2nd International Indian Ocean Expedition
2015-2025

# Newsletter

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

Volume-7, Issue-5
May, 2023

*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.*

## Upwelling variability in the Seychelles–Chagos Thermocline Ridge of the southwestern tropical Indian Ocean

The Seychelles–Chagos Thermocline Ridge (SCTR) in the southwestern tropical Indian Ocean exhibits a prominent subsurface upwelling (Figure-1), which plays an important role in the ocean environment, including ocean heat content and ecosystem variability. The SCTR upwelling is suppressed when downwelling Rossby waves propagate from the eastern Indian Ocean during the positive phase of the Indian Ocean Dipole (IOD) or El Niño periods. Recent studies have suggested that the upwelling can be further suppressed during the co-occurrence years of positive IOD and El Niño, associated with the strong easterly wind anomalies in the eastern Indian Ocean. This study examined the temporal variations in the SCTR upwelling strength during 1968–2017, identified strong upwelling suppression events, and analyzed their characteristics by focusing on the role of both remote and local wind forcing, not limited to the remote influence linked to the IOD and the El Niño Southern Oscillation.

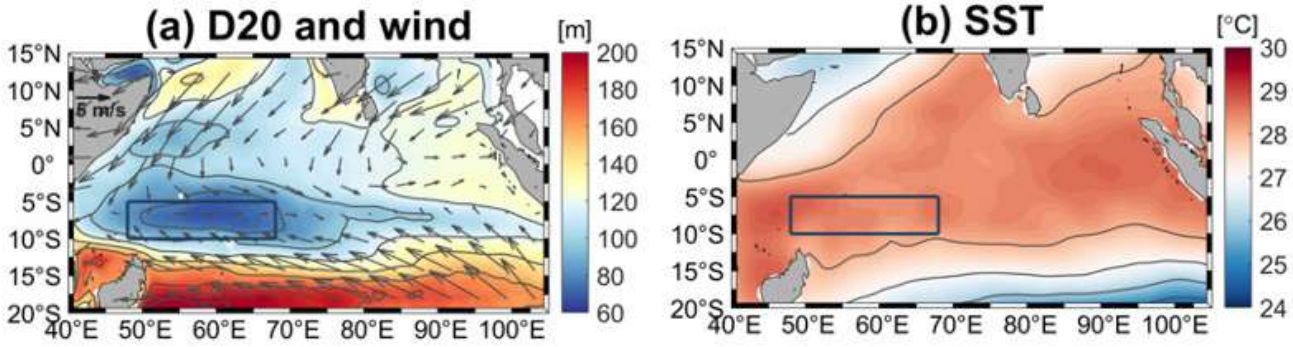



*Figure-1: The climatological December mean (1968–2017) of (a) 20°C isotherm depth (D20; shading) and 10m wind (vector) and (b) sea surface temperature over the tropical Indian Ocean. The rectangular boxes display the location of the SCTR (5° S–10°S, 48° E–68°E)*

A total of nine events were identified for the 50-year period (Figure-2), with seven of them occurring 3–6 months after the co-occurring peaks of positive IOD and El Niño in the eastern Indian Ocean (Figure-3). However, only IOD exhibited a positive phase before the 2011–2012 suppression event associated with the downwelling-favorable anticlockwise local wind anomalies in the SCTR. Furthermore, the 1978–1979 suppression event was primarily caused by the strong anticlockwise wind anomalies in the SCTR, without any significant influence of the positive IOD or El Niño. The results suggest that the role of local winds, as well as the remote forcing, are significant in the upwelling suppression over the SCTR, which would contribute to understanding the potential predictability of the upwelling variations.

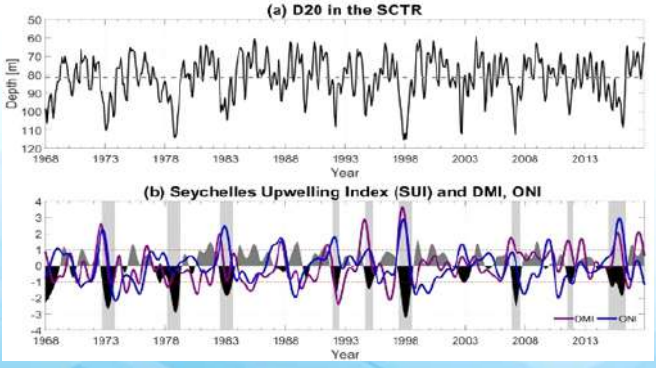



*Figure-2: Time series of (a) monthly D20 averaged in the SCTR and (b) the Seychelles Upwelling Index (SUI; shaded black and gray), the Dipole Mode Index (DMI; purple line), and the Ocean Nin o Index (ONI; blue line) for 1968–2017. The negative values of SUI (black shading) indicate the suppression of upwelling in the SCTR. The gray shadings denote the nine suppression events examined in this study.*

