IIOE-2 2nd International Indian Ocean Expedition 2015-2025

Newsletter

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(A basin-wide research program co-sponsored by IOC-UNESCO, SCOR and IOGOOS)

To advance our understanding of interactions between geologic, oceanic and atmospheric processes that give rise to the complex physical dynamics of the Indian Ocean region, and to determine how those dynamics affect climate, extreme events, marine biogeochemical cycles, ecosystems and human populations.

Optimising the design of an observational testbed using observing system simulation experiments: A case study in the southeastern Arabian Sea

Background: The southeastern Arabian Sea is a region of high oceanic variability shaped by monsoon-driven currents, coastal upwelling, and freshwater influences. To enhance model validation, improve ocean state forecasts, and support Blue Economy, four new moored buoys are proposed for deployment off the southwest coast of India. Given the high cost of ocean instrumentation, identifying optimal buoy locations is essential. This study uses Observing System Simulation Experiments (OSSEs) to determine where these platforms will deliver the greatest benefits to ocean analysis and prediction systems. An OSSE is a model-based experiment used to test and evaluate new instruments or observing systems before they are built or deployed. It helps us to know how much a proposed observing systems would improve the model performances.

Methodology: A fraternal-twin OSSE framework was employed, consisting of three core components:

1. Nature Run:

   A high-resolution (~9 km) ROMS model with 80-member LETKF data assimilation, representing the most realistic ocean state.

2. Reference System:

   A deliberately degraded configuration (~25 km ROMS, 40 ensemble members, modified physics and perturbed forcing) to represent an operational forecast system.

3. Synthetic Observations (SynOPs):

   Sixteen initial synthetic temperature and salinity profiles were created across the proposed deployment area. These mimic real buoy profiles through added bias, random noise, and realistic instrument/representation errors. Validation against existing moorings demonstrated that SynOPs behave like true observations.

The study proceeded in two phases. In phase 1 each of the 16 SynOPs was assimilated individually into the Reference System. Their impacts were evaluated across key ocean variables: SST, thermocline depth, mixed-layer depth, sea-level anomaly (SLA), sea-surface salinity, and West India Coastal Current (WICC) speed. A new Composite Impact Assessment Parameter (CIAP) was developed to quantify each SynOP's overall benefit. This CIAP allows to weigh the individual impact of each of the key ocean variables (SST, MLD etc) which provides a holistic approach to account for the improvements of the required ocean variables. In phase 2 six new SynOPs were placed in the most promising subregion identified in Phase 1. All 15 possible combinations of four SynOPs were assimilated and assessed using CIAP to determine the optimal configuration.

Results and Discussion: Southern offshore locations provide the strongest improvements across most variables, especially SST, thermocline depth, MLD, and SLA. Northern and near-coastal locations show limited or even detrimental influence, mainly due to strong coastal gradients that the coarse-resolution Reference System struggles to resolve. SynOPs most consistently improving ocean analysis are located in the southern belt between 7°–10°N and 72°–76°E. The top-performing set of four locations (as in Figure 1) identified through CIAP corresponds to: (72.32°E, 10.15°N), (73.98°E, 6.88°N), (75.35°E, 8.98°N), and (76.18°E, 7.35°N).

Key Highlights

- These locations provide a broad regional impact on major physical variables, significant wintertime improvements during strong WICC variability, and highest cumulative benefit for operational ocean state estimation.
- Deploying buoys at these locations will strengthen ocean model validation and forecast accuracy, enhance satellite calibration/validation, improve understanding of monsoon-driven coastal processes and support fisheries, coastal management, and Blue Economy initiatives.

