K	Mangalore University	Mahendra RS
83	Sai Durga Pavan T	VRSEC, Vijayawada	Venkat Shesu R
84	Samhitha Ch.	NIT Warangal	Mahendra RS
85	Sandra T.S	Kerala University of Fisheries and Ocean Studies (KUFOS)	Patanjali Kumar C
86	Sanjay Kumar	VRSEC, Vijayawada	Venkat Shesu R
87	Sanjay Stephen	CIFE, Mumbai	Nagaraja Kumar M
88	Sarangy Vichithra Bhanu	Kerala University of Fisheries and Ocean Studies (KUFOS)	Balakrishnan Nair TM
89	Sawini M	Kerala University of Fisheries and Ocean Studies (KUFOS)	Sourav Maity
90	Siva Gopal K	VRSEC, Vijayawada	Venkat Shesu R
91	Siva Nagababu M	Andhra University	Srinivas Rao N
92	Smitarani Panda	IASc Bangalore	Praveen kumar B
93	Sneha Ch	VRSEC, Vijayawada	Venkat Shesu R
94	Sneha Teresa George	Sacred Heart College	Prakash C Mohanty
95	Snehashis Alam	Pondicherry University	Sunanda MV
96	Sona Maria Theresa Nicholas	Sacred Heart College	Prakash C Mohanty
97	Sravya P	Andhra University	Srinivas Rao N
98	Sreehari K	Mangalore University	Prasad SJ
99	Supriyo Ghose	University of Hyderabad	Arnab Mukherjee

100	Susanth K	VRSEC, Vijayawada	Pavan Kumar J
101	Swarna Lakshmi	VRSEC, Vijayawada	Venkat Shesu R
102	Swathi DM	Mangalore University	Prakash C Mohanty
103	Swathi Kumari	TVRSEC, Vijayawada	Udaya Bhaskar TVS
104	Sween Josco	Kerala University of Fisheries and Ocean Studies (KUFOS)	Balakrishnan Nair TM
105	Tasneem AF	VIT Vellore	Kiran Kumar N
106	Tejaswini K	SASTRA University	Venugopala Rao V
107	Uday Kumar P	VITS, Nalgonda	Arun N
108	Vaishnavi N	KLEF, Hydearabd	Venugopala Rao V
109	Vaishnavi W	NIT Rourkela	Francis PA
110	VethaVarshini	VBIT, Hyderabd	Pavan Kumar J
111	Vijayapriya K	Anna University, Chennai	Murty PLN
112	Vikas Kumar	Vellore Institute of Technology	Kiran Kumar N
113	Vinaya Kumari	Mangalore University	Mahendra RS
114	Vineeth Sagar	Jawaharlal Nehru Technological University, Hyderabad	Vighneshwar SP
115	Vishwasena Raidu N	KITS, Warangal	Kiran Kumar N
116	Vyshnavi M	VRSEC, Vijayawada	Venkat Shesu R

12.12 Deputation Abroad

SL No.	Name of the Official (Dr./Mr./Ms.)	Meeting/Conference/Training
1	S.S.C. Shenoi, Director, INCOIS	To attend the 1st Meeting of Panel of Experts to evaluate the proposals received against the call of Belmont Forum for Collaborative Research Action (CRA) on "Transdisciplinary Research for Ocean Sustainability" during 6 May 2019 in Stockholm, Sweden.
		To attend the 52nd Session of the IOC Executive Council on 25th June 2019 and 30th Session of the IOC Assembly, Paris, France during 26th June to 04th July 2019.
		To attend the General Assembly of International Union of Geodesy and Geophysics (IUGG), held at Montreal, Canada during 8-14 July 2019.
		To attend the 51st Session of Intergovernmental Panel on Climate Change (IPCC) at Monaco during September 20 to 23, 2019.
		To attend IOC Officers meeting during 13-14 January 2020 and Executive Planning Group meeting during 15-17, January 2020 UNESCO Headquarters, Paris.

2	T. M. Balakrishnan Nair, Scientist 'G' and Head, ISG	To participate in the Tenth session of the JCOMM Ship Observations Team (SOT-10), at Hong Kong Observatory, Hong Kong, China from 1-4 April 2019.
		To attend the Thirty Fifth Session of the Data Buoy Cooperation Panel (DBCP) at Headquarters of the World Meteorological Organization at Geneva, Switzerland during 14-18 October 2019.
3	E. Pattabhi Rama Rao, Scientist 'F', Head-ODG & TWG	To attend the High Level Conference on Near-Field Tsunamis in the Makran Region held at Muscat, Oman, during 1-2 September 2019.
		To attend the Inter-ICG Task Team on Tsunami Watch Operations meeting and 13th Session of the Working Group on Tsunamis and other hazars related to sea-level warning and mitigations system (TOWS-WG-XIII) at Paris, France, 17-21 February 2020.
4	Sudheer Joseph, Scientist 'F' & Head, CSG	To participation in ETOOFS (JCOMM) meeting proposed to be held at UNESCO Headquarters, Paris, France, during 3-4 February 2020
5	T.V.S. Udaya Bhaskar, Scientist 'F', Head, TPG	To participate in the 20th Meeting of Argo Data Management Team (ADMT-20) held at Villefranche sur mer, France during 13-18 October 2019.
		To participate in workshop on Coordinated Quality Control System for the Historical Subsurface Ocean Temperature (and Salinity) Observations held at Brest, France, during 28 October-1 November 2019.
6	P. A. Francis, Scientist 'F' and Head-MDG	To attend "OCG-10 Regional Workshop- Observations to Services" organized by the IOC-WMO Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM) Observations Coordination Group and the Agency for Meteorology, Climatology and Geophysics of the Republic of Indonesia (BMKG), at Jakarta, Indonesia on 8 April 2019.
7	Hasibur Rahaman, Scientist 'E', CSG	To attend the UN Open-ended informal Consultative Process on Oceans and the Law of the Sea (ICP), USA during 10-14 June 2019.
8	Ch. Patanjali Kumar, Scientist 'E', TWG	To attend the Experts Meeting for 'Establishment of a Regional Working Group and Working Process between North West Indian Ocean Countries on Risk Knowledge' held at Muscat, Oman, during 3-6 September 2019.
9	R. Harikumar, Scientist 'D', ISG	As a faculty for the "International Training course on Basics of Operational Marine Meteorological Forecasting" during 9-13 November 2019 at Tehran, I.R. of Iran.

