Sixth meeting of the International Steering Committee of Second International Indian Ocean Expedition 2015-25

IIOE-2 SC6

REPORT

By

IIOE-2 Project Office, India (INCOIS, Hyderabad)

6th and 7th February 2023

Indian Ocean Marine Research Centre (IOMRC)
University of Western Australia (UWA)

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1. Preamble

The Second International Indian Ocean Expedition (IIOE-2) is a major global scientific program that engages the international scientific community in collaborative oceanographic and atmospheric research from coastal environments to the deep sea revealing new information on the Indian Ocean (i.e. its currents, its influence upon the climate, its marine ecosystems) which is fundamental for future sustainable development and expansion of the Indian Ocean's blue economy. The program was initially formulated for a period of five years (2015-2020) which was subsequently extended for another five years (till 2025) considering its importance. A large number of scientists from research institutions from around the Indian Ocean and beyond planned their involvement in IIOE-2 in accordance with the overarching six scientific themes of the program. IIOE-2 activities will also include a significant focus on the capacity building of all nations around the Indian Ocean to understand and apply observational data or research outputs for their own socio-economic requirements and decisions. In addition, an Early Career Scientist Network (ECSN) was also formed to exchange the ideas on the translation of the science and information outputs for societal benefit and training of relevant individuals from surrounding nations in these areas. More details about the program along with the governance structure including Steering Committee (SC), National committees, working groups and science themes are available at https://iioe-2.incois.gov.in/IIOE-2/index.jsp.

The sixth meeting of the IIOE-2 International Steering Committee (IIOE-2 SC6) was held at Indian Ocean Marine Research Centre (IOMRC), University of Western Australia (UWA) during 6th to 7th February 2023 back-to-back with meetings of IRF (15th major meeting), SIBER (13th major meeting), IORP (18th major meeting), IOGOOS (18th major meeting) and KUDOS Workshop as part of International Indian Ocean Science Conference (IIOSC 2023). The IIOSC 2023 was organised under the auspices of the Indian Ocean Global Ocean Observing System (IOGOOS) with IOMRC providing the venue and local logistics, and CSIRO sponsoring the conference's special events. Further, the Western Australian Global Ocean Observing System Inc. (WAGOOS) provided sponsorship and administrative support and Wise Wine, Margaret River, Western Australia supported the opening reception event.

The IIOSC-2023 Conference Information Booklet is available at https://iioe-2.incois.gov.in/documents/IIOE-2/IIOSC2023/InformationBooklet.pdf

The agenda of the Sixth meeting of the International Steering Committee of Second International Indian Ocean Expedition (IIOE-2 SC 6) is available at https://iioe-2.incois.gov.in/documents/IIOE-2/IIOSC2023/Draft%20Agenda_Sixth%20meeting_IIOE-2.pdf

2. Proceedings of the meeting

2.1. Introductory Remarks

Dr Nick D'Adamo welcomed the participants of the IIOSC 2023 including IIOE-2 SC6. Dr D'Adamo gave an overview of the venue i.e. IOMRC, UWA and also mentioned about the event sponsors. Further he provided the overview of the entire event including the logistic arrangements and acknowledged the contribution from those who helped to organize the event. He also expressed his heartfelt sympathy for sad demise of Prof Mathieu Rouault, UCT, South

Africa and Prof. Will de Ruijter, Uni Utrecht, Netherlands and their significant contribution in the oceanography. Subsequently Dr D'Adamo introduced Dr Christophe Gaudin, Director, UWA Oceans Institute and invited him for a welcome address.

Dr Christophe Gaudin welcomed the participants and expressed his pleasure to be part of IIOSC 2023. He mentioned that IIOE is an ambitious program that brings researchers from various countries to achieve a common goal towards understanding the Indian Ocean. Subsequently, the IIOE-2 Co-chairs addressed the gathering.

Dr. Vladimir Ryabinin, Co-chair addressed the meeting through a recorded video. He expressed his apologies for not attending the meeting in- person due to other official commitments. At the onset Dr Ryabinin welcomed the SC members on behalf of IOC and thanked IOMRC, UWA for hosting the meeting. He mentioned that IOC is taking a lead role towards understanding the ocean and its sustainability through the UN Ocean Decade. He appreciated the successful organisation of the IIOSC-2022 by INCOIS and IOGOOS that showcased the enormous progress achieved in scientific understanding of the Indian Ocean through IIOE-2. He urged that Indian Ocean community to work together to contribute to further develop the science base required for sustainable management of oceans including marine biodiversity conservation and climate smart management of ocean resources.

Marie-Alexandrine Sicre, Co-chair welcomed SC members on behalf of SCOR. Dr Sicre appreciated the efforts put by the IIOE-2 community in enhancing understanding of the Indian Ocean through focused field campaigns and projects endorsed under IIOE-2. She also appreciated the functioning and progress of the IIOE-2 Early Career Scientist Network. She further mentioned that capacity building is also an important component of IIOE-2 and principal investigators of all the endorsed projects should take an active part. Further She also committed to extend support from SCOR to IIOE-2.

Dr T Srinivasa Kumar, Co-chair welcomed SC members on behalf of IOGOOS. He mentioned that IIOE-2 program is in its second phase and completed eight years. During this time, a lot has been achieved with several expeditions in the Indian Ocean. There are more than 50 projects endorsed by IIOE-2 which speaks volumes about the success of the program. He mentioned that IIOE-2 program as it stands currently will be concluded in 2025, and it is time to look beyond. He also emphasized on the need to focus future research on the coastal Indian Ocean, which will be key to delivery of societal services to coastal communities to enhance safety of lives and livelihoods .