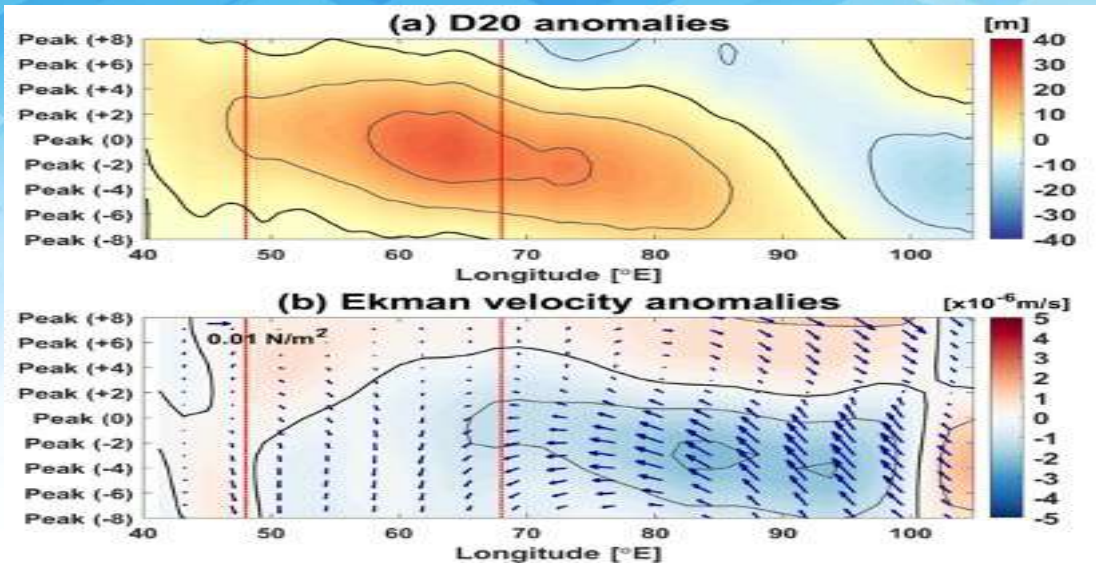



*Figure-3: Time–longitude plots of the (a) D20 anomalies and (b) Ekman velocity anomalies for the composites of the seven upwelling suppression events. The plots are produced by averaging over the latitude band of the SCTR. Red lines denote the longitude band of the SCTR.*

This study is based on the analysis of the Simple Ocean Data Assimilation (SODA) product. In addition, a group of Korean scientists has been conducting in situ mooring observation of the SCTR upwelling variability since May 2019, as a part of the KUDOS (Korea-US InDian Ocean Study) program. The time series dataset from the mooring would help improve our understanding of the SCTR upwelling variability and its relationship to climate variability.

Citation: Lee, E., Kim, C., & Na, H. (2022). Suppressed Upwelling Events in the Seychelles–Chagos Thermocline Ridge of the Southwestern Tropical Indian Ocean. Ocean Science Journal, 1-9. https://doi.org/10.1007/s12601-022-00075-x

*[Report Courtesy: Hanna Na and Eunsun Lee, Seoul National University, Republic of Korea; E-mail: hanna.ocean@snu.ac.kr]*

## Role of oceanic internal variability in the interannual-to-longer timescale variability in the Indian Ocean

The Indian Ocean (IO) with densely populated continents of Africa, Asia and Australia is prone to a plethora of climatic hazards. IO rim includes one-third of world's population, mostly living in developing countries that are highly vulnerable to climate variability. The interannual-to-longer timescale (also referred as low-frequency) variability in sea surface temperature (SST) of the Indian Ocean plays a crucial role in affecting the regional climate. These low-frequency variability can be caused by the surface forcings and oceanic internal variability.

Internal variability refers to the intrinsic variability arising from nonlinearity of the oceanic system. Considering that the internal variability is not tied with the external forcing, occurrence of internal variability limits the predictability of the oceanic system. Here we tried to identify the role of oceanic internal variability in the generation of low frequency variability in the Indian Ocean using high–resolution global Modular Ocean Model (MOM5) simulations. The model is first forced by climatological surface atmospheric fluxes from CORE-II climatological forcing and the simulation is carried out for 175 years from a state of rest. This climatological simulation is referred to as CLIM. The model is further integrated forward using an interannual forcing from JRA55do for 1958–2017 and is referred to as Control run (CTRL).