10	Kunal Chakraborty, Scientist 'D', MDG	To participate in the 4th Global Ocean Acidification Observing Network (GOA-ON) International Workshop on 14-17 April 2019 in Hangzhou, China.
11	Abhisek Chatterjee, Scientist 'D', MDG	To participate in the 9th IICWG-DA Workshop during 17-19, June 2019 at Bremen, Germany.
12	M. Vijaya Sunanda, Scientist 'D', TWG,	To attend the Experts Meeting for 'Establishment of a Regional Working Group and Working Process between North West Indian Ocean Countries on Risk Knowledge' held at Muscat, Oman, during 3-6 September 2019.
13	J. Padmanabham, Scientist 'D', TWG	To attend (i) International Symposium on the Lessons Learnt from the 2018 Tsunamis in Palu and Sunda Strait, and (ii) ICG/ IOTWMS Working Groups and Task Team meetings, during 26 September-2 October 2019 at Jakarta, Indonesia.
14	B. Ajay Kumar, Scientist 'C', TWG	To attend (i) International Symposium on the Lessons Learnt from the 2018 Tsunamis in Palu and Sunda Strait, and (ii) ICG/ IOTWMS Working Groups and Task Team meetings, during 26 September-2 October 2019 at Jakarta, Indonesia.
15	N. Suresh Kumar, Scientist 'D', ODG	To attend the Argo Float Technical Workshop hosted by IFREMER in Brest, France, during 28-30 January 2020.
16	Ravi Kumar Jha, Project Scientist 'B', TPG	To attend a training course on "Discovery and use of Operational Ocean Data and Products and Services" during 22-26 September 2019 at UMT, Malaysia.
17	B. Rohith, Project Scientist 'B', TPG	To attend the 27th IUGG General Assembly, during 8-18 July 2019 at Montreal, Canada.
		To attend the AGU-Ocean Sciences Meeting 2020 at San Diego, CA, USA, During 16-21 February 2020.
18	H. Shiva Kumar, Project Assistant, TWG	To attend IODE-OTGA/INIOAS training course on "Remote Sensing of Coral Reefs" during 20-23 October 2019 at Tehran, I.R of Iran.
19	M. Afroosa Balkies Bai, SRF, MDG	To visit LEGOS Laboratory, France to work with state-of-the-art ocean circulation model, NEMO during 5 January-8 February 2020.
		To attend the AGU-Ocean Sciences Meeting 2020 at San Diego, CA, USA, During 16-21 February 2020.
20	Jofia Joseph, SRF, ODG	To attend the AGU-Ocean Sciences Meeting 2020 at San Diego, CA, USA During 16-21 February 2020.
21	L. Jyothi SRF, CSG	To attend the AGU-Ocean Sciences Meeting 2020 at San Diego, CA, USA, During 16-21 February 2020.

12.13 INCOIS Human Capital

Category/Designation	Regular	Category/ Designation	Project Mode
Scientific Staff			
Director	1	Project Sci - D	1
Scientist 'G'	3*	Project Sci - C	4
Scientist 'F'	5*	Project Sci - B	28
Scientist 'E'	12	Project Assistant	32
Scientist 'D'	12	Admin Assistant/ Office Assistant/ Jr. Office Asst.	11
Scientist 'C'	09 #	Lab Attendants	7
Scientist 'B'	00	Driver-cum-Attendant	4
Scientific Support Staff		Consultants	1
Scientific Assistant B	16	Research Fellows (Ph.D Programme/ Women Scientist/Post Doctoral Fellow)	18
Scientific Assistant A	2 @		
Administrative Support			
Manager	1		
Jt. Manager	2		
Asst. Manager	4		
Sr. Executive	3		
Total:	**70**	**Total:**	**106**

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

Excluding the CAT Trainee appointments; @ one post is vacant due to resignation and recruitment is under process.

13. Acronyms

AAI	Airports Authority of India
ABC	Application of Basic geophysical equations for Calculations
ABIS	Algal Bloom Information System
ADCIRC	Advanced Circulation (Storm surge model)
ADCP	Acoustic Doppler Current Profiler
ADMT	Argo Data Management Team
ADT	Absolute Dynamic Topography
ARGO/Argo	Array for Real-time Geotropic Oceanography
AST	Argo Steering Team
AVHRR	Advanced Very High-Resolution Radiometer
AWS	Automatic Weather Stations
AYUSH	Ministry of Ayurveda, Yoga & Naturopathy, Unani, Siddha and Homoeopathy
BGC	Biogeochemical
BI	Bloom Index
BIO	Biogeochemical State of the Indian Ocean
BoB	Bay of Bengal
BPRs	Bottom Pressure Recorders
BSI	Boat Safety Index
CEC	Cross Equatorial Cell
CFP	Coastal Forecast Points
CFS	Climate Forecast System
Chl-a	Chlorophyll-a
CMFRI	Central Marine Fisheries Research Institute
CMLRE	Centre for Marine Living Resources & Ecology
COMMs	Communications Test
CORE	Coordinated Ocean-ice Reference Experiments
CSG	Ocean -Atmosphere Coupled System Group
CSIR	Council of Scientific & Industrial Research
CTD	Conductivity-Temperature-Depth
CUSAT	Cochin University of Science and Technology
CVC	Central Vigilance Commission
CVO	Central Vigilance Officer
CWG	Computational Facilities, Communications Network and Web Services Group

DDS	Digital Display Systems
DG	Director General
DMG	Data Management Group
DO	Digital Ocean
DSS	Decision Support System
ECMWF	European Centre for Medium-Range Weather Forecasts
EDBs	Electronic Display Boards
EFAS	Ed Fishery Advisory Services
EICC	East India Coastal Current
EIO	Eastern Indian ocean
EnKF	Ensemble Kalman Filter
EQ	Earth Quake
EQUINOO	Equatorial Indian Ocean Oscillation
ESG	Executive Support service Group
ESZ	Earthquake Source Zones
FORV	Fisheries Ocean Research Vessel
FRV	Fishery Research Vessel
FSI	Fishery Survey of India
FTP	File Transfer Protocol
FY	Financial Year
GAGAN	GPS Aided Geo Augmented Navigation
GB	Governing Board
GC	Governing Council
GEMINI	GAGAN Enabled Mariner's Instrument for Navigation and Information
GFS	Global Forecast System
GNSS	Global Navigation Satellite System
GODAE	Global Ocean Data Assimilation Experiment
GODAS	Global Ocean Data Assimilation System
GOOS	Global Ocean Observation System
GOVST	GODAE Ocean View Science Team
GPRS	General Packet Radio Service
GSI	Geological Survey of India
GTS	Global Telecommunication System
HF	High Frequency
HF RADAR	High Frequency RAdio Detection And Ranging
HOOFS	High Resolution Operational Ocean Re-Analysis and Forecast System
HPC	High Performance Computer

HWRF	Hurricane Weather Research and Forecast
HYCOM	Hybrid Coordinate Ocean Model
IIOE-2	International Indian Ocean Expedition-2
IISF	India International Science Festival
IITM	Indian Institute of Tropical Meteorology
IMD	Indian Meteorological Department
INCOIS	Indian National Centre for Ocean Information Services
IndOOS	Indian Ocean Observing System
IOC	Intergovernmental Oceanographic Commission
IODE	International Oceanographic Data Exchange
IOGOOS	Indian Ocean Global Ocean Observing System
IOTR	Indian Ocean Tsunami Ready
IOTWMS	Indian Ocean Tsunami Warning and Mitigation System
IOTWS	Indian Ocean Tsunami Warning System
ISG	Ocean Information and Forecast Services Group
ITEWC	Indian Tsunami Early Warning Centre
IUGG	International Union for Geophysics and Geodesy
JCOMM	Joint Technical Commission for Oceanography and Marine Meteorology
JPO	Joint Programme Office
JRF	Junior Research Fellow
KUFOS	Kerala University of Fisheries and Ocean Studies
LDCL	Lakshadweep Development Corporation
LETKF	Local Ensemble Transform Kalman Filter
LPS	Low Pressure System
LTA	Long Term Average
LW	Long Wave
MaMeAT	Marine Meteorological Atlas
MDG	Ocean Modeling and Data Assimilation Group
METOP	Meteorological OPerational
MFAS	Marine Fisheries Advisory Services
MODISA	Moderate Imaging Spectroradiometer-Aqua
MoES	Ministry of Earth Sciences
MOM	Modular Ocean Model
MOSAIC	Marine Observation System Along the Indian Coast
MW	Medium Wave
NCCR	National Centre for Coastal Research, Chennai
NCEP	National Centers for Environmental Prediction