2.2. Plenary keynote talks by invitation (Day 1)

Prof. Raleigh Hood, Chair USA IIOE-2 National Committee, Co- Chair SIBER and Co-Chair IIOE-2 WG1 gave a plenary keynote talk on "IIOE-2 progress, status and the future". The talk highlighted history of conceptualising IIOE-2 where SCOR, IOC and IOGOOS informally assumed leadership of the IIOE-2 planning process based on the IOC "Reference Group" planning meetings and national meetings in 2013 and 2014. The plan was finalized and printed for Goa Symposium in November 2015. The first expedition of IIOE-2 departed from Goa to Mauritius on 5th December 2015. Subsequently, joint India-Australia IPOs were established. Further All three co-sponsors (IOC, IOGOOS and SCOR)

enthusiastically approved an extension of the expedition to 2025**.** Further, Covid-19 pandemic setback impacted several activities such as IIOSC-2020 and operations of RAMA. In addition, Australia node of the IPO was also closed as Perth office was de-funded. However, there has been a rapid resumption of cruise activity and several US Expeditions to the Indian Ocean have resumed and planned for the near future. A total of 50 projects have been endorsed to date and there has been an active participation from working groups and science themes leads. There were set of synthesis papers on the Indian Ocean published as a special issue of EGU Journal. Also, there was set of special issues on IIOE-2 for publication in DSR II with 50 papers published so far.

Dr Peter Thompson, CSIRO gave a plenary keynote talk on "Revisiting the 110E transect IIOE-1 to IIOE-2". The talk highted the goal of the study which was to examine the response of the south-east Indian Ocean to climate change. Dr Thompson described the study area highlighting the various processes. He also presented the new technology for ocean observations in comparison to the expeditions held five decades ago. He also presented the characteristics and significant changes in the physical and bio-geochemical parameters along 110 ^{0}E since 1963. Further he described the conceptual model for nitrogen supply.

Dr Nerida Wilson, WA Museum gave a plenary keynote talk on "Falkor Expedition: exploring the marine biodiversity of the Cape Range Canyon". The talk highlighted the sampling gaps along mid-west canyons and the diverse flora and fauna observed during the Falkor expedition, which was analyzed using eDNA approach. Dr Wilson highlighted the outcomes which includes i) repeat multibeam surveys were useful in highlighting sediment dynamics and could be utilized for monitoring of marine parks, ii) special areas were identified in both Cape Range Canyon (glass sponge gardens) and Cloates Canyon (soft coral areas) which will be further elucidated and linked to geomorphology in continuing research and iii) genetic data is needed for many species-level assessments and will be forthcoming with further research.

2.3. IIOE-2 National Committee reports

In this session, representatives from eight countries (India, Australia, France, Japan, South Africa, Germany, United States of America and United Kingdom) presented the national activities under IIOE-2. Dr Yukio Masumoto, representing Japan, and Dr Hermann Bange, representing Germany, could not attend the meeting but provided pre-recorded presentation.

Dr T Srinivasa Kumar presented the IIOE-2 National Committee report of India. The report highlights the following:

- IIOE-2 Project Office India activities and progress.
- JPO India had played a key role in organising the IIOSC_2022 Conference Virtually during 14-18 March, 2022.
- Actively involved in the capacity development by organizing three training programs for IOR countries as part .of the ITCOOcean at INCOIS that is a UNESCO Category2Centre

- Sustained the Indian Ocean Observing network and its augmentation with state-of-art ECFS system.
- Plans for Deep Ocean Observing system using gliders, deep argo and wave drifters under Deep Ocean Mission of India.
- Indo-US joint research initiative and scientific expeditions to study air-sea interaction processes in the Arabian Sea.

Dr Lynnath Beckley presented the IIOE-2 National Committee report of Australia. The report highlights the following:

- Updates about the seven Australian IIOE-2 endorsed projects as follows.
    - IIOE2-EP24: Physical drivers of LME of Arafura Sea (2016)
    - IIOE2-EP08: Challenger Ocean glider Indian Ocean mission (2016-2018)
    - IIOE2-EP06: 110°E repeat line (2019)
    - IIOE2-EP33: Marine biodiversity of the Cape Range canyon (2020)
    - IIOE2-EP40: Biodiversity assessment of Australia's Indian Ocean Territories (2021 & 2022)
    - IIOE2-EP48: Valuing the Gascoyne Marine Park (2022)
    - IIOE2-EP47: Quantifying vertical & lateral ocean transport due to sub-mesoscale fronts and eddies (2023)
- Supporting services and infrastructure for Australian IIOE-2 activities that includes Integrated Marine Observing System, Marine National Facility (RV Investigator) and Forecasting, BlueLink, OceanMaps, AUSWAVE through Bureau of Meteorology.

Dr Francis Marsac presented the IIOE-2 National Committee report of France. The report highlights the following:

- Quantification of the submarine groundwater discharge of C, N & Si in India to the IO.
- Climatic and non-climatic stressors along East African coast.
- Biophysical coupling at sub-mesoscale in the Mozambique Channel: the RESILIENCE project
- OBS- AUSTRAL programme: Monitoring of the CO_2 sink in the Southern Ocean
- Towards Hydro acoustic and Ecology of Mid-trophic levels in Indian and Southern Ocean
- Observatory of Hydro Acousticity from SISmicity and Biodiversity in the Indian Ocean
- Monitoring the seismic and volcanic activity at Mayotte, SW Indian Ocean
- A unique system to characterize the mid-trophic levels by using image acquisition controlled by acoustic detection

- The Indian Ocean Mission 2022: By the Monaco Explorations and Partner Scientific organisations.
- Seychelles Digital Ocean Atlas
- To increase resilience to climate change, food insecurity and to reduce emerging conflicts in the Indian Ocean

Dr Yukio Masumoto presented the IIOE-2 National Committee report of Japan. The report highlights the following:

- Promoted research using samples and data obtained during the R/V Hakuho-Maru cruise in 2018 and R/V Mirai cruise in 2019/20
- Organized Indian Ocean Sessions at the JpGU meeting and OSJ fall meeting
- Obtained the R/V Hakuho-Maru ship-time for the eastern IO cruise in 2024.
- Making a detailed plan for R/V Hakuho-Maru cruise in collaboration with Indonesia
- The significant results derived from 2018 cruise include i) Dissolved trace metals in the eastern IO, ii) Effect of iron and light on microbial nitrogen cycles in the primary nitrate maxima of the eastern IO, iii) Factors controlling the latitudinal distribution of surface DOM in IO, iv) Impact o positive IOD on sea surface CO2 system in the IO, v) Second baroclinic mode Rossby waves in the south IO, vi) Possible mechanism of interannual variations in surface ML temperatures off Somalia during boreal summer, vii) A study on the intraseasonal scale coastal upwelling off Java and the IOD, viii) Mechanism of asymmetry in SST anomalies associated with IOD.

