

*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.*

## Blue Economy and Sustainable Ocean

In recent years, the Blue Economy has emerged as a pivotal framework for driving economic growth due to the vast resources and services the ocean can provide. The concept of the Blue Economy is gaining global attention among both developed and developing countries, and India is no exception. India has begun working towards this with well-planned mega projects such as Sagar Mala, PM Gati Shakti, and PM Matsya Sampada Yojana, among others. As activities to enhance the contribution of the Blue Economy to national GDP accelerate in the coming years, it is equally important to devise methodologies and philosophies to ensure the sustainable utilization and management of oceanic resources, protecting the oceans, their resources, flora and fauna, and the overall environment. As the great sage Chanakya said, governments should collect tax like honeybees gather nectar from flowers—gently, without inflicting pain or damage.

Achieving sustainable utilization and management of the oceans demands diverse data, informed decision-making, and the implementation of strict governance strategies. The Blue Economy encompasses a wide range of sectors, including research and data generation, the development of high-quality infrastructure, eco-friendly transportation, and high-end technologies. To emphasize the importance of promoting the Blue Economy across multiple sectors and ensuring sustainable utilization and management of the oceans in the Indian context, a series of articles has been published as a special section in Current Science (Volume 126, Number 2, pages 153-235, 25 January 2024). Written by esteemed researchers and experts, these articles offer invaluable insights into key facets of this evolving economic paradigm.

The special section covers topics ranging from economic and accounting practices within the marine context to the complex dynamics of marine fisheries, ports and shipping operations, energy and freshwater extraction from the oceans. This section serves as a repository of knowledge for the Blue Economy, especially in the Indian context.

The first article, titled "From Ocean Science to Sustainable Blue Economy," provides an overview of the Blue Economy, emphasizing the role of ocean science and technology in its promotion and the conservation of ocean space. The second article identifies the sectors contributing to India's Blue Economy and quantifies their economic value. The third article examines the intricate dynamics of fisheries in India and proposes a path to achieve self-sufficiency in fish production. The fourth article, discusses the challenges of expanding the shipping industry in India, while the fifth article explores the status of Indian efforts in freshwater and energy extraction from the ocean and future scalability.

The special section also delves into the rich reserves of marine minerals, biodiversity, and the burgeoning industry of coastal and island tourism, shedding light on extraction, preservation, and economic value. Discussions on ocean services, mariculture, and marine spatial planning further enrich the special section, highlighting pathways toward sustainable growth and resource management.

These articles collectively provide valuable insights into the diverse aspects of the Blue Economy, from accounting for the Blue Economy, fisheries, and coastal infrastructure for blue growth to technologies for energy and freshwater extraction, deep-sea mineral resources, and biodiversity preservation, as well as operational oceanographic services, tourism, and marine spatial planning. The wealth of knowledge presented underscores the multidimensional nature of the Blue Economy and its significance in fostering sustainable growth and resource management.



As the global community actively defines the future of our oceans during the United Nations Decade of Ocean Science for Sustainable Development (2021-2030), this special section serves as a guiding compass for policymakers, researchers, industry stakeholders, and environmental advocates. It calls for innovative approaches, collaborative strategies, and robust governance frameworks to foster a harmonious relationship between economic prosperity and environmental conservation.