The ratios of standard deviation (Figure-1) of sea surface temperature (SST), sea level anomaly (SLA) and eddy kinetic energy (EKE) from the CLIM and CTRL solutions show large influence of internal variability in regions between 20S°–40°S in the IO. The regions where the ratio between the internal variability from CLIM and "total" variability from CTRL is more than 0.5 are considered largely influenced by internal variability as the magnitude of internal variability exceeds 50% of the total variability and therefore, comparable to the atmospheric forcing in generating the low-frequency variability.

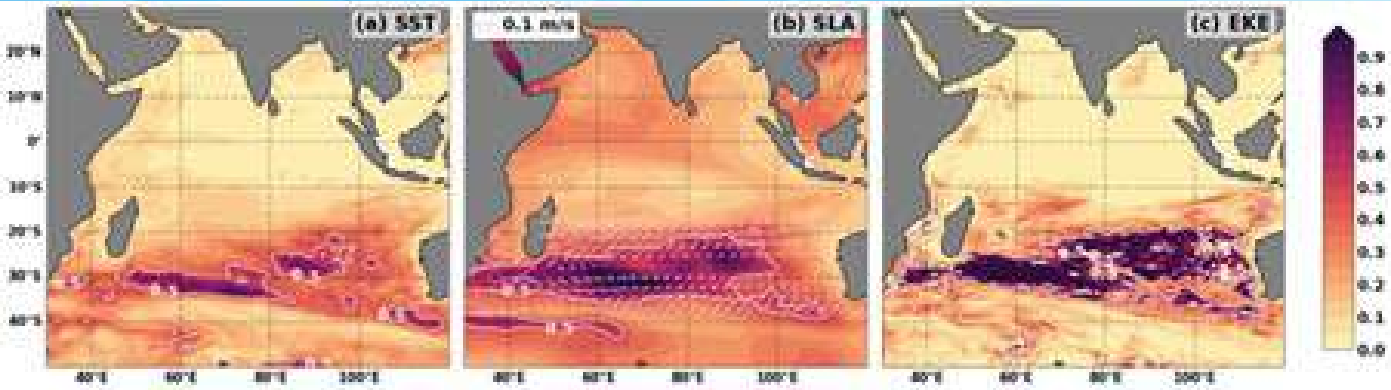



*Figure-1: The ratio of the standard deviations of (a) sea surface temperature, (b) sea level anomaly and (c) eddy kinetic energy derived from CLIM (last 50 years i.e., 126–175 years) and CTRL (1962–2017) simulation overlaid by a contour of 0.5. Standard deviation is calculated after removing the annual cycle and then filtered with a 15-month lowpass filter. The vectors overlayed in Panel (b) represents mean surface currents highlighting SEC and SICC in the SIO (Adopted from Anjana et al. 2023).*

EKE budget analysis shows that baroclinic instability is the primary cause for the internal variability. This instability is a result of the modulation of isothermal tilts (Figure-2) caused by the vertical shear of geostrophic zonal currents. It leads to an unstable upper water column, thereby enhancing the EKE in the region. The IO exhibits three distinct active low-frequency EKE regions: south of 25°S in the west and between 25° – 15°S in the east-central basin where EKE attain its peak during the Austral summer and on the southwest coast of Australia, EKE attains its peak during winter. While the vertical shear in the eastward SICC associated with a strong thermocline tilt is responsible for the baroclinic instability in the southwest, the baroclinic zonal current with eastward flowing surface SICC and underlying westward current associated with supergyre cause vertical shear and baroclinic instability in the central interior basin. Along the southwest coast of Australia, EKE is modulated by the strength of the Leeuwin Current and Leeuwin Undercurrent system. These instabilities then preferentially grow for the zonal scale of ~1,000 km with an e-folding timescale of interannual periods and, thus, cause low-frequency variability in the SIO latitudinal band. Further, as these disturbances match the scale of the lower-order modes of Rossby waves, they propagate westward, carrying the energy to the western part of the basin.