Dr Jenny Huggett presented the IIOE-2 National Committee report of South Africa. The report highlights the following:

- Regional Cruises: 1) No further DFFE (govt)-led regional cruises held or being planned since the two Regional Training & Research Cruises in the WIO in 2017 & 2018 [IIOE2-EP26]
- Resilience Cruise: Fronts, eddies and marine life in the Western Indian Ocean Mozambique Channel and East coast of South Africa, 19 April-24 May 2022
- SA Agulhas II chartered by Monaco Explorations for Indian Ocean mission (Oct/Nov 2022)
- ASCA/Seamester survey 2022: cruise focused on an eddy associated with early retroflection of the Agulhas Current
- Regional Research Projects: The Western Indian Ocean Upwelling Research Initiative (WIOURI)
- Role of canyons in influencing biological patterns along the continental shelf edge in the pelagic zone

- MetaZooGene: Metabarcoding Zooplankton Diversity is endorsed as a new UN Ocean Decade Action. The project is attached to the Ocean Decade Programme, Marine Life 2030
- 17th Southern African Marine Science Symposium held during 20-24 June 2022 at Durban
- Regional Research projects: Mozambique zooplankton (a ReMoTurb project)
- Regional Training Workshop on Shoreline Change Management for Coastal Municipalities Officials
- Opportunity for Early Career Scientists to participate in a research cruise R/V Roger Revelle sailing from Cape Town, South Africa, to Port Louis, Mauritius, to collect in-situ observations in the Madagascar Basin

Dr Hermann Bange presented the IIOE-2 National Committee report of Germany. The report highlights the following:

- Two cruises (SONNE 302: WAST-dredge and SONNE 303: BIOCAN-IIOE2) were re-scheduled due to Covid-19 pandemic and will be conducted in 2024.
- The workplan for SONNE 302: WAST-dredge include dredging of two sediment trap system in the Western Arabian Sea.
- The workplan for SONNE 303: BIOCAN-IIOE2 includes study of biogeochemistry of carbon and nitrogen in the Arabian Sea.
- A cruise onboard R/V Sonne is schedule to study interplay of monsoon, cyclone tectonics and anthropogenic impacts in the shelf of BoB.
- A cruise is scheduled onboard R/V Sonne Biogeochemistry -Atmospheric processes in the Bay of Bengal
- Other cruise are planned to study i) GEOTRACERS-South Indian Ocean, ii) East Antarctic Ice Sheet Instability, iii)

Prof. Raleigh Hood presented the IIOE-2 National Committee report of USA. The report highlights the following:

- U.S. IIOE-2 Steering Committee Activities and Plans
- The US IIOE-2 Science Plan
- Recently Completed/Upcoming US Projects: MINTIE (NSF), TRIUMPH (LIPI/NSF), BLOOFINZ (NSF), EIOURI, MADAGASCAR BASIN (NSF x 2), BGC MODELING (NSF), BIOSCAPE (NASA Applied Sciences Division), EKAMSAT (ONR/MOES/NOAA) and GO-SHIP IO5 (NOAA/NSF).
- Korea – US Bilateral Activities and Plans: R.V. Isabu cruises cancelled in 2020 and 2021 but are resuming post-COVID and have institutionalized KUDOS cruises for the next 5 years and Will support RAMA and other international collaborative efforts.

- RAMA 2.0: Severe negative impacts of COVID-19 on RAMA due to cancelation of mooring deployment and servicing cruises. All RAMA moorings now offline except one. Anticipate bringing RAMA 70% back on line by the end of 2023.

Dr Greg Cowie presented the IIOE-2 National Committee report of UK. The report highlights the following:

- Current Indian Ocean Research includes i) Oceanographic drivers of ecosystem variability in the Chagos Archipelago, ii) Can coral at d'Arros survive bleaching in a warming climate? iii) Multi-scale numerical modelling in support of regional marine science
- Oceanographic drivers of ecosystem variability in the Chagos Archipelago: 3 research cruises to Chagos Archipelago: 2019, 2020, 2022 focusing on the dynamics controlling ecosystem response at small-scale on atolls and seamounts.
- NEKTON MALDIVES MISSION: First systematic survey and sampling of the Maldives from the surface to 1000 metre depths

2.4. Upwelling research initiatives

WIOURI: Western Indian Ocean Upwelling Research Initiative

Dr Mike Roberts presented on WIOURI consisting of nine ecosystems with theme covering Impact of climate change on WIO ecosystems, and marine food security. These ecosystems include Agulhas current, Mozambique channel, MAD ridge, East Madagascar Bloom, East African coastal current, Somali Upwelling, Oman Upwelling, Chagos-Seychelles dome and Mascarene Plateau. The WIOURI was initiated in 2016 with a study of MAD ridge with France and South Africa collaboration. In 2017 with support from UK, two more ecosystems were studied along Agulhas current and East African Coastal current followed by Mozambique channel and East Madagascar Bloom. Dr Roberts described the significant results obtained in each ecosystem.