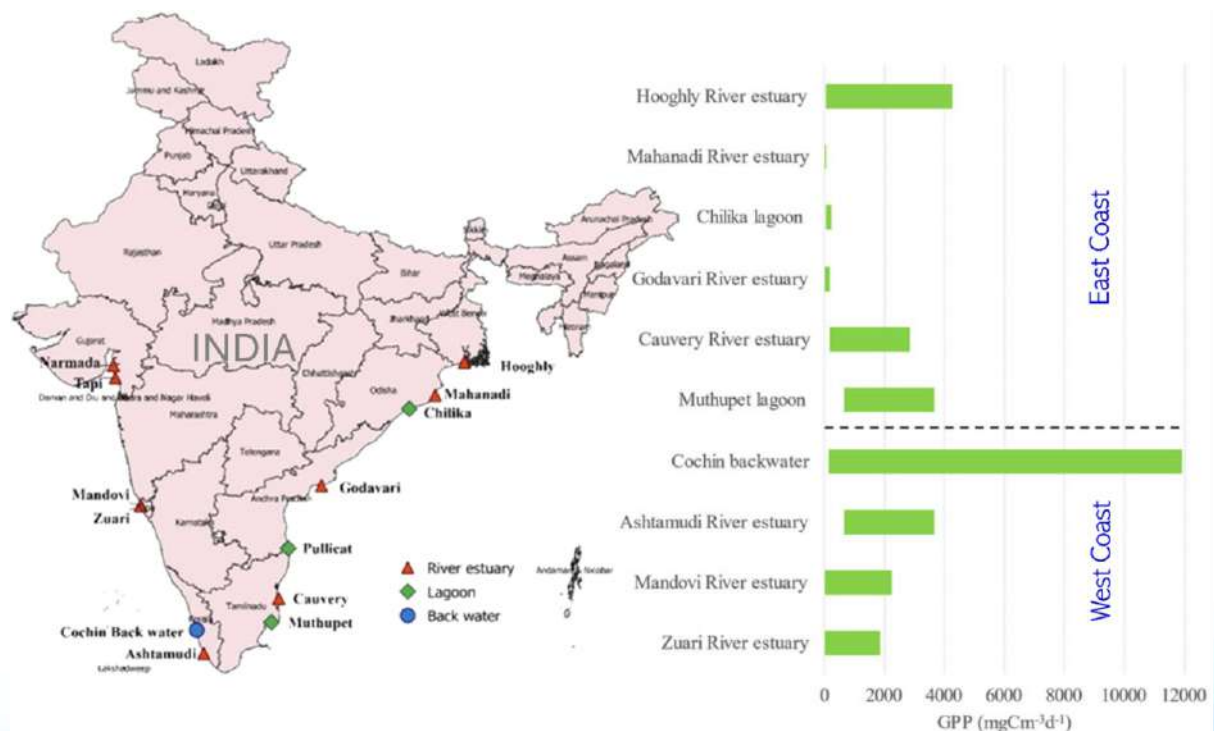
The special section on Blue Economy is accessible at

<https://www.currentscience.ac.in/show.issue.php?volume=126&issue=2>

[Report Courtesy: Dr. S.S.C. Shenoi (shenoi1958@gmail.com), MoES Chair Professor/Scientist & Former Director, INCOIS and N. Kiran Kumar (kirankumar@incois.gov.in), Scientist, INCOIS, Hyderabad, India.]

## Exploring the Phytoplankton Primary Production Dynamics in Indian Estuaries

Estuaries stand as dynamic ecosystems, and among them, Indian estuaries hold a special place. These coastal bodies, where freshwater meets the sea, are biogeochemical hotspots. Phytoplankton, those microscopic primary producers of the marine systems, play a pivotal role in these estuarine ecosystems, fueling the intricate food webs that sustain diverse marine life. A team of researchers from the Centre for Marine Living Resources and Ecology, India, Berhampur University, India, the Indian National Centre for Ocean Information Services, and Heriot-Watt University, UK, carried out a comprehensive review of the phytoplankton primary production in relation to environmental forcing in Indian estuaries. Their study delved deep into the variability of phytoplankton primary production (PPP) in Indian estuaries, offering insights into the patterns of productivity and the environmental factors shaping them. The findings, deduced from a comprehensive analysis of available literature, shed light on the methods employed for measuring PPP and the wide range of values observed across different estuaries. Interestingly, the study revealed a disparity in the methods used for measuring PPP, with the oxygen evolution method being more prevalent than the  $^{14}\text{C}$  incubation method. This preference might stem from safety concerns associated with the latter method, which requires hazardous materials and permissions for experimentation. The PPP values exhibited significant spatial and temporal variations, with estuaries along the west coast showcasing a wider range compared to their counterparts on the east coast. Among the riverine estuaries, lagoons, and backwaters, certain estuaries like Hooghly, Muthupet, and Cochin exhibited particularly high PPP values, highlighting the influence of local conditions on productivity. Seasonality emerged as a prominent factor influencing PPP dynamics, with post-monsoon seasons witnessing peaks in productivity driven by optimal conditions for phytoplankton growth.