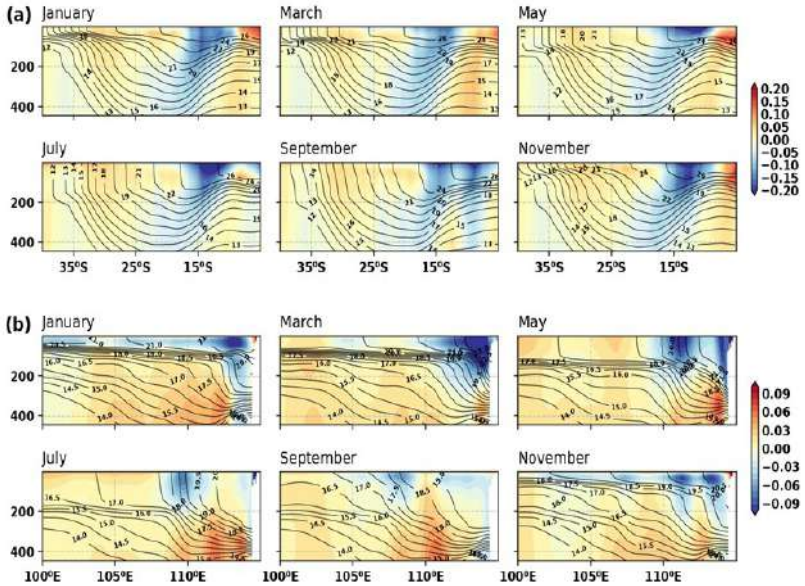



*Figure-2: (a) Vertical sections of climatological zonal currents (shaded) and temperature (contour) averaged over 60° – 100°E in the interior south Indian Ocean. (b) Vertical section of climatological meridional current (shaded) and temperature (contour) averaged at 30°S off the west coast of Australia. Note that all the climatological fields are derived from averaging the last 50 years of simulation (126–175) from CLIM experiment (adopted from Anjana et al., 2023). SEC and SICC in the SIO (Adopted from Anjana et al. 2023).*

Citation: Anjana, S., Chatterjee, A., Han, W., Prerna, S., & Sajidh, C. K. (2023). Role of oceanic internal instability in the generation of low-frequency variability in the Indian Ocean. Geophysical Research Letters, 50, e2022GL102489. https://doi.org/10.1029/2022GL102489

*[Report Courtesy: Anjana S, INCOIS, Hyderabad, India; E-mail: a.sukumaran-rf@incois.gov.in]*

# Future projections of storm surges and associated coastal inundation along the east coast of India

The tropical cyclones that make landfall along the Indian coasts have immense socio-economic implications. A tropical cyclone is a rotating storm system characterized by low atmospheric pressure, strong winds, and heavy rain. More than a hundred cyclones have hit the Indian coasts during the last five decades. The occurrence of tropical cyclones over the Bay of Bengal and Arabian Sea is of great concern to India's coasts. Understanding the stochastic nature of extreme storm surges and their effects on coastal locations is crucial for efficiently designing coastal protection structures and planning for future coastal adaptations. A comprehensive study of storm surge projections considering climate change impacts is crucial for disaster preparation and future coastal infrastructure development activities. The current study analyzes storm surges and associated coastal inundation along the East Coast of India. The study utilized historical cyclone tracks over the past five decades. Synthetic tracks were projected for the next hundred years considering the impact of climate change on cyclone path and intensity. An in-depth, comprehensive analysis of potential storm surges and associated coastal flooding was carried out using composite maps explaining the storm surge characteristics at various coastal locations. The ADCIRC model was used to compute storm surge heights and associated coastal inundation for historical and future cyclone tracks.