EIOURI: Eastern Indian Ocean Upwelling Research Initiative

Dr Yukio Masumoto presented on EIOURI which was initiated in 2016 as one of the core initiatives under IIOE-2. Several projects with observational cruises were conducted till 2019 providing interesting results. Dr Masumoto also presented the science plan for EIOURI which includes upwelling processes in the eastern Indian Ocean, Open ocean-coastal interactions, Bio-physical relationship, Biogeochemistry and Ecology and The human dimension, conservation, and societal impacts. Further, there are special EIOURI sessions planned during AGU, EGU, AOGS and JpGU meeting. The key projects executed under EIOURI incudes TRIUMPH, BUOOFINZ-IO. Subsequently Dr Masumoto presented the significant results.

2.5. Other major national initiatives

Dr Ocky Karna Radjasa presented the various activities under Badan Riset dan Inovasi Nasional / National Research and Innovation Agency (BRIN), Indonesia. The presentation highlighted the organizational structure of BRIN, research facilities, global engagement, National Talent Management in research innovation, Scheme of Research Falicitation and

Funding, Recent research activities related to Eastern Indian Ocean and TRIUMPH (Throughflow Indonesian Seas, Upwelling & Mixing Physics) project which is Multinational and multidiscipline collaborative program among scientists of Indonesian Research and Innovation Agency (BRIN), First Institute Oceanography (FIO)-China, and Univ o Maryland, College Park, USA. Dr Radjasa also presented cruises in Western Sumatra and engagement of Indonesian scientist on the EIOURI of IIOE-2. Further he presented the proposed research themes for the scientific exploration in the Indian Ocean that includes: Ocean dynamic and biogeochemistry, Marine biodiversity, Pollution and ecosystem health, Bioprospecting and biotechnology and Ecosystem & environmental change.

Dr Mike McPhaden presented Korea-US Indian Ocean Scientific Research Program (KUDOS). He presented the Physical, Biogeochemical and Ecological Dynamics of the Seychelles-Chagos Thermocline Ridge (SCTR) followed by Blue Ocean Project towards developing a Korea-US Cooperative Program in Marine Science. Further, he presented the KUDOS scientific plan developed to address scientific priorities via two international workshops. In summary Dr McPhaden highlighted Station K implementation, RAMA deployments, optimized mooring array design, many BGC shipboard observations made by KIOST and more R/V Isabu cruises to the Indian Ocean are planned through 2026 to address KUDOS scientific themes.

Dr Weidong Yu presented IIOE-2 related activities in China. South China Sea Institute of Oceanography has two projects in Indian Ocean namely Decade of Eastern Indian Ocean Observations and SCSIO-CSIRO Marine Heat Wave Project. Dr Yu presented significant results from these projects. First Institute of Oceanography has two initiatives in the Indian Ocean i.e. Equatorial Eastern Indian Ocean Survey covering four seasons and Pilot flux buoy study at IndOOS-2 new site. Second Institute of Oceanography is carrying out Joint Advanced Marine and Ecological Studies in collaboration with Myanmar, Thailand and Sri Lanka. Third Institute of Oceanography is carrying out China-Myanmar joint survey in Ayeyarwady waters and Marine Heat Wave and Ecological Impact in Tropical Indian Ocean.

2.6. Plenary introductory talks by invitation (Day 2)

Dr Francis Marsac gave a plenary keynote talk on the overview of Monaco Explorations as a part of IIOE-2. The initiative was launched in 2017 by HSH Prince Albert II of Monaco. The Monaco Explorations is a multi-partner project with 60 institutions from 20 countries involving 170 participants. The expedition was carried out onboard Oceanographic Research Vessel S.A. Agulhas II (South Africa). Further Dr Marsac presented the Multidisciplinary study of the Saya De Malha Bank with details of the area surveyed, onboard sampling and preliminary results of the benthic invertebrate inventory. Dr Marsac also presented photo-physiological experiments carried out along with the University of Mauritius for assessment of the resilience of corals and algae to thermal stress. Dr Marsec further presented primary productivity from Saya de Malha exported to Mascarene basin, Pelagic wildlife from moored camera and Saya de Malha preliminary summary along with the outreach programmes.

Prof Charitha Pattiaratchi gave a plenary keynote talk on "Two decades of surface current observations using drifters in Western Australia". Prof Pattiaratchi started the talk

by providing the importance of drifters and its design. Further he gave a comparison between the commercially available drifters and those designed and developed in UWA. He also showed few results from the Surf zone drifters to study rip currents. Subsequently Prof Pattiaratchi presented open ocean drifters, its design and showed the deployment locations and trajectory.

Dr Paul van Ruth gave a plenary keynote talk on "Australia's Integrated Marine Observing System (IMOS)". Dr Ruth presented the overview of the IMOS which is a national, collaborative, research infrastructure funded by the Australian Government to provide systematic, sustained, long-term observations of the marine environment for research, management and industry. The IMOS delivers observations and data that support operational services, research, management and industry, and create societal benefit at regional, national, and global scale. Further, Dr Ruth presented the working strategy of IMOS, its capability and operations in Western Australia. Subsequently Dr Ruth presented how IIOE-2/IOGOOS and IMOS work together more closely to identify and address observational/data gaps in shared area of interest.

Dr Luke Twomey gave a plenary keynote talk on "Strategic marine science in Western Australia". Dr Twomey presented an overview of Western Australian Marine Science Institution that provides strategic advice to WA Government, identify opportunities for partners, coordinate and manage large scale, collaborative projects and build environmental, social and economic value for WA. The WAMSI also provides management support, contribute to policy review and communication of science knowledge between and across end users. Further, Dr Twomey also presented the blueprint of focussed areas and themes along with institutional plans and programs and its linages with IIOE-2.

