

**SCOR/IOC/IOGOOS Second International Indian Ocean Expedition (IIOE-2)  
Report to SCOR 2020/2021  
Marie-Alexandrine (SCOR Executive Reporter)**

**GOAL**

The goal of IIOE-2 remains as *to advance our understanding of the Indian Ocean and its role in the Earth System in order to enable informed decisions in support of sustainable development and the well-being of humankind.*

**MANAGEMENT**

While delivery of IIOE-2 occurs through national activities these are coordinated by a Core Group comprising the following key personnel:

<b>Role</b>	<b>Name</b>	<b>Affiliation</b>
<b>Co-Chair IIOE-2</b>	Marie-Alexandrine Sicre	SCOR
	Vladimir Ryabinin	IOC
	Satheesh Sheno	IOGOOS
<b>Co-Chair WG 1 (Science &amp; Research)</b>	Raleigh Hood	USA
	Hermann Bange	Germany
<b>Co-Chairs WG 2 (Data &amp; Information Management)</b>	E. Pattabhi Rama Rao	India
	Harrison Ong'Anda	Kenya
<b>Chair WG 3 (Operational Coordination)</b>	Shailesh Nayak	India
<b>Supported by</b>		
<b>International Project Office (Perth)</b>	Nick d'Adamo	IOC
<b>International Project Office (Hyderabad)</b>	Satya Prakash / Nagaraja Kumar	IOGOOS
<b>SCOR Office</b>	Patricia Miloslavich	SCOR

**The Core Group** comprises 3 Working Groups (WG1 Science & Research; WG2 Data & Information Management & WG3 Operational Coordination). Each of these interact with each other, the Joint Project Offices's in Perth and Hyderabad and the Co-Chairs who represent the sponsors, oversee the Core Group. The International Project Offices deal with a day-to-day issues within IIOE-2.

Nick D'Adamo who has been in charge of the IPO in Perth has left September, 30, 2021. Sarah Gardner seconding N. D'Adamo left IPO in April 2021.

Satya Prakash who has been in charge of the IIOE-2 Joint Project Office and Co-Secretary of IOGOOS located at the Indian National Centre for Ocean Information Services (INCOIS) in Hyderabad sadly passed away in July 2021. Satya was an integral part of the Indian Ocean community, as a member of

GOOS/OOPC/SIBER/BGC Argo panels, and used to liaison with the Indian Ocean Region Panel for several activities. He will be missed by the Indian Ocean community.

### **Impact of the Codiv-19:**

The International Indian Ocean Science Conference 2020 (IIOSC-2020) that was scheduled to take place on the from 16th to 20th March 2020 in Goa, India, had to be postponed and is currently rescheduled from the 14 to 18<sup>th</sup> March 2022 on hybrid mode.

Several cruises and projects were cancelled and there are no clear plans to do them at a later date (e.g., Germany), though some were just postponed (e.g., USA). Our inability to have in person meetings has also had a significant negative impact on IIOE-2 activities.

### **WG1: SCIENCE and RESEARCH (co-chairs: Raleigh Hood and Hermann Bange)**

#### **Science Highlights**

- The IPCC Sixth Assessment Report specifically called out on the changes in the Indian Ocean and over South Asia. The report points out that the Indian Ocean warming is the fastest warming among all other oceans. The research mentioned in the IPCC report includes contributions from the IIOE2/IORP community, with participation from an IORP member (Dr Roxy Koll) in contributing to this report.

#### **Ocean Heat and Salinity**

At the ocean surface, temperature has on average increased by 0.88 [0.68–1.01] °C from 1850-1900 to 2011-2020, with 0.60 [0.44–0.74] °C of this warming having occurred since 1980. The ocean surface temperature is projected to increase from 1995–2014 to 2081–2100 on average by 0.86 [0.43–1.47, likely range] °C in SSP1-2.6 and by 2.89 [2.01–4.07, likely range] °C in SSP5-8.5. Since the 1950s, the fastest surface warming has occurred in the Indian Ocean and in Western Boundary Currents, while ocean circulation has caused slow warming or surface cooling in the Southern Ocean, equatorial Pacific, North Atlantic, and coastal upwelling systems (*very high confidence*). At least 83% of the ocean surface will *very likely* warm over the 21st century in all SSP scenarios. {2.3.3, 9.2.1}