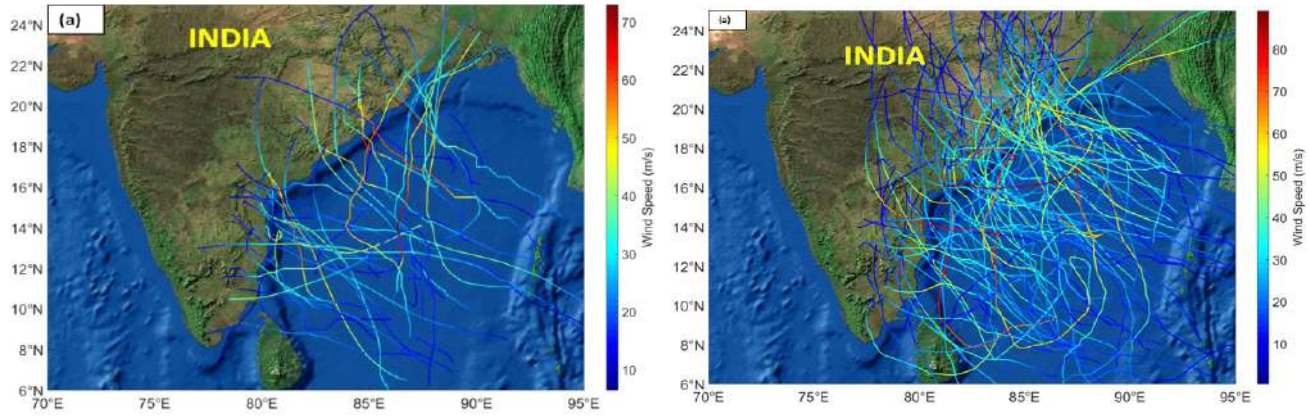



*Figure-1: (a) Historic cyclone tracks that made their landfall along the ECI from 1972 to 2020; (b) Synthetic tracks generated for 100 years considering climate change*

Figures-1(a) shows the historic cyclone tracks that made their landfall along the ECI from 1972 to 2020 and Figure-1(b) shows the generated future synthetic tracks for the next 100 years (by 2120) that may make landfall along the east coast of India. The generated synthetic tracks reveal that most coastal locations along the east coast of India will experience high wind intensities, increased cyclone frequency and a 12% increase in peak wind intensity in the future projections due to climate change.

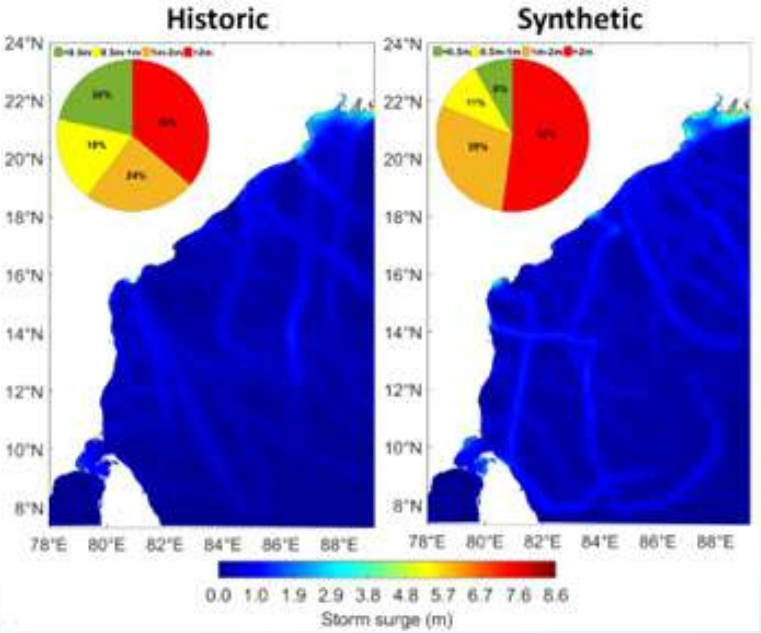



*Figure-2: Storm surge composite maps using historical tracks that made their landfall along the ECI, and synthetic tracks that made their landfall along the ECI by 2120. Where, ECI stands for east coast of India.*

Figures-2(a) and 2(b) show the storm surge composite maps for historical and future synthetic tracks obtained using ADCIRC. Figures 2(a) and 2(b) demonstrate that the coastal stretch that experiences storm surges greater than 2 m may grow drastically due to future cyclones. The inset pie chart explains the percentage of the entire coastal stretch that experiences storm surge heights >0.5, >1, and >2 m; this chart is helpful for quick assessments. Pie diagrams clearly show that the percentage of green- and yellow-colored zones (safe- and low-risk zones) decreases from historical to future. In contrast, the percentage of orange- and red-colored zones (moderate- and high-risk zones) shows an increase from 24 to 29% and 36 to 52%, respectively, from historical to future. As can be seen from the composite maps, the peak storm surge heights along different coastal segments also show an increase due to future tracks; high storm surge values are also found at locations other than those due to historical cyclones.