NCESS	National Centre for Earth Science Studies
NCMRWF	National Centre for Medium Range Weather Forecasting
NCPOR	National Centre for Polar and Ocean Research
NCS	National Centre for Seismology
NDBC	National Data Buoy Center
NDBP	National Data Buoy Programme
NDMA	National Disaster Management Authority
NDRF	National Disaster Response Force
NetCDF	Network Common Data Form
NFDB	National Fisheries Development Board
NGO	Non-Governmental Organisation
NGRI	National Geophysical Research Institute
NHO	National Hydrographic Office
NIO	National Institute of Oceanography
NIOT	National Institute of Ocean Technology
NMSRB	National Maritime Search and Rescue Board
NOAA	National Oceanic and Atmospheric Administration
NODC	National Oceanographic Data Centre
OBIS	Ocean Biogeographic Information System
OCM-2	Ocean Colour Monitor-2
ODG	Ocean Observations and Data Management Group
PFZ	Potential Fishing Zones
POGO	Partnership for Observation of Global Ocean
PTHA	Probabilistic Tsunami Hazard Assessment
RAIN	Regional Analysis of Indian OceaN
RIMES	Regional Integrated Multi-hazard Early warning System
ROMS	Regional Ocean Modelling System
SARAT	Search And Rescue Aid Tool
SIBER	Sustained Indian Ocean Biogeochemistry and Ecosystem Research
SOP	Standard Operating Procedure
SoVeAt	Sound Velocity Atlas
SRTMU	Swami Ramanand Teerth Marathwada University
SST	Sea Surface Temperature
SVAS	Small Vessel Advisory and Forecast Service
SWAN	Simulating WAves Nearshore
TPG	Training and Programme Planning and Management Group
TSP	Tsunami Service Provider

TWAD	Tsunami World Awareness Day
TWG	Tsunami and Storm Surge Early Warning Services Group
UCDI	Union Commission for Data and Information
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
VIIRS	Visible Infrared Imager Radiometer Suite
WEIO	Western Equatorial Indian Ocean
WHOI	Woods Hole Oceanographic Institute
WICC	West India Coastal Current
WMO	World Meteorological Organisation
WRB	Wave Rider Buoy
XBT	Expendable Bathy Thermograph
XCTD	Expendable CTD

14. Finance

Chartered Accountants
PPKG & Co

Batgach & AFFILIATES
A NETWORK APPROVED BY ICAI

AUDITORS' REPORT

To

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

We have audited the attached Balance Sheet of **The INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES** as at 31st March 2020, 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 Notes forming part of Accounts, the Balance Sheet as at 31st March 2020, 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 **PPKG & CO**
Chartered Accountants

PPKG & CO. CHARTERED ACCOUNTANTS

(Giridhari Toshniwal)
Partner
M.No.: 205140
FRN No.: 0099665S

Date: 06-08-2020
Place: Hyderabad
UDIN: 20205140AAAAEQ6814

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 2020

Particulars	Schedules	Current Year (2019-20) ₹	Previous Year (2018-19) ₹
CAPITAL & LIABILITIES			
Corpus fund	1	16,69,53,884	18,93,84,127
Earmarked funds	2	22,62,76,901	(4,59,66,254)
Current liabilities & Provisions	3	16,94,35,304	20,88,79,932
Total		**56,26,66,089**	**35,22,97,805**
ASSETS			
Fixed Assets	4	2,75,37,317	3,85,17,896
Current Assets, Loans & Advances	5	53,51,28,772	31,37,79,909
Total		**56,26,66,089**	**35,22,97,805**
Notes forming part of Accounts	11		

As per our report of even date

For PPKG & Co.

Chartered Accountants

Giridhari Toshniwal

Partner

M. No. 205140

FRN No: 009655S

Place: Hyderabad

Date: 06.08.2020

For and on behalf of

INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES

(S. Nageswara Rao)

Sr. Accounts Officer

S. Nageswara Rao
Senior Accounts Officer

(T.M. Balakrishnan Nair)

Director – I/C

Dr. T.M. Balakrishnan Nair
I/C - Director, INCOIS

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 2020

Particulars	Schedules	Current Year (2019-20) ₹	Previous Year (2018-19) ₹
INCOME			
Income from Sales / Other Income	6	83,49,056	58,37,681
Interest Earned on Investments	7	32,29,306	15,74,907
Recurring Grants	8	21,80,00,000	25,00,00,000
TOTAL - A		**22,95,78,362**	**25,74,12,588**
EXPENDITURE			
Establishment Expenditure	9	13,17,10,821	11,81,69,954
Other Administrative Expenses	10	10,75,33,088	10,30,29,511
Depreciation	4	1,27,64,696	99,71,931
TOTAL - B		**25,20,08,605**	**23,11,71,396**
Excess of Income over expenditure (A-B)	1	**-2,24,30,243**	**2,62,41,192**
Add / Less: Prior Period Items		-	-
Balance being net income / deficit transferred to Corpus Fund		**-2,24,30,243**	**2,62,41,192**
Notes forming part of Accounts	11		

As per our report of even date

For PPKG & Co.

Chartered Accountants

Giridhari Toshniwal

Partner

M. No. 205140

FRN No: 009655S

Place: Hyderabad

Date: 06.08.2020

For and on behalf of

INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES

(S. Nageswara Rao)

Sr. Accounts Officer

S. Nageswara Rao

Senior Accounts Officer

(T.M. Balakrishnan Nair)

Director – I/C

Dr. T.M. Balakrishnan Nair

I/C - Director, INCOIS

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 2020

RECEIPTS	CURRENT YEAR 2019-20		PAYMENTS	CURRENT YEAR 2019-20	
	₹	₹		₹	₹
Opening Balance			**Establishment Expenses**		
INCOIS Current A/c-SBI-HAL Campus Br.	9,41,50,483		Pay, Leave Salary Allowace	10,68,87,758	
AB Savings A/c	29,61,504		NPS & CPF	76,54,004	
AB Consultancy A/c	23,06,178		Staff Welfare (Medical IP & OP)	17,43,220	
Short Term Deposits with Bank	14,85,00,000		Leave Travel Concession Expenses	17,46,617	**11,80,31,599**
Andhra Bank PORSEC 2012 Savings Bank Account	19,942				
INCOIS IGOOS Secretariat- Local	7,48,706		**Administrative Expenses**		
INCOIS IGOOS Secretariat- Foreign	21,59,341		EL encashment during LTC	3,67,283	
INCOIS-CPF Account	72,44,223		Children Education Allowance	13,81,500	
INCOIS-IDBPS Account	1,06,999		Travel Expenses - Inland	4,26,080	
INCOIS-ISPRS	3,11,049		Foreign	10,60,420	
AB PORSEC-Deposit	29,00,000		Others	20,651	
CPF STDRs	1,10,00,000	**27,24,08,425**	Telephone & Fax Expenditure	5,15,217	
			Postage & Telegraphs	66,961	
Margin Money TDR Received			Printing & Stationery	9,50,555	
HROOF	4,51,95,279		Honorarium to External Experts	84,000	
Monsoon Mission	13,21,912		Advertisement & Publicity	18,74,055	
Ocean Observation Network	26,53,424	**4,91,70,615**	Subscription to Newspapers/Journals	15,986	
			Seminar, Conference & Workshop Expenses	27,07,552	
Earmarked Funds			Audit Fee	23,600	
Ocean Information and Advisory Services(O-IAS)	23,00,00,000		Office Expenses	82,32,233	
Ocean Observation Systems (OOS)	20,00,00,000		General Expenses	4,81,991	
Costal Monitoring of INCOIS	17,27,50,000		International Interface	15,35,557	**1,97,43,641**
Deep Ocean Mission	4,00,00,000				
O-MASCOT	1,00,00,000				