The figure shows (a) the locations of different coastal ecosystems along the Indian coast and (b) the range of phytoplankton Gross Primary Productivity (GPP) reported from the Indian estuaries. Source: Singh et al. (2023)



This seasonal fluctuation underscores the intricate interplay between environmental factors such as water residence time, light availability, and nutrient levels. Nutrient limitation emerged as a key determinant of PPP, with most Indian estuaries experiencing nitrogen limitation, albeit with transient phosphate limitations observed in some cases. Anthropogenic inputs, such as agricultural runoff and industrial effluents, can intensify nutrient imbalances, impacting estuarine productivity and ecosystem health. Despite the critical role of PPP in understanding estuarine ecosystems, there is a notable need for more research in this area, with only a limited number of estuaries being extensively studied. Challenges such as logistical constraints and methodological limitations underscore the need for collaborative efforts to enhance our understanding of PPP in Indian estuaries. Looking ahead, advancements in satellite-based ocean color remote sensing hold promise for expanding our knowledge of PPP at larger spatial and temporal scales. However, overcoming technical challenges such as spatial resolution limitations and interference from suspended sediment matter remains imperative for harnessing the full potential of satellite-based measurements. In essence, unraveling the complexities of PPP in Indian estuaries deepens our understanding of these important ecosystems. It underscores the urgent need for sustainable management practices in the face of mounting anthropogenic pressures and climate change. By bridging the gap between scientific inquiry and real-time application, the study suggests the adoption of a more holistic approach to conserving and preserving these invaluable coastal ecosystems.

Citation: Singh, S., Acharyya, T., Raulo, S., Sudatta, B.P., Sahoo, C., Srichandan, S., Baliarsingh, S.K., & Lotliker, A.A. (2023). A Review of Phytoplankton Primary Production in Relation to Environmental Forcing in Indian Estuaries. In: Tripathy, S.C., Singh, A. (eds) Dynamics of Planktonic Primary Productivity in the Indian Ocean. Springer, Cham. [https://doi.org/10.1007/978-3-031-34467-1\\_1](https://doi.org/10.1007/978-3-031-34467-1_1)