#### EGU Special Issue of IIOE-2 Synthesis Papers

IIOE-2 Working Group 1 (Science and Research) convened a meeting of the Science Theme working Group leaders at the GEOMAR Helmholtz Center for Ocean Research in Kiel, 28-30 November, 2018. This meeting was sponsored by SCOR and the Kiel Future Ocean Excellence Cluster. The goal of this meeting was to generate scientific products to highlight IIOE-2 progress. The major outcome of this effort was the development set of synthesis papers on the Indian Ocean for publication as a special issue of EGU Journals, with WG1 chairs, Raleigh Hood and Hermann Bange, as guest editors. The synthesis papers were inspired by the IIOE-2 Science Plan research themes. Seven manuscripts are now either published or in the final stages of revision.



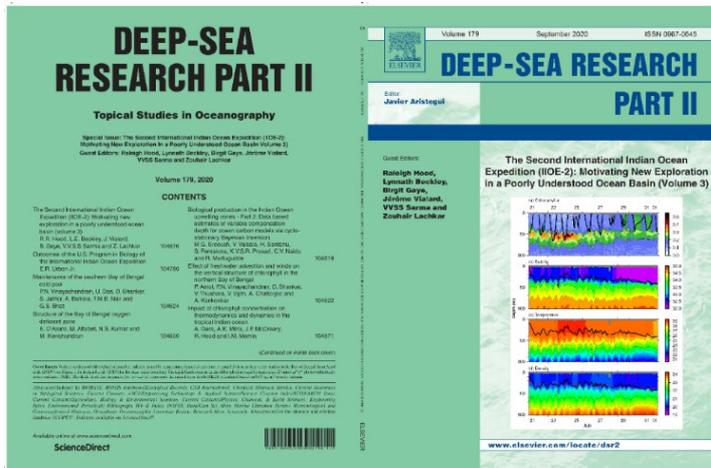
DSR II Special Issue Series on IIOE-2

IIOE-2 WG1 has been working for several years now on publishing a series of DSR II Special Issues on IIOE-2. More than 40 peer-reviewed papers have been published thus far. The volumes are titled “The 2nd International Indian Ocean Expedition (IIOE-2): «Motivating New Exploration in a Poorly Understood Basin”.

The guest editor team volumes 1 and 2 included Raleigh Hood, Jerry Wiggert, Lynnath Beckley, Birgit Gaye, Jerome Vialard and Sunil Singh. The guest editor team for volumes 3 and 4 included Raleigh Hood, Zouhair Lachkar, Lynnath Beckley, Birgit Gaye, Jerome Vialard, and VVSS Sarma. Volumes 1 -3 are published and Volume 4 is nearly complete with 12 manuscripts in various stages of review, revision and production. The deadline for submission of manuscripts for volume 4 was September, 30, 2021.