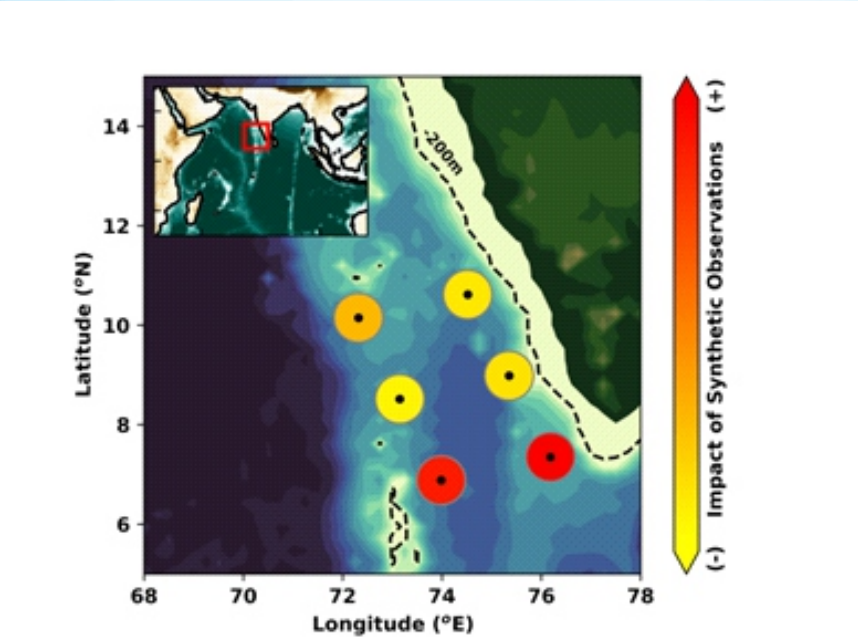

Figure-1: The impacts of each of the six synthetic buoy observations in the south eastern Arabian Sea

Citation: Paul, B., Baduru, B., Prajapati, J., Daiya, V., Athul, C.R. & Paul, A. (2025). Optimising the design of an observational testbed using observing system simulation experiments: A case study in the southeastern Arabian Sea. Quarterly Journal of the Royal Meteorological Society, e70069. Available from: DOI:/10.1002/qj.70069

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Tracking monsoonal impacts on trophic balance and phytoplankton size class dynamics in a tropical coastal lagoon

Tropical coastal lagoons are dynamic ecosystems where seasonal rainfall and freshwater inflow can rapidly alter water quality and productivity. Understanding how these changes affect the microscopic communities at the base of the food web is essential for predicting ecosystem health and supporting sustainable fisheries. Researchers from the "Kerala University of Fisheries and Ocean Studies, Kerala, India, the Department of Marine Sciences, Berhampur University, Odisha, India, the Wetland Research and Training Centre, Chilika Development Authority, Odisha, India, and the Centre for Geospatial Research, Department of Geography, University of Georgia, Athens, USA", have investigated how seasonal monsoon-driven hydrology influences phytoplankton communities and trophic structure in the Chilika Lagoon, one of India's largest coastal lagoons. The study focused on understanding how phytoplankton size classes (Pico-, Nano-, and Micro-Phytoplankton) respond to fluctuations in freshwater inflow and nutrient dynamics over two years (2018-2019) across a salinity gradient (Figure-1). Using high-performance liquid chromatography (HPLC) coupled with pigment-based chemotaxonomy, the researchers were able to reliably detect Pico- and Nano-phytoplankton, which are often underestimated by traditional microscopy techniques. Results revealed a marked shift in the lagoon's trophic status, from eutrophic conditions in 2018 (Trophic Level Index, TLI = 4.61) to mesotrophic conditions in 2019 (TLI = 3.98). This transition was associated with reduced nutrient concentrations and increased turbidity period. Across all seasons and sectors, Pico-phytoplankton consistently dominated (66-76%), highlighting their adaptive advantage under

varying nutrient and light regimes. Micro-Phytoplankton, in contrast, showed seasonal peaks, particularly during the 2019 monsoon, likely linked to increased silicate availability and elevated turbidity. Redundancy Analysis (RDA) indicated strong spatiotemporal associations between environmental factors and phytoplankton size classes. Pico-phytoplankton were positively correlated with salinity, transparency, and nutrient concentrations, whereas Micro-Phytoplankton were associated with higher turbidity and total suspended matter. Spatially, the northern sector of the lagoon exhibited higher phytoplankton biomass due to nutrient-rich freshwater inflow, while the southern sector remained low, likely influenced by limited inflow and higher grazing pressure. The findings carry important trophodynamic implications. The dominance of Pico-phytoplankton during pre- and post-monsoon seasons supports a microbial-based food web, whereas the increased abundance of Micro-Phytoplankton during the monsoon suggests a temporary shift toward a mixed trophic structure. These variations in size-structured phytoplankton communities are ecologically significant, as they influence energy transfer efficiency and potentially impact fisheries productivity. Beyond Chilika Lagoon, these insights are relevant to other monsoon-influenced tropical coastal lagoons globally, where hydrological and climatic variability governs ecosystem functioning. The researchers emphasize the importance of incorporating phytoplankton size-based monitoring and functional metrics into routine assessments to detect early trophic shifts. Additionally, upstream flow regulation and nutrient management could help stabilize lagoon ecosystems and prevent abrupt ecological changes. This study highlights how seasonal monsoon dynamics influence phytoplankton communities and trophic interactions, underscoring the critical need for adaptive management strategies to sustain the ecological and economic productivity of tropical coastal lagoons under changing climatic conditions.