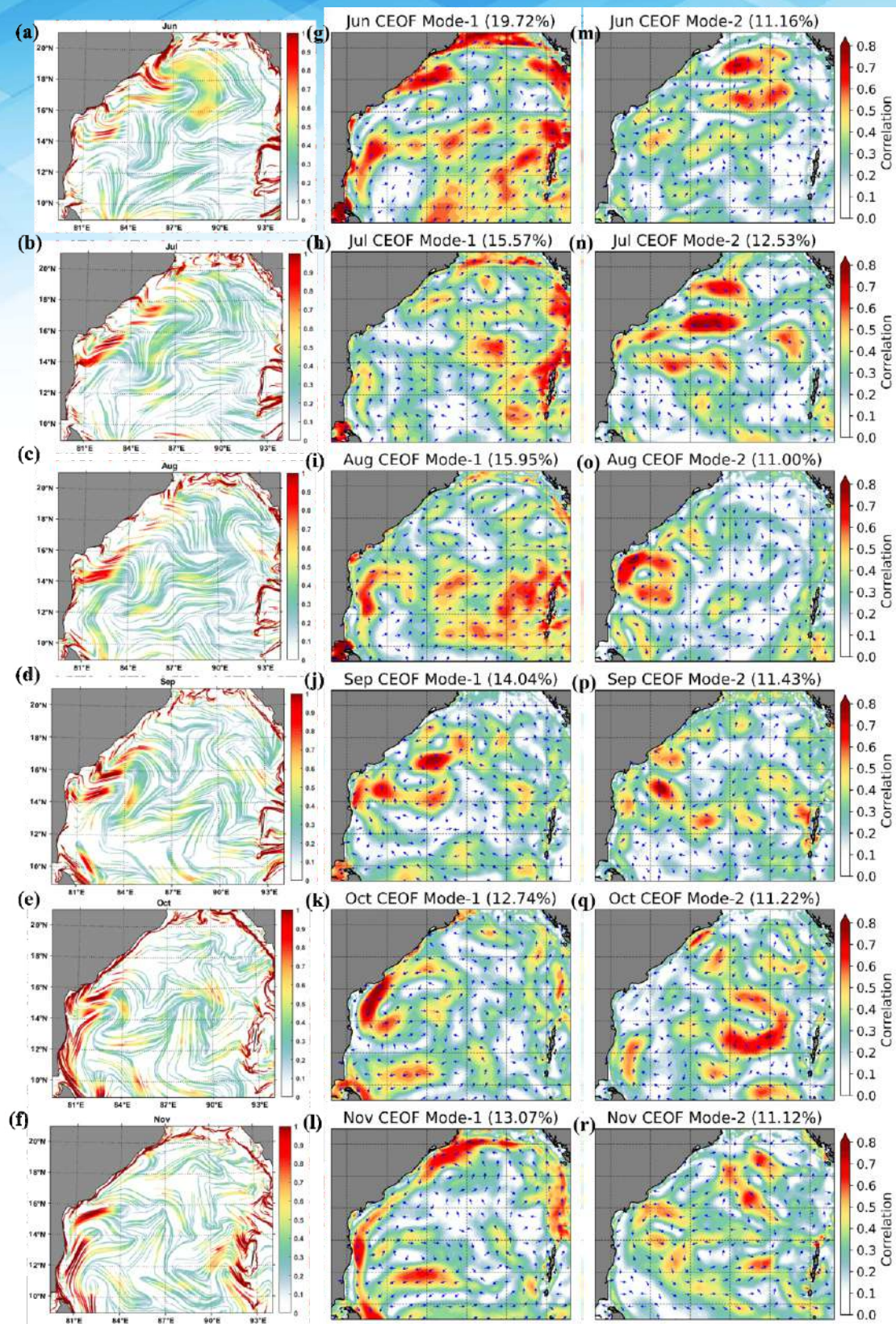
[Report Courtesy: Susmita Raulo ([s.raulo-p@incois.gov.in](mailto:s.raulo-p@incois.gov.in)), INCOIS, Hyderabad, India and Sambit Singh ([sambitsinghjspur@gmail.com](mailto:sambitsinghjspur@gmail.com)), CMLRE, Kochi, India]

### Extraction of persistent lagrangian coherent structures for the pollutant transport prediction in the Bay of Bengal

Persistent climatological Lagrangian coherent structures (cLCS) (surface transport patterns) were extracted from the computed long-term (1994-2017) surface velocity fields in the Bay of Bengal (BoB) for the first time (Trinadha Rao, et al., 2024, Sci Rep 14, 8761). LCS are the hidden fluid flow skeletons that provide meaningful information about the Lagrangian circulation. The LCSs were compared with the satellite drifter data and found to be reasonably matching other than in the sub-mesoscale activity region. The potential monthly cLCS maps in response to the SW monsoon, NE monsoon, and pre and post-monsoon periods were discussed. Further, this study also depicted and demonstrated the cLCS trends associated with the strong western boundary current (EICC) and the mesoscale processes (eddies) in the BoB. The results show one seasonal accumulation zone off Visakhapatnam, wherein the cLCS are strongly associated with the seasonal anticyclonic eddy. The robust, attractive cLCS are seen along the coastal boundary of the BoB throughout the year compared to the open ocean. Overall, the strong, attractive coastal cLCS are yielded in response to the monsoon-induced coastal currents and their associated mesoscale processes, such as eddies. Interestingly, the computed cLCS maps also depicted the transport pattern of the northern BoB freshwater plume southward along the east coast of India, indicating that these cLCS maps can also give meaningful information on freshwater plume transport. In the current study, we also used the CEOF (Complex empirical orthogonal functions) analysis to confirm the dominant features depicted by the cLCS and to reveal any features that the cLCS do not capture. The first and second modes of CEOF variability mainly contributed to the dominant features of surface transport, as revealed by the cLCS. The results show that the dominant transport pattern induced by the monsoon currents and eddies is more significant in cLCS than in EOFs. However, during July and August, a few transport patterns are more significant in EOFs than in cLCS (Figure-1).