IIOE-2	36,94,000		**Operation & Maintenance**		
Phase-II	4,42,95,000	**70,07,39,000**	Vehicle Hiring	17,52,333	
			House Keeping, Plumbing & Garden Expenses	1,20,22,420	
			Security Expenses	2,34,68,375	
Recurring Grants	21,80,00,000	**21,80,00,000**	Water Expenses	42,85,120	
			Civil Services	-	
Other Receipts:			Electricity Expenditure	2,84,08,501	
Consultancy Projects:			Pest Control Expenses	1,37,672	
FUGRO SURVEY INDIA	5,900		Maintenance & Repairs	1,75,03,625	
HCC-HDC JV	1,77,120		Material Consumable	3,90,892	
RKEC Projects	38,880		Emoluments to Consultants	7,67,643	
INCAP - DEPARTMENT OF PORTS	5,30,000		Air & Electrical Expenses	-	
INTERNATIONAL SEAPORT DREDGING	71,920		Payment of GSLIS to Dr. SSC Shenoi	69,062	
MAHARASHTRA MARITIME BOARD	11,27,840		Expenditure of ICG/IOTWS	8,45,687	
OCEAN SPARKLE LIMITED	35,640		Refund of unspent balance to ICG/IOTWS	47,710	
ONGC	14,66,676		Bank charges	1,496	**8,97,00,536**
PXE	3,00,000	**37,53,976**	Sponsorship of TA/DA reimbursement		
Other Receipts:					
Interest on Short Term Deposits	1,16,41,763				
Interest on IOGOOS Foreign A/c	75,289				
Interest on IOGOOS Local A/c	26,052				
Interest on AB Savings A/c	1,83,651		PF transfer to Dr. TVS Uday Bhaskar	2,50,000	
Interest on AB Consultancy A/c	1,14,024		PF transfer to Dr. SSC Shenoi	35,00,000	**37,50,000**
Interest on SBI CPF A/c	2,59,183				
Interest on IDBPS	3,656				
Interest earned on ACD-TSSPDCL	4,21,138				
Interest on Vehicle Advance	93,000				
Earnest Money Deposits	3,60,06,286				
Security Deposits	21,62,134				
Sale of Vehicle	3,79,485		POGO Membership fees	80,952	
Income from MP Hall	5,214		IOGOOS Contribution	36,925	**1,17,877**
Income from Tender Sales	500				
Income from Guest House	9,28,900				
RTI Fee	30				

Vehicle Advance to Employees (Recovery)	12,000				
Fee from training courses	2,43,500				
TA/LTC Refund received	1,37,293				
Devipriya Loss of pay recovered	18,318	**5,27,11,416**			
			Expenditure towards UNESCO/OTGA/IOC	44,81,785	
Funds received from IOGOOS Member Countries	3,41,432		Refund to UNESCO/OTGA/IOC	2,00,786	**46,82,571**
Amount received from UNESCO/OTGA/IOC	8,93,397				
Amount Received from UNESCO (ICG/IOTWS)	46,82,571	**59,17,400**			
Contribution received to CPF A/c	37,87,810				
CPF contribution received from Dr. M. Ravichandran	2,60,320		**Payments Against Earmarked Funds**		
CPF contribution received from Dr. T. Srinivasa Kumar	2,21,846		**Construction of New Building (Phase II)**		
Received from LIC- GSLIS of Dr. S.S.C Shenoi	69,062	**43,39,038**			
			Construction buildings		
			Refund of Encashed BG of Unity		
Unspent Balances received from Sub Projects:					
			OASIS		
Ocean State Forecast	1,42,744		Equipments	1,13,96,484	
HROOF	2,47,789		Hardware/Software	59,76,676	
Tsunami	46,72,079		Technical Support	4,32,48,903	
SATCORE	12,710		Administrative Expenses	4,33,40,067	
Ocean Observation Network	17,28,819	**68,04,141**	Travel	24,22,824	
			Consumable Material / Data	51,24,732	
			Advance against subprojects	-	
Grant received for Research Fellows:			Advance for Purchase	-	
Science & Engineering Research Board (SERB)	3,61,072		Depository Work (APWD)	96,58,404	
Inspire	25,64,169		Margin Money against LC	-	
National Post Doctoral Fellow	11,32,566	**40,57,807**	Interest Refunded	14,43,803	
			Other Assets	1,14,83,277	**13,40,95,172**

Amount received towards closure of Accounts to INCOIS Current Account					
ISPRS	9,711		**Ocean Observation Networks - OON**		
PORSEC Account	1,88,859	**1,98,570**	Technical Support	1,08,98,188	
			Administrative Expenses	1,71,08,075	
			Equipment	2,64,17,930	
IT Refund received	66,65,380	**66,65,380**	Travel	4,41,185	
			Consumable Material / Data	1,39,81,637	
Salary reimbursement from NCESS	1,28,80,221	**1,28,80,221**	Advance for Purchase	8,29,85,039	
			Margin Money against LC	-	
Refund of journals	5,596	**5,596**	Interest Refunded	9,87,712	
			Other Assets	6,45,919	**15,34,65,685**
Transfer of expenditure of Project Phase-II to INOPER1001 i/c with M/s Jangaiah works contract	18,71,288	**18,71,288**			
			Satellite Coastal and Oceanographic Research		
APWD (Depository Work)	72,53,876	**72,53,876**	Equipment	3,90,259	
			Adminisrtrative expenses	1,17,89,061	
			Travel	21,06,402	
			Advance against subprojects	70,48,839	
			Margin Money against LC	1,18,00,000	
			Interest Refunded	1,29,134	**3,32,63,695**
			International Training Centre (ITCOocean)		
			Technical support	29,50,000	
			Administrative Expenses	70,76,836	
			Travel	33,57,846	
			Consumable Materials / Data	4,59,813	
			Depository Work (RITES)	1,50,12,349	
			Margin Money against LC	21,00,000	

			Interest Refunded	32,70,036	
			Equipments	2,09,33,800	
			Computers / Software	49,95,102	**6,01,55,782**
			O-MASCOT		
			Technical support	7,91,850	
			Adminisrtrative expenses	1,25,43,162	
			Travel	75,58,586	
			Consumable Materials / Data	14,92,696	
			Advance against subprojects	15,61,333	
			Advance for Purchase	5,77,41,507	
			Interest Refunded	34,94,442	**8,51,83,576**
			IT & E Governance Fund		
			Interest Refunded	19,22,277	**19,22,277**
			V Sat Terrestrial Link		
			Adminisrtrative expenses	21,772	**21,772**
			Multi Hazard Vulnerability		
			Technical support	-	
			Interest Refunded	12,463	**12,463**
			Monsoon Mission		
			Technical support	1,180	
			Adminisrtrative expenses	16,47,531	
			Advance for Purchase	2,31,59,475	**2,48,08,186**

			RIMES Afro Asian Region		
			Computers / Software	1,60,65,886	
			Other Assets	1,50,63,451	
			Technical support	7,42,98,292	
			Adminisrtrative expenses	52,77,548	
			Travel	3,73,679	
			Advance for Purchase	40,33,116	
			Interest Refunded	2,19,640	**11,53,31,612**
			CSS		
			Equipments		
			Consumable Materials / Data		
			IIOE2		
			Adminisrtrative expenses	1,59,713	
			Travel	13,48,589	
			Interest Refunded	56,693	**15,64,995**
			Expenditure on Fixed Assets		
			Plant & Machinery	6,71,937	
			Office Equipment	-	
			Library Books	43,699	
			Vehicles	13,31,497	**20,47,133**
			Other Payments		
			Refund of Earnest Money Deposit	75,35,517	

			Security Deposits	19,74,438	
			Inspire Fellowship (Regn. Fee, travel etc.)	20,93,880	
			LTC Advance	4,74,000	**1,20,77,835**
			Closing Balance		
			INCOIS Current A/c-SBI-HAL Campus Br.	3,67,23,541	
			INCOIS SBI GEM POOL A/C	-	
			AB Savings A/c	67,71,226	
			AB Consultancy A/c	55,18,087	
			Short Term Deposits with Bank	41,58,00,000	
			INCOIS IGOOS Secretariat- Local	8,64,570	
			INCOIS IGOOS Secretariat- Foreign	24,71,049	
			INCOIS- CPF Account	75,41,216	
			INCOIS- IDBPS Account	1,10,655	
			CPF STDRs	1,10,00,000	**48,68,00,343**
Total	**1,34,67,76,749**	**1,34,67,76,749**	**Total**	**1,34,67,76,749**	**1,34,67,76,749**