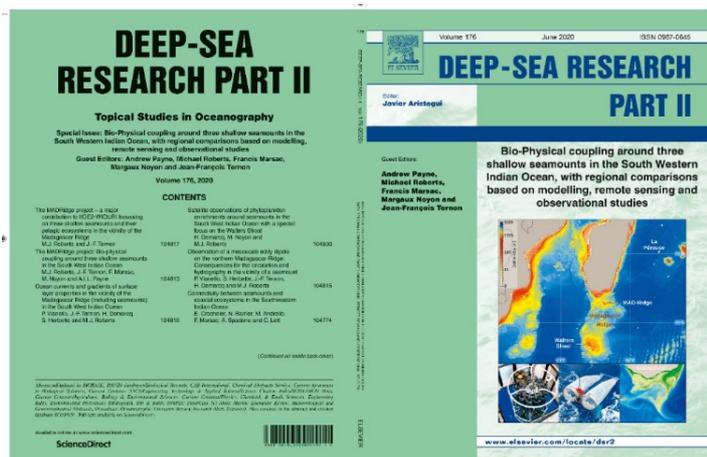
**IIOE-2 and SIBER**

Members of the SIBER community have continued to make major contributions to the organisation and delivery of the 2<sup>nd</sup> International Indian Ocean Expedition (IIOE-2), and to securing its extension from 2020 to 2025. Despite numerous research cruises being impacted by COVID-19, **SIBER members** have continued work on ongoing Indian Ocean research programmes. Notable examples are the *Sustainable Oceans, Livelihoods and food Security Through Increased Capacity in Ecosystem research in the Western Indian Ocean* (SOLSTICE-WIO) programme (co-led by Mike Roberts), a western Indian Ocean seamount survey programme (Francis Marsac) and the *Indonesian Throughflow Monitoring Program* (TRIUMPH, Dwi Susanto). **Multiple other cruises and related research have been rescheduled for 2022 onwards.**



Another important SIBER function has been to motivate and lead **publication of Indian Ocean region research results**, as special journal volumes dedicated to the latest IIOE-2 project results. The third volume of a *Deep-Sea Research II* series focused on IIOE-2 (Hood et al, eds.) appeared in September 2020, with a 4<sup>th</sup> volume in late stages of production and a 5<sup>th</sup> volume (to focus on Lynnath Beckley Raleigh Hood and Peter Thompson, 110°E voyage with the *RV Investigator*) now approved. 15 manuscripts are

anticipated. Other highlights are the *Biogeosciences* special issue of synthesis papers (Bange and Hood, eds), DSR II volumes on shallow southwest Indian Ocean seamounts (Marsac, Roberts et al, eds., June 2020), and on the SOLSTICE-WIO Agulhas Bank studies (Roberts et al, eds, approved, in production), and an Elsevier book on the Indian Ocean (Ummenhofer and Hood, eds). SIBER members also serve as IIOE-2 national committee chairs and as chairs/members of IIOE-2 working groups, and many are contributing to



the organization and delivery of the *International Indian Ocean Science Conference 2022*, which will highlight latest IIOE-2 research results and is now due to take place in Goa, India, in March 2022.

SIBER is also actively involved in other related Indian Ocean science initiatives, such as an IOGOOS virtual training workshop on “*Biological Observations in the Indian Ocean (From Microbes to Megafauna)*” planned for 8-12 November 2021, (see <https://incois.gov.in/ITCOcean/boi0921.jsp>), co-led by Jenny Huggett. Similarly, SIBER (with IOGOOS, *Coastal Predict* and others), is involved in developing a package of instrumentation, methods, best practices and training capacity for affordable and portable coastal hydrographic and biogeochemical measurements (COLAB), with related workshops being planned for late 2021- spring 2022.

### *Elsevier Book on the Indian Ocean*

WG1 is putting together an interdisciplinary book of synthesis chapters on the Indian Ocean for publication as an Elsevier book. The editors are Caroline Ummenhofer and Raleigh Hood. 20 chapters are anticipated, with most first drafts completed. The list of chapter authors and titles is as follows:

1. Raleigh Hood et al., “Introduction”
2. Timothy Walker et al., “History of the Indian Ocean”
3. Andrew Turner et al., “Monsoon variability and its drivers”
4. Helen Phillips et al., “Indian Ocean circulation”
5. Toshi Yamagata et al., “Climate phenomena of the Indian”
6. Jerome Vialard et al., “Decadal Indian Ocean variability”
7. Charlotte Demott et al., “Indian Ocean intraseasonal variability”
8. Janet Sprintall et al., “Oceanic Interbasin connections”
9. Caroline Ummenhofer et al., “Indian Ocean impact on global climate”
10. Francis Marsac et al., “Indian Ocean primary productivity & fisheries variability”
11. Raleigh Hood et al., “Nutrient, phytoplankton and zooplankton variability in the Indian Ocean”
12. Raleigh Hood et al., “Oxygen, Carbon and pH variability in the Indian Ocean”
13. Hermann Bange et al., “Air-sea exchange and its impacts on biogeochemistry in the Indian Ocean”
14. Carolin Löscher et al., “Microbiology of the Indian Ocean”
15. Faiza Al-Yamani et al., “Physical and biogeochemical characteristics of Indian Ocean marginal seas”
16. Michael McPhaden et al., “Observing the Indian Ocean”
17. Toshi Shinoda et al., “Modeling the Indian Ocean”
18. Mahyar Mohtadi et al., “Paleo evidence to understand Indian Ocean variability across a range of timescales”
19. MK Roxy et al., “Future projections for the Indian Ocean”
20. Ming Feng et al., “Extreme events & impacts”