To our knowledge, this is the first approach that has been used in the BoB to reveal surface transport patterns by augmenting the cLCS and EOFs. The application of these cLCS maps in pollutant trajectory prediction is also verified with the actual oil spill incident of Ennore Port, Chennai. The results match each other well and depict the oil spill's trajectory. This is an excellent method to ensure pollutant dispersion and movement in the region of the spill incident area. These extracted persistent cLCSs are exactly apt for the dispersion of the oil spill movement. The great advantage is that these maps help forecast the trajectory of oil spills or any surface floating pollutants caused by any accidents/incidents in the Bay of Bengal in the future. Thus, once these climatological Lagrangian Coherent Structures are available, they act as a primary proxy to identify the spill trajectory, mitigate the risk, and are helpful in planning the immediate response.





**Figure-1: climatological Lagrangian coherent structures and Complex empirical orthogonal function analysis mode-1 and 2 over the Bay of Bengal during 1994–2017 for the months of June, July, August, September, October and November.**

Citation: Trinadha Rao, V., Suneel, V., Gulakaram, V.S. et al. Extraction of persistent lagrangian coherent structures for the pollutant transport prediction in the Bay of Bengal. Sci Rep 14, 8761 (2024).

<https://doi.org/10.1038/s41598-024-58783-4>

[Report Courtesy: Trinadha Rao V, INCOIS, Hyderabad, India a; E-mail: vt.rao-p@incois.gov.in]

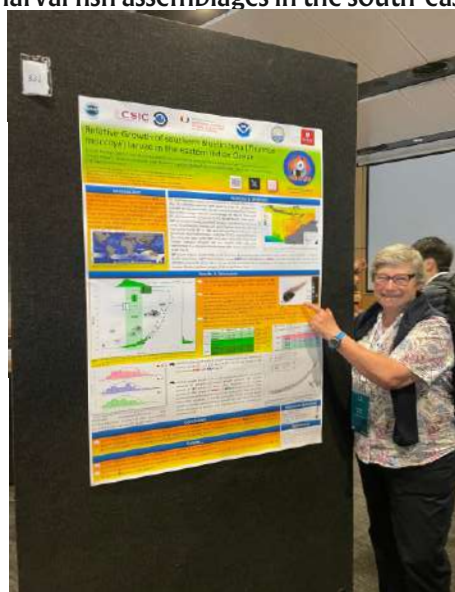


## Indo-Pacific Fish Conference

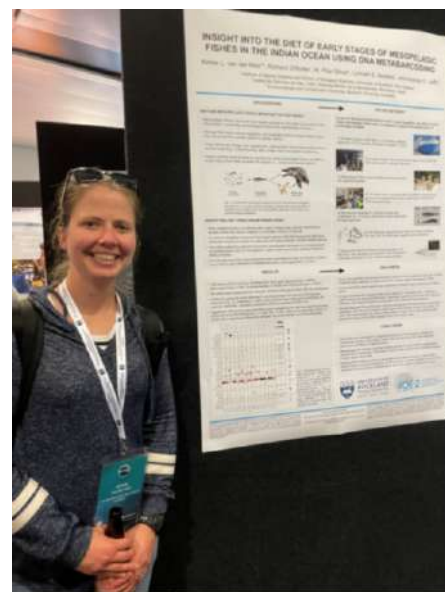
The eleventh Indo-Pacific Fish Conference (IPFC) was successfully hosted in November 2023 in Auckland, New Zealand in conjunction with the annual conference of the Australian Society for Fish Biology. The COVID-induced hiatus since the previous IPFC in Papeete, Tahiti in 2017 resulted in a bumper edition with more than 500 people attending the very well-organised meeting at the University of Auckland.



Amongst the five parallel sessions running daily and a bumper evening poster session there were several papers presented that pertained to the fishes of the Indian Ocean with delegates from South Africa, Kenya, Reunion, Seychelles, Saudi Arabia, UAE, India, Singapore and Australia all presenting their work on Indo-Pacific fish systematics and ecology. Included amongst these were presentations that related directly to two IIOE-2 endorsed projects, namely the BLOOFINZ and 110°E projects. These were a poster on growth of Southern Bluefin Tuna larvae in the Indo-Australian basin (Ricardo Borrego Santos et al.; Figure-1), a poster indicating the use of DNA metabarcoding to ascertain the diet of mesopelagic fish larvae from 110°E (Aimee van der Reis et al.; Figure-2) and an oral presentation by Lynnath Beckley and Pilar Olivar on the oceanic larval fish assemblages in the south-east Indian Ocean.