Dr Lisa Kirkendale gave a plenary keynote talk on "Western Australian Museum - Boola Bardip". Dr Kirkendale stated the talk by introducing WA Museum - Boola Bardip along with its role. Further she gave an overview on the various activities at the museum including digitizing all existing marine specimen metadata and collate records, undertake survey and collection of new specimens and share this wealth of knowledge through scientific and popular publications and innovative public programming. Dr Kirkendale also showed the exhibits from various scientific expeditions.

Dr John Keesing gave a plenary keynote talk on "RV Investigator Gascoyne Marine Park voyage 2022". The major objective of the survey was to describe habitats and diversity of fishes and marine invertebrates across latitudinal and depth gradients in the region. Dr Keesing presented the survey plan, equipment and unexpected organisms sited during the voyage using deep underwater baited videos.

2.7. IIOE-2 Working group reports

Prof Raleigh Hood presented the progress of WG-1: Science and Research. The presentation highlights the following:

- The development of the IIOE-2 Science Plan started in 2014, following initial discussions in 2011 and 2012.

- The plan aims to advance understanding of interactions among geologic, oceanic, and atmospheric processes in the Indian Ocean and their impact on climate, ecosystems, and human populations.
- The plan focuses on six scientific themes, including human impacts, boundary current dynamics, monsoon variability, circulation, extreme events, and unique features of the Indian Ocean.
- Existing monitoring, remote sensing, and modeling programs are incorporated and strengthened by IIOE-2.
- The success of IIOE-2 is measured by its contributions to sustainable development, marine resource management, and training of ocean scientists.
- Several working groups are actively involved in the research themes, while others are not currently active.
- COVID-19 pandemic caused a halt in cruises and research activities, but there has been a rapid resumption of cruise activity over the past year.
- Special issues of synthesis papers and research papers have been published in scientific journals, such as EGU and Deep-Sea Research.
- The outputs of IIOE-2 aim to provide a legacy for future research and contribute to the understanding of regional and global change in the Indian Ocean.
- Efforts are ongoing to bring RAMA (Research Moored Array for African-Asian-Australian Monsoon Analysis and Prediction) back online and resume monitoring activities.

Dr Pattabhi Rama Rao presented the progress of WG-2: Data and Information Management. The presentation highlights the following:

- The terms of reference of the WG-2 were discussed in detail and the progress made on and the present status of the ToR were explained to all the audience. Few important ToR of the WG-2 are on common data exchange policy for data collected under IIOE-2, data types and core measurements, sampling and analytical protocols and meta data structures, QC/QA procedures, data types, modalities of data dissemination and its mechanism, also modalities of long term preservation of IIOE-2 data.
- The progress on various activities of the WG2 were presented to the group the highlighted that being, the draft data policy has been reviewed and finalized, in consultation with Raliegh, IODE Co-Chair and Head, IODE.
- Development of a metadata catalogue for projects, cruises, moorings, datasets, and publications etc., the metadata of 6 cruises has been updated on the portal.
- Made significant progress in facilitate the establishment of a Regional Coordination Unit for IIOE-2 Data and Information Management at ESSO-INCOIS, Hyderabad.

- Another Important activity of drafting the Data and Information Management Policy's highlights were discussed. The policy intended to support the collection and curation of all data to encourage data sharing, in line with internationally agreed rules of data exchange which can facilitate data discovery and use in long term. The policy encourages open data sharing to facilitate the scientific goals of IIOE-2 while respecting the national data and information exchange policies. The data policy of IIOE-2 was discussed in detail in his presentation.
- The metadata portal of IIOE-2 and key highlights of the portal was discussed and the portal pages were shown. The data specification, on page tools, standards and compliances, forthcoming cruise schedules, keyword search features, and the backend technology of the portal was explained.
- He emphasised the need for Organizing meetings with Chairs of WG1 and WG3 and IIOE-2 Co-Chairs, to standardize and harmonise the core measurements and associated data types and units, IIOE-2 scientific activities, develop quality control procedures for all data types, and facilitate their adoption by the steering committee of IIOE-2.
- Expressed the need to develop and update data and information management capacity for all data acquired through various activities of IIOE-2.

Dr Kiran Kumar presented the progress of WG-3: Operational Coordination. The presentation highlights the following:

- WG 03 continues to be the interface between the PIs and the other stakeholders, primarily because of the enormous support from INCOIS and the PO. By and large, several of the activities under the ToR are being accomplished through and by the PO.
- Some of the continuing activities of this WG have been i) assisting the PO-India in the endorsement process of the projects received by IIOE-2 and ii) facilitating the updation and management of the IIOE-2 Website through the IIOE-2 Program Office and the Information & Communication Technology (ICT) Division at INCOIS, Hyderabad.
- Management of the central web-based expedition planning and progress utility (https://iioe-2.incois.gov.in/WebGIS.html) linked to the IIOE-2 website.
- Coordinating with the IIOE-2 PO India & WG-2 Data and Information Management in the management of the IIOE-2 Metadata Portal (https://iioe-2.incois.gov.in/IIOE-2/data.jsp).
- Helping INCOIS with THE INDIAN OCEAN BUBBLE and IIOE-2 Monthly Online Newsletters.

2.8. IIOE-2 Science Theme reports

Theme-1: Human Impacts and Benefits. Ben Milligan

There was no representation from ST-1 co-chair / members

Prof P. N. Vinayachandran presented IIOE-2 Science Theme-2: Boundary current dynamics, upwelling variability and ecosystem impacts The report highlights the following:

- Prof Vinayachandran represented and presented on behalf of the team representing the science theme 2, with various scientific research results. The reviews and synthesis of Physical and biogeochemical processes associated with upwelling in the Indian Ocean, and associated research publications and results were presented.
- Variability in concentration of lithium in the Indo-Pacific Ocean an associated study in Bay of Bengal Boundary Layer Experiment, and Southern bay of Bengal: A possible hotspot for CO2 emission during summer monsoon, where in the transportation of dynamics and movement of High Salinity Water mass from Arabina Sea to southern BoB were discussed.
- The research results of the discharge from Irrawaddy River jet in the Andaman Sea during the summer monsoon and its accumulation along the eastern coast of the Andaman Sea was presented.
- Prof Vinayachandran also informed about the planned R/V Hakuho-Maru cruise in Aug/Sep 2024 in collaboration with BRIN/Indonesia and U-Tokyo/Japan to study summer monsoon and upwelling periods off Java/Sumatra to understand the coastal and upwelling and offshore upwelling off Java and the relationship of these upwelling with biogeochemical variables and ecosystem conditions, mapping of Biogeography, effects of physical conditions and anthropogenic materials on marine biogeochemistry.