### *Status of IIOE-2 Research Initiatives*

The “Eastern Indian Ocean Upwelling Research Initiative” is ongoing anchored by China, Japan and USA. The main foci of this initiative are on the upwelling regions that develop seasonally off Java, Sumatra, and northwestern Australia. The “Western Indian Ocean Upwelling Research Initiative” is also ongoing, anchored by UK/South Africa-funded Solstice Project and the South Africa DEA-funded Agulhas II cruises. Significant progress has been made. In addition to these research initiatives, the IIOE-2 coincided with and embraced the Years of the Maritime Continent (YMC) as a major IIOE-2 field campaign in 2017-2018. This program has been completed.

### ***International Participation and Research Efforts***

Collaborated and continued with the endorsement of scientific activities. Endorsed three new scientific projects (IIOE2-EP43, IIOE2-EP44 & IIOE2-EP45) that align with the IIOE-2 objectives ([https://iioe-2.incois.gov.in/IIOE-2/Endorsed\\_Projects.jsp](https://iioe-2.incois.gov.in/IIOE-2/Endorsed_Projects.jsp)).

**The IIOE-2 now has 70 endorsed projects involving 18 Countries with the USA (10 projects), India (9 projects), UK (9 projects), Australia (8 projects) and South Africa (6 projects) leading the way.**

### **IIOE-2 and the Indian Ocean Global Ocean Observing System (IOGOOS)**

IOGOOS annual meeting was held on July 16, 2020 virtually and had a review of the progress of its activities and its allied projects i.e. Indian Ocean Regional Panel (IORP), Sustained Indian Ocean Biogeochemical and Ecological Research (SIBER), IndOOS Resource Forum (IRF), Second International Indian Ocean Expedition (IIOE-2), Modeling for Ocean Forecasting and Process Studies and Indian Ocean Core Remote Sensing Project. The major outcomes of the meeting are:

- INCOIS, India will continue to host the IOGOOS Secretariat for the next term of 6 years from November 2020 – October 2026.
- Dr. T. Srinivasa Kumar, Director, INCOIS has been elected as the IOGOOS Officer representing Central Indian Ocean and as the Interim Chair of IOGOOS.
- IOGOOS to participate in the Ocean Decade Activities and a planning workshop to consolidate the ideas and discuss and design implementable plans, etc. is being planned.
- IOGOOS will conduct workshop cum training to enhance the capabilities of the region in the fields of observations, modeling and operational services, with partial funding support through online/ in-presence depending upon the pandemic situation.

Two training programmes are scheduled to be held in coming months of 2021.

Training Programme on “*Biological Observations in the Indian Ocean (From Microbes to Megafauna)*” scheduled to be held on hybrid mode during November 8-12, 2021. The course announcement and application links are available at <https://incois.gov.in/ITCOcean/boi0921.jsp>

Training Programme on “*Modeling for Ocean Forecasting and Process Studies*” scheduled to be held on hybrid mode during December 6-10, 2021. The course announcement and application links are available at <https://incois.gov.in/ITCOcean/mops0921.jsp>

### **WG 2: DATA AND INFORMATION MANAGEMENT WORKING GROUP**

This Working Group is charged with early sharing of data using internationally agreed rules of data exchange. It is central to IIOE-2 and was ably led by Cyndy Chandler who sadly resigned on her retirement in 2019. The D&MI Plan she led was almost complete. The Core Group has appointed E. Pattabhi Rama Rao and Harrison O. Ong'Anda to take over and finish the Plan. The Group will then begin its Implementation. Metadata portal to make oceanographic data from the region discoverable and widely accessible (<https://iioe-2.incois.gov.in/IIOE-2/data.jsp>).