*Figure-1: Prof Lynnath Beckley presenting the *Thunnus maccoyi* larval growth poster on behalf of the members of the BLOOFINZ IIOE-2 endorsed project.*



*Figure-2: Dr Aimee van der Reis presenting a poster on the diet of mesopelagic fish larvae as determined using DNA metabarcoding of prey as part of the 110°E endorsed project.*

A highlight of the IPFC conference is always the presentation of the Bleeker Awards for outstanding contributions to Systematics and Ecology of Indo-Pacific fishes. Dr Doug Hoesé of the Australian Museum received the Bleeker Award for Systematics and gave a well-received plenary presentation on “How far has taxonomy progressed in the last 60 years with emphasis on Australian and gobioid fishes”. Prof Geoff Jones of James Cook University received the Bleeker Award for Ecology and enthralled everyone with his plenary presentation on “The secrets of larval fish dispersal on coral reefs: progress and prospects” with much content derived from his long-term work on the coral reef fishes in Kimbe Bay on the north coast of Papua New Guinea.

At each conference, a new International Steering Committee (ISC), representative of the geographically vast Indo-Pacific region, is elected. The Indian Ocean representatives on the 15-person committee are Dr Melita Samoilys (Kenya), Dr Mike Berumen (Saudi Arabia), Dr Zeehan Jaafar (Singapore) and Emeritus Prof Lynnath Beckley (Australia). Dr Tom Trnski (Auckland Museum, New Zealand) is the new chair of the ISC.

The next IPFC is planned for June 2025 in Taipei, Taiwan and, with many IIOE-2 endorsed projects including ichthyofauna, it would be great to have the IIOE-2 again well-represented. Nominations for the 2025 Bleeker Awards will be called for towards the end of 2024 and all enquiries should be addressed to Dr Tom Trnski ([ttrnski@aucklandmuseum.com](mailto:ttrnski@aucklandmuseum.com)).

[Report Courtesy: Lynnath Beckley, Environmental & Conservation Sciences, Murdoch University, Western Australia; E-mail: [L.Beckley@murdoch.edu.au](mailto:L.Beckley@murdoch.edu.au)]

## Join us for the Ocean Insights – Indian Ocean Seminar Series feat. ECRs. !

The IIOE-2 Early Career Scientist Network is thrilled to present yet another exciting talk of "Ocean Insights – Indian Ocean Seminar Series feat. ECRs", designed especially for early career scientists focusing on the Indian Ocean to share about their research. This captivating seminar series offers a unique opportunity for the Early Career Researchers to showcase their work, build connections, and explore collaborations within the marine sciences community.

Whether you are an early career researcher, an experienced scientist, or simply an enthusiast seeking to broaden your knowledge of marine science in the Indian Ocean, **ALL ARE INVITED!**

### Why Should You Join?

- Engaging presentations from early career marine scientists.
- Interactive Q&A sessions to delve deeper into research topics and foster innovative ideas.
- A platform to connect with like-minded researchers and experienced scientists.

Don't miss out on the opportunity to enhance your understanding of marine science in the Indian Ocean and connect with fellow researchers. [Register now](https://zoom.us/join/9171111111) and mark your calendars!

Details on the upcoming talk are given below. We look forward to your enthusiastic participation!