Dr Adrian Matthews presented IIOE-2 Science Theme-3: Monsoon variability and ecosystem response. The report highlights the following:

- Dr Adrian Matthews explained the overall schematic of decision and information system for real time forecasting, of coastal waters of Gulf of Oman.
- The newly initiated proposals in the Indian Ocean, such as BIOScape for mapping of phytoplankton functional types in collaboration with South Africa, and Development of a prototype of Kenya Ocean Monitoring and Decision Support System for in association with Kenya were presented.
- The scientific studies about the interannual variability, by Lagrangian tracing of South Asian summer monsoon rainfall by National Oceanography Center, Southampton, by Dipanjan Dey and the ML model revealing dynamics of Agulhas Bank productive up well that is sustain fisheries by Fatma Jebri, were discussed.
- The presentation of Dr Adrian Matthews also covers various research studies such as, The Accelerated warming of Indian Ocean by Jenny Mecking, An asymmetric change in surface circulation and nitrate transport in BoB during (1990-2060) by Jenny Jardine, and the coastal upwelling watch service by Matthew Hammond, Drivers of rainfall trends over mainland of southeast Asia by Nikolaos Skirlis, Changes in extreme sea

levels by 2100 by Svetlana Jeyrejeva, and various IIOE2 contributions by University of East Anglia, UK were presented.

Dr Helen Phillips presented IIOE-2 Science Theme-4: Circulation, climate variability and change. The report highlights the following:

- Dr Helen Phillips explained the activities scheduled on the scientific theme, during [IIOE2-EP50] in Deep Madagascar Basin (DMB) & [IIOE2-EP34] East Madagascar Current (EMC) after the delay due to covid pandemic. The cruise plan is between April 6 to May 13, 2023 onboard R/V Revelle from Cape Town, SA to Port Louis, Mauritius.
- Also mentioned about various research papers, publications and Outreach activities initiated by writing various articles, and newly endorsed projects [IIOE2-EP47] by Jones et al., Australia and [IIOE2-EP43] which is an update from Alejandra Sanchez-Franks, UK.
- The new initiatives of the scientific theme being Agulhas Current Array (ASCA) - update from Juliet Hermes and the plan is in progress to re-install the ASCA line in the next two years. South Africa has funded the South African Polar Research Infrastructure (covering marine as well as polar).
- EKAMSAT – Enhancing Knowledge of the Arabian Sea Marine Environment through Science and Advanced Training – has been established. An Arabian Sea bilateral India USA collaboration program, chief scientist Dr Srinivasa Kumar, INCOIS Director and Prof Amit Tandon, UMassD.
- The main achievements have been highlighted in the presentation, among them being the publication of a synthesis paper with 24 authors from 7 countries, with the title "Progress in the understanding of Indian Ocean circulation, variability, air-sea exchange, and impacts on biogeochemistry, in Ocean Sci., 17, 1677–1751, https://doi.org/10.5194/os-17-1677-2021.
- Dr Helen Phillips also highlighted the leadership and contributions made in chapters in Indian Ocean book. The Indian Ocean and its role in the global climate system, edited by Caroline Ummenhofer and Raleigh Hood.
- Convener to oral session (PL04) at Ocean Sciences 2022, poster presentation in session (PL05) and contributions to DSR-II Special Issues are few of the highlights of their contributions.

Prof. Charitha Pattiaratchi presented IIOE-2 Science Theme-5: Extreme events and their impacts on ecosystems and human populations. The report highlights the following:

- Prof Charitha Pattiaratchi highlighted the major maritime disasters (both natural and anthropogenic) in the Indian Ocean region such as the 2004 Tsunami and subsequent tsunamis in IO, missing of Malaysian Airlines 370, Oil spills in Mauritius and Sri Lanka, in 2020 and X-Press Pearl disaster in Sri Lanka in 2021. In addition, the natural occurring extreme events like Tsunamis (seismic and meteorological originated), Tropical cyclones and associated storm surges, Marine heat and cold waves, Mean Sea

level rise, Anthropogenic events were highlighted in his talk. He also emphasised reducing disasters such as the oil spill by MV Wakashio near Mauritius, using machine learning models.

- Another compelling anthropogenic maritime problem due to microplastics and nurdles has been discussed in detail. The disaster due to sinking of MV X-Press Pearl has been highlighted and relevant videos have been played in this context. In addition to this disaster, various riverine sources of plastic wastes, and their transportation in Indian Ocean was elucidated through his talk.
- Prof Charitha Pattiaratchi discussed about the tropical cyclones, associated storm surges and their impact which were originated and made land fall in the IOT region was discussed as part of his presentation.
- Prof Charitha Pattiaratchi finally concluded by discussing the details about the Tonga-hunga Ha'apai Volcanic Eruption and the tsunami modelling results, associated pressure perturbation with the eruption.