The IndOOS review had recommended public sharing of the data from India's ocean moorings (OMNI). With respect to this, IORP had initiated dialogue between MoES (India) and NOAA (US) during the IIOE2/IORP meeting at Jakarta in 2018. The OMNI-RAMA data portal has been established between MoES and NOAA and launched mid-August 2021 (<https://incois.gov.in/portal/datainfo/buoys.jsp>).

### WG 3: OPERATIONAL COORDINATION

This WG is charged with develop and integrate web-based tools, databases and partnerships to enable a sufficient level of cooperation, resource-sharing, scientific collaboration and capacity alignment. The WG is led by Dr Shailesh Nayak.

The IIOE-2 website ([iioe-2.incois.gov.in](http://iioe-2.incois.gov.in)) is well maintained and made up to date with the events happening. Published Online monthly by JPO India, to update the Indian Ocean community on the recent IIOE-2 activities, developments and new results. It also lists the upcoming events, meetings, conferences etc. It also provides early information and a platform for young scientists to explore the opportunity to participate in cruises. 55 issues have been published till date.

Recent IIOE-2 activities, developments, Newsletter, IO Bubble, upcoming events, meetings, conferences etc. are posted in Facebook & Twitter for wider publicity. The Indian Ocean Bubble, Issue No.14 was released in April 2021 and made available online at [https://iioe-2.incois.gov.in/IIOE-2/pdfviewer\\_pub.jsp?docname=IIOE-2-DOC\\_OM\\_211.pdf](https://iioe-2.incois.gov.in/IIOE-2/pdfviewer_pub.jsp?docname=IIOE-2-DOC_OM_211.pdf). The main aim of this IIOE-2 Bubble is to initiate informal discussions on the outstanding scientific issues in the Indian Ocean and to update the Indian Ocean community on the progress on IIOE-2. 14 issues have been published till date.

#### Meetings (from IIOE-2 Joint Program Office)

The IIOE-2 Steering Committee Executive Core Group Meeting No. 18 was held virtually on January 19, 2021 to discuss about the IIOE-2 activities.

The fourth meeting of the Steering Committee of IIOE-2 (SC4) was organized virtually in April 12-15, 2021 by the IIOE-2 Joint Project Office (JPO) through its respective nodes at the Indian National Center for Ocean Information Services (INCOIS), Hyderabad, and UNESCO IOC Perth Programme Office. The meeting was chaired by Marie-Alexandrine Sicre (SCOR) and Satheesh Shenoi (INCOIS), co-chairs of the Steering Committee of the IIOE-2 with Vladimir Ryabinin (IOC). Marie-Alexandrine Sicre (France) succeeded former co-chair Peter Burkill (UK) who stepped down in October 2020. Over 70 participants representing more than 45 organizations from 14 countries attended the three-day meeting.



Figure-1: Snapshot of some of the active cameras during the IIOE-2 SC4.

A full agenda and links to the background documents, including the presentations can be found at: [https://iioe-2.incois.gov.in/IIOE-2/SC4\\_agenda.jsp](https://iioe-2.incois.gov.in/IIOE-2/SC4_agenda.jsp)

- Reports on national activities were delivered on the first day by the chairs or representatives of IIOE-2 National Committees. The progress reports of the three Working Groups, WG1 (Science and Research), WG2 (Data and Information Management) and WG-3 (Operational

Coordination) presented by the respective co-chairs or representatives, highlighted the important achievements with regard to the publications, data management, and related operational aspects.