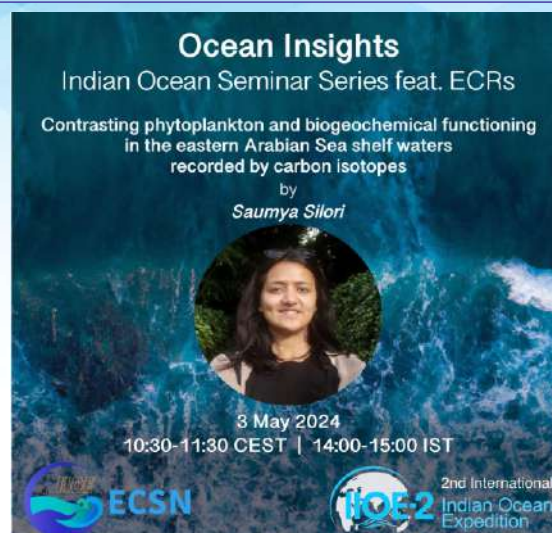
### Key Details:

Title: Contrasting phytoplankton and biogeochemical functioning in the eastern Arabian Sea shelf waters recorded by carbon isotopes; Region: Indian Ocean; Format: Online

Link: <https://zoom.us/join/9171111111>

Date: Every first Friday of the month, starting on **04<sup>th</sup> May 2024**

If you are enthusiastic about sharing your contributions, please reach out to us at the e-mail address: [ecsn.iioe@gmail.com](mailto:ecsn.iioe@gmail.com)



## DEEP-SEA RESEARCH PART II



Special  
Issue

Submit your paper >



The 2nd International Indian Ocean Expedition (IIOE-2): Motivating New Exploration in a Poorly Understood Basin (Volume 7)

*Deep Sea Research Part II: Topical Studies in Oceanography*

Edited by

Raleigh Hood, Birgit Gaye, Lynnaht Beckley, VVSS Sarma, Laure Resplandy, P.N. Vinayachandran

THE SUBMISSION PORTAL FOR VOL. 7 OF THE DEEP-SEA RESEARCH II SPECIAL ISSUE SERIES ON THE IIOE-2 IS NOW OPEN

Submission of manuscripts that describe the results of studies related to the physical, chemical, biological, and/or ecological variability and dynamics of the Indian Ocean (including higher trophic levels) is encouraged.

Submission of manuscripts from students and early career scientists is also encouraged.

If you are interested in submitting a manuscript, please contact Raleigh Hood ([rhoo@umces.edu](mailto:rhoo@umces.edu)).

### Important Dates:

Manuscript Submission Deadline: August 15, 2024

Editorial Acceptance Deadline: February 15, 2025

For more details please visit

<https://www.sciencedirect.com/journal/deep-sea-research-part-ii-topical-studies-in-oceanography/about/call-for-papers#the-2nd-international-indian-ocean-expedition-iioe-2-motivating-new-exploration-in-a-poorly-understood-basin-volume-7>





# AOGS2024

## 21<sup>ST</sup> ANNUAL MEETING

Pyeongchang, Gangwon-do  
Home to Winter Olympics  
23 to 28 Jun 2024



**Asia Oceania Geosciences Society (AOGS)** was established in 2003 to promote geosciences and its application for the benefit of humanity, specifically in Asia and Oceania and with an overarching approach to global issues. Asia Oceania region is particularly vulnerable to natural hazards, accounting for almost 80% human lives lost globally. AOGS is deeply involved in addressing hazard related issues through improving our understanding of the genesis of hazards through scientific, social and technical approaches. AOGS holds annual conventions providing a unique opportunity of exchanging scientific knowledge and discussion to address important geo-scientific issues among academia, research institution and public. Recognizing the need of global collaboration, AOGS has developed good co-operation with other international geo-science societies and unions such as the European Geosciences Union (EGU), American Geophysical Union (AGU), International Union of Geodesy and Geophysics (IUGG), Japan Geo-science Union (JpGU), and Science Council of Asia (SCA).

The website may be accessed here: <https://www.asiaoceania.org/aogs2024/public.asp?page=home.asp>

### Session-OS06: Physics, Biogeochemistry, and Climate Dynamics of the Indian Ocean

#### Session Details

##### Section(s):

OS - Ocean Sciences (Primary)

AS - Atmospheric Sciences



#### Announcements

##### SUBMIT ABSTRACTS

17 Oct 2023 – 02 Jan 2024

[Instructions](#) | [Submit Now](#)

##### APPLY FUNDING SUPPORT

17 Oct 2023 – 02 Jan 2024

[Instructions](#) | [Apply Now](#)

##### 2024 AWARD NOMINATIONS

17 Oct 2023 – 02 Jan 2024

[Guidelines](#)