Jerome Dyment presented IIOE-2 Science Theme-6: Unique geological, physical, biogeochemical and ecological characteristics of the Indian Ocean. The report highlights the following:

- He reminded the works and progress in marine geosciences, through the works by addition of remarkable amounts of multibeam bathymetric data around Australia to the data achieve.
- The tremendous amount of work carried out off Mayotte islands, in the Comoros archipelago, where catastrophic landslides are prevalent on the volcanic islands, and the birth of new volcano has been highlighted.
- Dr Jerome Dyment also reiterated the importance of having a data sharing incentive for a more significant number of geologists and geophysicists to join IIOE-2 by having piggybacking of geological and geophysical data and access to a new database by setting up a data server by the IIOE-2 office.
- Dr. Jerome Dyment concluded by showing the Indian Ocean view of the World Digital Magnetic Anomaly Map (WDMAM) version 2.1 which will be released by Aug 2023.

2.9. Early Career Scientists Network

IIOE-2 Early Career Scientists Network was formed 2nd December 2015 at the National Institute of Oceanography (NIO) in Goa. The idea of the network emerged in a session on "Recent Results from Early-Career Scientists in Indian Ocean Research" during the conference that celebrated the 50th Anniversary of Completion of the International Indian Ocean Expedition (IIOE). The motivation of the ECSN of IIOE-2 was to bring together the young scientists working on the Indian Ocean, to encourage exchange and participation, with overall all aim to enhance the understanding of the under-explored Indian Ocean. Subsequent to an initial, informal, and self-driven phase, the network was formally adopted on 24th August 2018. More details can be viewed at https://iioe-2.incois.gov.in/ecsn/index.html#

Ms Aditi Modi presented the status and update on IIOE-2 ECSN. The presentation began with the genesis of the network followed by the objectives. Ms Modi introduced the eight founding members of the ECSN who passed on the heritage to new members during IIOSC-2022. However, they continued to act as mentors in all major activities and extend their support through major challenges and opportunities. Further Ms. Modi introduced current core committee with members at different stages of their career - PhD candidates, postdocs, young scientist, research professor, technical officer, coming from 10 different universities and institutes situated across the globe. Presently Dr Fehmi Dilmahamod is President and Ms Aditi Modi is Secretary and Ms Mansi Gupta is Joint-Secretary of ECSN. Further Ms Modi presented the focused research area and highlights of the research contribution along with the way forward.

The status and update on IIOE-2 ECSN was followed by the flash talks from four ECSN Members as follows:

- Understanding the biophysical interactions in the tropical Indian Ocean in the changing climate by Ms Aditi Modi
- Air-Sea flux of DMS and its potential controls over the northern Indian Ocean during the post-monsoon season by Ms Mansi Gupta
- Investigating the surface chlorophyll bloom within the Seychelles-Chagos Thermocline Ridge and the role of the Indonesian Throughflow by Matthew Carr
- Recent progress on bio-optical studies along 110°E in the southeast Indian Ocean by Chandanal Parida

The abstract of the flash talks by the ECSN members can be viewed at https://iioe-2.incois.gov.in/documents/IIOE-2/IIOSC2023/Abstract_ECSNFlash%20Talks.pdf

2.10. Strategic discussion: IIOE-2 going forward.

2.10.1. IIOE-2 JPO Report

Dr Aneesh Lotliker presented the report from IIOE-2 Project Office (IPO) India hosted by Indian National Centre for Ocean Information Services (INCOIS), Ministry of Earth Sciences (MoES), Hyderabad, India. Dr Lotliker presented the roles and responsibility of the IIOE-2 project office and mentioned that with the discontinuation of IIOE-2 Perth office, the IPO India has continued with the activities. Since IIOE-2 SC5 meeting, Dr Shenoi stepped down as co-chair of IIOE-2 SC, Dr Shailesh Nayak stepped down as co-chair of WG-3 and the action item pending for the replacement for Dr Ben Milligan as ST-1 co-chair. Three projects were endorsed taking the total count of the endorsed project to 50. IPO India played a key role in organising the IIOSC-2022 Conference Virtually during 14th – 18th March, 2022. IPO India maintained the active IIOE-2 website (https://iioe-2.incois.gov.in/IIOE-2/index.jsp), continuing with the endorsement of scientific activities, maintained metadata portal (https://iioe-2.incois.gov.in/IIOE-2/data.jsp) and endorsed scientific projects that align with the IIOE-2 objectives (https://iioe-2.incois.gov.in/IIOE-2/Endorsed_Projects.jsp). In addition, IIOE newsletters (https://iioe-2.incois.gov.in/IIOE-2/Publications.jsp?mode_pub_id=NL) and The Indian Ocean Bubble (https://iioe-2.incois.gov.in/IIOE-2/Bubble.jsp) were continued.

The SC recommend aligning the endorsed project with respect to science themes and also provide link to the project proposal and endorsement form.

Dr Lotliker also presented the project entitled "KIOST Indian Ocean Study: Korea-US Joint Observation Study of the Indian Ocean" received for endorsement under IIOE-2. This proposal is part of KUDOS (IIOE2-EP31: https://iioe-2.incois.gov.in/IIOE-2/EP31.jsp) with the objectives i) Observation using research vessels in the SCTR region (Physical, Biogeochemical, and pelagic ecosystem characteristics), ii) Observation of changes in the marine environment using autonomous instruments, iii) Satellite data analysis, Time-series observation by Mooring, Development of SCTR seasonal prediction system and iv) Reproduction of past fluctuations of SCTR.

The project has links to IIOE-2 ST-2 i.e. Boundary Current Dynamics, Upwelling Variability and Ecosystem Impacts. The project is funded by Ministry of Oceans and Fisheries, Republic of Korea and has International Collaboration. The project duration is from April 01, 2022 – December 31, 2026, and adhere to the IIOE-2 Data Sharing Policy. The benefits from IIOE-2 endorsement is to increase the impact of our research by sharing it with the IIOE2 community and create collaborations to oceanographers in foreign countries to extent the impact of research proposal.

IIOE-2 SC reviewed the project proposal and found that it suffices all the criteria of endorsement and hence recommend to endorse the project under IIOE-2.