- Dr. Vladimir Ryabinin, Executive Secretary of the IOC of UNESCO and Assistant Director-General of UNESCO, as well as one of the Co-Chairs of IIOE-2 provided an update on the UN Decade of Ocean Science for Sustainable development and feedbacks on IIOE-2 endorsement request.
- During Day 2 and 3 of the meeting, the progress reports in respect of the six science themes were delivered by the respective chairs/co-chairs. This was followed by presentations from invited projects, the Early Career Scientists Network, and results of the GEOTRACES project in the Indian Ocean.
- An open Science Symposium was held on Day 4, with six long (15 minute) talks and seven flash (5 minute) talks on a diversity of topics including features of the Southern Bay of Bengal, Indian Ocean fisheries and variability, biological oceanography in upwelling regions, ocean circulation, climate change and extreme events in the Indian Ocean, among others.

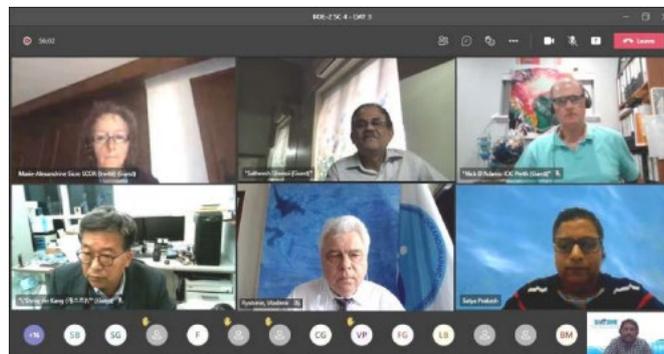


Figure-2: IIOE-2 co-chairs Marie Alexandrine Sicre (SCOR), Satheesh Shenoi (INCOIS), Vladimir Ryabinin (UNESCO-IOC) with members of the IIOE-2 Secretariat, Nick D'Adamo (UNESCO IOC Perth Programme Office) and Satya Prakash (INCOIS), and Dong-Jin Kang (KIOST, Korea).

The International Indian Ocean Science Conference (IIOESC) 2020 was rescheduled to be held during March 14-18, 2022 in Goa, India. The First Announcement of the International Indian Ocean Science Conference (IIOESC)-2022 was made on August 31 2021. Call for Abstracts Submission opened on 01 September, 2021 ([https://iiosc2020.incois.gov.in/WEBSITE\\_FILES/IIOESC2022/FirstAnnouncement-IIOESC2022.pdf](https://iiosc2020.incois.gov.in/WEBSITE_FILES/IIOESC2022/FirstAnnouncement-IIOESC2022.pdf)). The conference has been planned as an in-person conference (with an option to join online) in the hope that COVID situation eases by then. In the event that the travel situation does not improve, IIOESC-2022 will still go ahead as an online event. One of the focus of this conference will be to discuss how IIOE-2 might best contribute to the *UN Decade of Ocean Science for Sustainable Development*.

### **SOLAS Indian Ocean online meeting**

A Surface Ocean - Lower Atmosphere Study (SOLAS) sponsored event focusing on the Indian Ocean was held virtually on 30 September 2020. The workshop provided a platform to discuss upcoming research initiatives and to help initiate and foster collaborations between colleagues, institutions and projects such as IIOE-2. IIOE-2 was represented by keynote lectures given by Peter Burkill and Hermann Bange.

The meeting report can be found here: <https://www.solas-int.org/publications/publications-reader/issue-18-solas-indian-ocean-online-meeting.html>

**Other Issues: Now and the Future**

IORP (Indian Ocean Region Panel, Clivar /IOC-GOOS) has received funding from POGO and CLIVAR to run a workshop in the SW Indian Ocean aimed at coastal observing for under resourced countries. SIBER members are also involved in WIO workshop/capacity building initiatives. IORP is represented on the SCOR WG OASIS. IORP presented at the IIOE2 steering committee meeting and virtual conference (presentation) and were an invited Speaker at GOOS Africa's webinar on operational oceanography in Africa. IORP were invited speakers at an IORA webinar "*The Effects of Climate Change on the Indian Ocean Marine Environment*". They contributed to two commonwealth case studies, one on ocean women and the other on ocean observations in the Indian Ocean.

**Request to SCOR**

We request that SCOR agrees that the already allocated \$20k is used to underpin T&S at the re-scheduled IIOSC-22 conference, assuming that it will take place in person.