As per our report of even date
For PPKG & Co.
Chartered Accountants

Giridhari lal Toshniwal
Partner
M. No. 205140
FRN No: 009655S

Place: Hyderabad
Date: 06.08.2020

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

(S. Nageswara Rao)
Sr. Accounts Officer
S. Nageswara Rao
Senior Accounts Officer

(T.M. Balakrishnan Nair)
Director – I/C
Dr. T.M. Balakrishnan Nair
I/C - Director, INCOIS

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 2020

SCHEDULE 1 – CORPUS FUND

Particulars	Current Year (2019-20) ₹	Previous Year (2018-19) ₹
Corpus Fund at the beginning of the year	18,93,84,127	16,31,42,934
Add: Net income transferred from Income & Expenditure Account	-2,24,30,243	2,62,41,193
BALANCE AS AT THE YEAR END	**16,69,53,884**	**18,93,84,127**

As per our report of even date

For PPKG & Co.

Chartered Accountants

Giridhari Toshniwal

Partner

M. No. 205140

FRN No: 009655S

Place: Hyderabad

Date: 06.08.2020

For and on behalf of

INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES

(S. Nageswara Rao)

Sr. Accounts Officer

S. Nageswara Rao
Senior Accounts Officer

07/08/2020

(T.M. Balakrishnan Nair)

Director – I/C

Dr. T.M. Balakrishnan Nair
I/C - Director, INCOIS

INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES

SCHEDULE 2 - EARMARKED FUNDS

(Amount in ₹)

Particulars	FUND-WISE BREAK UP															TOTALS	
	Building Fund	OASIS	Ocean Observation Networks	SATCORE / CMI	ITCOO	O-MASCOT	IT & E Governance Fund	V SAT Node	MH Vulnerability	Monsoon Mission	RIMES	CSS	IIOE2	NCS	Deep Ocean Mission	Current Year 2019-20	Previous Year 2018-19
a) Opening balance of the funds	-4,58,11,401	-14,36,26,742	-7,00,64,654	36,25,134	9,14,25,465	5,08,78,483	19,22,277	62,55,840	8,66,032	4,36,10,182	1,22,54,038	5,49,274	15,64,995	5,84,823	-	-4,59,66,254	-2,22,49,991
b) Additions to the Funds:																	
i. Grants	4,42,95,000	23,00,00,000	20,00,00,000	17,27,50,000	-	1,00,00,000	-	-	-	-	-	-	36,94,000		4,00,00,000	70,07,39,000	88,46,74,000
ii. Interest if any	-	61,370	72,709	85,40,303	54,81,740	24,49,570	-	3,77,588	52,896	16,87,608	6,93,500	33,163	69,773	35,311	8,05,003	2,03,60,534	1,55,77,121
iii. Advance for sub projects utilised/ refund	-	3,49,99,285	2,10,67,243	-	-	-	-	-	-	-	11,10,78,856	-	-	-	-	16,71,45,384	4,52,448
iv. Advance for purchase Utilised	-	27,63,080	1,18,87,532	-	29,16,678	-	-	-	4,23,93,750	-	-	-	-	-	-	5,99,61,040	1,04,93,455
v. Margin Money Reversed	-	-	26,00,000	-	-	3,50,00,000	-	-	-	13,10,000	-	-	-	-	-	3,89,10,000	59,36,000
vi. Deposit Advance Utilized/refund	-	72,53,876	-	-	-	-	-	-	-	-	-	-	-	-	-	72,53,876	1,62,40,699
vii. Mobilization Advance Reversed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-
viii. Other Revenue	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	1,56,35,420
ix. BG encashment	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-
TOTAL (a+b) - A	**(15,16,401)**	**13,14,50,869**	**16,55,62,830**	**18,49,15,437**	**9,98,23,883**	**9,83,28,053**	**19,22,277**	**66,33,428**	**4,33,12,678**	**4,66,07,790**	**12,40,26,394**	**5,82,437**	**53,28,768**	**6,20,134**	**4,08,05,003**	**94,84,03,580**	**92,67,59,152**
c) Utilisation/Expenditure																	
i. Capital Expenditure																	-
W.I.P	(18,71,288)	95,95,312	-	-	2,99,87,651	-	-	-	-	-	-	-	-	-	-	3,77,11,675	19,71,79,835
Architect fee	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-
Equipments	-	1,13,96,484	2,64,17,930	3,90,259	2,09,33,800	5,27,793	-	-	-	-	-	-	-	-	-	5,96,66,266	1,11,58,760
Computers / Software	-	59,76,676	-	-	49,95,102	-	-	-	-	-	1,60,65,886	-	-	-	-	2,70,37,664	13,53,38,885
Other Assets	-	1,14,83,277	1,25,28,422	-	-	-	-	-	-	-	1,50,63,451	-	-	-	-	3,90,75,150	-
							-	-	-	-	-	-	-	-	-	0	
Total	**(18,71,288)**	**3,84,51,750**	**3,89,46,352**	**3,90,259**	**5,59,16,553**	**5,27,793**	**-**	**-**	**-**	**-**	**3,11,29,337**	**-**	**-**	**-**	**-**	**16,34,90,756**	**34,36,77,480**
ii. Revenue Expenditure																	
Technical support	-	4,32,48,903	1,08,98,188	-	29,50,000	7,91,850	-	-	4,22,13,750	1,180	7,42,98,292	-	-	-	-	17,44,02,163	7,13,11,699
Adminisrtrative expenses	-	5,42,90,106	2,38,75,802	1,17,89,061	70,79,805	1,25,43,162	-	21,772	-	16,47,531	52,77,548	-	1,59,713	-	-	11,66,84,501	7,11,49,560
Travel	-	24,22,824	4,41,185	21,06,402	33,73,726	75,58,586	-	-	-	-	3,73,679	-	13,48,589	-	-	1,76,24,991	1,42,86,196
Consumable Materials / Data	-	51,24,732	1,39,81,637	-	4,59,813	14,92,696	-	-	-	-	-	-	-	-	-	2,10,58,878	7,16,63,295
								-	-	-	-	-	-	-	-	0	-
Total	**-**	**10,50,86,566**	**4,91,96,812**	**1,38,95,463**	**1,38,63,344**	**2,23,86,294**	**-**	**21,772**	**4,22,13,750**	**16,48,711**	**7,99,49,519**	**-**	**15,08,302**	**-**	**-**	**32,97,70,533**	**22,84,10,749**
iii. Others																	
Advance against subprojects	-	-	-	70,48,839	-	15,61,333	-	-	-	-	-	-	-	-	-	86,10,172	4,39,05,773
Advance for Purchase	-	-	9,48,72,571	-	-	5,77,41,507	-	-	-	2,31,59,475	40,33,116	-	-	-	-	17,98,06,669	27,74,50,667
Deposit Works (APWD & RITES)	-	-	-	-	1,50,12,349	-	-	-	-	-	-	-	-	-	-	1,50,12,349	32,00,737
Margin Money against LC	-	-	-	1,18,00,000	21,00,000	-	-	-	-	-	-	-	-	-	-	1,39,00,000	4,34,80,000
Refund of Encashed BG of Unity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	3,26,00,000
Total	**-**	**-**	**9,48,72,571**	**1,88,48,839**	**1,71,12,349**	**5,93,02,840**	**-**	**-**	**-**	**2,31,59,475**	**40,33,116**	**-**	**-**	**-**	**-**	**21,73,29,190**	**40,06,37,177**
TOTAL (i+ii+iii) - B	**(18,71,288)**	**14,35,38,316**	**18,30,15,735**	**3,31,34,561**	**8,68,92,246**	**8,22,16,927**	**-**	**21,772**	**4,22,13,750**	**2,48,08,186**	**11,51,11,972**	**-**	**15,08,302**	**-**	**-**	**71,05,90,478**	**97,27,25,406**
Amount Refunded- C (Interest Refunded)		**14,43,803**	**9,87,712**	**1,29,134**	**32,70,036**	**34,94,442**	**19,22,277**	**-**	**12,463**	**-**	**2,19,640**	**-**	**56,693**	**-**	**-**	**1,15,36,200**	**-**
NET BALANCE AS AT THE PERIOD END {A -(B+C)}	**3,54,887**	**-1,35,31,249**	**-1,84,40,617**	**15,16,51,742**	**96,61,601**	**1,26,16,683**	**0**	**66,11,656**	**10,86,465**	**2,17,99,604**	**86,94,782**	**5,82,437**	**37,63,773**	**6,20,134**	**4,08,05,003**	**22,62,76,901**	**-4,59,66,254**

INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES

SCHEDULE - 3 CURRENT LIABILITIES & PROVISIONS

Particulars	Current Year (2019-20) ₹	Previous Year (2018-19) ₹
A. CURRENT LIABILITIES		
Earnest Money Deposit	54,48,113	62,83,733
Security Deposit	1,26,70,347	1,06,95,909
Outstanding Expenses	1,97,13,842	1,95,04,058
Sundry Creditors	2,91,72,375	8,85,60,182
INSPIRE/DISHA/RTF-DCS Fellowship	15,92,595	(9,13,506)
Other bank Liability	2,16,03,837	2,15,82,223
Total – A	**9,02,01,109**	**14,57,12,599**
B. PROVISIONS		
Gratuity	3,96,24,585	3,13,65,335
Accumulated Leave Encashment	3,96,09,610	3,18,01,998
Total – B	**7,92,34,195**	**6,31,67,333**
Total (A+B)	**16,94,35,304**	**20,88,79,932**

INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES

SCHEDULE – 4 FIXED ASSETS **(Amount in ₹)**

Description (% of Depreciation)	Gross Block				Depreciation				Net Block	
	As at 31.03.2019	Additions During The Year	Sale Value	As at 31.03.2020	As at 31.03.2019	For the Year 2019-20	As at 31.03.2020	Profit/loss sale of Fixed Asset	As at 31.03.2020	As at 31.03.2019
1. Land (0%)	1,000	-	-	1,000	-	-	-	-	1,000	1,000
2. Plant, Machinery & Equipment (15%)	4,55,27,620	6,71,937	-	4,61,99,557	4,48,58,782	1,76,148	4,50,34,931	-	11,64,627	6,68,838
3. Furniture & Fixtures (10%)	1,72,67,084	-	-	1,72,67,084	1,25,62,911	4,70,417	1,30,33,329	-	42,33,755	47,04,173
4. Office Equipment (15%)	34,52,865	-	-	34,52,865	27,91,146	99,258	28,90,404	-	5,62,461	6,61,719
5. Computer / Peripheral (40%)	12,90,17,761	-	-	12,90,17,761	12,02,71,319	34,98,577	12,37,69,896	-	52,47,865	87,46,442
6. Electric Installations (10%)	20,98,406	-	-	20,98,406	14,23,448	67,496	14,90,944	-	6,07,462	6,74,958
7. Library Books (40%)	8,38,27,535	43,699	-	8,38,71,234	6,45,63,798	77,22,974	7,22,86,772	-	1,15,84,462	1,92,63,737
8. Other Fixed Assets (15%)	70,47,041	-	-	70,47,041	42,14,580	4,24,869	46,39,449	-	24,07,592	28,32,461
Vehicles (existing) (15%)	8,92,277	13,31,497	-	22,23,774	1,90,724	3,04,957	4,95,682	-	17,28,092	7,01,553
9. Vehicles (sold) (15%)	18,49,835	-	4,19,674	14,30,161	15,86,819	-	15,86,819	1,56,658	-	2,63,016
Total	**29,09,81,424**	**17,14,230**	**4,19,674**	**29,26,08,883**	**25,24,63,528**	**1,27,64,697**	**26,52,28,225**	**1,56,658**	**2,75,37,316**	**3,85,17,896**
Previous Year	28,35,14,457	74,66,967	-	29,09,81,424	24,24,91,597	99,71,931	25,24,63,527	-	3,85,17,896	4,10,22,860

INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES

Schedule 4A - Earmarked Fixed Assets

	Description of the Assets	Gross Block					Depreciation				Net Block	
Sl. No	Name of the Fund/Project	As on 01-04-2019	Additions 2019-20	Grant Utilized/ Received till 31-3-20 (G/A -Gen/ Capital)	Total Amount as on 31-03-2020	As on 31.03.2019	For the Year 2019-20	Diff. of Previous Years Dep.	Total Depreciation for the year	As at 31.03.2020	As at 31.03.2020	As at 31.03.2019
i)	Building Fund	63,43,79,727	-18,71,288	63,25,08,439	1,26,50,16,878	-	-	-	-	-	-	-
ii)	MDC & Equipment Fund	6,59,21,618	-	6,59,21,618	13,18,43,236	-	-	-	-	-	-	-
iii)	Ocean Information and Advisory Services (OASIS)	1,72,98,87,955	3,84,51,750	1,76,83,39,705	3,53,66,79,410	-	-	-	-	-	-	-
iv)	Computational Facilities	15,28,06,467	-	15,28,06,467	30,56,12,934	-	-	-	-	-	-	-
v)	INDOMOD & SATCORE Projects	42,72,64,846	-	42,72,64,846	85,45,29,692	-	-	-	-	-	-	-
vi)	Ocean Observation Networks	59,79,01,603	3,89,46,352	63,68,47,955	1,27,36,95,910	-	-	-	-	-	-	-
vii)	International Training Center-ITCOocean	54,87,03,362	5,59,16,553	60,46,19,915	1,20,92,39,830	-	-	-	-	-	-	-
viii)	O-MASCOT (HROOFS)	1,99,42,324	5,27,793	2,04,70,117	4,09,40,234	-	-	-	-	-	-	-
ix)	IT & E Governance Fund	5,88,34,380	-	5,88,34,380	-	-	-	-	-	-	-	-
x)	HPC Systems - Others	1,33,61,57,396	-	1,33,61,57,396	2,67,23,14,792	-	-	-	-	-	-	-
xi)	CSS	14,37,371	-	14,37,371	-	-	-	-	-	-	-	-
xii)	V SAT Node	13,31,28,616	-	13,31,28,616	26,62,57,232	-	-	-	-	-	-	-
xiii)	Ernet India	72,00,000	-	72,00,000	1,44,00,000	-	-	-	-	-	-	-
xiv)	IOAS	51,25,986	-	51,25,986	1,02,51,972	-	-	-	-	-	-	-
xv)	MH Vulnerability	28,30,738	-	28,30,738	56,61,476	-	-	-	-	-	-	-
xvi)	Monsoon Mission	3,63,58,018	-	3,63,58,018	7,27,16,036	-	-	-	-	-	-	-
xvii)	RIMES	62,46,188	3,11,29,337	3,73,75,525	7,47,51,050	-	-	-	-	-	-	-
xviii)	Coastal Monitoring (CMI/ SATCORE)	-	3,90,259	3,90,259	7,80,518	-	-	-	-	-	-	-
	Total	**5,76,41,26,595**	**16,34,90,756**	**5,92,76,17,351**	**11,73,46,91,200**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
	Previous year	**5,23,60,38,838**	**32,08,24,717**	**-5,55,68,63,555**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
	GRAND TOTAL	**6,05,51,08,019**	**16,55,37,889**	**5,92,71,97,677**	**11,44,20,82,317**	**-25,24,63,528**	**-1,27,64,697**	**-26,52,28,225**	**-1,56,658**	**-2,75,37,316**	**-3,85,17,896**	**-**
	GRAND TOTAL (PREVIOUS YEAR)	**5,51,95,53,295**	**32,82,91,684**	**-5,55,68,63,555**	**-29,09,81,424**	**-24,24,91,597**	**-99,71,931**	**-25,24,63,528**	**-**	**-3,85,17,896**	**-4,10,22,860**	

*For S.No.i - Building Fund - Upon obtaining the necessary approvals of APEX Bodies, Management has transferred an amount of Rs.18,71,288/- being the repainting work transferred to INCOIS Society Account.

INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES

SCHEDULE 5 - CURRENT ASSETS, LOANS & ADVANCES

Particulars	Current Year (2019-20) ₹		Previous Year (2018-19) ₹	
A. CURRENT ASSETS				
1. Inventories (Valued at cost)	23,30,633	23,30,633	5,65,132	5,65,132
2. Cash & Bank Balance :				
a) With Scheduled Banks – Current Account				
State Bank of India HAL CAMPUS A/c	3,67,23,541		9,14,99,176	
Andhra Bank Pragathinagar SAVINGS A/c	62,83,365		29,63,131	
Andhra Bank Pragathinagar - Consultancy A/c	55,17,551		23,06,529	
Andhra Bank Savings PORSEC - A/c	-		19,942	
State Bank of India - CPF A/c	75,41,216		72,44,233	
State Bank of India - ISPRS A/c	-		3,11,049	
State Bank of India - IDBPS 4095 A/c	1,10,655	5,61,76,328	1,06,999	10,44,51,059
b) Short Term Deposits with SBI			14,85,00,000	
c) Short Term Deposits with CPF	41,58,00,000		1,10,00,000	
d) Short Term Deposits with PORSEC	1,10,00,000		29,00,000	
e) Short Term Deposits with AB		42,68,00,000	-	16,24,00,000
TOTAL A:		**48,53,06,962**		**26,74,16,191**
B. LOANS, ADVANCES & OTHER ASSETS				
1. Deposits				
a) Telephone	1,73,186		1,73,186	
b) Electricity	70,16,374		70,16,374	
c) Gas	13,100		13,100	
d) Petrol/Diesel	1,01,400	73,04,060	1,01,400	73,04,060
2. Advances & other amounts recoverable in cash or in kind or for value to be received				
a) Vehicle Advance to Employees	72,668		84,668	
b) Interest Accrued	2,59,69,555		1,58,14,255	
c) Other Advances	31,280		-	

d) Advance for Purchase		-		21,44,317	
e) Sundry Debtors		21,41,894		7,32,813	
f) Tour Advance		1,78,369		29,56,981	
g) LTC Advance		-		4,74,000	
h) TDS					
Opening Balance -	Rs.1,34,39,459				
Less: Refund received during the year	Rs.40,98,908				
Add: Current year accumulation	Rs.13,70,268				
Less: TDS Adjustment Entry	Rs.0.00	1,07,10,819		1,34,39,459	
i) Margin Money against Bank Guarantee		34,13,165	4,25,17,750	34,13,165	3,90,59,658
TOTAL B: (1+2)			**4,98,21,810**		**4,63,63,718**
GRAND TOTAL (A + B)			**53,51,28,772**		**31,37,79,909**

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SCHEDULE 6 - INCOME FROM SALES / OTHER INCOME

Particulars	Current Year (2019-20) ₹	Previous Year (2018-19) ₹
a) Sale of Tender Forms	0.00	1,500
b) Other Receipts	33,10,936	16,58,189
c) Consultancy Services	38,08,473	34,94,835
d) Income from staff quarters	12,29,647	6,83,157
TOTAL	**83,49,056**	**58,37,681**

SCHEDULE 7 - INTEREST EARNED		
a) Interest on Short Term Deposits & Others	19,65,271	14,39,227
b) Bank Accounts	11,71,035	1,25,311
c) Staff Advances	93,000	10,369
TOTAL	**32,29,306**	**15,74,907**

SCHEDULE 8 - IRRECOVERABLE GRANTS & SUBSIDIES RECEIVED		
a) Central Government (Recurring Grant received from MoES)	21,80,00,000	25,00,00,000
TOTAL	**21,80,00,000**	**25,00,00,000**

SCHEDULE 9 - ESTABLISHMENT EXPENDITURE		
a) Salaries, Wages & Allowances	12,02,35,508	10,67,82,368
b) Staff Welfare Expenses	17,43,220	20,57,745
c) Contributory Provident Fund	17,40,768	3,14,414
d) New Pension Scheme	62,44,708	56,54,008
e) IDBPS Trust	-	-
f) Leave Travel Concession	17,46,617	33,61,419
TOTAL	**13,17,10,821**	**11,81,69,954**

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SCHEDULE 10 - OTHER ADMINISTRATIVE EXPENSES

Sl No.	Particulars	Current Year (2019-20) ₹	Previous Year (2018-19) ₹
1.	Electricity & Power Expenses	2,84,08,501	2,98,03,776
2.	Water Charges	42,85,120	45,46,205
3.	Operation & Maintenance expenses	1,94,26,408	1,64,99,333
4.	Garden Expenses	13,88,030	11,29,035
5.	Vehicle Hiring Expenses	17,52,333	8,26,435
6.	Postage, Fax & ISDN Charges	5,82,178	6,55,709
7.	Printing & Stationery	9,50,555	14,62,248
8.	Travelling Expenses:		
	Inland	4,26,080	20,88,100
	Foreign	10,60,420	11,65,702
	Others	20,615	1,89,725
9.	Seminar/Workshops Expenses	2,71,060	1,97,874
10.	General Expenses	87,43,651	90,26,430
11.	Audit Fee	23,600	25,651
12.	House Keeping & Plumbing	88,49,279	1,34,65,247
13.	Security Expenses	2,34,68,375	1,54,09,362
14.	Advertisement & Publicity	18,74,055	15,68,289
15.	Emoluments to Consultants	7,67,643	7,22,763
16.	Internet Expenses	31,16,273	0.00
17.	Legal Expenses	92,440	2,12,900
18.	Papers & Periodicals	15,986	41,785
19.	Conveyance Expenses	0.00	0.00
20.	Material /Consumable	3,90,892	32,59,302
21.	International Interface	15,35,557	5,21,640
22.	Others	84,000	2,12,000
	TOTAL	**10,75,33,088**	**10,30,29,511**

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 2019-20, the Society received Rs.21.80 Crores towards Recurring Grant as shown in the Schedule-8.

The remaining Grant-in-aid of Rs.70.0739 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:**

i. Fixed Assets register was maintained by the Society.
ii. The management verified the assets physically by appointing a sub-committee.
iii. The additions to the fixed assets during the period of audit were stated at cost.
iv. Depreciation on Fixed Assets was provided on written down value, as per the rates prescribed under the Income Tax Rules.
v. Upon obtaining the necessary approvals from the Governing Body, Management had disposed of two vehicles at a sale value of Rs.4,19,674/- at a profit on sale of fixed assets of Rs.1,56,657/-. This was incorporated in Schedule 4.

d) **Inventories:**

Inventory of stores, stationery items and other material of significant value are valued at cost, and the same are taken as certified by the management.