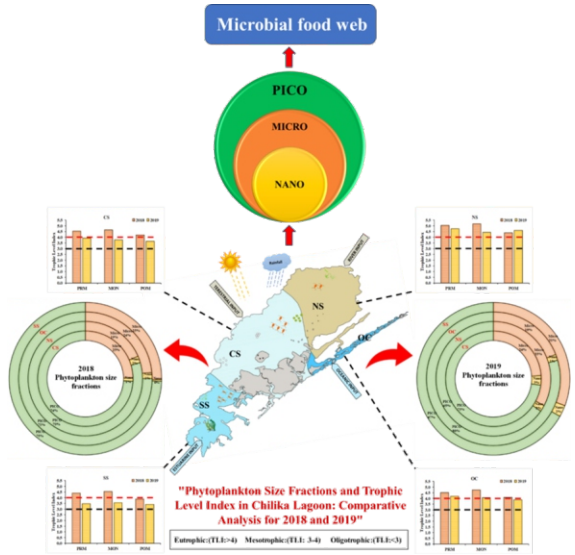

Figure-1: Phytoplankton size-fraction composition (Pico, Nano, Micro-phytoplankton) and trophic level index in Chilika Lagoon for 2018 vs. 2019.

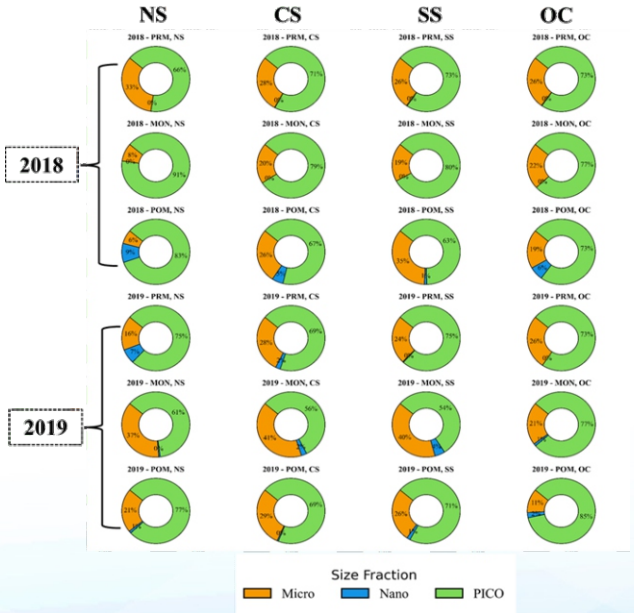

Figure-2: Seasonal distribution of phytoplankton size fractions (Pico, Nano, Micro-phytoplankton) across the Northern Sector (NS), Central Sector (CS), Southern Sector (SS), and Outer Channel (OC) of Chilika Lagoon during Pre-Monsoon (PRM), Monsoon (MON), and Post-Monsoon (POM) in 2018 and 2019.

Citation: Singh, Sambit, Susmita Raulo, Tamoghna Acharyya, Anu Gopinath, Pradipta R. Muduli, Deepak R. Mishra, and Gurdeep Rastogi. "Monsoon driven interplay between phytoplankton size classes and trophic status in a tropical coastal lagoon." Science of The Total Environment 997 (2025): https://doi.org/10.1016/j.scitotenv.2025.180198

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International Indian Ocean Science Conference (IIOSC) 2025

The Second International Indian Ocean Expedition (IIOE-2) is a major scientific program executed with the engagement of the global scientific community in collaborative marine research in the Indian Ocean. With participation from scientific institutions in more than 22 countries, IIOE-2 strives to advance our understanding of the physical, chemical, biological, geological and climatological aspects of the Indian Ocean thereby contributing to the sustainable management of this region and its resources which are critical to livelihoods of millions of people and economies of Indian Ocean rim and island nations.