#### Conveners

\* Prof SungHyun Nam (Seoul National University)

Dr Nicolino (Nick) D'Adamo (Adjunct Research Fellow, Oceans Institute of the University of Western Australia)

Dr Dong-Jin Kang (Korea Institute Of Ocean Science And Technology)

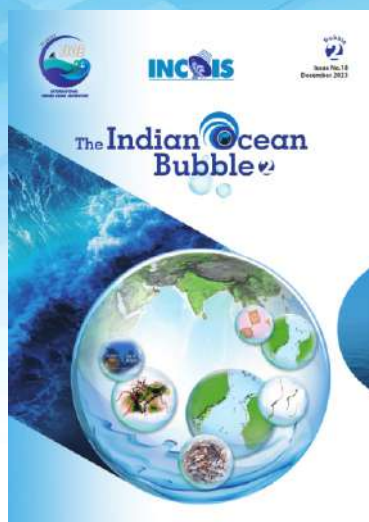
Dr Yukio Masumoto (The University of Tokyo)

#### Session-OS06: Description

Recent increases in extreme events such as flooding, droughts, heatwaves, and tropical cyclones have a large impact on the population living in the Asia and Oceania countries. Increasing evidence on the roles of Indian Ocean in impacting climate extremes, climate variability, and climate change via changes in energy, hydrological and biogeochemical cycles has been reported. The Indian Ocean is of particular interest, for example, as influenced by the seasonally reversing monsoon forcing and upwelling centers in the Indian Ocean are found in the off-equatorial regions unlike in the easterly wind-forced Pacific and Atlantic Oceans. The northern region is dominated by the monsoons whereas the seasonal reversal is less pronounced in the southern region. This session invites contribution of physics, biogeochemistry, and climate dynamics of Indian Ocean based on in-situ and remotely-sensed observations, models, theories, and paleo proxies that reveal processes, variability, and projected changes within the Indian Ocean. This includes, but not limited to 1) Indian Ocean variability such as Indian Ocean Basin Mode, Indian Ocean Dipole Mode, Madden-Julian Oscillations, 2) Upwelling in the Indian Ocean such as open-ocean upwellings or thermocline ridge/dome (e.g., Seychelles-Chagos Thermocline Ridge) and coastal upwellings at both western and eastern sides, 3) Processes underlying basin-scale or regional circulation, 4) Ocean-atmosphere interaction processes (heat, freshwater, momentum, carbon, etc.), 5) Biogeochemistry of the Indian Ocean water masses, 6) Links between ocean sciences and socio-economic requirements in the Indian Ocean, and 7) Interactions and exchanges between the Indian Ocean and other basins. Abstracts on related activities, such as capacity building, education, outreach, project development in the Indian Ocean, contributing to the UN Decade of Ocean Science for Sustainable Development and to the Second International Indian Ocean Expedition are also welcome.

**Keyword(s):** Indian Ocean; Physics; Biogeochemistry

## The Indian Ocean Bubble, Issue No.18 is now available online



Web Link: [https://iioe-2.incois.gov.in/IIOE-2/pdfviewer\\_pub.jsp?docname=IIOE-2-DOC\\_OM\\_293.pdf](https://iioe-2.incois.gov.in/IIOE-2/pdfviewer_pub.jsp?docname=IIOE-2-DOC_OM_293.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 (Word files) accompanied by suitable figures, photos (separate .jpg files)

Deadline for submission is upto: **05<sup>th</sup> May, 2024**

Send your contributions as usual to [iioe-2@incois.gov.in](mailto:iioe-2@incois.gov.in)

## 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 54 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](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 (May-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 May, 2024**



Access the latest issue of Indian Ocean Bubble-2

<https://iioe-2.incois.gov.in/IIOE-2/Bubble.jsp>



Enroll yourself with IIOE-2 Community

<https://iioe-2.incois.gov.in/IIOE-2/Signup.jsp>

Follow us:



[iioe-2.incois.gov.in](https://iioe-2.incois.gov.in)



@IIOE2



@iioe\_2



The IIOE-2 Newsletter is published online by:



Feedback? [iioe-2@incois.gov.in](mailto:iioe-2@incois.gov.in)