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 4A upon obtaining the necessary approvals in this regard.

f) **Employee Benefits:**

i) **Gratuity:**

The present value of the INCOIS obligations under Gratuity is recognized on the basis of an actuarial valuation given by the LIC of India Ltd., for the Financial Year 2018-2019 and the Current Year valuation was done proportionately as LIC, Mumbai office was closed down due to Covid-19 pandemic.

ii) **Pension:**

a) The IDBPS (INCOIS Defined Benefit Pension Scheme) is managed by a separate trust and employers contributions towards pension for the employees joined prior to 01-01-2004, was transferred by INCOIS to LIC of India Ltd up to August 31, 2015 only.

b) 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.

c) 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.

d) 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.

e) 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.

f) 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.

g) Subsequently, all the 11 employees sought permission of the Central Administrative Tribunal (CAT) to withdraw the O.A. Accordingly, permission accorded and O.A. dismissed as withdrawn on 16.03.2020.

h) Periodical contributions to IDBPS are charged to revenue up to August 31, 2015 only. Management decided to initiate required action and make provisions in accounts based on the Judgment from the Hon'ble Central Administrative Tribunal.

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 given by the LIC of India Ltd., for the Financial Year 2018-2019 and the Current Year valuation was done proportionately as LIC, Mumbai office was closed down due to Covid-19 pandemic.

g) **Interest on Deposits:**

The Society invested surplus funds from time to time in Short Term Deposits in Nationalized Banks. For the year 2019-20, an amount of Rs.1,97,25,040/- 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.1,97,25,040/-, the management had transferred an Interest of Rs.1,77,75,243/- to various projects classified in Earmarked Funds under Schedule-2, and the balance interest of Rs.19,49,797/- was considered as income of the Society.

In addition to the apportioned interest amount of Rs.1,77,75,243/- for various earmarked funds in Schedule-2, the funds earned interest directly also credited to the relevant funds and such amount is worked out to Rs.25,85,291/-. Accordingly, the total interest earned for the earmarked funds will be of Rs.2,03,60,534/-.

However interest is not being charged on excess funds (funds that are in negative balance) used for the Earmarked funds to the respective grants.

The details are furnished below:-

(Amount in ₹)

a.	Interest earned on closed STDRs	1,16,41,763.00
b.	Less: Transfer of outstanding Accrued Interest for the FY 2018-19	27,69,532.00
c.	Add: Net Accrued Interest for the current FY 2019-20 on SBI	94,75,854.00
d.	Add: TDS on accrued interest on Electricity Deposit	42,114.00
e.	Add: TDS on closed and accrued TDRs on SBI	13,34,841.00
f.	Total Interest earned for the FY 2019-20	1,97,25,040.00

2. Notes on Accounts:

a) EARMARKED FUNDS:

The Society during the year 2019-20, received Rs.70,07,39,000/- 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 funds positions in the Ear-marked funds for the OASIS and OON programmes are negative. The funds were temporarily used by Management from other projects and will be replenished upon receipt of funds from the Ministry to avoid delay in execution of the projects.

In this regard, the 15th ESSO council meeting held on 30th September 2014 under point no.12 of page-3 of the minutes delegated the powers to the centre Directors and the same is re-produced below for your reference:-

"In order to carry out the activities without any hindrance and achieve the objectives as highlighted in the administrative order, the available funds may be utilized from the different heads with the approval of Institute Director subject to the condition that the overall estimated cost of the programme indicated in the Administrative Order should not exceed due to shortage of funds under the relevant programme (Action: Directors/Heads of Organization)". Accordingly, upon such approval, the Management utilized the available funds to meet the expenditure of the projects.

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.

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 and contractual/warranty obligations, the total value of equipment is transferred to equipments under the same Schedule. The total value of "Advance for Purchase" as on 31-03-2020 was Rs.105.58 Crores.

The accumulated value of the capital expenditure as on 31-03-2020 (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. A separate schedule has been added at Schedule 4A.

Sl No.	Name of the Fund/ Project	As on 01-04-2019 ₹	Additions 2019-20 ₹	Total Amount as on 31-03-2020 ₹
i)	Building Fund*	63,43,79,727	-18,71,288	63,25,08,439
ii)	MDC & Equipment Fund	6,59,21,618		6,59,21,618
iii)	Ocean Information and Advisory Services (OASIS)	1,72,98,87,955	3,84,51,750	1,76,83,39,705
iv)	Computational Facilities	15,28,06,467		15,28,06,467
v)	INDOMOD & SATCORE Projects	42,72,64,846		42,72,64,846
vi)	Ocean Observation Networks	59,79,01,603	3,89,46,352	63,68,47,955
vii)	International Training Centre-ITCOocean	54,87,03,362	5,59,16,553	60,46,19,915
viii)	O-MASCOT (HROOFS)	1,99,42,324	5,27,793	2,04,70,117
ix)	IT & E Governance Fund	5,88,34,380		5,88,34,380
x)	HPC Systems – Others	1,33,61,57,396		1,33,61,57,396
xi)	CSS	14,37,371		14,37,371
xii)	V SAT Node	13,31,28,616		13,31,28,616
xiii)	Ernet India	72,00,000		72,00,000
xiv)	IOAS	51,25,986		51,25,986
xv)	MH Vulnerability	28,30,738		28,30,738
xvi)	Monsoon Mission	3,63,58,018		3,63,58,018
xviii)	RIMES	62,46,188	3,11,29,337	3,73,75,525
xix)	Coastal Monitoring (CMI/SATCORE)	0.00	3,90,259	3,90,259
	TOTAL	**5,76,41,26,595**	**16,34,90,756**	**5,92,76,17,351**

*For S.No.i - Building Fund - Upon obtaining the necessary approvals of APEX Bodies, Management has transferred an amount of Rs.18,71,288/- being the repainting work transferred to INCOIS Society Account.

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 :

a. In view of the non-fulfillment of the contractual obligations by M/s. Gaian, the Bank Guarantee amounting to Rs.9,50,000/- was encashed by INCOIS during 2018-19. Depending upon the satisfactory fulfillment amount will be refunded in future and the amount was shown in Current Liabilities.

b. Periodical contributions to IDBPS are charged to revenue up to August 31, 2015 only. Management decided to initiate required action and make provisions in accounts based on the Judgment from the Hon'ble Central Administrative Tribunal, the amount is to be ascertained subject to the approval of Governing Council.

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 advice 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 a 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 and also to take steps by seizing his properties available in the Mumbai for recovering the decreed amount. As per the orders of the above Hon'ble court, the case has been transferred to the City Civil Court, Mumbai at Dindoshi (Borivali Division), Goregaon Mumbai. The case is in progress.

e) **Input Tax Credit of GST**

INCOIS is being a Scientific Organization mandated with providing ocean data, information and advisory services to the society, industry, the Government and Scientific Community. There is an imbalance of payment of GST against the Purchases made and services obtained against input tax credit claimed. The matter is discussed with GST Department. Since Input GST is not agreed by the GST Department as credit allowable, GST is treated as part of expenditure and

GST collected as output GST, is treated as Income in the books of Accounts whereas while filing GST return we claim ITC and set off against Output GST.

f) Figures have been regrouped/rearranged whereever necessary.

g) Paise had been rounded off to the nearest rupee.

As per our report of even date
For PPKG & Co.
Chartered Accountants

(Giridhari Toshniwal)
Partner
M. No. 205140
FRN No: 009655S

Place: Hyderabad
Date: 06.08.2020

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

(S. Nageswara Rao)
Sr. Accounts Officer

S. Nageswara Rao
Senior Accounts Officer

(T.M. Balakrishnan Nair)
Director-I/C

Dr. T.M. Balakrishnan Nair
I/C - Director, INCOIS

Indian National Centre for Ocean Information Services

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

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