The International Indian Ocean Science Conference (IIOSC)-2025 will be held from 01–05 December 2025 in Hyderabad, India. The event will be hosted by the Indian National Centre for Ocean Information Services (INCOIS), Ministry of Earth Sciences (MoES), Govt. of India.

Technical Sessions

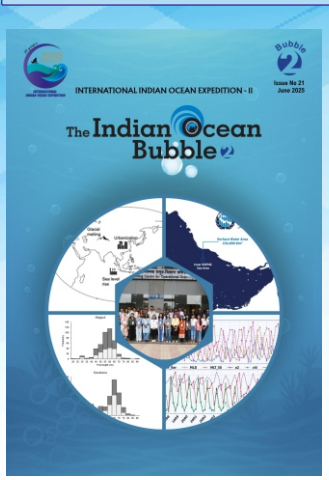
- Theme-1: Human benefits and impacts
- Theme-2: Boundary current dynamics, upwelling variability and ecosystem impacts
- Theme-3: Monsoon variability and ecosystem response
- Theme-4: Circulation, climate variability and change
- Theme-5: Extreme events and their impacts on ecosystems and human populations
- Theme-6: Unique geological, physical, biogeochemical, and ecological features of the Indian Ocean
- Theme-7: IIOE-2 contribution to sustainable development: toward the UN Decade of Ocean Science
- Theme-8: Marginal seas of the Indian Ocean
- Theme-9: Indian Ocean seabed and habitat mapping

To see Program Schedule : https://iiosc2025.incois.gov.in/iiosc2025/ProgrammeSchedule.jsp

Instructions for Presenters : https://iiosc2025.incois.gov.in/iiosc2025/presenter_instructions.jsp

Website: https://iiosc2025.incois.gov.in

The Indian Ocean Bubble, Issue No. 21 is now available online



Web Link: https://iioe-2.incois.gov.in/IIOE-2/pdfviewer_pub.jsp?docname=IIOE-2-DOC_OM_310.pdf

Informal articles are invited for the next issue. Contributions referring Indian Ocean studies, cruises, conferences, workshops, tributes to other oceanographers etc. are welcome.

Articles may be up to 1500 words in length (MS-Word) accompanied by suitable figures, photos (separate .jpeg files).

Send your contributions as usual to iioe-2@incois.gov.in

Deadline for Next Issue: **5th December 2025**

Endorse your projects in IIOE-2

Don't miss the opportunity to network, collaborate, flesh out your research project and participate in IIOE-2 cruises!!

The endorsement of your scientific proposal or a scientific activity focusing on the Indian Ocean region is a recognition of the proposal's or activity's alignment with the mission and objectives of IIOE-2, of its potential for contributing to an increased multi-disciplinary understanding of the dynamics of the Indian Ocean, and of its contribution to the achievement of societal objectives within the Indian Ocean region. Over 63 International, multi-disciplinary scientific projects have already been endorsed to date by the IIOE-2. Yours could be the next one!

Visit https://iioe-2.incois.gov.in/IIOE-2/EndorsementForm.jsp for further details and for projects already endorsed by IIOE-2 https://iioe-2.incois.gov.in/IIOE-2/Endorsed_Projects.jsp.

Call for Contributions

Informal articles/short notes of general interest to the IIOE-2 community are invited for the next (December-end) issue of the IIOE-2 Newsletter. Contributions referring IIOE-2 endorsed projects, cruises, conferences, workshops, "plain language summary" of published papers focused on the Indian Ocean etc. are welcome. Articles may be up to 500 words in length (Word files) accompanied by suitable figures, photos.(separate.jpg files).

Deadline: 25 December, 2025

Send your contributions to iioe-2@incois.gov.in

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IOGOOS Global Ocean Observing System for Indian Ocean

United Nations Educational, Scientific and Cultural Organization | Intergovernmental Oceanographic Commission

International Council for Science SCOR Scientific Committee on Oceanic Research