There was discussion on including capacity building to be included as one of the components for the projects endorsed under IIOE-2. The SC noted that whenever there is an expedition, there are participants who are trained in various scientific aspects unless it is a short voyage and need not to be mentioned explicitly.

IIOE-2 SC recommended that capacity development can be kept as an optional criterion for the endorsed projects.

The Australian IIOE-2 JPO Node ceased operation on 30th Sep 2021, following the cessation of underpinning funding to Perth Programme Office of the IOC from the Western Australian Government, having been its principal cash sponsor for almost 2 Decades. Subsequently IIOE-2 JPO India has taken over all the activities and hence it is required to change the addresses in the letter-head and on website considering one project office.

IIOE-2 SC recommended that IIOE-2 JPO India to be termed as IIOE-2 PO (IPO) India and the addresses on the letter head and the web content to be modified.

2.10.2. IIOE-2 tenure

The SC noted that the tenure of the IIOE-2 is till 2025. For last seven-years IIOE-2 community has contributed significantly to the understanding of the Indian Ocean in terms of observation, research and capacity development. Also there have been many international collaborations exchanging scientific ideas. In addition, the ECSN has gained momentum. Therefore, it is imperative that efforts should be put to extend the tenure of IIOE-2. While the expeditions may not be extended without a sunset date, research will continue to be done from the data generated. There may be benefit in finding synergies and aligning with the objectives and

outcomes of the UN Decade of Ocean Science for Sustainable Development that will run until 2030.

The SC recommended finding synergies and aligning with UN Decade objectives and outcomes, with more emphasis on coastal waters, considering priorities of the participating countries, best practices and stronger linkages with other initiatives like IOGOOS, IORP, IRF etc.

2.10.3. IIOE-2's administrative and steering committee structure

The SC discussed the IIOE-2 governance structure and noted that no change is required for the the overall governance structure. The SC noted that few changes are required in terms of leadership for ST-1, ST-6 and WG-3. In addition, it was also discussed to include ECSN member in SC and each WG and ST. The best way is to engage the members and identify new co-chairs for WG and STs where required, and have the co-chair invite additional members. Dr Halina T. Kobryn has kindly volunteered to lead ST-1 (Human benefits and impacts).

The SC agreed Dr Halina T. Kobryn to be co-chair of ST 1. The SC recommended to obtain willingness to continue from the existing co-chairs of Working Groups and Science Themes. Obtain nominations for new co-chairs, where rewuired. Subsequently the new co-chairs to review Terms-of-Reference of each WG and ST. Also obtain nominations from ECSN to be member of SC, WG and ST.

2.10.4. Financial Resources

The allocated budget for IIOE-2 by SCOR was 15000 USD per year which is to be utilized by the core members of IIOE-2 and co-chairs of the working group to participate in the business meetings. The left-over funds can be used for a scientific discussion meeting or for writing synthesis paper. This year requested budget was 20000 USD and additionally there is 8000 USD with capacity building committee.

Previously, IIOE-2 JPO Perth office was funded by IOC with an appropriate budget. Since the Perth office has stopped functions, there has been no clarity on how these funds would be allocated/managed by the IOC. This will be further discussed during the IOGOOS business meeting. In addition, the IIOE-2 project office in India is supported by INCOIS with in-kind support for human resources, capacity building and facilitating business meetings.

The SC recommended communicating with IOC to obtain modus operandi for funding IIOE-2

2.10.5. IIOE-2 SC 7: Host, Location/venue & date

The SC discussed on the venue for the IIOE-2 SC 7 and the options that were discussed include Sri Lanka, India, Tanzania and Indonesia.

Explore the possibility of organizing IIOE-2 SC 7 at Indonesia with India as a back-up option

3. Summary of the Recommendations and actions

Recommendations	Action

Endorsement of the project "KIOST Indian Ocean Study: Korea-US Joint Observation Study of the Indian Ocean"	The necessary formalities to be completed and communicated to the principal investigators - IPO
Aligning the endorsed project with respect to science themes	The necessary modifications to be made on the web page - IPO
IIOE-2 JOP India to be termed as IIOE-2 PO India	The addresses on the letter head and the web content to be modified - IPO
IIOE-2's tenure (to 2030?) New Program aligning with UN Decade with more emphasis on coastal waters Consider priorities of the participating countries, best practices etc. Establish linkages with other initiatives like IOGOOS, IORP, IRF etc.	Core members of the IIOE-2 SC to meet during the year subject to availability of funds, to discuss the gap areas and consider updating the science & implementation plan towards future activities and possible alignment with UN Ocean Decade – Co-chairs & IPO
IIOE-2 Governance structure	NO CHANGES
Change in the Leadership Dr Halina T. Kobryn to be Co-chair of ST 1.	Obtain willingness to continue from the Existing co-chairs of Working Group and Science Themes - IPO Obtain nominations for new co-chairs, where required - IPO New co-chairs to review Terms-of-Reference – Co-chairs
Finalize Terms-of-Reference for WG & ST by respective co-chairs	Communicate with the co-chairs to review the Terms-of-Reference - IPO
Members from ECSN to be included in the IIOE-2 SSC	Circulate form for nominations and develop a webpage for ECSN registration - IPO
Include Indonesia, Korea and China as a part of IIOE-2 Regional Coordination Level	Communicate with the country representative - IPO
The Joint Project Office - India will continue as IIOE-2 Project Office (IPO)	Necessary changes to be made on the website, Contact Address and letterhead - IPO
Adding Capacity Development as an optional item in the Project Endorsement Criteria	Necessary modifications to be made in the Endorsement Form - IPO
Financial and in-kind resources needed to run IIOE-2.	Communicate with IOC to obtain modus operandi for funding IIOE-2 – Co-Chairs & IPO
Explore the possibility of organizing IIOE-2 SC 7 at Indonesia with India as a back-up option	Communicate with host to arrange the meeting - IPO

4. Group Photo

---------- END OF THE REPORT ----------