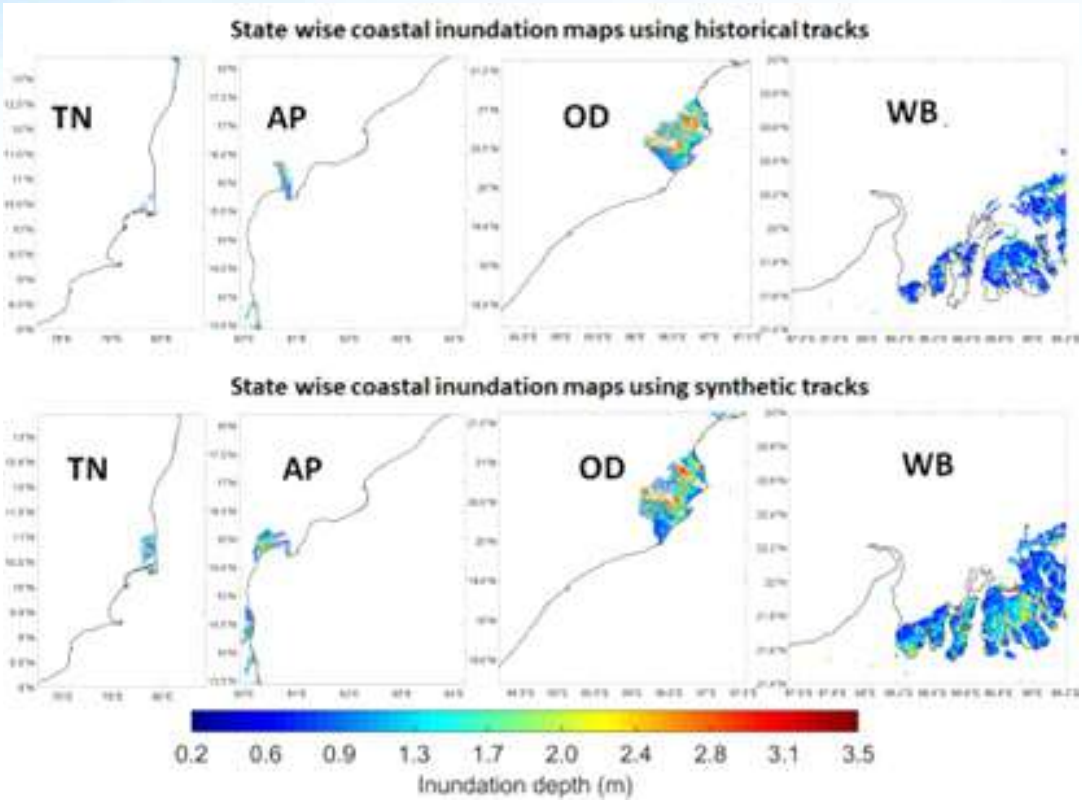



*Figure-3: Composite picture (state-wise) of the inundation depth and inundation extent due to all the historical and synthetic tracks. In the figure, TN, AP, OD, and WB denote Tamil Nadu, Andhra Pradesh, Odisha, and West Bengal respectively.*

Figure-3 shows the state-wise composite map of the inundation depth and extent due to all the historical and synthetic tracks. The maximum extent of inundation along the TN coast can only be seen in future projections. The same can be seen in historical and future scenarios along the AP, OD, and WB coasts. However, it can be noticed that the area of the inundated portion is increased in future projections. The maximum inundation depth of > 3.5 m can be observed in historical and future scenarios; the white-colored patches (dry cells) within the inundated portions represent the elevated portions.

Citation: Murty PLN, Siva Srinivas Kolukula; Future projections of storm surges and associated coastal inundation along the east coast of India. Journal of Water and Climate Change 2023; jwc2023358.

https://doi.org/10.2166/wcc.2023.358

*[Report Courtesy: Siva Srinivas Kolukula, INCOIS, Hyderabad, India; E-mail: sivasrinivas.k@incois.gov.in]*

# Eighth National Conference of Ocean Society of India (OSICON-23) during August 23- 25, 2023, Hyderabad, India

The 8th edition of the Biennial National Conference of the Ocean Society of India (OSICON-23), scheduled to be held at INCOIS, Hyderabad, India from August 23 - 25, 2023.

The conference website may be accessed here: https://osicon23.incois.gov.in/

The focal theme for OSICON-23 is 'Operational Oceanography - Science to Services,' which is a critical topic for the oceanographic community. It focuses on the translation of scientific knowledge into practical applications. The conference aims to bring together experts and researchers from around the world to discuss the latest advancements in operational oceanography, share knowledge, and promote collaboration among the ocean community.


Focal Theme
Operational Oceanography - Science to Services

OSICON-23 is expected to be attended by around 350 researchers from all over India to review and discuss the recent advances in Operational Oceanography and will help scientists and students involved in ocean-atmosphere studies to benefit from interactions with the experts in the following various sub themes:

## Sub Themes

1. Ocean Information and Advisory Services
2. Ocean Observations (In-situ & Satellite)
3. Ocean Modelling and Data Assimilation
4. Coastal and Open Ocean Processes
5. Air-sea Interactions
6. Biogeochemistry of the Ocean
7. Biodiversity and Ecology
8. Ocean and Climate Change
9. Ocean Engineering and Technology
10. Marine Geology and Geophysics
11. Polar Science and Cryosphere Studies
12. Blue Economy
13. Marine Resource Management
14. IMS Special Session on Importance of Ocean Observations to Monsoon Weather and Climate Forecasting NEW!


## Important Dates

Last date for Abstract Submission is extended upto: **June 07, 2023** NEW!
Notification of Acceptance of Abstract: **June 30, 2023**
Online Registration Starts: **July 01, 2023**
Last date for Online Registration of accepted abstracts: **July 15, 2023**
Last date for Online Registration of other participants: **July 31, 2023**

OSI encourages the active participation of research students in large numbers and will try to support the travel expenses of some limited deserving students.

## Contact Details

**Mr. E. Pattabhi Rama Rao**
INCOIS
Convener

**Dr. P. G. Remya**
INCOIS
Co-Convener

**Prof. P. Sreenivas**
Univ. of Hyderabad
Co-Convener

E-mail: osicon23@incois.gov.in
Website: https://osicon23.incois.gov.in/

# ICES - PICES 7th International Zooplankton Production Symposium during Autumn17-22 March 2024, Hobart, Australia

## SCOPE

We are living in the Anthropocene. Our oceans are warmer, more acidic, have widespread plastic and other pollution, and are subjected to increasing exploitation including overfishing. Zooplankton play a pivotal role in our oceans, as grazers of primary production, as drivers of carbon and nutrient cycles, and as prey for higher trophic level consumers including both harvested fish species and iconic marine mammals and seabirds. How zooplankton will respond to the dramatic changes in our marine ecosystems will impact the health and productivity of our oceans and our planet.


To better understand zooplankton in a changing world, ICES and PICES are holding the 7th International Zooplankton Production Symposium as a forum to discuss the latest zooplankton research. The ICES/PICES Zooplankton Production Symposium will bring together the top zooplankton researchers globally, showcasing recent advances. Understanding the current and evolving role of zooplankton will require new insights provided by:

- Assessing the impact on zooplankton of climate change, fishing, and pollution such as microplastics
- State-of-the-art sampling techniques such as DNA, imaging, and bioacoustics
- Biochemical methods applied to unravelling complex trophic ecology
- The application of cutting-edge approaches in zooplankton modelling, including size and trait-based biogeochemical and ecosystem models
- Revealing the role of microzooplankton in biogeochemical cycling and food webs
- Exploring the structure and functioning of macrozooplankton communities and their impact on carbon sequestration and trophic ecology
- Examining zooplankton in fisheries science, including dynamics of fish larvae, the impact of zooplankton on fish larval mortality and growth, and the commercial harvest of zooplankton
- Elucidating the vital role of zooplankton in polar environments
- Understanding the role of gelatinous filter feeders and jellyfish in carbon sequestration and trophic ecology
- The use of zooplankton as ecosystem indicators in a changing ocean

Our Symposium will be held over five days in the historic waterfront district of Hobart, Australia, during Autumn, from 17-22 March 2024. This event will be held in-person and provide the first opportunity since 2016 for zooplankton researchers to meet, build networks, and hear the latest science. We are monitoring the COVID-19 situation closely and will adapt our plans as needed.

The Organizing Committee invites proposals for sessions to be held during the Symposium. Proposals are welcome for sessions incorporating talks and posters, panel discussions and/or workshops. Sessions could cover, but are not limited to, the key areas listed above.

The symposium website may be accessed here: https://meetings.pices.int/meetings/international/2024/zps7/scope

Proposals may be submitted here: https://meetings.pices.int/meetings/international/2024/zps7/proposals

# 12th International Conference and Workshop on Lobster and crabs 22-27 October 2023 in Fremantle, Western Australia


The Organising Committee of the 12th International Conference and Workshop on Lobster and crab is pleased to announce the go ahead of this workshop that was originally planned for October 2020, for **22-27 October 2023. Please check the website** (https://icwl2023.com.au) **for updates on the conference.** This will be updated over the next month with more details on the program. We will be accepting abstracts and registrations from the 24 January 2023. This workshop is being planned as a face-to-face meeting.

The overall theme for the 2023 workshop is **'Ecosystem-based fisheries management (EBFM)'** as this generally represents best practice for fisheries management and reflects that fisheries research and management focus is now broader than just sustainability. Therefore we hope to attract presentations that cover a wide array of subjects under the EBFM banner including biology, stock assessment, management, ecosystem effects of fishing such as interaction with whales, habitat, economics, social, governance and management compliance.

We will be holding a **2-day EBFM workshop** which will be sponsored by the OECD Co-operative Research Programme: Biological Resource Management for Sustainable Agricultural Systems. This will occur on the first two days of the 5-day conference.

While this conference comes back to Western Australia where the 1st International Lobster Workshop was held in 1978, we have adopted the approach of the 2nd lobster conference in St Andrews in 1985 where **crab presentations** were welcome. We look forward to their participation in this conference.

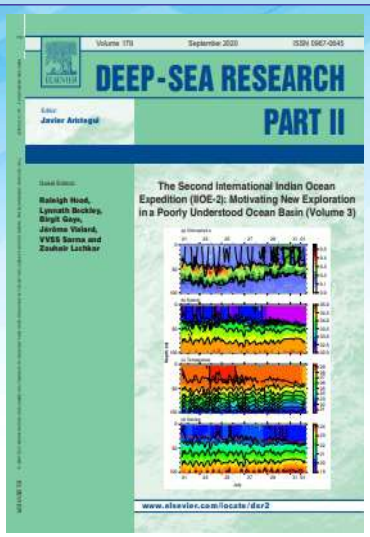
An **industry day** is also planned for Thursday 26 October and this is an important component of the program so we are looking forward to strong support from lobster and crab industry participants around the world. We are also keen to attract papers on **lobster and crab aquaculture** as this has been an important developing industry in Asia.

Students can apply for the **Paul Kanciruk Student award** for financial support to attend the conference.

The Department of Primary Industry and Regional Development (DPIRD) and the Western Rock Lobster (WRL) council are looking forward to hosting scientists, managers and industry participants in Western Australia in 2023. Don't hesitate to contact us or the conference organisers, Arinex, if you have any questions.

Co-hosts of the workshop Nick Caputi, DPIRD (nick.caputi@dpird.wa.gov.au) & Nic Sofoulis, WRL (sofs1@bigpond.com).

## DEEP-SEA RESEARCH PART II




THE SUBMISSION PORTAL FOR VOL. 6 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 (rhood@umces.edu).

## XI Indo-Pacific Fish Conference to be held in Auckland, New Zealand during 20-24 November 2023

A session entitled Larval fishes - solving phylogenetic, life-cycle and ecological questions will be part of the XI Indo-Pacific Fish Conference to be held in Auckland, New Zealand from 20-24 November 2023.

Most marine bony fishes have a two-phase life history with pelagic larvae that differ in morphology, ecology and habitat from the adults. These phases operate in separate evolutionary theatres, and ecologically, effectively function as separate species. Larval morphological features provide characters for phylogenetic analysis and aspects of life history are determined during the larval phase, including recruitment and scale of genetic and demographic connectivity. Although larval survival is necessary for persistence of species, larvae are often neglected by researchers and managers focused on adults. This session will address many of the unanswered questions about the pelagic larval phase of Indo-Pacific fishes.

The session will be co-chaired by
- Jeff Leis (University of Tasmania; jeffrey.leis@utas.edu.au)
- Lynnath Beckley (Murdoch University; L.Beckley@murdoch.edu.au) and
- Ainhoa Bernal (Institut de Ciències del Mar; bernal@icm.csic.es)

Those interested in contributing to the larval fish session should contact one of the session co-chairs.

Abstract Submission closes on 11 June 2023

The conference website is https://www.ipfc11-asfb.ac.nz/

## 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 51 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.

## CLIVAR May 2023 Bulletin is available online

The International CLIVAR Project Office distributes a monthly bulletin with announcements, funding opportunities, meeting notifications relevant to the ocean/climate science community.

The latest CLIVAR Bulletin May, 2023 is available at:

https://mailchi.mp/clivar.org/april-2023-bulletin-17055004?e=526ed2c9ae

## Call for Contributions

Informal articles/short notes of general interest to the IIOE-2 community are invited for the next (June-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 June, 2023**

The Indian Ocean Bubble 2

*Access the latest issue of Indian Ocean Bubble-2*

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

Join IIOE-2 Community

*Enroll yourself with IIOE-2 Community*

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

*Follow us:*

*iioe-2.incois.gov.in*

*The IIOE-2 Newsletter is published online by:*

INCOIS

@IIOE2

@iioe_2

*Feedback? iioe-2@incois.gov.in*